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March 29, 2000

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Subject: Waterford 3 SES
Docket No. 50-382
License No. NPF-38
Technical Specification Change Request NPF-38-217 Supplement
Addition of Main Feedwater Isolation Valves to Technical Specifications and Request for NRC Staff Review of an Unreviewed Safety Question

Gentlemen:

Per discussions with the NRC Staff, Entergy is hereby submitting additional supportive information for the review of Technical Specification Change Request (TSCR) NPF-38-217. The information provided in the attachment is in accordance with the guidelines of Regulatory Guide (RG) 1.174, An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant Specific Changes to the Licensing Basis. The results of risk informed and deterministic evaluations in accordance with the requirements of RG 1.174 are provided to support crediting non-safety features for closure of the Main Feedwater Isolation Valves (MFIVs) as presented in TSCR NPF-38-217.

Entergy is hereby requesting the attached information be incorporated with the original TSCR NPF-38-217 (Letter W3F1-99-0078, dated July 15, 1999) information. Entergy respectfully requests the NRC Staff approve TSCR NPF-38-217 based on the original and subsequent information provided.

The information provided in this correspondence does not change the original submittal's (TSCR NPF-38-217) Significant Hazards Consideration Determination; therefore, it remains valid.

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There are no new commitments generated by this correspondence.

Should you have any questions or comments concerning this request, please contact Arthur E. Wemett at (504) 739-6692.

Pursuant to 28 U.S.C.A. Section 1746, I declare under penalty of perjury that the foregoing is true and correct. Executed on March 29, 2000.

C.M. Dugger
Vice President, Operations
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CMD/AEW/rtk
Attachments: NPF-38-217, Supplemental Information

cc:
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NPF-38-217
Supplemental Information

ATTACHMENT

I. Introduction

In July of 1999, Entergy submitted Technical Specification Change Request (TSCR) NPF-38-217 for NRC Staff review. The purpose of this supplement is to add further detail and justification for the requested change, as discussed in the Waterford 3-NRC conference call held November 18, 1999. As requested, this supplement will follow the guidelines set forth in Regulatory Guide 1.174, An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant Specific Changes to the Licensing Basis.

In August 1995, the NRC adopted its final policy statement regarding the expanded use of PRA. The final policy statement provided that the use of PRA technology should be increased in all regulatory matters to the extent supported by the state of the art in PRA methods and data, and in a manner that complements the NRC's deterministic approach and supports the NRC's traditional defense-in-depth philosophy. The policy statement and the Staff's resulting PRA Implementation Plan were intended to improve the regulatory process in three areas: foremost, through safe decision-making enhanced by the use of PRA insights; through more efficient use of agency resources; and through a reduction in unnecessary burdens on licensees.

This report justifies crediting the non-safety Reactor Trip Override (RTO) and the Auxiliary Feedwater (AFW) pump high discharge pressure trip features for closure of the safety-related Feedwater Isolation Valve (FWIV) at Waterford 3, from both risk informed and deterministic/defense-in-depth standpoints, in conformance with the NRC policy statement. Crediting these features not only ensures closure of the FWIV, but also avoids a costly and unnecessary valve/actuator replacement. It will be shown that the quality and reliability of these features are commensurate with the safety functions they will be required to provide.

This report discusses the acceptability of a 30 second valve closure time for the FWIVs during AFW pump operation, following a Feedwater Line Break (FWLB). The potential 30 second closure does not adversely affect the consequences of the accident, and falls within regulatory guideline closure times for a valve of this size.

II. Description of Change and How the Licensing Basis is Affected

The Feedwater Isolation Valves were originally designed for closure against a differential pressure of 1400 psig, assuming a 0.2 valve friction coefficient. Through an investigation, which was initiated during a 1997 NRC Staff inspection, Entergy discovered that, if only safety related system functions were credited, the differential pressure across the valve could be postulated to reach values higher than 1400 psig. Further, based on industry and EPRI testing, the recommended, bounding, friction coefficient for this valve type and size is 0.4. The result is that the valve may not be able to meet its design basis 5 second closure time under certain design basis accident conditions if only safety related functions are credited. This would potentially allow greater mass and energy into containment or increased cooldown during FWLB and Main Steam Line Break (MSLB) events than is currently analyzed.

The proposed resolution involves an unreviewed safety question for crediting RTO to reduce the speed of the Steam Generator Feed Pumps (SGFPs) during an accident at full power; and the AFW pump high discharge pressure trip to stop the AFW pump during an accident at low power. The speed reduction and the trip function will decrease the differential pressure developed across the FWIV and facilitate rapid valve closure. Further, a 30 second closure time has been justified for the valve after a FWLB during AFW pump operation. The RTO and the AFW pump high discharge pressure trip are non-safety related, but will be credited to allow quick closure of the safety class 2 FWIVs. If the credited RTO or AFW pump control circuitry were to malfunction and a failure in the back-up valves (Main Feedwater Regulating Valves and Startup Feedwater Regulating Valves) occurred, the FWIVs may take longer to close than the required 5 seconds. The aspect of this change requiring NRC Staff review is the fact that FWIV closure, within its required design basis closure time, will be dependent on non-safety equipment. Credit for these features is not currently provided in the Waterford 3 licensing basis.

In order for a Risk-Informed Licensing Basis change to be approved, the change must be consistent with established regulatory requirements and staff positions, or risk information must be submitted to support the change. Therefore, multiple searches were performed on documents such as Regulatory Guides, the Waterford 3 SER, the SRP, and the General Design Criteria (GDC) to find positions or requirements that may need to be addressed. As a result of this review, four GDC were found to apply. Three of these were GDC 1, 2, and 3, which were specifically identified in the Waterford 3-NRC conference call held November 18, 1999. GDC 1 states that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. As will be shown in the body of this document, the safety significance associated with rapid closure of the Feedwater Isolation Valve in 5 seconds is minimal. Plus, the reliability of the non-safety related components being credited is high, and they will be subject to testing programs commensurate with their required functions. Therefore, because RTO and the AFW pump high discharge pressure trip are designed and maintained commensurate with the function Entergy requires them to perform, they meet the intent of the requirements of GDC 1.

GDC 2 states that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomenon such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The RTO and the AFW pump high discharge pressure trip functions are not designed to withstand the effects of all of the natural phenomenon specified. However, the only accidents applicable to the changes requested are the FWLB and the MSLB inside containment. These accidents should not, by design, be initiated by the natural phenomenon events stated. Further, as will be discussed later in this letter, the probability that core damage could be reached during a FWLB or a MSLB, due to the changes proposed, is negligible. If the probability of a natural phenomenon event occurring simultaneously with one of the two line break events is multiplied into the scenario, the potential impact on core damage frequency is negligible. In conclusion, designing the credited equipment to the specifications of Criterion 2 is not necessary for the equipment to fulfill its credited function.

GDC 3 states that structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and affect of fires and explosions. The RTO and the AFW pump high discharge pressure trip functions are not designed to withstand the effects of fires and explosions. However, the only accidents applicable to the changes requested are the FWLB and the MSLB inside containment. These accidents should not, by design, be initiated by fires or explosions. Further, as stated in the GDC 2 discussion, if the probability of a fire or explosion occurring simultaneously with one of the two line break events is multiplied into the scenario, the potential impact on core damage frequency is negligible. In conclusion, designing the credited equipment to the specifications of Criterion 3 is not necessary for the equipment to fulfill its credited function.

GDC 54 states, "Piping systems penetrating primary reactor containment shall be provided with leak detection, isolation, and containment capabilities which reflect the importance to safety of isolating these piping systems." Although closure of the Feedwater Isolation Valve may be delayed under specific conditions, it does eventually close to provide the isolation function. As stated in the discussion for GDC 1, this document will explain that the safety significance associated with rapid closure of the Feedwater Isolation Valve in 5 seconds is minimal. Plus, the reliability of the non-safety related components being credited is high, and they will be subject to testing programs commensurate with their required functions. Therefore, because RTO and the AFW pump high discharge pressure trip are designed and maintained commensurate with the safety function they are required to perform, they meet the intent of the requirements of GDC 54.

Another containment isolation issue is a 30 second allowable closure time for the FWIV when the AFW pump is in operation prior to a FWLB. For containment isolation, ANSI N271-1876/ANS-56.2, Section 4.4.4, states, "All valves larger than 12 inches in diameter should close within one minute unless an accident radiation dose calculation is performed to show that the longer closure time does not result in a significant increase in off-site dose." Section 4.4.4 also states, "In general, power-operated valves 3-1/2 inches to 12 inches in diameter should be closed at least within a time determined by dividing the nominal valve diameter by 12 inches per minute." Regulation Guide 1.141 states that the requirement and recommendations for containment isolation of fluid systems that penetrate primary containment as specified in ANSI N271-1976 are generally acceptable. No exceptions were taken for Section 4.4.4. Therefore, the 30 second closure time falls within the established regulatory requirements.

Another key point is that any potential release from containment (from an isolation standpoint) is not affected by the proposed change. As long as the feedwater piping is full and pressurized, no release from containment would be allowed through the pipe. Immediately upon depressurization of the piping fluid, the FWIV will completely close, thus isolating containment. This scenario will occur whether RTO functions or not. Further, for any event that does not involve a line break (i.e. – Steam Generator Tube Rupture), the normal operating pressure in the steam generator is sufficient to decrease the differential pressure across the FWIV so that it will close within its required 5 seconds. Therefore, although in some design basis scenarios the FWIV may take longer to close than the currently established 5 seconds, no increased potential of a release from containment will occur.

One final regulatory document section reviewed, which should be discussed, is the Standard Review Plan (SRP) section 15.1.5, Steam System Piping Failures Inside and Outside of Containment. Item (i) states, "For postulated instantaneous pipe failures in seismically qualified portions of the main steam line (inside containment and upstream of the MSIVs), only safety grade equipment should be assumed operative. If in addition, a single malfunction or failure of an active component is postulated, credit may be taken for the use of a backup non-safety grade component to mitigate the consequences of the break." This letter will show the FWIV will still close rapidly following a MSLB with the steam generator feed pumps in operation and a failure of RTO to function. Therefore, the proposed change will not affect this scenario. When the AFW pump is in operation and a MSLB occurs, the non-safety AFW pump high discharge pressure trip or operator action must be credited for rapid valve closure. However, the consequences of the longer valve closure time are not increased and accident mitigation is not affected. This will be discussed further in Section IV.

Based on the above regulatory discussions, credit for these two non-safety related functions to increase FWIV reliability is not in conflict with the intent of established regulations. The supplemental information in this letter will show that rapid closure of the FWIV for the scenarios in question is of minimal safety significance and no adverse consequences will result from the proposed change. The justification will be discussed from both a qualitative deterministic and a risk informed perspective. The result will show that RTO and the high discharge pressure trip of the AFW pump are adequately built and maintained to perform the desired function.

III. Description of SSCs Affected by Change

The operation of the Feedwater System was described in the body of the previous TSCR. Therefore, this section will focus only on the three components affected by this submittal: the FWIVs, RTO, and the AFW pump high discharge pressure trip.

a. FWIV: FW-184A(B) are 20" x 18" x 20" (20") 900 lb class Anchor/Darling double disc gate valves. Each valve is equipped with an Anchor/Darling hydraulic piston actuator supported by two pneumatic/hydraulic accumulators, two air accumulators, an air-operated hydraulic pump, four 4-way air-piloted hydraulic directional control valves, a hydraulic reservoir, and other accessories, controls, and instrumentation. Each valve actuator is powered by two pneumatic/hydraulic accumulators that have been precharged with nitrogen and pressurized by an air-operated hydraulic pump. Valve actuation may also be accomplished by the hydraulic pump to pressurize the actuator cylinder directly.

   The Instrument Air system supplies the motive force to operate the air motor of the hydraulic pump and to position the 4-way hydraulic valves that direct hydraulic fluid to the piston actuator and the hydraulic accumulators. The hydraulic system for each valve actuator is composed of two trains, with a total of two 4-way hydraulic directional control valves and four pneumatic 3-way DC-powered solenoid valves per train. There are two 3-way solenoid valves associated with each 4-way hydraulic valve for positioning. An air accumulator provides a back-up source of air to each train of 3-way solenoid valves in the event that Instrument Air is lost. This enables the positioning of the 4-way hydraulic valves that direct hydraulic fluid from the hydraulic accumulators to the piston actuator to close the FWIV. Both hydraulic accumulators on each valve are required for rapid valve closure.

The accidents/events that may be affected by the proposed change are the events that result in a large pressure differential across the FWIV. The limiting events with respect to design and regulatory consequences are the Main Steam Line Break (MSLB) and the Feedwater Line Break (FWLB) on the affected steam generator, due to the high differential pressure created across the valve. Other events that result in closure of the FWIVs (i.e. Loss of Coolant Accident and Steam Generator Tube Rupture), and isolation of the intact steam generator during a MSLB or FWLB, do not challenge closure of the FWIV, and are therefore not affected by the proposed change. Due to the low differential pressure across the FWIVs in these latter events, the FWIVs are able to close in 5 seconds with no credit for the RTO or AFW pump high discharge pressure trip features required.

Per the Waterford 3 Technical Specifications, the FWIVs are required to close within 5 seconds following a Main Steam Isolation Signal (MSIS) actuation. It was discovered during investigation of the FWIV issue that, if only safety related equipment was assumed to function properly, the valve may take longer than the required 5 seconds for closure on the affected steam generator. This is due to the high differential pressure developed across the valve between the upstream shut-off head of the pump and the downstream depressurizing steam generator. Therefore, solutions to decrease this differential pressure or increase actuator capability were investigated and are discussed in the body of the original Technical Specification Change Request. The optimum solution found was to credit the RTO feature, which quickly decreases the SGFP speed to minimum upon a reactor trip, and the AFW pump high discharge pressure trip. These functions already exist in the plant, have a proven reliability record, and would not alter current plant operation practices. They will decrease the pressure across the valve, allowing a closure time that will be bounded by the current safety analyses.

One more point to note about the FWIVs is that, upon closure actuation, the valves will continue to try to close until full closure is achieved. As line pressures decrease due to the isolation of main steam to the SGFPs or operator actions, the required valve thrust will decrease; and as the FWIV valve actuator nitrogen accumulators' pressures equalize due to temperature stabilization (reaching isothermal expansion), the available actuator thrust will increase. Therefore, although the FWIV may not be able to completely close within its required 5 seconds in some scenarios if RTO or the AFW pump high discharge pressure trip were to fail, the valve would close eventually.

b. RTO: The purpose of RTO is to prevent overcooling of the reactor coolant system after a reactor trip. This is accomplished by limiting the feedwater flow to a minimum rate, which will slowly refill the Steam Generators (SGs) and make up for decay heat.

The RTO condition is initiated by a reactor trip through four undervoltage relay status signals received from the Control Element Drive Mechanism Control System (CEDMCS). They are input as undervoltage (UV) to the Feedwater Control System (FWCS). At least one UV signal directly from CEDMCS coupled with one UV signal from the other FWCS is required to initiate RTO. This increases system reliability by requiring both FWCSs to recognize a reactor trip before starting control action. Since four signals are sent, reliability is high for both preventing an inadvertent RTO and preventing an RTO failure.

If one or both pairs of UV signals are present, a bistable output is generated to the three time delay (seal-in) networks. The time delay networks will hold an output for 10 seconds after receiving an input signal. The 10 second hold is to ensure that RTO is initiated, even with a signal present for only a short period of time. This assures that the FWCS will maintain the reactor trip status long enough to switch to RTO. An output from two of three time delay networks generates the RTO logic immediately. Once the relays perform their function, RTO is locked in until flow demand is less than the RTO flow signal to the respective startup valves.

When the RTO logic signal exists, the following limitations are placed on the valves and the pump speed program: flow demand to the SGFPs is limited to $\leq$3.5%, flow demand to the Startup Feedwater Regulating Valves (SFRVs) is limited to $\leq$3.5%, flow demand to the Main Feedwater Regulating Valves (MFRVs) is limited to 0%.

The feature of concern for the FWIV is the pump speed limitation to $\leq$3.5% flow demand (3900 rpm). At this speed, the shutoff head of the pump is small enough to allow rapid valve closure in any line break scenario with the SGFPs in operation. Plant computer data shows that pump speed is rapidly decreased to 3900 rpm upon RTO initiation (within approximately 3 seconds). Closure of the FWIV should also facilitate pump speed decrease.

When a MSIS occurs, the FWIVs, MFRVs and SFRVs all close within 5 seconds, which overrides the above $\leq$3.5% setpoint actions of the RTO circuitry. The valves go to their closed position and feedwater flow is isolated. Closure of the regulating valves would adequately reduce the differential pressure across the FWIV, however, a single failure of the regulating valve to close is being assumed in order to calculate FWIV closure against maximum expected differential pressures.

Note that the RTO program currently only activates the Turbine Control Stations if they are in the auto mode of operation. Pending approval of crediting RTO for FWIV closure, a modification to the RTO system will be implemented to ensure the SGFPs will also automatically run back to minimum speed on a reactor trip when the Turbine Control Stations are in manual. This will improve the reliability of the RTO circuitry and eliminate the reliance on operator action when the FWCS is in manual.

The RTO system at Waterford 3 has proven to be an exceptionally reliable system. The FW Controls System Engineer and the Instrumentation & Controls Maintenance Supervisor can recall no failures of the RTO system to reduce SGFP speed when required during the history of plant operation. A search of the Waterford 3 Condition Report System also showed no failures of the RTO to reduce SGFP speed. Further, the RTO circuitry is tested every refuel outage to ensure it is working properly. Multiple inputs are simulated, and the outputs, such as valve positioning and pump speed, are verified. This will continue after approval of this submittal, and the requirements for this testing will be moved to the Technical Requirements Manual (TRM) to increase emphasis on the importance of this testing. The FWCS is also included in the Maintenance Rule as a system whose functions encompass satisfactory automatic operation during load rejection, reactor trip (RTO), and high SG level.

c. AFW High Discharge Pressure Trip: The AFW pump is a high head, low flow pump, originally designed as a High Pressure Safety Injection (HPSI) Pump. Therefore, it is capable of developing high pressures, much more than required by the Feedwater system. The purpose of the AFW high discharge pressure trip is to protect the pump from damage and the piping from overpressurization. The AFW pump high discharge pressure trip is set for 1350 +/- 25 psig. It is actuated by a single pressure switch in the AFW pump discharge header.

For FWIV closure, the AFW pump high discharge pressure trip will also result in limiting the maximum expected pressure developed upstream of the FWIV. If the FWIVs were actuated to close while the AFW pump was operating, the pump discharge pressure would increase quickly due to valve closure choking the available flow paths. Since the FWIVs will be able to close at a discharge pressure greater than the trip setpoint, allowing pressure to exceed the setpoint, the pump will trip, causing the FWIV upstream pressure to significantly decrease. This will allow full closure of the valve on the affected generator.

The trip has a 2 second time delay. It may cause a momentary hesitation in the MSLB scenario. However, it is expected that the discharge pressure will quickly increase to the trip setpoint as the FWIV closes, due to the incompressibility of the liquid. Also, since AFW flow is significantly less than normal feedwater flow, the consequences of a MSLB during AFW pump operation are bounded by the same event with the SGFP operation, even if a few seconds of hesitation is encountered due to the time delay. The potential slight delay in closure will not affect the FWLB scenario, in which a 30 second closure time has been justified (based on the lower flow rate of the AFW pump compared to the SGFP). The 30 second delay allows sufficient time for the nitrogen pressure in the actuator accumulator to equalize, and for a 1.4 discharge coefficient to be used (rather than the 1.9 used for rapid closure), thus providing a greater actuator thrust and ensuring the valve will fully close.

The AFW pump high discharge pressure trip switch is currently tested and calibrated every 18 months. Plant operators interviewed recollect no occurrences of failure of this trip to stop the pump on high discharge pressure in the past. Further, a search of the Waterford 3 corrective action system showed no failures of the discharge pressure trip, and the AFW system is included in the maintenance rule as a "risk significant" system.

IV. DETERMINISTIC/DEFENSE-IN-DEPTH DISCUSSION

The expected consequences of a FWLB and MSLB will not change with the crediting of RTO and the AFW pump high discharge pressure trip. The following discussion will outline the deterministic significance of the four events in question, with a qualitative discussion of the expected outcomes if the credited non-safety related functions were to fail. In each scenario, the FWIV closure refers to the valve on the ruptured steam generator, since the FWIV on the unaffected steam generator does not need to credit the non-safety functions. Also, in each scenario, the initial single failure assumed is the failure to close the Feedwater Regulating Valve for the affected steam generator. A bounding 0.4 friction coefficient is also used in all thrust calculations.

NOTE: RTO is only necessary during a MSLB or FWLB with the Steam Generator Feed Pump (SGFP) in operation, and the AFW pump high discharge pressure trip is only necessary during a MSLB or FWLB with the AFW pump in operation.

SGFP – MSLB in Containment – 100% Power:

This scenario entails a MSLB inside containment, followed by a failure of a FW Regulating Valve of the affected steam generator, followed by a failure of RTO to decrease SGFP speed. The MSLB will cause an MSIS actuation, thus signaling the FWIV and the FW Regulating Valves to close to stop feedwater flowing to the broken SG and isolate containment. If the FW Regulating Valve then fails to close, the FWIV will be subject to full differential pressure. If RTO then fails to run the pump back to minimum speed, the FWIV will be subject to a higher differential pressure. However, even if RTO did not operate properly, the FWIV should still close within 5 seconds.

In the MSLB scenario, the affected steam generator remains partially pressurized, which reduces the differential pressure across the FWIV. If an assumption is made that the pump will not increase speed after a line break to more than 10% above its steady state speed, due to conflicting signals to the FWCS subsequent to the break, the available and required thrusts are approximately equal. It is expected the conflicting signals being sent to the pump after a line break would not significantly increase the pump speed. Further, because the friction coefficient, calculational methods, feedwater temperature and packing assumptions used are bounding, it is likely that the actual required thrust would be much less than calculated. Also, the accumulator nitrogen pressure used in the calculation was assumed to be that of the low alarm setpoint, less tolerances and inaccuracies. The actual pressure would be above this value since actions are taken to immediately recharge the accumulators when this alarm occurs. Therefore, the available actuator thrust would be higher than calculated. With these conservative items, the valve should easily close within the required 5 seconds for this scenario, even without RTO credit. Regardless of all the stated conservatism and assumptions, the valve will eventually close once steam is isolated from the turbine due to the closure of the Main Steam Isolation Valves (MSIVs) and the pumps no longer having motive force to develop pressure upstream of the FWIVs.

Potential consequences:

During a MSLB, slow closure of the FWIV can affect the positive reactivity addition due to RCS cooldown and the mass and energy addition to containment for the peak containment pressure analysis. If the regulating valve fails to close and RTO fails to decrease the SGFP speed and the FWIV does not completely close, the consequences of a MSLB will not be significantly affected. The FWIV will be substantially closed so that only a small fraction of flow will pass through the valve. This small additional flow does not significantly contribute to the cooldown of the RCS caused by the MSLB. Furthermore, since the regulating valve was the assumed single failure, both HPSI pumps start to inject borated water that counteracts the positive reactivity due to the cooldown. The net result is less limiting than the single failure of the HPSI pump. Furthermore, in the peak containment pressure analysis, the small additional mass and energy added to containment is also offset by the second containment spray pump that would be operating since the single failure was the FW Regulating Valve. Eventually, the FWIV will close completely as steam to the SGFP is lost, due to closure of the MSIV.

Therefore, even if the regulating valve failed to close and RTO failed to decrease SGFP speed and the FWIV still failed to close completely, the consequences of a MSLB would not be significantly affected.

SGFP – FWLB in Containment – 100% Power:

This scenario entails a FWLB inside containment, between the containment wall and the steam generator, followed by a failure of the FW Regulating Valve of the affected steam generator, followed by a failure of RTO to decrease SGFP speed. The FWLB will cause an MSIS actuation, thus signaling the FWIV and the FW Regulating Valves to close to stop feedwater (mass and energy) from flowing into containment and to isolate containment. If the FW Regulating Valve then fails to close, the FWIV will be subject to full differential pressure. If RTO then fails to run the pump back to minimum speed, the FWIV will be subject to a higher differential pressure, which would prevent rapid valve closure.

RTO must be credited in this scenario to ensure rapid valve closure. The difference between this scenario and the previous MSLB scenario is that there is no residual pressure assumed remaining in the steam generator, downstream of the valve. The downstream pressure is at containment pressure (assumed to be zero psig).

Potential consequences:

The only potential consequences of an open FWIV would be an increase in mass and energy to containment from the approximately 450 degree Feedwater out of the break. However, even if the FW Regulating Valve fails to close and RTO fails to decrease SGFP speed, the FWIV still would not be fully open. Therefore, there would be reduced feedwater flow to containment. The FWIV would not fully close until the pressure across the valve was equivalent to the available actuator thrust. Then, it would continue closing as nitrogen pressure equalized (approaching an isothermal reaction over time) and as the SGFP was cut off from its steam supply through MSIV closure. The expected maximum closure time would be less than one minute, due to pump speed decrease.

The peak containment pressure for a Feedwater Line Break is not analyzed for Waterford 3 since it is bounded by the peak pressure for a MSLB and LOCA. If the FWIV did not fully close for a FWLB until one minute into the event, the small additional mass and energy might cause a slight increase in the containment pressure. However, the MSLB is expected to remain the bounding scenario and consequences (containment pressure) would not be increased. Furthermore, since a single failure of a regulating valve to close is assumed, the second containment spray pump more than offsets the small additional mass and energy to lower containment pressure.

AFW – MSLB in Containment – 0% Power:

This scenario entails a MSLB inside containment, followed by a failure of the FW Regulating valve of the affected steam generator, followed by a failure of the AFW pump high discharge pressure trip to stop the AFW pump. The MSLB will cause an MSIS actuation, thus signaling the FWIV and the FW Regulating Valves to close to stop feedwater flowing to the broken SG and isolate containment. If the FW Regulating Valve then fails to close, the FWIV will be subject to full differential pressure. As the FWIVs close, the pump discharge pressure would increase quickly due to valve closure choking the available flow paths. When the FWIVs block enough flow to overcome the trip setpoint, allowing pressure to exceed the setpoint, the pump will trip, causing the FWIV upstream pressure to significantly decrease. This will allow full closure of the valve on the affected generator, which should occur within the required 5 seconds. However, if the high discharge pressure trip fails to stop the pump, the FWIV will be subject to a higher differential pressure, which would prevent full valve closure.

Therefore, if the FW Regulating Valve were to fail to close and the AFW pump high discharge pressure trip were to fail, full valve closure could not be credited until the operator took action to secure the pump, which can be done from the control room. This operator action should occur within approximately 30 minutes.

Potential consequences:

The consequences of this scenario would be increased cooldown from the approximate 500 gpm flow of cool outside water, allowed through the mostly closed valve, to the affected steam generator. However, since the single failure assumed is the failure of the FW Regulating Valve to close, both HPSI pumps are available. The boron addition from the combined HPSI pumps should be more than adequate to mitigate the increased cooldown from the AFW flow. Therefore, consequences would not increase above those previously analyzed.

AFW – FWLB in Containment – 0% Power:

This scenario entails a FWLB inside containment, followed by a failure of the FW Regulating valves of the affected steam generator, followed by a failure of the AFW pump high discharge pressure trip to stop the AFW pump. The FWLB will cause an MSIS actuation, thus signaling the FWIV and the FW Regulating Valves to close to stop feedwater flowing to containment and to isolate containment. If the FW Regulating Valve fails to close, the FWIV will be subject to full differential pressure. As the FWIVs close, the AFW pump discharge pressure would increase quickly due to valve closure choking the available flow paths. When the FWIVs block enough flow to overcome the trip setpoint, allowing pressure to exceed the setpoint, the pump will trip, causing the FWIV upstream pressure to significantly decrease. This will allow full closure of the valve on the affected generator, which should occur within 30 seconds.

In this last scenario, the AFW pump high discharge pressure trip must be credited to ensure the FWIV closes within 30 seconds. The difference between this scenario and the above MSLB scenario is that a 0 psi downstream pressure is assumed for the valve, rather than the higher pressure for the MSLB. The 30 second valve closure allows time for nitrogen temperature and pressure equalization, and the use of a 1.4 discharge coefficient, rather than 1.9. The 1.9 discharge coefficient is based on Anchor Darling test data for rapid valve closure of the Waterford 3 FWIVs. This value is therefore used in the rapid valve closure calculations. However, once some time is allowed for temperature and pressure equalization, a standard discharge coefficient for nitrogen (1.4) is considered valid. Using this coefficient in the thrust calculation results in the valve being able to overcome the pump high discharge pressure trip setpoint.

However, if the AFW pump high discharge pressure trip fails to trip the AFW pump, the FWIV will be subject to a high differential pressure, which would prevent full valve closure. Therefore, if the regulating valve were to fail to close and the high AFW pump high discharge pressure trip were to fail, full valve closure could not be credited until operations took action to secure the pump. This action can be done from the control room and should occur within approximately 30 minutes.

Potential consequences:

If the FW Regulating Valve failed to close and the AFW pump high discharge pressure trip were to fail, full valve closure could not be credited until the operator took action to secure the AFW pump. The result would be continued flow of AFW into containment. However, the water being pumped into containment is well below the saturation temperature of the containment atmosphere. Therefore, this flow will condense steam and not contribute to increased containment pressure.

Hot-Standby – Post Trip:

This scenario entails a line break inside containment followed by the failure of a FW Regulating valve of the affected steam generator to close. In this unusual condition the plant has either been shutdown or tripped and decay heat available from the reactor is sufficient to create steam to allow operation of the SGFPs. If a line break occurred during this time and a MSIS was actuated, the SGFPs would not receive a RTO signal and would not reduce to minimum speed. RTO would not function because the UVO relays (RTO demand generation signal) would have been actuated due to reactor trip and have not been reset. The time frame for operation in this condition is limited to shortly after plant shutdown, as long as sufficient decay heat is available to produce steam to allow operation of the SGFPs.

The line break will generate a MSIS actuation, thus signaling the FWIV and the FW Regulating Valves to close to isolate feedwater flow to the affected SG and to isolate containment. If the FW Regulating Valve fails to close, the FWIV will be subject to full differential pressure. As the FWIVs close, the pump discharge pressure would increase quickly due to valve closure choking the available flow paths. Even though RTO is not available to reduce the SGFP to the minimum speed, the FWIV still would not be fully open. Therefore, there would be reduced feedwater flow to containment. The FWIV would continue closing, as nitrogen pressure in the actuator accumulator equalized and as the SGFP was isolated from its steam supply through MSIV closure. The expected maximum closure time would be less than one minute, due to pump speed decrease.

Potential consequences:

The potential consequences of this scenario are similar to those described for the AFW line break scenarios, since decay heat removal involves low flow rates and the feedwater being supplied is at lower temperatures. As in the other SGFP cases when RTO failure was discussed, the SGFP speed is expected to be reduced to the minimum speed within one minute, due to MSIV closure, thus allowing the valve to fully close. The consequences of this final scenario would be bounded by currently analyzed events.

In summary, this scenario has been reviewed and due to the short duration, the scenario's transitional nature, and being bounded by the more limiting scenarios discussed, there are no adverse consequences to this scenario. This scenario remains bounded as long as the valve meets the five second closure time in the more limiting scenarios.

V. How and Where the Change Will Be Documented in the LB

The potential impacts on defense-in-depth have been discussed in detail in Section IV. The evaluation of the scenarios in question shows no adverse impact to previously analyzed events with the proposed change. The RTO and AFW pump high discharge pressure trip will increase reliability of the FWIVs, minimize pressurization of the secondary system, and ensure that the potential consequences remain at a minimum. They will also ensure that the FWIVs will meet the required closure times specified in the current Technical Specifications.

The specified changes will be documented in multiple areas, upon NRC Staff approval. First, changes will be implemented in to the Technical Specifications and Bases, as outlined in the original submittal. Second, FSAR Chapter 10, Section 4, will be revised to explain the crediting of RTO and the AFW pump high discharge pressure trip for FWIV closure. It will also explain the slower closure time allowed for AFW pump operation during a FWLB, and the fact that both accumulators for each FWIV are required for rapid valve closure (currently only one is specified as being necessary for valve closure). FSAR Table 6.2-32, Containment Penetrations and Isolation Valves, will also be modified to note the longer allowed closure time of the valve during AFW pump operation with a FWLB.

Third, the TRM will be updated to include the testing requirements for the Main Feedwater Regulating Valves, the Start-up Feedwater Regulating Valves, RTO, and the AFW pump high discharge pressure trip. Table 3.3-5 will also be notated to specify the longer allowed closure time of the valve during AFW operation with a FWLB.

Finally, the current testing practices/procedures of the Main Feedwater Regulating Valves, the Start-up Feedwater Regulating Valves, RTO, and the AFW pump high discharge pressure trip will be updated/modified to ensure appropriate testing practices and intervals.

VI. SSCs for Which Requirements Will Be Increased

The current testing requirements of the Main Feedwater Regulating Valves, the Start-up Feedwater Regulating Valves, RTO, and the AFW pump high discharge pressure trip are adequate and commensurate with their safety functions. They are all currently tested on an 18-month interval, during shutdown conditions.

As previously stated, the FWCS is included in the Maintenance Rule as a system whose functions encompass satisfactory automatic operation during load rejection, reactor trip (RTO), and high SG level. Therefore, RTO is encompassed in the trending. However, the Main Feedwater Regulating Valves, the Start-up Feedwater Regulating Valves, RTO, and the AFW pump high discharge pressure trip will all be reviewed further for individual trending through the Maintenance Rule, and to ensure they are properly incorporated within their respective system's trending.

VII. RISK ASSESSMENT

Failure to close the FWIVs is not included in the Level 1 PSA model for core damage frequency. The only area of the model in which failure to close the FWIVs is modeled is in the Containment Isolation fault tree, which is used in calculating Large Early Release Frequency (LERF). Therefore, LERF is the only PSA result that would be impacted if a FWIV failed to close.

The failure to close a FWIV in 5 seconds is not in the Level 1 model because it has no affect on core damage. The FWIV will eventually close when the SGFP speed reduces due to a loss of steam after the MSIV closes. This is expected to occur within approximately one minute. The short additional time that the FWIV may remain open has no impact on core damage. The only way core damage could be achieved from a MSLB or FWLB is if failure of Emergency Feedwater (EFW) occurred, thus eliminating decay heat removal. The change in question does not affect the ability to get water to the steam generators and does not affect EFW. Plus, EFW is not normally injected into the affected steam generator and the change in question does not affect isolation of the unaffected steam generator. If operators would for some reason decide they wanted to feed the affected generator (due to multiple failures), and the FWIV had not yet closed, the check valve upstream of the FWIV would prevent EFW diversion into the main feedwater system. In conclusion, failure of the FWIV to close within 5 seconds on demand does not affect Waterford 3 Core Damage Frequency.

In the original submittal, a simple and conservative risk assessment was performed to determine the significance of a failure to close the Feedwater Isolation Valves (FWIV) due to a failure of RTO. This calculation was based on a conservative assumption that EFW operation could be affected through overfilling the steam generators prior to FWIV closing. The only line break in which this could occur would be a break between the MSIVs and the EFW steam line outside containment, which is less than 50' of piping on each train. Any other break would cause the feedwater to flow out of the main steam and feedwater lines prior to reaching the EFW steam line. The increase in core damage frequency was conservatively calculated for this scenario and is detailed in the original submittal. The results produced an increase in core damage frequency of 1.8×10^{-13} for the postulated scenario.

However, as stated in Section VI, during a MSLB with SGFP operation, the valve should close near its 5 second requirement, even without crediting RTO. Therefore, overfill of the steam generator in this scenario would not be an issue if RTO failed. Further, the volume available in a steam generator between the high level alarm pre-trip alarm setpoint and the top of the steam generator is calculated as 26,541 gallons. However, considering an approximate Reactor Coolant System temperature of 560°F the expansion of the fluid resulted in a conservative inventory value of 19,330 gallons. This is greater than 30 minutes of AFW flow at approximately 500 gpm (based on the pump curve at the pressure after 5 seconds), or 15,000 gallons. It is expected that operators will take action to isolate the non-intact steam generator during a MSLB within 30 minutes, thereby precluding the potential to overfill the steam generator. The Excess Steam Demand Recovery Procedure, OP-902-004 Step 12, instructs the operators to close the associated EFW Pump AB Steam Supply Valve, MS-401, on the non-intact steam generator to minimize or secure the excess cooldown. This action supports the protection of the EFW Pump AB turbine from water introduction if steam generator level continued to rise. This step of the recovery procedure also requires the associated Main Feedwater Isolation Valve, FW-184A or B, to be closed. An indication of open or intermediate position of the valve would lead the operators to secure the AFW pump to prevent continued feeding and overcooling. Therefore, based on the conservative assumptions made in the original calculation (that the valve would fail to close, and the operators would not isolate the generator or secure the pump), overfill of the affected steam generator is not a credible assumption. In conclusion, failure of the FWIV to close is not risk significant. Because there is no impact in CDF, the change in LERF is small. However, since the failure of the FWIVs to close is located in the Containment Isolation fault tree, Waterford 3 has quantified the change in LERF.

Because the failure of the FWIV to close does not affect any bypass or high-pressure-melt-ejection sequences and the CDF has not been impacted, the contribution from the containment isolation standpoint is the only factor to impact LERF. Therefore, the change in LERF is equivalent to the Waterford 3 base CDF multiplied by the change in the containment isolation fault tree results. The containment isolation top gate, J001, was quantified using a truncation of 10^{-10}, with a result of 4.972E-3. It was then again quantified with the FWIV fail to close event set to true, with a resulting 4.972E-3. J001 was quantified a third time with both the FWIV fails to close and the steam generator fails to isolate events set to true. This means that one of the two FW Regulating Valves fails to close or the FW Regulating Valves Bypass Valve transfers open and the steam generator is not isolated. The result was 4.994E-3. Using this conservative scenario, the change in J001 was 2.2E-5. Multiplying this by the current Waterford base CDF of 2.54E-5 gives a conservative change in LERF of 5.59E-10, which is well below the Regulatory Guide 1.174 guideline of $5E10^{-8}$ per reactor year. The results are conservative since failure of both the FWIV and the upstream FW Regulating Valve are both assumed to occur (with a failure probability of 1.0).

Because closure of the valve does not impact core damage, no change to the model will be made. Because closure of the valve does not impact the Level 1 model and the Level 1 model was not solved for resultant CDF, uncertainties in the Level 1 model are irrelevant. The only part of the model that was solved, with results provided, were the inputs to the LERF calculation. However, as depicted, even with the use of a conservative assumption, the change in LERF is so insignificant that any addition of uncertainties would not change the fact that the results are very small. Therefore, an in depth discussion of uncertainties is unnecessary and not included.

VIII. Scope, Level of Detail and Quality of PRA

The IPE Model at Waterford 3 is referred to as Revision 0 of the PSA Model. The current revision is Revision 2. Revision 2 is the IPE model with the incorporation of model improvements and plant changes since the IPE submittal. Changes to Revision 2 (Revision 3) are currently in development, and will incorporate further improvements and plant changes, keeping in line with the "living model" philosophy. The revision used for this submittal was Revision 2, since Revision 3 is not complete.

Three levels of reviews were performed on the original Waterford 3 PSA. The first was a basic QA review carried out by the organization that developed the analysis. A qualified individual with knowledge of PSA methods and plant systems performed an independent review of all assumptions, calculations, and results for each task and the system models in the Level 1 analysis (except internal flood analysis). Plant personnel not involved in the development of the PSA performed the second level of review. This review group consisted of individuals from Operations, Licensing, Engineering, and Training; providing diverse expertise with plant design and operations knowledge to review the system fault trees for accuracy. The third level of review was performed by PSA experts from ERIN Engineering. ERIN provided broad insights on techniques and results based on experience from other plant PSAs. They reviewed the overall PSA methodology, accident sequence analyses, system fault trees, Level 1 results, and the human failure and recovery analysis.

Revisions and changes performed since the original IPE have been independently reviewed by Waterford 3 PSA personnel or PSA personnel from other Entergy sites, as necessary.

During the week of 1/17/00, a PSA Certification Team reviewed the Waterford 3 PSA Model. The certification was scheduled through Combustion Engineering Owner's Group participation. The team was made up of a lead from Combustion Engineering (CE) and four experienced PSA peers from other CE plants. The team identified some concerns, most of which had been previously identified by Waterford personnel. The team also identified some conservatisms. All items will be prioritized and evaluated for implementation. The items identified in this review do not affect the conclusions made in this submittal.

Through Configuration Risk Management Program (CRMP) implementation, a documented methodology for PSA updates (based on the existing site calculation procedure) is being developed. This will ensure a consistent, repeatable methodology for model update, and a consistent reflection of plant and operating changes. It will also provide guidance on applications that may need to be re-reviewed for impact after updates, such as Allowed Outage Time (AOT) extension inputs.

IX. Define Implementation and Monitoring Program

As previously stated, the current testing requirements of the Main Feedwater Regulating Valves, the Start-up Feedwater Regulating Valves, RTO, and AFW pump high discharge pressure trip are adequate and commensurate with their safety functions. The requirement for testing all these components will be added to the Waterford Technical Requirements Manual, in order to stress the importance of these components. Also, the Maintenance Rule will be reviewed to ensure the basis and trending documents reflect the importance of the function of these SSCs.

Finally, Waterford 3 is currently implementing a CRMP to support Risk-Informed Technical Specification Allowed Outage Time submittals and to support implementation of Paragraph A4 of the Maintenance Rule. The CRMP will facilitate monitoring plant risk while components are out of service. The EOOS Risk Monitor is the quantitative tool, which will facilitate the performance of risk assessments. Because closure of the FWIV and its backup valves is not in the Level 1 model, taking the valve out of service for a closure issue will not impact the EOOS output. However, the qualitative guidance that supplements EOOS will describe that fast closure of the FWIV relies on the RTO and the AFW pump high discharge pressure trip.