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Waterford 3

W3F1-2005-0004

January 14, 2005

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

SUBJECT: Supplement to Amendment Request NPF-38-249
Extended Power Uprate
Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCES:
1. Entergy Letter dated November 13, 2003, "License Amendment Request NPF-38-249 Extended Power Uprate"
2. Entergy Letter dated October 18, 2004, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"
3. Entergy Letter dated November 19, 2004, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"
4. Entergy Letter dated May 12, 2004, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"
5. Entergy Letter dated July 14, 2004, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"

Dear Sir or Madam:

By letter (Reference 1), Entergy Operations, Inc. (Entergy) proposed a change to the Waterford Steam Electric Station, Unit 3 (Waterford 3), Operating License and Technical Specifications to increase the unit's rated thermal power level from 3441 megawatts thermal (MWt) to 3716 MWt. Section 2.13.6.3.2, of Attachment 5 in Reference 1 provides the analysis results for the steam generator tube rupture event and was supplemented by Reference 2.

On October 14, 2004, Entergy and members of your staff held a call to discuss the assumption that the loss of offsite power (LOOP) would be delayed for 3-seconds following the reactor trip that resulted from a steam generator tube rupture event. As a result of the call, two questions were determined to need formal response. Entergy provided that response in Reference 3. Follow-up questions were discussed with the staff during calls held on December 9, 2004, and December 15, 2004. As a result of these calls, eight additional questions were determined to need formal response. The response to these eight questions is provided in Attachment 1.

On December 15, 2004, Entergy communicated, to the staff, the need to clarify Section 2.7.1.1 in Attachment 5 of Reference 1 regarding fission product escape coefficients. The clarification is provided in Attachment 2. This clarification does not change the results or

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conclusions of the analysis since the clarification is consistent with the analysis performed and documented in Reference 1.

On January 6, 2005, Entergy communicated, to the staff, the need to implement additional actions to prevent a complete loss of feedwater following the loss of two or more heater drain pumps at Extended Power Uprate (EPU) conditions. Entergy anticipates that the actions can be implemented under the provisions of 10 CFR 50.59 and therefore is not requesting staff review and approval of these actions. Entergy commits to complete actions to prevent the complete loss of feedwater upon the loss of two or more heater drain pumps prior to exceeding the current (i.e., pre-EPU) rated thermal power of 3441MWt. A brief description of the issue and potential actions are provided in Attachment 3.

Following discussions with the staff on January 11, 2005, Entergy wishes to confirm that measurement uncertainty is always considered for Technical Specification (TS) parameters. Uncertainty is either added (or subtracted as appropriate) to the TS value for surveillance testing purposes unless the uncertainty has already been considered by the safety analysis upon which the TS parameter is based. Consideration of uncertainty in the safety analysis is typically performed in one of two ways. It is considered either by including the uncertainty in the input parameters used in the safety analysis or by evaluating the conservatisms, margins, and/or sensitivity of the safety analysis compared to the uncertainty (e.g., containment pressure analysis as described in Reference 4).

The no significant hazards consideration included in Reference 5 is not affected by any information contained in the supplemental letter. This letter contains one new commitment as summarized in Attachment 4.

If you have any questions or require additional information, please contact D. Bryan Miller at 504-739-6692.

I declare under penalty of perjury that the foregoing is true and correct. Executed on January 14, 2005.

Sincerely,

R Dodds, III

RAD/DBM/ssf

Attachments:

1. Response to Request For Additional Information
2. Clarification to Extended Power Uprate Report Section 2.7.1, Source Terms for Radwaste System Analysis
3. Potential Loss of Feedwater Due to Loss of Two or More Heater Drain Pumps
4. List of Regulatory Commitments

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Attachment 1

To

W3F1-2005-0004

Response to Request for Additional Information

Response to Request For Additional Information Related To Loss of Offsite Power Time Delays Associated With the Steam Generator Tube Rupture Analysis

Question 1:

Attachment 1 to the Entergy Operations, Inc. (Entergy) November 19, 2004, letter states that Entergy currently performs real time contingency analysis on an N-1 (single generation or transmission element contingency) basis by simulating the loss of transmission facilities at 230kV and above within the Entergy controlled area including Nuclear Power Plants. Does the Entergy transmission operator presently have the Waterford Steam Electric Station, Unit 3 (Waterford 3) minimum required switchyard voltages? Will the contingency analysis program alarm and the Waterford 3 operator be notified when the surrounding grid is in a condition that will not maintain these voltages above the required minimum level following a trip of Waterford 3? What are the Waterford 3 minimum required switchyard voltages that are necessary to maintain adequate safety-related terminal voltages and preclude tripping of degraded voltage relays?

Response 1:

Entergy Transmission continuously monitors the overall state of the grid as an entity and also significant load pockets within the grid for "stressed grid" conditions. The Entergy policy entitled, "Entergy Curtailment Policy and Procedure", provides for real time notification of key personnel for several distinct levels of grid conditions, including consideration for the capability of the grid to respond to possible future contingencies, as well as present capability. If conditions warrant, immediate notification of such conditions is communicated to the Operating Subcommittee, which includes representation by Entergy Nuclear South personnel. This allows Entergy Nuclear South to immediately begin appropriate evaluations of grid conditions as they relate to the Waterford 3 offsite sources.

Existing commitments between Waterford 3 and Entergy Transmission are delineated in Section 5 of the Entergy Switchyard Coordination Policy. Section 5 of this Policy provides the following guidelines:

GRID OPERATOR INTERFACE

- The dispatching and switching organizations are aware of the unique operating restrictions for the nuclear units and maintain an awareness of their role in assuring the public health and safety with reference to the nuclear plant/grid interface.
- The transmission grid operator will provide affected nuclear plant Operations organizations of early warning of potential or developing grid instabilities.
- The nuclear units are recognized as preferred restorable loads for nuclear safety purposes and this status is reflected in grid load-shedding schemes.
- Entergy Nuclear South nuclear units are considered Priority Class 0 (the highest level) within the native load curtailment scheme.

The present agreements between Waterford 3 and Entergy Transmission do not specifically delineate the "required voltage range and the post-trip load from Waterford 3 that will be connected to the grid". However, the periodic studies performed on behalf of Waterford 3 including consideration for plant trip, combined with other concurrent limiting contingency events, do explicitly incorporate these values for determination of the adequacy of offsite sources for Waterford 3.

The Waterford 3 specific requirements for grid voltage and the load imposed by the plant post-trip have been communicated to the appropriate Entergy Transmission personnel on several fronts to facilitate their understanding and consideration. These requirements are clearly contained within the periodic studies performed on behalf of Waterford 3 and are confirmed with each update of such studies. In addition, Entergy Nuclear South has specifically provided key Transmission personnel that perform duties relating to these requirements, with presentations that highlight both the requirements and the basis for them.

Waterford 3 has a site specific basis for relation of the required safety bus voltage range to the degraded grid set point. Nominal grid voltage is 230KV. The degraded voltage (DV) relays are set at 93.1% (3873 V) of 4160V safety related busses. A reduced voltage alarm is actuated in the control room if the grid voltage degrades to 224.6KV with the plant at 100% power. This corresponds to a minimum voltage required at the 4160V safety related busses to allow for large motor starts without actuating the degraded voltage relays due to a momentary dip in the bus voltages. The reduced voltage alarm is set above the minimum allowable post trip voltage required for plant shutdown.

This alarm allows time for operations to change plant lineups placing the plant in the safest condition to cope with grid instability. The alarm provides an early warning to allow Waterford 3 to contact the Transmission System Operator for any information on impending grid problems.

The actual grid voltage that is required to ensure that the DV relays do not trip depends on the plant auxiliary loading conditions as this is a factor of voltage drop through the unit auxiliary or start up transformers. For the worst case loading, informal calculations indicate that the grid can be at 96% (220.8KV) auxiliary loading without the relays tripping.

Waterford 3 procedures require Operations personnel to call the Transmission Operators upon detection of low voltage (3940V) on the 4160V safety related busses.

Question 2:

Attachment 1 to the Entergy November 19, 2004, letter has provided an assessment of Waterford 3 equipment operability for a double sequencing scenario where the degraded voltage on offsite power is taken to be approximately 90% of nominal. What is the time delay and voltage setting of the loss of voltage protective relaying on the 4160V safety buses? What is the minimum voltage the 230 kV grid surrounding Waterford can maintain in the Waterford switchyard without the grid becoming unstable and/or voltage collapse occurring? Would the assessment provided in the November 19, 2004, letter still find acceptable equipment operability if the double sequencing degraded voltage was taken to be the higher of these two values? Please explain your rationale.

Response 2:

The 4160V buses 3A3-S and 3B3-S have been provided with undervoltage relays to monitor the voltage condition on these buses. The loss of voltage (LOV) relays (induction disc relays with inverse time characteristics) are set at 88.3%. At 79.5% bus voltage, these relays take 9 seconds to generate a LOV signal. A complete loss of offsite power will result in approximately 2 second delay in a loss of voltage signal (LOVS) actuation. The relay contacts are combined in 'a three out of three' logic to generate a loss of voltage signal. The design basis for operation of these relays is shown in Waterford 3 UFSAR Table 8.3-13.

Studies were performed during the Summer 2003 load (5668 MW) conditions for the grid in the vicinity of Waterford 3. These studies analyzed switchyard voltage conditions for various contingencies. The results of these studies indicate that the grid voltage remains above 99% after loss of Waterford 1 (495MVA), Waterford 2 (495MVA), Waterford 3 (1333 MVA) and a large 500/230KV (1200MVA) transformer. Other contingencies indicate that voltage levels remain above 100% with more than one unit out of service.

In October 2003 Waterford 3 updated the grid analyses study for the Extended Power Uprate Project. The results of this study are detailed in the "Report on the Offsite Study for Waterford Unit #3 Uprate."

For this analysis, the Entergy System and the neighboring utilities were modeled using the Power System Simulator and Evaluator ("PSS/E"). PSS/E is analytical software used for simulating system load flow and dynamics behavior under varying system conditions. The model contains transmission line data (line impedance), generator data (generator capability) and the load data (MW & MVAR).

The system was simulated for Summer peak conditions for 2005. The transmission system in the vicinity of Waterford 3 does not have a specific voltage below which the grid gets unstable and will collapse. To facilitate a comprehensive analysis, P-V analysis approach was used to determine the voltage level at the Waterford 230 kV bus as a function of the load in Amite South. This establishes a relationship between grid voltages and loading criteria and available generation/transmission network.

A P-V curve is a plot of voltage at critical bus or buses (along the Y-axis) versus the power transfer into the local area (along the X-axis). A typical P-V curve for a transmission system would depict a decline in voltage with increases in area load, until the point where the system cannot support the load requirements, which leads to voltage collapse. A typical curve would show a "knee" or bend of the P-V curve which would define that critical operating point.

Various contingency scenarios, involving generators and critical transmission line outages were studied. Based on the P-V curves, a voltage collapse point for each contingency case was established.

Operating limits on various facilities in the Amite South region were ignored while computing the voltage at Waterford 3. The operating limits due to a facility overload occur in the Amite South region before the voltage approaches less than desirable values at Waterford 3. In reality, compensatory actions are taken by the system operators to mitigate the facility overloads. Generation re-dispatch and reducing the load (load shedding) in the area (using 'curtailable' loads) are typical compensatory actions performed by the system operator. These operating guidelines preclude unacceptable voltage at Waterford 3.

Analyses with projected load growth to 6500 MW and higher for the Amite South area concluded that the 230KV grid voltage would remain above 97% for the following contingencies coupled with a Waterford 3 trip:

Loss of Ninemile Unit 4 and grid load at 7700 MW
Loss of Waterford Units 1 & 2 and grid load at 8100 MW
Loss of Waterford Unit 1 and Ninemile Unit 4 with the grid at 7250 MW
Loss of Ninemile Unit 4 and a 230 KV line from Ninemile units and grid at 7360 MW
Loss of Ninemile Unit 4 and a 500KV Willow Glen Line with the grid at 6880MW

The voltage of 0.97 P.U. (per unit) is an analytical limit established by Waterford 3 as the minimum acceptable voltage level at the Waterford 230 kV bus for safe operation of the plant. Lower grid voltage levels are acceptable for different shutdown conditions for Waterford 3.

Other cases analyzed conditions that exceed the operating guidelines employed by the Transmission System Operations group in the Amite South region. These cases evaluated conditions that result in lower grid voltages while the projected load in the Amite South area was increased. The limiting case was established with Ninemile Units 4 and 5 offline coupled with a Waterford 3 trip and grid load at 6500MW. The grid voltage approaches 94% and a small change in load conditions (less than 200MW) drops the voltage to below 94%. Thus 94% grid voltage is considered the 'knee' point for this analyzed condition. The 'knee' point for other contingencies is higher than this case study.

It should be noted that for the extreme cases, the thermal limits of the transmission network are reached prior to concerns for voltage profiles in the system. The Transmission System Operator have operating guidelines, which require load shedding or other compensatory actions to ensure system operating conditions are acceptable.

The assessment provided in the November 19, 2004, letter conservatively evaluated equipment at 90% of bus voltage. This value is well below the DV relay setting (93.1%) and marginally above the 88.3% setting of the Loss of Voltage relays. This 90% value was selected to consider maximum duration (12 seconds) for rotating equipment to operate at reduced voltage conditions.

The qualitative evaluation provided in November 19, 2004, letter is acceptable as there is conservatism in the analytical studies providing margin:

- The knee point for the grid is evaluated at approximately 94% grid voltage with projected summer loads. At this voltage, the Waterford 3 safety busses will be higher than 90%.
- The Degraded Voltage relays are set at 93.1% and the corresponding grid voltage limit of 97% is based on voltage drop through Waterford 3 transformers with maximum auxiliary loading and some margin added on bus loads.
- The rotating equipment is rated for operation at 3,300 feet per National Electric Manufacturers Association (NEMA) standards. The density of air at Waterford 3 (sea level) is higher with increased ability of the air to cool motors. This was not factored into the qualitative analyses.

- The evaluation and relay settings are based on 4160V system. The motors for the 4160V system are rated at 4000V. Thus, the degraded voltage relay setting at 93.1% corresponds to 96.8% on the motor base. Allowing for a maximum 3% volt drop from the bus to the motor terminals, the motor terminal voltage would be above 93.8% of its rated voltage. For the LOV relay set at 88.3%, the corresponding voltage on motor terminals is 88.8% of motor rated voltage. Thus the 90% voltage value selected for qualitative discussion in the November 19, 2004, submittal is acceptable for equipment operability.

Question 3:

Attachment 1 to the Entergy November 19, 2004, letter states that the normal running emergency core cooling system (ECCS) loads such as the containment spray pumps, component cooling water pumps, auxiliary component cooling water pumps, chillers and heating ventilation and air conditioning (HVAC) fans are specified to start and accelerate driven equipment at 90 percent rated voltage at rated frequency without exceeding the permissible temperature in accordance with National Electric Manufacturers Association (NEMA) Standards MG-1. Identify which of this equipment is, or could be, subject to double sequencing. If some of these motors are cycled on and off by a process signal then there is a potential for motor starting at initial offsite power terminal voltages below 90 percent, followed by starting on the Emergency Diesel Generator (EDG) at terminal voltages less than 85 percent (November 19, 2004, letter Attachment 1, page 8). The motors that are running continuously through the offsite power portion of load sequencing, on the other hand, will be subject to running terminal voltages below 90 percent, followed by starting on the EDG at terminal voltages less than 85 percent. Both of these are outside the NEMA MG-1 standard. You should provide endorsements from the manufacturers of these motors that they have the capability to perform in this fashion, at least for some limited number of times over their service life.

Question 4:

Attachment 1 to the Entergy November 19, 2004, letter states that the original low pressure safety injection (LPSI) motors are capable of six consecutive starts with motor initially at ambient temperature, but that one of the LPSI motors was replaced with a Westinghouse motor that is capable of only two consecutive starts with the motor initially at ambient temperature. What is the specified minimum starting voltage of the LPSI motors? If the Westinghouse LPSI motor will be started or operated at voltages during degraded voltage double sequencing that are less than those specified in NEMA MG-1, you should provide an endorsement from Westinghouse that this motor will have the capability to perform in this fashion, at least for some limited number of times over its service life. If there are continuous duty motors other than the high pressure safety injection (HPSI), LPSI, and 90 percent normal running ECCS motors discussed in the attachment to the Electric Power Research Institute (EPRI) letter, they should also be identified, together with their specified minimum starting voltages and consecutive start capability.

<u>Response 3 & 4:</u>

Questions 3 and 4 will be answered together

<u>4000 VAC motors</u>

The following safety related motors are fed from the 4160VAC safety related switchgears:

High Pressure Safety Injection (HPSI) Pump A, B, & AB
Low Pressure Safety Injection (LPSI) Pump A & B
Auxiliary Component Cooling Water (ACCW) Pump A, B
Emergency Feedwater (EFW) Pump A & B
Component Cooling Water (CCW) Pump A, B, & AB
Containment Spray (CS) Pump A, B
Essential Chiller A, B, & AB
Reactor Auxiliary Building (RAB) Exhaust Fan E22 A & B

The HPSI, LPSI, ACCW, and EFW pumps could be subject to double sequencing if a Loss of Offsite Power (LOOP) should occur subsequent to the initiation of a safety injection actuation signal (SIAS). The CCW pumps and the essential chillers are normally running and thus are not subject to double sequencing. The chillers are equipped with a hot gas bypass line (artificial load) such that the chillers do not trip off line during low load conditions. The CS pumps start only on containment spray actuation signal (CSAS) which is not expected to occur during the steam generator tube rupture (SGTR) event. The RAB exhaust fans trip on SIAS and are not restarted.

The concern with starting and running motors at degraded voltage condition is that the motors may overheat and adversely affect motor qualified life. NEMA MG-1 allows the running and starting voltage for motors at plus or minus 10 percent of rated voltage, with rated frequency. In addition, the standard is based on an ambient temperature of 40°C and altitude not exceeding 3300 feet above sea level. The motor thermal capacity is increased about 1% for each 330 feet reduction in altitude below 3300 feet. The motors at Waterford 3 at sea level will allow the motor thermal capacity to increase by 10% without exceeding motor rated temperature rise. Similarly, the motor thermal capacity is increased about 1% for each degree the ambient temperature is less than 40°C. The HPSI, LPSI, and EFW are located in areas with safety related air cooler ventilation that keep the area fairly cool. Although the design ambient temperature for these areas is 40°C, realistically early into the SGTR event, the ambient temperature is expected to be less than 40°C which will increase the thermal capacity of these motors.

The starting duty for the Westinghouse LPSI motor is designed within the NEMA limits of two consecutive starts at ambient temperature. The LPSI motors, designed with a service factor of 1.15, have an additional 10 degrees C temperature rise over those motors with service factor of 1 per NEMA MG-1 Section 20.40. The HPSI motors also have a service factor of 1.15. Whereas, the ACCW and EFW motors have a service factor 1.0.

NEMA MG-1 Section 20.92 specifies that large motors while running at rated temperature shall be capable of withstanding a current equal to 150% of rated current for 30 seconds. Considering the available design margins (i.e. minus 10% of rated voltage, 10% additional thermal capacity for differences in altitude, and increase in thermal capacity due to lower starting ambient temperature, and service factor) the increase in motor current for 12.5 seconds (time delay of degraded voltage relay at 93.1%) at approximately 90% voltage condition couple with two consecutive starts (first start at 90% bus voltage and second start on the EDG) will not cause any damage to the HPSI, LPSI, ACCW, and EFW motors nor adversely affect their qualified life.

The second motor start with the EDG supplying power is considered to be a start at nominal motor voltage. The momentary dip of approximately 85% voltage predicted during large motor start recovers to nominal voltage within 0.3 second. This period is significantly less than the expected acceleration time of the motor and therefore the majority of the start is performed with the terminal voltage near nominal.

460 VAC motors

The following safety related 460 VAC motors may be subject to double sequencing due to cycling on and off by a process signal or SIAS:

Control Room AH-12
Controlled Ventilation Area System (CVAS) Exhaust Fan E-23
Control Room Emergency Filtration Unit A S-8
Battery Room A Exhaust Fan E-29
Battery Room B Exhaust Fan E-30
Battery Room A/B Exhaust Fan E-31
Computer Battery Room Exhaust Fan A E-46
Switchgear Area AH-30
HVAC Equipment Room Exhaust Fan E-41
EFW Pumps A & B Coolers AH-17
Charging Pump A, B, AB
Charging Pump A, B, AB Coolers
Emergency Diesel Generator A Room Exhaust Fan
Emergency Diesel Generator B Room Exhaust Fan
Essential Chiller Water Pump A, B, AB
Essential Chiller Oil Pump A, B, AB
Safeguard Pump Room A Cooler A and C
Safeguard Pump Room B Cooler B and D
Safeguard Pump Room AB Cooler
Equipment Room Cooler AH-26
Switchgear Area RAB AH-25
RAB HVAC Equipment Room Supply Fan AH-13
Dry Cooling Tower Fan No. 1 thru 15 (15 fans per train)
Wet Cooling Tower Fan No. 1 thru 8 (8 fans per train)
Containment Fan Coolers A, B, C, D
CCW Makeup Pump A & B
Shutdown Cooling HX A and B Coolers
CCW Pump A, B, AB Coolers
Fan Room Exhaust Fan E-21
Fuel Handling Building Emergency Filtration Unit Fan E-35
CCW Heat Exchanger Room A & B Coolers
Shield Building Vent Fan E-17 A & B

NEMA MG-1 Section 12.48 states "polyphase motors having outputs not exceeding 500 HP and rated voltage not exceeding 1kV shall be capable of withstanding a current equal to 1.5 times the full load rated current for not less than two minutes when the motor is initially at normal operating temperature." The reduced voltage that increase the line current to 150% is 306 VAC (460VAC/1.5). The 460 VAC motors can operate at 306 VAC for at least two minutes without exceeding the motor damage curve. At 93.1% degraded voltage on the 4160 VAC bus the lowest corresponding voltage at the 480 VAC buses is approximately 417 VAC. Due to settings on the degraded voltage relay, it is not credible that the 460 VAC motors at Waterford 3 will operate at voltages less than 417 VAC for any duration exceeding 12.5 seconds. Since this is an inverse time relay, the time spent at lower voltages decreases until the loss of voltage relay is actuated.

Motors running at reduced voltages have reduced torque output proportional to the square of the voltage. The torque for a reduced voltage start is reduced approximately 19% (100% - 0.90^2) for reduced motor start at 90% which result in lower starting current. NEMA MG-1 requires a minimum motor breakdown torque as a percentage of full load torque. The minimum breakdown torque found in NEMA MG-1 is 175% of full load torque. The reduced breakdown torque at reduced voltage as a percentage of full load torque is 142% (0.90^2 x 175%). This concludes that running motors will not stall since the breakdown torque is greater than the running torque.

NEMA MG-1 Section 12.49 states "polyphase motors having outputs not exceeding 500 HP and rated voltage not exceeding 1kV shall be capable of withstanding locked-rotor current for not less than 12 seconds when the motor is initially at normal operating temperature." Typically, motors with voltage rating of 460 VAC or less accelerate to full speed well within five seconds. Therefore, two consecutive starts are within the capability of the motor to withstand the lock-rotor current for at least 12 seconds.

Based on NEMA MG-1 Sections 12.48 and 12.49 and available design margins (i.e. minus 10% of rated voltage, 10% additional thermal capacity for differences in altitude, and increase in thermal capacity due to lower starting ambient temperature, and service factor for some motors) as described in the 4000V motor discussion, it is reasonable to conclude that the increase in motor current for 12.5 seconds due to degraded voltage condition coupled with two consecutive starts will not cause any damage to the 460 VAC motors.

<u>Question 5:</u>

Attachment 1 to the Entergy November 19, 2004, letter states that for 480V MCCs, the motor protective devices were designed to provide overcurrent and locked rotor protection when the motor operates within the range of 110 to 90 percent of its rated voltage and under the abnormal electrical supply condition (336 volts recovers to 408 volts in 2 seconds). While this design criteria would appear to provide confidence that overcurrent and locked rotor protection would not activate when the 480V MCC motors are operated from the EDGs, it's not clear that this can be relied upon to preclude tripping of these devices when the motors are initially started on a degraded voltage offsite power source and then subsequently restarted on the EDGs. Under these circumstances the thermal sensing elements of the overcurrent and locked rotor protection will have been abnormally preheated due to the first degraded voltage start, prior to starting on the EDGs. Please address.

<u>Response 5:</u>

The staff has requested additional information regarding the performance of protective devices in the event of a double sequence start. The primary concern is premature actuation of thermal overload relays which protect station loads powered from the 480 V motor control centers (MCCs). The question is raised as to whether an undesired actuation will occur when subjected to a motor start at reduced voltage followed by a motor start at full voltage on the station diesel generator.

The thermal overloads used by Waterford 3 for motor protection utilize a Class 20 bimetallic heating element. These overload elements were originally manufactured by ITE Gould. The

Class 20 designation denotes that the relay has a maximum tripping time of 20 seconds at 600% of rated current. This 600% value corresponds to typical locked rotor current for induction motors. When properly sized for the protected load, these relays are designed to provide 125% protection, that is they will operate up to 125% of rated current for extended periods without tripping.

The ITE Gould line has changed hands several times since construction. It was originally sold to Telemechanique and ultimately to Square D. The line was discontinued when it was sold to Square D corporation.

As defined in NEMA ICS 2-2000, Section 3.1.2, "inverse-time overload relays are characterized by their ability to consider the cumulative heating effect in the motor circuit as a result of motor operation or overload. This cumulative heating effect, called operating memory, can either be volatile or nonvolatile." A relay that has exhibited a degradation of 15% or more in its time-inverse characteristic after an overload actuation is categorized as non-volatile and provided a Category A NEMA label. Conversely, a relay that has exhibited a degradation of less than 15% in its time-inverse characteristic after an overload actuation is categorized as volatile and provided a Category B NEMA label.

With our present documentation it could not be established whether the overload relays currently employed have volatile or non volatile memory. When questioned about the issue of memory, Square D responded that their published time-inverse characteristics are "cold start" curves, i.e., they apply to a relay tested at 40° ambient.

Square D did indicate that European manufacturers publish "cold" and "hot" start curves. A review of two European curves (Telemecanique LR2 and LR3D) indicate the "hot" start curve sits below and to the left of the "cold" start curve, therefore indicating an operating memory for the overloads.

It should be pointed out that the Square D and Telemecanique curves are for bi-metallic thermal overload relays. The primary difference is the European relays are covered by International Electrotechnical Commission (IEC) where the American relays are NEMA, i.e., IEC requires cold and hot start curves, where NEMA does not. However, the same NEMA and IEC characteristics pertain to eutectic (melting) alloy elements also.

All indications lead to the general conclusion that all thermal overload elements possess some degree of thermal memory, i.e., undergo some shift in their characteristic curve when subjected to heat outside of their ambient design. With respect to a double sequence event, the additional heat comes in the form of I^2t from the first motor start. The question then becomes, what degree of I^2t heat affects the curve and how much?

One thing can be inferred from both the NEMA and IEC examples: measurable degradation in the relay's characteristic requires a fairly large amount of I^2t energy. NEMA tests for volatile and nonvolatile memory by applying 600% current until the relay trips. The trip is repeated for a total of three times and the trip time is compared the trip times of the first trip. Telemecanique's "hot" state is defined as a "long period at the set state" which means that motor full load amps (FLA) are applied to the heater element for a long time prior to testing the relay at 600% FLA.

In the above two instances, NEMA and IEC subject the thermal overload elements to a significant degree of heat in anticipation of degrading the overload's characteristic. Comparing the energy levels in the NEMA and IEC tests with that of the first motor start would be a good indicator of how much operating memory the overload element would experience during the first motor start.

These comparisons cannot be quantified without the manufacturer's help or lab testing. However, logical comparisons can be made between the NEMA and IEC tests defined above and the first low voltage start of a double sequence event.

- The energy created for the IEC's pre-heating (long time at FLA) is dominated by time and most likely can not be compared to the energy created during a low voltage motor start (lower than normal starting current with longer acceleration times), i.e., $I^2t_{preHeat} >> I^2t_{firstStart}$.
- The energy created during NEMA's memory test is dominated by the actual energy required to pick-up the relay, not once, but twice, i.e., $(I^2t_{600\%\ Trip} + I^2t_{600\%\ Trip}) >> I^2t_{firstStart}$.

What all this tells us is that overloads have a cumulative thermal memory but the amount of thermal trip degradation for a low voltage motor start is not equivalent to the tests performed by NEMA and IEC.

It is reasonable to address the double sequence event as a cumulative application of thermal energy provided by two back to back motor starts; the first being a low voltage start.

<u>Motor Start Analysis:</u>

A low and normal voltage motor start analysis was conducted for a typical Waterford 3 motor. The acceleration times for both motor starts were then cumulatively summed. This methodology is considered conservative in that it assumes that the motor starts occur back to back. There is therefore no time for the thermal element to cool as there would be in a postulated double sequencing event.

A typical motor was selected based on its voltage, duty cycle, and application; the most important being application. The application selected is the diesel generator room exhaust fan: a 3 phase, 460 v, 60 hp, 900 rpm motor. This motor drives a fan rotor assembly with an 84" blade – 254.7 lb-ft^2 moment of inertia, requiring 45.76 brake-horsepower at maximum density. A fan was chosen since fans typically have higher moments of inertia than pumps and correspondingly longer acceleration times.

The fan was modeled for a normal 100% voltage motor start; the total motor acceleration was broken into five time segments equally spaced between 0 and 900 rpm. Each segment was then increased by 143% to reflect an 85% voltage motor start. Each corresponding full and low voltage acceleration segment was then added together and plotted with respect to the full voltage motor start current for that segment. The use of the full voltage motor start current is the conservative current. This is because at a reduced starting voltage, starting amps are also reduced. This yields a more conservative motor start curve when plotted on the overload's characteristic curve.

The resulting data is provided in the table below:

Segment	Segment Acceleration Time (sec) (reduced voltage start)	Segment Acceleration Time (sec) (nominal voltage start)	Cumulative Acceleration Time (sec) for both Segments Plotted	% I_{start}
1	0.63	0.44	1.07	630
2	0.50	0.35	1.92	630
3	0.37	0.26	2.59	600
4	0.34	0.24	3.13	280
5	0.26	0.18	3.57	125

The plotted time vs. current points of the table above reflect the motor start curve of the typical fan motor modeled.

Plotting this curve on a Size 4 overload relay characteristic curve will provide an indication of whether a double motor start will provide enough energy to pick-up the relay.

As thermal overload curves for a size 4 Gould Relay could not be obtained, the results were plotted on curves from various manufacturers. The results show that the energy generated during the double sequencing event is not sufficient to trip the thermal overloads modeled.

In general, most overload relays of this size have a typical minimum clearing time of 7 to 8 seconds at 630% of full load current. With a cumulative acceleration time of 3.57 seconds for two back to back starts during the double sequencing scenario postulated, the motor could remain at locked rotor current for the entire start sequence and not result in an overload trip.

In conclusion, two subsequent starts of a motor would not result in tripping of a thermal overload relay during a double sequencing event.

Question 6:

Attachment 1 to the Entergy November 19, 2004, letter provides an assessment of the ability of the HPSI pump to start during a degraded-voltage, double-sequencing transient with the outlet valves in the open position versus the closed position. A similar assessment should be provided for the remaining safety-related pumps at Waterford 3.

Response 6:

Safety related centrifugal pumps which are loaded onto the sequencer were reviewed for the impact of starting the pumps with open discharge valves. This review reached the following conclusions.

The HPSI pump motors are designed to start the pumps against check valves, normally open motor operated discharge valve, and partially open flow control valves, all in series. The stroke time for the HPSI flow control valves is 10 seconds. The motor operated flow control valves start to open immediately upon SIAS. During an SIAS event without LOOP, the HPSI motor sequences on the safety bus 3.5 seconds after the SIAS at which time the HPSI flow control valves are at approximately 35% opening. Thus the issue of starting HPSI motors with the outlet valves in the open position is within the normal design configuration

The LPSI motors are sequenced on the safety bus 19 seconds after the SIAS during which time the LPSI flow control valves are fully open. Thus, the issue of starting LPSI motors with the outlet valves in the fully open position is within the normal design configuration.

The component cooling water pump, auxiliary component cooling water pump, containment spray pump, emergency feedwater pump, and the essential chiller compressor motor specification specifies that the motors be sized such that the motor can accelerate with fully open valves. Therefore, an open outlet valve following a LOOP would not create a concern for these components.

Each chilled water pump discharges to its respective supply header through a check valve and normally open discharge isolation valve. As a result, starting a chilled water pump with the outlet valves in the open position is within the normal design configuration.

The component cooling water makeup pumps receive a start signal on the 200 second sequencer load block. Their discharge flow control valves are normally closed/fail open air operated valves that open when surge tank level drops to a predetermined level. The valves cycle on surge tank level and are not controlled by an SIAS signal. Therefore, the normal design configuration allows the discharge valves to be fully opened based on a demand from the surge tank level. Thus, the issue of starting the component cooling water makeup pump motors with the outlet valves in the fully open position is within the normal design configuration.

The boric acid pumps receive a start signal on the 200 second sequencer load block. Their respective discharge valves (reactor makeup bypass valves) receive an immediate signal to open upon an SIAS. Therefore, starting boric acid pump motors with the outlet valves in the fully open position is within the normal design configuration.

Question 7:

Attachment 1 to the Entergy November 19, 2004, letter describes the periodic maintenance performed on the HPSI pump motor that provides assurance of reasonable motor condition prior to a degraded-voltage, double sequencing transient. A similar assessment should be provided for the remaining safety-related motors at Waterford 3.

Response 7:

Motor maintenance is performed in accordance with Electrical Maintenance procedures for each safety related 4160 volt motor listed below. Each motor has a specific maintenance plan as well as specified maintenance frequencies. Typical maintenance tasks include the following; perform resistance-to-ground measurements using a megohmmeter (Maintenance & Test Equipment (M&TE)) and phase-to-phase resistance values (M&TE), motor is checked to ensure that it is dry and free of loose dust, dirt, rust and corrosion buildup, remove the main junction box cover and verify that the connections and tape are not damaged or heat degraded, and check the resistance of the grounding cable at the motor's casing.

On-line and off-line motor testing is performed per Electrical Maintenance procedures for trending purposes. The off-line testing includes a standard AC test (phase-to-phase resistance imbalances, phase-to-phase inductance imbalances, capacitance-to-ground measurements), polarization index test, and a step voltage test. The on-line testing includes current and power analysis testing. The on-line and off-line motor testing program implementation is on going.

Vibration readings are taken for trending purposes on the motors either during the In-Service Test (IST) or as directed by Plant Programs Engineering. Thermography scans are also taken periodically during pump ISTs. Motor bearing oil samples are taken to analyze for particulates, viscosity, water, and bearing wear metals (motors with sleeve bearings only).

<u>Safety Related Motor Maintenance – "A" Train</u>

- Auxiliary Component Cooling Water Pump A
- Component Cooling Water Pump A
- Containment Spray Pump A
- Emergency Feedwater Pump A
- RAB Normal Exhaust Fan A
- Water Chiller WC-1(3A-SA) Compressor
- High Pressure Safety Injection Pump A
- Low Pressure Safety Injection Pump A

<u>Safety Related Motor Maintenance – "B" Train</u>

- Auxiliary Component Cooling Water Pump B
- Component Cooling Water Pump B
- Containment Spray Pump B
- Emergency Feedwater Pump B
- RAB Normal Exhaust Fan B
- Water Chiller WC-1(3B-SB) Compressor
- High Pressure Safety Injection Pump B
- Low Pressure Safety Injection Pump B

<u>Safety Related Motor Maintenance – "AB" Train</u>

- Component Cooling Water Pump AB
- Water Chiller WC-1(3CSAB) Compressor
- High Pressure Safety Injection Pump AB

Question 8:

Attachment 1 to the Entergy November 19, 2004, letter states that thermal overload relays for safety related motor operated valves (MOVs) are bypassed to prevent tripping when an engineered safety features actuation signal is present. This eliminates concerns that the overload relays will trip during a degraded-voltage, double-sequencing transient but does not necessarily mean the motor itself could not fail due to the transients. MOV motors are typically short duty cycle motors with limited run-time capability before overheating. Please provide an assessment of MOV motor capability at Waterford 3 for the degraded-voltage, double-sequencing scenario. Indicate their specified minimum starting voltage and consecutive start capability.

Response 8:

MOVs installed at Waterford 3 are manufactured by Limitorque Corporation. Limitorque Technical Update 92-01 states that Limitorque AC motors are designed such that current draw decreases as motor voltage decreases. Limitorque AC motors are designed such that motor current is comprised mostly of magnetizing current, which decreases as terminal voltage decreases. These motors are sized such that the torque produced will be capable of operating the valve at reduced voltage levels. Limitorque Technical Update 93-03 states that the standard sizing factor for MOV motors is acceptable as long as motor terminal voltage is above 90%. Below 90% voltage, a higher sizing factor must be applied based upon the application.

Waterford 3 calculation determines the MOV minimum terminal voltage based on degraded voltage conditions. This minimum terminal voltage is then used as an input to various mechanical design calculations to ensure that the torque produced at the minimum calculated voltage level is acceptable to operate the valve.

During the degraded-voltage, double sequencing scenario, MOVs will begin operating immediately upon SIAS. Some MOVs with short cycle times may reach their intended position before LOOP occurs and will be unaffected by the double sequencing. Upon LOOP, any MOV still positioning itself will stop as terminal voltage is lost. After the sequencer resets and re-energizes the applicable MCCs, the MOVs will finish the cycle originally started before the LOOP occurred. For these MOVs, the scenario will cause the motor to start, perform a partial cycle, stop, start again and finish the cycle.

Limitorque Technical Update 93-03 shows a calculation of temperature rise for a typical motor. The total temperature rise is calculated using a rise of 75°C/15min for running conditions and 75°C/10sec for starting conditions. Assuming that MOVs operate for 152 seconds and have two starts at 0.5 seconds each, the total temperature rise associated with the double-sequencing event is approximately 20°C for this typical motor. 152 seconds was chosen as the stroke time because this would depict the longest stroke time of any applicable MOV, and 0.5 seconds was chosen as a starting time to include margin per discussions with Limitorque. Industry Standard motors allow for continuous operation at 120°C (rise – ambient) or greater depending on insulation class. The technical update further states that "the motor temperature rise associated with stroking the valve is insignificant." For additional conservatism, Limitorque AC motors are typically designed and sized such that they can operate at twice the running torque with assumed duty cycles of 5 to15 minutes.

Limitorque Bulletin LM-77 also states that motors will stroke the valve at least open and close without exceeding its safe thermal rating. Per Waterford 3 maintenance and engineering personnel it is common to fully open an MOV, wait a few seconds, and then fully close the MOV during testing. No instances of MOV failure due to this activity were known.

Based on the above manufacturer data and calculations, applicable MOVs are capable of performing their intended functions during the double-sequencing, degraded voltage scenario.

Attachment 2

To

W3F1-2005-0004

Clarification to Extended Power Uprate Report Section 2.7.1
Source Terms for Radwaste System Analysis

Clarification to Extended Power Uprate Report Section 2.7.1 Source Terms for Radwaste System Analysis

On December 15, 2004, Entergy communicated, to the staff, the need to clarify Section 2.7.1.1 in Attachment 5 of the November 13, 2003, Extended Power Uprate (EPU) submittal regarding fission product escape coefficients. The clarification is provided below. This clarification does not change the results or conclusions of the analysis since the clarification is consistent with the analysis performed and documented in Section 2.7.1 in Attachment 5 of the EPU submittal. Specifically, the information submitted in Table 2.7-1, "Comparison of Maximum Reactor Coolant Radionuclide Concentrations Based on 1% Fuel Failure," is consistent with the clarification provided below.

The following sentence is contained in the second paragraph of Section 2.7.1.1, "Description of Analysis and Evaluation."

> "Fission product escape coefficients, purification flow rate, and ion exchange removal efficiency are unchanged from the original Waterford 3 design basis as specified in Section 11.1."

This sentence is replaced with the following information.

> "Purification flow rate is unchanged from the original Waterford 3 design basis as specified in Section 11.1. Fission product escape coefficients are unchanged for the noble gases and halogens. However, based on current industry experience, the escape coefficients for cesium and all other fission products have been reduced, except molybdenum and rubidium which have increased significantly. Additionally ion exchange removal efficiency is unchanged for cesium and rubidium (50%), but is increased to 99.18% for iodine, bromine, and tellurium and is increased to 98% for all others except xenon and krypton. Xenon and krypton are 0% resin efficiency without gas stripping and 99.9% with gas stripping."

The need for this clarification has been entered into Entergy Operations, Inc. (Entergy's) 10CFR50 Appendix B corrective action program at Waterford Steam Electric Station, Unit 3.

Attachment 3

To

W3F1-2005-0004

Potential Loss of Feedwater Due to Loss of Two or More Heater Drain Pumps

Potential Loss of Feedwater Due to Loss of Two or More Heater Drain Pumps

Entergy Operations, Inc. (Entergy) recently identified that a loss of two or more heater drain pumps could result in a complete loss of feedwater at Waterford Steam Electric Station, Unit 3 (Waterford 3) at Extended Power Uprate (EPU) operating conditions. A complete loss of feedwater is not postulated for pre-EPU operating conditions upon the loss of two or more heater drain pumps. (See below for additional details.)

Waterford 3 normally operates with all three condensate pumps and all three heater drain pumps in service. Final Safety Analysis Report (FSAR) Section 10.4.7.3, states that Waterford 3 is capable of operating at full load should either a condensate pump or all three heater drain pumps trip or be removed from of service (i.e., at pre-EPU conditions). Following EPU, Waterford 3 will still be capable of operation at full load should one condensate pump trip or be removed from service, however Waterford 3 will not have the capability to operate at full load should two or more heater drain pumps trip or be removed from service. A downpower would be required because the condensate pumps alone can not provide the necessary head at the EPU full load conditions to sustain simultaneous operation of both main feedwater pumps. Thus, should two or more heater drain pumps trip, a plant trip would result due to low main feedwater pump suction pressure causing a loss of normal feedwater (i.e., loss of steam generator level).

Design reviews performed prior to the EPU submittal dated November 13, 2003, did not identify this reduction in operating margin or the need to install a modification to prevent a complete loss of feedwater therefore this issue has been entered into Entergy's 10CFR50 Appendix B corrective action program.

Because this issue was only recently identified, corrective actions and potential modifications are still being developed and evaluated. At this time Entergy believes that a modification will be necessary to prevent the complete loss of feedwater upon the loss of two or more heater drain pumps. This modification would implement a protection scheme to ensure one main feedwater pump remains in service should two or more heater drain pumps trip at EPU operating conditions. This can be accomplished by setting up a staggered time delay for the main feedwater pump low suction pressure trip or a trip scheme that will trip only one main feedwater pump should two or more heater drain pumps trip. Post modification testing would most likely consist of loop calibrations that would be performed prior to power operation. Other corrective actions such as the implementation of power limitations in operating procedures for the planned removal of heater drain pumps from service are also being evaluated.

These corrective actions are being addressed in accordance with Entergy's 10CFR50 Appendix B corrective action program. At this time Entergy anticipates that these corrective actions can be implemented under the provisions of 10CFR50.59 without prior NRC review and approval and therefore is not requesting NRC review and approval of these corrective actions.

Entergy commits to complete corrective actions to prevent the complete loss of feedwater upon the loss of two or more heater drain pumps prior to exceeding the current (i.e., pre-EPU) rated thermal power of 3441MWt.

Attachment 4

To

W3F1-2005-0004

List of Regulatory Commitments

List of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE (If Required)
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
Entergy commits to complete corrective actions to prevent the complete loss of feedwater upon the loss of two or more heater drain pumps prior to exceeding the current (i.e., pre-EPU) rated thermal power of 3441MWt.	X		Prior to exceeding 3441 MWt.