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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
Tornado Missile Protection

Gentlemen:

The attachment to this letter provides information regarding tornado missile protection for Waterford 3. The attachment provides a discussion of the work we have done in this area and the improvements we have made and plan to finalize.

Please contact me or Mr. T.J. Gaudet at (504) 739-6666 should there be any questions regarding this submittal.

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Very truly yours,

A001

E.C. Ewing
Director
Nuclear Safety & Regulatory Affairs

ECE/RJM/tjs
Attachment

cc: E.W. Merschoff (NRC Region IV), C.P. Patel (NRC-NRR), J. Smith, N.S. Reynolds, NRC Resident Inspectors Office

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TORNADO MISSILE PROTECTION

Background

On October 21, 1996, Entergy, Waterford 3, provided a letter to the NRC, reference one, regarding tornado missile protection for the Ultimate Heat Sink (UHS). This letter dealt with the evaluation of the vulnerability of some conduit for the UHS routed above the Reactor Auxiliary Building (RAB) walls to tornado missiles. The letter also provided some perspectives about the design and licensing basis for the UHS and a discussion of the design and licensing basis work planned for tornado missile protection. The purpose of this response is to update the NRC regarding the resolution of the conduit issue and to apprise the NRC about the follow-up work which has been performed on the design and licensing basis for tornado missile protection. Also, this response discusses the recent discovery and resolution of a separate but related issue regarding a RAB hatch cover which did not have restraining devices for tornado overpressure protection. This response discusses these matters in the following order: the Waterford 3 design and licensing basis, the resolution of the conduit issue, confirmatory calculation to establish low probability of damage, update planned for the Waterford 3 design and licensing basis, resolution of hatch cover issue, and summary and conclusions.

Waterford 3 Design and Licensing Basis

The regulatory requirements specific to tornado missile protection are tabulated in Table One (1). In general, these requirements require that systems, structures, and components be protected from the effects of a design basis tornado including externally generated missiles. Safety related structures, systems, and components must be designed to withstand the combined loads imposed by the design basis tornado wind, pressure differential, and postulated tornado missiles.

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Table 1 Regulatory Requirements Specific to Tornado Protection	
Requirement	**Summary**
10 CFR 50, Appendix A, Criterion 2	Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as tornadoes without the loss of capability to perform their safety function.
10 CFR 50, Appendix A, Criterion 4	Structures, systems, and components important to safety shall be designed to accommodate the effects of and be compatible with the environmental conditions associated with postulated accidents and be protected against dynamic effects including the effects of missiles.
Standard Review Plan 2.2.3	Offsite hazards which have the potential for causing onsite accidents leading to the release of significant quantities of radioactive fission products should have a sufficiently low probability of occurrence. Because of the difficulty of assigning accurate numerical values to the expected rate of unprecedented potential hazards, judgment must be used in the acceptability of overall risk. Accordingly, the expected rate of potential exposure in excess of the 10 CFR 100 guidelines of approximately 10^{-6} per year is acceptable, if when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower.
Regulatory Guide 1.13, Revision 0, March 1971	The facility should be designed (a) to keep tornado winds and missiles generated by these winds from causing significant loss of watertight integrity of the fuel storage pool and (b) to keep missiles generated by tornado winds from contacting fuel within the pool.
Regulatory Guide 1.27, Revision 2, January 1976	The Ultimate Heat Sink complex should be capable of withstanding without loss of the sink safety function the most severe natural phenomena expected at the site.
Regulatory Guide 1.76, April 1974	Nuclear power plants shall be designed to withstand the Design Basis Tornado. The maximum wind speed, rotational speed, maximum and minimum translational speeds, radius of maximum rotational speed, pressure drop, and rate of pressure drop are defined.

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Waterford 3 Design and Licensing Basis (continued)

The missile protection for Category I structures, systems, and components is described in FSAR section 3.5 and Table 3.5-3, and FSAR section 9.2.5.3.3 for the UHS. The Category I structures and barriers were required to withstand the impact of the multiple missiles tabulated in FSAR Table 3.5-10. This information is provided in Table Two (2) for completeness.

TABLE 2
DESIGN BASIS MISSILES

Missile	Weight (lbs)	Impact Area (sq. ft)	Maximum Velocity(1) (ft/sec)	Kinetic Energy (ft-lbs)	Impact Height
1) 2" x 4" x10' wooden plank traveling at 300 mph	27.8	0.055	440	8.36×10^4	Grade to top of structure
2) 3" dia. Schedule 40 pipe 10' long traveling on end at 100 mph	75.8	0.063	147	2.54×10^4	Grade to top of structure
3) Automobile traveling at 50 mph	4000	20.0	73.5	3.36×10^5	Grade to 25' above grade
4) 1" diameter steel rod 3' long traveling at 216 mph	8	0.00545	316.8	1.25×10^4	Grade to top of structure
5) 13.5" diameter utility pole, 35' long traveling at 144 mph	1490	0.994	211.2	1.03×10^6	Grade to 30' above grade

Note (1) The five missiles in Table 2 are capable of striking in all directions and heights with the maximum velocity indicated. However when evaluating roof slabs or other structures where a vertical missile strike is critical, the maximum vertical velocity of Missiles 4 and 5 may be reduced to 80% of the maximum velocity indicated.

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Waterford 3 Design and Licensing Basis (continued)

The design and licensing basis for tornado missile protection for particular systems and components, including the UHS, was also predicated on two important concepts, (1) the concept of low probability of damage by virtue of the diversity, redundancy, robustness of design features, and (2) the concept of a low probability of offsite hazards incorporated in Standard Review Plan (SRP) 2.2.3.

The concept of low probability of damage by virtue of the diversity, redundancy, robustness of the design features for the UHS is discussed in FSAR Section 9.2.5.3.3, which states the wet and dry cooling towers are designed to ensure low probability of damage by tornado missiles. There is no known specific probability calculation that was performed as part of the licensing review process that calculated the probability a given missile would strike and damage a particular component of the UHS. Rather as stated in FSAR Section 9.2.5.3.3, a low probability of damage was ensured by a combination of design features. These design features included the following.

- The cooling towers and equipment are protected on all sides by the plant outside walls up to elevation + 30 MSL.

- The cooling towers are designed with multiple cells, five cells for each dry cooling tower and two cells for each wet cooling tower, and multiple fans, 15 fans for each dry cooling tower and 8 fans for each wet cooling tower.

- Sixty percent of the dry cooling tower coils have been protected by missile proof grating located above them.

- Sixty percent of the dry cooling towers will provide sufficient heat dissipation to the atmosphere and will ensure safe shutdown of Waterford 3 after a design basis tornado assuming the worst case single failure, (the loss of one emergency diesel generator), coincident with the loss of offsite power.

These design features provided a basis to conclude, based on qualitative reasoning, the wet and dry cooling towers are designed to ensure low probability of damage by tornado missiles. The Safety Evaluation Report (SER) evaluation, Section 3.5.2, is consistent with the concept of low probability of damage by virtue of the diversity, redundancy, and robustness of the design features. In particular, SER section 3.5.2 concludes safety related systems and components

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Waterford 3 Design and Licensing Basis (continued)

are located within tornado missile protected structures or are provided with tornado missile barriers. SER section 9.2.5 states the ultimate heat sink is protected against tornado missiles by the reactor auxiliary building walls and missile grating. FSAR section 9.2.5.2 states the dry cooling tower fans and motors are located below grade, and are protected from tornado missiles by building walls and access platforms. The walls provide protection from missiles for the dry cooling tower fans and motors through a range of angles, but not for all angles. As a further detail, FSAR Section 9.2.5.3.3.c, includes a statement that the arrangement of safety related cooling tower components protected by grating is shown in Figure 1.2-24. This figure clearly depicts that the DCT fan motors, valves, and valve accumulators are not under grating. The physical configuration of the UHS has not been changed since the initial operation of the plant, until the recent conduit re-routing, and the physical configuration of the UHS has been in accordance with the design drawings.

Waterford 3 was evaluated for offsite hazards, which included tornado missiles from natural phenomena, on the basis of a commonly applied qualitative probability standard of 10^{-6} documented in SRP 2.2.3. The qualitative probability standard in SRP 2.2.3 specifically states, "... the expected rate of occurrence of potential exposures in excess of 10 CFR Part 100 guidelines of approximately 10^{-6} per year is acceptable if when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower." SRP 3.5.1.4 reinforced this standard by stating, " ... The methodology of identification of appropriate design basis missiles generated by natural phenomena shall be consistent with the acceptance criteria [10^{-6} per year] defined for the evaluation of potential accidents from external sources in SRP 2.2.3." SER section 3.5.1.4 concluded that the missile spectrum and the identification of missiles generated from natural phenomena was acceptable and met the guidelines of Regulatory Guide 1.76. Regulatory Guide 1.117 was later promulgated by the NRC, and this regulatory guide defined a credible tornado strike as having a probability of occurrence of 10^{-7} per year. However, Waterford 3 is not committed to Regulatory Guide 1.117 in the FSAR. Although a reference to Regulatory Guide 1.117 is made in the SER in section 3.5.2, there is no mention made to the 10^{-7} per year probability criterion, nor does the SER cite any acceptance criteria in referencing Regulatory Guide 1.117.

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Waterford 3 Design and Licensing Basis (continued)

A review of the evolution of the Waterford 3 licensing design basis shows tornado missile protection received detailed evaluations and walkdowns by the owner, the regulator, the designer, and the manufacturer. The foregoing information provides objective evidence to conclude the design and licensing basis for tornado missile protection was found to meet the requirements in place at the time of initial licensing. This conclusion was based on the protection provided by walls and barriers; the diversity, redundancy, and robustness of the design; and qualitative reasoning which considered the protection and design and concluded the probability of damage was less than 10^{-6} in accordance with SRP 2.2.3.

Resolution of conduit issue

In October 1996, Waterford 3 personnel became aware that conduit for safety related equipment was routed above the RAB wall. The following information provides a summary of how this condition was resolved.

In October 1996, Waterford 3 personnel confirmed that various conduits were routed above the RAB walls on the east and west sides above elevation + 30 ft MSL, and therefore the conduits were potentially subject to strikes by tornado missiles. Waterford 3 personnel determined the conduits contained control cables for safety related equipment, primarily equipment for the UHS.

Since October 1996, Waterford 3 personnel have performed various walkdowns and intensive evaluations to identify the cables in the conduits and the affected equipment. Further, the vulnerable conduits have been re-routed to ensure they are protected from tornado missiles. The following information provides additional details about how the condition was resolved.

Safety related conduits installed within the Ultimate Heat Sink area at elevations less than + 30'0" were considered to be adequately protected from tornado generated missiles. Similarly, safety related conduits installed within the UHS area at elevations higher than + 30'0" and which were not protected by missile shields were considered to be vulnerable to tornado missiles. Each cable important to safety in the Cooling Tower Areas which was routed through a conduit and was not protected from a tornado missile was

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Resolution of conduit issue (continued)

evaluated. The determination of whether a cable should be re-routed was made by ensuring the loss or failure of each cable due to a tornado missile and a single failure, coincident with loss of offsite power, would not prevent safe shutdown of the plant nor result in a release of radioactivity from the plant. Every safety related conduit in the UHS area was identified using the Plant Data Management System, General Arrangement Drawings, and field walkdowns. The physical location of each conduit was verified by visual inspection during field walkdowns.

The conduits and cables which were identified as potentially vulnerable to tornado missiles and which were re-routed included cables for the following major equipment :

- Dry Cooling Tower bypass and isolation valves
- Component Cooling Water surge tank level transmitter
- Dry Cooling Tower fans 7 to 15
- 480 Volt Motor Control Centers 314 and 315
- Wet Cooling Tower level transmitter

The cables and conduits were re-routed at an elevation less than 30 ft MSL via a route that provided protection from tornado missiles by grating or walls.

An associated circuit analysis and Regulatory Guide 1.75 evaluation were performed. These analyses were performed to ensure there was not an adverse impact on the associated circuit analysis and to ensure adequate separation of the trains was maintained. The review established that the criteria of the associated circuit analysis and Regulatory Guide 1.75 was met. Also, a cable tray fill analysis was performed. This analysis was performed in order to monitor the cable fill in the trays. The analysis established the cable tray fill levels are acceptable.

Confirmatory calculation to establish low probability of damage

As previously discussed, the design and licensing basis for tornado protection is predicated on two concepts: (1) the concept of low probability of damage by virtue of the diversity, redundancy, robustness of design features, and (2) the concept of a low probability of offsite hazards, 10^{-6}, incorporated in SRP 2.2.3.

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Confirmatory calculation to establish low probability of damage (continued)

Nonetheless, we also recognized the design and licensing basis for tornado protection has not been well documented, and there did not exist to our knowledge a specific calculation which confirmed the principles upon which the design and licensing basis was approved. In the October 1996 response, we communicated to the NRC we would review our design and licensing basis for tornado missile protection. As part of this review, we have identified the need for, completed, and approved calculation EC-C97-003 which confirms there is a low probability of damage to safety related equipment from tornado missiles. We note the calculation is not a change to the design and licensing basis of record, but rather a confirmatory calculation that verifies there is a low probability of damage to safety related equipment from tornado missiles. The following is a description of the methodology and the results of the calculation.

The purpose of the calculation is to calculate the probability of a tornado missile striking certain vulnerable areas of Waterford 3. These targets do not have physical barriers which protect them from tornado missiles or are only protected through a range of certain angles by physical barriers. In general, the targets include some of the UHS cooling tower areas, for example, dry cooling tower fans and cooling coils, and certain safety related piping on the roof of the RAB.

Some of the major targets evaluated in the calculation are listed in Table 3.

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Table 3 Major Targets Evaluated In Calculation EC-C97-003			
ITEMS	**LOCATION**	**PROBABILITY**	**PERCENTAGE**
a) Ultimate Heat Sink Related Targets			
1) Dry Cooling Towers - Fans 'A' Train (60%)	DCT Area -35' to +21'	4.00E-10	
2) Dry Cooling Towers - Motors 'A' Train (60%)	DCT Area -35' to +21'	3.37E-11	
3) Dry Cooling Towers - Conduits & Elec. Boxes 'A' Train	DCT Area -35' to +21'	1.31E-09	
4) Dry Cooling Towers - Fans 'B' Train (60%)	DCT Area -35' to +21'	7.58E-09	
5) Dry Cooling Towers - Motors 'B' Train (60%)	DCT Area -35' to +21'	6.32E-10	
6) Dry Cooling Towers - Conduits & Elec. Boxes 'B' Train	DCT Area -35' to +21'	3.63E-09	
7) Relocated conduits for UHS on west side	RAB -35' west side	1.37E-08	
8) Relocated conduits for UHS on east side	RAB -35' east side	1.64E-08	
9) Air Accumulators, Instrument Cabinets for east and west side	RAB -35' east & west side	7.42E-11	
10) CCW piping for Ultimate Heat Sink	East and West Side DCT Areas	2.96E-08	
11) West Side DCT Cooling Coils (60%)	West Side DCT Area -35' to +21'	8.38E-09	
12) East Side DCT Cooling Coils (60%)	East Side DCT Area -35' to +22'	3.24E-08	
SUBTOTAL		**1.14E-07**	**69.7%**

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Table 3 (Continued) Major Targets Evaluated In Calculation EC-C97-003			
ITEMS	**LOCATION**	**PROBABILITY**	**PERCENTAGE**
b) Safety Related Targets			
1) MS & FW Pipe	RAB Roof +69'	3.00E-11	
2) Plant Stack	RAB Roof +69'	3.70E-08	
3) Terry Turbine Stack	RAB Roof +69'	3.96E-12	
4) Containment Escape Hatch Doors and Misc. Items	RAB +21', +46'	1.22E-09	
5) EDG Stacks Area	RAB Roof +95.50'	2.80E-10	
SUBTOTAL		**3.85E-08**	**23.5%**
c) Non-Safety Related Targets			
1) Sump No. 2, sump Motor and Drains	-35' RAB Wing Area	2.51E-12	
2) Control Room Breathing Air Tanks	-35' East Side DCT Area	1.09E-08	
3) Main Steam Relief Valve stacks East side	RAB Roof +69'	6.61E-11	
4) Main Steam Relief Valve stacks West Side	RAB Roof +69'	3.80E-11	
5) Waste management Piping (Safety Class 7)	Between RAB & FHB, +10'	5.15E-12	
6) Main Steam Dump Valve East Side	RAB Roof +69'	1.66E-11	
7) Main Steam Dump Valve West Side	RAB Roof +69'	9.77E-12	
8) RB Roof Drains	RB Wall Az 90 degree	2.18E-11	
SUBTOTAL		**1.11E-08**	**6.8%**
TOTAL		**1.64E-07**	**100%**

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Confirmatory calculation to establish low probability of damage (continued)

The following equations were used in calculating the probability of a tornado missile risk.

$P_T = \sum_{i}^{n} P(T_i)$, where

P_T = Total probability of tornado missile striking all vulnerable targets, per year

$P(T_i)$ = Probability of tornado missile striking a particular target, T_i, per year

n = Number of vulnerable targets

The target probabilities are based on the methodology developed by Twisdale, references 2 and 3.

Each target probability is calculated using the following equations.

$P(T_i) = \sum_{j}^{N} P(T_i/F_j)\, P(F_j)$, where

$P(T_i)$ = Probability of tornado missile striking the target T_i, per year

$P(F_j)$ = Probability of tornado striking the plant site with wind speed intensity, F_j, per year

$P(T_i/F_j)$ = Conditional probability of tornado missile striking target T_i after the tornado of intensity, F_j, has struck the plant site

N = Number of tornado intensities

The probability of a tornado of intensity F_j striking the plant site, $P(F_j)$, is calculated using the following equation.

$P(F_j) = cP(F_j)_I$, where

$P(F_j)$ = Probability of tornado of intensity F_j striking the plant site per year

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Confirmatory calculation to establish low probability of damage (continued)

$P(F_j)_I$ = Probability of tornado of intensity F_j striking the NRC region I per year. This probability is calculated using the tornado data given in EPRI Report No. NP-2005, references 2 and 3.

c = $P(F)/P(F)_I$, which is a constant, $c \approx 0.1$, where

P(F) = Probability of a tornado strike at plant site per year, $P(F) = 4.6072 \times 10^{-5}$ per year. The probability of 4.60272×10^{-5} is based on Waterford 3 Project Evaluation Information Request (PEIR) PEIR 20003. PEIR 20003 updates the probability of a tornado strike at Waterford 3 from the value in the FSAR, Section 2.3.1.2.4, based on updated data from the National Severe Storms Forecast Center and the same methodology as used in the FSAR.

$P(F)_I$ = Probability of tornado strike at NRC region I, $P(F)_I = 47.544 \times 10^{-5}$. This probability is calculated using the data from EPRI Report No. NP-2005, references 2 and 3.

Some of the major conditions employed in the calculation are the following.

- The Waterford 3 plant is located in region I as defined in Regulatory Guide 1.76.
- The tornado missile spectrum used in the calculation is from FSAR Table 3.5-10.
- Missiles beyond a one half mile radius from the center of the plant are unlikely to reach the plant structures.
- The calculation was performed assuming the missiles are capable of striking in all directions which are not protected by missile proof barriers or walls.

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Confirmatory calculation to establish low probability of damage (continued)

Some of the conservatisms employed in the calculation are the following.

- The surface areas used for circular objects such as pipes, conduits, and stacks in the calculation were based on the full circumference of the area multiplied by 10 %. For example, area = 1.10 x π x diameter x length, rather than area = projected diameter x length. This procedure was used for the entire length of the object.

- Wherein there was a group of pipes or conduits, the shielding effect of any individual pipe or conduit in the group was not considered.

- The calculation employs the assumption that if the missile strikes a target, the target is assumed to fail. More likely the failure probability is less than 10%.

The probabilities of tornado missiles striking vulnerable targets were calculated using the Sargent and Lundy TORMIS computer code, originally developed by EPRI, reference 2. The TORMIS methodology has been used at other nuclear facilities for calculating tornado missile probabilities.

The probabilities determined for various components in the calculation are listed in Table 3 by category.

The total probability of tornado missiles striking any of the targets was calculated to be 1.64×10^{-7}. The probability of damage would be some value less than 1.64×10^{-7}. This probability meets the Waterford 3 design and licensing basis criterion of low probability of damage and 10^{-6}. Further, the probability reasonably meets the 10^{-7} criterion of more recent regulatory guidance, specifically Regulatory Guide 1.117, which was issued after the approval of the Waterford 3 design and licensing basis.

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Update planned to Waterford 3 design and licensing basis

In the recent past, we have undertaken various initiatives to upgrade the design and licensing basis of Waterford 3. These initiatives in part are documented in our 10CFR 50.54(f) response, reference 4. We also communicated to the NRC in the October 1996 letter a need to further review the design and licensing basis for tornado protection.

We have confirmed as part of this review the design and licensing basis for tornado protection, although understood, is not well documented. Accordingly, we have developed and are finalizing a document which comprehensively collects in one location the design requirements and criteria for tornado protection. This design criteria document in conjunction with the probability calculation will provide information to update the FSAR and clarify the Waterford design and licensing basis for tornado protection. We do not expect the fundamental requirements and principles of the design and licensing basis will need to change. The FSAR update will be a clarification within the framework of the approved FSAR.

Nonetheless, any changes will be reviewed and approved in accordance with the 10CFR 50.59 change process, and any changes which do not meet the criteria of 10CFR 50.59 will be submitted to the NRC for prior approval.

Resolution of RAB hatch cover issue

On May 1, 1997 a Condition Report was written documenting that RAB hatch covers were not secured, and therefore not designed to withstand the depressurization loadings from a tornado. This condition was discovered as a result of plant walkdowns being done by Waterford 3 personnel in order to perform work on the tornado missile probability calculation and the tornado design criteria document.

RAB hatch HC-31 is located on the RAB roof at elevation + 69'. The RAB hatch is used to provide needed access to the + 46' heating and ventilation room located below for the transfer of materials and equipment. The RAB hatch is 12' long by 6'-6" feet wide. The hatch is covered by two 2'- 4" thick concrete covers, each cover weighing approximately 16,000 pounds. There is no safety related equipment located below the hatch. The area below the hatch is used solely as a designated storage area.

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Resolution of RAB hatch cover issue (continued)

The hatch covers do not have restraining devices to restrain the hatch covers in place in the event they are subjected to overpressure forces from a tornado. Calculation EC-C90-010 was completed and approved, and the calculation established there was a net uplift on the RAB hatch covers due to pressure loadings from a tornado. A steel plate restraining device was designed to hold the hatch covers in place in the event of a tornado. The required work is in progress, and the installation of the steel plate design will be completed prior to entering mode 4. Calculation EC-C90-010 provided the qualification for the steel plate design. The calculation employed the same methodology used in FSAR section 3.3.

Summary and conclusions

The Waterford 3 design and licensing basis of record is based on the concept of low probability of damage by virtue of the diversity, redundancy, and robustness in the design of equipment and a qualitative probability acceptance criterion of 10^{-6}. The conduit issue has been resolved. A confirmatory calculation verifies the total probability of tornado missiles striking targets is 1.64×10^{-7} which meets the design and licensing basis of record. This probability also reasonably meets the probability acceptance criterion of Regulatory Guide 1.117 which was promulgated after the approval of the Waterford 3 design and licensing basis. A document is being finalized which will collect in one location the design and licensing criteria for tornado protection. The probability calculation and the tornado protection criteria document will provide the basis to update the FSAR. The fundamental requirements and principles for tornado protection in the FSAR are not expected to change, and the update will be a clarification of the existing FSAR information on tornado protection. The FSAR update will be performed in accordance with 10 CFR 50.59.

Therefore, we believe the tornado missile protection issue and the RAB hatch cover issue have been resolved.

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References

1. Entergy, Waterford 3 letter No. W3F1-96-0188, dated October 21, 1996.

2. Electric Power Research Institute (EPRI) Report No. NP-2005, "Tornado Missile Simulation Methodology - Computer Code Manual," August 1981.

3. Electric Power Research Institute (EPRI) Report No. NP-2005 Volume 2, "Tornado Missile Simulation and Design Methodology - Volume 2: Model Verification and Data Base Updates," August 1981.

4. Entergy, Waterford 3 letter No. W3F1-97-0025, dated February 6, 1997.