

TORNADO MISSILE RISK EVALUATOR (TMRE) METHODOLOGY TOPICS  
AND METHODOLOGY FEEDBACK  
SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1  
VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2  
GRAND GULF NUCLEAR STATION, UNIT 1  
DOCKET NOS. 50-400, 50-424, 50-425, AND 50-416

The following represents initial Nuclear Regulatory Commission (NRC) staff review of Nuclear Energy Institute (NEI) 17-02, Tornado Missile Risk Evaluator (TMRE) Industry Guidance Document,” Revision 0 (Agencywide Document and Access Management System (ADAMS) Accession No. ML17181A307), as provided by NEI for information on June 23, 2017 in support of the July 6, 2017 public meeting on TMRE. The NRC staff intends to develop additional, detailed comments for discussion in a future public meeting, with the specific topic to discuss TMRE methodology and the information in the TMRE guide.

1. SECTION 2 - COMPLIANCE WITH TORNADO-GENERATED MISSILE DESIGN AND LICENSING BASIS
  - a. Adoption of a 10 sq. ft de-minimus value has not been vetted by the NRC staff, so pilots should not adopt and summarily exclude small unprotected openings without identification or explanation of those openings.
  - b. For any area where a pilot plant identifies changes, or re-interprets their site specific current licensing basis, the guidance should support the development of a detailed explanation of the current basis, justification for change to the current basis, and mark up of final safety analysis report (FSAR), as updated, section(s) affected with proposed changes as part of the amendment request.
  
2. SECTION 3 - OVERVIEW OF TORNADO MISSILE RISK EVALUATOR METHODOLOGY
  - a. The guidance should ensure that target and missile characteristics is demonstrated to bound their design and licensing basis, or if changes are proposed, specifically detail changes with justification. Section 3.4 discusses the TMRE consideration of wall, roof, and steel plate thicknesses, and pilots using this guidance should review and document site specific design criteria in comparison to TMRE values.
  - b. Additional detail should be provided when identifying “grade” for determination of 30 ft. missile impact parameter (MIP) applicability. Limited information is provided in this section for consistent application of each target to the less than and greater than 30 ft. demarcation for MIP. However, elsewhere in the guide, additional information is provided to alert the licensee to consider the source of missiles affecting the specific target (as example, roof top massive missiles, or elevated parking areas). The guidance should ensure proper documentation of missile source applicability for each target relative to the 30 ft. demarcation.

- c. Throughout the guide, and beginning in Section 3, the guidance should be specific such that each application applies TMRE in the same manner to the extent possible.
3. SECTION 4 - IDENTIFY NONCONFORMING AND VULNERABLE SYSTEMS, STRUCTURES AND COMPONENTS (SSCs)
- a. Under Section 4.4, clarification is needed regarding how the pilot plants will compare their licensing basis missiles with the 23 TMRE missiles. The guidance should assure a discussion regarding bounding the licensing basis is included in the submittals.
  - b. In Section 4.4, the discussion implies that small non-protected openings can be ignored. The guidance should ensure that detailed analysis and justification for exclusion methodology are provided.
  - c. In Section 4.4, there is a reference for allowance for shielding of targets by other structures such that some additional crediting is available. Additional guidance may be warranted to support credit for shielding as part of the calculation.
  - d. In Section 4.4, the guide provides specific information for how a licensee disposes vulnerabilities, which may not be in accordance with the licensee specific corrective action program (CAP). The NRC expects that all vulnerabilities identified during walkdowns were dispositioned in accordance with Appendix B to Part 50 of Title 10 to the *Code of Federal Regulations* (10 CFR 50) regulations as implemented by site programs.
4. SECTION 5 - PERFORM PLANT TMRE WALKDOWN
- a. Starting in Section 5, there are references to information on performing TMRE specific activities in other documents (example specific industry standard or vendor methodology related documents). The guidance should ensure that references are provided for specific sections of other documents that are specifically used for performance of actions.
  - b. Concerning small non-protected openings, the guidance should ensure that a detailed analysis and justification to support exclusion from the methodology is provided.
  - c. In Section 5.1, the guide states that SSCs that are dependent on offsite power are screened. The guidance should ensure that further information justifying the assumption of a non-recoverable loss of offsite power is provided as SSCs that are dependent on offsite power may need to be considered.
  - d. In Section 5.2, there is limited instruction on how to consider secondary effects. The guidance should ensure the submittals identify and discuss vulnerability of potential targets to secondary effects, and justify their inclusion (or exclusion). These effects should include consideration for fluid filled tanks and pipes and combustion motor intake effects (loss of oxygen from inert gas tank rupture or exhaust re-direction scenarios) as well as other potential secondary effects to SSC function.

- e. In Section 5.3, the guidance should ensure that a justification is included for treatment of actions performed within 1 hour of the tornado event.
  - f. In Table 5-2, 23 missiles are identified, but in Tables and calculations following (including the Appendices) 22 missiles are identified. Missiles in the Section 5 tables are only referred to by number, so the guidance should ensure adequate missile identification and justification is provided to support each missile that has been excluded.
5. SECTION 7 - EVALUATE TARGET AND MISSILE CHARACTERISTICS
- a. In Section 7.2, a crushed/cripped percentage of 50 percent for the pipe failure value is used. The guidance should ensure justification for the different types of components that may be considered targets, and that a methodology is provided, which consistently applies either a bounding or comparison to the plant specific target.
  - b. For the targets described in Table 7.2, the guidance should ensure a justification is provided to support the target material thicknesses, and a method to justify or means to bound the TMRE thickness values related to the site specific design bases for targets.
  - c. The discussion related to concrete wall/roof spalling is briefly discussed in Appendices, and indicates that spalling is not considered. The guidance should allow and provide guidance related to crediting spalling consistent with plant design bases assumptions, or justified otherwise.
  - d. Table 7-2 and Table B – 18 provide the percentage of general target descriptions to be used to adjust fragility (by number of missiles). The calculations for these values should be validated and the methodology to obtain the methodology discussed if unchanged.
  - e. The robust target percentages presented in Table 7-2 appear to depend on the contribution of each missile type to overall missile population. Therefore, the guidance should ensure that the contribution of each missile type to overall missile population is appropriately identified to avoid an anomaly in missile distribution and a potential bias toward a specific missile type.
  - f. Several references in Section 7 discuss target thickness, tank and pipe failure susceptibility, as well as other considerations for identifying target failure. The guidance should ensure that a comparison of the generalized considerations to plant specific design criteria is performed and demonstrate that the methodology is bounding or justify any deviations.
  - g. Examples in Section 7.5 appear to use values different than the percentages in Table 7-2. The guidance should ensure that examples use verified values.
  - h. In Section 7.6, the guidance should provide sufficient detail to justify a correlated target(s) used in the TMRE.

6. SECTION 8 - DEVELOP TMRE PROBABILISTIC RISK ASSESSMENT (PRA) MODEL
  - a. The guidance states that recovery and repair are not credited in the TMRE PRA. Additional justification, which may include a sensitivity analysis, should be provided.
  - b. Section 8.4 states that for short-term actions the TMRE method assumes that the actions cannot be performed and thus the human error probabilities (HEPs) for those actions are set to 1.0. The guidance should ensure a justification is included for treatment of actions performed within 1 hour of the tornado event.
  - c. Section 8.4 states that if necessary, operators should be interviewed to ensure that the operator actions used in the internal events PRA are applicable to tornado events. The guidance should ensure that the applicability of other factors such as procedures and training are evaluated to determine whether those factors affect the HEP.
  
7. SECTION 9 - QUANTIFY RISK, PERFORM SENSITIVITY ANALYSES, AND COMPARE TO THRESHOLDS
  - a. Section 9.3 states that it is possible that some licensees may exceed the “very small” change in risk thresholds, in which case, additional discussion on defense-in-depth and safety margins may be warranted in the LAR. If the “small” threshold is exceeded, the NRC staff will consider applications only if it can be reasonably shown that the total core damage frequency (CDF) and large early release frequency (LERF) is less than  $10^{-4}$  and  $10^{-5}$ , respectively, per reactor year (Region II).
  - b. Section 9.4 states that if part of the SSC is shielded or inconsequential, a smaller area could be used. The guidance should address the considerations for addressing shielding in calculating area.
  - c. Consistent with Regulatory Guide 1.174 “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis” Revision 2, in order to address the unknown and unforeseen mechanisms or phenomena failure, traditional defense-in-depth considerations should be used or maintained. Therefore the defense-in-depth criteria discussed in Section 9.5 should ensure that all seven principles are explicitly addressed.
  - d. The safety margin discussion in Section 9.5 should ensure that sufficient information is provided to conclude that sufficient safety margins established in the licensing and design bases (e.g. design bases related Industry codes and standards, other licensing requirements, etc...) will not be significantly reduced or exceeded by any of the proposed design bases change requests.
  
8. SECTION 10 - LICENSE AMENDMENT REQUEST
  - a. The guidance should ensure the submittals explicitly identify those SSCs for which the methodology will be employed. Conversely the guidance should ensure the limitations for the methodology are explicitly identified within the guidance. Including the following:

- i. The methodology is not applicable for risk-informed applications other than changing the current licensing basis to address nonconforming conditions related to protection against tornado generated missiles.
  - ii. The methodology is not intended for justifying the elimination of existing tornado protected SSCs or tornado barriers, nor for justifying the elimination or relaxation of technical specification (TS) (or other) requirements that have been established for those SSCs and barriers.
  - iii. Application of the methodology does not provide a basis for modifications to remove existing tornado missile protection or to omit protection for new configurations that otherwise require tornado missile protection according to the plant licensing basis.
- b. Consistent with RG 1.174, to ensure a determination can be made that the proposed change meets the current regulations applicable to the specific licensee, the guidance should ensure that the submittals address, in its entirety, the current licensing/design basis related to tornado missile protection, including any existing licensing commitments, deviations, or exemptions.
- c. The guidance should ensure that deviations from the methodology are explicitly identified and justified. The guidance should also address the applicability or lack thereof of deviations to significant portions of the methodology.

## 9. APPENDIX A

- a. The basis for the assumption of non-recoverable offsite power appears to be conservative for estimating base CDF, but could be non-conservative for calculating change in risk. Therefore, the guidance should ensure that sufficient justification, appropriate to the circumstance, is provided or a sensitivity analysis performed.
- b. Section 9.2.1 addresses sensitivities. Section A.2.1.3 states that Section 9.2.1 provides guidance on performing sensitivity studies that addresses specific issues; however there does not appear to be any explicit guidance. The guidance should be consistent and ensure that specific guidance regarding the performance of sensitivity studies or an appropriate reference is provided.
- c. The discussion in Appendix A, Section A.7, recognizes unexplainable differences between zonal and uniform missile distributions. Nonetheless, targets were categorized in Appendix A to separate intuitive from non-intuitive trends and propose an adjustment factor to account for zonal distribution of missiles. As there is no justification the validity of the results in Appendix E, and the interpretation in Appendix A appear questionable. The guidance should ensure an appropriate justification is provided for the categorization in Appendix A.

## 10. APPENDIX B

- a. Section B.4 states:

[t]he demarcation between near ground and elevated targets is 30 feet above the primary missile source for a target.

The document does not appear to provide guidance for determining “the primary missile source for a target”. In addition, the basis for specified demarcation height (30 feet) does not appear to be clearly defined.

- b. The derivation of the MIP for near ground targets includes the containment building (Target 1), which receives relatively few hits on the exposed surface. Target 1 is not impacted by near-ground missile hits (the lower part of the containment building is protected by other buildings, only the upper part including the dome is exposed). The guidance should ensure that a technical basis is provided justifying the inclusion of the containment building on the average MIP to compute the hit probability for near-ground targets.
- c. It appears that in some cases (example, missiles 10 and 11) an explanation was not provided regarding why these missiles vary widely in damage profiles. As a detailed justification for the results in Table B-14 have not been provided, the guidance should ensure the submittals should provide justification for the assumptions used and conclusions made in this table.
- d. The values in Table B-18 should be validated. Additional guidance should be provided to explain how the data in Tables B-14 through B-17 were used to create the fragility percentages in Table B-18 (and also in Table 7-2).

## 11. APPENDIX C

- a. Figure C-1 and Table C-1 do not appear to conclude that the assumptions are representative of plant targets. Specifically, the assumption for exhausts and stacks is described as having the exhaust/stack being supported on both ends. Generally, and specific to the example in Figure C-1, these targets are unsupported at the end. The guidance should ensure justification is provided to demonstrate the appropriateness of this assumption.
- b. In Section C.3.1, it is the NRC staff’s understanding that M should be the mass of the missile, vice the weight provided in the missile descriptions (mass = weight/32.2). For non-cylindrical missiles, the guidance should ensure that the equivalent diameter used is the diameter of a circle equal to the frontal area of the non-cylindrical missile.
- c. The assumption that only steel missiles are capable of perforating steel targets, should be verified and a justification provided. Also, in the associated reference document that describes the equation above, it is said that the thickness of the steel barrier required to prevent perforation should exceed the thickness for threshold of perforations by 25 percent. It should be considered whether this assumption is significant enough to be added.
- d. In Section C.3.1, the guidance should provide a table of values of perforation thicknesses for the different targets in question, or an example of this equation used to evaluate one of the targets.
- e. On the Variation of Impact Velocity with Missile Weight (Figure C-3) plot provided shows how missile velocity assumed in this analysis varies with weight. The equation of the line provided represents the best fit line for the data (blue dotted

line), but the model uses the green line, which is conservatively shifted up to a maximum velocity of 230 mph. The guidance should include the equation of the line for the green line in order to calculate any missile velocity given missile weight or vice versa.

- f. In section C.3.1, the assumption is that only like materials can cause perforation (steel to steel). The guidance should ensure that a justification is provided to support this assumption.
- g. Figure C-14, should be reviewed to determine whether it can be used to estimate tank rupture
- h. The NRC staff notes despite the Bechtel Topical Report, BC-TOP-9A, Revision 2, "Design of Structures for Missile Impact," being referenced throughout, guidance on crediting spalling was not provided. Further, the NRC staff noted that BC-TOP-9A recommended using the equation  $T_s = 2T$  to estimate the thickness of concrete that will just start spalling. That is, for the calculated thickness of concrete to be just perforated about double that thickness would be necessary to just start spalling. Given that concrete fragments may fall from the roof and potentially damage anything that is under the impact area, the guidance should account for spalling in support of the concrete roofs evaluation.
- i. The data in Table C-5, specifically the minimum perforation thickness in the first column, should be validated and more comprehensive guidance provided regarding the use of the Concrete Perforation equation. Additionally, the evaluations on the failure of the concrete using those values should be addressed should the validation demonstrate that the values should be changed. Similar validation efforts should be performed on vehicle impact and the tree impact evaluation.

## 12. APPENDIX F

- a. The marked-up FSAR, as updated, pages are not for information only, as Section 50.90 to 10 CFR requires the submittal to fully describe the changes desired following as far as applicable, the form prescribed for original applications. Each application will be expected to provide mark ups of the applicable FSAR, as updated, pages. It should be noted that if approved, the NRC staff would expect the FSAR to be updated consistent with the periodicity prescribed in 10 CFR 50.71(e).