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DTE Energy

10 CFR 50.90

January 11, 2013
NRC-13-0002

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington D C 20555-0001

Reference: Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

Subject: Proposed License Amendment to Revise the Fermi 2 Licensing Bases for Protection from Tornado-Generated Missiles

Pursuant to 10 CFR 50.90, DTE Electric Company (DTE) proposes to update the Fermi 2 Updated Final Safety Analysis Report (UFSAR) to describe the methodology and results of the analysis performed to evaluate the protection of the plant's structures, systems and components (SSCs) from tornado generated missiles. The analysis is consistent with the guidance provided in Regulatory issue Summary 2008-14, "Use of TORMIS Computer Code for Assessment of Tornado Missile Protection."

Enclosure 1 provides an evaluation of the proposed license amendment, including an analysis of the issue of significant hazards consideration using the standards of 10 CFR 50.92. DTE has concluded that the change proposed in this submittal does not result in a significant hazards consideration. Enclosure 2 provides information on a Piping Penetration Screening Algorithm utilized in the analysis. Enclosure 3 provides marked up pages of the Fermi 2 UFSAR to show the proposed changes including a list of plant targets included in the analysis. Enclosure 4 provides a list of plant targets excluded from the analysis or included for information only.

DTE has reviewed the proposed change against the criteria of 10 CFR 51.22 and has concluded that it meets the criteria provided in 10 CFR 51.22(c)(9) for a categorical exclusion from the requirements for an Environmental Impact Statement or an Environmental Assessment.

Approval of the proposed license amendment is requested by January 11, 2014. Once approved, the amendment will be implemented within 60 days.

No new commitments are being made in this submittal.

In accordance with 10 CFR 50.91, a copy of this application, with attachments, is being provided to the designated Michigan State Official.

Should you have any questions or require additional information, please contact Mr. Zackary Rad of my staff at (734) 586-5076.

Sincerely,

Enclosures:

1. Evaluation of the Proposed Change
2. Piping Penetration Screening Algorithm
3. Section 3.5 of the UFSAR Showing Proposed Changes
4. List of Targets Excluded or Included For Information Only

cc: NRC Project Manager
NRC Resident Office
Reactor Projects Chief, Branch 5, Region III
Regional Administrator, Region III
Supervisor, Electric Operators,
Michigan Public Service Commission

I, J. Todd Conner, do hereby affirm that the foregoing statements are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

J. Todd Conner
Site Vice President, Nuclear Generation

On this 11 day of January, 2013 before me personally appeared J. Todd Conner, being first duly sworn and says that he executed the foregoing as his free act and deed.

Sharon S. Marshall
Notary Public

SHARON S. MARSHALL
NOTARY PUBLIC, STATE OF MI
COUNTY OF MONROE
MY COMMISSION EXPIRES Jun 14, 2013
ACTING IN COUNTY OF Monroe

Enclosure 1 to
NRC-13-0002

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

Proposed License Amendment to Revise the
Fermi 2 Licensing Bases for Protection from Tornado-Generated Missiles

Evaluation of the Proposed License Amendment

Evaluation of the Proposed License Amendment

Subject: Revision of UFSAR for Tornado Missile Protection

1.0 SUMMARY DESCRIPTION

The proposed amendment would modify the Fermi 2 Plant Licensing Bases by revising the Updated Final Safety Analysis Report (UFSAR) to describe the methodology and results of the analysis performed to evaluate the protection of the plant's structures, systems and components (SSCs) from tornado generated missiles. The analysis utilized a probabilistic approach implemented through the application of the TORMIS computer program as described in Regulatory Issue Summary (RIS) 2008-14.

2.0 DETAILED DESCRIPTION

DTE Electric Company (DTE) proposes to update the Licensing Bases in the Fermi 2 UFSAR with safety analysis performed using an updated version of the TORMIS computer code. The analysis was performed in accordance with the guidance provided in the 1983 TORMIS SER (Reference 1), as clarified by RIS 2008-14 (Reference 2), dated June 16, 2008.

The updated Fermi 2 analysis is based on the NRC approved methodology as detailed in two topical reports, EPRI NP-768/769, "Tornado Missile Risk Analysis and Appendices," May 1978 (References 3 and 4) and EPRI NP-2005, "Tornado Missile Risk Evaluation Methodology," August 1981 (Reference 5), utilizing the TORMIS computer code. TORMIS employs Monte Carlo techniques in order to assess, through a Probabilistic Risk Assessment (PRA) methodology, the probability of multiple missile strikes causing unacceptable damage to unprotected, safety-related plant features. This is accomplished by simulating tornado strikes on the plant in such a way that, for each tornado strike, a tornado wind field is simulated, missiles are injected and flown, and missile impacts on SSCs are analyzed. These models are then linked to form an integrated, time-history simulation. By replicating these simulations, the cumulative mean annual probability of missiles impacting and damaging individual target SSCs and groups of target SSCs are estimated. Statistical convergence of the results is achieved by performing multiple replications with different random number seeds. The statistical confidence bounds of the results can then be estimated using conventional methods.

Consistent with the guidance provided in Reference 2, the Fermi 2 analysis performed thirty replications for each of the five selected Enhanced-Fujita tornado wind speed classifications (EF1-EF5), each replication consisting of 2,000 simulated tornado strikes. Each simulated tornado strike consisted of 5,000 missiles sampled from the total missile population and flown as tornado missiles. Therefore, the total number of TORMIS simulations represented in the analysis is 30 x 5 x 2,000 x 5,000 = 1.5 billion. The results of the new TORMIS analysis predict a site mean aggregate tornado missile damage probability of 6.82 x 10^{-7} per year for an identified scope of 81 safety-related targets. This value satisfies the acceptance criterion of 10^{-6} per year established in NRC Standard Review Plan Section 2.2.3.

The current Fermi 2 UFSAR, Section 3.5.1.3.2.3, describes the results of a probabilistic analysis performed in accordance with the EPRI TORMIS methodology to determine the mean strike probability of a design basis Tornado Generated Missile strike on 51 identified penetrations in the exterior walls of the Reactor and Auxiliary buildings. The analysis was performed in 1989 to address an internal condition report regarding the adequacy of protection from tornado missiles associated with these penetration areas in the buildings that do not have the same protection provided by the reinforced concrete walls. Due to the significant cost associated with potential physical modification to the plant structures to provide protection from the missiles, the probabilistic analytical approach was selected to address the identified vulnerability. The missile hazard analysis was performed using the TORMIS methodology developed by EPRI (References 3, 4 and 5). The analysis was evaluated in accordance with 10 CFR 50.59 and determined to not result in an Unreviewed Safety Question. Accordingly, the UFSAR was updated to describe the design basis analysis.

In November, 2008, the NRC issued inspection report number 05000341/2008-004 (Reference 6) to document inspection activities and associated findings regarding compliance with rules and regulations. The inspection report included a finding of an inadequate 10 CFR 50.59 evaluation of reactor building missile protection. Specifically, the report stated:

> *The inspectors identified a Green (Severity Level IV) NCV of 10 CFR 50.59(a)(2)(i) for the failure to obtain NRC approval prior to revising UFSAR Section 3.5.1.3.2.3 to include the tornado missile hazard analysis for the reactor and auxiliary building exterior wall penetrations and openings.*
>
> *Title 10 CFR 50.59(a)(2)(i) (1989) stated, in part, that a licensee shall obtain a license amendment pursuant to Section 50.90 prior to implementing a proposed change, test, or experiment if the change, test, or experiment would result in an increase in the probability of a malfunction of equipment important to safety previously evaluated in the UFSAR.*
>
> *Contrary to the above, on September 22, 1989, the licensee approved a 10 CFR 50.59 evaluation (SE-89-0094) incorporating a change to the Fermi design basis which resulted in an increase in the probability of a malfunction of equipment important to safety previously evaluated in the UFSAR without obtaining a license amendment. Corrective actions included modifications to provide missile shields to affected components. At the conclusion of this inspection, long term corrective actions were still being evaluated. However, because this violation was of very low safety significance and it was entered into the CAP as CARD 08-20821, this Severity Level IV violation is being treated as an NCV, consistent with Section VI.A.1 of the NRC Enforcement Policy.*

As a result of the above NRC finding and in accordance with the Fermi 2 corrective action program, a thorough review of the analysis performed in 1989 was conducted to assess compliance with References 1 and 2. This review concluded that the 1989 analysis did not fully comply with NRC requirements for applying the EPRI methodology as provided in References 1 and 2.

Also, a detailed walkdown of the site area identified approximately 30 additional targets that should be considered as potential tornado missile hazard areas. For some targets, it was determined that the vulnerability can be best addressed through the implementation of plant modifications to provide physical protection from tornado generated missiles. These plant modifications have been fully implemented. For many other targets, additional costly protective barriers or other alternative systems would be required to provide the required protection from missiles. Therefore, a new TORMIS analysis has been performed to address the remaining identified deficiencies. The new analysis described herein was performed in accordance with the guidance provided in the 1983 TORMIS SER (Reference 1), as clarified by RIS 2008-14 (Reference 2), dated June 16, 2008.

3.0 TECHNICAL EVALUATION

Reference 1 established the following required attributes:

1. Data on tornado characteristics should be employed for both broad regions and small areas around the site. The most conservative values should be used in the risk analysis or justification provided for those values selected.

2. The EPRI study proposes a modified tornado classification. F'-scale for which the velocity ranges are lower by as much as 25% than the velocity ranges originally proposed in the Fujita, F-scale. Insufficient documentation was provided in the studies in support of the reduced F'-scale. The F-scale tornado classification should therefore be used in order to obtain conservative results.

3. Reductions in tornado wind speed near the ground due to surface friction effects are not sufficiently documented in the EPRI study. Such reductions were not consistently accounted for when estimating tornado wind speeds at 33 feet above grade on the basis of observed damage at lower elevations. Therefore users should calculate the effect of assuming velocity profiles with ratios V_0 (speed at ground level) ÷ V_{33} (speed at 33 feet elevation) higher than that in the EPRI study Discussion of sensitivity of the results to changes in the modeling of the tornado wind speed profile near the ground should be provided.

4. The assumptions concerning the locations and numbers of potential missiles presented at a specific site are not well established in the EPRI studies. However, the EPRI methodology allows site specific information on tornado missile availability to be incorporated in the risk calculation. Therefore, users should provide sufficient information to justify the assumed missile density based on site specific missile sources and dominant tornado paths of travel.

5. Once the [TORMIS] methodology has been chosen, justification should be provided for any deviations from the original [EPRI] methodology.

The manner in which the Fermi 2 analysis satisfies the SER criteria is as follows:

1. Definition of the Fermi 2 TORMIS Tornado Sub-Region:

   A site-specific analysis was performed to generate a tornado hazard curve data set for the TORMIS analysis. The tornado data retained in the National Climatic Data Center Storm Events Data Base (NCDC, 2006) files for the years 1950-2005 were used to analyze both broad and small regions around Fermi 2 in order to identify a suitable representative sub-region for the site. Tornado occurrences were mapped for the large region, a 15° longitude x 15° latitude area centered on the Fermi 2 site, and statistical tests were performed using 1° x 1° and 3° x 3° blocks to identify a suitably homogeneous sub-region. The historical records of tornado occurrences within the sub-region tornado were used to establish the tornado occurrence rate, Enhanced-Fujita (EF)-scale intensities, path length, width, and direction variables to be specified as input for use in the TORMIS analysis.

   The statistical analysis of the sub-region data established a mean occurrence rate of 3.1E-4 per square mile per year over the 56-year period. In accordance with the TORMIS methodology, backwards averaging was used to estimate a de-trended occurrence rate to correct for changes in the annual reporting trends. The adjusted mean occurrence rate was determined to be 4.002E-4/year based on the 30-year backwards average.

2. Tornado Wind Speed Intensity:

   The hazard curve developed for the Fermi 2 analysis does not utilize either the SER specified Fujita (F) scale or the SER prohibited modified Fujita (F') scale. Instead the analysis utilizes the original Enhanced Fujita (EF) scale wind speeds as per NUREG/CR-4461 (Reference 7). Though the 1983 NRC SER called for the use of the F-scale of tornado intensity for assigning tornado wind speeds to each intensity category (F1-F5), the NRC subsequently adopted the EF scale in the positions of NRC Regulatory Guide 1.76 Revision 1 that are based on NUREG/CR-4461, Rev 2.

3. Characterization of Tornado Wind Speed as a Function of Height Above Ground Elevation:

   The Fermi 2 TORMIS simulations were performed with the TORMIS rotational velocity Profile 3, which has increased near ground wind speeds over the TORMIS Profile 5 values that were used in the 1981 EPRI TORMIS reports. Hence, the Fermi 2 runs were made with higher near ground wind speeds than in the EPRI study. A sensitivity study was conducted by running the original EPRI profiles and comparing the results. The Profile 3 results (enhanced near ground wind speeds below 33ft) produced damage probabilities that averaged approximately 4% higher than the Profile 5 results. Hence, the use of Profile 3 with higher near ground wind speeds was conservative when compared to Profile 5.

4. Missile Characterization and Site-Structure Models:

Walkdowns of the Fermi 2 site were performed to characterize the missile sources and plant configuration. This information was developed into the plant modeling inputs for the TORMIS analysis that describe the facility by specifying the geometry, location, and material properties of the structures/components and the location of potential missile sources. Missile sources (buildings, houses, storage areas, vehicles, etc.) were catalogued and modeled to a distance of approximately 2,500 feet. This is done by specifying missile origin zones around the facility and a statistical description of missile types, based on the facility survey. The site surveys were conducted just prior to refueling outages to maximize the estimated population of available missiles and missiles sources; thus, the analysis is intended to represent a reasonable bounding maintenance configuration.

The three-dimensional plant model assumes that all structures, except reinforced concrete buildings and the frames of heavy steel buildings, will break up into component missiles. The number of missiles produced from this total inventory was specified to be dependent on the wind speeds experienced by the building. For example, light damage might be expected in 100 mph winds, while catastrophic failure might occur in 200 mph winds. The research performed in the development of the HAZUS wind model (Reference 8) was used as the basis for determining the number of missiles available for each building type in each tornado EF-scale.

HAZUS Damage State Exceedence Probabilities for EF Scale Mid-Point Wind speeds

Building Type	Hazard Damage State	Enhanced Windspeed (mph)					
		EF0	EF1	EF2	EF3	EF4	EF5
		65-85	86-110	111-135	136-165	166-200	200-230
Trailer, Manufactured Bldg	2	0.01	0.03	0.54	0.96	1.00	1.00
Wood Frame/Modular	4	0.00	0.01	0.12	0.75	0.99	1.00
Masonry Frame	4	0.00	0.01	0.03	0.35	1.00	1.00
Pre Engr Steel Frame	4	0.00	0.00	0.02	0.32	0.85	0.98
Engineered Frame	4	0.00	0.00	0.00	0.03	0.50	0.90

All postulated missiles were conservatively treated as minimally restrained so that each sampled missile is injected into the wind field near the peak aerodynamic response, thus maximizing its transport range and impact speed and increasing the missile strike and damage frequencies.

The total number of modeled missiles used in the TORMIS analysis of Fermi 2 includes:

Intensity	Zone Origin Missiles	Structure Origin Missiles	Total
EF1	75,369	1,571	76,940
EF2	75,369	4,636	80,005

EF3	75,369	33,095	108,464
EF4	75,369	101,511	176,880
EF5	75,369	127,734	203,103

The Fermi 2 site missiles include the standard TORMIS missiles in EPRI NP-769 (Reference 4), including structural sections, pipes, wood members, other construction materials, and an automobile category. In addition to the 20 standard TORMIS missile types, three Fermi 2 specific missiles were created for the analysis.

5. Deviations from the Original EPRI Methodology:

The TORMIS code is a legacy FORTRAN computer code that has been ported to modern computers and compilers and has had bug fixes and other enhancements since 1981. The updated Fermi 2 analysis was performed using a version of TORMIS developed from the original EPRI NP-2005 (Reference 5) version of the code by Applied Research Associates, Inc (ARA). The updates and enhancements made to TORMIS since 1981 include: porting the legacy code from mainframe to minicomputer to PC computers; post processing data routines; updates to the random number generation; minor update to aerodynamic tip loss function; enhanced output options; and addressing compiler differences and numerical round-off issues in various functions from the legacy code. All code changes have been checked and verified through comparisons to the preceding version.

Also included in the updates were the replacement of the original main frame based random number generator. A new machine independent algorithm and the code was re-dimensioned to allow larger numbers of missiles and targets.

The TORMIS code verification includes duplications and comparison to each preceding TORMIS version as well as the original TORMIS Sample Problem in EPRI NP 2005. These statistical comparisons show that the basic TORMIS code calculational approach has not deviated from the original version. In the context of 10 CFR 50.59, alterations such as those described above would not be considered deviations from the original approved methodology.

An enhanced method for evaluating missiles passing through openings, such as pipe penetrations in reinforced concrete walls was used for Fermi analysis. This calculation was done in addition to the standard TORMIS hit probability calculation for such targets. Hence, it provides supplemental outputs that are intended to cover special cases of missiles flying through openings. The method consists of identifying the minimum required missile size, angle of orientation, and angle of incidence at impact necessary for a missile to be capable of passing through a pipe penetration target. Missiles that are too large, not oriented correctly, or impinge obliquely on a target are screened out on these criteria. This method eliminates from the calculated cumulative risk those impacts which would not realistically have resulted in missile penetration of a pipe penetration target. Since this method of screening out missile strikes on penetrations is an enhancement of the originally reviewed and approved methodology, it is presented in this submittal for formal review and approval. A detailed description of this algorithm is included as Enclosure 2.

Subsequent to the original NRC SER (Reference 1), the NRC issued Regulatory Issue Summary 2008-14 (Reference 2) to inform licensees of NRC experience with shortcomings identified in submitted licensee TORMIS analyses.

1. The RIS identified that licensees had failed to meet the constraints of the original SER by:

a. *not providing adequate justification that the analysis used the most conservative value for tornado frequency*
b. *not including the entire TORMIS missile spectrum*
c. *not providing adequate explanation for the number and adequacy of tornado simulations and histories*
d. *inadequate justification and information regarding the development and use of area ratios*

2. Licensees did not fully address the fifth point identified in the SER and explain how the methodology was implemented when the parameters used differed from those specified in the TORMIS methodology. Examples include the following:

a. *inappropriately limiting the number of targets modeled*
b. *failing to address missile tumbling when modeling targets*
c. *failing to properly consider and use the variance reduction techniques and parameters specified by TORMIS*
d. *inappropriately crediting nonstructural members*
e. *failing to consider risk significant, non-safety-related equipment*

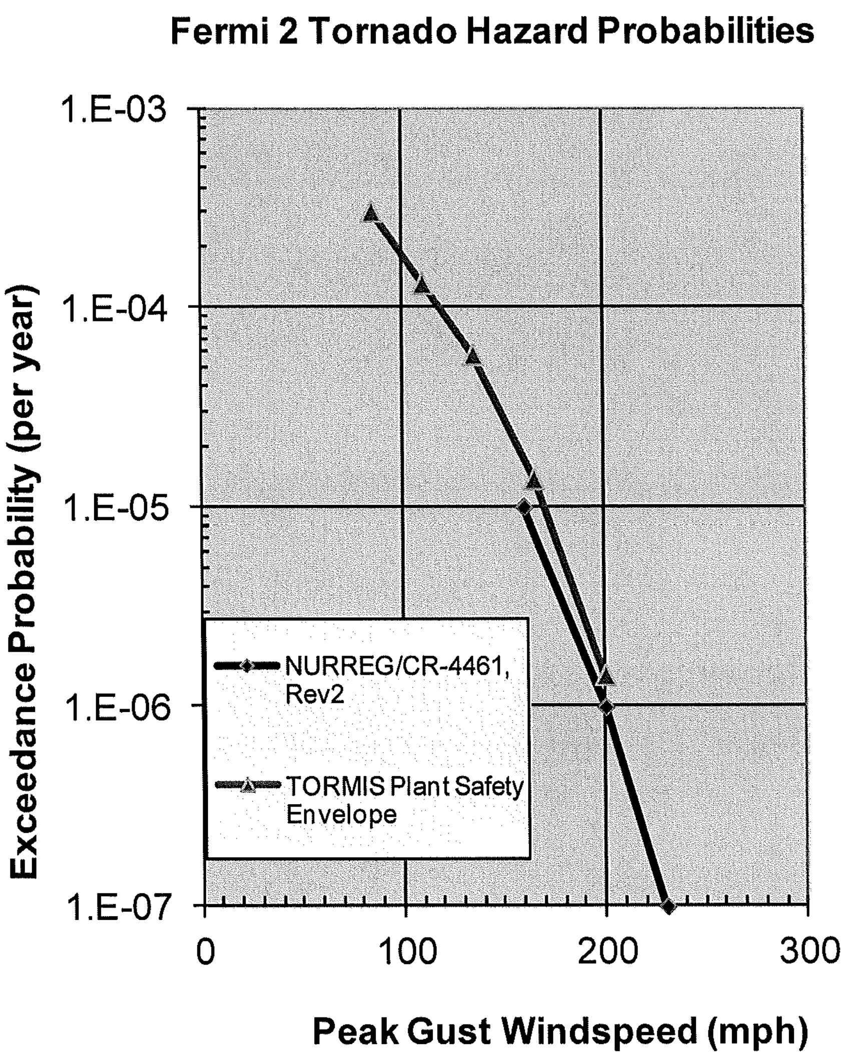
3. Licensees used the TORMIS methodology to address situations for which the methodology was not approved. Examples include the following:

a. *proposing the elimination of existing tornado barriers*
b. *proposing changes to Technical Specifications, and*
c. *proposing plant modifications*

DTE considered these observations in the development of the updated TORMIS analysis. Specifically:

(1) a. Justification for Tornado Frequency:

The Fermi 2 tornado frequency value conservatively considers regions around the plant and corrects for reporting trend and tornado classification error and random encounter errors, per the TORMIS methodology. The developed tornado hazard curve is conservative when compared to USNRC Region I characterization

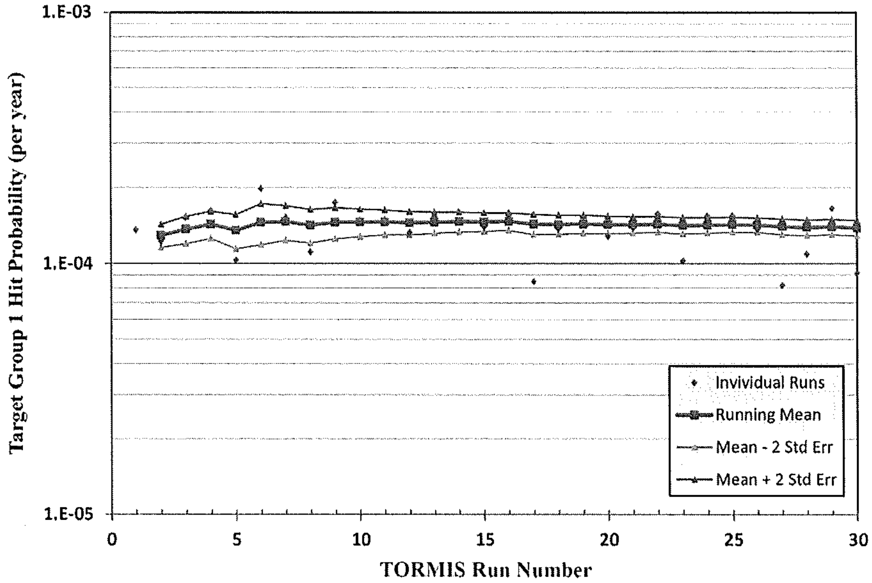


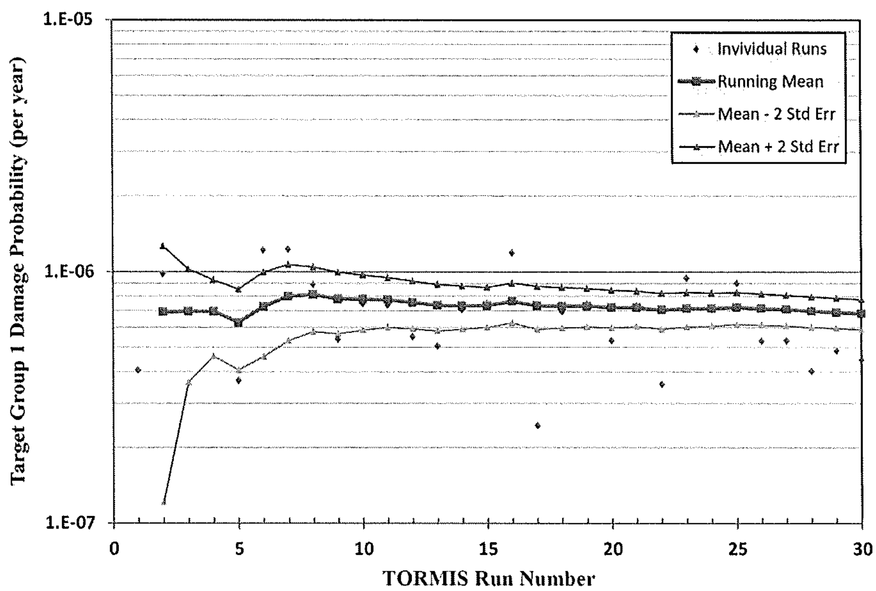
(1) b. Spectrum of Missile Considered:

In addition to the 20 standard TORMIS missile types, three Fermi 2 specific missiles were created for the analysis: one to represent scaffold clamps of which there were a large number present during the site missile hazards walkdown; one to represent the sections of metal siding that enclose the upper portions of the reactor, auxiliary, and turbine buildings; and the third to represent the large number of concrete blocks also identified during the site walkdowns.

(1) c. Justification for the Number and Adequacy of Tornado Simulations:

Thirty complete TORMIS replications (2,000 tornado strikes and 5,000 sampled missiles for each of 5 EF Scales) were run with different random number seeds. A total of 300 million missile simulations were performed for each EF scale, for a total of 1.5 billion missile simulations. The standard deviations (σ) of these replications were computed and the standard error (ε) in the aggregate mean probability (μ) was computed from $\varepsilon = \sigma/\sqrt{n}$. The 95% confidence bounds in the mean probability were conservatively approximated by $\mu \pm 2 \bullet \varepsilon$.





(1) d. Use of Area Ratios:

Area ratios are not used to adjust the TORMIS outputs for small targets, based on a ratio of hit probabilities from a large target or surface. However, a variance reduction approach that is available in TORMIS was used for Fermi 2 that allows for increasing the size of small targets explicitly within the code. TORMIS applies the input variance reduction weight (ka) in the TORMIS scoring equation. These adjustments are used within TORMIS for the single missile impact probability. They are NOT used to "ratio down" the multiple missile impact probabilities following a TORMIS simulation. It is not technically acceptable to ratio down the TORMIS results since it can result in an underestimation of the multiple missile risk. Such an approach was used in some TORMIS submittals to the USNRC; however, ARA's technical review of that practice lead to the RIS Item (1)d comment.

(2) a. Inappropriately limiting of the number of targets modeled:

The original Fermi 2 TORMIS analysis considered approximately 51 unprotected features of the plant consisting exclusively of penetrations and doors located on the exterior of the reactor and auxiliary buildings including a large (10 ft x 10 ft, 6 inch thick) removable concrete panel, a security door, and the reactor building airlock door.

The updated TORMIS analysis expands the scope of targets to consider a population of 161 potential plant features identified primarily as a result of a site tornado hazard walkdown. Of these, 81 targets were identified as the specific features to be evaluated probabilistically as not requiring unique tornado missile protection in the new TORMIS analysis. These targets are to be explicitly identified in a new UFSAR Table (3.5-3) as described in Enclosure 3. The scope of specific targets included in this table generally represents wall penetrations and doors in the exterior surfaces of these structures. Generally, no specific safety-related systems are associated with any particular penetration; hence, the tornado missile hazard associated with these penetrations and openings is limited to and characterized by the probability of missile penetration of the target itself. Exceptions include the targets associated with missiles penetrating the reactor building railroad air lock doors, the first floor auxiliary building south wall entrance, and the EDG removable wall panels.

Enclosure 4 tabulates the balance of targets considered that were excluded from or otherwise considered for information only in updated TORMIS analysis including the basis for exclusion. The criteria for exclusion consist of the following:

- Unprotected safety-related equipment not identified in UFSAR Table 3.3-2 as required for safe reactor shutdown following a tornado was not included as targets. Examples include Control Room Emergency Filtration system as associated with the south emergency makeup intake and the south portion of the Auxiliary Building rooftop and the Standby Gas Treatment equipment located on the refuel floor.

- Equipment already specifically licensed as not requiring additional tornado missile protection was excluded. For example, the RHR Mechanical Draft Cooling Tower Fans are specifically licensed for post-tornado repair and restoration (See UFSAR Section 3.5.1.3.2.2) and the Spent Fuel Pool which was evaluated and accepted on the basis of an alternative risk analysis (See Section 3.5.1.3.2.1) were both excluded from the scope of analysis.

- Other features that were excluded for this risk analysis are the buried underground cable vaults between the RHR complex and the auxiliary building and the EDG fuel oil tank vents and the EDG exhaust stacks, which are located on the roof of the RHR complex. Both of these rooftop features are provided with tornado missile shield protection specifically designed to prevent vertically travelling missiles from entering the RHR complex and damaging the EDG fuel oil tanks and diesel engines.

These existing design bases are taken to remain valid and therefore excluded from consideration in the updated TORMIS analysis.

(2) b. Consideration of Missile Tumbling:

With the exception of pipe penetrations, all targets were modeled to allow for tumbling missile hits (offset hits) per the TORMIS technical reports (References 3, 4 and 5). The size of all safety-related targets that are vulnerable to "offset" hits (tumbling missiles) was increased by 1.5 ft for each free face in the three-dimensional model. Pipe penetration targets were not increased in size to reflect tumbling missiles since offset hits of large missiles cannot result in penetration of a small opening in a concrete wall. See the discussion of the pipe penetration screening method introduced under SER Item 5 above.

(2) c. Use of Variance Reduction Techniques:

The new Fermi 2 analysis used the following variance reduction techniques:

1. Tornado Strike Probability (Analytical Equivalence)
2. EF Scale (Stratified Sampling)
3. Tornado Offset (Importance Sampling)
4. Missile orientation (β =1)
5. Missile Injection Height ($\gamma_z = 2.0$)
6. Trajectory Termination ($P_{rr} = 0.5$)
7. Target Size (k_a by target surface)

The first two techniques are an inherent part of the TORMIS methodology. Techniques 3-7 were used for Fermi 2 specifically. Due to the large number of simulations performed, no variance reduction techniques were used for tornado wind speed, tornado direction, missile zone population, missile type, or missile impact orientation. The effectiveness of the application of these variance reduction methods is demonstrated in the calculation convergence data provided in the response to item (b) above

(2) d. Inappropriate Credit For Non-Structural Members:

The updated TORMIS analysis generally did not take credit for missile resistance for non-structural members. Targets representing penetration P-156 (nitrogen system) and

Residual Heat Removal Service Water (RHRSW) and Emergency Equipment Service Water (EESW) piping located on the first floor of the Reactor Building (RB1), the removable EDG walls, mechanical draft cooling tower fan motor doors, RB5 refuel floor equipment hatch cover, and the third floor of the Auxiliary Building (AB3) doors and block walls were evaluated for perforation damage.

(2) e. Failure to consider Risk Significant, Non-Safety-Related Equipment:

Of the safe shutdown equipment identified in UFSAR Table 3.3-2 none relies solely on risk significant, non-safety-related equipment. While Reactor Core Isolation Cooling (RCIC), which is identified as a credited injection source can utilize the water in the Condensate Storage Tank (CST), the analysis excluded consideration of the CST on the basis that this tank was not designed to be tornado proof and is designed to automatically swap RCIC suction to the safety-related and inherently missile protected suppression pool.

(3) Inappropriate use of TORMIS:

TORMIS has not been used to propose the elimination of tornado barriers, changes to the plant technical specification, or as justification to modify plant features to reduce or eliminate or otherwise engineer the design of existing or new tornado missile protection features.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements/Criteria

The proposed changes have been evaluated to determine whether applicable regulations and requirements continue to be met. DTE's technical analysis, which includes risk information, satisfies all applicable regulatory requirements and criteria as per the 1983 NRC SER, RIS 2008-14, the two topical reports, EPRI NP-768/769 (May 1978) and EPRI NP-2005 (August 1981), NRC Regulatory Guide 1.76, Revision 1, and the NRC Standard Review Plan (NUREG-0800) sections. There are no formal commitments to administrative controls needed to ensure compliance.

Based on these considerations, there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, such activities will be conducted in compliance with the Commission's regulations, and the issuance of the amendment will not be inimical to the common defense and security or the health and safety of the public.

4.2 <u>No Significant Hazards Consideration Determination</u>

DTE Electric Company (DTE) has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of Amendment", as discussed below:

1. Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

   Proposed for NRC review and approval are changes to the Fermi 2 Updated Final Safety Analysis Report (UFSAR) which in essence constitute a license amendment to incorporate use of an NRC approved methodology to assess the need for additional positive (physical) tornado missile protection of specific features at the Fermi 2 site. The UFSAR changes will reflect use of the Electric Power Research Institute (EPRI) Topical Report "Tornado Missile Risk Evaluation Methodology" (EPRI NP-2005), Volumes I and II. As noted in the NRC Safety Evaluation Report on this topic dated October 26, 1983, the current licensing criteria governing tornado missile protection are contained in Standard Review Plan (SRP) Sections 3.5.1.4 and 3.5.2. These criteria generally specify that safety-related systems be provided positive tornado missile protection (barriers) from the maximum credible tornado threat. However, SRP Section 3.5.1.4 includes acceptance criteria permitting relaxation of the above deterministic guidance, if it can be demonstrated that the probability of damage to unprotected essential safety-related features is sufficiently small.

   As permitted in NRC Standard Review Plan (NUREG-0800) sections, the combined probability will be maintained below an allowable level, i.e., an acceptance criterion threshold, which reflects an extremely low probability of occurrence. The Fermi 2 approach assumes that if the sum of the individual probabilities calculated for tornado missiles striking and damaging portions of important systems or components is greater than or equal to 10^{-6} per year per unit, then installation of unique missile barriers would be needed to lower the total cumulative probability below the acceptance criterion of 10^{-6} per year per unit.

   With respect to the probability of occurrence or the consequences of an accident previously evaluated in the UFSAR, the possibility of a tornado reaching the Fermi 2 site and causing damage to plant structures, systems and components is a design basis event considered in the Updated Final Safety Analysis Report. The changes being proposed do not affect the probability that the natural phenomenon (a tornado) will reach the plant, but from a licensing basis perspective they do affect the probability that missiles generated by the winds of the tornado might strike and damage certain plant systems or components. There are a limited number of safety-related components that could theoretically be struck and consequently damaged by tornado-generated missiles. The probability of tornado-generated missile strikes on "important" systems and components (as discussed in Regulatory Guide 1.117, "Tornado Design Classification") is what is to be analyzed using the probability methods discussed above. The combined probability of damage will be maintained below an extremely low acceptance criterion to ensure overall plant safety. The proposed change is not considered to constitute a significant increase in the probability of occurrence or the consequences of an accident, due to the extremely low probability of damage due to tornado-generated missiles and thus an extremely low probability of a radiological release.

Therefore, the proposed changes do not involve a significant increase in the probability or consequences of previously evaluated accidents.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

   The possibility of a tornado reaching the Fermi 2 site is a design basis event that is explicitly considered in the UFSAR. This change involves recognition of the acceptability of performing tornado missile probability calculations in accordance with established regulatory guidance. The change therefore deals with an established design basis event (the tornado). Therefore, the proposed change would not contribute to the possibility of a new or different kind of accident from those previously analyzed. The probability and consequences of such a design basis event are addressed in Question 1 above.

   Based on the above discussions, the proposed change will not create the possibility of a new or different kind of accident than those previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

   The existing Fermi 2 licensing basis for protection of safety-related equipment required for safe shutdown from design basis tornado generated missiles is to provide positive missile barriers for all safety-related systems and components. With the change, it will be recognized that there is an extremely low probability, below an established acceptance limit, that a limited subset of the "important" systems and components could be struck and consequently damaged. The change from protecting all safety-related systems and components to ensuring an extremely low probability of occurrence of tornado-generated missile strikes and consequential damage on portions of important systems and components is not considered to constitute a significant decrease in the margin of safety due to that extremely low probability.

   Therefore, the changes associated with this license amendment request do not involve a significant reduction in the margin of safety.

Based on the above, DTE concludes that the proposed amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92, and, accordingly, a finding of "no significant hazards consideration" is justified.

4.3 Conclusions

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

5. ENVIRONMENTAL CONSIDERATION

The changes have been evaluated using the identification criteria for licensing and regulatory action requiring an environmental assessment as specified in 10 CFR 51.21. The proposed changes meet the eligibility criteria for a categorical exclusion as set forth in 10 CFR 51.22. Therefore, pursuant to 10 CFR 51.22(b), an environmental assessment of the proposed change is not required.

6. REFERENCES

1. NRC Safety Evaluation Report – Electric Power Research Institute (EPRI) Topical reports Concerning Tornado Missile Probabilistic Risk Assessment (PRA) Methodology, dated October 26, 1983 (ML080870291)

2. NRC Regulatory Issue Summary 2008-14, "Use of TORMIS Computer Code for Assessment of Tornado Missile Protection," dated June 16, 2008 (ML080230578)

3. Electric Power Research Institute (EPRI) Topical Report NP-768, "Tornado Missile Risk Analysis," May 1978

4. Electric Power Research Institute (EPRI) Topical Report NP-769, "Tornado Missile Risk Analysis - Appendices," May 1978

5. Electric Power Research Institute (EPRI) Topical Report NP-2005 Volumes, I & II, "Tornado Missile Risk Evaluation Methodology," August 1981

6. NRC Inspection Report 05000341/2008-004, "Fermi Power Plant, Unit 2, Integrated Inspection Report," dated November 12, 2008

7. NUREG/CR-4461, Revision 2, "Tornado Climatology of the Contiguous United States, (PNNL-15112, Rev 2)," Ramsdell and Rishel, 2007

8. HAZUS-MH MR3, "Multi-hazard Loss Estimation Methodology - *Hurricane Model*, Technical Manual, FEMA, 2007

**Enclosure 2 to
NRC-13-0002**

**Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43**

**Proposed License Amendment to Revise the
Fermi 2 Licensing Bases for Protection from Tornado-Generated Missiles**

Piping Penetration Screening Algorithm

Piping Penetration Screening Algorithm

The approach to evaluating the risk of missiles penetrating piping penetration targets is to use the TORMIS impact data for each missile that hits a piping penetration (PP) target to screen out those missile impacts that obviously cannot pass through a PP opening. This impact data consists of the angles (ß and θ in Figure 3-1), missile diameter (d), and missile length (L) (see Figure3-2, below)

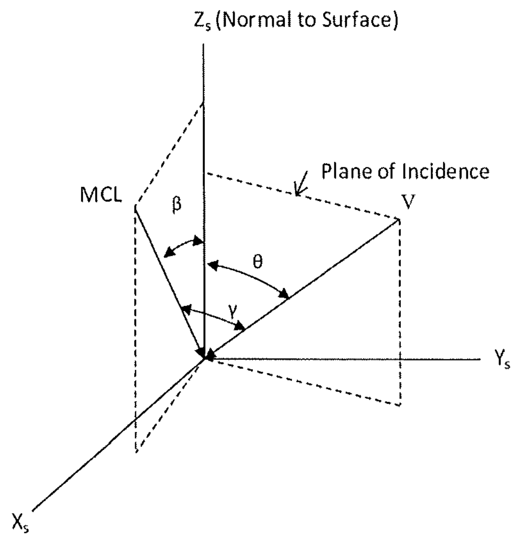


Figure 3-1. TORMIS Missile Impact Geometry

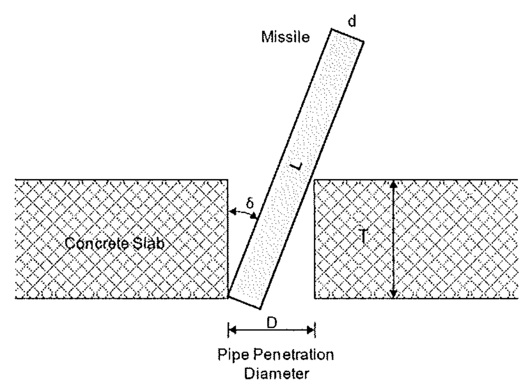


Figure 3-2. Missile Impact Geometry on Pipe

This screening is done in the processing of the TORMIS impact data without modifying the TORMIS physics engine in the IMPACT Sub-routine. The screening criterion used for Fermi 2 PP targets is shown in Figure 3-5. The following paragraphs discuss the screening sequence of this event tree.

1. ***Level I Screen (Missile diameter too large***?).

The first screen addresses missile diameter relative to PP opening diameter. If the missile diameter (d) is much greater than the PP opening diameter (D), then the missile is assumed to be too large to be able to successfully penetrate a PP target. The PP opening is modeled as a circular hole in the barrier. If the opening is not a circle, its diameter is developed from an equivalent area circle with diameter D. This screen reflects that fact that the missile spectrum at Fermi 2 includes missiles with diameters that are both larger and smaller than the PP diameter. Since many PP openings are small, many missiles are too large to pass through a PP opening even for a perfectly-aligned strike. That is, they are so large that they cannot simply hit and pass through the PP opening, but must penetrate the concrete barrier. Since the concrete barriers have already been qualified as acceptable protection, we eliminate these large missiles from consideration for PP targets (see Missile Hit Outcome 1 in Figure 3-5). We use a conservative factor of 1.1 on the PP diameter for this screen. That is, even if the missile diameter is larger than the diameter of the PP opening (up to 1.1 times larger), we conservatively assume (at the first level of screening in Figure 3-5) that it could still penetrate the PP target and damage any safety-related equipment inside.

2. Level II Screen (Missile length is small relative to opening diameter?).

The second screen in Figure 3-5 regards the length of the missile, given that the missile diameter is smaller than 1.1D. For this screen, if the missile length (L) is less than D, then the missile is small compared to the PP diameter. For this case, a conservative assumption is that any hit on the PP target results in a penetration through the PP target because the missile's greatest dimension is less than D. Hence, we consider any impact by "relatively-small" missiles to be a potential penetration (see Outcome 5 in Figure 3-6). For added conservatism in treating this outcome, we use a screening criteria based on the missile length being less than $2\sqrt{(1.1D)^2 - d^2}$. This criterion is based on the geometry in Figure 3-3. For a missile whose center of mass hits right on the edge of the opening, if the length (L) of the missile is shorter than $2\sqrt{D^2 - d^2}$, we can conservatively consider it a small missile and assume that it passes through the opening regardless of the impact angles. We note that for slender missiles, with d approaching 0, this reduces to L ≤ 2D for the missile to be considered small and pass through the opening every time. This screening criteria for small missiles is obviously much more conservative than one that uses L ≤ D to determine small missiles that are assumed to pass through on every hit.

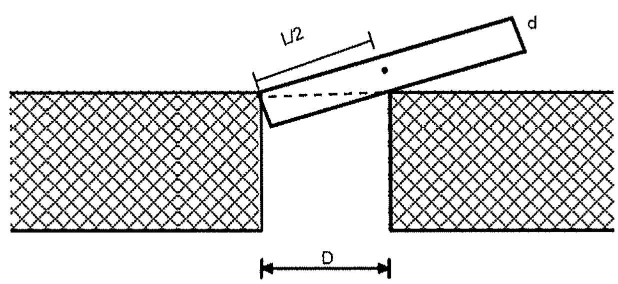


Figure 3-3. Small Missile Level II Screen

3. ***Level III Screen (Missile axis too oblique?).***

The third screen in Figure 3-5 is based on the missile impact angle ß in Figure 3-1. This screen only applies to relatively long missiles (L > 2D) relative to the opening diameter. For this screen, we develop criteria based on the missile geometry in Figure 3-2. The angle δ is the largest oblique angle that a long missile can be oriented at impact and still have a feasible chance of passing through the opening. Angles larger that δ are expected to result in ricochet by virtue of the impact geometry. Impacts that occur with missile orientation angles (ß) larger than δ are assumed to ricochet off the concrete slab. The following trigonometric equation can be solved by numerical methods to yield the angle δ in Figure 3-2.

$$d - (D \cos \delta - T \sin \delta) = 0 \qquad \textit{3-1}$$

where d = missile diameter; D = PP opening diameter; and T = slab thickness. Denote the solution of Equation 10-1 for given d, D, and T as δ^*. This angle can be solved in advance for each TORMIS missile and PP target and used in the post-processing of the TORMIS impact data. Based on these calculations for every combination of missile and PP target, the Level III screen compares the TORMIS missile impact angle (ß) in Figure 3-1 to the critical value δ^* from the solution of Eq. 3-1. If ß is greater than δ^*, then the missile axis at impact is not aligned for a penetration of the PP target and the missile is assumed to ricochet, producing Outcome 4 in Figure 3-5. This screening also uses a conservative factor of 1.1 on δ^*, as shown in Figure 3-5. This screen requires comparisons of impact angles to the actual δ^* for each PP impact in TORMIS.

4. Level IV Screen (Missile velocity vector too oblique?).

The fourth screen in Figure 3-5 is based on the missile velocity vector angle in Figure 3-2. This screen corresponds to the consideration that the velocity vector has a line of sight through the opening. Outcome 2 corresponds to the case where both the missile orientation and the velocity vector are within the "perfect impact" tolerances and, hence, each long missile impact with these orientations is assumed to be able to penetrate the PP target. Outcome 3 corresponds to the no penetration case where the missile axis is within angle tolerance but the velocity vector isn't. We also introduce a conservative factor of 1.1 on δ^{*0} in this screen.

5. Level V Screen (Multiple Opening Penetrations).

This final screen considers cases where the missile must effectively pass through several openings to reach a target and there is no line of sight to the target as it passes through the PP model of the openings. For this case, the Level III and IV screens need to also consider the pipe tunnel the missile must pass through to reach the second opening. For example, see Figure 3-4, which illustrates a multiple opening scenario in which the missile must clear a second barrier and ricochet down a hallway in order to have any chance of hitting the target of interest. That is, there is no line of sight to the target if the missile passes through the pipe penetration (tunnel) and the missile must pass down a second opening. If the missile is longer than H, the effective diameter of the second opening, then it will ricochet after impact in such a manner that its forward momentum will be lost since it is physically too long to pass through the remaining length of the second opening. Obviously, if there is a line of sight to the target from the modeled PP tunnel, or if there is no second opening, then this screen is not used in the model.

The multiple opening screen for Fermi 2 consists of $L \leq H$. This includes a conservative factor of 1.1 on H (increase its size to allow more missiles past the screen), and hence this screen for second opening (ricochet required and no line of sight) becomes $L \leq 1.1H$ for the missile to pass. If the missile is longer than 1.1H, the screen eliminates the missile from having any chance of hitting the distant target.

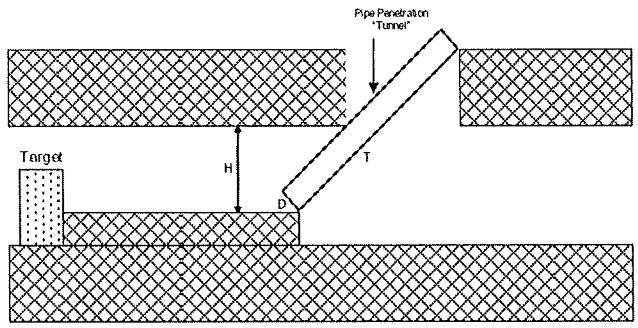


Figure 3-4. Missile Length Screen (Level V) for Second Opening

Conservatisms in PP Model and Deviations from Calculation Approach.

Given that a penetration of a PP target requires a near perfect alignment of a non- rotating missile with sufficient energy to overcome friction and, in most cases, perforate the pipe twice to reach the interior of the target, this approach is very conservative. In addition, the method applies additional conservatisms:

1. A safety factor of 1.1 on the pipe penetration diameter when compared to impacting missile diameter (or depth). That is, missiles with diameters 10% larger than the PP opening are assumed to be able to penetrate through the opening.

2. Missiles with diameters less than 10% larger than the pipe penetration diameter and lengths less than twice the pipe penetration diameter were assumed to penetrate the opening 100% of the time. Thus, slender missiles with lengths up to twice the diameter of the PP diameter are assumed to be able to pass through the PP given that it hits the PP, regardless of impact angles of the missile axis or velocity vector.

3. A safety factor of 1.1 on both the missile velocity vector angle and the missile axis impact angle was used in determining if the missile axis is aligned with the opening.

4. A safety factor of 1.1 on second opening diameter when compared to missile length.

5. Missile rotation velocity at impact is neglected. Missile rotation at impact makes it more difficult for the missile to pass through the small opening.

6. The penetration of the pipe itself or the pipe covers, if present, are not credited. Up to two penetrations are required for the missile to make it inside the barrier. Unless the impacts are perfectly aligned, the penetration forces will generally produce a ricochet of the missile instead of a penetration inside the target.

7. Friction forces acting on the missile as it slips through the opening ignored. Thus, if a missile is aligned with an opening, it is assumed to pass through the opening and not "stick" in the opening due to frictional and side forces resulting from impact.

8. Assumption that every pipe penetration automatically produces damage to a critical component inside the barrier.

Piping Penetration Screening Algorithm

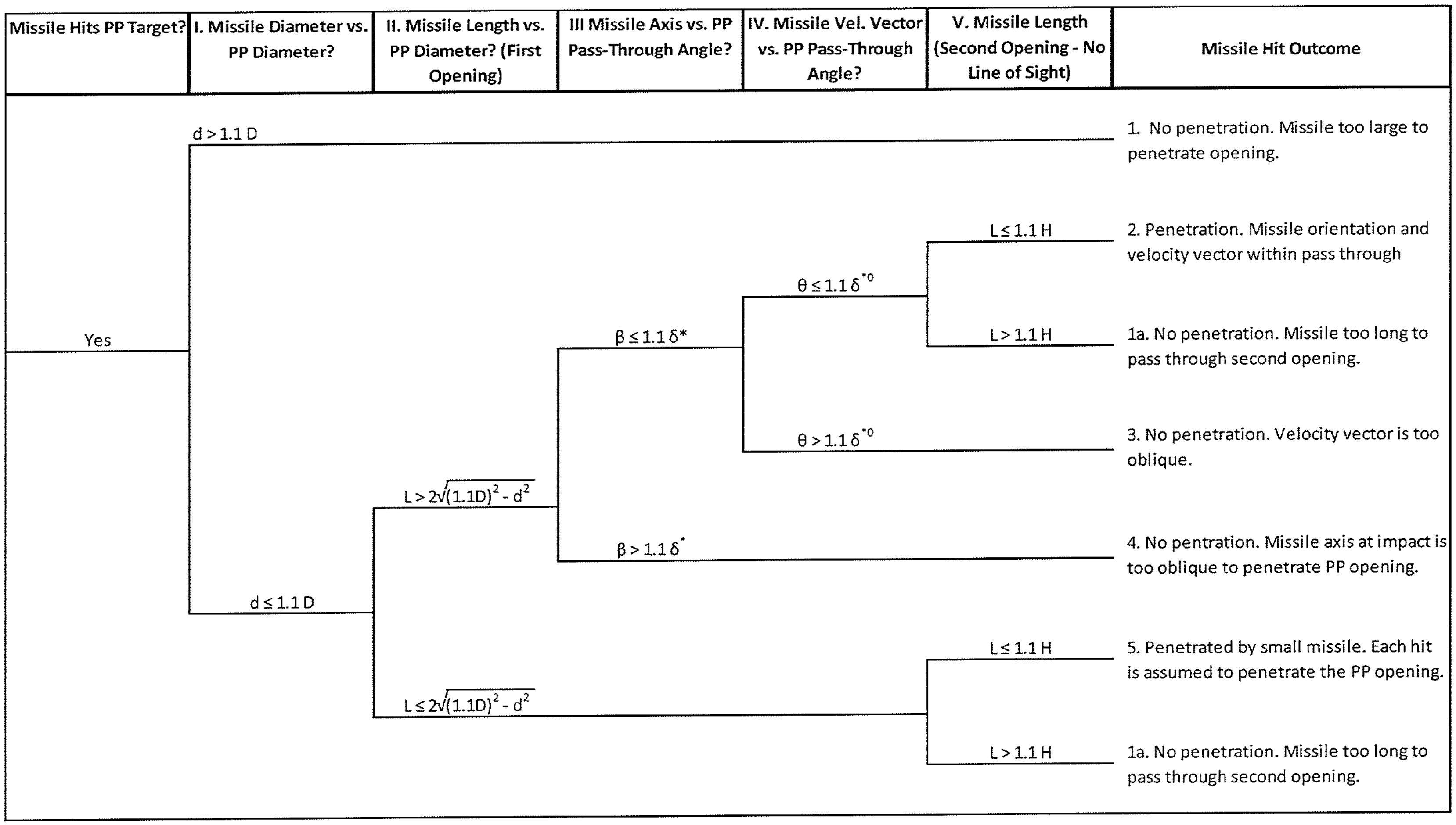


Figure 3-5. Screening Criteria for Post-Penetration Missile Impacts on PP Targets

The Fermi 2 analysis applied the logic above in the processing of the TORMIS impact results on a missile-by-missile basis for PP targets. Outcomes 1 or 1a, 3, and 4 do not produce PP target penetrations (potential penetrations of the target to the interior). Outcomes 2 and 5 produce PP target penetrations and are scored as damage to the target.

Enclosure 3 to
NRC-13-0002

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

Proposed License Amendment to Revise the
Fermi 2 Licensing Bases for Protection from Tornado-Generated Missiles

Marked-Up UFSAR Pages

Section 3.5

3.5 MISSILE PROTECTION

Protection against the hypothetical effects of missiles is provided in accordance with the following damage limit criteria:

a. The integrity of the containment system is maintained

b. The capability for shutdown of the reactor and maintenance of core cooling capability is maintained

c. A missile accident that is not a LOCA does not initiate a LOCA.

Where possible, missile protection is achieved through basic plant component arrangement such that, if a missile-generating failure should occur, the direction of the flight of the missile would be away from Category I structures or other critical system components. Examples of such arrangements are shown in Figure 3.5-1, Sheets 1 through 6, which show the general arrangement of piping, pumps, motor, valves, and other equipment in the drywell indicating component missile protection by separation. Where it is impossible to provide protection through selective plant layout and where the structures available do not provide sufficient missile protection, barriers are provided to prevent potential missiles from damaging critical systems and structures.

An analysis of potential missiles and the missile protection provided follows. Although it is not given in the order specified in Regulatory Guide 1.70, the information requested in the guide is presented. The reason for the change in order is to present a more comprehensive discussion of the missile protection included in the Fermi 2 design.

3.5.1 Missile Selection (Sources)

3.5.1.1 Missiles From Pressurized Equipment

3.5.1.1.1 Missiles Considered

Potential missiles from pressurized equipment that were investigated include the following:

a. Valve bonnets (large and small)

b. Valve stems

c. Thermowells

d. Vessel head bolts

e. Pieces of pipe

f. High-pressure gas cylinders.

3.5.1.1.2 Design Evaluation

Using conservative assumptions, it has been determined that the potential missiles from items a. through e. above, originating from fluid lines, cannot achieve sufficient energy to penetrate the drywell, critical system components, or missile shields to the extent that safe reactor shutdown would be impaired. An added conservatism exists because of the separation criteria and barriers described in Subsections 3.5.3 and 3.5.4. The probability of incapacitating more than one of the redundant reactor protection system (RPS) safe-shutdown and engineered safety feature (ESF) system components by a single missile is negligible. The driving force for these potential missiles is assumed to come from the kinetic energy of the water or steam.

In the event of a break in a fluid-carrying component, the velocity of the exiting fluid is determined. The drag force of the fluid that propels a missile is proportional to the product of the fluid mass density and velocity squared. By applying this drag force to each potential missile, the missile attaining the most kinetic energy is determined. Damage resulting from impact of this missile is then analyzed. Small missiles are assumed to achieve maximum fluid velocity instantly, which is conservative because a missile requires a finite time to accelerate to this velocity after being dislodged. In addition, missiles in a horizontal trajectory tend to fall out of the fluid jet. Therefore, the driving force acts for a shorter time and the missile probably achieves a velocity lower than its maximum.

High-pressure gas cylinders on the Fermi 2 site that are capable of generating potentially high-energy missiles are as follows:

a. Hydrogen gas storage cylinders

b. Service gas storage cylinders (welding gases, nitrogen, and spare breathing air)

c. Emergency breathing air cylinders

d. Oxygen and hydrogen reagent cylinders

e. Hydrogen and oxygen storage vessels at the HWC Gas Supply Facility

The hydrogen and service gas storage cylinders are located more than 300 ft from the reactor building. Any potential missiles must first pass through the first floor of the turbine building and through several concrete walls (with a combined thickness of more than 5 ft) before reaching the reactor building wall. There is insufficient energy stored in these cylinders for any potential missile to penetrate these walls.

Emergency breathing air cylinders are stored in seismically qualified storage racks located along the north wall of the reactor building ventilation room. The concrete walls of this room are sufficient to prevent any potential missiles from reaching critical locations outside of this room. Equipment inside this room can be damaged by potential missiles, but this will not prevent a safe reactor shutdown. A design-basis earthquake (DBE) will not initiate emergency breathing air cylinder damage because the cylinders are secured in seismically qualified storage racks.

The primary containment hydrogen monitors require supplies of hydrogen and oxygen to act as reagent gases. These cylinders are located adjacent to each monitor, thereby minimizing the tubing run to each instrument. The cylinders, regulators, piping, and racks are seismically designed and installed. The racks are also designed to restrain the cylinders to prevent them from becoming missiles if punctured.

Using the barrier and procedures of Subsections 3.5.3 and 3.5.4, respectively, results of the investigation showed that additional missile barriers for potential missiles from pressurized equipment are not required. With the assumption of maximum missile velocity and minimum missile energy required for perforation, the results are conservative.

The HWC gas supply facility is located approximately 1100 feet northwest of the nearest safety-related structure (the RHR Complex). The hydrogen and oxygen storage tanks and the gaseous hydrogen tube bank are designed to remain in position during the design basis earthquake. Since the site for the HWC Gas Storage Facility was chosen to provide the required separation from safety-related structures, a release from this location would not affect plant safety. Potential blast effects from tank ruptures are enveloped by the existing analyses of the design basis tornado and design basis earthquake.

3.5.1.2 Missiles From Rotating Equipment

3.5.1.2.1 Missiles Considered

Potential missiles from rotating equipment, which could require a missile barrier, include

a. High-pressure turbine rotor segment

b. Low-pressure turbine rotor segment

c. Recirculation pump or motor segment

d. Emergency diesel generator (EDG) segment.

All probable paths of flight of these potential missiles have been investigated.

3.5.1.2.2 Design Evaluation

As stated in Subsection 10.2.3, after the low pressure (LP) turbine rotor replacement during RFO5, there is no design basis turbine missile at Fermi 2. The HP turbine rotor was replaced in RFO7. The new HP turbine rotor, which was reviewed for overspeed capability, was found to be higher in overspeed than the maximum theoretical overspeed of the unit (LP rotors and generator). Moreover, the seventh stage blades of the HP turbine rotor are smaller in length and lighter in weight that the eighth stage blades of the LP turbine rotors. Based on this, it is concluded that the HP turbine rotor missile analysis is bounded by the LP turbine missile analysis. The HP turbine rotor and generator rotor missiles cannot completely breach their respective outer casings. The new HP and LP turbine rotors are of monoblock construction. The monoblock rotors have higher speed capability than the maximum attainable speed of the turbine generator units. Per General Electric, the supplier of the new rotors, the probability of missiles being generated is well below 10 to the -8 power.

The most substantial piece of nuclear steam supply system (NSSS) rotating equipment is the reactor recirculation system (RRS) pump and motor. This potential missile source is addressed in detail in References 3 and 4.

It is concluded in Reference 3 that destructive pump overspeed can result in certain types of missiles. A careful examination of shaft and coupling failures shows that the fragments will not result in damage to the containment or to vital equipment.

a. Low-Energy Missiles (Kinetic Energy Less Than 1000 ft-lb)

   Low-energy-level missiles may be created at motor speeds of 300 percent of rated as a result of failure of the end structure of the rotor. The structure consists of the retaining ring, the end ring, and the fans. Missiles potentially generated in this manner will strike the overhanging ends of the stator coils, the stator coil bracing, support structures, and two walls of 1/2-in.-thick steel plate. Because of the ability of these structures to absorb energy, it is concluded that missiles would not escape this structure. It is at this point that frictional forces would tend to bring the overspeed sequence to a stop

b. Medium-Energy Missiles (Kinetic Energy Less Than 20,000 ft-lb)

In the postulated event that the body of the rotor were to burst, medium-energy missiles could be created. The likelihood that these missiles would escape the motor is considered less than the likelihood of escape for the low-energy missiles described above, because of the additional amount of material constraining missile escape, such as the stator coil, field coils, and stator frame directly adjacent to the rotor

c. The Motor As a Potential Missile

Since bolting is capable of carrying greater torque loads than the pump shaft, pump bolt failure is precluded. Since pump shaft failure decouples the rotor from the overspeed driving blowdown force, only those cases with peak torques less than those required for pump shaft failure (five times rated) will have the capability of driving the motor to overspeed. When missile-generation probabilities are considered along with a discussion of the actual load-bearing capabilities of the system, it is evident that these considerations support the conclusion that it is unrealistic that the motor would become a missile.

It is concluded in Reference 4 that destructive overspeed of the pump and motor could occur as a result of a full double-ended pipe break LOCA in the recirculation pump suction line. In the event of motor failure, the motor stator and frame structure would prevent the release of any missiles as indicated above. In the event of pump destructive overspeed, impeller missiles could be produced. However, they will not penetrate the pump case. They could be ejected from the open end of the broken pipe. However, pipe restraints have been installed to prevent potential missile points in the pipe from developing. (See Subsection 5.5.1.4.)

Potential missiles from an EDG would be small auxiliary items knocked loose from the engine exterior by blows from within. Analysis has shown that the maximum velocity of these missiles would be 40 fps, with a maximum mass of 5 lb each. These missiles are of lower energy than potential tornado-generated missiles. As the external walls of the EDG rooms are constructed to withstand the tornado-generated missiles, missiles ejected from an EDG will be contained within that EDG room and therefore cannot incapacitate another EDG in the other division.

3.5.1.3 Tornado-Generated Missiles

3.5.1.3.1 General

Tornado forces and the design-basis tornado are discussed in Section 3.3. Objects lying in the path of tornadoes may be picked up by the tornado due to aerodynamic lift force or due to the rapid pressure reduction that may have injected the object into the tornado wind field. The objects that are potential missiles vary in size, shape, and number. The design-basis missiles selected for consideration in the Fermi 2 design are a 4-in. x 12-in. x 12-ft plank with a density of 40 lb/ft^3, and a 4000-lb passenger car traveling at 50 mph at a maximum of 25 ft above grade elevation. The design-basis missiles are given in Subsection 12.2.1.7.1 of the PSAR.

For the Category I 4160-V electrical ductbanks between the RHR cable vaults and the Reactor/Auxiliary building cable vaults, the top of the ductbanks is located approximately six inches below grade, the top of the manholes is located at grade level, and RHR cable vaults are located above grade. The design for this ductbank system is based on Regulatory Guide 1.76 Revision 1 (March 2007) (Reference 17) and, as such, the design is evaluated for the design-basis tornado missiles described in Regulatory Guide 1.76 Revision 1.

3.5.1.3.2 Additional Analyses

The missile barriers listed in Subsection 3.5.3 provide protection against tornado generated missiles; however, three areas received additional analysis to ensure resistance to tornado generated missiles. They are the spent fuel pool, the fan blades of the cooling towers in the Residual Heat Removal (RHR) complex, and the miscellaneous penetrations and openings in the exterior walls/roofs of the Reactor/Auxiliary Building and RHR Complex.

3.5.1.3.2.1 Spent Fuel Pool - Reactor Building

As the siding above the refueling floor is designed to release in the event of a design-basis tornado, potential damage to fuel in the spent fuel pool from tornado-generated missiles is of concern. The AEC noted this concern in its Safety Evaluation Report on the Construction Permit (Reference 2). The concern was identified as Post Construction Permit Open Item No. 9. This concern has also been the subject of analyses submitted to the AEC by GE (Reference 5). The Edison position on this open item was submitted to the AEC in August 1973 (Reference 6). The Edison position was based on the GE report (Reference 5) and a study of the probability of a tornado striking the site and showed that the probability of damage to fuel in the spent fuel pool by a tornado-borne missile is extremely small (7×10^{-10} per year) and that no additional protection is required. The AEC waived the requirement to provide tornado protection of the spent fuel pool in June 1974 (Reference 7) based on its own independent assessment. The AEC cited the low probability of a tornado, the lower likelihood that objects could be lifted to the elevation of the fuel pool and become missiles, and the expectation that where spent fuel damage were to occur, the associated offsite exposure radiological consequences would likely be within 10CFR100 limits.

3.5.1.3.2.2 Residual Heat Removal Complex Mechanical Draft Cooling Towers

A study was performed to determine the probability that both cooling tower divisions can be rendered out-of-service by tornado- generated missiles entering the fan discharge stack (Reference 8). The result of this study, as determined below, is that this probability is very small and is conservatively estimated between 10^{-9} and 10^{-10} per year. The RHR cooling towers and their missile protection features are described in Subsection 9.2.5.

In the cooling tower study, several potential design-basis tornado missiles are considered. These represent the complete range of all possible missiles that may be potential threats to the safety of the cooling towers:

a. A 4-in. x 1-ft x 12-ft wood plank

b. A 13.5-in.-diameter x 35-ft-long utility pole

c. A 1-in.-diameter x 3-ft-long steel rod

d. A 6-in.-diameter x 15-ft-long schedule 40 steel pipe

e. A 12-in.-diameter x 15-ft-long schedule 40 steel pipe.

Other missiles cited in the literature, such as a 2-in. x 4-in. x 1-ft wood piece, a 9-in. brick, a 6-in. x 12-in. x 2-in.-thick concrete slab, a 1-ft block concrete, and a "standard" automobile are not able to reach the level of the cooling towers if they are injected at ground level or at elevations of 200 ft or less (Reference 9).

Each design-basis missile was then analyzed for its ability to impact the cooling tower fan blades.

Using the three-dimensional wind flow field proposed by Bates and Swanson (Reference 10), the vertical impact velocities of the design-basis missiles at different roof elevations have been calculated assuming the objects are injected into the tornado wind field at different elevations. The results are shown in Table 3.5-1.

None of the missiles except the wood plank picked up at ground level or injected at 50-ft or 100-ft elevations, is able to reach the level of the cooling tower. The steel rod injected at 50 ft and other objects injected into the tornado wind field at higher elevations (250 ft) may be hurled into the cooling towers, but only a few missiles could be of this type.

Even if a missile lands in the cooling tower, it will not damage the cooling tower fan blades. The Marley Company, the manufacturer of the Fermi 2 RHR complex mechanical draft cooling towers, has calculated that the fan blades would safely withstand the impact from an object weighing 17 lb falling freely from an elevation of 250 ft. This is equivalent to a kinetic energy of about 8.5×10^4 ft-lb. Therefore, the fan blades are able to withstand the impact from smaller missiles; e.g., design-basis missile c. listed above (1-in.-diameter x 3-ft-long steel rod).

The number of missiles assumed to impact a cooling tower is then determined. The number of missiles that are injected into the tornado field depends on factors such as the number of "loose" objects lying in an area of a 3000-ft radius circle around the RHR complex, which contains the cooling towers. Therefore, the number of missiles injected into the tornado funnel cannot be decided with any degree of certainty. It is assumed that of all the potentially damaging objects available, two of them will be picked up by the design-basis tornado at just the right time and location to become a missile.

The cooling tower system is designed such that it can function even if one tower division is damaged and rendered out of operation. Therefore, for the cooling tower system to be out of service, both tower divisions must be damaged simultaneously by tornado missiles. For this to happen, the following sequence of events must occur:

a. A tornado strikes a point in the plant site. Based on the meteorological data and on Thom's model, the probability of this event is calculated as 7×10^{-4} per year

b. An object which is accelerated horizontally does not bounce and is ejected into the tornado at a 45° angle. This probability is conservatively estimated at 10^{-1}

c. The object maintains the orientation inside the tornado and exposes its maximum cross-sectional area to the full wind force. Since objects will tend to tumble, the probability of this event is conservatively estimated at 10^{-1}

d. The object is thrown into a cooling tower division. Objects of the type being considered here could land anywhere within 100 ft of the tornado funnel. This is a circular area of 500 ft diameter. The area of the cooling tower fan discharges in the RHR complex is about 850 ft^2. Therefore, the probability of a missile landing in a cooling tower division is approximately 4.3×10^{-3}. This is multiplied by two because it was assumed earlier that the two objects would be injected into the tornado wind field

e. The missiles land simultaneously in both tower divisions. The probability of this joint occurrence is calculated as the product of the probability of one missile landing in one tower division and the probability of the second missile landing in the other tower division simultaneously. Using the concept of statistical independence of these events, the probability of the joint event is conservatively estimated to be between 10^{-9} and 10^{-10} per year.

The draft ANSI standard on Plant Design Against Missiles (Reference 11) recommends that no protective measures be required if the combined probability of missile ejection and subsequent unacceptable damage is less than 10^{-7} per year. As the probability of tornado damage to the cooling tower unit calculated above is considerably lower than the acceptable limit, and because certain components and portions of the tower structure are hardened against tornado missiles and the fan blades can be replaced after a tornado (as described in subsection 9.2.5.2.2), it is concluded that no missile protective covers are required for the cooling towers. It may be noted that the probability evaluated herein is very conservative because most tornadoes have velocities lower than 300 mph. Some missiles, even though hurled into the towers, may lose part of their kinetic energy if they strike the walls. Such missiles are not effective in damaging the fan blades.

The 8-lb steel-rod missile could damage the fan blades if the velocity were high enough (i.e., slightly higher than listed in Table 3.5-1). The latest probability study on damage to the towers indicated a probability of 5×10^{-18} per year for all four cooling tower fans to be damaged by 20 steel-rod (rebar) missiles.

3.5.1.3.2.3 <u>Exterior Walls/Roofs - Reactor/Auxiliary Building/RHR Complex</u>

~~An analysis of tornado missile hazard due to certain vulnerable areas on the exterior walls of the Reactor/Auxiliary Building was performed to assess the probability of any design-basis missile penetrating the building. The analysis resulted in a calculated cumulative missile penetration probability of 1.15x10^-7 per year. The calculated probability is very comparable to 1x10^-7 per year, the level interpreted by experts working in the design of nuclear power plants as acceptable for not considering protective measures against external events.~~

~~The exterior walls of the Reactor/Auxiliary Building have been designed to resist the impact of tornado-generated missiles. The missile protection adequacy of certain small penetrations~~

~~and some doors and HVAC intake enclosures on the exterior walls was evaluated. The vulnerable areas consist of 51 small penetrations located on the south, west and north walls; a security door on the south wall; an HVAC intake enclosure on the south wall; and the rail car door on the south wall.~~

~~The analysis (Reference 11a) was performed to evaluate the probability of missile perforation due to the vulnerable areas. The tornado missile hazard associated with these penetrations and openings is limited to the penetration of missiles through the cited areas which may then impact and damage safety related items inside the buildings. For the rail car door, perforation of the door was considered in the analysis.~~

~~The individual calculated probabilities are smaller than $1x10^{-7}$ per year. Their aggregate as an indicator of total plant damage probability is $1.15x10^{-7}$. In addition, some of the penetrations are protected with steel blind flanges, however, these flanges were conservatively ignored in the analysis. Given the conservative approach of the analysis, further refinement of the calculated probability would yield a value less than $1x10^{-7}$.~~

~~Since the conservatively calculated missile damage probability of $1.15x10^{-7}$ per year is very comparable to $1x10^{-7}$ per year for not considering protective measures against external events, as described above, no further analysis is required. The occurrence of tornado missile perforation due to cited vulnerable areas is not considered a design-basis event.~~

The exterior walls/roofs of the Reactor, Auxiliary, and Residual Heat Removal Complex buildings have been designed to resist the impact of tornado-generated missiles such that the safety related systems and components required for safe shutdown as identified in Tables 3.3-2 and 3.5-2 are generally protected. A limited number of these Seismic Category I systems and components located outside of (or otherwise not protected by these) Seismic Category I structures are evaluated based on a probabilistic missile damage analysis (Reference 19). The specific targets for which no tornado missile protection was required based on the risk analysis are listed in Table 3.5-3. The specific acceptance criterion for tornado damage for the unprotected systems and components required for safe-shutdown following a tornado event is that the cumulative sum of the mean damage probabilities for these systems and components be less than 10^{-6} per year. The aggregate mean damage probability corresponding to the scope of equipment identified in Table 3.5-3 is 6.82E-07 per yr, which satisfies the regulatory acceptance criterion.

The manner in which these targets were identified and selected for evaluation is described under the "Scope" section below. The use of TORMIS as an appropriate tool for evaluating tornado missile risk was generically accepted by the NRC in Reference 23 subject to site-specific approval of the first application. The "Analysis" section below describes the manner and degree to which the Fermi 2 analysis meets the constraints of the original NRC SER or was otherwise found to be acceptable in the site-specific SER approving its use (Reference 23).

3.5.1.3.2.3.1 Scope

The exterior walls/roofs of the Reactor, Auxiliary, and Residual Heat Removal Complex buildings have been designed to resist the impact of tornado-generated missiles such that the safety related systems and components required for safe shutdown identified in Tables 3.3-2 and 3.5-2 are generally protected. A limited number of these Seismic Category I systems and components located outside of (or otherwise not protected by these) Seismic Category I structures are evaluated as not requiring unique tornado missile protection by burial or barriers on the basis of a probabilistic missile damage analysis.

Table 3.5-3 identifies the specific features evaluated in the probabilistic tornado missile analysis. The specific targets included in this table represent wall penetrations and doors in the exterior surfaces of these structures. No specific safety-related systems are associated with any particular penetration; hence, the tornado missile hazard associated with these penetrations and openings is limited to and characterized by the probability of missile penetration of the target itself. Exceptions include the targets associated with missiles penetrating the reactor building railroad air lock doors, the first floor auxiliary building south wall entrance, and the EDG removable wall panels.

Unprotected safety-related equipment not identified in UFSAR Table 3.3-2 as being required for safe reactor shutdown following a tornado was not included as targets. Examples include Control Room Emergency Filtration system south emergency makeup intake, the south portion of the Auxiliary Building rooftop and the Standby Gas Treatment equipment located on the refuel floor. In addition, the RHR Mechanical Draft Cooling Towers which are specifically licensed for post-tornado repair and restoration (See UFSAR Section 3.5.1.3.2.2) and the Spent Fuel Pool which was evaluated on the basis of an alternative risk analysis (See Section 3.5.1.3.2.1) were both excluded from the scope of analysis.

Other features that were excluded for this risk analysis are the buried underground cable vaults between the RHR complex and the auxiliary building, the EDG fuel oil tank vents and the EDG exhaust stacks, which are located on the roof of the RHR complex. Both of these rooftop features are provided with tornado missile shield protection specifically designed to prevent vertically travelling missiles from entering the RHR complex and damaging the EDG fuel oil tanks and diesel engines.

3.5.1.3.2.3.2 Analysis

The mean cumulative damage probability for the targets identified in Table 3.5-3 was evaluated using TORMIS, a Monte Carlo based program for simulating tornados that was developed from the NRC approved EPRI version of this program (References 20, 21, 22). Major inputs to the analysis include:

- the regional probabilities of the occurrence of tornados
- the location and size of eligible targets
- location and number of potential missile sources

Given these inputs, TORMIS computes the hit and damage probabilities associated with each target. These probabilities are post-processed to generate the aggregate risk associated with all targets. The term "target damage" is used in a general sense to mean any damage (or "loss of function") criteria caused by a tornado missile hitting the target. Target damage is not necessarily the same as target hit, but hit can equal damage for fragile equipment. The "damage" probabilities included in this analysis consisted of using the built-in TORMIS penetration, spall, and perforation equations for selected steel and concrete targets. In addition, the missile size, impact orientation, and velocity vector orientation were used to compute the probabilities of missiles entering "pipe-penetration" type openings. The TORMIS feature for overall structural response damage modeling capability was not used for this analysis.

In Reference 23, the NRC approved use of the (EPRI) TORMIS methodology subject to the following constraints:

1. Data on tornado characteristics should be employed for both broad regions and small areas around the site. The most conservative values should be used in the risk analysis or justification provided for those values selected.

2. The EPRI study proposes a modified tornado classification, Modified F (F')-scale for which the velocity ranges are lower by as much as 25% than the velocity ranges originally proposed in the Fujita (F)-scale. Insufficient documentation was provided in the studies in support of the reduced F'-scale. The F-scale tornado classification should therefore be used in order to obtain conservative results.

3. Reductions in tornado wind speed near the ground due to surface friction effects are not sufficiently documented in the EPRI study. Such reductions were not consistently accounted for when estimating tornado wind speeds at 33 feet above grade on the basis of observed damage at lower elevations. Therefore, users should calculate the effect of assuming velocity profiles with ratios Vo (speed at ground level) ÷ V33 (speed at 33 feet elevation) higher than that in the EPRI study. Discussion of sensitivity of the results to changes in the modeling of the tornado wind speed profile near the ground should be provided.

4. The assumptions concerning the locations and numbers of potential missiles presented at a specific site are not well established in the EPRI studies. However, The EPRI methodology allows site specific information on tornado missile availability to be incorporated in the risk calculation. Therefore, users should provide sufficient information to justify the assumed missile density based on site specific missile sources and dominant tornado paths of travel.

5. Once the EPRI methodology has been chosen, justification should be provided for any deviations from the calculation approach.

The Fermi 2 analysis performed using the TORMIS program is based on the following characteristics of the analysis:

1. Definition of the Fermi 2 TORMIS Tornado Sub-Region

A site-specific analysis was performed to generate a tornado hazard curve data set for the TORMIS analysis. The tornado data retained in the National Climatic Data Center Storm Events Data Base (NCDC, 2006) files for the years 1950-2005 were used to analyze both broad and small regions around Fermi 2 in order to identify a suitable representative sub-region for the site. Tornado occurrences were mapped for the large region, a 15° longitude x 15° latitude area centered on the Fermi 2 site, and statistical tests were performed using 1° x 1° and 3° x 3° blocks to identify a suitably homogeneous sub-region. The historical records of tornado occurrences within the sub-region tornado were used to establish the tornado occurrence rate, (Enhanced-Fujita) EF-scale intensities, path length, width, and direction variables to be specified as input for use in the TORMIS analysis.

The statistical analysis of the sub-region data established a mean occurrence rate of 3.1E-4 per year over the 56-year period. In accordance with the TORMIS methodology, backwards averaging was used to estimate a detrended occurrence rate to correct for changes in the annual reporting trends. The adjusted mean occurrence rate was determined to be 4.002E-4/year based on the 30-year backwards average.

2. Tornado Windspeed Intensity

The analysis utilizes the original Enhanced Fujita (EF) scale windspeeds as per Reference 24. Though the 1983 NRC SER called for the use of the F-scale of tornado intensity for assigning tornado windspeeds to each intensity category (F1-F5), the EF-scale was subsequently adopted in the positions of NRC Reg. Guide 1.76 Revision 1 that are based on Reference 24.

3. Characterization of Tornado Windspeed as a Function of Height Above Ground Elevation

The Fermi 2 TORMIS simulations were performed with the TORMIS rotational velocity Profile 3, which has increased near ground windspeeds over Profile 5; the profile used in the 1981 EPRI TORMIS reports. Hence, the Fermi 2 runs were made with higher near ground windspeeds than in the EPRI study. A sensitivity study was conducted by running the original EPRI profiles and comparing the results. The most conservative profile with highest near ground windspeeds was conservatively used.

4. Missile Characterization and Site-Structure Models

Walkdowns of the Fermi 2 site were performed to characterize the missile sources and plant configuration. This information was developed into the plant modeling inputs for the TORMIS analysis that describe the facility by specifying the geometry, location, and material properties of the structures/components and the location of potential missile sources. Missile sources (buildings, houses, storage areas, vehicles, etc.) were catalogued and modeled to a distance of approximately 2,500 feet. This is done by specifying missile origin zones around the facility and a statistical description of missile types, based on the facility survey. The site surveys were conducted just prior to refueling outages to maximize the estimated population of available missiles and missiles sources. The Fermi 2 site missiles include the 20 standard TORMIS missiles in Reference 21, including structural sections, pipes, wood members, other construction materials, and an automobile category. In addition to the 20 standard TORMIS missile types, three Fermi 2 specific missiles were created for the analysis, one to represent scaffold clamps of which there were a large number present during the site walkdown, one to represent the sections of metal siding that enclose the upper portions of the reactor and turbine buildings, and the third to represent the large number of concrete block also identified during the site walkdowns. The TORMIS analysis used over 200,000 missiles in the simulations of EF5 tornadoes striking Fermi 2.

5. Deviations from the Original EPRI Methodology

The Fermi 2 analysis is performed using an updated of TORMIS developed from the original EPRI NP-2005 source code. With some exceptions, this version of TORMIS implements the original NRC SER approved methodology. Revisions of the original NRC-approved version of the code generally implement changes necessary to enable continued use of the program on modern computing platforms and to enable analysis of larger problems. Specifically, the original main frame based random number generator has been replaced with a new machine independent algorithm and the code was re-dimensioned to allow larger numbers of missiles and surfaces.

The updated TORMIS program implements an algorithm for evaluating the risk of damage to piping penetrations credited in the Fermi 2 analysis that was not present in the original NRC approved methodology. The method consists of identifying the minimum required missile size, angle of orientation and angle of incidence at impact necessary for a missile to be capable of passing through a pipe penetration target. Missiles that are too large, not oriented correctly, or that impinge obliquely on a target are screened out based on these criteria. This method eliminates from the calculated cumulative risk those impacts which would not realistically have resulted in missile penetration of a pipe penetration target.

3.5.1.3.3 Conclusion

As a result of these studies, the tornado-generated missiles to be considered in barrier design are the wood plank and the automobile, previously described.

3.5.1.4 Site-Related Missiles

3.5.1.4.1 Airplanes

Airports in the vicinity of the Fermi 2 site are listed in Table 2.2-2 and shown in Figure 2.2-1. Table 2.2-2 also lists the proximity to the site, number of and type of aircraft, and other physical and operations data. As discussed in Section 2.2, the nearest airport (2 miles away) cannot accommodate aircraft large enough to be a hazard to Fermi 2 and the nearest major airport is too far away (19 miles north-northwest of the site) to be considered a potential hazard with regard to large-aircraft takeoff and landing. In addition, there are no nearby military airports that could be expected to accommodate aircraft with bomb or explosive loads.

3.5.1.4.2 Military Activities

There are no military facilities within 10 miles of the plant. There are two restricted areas in Lake Erie, 20 and 27 miles from the plant, which are used as impact areas for small arms, ground artillery, and anti-aircraft artillery from Camp Perry and from the test-firing range at Erie Industrial Park. However, restriction to weapon horizontal-firing range and direction, as well as the nature of the projectiles, preclude a threat to the plant.

3.5.1.5 Primary Containment Internal Missiles

The potential for missiles inside the containment due to gravitational effects from unrestrained equipment is possible only during maintenance situations. All equipment and components located inside the containment and associated with reactor operation and safety are restrained. Equipment moved into the containment for maintenance operations (including hoists) is controlled by administrative procedures and is removed when personnel leave the maintenance site or prior to returning to reactor operation. Where possible and practical, maintenance equipment used inside the containment is temporarily restrained. In view of the above, any missiles due to gravitational effects are expected to be relatively small and any resulting damage is anticipated to be minor.

3.5.2 Selected Missiles

As a result of the investigations described in Subsection 3.5.l, the missiles to be considered in barrier design are the tornado generated missiles. These missiles are those considered as a design basis in the PSAR and approved by the AEC as documented in the AEC Safety Evaluation Report (Reference 2). For the Category I 4160-V electrical ductbanks between the RHR cable vaults at the RHR complex and the Reactor/Auxiliary building, the tornado missiles identified in Regulatory Guide 1.76 Revision 1 (Reference 17) are considered.

3.5.2.1 Tornado-Generated Missiles

The tornado-generated missiles are a 4-in. x 12-in. x 12-ft wood plank with a density of 40 lb/ft^3, traveling end-on at a velocity of 255 mph with a contact area of 48 in.^{2}; and a 4000 lb passenger car traveling through the air at 50 mph at a maximum 25 ft above grade elevation. The car has a contact area of 20 ft^2. In the case of tornado-generated missiles, it is assumed that only walls and other vertical exposed surfaces are subject to impacts. Roof structures would be subject only to free-falling ballistic-type projectiles (e.g., wood or stone debris) without high tornadic wind force components. If penetration of the roof structures should occur, such penetration would not constitute a hazard, since the projectile would have very low energy, and the concrete floors and walls protect safety-related equipment for safe shutdown.

The following Design Basis Tornado missiles from Table 2 of Regulatory Guide 1.76 Revision 1 (March 2007) (Reference 17) are considered for the Category I 4160-V RHR cable vaults and the manholes and ductbanks between these cable vaults and the Reactor/Auxiliary building cable vaults:

a. 6.625" diameter x 15 ft long Schedule 40 steel pipe weighing 287 lbs and traveling horizontally at 135 fps

b. 4,000 lb, 16.4 ft x 6.6 ft x 4.3 passenger car traveling horizontally through the air at 135 fps at a maximum height of 30 ft above ground

c. 1" diameter solid steel sphere, weighing 0.147 lb and traveling horizontally at 26 fps

Vertical missiles are all missiles listed above with a vertical velocity equal to 67% of their horizontal speed.

In addition, the following missiles addressed in the Safety Evaluation Report are also evaluated for penetration resistance and regeneration of secondary missiles:

a. 1" diameter x 3 ft long steel rod weighing 8 lbs, traveling horizontally at 250 fps

b. 13.5" diameter x 35 ft long utility pole weighing 1490 lbs, traveling at 247 fps

Vertical missiles are all missiles listed above with a vertical velocity equal to 67% of their horizontal speed.

3.5.3 Missile Barriers and Loadings

Structures, shields, and barriers designed to withstand missile effects are given in Table 3.5-2 according to the equipment protected. In addition to these barriers, the steel plate primary containment vessel is completely enclosed in and surrounded by a reinforced-concrete structure as described in Subsection 3.8.4. This concrete structure, in addition to serving as a radiation shield for personnel in the reactor building, provides a major structural barrier for the protection of the containment and reactor system against missiles that may be generated external to the primary containment.

The suppression chamber has no source of internal or external missile generation. The vent pipes connecting the suppression chamber to the drywell are protected by jet deflectors. The vent discharge headers and piping are designed to withstand the jet reaction force caused by flow discharge into the suppression pool. The control rod drive (CRD) mechanisms are located in a concrete vault below the reactor pressure vessel.

3.5.4 Barrier Design Procedures

3.5.4.1 Overall Structural Response

To determine the capability of the missile barriers provided, the impact and penetration of potential missiles must be determined. Since the missile mass is small compared with the mass of any Category I structure, the only meaningful overall structural response is that of the structural element impacted by the missile. The overall response of the structural element is investigated by designing the element for the forces transmitted to it by the missile.

3.5.4.2 Edge Impact

For edge impact, punching shear stress was checked after obtaining the maximum force impacted to the element by the missile. The punching shear stress is given by the following expressions:

$$Qs = \frac{mV_o}{t_d s} \quad \text{(for rigid missles)} \tag{3.5-2}$$

$$Qs = \frac{F_1}{s} \quad \text{(for nonrigid missles)} \tag{3.5-3}$$

where

F_1 = maximum contact force = $1.14WV_o$

and

t_d = impact time = $\frac{2D}{V_o}$

D' = penetration depth calculated by modified Petry Formula (Subsection 3.5.4.7)

V_o = initial velocity of missile

m = mass of missile

s = perimeter of area enclosed by a border extending one-half of the panel thickness beyond contact area

W = weight of missile

3.5.4.3 Central Impact

For central impact in the case of rigid missiles, the maximum force impacted to a structural element is calculated by the following expression:

$$F = \frac{mV_o2}{2D\prime} \tag{3.5-4}$$

and

$$t_d = \text{duration of force} = \frac{2D\prime}{V_o} \tag{3.5-5}$$

After the force F and its duration t_d are obtained, the element is designed for this dynamic load. For central impact in the case of nonrigid missiles, the panel is modeled as a single degree of freedom system with equivalent mass and equivalent stiffness. The equation of motion for impact is solved to get maximum deflection of the element. This deflection is compared with allowable (or ductility ratio) to arrive at a satisfactory design.

3.5.4.4 Impact Analytical Procedures

The impact of the missile is considered plastic because of the local unrecoverable deformations of either the missile or the target or of both. The velocity of the missile and the target (concrete panel) after the impact, V_a, is determined from the consideration of conservation of linear momentum and is expressed by the following equation:

$$M_m V_i = M_m V_a + M_e V_a \qquad (3.5\text{-}6)$$

where

M_m = mass of missile

V_i = velocity of impact

M_e = effective mass of target

For the Category I 4160-V RHR cable vaults and the manholes and ductbanks between these cable vaults and the Reactor/Auxiliary building cable vaults, overall structural response is based on the dynamic response of the structures and impulse-load time history. A simplified method based on idealization of the structure to an equivalent single-degree-of freedom system is utilized.

The procedure used in determining impactive force and time duration of the impact follows the guidance in Reference 16.

The impactive force and time duration of a hard missile, such as the 6" diameter schedule 40 steel pipe, is determined by the expression shown in Section 3.5.4.3. The impactive force and time duration for soft missiles, such as the automobile and wood plank, is determined by the Riera formula, as outlined in Reference 16.

3.5.4.5 Punching Shear Analytical Procedure

Reinforced-concrete panels are checked for the punching shear failure and the flexural yielding failures. The effective mass, M_e, of the panel for the case of punching shear failure is obtained as follows:

$$M_e = (A + d)(B + d)dw \qquad (3.5\text{-}7)$$

where

A, B = dimensions of missile

d = thickness of panel

w = density of target material

3.5.4.6 Flexural Failure Analytical Procedure

The effective mass for the case of flexural failure of a panel is defined as that mass which must be concentrated at the point of impact on an equivalent weightless slab so that it will have the same kinetic energy as the actual slab when the point of impact is subjected to unit velocity.

For a flexural failure, the energy transferred to the slab is compared with its energy capacity at an appropriate ductility ratio. For a punching shear failure, the shear capacity at the critical section is compared with the shear force transferred to the slab.

3.5.4.7 Depth of Penetration Analytical Procedure

The depth of penetration into concrete walls is calculated using the Modified Petry Formula (Reference 12). The concrete barrier thickness was selected to prevent secondary missiles formed by scabbing from damaging both divisions of protected systems safe shutdown equipment.

Concrete wall/slab thickness provided for the Category I 4160-V RHR cable vaults, manholes, manhole covers, and ductbanks between these cable vaults and the Reactor/Auxiliary building cable vaults are more than the minimum acceptable barrier thickness required as shown in Table 1 of NUREG-0800, Standard Review Plan 3.5.3 Revision 3, dated March 2007 (Reference 18).

Modified Petry Formula (Reference 12) is used to determine the concrete protective cover thickness to prevent penetration and regeneration of secondary missiles for the two additional tornado missiles identified in the Safety Evaluation Report.

The method of calculation used to determine the energy required to penetrate a steel plate is based on extensive tests conducted by the Stanford Research Institute (Reference 13). During these tests, rod-shaped missiles were impacted against square steel plates having clamped edges. The results of the tests are described by the following expression for minimum energy per unit diameter of missile required for perforation of a steel plate:

$$\frac{E}{D} = U\left(0.344T^2 + \frac{W}{W_s}0.032T\right) \qquad (3.5\text{-}8)$$

where

E	=	critical energy required for penetration, ft-lb
D	=	diameter of missile, in.
U	=	ultimate tensile strength of steel plate, lb/in.^{2}
T	=	plate thickness, in.
W	=	length of side of square window in the target frame between the rigid supports, in.
W_s	=	test constant = 4 in.

No composite section (concrete with steel plate backing or the like) has been used for missile-resistant structural elements.

The impact of a turbine-generator missile on the reactor building or auxiliary building is discussed and references are cited in Subsection 10.2.3. The impact of a turbine missile on the RHR complex has also been evaluated.

3.5.5 Missile Barrier Features

The missile barriers listed in Table 3.5-2 provide adequate protection against potential tornado-generated missiles. In addition, it has been shown that the probability of missile damage to either fuel in the spent-fuel pool or the RHR cooling tower fans, both of which could be exposed to such damage, is extremely small. Together with the redundancy and separation provided, the missile protection provided for Fermi 2 is adequate.

The general arrangement of piping and equipment in the drywell showing the separation of redundant systems is given in Figure 3.5-1, Sheets 1 through 6.

For assumed failures of the high pressure coolant injection (HPCI) system, the automatic depressurization system (ADS) functions to reduce the reactor pressure to a value low enough to allow the low pressure coolant injection (LPCI) and core spray systems to pump water to the reactor pressure vessel (RPV) in time to cool the core consistent with the design basis. (See Subsection 6.3.2.2.2.) The ADS uses five of the 15 safety/relief valves (SRVs) of the nuclear boiler pressure-relief system to achieve the automatic blowdown to the suppression pool. Protection from simultaneous damage to the HPCI steam line inside the containment and to the SRVs designated for ADS function due to pipe whip or fragments of pipes is provided by physical separation. The HPCI steam source is provided from main steam line A, while only the SRVs on main steam lines C and D are considered available for performance of the ADS function.

3.5 MISSILE PROTECTION

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3.5 MISSILE PROTECTION

REFERENCES

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TABLE 3.5-1 MISSILE TRAJECTORY DATA FOR TORNADO MISSILES NEAR THE RESIDUAL HEAT REMOVAL COMPLEX COOLING TOWERS

Missile	Initial Elevation (ft)	Peak Elevation (ft)	Vertical Velocity at Impact (fps)
a. 4-in. x 1-ft x 12-ft-long wood plank	0	734	97
	50	739	97
	100	732	97
	250	702	96
b. 13.5-in. diameter x 35-ft-long utility pole	0	0	-
	60	60	-
	100	100	-
c. 1-in. diameter x 3-ft-long steel rod	0	2	-
	50	662	133
	100	664	132
	250	604	128
d. 6-in. diameter x 15-ft-long Schedule 40 steel pipe	0	-	-
	50	50	-
	100	100	-
	250	268	96
e. 12-in. diameter x 15-ft-long Schedule 40 steel pipe	0	-	-
	50	50	-
	100	100	-
	250	250	77

TABLE 3.5-2 EQUIPMENT PROTECTED FROM MISSILES AND ASSOCIATED MISSILE BARRIERS

A. REACTOR AND AUXILIARY BUILDINGS

Equipment Protected	Missile Barriers
1. All items whose failure could affect the operation and functions of the primary reactor containment and those that are necessary for safe shutdown of the reactor	1. a. All exterior concrete walls b. Reactor building fifth floor concrete slab c. Auxiliary building concrete roof slab d. Auxiliary building fifth floor concrete slab e. Reactor building fifth floor equipment hatch cover
2. Air conditioning equipment for the control center	2. a. Auxiliary building concrete roof slab b. Walls between auxiliary and turbine building c. Shield barrier at the Auxiliary Building / Turbine Building third floor portal. (see Note 1)
3. Reactor pressure vessel	3. Shield plug over reactor pressure vessel
4. Main control room, battery room ESF switch-gear room, emergency closed cooling water system, residual heat removal system, relay room, control rod drive units	4. Combined thickness of walls and/or floors of the reactor and auxiliary buildings above and including the fourth floor. Removable exterior precast panel in Division I Switchgear Room South Wall is protected by a 1-inch steel plate.

Note 1: There are two EECW lines in the Auxiliary Building which are potentially susceptible to tornadic induced missiles coming from the Turbine Building through the connecting portal on the third floor.

B. RHR COMPLEX BUILDING

Equipment Protected	Missile Barriers
All items whose failure could affect the operation and functions of the primary containment and those that are necessary for safe shutdown of the reactor (including the EDGs)	a. All exterior concrete walls b. All concrete roof slabs except the RHR complex cooling tower discharges c. Isolation walls between redundant systems

C. Category I 4160-V RHR cable vaults and the manholes and ductbanks between these cable vaults and the Reactor/Auxiliary building cable vaults

Equipment Protected	Missile Barriers
All items whose failure could affect the operation and functions of the primary containment and those that are necessary for safe shutdown of the reactor (including the EDGs)	a. All ductbanks b. All concrete walls c. All concrete roof slabs d. Access covers at RHR cable vaults e. Manholes

TABLE 3.5-3 List of Unprotected Plant Targets Accepted Based on TORMIS Analysis

TORMIS Target #	DESCRIPTION	BUILDING / SITE LOCATION
1	Pipe penetration P-150	AB
2	Pipe penetration P-151	AB
3	Pipe penetration P-152	AB
4	Pipe penetration P-153	AB
5	Electrical penetration E-11117	AB
6	Electrical penetration E-11116	AB
7	Instrumentation penetration I-5504	AB
8	Instrumentation penetration I-5505	AB
9	Ventilation penetration V-521	AB
10	Electrical Penetration E-5654	AB
11	Pipe penetration P-139	AB
12	Pipe penetration P-140	AB
13	Pipe penetration P-141	AB
14	Pipe penetration P-142	AB
15	Pipe penetration P-143	AB
16	Electrical penetration E-11153	AB
17	Electrical penetration E-11154	AB
19	Pipe penetration P-136	AB
20	Pipe penetration P-137	AB
21	Pipe penetration P-138	AB
22	Electrical penetration E-1270	AB
23	Electrical penetration E-1271	AB
24	Electrical penetration E-1272	AB
25	Electrical penetration E-1273	AB
26	Pipe penetration P-10765	AB
27	Electrical penetration E-15132	AB
28	Electrical penetration E-11054	AB
29	Pipe penetration P-10766	AB
53	Class 1E Electrical Cables East of Door R1-15 (Safety related electrical cables East of R1-15)	AB
30	Electrical penetration E-5757	RB
31	Pipe penetration P-5609	RB
32	Pipe penetration P-5624	RB

TABLE 3.5-3 List of Unprotected Plant Targets Accepted Based on TORMIS Analysis

TORMIS Target #	DESCRIPTION	BUILDING / SITE LOCATION
33	Pipe penetration P-5625	RB
34	Pipe penetration P-17305	RB
35	Pipe penetration P-17319	RB
55	Outer Railroad Air Lock Door R1-1	RB
36	Electrical penetration E-5543	RB
37	Electrical penetration E-10764	RB
38	Pipe penetration P-156 (Area around pipe protected by flange)	RB
39	Pipe penetration P-156 (Pipe in opening)	RB
40	Electrical penetration E-5521	RB
41	Pipe penetration P-158	RB
42	Pipe penetration P-157	RB
43	Pipe penetration P-161	RB
44	Pipe penetration P-162	RB
45	Instrumentation penetration I-5657	RB
46	Pipe penetration P-160	RB
47	Pipe penetration P-12343	RB
48	Pipe penetration P-159	RB
61	Removable Panel (EDG-11)	RHR
62	Removable Panel (EDG-12)	RHR
63	Removable Panel (EDG-13)	RHR
64	Removable Panel (EDG-14)	RHR
65	Door to Motor Drive for Cooling Tower Fan (North End, East Tower, Top Door)	RHR
66	Door to Motor Drive for Cooling Tower Fan (North End, East Tower, Bottom Door)	RHR
67	Door to Motor Drive for Cooling Tower Fan (North End, West Tower, Top Door)	RHR
68	Door to Motor Drive for Cooling Tower Fan (North End, West Tower, Bottom Door)	RHR
69	Door to Motor Drive for Cooling Tower Fan (South End, East Tower, Top Door)	RHR
70	Door to Motor Drive for Cooling Tower Fan (South End, East Tower, Bottom Door)	RHR
71	Door to Motor Drive for Cooling Tower Fan (South End, West Tower, Top Door)	RHR
72	Door to Motor Drive for Cooling Tower Fan (South End, West Tower, Bottom Door)	RHR

TABLE 3.5-3 List of Unprotected Plant Targets Accepted Based on TORMIS Analysis

TORMIS Target #	DESCRIPTION	BUILDING / SITE LOCATION
77	Roof Penetration MK-142	RHR
78	Roof Penetration MK-144	RHR
94	West Wall Penetration MK-219	RHR
95	West Wall Penetration MK-220	RHR
96	West Wall Penetration MK-221	RHR
97	West Wall Penetration MK-222	RHR
98	West Wall Penetration MK-344	RHR
99	West Wall Penetration MK-345	RHR
100	West Wall Penetration MK-346	RHR
101	West Wall Penetration MK-347	RHR
49	Doors R3-13 (Security Door RBD17) & R3-28	AB
50	Door R3-12 (Security Door RBD21)	AB
51	Concrete Block Wall # 215	AB
52	Refuel Floor Equipment Hatch Cover (A/B – 10/11)	RB
56	Inner Railroad Air Lock Door R1-2 (effectively modeled as intersection with targets 57, 58, 59, and 60)	RB
54	Class 1E Equipment West of Interior Access Door R1-12	AB
57	Safety-related piping behind Railroad Air Lock Doors (Div. 2 EESW supply & return & RHR Containment Spray)	RB
58	Safety-related piping behind Railroad Air Lock Doors (Div. 1 EESW supply & FPCCU supply & return)	RB
59	Safety-related piping behind Railroad Air Lock Doors (RHR Containment Spray - vertical)	RB
60	Safety-related piping behind Railroad Air Lock Doors (RHR Containment Spray - horizontal)	RB

Enclosure 4 to
NRC-13-0002

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

Proposed License Amendment to Revise the
Fermi 2 Licensing Bases for Protection from Tornado-Generated Missiles

List of Targets Excluded or Included for Information Only

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
1	N/A	Excluded	Auxiliary Building	Architectural penetration A-2654	Target in original Fermi 2 TORMIS analysis was eliminated by installing an engineered missile barrier (EDP-36069) consisting of 1" thick steel plate.
2	18	INFO ONLY	Auxiliary Building	Ventilation penetration V-10836	RB & CCHVAC/CREFS South air intake - path has a 90° turn with cast-in-place concrete wall overlap. South intake provides makeup air for control room pressurization via the CREFS/CCHVAC. The CREFS is not identified as required for post tornado safe-shutdown (UFSAR Table 3.3.2).
3	N/A	Excluded	Auxiliary/Turbine Building	3rd Floor Corridor I Room B-20A	Unprotected Division 1 EECW supply and return piping exposed at interface between turbine and auxiliary building was protected by installing an engineered tornado missile barrier (EDP-35685).
4	N/A	Excluded	Auxiliary Building	North AB Roof slab	This portion of roof, which covers the division 1 and 2 standby gas treatment filter and control center HVAC equipment rooms, is protected by 5'-6" thick concrete slab.

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
5	93	INFO ONLY	Auxiliary Building	South AB Roof slab	This portion of roof, which covers the south control center emergency air intake and control room emergency filtration system filters, is protected by a 4-inch thick roof slab. The CREFS is not identified as required post-tornado safe-shutdown (UFSAR Table 3.3.2).
6	N/A	Excluded	Reactor Building (RB)-South	Pipe penetration P-17304	This spare RB1 penetration was eliminated by installing an engineered tornado missile barrier (EDP-36498).
7	N/A	Excluded	Residual Heat Removal (RHR) Complex - East wall	EDG11 East Wall Access port (G-6/7)	10" blind flanged access port is part of TORMIS targets # 61, 62, 63 and 64 when closed. Each cover is same thickness as target wall. Online opening of access during maintenance is controlled in accordance with TS 3.0.9.
8	N/A	Excluded	RHR Complex - East wall	EDG12 East Wall Access port (G-5/6)	
9	N/A	Excluded	RHR Complex - East wall	EDG13 East Wall Access port (G-8/9)	
10	N/A	Excluded	RHR Complex - East wall	EDG14 East Wall Access port (G-7/8)	
11	N/A	Excluded	RHR Complex - Intake East wall, South end	Vent Louvers LV-1	Air intakes for Division 1 and 2 essential service water pump room HVAC equipment are provided with

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
12	N/A	Excluded	RHR Complex - Intake East wall, North end	Vent Louvers LV-2	engineered missile protection consisting of 90° turn for air route inside plenum with 18" thick concrete barrier wall inside the Pump Room.
13	N/A	Excluded	RHR Complex - Intake West wall, Roof (EDG-11)	Vent Louvers LV-4	Air intakes for EDG combustion air intake plenums are provided with engineered tornado missile barriers consisting of 90° turns for air routed inside plenum with an 18" thick concrete barrier wall inside the Room.
14	N/A	Excluded	RHR Complex - Intake West wall, Roof (EDG-12)	Vent Louvers LV-3	
15	N/A	Excluded	RHR Complex - Intake West wall, Roof (EDG-13)	Vent Louvers LV-6	
16	N/A	Excluded	RHR Complex - Intake West wall, Roof (EDG-14)	Vent Louvers LV-5	
17	N/A	Excluded	RHR Complex - Roof, West wall	Access Door D-43	These RHR complex rooftop doors access each of the EDG air intake rooms adjacent to their respective EDG air intake louver. The door opens into the missile barriers described in items 13-16 above.
18	N/A	Excluded	RHR Complex - Roof, West wall	Access Door D-44	
19	N/A	Excluded	RHR Complex - Roof, West wall	Access Door D-55	
20	N/A	Excluded	RHR Complex - Roof, West wall	Access Door D-56	
21	N/A	Excluded	RHR Complex – South Roof	EDG-11 Room Ventilation Exhaust	Each EDG room HVAC ventilation exhaust consists of a 90° turn for air

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
22	N/A	Excluded	RHR Complex – South Roof	EDG-12 Room Ventilation Exhaust	route inside plenum with an 18" thick concrete barrier. Concrete cap overhangs top & sides.
23	N/A	Excluded	RHR Complex – North Roof	EDG-13 Room Ventilation Exhaust	
24	N/A	Excluded	RHR Complex - Roof	EDG-14 Room Ventilation Exhaust	
25	N/A	Excluded	RHR Complex - Roof Exhaust	RHR North Pump Room Ventilation Exhaust	Each essential service water pump room HVAC ventilation exhaust consists of a 90° turn for air route inside plenum with an 18" thick concrete barrier. Concrete cap overhangs top & sides.
26	N/A	Excluded	RHR Complex - Roof Exhaust	RHR South Pump Room Ventilation Exhaust	
27	122	INFO ONLY	RHR Roof - North end, East tower	RHR MDCT	Each of the four cooling tower fan cells is protected horizontally by a 22-inch thick concrete shell. Per UFSAR Section 9.2.5 the RHR mechanical draft cooling towers are licensed assuming tornado damage from vertical missiles with subsequent repair to restore function. Hit probabilities are computed for information only.
28	121	INFO ONLY	RHR Roof - North end, West tower	RHR MDCT	
29	120	INFO ONLY	RHR Roof - South end, East tower	RHR MDCT	
30	119	INFO ONLY	RHR Roof - South end, West tower	RHR MDCT	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
31	N/A	Excluded	RHR South Pump Room to Resv. West wall.	Access Door D-3	These doors, which access their respective essential service water pump rooms from the RHR roof, are located at the bottom of a 13'-6" wide x 21'-6" deep x 88'-10" long concrete walled stairway. The doors open into 18" thick concrete barrier wall inside the Pump Room.
32	N/A	Excluded	RHR North Pump Room to Resv. West wall.	Access Door D-28	
33	N/A	Excluded	RHR North Roof access door	Access Door D-58	These doors, which access the RHR complex north and south rooftops from the EDG switchgear rooms, are protected by a missile barrier having 18" thick concrete walls and roof.
34	N/A	Excluded	RHR South Roof access door	Access Door D-31	
35	N/A	Excluded	RHR East Wall	Div I Pump Room Access Door D-1	These doors are protected by a missile barrier having 18" thick concrete walls inside the RHR Room and outside with an 18" thick concrete roof.
36	N/A	Excluded	RHR East Wall	Div I EDG-12 Room Access Door D-6	
37	N/A	Excluded	RHR East Wall	Div I EDG-11 Room Access Door D-7	
38	N/A	Excluded	RHR East Wall	Div II EDG-14 Room Access Door D-16	
39	N/A	Excluded	RHR East Wall	Div II EDG-13 Room Access Door D-17	
40	N/A	Excluded	RHR East Wall	Div II Pump Room Access Door D-27	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
41	73	INFO ONLY	RHR Roof South	EDG Fuel Oil Tank Vents Penetrations MK-211 & MK-216	Original installed missile shields were installed over their respective EDG day and main fuel oil tank vents to protect EDG main fuel oil tanks from perforation due to vertical missile impacts. Each installed missile shield consists of 18" thick, 7'-6" square concrete slab supported by 18" x 18" square concrete columns at the corners. TORMIS was used to tally horizontal strike probability for information only. Due to the small size of opening required to provide vacuum relief, it was not considered credible to assume a strike could pinch a vent closed.
42	74	INFO ONLY	RHR Roof South	EDG Fuel Oil Tank Vents Penetrations MK-212 & MK-215	
43	75	INFO ONLY	RHR Roof North	EDG Fuel Oil Tank Vents Penetrations MK-213 & MK-218	
44	76	INFO ONLY	RHR Roof North	EDG Fuel Oil Tank Vents Penetrations MK-214 & MK-217	
45	102	INFO ONLY	Yard	Manhole MH-16946 - Cover (Class IE conduits running between RB & RHR)	Per UFSAR Section 8.3.1.1.8.1, the original installed Class 1E cable vaults that run between the Auxiliary building south wall and the RHR complex east wall are protected by depth of earth and divisional separation. Original design for manholes (MH) has ~12" of soil above MH roof with
46	112	INFO ONLY	Yard	Manhole MH-16946 - Vault (Class IE conduits running between RB & RHR)	
47	114	INFO ONLY	Yard	Manhole MH-16946 - SW Conduit (Class IE conduits running between RB & RHR)	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
48	115	INFO ONLY	Yard	Manhole MH-16946 - South Central Conduit (Class IE conduits running between RB & RHR)	2"-3" of soil above MH Cover - 30" Ø cover is malleable iron and support ring is cast iron. Recently installed high voltage Class 1E duct banks (EDP-35607) are excluded from the TORMIS analysis altogether on the basis that they were engineered against the Regulatory Guide 1.76 Rev 1 missiles.
49	118	INFO ONLY	Yard	Manhole MH-16946 - SE Conduit (Class I conduits running between RB & RHR)	
50	103	INFO ONLY	Yard	Manhole MH-16947 - Cover (Class I conduits running between RB & RHR)	
51	113	INFO ONLY	Yard	Manhole MH-16947 - Vault (Class I conduits running between RB & RHR)	
52	116	INFO ONLY	Yard	Manhole MH-16947 - NW Conduit (Class I conduits running between RB & RHR)	
53	117	INFO ONLY	Yard	Manhole MH-16947 - North Central Conduit (Class I conduits running between RB & RHR)	
55	83	INFO ONLY	Yard	Div I RHRSW & EESW Supply & Return piping underground (Section A)	Per UFSAR Section 9.2.5.3.1, underground service water piping is protected by physical separation. 4'-2" Min. soil cover for the 24" Ø RHRSW Supply piping at ℄ Elev.
56	84	INFO ONLY	Yard	Div I RHRSW & EESW Supply & Return piping underground (Section B)	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
57	85	INFO ONLY	Yard	Div I RHRSW & EESW Supply & Return piping underground (Section C)	577'-10" near West wall of RB. The 10" Ø EESW Supply piping has the worst case of Min. soil cover at 4'-0⅝" near the West wall of the RB and ~45'-0" to the West. The 24" Ø RHRSW Return has the worst case of Min. vert. divisional separation at 4'-10" edge to edge, and also the worst case horiz. at 16'-0" edge to edge, and 4'-2" Min. soil cover. The 10" Ø EESW Return ties into the 24" Ø RHRSW Return within 10'-0" West of the RB.
58	86	INFO ONLY	Yard	Div I RHRSW & EESW Supply & Return piping underground (Section D)	
59	87	INFO ONLY	Yard	Div I RHRSW & EESW Supply & Return piping underground (Section E)	
60	88	INFO ONLY	Yard	Div II RHRSW & EESW Supply & Return piping underground (Section A)	Per UFSAR Section 9.2.5.3.1, protected by physical separation. 4'-2" Min. soil cover for the 24" Ø RHRSW Supply piping at ℄ Elev. 577'-10" near West wall of RB. The 10" Ø EESW Supply piping has the worst case of Min. soil cover at 4'-0⅝" near the West wall of the RB and ~21'-0" to the West. The 24" Ø RHRSW Return has the worst case of Min. vert. divisional separation at 4'-10" edge to edge, and also the worst case horiz. at 16'-0" edge to edge, and 4'-2" Min. soil cover. The 10" Ø EESW Return ties into the 24" Ø RHRSW Return within 10'-0" West of the RB.
61	89	INFO ONLY	Yard	Div II RHRSW & EESW Supply & Return piping underground (Section B)	
62	90	INFO ONLY	Yard	Div II RHRSW & EESW Supply & Return piping underground (Section C)	
63	91	INFO ONLY	Yard	Div II RHRSW & EESW Supply & Return piping underground (Section D)	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
64	N/A	Excluded	Auxiliary/Turbine Building	Doors T3-6 (Security Door TBD09) & R3-27 from 3rd Floor TB laydown area to Control Room	Door T3-6 is a QA-1 pressure tight hardened door. Door R3-27 is a QA-1 Control Center pressure boundary door. Double concrete walls are separated for AB/TB expansion threshold.
65	N/A	Excluded	Auxiliary/Turbine Building (into 4th Floor stairwell from Corridor I Room B-20A to TB 3rd Floor)	Concrete Block Wall # 219	Wall protects stairwell. No targets on other side of wall.
66	N/A	Excluded	Auxiliary/Turbine Building (to 4th Floor stairwell from Corridor I Room B-20A to TB 3rd Floor)	Door R3-4 (Security Door RBD18)	Wall protects stairwell. No targets on other side of wall. Door R3-4 is a QA-1M hardened door w/air seal.
67	104	INFO ONLY	RHR East wall	Div. I RHR flood protection Make-up overflow MK-121 (pipe itself)	Vent is designed for external flood protection. Pipe is directed toward Pump Room sump pit wall without direct access to building internals.
68	105	INFO ONLY	RHR East wall	Div. I RHR flood protection Make-up overflow MK-121 (open space around pipe)	
69	106	INFO ONLY	RHR East wall	Div. I RHR flood protection Make-up overflow MK-122 (pipe itself)	
70	107	INFO ONLY	RHR East wall	Div. I RHR flood protection Make-up overflow MK-122 (open space around pipe)	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
71	108	INFO ONLY	RHR East wall	Div. II RHR flood protection Make-up overflow MK-284 (pipe itself)	Vent is designed for external flood protection. Pipe is directed toward Pump Room sump pit wall without direct access to building internals.
72	109	INFO ONLY	RHR East wall	Div. II RHR flood protection Make-up overflow MK-284 (open space around pipe)	
73	110	INFO ONLY	RHR East wall	Div. II RHR flood protection Make-up overflow MK-285 (pipe itself)	
74	111	INFO ONLY	RHR East wall	Div. II RHR flood protection Make-up overflow MK-285 (open space around pipe)	
75	79	INFO ONLY	RHR Roof	South EDG exhaust opening	Original tornado missile barrier was designed to protect the EDGs from vertically travelling tornado missiles entering the EDG room via the EDG exhaust penetration. TORMIS was used to assess the probability of a strike on each of these targets via the open (East) end of the missile barrier through which the exhaust and exhaust muffler extend. The exhaust itself was not treated as a target.
76	80	INFO ONLY	RHR Roof	South-central EDG exhaust opening	
77	81	INFO ONLY	RHR Roof	North-central EDG exhaust opening	
78	82	INFO ONLY	RHR Roof	North EDG exhaust opening	

List of Targets Excluded or Included for Information Only

TARGET #	TORMIS #	SCOPE STATUS	BUILDING/SITE LOCATION	DESCRIPTION	BASIS FOR EXCLUSION
79	92	INFO ONLY	Auxiliary Building	Door R1-8	There are no safety-related targets directly beyond this door.