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Dominion

April 6, 2006

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

Serial No. 05-830
KPS/LIC/GR: R2
Docket No: 50-305
License No. DPR-43

DOMINION ENERGY KEWAUNEE, INC
KEWAUNEE POWER STATION
LICENSE AMENDMENT REQUEST 214 - REQUEST FOR REVIEW AND APPROVAL OF METHODOLOGY CHANGE REGARDING TORNADO MISSILES

Pursuant to 10 CFR 50.90 Dominion Energy Kewaunee, Inc. (DEK) requests Nuclear Regulatory Commission (NRC) approval of a proposed license amendment request (LAR) for the Kewaunee Power Station (Kewaunee). The proposed amendment would allow the use of a different methodology for determining the design requirements necessary for protecting safety-related equipment from damage by tornado generated missiles. Currently, Kewaunee uses a deterministic methodology to establish these design requirements. The proposed amendment would allow the use of a probabilistic methodology in place of the current deterministic methodology for specifically identified plant equipment. The use of the proposed probabilistic methodology would constitute a change to a method of evaluation as described in the Updated Safety Analysis Report (USAR). Therefore, per 10 CFR 50.59 (c)(2), a license amendment is required to be obtained prior to implementing this change at Kewaunee.

Specifically, this LAR requests approval to use a different methodology to assess the need for tornado missile protection for the Kewaunee emergency diesel generator (EDG) exhaust ducts and EDG fuel oil tank vent lines. This equipment is not currently physically protected from the effects of a strike from a design basis tornado missile. The proposed new methodology is a probabilistic methodology that the NRC has concluded may be used when assessing the need for positive tornado missile protection in accordance with the criteria of the Standard Review Plan (SRP) Section 3.5.1.4, "Missiles Generated by Natural Phenomena."

Additional information and documents to support this license amendment request are provided as attachments to this letter. Attachment 1 provides a detailed description of the proposed change, background and technical analysis, no significant hazards consideration determination, and environmental review consideration. Attachment 2 provides marked-up USAR pages showing the proposed changes. Attachment 3 provides a site-specific analysis, which supports the change.

Upon NRC Staff approval of this amendment request, the USAR will be revised as indicated in Enclosure 2.

DEK requests approval of the proposed amendment by March 31, 2007.

If you have any questions or require additional information, please contact Mr. Gerald Riste at (920) 388-8424.

Very truly yours,

David A. Christian
Senior Vice President – Nuclear Operations
and Chief Nuclear Officer

Commitments made in this letter: None

Attachments (3)

1. Evaluation of License Amendment Request 214
2. USAR Markup Pages For License Amendment Request 214
3. Site Specific TORMIS Results

cc: Regional Administrator
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COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by David A. Christian, who is the Senior Vice President – Nuclear Operations and Chief Nuclear Officer of Dominion Energy Kewaunee, Inc. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 6th day of April, 2006.

My Commission Expires: August 31, 2008.

Margaret B. Bennett
Notary Public

(SEAL)

Attachment 1

LICENSE AMENDMENT REQUEST 214
REQUEST FOR REVIEW AND APPROVAL OF METHODOLOGY CHANGE REGARDING TORNADO MISSILES

EVALUATION OF LICENSE AMENDMENT REQUEST 214

KEWAUNEE POWER STATION

DOMINION ENERGY KEWAUNEE, INC.

EVALUATION OF LICENSE AMENDMENT REQUEST 214
Methodology Change Regarding Tornado Missiles

1.0 DESCRIPTION

This letter is a request to amend Operating License No. DPR-43, for the Kewaunee Power Station (Kewaunee).

In accordance with 10CFR50.90 and 10CFR50.59, Nuclear Regulatory Commission (NRC) Staff review and approval is required for changes to the Kewaunee design basis as described in the Updated Safety Analysis Report (USAR). Specifically, Dominion Energy Kewaunee (DEK) proposes to revise the USAR to permit the use of an NRC approved alternative methodology for determining physical protection requirements for two specific support components for safety-related equipment, which may be adversely affected by tornado missiles. The following provides a description and the purpose of the proposed changes as well as the associated safety analysis, evaluation of no significant hazards consideration, and environmental impact evaluation.

2.0 PROPOSED CHANGE

The purpose of this amendment is to modify the Kewaunee licensing bases for tornado missile protection to permit the use of Standard Review Plan (SRP) methodology for site evaluation of missile phenomena and to specifically permit use of TORMIS in determining protection requirements for the emergency diesel generator (EDG) exhaust header/ductwork and fuel oil vents.

Following NRC approval, Section 2, Section 8, and Appendix B of the Kewaunee USAR will be modified in accordance with 10CFR50.71(e), as shown in Attachment 2.

3.0 BACKGROUND

In February of 2005, after the shutdown described in Kewaunee LER 2005-002 (ADAMS Accession NO. ML051090263), Kewaunee staff conducted an extent-of-condition evaluation for tornado protection features in the turbine building. This walkdown identified an issue with the EDG exhaust ducts.

The turbine building is a mixed classification building according to Appendix B, Section B.2 of the USAR. In that regard, the turbine building has to be able to withstand design basis tornado wind conditions without jeopardizing the Class I equipment housed in the turbine building.

Through study of design information for Kewaunee and consultation with a recognized industry expert in tornadoes and response of structures to tornadoes, it has been determined that the turbine building response to design basis tornado winds would not jeopardize the Class I equipment housed in the building.

However, the response of the sheet metal panels in the turbine building (which are designed as blowout panels to protect the turbine building structure from excessive wind loads) would likely be such that the Class III portion of both A & B emergency diesel generator exhaust header/ductwork could be exposed to tornado missiles generated by full design basis tornado force winds (300 mph plus 60 mph translational speed for a total of 360 mph). An extent-of-condition review identified that the emergency diesel generator fuel oil vents were also vulnerable to tornado missiles.

DEK has determined by using SRP Section 3.5.1.4 and Section 2.2.3 for evaluating missiles generated by natural phenomena, that the diesel generator exhaust header/ductwork and diesel generator fuel oil vents are acceptable as designed.

The proposed license change involves the use of an NRC Staff approved probabilistic risk methodology to assess the need for additional positive (physical) tornado missile protection of specific features at Kewaunee. During reviews of the diesel generator exhaust header/ductwork, it was identified that portions of this equipment are not protected from tornado missiles. An analysis was performed which demonstrates that the probability of damage due to tornado missiles striking the diesel generator exhaust header/ductwork or fuel oil vent lines is acceptably low. This analysis was based on Electric Power Research Institute (EPRI) Topical Report, "Tornado Missile Risk Evaluation Methodology (EPRI NP-2005)," Volumes I and II, implemented using the EPRI computer code TORMIS.

The USAR changes associated with this request are based on use of the TORMIS methodology. In this regard, the following is noted in the NRC Safety Evaluation dated October 26, 1983, issued for the EPRI topical report:

> *"The current licensing criteria governing tornado missile protection are contained in 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."*
>
> *"Certain Operating License (OL) applicants and operating reactor licensees have chosen to demonstrate compliance with tornado missile protection criteria for certain portions of the plant... by providing a probabilistic analysis, which is intended to show a sufficiently low risk, associated with tornado missiles. Some... have used the tornado missile probabilistic risk assessment (PRA) methodology*

developed by...EPRI in (the) two topical reports [i.e., EPRI NP-2005, Volumes I and II]."

The NRC concluded:

> *"...the EPRI methodology can be used when assessing the need for positive tornado missile protection for specific safety-related plant features in accordance with the criteria of SRP Section 3.5.1.4."*

The EPRI methodology has been previously applied by other licensees to resolve tornado missile protection issues without requiring additional physical protection because of low missile strike probabilities.

4.0 TECHNICAL ANALYSIS

As previously discussed, the methodology of EPRI NP-2005 (TORMIS) was used to evaluate tornado missile hazards at Kewaunee. The analysis results in a tornado missile strike probability of approximately 5.75×10^{-7} per year for the emergency diesel generator exhaust vents and fuel oil vents (see Attachment 3, Table 4). General guidance concerning the acceptance criteria for such analyses is provided in the Standard Review Plan (NUREG-0800), Section 3.5.1.4, "Missiles Generated by Natural Phenomena," and by reference Section 2.2.3, "Evaluation of Potential Accidents."

In Section 2.2.3, the following guidance is provided:

> *"The probability of occurrence of the initiating events leading to potential consequences in excess of 10CFR100 exposure guidelines should be estimated using assumptions that are as representative of the specific site as is practicable. In addition, because of the low probabilities of the events under consideration, data are often not available to permit accurate calculation of probabilities. Accordingly, the expected rate of occurrence of potential exposures in excess of the 10CFR100 guidelines of approximately 1×10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower."*

The 5.75×10^{-7} per year probability for Kewaunee falls within the above guidelines.

The tornado missile hazards analysis for Kewaunee contains applicable site-specific assumptions, and the results are within the range described in Standard Review Plan, Section 2.2.3. The site-specific assumptions for Kewaunee are discussed in Attachment 3.

The NRC Staff concluded that this probabilistic approach is acceptable for demonstrating compliance with the requirements of General Design Criteria 2 and 4 regarding protection of specific safety-related plant features from the effects of tornado and high-wind generated missiles.

Kewaunee USAR Appendix B describes the design basis and deterministic evaluation regarding tornado winds and missiles. It does not list a specific methodology for the evaluation. This LAR will insert new wording into Appendix B which describes the use of the SRP methodology for the site evaluation of missiles generated by natural phenomena and the use of the NRC approved computer code, TORMIS, for the EDG exhaust header/ductwork and fuel oil vents. Presently, Kewaunee uses a deterministic methodology for tornado analysis; the request to use the SRP and TORMIS is considered a change in methodology requiring prior NRC approval.

5.0 REGULATORY SAFETY ANALYSIS

5.1 No Significant Hazards Consideration

Dominion Energy Kewaunee, Inc. (DEK) proposes to modify the Kewaunee licensing bases for tornado missile protection to permit the use of standard review plan (SRP) methodology. Specifically, DEK requests approval to use TORMIS to evaluate missile phenomena to determine protection requirements for the emergency diesel generator (EDG) exhaust header/ductwork and fuel oil vents.

Dominion Energy Kewaunee, Inc. (DEK) 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?

   Response: No.

   The probability of occurrence of an accident previously evaluated is not significantly increased by the proposed change to permit probabilistic evaluation of missiles generated by natural phenomena. The actual frequency of tornado occurrence at Kewaunee is unaffected by the proposed change in assessment methodology. Furthermore, the projected frequency of tornado occurrence, as specified in the USAR, is not significantly affected by this change. The value for the probability of tornado occurrence in the updated study is in general agreement with the original value in the USAR (i.e. 3.97E-4 vs. 4.86E-4).

Similarly, the probability of a tornado-generated missile is not significantly affected by this change.

Likewise, the consequences of an accident previously evaluated are not significantly increased by the proposed change. The actual probability of a tornado missile onsite remains unchanged. The actual probability of a tornado missile strike remains unchanged. For the limited number of components affected by this proposed change (i.e. exhaust ducts and fuel vent), the missile strike probability is approximately 5.75×10^{-7} per year, which is significantly lower than the SRP acceptance criteria of 1×10^{-6} per year. Therefore, the proposed change is not considered to constitute a significant increase in the consequences of an accident due to the low probability of occurrence.

In addition, use of a probabilistic versus a deterministic methodology to assess missile hazard acceptability has no impact on accident initiation or consequence. Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

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

Response: No.

The proposed changes involve use of an evaluation methodology to determine protection requirements for two specific support components for safety-related equipment, which may be adversely affected by missiles during a tornado. A tornado at Kewaunee is considered in the USAR as a separate event and not occurring coincident with any of the design basis accidents in the USAR. As such, no new or different kind of accident is created by the proposed change to permit probabilistic evaluation of missiles generated by natural phenomena.

This change involves recognition of the acceptability of performing tornado missile strike probability calculations in accordance with established regulatory guidance in lieu of using deterministic methodology alone. Therefore, the change would not create the possibility of, or be the initiator for, any new or different kind of accident. The acceptance criterion of the SRP guidance establishes a threshold for tornado missile damage to system components that is consistent with this conclusion.

Therefore, the proposed change does not create the possibility of a new or different kind of accident from any previously evaluated.

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

   Response: No.

   The request does not involve a significant reduction in a margin of safety.

   The existing design basis for Kewaunee, with respect to a tornado affecting safety related equipment, is to provide positive missile barriers for all safety-related systems and components. The proposed change recognizes that for probability of occurrences below the SRP established acceptance limit, the extremely low probability associated with an "important" system or component being struck by a tornado missile does not represent a significant reduction in the margin of safety provided by use of the deterministic methodology. The change from "protecting all safety-related systems and components" to "an extremely low probability of occurrence of tornado generated missile strikes on portions of important systems and components" is not considered to constitute a significant reduction in the margin of safety.

   Therefore, the proposed change does not involve a significant reduction in a margin of safety.

5.2 Applicable Regulatory Requirements/Criteria

The US Atomic Energy Commission (AEC) issued their Safety Evaluation (SE) of the Kewaunee Power Station on July 24, 1972 with supplements dated December 18, 1972 and May 10, 1973. In the AEC's SE, section 3.1, "Conformance with AEC General Design Criteria," described the conclusions the AEC reached associated with the General Design Criteria in effect at the time. The AEC stated:

> *"The Kewaunee plant was designed and constructed to meet the intent of the AEC's General Design Criteria, as originally proposed in July 1967. Construction of the plant was about 50% complete and the Final Safety Analysis Report (Amendment No. 7) had been filed with the Commission before publication of the revised General Design Criteria in February 1971 and the present version of the criteria in July 1971. As a result, we did not require the applicant to reanalyze the plant or resubmit the FSAR. However, our technical review did assess the plant against the General Design Criteria now in effect and we are satisfied that the plant design generally conforms to the intent of these criteria."*

As such, the appropriate General Design Criteria Kewaunee is licensed to from the Final Safety Analysis Report (Amendment 7), which has been updated and now titled the Updated Safety Analysis Report (USAR) are listed below.

5.3 Kewaunee Design Criteria

1. Criterion 2 – Performance Standards

   Those systems and components of reactor facilities which are essential to the prevention of accidents which could affect the public health and safety or to mitigation of their consequences shall be designed, fabricated and erected to performance standards that will enable the facility to withstand without loss of the capability to protect the public. The additional forces that might be imposed by natural phenomena such as earthquakes, tornadoes, flooding conditions, winds, ice and other local site effects. The design bases so established shall reflect:

   a) appropriate consideration of the most severe of these natural phenomena that have been recorded for the site and the surrounding area, and
   b) an appropriate margin for withstanding forces greater than those recorded to reflect uncertainties about the historical data and their suitability as a basis for design.

2. U.S. Nuclear Regulatory Commission, NUREG 0800, "Standard Review Plan"

   a) Section 2.2.3, "Evaluation of Potential Accidents," Revision 2, 1981.

   b) Section 3.5.1.4, "Missiles Generated By Natural Phenomena," Revision 2, 1981.

The use of the TORMIS provides additional means for evaluating the effect of tornado-generated missiles consistent with SRP.

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.

6.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

7.0 REFERENCES

1. NUREG 0800, "Standard Review Plan", Section 3.5.1.4, "Missiles Generated By Natural Phenomena".
2. EPRI NP-2005, Tornado Missile Simulation and Methodology, Volumes I and II, Final Report dated August 1981.

Attachment 2

LICENSE AMENDMENT REQUEST 214
REQUEST FOR REVIEW AND APPROVAL OF METHODOLOGY CHANGE
REGARDING TORNADO MISSILES

USAR MARKUP PAGES FOR LICENSE AMENDMENT REQUEST 214

(For Information Only)

2.7-1 through 2.7-5
2.10-4
8.2-26
B.4-2
B.6-5 through B.6-7
B.10-5
Table B.6-8

KEWAUNEE POWER STATION

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2.7 METEOROLOGY

Refer to the KNPP Off-Site Dose Calculation Manual (ODCM) and supporting documents for current meteorological data and other related information.

2.7.1 METEOROLOGICAL PROGRAM

Meteorology in the region of the site has been evaluated to provide a basis for determination of annual average waste gas release limits, estimates of exposure from potential accidents and design criteria for storm protection. The meteorology section in this USAR is based on nineteen months of site data from August 1968 through February 1970. Site data are continually being recorded. The meteorological data acquisition system was upgraded in 1982 in response to the NRC criteria for emergency preparedness discussed primarily in NUREG 0654 (Appendix 2), Regulatory Guide 1.23 (proposed revision 1), Regulatory Guide 1.97, and NUREG 0737, Supplement 1.

The primary meteorological tower is located 1200 ft. from the center of containment at 202° and is instrumented at the 10-meter and 60 meter elevation. The meteorological parameters measured at the primary tower include:

- 60 & 10 meter wind speed
- 60 & 10 meter wind direction
- 10 meter ambient temperature
- Differential temperature
- 10 meter $\sigma\theta$

A backup tower is located in close proximity to the primary tower and is available to provide the following meteorological information:

- 10 meter wind speed
- 10 meter wind direction
- 10 meter $\sigma\theta$
- 10 meter ambient temperature

There is analog readout for the meteorological data in the basement of the Technical Support Center and digital inputs to the plant process control computer.

Power is available to the primary tower from either the transmission system on highway 42 or from MCC 1-46C which is capable of being fed by the TSC diesel generator. The backup tower is supplied entirely from the transmission lines on Highway 42.

Site meteorological data were used as input to a CDC 6600 computer. WINDVANE, a code developed by NUS, operates on this data to determine significant meteorological statistics and distributions for further analysis. Summary pages of WINDVANE output for reported Kewaunee data are on file and available as reference material.

Data recovery during this nineteen-month period, August 1968 through February 1970, was approximately 90%. Periods of missing data did not result in any data bias and were generally of short duration except for March 24, 1969 to April 24, 1969 when the facility was inoperative due to storm damage.

Stability in this report is classified into categories proposed by Pasquill (Reference 9) and Turner for a system based on wind direction range or wind variance formulated by Slade (Reference 10).

In assessing the meteorology of a nuclear reactor site the purpose is to ascertain the dilution capacity of the atmosphere in cases of radioactive releases. Wind direction and speed are obvious factors since the direction determines the trajectory of the material, and the speed is a measure of the flow into which the contaminant is diluted. However, wind turbulence expands the plume about its centerline. It is actually wind turbulence that progressively spreads the plume (both vertically and horizontally) as it is transported from its source, resulting in a conical configuration.

Stability characterizes the capability of the atmosphere to return to equilibrium or its original state after being disturbed. A stable atmosphere is quiescent and an unstable one is quite variable. The vertical rate of change of temperature (lapse rate) is frequently used to define stability by those interested in air parcels subjected to buoyancy forces. However, in considering releases from the Kewaunee Plant, buoyancy is not an important factor, and it is more conclusive to examine the disturbances of the mean wind direction.

The stability classes proposed by Pasquill range from "A", the most unstable, to "F", stable. Wind direction variance or standard deviation, which is determined by the Wind Variance Computer on a real-time basis, can be used to classify data in the various categories. It is also possible to infer the standard deviation by dividing the range of wind directions by a constant, usually 6.0 for fifteen-minute periods. Table 2.7-1 describes the various stability categories. An additional category "G" has been added to facilitate a more complete classification system.

A low degree of wind turbulence and consequently relatively unfavorable diffusion conditions can be expected for stable conditions. Conversely, during periods of instability, a high degree of wind turbulence associated with favorable dilution conditions can be expected.

2.7.2 DESCRIPTIVE METEOROLOGY

The climate of the site region is basically continental and influenced by the general storms which move eastward along the northern tier of the United States and by those which move northeastward from the southwestern part of the country to the Great Lakes. The climate is modified by Lake Michigan. Climatic characteristics are illustrated in Figure 2.7-1 which shows average and extreme temperatures, precipitation and extreme winds for forty years of USWB record (1930-1969) at Kewaunee and Manitowoc, Wisconsin. Rainfall averages about 28 inches per year, with 55% falling in the months of May through September. Maximum rainfall during twenty-four hours was 6 inches in September 1964. Snowfall averages about 45 inches per year, with a maximum of 15 inches in twenty-four hours in January 1967.

According to the compilation by Thom (Reference 11) extreme winds at the 30-foot elevation, as illustrated in Figure 2.7-1, are not expected to exceed 54 mph with a recurrence interval of once in two years, and 90 mph with a one hundred-year recurrence interval. (The extreme-mile wind speed is defined as the highest 1-mile passage of wind for a given length of time.)

Tornadoes

Wisconsin lies to the northeast of the principal tornado belt in the United States. During the ten-year period 1960-1969, 161 tornadoes were reported in the state. Only six of these tornadoes occurred in Brown, Door, Kewaunee, or Manitowoc Counties. During the period 1916-1969, only one tornado caused injury to people or major property damage within these four counties. This one occurred in Green Bay, 27 miles WNW of the site, on May 10, 1959, at 8:50p.m. Three persons were injured and property damage ranged from $500,000 to $5,000,000. The tornado path was 6 miles long and 600 yards wide. The region north of Sheboygan, along the Lake Michigan coast, appears to be relatively free of tornadoes. Approximately six tornadoes occurred in the Green Bay-Kewaunee area on April 22, 1970. Damages were estimated at approximately $500,000 and four to five people were injured.

Tornadoes appear to advance from the west with most of the tracks from the southwest to northeast. Maximum occurrence during the year is in May, with 90% reported in May through September. According to statistical methods proposed by Thom, (Reference 12) the probability of a tornado striking a point within a given area may be estimated as follows:

$$P = \frac{\bar{z}\,\bar{t}}{A}$$

P is the mean probability per year, $\bar{z}$ is the mean tornado path area, $\bar{t}$ is the mean number of tornadoes per year in area A. The value of $\bar{t}$ is 16.7 for Wisconsin and 1.2 for the four counties surrounding the Kewaunee site, if the April 22, 1970 tornadoes are included. The average path length and width for tornadoes occurring in the state are 7 miles and 200 yards, respectively, and yield a value of $\bar{z}$ equal to 0.80 square mile. Using a value of A equivalent to the total area of Brown, Door, Kewaunee, and Manitowoc counties yields:

$$P = 4.86\text{E-}4 \text{ year}^{-1}$$

An equivalent value of 2.45E-4 year-1 is obtained using data based on the entire state.

At a 95% confidence interval Thom's formula becomes:

$$P' = P\left[1 \pm \frac{1.96}{(N)^{.5}}\right]$$

N is the total number of tornadoes in the area of concern during the ten years of record, 1960-1969 (the tornadoes of April 1970 are also included for conservatism).

The 95% confidence limits in the four counties around the site are 7.65E-4/yr and 2.09E-4/yr. The mean recurrence interval, R = 1/Pρ, is 2060 years, and at these confidence limits, the recurrence intervals R = 1/Pρ, range between 1310 and 4770 years. The danger from tornadoes is therefore very slight.

Damage caused by tornadoes results from three principal effects:

1. The dynamic forces resulting from the high velocity vortex winds;
2. The bursting forces caused by differential static pressure resulting from the sharp pressure reduction in the immediate vicinity of a tornado funnel;
3. The impact of missiles generated by (1) and (2) above.

The most widely accepted values of wind speed in a tornado appear to be about 300 mph (References 13, 14 and 15) or less for a very severe tornado at the peak of its intensity. Some sources mention values as high as 500-600 mph, (References 13 and 16) but these estimates appear to be based on indirect observations of phenomena such as straws driven into trees, etc., and are not regarded as authoritative.

The highest directly observed wind velocities were derived from motion pictures of debris in the Dallas Tornado of April 2, 1957 (Reference 14). These velocities ranged up to 170 mph tangential and 150 mph upward, resulting in a maximum wind vector of 227 mph. If higher velocities were present, they must have been very localized and not typical of the average wind on large bodies and structures.

The design wind speed of 300 mph with a forward progression of 60 mph is about 36% greater than that of the Dallas tornado and is thought to be conservative in view of the Kewaunee plant location. The greatest pressure drop associated with a tornado yet recorded was equivalent to a bursting pressure of approximately 3-psi (Reference 13). This measurement, however, is highly questionable and not regarded as authoritative. The greatest measured pressure drops have been on the order of 1.5 psi. For the Dallas tornado mentioned above, a maximum pressure drop of about 0.9 psi was determined from calculations (Reference 17).

An updated tornado study was performed in 2005 as part of the KPS Tornado Missile Risk Analysis (Reference 27). The study used data from 1950 to 2003. It developed a KPS tornado sub-region for the analysis that encompassed Wisconsin, Michigan, northern Illinois, and most of Minnesota. The sub-region's characteristics were:

1. It was homogeneous with respect to key tornado characteristics.
2. It was large enough to contain sufficient data for quantitative analysis.

The probability of occurrence of a tornado in the sub region was determined to be 3.97E-4 per square mile per year

The structural design criteria used to assure adequate design to accommodate the most severe storm conditions are discussed in Appendix B.

Ice Storms

Ice storms are infrequent in this region of Wisconsin. Wisconsin Public Service Corporation had transmission lines in this area, one of which was a line from Green Bay to Kewaunee to Sturgeon Bay. Six outages due to ice storms occurred on this line between 1940 and 1956, ranging in duration from 22 minutes to 2.5 hours. The line was rebuilt in 1956 with improved conductors. Only one outage occurred due to ice storms between 1956 and plant licensing.

Wind Direction and Speed

The distribution of wind direction frequencies is important in these analyses. Winds from certain directions may transport contaminant releases to uninhabited areas, as with offshore winds at this site, or conversely for onshore winds to populated areas. Table 2.7-2 illustrates the distribution of onshore and offshore winds. Onshore winds are winds that blow from the lake toward the land and are defined at the Kewaunee location as north-northeast through south. Offshore winds blow from the land toward the lake from south-southwest through north.

It is significant that offshore winds (blowing toward Lake Michigan) occur over 60% of the time on an annual basis.

Onshore winds occur most frequently during the spring and summer. The maximum occurrence of offshore winds is during the autumn and winter. These are typical conditions associated with a lake-breeze effect. Due to the temperature lag of Lake Michigan, land temperatures are warmer than the lake during spring and summer and colder during autumn and winter. During spring and summer a circulation results when air is heated from below by the land, rises, and is replaced by air over the lake flowing toward the land. A reversal occurs during the autumn and winter; air ascends over the warmer lake surface and is replaced by air flowing from the land. Actually this offshore lake-breeze wind can occur nocturnally during the summer but is usually quite weak. Onshore lake breezes normally only penetrate a mile inland.

The seasonal and annual distributions of wind direction are presented in Figure 2.7-2. The percentage of occurrence (in percent of the total number of observations in the period) for each of 16 directions is represented by the length of the bars on the wind rose.

Winds occur mainly from the western (180° through 360°) half of the compass (74.26%) annually. The distribution is quite similar to data presented in the Point Beach USAR (Reference 18). There appears to be no significant channeling effects or predominant directions although there is a low frequency of easterly component winds. Easterly winds, usually

REFERENCES (cont'd) - SECTION 2

27. Applied Research Associates, Inc, "Tornado Missile Risk Analysis for Kewaunee Nuclear Plant", ARA Report 16891, July 2005

pressure alarm on one header, isolate that header from the auxiliary building and then trip the pumps.

The rupture of a service water line in an Emergency Diesel Generator Room could result in the loss of the generator or the Safeguards bus in that room. Administrative operation from the Control Room of Type I Service Water valving would isolate the break and if required, realign the Service Water supplies through the intact piping from the operating Service Water Pumps.

The EDG exhaust duct and EDG fuel oil tank vent lines were evaluated using the EPRI computer code TORMIS to determine the probability of a damaging tornado missile strike. The evaluation determined that the probability of a tornado missile strike damaging one of these SSCs to the extent of inoperability is sufficiently small as to establish the acceptability of the SSC without the need for physical missile protection. This is consistent with the guidance of NRC SRP Sections 2.2.3 and 3.5.14.

Surveillance Requirements

The monthly tests specified for the diesel generators will demonstrate their continued capability to start and carry rated load. The fuel supplies and starting circuits and controls are continuously monitored, and abnormal conditions in these systems would be indicated by an alarm without need for test startup (Reference 2).

The less frequent overall system test demonstrates that the emergency power system and the control system for the engineered safety features equipment function automatically in the event of loss of all other sources of a-c power, and that the diesel generators start automatically in the event of a loss-of-coolant accident. This test demonstrates proper tripping of motor feeder breakers, main supply and tie breakers on the affected bus, and sequential starting of essential equipment, to the extent possible, as well as the operability of the diesel generators.

The specified test frequencies provide reasonable assurance that any mechanical or electrical deficiency is detected and corrected before it can result in failure of one emergency power supply to respond when called upon to function.

Station batteries will deteriorate with time, but precipitous failure is extremely unlikely. The continuous and periodic surveillance performed on the batteries will demonstrate battery degradation long before a cell becomes unserviceable or fails.

If a battery cell has deteriorated, or if a connection is loose, the voltage under load will drop excessively, indicating need for replacement or maintenance.

8.2.4 STATION BLACKOUT

Introduction

An evaluation was performed using the EPRI computer code TORMIS (reference 27) to determine the probability of a damaging tornado missile strike on two specific support components for safety-related equipment which may be adversely affected by tornado missiles. The evaluation used NRC Standard Review Plan criteria to determine if the probability of a damaging missile strike was sufficiently small as to establish acceptability of the SSC without the need for physical missile protection.

B.4.3 LIVE LOADS

Equipment loads are specified from manufacturer's drawings and floor loads are based upon the intended use of the floor.

B.4.4 DEAD LOADS

Dead loads consist of the weight of structural steel, concrete, dead weight of the component, etc., as computed for each case.

B.4.5 SEISMIC LOADS

Several different seismic loads were used in the design of this plant.

a. Operational Basis Earthquake (OBE):

   The Operational Basis Earthquake was based upon a maximum horizontal ground acceleration of 0.06g and the response spectra are given on Plate 8-A in Appendix A.

b. Design Basis Earthquake (DBE):

   The Design Basis Earthquake was based upon a maximum horizontal ground acceleration of 0.12g and the response spectra are given on Plate 8-B in Appendix A.

c. Uniform Building Code Earthquake Loads:

   The seismic loads for this category are in accordance with the requirements of the Uniform Building Code. This code specifies the location of the plant site to be in a "Zero" earthquake area. However, for conservatism, earthquake loads applicable to Zone 1 areas were used in the design under this category.

B.4.6 DESIGN BASIS ACCIDENT (DBA) LOADS

The Design Basis Accident for this plant was the instantaneous double-ended rupture of the cold leg of the Reactor Coolant System (RCS). This accident transmits loads to structures and equipment, which were designated as DBA loads.

A probabilistic evaluation using the EPRI computer code TORMIS was used to determine the likelihood of a damaging tornado missile strike on the EDG exhaust duct and EDG fuel oil tank vent lines. The missiles used in this evaluation were based on a walk down of the site. Table B.6-8 lists the missiles used in the TORMIS analysis and the critical closure velocities for each missile and each target.

Design for Missiles

The concept in analysis and design considered impact to be a plastic collision between the missile and the structure.

Tornado missiles generally are of an intermediate energy level. Their total kinetic energy is dissipated by energy absorption of the affected structure as a whole. This results from the elastic and plastic response of the structure to the impact force, energy absorption by the missile itself due to plastic deformation of the missile, and by the building structure missile barrier member due to local plastic deformation.

A missile barrier of reinforced concrete will react to missile impact as a combination of non-ductile concrete and ductile reinforcing steel. The mode of concrete failure will be brittle fracture such as might result from punching shear. Shear cracks will occur at the impact area perimeter and progress outward as concentric perimetric rings of fracture. A reinforced concrete member will respond elastically and plastically as a moment-resisting reinforced concrete element up to the point of brittle fracture of the concrete, and then the reinforcement will respond as tensile strands in membrane actions, elongating plastically to absorb the kinetic energy.

The problem of establishing a missile barrier can be subdivided according to the behavioral response of the characteristic structural element, i.e., slab, wall, beam, and column.

Slab and walls can respond by perforating or shear failure, plastic bending, and finally forming a tensile membrane as described above.

A comparison was made of various penetration formulas such as the Army Corps of Engineers, Ballistic Research Laboratory, and Modified Petry before selection of the Modified Petry formula as the most commonly used and best fit to the controlling conditions. None of the available formulas developed from empirical ballistic information were particularly suited to tornado missile problem solutions.

In using the Petry formula, the usual rule is to make a slab or wall of a thickness at least twice the penetration determined by the second Modified Petry formula for concrete of finite thickness. This was done assuming all deformation to occur in the concrete (indestructible missile). A correction factor was applied to steel missiles of non-circular or open cross-section, such as steel girts and steel pipe, so that the area used in the Petry formula to determine the theoretical penetration of an indestructible missile was 3 times the net cross-sectional area of the steel.

Assumption of an indestructible missile leads to very high peak loads and shear stresses when making an analysis for impulse loading, therefore, experiments of limited scope were performed which verified that almost all of the local plastic deformation would occur in the wood (for a wood missile) impacting on concrete, and that steel missiles would enter a plastic range while penetrating concrete.

To provide a workable solution for applying the Petry formula to a wood missile, a "K" value predicted on plastic deformation (or destruction) of the wood was used to determine the "penetration" or deceleration path, and from this a peak load was obtained. In the case of the steel missile, the peak load is limited by the short-duration yield strength of the steel.

Table B.6-6 is a tabulation of tornado-generated missiles, which shows the weight to cross sectional area ratio and gives the impact velocity of the worst case for these missiles. All tornado-generated missiles were assumed to impact end on at 90° to the surface being impacted, and all areas of Class I structures exposed to either falling or horizontally flying tornado missiles are investigated. The tornado missiles were assumed to come from stored material, destruction of lower class structures, off-site construction, etc. The peak loads associated with the various missiles are as follows:

- Horizontal flying wood plank 400 kips
- Vertical falling wood plank 288 kips
- Steel girts 197 and 257 kips
- Steel pipe 180 kips
- Automobile 182 kips

Using the peak load, slabs and walls were analyzed for their response to shear (approximately at the ultimate strength of the concrete, in shear) and ability to develop plastic hinges and a tensile membrane of reinforcing steel. After the shear failure of the slab or wall, the plastic deformation of the longitudinal reinforcing is calculated not to exceed a strain of 5%.

Reinforced concrete beams in a horizontal plane were analyzed for impulse loading. A rectangular force-time curve was assumed so that the methods contained in Reference 1 could be used. The dynamic system was established, including boundary conditions, size of member, member characteristics, reinforcing, loading, span, etc., to determine the natural frequency and plastic strength of the member. From the peak load previously found and the plastic resistance, the ductility factor was determined and this was conservatively limited to 6. If this is exceeded, the beam is redesigned to limit the ductility factor to 6. The dynamic reactions were calculated for the elastic or plastic strain range, as required, and combined with other loads (Dead loads, etc.). A minimum value of missile impact reaction of 300 kips was used in order to provide a minimum shear strength capability for missiles impacting near a support.

The allowable shear stresses used were:

$\phi\, 4 \sqrt{f'_c}d$ for reinforced beam webs,

$\phi\ 6\ \sqrt{f'_c}d$ for d/2 stirrup spacing,
$\phi\ 10\ \sqrt{f'_c}d$ for d/4 stirrup spacing

where:

ϕ = 0.85, and d = 1.25,
f'_c = ultimate compressive strength of concrete,

and using a minimum web reinforcement of 0.15% bs (beam width, b x bar spacing, s). Stirrup stress was limited to 0.85 times 1.25 f_y (yield strength of reinforcing bars) and bond stress was limited to $0.15f'_c$ with 0.85 of the summation of the perimeter of bars.

Beams designed by this procedure will have very minimal plastic deflection under tornado missile impact. Beams, which were too small to comply with the above requirements were investigated for the capability to hang from adjacent slabs as a thickened portion of the slab.

Columns were designed for a 300-kip missile impact load, centered on top, combined with all other applicable loading. The 300-kip load was chosen to establish a minimum strength in columns subject to missile impact and exceeds the dynamic reaction from the beams.

The stress level in columns under the above loading was limited to 1.5 times the ACI code allowable stress to provide a higher factor of safety in the columns than that used in beam and slab design.

The listed procedures were conservative and provide for missile barriers that can absorb sufficient missile energy to reduce the missile velocity to zero without physical breach of the barrier, and keep cracking and plastic deformation within acceptable levels.

An alternate methodology for evaluating tornado missiles is the EPRI computer code TORMIS. TORMIS can be used to show that the probability of a tornado missile strike damaging a SSC to the extent of inoperability is sufficiently small as to establish the acceptability of the SSC without the need for physical missile protection. The TORMIS evaluation for KPS showed that the probability of a damaging tornado missile strike on either EDG exhaust duct was 4.09E-7 per year and that the probability of a damaging tornado missile strike on one or more EDG fuel oil tank vent lines was 1.66E-7 per year. Both of these probabilities are less than the 1.0E-6 per year acceptance delineated in the NRC Standard Review Plan so missile protection is not required.

Internally-Generated Missiles

Missiles generated within containment, their weight-to-area ratio, and impact point and velocity are listed in Table B.6-7. Analyses of the effects of these missiles were based on a 90° angle of impact and are treated in the same manner as the tornado missiles.

Class I* Structures

REFERENCES – APPENDIX B (cont'd)

27. Applied Research Associates, Inc, "Tornado Missile Risk Analysis for Kewaunee Nuclear Plant", ARA Report 16891, July 2005

Table B.6-8 TORMIS Tornado Generated Missiles				
		Weight per	Critical Velocity (fps)	
Missile	Average Weight (lbs)	Unit Length (lb/ft)	EDG Exhaust	EDG FO Tank Vent
Rebar	8	2.67	>540	250
Gas Cylinder	226	38.64	120	9
Drum, Tank	163	23.55	166	12
Utility Pole	1122	32.06	24	3
Cable Reel	272	140.7	99	11
3" Pipe	76	7.58	267	26
6" Pipe	284	18.9	71	7
12" Pipe	743	49.6	36	3
Storage Bin	256	40.0	105	8
Concrete Paver	18	12.73	>540	120
Wood Beam	114	9.5	237	26
Wood Plank	33	3.3	>540	91
Metal Siding	110	11.0	184	18
Plywood Sheet	120	15.02	225	25
Wide Flange	892	27.87	30	2
Channel Section	225	11.88	90	9
Small Equipment	174	30.0	155	11
Large Equipment	4733	88.67	6	1
Steel Frame, Grating	194	12.37	104	10
Large Steel Frame	1421	50.0	19	1
Vehicle	3988	250.0	7	1
Tree	1400	35.0	19	2

Attachment 3

LICENSE AMENDMENT REQUEST 214
REQUEST FOR REVIEW AND APPROVAL OF METHODOLOGY CHANGE REGARDING TORNADO MISSILES

SITE SPECIFIC TORMIS RESULTS

KEWAUNEE POWER STATION

DOMINION ENERGY KEWAUNEE, INC.

Site Specific Tornado Hazard Analysis

TORMIS implements a methodology developed by the Electric Power Research Institute. TORMIS determines the probability of a tornado missile striking a particular target. The probability is calculated by simulating a large number of tornado strike events at the site for each tornado wind speed intensity scale. The TORMIS evaluation for Kewaunee is in accordance with EPRI NP-2005 using the site-specific information described below.

Site Specific Tornado Hazard Analysis

A site-specific analysis was performed to generate a tornado hazard curve for Kewaunee and a data set for the TORMIS analysis. The National Climatic Data Center database files for the years 1950 to 2003 were used as the source of data for the hazard analysis.

The site-specific tornado hazard analysis was performed in three steps:

1. Identification of an appropriate tornado subregion.
2. Development of the TORMIS data for that subregion.
3. Conversion of F-scale distribution to local tornado occurrence rates and the analysis of path length, width, and directional data.

There were three considerations in developing the Kewaunee tornado subregion. First, the subregion must contain the plant; second, the subregion must be homogeneous with respect to key tornado characteristics; and third, the subregion must be large enough to contain sufficient data for quantitative analysis.

A 15° X 12° latitude-longitude area, centered on the plant, was selected initially. This region is large enough to adequately represent the tornado risk in the vicinity of the plant, and reaches from St. Joseph, MO to Erie, PA, and north to the Canadian border. Cluster analysis was use to test the subregion homogeneity and further refine its extent.

The analysis constructed clusters from key tornado risk variables. The subregion means of these variables have standard errors due to tornado-to-tornado variation. By using the mean of the parameters for each 1° square block, the inherent and large tornado-to-tornado and year-to-year randomness is eliminated. Instead the identification of homogeneity is focused on more significant measures averaged over the 54 year period. The tornado risk parameters considered in this study included occurrence rate, point probability (the estimated probability of a tornado striking a point in a given area), and path direction.

Based on the cluster analysis, the final Kewaunee subregion was determined to include essentially all of Wisconsin, Michigan, and Minnesota. It also includes northern Illinois and a small portion of Indiana and Ohio. The total land area in the Kewaunee tornado subregion is 186,847 square miles.

Development of the required tornado data for TORMIS includes F-scale occurrence rates and path length, width, and direction. Table 1 summarizes the number of tornadoes reported by F-scale for the Kewaunee subregion. A total of 3,135 rated and 58 unrated tornadoes were reported in the 54-year period, producing an average of 59 per year. The mean unadjusted occurrence rate is 3.165E-4 tornadoes per square mile per year.

Table 1
Number of Reported Tornadoes – Kewaunee SubRegion (1950 – 2003)

F-Scale	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Unrated	58	-	-	-
-	11	0.4	11	0.4
0	954	30.4	965	30.8
1	1112	35.4	2077	66.3
2	701	22.4	2778	88.6
3	224	7.1	3002	95.8
4	115	3.7	3117	99.4
5	18	0.6	3135	100.0
Total Rated	3,135	100.0		
Total	3,193			

The F-scale distribution was adjusted for local tornado occurrence rates and the path length, width, and directional data from the Kewaunee subregion was statistically analyzed. Table 2 provides the results of this analysis.

Table 2
Adjusted Occurrence Rates and Windspeed Intervals for TORMIS Simulations

Local Tornado Intensity	Occurrence Rate (per square mile per year)	F-Scale Windspeed (mph)
F0	2.15 E-04	40 – 73
F1	7.98 E-05	73 – 112
F2	6.49 E-05	112 – 157
F3	2.44 E-05	157 – 206
F4	1.11 E-05	206 – 260
$\geq$F5	1.81 E-06	260 – 318
All	3.97 E-04	40 - 318

Probability distributions of tornado windspeed frequencies for the Kewaunee subregion were calculated using the TORRISK computer code. For the windspeed exceedance calculations, six windspeeds were analyzed in the simulations: 73, 100, 150, 200, 250, and 300 mph. These windspeeds correspond to structural damage producing gusts (several second time averages) at a height of 33 feet above grade.

Missile Characterization and Plant Model

Detailed surveys of Kewaunee were performed to characterize the targets and document potential wind-borne missile sources. A total of 21 missile source zones were used to describe the potential missiles found on site. The missile origin zones extended out approximately 1,600 feet from the targets of concern.

The basic missile spectrum used in the analysis consisted of 26 aerodynamic sets comprised of various prismatic shapes and three material types. Each aerodynamic set was divided into one to five subsets based on depth or diameter. The 53 subset combinations were reduced to a collection of 22 final missile subsets. The pertinent information for missile transport and damage calculations for each missile subset is given in Table 3. This information reflects the characteristics of the seven NRC stipulated missiles given in NUREG 0800, Section 3.5.1.4, Missiles Generated by Natural Phenomena.

Table 3

Tornado Missile Subset Characteristics

Final Missile Subset	Description (Typical)	Depth d (in)	WEIGHT PER UNIT LENGTH (lb/ft)	A_{min} (in^2)	Length/Depth Ratio Minimum (in)	Length/Depth Ratio Maximum (in)
1*	Rebar	1.00	2.67	0.79	36.0	36.0
2	Gas Cylinder	10.02	38.64	9.45	4.0	10.0
3	Drum, Tank	19.98	23.55	311.60	2.3	6.0
4*	Utility Pole	13.50	32.06	143.10	31.1	31.1
5	Cable Reel	42.21	140.70	126.60	0.5	0.6
6*	3" Pipe	3.50	7.58	2.20	34.3	34.3
7*	6" Pipe	6.63	18.90	5.60	27.2	27.2
8*	12" Pipe	12.75	49.60	14.60	14.1	14.1
9	Storage Bin	38.40	40.00	40.50	1.0	3.0
10	Concrete Paver	11.75	12.73	22.15	1.4	1.4
11*	Wood Beam	12.00	9.50	48.00	12.0	12.0
12	Wood Plank	12.00	3.30	12.00	8.0	12.0
13	Metal Siding	24.00	11.00	6.00	2.0	4.0
14	Plywood Sheet	48.00	15.02	50.74	2.0	2.0

Table 3

Tornado Missile Subset Characteristics

Final Missile Subset	Description (Typical)	Depth d (in)	WEIGHT PER UNIT LENGTH (lb/ft)	A_{min} (in^2)	Length/Depth Ratio	
					Minimum (in)	Maximum (in)
15	Wide Flange	11.29	27.87	8.16	8.0	60.0
16	Channel Section	5.11	11.88	3.49	9.0	80.0
17	Small Equipment	46.48	30.00	1.00	2.0	13.3
18	Large Equipment	67.07	88.67	15.70	0.3	18.8
19	Steel Frame, Grating	43.31	12.37	2.22	1.2	7.5
20	Large Steel Frame	97.41	50.00	11.00	2.0	5.0
21*	Vehicle	66.00	250.00	2574.0	2.9	2.9
22	Tree	8.00	35.00	50.27	30.0	90.0

* - Denotes membership in NUREG 0800 Sect. 3.5.1.4 standard spectrum of missiles

During the site surveys, each potential missile was classified into one of the 22 aerodynamic subset categories. It should be noted that classification was approximate in some cases, since the aerodynamic set cannot cover all possible shapes, sizes, weights, and materials of potential debris that can occur at a plant. For Kewaunee, several of the missiles were customized based on the site survey. The concrete missile was given the dimensions and weight of the concrete pavers on the Turbine Building roof. The metal siding missile was given the properties of the panels on the Turbine Building.

Failure windspeeds were specified for the buildings on site. Buildings that would be expected to experience wind failure include warehouses, trailers, and other non or marginally engineered buildings. Structures that are expected to experience minor to moderate damage include non-safety related structures constructed with either block walls or metal-sided exterior.

The estimated failure windspeed of the engineered buildings is in the range of 140 mph (peak gust) to 160 mph. The estimated failure windspeed of marginally engineered buildings such as old wood and metal constructed buildings is in the range of 120 mph to 140 mph. In the TORMIS analysis, the actual failure windspeed used is set to be equal to the lower value of windspeed associated with the F-scale which includes the failure windspeed. For example, a building with a failure windspeed of 140 mph, fails in a F-2 tornado (windspeeds between 112 and 157 mph) so a failure windspeed of 113 mph is assigned to the structure.

In the case of the Turbine Building, the four walls have been modeled as 18 separate missile sources; 9 concrete lower walls and 9 upper metal walls. The Turbine Building floor sections and the concrete roof deck have been modeled separately. The roof deck is modeled as 11 separate missile sources based on the areas that will experience similar pressures and have similar resistance.

The design pressure of the Turbine Building walls is 63 psf. Using the ASCE-7-02 pressure coefficients for components and cladding on walls, these panels have a failure windspeed of about 165 mph. Consistent with the methodology described above, Turbine Building panel failure was modeled to begin with a F-3 tornado (windspeeds of 157 to 206 mph).

A total of 27,826 potential missiles were identified. 5,275 missiles were due to material stored around the site (eg. scaffold poles and planks) and the failure of trailers located on site. 22,551 missiles were due to the failure of site structures.

TORMIS Results

The SSCs of interest for this evaluation were the A Emergency Diesel Generator (EDG) Exhaust Duct, the B EDG Exhaust Duct and the EDG fuel oil tank vent lines. A total of 14,000 tornadoes and a total of 28,000,000 missile histories were simulated for F1-F5 tornadoes for these targets. Each simulated tornado strikes the plant safety envelope. Damage to each component is based on the following criteria.

The TORMIS methodology evaluates target damage due to tornado missile impact by scoring the following events:

1. Missile hit on the target with impact velocity greater than the defined critical impact velocity.
2. Missile hit or impact on the target.
3. Local effects of missile damage, i.e. perforation of steel targets and either scabbing or perforation of reinforced concrete targets.
4. Velocity exceedance for 4 impact speeds for the automobile missile (The automobile is considered a "soft" missile that induces an overall structural response failure model, in contrast to local penetration failure caused by a semi-rigid or "hard" missile).

For the EDG exhaust vents and fuel oil tank vent lines, damage is assumed to result from crushing the components to a critical closure percentage. Penetration of these targets does not constitute damage. Table 4 gives a summary of the damage results.

Table 4
Target Hit and Damage Probabilities

Description	Hit Probability per Year	Crush Probability per Year
A EDG Exhaust Vent	4.96 E-06	2.73 E-07
B EDG Exhaust Vent	5.46 E-06	1.49 E-07
A or B EDG Exhaust Vent	7.56 E-06	4.09 E-07
A and B EDG Exhaust Vent	2.97 E-06	<1 E-07
EDG Fuel Oil Tank Vent Lines	5.76 E-07	1.66 E-07

The cumulative tornado generated missile strike probability (crush probability) for the EDG exhaust ducts and EDG fuel oil tank vent lines is 5.75 X 10^{-7} per year (4.09 E-7 + 1.66 E-7). General guidance covering the acceptance criteria for such analysis is given in the Standard Review Plan (NUREG 0800) Section 3.5.1.4, "Missiles Generated by Natural Phenomena," and by reference Section 2.2.3, "Evaluation of Potential Accidents." In Section 2.2.3, the following guidance is provided:

"The probability of occurrence of the initiating events leading to potential consequences in excess of 10CFR100 exposure guidelines should be estimated using assumptions that are as representative of the specific site as practicable. In addition, because of the low probabilities of the events under consideration, data are often not available to permit accurate calculation of probabilities. Accordingly, the expected rate of occurrence of potential exposures in excess of the 10CFR100 guidelines of approximately 1 X 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower."

The 5.75 X 10^{-7} per year probability for Kewaunee falls within the above guidelines.

Resolution of NRC's Five Points in the TORMIS Safety Evaluation Report

The following explanation provides the Kewaunee specific response to the five points the NRC staff raised in the safety evaluation of EPRI Report NP-2005 dated October 26, 1983.

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

Response:

As described in USAR Section 2.7.2, Descriptive Meteorology / Tornadoes, the probability of a tornado strike at Kewaunee is 4.86 E-04 per year with 95% confidence limits of 2.09 E-04 per year and 7.65 E-04 per year. This probability is based on 6 tornadoes reported in the four counties surrounding Kewaunee for the years 1960 to 1969.

For the TORMIS analysis, a more refined probability for tornado strikes was developed using data from the National Climatic Data Center database files for the years 1950 to 2003. The Kewaunee subregion used in the analysis is 186,847 square miles and includes essentially all of Wisconsin, Michigan, and Minnesota. It also includes northern Illinois and a small portion of Indiana and Ohio. A total of 3,135 rated and 58 unrated tornadoes were reported in the 54-year period, producing an average of 59 per year. The mean unadjusted occurrence rate is 3.165 E-04 tornadoes per square mile per year. The occurrence rate adjusted for local tornado occurrence rates and the path length, width, and directional data is 3.97 E-04 per square mile per year or 7.86 E-1 per year for the four counties surrounding the plant

The refined tornado occurrence rate was used, as it is more representative when applied over the same four county area used in the USAR methodology.

2. The EPRI study proposes a modified tornado classification, F' Scale, for which the velocity ranges are lower by as much as 25% than 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.

Response:

The Fujita Scale (F-Scale) wind speeds were used in lieu of the TORMIS wind speeds (F'-Scale) for the F-0 through F-5 tornadoes.

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, the user should calculate the effect of assuming velocity profile 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.

Response:

The tornado windfield parameters in the Kewaunee TORMIS analysis were adjusted to increase the windfield profile in the lowest 10 meters over the original profile in TORMIS. This adjustment applied the ratio of V_0 / V_{33} in a conservative manner in accordance with the NRC's October 26, 1983 TORMIS SER.

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 on the site specific missile sources and dominant tornado paths of travel.

Response:

A site specific walk down was performed that included the contents of the Turbine Building, parking lots, and switchyard. A total of 27,826 potential missiles were identified. 5,275 missiles were due to material stored around the site (e.g. scaffold poles and planks) and the failure of trailers located on site. 22,551 missiles were due to the failure of site structures. All the postulated missiles at Kewaunee were treated as minimally restrained in which each sampled missile is injected near the peak aerodynamic force, thus, maximizing the transport range and impact and consequently the damage frequency.

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

Response:

The TORMIS tornado missile risk analysis was performed consistent with the methodology reviewed and approved by the NRC.