TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

August 10, 1981

RECEIVED
AUG 17 1981
U.S. NUCLEAR REGULATORY COMMISSION

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ms. Adensam:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

As requested by NRC, TVA has reevaluated the issue concerning the potential for tornado generated missiles to compromise plant safety at Sequoyah Nuclear Plant by damaging the 480-V shutdown board transformers in the Auxiliary Building. My letter to you dated June 1, 1981 transmitted TVA's initial reevaluation of this issue. We have since had time to carefully study the issue and have determined that some erroneous information was included. A revised writeup discussing our study is enclosed.

If you have any questions, please get in touch with D. L. Lambert at FTS 857-2581.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L M Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 10th day of August 1981
Paulette H. White
Notary Public
My Commission Expires 9-5-84

Enclosure

B021 S 1/1

8108180193 810810
PDR ADOCK 05000327
P PDR

ENCLOSURE
SEQUOYAH NUCLEAR PLANT
ASSESSMENT OF THE POTENTIAL
FOR DAMAGE TO THE 480-V SHUTDOWN BOARD
TRANSFORMERS FROM TORNADO MISSILES

The total event probability, P_t, of a vertical tornado missile impacting one of the intake and exhaust vents on the roof of the auxiliary building is the product of several conditional probabilities:

$$P_t = P_s * P_n * P_v * P_a$$

where P_s is the probability of a tornado striking the plant

P_n is the probability of a missile striking a safety-related building given a tornado strike.

P_v is the probability of a vertical strike on a horizontal roof surface given a missile has impacted a safety-related building.

P_a is the probability of the missile striking that area of the roof containing a vent, given that a tornado missile has hit the roof.

<u>Tornado Strike Probability</u> (P_s)

The tornado strike probability, P_s, can be estimated using the information contained in References 1, 2, and 4. The tornado strike probability for the Sequoyah Nuclear Plant (SQN) area is given in WASH-1300 (Reference 1) as 1×10^{-3} per year for any tornado intensity. This probability assumes an average tornado damage path area of 2.8 mi^2. This is the probability of occurrence of tornadoes of any intensity. The fraction of tornadoes for given tornado tornadoes of any intensity. The fraction of tornadoes for given tornado intensities is given in Table 1. Sophisticated methods of predicting site specific tornado occurrence frequencies and frequencies for specific tornado intensities have been developed by several authors. One such method is incorporated in Reference 2 to predict the average occurrence frequencies for tornadoes with intensities of F2 and larger.

<u>Missile Strike Probability</u> (P_n)

The estimation of missile strike probabilities is based on the tornado missile risk analysis presented in Reference 2. Reference 2 considered a range of tornado intensities from F2 to F6 as having significant intensities (greater than 113 mi/h windspeed) to generate missiles.

A summary of the results of the analysis performed in Reference 2 is presented in Reference 3. An example case study is also presented in these references for a typical two-unit nuclear plant. The study assumes that unit 1 operates for the three years before completion of unit 2. During this three-year construction period, the analysis assumes a total of 5,000 available missiles from a spectrum of 26 missile types. This is more than the number of missiles that would normally be available during the remaining life of the plant when both units are operating. For the typical auxiliary building in tornado Region I the probability of a tornado missile impact is given in Reference 2 as 1.56×10^{-5} per year during the three-year period when unit 2 is under construction. This missile strike probability includes the estimate of the tornado occurrence frequency for Region I. Thus, the following estimate is reasonable for the Sequoyah auxiliary building.

$$P_s * P_n = 1.56 \times 10^{-5} \text{ per year}$$

The probability of a missile impact ($P_s * P_n$) for all targets of unit 1 in the example is given in Reference 2 as:

Lower Limit = 4.92×10^{-5} per year
Mean = 8.42×10^{-5} per year
Upper Limit = 1.19×10^{-4} per year

These upper and lower limits are the 95 percent confidence bounds for all targets.

Vertical Strike Probability (P_v)

In order for a missile to pass through a roof opening it must first strike in the roof area of the building. In addition, the missile trajectory must be nearly vertical in order for it to pass through a vent and pose a threat to the 480-V shutdown board transformers. The missile histories developed in Reference 2 show that a very small percent of all barrier impact events are on roof surfaces. From this, one can conservatively estimate the conditional probability of a vertical strike on the roof as $P_v = 1 \times 10^{-1}$.

Probability of Striking a Vent (P_a)

There is a total of 22 vents considered as potential missile entry points on the roof of the auxiliary building. Of these, eight have dimensions 4 feet x 8 feet and 14 have dimensions 4 feet x 4 feet. This is a total target area of 480 ft^2. The roof area of the auxiliary building in the example problem is 44,000 ft^2. It is reasonable to assume that a tornado missile has an equally likely probability of striking any area on the roof. The geometric probability of striking an area that contains a vent is then estimated as:

$$P_a = \frac{480}{44,000} = 0.01$$

Applicability to SQN

It is recognized that the studies presented in References 2 and 3 are for a representative two-unit nuclear plant site and that the probability values presented are not developed specifically for SQN. However, the representative site layout used in Reference 2 does consider similar basic safety features as the Sequoyah plant with similar sizes and distances. Also, the representative site is oriented with respect to the wind field in order to maximize potential missile trajectories. This is a conservatism due to the fact that not all tornado strikes at a specific site will be oriented in a similar manner.

The studies in Reference 2 also estimate the probability of a missile strike for a representative one-unit plant. The results for this site configuration show only a 5 to 10 percent decrease over the values for a representative two-unit site. This demonstrates the strike probabilities are not very sensitive to variations in the specific plant target area. Therefore, the calculation of site-specific probability values for SQN would not differ radically from those found in the representative site study.

The number and type of missiles available is also a site-specific consideration. As a conservative estimate of the tornado missile strike probabilities, the results for the case with one unit under construction are used.

Conclusion

Using the probabilities discussed above, a conservative estimate of the probability of a vertical tornado generated missile striking a vent on the auxiliary building is:

$$P_t = (P_s * P_n) * P_v * P_a = (1.56 \times 10^{-5})\ (0.1)\ (0.01)$$
$$= 1.56 \times 10^{-8} \text{ per year}$$

The probability of the missile entering the opening at the exact trajectory to hit a safety-related component is thus extremely unlikely. Postulating a double strike event occurring in such a manner as to damage redundant transformers would certainly be less likely and is, therefore, not considered to be a credible event for SQN.

The event that a vertical missile strikes one of the vents on the auxiliary building roof does not guarantee that one of the 480-V shutdown board transformers will be damaged. Further conditional probabilities must be considered such as the deflection and ricochet of the missile after impacting a vent and the remaining energy available for causing damage to the transformers.

The concern regarding the presence of roof openings over the transformer rooms was recently reviewed for TVA's Nuclear Safety Review Staff. The review focused on the damage which could result from the passage of a single missile through one of the roof openings. Due to the presence of separation barriers between transformers and separation of electrical cables and conduits, no interaction of losses were found which could result in the loss of both trains of safety-related systems. The impact of a second missile in another transformer room was not considered credible for the reasons discussed above.

In summary, the probability of a tornado missile impacting a vent on the auxiliary building roof with the resulting damage leading to events which endanger the safe operation of the plant is believed to be negligibly small.

TABLE 1
WINDSPEED DISTRIBUTION

Windspeed Classification	No. of Observed Tornadoes (Reference 4)	Predicted Fraction of Total for Region I (Ref. 2)	Observed Fraction of Total (Ref. 4)
F6 (windspeed 318 mi/h)	0	0.001	0.0
F5 (windspeed 260 to 318 mi/h)	127	0.0012	0.005
F4 (207 to 260 mi/h)	673	0.0211	0.027
F3 (158 to 206 mi/h)	2,665	0.0713	0.107
F2 (113 to 157 mi/h)	7,102	0.2668	0.285
F1 (73 to 112 mi/h)	8,645	0.4405	0.346
F0 (40 to 72 mi/h)	5,718	0.1991	0.229

REFERENCES

(1) WASH-1300, "Technical Basis for Interim Regional Tornado Criteria."

(2) L. A. Twisdale, Tornado Missile Risk Study, EPRI NP-768, May 1978.

(3) L. A. Twisdale, W. L. Dunn, J. Chu, "Tornado Simulation and Risk Analysis," ANS Topical Meeting on Probabilistic Analysis of Nuclear Reactor Safety, Los Angeles, California, May 1978.

(4) J. J. Tecson, T. T. Fujita, and R. F. Abbey, Jr., "Statistics of U.S. Tornadoes Based on the DAPPLE Tornado Tape," American Meteorological Society, 11th Conference on Severe Local Storms, Kansas City, Missouri, October 1979.