July 30, 1979

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Doc. Nos. 50-338 SP
VIRGINIA ELECTRIC AND POWER COMPANY	)	50-339 SP
	)	
	)	
(North Anna Power Station, Units 1 and 2)	)	Proposed Amendment to Operating License NPF-4

VEPCO'S TESTIMONY ON TORNADO MISSILES

I. PURPOSE OF THIS TESTIMONY

The purpose of this testimony is to supplement pages 14-15 of "Vepco's Testimony on High-Density Spent Fuel Storage Racks," dated June 23, 1979. The substance of the testimony at that point is that the risk of tornado missiles striking the spent fuel assemblies stored in the spent fuel pool for North Anna 1 and 2 is not significant for either large or small tornado missiles. The testimony says that the thick reinforced concrete walls of the fuel building protect the fuel assemblies from the direct impact of missiles with angles of approach up to approximately 45 degrees above the horizontal, so that the only missiles that could strike the fuel assemblies would be missiles coming in from a high angle. Large missiles (such as utility poles and automobiles), the testimony says, lack sufficient lift or velocity to clear the wall and could not

therefore enter the fuel pool at all. Smaller missiles, on the other hand, might rise high enough to avoid the fuel pool wall and enter the pool, but they would be less destructive than large missiles: a small downward traveling missile, the testimony says, would impact no more than a single fuel assembly.

Vepco now believes that the June 23 testimony needs to be qualified in certain respects. First, the statement that large tornado missiles cannot reach a height of 25 feet is not something that can be said with certainty. It is true that there has never, so far as we know, been a documented case of a utility pole being lifted higher than 25 feet above its original elevation in a tornado. Furthermore, field data indicate that objects that are actually displaced by tornadoes tend to tumble along the ground and that most are not sustained by the tornado winds. Evidence of large missiles being lifted 25 feet or more and propelled a significant distance is rare, and the information is often incomplete.

The available information does, however, suggest the possibility of such events. For example, there is one known case of a 4200-pound station wagon apparently rising to a height of 20 feet or more. The car in question was carried by a 1970 tornado in Lubbock, Texas, from the car's original

location to a spot 1,000 feet away. At the midpoint of its most likely trajectory was an earth-filled highway overpass approximately 20 feet high. While it is possible that the automobile may have tumbled along the ground for the 1,000-foot distance, there is no evidence that it did, and thus it is possible that the automobile cleared a height of about 20 feet as it crossed the overpass.

The potential for objects to be propelled by tornadoes has also been analyzed using computer programs that are based on analytically derived models as well as experiments and field data. Some of these models predict that it is possible for certain missiles to be lifted to heights of 25 feet or more. However, computer simulation of most large missiles predicts trajectories that have little or no upward lift.

Another statement in Vepco's testimony that needs to be qualified is the statement that the building geometry protects the fuel elements from direct impact of missiles approaching at lower than 45 degrees above the horizontal. The maximum angle of protection is 43.7 degrees and is for missiles entering the pool directly from the south side of the pool. If missiles were to come from directions approaching either the southwest or the southeast, the protection angle would decrease until the trajectories are blocked by the containments. The smallest

angle of protection is 23 degrees above the horizontal, which assumes the longest possible trajectory over stored fuel.

Because of the possibility, however small, that a large missile might enter the fuel pool, Vepco commissioned a computer study of the tornado missile risk to the North Anna 1 and 2 fuel pool. This testimony will summarize the results of that study in section III below. First, though, the testimony will address the probability of tornadoes occurring at the site at all.

II. PROBABILITY OF A TORNADO

The likelihood of occurrence of a tornado at the North Anna site is very small. The probability of a tornado striking North Anna 1 and 2 has been estimated using statistical methods proposed by H. C. S. Thom, which are appropriate means for estimating such probabilities. The analysis is described in Section 2.3.1.3.2 of the Final Safety Analysis Report (FSAR) for North Anna 1 and 2. Thom's method gives a rough approximation of the probability that a tornado will strike the site in any given year.

In the period January 1951 through June 1972, a total of 20 tornadoes were reported within a 50-mile radius of the North Anna site. This averages out to 0.93 tornadoes per year

within this radius. According to Thom, the probability of a tornado striking a point within a given area may be estimated as follows:

$$P = \frac{z \times t}{A}$$

Where:

P = the mean probability per year

z = the mean tornado path area

t = the mean number of tornadoes per year

A = the area of concern.

For the region surrounding the North Anna site, the mean tornado path length reported was about two miles, and the mean path width was about 240 yards. These values yield a z of 0.28 square miles, based on the January 1951 through June 1972 period of record. Using a 50-mile radius as a basis for A and a value of 0.93 tornadoes per year for t yields a probability of 3.3×10^{-5} per year for all tornadoes or a recurrence interval of 30,000 years.

Data compiled by Thom, which are based on 1953-1962 Iowa tornado data, yield a z of 2.8 square miles, a t of 0.5 per year, and an A of 3,700 square miles. This gives a probability of 3.8×10^{-4} per year or a recurrence interval of 2,600 years. However, Thom conservatively used a z value based on Iowa tornadoes, which greatly overestimates the path area in

Virginia.

These occurrence probabilities include the entire spectrum of tornadoes, ranging from very weak to severe storms. Since most tornadoes that occur are not classified as severe, the likelihood of a severe storm is even smaller. For example, the design basis tornado for a Region I site (North Anna is in Region I) is listed in WASH-1300, Technical Basis for Interim Regional Tornado Criteria (May 1974), as having a probability of occurrence of about 10^{-7} per year.

III. MISSILE RISK ANALYSIS

The study of the tornado missile risk to the North Anna 1 and 2 spent fuel pool, mentioned above, was prepared by the Research Triangle Institute and is entitled "Tornado Missile Risk Analysis of the North Anna Nuclear Power Station Units 1 and 2 Spent Fuel" (July 1979). The models and methodology used in the investigation to estimate the probabilities of missile impacts on the spent fuel pool are documented in another report, "Tornado Missile Risk Analysis," EPRI NP-768 and NP-769, Project 616, May 1978, prepared for the Electric Power Research Institute. The North Anna study utilized a simulation computer code, described in the above-referenced work, that employs mathematical models of the events contributing to the

tornado missile hazard to obtain estimates of the tornado missile event likelihoods. The study considered a whole spectrum of missiles, both large and small: the wood beam, the six-inch pipe, the one-inch rod, the utility pole, the twelve-inch pipe, and the automobile. This is the same missile spectrum specified in the NRC Staff's Standard Review Plan § 3.5.1.4.

The analysis shows that, for the entire population of postulated missiles, the combined probability of at least one tornado-generated missile entering the North Anna 1 and 2 spent fuel pool has been estimated as 7.65×10^{-7} per year. The majority (approximately 95 percent) of this risk is due to missile impact on the upper portion of the interior walls of the pool. The probability of missiles directly hitting stored fuel, which is covered by about 24 feet of water, was found to be much smaller. The computer simulation predicts that the probability of at least one tornado-generated missile directly hitting stored fuel, or even portions of the interior fuel pool wall extending six feet above the fuel racks, is about 4.34×10^{-8} per year. (This figure does not take into account the effect of the 24 feet of water.) The utility pole, 12-inch pipe, and automobile contributed less than one percent combined to the impact risk, which is to say that many of the predicted

missile impacts involved the lighter missiles that have a relatively weak damage potential.

Studies by the Electric Power Research Institute indicate that a utility pole shatters upon impacting a concrete slab 12 inches or more in thickness, and so utility poles (or other wooden missiles, such as the wood beam) that strike the fuel pool wall (which is six feet thick and constructed of reinforced concrete) do not present a serious threat to the spent fuel assemblies.

IV. CONCLUSION

On the basis of the referenced studies of tornado missiles and tornado missile risk, the following sequence of conclusions can be made regarding tornado missile hazards to the North Anna 1 and 2 spent fuel pool:

The regional tornado risk is small -- on the order of 10^{-4} to 10^{-5} per year. The chance of a severe tornado (which general must occur to produce a significant number of large heavy missiles) striking the plant is only a fraction of this risk, on the order of 10^{-6} per year. The probability of at least one tornado-generated missile entering the spent fuel pool has been estimated to be approximately 10^{-7} per year. Most such missiles were predicted to impact the interior pool

walls, rather than the stored fuel directly. Since the spent fuel assemblies are stored at the bottom of the pool in racks constructed of stainless steel and covered by about 24 feet of water, the probability of tornado missiles directly hitting stored fuel is even less. The study predicted that the probability of tornado missiles directly hitting stored fuel is on the order of 10^{-8} per year. (This figure does not take into account the protection afforded by the 24 feet of water or the steel racks themselves.) The risk analysis showed that large missiles represent less than one percent of the risk of direct impact to stored fuel and therefore represent only a small fraction of the hit probability.

Also, small missiles have a much smaller damage probability in that not all small missiles that reach the stored fuel would have sufficient damage capability to result in radiological consequences. Thus, the probability of radiological consequences in excess of 10 CFR Part 100 is even smaller (as shown by NRC Staff experts Campe and Ferrell, see "Affidavit of Kazimieras M. Campe and Charles M. Ferrell on Contention 3: Missile Accidents," page 6) than the probability of strike, and hence the overall risk of the tornado missile hazard to the North Anna 1 and 2 spent fuel pool is considered to be acceptably small.

These probabilities will be unaffected by the additional fuel to be stored in the pool as a result of Vepco's proposed modification. The probabilities presented are the probabilities of a tornado missile entering the spent fuel pool and striking the volume of the pool in which fuel is stored. Since the volume in which fuel is stored is unchanged from that used in the risk analysis, the probabilities will remain unchanged no matter whether the high-density or the low-density racks are used.

CERTIFICATE OF SERVICE

I certify that I have served a copy of Vepco's Testimony on Tornado Missiles on each of the persons named below by first-class mail, postage prepaid.

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