

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)	50-339 SP
COMPANY)	
)	
(North Anna Power Station,)	Proposed Amendment to
Units 1 and 2))	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

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

7 Vepco now believes that the June 23 testimony needs to
8 be qualified in certain respects. First, the statement that
9 large tornado missiles cannot reach a height of 25 feet is not
10 something that can be said with certainty. It is true that
11 there has never, so far as we know, been a documented case of a
12 utility pole being lifted higher than 25 feet above its
13 original elevation in a tornado. Furthermore, field data
14 indicate that objects that are actually displaced by tornadoes
15 tend to tumble along the ground and that most are not sustained
16 by the tornado winds. Evidence of large missiles being lifted
17 25 feet or more and propelled a significant distance is rare,
18 and the information is often incomplete.

19 The available information does, however, suggest the
20 possibility of such events. For example, there is one known
21 case of a 4200-pound station wagon apparently rising to a
22 height of 20 feet or more. The car in question was carried by
23 a 1970 tornado in Lubbock, Texas, from the car's original
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1 location to a spot 1,000 feet away. At the midpoint of its
2 most likely trajectory was an earth-filled highway overpass
3 approximately 20 feet high. While it is possible that the
4 automobile may have tumbled along the ground for the 1,000-foot
5 distance, there is no evidence that it did, and thus it is
6 possible that the automobile cleared a height of about 20 feet
7 as it crossed the overpass.

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

15 Another statement in Vepco's testimony that needs to be
16 qualified is the statement that the building geometry protects
17 the fuel elements from direct impact of missiles approaching at
18 lower than 45 degrees above the horizontal. The maximum angle
19 of protection is 43.7 degrees and is for missiles entering the
20 pool directly from the south side of the pool. If missiles
21 were to come from directions approaching either the southwest
22 or the southeast, the protection angle would decrease until the
23 trajectories are blocked by the containments. The smallest
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1 angle of protection is 23 degrees above the horizontal, which
2 assumes the longest possible trajectory over stored fuel.

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

10 II. PROBABILITY OF A TORNADO

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

20 In the period January 1951 through June 1972, a total
21 of 20 tornadoes were reported within a 50-mile radius of the
22 North Anna site. This averages out to 0.93 tornadoes per year
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1 within this radius. According to Thom, the probability of a
2 tornado striking a point within a given area may be estimated
3 as follows:

$$4 \quad P = \frac{z \times t}{A}$$

5 Where:

6 P = the mean probability per year

7 z = the mean tornado path area

8 t = the mean number of tornadoes per year

9 A = the area of concern.

10 For the region surrounding the North Anna site, the
11 mean tornado path length reported was about two miles, and the
12 mean path width was about 240 yards. These values yield a z of
13 0.28 square miles, based on the January 1951 through June 1972
14 period of record. Using a 50-mile radius as a basis for A and
15 a value of 0.93 tornadoes per year for t yields a probability
16 of 3.3×10^{-5} per year for all tornadoes or a recurrence
17 interval of 30,000 years.

18 Data compiled by Thom, which are based on 1953-1962
19 Iowa tornado data, yield a z of 2.8 square miles, a t of 0.5
20 per year, and an A of 3,700 square miles. This gives a
21 probability of 3.8×10^{-4} per year or a recurrence interval of
22 2,600 years. However, Thom conservatively used a z value based
23 on Iowa tornadoes, which greatly overestimates the path area in
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1 Virginia.

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

10 III. MISSILE RISK ANALYSIS

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12 The study of the tornado missile risk to the North Anna
13 1 and 2 spent fuel pool, mentioned above, was prepared by the
14 Research Triangle Institute and is entitled "Tornado Missile
15 Risk Analysis of the North Anna Nuclear Power Station Units 1
16 and 2 Spent Fuel" (July 1979). The models and methodology used
17 in the investigation to estimate the probabilities of missile
18 impacts on the spent fuel pool are documented in another
19 report, "Tornado Missile Risk Analysis," EPRI NP-768 and
20 NP-769, Project 616, May 1978, prepared for the Electric Power
21 Research Institute. The North Anna study utilized a simulation
22 computer code, described in the above-referenced work, that
23 employs mathematical models of the events contributing to the
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1 tornado missile hazard to obtain estimates of the tornado
2 missile event likelihoods. The study considered a whole
3 spectrum of missiles, both large and small: the wood beam, the
4 six-inch pipe, the one-inch rod, the utility pole, the
5 twelve-inch pipe, and the automobile. This is the same missile
6 spectrum specified in the NRC Staff's Standard Review Plan
7 § 3.5.1.4.

8 The analysis shows that, for the entire population of
9 postulated missiles, the combined probability of at least one
10 tornado-generated missile entering the North Anna 1 and 2 spent
11 fuel pool has been estimated as 7.65×10^{-7} per year. The
12 majority (approximately 95 percent) of this risk is due to
13 missile impact on the upper portion of the interior walls of
14 the pool. The probability of missiles directly hitting stored
15 fuel, which is covered by about 24 feet of water, was found to
16 be much smaller. The computer simulation predicts that the
17 probability of at least one tornado-generated missile directly
18 hitting stored fuel, or even portions of the interior fuel pool
19 wall extending six feet above the fuel racks, is about $4.34 \times$
20 10^{-8} per year. (This figure does not take into account the
21 effect of the 24 feet of water.) The utility pole, 12-inch
22 pipe, and automobile contributed less than one percent combined
23 to the impact risk, which is to say that many of the predicted
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1 missile impacts involved the lighter missiles that have a
2 relatively weak damage potential.

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

10 IV. CONCLUSION

11
12 On the basis of the referenced studies of tornado
13 missiles and tornado missile risk, the following sequence of
14 conclusions can be made regarding tornado missile hazards to
15 the North Anna 1 and 2 spent fuel pool:

16 The regional tornado risk is small -- on the order of
17 10^{-4} to 10^{-5} per year. The chance of a severe tornado (which
18 general must occur to produce a significant number of large
19 heavy missiles) striking the plant is only a fraction of this
20 risk, on the order of 10^{-6} per year. The probability of at
21 least one tornado-generated missile entering the spent fuel
22 pool has been estimated to be approximately 10^{-7} per year.
23 Most such missiles were predicted to impact the interior pool

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

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

1 These probabilities will be unaffected by the
2 additional fuel to be stored in the pool as a result of Vepco's
3 proposed modification. The probabilities presented are the
4 probabilities of a tornado missile entering the spent fuel pool
5 and striking the volume of the pool in which fuel is stored.
6 Since the volume in which fuel is stored is unchanged from that
7 used in the risk analysis, the probabilities will remain
8 unchanged no matter whether the high-density or the low-density
9 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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