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UTILITY POLE TORNADO MISSILE ANALYSIS OF DIESEL GENERATOR COMPARTMENTS AND REACTOR BUILDING AIRLOCK STRUCTURE AT OYSTER CREEK NUCLEAR GENERATING STATION

Prepared for

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I. INTRODUCTION

This report is an addendum to Applied Research Associates Final Report C570, "Tornado Missile Analysis of Diesel Generator Compartments and Reactor Building Airlock Structure at Oyster Creek Nuclear Generating Station," dated May 1983 [1]. It documents a study of the probability of utility pole tornado missile impact and damage to the diesel generator and airlock structures at Oyster Creek. The utility pole missile of the NRC standard missile spectrum [2] was not included in the previous study [1]. This report addresses this omission and combines the results with those obtained in Ref. 1 for the other NRC missiles.

The TORMIS methodology [3-12] has been used to estimate the tornado missile impact and damage probabilities. The plant structures, targets, and missile origin zones are identical to those documented in Ref. 1. This report documents the input data for the utility pole missiles and summarizes the results of the TORMIS simulations. The reader is urged to consult Ref. 1 for background information, figures, tables, and the detailed results for the other NRC missiles, namely, the 1-in rod, 3-in pipe, 6-in pipe, 12-in pipe, wood plank, and automobile.

II. UTILITY POLE MISSILE DATA

As documented in Ref. 1, a total of 14 missile origin zones have been used for the Oyster Creek Plant. GPU Nuclear Corporation conducted a plant survey to quantify the numbers of wood and steel poles in each of these missile origin zones. The total number of poles for each zone is given in Table II-1. All of these poles are treated as NRC utility pole missiles for the TORMIS simulations. The GPU survey also indicated that these poles are standing upright with none of them stored loose at the site. However, for a conservative TORMIS analysis, these poles were all treated as minimally restrained and released to the moving windfield at peak aerodynamic force so as to maximize missile transport [see Ref. 3 for a discussion of TORMIS injection modes]. The injection heights of the center of mass of the poles was conservatively specified as uniformly distributed between 20 and 30 feet above grade, as noted in Table II-1. No utility pole missiles were specified to originate as structure origin missiles.

TABLE II-1. NUMBERS OF UTILITY POLES AND INJECTION HEIGHTS

Missile Origin Zone	Number of Utility Pole Missiles	Injection Height (ft) Above Grade	
		Minimum	Maximum
1	39	20	30
2	35	20	30
3	7	20	30
4	15	20	30
5	17	20	30
6	13	20	30
7	5	20	30
8	72	20	30
9	7	20	30
10	18	20	30
11	10	20	30
12	15	20	30
13	5	20	30
14	16	20	30
Total	274		

III. TORMIS RESULTS

A. General

An Oyster Creek TORMIS data set was developed using the utility pole data given in Section II and data in Ref. 1. The data set was checked in a two step process prior to the TORMIS production runs. First, a TORMIS data set was created to duplicate results in Ref. 1 for the first two tornadoes (each simulating 100 missile histories) from the F5 production runs for each target group (diesel generators and airlock structure). Identical results were obtained in both cases and hence validation of the correct data sets for tornado, target, and missile characteristics was achieved. Modifications were then made to the missile data for the utility pole missile. The modified data set was checked carefully and sample problems were run for each target group at F 5 intensity.

At the completion of this validation and checking phase, the TORMIS production runs were submitted in two batches corresponding to the two target groups. Each batch consisted of a total of 30,000 tornado missile histories, corresponding to 5,000 histories for each F-scale intensity from F'1 through F'6. The variance reduction parameters were developed separately for the Diesel Generator targets (Batch 1) and the Airlock Structure targets (Batch 2). This procedure follows the recommended TORMIS approach for separate target clusters, as outlined in Ref. 3. The results of these F-scale simulations were aggregated to yield total probability estimates over all tornado intensities for each diesel generator and airlock structure target, as summarized in Table III-1.

B. Diesel Generator Targets

For the diesel generator targets, utility pole missile impacts were obtained on all 9 targets. The utility pole hit probability is estimated as 4.5×10^{-6} and 1.3×10^{-6} per year for Targets 1 and 2, respectively. The increased hit probability of Target 1 over Target 2 is due principally to the south and west wall exposures of Target 1, as noted in Ref. 1. Neither diesel generator compartment was scabbed by the utility pole missiles on the 18-in

TABLE III-1. TARGET IMPACT AND PERFORATION PROBABILITIES

		Utility Pole Missiles					
		Impact			Scabbing, Perforation Damage		
Target Number	Target Description	Lower Bound	Mean	Upper Bound	Lower Bound	Mean	Upper Bound
1	DG-U1	1.9×10^{-6}	4.5×10^{-6}	7.1×10^{-6}		*	
2	DG-U2	5.4×10^{-7}	1.3×10^{-6}	2.1×10^{-6}		*	
3	GE-U1	0	1.9×10^{-7}	5.2×10^{-7}		*	
4	GI-U1	0	1.3×10^{-8}	3.1×10^{-8}		*	
5	GE-U2	0	1.2×10^{-9}	3.4×10^{-9}		*	
6	GI-U2	0	1.0×10^{-7}	3.0×10^{-7}		*	
7	ESO-U1	0	8.5×10^{-9}	2.1×10^{-8}	0	8.5×10^{-9}	2.1×10^{-8}
8	ESO-U2	0	4.4×10^{-10}	1.2×10^{-9}	0	4.4×10^{-10}	1.2×10^{-9}
9	DOTC	2.8×10^{-7}	6.8×10^{-7}	1.1×10^{-6}		*	
10	AS	1.7×10^{-6}	1.0×10^{-6}	1.8×10^{-5}	1.5×10^{-8}	1.0×10^{-7}	1.9×10^{-7}
12	IAD-SO	0	2.3×10^{-7}	6.1×10^{-7}		*	
13	IAD-NO	0	3.5×10^{-7}	8.8×10^{-7}		*	
3n5			*			*	
3u5		0	1.9×10^{-7}	5.2×10^{-7}		*	

* Denotes no impacts or damages occurred in the simulation.

reinforced concrete walls or the 12-inch roof barriers, as noted in Table III-1. These impact probabilities are factors of 10 and 5, respectively, less than those reported in Ref. 1 for the other NRC missiles.

The impact probability on the diesel oil tank compartment (Target 9) is estimated as 6.8×10^{-7} per year. No scabbing damages occurred in the TORMIS simulations on the 18-inch reinforced concrete walls. Hence, the 18-inch walls and 12-inch roo^ slabs are not vulnerable to utility pole tornado missile damage.

The probabilities of hitting the exhaust and intake grating targets (Targets 3-6) vary from 1.0×10^{-7} to 1.2×10^{-9} per year. These small probabilities are similar to the results in Ref. 1 and the variation among target of similar size reflects the rooftop location of these targets and their relatively small size (160 sq ft). As noted in Table III-1, these heavy duty gratings were not perforated in any of the TORMIS simulations.

Targets 7 and 8 represent the Exhaust Stack openings for compartments 1 and 2, respectively. These targets were modeled with no perforation resistance and hence missile impact is assumed to be equivalent to missile entrance into the diesel generator compartment. The utility pole missile entrance probabilities vary from 8.5×10^{-9} for Target 7 to 4.4×10^{-10} per year for Target 8 with the variation in these estimates resulting from limited Monte Carlo sample sizes. These probabilities are significantly less than those obtained for other missiles in Ref. 1 (compare to 1.1×10^{-7} and 4.8×10^{-9}, respectively) and hence constitute a negligible increment to the total target risk. Hence, the utility pole missile does not affect significantly the results presented in Ref. 1 for the tornado missile vulnerability of the diesel generator compartments at Oyster Creek.

C. Airlock Structure

The estimated utility pole impact and perforation probabilities for the Airlock Structure are 1.0×10^{-6} and 1.0×10^{-7} per year, respectively. These probabilities are smaller than those obtained in Ref. 1 for the other missile sources (compare to 1.4×10^{-5} and 6.6×10^{-6}, respectively) by about a factor of 7. Hence, the incremental risk for the utility pole missile is also negligible for the Airlock Structures.

IV. CONCLUSIONS

In Ref. 1, the results were conservatively presented by taking into account statistical uncertainties from finite Monte Carlo sample size coupled with a model uncertainty factor of two. The following probability estimates of tornado missile damage to the diesel generator and airlock targets were thus obtained (see page IV-1 of Ref. 1):

Target Group	Missile Damage Probability (per yr)
Diesel Generator	$\sim1\times10^{-7}$
Airlock Structure (Door Open)	$\sim1\times10^{-6}$ to 6×10^{-6}
Airlock Structure (Door Closed 80%)	$\sim2\times10^{-7}$ to 1×10^{-6}

When the utility pole results are adjusted in a similar manner (as in Ref. 1) to reflect statistical and model uncertainties and are added to the above results, one obtains

Target Group	Missile Damage Probability (per yr)
Diesel Generator	$\sim1.4\times10^{-7}$
Airlock Structure (Door Open)	$\sim1.1\times10^{-6}$ to 6.1×10^{-6}
Airlock Structure (Door Closed 80%)	$\sim2.2\times10^{-7}$ to 1.2×10^{-6}

Hence, the utility pole missile results in only a marginal increase in the total damage probabilities for these targets. As emphasized in Ref. 1, these probabilities are based on numerical estimates obtained from a plant-specific evaluation with judgmental factors and some consideration of statistical and model uncertainties. The confidence intervals on the mean probabilities given in Table III-1 include only the statistical uncertainties resulting from a finite sample size in the Monte Carlo calculations. In the absence of additional simulations and sensitivity analyses using a more general missile spectrum, these probabilities represent realistic to conservative estimate of missile damage probabilities for Oyster Creek. They reflect statistical and model uncertainties as well as conservatisms in the tornado parameters, number of missiles, and TORMIS missile injection methodology.

V. REFERENCES

1. Twisdale, L. A., and Dunn, W. L., "Tornado Windspeed and Missile Risk Analysis of Diesel Generator Compartments and Reactor Building Airlock Structure at Oyster Creek Nuclear Generating Station," Final Report C570, Applied Research Associates, Inc., Raleigh, North Carolina, May 1983.

2. Nuclear Regulatory Commission, "Missiles Generated by Natural Phenomena," Section 3.5.1.4, Standard Review Plan, Revision 1, November 1975.

3. Twisdale, L. A., and Dunn, W. L., "Tornado Missile Simulation and Design Methodology," EPRI NP-2005, Electric Power Research Institute, Palo Alto, California, August 1981.

4. Twisdale, L. A., et al, "Tornado Missile Risk Analysis," EPRI NP-768 (Vol. I) and EPRI NP-769 (Vol. II), Electric Power Research Institute, Palo Alto, California, May 1978.

5. Twisdale, L. A., "Risk-Based Design Against Tornado Missiles," Proceedings of the Third ASCE Specialty Conference on Structural Design of Nuclear Power Plant Facilities, Boston, Massachusetts, April 1979.

6. Twisdale, L. A., "Tornado Data Characterization and Windspeed Risk," Journal of the Structural Division, Proceedings ASCE, Vol. 104, No. ST10, October 1978.

7. Twisdale, L. A., Dunn, W. L., and Davis, T. L., "Tornado Missile Transport Analysis," Journal of Nuclear Engineering and Design, 51, 1979.

8. Dunn, W. L., and Twisdale, L. A., "A Synthesized Windfield Model for Tornado Missile Transport," Journal of Nuclear Engineering and Design, 52, 1979.

9. Twisdale, L. A., "Probabilistic Considerations in Missile Impact Assessment," Proceedings of the International Seminar on Probabilistic Design of Nuclear Power Plants, San Francisco, California, August 1977.

10. Twisdale, L. A., "An Assessment of Tornado Windfield Characteristics for Missile Loading Prediction," Proceedings of the Fourth U.S. National Conference on Wind Engineering Research, University of Washington, Seattle, Washington, July 1982.

11. Twisdale, L. A., "Regional Tornado Data Base and Error Analysis," Preprint, AMS Twelfth Conference on Severe Local Storms, San Antonio, Texas, January 1982.

12. Twisdale, L. A., and Dunn, W. L., "Probabilistic Analysis of Tornado Wind Risks," Journal of Structural Engineering, Vol. 109, No. 2, February 1983.