Item A-38: Tornado Missiles (Rev. 3)

DESCRIPTION

Historical Background

The AEC first established missile-protection requirements in 1967. GDC-2 and GDC-4 of 10 CFR Part 50, Appendix A, require in part that structures, systems, and components important to safety be designed to be able to withstand the effects of tornado missiles. Specific design acceptance criteria to meet the requirements of GDC-2 and GDC-4 and recommended methods of satisfying the acceptance criteria are detailed in SRP[11]

Sections 3.3.2 and 3.5.1.4 and in Regulatory Guides 1.76[1] and 1.117.[2]

A limited reexamination of tornado missile protection requirements in 1976 resulted in significant reduction in requirements. However, it was suggested[3] that the existing tornado missile protection requirements may have been more conservative than necessary. The purpose of this NUREG-0371[2] item was to reexamine the requirements more precisely with a view to a possible outcome of adequate protection at less industry cost. The evaluation of this issue included consideration of Issue A-32.

Safety Significance

Missiles generated by tornadoes could potentially damage systems or components containing radioactivity or

necessary for the safe shutdown of a reactor.[4] This damage may directly result in the release of radioactivity to the environment or ultimately affect core cooling and result in core damage or melting.

Possible Solution

The existing tornado missile requirements included structural strengthening of potential safety-significant targets of tornado missiles, concrete missile protection for spent fuel pools, and increased concrete wall thickness around safety-class structures other than containment to stop tornado missiles.

The suggested task was to investigate whether postulated missile velocities, size, and orientation used in plant safety analyses were more conservative than tornado damage histories warranted. The end product of this task was to be a set of design basis missiles that did not impose unnecessary design requirements on plant construction and for which a sound technical basis existed.

PRIORITY DETERMINATION

Frequency Estimate

This issue was addressed in WASH-1400[5] where the findings presented were based on work by Doan.[6] It

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[1] Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, April 1974. [7907100297]
[2] Regulatory Guide 1.117, "Tornado Design Classification," U.S. Nuclear Regulatory Commission, June 1976, (Rev. 1) April 1978. [7907110104].
[3] NUREG-0371, "Task Action Plans for Generic Activities (Category A)," U.S. Nuclear Regulatory Commission, November 1978.
[4] Nuclear Safety, Vol. 11, No. 4, pp. 296–308, "Tornado Considerations for Nuclear Power Plant Structures Including the Spent Fuel Storage Pool," P.L. Doan, July 1970.
[5] WASH-1400 (NUREG-75/014), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," U.S. Atomic Energy Commission, October 1975.
[6] Nuclear Safety, Vol. 11, No. 4, pp. 296–308, "Tornado Considerations for Nuclear Power Plant Structures Including the Spent Fuel Storage Pool," P.L. Doan, July 1970.

was stated that the probability of energetic tornado-generated missiles would be less than 5 x 10^{-6} and that the only likely damage to sensitive plant systems would be the loss of the diesel generator building doors. The probability of this event causing a core-melt accident or any other significant radioactive release would be less than 10^{-3}.

Thus, the frequency of a core-melt accident resulting from a tornado was estimated to be 5 x 10^{-9} /RY or 1.5 x 10^{-7}/reactor over a 30-year operating life. Large changes to the missile criteria would not be made and the effect on core-melt frequency would be intentionally small (10%). A 10% increase in the core-melt frequency would be

1.5 x 10^{-8}/reactor.

Consequence Estimate

Depending on the systems or structures that are damaged, almost any type of core-melt scenario could occur. However, as a bounding estimate, it was assumed that the worst core-melt scenarios (Release Categories PWR-1, PWR-2, PWR-3, BWR-1, and BWR-2) would occur. Although a tornado missile event is likely to be followed by high winds, typical meteorological behavior was assumed along with a mean population density of 340 people per square-mile. The release categories listed above were calculated to result in between 4 and 7 million man-rem. Therefore, the release from a tornado missile event was estimated to result in about 5 x 10^{6} man-rem.

Assuming possible reduced (lower-cost) tornado missile protection requirements, the total increase in risk for future reactors was estimated to be (1.5 x 10^{-8}) (5 x 10^{6}) man-rem/reactor or 0.08 man-rem/reactor.

Cost Estimate

Industry Cost: The potential cost savings to future plants was estimated, to a rough approximation, by considering the volume of reinforced concrete potentially saved. According to an estimate from SEB/DE/NRR, tornado protection (for wind loads and missiles combined - they are not readily separable) involved roughly 2,200 cubic-yards of reinforced concrete for a typical plant. At $900/cubic-yard of concrete in place (based

on Means, "Building Construction Cost Data, 1981," for elevated slabs, plus 15% inflation since January 1981 and 100% for NRC special requirements), the estimated cost was about $2M/plant. Since only modest

changes to the criteria were intended, the reduction in missile resistance reflected in design parameters, such as wall thickness, would be small (again 10%). A 10% saving due to reduced missile requirements would mean

$200,000 saved per future plant.

NRC Cost: The proposed NRC study was estimated to cost about $300,000, based on the NUREG-0371[7] estimate of 2.4 man-years plus a $60,000 technical assistance contract. However, when amortized over more than 10 future plants, the NRC cost was small compared to industry costs.

Total Cost: The total industry and NRC cost associated with a possible solution to the issue was estimated to be

$0.2M/reactor

Value/Impact Assessment

The estimated value/impact score for retention of the existing tornado missile protection requirements for future plants (rather than relaxing them as discussed) was given as follows:

[7] NUREG-0371, "Task Action Plans for Generic Activities (Category A)," U.S. Nuclear Regulatory Commission, November 1978.

$$S = \frac{0.08\text{man} - \text{rem / reactor}}{\$0.2\text{M / reactor}}$$

$$= 0.4\text{man} - \text{rem / reactor}$$

Uncertainties

At the time this issue was evaluated, tornado missile protection was a recent development nearly unique to nuclear power plants and was not a matter of any long-established engineering practice. The probabilistic

estimates were widely recognized as subject to great data-base uncertainties (See NUREG/CR-2300,[8] p.10-1). Existing and possible modified future requirements depended heavily on engineering judgment and intuitive interpretation of limited data. However, even if the estimated frequency of a core-melt accident resulting from a tornado (which was very small) was increased by a factor of 10 or even 100, the conclusion would not change.

The magnitude of the cost savings (if any) that could be achieved, depending on the outcome of the proposed study, could not be reliably predicted at the time this issue was evaluated. At best, these savings could be bounded by consideration of the total cost of tornado protection. The total savings achievable would be a function of the number of future plants affected and the distribution of these plants among the three regions of the U.S. with a high incidence of tornadoes. If the cost savings were significantly smaller, the net cost savings including NRC costs would become negligible.

Other Considerations

Reduction of tornado missile protection requirements may not be fully reflected in reduced concrete wall thicknesses, etc., because, at some point, other factors such as tornado wind loadings may become controlling. Also involved here were various man-made external events for which specific consideration had not been required, because of reliance on tornado missile protection to provide an adequate "umbrella" of protection.

These events include small aircraft crashes, missiles from offsite explosions, and physical attacks.

CONCLUSION

It was possible that further reexamination of tornado missile requirements could have led to industry cost savings due to reduction of these requirements (beyond the reductions made on the basis of the 1976 reexamination) without significant risk increase. If there was greater assurance that these cost savings would be significant

and likely to be achieved (by performing a more detailed design and cost analysis), this issue would have warranted a high priority. However, the savings could only be realized in those plants not yet designed or under construction. Since such new plants were possible at some indefinite future time, the issue was given

a low priority ranking (see Appendix C) in November 1983. In NUREG/CR-5382,[9] it was concluded that consideration of a 20-year license renewal period did not change the priority of the issue. Further prioritization,

using the conversion factor of $2,000/man-rem approved[10] by the Commission in September 1995,

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[8] NUREG/CR-2300, "PRA Procedures Guide," U.S. Nuclear Regulatory Commission, (Vols. 1 and 2) January 1983.
[9] NUREG/CR-5382, "Screening of Generic Safety Issues for License Renewal Considerations," U.S. Nuclear Regulatory Commission, December 1991.
[10] Memorandum for J. Taylor from J. Hoyle, "COMSECY-95-033"Proposed Dollar per Person-Rem

resulted in an impact/value ratio (R) of $2.5M/man-rem, which placed the issue in the DROP category.

Conversion Factor; Response to SRM Concerning Issuance of Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission and SRM Concerning the Need for a Backfit Rule for Materials Licensees (RES-950225) (WITS-9100294)," September 18, 1995. [9803260148]