ANALYSIS GROUP TECHNICAL REPORT

SAFETY AND AVAILABILITY ASSESSMENT

NMP1 Tornado Missile Risk – Diesel Generator Rooms

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1.0 Background and Objectives

The risk from high winds and tornadoes was assessed in the NMP1 IPEEE[1]. The risk of missiles was judged as bounded by the analysis of wind; no quantitative analysis of missiles was provided. NRC has asked[2] specifically that NMPC determine the contribution to core damage frequency (CDF) from tornado missiles hitting one or both EDG rooms.

The objectives of this analysis are as follows:

- Provide a simplified analysis of CDF due to tornado missiles to show that this risk is less than 1E-6/year as judged in the IPEEE.
- Use the simplified analysis to support sensitivity analysis and decision-making with regard to further protecting the diesel generators from turbine missiles.

2.0 Approach

Two different analyses are presented here. These support and compliment one another. The first analysis, presented in section 5 is a simplified analysis based on engineering judgment and data from Reference 4 and the IPEEE. This method was used to support sensitivity studies. The second analysis is based on a data from a detailed TORMIS[7] analysis of Unit 2. This was performed as a "sanity check" for the first analysis.

This analysis excludes the impact of tornadoes on areas of the plant other than the EDG room doors. This analysis also excludes the impact of effects other than tornado missile strikes.

3.0 Results and Conclusions

The base case analysis in Section 5 indicates that CDF is less than 1E-6/year due to tornado missiles. The total core damage is 3.5E-7/year.

In Section 6, another approach was taken to evaluate tornado missile risk utilizing an NMP2 analysis. In this analysis, the results are similar.

Based on these analyses and the sensitivity cases in section 4, the risk of tornado missiles is judged acceptably small (<1E-6/year CDF).

4.0 Sensitivity Cases

Sensitivity cases were run with the model in Section 5 as summarized below:

1. Failure probability of top event Door was increased to 0.1 (versus 0.01), 0.5 (versus 0.1), and 0.9 (versus 0.5). The resulting CDF due to Missiles is 8.5E-7. This case shows that the conclusions are not sensitive to the probability of a missile hitting a door (e.g. CDF is on the order of 1E-06 or less).

2. Failure probability of EDG1 and 2 were increased to 0.5 (versus 0.1), 0.9 (versus 0.3), and 1.0 (versus 0.9). The resulting CDF due to Missiles is 8.8E-7. This case shows that the conclusions are not very sensitive to diesel fragility.

3. Same as Case 1 above plus EDG2 was set to 1.0 when EDG1 fails. The resulting CDF due to Missiles is 2.0E-6. This case shows that the conclusions are sensitive to increasing the probability of door hits combined with increasing the common cause failure probability of the diesels.

During a recent plant walk-down, trucks and barrels were observed in the area adjacent to the diesel rollup doors. Since these objects are parked here in preparation for a refueling outage, the applicable fraction of time during the year must be considered as well as the impact on top events "Door" and "EDG" in order to evaluate the CDP associated with this condition. In our judgment, the sensitivity cases above envelope these temporary conditions.

5.0 Analysis Method 1

A simplified quantitative analysis of tornado missile risk associated with hitting the diesel generator rollup doors is provided below. The event tree below is used to represent key aspects and uncertainties of the event and show the frequency (freq) of each scenario (#). Then, based on the impact of each scenario (Impact), a conditional core damage probability (CCDP) is calculated from the NMP1 PRA[3]. This is documented below and in Attachment 1. Core damage frequency (CDF) is the product of sequence frequency (freq) and CCDP.

Tornado	Speed	Door	EDG1	EDG2	#	freq	Impact	CCDP	CDF
0.001	0.30				1	2.97E-04	losp	4.00E-04	1.19E-07
		0.01			2	2.43E-06	losp	4.00E-04	9.72E-10
				0.10	3	2.70E-07	losp, edg2	7.88E-03	2.13E-09
			0.10		4	2.70E-07	losp, edg1	6.90E-03	1.86E-09
				0.10	5	3.00E-08	losp, edg1&2	2.40E-01	7.20E-09
	0.017				6	1.53E-05	losp	4.00E-04	6.12E-09
		0.10			7	8.33E-07	losp	4.00E-04	3.33E-10
				0.30	8	3.57E-07	losp, edg2	7.88E-03	2.81E-09
			0.30		9	3.57E-07	losp, edg1	6.90E-03	2.46E-09
				0.30	10	1.53E-07	losp, edg1&2	2.40E-01	3.67E-08
	0.003				11	1.50E-06	losp	4.00E-04	6.00E-10
		0.50			12	1.50E-08	losp	4.00E-04	6.00E-12
				0.90	13	1.35E-07	losp, edg2	7.88E-03	1.06E-09
			0.90		14	1.35E-07	losp, edg1	6.90E-03	9.32E-10
				0.90	15	1.22E-06	losp, edg1&2	2.40E-01	2.92E-07
							Total CDF		4.74E-07
							Total CDF	Missiles	3.47E-07

Tornado = tornado frequency
Speed = severity of tornado by speed

Door = probability that tornado & missile(s) does not impact EDG door area
EDG1 = probability that missile(s) does not disable EDG102
EDG2 = probability that missile(s) does not disable EDG103

The above event tree and analysis represents our judgment and present state of knowledge regarding CDF risk. Each event tree top event is described below with regard to scenarios, top event probability, and how they impact the plant and the PRA calculation of CCDP.

Tornado – tornado frequency
The frequency of a tornado in a 1° x 1° area in which NMP1 is located is 1E-3/year according to Rutch[4]. The above model assumes irrecoverable loss of normal AC power (LOSP impact) for this event, which is conservative because every tornado occurrence does not cause loss of offsite power. Also, not all LOSP events are unrecoverable.

Speed – severity of tornado by speed
There are three branches in this simplified analysis to represent tornado severity as summarized below:

- Top branch is the conditional probability that tornado speed is between 80 and 150 MPH. This represents relatively smaller tornadoes.
- Middle branch is the conditional probability that tornado severity is such that speed is between 150 and 190 MPH. This represents a more severe tornado.
- Lower branch is the conditional probability that tornado severity is such that speed is greater than 190 MPH. This event is a very severe tornado.

The conditional probability for each branch is based on the following data from Rutch[4]:

Wind Speed (MPH)	Probability of Exceedance
80	0.32
150	2.0E-2
190	3.0E-3

This simplified set of branches are set up to obtain a more reasonable probability of the tornado effecting the target (EDG rollup doors) versus the size or severity of the tornado. The probability of top events "Door" and "EDG1 & EDG2" below are dependent on tornado severity.

Door – probability that tornado and missile(s) does not impact EDG door area
The failure branch represents the conditional probability that the tornado and its missiles impact the EDG rollup door area. This is a localized area between Unit 1 and Unit 2 structures. The more severe and larger the tornado, the more likely it is to effect the EDG rollup door area on site. Each of the three branches in the event tree are summarizes below:

- The top "Speed" Branch: The likelihood of a smaller tornado or its missiles moving between the two Units (a localized area protected by both Unit 1 and Unit 2 structures) is unlikely. The likelihood of reaching this localized area is small. The probability value used in the event tree is based on judgment.
- The middle "Speed" Branch: The likelihood of a more severe tornado or its missiles effecting the area between the two Units is judged more likely. The probability value used in the event tree is an order of magnitude higher and based on judgment.
- The lower "Speed" Branch: The likelihood of a severe tornado or its missiles effecting the area between the two Units is judged even more likely since such a severe event could engulf the site. The probability value used in the event tree is based on judgment.

This simplified analysis is not based on a detailed analysis of tornadoes and missiles; it is based on judgment to determine an order of magnitude importance of the scenarios. Overall, it is judged reasonable or conservative.

EDG1 & EDG2 – probability that missile does not disable EDG

The failure branch represents the probability that missile(s) penetrate and fail the EDG or damage the door preventing it from opening (door jams and diesel loses ventilation). Each EDG rollup door is treated as independent random events in the analysis, given the preceding conditions in the event tree.

The rollup doors are closed during a tornado per procedure[5]. The rollup doors are constructed of heavy steel. In the EDG room, there is a steel barrier just inside the rollup door that protects the lower 4 feet of the rollup door. This structure provides protection that appears capable of preventing heavy objects from getting into the room. The more severe and larger the tornado, the more likely it is to generate significant missile(s) that could penetrate or damage the rollup door. Damage to the roll-up door could prevent adequate ventilation to the room. The room could exceed the safe operating temperature limit for electrical equipment. This is difficult to analyze because if the door is damaged enough to jam it, preventing opening, it could also be buckled sufficiently to allow adequate ventilation. The likelihood of getting through the door and damaging a diesel is judged unlikely, but again dependent on tornado severity. The EDG fragility used in the three branches of the event tree is based on judgment. For the lower "Speed" branch (most severe tornado), failure is essentially guaranteed (0.9). The other branches are reduced in probability by a factor of three, with 0.1 as the lowest value for the least severe event.

This simplified analysis is not based on a detailed analysis of tornadoes, missiles, and the capacity of the rollup door; it is based on judgment to determine an order of magnitude importance of the scenarios. Overall, it is judged reasonable or conservative.

Failure at this top event is treated as an irrecoverable failure of both EDGs in the PRA calculations of CCDP.

6.0 Analysis Method 2

The approach used here is to evaluate diesel room roll-up doors by analogy to an analysis performed for the NMP2 Reactor Building[6]. This is also similar to the analysis performed for the IPEEE, which was never formally documented. The results are summarized in the table below.

1	2	3	4	5	6	7	8	9	10	11
Tornado Intensity	Tornado Speed (MPH)	Tornado Occurrence Rate (/sq m/yr)	Path Area (sq m)	Tornado Prob of Strike (/yr)	Cond Prob Missile Strike	Prob Missile Strike	Cond Prob EDG Impact	Prob EDG Impact	CCDP	CDF (/yr)
F1	73-103	1.36E-04	0.72	9.79E-05	4.00E-03	3.92E-07	0.1	3.92E-08	0.25	9.79E-09
F2	103-135	8.50E-05	1.86	1.58E-04	6.00E-03	9.49E-07	0.2	1.90E-07	0.25	4.74E-08
F3	135-168	2.95E-05	3.74	1.10E-04	1.20E-02	1.32E-06	0.3	3.97E-07	0.25	9.93E-08
F4	168-209	6.23E-06	7.22	4.50E-05	7.00E-03	3.15E-07	0.5	1.57E-07	0.25	3.94E-08
F5	209-277	8.48E-07	13.48	1.14E-05	3.40E-02	3.89E-07	0.8	3.11E-07	0.25	7.77E-08
F6	277-360	6.24E-08	21.12	1.32E-06	2.46E-01	3.24E-07	1	3.24E-07	0.25	8.11E-08
Total				4.24E-04		3.69E-06		1.42E-06		3.55E-07

This method contains some conservatism and some non-conservatism as follows:

- The target area used for the Reactor Building is 13,423 ft^2. This is conservative relative to the roll-up doors because these doors have a smaller area.
- The number of missiles in the Reactor Building analysis was judged to be conservative compared to the number available to strike the diesel roll-up doors.
- The Reactor building target area is in the upper portion of the structure (60 feet above the ground). This is non-conservative compared to the roll-up doors. A larger percentage of missiles would be expected to reach the doors.
- The influence of intervening structures is ignored. This is conservative for the roll-up doors because the roll-up doors are shielded to a large degree by other structures.
- The analysis assumes that the same missile(s) impacts both roll-up doors simultaneously and fails both diesels. This is conservative.

Columns 1 through 7 are from Reference 6. The probability of a tornado strike is conservatively derived in this reference. The NMP2 USAR reports a probability of 3.75E-05/year of a tornado striking NMP2 (this should also apply to NMP1).

The table presents conditional probabilities and resulting frequencies for various tornado intensities. Conditional probabilities of diesel failure are relatively high and are based on uncertainty associated with diesel room cooling if the roll-up doors are damaged (jammed).

The total CDF for this method is 3.55E-07/yr.

7.0 References

1. Francisco et al., Nine Mile Point Nuclear Station Unit 1 Individual Plant Examination for External Events (SAS-TR-96-001), August, 1996
2. NRC Letter dated May 18 – RAI relative to NMP1 IPEEE (File NMP1L 1318).
3. Kirchner et al., Nine Mile Point Nuclear Station Unit 1 Individual Plant Examination, Rev. 0, Niagara Mohawk Power Corporation, July 1993
4. Rutch, Christine, et.al., "Tornado Risk Analysis" July 1992, Pages 134-139 in Plant/Operations Progress (Vol. 11, No 3)
5. N1-SOP-10, Revision 5, High Winds, July 1998
6. NMP Calculation No. MS-1991, Rev 01, Probability of Tornado Missile Strike to RB Openings
7. Tornado Missile Simulation and Design Methodology and Computer Manual Vol. 1 Simulation Methodology, Design Applications and TORMIS Computer Code, Electric Power Research Institute (EPRI), Report NP-2005, August, 1981

Attachment 1 – RISKMAN PRA Calculations

Case 1 – LOSP (1.0/year) Initiator

CCDP for sequences 1, 2, 6, 7, 11, and 12 are based on LOSP initiator set at 1.0/year and the following model changes; CDF quantified with a 1E-12 cutoff:

Top event OGR in SUP1 event tree set to failure (OGRF) to ensure no recovery
Top event OSP in SBO event tree set to failure (OSPF) to ensure no recovery
Result; CCDP = 4.0E-04

Case 2 – LOSP (1.0/year) Initiator and EDG102 failed

CCDP for sequences 4, 9, and 14 are based on LOSP initiator set at 1.0/year and the following model changes; CDF quantified with a 1E-12 cutoff:

Top event OGR in SUP1 event tree set to failure (OGRF) to ensure no recovery
Top event A2 in SUP1 event tree set to failure (A2F)
Top event EDG rules in SBO event tree set to ensure only 1 EDG is recoverable
- Added EDGF if D2=F
- Deleted EDG1, EDG2, EDG4, and EDG8 (these allow 1of 2 EDG recovery)
- Revise EDGA, EDGB, EDGC, and EDGD as follows
  - EDGA CD1
  - EDGB CD2
  - EDGC CD4
  - EDGD CD8

Top event OSP in SBO event tree set to failure (OSPF) to ensure no recovery
Result; CCDP = 6.0E-03

Case 3 – LOSP (1.0/year) Initiator and EDG103 failed

CCDP for sequences 3, 8, and 13 are based on LOSP initiator set at 1.0/year and the following model changes; CDF quantified with a 1E-12 cutoff:

Top event OGR in SUP1 event tree set to failure (OGRF) to ensure no recovery
Top event A3 in SUP1 event tree set to failure (A3F)
Top event EDG rules in SBO event tree set to ensure only 1 EDG is recoverable
- Added EDGF if D1=F
- Deleted EDG1, EDG2, EDG4, and EDG8 (these allow 1of 2 EDG recovery)
- Revise EDGA, EDGB, EDGC, and EDGD as follows
  - EDGA CD1
  - EDGB CD2
  - EDGC CD4
  - EDGD CD8

Top event OSP in SBO event tree set to failure (OSPF) to ensure no recovery
Result; CCDP = 7.9E-03

Case 4 – LOSP (1.0/year) Initiator and EDGs Failed

CCDP for sequences 5, 10, and 15 are based on LOSP initiator set at 1.0/year and the following model changes; CDF quantified with a 1E-12 cutoff:

Top event OGR in SUP1 event tree set to failure (OGRF) to ensure no recovery
Top event A2 in SUP1 event tree set to failure (A2F)
Top event A3 in SUP1 event tree set to failure (A3F)
Top event EDG in SBO event tree set to failure (EDGF) to ensure no recovery
Top event OSP in SBO event tree set to failure (OSPF) to ensure no recovery
Result; CCDP = 0.24