ENCLOSURE

Technical Evaluation of Report NUS - 4396 "The Effects of Tornadoes on the Availability of the Auxiliary Feedwater System at H. B. Robinson Unit 2" (Second Revision, August 1983).

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1. INTRODUCTION

The objective of this evaluation is to assess the validity and the degree of conservatism of the assumptions, data, and mathematical approach used in the Report NUS - 4396[a] to estimate the effect of extreme winds on the availability of the Auxiliary Feedwater System at H. B. Robinson Unit 2.

2. NOTATIONS

The following notations are used:

Events

W	Occurrence of winds in excess of 73 mph
O	Loss of Offsite Power due to wind
E	Failure of Emergency Power Sources due to mechanical and electrical failure unrelated to occurrence of extreme winds
A	Failure of Auxiliary Feedwater Sources due to mechanical failure unrelated to occurrence of extreme winds

[a] Hereinafter referred to as the Report

C	Failure of Condensate Storage Tank due to extreme winds or wind-borne missiles
M	Failure of operators to realign valves manually in less than 30 minutes to direct suction from Condensate Storage Tank to Service Water System
S	Failure of Service Water Pumps due to extreme winds or wind-borne missiles
F_3	Occurrence of winds corresponding to the F_3 Fujita Scale or stronger (i.e., winds in excess of 158 mph)

Probabilities

P(J)	Probability of event J
P(J,K)	Probability of events J and K

3. ASSUMPTIONS USED IN THE REPORT

The following assumptions are listed in the Report:

1. The occurrence of winds in excess of 73 mph (event W) at the plant site will cause the loss of offsite power (event O) and, therefore, the failure of the deep well sources since no emergency power is supplied to the well pumps. Thus, P(O) = P(W).

2. Offsite power is not recoverable in the short term (less than a few hours).

3. The Condensate Storage Tank will fail owing to direct wind or to missile effects if and only if subjected to winds corresponding to the F3 Fujita scale or stronger (i.e., winds in excess of 158 mph) at the location of the tank, so that $P(C) = P(F_3)$.

4. The probability of the failure of operators to manually realign valves to direct suction from the Condensate Storage Tank to the Service Water System in less than 30 minutes is about 10^{-2}, i.e., $P(M) = 10^{-2}$.

5. The probability that both emergency power sources will not function owing to mechanical or electrical failures unrelated to the occurrence of extreme winds is 10^{-3} per demand, i.e., $P(E) = 10^{-3}$.

6. The probability that the Auxiliary Feedwater Sources will not function owing to mechanical failures unrelated to the occurrence of extreme winds is 10^{-4} per demand, i.e., $P(A) = 10^{-4}$.

7. In the absence of any details on the capacity of the service water pump motors, it is assumed that the pump motors will fail (i.e., event S will occur) if and only if subjected to winds corresponding to the F3 Fujita scale or stronger (i.e., winds in excess of 158 mph) at the pump site.

8. Because (a) Service Water Pumps are likely to be shielded by the circulating water pumps, and (b) it would appear that missiles would be hurled from Unit 1 in the direction of the intake structures only by relatively wide tornadoes or tornadoes traveling in an E or ESE direction, it is assumed in the Report that damage from missiles to all four Service Water Pumps is unlikely.

9. The probability of failure due to high winds of the Service Water Pumps is numerically the same as the probability of failure of the Condensate Storage Tank, i.e., P(S) = P(C) (see assumptions 3 and 7). Note that the numerical equivalence does not imply the simultaneity of events C and S since the same tornado does not necessarily cause both events).

10. The probability of simultaneous failure due to high winds of both the Condensate Storage Tank and the Service Water Pumps is about one sixth of the probability of failure of either the Condensate Storage Tank or of the Service Water Pumps alone, i.e., P(C,S) = (1/6) x P(C).

11. Events O, E, and A are mutually independent.

12. Events C and M are independent.

4. DATA USED IN THE REPORT

The Report uses data on tornadoes obtained from the National Severe Storms Forecast Center (NSSFC), and on the NSSFC classification of these tornadoes in terms of the Fujita scale. Data on non-tornadic extreme winds are not used in the Report.

5. PROBABILISTIC ANALYSIS OF WIND EFFECTS ON THE AVAILABILITY OF THE AUXILIARY FEEDWATER SYSTEM (AFWS)

It is stated in the Report that the Auxiliary Feedwater System may become unavailable in one of three ways, described in subsections 5.1, 5.2, and 5.3, respectively.

5.1 FAILURE DUE TO EVENTS O AND E

The following relation holds (see assumption 11, Sect. 3):

$$P(O,E) = P(O)\,P(E) \qquad (1)$$

According to assumption 1, Sect. 3, P(O) = P(W). According to the Report, $P(W) = 1.9 \times 10^{-4}$ per year (due only to tornadoes). However, according to memorandum Docket No. 50-261 from William P. Gamill to Olan D. Parr, dated June 12, 1982 on Tornado and Extreme Wind Frequencies for H. B. Robinson Plant (TAC # 49223), winds in excess of 73 mph due to non-tornadic phenomena are more likely than those due to tornadoes, so that $P(W) \approx 3\text{x}10^{-3}$ per year (see Fig. 1). Since, according to assumption 5, Sect. 3, $P(E) = 10^{-3}$, it follows from Eq. 1 that

$$P(O,E) \approx 3\text{x}10^{-3} \times 10^{-3} = 3\text{x}10^{-6} \text{ per year} \qquad (1a)$$

5.2 FAILURE DUE TO EVENTS O AND A

The following relation holds (see assumption 11, Sect. 3):

$$P(O,A) = P(O)\,P(A) \qquad (2)$$

From assumptions 1 and 6, Sect. 3, and Fig. 1, it then follows

$$P(O,A) \approx 3\text{x}10^{-3} \times 10^{-4} = 3\text{x}10^{-7} \text{ per year} \qquad (2a)$$

5.3 FAILURE DUE TO LOSS OF OFFSITE POWER AND UNAVAILABILITY OF AUXILIARY FEEDWATER SOURCES CAUSED BY EXTREME WINDS

Three possible scenarios are considered in the Report with regard to the unavailability of auxiliary feedwater sources. These are described in subsections 5.3.1, 5.3.2 and 5.3.3.

5.3.1 FAILURE DUE TO EVENTS O AND C AND M

The following relation holds:

$$P(O,C,M) = P(C,M) \qquad (3a)$$

$$= P(C)P(M) \quad (3b)$$

$$= P(F_3)P(M) \quad (3c)$$

Equation 3a holds because the occurrence of the extreme winds that result in the failure of the Condensate Storage Tank also causes the loss of offsite power. Equation 3b and 3c follow from assumptions 12 and 3, Sect. 3, respectively. According to the Report, $P(F_3) = 1.55 \times 10^{-6}$ per year. However, according to Fig. 1, $P(F_3) \approx 10^{-5}$ per year. From Eq. 3c and assumption 4 it then follows that

$$P(O,C,M) \approx 10^{-5} \times 10^{-2} = 10^{-7} \text{ per year} \quad (3d)$$

5.3.2 FAILURE DUE TO EVENTS O AND S

The following relation holds:

$$P(O,S) = P(S) \quad (4a)$$

$$= P(F_3) \quad (4b)$$

Equation 4b follows from assumptions 9 and 3, Sect. 2. From fig. 1 it then follows:

$$P(O,S) \approx 10^{-5} \text{ per year}$$

Note that, according to the Report, $P(O,S) \approx 1.55 \times 10^{-6}$ per year.

5.3.3 FAILURE DUE TO EVENTS O, AND C, AND S

The following relation holds:

$$P(O,C,S) = P(C,S) \quad (5a)$$

$$= 1/6\ P(C) \quad (5b)$$

$$= 1/6\ P(F_3) \quad (5c)$$

Equations 5b and 5c follow from assumptions 10 and 3, respectively. From Eq. 5c and Fig. 1

$$P(0,C,S) = 1/6 \times 10^{-5}$$

Denoting the complement of event S by $\overline{S}$, it follows that

$$P(0,C,\overline{S}) = P(C,\overline{S})$$

$$= 5/6 \times 10^{-5}$$

Note also that $P(0,C,\overline{S},M) = P(0,C,\overline{S})\ P(M)$.

6. DISCUSSION AND SUMMARY

It is stated in the Report (last paragraph of p. 4-6) that "the Service Water provides cooling for the Auxiliary Feedwater Pumps (Motor and Steam driven)", and that failure of the Service Water Pump Motors would result in "failure of the Auxiliary Feedwater System even if the Condensate Storage Tank were available". It is further stated (p. 4-7 of Report) that "It is possible to realign the system so that the lube oil cooler can be cooled by Auxiliary Feedwater pump flow but this would need to be done within 30 minutes. Conservatively, no credit was taken for this action".

The assumptions listed in the Report (see Sect. 3 of this evaluation) are acceptable from the point of view of their conservatism, as is the assumption that failure of the Service Water System Motors entails failure of the Auxiliary Feedwater System even if the Condensate Storage Tank were available. The mathematical approach is also acceptable. However, the reviewer feels that the data are incomplete in that nontornadic wind speed information is not included. Indeed, probabilities P(O) and P(W) are determined by the occurrence of nontornadic winds (see Fig. 1).

From the assumptions listed in the Report (see Sect. 3 herein), the information on wind speeds provided by NRC (see Fig. 1 herein), and the description in the Report of the ways in which the Auxiliary Feedwater System

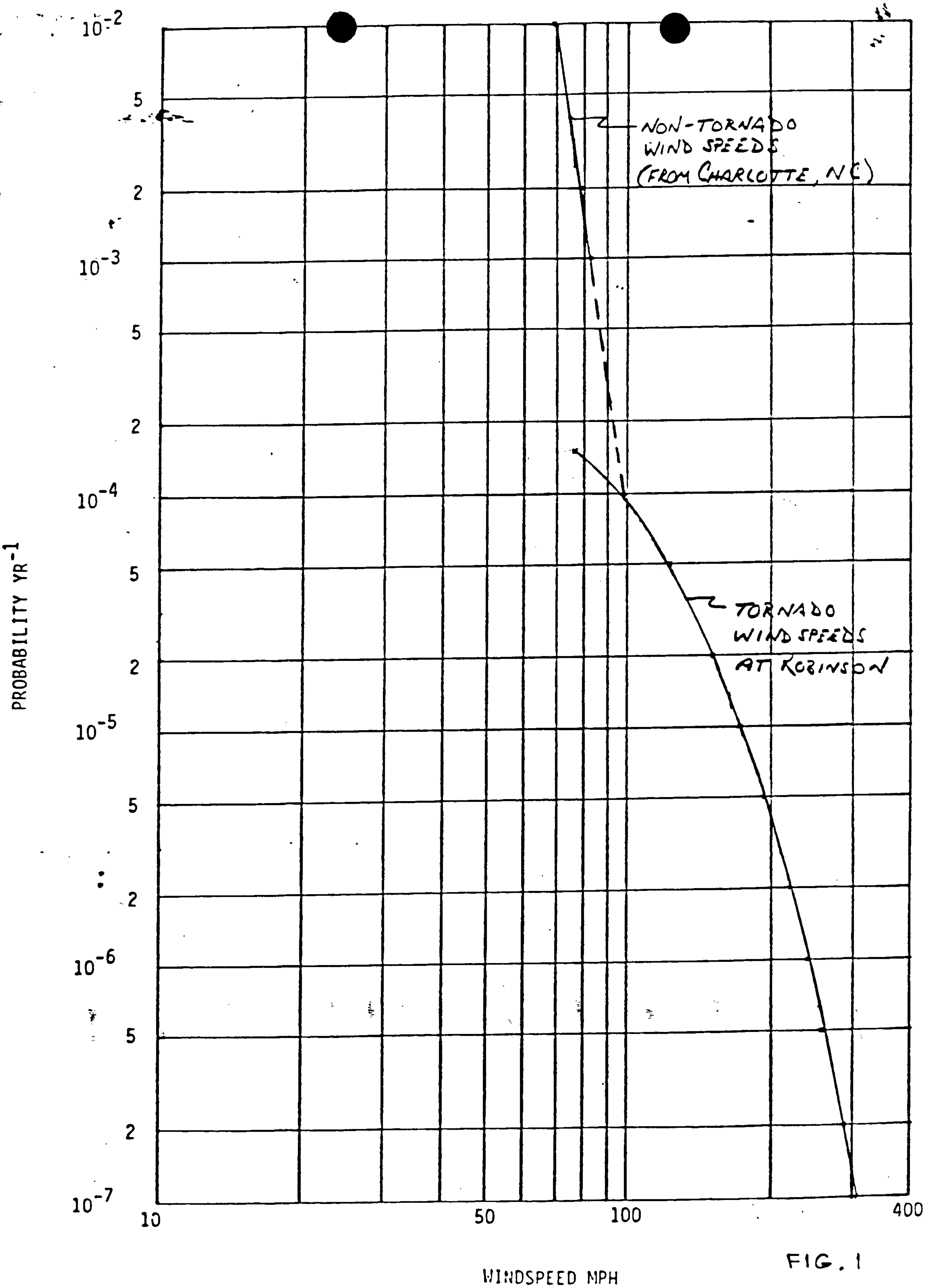
may become unavailable (see Sect. 5 herein), it follows that the probability of failure of the Auxiliary Feedwater System can be estimated as follows:

$$P_f \simeq P(0,E) + P(0,A) + P(0,C,\overline{S},M) + P(0,S)$$

$$\simeq 3 \times 10^{-6} + 3 \times 10^{-7} + \frac{5}{6}\, 10^{-7} + 10^{-5}$$

$$\simeq 1.34 \times 10^{-5} \text{ per year}$$

This is about one order of magnitude higher than the probability of failure estimated in the Report.



10-2
5
2
10-3
5
2
10-4
5
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10-5
5
2
10-6
5
2
10-7
PROBABILITY YR-1
NON-TORNADO WIND SPEEDS (FROM CHARLOTTE, NC)
TORNADO WIND SPEEDS AT ROBINSON
10
50
100
400
WINDSPEED MPH

FIG. 1