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WIND AND TORNADO HAZARD LEVELS

FOR THE

OAK RIDGE NATIONAL LABORATORY

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EXECUTIVE SUMMARY

The Department of Energy (DOE) Order 420.1A, *Facility Safety*, requires that site-specific natural phenomena hazard assessments be conducted for DOE sites, and in addition requires the assessments to be reviewed as a minimum every ten years, or updated whenever new information becomes available. The last site-specific wind and tornado hazard assessment for the Oak Ridge National Laboratory (ORNL) was performed in 1995. Since then, new information and new methodologies have been developed. This report provides the results of the latest updated wind and tornado hazard assessments, using the new information and methodologies, for ORNL.

This report parallels documentation prepared by the Facility Design Engineering organization for BWXT Y-12, LLC, the managing and operating contractor for the Y-12 National Security Complex. The high wind and tornado hazards for the DOE Oak Ridge Reservation are documented in DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to update the wind and tornado hazard criteria to reflect the additional wind/tornado data, changes in the definition of wind speeds, and changes in the hazard methodologies since 1995.

This report provides the updated wind and tornado hazard criteria for designing new and evaluating existing natural phenomena hazards performance category (PC) 1, 2, and 3 structures, systems, and components at the Department of Energy (DOE) Oak Ridge National Laboratory.

1.2 Background

DOE O 420.1A, *Facility Safety,* and DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities,* require that the natural phenomena hazard (NPH) assessments be updated whenever there are significant changes in the NPH assessment state-of-the-art or changes in the site-specific information.[1, 2] The requirement also states that a review of the state-of-the-art of the NPH methodology and of site-specific information be conducted at least every ten years.

The existing wind/tornado assessments for the ORNL site are documented in ES/CNPE-95/3, *Recommended High Speed Straight Wind and Tornadic Hazard Levels for the Oak Ridge, Tennessee Department of Energy Reservation*, September 1995.[3] This report was an update of studies done by Lawrence Livermore National Laboratory (LLNL) and Martin Marietta Energy Systems, Inc. (MMES).[4, 5]

This report parallels Y/EN-7400, "Wind and Tornado Hazard Levels for the Y-12 National Security Complex," prepared by the Facility Design Engineering organization for BWXT Y-12, LLC, the managing and operating contractor for the Y-12 National Security Complex.[6]

2.0 CHANGES IN THE WIND AND TORNADO HAZARD ASSESSMENTS

Wind/tornado hazard assessments are made up of four parts, which are straight winds, tornado winds, tornado-generated missiles, and atmospheric pressure changes (APC). The changes in these parts are discussed below.

2.1 Changes in the Wind Hazard Assessments

There have not been any significant changes in the hazard methodology for determining the straight wind speeds since the update that was performed in 1995. The main change has been to change the definition of the straight wind speeds from fastest mile wind speeds to 3-second gust wind speeds. In addition, additional wind speed data have been recorded since 1995.

2.1.1 Changes in the Definition of the Wind Speeds

DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, provides the minimum wind speeds to be used in design, and references the American Society of Civil Engineers (ASCE) Standard 7, *Minimum Design Loads for Buildings and Other Structures*, for the wind design criteria to be used for DOE facilities.[7, 8]

In 1995, ASCE 7 changed the definition of the wind speed from the fastest-mile wind speed to the 3-second gust wind speed. This change was made because the National Weather Service (NWS), which monitors and records the wind speeds across the United States, phased out the measurements of the fastest-mile wind speeds and began recording the 3-second wind gust speeds. This definition change does not change the methodology for defining the wind hazard levels and associated speeds.

The Oak Ridge Reservation wind hazard update of 1995 considered this change in the definition of the wind speeds, and defined the wind hazard curve as a 3-second wind gust speed. The result of this change was basically to define a minimum 3-second wind gust speed of 90 mph instead of the previous minimum 70 mph fastest-mile wind speed. Other changes were made in the wind design criteria to allow for this change in definition of the wind speeds, such that the wind speed change did not significantly impact the wind design of SSCs.

2.1.2 Additional Wind Speed Data Since 1995

ES/CNPE-95/3 lists the estimated annual peak gust wind speeds obtained from NWS data recorded at the Knoxville airport from 1942 through 1995. These data along with the available data from the NWS from 1996 to 2002 are listed in Table 1. Comparison of these data indicates that there have not been any significant changes in the recorded wind speed data that might impact the wind hazard curve that was developed in 1995. This is

particularly the case, since a minimum value of 90 mph is required per DOE-STD-1020-2002, regardless of the site-specific wind hazard curve. The 3-second wind gust hazard curve for ORNL is shown in Figure 1.

2.2 Changes in the Tornado Hazard Assessments

There have been significant changes in the tornado wind hazard methodologies. Subsequent to the wind/tornado hazard assessments performed by LLNL and MMES in 1985, the Nuclear Regulatory Commission (NRC) sponsored a study by the Pacific Northwest Laboratory to develop tornado hazard curves for the contiguous U.S., which was published in NUREG/CR-4461.[9] Because of different modeling assumptions and underlying data used to develop the tornado information, the tornado wind speeds from the NRC study, at specified exceedance levels and at a certain location, are different than the LLNL and MMES studies. Based on these differences, the Defense Nuclear Facility Safety Board (DNFSB) raised questions about the earlier studies and their adequacy.

To resolve these differences in tornado wind speeds, DOE funded LLNL to review the different methodologies and develop an updated state-of-the-art tornado wind methodology for use at DOE sites. The results of the LLNL study are documented in UCRL-ID-140922 Vol I, *Development of a Probabilistic Tornado Wind Hazard Model for the Continental United States.*[10]

2.2.1 Changes in the Tornado Wind Hazard

The UCRL-ID-140922 report provides the updated tornado wind hazard curve for the ORNL site using the latest tornado data and assessment methodology. Figure 1.0 shows a comparison of the existing wind/tornado curve with the new LLNL curve for the ORNL site. This comparison shows that the tornado wind hazard has increased significantly for the ORNL site.

2.2.2 Changes in the Tornado-Generated Missiles and Atmospheric Pressure

Part of the DOE tornado criteria includes consideration of tornado-generated missiles and atmospheric pressure changes. The earlier studies documented the missile criteria and the atmospheric pressure changes that should be considered in design/evaluation of facilities. The new study by LLNL did not address tornado-generated missiles or the atmospheric pressure changes, but the increased speeds at ORNL would influence the type of missiles and atmospheric pressure changes that should be used. The earlier studies had documented the type of missiles and atmospheric pressure changes for tornado wind speeds of 170 to 200 mph. Therefore, the missile criteria and the atmospheric pressure changes for the speeds of 170 to 200 mph can be used for the new 200 mph tornado wind speed for the ORNL site.

3.0 WIND AND TORNADO HAZARD LEVELS AND ANALYSIS CRITERIA

The updated wind and tornado hazard levels and analysis criteria to be used for the design of new PC-1, PC-2, and PC-3 SSCs at the ORNL site are defined in Table 2. For existing facilities, some relief in the criteria is allowed. It is permissible to perform the evaluations using a NPH exceedance probability of twice the value specified for new design. The wind/tornado hazard curves are used to scale the wind/tornado speeds down for the evaluation of existing facilities. The updated wind and tornado hazard levels and analysis criteria to be used for the evaluation of existing PC-1, PC-2, and PC-3 SSCs at the ORNL site are defined in Table 3. These criteria are based on the latest DOE-STD-1020, ASCE 7, and the LLNL tornado hazard criteria.

4.0 REFERENCES

1. DOE Order 420.1A, *Facility Safety,* Department of Energy, May 2002.

2. DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities*, Department of Energy, March 2000.

3. ES/CNPE-95/3, *Recommended Straight Wind and Tornadic Hazard Levels for the Oak Ridge, Tennessee Department of Energy Reservation*, Lockheed Martin Energy Systems, Inc., September 1995.

4. UCRL-53526 R-1, *Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites*, Lawrence Livermore National Laboratory, August 1985.

5. Y/EN-1036, *Recommended Straight Wind, Tornado, and Wind-Generated Missiles Hazards for the Oak Ridge, Tennessee; Paducah, Kentucky; Fernald, Ohio; and Portsmouth, Ohio Department of Energy Reservations*, Martin Marietta Energy Systems, Inc., August 1985.

6. Y/EN-7400, *Wind and Tornado Hazard Levels for the Y-12 National Security Complex*, Facility Design Engineering, BWXT Y-12, LLC, September 2002.

7. DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, Department of Energy, January 2002.

8. ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers, 1998.

9. NUREG/CR-4461, *Tornado Climatology of the Contiguous United States*, Pacific Northwest Laboratory, prepared for the U.S. Nuclear Regulatory Commission, May 1986.

10. UCRL-ID-140922, VOL I, *Development of a Probabilistic Tornado Wind Hazard Model for the Continental United States*, Lawrence Livermore National Laboratory, July 2000.

TABLES

Table 1

Annual Peak Gust Wind Speeds at the Knoxville Airport

Year	Annual Peak Gust Wind Speed (mph)	Year	Annual Peak Gust Wind Speed (mph)
1942	55	1972	53
1943	67	1973	53
1944	84	1974	64
1945	64	1975	42
1946	53	1976	42
1947	69	1977	44
1948	74	1978	42
1949	48	1979	33
1950	57	1980	35
1951	60	1981	37
1952	72	1982	40
1953	71	1983	43
1954	64	1984	60
1955	64	1985	74
1956	78	1986	50
1957	57	1987	57
1958	69	1988	81
1959	68	1989	73
1960	69	1990	67
1961	68	1991	54
1962	59	1992	55
1963	68	1993	73
1964	57	1994	55
1965	55	1995	86
1966	53	1996	76
1967	48	1997	68
1968	53	1998	55
1969	66	1999	52
1970	64	2000	61
1971	47	2001	56
		2002	59

Table 2

Wind/Tornado Hazard Levels and Analysis Criteria for Design of New Structures, Systems, and Components [Note 1]

Performance Category (PC)	Wind/Tornado Levels	Wind/Tornado Analysis Criteria
PC-1	90 mph 3-second wind gust	ASCE 7 Importance Factor (I) = 1.0
PC-2	96 mph 3- second wind gust	ASCE 7 Importance Factor (I) = 1.0
PC-3 [Note 2]	200 mph tornado	2x4 timber plank 15 lb. @ 150 mph (horiz.), max. height 200 ft., 100 mph (vert.) 3 in. dia. std. steel pipe, 75 lb. @ 75 mph (horiz.), max height 100 ft., 50 mph (vert.) 3000 lb. automobile @ 25 mph, rolls and tumbles APC = 125 psf @ 50 psf/sec.

Source: DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, Department of Energy, January 2002

Note 1: The analysis criteria should be used for any systems or components which are not inside a structure and can be exposed to wind/tornado.

Note 2: DOE-STD-1020-2002 recommends that for sites with PC-3 facilities where tornado wind speeds have substantially increased (above 175 mph), the APC and missile criteria for PC-4 should be used in lieu of PC-3.

Table 3

Wind/Tornado Hazard Levels and Analysis Criteria for Evaluation of Existing Structures, Systems, and Components Note 1

Performance Category (PC)	Wind/Tornado Levels	Wind/Tornado Analysis Criteria
PC-1	84 mph 3-second wind gust	ASCE 7 Importance Factor (I) = 1.0
PC-2	90 mph 3- second wind gust	ASCE 7 Importance Factor (I) = 1.0
PC-3 Note 2	180 mph tornado	2x4 timber plank 15 lb. @ 150 mph (horiz.), max. height 200 ft., 100 mph (vert.) 3 in. dia. std. steel pipe, 75 lb. @ 75 mph (horiz.), max height 100 ft., 50 mph (vert.) 3000 lb. automobile @ 25 mph, rolls and tumbles APC = 125 psf @ 50 psf/sec.

Source: DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, Department of Energy, January 2002

Note 1: The analysis criteria should be used for any systems or components which are not inside a structure and can be exposed to wind/tornado.

Note 2: DOE-STD-1020-2002 recommends that for sites with PC-3 facilities where tornado wind speeds have substantially increased (above 175 mph), the APC and missile criteria for PC-4 should be used in lieu of PC-3.

FIGURES

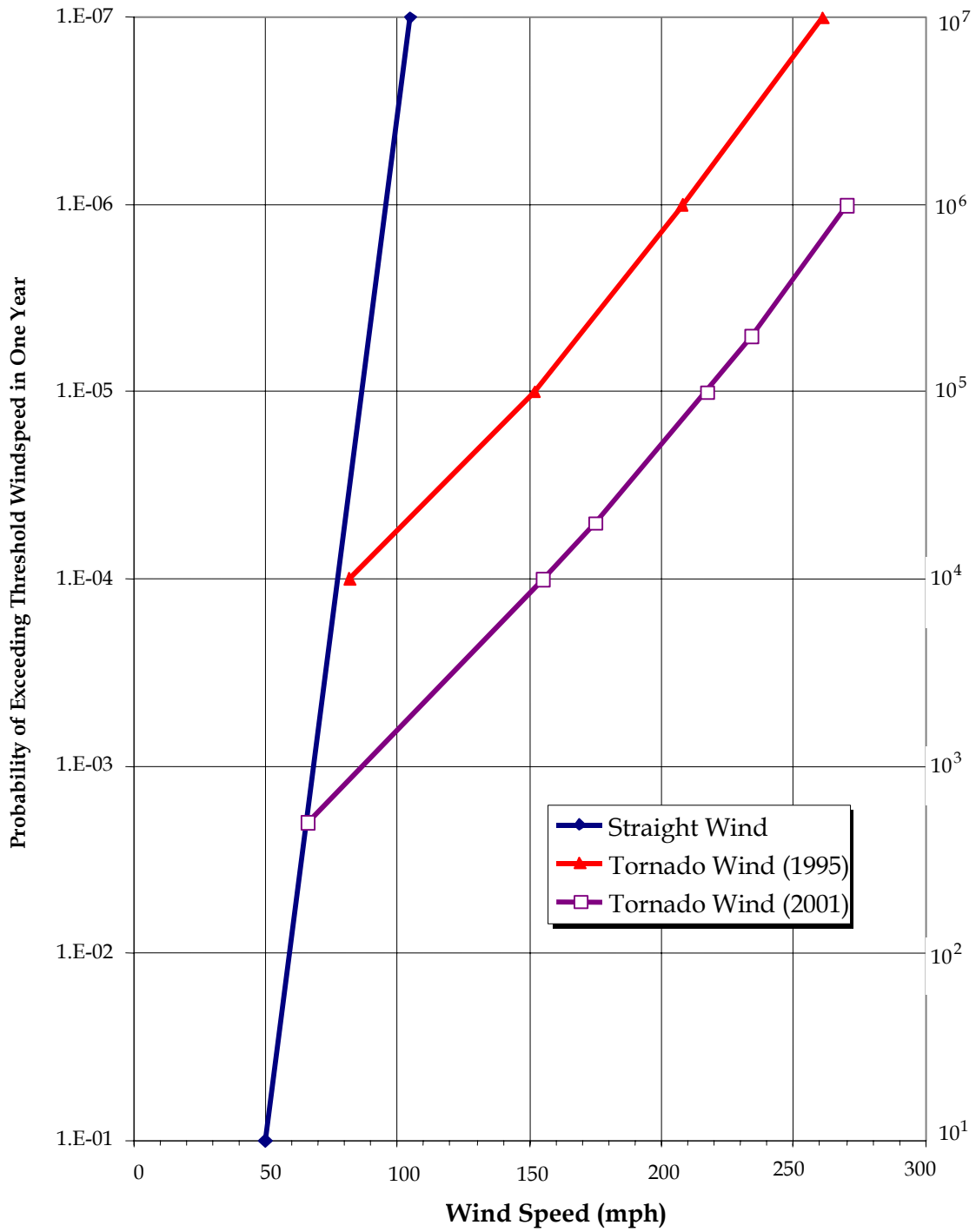

Figure 1.0
Comparison of New and Existing Straight Wind and Tornado Hazard Curves
for Oak Ridge National Laboratory