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OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.76

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DESIGN-BASIS TORNADO AND TORNADO MISSILES FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

This regulatory guide provides licensees and applicants with new guidance that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in selecting the design-basis tornado and design-basis tornado-generated missiles that a nuclear power plant should be designed to withstand to prevent undue risk to the health and safety of the public. This guidance applies to the contiguous United States, which is divided into three regions; this document provides separate guidance for each region.

This guide does not address the determination of the design-basis tornado and tornado missiles for sites located in Alaska, Hawaii, or Puerto Rico; the NRC will evaluate such determinations on a case-by-case basis. This guide also does not identify the specific structures, systems, and components that should be designed to withstand the effects of the design-basis tornado or should be protected from tornado-generated missiles and remain functional. This guide also does not address extreme winds, such as hurricanes, or the missiles attributed to such winds. Tornado wind speeds may not bound hurricane wind speeds for certain portions of the Atlantic and Gulf coasts, at the wind speed frequencies of occurrence considered in this guide. The NRC will address these extreme conditions on a case-by-case basis. This guide also does not address other externally generated hazards such as aviation crashes, nearby accidental explosions resulting in blast over-pressure levels and explosion-borne debris and missiles, and turbine missiles.

General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities" (Ref. 1), requires that structures, systems, and components that are important to safety shall be designed to withstand the effects of natural phenomena, such as tornadoes, without loss of capability to perform their safety functions. GDC 2 also requires that the design bases for these structures, systems, and components shall reflect (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed.

GDC 4, "Environmental and Dynamic Effects Design Bases," of Appendix A to 10 CFR Part 50 requires, in part, that structures, systems, and components that are important to safety shall be adequately protected against the effects of missiles resulting from events and conditions outside the plant.

For stationary power reactor site applications submitted before January 10, 1997, paragraph 100.10(c)(2) of 10 CFR Part 100, "Reactor Site Criteria" (Ref. 2), states that meteorological conditions at the site and in the surrounding area should be considered in determining the acceptability of a site for a power reactor.

For stationary power reactor site applications submitted on or after January 10, 1997, paragraph 100.20(c)(2) of 10 CFR Part 100 requires that meteorological characteristics of the site that are necessary for safety analysis or may have an impact upon plant design (such as maximum probable wind speed) must be considered in determining the acceptability of a site for a nuclear power plant. In addition, paragraph 100.21(d) of 10 CFR Part 100 requires that the physical characteristics of the site, including meteorology, must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site.

This regulatory guide relates to information collections that are covered by the requirements of 10 CFR Part 50, 10 CFR Part 52, and 10 CFR Part 100, which the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0011, 3150-0151, and 3150-0093, respectively. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Regionalization of Tornado Wind Speeds

Nuclear power plants must be designed so that they remain in a safe condition under severe meteorological events, including those that could result in the most severe tornado that could reasonably be predicted to occur at the site. The NRC based the original version of Regulatory Guide 1.76, published in April 1974, on WASH-1300 (Ref. 3). WASH-1300 chose the design-basis tornado wind speeds so that the probability that a tornado exceeding the design basis would occur was on the order of 10^{-7} per year per nuclear power plant. WASH-1300 used only 2 years of observed tornado intensity data (1971 and 1972) to derive the conditional probability that, if a tornado were to strike a nuclear power plant, the maximum tornado wind speed would exceed a specified value. The probability that the tornado would strike a nuclear power plant (treated as a point) was based on more data.

The design-basis tornado wind speeds presented in this regulatory guide are based on Revision 2 of NUREG/CR-4461 (Ref. 4). The tornado database used in that revision of NUREG/CR-4461 includes information recorded for more than 46,800 tornado segments occurring from January 1, 1950, through August 31, 2003. More than 39,600 of those segments had sufficient information on their location, intensity, length, and width to be used in the analysis of tornado strike probabilities and maximum wind speeds. Revision 2 of NUREG/CR-4461 differs from Revision 1 of that report, which was published in April 2005. The second revision of NUREG/CR-4461 relies on the Enhanced-Fujita (EF) scale (Ref. 5) to relate the degree of damage from a tornado to the tornado maximum wind speed. The earlier versions of the report used the original Fujita scale. The methods used in Revisions 1 and 2 of NUREG/CR-4461 are similar to those used in the initial version of NUREG/CR-4461, published in 1986, with the addition of a term to account for the finite dimensions of structures (sometimes called the "lifeline" term) and consideration of the variation of wind speeds along and across the tornado footprint. R.C. Garson et al. (Ref. 6) discuss in detail the term associated with the finite dimensions of structures. The lifeline term assumes that a tornado striking any point on a finite structure can cause damage. The original version of NUREG/CR-4461 used a point model and assumed the nuclear power plant to be a point structure. Therefore, including the finite dimensions of structures increases the tornado strike probability. WASH-1300 and the original version of this regulatory guide did not consider the lifeline term and used the original Fujita scale.

Meteorological and topographic conditions, which vary significantly within the continental United States, influence the frequency of occurrence and intensity of tornadoes. The NRC staff has determined that the design-basis tornado wind speeds for new reactors should correspond to the exceedance frequency of 10^{-7} per year (calculated as a best estimate), thus using the same exceedance frequency as the original version of this regulatory guide. The results of the analysis indicated that a maximum wind speed of 103 meters per second (m/s) [230 miles per hour (mph)] is appropriate for tornadoes for the central portion of the United States; a maximum wind speed of 89 m/s (200 mph) is appropriate for a large region of the United States along the east coast, the northern border, and western Great Plains; and a maximum wind speed of 72 m/s (160 mph) is appropriate for the western United States. These geographic wind speed regions are defined by observed tornado occurrences within the two-degree latitude and longitude boxes in the contiguous United States. Figure 1 shows the three tornado intensity regions for the contiguous United States at the 10^{-7} per year probability level, in which the abscissa is the longitude (degrees west) and the ordinate is the latitude (degrees north).

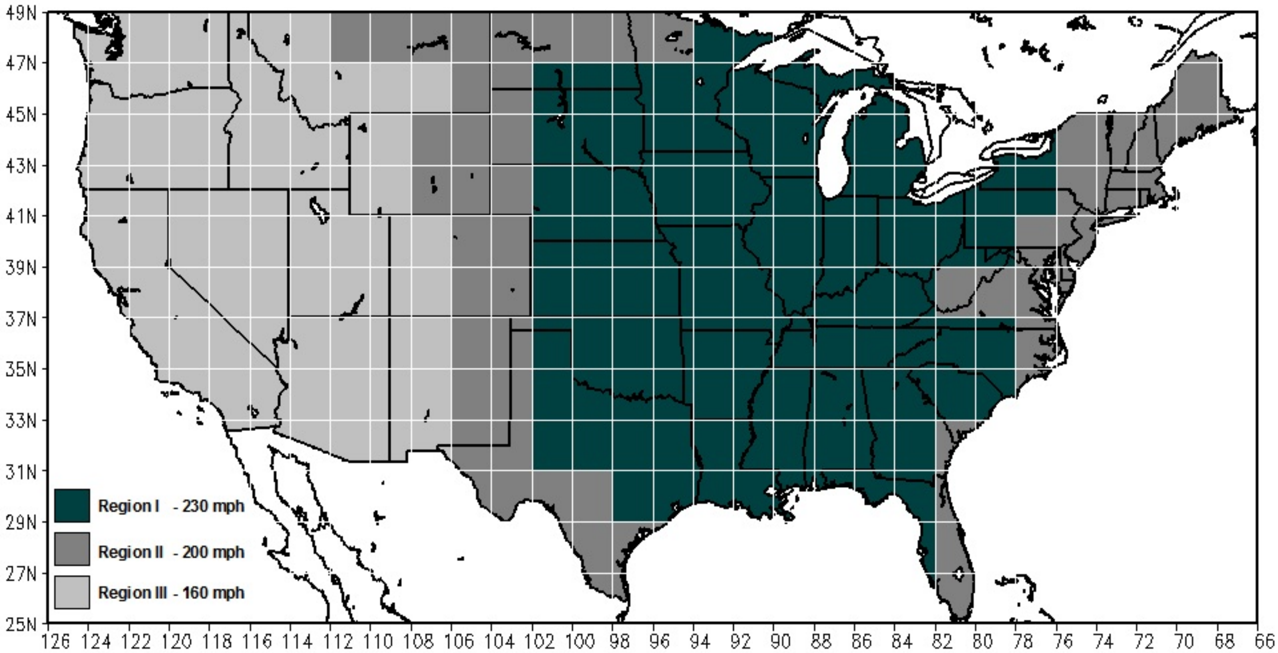

Figure 1. Tornado intensity regions for the contiguous United States
for exceedance probabilities of 10^{-7} per year

Tornado Characteristics

Tornadoes can be characterized by a mutually consistent set of parameters, including maximum total wind speed; radius of maximum tangential (rotational) wind speed; tornado tangential, vertical, radial, and translational wind speeds; and associated atmospheric pressure changes within the core.

To estimate the pressure drop and rate of pressure drop associated with the design-basis tornado, this regulatory guide models the tornado as a single Rankine combined vortex, as in the original version of Regulatory Guide 1.76. A single Rankine combined vortex is a simple model possessing only azimuthal velocity. The wind velocities and pressures are assumed not to vary with the height above the ground. Therefore, the flow field is two-dimensional. The flow field of a Rankine combined vortex is equivalent to that of a solid rotating body within the core of radius R_m. Outside the core, the rotational speed falls off as *1/r* where r is the distance from the center of the vortex. That is to say, the rotational speed V_R is given by the following equations:

(1a) $$V_R = \frac{V_{Rm}\, r}{R_m} \quad for\ r \le R_m$$

(1b) $$V_R = \frac{V_{Rm}\, R_m}{r} \quad for\ r \ge R_m$$

In these equations, V_{Rm} is the maximum rotational speed, occurring at radius $r = R_m$. In addition, the Rankine combined vortex moves with the translational speed V_T of the tornado.

The pressure drop from a normal atmospheric pressure to the center of the Rankine combined vortex is computed by balancing the pressure gradient and the centrifugal force (cyclostrophic balance) and integrating from infinity to the center of the vortex. The following equation describes this relationship:

(2) $\Delta p = \rho V_{Rm}^2$, where ρ is the air density, taken as 1.226 kg/m³ (0.07654 lbm/ft³)

The following equation describes the maximum rate of pressure drop:

(3) $(dp/dt)_{max} = (V_T/R_m)\ \Delta p$

The NRC staff chose the Rankine combined vortex model for its simplicity, as compared to the model developed by T. Fujita (Ref. 7). Fujita's model has a tornado with an inner core and an annulus (outer core) where the vertical motions are concentrated. In the annulus between the inner core radius and the outer core radius, suction vortices form in strong tornadoes and rotate around the center of the parent tornado.

In the Fujita model, the tornado radius R_m is larger than the 45.7 meters (150 feet) assumed in the original version of Regulatory Guide 1.76. In fact, the tornado radius of maximum rotational wind speed for a 103-m/s (230-mph) tornado is 123 meters (404 feet). However, the maximum rotational wind speeds of the suction vortices occur at a radius of 29 meters (96 feet). Despite the fact that the pressure drop associated with a suction vortex (i.e., the pressure drop from ambient pressure to the center of the suction vortex) is less than that for the parent tornado, the maximum rate of pressure drop is greater because the maximum time rate of change of pressure is inversely proportional to the Rankine combined vortex radius and is directly proportional to the translational speed of the Rankine combined vortex. The radius for the suction vortex is smaller than that for the parent tornado, and the maximum translational speed for a suction vortex is the sum of the translational speed of the tornado and the speed with which the suction vortex rotates around the center of the parent tornado. To avoid a nonconservative maximum time rate of change of pressure, this regulatory guide retains the 45.7-meter (150-foot) radius of maximum wind speed for the tornado used in the original version of Regulatory Guide 1.76. In addition, this regulatory guide retains the definition of the tornado maximum rotational wind speed V_{Rm} as the difference between the maximum tornado wind speed V and the translational speed V_T. The tornado translational speed is one-fifth of the maximum tornado wind speed, which is consistent with the tornado translational speeds in the original version of Regulatory Guide 1.76. Figure 2 depicts the translational and rotational (or tangential) wind velocity components of the Rankine combined vortex.

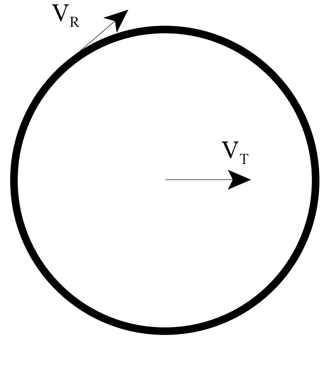

Figure 2. Rankine combined vortex model showing the components of the wind velocity

Design-Basis Tornado Characteristics

The original version of Regulatory Guide 1.76 characterized tornadoes in each geographical region by (1) maximum wind speed, (2) translational speed, (3) maximum rotational speed, (4) radius of maximum rotational speed, (5) pressure drop, and (6) rate of pressure drop. Because the model used in this regulatory guide is based on a single Rankine combined vortex, the same parameters apply. If a tornado model with suction vortices were used, additional parameters would be necessary. Table 1 summarizes the design-basis tornado characteristics used in this regulatory guide.

Table 1. Design-Basis Tornado Characteristics

Region	Maximum wind speed m/s (mph)	Translational speed m/s (mph)	Maximum rotational speed m/s (mph)	Radius of maximum rotational speed m (ft)	Pressure drop mb (psi)	Rate of pressure drop mb/s (psi/s)
I	103 (230)	21 (46)	82 (184)	45.7 (150)	83 (1.2)	37 (0.5)
II	89 (200)	18 (40)	72 (160)	45.7 (150)	63 (0.9)	25 (0.4)
III	72 (160)	14 (32)	57 (128)	45.7 (150)	40 (0.6)	13 (0.2)

Tornado-Generated Missile Characteristics

To ensure the safety of nuclear power plants in the event of a tornado strike, NRC regulations require that nuclear power plant designs consider the impact of tornado-generated missiles (i.e., objects moving under the action of aerodynamic forces induced by the tornado wind), in addition to the direct action of the tornado wind and the moving ambient pressure field. Wind velocities in excess of 34 m/s (75 mph) are capable of generating missiles from objects lying within the path of the tornado wind and from the debris of nearby damaged structures.

The two basic approaches used to characterize tornado-generated missiles are (1) a standard spectrum of tornado missiles, and (2) a probabilistic assessment of the tornado hazard. No definitive guidance has been developed for use in characterizing site-dependent tornado-generated missiles by hazard probability methods. The damage to safety-related structures by tornado or other wind-generated missiles implies the occurrence of a sequence of random events. That event sequence typically includes a wind-based occurrence in the plant vicinity in excess of 34 m/s (75 mph), existence and availability of missiles in the area, injection of missiles into the wind field, suspension and flight of those missiles, impact of the missiles with safety-related structures, and resulting damage to critical equipment. Given defense-in-depth considerations, the uncertainties in these events preclude the use of a probabilistic assessment as the sole basis for assessing how well the plant is protected against tornado missile damage.

Protection from a spectrum of missiles (ranging from a massive missile that deforms on impact to a rigid penetrating missile) provides assurance that the necessary structures, systems, and components will be available to mitigate the potential effects of a tornado on plant safety. Given that the design-basis tornado wind speed has a very low frequency, to be credible, the representative missiles must be common items around the plant site and must have a reasonable probability of becoming airborne within the tornado wind field.

To evaluate the resistance of barriers to penetration and gross failure, the tornado missile speeds must also be defined. Simiu and Scanlan (Ref. 8) estimate tornado-generated missile speeds for nuclear plant design purposes. They assumed that missiles start their motion from a point located on the tornado translation axis, at a distance downward of the tornado center equal to the radius of the maximum circumferential wind speeds. In addition, they assumed that the speed with which a missile hits a target is equal to the maximum speed (V^{max}) that the same missile would attain if its trajectory were unobstructed by the presence of any obstacle.

The tornado wind field model used to calculate the maximum missile velocities differs somewhat from the tornado wind field model used in the above discussion of tornado characteristics to obtain the tornado pressure drop and maximum time rate of change of the pressure. Chapter 16 of Reference 8 provides the tornado wind field model (which includes a radial component for the tornado wind speed) and the equations of motion used for the maximum missile velocities. The NRC staff developed a computer program to calculate the maximum horizontal missile speeds by solving these equations.

Design-Basis Tornado Missile Spectrum

In accordance with 10 CFR 50.34, "Contents of Applications; Technical Information," GDC 2, and GDC 4 structures, systems, and components that are important to safety must be designed to withstand the effects of natural phenomena without losing the capability to perform their safety function. Tornado missiles are among the most extreme effects of credible natural phenomena at nuclear power plant sites. The selected design-basis missiles for nuclear power plants include at least (1) a massive high-kinetic-energy missile that deforms on impact, (2) a rigid missile that tests penetration resistence, and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers. The NRC staff considers a 6-inch (15.24-centimeter) Schedule 40 steel pipe and an automobile to be acceptable as the penetrating and massive missiles, respectively, for use in the design of nuclear power plants. Automobiles are common objects near the plant site, and ample evidence supports their potential to be lifted in a tornado wind field. Schedule 40 pipe is also common around plant sites. However, such pipe is intended to represent a rigid component of a larger missile (e.g., building debris or an automobile) that may be lifted in the tornado wind field. Thus, the staff used the maximum speed calculated for the automobile missile for the penetrating missile as well, rather than the speed calculated for a pipe. To test the configuration of openings in the protective barriers, the missile spectrum also includes a 1-inch (2.54-centimeter) solid steel sphere as a small rigid missile. Simiu and Scanlan (Ref. 8) describe the methods that form the bases for the characteristics of these missiles. Table 2 summarizes the design-basis tornado missile spectrum and maximum horizontal speeds.

Table 2. Design-Basis Tornado Missile Spectrum and Maximum Horizontal Speeds

<table>
<tr><th colspan="2">Missile Type</th><th>Schedule 40 Pipe</th><th>Automobile</th><th>Solid Steel Sphere</th></tr>
<tr><td colspan="2" rowspan="2">Dimensions</td><td rowspan="2">0.168 m dia × 4.58 m long
(6.625 in. dia × 15 ft long)</td><td>Region I and II
5 m × 2 m × 1.3 m
(16.4 ft x 6.6 ft x 4.3 ft)</td><td rowspan="2">2.54 cm dia
(1 in. dia)</td></tr>
<tr><td>Region III
4.5 m x 1.7 m x 1.5 m
(14.9 ft x 5.6 ft x 4.9 ft)</td></tr>
<tr><td colspan="2" rowspan="2">Mass</td><td rowspan="2">130 kg
(287 lb)</td><td>Region I and II
1810 kg
(4000 lb)</td><td rowspan="2">0.0669 kg
(0.147 lb)</td></tr>
<tr><td>Region III
1178 kg
(2595 lb)</td></tr>
<tr><td colspan="2" rowspan="2">C_DA/m</td><td rowspan="2">0.0043 m^2/kg
(0.0212 ft^2/lb)</td><td>Region I and II
0.0070 m^2/kg
(0.0343 ft^2/lb)</td><td rowspan="2">0.0034 m^2/kg
(0.0166 ft^2/lb)</td></tr>
<tr><td>Region III
0.0095 m^2/kg
(0.0464 ft^2/lb)</td></tr>
<tr><td rowspan="3">V_{Mh}^{max}</td><td>Region I</td><td>41 m/s
(135 ft/s)</td><td>41 m/s
(135 ft/s)</td><td>8 m/s
(26 ft/s)</td></tr>
<tr><td>Region II</td><td>34 m/s
(112 ft/s)</td><td>34 m/s
(112 ft/s)</td><td>7 m/s
(23 ft/s)</td></tr>
<tr><td>Region III</td><td>24 m/s
(79 ft/s)</td><td>24 m/s
(79 ft/s)</td><td>6 m/s
(20 ft/s)</td></tr>
</table>

The NRC considers the missiles listed in Table 2 to be capable of striking in all directions with horizontal velocities of V_{Mh}^{max} and vertical velocities equal to 67 percent of V_{Mh}^{max}. Barrier design should be evaluated assuming a normal impact to the surface for the Schedule 40 pipe and automobile missiles. The automobile missile is considered to impact at all altitudes less than 30 feet (9.14 meters) above all grade levels within 0.5 mile (0.8 kilometer) of the plant structures. Table 2 includes a different size and weight automobile for Region III than for Regions I and II. The heavier automobile used in the calculations for Regions I and II will have a lower kinetic energy in Region III. This effect is a consequence of the low maximum horizontal speed V_{Mh}^{max} of the heavier automobile in the Region III tornado wind field.

C. REGULATORY POSITION

The NRC staff has established the following regulatory positions for licensees and applicants to use in selecting the design-basis tornado and design-basis tornado-generated missiles that a nuclear power plant should be designed to withstand to prevent undue risk to the health and safety of the public.

1. Design-Basis Tornado Parameters

Nuclear power plants should be designed to withstand the design-basis tornado. The parameter values specified in Table 1 for the appropriate regions identified in Figure 1 are generally acceptable to the NRC staff for defining the design-basis tornado for a nuclear power plant. If a design-basis tornado proposed for a given site is characterized by less-conservative parameter values than the regional values in Table 1, a comprehensive analysis should be provided to justify the selection of the less-conservative design-basis tornado. Sites located near the general boundaries of adjoining regions may involve additional considerations. The radius of maximum rotational speed of 45.7 meters (150 feet) is used for all three tornado intensity regions.

2. Design-Basis Tornado-Generated Missile Spectrum

The design-basis tornado-generated missile spectrum in Table 2 is generally acceptable to the staff for the design of nuclear power plants.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide. No backfitting is intended or approved in connection with its issuance.

Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the NRC staff will use the methods described in this guide to evaluate (1) submittals in connection with applications for construction permits, standard plant design certifications, early site permits, operating licenses, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications that have a clear nexus with the subject for which guidance is provided herein.

REGULATORY ANALYSIS / BACKFIT ANALYSIS

The regulatory analysis and backfit analysis for this regulatory guide are available in Draft Regulatory Guide DG-1143, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants" (Ref. 9). The NRC issued DG-1143 in January 2006 to solicit public comment on the draft of this Revision 1 of Regulatory Guide 1.76.

REFERENCES

1. *U.S. Code of Federal Regulations*, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.[1]

2. *U.S. Code of Federal Regulations*, Title 10, Part 100, , "Reactor Site Criteria," U.S. Nuclear Regulatory Commission, Washington, DC.[1]

3. WASH-1300, "Technical Basis for Interim Regional Tornado Criteria," U.S. Atomic Energy Commission, Washington, DC, May 1974.[2]

4. Ramsdell, J.V., Jr., NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," Revision 2, PNNL-15112, U.S. Nuclear Regulatory Commission, Washington, DC, February 2007.[3]

5. "A Recommendation for an Enhanced Fujita Scale (EF-Scale)," Wind Science and Engineering Center, Texas Tech University, Lubbock, TX, June 2004.[4]

6. Garson, R.C., et al., "Tornado Design Winds Based on Risk," *Journal of the Structural Division, Proceedings of the American Society of Civil Engineers*, Vol. 101, No. 9, pp. 1883–1897, September 1975.[5]

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[1] All NRC regulations listed herein are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/cfr. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov.

[2] Copies are available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209, by fax (301) 415-3548, and by email to PDR@nrc.gov.

[3] Copies are available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov. Copies are also available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328, telephone (202) 512-1800; or from the National Technical Information Service (NTIS) at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703) 605-6000, or by fax to (703) 605-6900. This document is also available electronically through the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4461/.

[4] This document is available electronically at http://www.wind.ttu.edu/F_Scale/images/efsr.pdf.

[5] Copies may be purchased from the American Society for Civil Engineers (ASCE), 1801 Alexander Bell Drive, Reston, Virginia 20190, telephone (800) 548-ASCE (2723). Purchase information is available through the ASCE Web site at http://www.pubs.asce.org/WWWdisplay.cgi?5011559.

7. Fujita, T. Theodore, "Workbook of Tornadoes and High Winds for Engineering Applications," SMRP Research Paper No. 165, September 1978.[6]

8. Simiu, Emil, and Robert H. Scanlan, *Wind Effects on Structures: Fundamentals and Applications to Design*, 3rd Edition, John Wiley & Sons, Hoboken, NJ, August 1996.[7]

9. Draft Regulatory Guide DG-1143, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, January 2006.[8]

6 Copies are available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland, the PDR's mailing address is USNRC PDR, Washington, DC 20555. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov. This document is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession #ML052650410.

7 Copies may be purchased from the publisher, John Wiley & Sons, 111 River Street, Hoboken, NJ 07030-5774, telephone (201) 748-6000. Purchase information is available through the publisher's Web site at http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471121576.html.

8 Draft Regulatory Guide DG-1143 is available electronically under Accession #ML053140225 in the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4209 by fax at (301) 415-3548, and by email to PDR@nrc.gov.