American Nuclear Society

# standard for estimating tornado and extreme wind characteristics at nuclear power sites

an American National Standard





published by the
American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60525 USA

ANSI/ANS-2.3-1983

# American National Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites

Secretariat
**American Nuclear Society**

Prepared by the
**American Nuclear Society Standards Committee Working Group ANS-2.3**

Published by the
**American Nuclear Society**
**555 North Kensington Avenue**
**La Grange Park, Illinois 60525 USA**

Approved October 17, 1983
by the
**American National Standards Institute, Inc.**

**American National Standard**

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

**CAUTION NOTICE:** This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Purchasers of this standard may receive current information, including interpretation, on all standards published by the American Nuclear Society by calling or writing to the Society.

Published by

**American Nuclear Society**
**555 North Kensington Avenue, La Grange Park, Illinois 60525 USA**

Price: $25.00



Printed in the United States of America

# Foreword

(This Foreword is not a part of American National Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites, ANSI/ANS-2.3-1983.)

The purpose of this standard is to specify guidelines to determine the wind velocity, atmospheric pressure change, missile type, size, and velocity that result from tornadoes, hurricanes, and other extreme winds to be used in nuclear plant design. The standard does not treat the forces that result from these natural events.

This proposed standard was prepared by Working Group ANS-2.3 of the Subcommittee ANS-2, Site Evaluation, of the American Nuclear Society Standards Committee. Working Group ANS-2.3 was formed in the fall of 1973 and had its initial meeting in November. The working group has met 15 times during the succeeding years to develop Draft 2, Revision 5 of the standard. Draft 1, Revision 0 was written in November 1974 and was circulated for comments internal to Working Group ANS-2.3. These comments resulted in Draft 1, Revision 1, which was circulated to utilities, architect-engineers, and universities for comments. Thirty of these groups responded with comments that were incorporated into the proposed standard as Draft 1, Revision 2. Additional review and comments by the working group resulted in Draft 1, Revision 3, Revision 4, and Revision 5. Draft 2, Revision 0 was reviewed by ANS-2, whose comments led to Draft 2, Revision 1, 2, 3, 4 and this Revision 5.

## History of Major Points Discussed and Their Resolution

(These points are not a part of the proposed ANS-2.3 Standard.)

**Point 1:** Choice of 1° latitude by 1° longitude area as the base for data analysis.

The 5° by 5° area, which was considered initially, was determined to be too large after study. It used results in understanding the frequency of occurrence of tornadoes when the proposed site is in a high frequency region, and it results in overestimating the frequency of occurrence in lower frequency regions. However, due to population bias in reporting tornadoes and differing opinions regarding intensities as well as meteorological and topographical variations, the averaging approach utilizing the 3° by 3° running mean was chosen to smooth out apparent inconsistencies.

**Point 2:** Initially, special "local areas" were considered in nonhomogeneous terrain. This method permitted the regionalization of "design basis tornado" windspeeds. Local variations exist within the different regions, but the regional values are meant to provide an upper limit on $10^{-5}$, $10^{-6}$, and $10^{-7}$ tornadic windspeeds.

**Point 3:** The need for a prototype wind profile for a design basis tornado.

The Dallas, Texas, tornado documented by W. H. Hoecker (*Monthly Weather Review*, **88**, 167-180; 1960) was originally chosen as the prototype wind profile for the design basis tornado. However, the review and comments on Draft 1, Revision 1, by both the working group members and by reviewers from industry and universities indicated a strong preference for the combined Rankine tangential wind field model for a design tornado.

**Point 4:** The original intent of the working group was to provide explicit guidance on tornado-borne missiles using two approaches: specified missile velocities for a representative list of missiles and methods based on risk analyses. A consensus was achieved on specified missile velocities for each tornado wind-speed corresponding to $10^{-5}$, $10^{-6}$, and $10^{-7}$ per year probabilities as given on the regionalization maps by relying on methods such as the one recommended by E. Simiu and M. Cordes ("Tornado-Borne Missile Speeds," NBSIR 76-1050, National Bureau of Standards, Washington, D.C., 1976). For risk analysis methods, a consensus was gained only on an acceptable level of risk. This approach is still under development, and the amount of experience necessary to develop a consensus on standardized procedures has not yet been accumulated.

**Point 5:** The tornadic windspeeds presented in Section 3, Tornadoes, are meant to apply at the 33 ft (10 m) level above ground. This height is consistent with standard meteorological practice.

**Point 6:** Methods of determining velocities of extreme winds other than tornadoes.

In Draft 1, Revision 1, two methods of determining extreme winds, were considered. Method One, utilizing the approach in ANSI A58.1-1972, was recommended for open areas and coastal regions including hurricanes. Method Two provided for the development of design windspeeds in areas other than open country and to gain more accuracy and precision in estimating the speeds.

The working group agreed to eliminate Method One in Draft 1, Revision 3, because:

(1) The maps used in American National Standard Minimum Design Loads for Buildings and Other Structures, ANSI A58.1-1972 were developed using 13 years of data to determine the design basis windspeed; over nine additional years of data are available that significantly increase the statistical validity of the data.

(2) The isolines of design basis windspeeds for the 100-year return interval contain errors and should not be used.

(3) There is a tendency for designers to extract interpolated values from the ANSI A58.1-1972 maps; these approach maps do not adequately represent appropriate windspeeds.

In Draft 2, Revision 3, the committee decided, on the basis of recent publications, that the Fisher-Tippett Type I extreme value distribution should be used to determine design basis windspeeds from available windspeed records. This approach is proposed in lieu of use of the Fisher-Tippett Type II distribution proposed in earlier revisions of the standard. In most cases of well-behaved wind climates, the Type I distribution fits the windspeed data better than the Type II. (E. Simiu and J. J. Filliben, "Statistical Analysis of Extreme Winds," National Bureau of Standards, Technical Note No. 868, 1975.)

The Type I distribution will likely be used in the revised version of the American National Standard ANSI A58.1-1972. The National Building Code of Canada (1975) also assumes that the extreme winds are modeled by the Type I distribution.

**Point 7:** Severe weather warning systems.

Draft 1, Revision 1, contained a section on severe weather warning systems as directed by ANS-2. It was later decided that ANS-2.3 was concerned with the design phase of nuclear power plants and not the operational phase. ANS-2.3 agreed to eliminate this section, as it was an operational and not a design function of nuclear power plants.

**Point 8:** Probability of tornado hazard.

Draft 1, Revision 1, contained one tornado windspeed regionalization map for a hazard probability of $10^{-7}$ per year. Comments were received to suggest that additional maps be prepared to correspond to annual probabilities of $10^{-5}$ and $10^{-6}$ as well. Depending on type of facility and consistency with American National Standard Guidelines for Combining Natural and External Man-Made Hazards at Power Reactor Sites, ANSI/ANS-2.12-1978, the appropriate tornado windspeed and missile characteristics can be selected for a given region.

**Point 9:** As recent data became available during the Draft 2, Revision 5 update, the committee found it necessary to increase the maximum tornado windspeed from 300 to 320 mph and to change the areas of windspeed categories on the regionalization maps.

Working Group ANS-2.3 of the Standards Committee of the American Nuclear Society had the following membership:*

G. W. Nicholas, Chairman, *Dames & Moore*
R. F. Abbey, Jr., *Department of the Navy, Office of Naval Research (formerly with the U.S. Nuclear Regulatory Commission)*
J. E. Cermak, *Colorado State University*
J. F. Costello, *U.S. Nuclear Regulatory Commission*
T. T. Fujita, *University of Chicago*
J. R. McDonald, *Texas Tech University*
K. Wiedner, *Bechtel Power Corporation*

*Contributions were also made by the following individuals who served as members of ANS-2.3 for a significant portion of this effort:

A. Almuti, *Bechtel Associates Professional Corporation*
R. Beebe, *Tennessee Valley Authority (formerly with Dames & Moore)*
H. L. Crutcher, *Consultant (formerly with National Oceanic and Atmospheric Administration)*
N. L. Hallanger, *Meteorological Research, Inc.*
G. C. Hart, *University of California, Los Angeles*
S. H. Hobbs, *Brown & Root, Inc.*
R. Kornasiewicz, *U. S. Nuclear Regulatory Commission*
F. Nicholson, *Science Applications, Inc. (formerly with Dames & Moore)*
E. W. Peral, *University of Chicago*
K. E. Sanders, *U. S. Nuclear Regulatory Commission*
T. Smith, *Meteorological Research, Inc.*
J. Shanahan, *Stone & Webster Engineering Corporation*
I. Spickler, *U. S. Nuclear Regulatory Commission (formerly with Dames & Moore)*

Subcommittee ANS-2, Site Evaluation, of the American Nuclear Society Standards Committee, had the following membership at the time of its approval of this standard:*

R. V. Bettinger, Chairman, *Pacific Gas and Electric Company*
L. L. Beratan, *U. S. Nuclear Regulatory Commission*
A. Brearley, *Sargent & Lundy*
L. E. Escalante, *Los Angeles Department of Water and Power*
M. I. Goldman, *NUS Corporation*
W. W. Hays, *U. S. Geological Survey*
G. E. Heim, *Battelle-Columbus*
U. Kappus, *Dames & Moore*
C. R. McClure, *Bechtel Civil and Minerals, Inc.*
S. J. Milioti, *American Electric Power Service Corporation*
G. W. Nicholas, *Dames & Moore*
R. M. Noble, *R. M. Noble & Associates*
D. Ostrom, *Southern California Edison Company*
I. Spickler, *U. S. Nuclear Regulatory Commission*
J. D. Stevenson, *Stevenson & Associates*
A. Vaish, *PMB Systems Engineering, Inc.*
R. W. Whalin, *U. S. Army Corps of Engineers*
K. Wiedner, *Bechtel Power Corporation*

***The subcommittee acknowledges the participation of the following former members:**

D. H. Johns, *Southern California Edison Company*
E. J. Keith, *EDS Nuclear, Inc.*
T. Pickel, *Oak Ridge National Laboratory*
D. Siefken, *U. S. Nuclear Regulatory Commission*
J. M. Smith, *General Electric Company*
S. Tucker, *Florida Power and Light Company*

****The American Nuclear Society's Nuclear Power Plant Standards Committee (NUPPSCO) had the following membership at the time it balloted this standard in May 1980:**

J. F. Mallay, Chairman
M. D. Weber, Secretary

| Name of Representative | *Organization Represented* |
|---|---|
| G. A. Arlotto | *U.S. Nuclear Regulatory Commission* |
| R. G. Benham | *General Atomic Company* |
| | *(for the Institute of Electrical and Electronics Engineers Inc.)* |
| R. E. Allen (Alt.) | *United Engineers & Constructors, Inc.* |
| | *(for the Institute of Electrical and Electronics Engineers Inc.)* |
| R. V. Bettinger | *Pacific Gas and Electric Company* |
| P. Bradbury | *Westinghouse Advanced Reactor Division* |
| D.A. Campbell | *Westinghouse Electric Corporation* |
| C.O. Coffer | *Kaiser Engineers* |
| L. J. Cooper | *Nebraska Public Power District* |
| W. H. D'Ardenne | *General Electric Company* |
| C. J. Gill | *Bechtel Power Corporation* |
| H. J. Green | *Tennessee Valley Authority* |
| W. Johnson | *Catalytic, Inc.* |
| A. R. Kasper | *Combustion Engineering, Inc.* |
| R. W. Keaten | *GPU Services Corporation* |
| J. W. Lentsch | *Portland General Electric Company* |
| J. F. Mallay | *NUTECH Engineers* |
| | *(for the American Nuclear Society)* |
| A. T. Molin | *United Engineers and Constructors, Inc.* |
| J. H. Noble | *Chas. T. Main, Inc.* |
| E. P. O'Donnell | *Ebasco Services, Inc.* |
| | *(for the Atomic Industrial Forum)* |
| T. J. Pashos | *Quadrex/Nuclear Services Corporation* |
| M. E. Remley | *Rockwell International* |
| J. Stacey | *Yankee Atomic Electric Company* |
| S. L. Stamm | *Stone & Webster Engineering Corporation* |
| J. D. Stevenson | *Stevenson & Associates* |
| | *(for the American Society of Civil Engineers)* |
| G. Wagner | *Commonwealth Edison Company* |
| G. L. Wessman | *Torrey Pines Technology* |
| J. E. Windhorst | *Southern Company Services, Inc.* |
| E. R. Wiot | *NUS Corporation* |

****This roster indicates NUPPSCO members' affiliations at the time of consensus committee ballot.**

# Contents

# Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites

## 1. Scope

This standard establishes guidelines to estimate the frequency of occurrence and the magnitude of parameters associated with tornadoes, hurricanes, and other extreme winds at nuclear power reactor sites. It treats data and methods to determine wind speed, characteristics of the wind field, atmospheric pressure change, rate of pressure change, and missile characteristics. It does not treat the forces on structures that result from these physical phenomena.

For a site within the contiguous United States, the standard presents the design basis tornado and tornado-generated missile characteristics and a recommended methodology for determining non-tornadic extreme winds that a nuclear power plant be designed to withstand in order to assure that public health and safety will be maintained as required in the Code of Federal Regulations, Title 10 "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, Criteria 2 and 4 [1].[1] Tornadoes have occurred in all states covered by this standard. The standard does not address the determination of the design basis tornado, other extreme windspeeds for sites located in Alaska, Hawaii, and Puerto Rico or over the oceans. Such determinations should be evaluated on a case-by-case basis. Additionally, the standard does not identify the structures, systems, and components that should be designed to withstand the effects of the design basis windspeeds and remain functional; nor does it treat the structural design requirements for protection from these winds.[2]

## 2. Definitions

**cyclostrophic wind.** The cyclostrophic wind is the horizontal wind velocity for which the centrifugal force exactly balances the horizontal pressure gradient force. The cyclostrophic wind is a good approximation of the real wind in cases of very great windspeed and strong curvature such that the centrifugal force is clearly dominant over nonpressure gradient forces, such as the Coriolis force.

**design data tornado.** The design basis tornado is a postulated tornado, used for design purposes only, having characteristics consistent with an acceptably low probability of exceedance.

**F scale.** A rating system devised (Fujita [2]) to facilitate categorizing tornadoes according to the damage they produce, F. F-scale winds are defined to apply at the 33 ft (10 m) height.

Although windspeeds are associated with each F-scale rating, rigorous justification for them has not been firmly established.

**rankine vortex.** A two-dimensional circular flow in which a circular region about the origin is in solid rotation:

$$\frac{V}{R} = \text{constant},$$

where V is the tangential speed and R the distance from the origin; and the region outside is free of vorticity, the speed being inversely proportional to the distance from the origin,

$$VR = \text{constant}.$$

**tornado.** A violently rotating column of air whose circulation reaches the ground, pendant from the base of a convective cloud, and often observable as a condensation funnel attached to the cloud base, or as a rotating dust cloud rising from the ground.

**tornado-generated missile.** Tornado-generated missiles are objects that either become airborne, or tumble along the ground, or both, as the result of the wind pressure forces of a tornado and the aerodynamic characteristics of the objects.

**vortex.** A vortex is any closed circulation flow.

[1] Numbers in brackets refer to corresponding numbers in Section 5, References.

[2] U.S. NRC Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants" and its supporting document WASH-1300 were issued in 1974. The analyses and conclusions contained in ANSI/ANS-2.3-1983 are felt to represent the current state of knowledge on tornado and extreme wind characteristics.