April 1974

U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.76

DESIGN BASIS TORNADO FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, in part, that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as tornadoes without loss of capability to perform their safety functions. Criterion 2 also requires that the design bases for these structures, systems, and components reflect (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding region, with sufficient margin for the limited accuracy and quantity of the historical data and the period of time in which the 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.

Paragraph 100.10(c) of 10 CFR Part 100, "Reactor Site Criteria," requires that physical characteristics of the site, including meteorological conditions at the site and in the surrounding area be considered in determining the acceptability of a site for a nuclear power plant.

This guide describes a design basis tornado acceptable to the Regulatory staff for each of three regions within the contiguous United States that a nuclear power plant should be designed to withstand without undue risk to the health and safety of the public. This guide does not address the determination of the design basis tornado for sites located in Alaska, Hawaii, and Puerto Rico. Such determinations will be evaluated on a case-by-case basis. This guide does not identify the specific structures, systems, and components which should be designed to withstand the effects of the design basis tornado and remain functional, nor does this guide discuss the structural design requirements for tornado protection. Subsequent guides are intended (1) to identify the specific structures, systems, and components which should be designed to withstand the effects of the design basis tornado and (2) to describe design basis tornado-generated missiles and other tornado-induced effects on nuclear power plant structures, systems, and components important to safety. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

Nuclear power plants must be designed so that the plants remain in a safe condition in the event of the most severe tornado that can reasonably be predicted to occur at a site as a result of severe meteorological conditions. For the last several years, many investigators have studied the meteorological circumstances preceding and during tornado occurrences and the destruction following tornado strikes. Because of the inherent difficulty in directly observing a tornado and the great uncertainty in predicting the time and location of its occurrence, the possibility of directly sensing tornado properties such as a maximum wind speed is remote. Essentially all conclusions concerning tornado properties have been based on indirect observations of subsequent destruction, structural failure, generated missiles, or tornado markings rather than direct measurement of the tornado. Determinations of maximum speeds in tornadoes have been rough approximations. As a result of these studies, however, tornadoes have been characterized by a set of properties which are significant for purposes of structural design and siting. These significant properties, or parameters, are (1) geographical distribution of frequency of occurrence, (2) rotational wind speed, (3) translational wind speed, (4) pressure drop across the tornado, (5) rate of this pressure drop, and (6) radius of maximum rotational wind speed. Using

these properties, it is possible to develop a definition for a design basis tornado in terms of the six tornado parameters and use analytical techniques for estimating values of these parameters for purposes of design with an adequate level of conservatism.

The results of a study[1] to obtain a regionalized design basis tornado are summarized in Table I and Figure 1 of this guide. This study demonstrates the methods used to estimate probable values of tornado parameters. The design basis tornado is defined in terms of values for the six descriptive parameters in Table I.

These values are listed for each of the three tornado intensity regions within the contiguous United States.

[1] This study, entitled "Technical Basis for Interim Regional Tornado Criteria," is available as WASH-1300 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Figure 1 depicts the general boundaries of the three regions to which the three sets of parameters apply. The western boundary of Region I lies generally in the eastern foothills of the Rocky Mountains.

C. REGULATORY POSITION

1. Nuclear power plants should be designed to withstand the Design Basis Tornado (DBT). The values of the parameters specified in Table I for the appropriate regions of Figure 1 are generally acceptable to the Regulatory staff for defining the DBT for a nuclear power plant. Sites located near the general boundaries of adjoining regions may involve additional consideration.

2. If a DBT proposed for a given site is characterized by less conservative values for the parameters than the regional values in Table I, a comprehensive analysis should be provided to justify the selection of the less conservative design basis tornado.

TABLE I

DESIGN BASIS TORNADO CHARACTERISTICS

Region	Maximum Wind Speed[a] (mph)	Rotational Speed (mph)	Translational Speed (mph) Maximum	Translational Speed (mph) Minimum[b]	Radius of Maximum Rotational Speed (feet)	Pressure Drop (psi)	Rate of Pressure Drop (psi/sec)
I	360	290	70	5	150	3.0	2.0
II	300	240	60	5	150	2.25	1.2
III	240	190	50	5	150	1.5	0.6

[a] The maximum wind speed is the sum of the rotational speed component and the maximum translational speed component.

[b] The minimum translational speed, which allows maximum transit time of the tornado across exposed plant features, is to be used whenever low travel speeds (maximum transit time) are a limiting factor in design of the ultimate heat sink. The ultimate heat sink is that complex of water sources, including associated retaining structures, and any canals or conduits connecting the sources with, but not including, the intake structures of nuclear reactor units. Regulatory Guide 1.27 (Safety Guide 27), "Ultimate Heat Sink," describes a basis that may be used to implement General Design Criterion 44 of Appendix A to 10 CFR Part 50 with regard to the ultimate heat sink.

U.S. GOVERNMENT PRINTING OFFICE: 1974—543-118:226

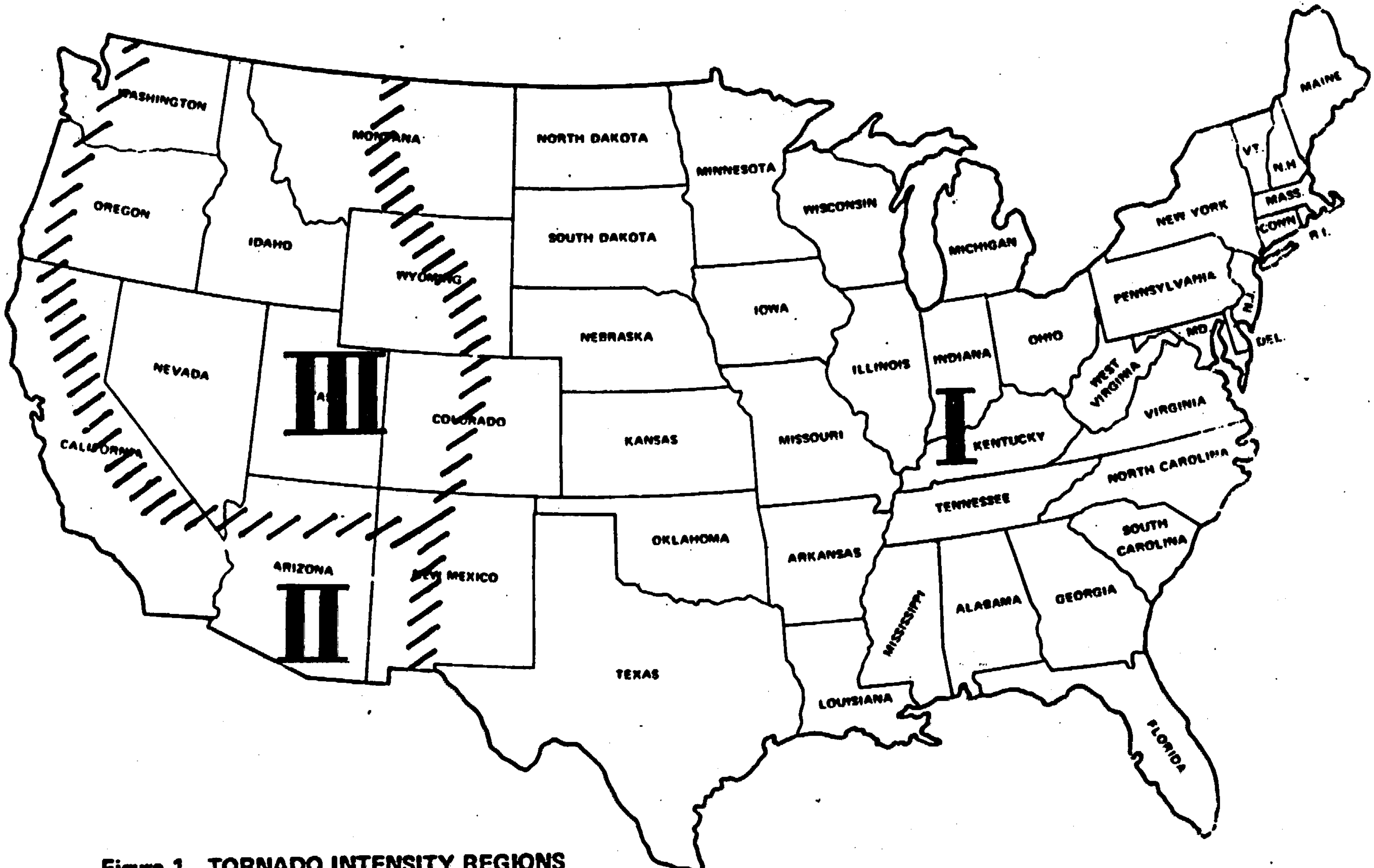

Figure 1. TORNADO INTENSITY REGIONS