# American Nuclear Society

## guidelines for combining natural and external man-made hazards at power reactor sites

## an American National Standard

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# American National Standard Guidelines for Combining Natural and External Man-Made Hazards At Power Reactor Sites

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# Foreword

(This Foreword is not a part of American National Standard Guidelines for Combining Natural and External Man-Made Hazards at Power Reactor Sites, ANSI/ANS-2.12-1978.)

In May 1974, the ANS-2 Subcommittee, Site Evaluation, was given the responsibility for developing a standard to determine the combination of natural and external man-made hazards to be considered in plant design.

A working group was formed and designated ANS-2.12, "Guidelines for Combining Natural and External Man-Made Hazards for Power Reactor Sites." A scope for this effort was developed by the working group as given in this standard.

The working group met in September and November 1974. In January 1975, the working group was selected to participate in an experiment on accelerating the establishment of nuclear standards which was sponsored by the American National Standards Institute (ANSI) using funds provided by the U.S. Nuclear Regulatory Commission. Battelle-Northwest conducted the experiment under contract with ANSI. The key ingredient of the experiment was a one-week working session at the Battelle Seattle Research Center with Battelle providing an executive secretary and clerical assistance. The first draft of the standard was a product of these three meetings.

The working group felt that this standard should attempt to:

(1) include a thorough candidate list of the natural and external man-made hazards to be considered.

(2) establish a probability approach for combining natural and external man-made hazards.

(3) develop a set of exclusion criteria which would allow candidate hazards or hazard combinations to be judged as not requiring consideration in nuclear power plant design.

(4) provide a methodology for combining hazards which designers could use.

(5) give a list of standard hazard combinations.

(6) where possible, refer to other existing ANSI standards for characterization of the individual natural hazards.

(7) provide a reference document for external man-made hazards, and

(8) attempt to provide a probability level for hazard combinations where possible.

The scope and these guidelines have been followed in this standard.

In preparing this standard, it was found that data on the probability of occurrence and the duration of natural hazards are very scarce, particularly for the extreme "probable maximum events." The ANS-2.12 working group partially circumvented this status by using the concept of recurrence intervals for the natural hazards which occur more frequently than the "probable maximum events." It is left to the designer to determine the magnitude of an event with a given recurrence interval for his site. More work is needed in defining the probabilities of occurrence of severe or extreme phenomena.

Another area which needs more evaluation is whether, and to what extent, natural hazards cause or increase the probability of external man-made hazards, as for example, the effect of ice or fog on airplane accidents. Similarly, research is required on the degree of dependence or effects of one natural hazard causing another, as for example, the relationship between a tornado and rain.

The ANS-2.12 Working Group wishes to clearly state that it is difficult to precisely establish the probability of occurrence of natural and external man-made hazards. The phenomena are complex and the probability of each is a function of parameters such as geographical location, time of year and nature of the hazard. There are different probabilities for the various intensities of a hazard. When one takes the next step, to develop a methodology of combining these hazards and attempts to use a probability acceptance limit for the combination, as was done, the task is even more difficult.

In this standard, the working group took what they consider to be an engineering approach. It is believed some guidance on hazard combination is needed relatively

quickly for nuclear power plant designers. The working group saw that in some areas designers are working on the basis of conservative assumptions in states of uncertainty, where the data are incomplete and not perfectly known. The working group therefore used their judgment in setting down the bounding values for the frequency of occurrence of certain hazards and their durations. In some instances estimates were made based on the group's collective experience. Summaries of data on hazards and published methodologies for estimating their probabilities of occurrence were reviewed. Where possible, values were used which are already generally accepted in the nuclear industry or which are believed to be acceptable, based on past licensing actions.

When the standard hazard combinations in this document were derived, they were not further examined for their consequences to see if the damage which they would cause to a nuclear plant is acceptable. This will involve further refinement and study by the designer.

Only hazards external to the plant are considered in this standard. In-plant hazards such as internal missiles and pipe ruptures are not included. Sabotage is not included as a man-made hazard.

This standard does not address the effects of a combination of hazards on a nuclear plant, nor does it consider repair times or the plant process condition which is appropriate to the hazard combination. Further guidance on these matters is expected to be addressed by the reactor criteria documents under development by ANS-50, Power Reactor Systems Committee.*

In defining durations for hazards, the repair time of the plant is not included because the plant operating state subsequent to the event will be significantly altered by the original event. Hence only the duration of the event itself as specified in the standard is used. For example, if an SSE occurs the plant will be shutdown for inspection and evaluation.

This standard does not include the development of specific loading combinations, load factors or behavior requirements to be used in design because these criteria are to be determined in accordance with the applicable codes or standards governing the design of the specific systems, components or structures being considered. In addition, it should be understood that the rational development of design requirements, not otherwise covered by applicable codes and standards, includes an evaluation of the consequences as well as the probability of occurrence of all hazards, both man-made and natural, and external and internal to the reactor system.

The working group believes the approach used in this standard will be useful to nuclear plant designers in developing severe and extreme load design criteria.

Working Group ANS-2.12 of the Standards Committee of the American Nuclear Society had the following membership:**

S. J. Milioti, Chairman, *American Electric Power Service Corporation*
R. O. Barnett, *Tennessee Valley Authority*
P. Gottlieb, *Dames & Moore*
L. L. Beratan, *U.S. Nuclear Regulatory Commission*
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*ANS-52.1-1978, "Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants," Revision to N18.2-1973 (ANS-51.8), "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," and draft standards under development: ANS-53.1 (N213) "Nuclear Safety Criteria for the Design of Stationary Gas Cooled Reactor Plants," and ANS-54.1 (N214) "General Safety Design Criteria for an LMFBR Nuclear Power Plant."

**Contributions were also made by W.R. Sugnet of Westinghouse Electric Corporation and C.E. Johnson of the U.S. Nuclear Regulatory Commission who served as members of ANS 2.12 for a major portion of this effort. N.G. Wittenbrock of Battelle, Pacific Northwest Laboratories served as executive secretary during the ANSI-sponsored experiment in writing nuclear standards.

The membership of ANS-2, Site Evaluation, at the time of approval of this standard was:

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The American National Standards Committee N18, Nuclear Design Criteria, had the following membership at the time it reviewed and approved this Standard:

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# Contents

# Guidelines for Combining Natural and External Man-Made Hazards at Power Reactor Sites

## 1. Scope

This standard presents guidelines which will allow power reactor designers to select (1) combinations of natural hazards, (2) combinations of external man-made hazards, and (3) combinations of natural and external man-made hazards to be used in the design of power reactor structures, systems, and components. The hazards to be considered in these categories are identified. Probability level acceptance criteria are defined which will enable designers to select the combinations of hazards which are design bases for a particular site. Methods for calculating probabilities of combinations are discussed.

## 2. Definitions

The following special definitions will be useful in understanding this standard.

**aircraft impact.** Accidental impact of an aircraft into a safety-related structure, system or component such that the resulting missile, fire, or smoke could affect the ability of the structure, system or component to perform its intended safety function.

**combined event.** An event consisting of the simultaneous occurrence of two or more natural or external man-made hazards.

**dependent events.** Event combinations for which the occurrence of one event gives information about (increases or decreases) the possibility of the occurrence of the other event. For example, the occurrence of a hazard such as an earthquake may increase the chance of an explosion at a nearby industrial facility.

**extreme environmental load.** Load which is credible but highly improbable.

**flood-coastal.** Abnormally high water on open and semi-enclosed bodies of water resulting from storm surge and tsumami, precipitation, tide, wind-wave activity, and possible flood at nearby stream.

**flood-lake.** Abnormally high water on enclosed bodies of water resulting from high lake level, storm surge and seiche, precipitation, wind-wave activity, and possible flood of nearby stream.

**flood-river.** Abnormally high water on an inland stream resulting from precipitation and snowmelt runoff, possible ice blockage, wind-wave activity, and possible dam failure or stream diversion.

**independent events.** Event combinations for which the occurrence of one event does not give information about (increasing or decreasing) the probability of the occurrence of the other. If two events A and B are independent, the conditional probability for the occurrence of A given the occurrence of B is simply the probability for the occurrence of A alone (unaffected by the occurrence of B).

**industrial or military facility accident.** Explosion, missile, fire, toxic gas release or other potential hazard from a fixed facility.

**man-made hazard.** An accident involving vehicles, equipment, or structures created by man which occurs external to a nuclear power generating station and has the potential for causing damage to safety related structures, systems, or components or a nuclear power generating station.

**missile.** A mass which has kinetic energy and is unrestrained.

**mutually exclusive.** Two or more events which cannot physically occur simultaneously.

**natural hazard.** A natural phenomenon which has the potential for causing damage to safety-related structures, systems, or components of a nuclear power generating station.

**operating basis earthquake (OBE).** That