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**IEEE Recommended Practices for
Seismic Qualification of Class 1E Equipment for
Nuclear Power Generating Stations**

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**IEEE Recommended Practices for
Seismic Qualification of Class 1E Equipment for
Nuclear Power Generating Stations**

Sponsor
**Nuclear Power Engineering Committee of the
IEEE Power Engineering Society**

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American National Standards Institute

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Foreword

(This foreword is not a part of IEEE Std 344-1975, Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.)

The IEEE has developed this document to provide direction for developing programs to seismically qualify Class 1E equipment for nuclear power generating stations. It supplements IEEE Std 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations, which describes the basic requirements for equipment qualification.

The Class 1E equipment to be qualified by procedures or standards established by this document are of many forms, characteristics, and materials; therefore, the document presents many acceptable methods with the intent of permitting the user to make a judicious selection from among the various options. In making such a selection, the user should choose those that best meet a particular equipment's requirements. Further, in using this document as a specification for the purchase of equipment, the many options should also be recognized and the document invoked accordingly.

It is recommended that the need for specific standards for the seismic qualification of particular kinds of equipment be evaluated by those responsible for such documents and that consideration be given to the application of particular methods from this document which are most suitable. Those preparing such specific standards may wish to consider the establishment of seismic ratings, design criteria, or other subjects not covered by these recommended practices but in so doing should follow the principles established herein.

This document will be revised from time to time as more information becomes available. Topics under consideration for future inclusion are: simplified methods and equipment for multiaxis testing; expanding the guidance on combined testing and analysis; and guidance for power spectral density testing.

Adherence to this document alone may not suffice for assuring public health and safety since it is the integrated performance of structures, fluid systems, instrumentation systems, and electrical systems of the nuclear power generation station that establishes safe operating conditions.

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An American National Standard

IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

1. Scope

These recommended practices provide direction for establishing procedures that will yield data which verify that the Class 1E equipment can meet its performance requirements during and following one SSE (safe shutdown earthquake) preceded by a number of OBEs (operating basis earthquakes). This document may be used by equipment manufacturers to establish procedures that will yield data to substantiate performance claims or by equipment users to evaluate and verify performance of representative devices and assemblies as part of an overall qualification effort.

2. Definitions

The definitions in this section establish the meanings of words in the context of their use in this document.

assembly. Two or more devices sharing a common mounting or supporting structure.

NOTE: Examples are control panels and diesel generators.

broadband response spectrum. A response spectrum that describes the motion indicating that multiple frequency excitation predominates.

Class 1E. The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or otherwise are essential in preventing significant release of radioactive material to the environment.

device. An item of electric equipment that is used in connection with, or as an auxiliary to, other items of electric equipment.

floor acceleration. The acceleration of a particular building floor (or equipment mount-

ing) resulting from a given earthquake's motion. The maximum floor acceleration can be obtained from the floor response spectrum as the acceleration at high frequencies (in excess of 33 Hz) and is sometimes referred to as the ZPA (zero period acceleration).

fragility. Susceptibility of equipment to malfunction as the result of structural or operational limitations, or both.

fragility level. The highest level of input excitation, expressed as a function of input frequency, that an equipment can withstand and still perform the required Class 1E functions.

fragility response spectrum (FRS). A TRS (test response spectrum) obtained from tests to determine the fragility level of equipment. (See test response spectrum.)

ground acceleration. The acceleration of the ground resulting from a given earthquake's motion. The maximum ground acceleration can be obtained from the ground response spectrum as the acceleration at high frequencies (in excess of 33 Hz).

low-cycle fatigue. A progressive fracture or cumulative fatigue of the material which may occur for less than 1000 cycles because of localized stress concentration at high strains under fluctuating loads.

NOTE: As the strain is reduced, the fatigue life increases exponentially. Ultimately, the number of cycles can be increased indefinitely at a reduced stress designated as the endurance limit of the material.

malfunction. The loss of capability of Class 1E equipment to initiate or sustain a required function, or the initiation of undesired spurious action which might result in consequences adverse to safety.

narrow band response spectrum. A response spectrum that describes the motion indicating that a single frequency excitation predominates.

natural frequency. The frequency or frequencies at which a body vibrates due to its own physical characteristics (mass, shape) and elastic restoring forces brought into play when the body is distorted in a specific direction and then released, while restrained or supported at specified points.

octave. The interval between two frequencies which have a frequency ratio of two.

operating basis earthquake (OBE). That earthquake which could reasonably be expected to affect the plant site during the operating life of the plant; it is that earthquake which produces the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.

power spectral density (PSD). The mean squared acceleration density of a random waveform. PSD is usually expressed in square gauss per hertz.

required response spectrum (RRS). The response spectrum issued by the user or his agent as part of his specifications for proof testing, or artificially created to cover future applications. The RRS constitutes a requirement to be met.

response spectrum. A plot of the maximum response of single-degree-of-freedom bodies, at a damping value expressed as a percent of critical damping of different natural frequencies, when these bodies are rigidly mounted on the surface of interest (that is, on the ground for the ground response spectrum or on the floor for the floor response spectrum) when that surface is subjected to a given earthquake's motion as modified by any intervening structures.

safe shutdown earthquake (SSE). That earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to assure: (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut-down the reactor and maintain it in a safe

shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of Code of Federal Regulations, Title 10, Part 100 (December 5, 1973).

sine beats. A continuous sinusoid of one frequency, amplitude modulated by a sinusoid of a lower frequency.

NOTES: (1) As used in this document, the amplitudes of the sinusoids represent acceleration and the modulated frequency represents the frequency of the applied seismic stimulus.

(2) Beats are usually considered to be the result of the summation of two sinusoids of slightly different frequencies with the frequencies within the beats as the average of the two, and the beat frequency as one-half the difference between the two. However, as used here, the sine beats may be an amplitude-modulated sinusoid with pauses between the beats (see Fig 2).

test response spectrum (TRS). The response spectrum that is constructed using analysis or derived using spectrum analysis equipment based on the actual motion of the shake table.

NOTE: When qualifying equipment by utilizing the response spectrum, the TRS is to be compared to the RRS, using the methods described in the body of this document.

3. Earthquake Environment and Equipment Response

This section is intended to provide information on earthquake behavior and on the dynamic performance of equipment during earthquakes and simulated seismic events. Numerical values in this section are typical and illustrative but should not be considered as standards.

3.1 Earthquake Environment. Earthquakes produce random ground motions which are characterized by simultaneous but statistically independent horizontal and vertical components. An earthquake of magnitude 6.0 or higher on the Richter scale may persist for 15 to 30 seconds and produce a maximum horizontal ground acceleration from 0.1 to 0.6 *g* or higher with the major energy content usually occurring in the first 5 or 10 seconds. The typical broadband random motion produces damaging effects over a frequency range from 1 to 33 Hz. Usually the vertical component of the ground motion is assumed to be between 67