



REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.100

SEISMIC QUALIFICATION OF ELECTRIC EQUIPMENT FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

Criterion III, "Design Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, among other things, that design control measures provide for verifying the adequacy of design such as by the performance of a suitable testing program. Where a test program is used to verify the adequacy of a specific design feature, it is required to include suitable qualification testing of a prototype unit under the most adverse design conditions. This regulatory guide describes a method acceptable to the NRC staff for complying with the Commission's regulations with respect to verifying the adequacy of the seismic design of electric equipment for all types of nuclear power plants. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

IEEE Std 344-1975¹ (revision of IEEE Std 344-1971), "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," dated January 31, 1975, was prepared by Working Group 2.5 (Seismic Qualification) of Subcommittee 2 (Equipment Qualification) of the Institute of Electrical and Electronics Engineers (IEEE) Nuclear Power Engineering Committee and was subsequently approved by the IEEE Standards Board on December 20, 1974.

*Lines indicate substantive changes from previous issue.

¹ Copies may be obtained from the Institute of Electrical and Electronics Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.

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The provisions of the standard include principles, procedures, and methods of seismic qualification which, when satisfied, will confirm the adequacy of the equipment design for the performance of Class 1E functions during and after the time the equipment is subjected to the forces resulting from one safe shutdown earthquake (SSE) preceded by a number of operating basis earthquakes (OBE's). The standard contains requirements indicated by the verbs "shall" and "must" and recommendations indicated by "should."

The standard, which is an ancillary standard of IEEE Std 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," (endorsed, with exceptions, by Regulatory Guide 1.89, "Qualification of Class 1E Equipment for Nuclear Power Plants"), supplements part of the test methods required and references the margins given in IEEE Std 323-1974.

C. REGULATORY POSITION

Conformance with the requirements and recommendations specified by IEEE Std 344-1975¹ for conducting seismic qualification of Class 1E equipment, when such qualification is performed in conjunction with Regulatory Guide 1.89, provides an adequate basis for complying with design verification requirements of Criterion III of Appendix B to 10 CFR Part 50 with respect to verifying the seismic adequacy of electric equipment, subject to the following:

1. As indicated in Section 5.3, "Static Coefficient Analysis," a static coefficient of 1.5 is used for equipment analysis to take into account the effects of both multifrequency excitation and multimode response. The use of 1.5 as the static coefficient is acceptable for verifying structural integrity of frame-type struc-

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tures, such as members physically similar to beams and columns, that can be represented by a simple model. For equipment having configurations other than a frame-type structure, justification should be provided for use of a static coefficient.

2. Section 6.6.2.1, "Derivation of Test Input Motion," (concerning single-frequency test input motion) states that, for equipment with more than one predominant frequency, the shake table motion should produce a test response spectrum (TRS) acceleration at the test frequencies equal to 1.5 times the acceleration given by the specified required response spectrum (RRS) or less if justified. The section also states that the TRS need not envelop the RRS provided the factor of 1.5 is used.

The use of a factor of 1.5 and the concept that the TRS need not envelop the RRS as a consequence of using 1.5 should not, in the absence of justification, be considered acceptable. For example, in the event that the RRS is broad band, the use of single-frequency test input with a 1.5 magnification factor may not be adequate to excite all modes to the required levels. For ensuring operability of an equipment under seismic event, the test input motion should closely simulate the characteristics of excitation. An equipment malfunction may not be governed by the level of stress but is frequently caused by the vibratory behavior of the response. As stated in Section 6.6.1 of the standard, one of the general requirements for a justifiable seismic test input is that the wave forms should produce a TRS that closely envelops the applicable portion of the RRS. This requirement is intended to ensure that all modes of an equipment are adequately and simultaneously excited to the required levels. Since the TRS produced by the single-frequency test input is narrow band and the RRS may be broad band, the use of single-frequency test input with a 1.5 magnification factor may not always be adequate to excite all modes of the equipment to the required levels. Thus it is necessary that the TRS closely envelop the applicable portion of the RRS to verify the adequacy of test input motion.

3. In the absence of justification, those portions of Section 6.6.2.5, "Sine Sweep Test," which indicate that, for qualifying equipment using the sine sweep test input, the TRS must envelop the RRS according to the criteria described in Sections 6.6.2 and 6.6.2.1 should not be considered acceptable.

As stated in regulatory position 2, one of the requirements to ensure equipment operability is to excite all modes of the equipment adequately and simultaneously to the required levels. One of the criteria used to verify the adequacy of the test input is to have the TRS enveloping the RRS as specified in Section 6.6.1 of the standard. The sine sweep test may not be suitable for equipment qualification for the following reasons:

a. For a fast sweep, even though the equipment may sense nearly simultaneous multimode effects, the duration for each mode to be excited may be too brief to induce adequate resonance as compared to the actual excitations.

b. For a slow sweep, the effects are nearly excitation of one mode at a time. Even with the TRS being broad band and enveloping the RRS, the true sense of simultaneous multimode response is not provided.

Sections 6.6.2 and 6.6.2.1 do not provide specific guidelines concerning either the sweep rate or a justifiable methodology to define the TRS for a sweep input motion.

4. The requirements given in Section 8, "Documentation," should be supplemented by the following:

8.6 Malfunction Data

If a malfunction as defined in Section 2, "Definitions," is experienced during any test, the effect of that malfunction should be determined and documented in the test report.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method described herein is being and will continue to be used in the evaluation of submittals for construction permit applications until this guide is revised as a result of suggestions from the public or additional staff review.

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