



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
 OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 3.10

SEISMIC QUALIFICATION OF CATEGORY I
 INSTRUMENTATION AND ELECTRICAL EQUIPMENT

REVIEW RESPONSIBILITIES

Primary - Mechanical Engineering Branch (MEB)

Secondary - Electrical, Instrumentation and Control Systems Branch (EICSB)

I. AREAS OF REVIEW

Information concerning the methods of test and analysis employed to assure the operability of essential instrumentation and electrical equipment in the event of an earthquake should be provided in the applicant's safety analysis report (SAK) and is reviewed by the MEB in accordance with this plan. Systems and components that must retain structural integrity, remain leaktight, or continue to function in the event of an earthquake, in order to assure safe operation or shutdown of the plant, are designated seismic Category I systems and components.

At the construction permit (CP) stage, the staff review covers the following specific areas:

1. The criteria for seismic qualification, such as the deciding factors for choosing between tests or analyses, the considerations in defining the seismic input motion, and the demonstration of adequacy of the seismic qualification program.
2. The methods and procedures, including tests and analyses, used to assure the operability of seismic Category I instrumentation and electrical equipment in the event of a safe shutdown earthquake (SSE) or less severe earthquakes such as the operating basis earthquake (OBE). Instrumentation and electrical equipment designated as seismic Category I include the reactor protection system, engineered safety feature circuits, emergency power systems, and all auxiliary safety-related electrical systems.
3. The analysis or testing of supports for seismic Category I instrumentation and electrical equipment, and the procedures used to account for possible amplification of vibratory motion (amplitude and frequency content) under seismic conditions. Supports include items such as battery racks, instrument racks, control consoles, cabinets, panels, and cable trays.

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to Revision 2 of the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

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At the operating license (OL) stage, the staff reviews the results of tests and analyses to assure the proper implementation of criteria accepted in the CP review, and to demonstrate adequate seismic qualification.

The EICSB verifies that all of the seismic Category I instrumentation and electrical equipment and supports are included in the seismic qualification program, that the electrical performance aspects of the seismic qualification testing meet safety requirements, and that the equipment mounting during the test adequately simulates the actual service mounting. The EICSB also verifies, at the OL stage, that the equipment and instrumentation used in the plant have been appropriately qualified.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review of this plan are as follows:

1. For plants for which the CP application, including the preliminary safety analysis report (PSAR), was docketed before October 27, 1972, the seismic qualification of Category I instrumentation, electrical equipment, and supports should meet the requirements of IEEE Std 344-1971 (Ref. 3). In addition, the following requirements should be met:

- a. Seismic Qualification for Equipment Operability

- (1) Tests or analyses are required to confirm the functional operability of all seismic Category I electrical equipment and instrumentation during and after an earthquake of magnitude up to and including the SSE. (The analysis method is not recommended for complex equipment that cannot be modeled accurately enough to predict its response correctly.)

Designs and equipment that have been previously qualified by means of tests and analyses equivalent to those described here are acceptable provided that proper documentation of such tests and analyses is submitted.

- (2) Input excitations such as continuous single frequency sinusoidal motions or sine beat motions should be used. The maximum input motion acceleration should equal or exceed the maximum seismic acceleration expected at the equipment mounting location. See II.1.b(3) below for a discussion of the participation of the equipment supports.
 - (3) The discrete frequencies at which the test input motion is applied should cover the range 1-33 Hz. If resonant frequencies of the equipment and equipment supports are identified by prior analysis or "sweep" testing or both, tests conducted only at the resonant frequencies are acceptable.
 - (4) Equipment should be tested in the operational condition. Procedures for monitoring the equipment under test are reviewed by EICSB.
 - (5) The test motion should be applied to one vertical and two orthogonal horizontal axes separately.
 - (6) The test program may be based upon selectively testing a representative number of mechanical components according to type, load level, size, etc. on a prototype basis.

b. Seismic Design Adequacy of Supports

- (1) Analyses or tests should be performed for all supports of seismic Category I electrical equipment and instrumentation to assure their structural capability to withstand seismic excitation.
- (2) The analytical results should include the maximum accelerations and associated frequencies at the equipment mounting location, and the combined stresses of the support structures should be within the limits of the ASME Code, Section III, Subsection NF, "Component Support Structures" (Ref. 2).
- (3) Supports should be tested with equipment installed. If the equipment is installed in a nonoperational mode for the support test, the response at the equipment mounting location should be monitored such that the maximum accelerations and associated frequencies can be defined. In such a case, equipment should be tested separately for operability and the actual input motion to the equipment should be more conservative in amplitude and frequency content than the monitored response.
- (4) The requirements of II.1.a(2), (3), and (5), above, are applicable when tests are conducted on the equipment supports.

2. For plants for which the CP application was docketed after October 27, 1972, the seismic qualification of Category I and instrumentation, electrical equipment, and supports should conform to the following (also see Ref. 4):

a. Seismic Qualification for Equipment Operability

- (1) Tests and analyses are required to confirm the functional operability of all seismic Category I electrical equipment and instrumentation during and after an earthquake of magnitude up to and including the SSE. Analyses alone, without testing, are acceptable as a basis for seismic qualification only if the necessary functional operability of the instrumentation or equipment is assured by its structural integrity alone. When complete seismic testing is impractical, a combination of tests and analyses is acceptable.

Designs and equipment that have been previously qualified by means of tests and analyses equivalent to those described here are acceptable provided that proper documentation of such tests and analyses is submitted.

- (2) The characteristics of the required (seismic) input motion should be specified by response spectrum, power spectral density function, or time history methods. These characteristics, derived from the structures or systems seismic analysis, should be representative of the seismic input motion at the equipment mounting locations.
- (3) Equipment should be tested in the operational condition. Operability should be verified during and after the testing.
- (4) The actual (test) input motion should be characterized in the same manner as the required input motion, and the conservatism in amplitude and frequency content should be demonstrated.

- (5) Seismic excitation generally has a broad frequency content. Random vibration input motion should be used. However, single frequency input motions, such as sine beats, are acceptable provided the characteristics of the required input motion indicate that the motion is dominated by one frequency (e.g., by structural filtering effects), the anticipated response of the equipment is adequately represented by one mode, or the input has sufficient intensity and duration to excite all modes to the required amplitudes such that the testing response spectra will envelope the corresponding response spectra of the individual modes.
 - (6) The test input motion should be applied to one vertical axis and one principal horizontal axis (or two orthogonal horizontal axes) simultaneously unless it can be demonstrated that the equipment response in the vertical direction is not sensitive to the vibratory motion in the horizontal direction, and vice versa. The time phasing of the inputs in the vertical and horizontal directions must be such that a purely rectilinear resultant input is avoided. An acceptable alternative is to test with vertical and horizontal inputs in-phase, and then repeat the test with inputs 180 degrees out-of-phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally.
 - (7) The fixture design should simulate the actual service mounting and should not cause any extraneous dynamic coupling to the test item.
 - (8) The in situ application of vibratory devices to superimpose the seismic vibrator motions on a complex active device for operability testing is acceptable when it is shown that a meaningful test can be made in this way.
 - (9) The test program may be based upon selectively testing a representative number of components according to type, load level, size, etc., on a prototype basis.
- b. Seismic Design Adequacy of Supports
- (1) Analyses or tests should be performed for all supports of seismic Category I electrical equipment and instrumentation to assure their structural capability to withstand seismic excitation.
 - (2) The analytical results should include the required input motions to the mounted equipment as obtained and characterized in the manner stated in 11.2.a(2), above and the combined stresses of the support structures should be within the limits of the ASME Code, Section III, Subsection NF, "Component Support Structures" (Ref. 2).
 - (3) Supports should be tested with equipment installed or with a dummy simulating the equivalent equipment inertial mass effects and dynamic coupling to the support. If the equipment is installed in a nonoperational mode for the support test, the response in the test at the equipment mounting location should be monitored and characterized in the manner as stated in 11.2.a(2), above. In such a case, equipment should be tested separately for operability and the actual input motion to the equipment in this test should be more conservative in amplitude and frequency content than the monitored response from the support test.
 - (4) The requirements of 11.2.a(2), (4), (5), (6), and (7), above, are applicable when tests are conducted on the equipment supports.

3. In documenting the implementation of the seismic qualification program described above, the SAR should:
 - a. Describe briefly the testing facilities, including the capability of the facilities to test the functioning of the equipment being tested and to provide the test input.
 - b. Provide a list of equipment (devices or assemblies) and support structures tested.
 - c. Identify the type of testing input motion, including intensity level, frequency content, number of axes, input duration, and time history sketches of the typical input. The validity of such testing input motion should be demonstrated.
 - d. Describe the number, type, and location of monitoring sensors used.
 - e. Identify whether devices are tested in the operating condition.
 - f. Identify whether devices are mounted during the testing of assemblies or supporting structures (i.e., panels, racks, etc.) and demonstrate the validity of any tests conducted without the devices (or suitable substitutes) or with the mounted devices in inoperative condition.
 - g. In the event testing is replaced by analysis, provide justification that the analysis assures the proper functioning of the equipment during the SSE.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from the procedures described below as may be appropriate for a particular case.

For each area of review the following review procedures are used:

1. At the CP stage, the staff reviews the program which the applicant has described in the PSAR for the seismic qualification of all Category I instrumentation and electrical equipment. The program is measured against the requirements listed in Section II of this plan. Of particular interest are the proper use of test and analytical procedures. Equipment which is too complex for reliable mathematical modeling should be tested unless the analytical procedures and corresponding design are convincingly conservative. Both the test and the analysis methods are reviewed for assurance that all important modes of response have been excited in tests or considered in analyses. Proper application of input motions so as to bound the required input, whether in terms of response spectra, power spectral density, or time history in all necessary directions is verified. The use or treatment of supports is also reviewed.
2. At the OL stage, the staff reviews the program again as described by the applicant in the FSAR. In addition, the FSAR is reviewed for documentation of the successful implementation of the seismic qualification program including test and analysis results. Also, the acceleration levels used in the tests and in the analyses are reviewed for assurance that they equal or exceed the levels at the equipment mounting locations derived from structural response studies of the plant structure as built or as designed.

IV. EVALUATION FINDINGS

The reviewer should verify that sufficient information has been provided and that the review supports conclusions of the following type (for a CP review), to be included in the staff's safety evaluation report:

"The proper functioning of essential instrumentation and electrical equipment in the event of the safe shutdown earthquake (SSE) is necessary to initiate protective actions including, for example, operation of the reactor protection system, engineered safety features, and standby power systems.

"The seismic qualification testing program which will be implemented for seismic Category I instrumentation and electrical equipment provides adequate assurance that such equipment will function properly during the excitation from vibratory forces imposed by the safe shutdown earthquake and under the conditions of post-accident operation. This program constitutes an acceptable basis for satisfying the applicable requirements of General Design Criterion 2."

At the OL stage, the review should provide justification for a finding similar to that above with the phrase "will be implemented" modified to read "has been implemented."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."
2. ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Power Plant Components," American Society of Mechanical Engineers.
3. IEEE Std 344-1971, "Guide for Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.
4. IEEE Std 344-1975, "Guide for Seismic Qualification of Class I Electric Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.
5. K. M. Skreiner, E. G. Fischer, S. N. Hou, and G. Shipway, "New Seismic Requirements for Class I Electrical Equipment," IEEE Paper T 74 048-5, 1974 Winter Meeting of IEEE Power Engineering Society, Institute of Electrical and Electronics Engineers.

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