12-28-79

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 28 1979

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Saul Levine, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NO. 79 AN EVALUATION OF SEISMIC QUALIFICATION TESTS FOR NUCLEAR POWER PLANT EQUIPMENT

INTRODUCTION

This Research Information Letter (RIL) transmits the findings of a research program whose objectives were to subject a typical electrical cabinet specimen to a series of different currently acceptable seismic qualification tests, to acquire therefrom dynamic response data, and to provide a basis for comparison of the tests' effectiveness. The results to date provide some quantitative basis for a decision to use a given type of test, to determine the effectiveness of the method of qualification for a passive structure which may be already installed in an operating plant relative to currently accepted methods of qualification, and to allow recommendations for possible future update of present guidelines for seismic qualification tests. Complete documentation of this program is published in NUREG/CR-0345, entitled "An Evaluation of Seismic Qualification Test for Nuclear Power Plant Equipment." The study was conducted by the Southwest Research Institute under Contract NRC-04-76-372 (formerly AT(49-24)0372), for the Office of Nuclear Regulatory Research.

BACKGROUND

Seismic qualification of Class I equipment and equipment supports for use in nuclear power plants can be demonstrated by analysis or test, or both in combination, depending on the exact nature of the equipment and its function. Applicable procedures are affected by many combinations of parameters, so that standardization of the procedures, if possible, would be helpful. The NRC Regulatory Guide 1.100, and other regulatory guides, as well as several IEEE Standards, specifically govern qualification tests of seismic Category I electric equipment and equipment supports. For years, these guidelines generally have increased in complexity, as safety requirements have become increasingly more rigid.

In view of the variety of equipment that must be considered, useful guidelines must, of necessity, be general in nature, and their application to specific cases must be accomplished with considerable experience and engineering judgement. Furthermore, the use of simpler procedures for qualification of earlier items poses the question of a possible requirement for assessing the effectiveness of the simpler procedures previously used as compared with the methods currently acceptable for seismic qualification of equipment. It is possible that several significantly different detailed qualification procedures, all of which fall within the general guidelines, could be prescribed for a current equipment item.

DISCUSSION

A typical electrical network control cabinet was subjected to a variety of seismic tests that are currently recognized by IEEE-344 (1975) and by Regulatory Guide 1.100. Three triaxial accelerometer positions and three strain gage channels were used to measure excitation and response data. In preliminary tests, cabinet natural modes and damping were determined from resonance searches conducted for both a floor-mounted and seismic simulator-mounted configuration. Subsequently, the cabinet was subjected to a series of different seismic qualification tests according to four different ground-level, and six different floor-level test specifications. Biaxial independent random, biaxial dependent random, uniaxial random sine beat, and sine dwell tests were included. Time histories were generated from both earthquake and random signal sources.

RESULTS

Data from resonance searches were presented in terms of mode shapes, damping values, and transfer functions below 33 Hz. It was found that some differences can occur between modal data obtained from the same cabinet when mounted to a concrete floor and when mounted on the seismic simulator. There is a reduction in natural frequencies in a simulator-mounted condition due to reduced restraint at the base of the cabinet when compared to a floor-mounted condition.

It was found that the currently used criterion that a test response spectrum (TRS) envelope a required response spectrum (RRS), needs to be augmented so as to assure a proper distribution of energy with frequency is achieved during a qualification test. This is vital for equipment operability verifications, but less critical for verifying structural capability of equipment supports, such as the control cabinet used in the tests.

Data from simulated seismic tests were acquired in terms of time histories and response spectra. Then analytical parameters were developed for correlation of the data in terms of peak responses, time average root mean square (RMS) responses, and a new parameter defined as a damage severity factor (DSF). The DSF is defined as a numerical measure of relative damage that can be inflicted by an earthquake transient on structures and components.

Use of a DSF can provide a means of comparison of test severity for all types of tests considered for equipment support structures. It can also be used for purely theoretical comparisons.

Use of DSF indicates that sine dwell and sine beat tests at resonance are more severe than biaxial random tests for verifying structural integrity of passive equipment supports. However, such a conclusion is not applicable to verify operability of active equipment in a seismic event.

Effects of excess zero period acceleration (ZPA) in a test response remain unresolved. That is, possible overtest due to excessive ZPA remains a possibility.

CONCLUSIONS AND RECOMMENDATIONS

A reassessment of the TRS enveloping a RRS, as a criterion for a seismic qualification test, should be initiated. Equipment qualification criteria to ensure operability should be distinguished from those for evaluating structural integrity. Consideration should be given to additional specification of time average power spectra densities to assure that proper frequency content is utilized in excitation time histories.

Resonance searches should be conducted for both simulator-mounted and floor-mounted configurations for items where dynamic coupling with the simulator table is expected. Then, for any subsequent response spectrum test, the TRS should be widened to include the extra range or resonance shift.

The new parameter, the DSF, has been developed for comparing severity of seismic qualification tests. For practical applications, the DSF is computed directly from a real or simulated acceleration time history, and provides a means for comparison of relative damage severity for typical test procedures used for seismic qualifications of subsystems and components. DSF might also be used for qualification of large structures by analysis. Use of the DSF should be considered for preliminary comparison of the severity of different types of seismic qualification tests and/or analysis and of equipment support structures. Through the use of DSF, it may be possible to upgrade equipment support to higher seismic excitation, a situation that can arise as a result of upgrading the seismic hazard of an operating plant. However, the results must be applied with discretion.

We have coordinated the preparation of this RIL with the staff of the Mechanical Engineering Branch and the Systematic Evaluation Program Branch, NRR.

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Consideration should also be given to the conduct of resonance searches for both, simulator-mounted and floor-mounted configurations for items where dynamic coupling with the simulator table is expected. Then, for any subsequent response spectrum test, the TRS should be widened to include the extra range or resonance shift.

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*See previous concurrence sheet

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