Task A-46

SEISMIC QULAIFICATION OF EQUIPMENT IN OPERATING PLANTS

Lead NRR Organization:	Division of Safety Technology
Task Manager:	Patrick Sears, Generic Issues Branch, DST
Applicability:	All Light Water Operating Reactors
Projected Completion Date:	April 1984

1. DESCRIPTION OF PROBLEM

There is a recognized need to demonstrate the functional capability of safety related nuclear plant equipment which would be subjected to a seismic event. The General Design Criteria for Nuclear Power Plants (GDC) states that structures, systems and components important to safety shall be designed to withstand the effects of natural phenomena, such as earthquakes, without a loss of capability to perform their safety functions (10 CFR Part 50, Appendix A, Criterion 2). Also the GDC states design control measures shall provide for verifying or checking the adequacy of design by the performance of a suitable testing program. It shall include suitable qualification testing under the most adverse design conditions (10 CFR Part 50, Appendix B, Section III). Guidance on compliance with these areas of 10 CFR Part 50 is contained in Revision 2 to Standard Review Plan Section 3.10.

Today, equipment is seismically qualified by analysis and/or testing. Analyses alone are acceptable only if the necessary functional operability of the equipment is assured by its structural integrity alone. If not, some testing is required. The seismic input motion to the equipment is specified by a required response spectrum or time history. Equipment that is small enough is subjected to a test response spectrum which envelopes the required response spectrum. The equipment should be tested in the operating condition. For equipment too large to fit on a test table, a combined analysis and test procedure is adopted.

Since commercial nuclear power plants were first introduced, significant changes in seismic qualification criteria have evolved. Also, the analytical and experimental methods used to qualify equipment have changed. Therefore, the seismic resistance of existing equipment installed in operating nuclear plants may vary considerably.

Operating plant equipment may not meet the current seismic qualification criteria. The seismic qualification of this operating equipment may have to be reassessed to ensure its performance during and after a seismic event.

The objective of this Unresolved Safety Issue (USI) is to develop seismic and dynamic qualification methods and acceptance criteria that can be used to assess the capability of mechanical and electrical equipment in operating nuclear power plants to perform their intended safety function during and after a seismic event.

USI A-46 is part of a larger NRC effort to develop and implement a new rule which includes seismic and dynamic qualification of mechanical and electrical equipment. An Advance Notice of Rulemaking (ANR) will be prepared by the NRC Office of Research (RES) and will be issued for public comment. Public comments will be resolved and then RES may draft a proposed rule. Technical

input from A-46 will be provided at various stages in development of the rule.

Technical work in support of USI A-46 will be provided by Technical Assistance contracts managed by NRR, from the SEP program, and from ongoing research programs in the seismic area.

The Equipment Qualification Branch (EQB) of NRR is implementing technical work which includes (1) risk sensitivity of safety system components, which will form the basis for development of a minimum equipment list, (2) cost benefit analyses of seismic qualification of equipment on the minimum equipment list, and (3) development of guidelines and criteria for seismic and dynamic qualification review.

RES is supporting a research program which, in part, is an historial survey of methods used for seismic qualification of nuclear plant equipment and components and a comparison with current criteria.

The Generic Issues Branch (GIB) of NRR is supporting a program for correlation of seismic response of equipment in non-nuclear facilities to the qualification of nuclear plant equipment, and a program for the development of in-situ test methods and the collection and correlation of test data from both laboratory tests and in-situ tests.

All of the programs mentioned above either partially or entirely support the proposed equipment qualification rule. A major activity of A-46 will be the close coordination of these programs such that their results will form a timely input to the proposed rule.

2. PLAN FOR PROBLEM RESOLUTION

A. Approach

A minimum list of equipment to be qualified will be developed from a risk study conducted under contract to Brookhaven National Laboratory (BNL). The reliability of components in systems which perform important safety functions will be varied and the effect on risk computed. A Sensitivity analysis will be used to identify equipment where changes in reliability result in large incremental risks, allowing a cost benefit analysis to be made. Only those components whose failure significantly affects safety functions will be included on the minimum equipment list.

Mechanical and electrical components on the minimum equipment list will still be too numerous to consider on an individual basis. Generic groups of these components will be developed according to function and similarity of methods to be used for seismic qualification. The groups will be developed considering the equipment lists used in the NRC Seismic Safety Margins Research Program (SSMRP) and equipment lists developed on other qualification programs.

A review of past and present criteria and methods used to structurally and operationally qualify the various categories of equipment is being conducted. Both analytical and test methods are being considered. The conservatisms, disavantages, deficiencies, and anomalies of the methods will be determined. This review is part of a research program sponsored by RES and being performed at the Southwest Research Institute (SWRI). Activities of this research program in support of A-46 are an evaluation of past and present analytical and test methods of seismically qualifying operability of safety related equipment and correlation of these methods with current criteria.

The NRC Systematic Evaluation Program (SEP) complements this USI program. In Phase I of SEP Topic III-6, a sampling of existing seismic design documents from five older plants was reviewed, and a limited amount of reevaluation was also made. Some structrual retrofitting to ensure proper equipment anchoring was recommended for the five plants. Five additional SEP licensees were asked to submit a detailed structural evaluation program for their plants. Safety related systems and components were reviewed in selected plants to some extent for operability. Some systems and components were found to require additional seismic evaluation. SEP plant owners have initiated a generic program to tabulate the equipment present in the SEP plants. Appropriate information will be available from this program for consideration in developing USI A-46 resolution.

An effort has been initiated by a plant owners group to survey mechanical and electrical equipment installed in non-nuclear plants built in high seismic areas. Non-nuclear power plants and many industrial facilities contain mechanical and electrical equipment similar in design and function to equipment used in nuclear power plants. A number of these non-nuclear power plants and industrial facilities have been subjected to seismic events. Experience with equipment in these plants and facilities can be useful in determining the seismic and dynamic response of comparable equipment in nuclear power plants. One Task of USI A-46 is to monitor that survey, and if it is determined that the resulting information is useful, it will be integrated into the development of seismic qualification guidelines.

A program has been initiated for development of in-situ test methods for qualifying equipment in operating plants. In that program, a review and summary of existing methods for performing in-situ qualification of equipment will be made. In addition, operability and failure for various types of equipment will be defined, and a data base of laboratory test and in-situ test information will be developed. Information on in-situ and laboratory qualification tests will be used in development of guidelines for qualification of equipment in operating plants.

B. Tasks

Task 1 Develop Bases for Selecting Equipment to be Qualified

It must be ensured that (1) modification of safety related equipment provides substantial additional protection which is required for the public health and safety, and (2) equipment considered for upgrading be those that contribute most to risk.

Task 1(a) Perform Sensitivity Analysis

Using a list of systems essential to reactor shutdown and prevention of radioactive release, a sensitivity analysis will be performed using previously developed computer codes. The result is expected to be a list of equipment whose changes in reliability result in large effects on public risk. That list will be compared to a similar list developed in the SSMRP program.

Task 1(b) Perform Cost Benefit Analysis of Seismic Upgrading of Equipment

Using the list of equipment developed in the previous subtask, cost will be estimated to upgrade the equipment. Benefit to the public will be estimated.

Task 2 Survey and Evaluation of Equipment Seismic Qualification Methods

This task involves the evaluation of past and present methods to qualify mechanical and electrical equipment to withstand seismic events.

Also, a study will be made to establish methods for requalifying equipment installed in operating plants which have been previously qualified using methods which are not in accordance with current criteria.

The structural adequacy of equipment subjected to seismic events is also being reviewed in the Systematic Evaluation Program (SEP). Information developed will be reviewed and incorporated into this task.

Task 2(a) Evaluation of Methods Used to Seismically Qualify Equipment

Past and current analytical and test methods used to qualify equipment will be cataloged, compared and evaluated. The contractor's developed equipment list will be used in this sub-task.

Task 2(b) Comparison to Present NRC Requirements for Equipment Qualification

Methods to qualify equipment in operating plants will be compared to present requirements. Important differences will be determined.

Task 2(c) Initial Conclusions and Preliminary Guidelines

Initial conclusions on seismic qualification methods will be developed. Preliminary guidelines will be drafted as part of this task.

Task 3 Develop Methods for In-Situ Testing of Equipment In Operating Plants

This task will involve surveying existing methods for performing in-situ and laboratory tests which may be used to qualify nuclear plant equipment. Also, analytical methods which would be used in conjunction with those in-situ and laboratory tests will be reviewed and summarized. The effects of component aging will be considered. The final part of this task will be an effort to improve in-situ and laboratory testing for use in seismic and dynamic equipment qualification.

Task 3(a) Develop Preliminary In-Situ Test Methods

Operability and failure of various types of equipment will be defined in the first part of this sub-task. Existing methods for performing in-situ tests will be surveyed. Equipment will be categorized according to which test procedures are appropriate. Limitations, shortcomings and nonconservatisms associated with the methods will be identified.

Task 3(b) Improve and Verify In-Situ Methods

The limitations identified in Task 3(a) previously will be studied and recommendations made for improvement and verification of test methods.

Task 3(c) Establish Appropriate Methods of Inservice Surveillance

Existing inservice surveillance methods used in operating plants will be reviewed to ascertain which methods can be used to identify aging and degradation which could affect seismic capability of equipment in operating plants. Limitations will be identified and possible improvements developed and recommended.

Task 3(d) Prepare Program Report

A formal report, in NUREG format, will be written covering the results of Task 3.

Task 4 The Seismic Qualification of Equipment Using Non-Nuclear Plant In-Service Dynamic Response Information

A program has been developed by a Plant Owner's Group to survey equipment in non-nuclear plants which has been subjected to severe

events. The equipment to be surveyed is similar to equipment installed in operating nuclear plants. The seismic events which the equipment survived were, in some instances, significant seismic events. The Owner's Group program will be closely monitored as part of this task and the results will be studied for possible use in the development of equipment fragilities. Other sources of information pertinent to response, damage and operability of equipment in non-nuclear facilities subjected to seismic events will be reviewed to determine if non-nuclear equipment experience can be used to predict equipment fragilities. If it is possible to predict equipment fragilities from non-nuclear equipment surveys, then methods will be developed for the use of seismic experience in non-nuclear facilities in developing guidelines for equipment qualification in nuclear plants.

Task 4(a) Feasibility Study

To assess the feasibility of using data on equipment from non-nuclear plants which have been subjected to strong earthquakes, a significant amount of data will be assembled from known sources and from the Owner's Group program. It will be determined if a correlation exists or can be developed between structural and functional survival of equipment in non-nuclear plants and nuclear plants. To assist in assessing the feasibility, expert consultants will be provided by the contractor to review sub-task results.

Task 4(b) Develop Guidelines for Application of Experience Data

Guidelines for the use of the experience data collected previously will be developed and recommendations will be made for criteria to be incorporated into the proposed guidelines on equipment qualification.

Task 4(c) Prepare Program Report

The methods of analysis and correlations developed along with the assumptions and shortcomings of the program will be reported using NUREG format.

Task 5 Guidelines and Criteria for Development of Qualification Response Spectra

The feasibility of seismically qualifying equipment using a set of generic enveloping response spectra will be investigated in this task. Guidelines for developing such response spectra for use by the licensees will be developed, along with guidelines for dynamic load profiles for accident and operating conditions.

Task 5(a) Feasibility Investigation

The feasibility of seismically qualifying equipment by using a set of generic enveloping response spectra will be investigated. These

response spectra will be derived by considering specific earthquakes zones in accordance with UBC or ATC, specific site geological conditions, specific plant installation configurations, or a combination of all of the above.

Task 5(b) Develop a Method to Calculate Enveloping Seismic Response Spectra

A recommended method for using generic enveloping response spectra will be developed.

Task 5(c) Develop a Procedure to Calculate Dynamic Load Profiles

A recommended procedure for developing dynamic load profiles, for normal plant operating conditions and for accident conditions, will be developed.

Task 5(d) Develop Procedures to Use Enveloping Seismic Response Spectra and Dynamic Load Profiles

For specific equipment identified in Task 1, procedures for assessing safety margins for seismic and operating events will be recommended. A report in NUREG format will be prepared documenting the results of Task 5.

Task 6 Establish Guidelines for Seismic Qualification for Equipment in Operating Plants

This Task will present the results of Tasks 1 through 5 and complete documentation of USI A-46. An explicit set of guidelines will be written for the seismic qualification of mechanical and electrical equipment at operating plants. Guidelines will be written for methods of re-qualifying operating equipment where original methods of qualification are found to be inadequate.

Task 6(a) Guidelines to Judge the Adequacy of Methods of Equipment Seismic Qualification

From the conclusions reached during the continued performance of research programs on equipment qualification, the SEP program on seismic qualification and this Task Action Plan, a set of explicit guidelines will be written to judge the adequacy of equipment seismic qualification methods. Both structural and functional qualification requirements will be considered. If previously used qualification methods are found to be inadequate, guidelines for requalification will be developed.

Task 6(b) NUREG Final Report

In this task a final NUREG report will be written to summarize program accomplishment, conclusions, and recommendations. The justification for each guideline will be stated and limitations will be given. The NUREG report will be issued for public comment prior to final issuance.

Task 6(c) Licensing Changes

In addition to providing technical bases for the proposed rule, changes to SRPs and/or Regulatory Guides will be recommended if needed.

C. END PRODUCT

On Task 6 of this study, proposed guidelines and criteria for requalification of equipment in operating plants will be developed. A NUREG report will be written summarizing the work performed, the conclusions reached, and recommendations regarding methods of requalifying equipment. Guidelines for the qualification of equipment in operating plants will be presented in detail. Also the logic behind these guidelines will be given. If new Standard Review Plans, Regulatory Guides, or changes to the proposed rule are recommended they will be specified in the final report.

3. JUSTIFICATION FOR CONTINUED OPERATION

Although many operating plants were designed before the development of current licensing criteria, the design rules and procedures incorporated inherent conservatisms. These include: (1) the margins between allowable stresses and ultimate strength of engineering materials, (2) the methods used for combining loads, (3) the inherent ductility of materials, and (4) the seismic resistance of nonstructural elements which are not normally considered in design calculations.

An expanding data base of observations at large industrial facilities that have experienced strong ground motion suggests that these facilities have significant seismic resistance capabilities. From that data, it can be inferred that the inherent seismic resistance of engineered structures and equipment is usually greater than is generally assumed. When even the most modest attention is paid in design to providing lateral load carrying paths, significant capability results. Most Nuclear power plants have been designed using more rigorous techniques; therefore, it is reasonable to expect high inherent margins.

Because of the above cited reasons and the continued staff review of seismic issues, it is concluded that operating plants can continue

to operate without endangering the health and safety of the public, pending resolution of this Unresolved Safety Issue.

4. PROGRAM SCHEDULE AND EFFORT

The main purpose of A-46 is to provide guidance and criteria for the development of a rule covering seismic and dynamic qualification of equipment. The following milestones have been established from that rulemaking schedule:

	Preliminary Results to Support Rulemaking	Completion Date
Task 1	9/82	3/83
Task 2	9/82	5/84
Task 3	9/82	3/83
Task 4	9/82	3/83
Task 5	9/82	3/83
Task 6	--	5/85

Technical assistance funding required is as follows:

Task 1	$ 50K	BNL (T.A. Contract by NRR/EQB)
Task 2	$392K	SWRI (Funded by RES)
Task 3	$125K	INEL (T.A. Contract NRR/GIB)
Task 4	$ 75K	LLNL (T.A. Contract NRR/GIB)
Task 5	$100K	BNL (T.A. Contract NRR/EQB)
Task 6	--	--

The level of NRC effort to complete A-46 is summarized below in staff years:

	FY82	FY83	FY84	FY85
Generic Issues Branch	1.0	1.0	1.0	1.0
Division of Engineering Technology (RES)	1.0	1.0	1.0	0
Equipment Qualification Branch	1.0	1.0	1.0	0

5. TECHNICAL ORGANIZATIONS INVOLVED

A. Generic Issues Branch, Division of Safety Technology

The Generic Isuses Branch (GIB) has the overall responsibility for the performance of this unresolved safety issue program.

(1) Task 3

The GIB will establish a plan evaluating methods for in-situ and laboratory qualification of equipment in operating plants. This will

be done through a technical assistance program to study methods of requalifying equipment installed in operating plants. The GIB will manage the performance of this technical assistance program and the publication of a final study report.

(2) Task 4

The GIB will develop a program plan to review and correlate available information on the inservice response of non-nuclear plant equipment that has been subjected to seismic or severe dynamic events.

This will be accomplished by close cooperation between an in-place Owner's Group program which is collecting data on equipment in non-nuclear plants which have been subjected to earthquakes, and the technical assistance program with LLNL. The GIB will coordinate these programs and manage the performance of the technical assistance program and the publication of a final study report.

(3) Task 6

The GIB will establish the appropriate guidelines for the seismic qualification of equipment in operating plants. These guidelines will be documented in a final NUREG report. This report will also summarize the work performed in this USI program and the conclusions reached.

B. Mechanical and Structural Engineering Branch, Division of Engineering Technology, Office of Nuclear Regulatory Research

(1) Task 2

The Mechanical and Structural Engineering Branch (RES) has a contract entitled, "Seismic Qualification of Nuclear Plant Mechanical and Electrical Equipment," with SWRI. This research program will be coordinated with the USI program. The research program will survey existing knowledge and develop a basis and the methodology for evaluating conservatisms, limitations, and anomalies related to current and past methods used to qualify equipment.

C. Systematic Evaluation Program Branch, Division of Licensing

The Systematic Evaluation Program Branch (SEPB) is conducting a program to review and evaluate the seismic design criteria and the ability of safety related mechanical and electrical equipment to retain their structural integrity during and after a seismic event. The functional operability of the equipment is not being considered. This SEP branch program will complement the USI study. Appropriate information generated will be integrated into the USI program.

D. Equipment Qualification Branch, Division of Engineering

(1) Task 1

EQB is developing a program to (a) identify equipment that contributes most to risk during and after a seismic event, and (b) perform a cost benefit analysis to establish the extent to which safety related equipment needs to be upgraded. This will be accomplished by a technical assistance program with BNL.

(2) Task 5

EQB is developing a program to investigate the feasibility of seismically qualifying equipment by employing a set of generic enveloping response spectra. This will be done through a technical assistance program with BNL.

6. TECHNICAL ASSISTANCE

The following is a summary of technical efforts along with sponsoring branches by task:

	Sponsoring Branch	Technical Assistance Organization/Contractor
Task 1	EQB	BNL
Task 2	MSEB	SWRI
Task 3	GIB	INEL
Task 4	GIB	LLNL
Task 5	EQB	BNL

7. INTERACTIONS WITH OUTSIDE ORGANIZATIONS

In Task 4 of this program, a program to review and correlate available information on the inservice response of non-nuclear plant equipment that has been subjected to severe seismic or dynamic events will be developed with technical assistance from LLNL. A concurrent program is being sponsored by a nuclear plant Owner's Group to collect data on equipment in non-nuclear plants which have been subjected to earthquakes. The Owner's Group program will be closely monitored by GIB so that data from that program can be used in the LLNL program.

As this task progresses, it is anticipated that meetings and information exchange with industry groups such as AIF and EPRI will take place.

8. ASSISTANCE REQUIREMENTS FROM OTHER NRC OFFICES

Requirements for assistance from NRC Offices other than input through RES sponsored work at SWRI discussed in Task 2 are not anticipated at this time.

9. POTENTIAL PROBLEMS

None expected at this time.

JUL 29 1980

Item #7

Distribution:
Subject
PAS Reading
CIRC
CHRON
Bernero Reading

MEMORANDUM FOR: Roger J. Mattson, Director
Division of Safety Technology
Office of Nuclear Reactor Regulation

FROM: Robert M. Bernero, Director
Probabilistic Analysis Staff
Office of Nuclear Regulatory Research

SUBJECT: INTERIM QUANTITATIVE ACTION CRITERIA

I have just noticed that my memo to you dated July 22, 1980 contains significant typographical errors. On page 3 of that memo part of the interim action standard was inadvertantly coalesced. It should have said:

$P_{CD} > 1 \times 10^{-2}$/yr: fix in days

1×10^{-2}/yr > $P_{CD} > 1 \times 10^{-3}$/yr: fix in months

1×10^{-3}/yr > $P_{CD} > 1 \times 10^{-4}$/yr: fix in years

1×10^{-4}/yr > $P_{CD} \geq 1 \times 10^{-5}$/yr: consider fixing

1×10^{-5}/yr > P_{CD} : acceptable

where P_{CD} is the probability of severe core damage.

Frank Rowsome has also provided some interesting additions to his calculations in his July 11, 1980 memo to me which was attached to my memo. I have attached his addenda.

PDR
8107290739

"Original Signed By"

Robert M. Bernero, Director
Probabilistic Analysis Staff
Office of Nuclear Regulatory Research

Attachment: As Stated

OFFICE	RES/PAS/D					
SURNAME	RBernero:bsr					
DATE	07/25/80					

July 25, 1980

NOTE TO: Robert M. Bernero, Director
Probabilistic Analysis Staff, RES

FROM: Frank H. Rowsome, Deputy Director
Probabilistic Analysis Staff, RES

SUBJECT: ADDENDA TO "BACKFIT DEADLINES BASED UPON HYPOTHETICAL INTERIM ACCEPTABLE RISK NUMBERS"

I have added a few more corrolaries to my calculation.

Corollary 5.1

The model developed in Hypothesis 5 permits us to answer the question: What fraction of the statistical exposure to one or more significant accidents in the 14 year period after TMI is due to:

a. IREP moves too slowly? Answer ≈ 50%
b. IREP misses too much? Answer ≈ 33%
c. the 10^{-4}/yr interim criterion is too lenient? Answer ≈ 17%

Observation 5.2

The balance of risk between IREP speed and thoroughness is likely to be an artifact of the assumptions, i.e., not very robust. However, I suspect that an uncertainty analysis would show that the 10^{-4} interim criterion is unlikely to be a weak link in the strategy, i.e., the smallness of risk associated with its leniency (as distinct from IREP completeness) is a robust conclusion.

Observation 5.3

One could replace the assumption of an instantaneous short term fix associated with IREP in Hypothesis 5 with the phased fixes described in Hypothesis 1 and then assess where the weaknesses of the strategy lie. However, I don't think the model has the accuracy to warrant such fine tuning. If we do this over with a proper treatment of uncertainties, we might then do sensitivity studies on hypothetical strategies like Hypothesis 1 and 5.

Observation 5.4

If we were to alter the model to address only killer accidents, one would expect the following changes in results:

- o failure rates and probabilities would be of the order of 1/10 those cited for significant core damage

- o IREP screening effectiveness is probably a little better than for core damage scenarios, i.e., a smaller completeness error for killer accidents, at least at comparable λ's

- o If we leave the criteria of Hypothesis 1 unaltered but consider the balance of risk distributed among IREP speed, thoroughness, and the residual risk associated with a 10^{-4} interim criterion for killer accidents only, we would find a more nearly uniform balance, i.e., IREP is probably well-optimized for public health and safety. This refinement, too, should be considered if we elect to do this job again with uncertainty analysis.

Frank H. Rowsome, Deputy Director
Probabilistic Analysis Staff
Office of Nuclear Regulatory Research