SQUG

Volume 2, Issue 3 | Seismic Qualification Utility Group Newsletter | December 1994

This edition of the SQUG Newsletter contains a single, feature length article on integration of the various seismic resources available to utility engineers and others at both A-46 and non-A-46 plants. This article describes the areas where the SQUG program for New and Replacement Equipment (NARE) can be used in relationship to the programs of two other utility groups: Seismic Qualification Reporting and Testing Standardization (SQURTS) and Generic Seismic Technical Evaluation of Replacement Items (G-STERI). Together with the chairmen of these two other utility-run groups, I have co-authored this article to help promote better understanding and more cost-effective utilization of these programs in our nuclear plants. Any questions you may have regarding these programs or other industry seismic issues may be directed to one of the following chairmen of these industry groups:

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Neil P. Smith

# INTEGRATION OF SEISMIC RESOURCES

by Neil P. Smith, John M. Richards, and Garry V. Chapman

## EXECUTIVE SUMMARY

Utility managers have devoted a vast amount of resources over the past several decades to deal with various seismic issues such as Unresolved Safety Issues (USI's), equipment qualification, and seismic evaluations of replacement items. The fruits of the industry's labors are as varied as the issues themselves because the methods were each developed for very specific purposes.

The Seismic Qualification Utility Group (SQUG) worked diligently to develop a resolution to USI A-46 which largely eliminates the need for costly shake table testing and dynamic analyses for older plant designs. As part of this effort, SQUG developed criteria for seismic qualification of New and Replacement Equipment (NARE) but, again, the applicability is limited at this time to older plant designs. An EPRI-PSE task group developed a guideline for the Seismic Technical Evaluation of Replacement Items (STERI) for all plants but, its use is limited to equivalent replacements, not new qualification or design changes. A follow-on task is developing generic STERI evaluations (G-STERI) for common equivalent replacements but, again, not for new equipment or design changes. More recently, a utility group was formed for Seismic Qualification Reporting and Testing Standardization (SQURTS) to conduct collaborative seismic qualification testing. This effort is focused on shake table testing and the results are limited to funding members. Each of these initiatives grew from a specific need for specific audiences and each contribute significantly to the reduction of O&M costs. A significant portion of the end products, however, have a broader applicability.

The present fiscal environment requires utilities to make coordinated, effective use of all available tools which offer cost savings. First, products which have been developed in the past must be utilized to the greatest practical extent regardless of their initial purpose. Second, any future industry effort must be broad-based and coordinated to maximize efficiency. Utilities must work more closely and cleverly than ever before.

The purpose of this paper is to briefly describe the three programs undertaken to provide practical, cost-beneficial seismic qualification methods for new and replacement equipment, to discuss where these methods can be applied and how they should be coordinated to maximize the benefit from integrating the approaches. This paper is a result of the on-going coordination between the chairmen of the three current principal industry groups (i.e., SQUG, SQURTS, and G-STERI).

## INTRODUCTION

Seismic issues have commanded significant resources from utilities, contractors, A/E's, and the Nuclear Regulatory Commission (NRC) over the past several decades. Industry efforts have addressed, and continue to address, specific licensing needs, safety, and efficiency. The Seismic Qualification Utility Group (SQUG) is working to resolve NRC Unresolved Safety Issue (USI) A-46 for older plant designs. The Institute of Electrical and Electronic Engineers (IEEE), American Society of Mechanical Engineers (ASME), and others are upgrading the seismic qualification standards. Other groups are working to address the procurement of replacement items subject to seismic design criteria (e.g., STERI, SQUG/NARE) and still others are cooperating through collaborative seismic qualification testing (e.g., SQURTS). Each effort has focused on a specific aspect of ensuring adequate seismic performance of plant equipment. This common denominator of "adequate seismic performance" allows cross-utilization of the individual experiences. Coordination ensures that efforts are not duplicative or contradictory. The efforts of each of these groups have resulted in end-products and data which can be used by others to reduce O&M costs. Coordination of the industry's seismic assets will ensure that the combined benefit outweighs the sum of individual benefits from any one program. Today's fiscal pressures mandate this synergy. The purpose of this paper is to briefly describe the three programs undertaken to provide practical, cost-beneficial seismic qualification methods for new and replacement equipment, to discuss where these methods can be applied and how they should be coordinated to maximize the benefit from integrating the approaches.

## BACKGROUND

Seismic design criteria, guidelines, and regulations have evolved throughout the nuclear power plant operating history. U.S. nuclear plants are segregated into two basic groups related to seismic criteria. First, there are those plants which were designed and licensed prior to the detailed equipment seismic qualification criteria described in IEEE 344-1975. The plants in this group are subject to a special seismic adequacy review as part of NRC USI A-46. Second, there are those designed to modern criteria and reviewed to this criteria by the NRC. These are referred to as A-46 Plants and non-A-46 plants, respectively. While the initial Seismic Equipment Qualification (SEQ) requirements for the A-46 and non-A-46 plants differ significantly, each have taken measures to assure that their plant equipment will function adequately during and after an earthquake.

## LICENSING BASES AND USI A-46

Plants were licensed based upon the NRC's review of the plant design and supporting analyses. While seismic loading has always been a design consideration, early plants evaluated the seismic adequacy based upon the state of the art at the time and good engineering practice. Not until later were detailed standards and regulatory guidance developed. Thus, newer plants were subjected to more structured design/qualification procedures and increased regulatory review.

USI A-46 was generated in the early '80s because older plants had not been reviewed against the then-current (e.g., IEEE 344-1975, Reg. Guide 1.100 rev. 1, etc.) licensing criteria for seismic qualification of equipment. Given the generic nature of this issue and the fact that the equipment in question was already installed in their plants, owners and operators of plants subject to USI A-46 determined that a new and unified approach to resolution was appropriate and formed the Seismic Qualification Utility Group (SQUG). SQUG, in close coordination with the NRC, developed a methodology to resolve USI A-46. The generic implementation procedures (GIP) make use of experience in strong motion earthquakes and prior shake table tests. This approach avoids the need for costly, and mostly impractical shake table testing, and instead, employs experience-based design reviews, engineering judgment, and plant walkdowns to verify that plant equipment is seismically adequate.

The experience-based methods used in resolution of USI A-46 evaluate plant equipment on a generic, "class" basis. Earthquake and test data for a diverse set of equipment within a given class were accumulated, studied, and reduced to produce a set of criteria (e.g., inclusion rules, seismic capacity levels, and caveats) to which existing plant equipment can be evaluated. These criteria are contained in the GIP.

Non-A-46 (i.e., newer) plants were designed and qualified to more detailed criteria. Equipment seismic adequacy was determined explicitly for specific equipment as opposed to a "class" of equipment. Adequacy was based, to a large degree, on seismic qualification testing or rigorous dynamic analysis to the requirements of IEEE 344-1975.

While these two approaches to determine seismic adequacy are significantly different, each provides an accepted basis to ensure that nuclear plant equipment will function as required during and after the design basis earthquake.

## LOOKING BEYOND THE INITIAL DESIGN

The initial qualification efforts of newer plants and the verification of seismic adequacy of older plants each apply to a single point in time. Plant designs are not static and changes are routinely implemented due to the obsolescence of plant equipment, product improvements, or more significant changes to improve the operation of the plant. These changes fall within the Engineering Change Process (ECP) at a given plant. Given the requirement to ensure that a level of safety is maintained, utility procedures are implemented to ensure that the changes do not result in a degradation of plant safety. This applies to the seismic adequacy of plant equipment, as well, and seismic considerations must be factored into the ECP. Figure 1 illustrates the seismic considerations and available options in the Engineering Change Process.

Changes may be grouped into two major categories. There are changes resulting from routine replacements and changes resulting from the addition or modification of new equipment and systems. Replacements involve the substitution of one item with a non-identical item performing the same function and having the same interfaces. These are referred to as equivalent replacements. Roughly speaking, these replacement items meet the same "fit, form and function" as the original item. New equipment, on the other hand, may be added to the plant design to perform a new function or require new or different interfaces. Similarly, equipment may be modified to perform different functions and may have different interfaces with existing equipment. These latter categories of equipment additions and modifications are generally classified as design changes rather than replacements. Note that specific plant definitions of "replacement" and "design change" differ from site to site and are largely governed by licensing commitments; however, all must be evaluated to ensure they perform as required during and after a seismic event.

Under the current regulatory environment, verification of the seismic adequacy of new and replacement equipment may be done in one of two ways, depending on whether the item being procured is for an equivalent replacement or a new or modified installation (i.e., design change). Under the guidance of ANS N18.7, the seismic adequacy of replacements, as defined above, can be established by showing they are seismically equivalent to the original. This process is intended to demonstrate that the initial qualification of the original item is maintained (i.e., not degraded). The basis for the initial qualification is not an issue. On the other hand, equipment procured for nuclear safety related applications involving new equipment or plant design changes require a new (i.e., initial) seismic qualification in accordance with the plant licensing basis. For newer plants this will likely be IEEE 344-75; for older A-46 plants, this could be an earlier version of IEEE 344, plant-specific criteria, and/or the SQUG GIP. These differences in licensing basis requirements for A-46 and non-A-46 plants are important in determining what seismic qualification methods are currently acceptable for equipment additions involving design changes.

**INDUSTRY RESPONSES**

As described above, nuclear plants are subject to two major seismic licensing bases. Further, changes during operation may involve either equivalent replacements or new equipment for plant design changes, both of which are subject to a plant's engineering change process. The industry has responded to address the seismic evaluations/analyses required for these scenarios. Several examples are described in the following.

SQUG: The EPRI-Seismic Qualification Utility Group (SQUG) has developed the program adopted by most affected plants to resolve Unresolved Safety Issue A-46. The implementing procedures employed (i.e., the GIP) have been reviewed and accepted (with conditions) in an NRC SER as an acceptable means to verify that plant equipment is adequate for seismic conditions. The NRC has also allowed use of these experience-based procedures for seismic verification of new and replacement equipment after resolution of the USI. However, the NRC has approved these procedures for A-46 plants only. Thus, the SQUG method as outlined in the GIP is not available for newer, non-A46 plants to qualify their equipment.

SQUG/NARE: In response to this NRC decision, SQUG has developed guidance for seismic evaluation of New and Replacement Equipment (NARE). The NARE process incorporates the STERI guidance (for replacements), but provides additional guidance for seismic verification of new equipment procured for design changes. GIP methods may be used for both new and replacement equipment in A-46 plants (options not available to newer plant designs).

STERI: The EPRI-PSE Task Group for Seismic Technical Evaluation of Replacement Items (STERI) developed a guideline for performing seismic evaluations for replacement items for all plants. The guideline's intent is to ensure that the replacement will not degrade the seismic adequacy of the item or its host. This is generally accomplished by comparison to a previously approved item, identifying differences, and reconciling these differences to the required seismic criteria. The STERI process is not limited to one vintage or another, but explicitly excludes design changes. Thus, the STERI process would not be used for seismic qualification of new equipment to be used in design changes and additions.

G-STERI: G-STERI is another task under EPRI-PSE which seeks to develop Generic Seismic Technical Evaluations for Replacement Items through selected implementation of the STERI Guideline. While the STERI task developed a guideline for on-going use at a utility, G-STERI strives to develop stand-alone generic seismic evaluations of commonly replaced items which could be adopted at the utility with a minimal review. This effort is similar to SQUG methods in that it evaluates items on more of a "class" basis using data from qualification tests, other seismic tests, earthquake experience, and engineering analyses. But, again, G-STERI addresses equivalent replacements and not new seismic qualifications needed for design changes.

SQURTS: A number of nuclear utilities have joined together for Seismic Qualification Reporting and Testing Standardization (SQURTS). Membership includes owners and operators of various vintages of plant designs. SQURTS conducts collaborative seismic testing using standardized seismic test procedures, reports, and generic seismic test levels. SQURTS is fully funded by the member utilities and, thus far, has tested a diverse set of equipment and items for seismic qualification and to support commercial grade dedication. Testing is conducted to current industry standards and results are therefore usable by all members. However, as this is a self funded project, test reports are only available to member utilities. The equipment is also limited to sizes which can be accommodated on the test table; large pumps, motor generators, diesels, etc., could not be tested.

In summary, SQUG has developed a procedure to verify the seismic adequacy of plant equipment using earthquake and test experience; this procedure is given in the GIP. The GIP method may also be used for seismic verification of equipment procured for both replacements and design changes. However, SQUG procedures have not been approved for use by non-A-46 plants which committed to IEEE 344-75. The STERI task group developed a guideline for evaluating replacement items for all plants, but it is not applicable for new equipment for design changes and modifications. G-STERI provides generic evaluations for common replacement items, but, again, it is not applicable for new equipment qualification. Finally, SQURTS provides a low cost option for full IEEE 344 qualification testing but is limited in use to the funding utilities and to equipment which is readily testable. Thus, there are many programs and products available, each has demonstrated potential to save future O&M dollars, but each has its own applicability in a given plant's seismic verification process. The specific applicability is a function of the type of replacement/design change, the plant-specific licensing basis for seismic qualification, and the relative practicality and economy of the options. Examples showing how these methods are being used today for a wide variety of applications are given in Table 1.

## USEFUL INTEGRATION/SEISMIC SYNERGY

While the various industry initiatives target specific audiences and products, there exists an opportunity to share and benefit from seismic experience. Regardless of the method ultimately best suited to determine seismic adequacy, reliance is placed on technical experience and data. For example, test data generated through SQURTS is useful to SQUG for inclusion in the body of seismic experience data. Lessons learned and seismic experience data generated through SQUG programs can be factored into the design process for the next generation of nuclear plants. While seismic adequacy has been the "common denominator" of interest in the past, seismic experience offers a viable and rational common denominator for future activities (e.g., on-going replacements, design changes, advanced reactor design). In fact, the judgment of knowledgeable seismic engineers has always been a key element of seismic qualifications performed by analysis, test and similarity under IEEE 344. Clearly, seismic experience data strengthens and calibrates such engineering judgment. This body of seismic experience data represents a valuable source of data to be used when conducting seismic evaluations.

## SEISMIC EXPERIENCE DATA

Many have considered Seismic Experience Data to be a compilation of reconnaissance reports from earthquake damage surveys. However, seismic experience data includes much more. It also includes data from fragility testing and seismic proof tests conducted for the nuclear industry. The large numbers of seismic analyses performed over the years - particularly for ASME Code and other mechanical components - also provides significant data on equipment seismic ruggedness. This information as a whole represents a comprehensive and true representation of how equipment behaves in a severe dynamic environment. Seismic experience has been used extensively in resolution of USI A-46 and has undergone a rigorous review by leading experts in the field. However, the technical staffs at non-A-46 plants have been reluctant to utilize the experience data. Reasons for excluding this source of data include perceptions that the regulators would not allow use of the data, limited access to the data, and misconceptions related to the content and applicability of the data. Perceptions aside, one restriction for use of the data at a modern plant is contained in Regulatory Guide 1.100, revision 2, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants," Section B, "Discussion," which states

> *"IEEE Std 344-1987 recognizes the use of justified experience data as a method for seismic qualification. This method of qualification will be evaluated by the NRC staff on a case-by-case basis."*

This is *not a prohibition* of using experience data for qualification, but rather represents the expectation of how the NRC would render a determination of the appropriateness of the method at a particular plant.

Given the increased regulatory scrutiny which could be expected for a non-A-46 plant using experience data for qualification, it is important to make a distinction between equipment qualification and a technical evaluation for a replacement (i.e., equivalency evaluation). As discussed above, the latter is not a qualification activity. Replacements often involve a portion of a larger qualified item. For these cases, adequacy can be evaluated through a determination of whether differences between the replaced item and the replacement item would adversely affect the performance of the larger assembly or host. With differences identified, they may be, and should be, evaluated using all available data and experience. This includes previous seismic test reports, an individual's professional experience and judgment, other seismic tests, and/or earthquake experience data. Data is factual information and can not be legitimately dismissed as inappropriate. It is the method in which this data is reduced and applied to the item or equipment under review which defines the appropriateness of its use.

Use of seismic experience data for equivalency evaluations is clearly legitimate. Use of seismic experience data for equipment qualification as part of plant additions and design changes at non-A-46 plants is not currently approved. Explicit guidance for using experience data first appeared in the 1987 revision of IEEE 344 and, as noted previously, would be reviewed by the NRC on a case-by-case basis. However, even the 1975 edition recognized that "other methods, if justified, may also be used." Further, it states that the "choice should be based on the practicality of the method for the type, size, shape, and complexity of the equipment and the reliability of the conclusions. Qualification methods may be standardized for a particular form of equipment." Therefore, provided the data could be appropriately applied, a case could be made that the 1975 revision would also allow use of seismic experience data for qualification.

Given the current environment, it is the consensus of the SQUG and STERI task groups that seismic experience data may be legitimately used in the following applications:

- For A-46 Plants - Seismic experience data may be used in accordance with the SQUG GIP for resolution of USI A-46 and for demonstrating the seismic adequacy of new and replacement items for which seismic experience exists. These applications include equivalent replacements, as well as design changes and modifications. Seismic experience can also be used as a supplement to sound engineering judgment as part of STERI equivalency evaluations for replacements. Where plant licensing bases do not recognize the GIP, straight forward methods (e.g., 50.59) pre-approved by the NRC are available to make necessary changes.

- For Non-A-46 Plants - Seismic experience is clearly a legitimate and necessary source of data for seismic equivalency evaluations made following STERI guidance (ref. EPRI Report NP-7484). However, use of seismic experience data for new equipment qualifications (e.g., for plant additions and design changes) is currently restricted by these plants' seismic qualification licensing bases to IEEE 344-75 and later revisions. Changes to these licensing bases and/or case-specific NRC approval are needed to assure the acceptability of the experience based methods for these newer plants. Generic action on behalf of these newer plants is recommended to eliminate this current limitation.

With regard to wider use of experience-based seismic qualification methods, it is important to note that other efforts are underway to expand their use. These include working groups of IEEE and ASME clarifying the guidance provided in IEEE 344-1987 and development of the methods for the next generation of nuclear plants. These methods are also being adopted and used in Department of Energy facilities and are finding their way into other commercial industries. Ultimate regulatory acceptance will be facilitated as a result of these concerted utility, government and industry efforts.

## SUMMARY

Much time and many resources have produced sound technical procedures and guidelines to ensure that nuclear plant equipment is capable of performing its intended function during and following a seismic event. Incremental products may only be suited to a sub-set of plants, however data from the lab and from the earth itself can and should be used as input to seismic evaluations/analyses. Utilities are working smarter together and data from one effort can be shared with others. Likewise, common methods such as those based on experience are being pursued for broader application. The end result is that plants need to implement their engineering change process to take full advantage of all available resources. This is wholly consistent with fiscal responsibility in that no option is excluded based on perception and the experience of the industry as a whole is teamed to forge technically sound and economically viable solutions for all.

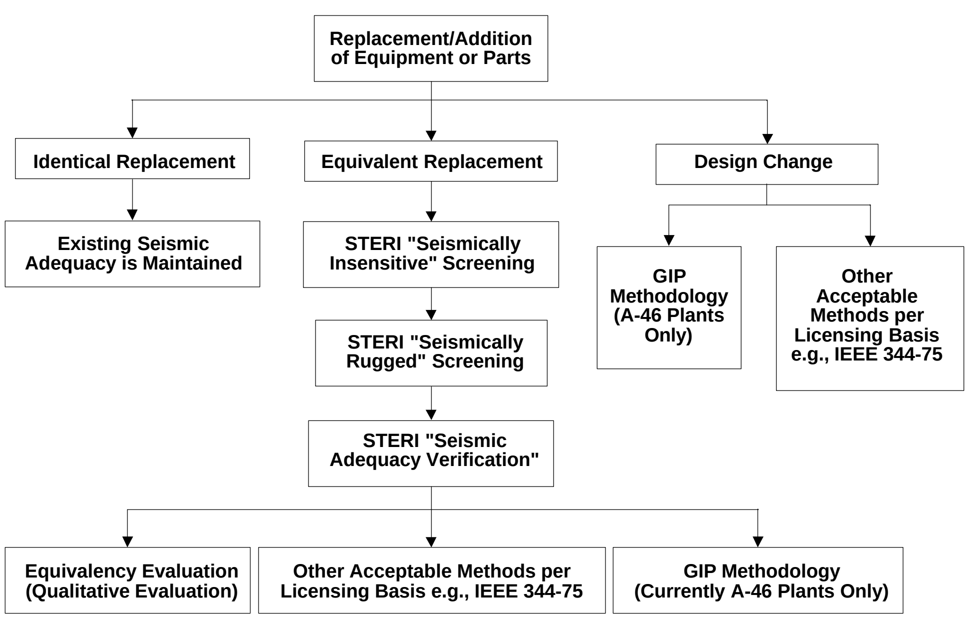


**Figure 1**. Seismic Considerations in the Engineering Change Process

**Table 1:** Seismic Verification Method Applicability

| Method | EQUIVALENT REPLACEMENT | | | DESIGN CHANGE | |
|---|---|---|---|---|---|
| | Commodity | Part | Equipment | Part | Equipment |
| | Examples:<br>! Packing<br>! Gaskets<br>! O-Rings<br>! Grease | Examples:<br>! Fuse<br>! Terminal Block<br>! Motor<br>! Breaker | Examples:<br>! Motor Control Ctr.<br>! MOV<br>! Horiz. Pump/Driver<br>! Switchgear | Examples:<br>! Fuse<br>! Terminal Block<br>! Motor<br>! Breaker | Examples:<br>! Motor Control Ctr.<br>! MOV<br>! Horiz. Pump/Driver<br>! Switchgear |
| STERI | YES | YES | YES | NO | NO |
| GIP | NO | YES<br>(Most effective if host meets GIP) | YES | YES<br>For A-46 Plants | YES<br>For A-46 Plants |
| SQURTS & Other IEEE 344-75 Methods | YES<br>(Applicable, but unnecessary) | YES | YES | YES | YES |

SEISMIC QUALIFICATION UTILITY GROUP (SQUG)



*The Seismic Qualification Utility Group (SQUG) was formed in 1982 to develop a technically sound and cost effective alternative for verifying the seismic adequacy of equipment installed in older nuclear power plants. This newsletter reports on the generic activities of the SQUG program as well as the results and lessons learned from utility implementation of the SQUG methodology.*

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