NUCLEAR ENERGY INSTITUTE

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April 22, 2002

Mr. Jack Strosnider, Jr.
Director, Division of Engineering
Office of Nuclear Reactor Regulation
Mail Stop O9-E3
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: Response to Request for Additional Information, SEQUAL Topical Report, *Basis for Adoption of the Experience-Based Seismic Equipment Qualification Methodology by Non-A-46 Nuclear Power Plants*

PROJECT NUMBER: 689

Dear Mr. Strosnider:

Enclosed are responses to NRC staff requests for additional information (RAI) on the subject topical report. These responses, prepared by the Seismic Experience-Based Qualification Owners Group (SEQUAL), address review issues identified in letters dated January 31, 2002, (Request for Information) and August 13, 2001, (Acceptance Review of SEQUAL Topical Report). The enclosure includes a response to each of thirteen issues.

In our review of the RAIs, we are somewhat concerned that the NRC has raised issues that appear to indicate a lack of understanding as to how the experience-based methodology fits into the regulatory process. The experience-based seismic equipment qualification method (EBSEQ) is one approach to meeting the NRC regulations for seismic qualification of equipment. While we maintain that the approach meets regulations, it does not in all respects meet the NRC's guidance in the Standard Review Plan (NUREG-0800) or regulatory guides, including standards referenced in those guidance documents.

The NRC establishes regulatory guidance to identify one or more acceptable methods or means of complying with regulatory requirements. The guidance is generally much more detailed than the regulations themselves. The NRC, however, has the discretion to approve other methods and means that ensure compliance with regulations. The EBSEQ is one means of complying with the NRC's regulatory requirements in 10 C.F.R. Part 50, Appendix A, General

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Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," and in Section VI, "Application to Engineering Design," of Appendix A to 10 C.F.R. Part 100, for certain equipment in nuclear power plants. Our attached responses, in addition to providing requested information, attempt to further identify the manner in which the EBSEQ meets these regulatory requirements.

The EBSEQ methodology is based upon the SQUG Generic Implementation Procedure (GIP), approved for use by greater than half of operating reactor units. In the GIP safety evaluation report, the NRC determined that implementation of the GIP experience-based approach "satisfy[ies] the pertinent equipment seismic requirements of GDC 2 and the purpose of the NRC regulations relevant to equipment seismic adequacy including 10 CFR Part 100." An allowance for use of experience-based approaches at the remaining half of operating units provides a significant cost and burden reduction potential, in line with NRC Performance Goals, while maintaining an adequate level of safety.

NEI and the SEQUAL group would like to meet with the NRC staff to discuss the information presented in the responses. Following the meeting, SEQUAL will revise the Topical Report as discussed in the responses and, considering discussions at the meeting, submit the revised report to the NRC.

If you have any questions, please contact John Butler 202-739-8108, jcb@nei.org, or me.

Sincerely,

Alex Marion

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JCB/maa

Enclosure

c: Mr. Peter Wen, U. S. Nuclear Regulatory Commission
Mr. Eugene Imbro, U. S. Nuclear Regulatory Commission
Mr. Kamal Manoly, U. S. Nuclear Regulatory Commission
Mr. Gregory Ferguson, Entergy Operations, Inc.
Mr. James Fisicaro, Duke Energy
Dr. Robert Kassawara, EPRI

NRC Issues and SEQUAL Responses

Introduction

Format of Responses: The information presented below includes three parts for certain of the NRC's issues. The first part presents a restatement of the NRC's issue identified in its letter of January 31, 2002, containing requests for additional information. For the issues originally identified by the NRC in its acceptance review letter dated August 13, 2001, a restatement is provided. For each issue, a response follows the NRC's description of the issue.

Regulatory Process Issues: We are somewhat concerned that the NRC has raised issues that appear to indicate a lack of understanding as to how we believe the experience-based methodology fits into the regulatory process. The EBSEQ methodology is one approach to meeting the NRC regulations for seismic qualification of equipment. While we maintain that the approach meets regulations, it does not in all respects meet the NRC's guidance in the Standard Review Plan (NUREG-0800) or regulatory guides, including standards referenced in those guidance documents. If the approach fully complied with that guidance, we maintain that further NRC approval of the methodology would not be necessary.

The NRC establishes guidance to identify one or more acceptable methods or means of complying with regulatory requirements. The guidance is generally much more detailed than the regulations themselves. The NRC, however, has the authority and discretion to approve other methods and means that ensure compliance with regulations. The EBSEQ methodology is one means of complying with the NRC's regulatory requirements in 10 C.F.R. Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," and in Section VI, "Application to Engineering Design," of Appendix A to 10 C.F.R. Part 100, for certain equipment in nuclear power plants.

EBSEQ Methodology Provides a Performance-Based Approach: While NRC guidance concerning seismic qualification of equipment provides deterministic, prescriptive methods, the EBSEQ methodology offers a performance-based method. As discussed further below, the NRC has established goals to use risk-informed insights and performance-based methods to reduce unnecessary regulatory burden while maintaining safety. The EBSEQ methodology provides an excellent opportunity for a performance-based approach as a new regulatory initiative in line with the high-level guidelines for performance-based activities delineated in SECY-00-0191.[1]

EBSEQ Methodology Provides Burden Reduction In Line With NRC Performance Goals: The EBSEQ methodology also is in line with the NRC's performance goals for reducing unnecessary

[1] SECY-00-0191, "High-Level Guidelines for Performance-Based Activities" (Sept. 1, 2000), describing NRC Staff development of guidelines, at Commission direction, to "increase reliance on performance-based regulatory approaches throughout the agency."

regulatory burden on stakeholders.[2] By allowing the use of an experience-based method for seismic qualification of certain equipment, the EBSEQ methodology can reduce the resource burden on licensees for certain new and replacement equipment while maintaining safety. The NRC describes its goals for regulatory burden reduction as follows:

> By reducing unnecessary regulatory burden, both the NRC and licensee resources may be made available to more effectively focus on safety issues. Unnecessary regulatory burden for NRC licensees may be defined as requirements that go beyond what is necessary and sufficient for providing reasonable assurance that public health and safety, the environment, and the common defense and security will be protected. ... During the past 30 years, an ever-increasing body of technical knowledge and operational experience has been accumulated, both domestic and international, that allows for refinements and enhancements in NRC requirements and programs that can reduce unnecessary regulatory burden, while assuring maintenance of safety. The NRC believes that for some areas of NRC regulations and practices, the burden is not commensurate with the safety benefit. Not all of our requirements and programs have been updated to take into account these advancements, and thus they may not be as efficient and effective as possible. Reduction in unnecessary regulatory burden may contribute to the NRC effectiveness and efficiency by allowing more focus on safety and risk-significant issues. For example, the new reactor oversight process is allowing more effective staff focus on safety significant issues related to licensee performance.
>
> Although regulation, by its nature, is a burden, we will impose on licensees only the necessary level of burden that is required to maintain safety. While our current performance goal is to reduce unnecessary regulatory burden, our long-range plans are to eliminate unnecessary regulatory burden to the extent feasible and cost effective. We will pursue risk-informed and performance- based approaches, if justified, so that we can focus our attention on those areas of highest safety priority. We will make more realistic decisions through reducing excessive conservatism.
>
> The NRC will employ the following strategies to reduce unnecessary regulatory burden on stakeholders:
>
> Strategies
>
> - We will utilize risk information and performance-based approaches to reduce unnecessary regulatory burden.
>
> - We will improve and execute our programs and processes in ways that reduce unnecessary costs to our stakeholders.

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2 *See* the NRC's performance goals included in the NRC's strategic plan at the following NRC Web Site: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1614/v2/part1/index.html

- We will improve our reactor oversight program by redirecting resources from those areas less important to safety.

- We will actively seek stakeholder input to identify opportunities for reducing unnecessary regulatory burden.

- We will use the following measure to assess our results in reducing unnecessary regulatory burden on stakeholders:

  Measure - Complete those specific milestones to reduce unnecessary regulatory burden as identified in the annual Performance Plan.

Where appropriate, in our responses below, we explain how the EBSEQ methodology provides an opportunity for the NRC to meet these performance goals.

Limitations in Using the EBSEQ Methodology: In reviewing the responses to the NRC's issues given below, the NRC should be mindful that the use of EBSEQ methodology is subject to a number of limitations. The limitations are necessary because the EBSEQ methodology is based on demonstrating a bounding method for various types of equipment. For certain elements of the regulations and certain applications, the EBSEQ methodology is not appropriate because, for example, it may not be bounding for those applications. The limitations are intended to address such applications – these limitations are not intended to limit the use of EBSEQ methodology when its application is appropriate for assuring compliance with regulatory requirements. With this understanding, the responses below address the NRC's issues concerning the limitations and explain why the limitations exist.

Issue #1: Treatment of Concurrent Loads

NRC's Request: For the issue of concurrent loads, Section 5.3.1 of the Topical Report states that the application of the EBSEQ method covers concurrent normal operating loads and that concurrent accident loads must be addressed by supplemental analysis or testing. The staff interprets SEQUAL's preceding statement to mean that the EBSEQ method does not cover the concurrent loading requirements found in Section VI of Part 100. The Topical Report needs to clarify this issue. In addition, Section 2.2 of the Topical Report indicates that the tank and heat exchanger evaluation criteria specified in Part II, Section 7 of the GIP-2 are applicable. The licensing basis for non-A-46 plants may require compliance with ASME [American Society of Mechanical Engineers] Code criteria for the design of tanks and heat exchangers as well as other mechanical equipment such as pumps and valves. As indicated in Section 5.3.1 of the report, the EBSEQ method does not address ASME Code pressure boundary acceptance. However, the ASME Code specifies that earthquake loads shall be taken into account in the design of these components. The ASME Code specifies the combination of earthquake loads with pressure loads in determining the pressure boundary acceptance. Describe how the EBSEQ methodology procedure for tanks and heat exchangers, as well as other mechanical components, assures that the ASME Code criteria, applicable to load combinations that include earthquake loads, are satisfied.

Description in August 13, 2001, Letter: The staff's first concern dealt with the issue of concurrent functional and accident-induced loads as required by Section VI of Part 100. Concurrent functional and accident-induced loading is not considered by the GIP-2 methodology but is a requirement that must be met by non-A-46 plants licensed to Part 100. In its response to this concern, SEQUAL stated that the EBSEQ method is not to be used to qualify equipment or parts that are unique to nuclear power plants or for loads arising from simultaneous earthquake loading and loading due to accident or abnormal conditions. SEQUAL stated that the EBSEQ method applies to non-nuclear steam supply system (NSSS) equipment and conventional electrical and mechanical equipment classes. In addition, SEQUAL stated that application of the EBSEQ method covers concurrent normal operating loads and that concurrent accident loads must be addressed by supplemental analysis or testing. The staff interprets SEQUAL's preceding statement to mean that the EBSEQ method does not cover the concurrent loading requirements found in Section VI of Part 100. SEQUAL needs to clarify this issue.

Response:

Section VI of Appendix A to 10 C.F.R. Part 100 states that "[i]n addition to seismic load, including aftershocks, applicable concurrent functional and accident-induced loads shall be taken into account in the design of these safety-related structures, systems, and components" (emphasis added). The limitations identified in the Topical Report concerning application of the EBSEQ methodology are intended to address those situations when applicable concurrent loads must be considered. The EBSEQ methodology is appropriate, without additional analyses, for qualification of equipment that is not sensitive to accident-induced loads. SEQUAL proposes to modify the Topical Report to clarify this. In Section 2.2, second bullet stating specific limitations, the first paragraph will be replaced with the following insert (Pages 14, 30, App. A pg. 1-2 of the Topical Report):

> "The EBSEQ method addresses the effects of earthquake in combination with normal operating loads for the equipment that is not sensitive to accident loads. It does not address earthquake in combination with other loads, such as accident loads and BWR suppression pool loads, found in Section VI of 10CFR100. The effect of earthquake in combination with such loads, if they are significant compared to the earthquake loads, must be addressed by another qualification method such as test or analysis used in accordance with the plant's licensing basis. The significance determination must be documented in the same manner as is customarily done for seismic qualification by analysis or test. This is discussed further in Section 5.3.1."

Other sections of the Topical Report (e.g., Section 5.3.1) will be revised appropriately.

Regarding the interface between EBSEQ methodology and ASME Code load combinations, if a licensee has committed to compliance with ASME Code criteria for components that require pressure boundary integrity, then the ASME Code criteria must be met for purposes of addressing maintaining pressure boundary integrity during earthquakes. Therefore, in those cases where the ASME Code specifies a combination of earthquake and pressure loads for determining the pressure boundary acceptance, these load combinations must be addressed as a part of the ASME Code evaluation. The EBSEQ procedure does not describe or specify how these load combinations should be addressed to meet the ASME Code. SEQUAL proposes to modify the Topical Report to clarify this issue. In Section 5.3.1, SEQUAL Response, the last paragraph will be modified as follows:

> "The EBSEQ method addresses functionality of ASME mechanical equipment. The method does not address ASME Code requirements for pressure boundary integrity of components. If a licensee has committed to use of the ASME Code criteria for components that require pressure boundary integrity, then the ASME Code criteria must be met. For example, valve body pressure stress is addressed as part of the ASME Code evaluation of the valve body while the EBSEQ method addresses the operator and yoke (outside ASME Code pressure boundary). Where the ASME Code specifies a combination of earthquake and pressure loads for determining the pressure boundary acceptance, these load combinations must be addressed as a part of the ASME Code evaluation. In this manner, the EBSEQ

and the ASME Code evaluation are used in conjunction to qualify the entire valve and operator assembly."

Issue #2: Number of Response Spectra Used to Create Reference Spectrum

Description in August 13, 2001. Letter: The staff's second concern dealt with the adequacy, based on the low number of response spectra (four), and the accuracy of two of the four response spectra used to create the GIP-2 reference spectrum (RS). In its response to the staff's concern, SEQUAL provided new ground motion estimates for the Pleasant Valley Pumping Plant from the 1983 Coalinga, California earthquake and the Sylmar Converter Station from the 1971 San Fernando, California earthquake. Since the original Pleasant Valley Pumping Plant ground motion estimate was also intended as the ground motion estimate for other nearby oil field facilities, which also experienced the 1983 Coalinga earthquake, SEQUAL provided more accurate and up-to-date ground motion estimates for these five oil field facilities. Similarly, since the original Sylmar Converter Station ground motion estimate was also used as the ground motion estimate for the Rinaldi Receiving Station, SEQUAL provided an updated estimate of the ground motion estimate at the Rinaldi facility. SEQUAL then determined the average response spectra from the six Coalinga sites to provide a single representative Coalinga response spectrum. Similarly, SEQUAL determined the average response spectra from the Sylmar and Rinaldi sites.

SEQUAL combined these two average response spectra with the original two response spectra from the El Centro Steam Plant and the Llolleo Water Pumping Plant to create a revised reference spectrum. SEQUAL shows that this revised RS has essentially the same spectral acceleration level (1.18 g) as the GIP-2 RS (1.2 g) over the frequency range 2.5 - 7.5 Hz. The revised RS has resolved the staff's second concern since it has a similar spectral acceleration level as the GIP-2 RS. However, the staff has concerns about the continued use of the GIP-2 RS as part of the EBSEQ method. These concerns are presented later as part of the evaluation of SEQUAL's response to our fifth concern, which dealt with the adequacy of GIP-2 reference spectrum to represent the seismic capacity of all of the equipment in the earthquake experience database.

Response: The NRC concern in Issue #2 is resolved. The supplemental concern noted above is addressed under Issue #5.

Issue #3 - Use of GIP-2 Method A

NRC's Request: Regarding the use of GIP-2 Method A in the EBSEQ method, the arguments present in Section 5.3.3, Section 6, and Appendix C are not sufficient to modify the staff's position that non-A-46 plants must use their design basis in-structure response spectra (IRS) to define the seismic demand. As stated in the staff's acceptance review letter, dated August 12, 2001, in the event that licensees believe, as shown in Appendix C of the Topical Report, that there were overly conservative assumptions made in the development of their design basis IRS, they may submit, via a license amendment request, less conservative spectra. Then, the appropriate comparison between seismic demand and capacity for a seismic experience-based qualification method would be between the plant's IRS and the equipment class capacity spectrum determined from seismic experience.

Description in August 13, 2001, Letter: The staff's third concern dealt with the assumption made in GIP-2 that in-structure response spectra (IRS) at all elevations within 40-feet above the plant's grade are identical to the ground response spectrum. This assumption is not technically justified for non-A-46 plants since these newer plants have available calculated IRS that are in general agreement with the Standard Review Plant (SRP). These IRS for non-A-46 plants are part of the licensing basis for these plants and considered by the staff to be substantially more reliable for estimating the seismic demand for plant structures, since they account for amplification of the ground response spectrum at higher elevations. In its response to the staff's concern, SEQUAL stated that non-A-46 plants should be able to use Method A from the GIP-2 for the same reasons, and under the same limitations, as A-46 plants. This conclusion from SEQUAL is based on a demonstration in Section 6 of the Topical Report that attempts to show that the use of "realistic, median-centered in-structure response spectra for demand yields a level of seismic risk equivalent to conventional seismic qualification by testing or analysis using typical design basis in-structure response spectra for demand." SEQUAL further stated that A-46 plants were required to justify the use of Method A wherever the plant licensing basis floor response spectra significantly exceeded 1.5 times the design free-field spectrum and, similarly, SEQUAL plants would also do this, "using the same approach as the A-46 plants; i.e., by quantifying the conservatisms in the plant's licensing basis spectra compared to what median-centered spectra would have." Regardless of what is shown in Section 6 of the Topical Report, the staff concludes that non-A-46 plants must use their design basis IRS for seismic demand. In the event that licensees believe that their design basis IRS are overly conservative, they may submit, via a license amendment request, less conservative spectra, which are developed using methods previously approved by the staff. Based on the above discussion, the staff concludes that SEQUAL has not adequately addressed the staff's concern regarding this issue.

Response:

As noted above in the "Introduction" section, while the EBSEQ methodology meets the regulatory requirements, it does not fully comply with all of the elements in the NRC's guidance. Therefore, SEQUAL submitted the Topical Report to the NRC for review and approval as an alternative, performance-based methodology for meeting the regulatory requirements. Through the use of actual earthquake experience data evidencing equipment performance during and after an earthquake, considering the limitations and caveats regarding the application of the EBSEQ, the methodology conforms with the NRC's high-level guidelines for performance-based

initiatives: measurable or calculable parameters, objective performance criteria, flexibility, and a performance failure not resulting in an immediate safety concern. It also provides an opportunity for reducing the regulatory burden of seismic qualification for certain equipment while maintaining safety.

NRC's regulations establish requirements such that there is reasonable assurance that public health and safety is protected. It has been demonstrated that use of Method A provides reasonable assurance that the public health and safety will be protected for the majority of nuclear plants in the country. *See* NRC SSER No. 2. The EBSEQ methodology provides an opportunity to reduce unnecessary regulatory burden while maintaining an adequate level of assurance that public health and safety are protected, as demonstrated by the plants using the GIP methodology, which includes approximately two-thirds of currently operating plants in the U.S., considering the following:

- The NRC staff has already concluded that "equipment installed in nuclear power plants is inherently rugged and not susceptible to seismic damage" subject to certain exceptions and caveats (NUREG-1211, at 16). The EBSEQ method uses the same exceptions and caveats that have been accepted by the NRC for use by A-46[3] plants.
- A-46 plants not only used Method A for resolution of A-46, but may also use it for new and replacement equipment and parts for the remainder of the plant operating life. Non-A-46 plants will be using the EBSEQ method in much the same manner for new and replacement equipment and parts.
- SEQUAL has provided a risk-informed evaluation in Section 6 of the Topical Report showing that median-centered in-structure response spectra for demand (the approach upon which Method A is based) yields a level of seismic risk equivalent to conventional seismic qualification by testing or analysis using typical design basis in-structure response spectra for demand.

In its letter dated August 13, 2001, the NRC incorrectly stated that the GIP[4] Method A assumes that "in-structure response spectra (IRS) at all elevations within 40-feet above the plant's grade are identical to the ground response spectrum." More correctly, for GIP Method A1, the <u>ground</u> response spectrum at nuclear plants is treated as the seismic demand and compared to the GIP Bounding Spectrum (capacity) which is based on average <u>ground</u> response spectra from database sites <u>reduced</u> by a factor of 1.5 to account for potential amplification within the structure up to an elevation of 40 feet above the effective grade. GIP Method A2 allows seismic demand to be estimated by using the ground response spectrum but it must be <u>increased</u> by a factor of 1.5 to

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3 "A-46" refers to Unresolved Safety Issue A-46, "Seismic Qualification of Equipment in Operating Plants," identified by the NRC in Dec. 1980.

4 The "GIP" refers to the Generic Implementation Procedure for Seismic Verification of Nuclear Plant Equipment," Feb. 1992, which was reviewed and approved by the NRC for resolution of Unresolved Safety Issue A-46 for approximately two-thirds of the NRC-licensed nuclear plants.

account for potential amplification within the structure up to an elevation of 40 feet above the effective grade.

Also, in its letter dated August 13, 2001, the NRC stated that the licensing basis for the non-A-46 plants is "considered by the staff to be substantially more reliable for estimating seismic demand for plant structures, since they account for amplification of the ground response spectrum at higher elevations." As explained above, GIP Method A does account for amplification of the ground response spectrum at higher elevations in the structure (i.e., a factor of 1.5 is used for equipment with its lowest natural frequency below about 8 Hz and mounted below about 40 feet above the effective grade). The basis for using a 1.5 factor is contained in Appendix A of the SSRAP Report,[5] which the NRC has reviewed as part of the resolution of Unresolved Safety Issue A-46.

In its request for additional information concerning the EBSEQ method, the NRC indicates that the arguments provided in the SEQUAL Topical Report for using Method A in the EBSEQ method are "not sufficient to modify the staff's position that non-A-46 plants must use their design basis in-structure response spectra (IRS) to define the seismic demand." Instead, the staff suggests that each licensee "submit, via a license amendment request, less conservative spectra" and that these seismic demand spectra be used for comparison to the equipment class capacity spectrum from seismic experience. The NRC states no technical justification for such a requirement, which is not specified in the regulations. As discussed above in the Introduction section, alternative methods other than those that the staff has already accepted may be used to satisfy regulatory requirements, and SEQUAL requests NRC generic approval of the high-level concept through the Topical Report of the use of such an approach, rather than requiring that each licensee request specific NRC approval, except as may be necessary for other reasons.

The NRC staff has already accepted use of Method A as an alternative method for comparing the seismic capacity of equipment to demand for those nuclear plants that are subject to A-46 (the majority of the nuclear power plants in the country). Having accepted use of Method A and the related use of median-center in-structure response spectra for the A-46 plants, the staff has determined that this method provides reasonable assurance that the public health and safety are protected.

The plants that elect to use the EBSEQ methodology, which incorporates Method A and a median-center in-structure response spectra, will need to develop a plant-specific basis for using 1.5 times GRS whenever the ISRS exceeds this value. Because of the variations in the GRS and ISRS for each plant, SEQUAL will work with the plants to ensure that the approach is acceptable on a plant-specific basis, consistent with the discussion in Appendix C of the Topical Report.

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5 SSRAP Report, "Use of Seismic Experience and Test Data to Show Ruggedness of Equipment in Nuclear Power Plants," Senior Seismic Review and Advisory Panel, Rev. 4, Feb. 28, 1991.

Issue #4 - Equipment Class Definitions

NRC's Request: The EBSEQ methodology proposes to use the same 20 equipment classes as defined for GIP-2. In its acceptance review, the staff noted that the GIP-2 definitions of equipment classes are too broad for use in an experience-based seismic qualification methodology that would be expected to provide a level of confidence comparable to that established from seismic qualification by testing or dynamic analysis, which is currently required by Part 100. As stated in the staff's letter dated August 13, 2001, ". . . the equipment class definitions, in terms of the equipment physical and dynamic characteristics, must be justified and presented as part of the EBSEQ methodology. The equipment characteristics for each class should include the number of equipment items as well as the average and variance of the equipment parameters. Furthermore, each individual equipment entry should contain the equipment's physical and dynamic characteristics as well as a list of the earthquakes that the equipment has experienced."

Section 3.3.1 of Appendix A to the SEQUAL Topical Report, states that ". . . it should be noted that data from earthquakes that occurred after about 1985 were not available at the time that the GIP was being prepared, reviewed, and accepted. Attachment E contains a listing of those earthquakes and database facilities that can be used to establish representation in the GIP earthquake experience equipment classes."

To ensure that the earthquake experience database used for EBSEQ meets the standard and level of confidence required for a seismic qualification methodology, as opposed to seismic adequacy verification, the staff requests that SEQUAL provide the detailed documentation relating to the earthquake experience data for each class of equipment for staff review from those post 1985 earthquakes. The equipment data documentation should consider the staff's comments stated above and the design attributes presented in Table 3-1 of the EBSEQ methodology (Appendix A), to either confirm the validity of the definitions of each earthquake-experience-equipment class given in GIP-2, or redefine the equipment class definition as well as the associated equipment capacity for each type of equipment as appropriate.

In addition to seismic experience data, the EBSEQ method also proposes to use test experience, which are shake table tests by utilities, equipment vendors, and test laboratories. The staff requests further information as to how this test experience will be used in conjunction with the earthquake experience data to define equipment capacity. Specifically, will equipment classes have separate capacities derived from testing experience, as was the case for GIP-2?

Description in August 13, 2001, Letter: The staff's fourth concern dealt with the continued use of the GIP-2 equipment classes for non-A-46 plants. The staff noted that the GIP-2 definitions of equipment classes are too broad for use in an experience-based seismic qualification methodology that would be expected to provide a level of confidence comparable to that established from seismic qualification by testing or dynamic analysis, which is currently required by Part 100. Furthermore, the staff noted that the equipment classes should not be based solely on equipment function, since equipment with the same function may be dynamically very different. Instead, the class groupings should also consider appropriate physical characteristics such as dimensions, weight, vibration frequency, and mounting configuration. In its response, SEQUAL stated that, the categorization of equipment into 20 generic classes was a well thought

out, iterative process between the SQUG members, their consultants who prepared the GIP, and the Senior Seismic Review and Advisory Panel (SSRAP). SEQUAL further stated that the similarity of the seismic responses of each equipment class "is demonstrated by some 280 examples in the earthquake experience database." In addition, SEQUAL stated that the grouping of the equipment classes was based on more than just equipment function. Other factors used by SQUG to group the equipment into the 20 classes included construction, operation, capacity, and application. The staff takes exception to SEQUAL's assertion regarding the implied agreement between SQUG, SSRAP, and the staff on the adequacy of equipment grouping into 20 generic classes for seismic qualification of mechanical and electrical equipment. The staff's SSER-2 on GIP-2 explicitly stated that the staff did not review the details of the earthquake experience data for the equipment relied upon in establishing the 20 generic classes. Furthermore, in its letter to the staff dated July 23, 1991, SSRAP stated that it has not endorsed the EQE reports that provide the basis for the establishment of the generic equipment classes.

Regarding the similarity of the equipment within each of the classes, a cursory review by the staff of the earthquake experience equipment database, showed very dissimilar physical characteristics among some of the equipment classes. In addition, there are no actual equipment response spectra in the earthquake experience database and, therefore, it would be impossible to verify the "similarity of the seismic responses of each equipment class" as asserted by SEQUAL. In addition, many of the equipment characteristics, such as dimensions, weight, natural frequency, etc. are missing from the equipment entries in the database. To meet the level of confidence comparable to that established from seismic qualification by testing or dynamic analysis, as required by Part 100, the equipment class definitions, in terms of the equipment physical and dynamic characteristics, must be justified and presented as part of the EBSEQ methodology. The equipment characteristics for each class should include the number of equipment items as well as the average and variance of the equipment parameters.

Furthermore, each individual equipment entry should contain the equipment's physical and dynamic characteristics as well as a list of the earthquakes that the equipment has experienced. Based on the above discussion, the staff concludes that SEQUAL's response does not adequately address the staff's concern.

Response:

Concerning the NRC request that additional earthquake experience data be collected for defining equipment classes to be used in the EBSEQ method, we note that this requested approach is based on seismic qualification methods already accepted by the NRC, i.e., reliance upon detailed information concerning the physical and dynamic equipment characteristics of each item of equipment being qualified. Such detail is appropriate when seismically qualifying an individual item of equipment using a single test or analysis.

However, as discussed above, the regulatory requirements in 10 CFR 100, Appendix A, Section VI, include the flexibility for the NRC to allow the use of alternative methods other than those already accepted in NRC guidance. The EBSEQ approach is an alternative method for seismic qualification of equipment. The EBSEQ method defines the scope of equipment included within each equipment class based on the following approach:

- As described in Section 5.3.4 of the Topical Report, equipment was grouped into 20 classes based on commonality of physical and operating characteristics.
- Based on the range of physical and operating characteristics of equipment that had been exposed to earthquakes, the EBSEQ method defines the range of pertinent parameters (inclusion rules) for each class of equipment.
- Instances where failures or malfunctions have occurred during these earthquakes (and during shake table tests on similar equipment) are identified.
- Based on these failures and malfunctions, the EBSEQ method imposes limitations and restrictions (caveats) to preclude use of equipment with such vulnerabilities.

One reason that the EBSEQ method provides an acceptable performance-based alternative for seismic qualification of equipment is that there have been very few failures of commercial equipment that had been exposed to significant earthquakes. The EBSEQ approach is not primarily focused on collection of detailed data concerning the characteristics of each item of equipment that had performed satisfactorily during the earthquakes (i.e., success data). Instead, the primary focus on data collection has been to identify the cause of those few instances where failures occurred to accumulate failure data. This failure data was then used in the EBSEQ method to define limitations and restrictions (caveats) that must be avoided to preclude use of equipment with such vulnerabilities.

Based on this performance-based approach and the review of the work performed by SQUG and SSRAP, the NRC staff came to the following conclusion in its regulatory analysis of the method for resolution of USI A-46:

> First, subject to certain exceptions and caveats, the staff has concluded that equipment installed in nuclear power plants is inherently rugged and not susceptible to seismic damage.[6]

For resolution of USE A-46, the NRC accepted use of the GIP methodology for "verifying the seismic adequacy of equipment rather than a seismic qualification method." NRC SSER No. 2, at 4. To address the difference between the seismic "verification" for USI A-46 and seismic "qualification" for new and replacement equipment, two additional elements have been added to the earthquake experience-based seismic qualification method. First, SQUG has continued to investigate earthquakes and evaluate any reports of damage to equipment within the GIP classes to determine if further restrictions to the equipment class definitions are needed. In the 15 years since the SSRAP report and the GIP were first issued, no equipment damage from earthquakes has been discovered that would require changes to the current GIP class definitions (inclusion rules) and restrictions (caveats). This additional data provides further assurance of the adequacy of the EBSEQ method as a performance-based alternative seismic qualification method.

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6 NUREG-1211, at 16.

The second element added to the EBSEQ method for new and replacement equipment is the requirement that a design difference evaluation. This evaluation requires that the user identify and evaluate those features of equipment that may reduce its seismic capacity. This approach parallels the qualification method described in Section 7.3 of IEEE Standard 344-1975 where extrapolation from previously qualified equipment is used to qualify variations in subsequent designs. It should be noted, however, that the EBSEQ method, as described in the Topical Report, Appendix A, Section 3.3, goes beyond the general requirements in IEEE 344-1975. The EBSEQ method provides more guidance on how the similarity evaluation should be performed and documented. In addition, the EBSEQ method requires that the similarity evaluation be performed only by Seismic Capability Engineers with relevant educational backgrounds (degreed civil or mechanical engineer), on-the-job experience (minimum of five years), and training in the use of the EBSEQ method (SQUG Walkdown Training Course). This design difference evaluation provides additional assurance of the adequacy of the EBSEQ method as a performance-based alternative seismic qualification method.

The EBSEQ method with respect to definition of equipment classes provides reasonable assurance that public health and safety are protected, and meets the regulatory requirements for seismic qualification of equipment. It is not necessary, based on the limitations on the use of the EBSEQ approach, to redefine the equipment classes.

The limitations also preclude the need for collecting detailed physical and dynamic characteristics for independent items of equipment in each of the 20 equipment classes. The SQUG utilities expended millions of dollars supporting the development of the methodology, including the class definitions, and the NRC also expended substantial funds during this period in reviewing the SSRAP work and trial implementations at two nuclear plants. Redefining the equipment classes would, in essence, repeat the work already completed.

To help resolve this issue, SEQUAL recommends that NRC representatives participate with SEQUAL in a visit to one or two facilities included in the earthquake experience database to demonstrate the validity of the definitions of a number of earthquake experience equipment classes identified in the GIP. Such a visit would provide the NRC staff with first-hand knowledge and understanding of the scope of equipment covered and the basis for the conclusion that commercial equipment is seismically rugged.

Concerning the use of test data with earthquake experience data, and to explain how test data can be used in conjunction with earthquake experience data, test experience data were used in two ways to support the earthquake experience method for seismic qualification of equipment. First, it was used in conjunction with the earthquake experience data to identify the seismic vulnerabilities and weaknesses that are included as caveats for the earthquake experience equipment classes. Second, as discussed in response to Issue #9 (see below), test data were also used to support the EBSEQ conclusion that equipment in the earthquake experience equipment classes is sufficiently rugged and capable of functioning during an earthquake (i.e., during the period of time when strong ground motion is occurring).

Since SEQUAL intends to delete all references to use of GERS in the Topical Report (see response to Issue #6), there will not be separate equipment classes and capacities based on test experience. Nevertheless, test data from seismic qualification reports (e.g., those based on use of

IEEE 344-1975) may be used within the EBSEQ method to establish the seismic capacity of equipment and parts.

The SEQUAL Topical Report will be revised to clarify the role that test experience data played in developing the EBSEQ method and how seismic qualification data may be used in determining the seismic capacity of equipment. For example, Section 5.1 of the Topical Report will be revised as shown on the following pages in order to clarify these points.

Proposed Changes to Topical Report Section 5.1 to Address Issue #4 (In Part)

5.1 Technical Bases

An experience-based method of assuring seismic adequacy, as defined by SQUG in the GIP and the NARE Guidelines, was developed . . .

The EBSEQ method, delineated in Appendix A, builds on the principles in the GIP and NARE Guidelines.

The method is based on (a) data collected through literature and field surveys on the performance of conventional power plant and industrial equipment in many strong motion earthquakes worldwide, and (b) data from shake table tests by utilities, equipment vendors, and test laboratories. From this information, earthquake experience equipment classes were defined by inclusion rules. Specific vulnerabilities/weaknesses (caveats) were also identified and prohibited for each class. The data from shake table tests was an important factor in developing these caveats. In addition, data from shake table tests supported the conclusion that the equipment in the earthquake experience equipment classes is capable of performing its safety functions during the earthquake, i.e., during the period of time when strong ground motion is occurring. Equipment capacity (Reference Spectrum) was defined on the basis of ground motions at the earthquake sites. Although the GIP includes equipment classes and corresponding equipment capacities based on test response spectra (Generic Equipment Ruggedness Spectra or GERS), the EBSEQ method does not include these test experience equipment classes or capacities. However, test data from seismic qualification reports (e.g., those based on use of IEEE 344-1975) may be used within the EBSEQ method to establish the seismic capacity of the equipment and parts.

The main conclusion of this research, as reported by the independent review panel SSRAP (Reference 9.14), is that equipment within the bounds of the earthquake equipment classes included in the scope of the EBSEQ, subject to the class-specific caveats, are inherently rugged, provided the equipment are properly anchored, adverse spatial interactions are avoided, and the possibility of chatter of electrical relays and contractors is evaluated separately.

The main elements of the EBSEQ procedures for applying earthquake experience are listed below:

- Demonstration that the candidate equipment falls within the defined inclusion rules for the applicable earthquake equipment class (i.e., is represented in the earthquake experience data).

- Assurance that known equipment vulnerabilities are not present in the equipment.
- Verification that the earthquake experience-based seismic capacity of the equipment class exceeds the plant-specific seismic demand.
- Verification that equipment anchorage and associated load paths are adequate.
- Verification of no potential for adverse seismic spatial interaction with nearby equipment and structures.
- Review of potential design differences that could affect seismic performance of the equipment.
- Review and concurrence in all results by two qualified and trained Seismic Capability Engineers.
- Documentation of the entire process, including required supplemental analyses and inspections.

Issue #5 - Use of Reference Spectrum for All Equipment Classes

NRC's Request: Regarding the continued use of the GIP-2 reference spectrum to represent the seismic capacity of all of the equipment classes for EBSEQ, the staff requests that SEQUAL determine a unique seismic capacity spectrum for each equipment class using the equipment data from post 1985 earthquakes. The seismic capacity spectrum for each class should be determined using the proposed ASME QME methodology. In the event that each equipment class capacity spectrum entirely envelopes the GIP-2 reference spectrum, then the GIP-2 reference spectrum may continue to be used to represent the seismic capacity of all of the equipment classes for EBSEQ.

Description in August 13, 2001, Letter: The staff's fifth concern dealt with the adequacy of GIP-2 reference spectrum to represent the seismic capacity of all of the equipment in the earthquake experience database. The staff noted that it would be preferable if each class of equipment had its own unique seismic capacity spectrum rather than a single generic spectrum for all types of equipment. The staff further noted that each class of equipment should be sufficiently populated to provide reasonable assurance that the equipment in the class will function during and after an earthquake. In its response, SEQUAL justified the use of a single reference spectrum to represent the seismic capacity of all of the equipment in the database by stating that (1) the four response spectra used to develop the GIP-2 RS are from earthquakes whose magnitudes were greater than 6.0 and the estimated peak ground acceleration (PGA) at the four sites was greater than about 0.4g and (2) these four RS sites contained a "significant number of data base equipment in each of the equipment classes." In addition, SEQUAL showed in Appendix D of the Topical Report that the seismic capacity spectra it developed for each of the 20 classes are, in general, higher than the GIP-2 RS over the frequency range 2.5 - 7.5 Hz. SEQUAL developed these 20 seismic capacity spectra using the methodology "currently being considered for inclusion in industry standards for equipment seismic qualification." The staff notes that this proposed methodology for determining a seismic capacity spectrum (ASME QME) requires the use of 30 "independent items" for the determination of the equipment capacity spectrum. An independent item is defined in the proposed standard as "pieces of equipment that are not installed side by side in a facility, and are neither identical, nor identically mounted or supported." The staff concludes that the 20 equipment capacity spectra developed in Appendix D of the Topical Report are only loosely assumed to be from independent equipment items since SEQUAL stated, "estimates of the number of independent items were made based on kind of equipment normally found in the type of facility." It is therefore unlikely that the 20 seismic capacity spectra developed by SEQUAL in Appendix D of the Topical Report meet the proposed ASME QME provisions for the development of earthquake experience spectrum (EES). The staff also notes that the EES, shown in Appendix D of the Topical Report, do not follow the proposed ASME QME standard since they are truncated at an average value between 2.5 - 7.5 Hz, which may result in an unconservative estimate of the equipment capacity. To meet the level of seismic qualification of equipment, which is comparable to the level of qualification required by Part 100, requires a more accurate representation of the seismic capacity of equipment than that provided by the GIP-2 RS. An EES for each of the equipment classes, which meets the requirements set forth in the proposed ASME QME standard, would provide a more accurate representation of the equipment seismic capacity. Alternatively, SEQUAL could use a single spectrum to define the equipment capacity that falls below the lowest EES determined for each of the equipment classes.

Response:

While development of a unique seismic capacity spectrum using the proposed American Society of Mechanical Equipment (ASME) Qualification of Mechanical Equipment (QME) method for each equipment class based on equipment data from post-1985 earthquakes may be one way for establishing the seismic capacity of the equipment classes, it is not the approach used for the EBSEQ. The approach described in the Topical Report is a performance-based alternative that provides an acceptable level of safety assurance for its application. Summarized below are the two reasons for concluding that this alternative approach provides a measure of assurance that is comparable to using the ASME QME method for defining seismic capacity.

First, the ASME QME method has no restrictions on who can use it for developing new equipment classes. As a result, the method uses prescriptive, conservative steps to assure that non-experts can apply it. Part of that process is to comprehensively collect and document all the data to establish a capacity spectrum. While this is a valid approach, assembling such data is not necessary in order to apply the EBSEQ performance-based approach.

In contrast to the ASME QME method, the Reference Spectrum was developed by an independent expert panel (i.e., SSRAP), which not only reviewed the information provided by SQUG, but independently verified that such information was adequate to establish the basis for defining the Reference Spectrum. This included review of numerous documents (References 13 through 22 in the SSRAP Report) and walk-through reviews at several power plants in California. The NRC staff also participated in these reviews. SSRAP came to the following conclusion in its report (Topical Report Reference 9.14, page 10):

> Therefore, with a number of caveats and exclusions as discussed in subsequent sections, it is the judgment of SSRAP that for excitations below the seismic motion bounds described in Section 3 [i.e., the Bounding Spectrum], it is unnecessary to perform explicit seismic qualification of existing equipment in these classes (Table 2-1) for A-46 nuclear power plants to demonstrate functionality during (except for relay chatter) or after the strong shaking has ended. The existing data base reasonably demonstrates the seismic ruggedness of this existing equipment up to these seismic motion bounds.

The NRC staff made a similar conclusion in 1987 after review of the available data:

> First, subject to certain exceptions and caveats, the staff has concluded that equipment installed in nuclear power plants is inherently rugged and not susceptible to seismic damage.[7]

The staff amplified its conclusion by stating that there was such a preponderance of evidence of successful performance of equipment in earthquakes, that it was not necessary to collect

[7] NUREG-1211, at 16.

additional seismic experience data on the remaining types of equipment not included in the SQUG pilot program (i.e., the initial eight classes of equipment):

> The NRC staff has closely followed the SSRAP work and is in broad agreement with its conclusions. The staff has concluded that if the SSRAP spectral conditions [i.e., the Bounding Spectrum] are met, it is generally unnecessary to perform explicit seismic qualification on the eight classes of equipment studied. On the basis of the equipment damage survey conducted in the data base plants and a broad damage survey of strong motion earthquakes around the world, the staff has further concluded that there is no need to collect additional seismic experience data on the remaining type of equipment, provided: (1) anchorage and support adequacy of equipment is ensured, (2) certain caveats or exclusions for this equipment (derived from licensee, SEP, and SQRT review experience) as outlined in paragraph 6 of the enclosure to the proposed generic letter are addressed, and (3) the SQUG documents the basis for seismic capability of each equipment type not included in the original eight types for which detailed data were collected."[8]

Basing its process on the NRC's conclusion, SQUG focused its resources during the subsequent 15 years of earthquake investigations on collecting failure data rather than additional success data. Significant resources would be required to go back and collect the type of success data needed to apply the ASME QME method. Appendix D of the SEQUAL Topical Report provides an estimate of the total number of independent items for developing capacity spectra for individual equipment classes, which is appropriate for an experience-based approach.

The second basis for concluding that the Reference Spectrum accurately represents the seismic capacity of the earthquake experience equipment classes is that, since 1987, when the NRC staff reached the above conclusions, SQUG has continued to evaluate the results of significant earthquakes around the world. The results of these reviews show that no equipment damage has been discovered that would require changes to the current GIP class definitions (inclusion rules) and restrictions (caveats). The facilities investigated by SQUG included those that experienced large earthquakes (magnitude $M_w \geq 6.0$) with ground motions equivalent to those used in 1985 to develop the Reference Spectrum. Such earthquake/facility pairs include those listed in Table 5-1 below. SEQUAL is considering including this table and a plot of the ground response spectra for these facilities compared to the Reference Spectrum (see Figure 5-1 below) in the revised Topical Report.

This evidence provides the additional measure of assurance sought by the NRC staff, beyond the basis for accepting this method for USI A-46 plants, to allow use of the EBSEQ performance-based method for non-A-46 nuclear power plants.

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8 NUREG-1211, at 17.

Table 5-1

Post-1985 Earthquake/Facility Pairs
With Ground Response Spectra
Equivalent to Reference Spectrum

Earthquake Date, Name & Magnitude	Site & Location
1986 – North Palm Springs $M_w = 6.0$	Whitewater Hydroelectric Plant Banning, California
1989 – Loma Prieta $M_w = 7.0$	UCSC Central Campus Santa Cruz, California
1989 – Loma Prieta $M_w = 7.0$	Santa Cruz Water Treatment Plant Santa Cruz, California
1989 – Loma Prieta $M_w = 7.0$	Watkins-Johnson Instrument Plant Scotts Valley, California
1992 – Petrolia $M_w = 7.0$	PALCO Cogeneration Plant Scotia, California
1994 – Northridge $M_w = 6.7$	Great Western Financial Data Center Northridge, California
1994 – Northridge $M_w = 6.7$	Placerita Cogeneration Plant Newhall, California
1994 – Northridge $M_w = 6.7$	Rinaldi Receiving Station Mission Hills, California
1994 – Northridge $M_w = 6.7$	Sylmar Converter Station Sylmar, California

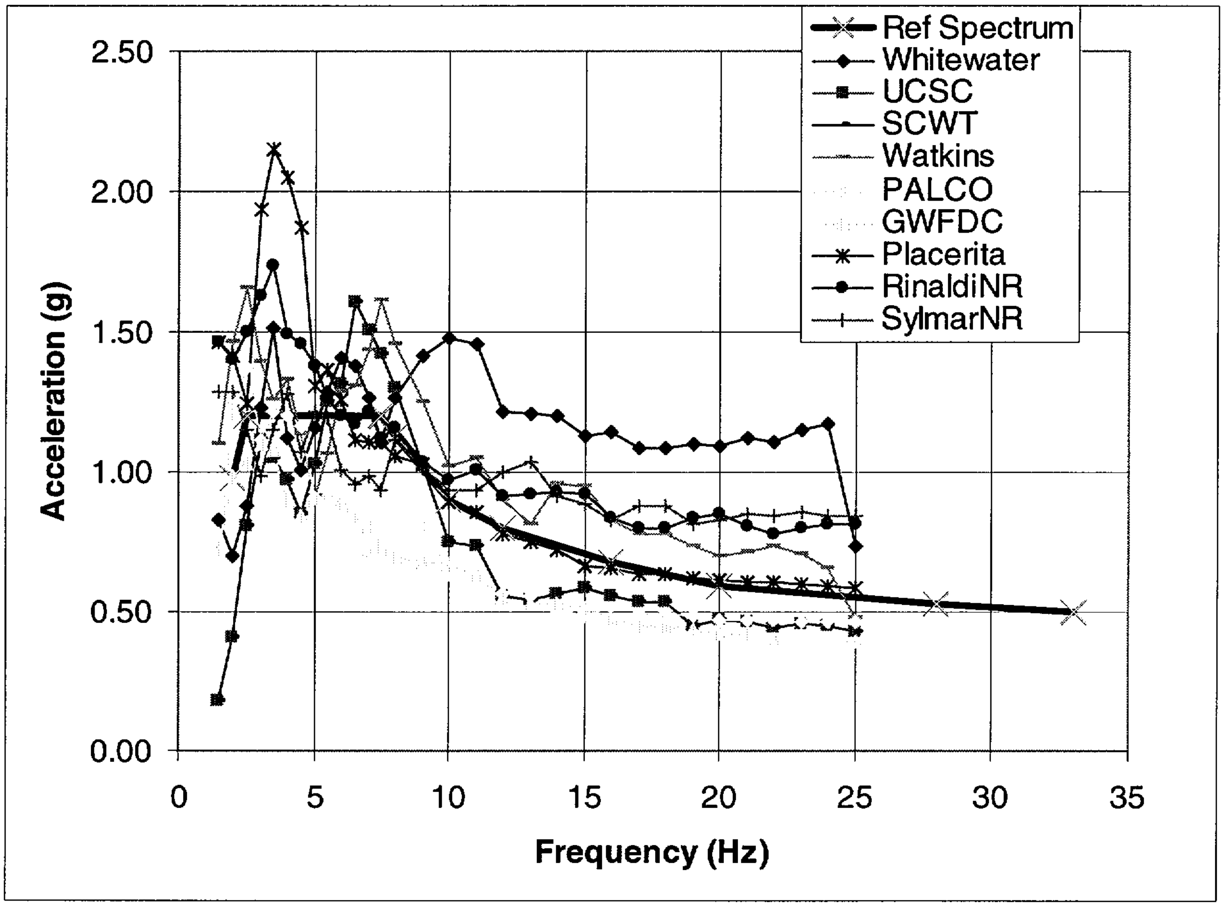

Figure 5-1

Post-1985 Earthquake/Facility Pairs With Ground Response Spectra Equivalent to Reference Spectrum

Issue #6 - Evaluation of Subassemblies

NRC's Request: On the issue involving the evaluation of subassemblies, one of the additional requirements for the EBSEQ method in Section 5.3.6 of the Topical Report is that, if a part is required to perform a safety function, its seismic adequacy must be verified by demonstrating that it is represented in the GIP equipment classes or else a part-specific evaluation must be performed using GERS or part-specific qualification data. It is specifically required in Section 4.4.1(b) of the EBSEQ procedure that a part-specific design difference evaluation be performed.

Since the staff stated in the acceptance review that the use of Generic Equipment Ruggedness Spectra (GERS) is inappropriate, SEQUAL has informally communicated to the staff its intention of deleting references to the GERS from the topical report. Please clarify SEQUAL's intention on this issue. In addition, regarding the evaluation of subassemblies, the staff requests that SEQUAL:

- List the types or classes of equipment that SEQUAL intends to apply the "rule of the box" (e.g., limited to electrical cabinets and enclosures only) and define the scope of "rule of the box" for each type or class of equipment.

- Provide detailed limitations of the use of "rule of the box" for seismic qualification of parts/subassemblies for each class of equipment where the rule applies. For example, for equipment installed in the same foundation mat (e.g., diesel generators) state how the "rule of the box" applies to the equipment and the subcomponents in the host equipment.

Description in August 13, 2001, Letter: The staff's sixth concern dealt with continued use of the "rule of the box" concept rather than an explicit evaluation of subassemblies within an item of equipment. In its response SEQUAL defended the use of the "rule of the box" concept from the GIP-2 methodology; however, since the GIP-2 was used to verify the seismic adequacy of equipment rather than to qualify equipment, the EBSEQ procedure "expands" upon the GIP-2 by including additional requirements. These additional requirements are that (1) the host equipment must first be shown to meet the seismic qualification requirements specified in Section 3 of the EBSEQ Procedure, (2) the load path from the new or replacement part must be evaluated to assure that the part will remain attached, will not degrade the structural integrity of the host equipment, and will not interfere with the function and structural integrity of the host equipment, (3) an evaluation of the safety function requirements to determine if the part requires verification of seismic adequacy or if it only requires verification of attachment and load path, and (4) if the part is required to perform a safety function, then its seismic adequacy must be verified by demonstrating that it is represented in the GIP-2 equipment classes or else a part-specific evaluation must be performed using Generic Equipment Ruggedness Spectra (GERS) or part-specific qualification. The additional requirements introduced in the EBSEQ procedure address the majority of the staff's concerns with respect to the use of the "rule of the box" concept. However, the provision in item (4) of these requirements permit the use of a composite spectrum (GERS), established for an equipment class based on testing data, which the staff finds inappropriate since the capacity of the equipment at high excitation levels can vary drastically with only minor variations in the equipment dynamic characteristics. These variations may result from the equipment itself, subassemblies, or devices in the equipment.

Response:

Use of GERS: The basis for the NRC's objection to use of the GERS appears to be the wide variation in the test response spectra. However, these variations in test response spectra simply reflect the differences in the input loadings used in various tests on similar equipment. In most cases, these were proof tests in which no failures or malfunctions were found. Therefore, these variations in input loadings bear little or no relationship to the seismic capacity of the equipment that was tested.

Further, as described in EPRI Report NP-5223, Revision 1, "Generic Seismic Ruggedness of Power Plant Equipment," the GERS are set at levels below any failure data. Since the variations in the test excitation levels are accounted for in the GERS, the use of GERS as applied in the EBSEQ procedure is appropriate. Nevertheless, even though there is a justified technical basis for using GERS in the EBSEQ procedure, SEQUAL agrees to delete all references to use of GERS.

Note, however, that the use of part-specific seismic qualification data, from test or analyses, may continue to be used in the EBSEQ procedure. In order to use this data, the candidate part must be shown to satisfy the licensing basis requirements for qualification of equipment using tests or analyses (e.g., IEEE Std. 344-1975).

It is also important to recognize that the experience gained from seismic qualification of equipment by shake table testing and analysis was an important factor in identifying the vulnerabilities and weaknesses (i.e., caveats) for the earthquake experience equipment classes. The functioning of this equipment during shake table testing also supports the conclusion that the equipment in the earthquake experience equipment class is capable of functioning during the earthquake – i.e., during the period of time when strong ground motion is occurring – because this equipment was shown to continue to operate during the shake table tests in which seismic loadings were imposed that were higher than the Reference Spectrum.

Rule of the Box: The "rule of the box" is simply the conclusion that for the equipment included in the 20 GIP equipment classes, the entire equipment assembly will withstand the earthquake and be operational (subject to a relay chatter analysis) if the overall equipment assembly meets the GIP inclusion rules (class definition) and caveats (restrictions). The "rule of the box" applies to all of the classes. Certain classes, however, contain restrictions on the use of the "rule of the box" in that certain types of subassemblies are excluded from the rule (e.g., programmable controllers in control panels). These exclusions are explained in the GIP for each equipment class.

Qualification of new or replacement parts can be performed using earthquake equipment data by demonstrating that the part or subassembly is represented in the equipment class. The process for performing this evaluation is described in Section 5.3.6 and Appendix A, Section 4, of the Topical Report.

Issue #7: Experience-Based Method

Description in August 13, 2001, Letter: The staff's final concern dealt with the adequacy of the GIP-2 document since it is not written as a seismic qualification document but rather as a guide for successfully addressing USI A-46 implementation. SEQUAL concurred with the staff's concern and, as such, has developed the EBSEQ method, which is presented in Appendix A of the Topical Report.

Response: The NRC indicated that this issue is resolved by the submittal of the Topical Report.

Issue #8: Fatigue-Sensitive Items

NRC's Request: Section 2.2 of the report describes the specific limitations of the EBSEQ method. One limitation is that the procedure is not applicable to low-cycle, fatigue-sensitive items (e.g., items shown to be affected by prior Operating Basis Earthquake cycles), as defined in the EBSEQ. The intent of this limitation is not clear. Equipment designed to meet the requirements of 10 CFR Part 100, Appendix A must be capable of withstanding a specified number of Operating Basis Earthquake (OBE) events (generally five OBEs) and a Safe Shutdown Earthquake event and remain functional.

Explain the evaluation performed to insure that equipment covered by the EBSEQ procedure are capable of withstanding the number of earthquake events specified in the licensing basis criteria for non-A-46 facilities while remaining functional. Provide specific examples for each equipment class that demonstrates that the functionality of the equipment is not sensitive to the number of earthquake events.

Section 4.2.2.7 of the EBSEQ report indicates that the GIP procedure for the fatigue evaluations of cable tray and conduit rod supports are an integral part of the EBSEQ method. The inclusion of GIP procedure for the fatigue evaluation of cable tray and conduit rod supports is not consistent with the limitation stated in Section 2.2 that the EBSEQ procedure is not applicable to fatigue sensitive items.

Response:

The EBSEQ method is intended to provide a procedure for performing seismic equipment qualification using seismic experience data to the extent that seismic experience is applicable. The limitation related to low-cycle, fatigue-sensitive items is intended to apply to equipment that is affected by operating basis earthquake (OBE) cycles. The regulations do not specifically require that equipment necessary for continued operation during an operating basis earthquake be capable of withstanding a certain number of cycles. The regulations specify that the engineering method used to insure that these structures, systems, and components are capable of withstanding the effects of the OBE shall involve the use of a suitable dynamic analysis or a suitable qualification test. To the extent applicable, the EBSEQ methodology meets the requirement for a performance-based method that uses experience data to make this demonstration.

Regarding Section 4.2.2.7, concerning the cable tray and conduit support evaluation procedure, the procedure referred to is an evaluation of rod supports specifically to identify and exclude fatigue sensitive rods, not to include them. The procedure was developed as a result of shake table testing of threaded rod support configurations during the NRC's Systematic Evaluation of Plants program and provides an example of test experience considered in developing the GIP. This procedure is consistent with the EBSEQ methodology limitations concerning fatigue sensitive equipment.

Issue #9: Equipment Functionality During Earthquake

NRC's Request: 10 CFR Part 100, Appendix A requires that structures, systems and components be designed to withstand the vibratory motions associated with the safe shutdown earthquake and operating basis earthquake, including the applicable concurrent accident and operating loads, and remain functional. The GERS spectra presented in the GIP indicate that some equipment may have a lower capacity if it is required to function during an earthquake (e.g., motor control centers). It is logical to conclude that similar functional limitations may exist for non-GERS equipment in the experience database. Although equipment functionality has been discussed in references such as the SSRAP report, no specific criteria have been given for determining whether all of the equipment in the database remained functional during the earthquakes. Discuss the measures taken to assure that all equipment in the experience database functioned during and after the earthquake. Provide specific procedures for each equipment class that were used to verify the functionality of the equipment included in the experience database.

Response:

The GIP presents GERS for 10 of the 20 equipment classes. All of the GERS have capacity levels ranging from 1.5g to 22g. Only one of the ten GERS has a difference for "function during" and "function after." This is the Motor Control Center GERS, which indicates a capacity of 1.5g for "function during" and 2.5g for "function after." The difference is because of the contactors and relays contained in motor control centers. These contactors and relays have a GERS capacity of 4.5g, which when divided by the generic cabinet amplification factor of 3 results in a contactor chatter GERS for the MCC as a whole of 1.5g (for seismic demand specified at the base of the unit.) This capacity level, and those of the GERS for the other classes, is above the 1.2g capacity of the Reference Spectrum.

Thus, the GERS supports the conclusion reached during development of the GIP that the equipment will function during as well as after the earthquake up to the 1.2g capacity level of the Reference Spectrum. The exception to this conclusion is relays and contactors. Equipment with relays and contactors must be evaluated for relay chatter, which could affect function during the earthquake at levels below the 1.2g spectral acceleration of the Reference Spectrum.

During the development of the GIP, the SSRAP and others reviewed each equipment class for characteristics needing to be evaluated to assure that the equipment would function during the earthquake. For this purpose, the classes divide into electrical and mechanical equipment. Electrical equipment has no moving parts other than relays, contactors, gauges, sensors, etc. Other than relay chatter, it was seen that nothing would prevent operation during the earthquake other than gross structural damage of the equipment assembly. It was determined from the earthquake data that, subject to meeting the caveats and anchorage requirements, gross structural damage would not occur. Thus, it was concluded for electrical equipment that meeting the inclusion rules and caveats, plus performing a chatter evaluation for any relays, switches or contactors, assured function during the earthquake.

Mechanical equipment (pumps, valves, fans, chillers, air handlers, compressors, engine generators) contains moving parts, which are subject to binding if parts are distorted during the

earthquake. The mechanical equipment items observed at earthquake sites were seen to be able to operate following the earthquake (any exceptions were root-caused and caveats developed to prohibit the weakness). It was observed that there were no cases of noticeable distortion of the equipment. However, the internal parts could not be directly inspected.

The SSRAP and other individuals developing the GIP provisions reviewed manufacturer information for the equipment. They determined the parts that would be subject to binding and seizure (impellers, shafts, bearings). They reviewed these parts and determined that, up to the 1.2g demand level of the Reference Spectrum, the stresses in these parts would be low and clearances would not be compromised. Also, they were familiar with analyses and tests, performed for much higher levels of seismic demand, which showed the equipment to be capable of functioning during the earthquake. For example, motor operated valves have discs, globes or butterfly plates with tight clearance and long shafts with heavy, unrestrained operators, and they have functioned during tests under seismic demands of 22g (as per the GERS), more than 10 times the 1.2g demand level of the Reference Spectrum.

Thus, for equipment covered by the inclusion rules of the classes in the GIP, and meeting the caveats (i.e., not containing the prohibited physical characteristics potential compromising their ability to function), and whose function would not be compromised by relay, switch or contactor chatter, it was concluded that operation during earthquake was assured up to the seismic demand level of the Reference Spectrum.

Issue #10: Risk Significance of EBSEQ Approach

NRC's Request: Appendix B of the EBSEQ report contains an evaluation of the risk significance of seismic qualification using the EBSEQ approach. The risk evaluation is based, in part, on equipment capacity factors presented in the referenced paper by Salmon and Kennedy (1994), "Meeting Performance Goals by the Use of Experience Data." The 1.4 factor used for the testing qualification is applied [at] an assumed site SSE ZPA of .15g in order to derive a median capacity for components qualified by test. This results in a median capacity of the tested components being lower than the median capacity of components that are not tested (capacity based on EBSEQ method). The staff considers this result illogical. Use of equipment capacity factors found in the literature with arbitrary spectra values does not provide a meaningful estimate of median capacity.

The median equipment capacity for testing qualification should be based on the enveloped floor response spectra that is used to test the equipment and not the arbitrarily assumed site value used in the study. This would result in a much higher median capacity for most of the tested equipment than for the equipment qualified by the EBSEQ method. This fact is illustrated by Figures 2 and 3 in the referenced Salmon and Kennedy paper. Figure 2 provides the GIP spectra which provides the basis for the median capacity derived from the EBSEQ procedure. Figure 3 provides examples of GERS spectra which are collections of actual test response spectra. It is clearly evident from comparison of the two figures that the tested equipment is qualified to much higher spectral accelerations than the EBSEQ spectra. This is a serious flaw in the risk assessment. The risk study should be revised using estimates of median capacities based on the actual test inputs. Provide the results of a revised risk study based on median capacities for tested equipment derived from actual equipment test spectra.

The revised risk study should also consider the cumulative effects of all equipment that may be qualified using the EBSEQ method.

Response:

We believe that a meeting to discuss this whole risk significance evaluation in more detail would be productive to resolve these comments. To address the issue, it is necessary to understand the process and philosophy of deriving and using seismic fragilities (described by a mean fragility curve of probability of failure versus peak ground acceleration).The process used in Appendix B of the Topical Report to assess the risk significance of using the two methods of qualification consisted of generating a generic fragility for a random component qualified by 1) the EBSEQ method, and 2) by testing in conformance with IEEE 344.

With respect to the NRC comments above with regard to the use of "an assumed site SSE ZPA of 0.15g", these fragilities are independent of the site-specific nature of the peak ground acceleration (PGA), and the same fragility would result from any other site as long as the shape of the safe shutdown earthquake is the same. The capacity of this generic component is assumed to be unknown, much like the situation for qualifying a new component. For that situation, the only method to fairly and consistently compare the risk significance of the two methods is to assume that, in each case, the required response levels at the floor location in question results in an acceleration right up to the capacity levels of each of the methods (*i.e.*, the Reference

Spectrum level for EBSEQ and the test response spectra (TRS) for the testing method). Various scenarios could be postulated where either method would show reserve capacities beyond these amounts due to the RRS level being much below either he TRS or the Reference Spectrum, but that would not be a correct comparison of the elements of both methods.

With respect to the median capacity for testing qualification, it is based on the enveloped floor response spectrum that would be allowed at a nuclear plant site using the IEEE 344 method. It is not characterized as a site value in terms of "g" level, but rather a generic value estimated to be a factor above the TRS (Kennedy and Salmon paper).

As to providing the results of a revised risk study based on median capacities for tested equipment derived from actual equipment test spectra, test results such as GERS that provide capacities up to the failure level of components can allow generation of fragilities for that component based on known data and response at the specific floor level in question. While this results in a fragility that could be used in a seismic PRA, it is not a means to compare two methods of qualification. The technique in the Topical Report to assess the merits of each of the methods on a risk-informed basis is the appropriate means of comparing the two methods.

Issue #11: New and Replacement Equipment

NRC's Request: Attachments A and B of Appendix A to the SEQUAL Topical Report provide a checklist for seismic qualification of new and replacement equipment (Attachment A) and parts (Attachment B) using the EBSEQ methodology. Checklist item 5 in Attachment A and item 7 of Attachment B address the design differences between the candidate equipment or part and the equipment in the earthquake experience database. However, the design attributes listed for comparison in the Attachment A and B checklists are generally not documented and not available in the earthquake experience database. As such, the comparison and evaluation of the design attributes for the new and replacement equipment or parts is ambiguous. In the absence of adequate equipment attributes in the earthquake experience database, justify the comparisons called for by the checklists for new and replacement equipment and parts.

Response:

NRC's SSER No. 2 concerning the GIP specifies that use of the GIP methodology for new and replacement equipment consider the possibility of the use of materials and parts, which may be vulnerable to earthquake loading and which were not used in equipment in the earthquake experience database. This might apply, for example, if the equipment manufacturer substituted a brittle plastic part for one that previously was metal. In applying the EBSEQ methodology, new equipment must be examined for such substitutions.

In the initial guidelines developed by SQUG for application of the GIP to new and replacement equipment and parts, this design difference evaluation was called for, and a list of design attributes which might affect the seismic adequacy of equipment was given. Later, the NRC requested that these attributes be added to the checklists for equipment and parts in order to document that each potential design attribute was considered by the seismic engineer.

The goal of the design difference review is to identify if the new equipment is significantly different from older equipment (which would have been in the observed earthquakes) in a manner that would compromise its seismic ruggedness. It is not necessary to observe these characteristics in the earthquake experience data. It is only necessary to determine if the characteristic has recently changed in a seismically adverse manner. This may be determined by contacting the manufacturer or an expert on the equipment within the plant staff. It may also be determined by review of manufacturer catalog or other equipment information, and comparing the information for old and new equipment. It may be possible, for a certain attribute, to determine the characteristic from the earthquake experience database.

SEQUAL proposes to clarify the Topical Report by modifying the design difference evaluation portion of the checklists to indicate that the attribute has been considered for differences in new versus older equipment, not that the attribute has been evaluated and shown not to adversely impact seismic adequacy. That is not part of the design difference evaluation, but, rather, has already been factored into the GIP through inclusion rules and caveats for the various equipment classes. The explanatory text will be changed to make this clearer.

Issue #12: IEEE 323 Test Sequence Requirements

NRC's Request: Section 3.2 of the EBSEQ report discusses compliance plant licensing bases. The discussion indicates that, "[b]y adding the EBSEQ methodology to the SAR, it is not the objective that plant specific commitments, related to existing licensing basis SEQ methods would change since the proposed change is to add an alternative, acceptable SEQ method." The licensing basis for non-A-46 plants may commit to follow Standard Review Plan (SRP) Sections 3.10 and 3.11, and may require compliance with IEEE Std. 344-1975 and IEEE Std. 323-1974 (endorsed with exceptions by Regulatory Guide 1.89). In accordance with SRP Section 3.10.II.1.c (related to seismic qualification of equipment), for plants whose construction permit SER is dated July 1, 1974, or later, the seismic and dynamic testing portion of the overall qualification of Class 1E equipment should be performed in its proper sequence as delineated in Section 6.3.2 of IEEE Std. 323-1974. Describe how the EBSEQ procedure for Class 1E equipment assures that the IEEE-Std. 344-1975 and IEEE Std. 323-1974 criteria, as related to the seismic qualification of Class 1E equipment in the test sequence [i.e., Section 6.3.2 of IEEE Std. 323-1974], are satisfied.

Response:

The test sequence in IEEE 323 is for qualification of equipment in harsh environments. The EBSEQ method may be used for equipment in mild environments. If a licensee applies the EBSEQ method in an IEEE 323 harsh environment qualification program, it will need to evaluate the impact on the IEEE 323 program and the IEEE 323 pre-seismic qualification aging requirements on the seismic qualification as well as the vibration and seismic aging conditions prior to IEEE 323 loss-of-coolant accident testing.

Issue #13: Editorial Changes

NRC's Request: In Section 5 of Appendix A of the Topical Report, References 18, 19, and 20 are missing. In addition, References 10,15, and 16 in Section 4.4.2 are incorrect, Attachment D in Section 3.1.1 should be Attachment C, and Attachment E in Section 3.3.1 should be Attachment D. Provide the appropriate corrections to the Topical Report.

Response:

These items will be corrected in the revised Topical Report.