

**April 25, 2003**

Mr. Alexander Marion, Engineering Director  
Nuclear Energy Institute  
1776 I Street, NW  
Suite 400  
Washington, D.C. 20006-3708

**SUBJECT: PROPOSED APPROACH FOR THE USE OF EXPERIENCE-BASED  
SEISMIC EQUIPMENT QUALIFICATION (EBSEQ) METHODOLOGY**

Dear Mr. Marion:

On December 4, 2002, NRC staff met with representatives from the Nuclear Energy Institute (NEI) and the Seismic Experience-Based Qualification (SEQUAL) Owner's Group as part of our ongoing dialogue on the proposed subject methodology. NRC staff and SEQUAL discussed issues related to the staff's request for additional information (RAI) on the EBSEQ Topical Report, SEQUAL's responses to the staff's RAIs, as documented in SEQUAL's letter of April 22, 2002, and the staff's assessment of SEQUAL's RAI responses. One of the issues raised by the staff in the RAIs was the adequacy of the EBSEQ database and methodology. During the meeting, SEQUAL presented a summary of the seismic experience data for the Fluid-Operated Valves (FOVs) equipment class, 1 of 20 equipment classes, to demonstrate the adequacy of the EBSEQ database and methodology.

Based on the SEQUAL Owner's Group response to the staff's RAIs, the staff continues to have three significant technical concerns with the use of the current SEQUAL methodology. The first involves the continued use of GIP-2 Method A in the EBSEQ methodology to determine the seismic demand for equipment within 40 feet above the plant grade level. The assumption in Method A is that the structural amplification is insignificant for the first 40 feet above grade. This assumption, therefore, does not account for structural amplification of the seismically-induced ground motion. The staff does not endorse this simplification, since Method A underestimates the seismic demand in a structure in comparison to the calculated in-structure response spectra. Furthermore, the staff does not see a need for this simplification, since facilities licensed to 10 CFR Part 100 have analytically determined in-structure response spectra as part of their licensing bases and are able to quantify seismic accelerations at various plant elevations.

The second of the staff's technical concerns involves the lack of documentation for each earthquake experience equipment class. The data for each equipment class is not sufficient to establish the basis for: (1) the minimum number of independent equipment items within a class, (2) class composition in terms of degree of similarity between component functional characteristics, physical and dynamic characteristics, and seismic capacity, (3) class inclusion rules, and (4) prohibited features, which would exclude a component from a class. The EBSEQ database captures only components that sustained structural damage during a seismic event and it does not capture components that successfully withstood the seismic event.

The class exclusion rules are based on the characteristics of components that did not survive the seismic event. Therefore, it is possible that there are other component characteristics, not yet identified, that would result in a vulnerability to a seismic event, which would exclude a component from an equipment class. In addition, lack of visually observable structural damage to equipment examined after an earthquake by a plant walk-down is not a sufficient basis to conclude that the equipment can continue to perform its mechanical and electrical functions.

The third of the staff's technical concerns is that the EBSEQ database does not contain sufficient documentation to address equipment functionality during an earthquake and to demonstrate that database equipment have been successfully subjected to safe shutdown earthquake (SSE) and aftershocks as required by 10 CFR Part 100. It is the staff's position that sufficient documentation must be available for each of the 20 equipment classes defined by SEQUAL to also address these specific requirements of 10 CFR Part 100.

An assessment of SEQUAL's responses to the RAIs is provided in the attachment. The RAIs covered 12 issues that represent specific areas noted by the staff during its review of the EBSEQ Topical Report. These 12 issues can be categorized into three different categories. The first category contains the single item (Issue No. 2) for which SEQUAL has provided sufficient information to resolve the staff's concerns. The second category contains items for which changes to the EBSEQ Topical Report are necessary before staff's approval could be granted. These changes were discussed during the December 4, 2002, meeting with SEQUAL. The items included in this category are issues No. 1, 7, 10, and 12. The third category contains issues No. 3, 4, 5, 6, 8, 9, and 11, which are unacceptable to the staff and which we believe would require substantial effort by SEQUAL to resolve. These issues include the use of Method A, the adequacy, in terms of both completeness and detail, of the earthquake experience database referenced in EBSEQ, and the conformance of the proposed methodology with the functionality requirements in 10 CFR Part 100.

The staff does not believe that the technical concerns described above can be readily resolved. On this basis, we reject the EBSEQ Topical Report. This completes our efforts under TAC No. MB3155. Should NEI or the Owners Group wish to pursue an experience-based seismic qualification methodology in the future, we recommend that you request a management meeting with the NRC to discuss how these issues will be addressed, as well as the schedule and resources for any further review effort.

Sincerely,

**/RA/**

Richard Barrett, Director  
Division of Engineering  
Office of Nuclear Reactor Regulation

Attachment: Assessment of SEQUAL's responses

The class exclusion rules are based on the characteristics of components that did not survive the seismic event. Therefore, it is possible that there are other component characteristics, not yet identified, that would result in a vulnerability to a seismic event, which would exclude a component from an equipment class. In addition, lack of visually observable structural damage to equipment examined after an earthquake by a plant walk-down is not a sufficient basis to conclude that the equipment can continue to perform its mechanical and electrical functions.

The third of the staff's technical concerns is that the EBSEQ database does not contain sufficient documentation to address equipment functionality during an earthquake and to demonstrate that database equipment have been successfully subjected to safe shutdown earthquake (SSE) and aftershocks as required by 10 CFR Part 100. It is the staff's position that sufficient documentation must be available for each of the 20 equipment classes defined by SEQUAL to also address these specific requirements of 10 CFR Part 100.

An assessment of SEQUAL's responses to the RAls is provided in the attachment. The RAls covered 12 issues that represent specific areas noted by the staff during its review of the EBSEQ Topical Report. These 12 issues can be categorized into three different categories. The first category contains the single item (Issue No. 2) for which SEQUAL has provided sufficient information to resolve the staff's concerns. The second category contains items for which changes to the EBSEQ Topical Report are necessary before staff's approval could be granted. These changes were discussed during the December 4, 2002, meeting with SEQUAL. The items included in this category are issues No. 1, 7, 10, and 12. The third category contains issues No. 3, 4, 5, 6, 8, 9, and 11, which are unacceptable to the staff and which we believe would require substantial effort by SEQUAL to resolve. These issues include the use of Method A, the adequacy, in terms of both completeness and detail, of the earthquake experience database referenced in EBSEQ, and the conformance of the proposed methodology with the functionality requirements in 10 CFR Part 100.

The staff does not believe that the technical concerns described above can be readily resolved. On this basis, we reject the EBSEQ Topical Report. This completes our efforts under TAC No. MB3155. Should NEI or the Owners Group wish to pursue an experience-based seismic qualification methodology in the future, we recommend that you request a management meeting with the NRC to discuss how these issues will be addressed, as well as the schedule and resources for any further review effort.

Sincerely,

**/RA/**

Richard Barrett, Director  
Division of Engineering  
Office of Nuclear Reactor Regulation

Attachment: Assessment of SEQUAL's responses

**DISTRIBUTION:**

EMEB RF  
PWe

\*See previous concurrences.

**ADAMS ACCESSION NO.:ML031150713**

OFFICE	EMEB:DE*	EMEB:DE*	EMEB:SC*	EMEB:BC*	RPRP:BC	DE:D
NAME	PYChen*	CMunson*	KManoly*	Elmbro* for/ KAM	CGrimes	RBarrett
DATE	04/22/03	04/22/03	04/22/03	04/22/03	04/25/03	04/25/03

## **Assessment of SEQUAL's Responses To Staff's Request For Additional Information**

### **ISSUE NO. 1: Treatment of concurrent loads**

This issue covers the staff's concern with concurrent functional and accident-induced loads as required by Section VI of Appendix A to 10 CFR 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 10 CFR Part 100. In response to Issue No. 1, SEQUAL agreed to modify the Topical Report to state that the EBSEQ methodology is appropriate, without additional analyses, for qualification of equipment that is not sensitive to accident-induced loads.

As part of Issue No. 1, the staff stated that the licensing basis for non-A-46 plants may require compliance with the American Society of Mechanical Engineers (ASME) Code criteria for the design of tanks and heat exchangers as well as other mechanical equipment such as pumps and valves. The EBSEQ method does not address ASME Code pressure boundary acceptance. Regarding the interface between the EBSEQ method and ASME Code load combinations, SEQUAL stated that 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. However, the EBSEQ procedure does not describe or specify how these load combinations should be addressed to meet the ASME Code. Furthermore, ASME code does not cover the integrity of non-pressure boundary components.

SEQUAL's response is not totally acceptable because it does not fully address non-pressure boundary components (i.e., mechanical component internals and electrical equipment sub-assemblies and devices), and does not adequately address concurrent functional loads (e.g., nozzle loads for pumps and valves) for applicable mechanical components.

### **ISSUE NO. 2: Number of response spectra used to create reference spectrum**

The staff's second concern dealt with the adequacy and accuracy of the GIP-2 reference spectrum, which is still used as part of the EBSEQ method. In its response to the staff's concern, SEQUAL provided new seismic ground motion data to show that the original GIP-2 reference spectrum is still valid. The staff's concern in Issue No. 2 is resolved.

### **ISSUE NO. 3: Use of GIP-2 Method A**

Issue No. 3 concerns the continued use of GIP-2 Method A for the EBSEQ method. The staff's position is that non-A-46 plants must use their design basis in-structure response spectra to define the seismic demand. GIP-2 Method A is based on median-centered in-structure response spectrum approach that is not consistent with the existing licensing basis for the affected facilities. Furthermore, Method A does not adequately consider the in-structure amplification of the free field seismic motion within 40 feet of the ground level. This simplification is also inconsistent with the licensing basis for the affected facilities. Therefore, the staff considers Method A unacceptable.

ATTACHMENT

### **ISSUE NO. 4: Equipment class definitions**

The EBSEQ method continues to use the same 20 equipment classes as defined in GIP-2. The staff's position is that all equipment (including sub-assemblies) within the same reference equipment class should possess similar physical and dynamic characteristics that establish an acceptable set of inclusion rules to ensure seismic ruggedness and equipment function as demonstrated by earthquake experience data. In its RAI, the staff requested SEQUAL to provide the detailed documentation relating to the earthquake experience data for each class of equipment to support its position. In response to Issue No. 4, SEQUAL stated that the EBSEQ approach is not primarily focused on collection of detailed success data. Instead, the primary focus is on collection of failure data to define limitations and restrictions (caveats). It is noted that the identification and prohibition of specific vulnerabilities/weaknesses (caveats) of equipment are good measures of enhancement for seismic qualification of equipment. However, they cannot be used to satisfy the requirements of 10 CFR Part 100, which requires the successful demonstration of equipment function. Therefore, the EBSEQ method does not meet the requirements of 10 CFR Part 100 unless all criteria and procedures including equipment class definitions are supported by appropriate earthquake experience data. Therefore, SEQUAL's response to this issue is unacceptable.

#### **ISSUE NO. 5: Use of reference spectrum for all equipment classes**

This issue dealt with the continued use of GIP-2 Reference Spectrum to represent the seismic capacity of all of the equipment classes included in the EBSEQ method. SEQUAL maintains that the GIP-2 Reference Spectrum accurately represents the seismic capacity of each of the earthquake experience equipment classes. The staff has no concern regarding the use of a single spectrum to represent capacity for all equipment classes, if SEQUAL demonstrates that the single spectrum is enveloped by the earthquake experience spectrum for each equipment class. Since the issue of equipment class definition (Issue No. 4) was not adequately addressed, and the EBSEQ approach for establishing the seismic capacity of the equipment classes is different from that specified in the proposed ASME QME (Qualification of Active Mechanical Equipment Used in Nuclear Power Plants) criteria for mechanical equipment, the staff considers SEQUAL's response to this issue unacceptable.

#### **ISSUE NO. 6: Evaluation of Sub-assemblies**

Issue No. 6 dealt with the staff's concerns about continued use of the "rule of the box" concept provided in GIP-2 and the use of Generic Equipment Ruggedness Spectra (GERS) test experience equipment classes and capacities for seismic qualification of equipment and its sub-assemblies. With regard to the concern involving the use of test experience, SEQUAL discussed its position, in part, in its responses to Issues No. 4 and No. 6. In the proposed changes to EBSEQ Topical Report Section 5.1 to address Issue No. 4, SEQUAL stated that the EBSEQ method does not include GERS test experience equipment classes or capacities. This is acceptable to the staff. SEQUAL also stated that test data from seismic qualification reports (e.g., those based on use of Institute of Electrical and Electronic Engineers IEEE 344-1975) may be used within the EBSEQ method to establish the seismic capacity of the equipment and sub-assemblies. The staff considers SEQUAL's approach with respect to the use of test experience acceptable provided that similarity principles are met to seismically qualify a candidate equipment.

Regarding the issue relating to the use of the "rule of the box," SEQUAL maintains its support for the use of "rule of the box" as presented in GIP-2 and the EBSEQ Topical Report. This response is not acceptable because: (1) the issue of equipment class definitions (Issue No. 4) is not adequately addressed; (2) assumptions inherent in the justification to use the "rule of box"

are too broad and the methodology permits qualification of sub-components without any verification of the load path to host equipment; and (3) the use of “rule of the box” ignores the demonstration of specific function of each sub-component in the host equipment. Based on the above, the staff considers SEQUAL’s response to this issue unacceptable.

**ISSUE NO. 7: Stand alone procedure for documentation of the EBSEQ methodology**

This issue dealt with concerns that SEQUAL’s proposed EBSEQ methodology uses information documented in GIP-2 as part of EBSEQ methodology. SEQUAL has not addressed this issue as the EBSEQ method still relies on information in GIP-2. The EBSEQ procedure should contain a stand-alone documentation of final resolutions of equipment classes, their definitions of inclusion and exclusion rules, the seismic capacity of each equipment class (or bounding spectrum), and any other related issues. Therefore, SEQUAL’s response to this issue does not address the staff’s concern.

**ISSUE NO. 8: Fatigue-sensitive items**

The concern of this issue is the adequacy of equipment covered by the EBSEQ procedure to ensure that the equipment is capable of withstanding the number of earthquake events specified in the licensing basis criteria for non-A46 facilities while remaining functional. In its RAI, the staff requested SEQUAL to provide examples for each equipment class that demonstrates that the functionality of the equipment is not sensitive to the number of earthquake events. In its response, SEQUAL stated that 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. This response did not adequately address the staff’s concern in the RAI. To address this concern, SEQUAL should identify and document all fatigue sensitive equipment or subassemblies from the earthquake experience database, or identify well-documented test experience in the database for each equipment class. It is necessary for SEQUAL to demonstrate that equipment within the database have been successfully subjected to safe shutdown earthquake SSE and aftershocks as required by 10 CFR Part 100. This means that SEQUAL should either (1) demonstrate that the equipment in the database has been subjected to a sufficient number of earthquake cycles to satisfy the licensing basis requirements, or (2) perform analysis or testing to demonstrate that the equipment in the database is not sensitive to the number of earthquake cycles. Therefore SEQUAL’s response to this issue is unacceptable.

**ISSUE NO. 9: Equipment functionality during earthquakes**

The concern of this issue is the adequacy of EBSEQ methodology with regard to the equipment functionality during earthquake to meet 10 CFR Part 100. In its RAI, the staff requested SEQUAL to provide specific procedures for each equipment class that were used to verify the functionality of the equipment included in the experience database. SEQUAL’s response to this issue did not adequately address the staff’s concern in the RAI because SEQUAL continues to use GERS results as presented in GIP-2 to address equipment functionality, as a class, during earthquake activity. As indicated in Issue No. 6, SEQUAL agreed to eliminate the reference to the use of GERS as part of the EBSEQ methodology.

The use of results from equipment experience to address this issue may be acceptable for some mechanical equipment, if they can be grouped into a class (or classes) that has exhibited considerable ruggedness to dynamic excitation through documented testing or analysis.

The NRC staff maintains that equipment performance during and after an earthquake must be established to satisfy the requirements of 10 CFR, Part 100. To demonstrate functionality

during an earthquake using the EBSEQ method, SEQUAL should identify and document those relevant equipment in the earthquake experience database that have actually performed their required function during the earthquake. Lack of structural damage to equipment examined during the walk-down following recorded earthquake events in database sites is not a sufficient demonstration of mechanical and electrical functionality during cited earthquakes. Therefore, SEQUAL's response to this issue is unacceptable.

**ISSUE NO. 10: Risk significance of EBSEQ approach**

To further support the methodology, Section 6 of the Topical Report provides a risk-informed justification for the proposed EBSEQ Method. SEQUAL asserted that the EBSEQ methodology provides seismic safety that is comparable to that provided by the current Standard Review Plan (SRP) criteria. The analysis supporting SEQUAL's assertion is provided in Appendix B of the Topical Report. The staff review of Appendix B found that some of the underlying assumptions for the risk analysis were questionable. As a result, the staff disputes SEQUAL's claim that the EBSEQ methodology provides seismic safety comparable to that provided by the SRP. In its current form, the EBSEQ method is an experience-based approach, and is not intended to be a risk-informed approach or intended in support of risk-informed license amendments. Therefore, the use of risk-based argument is not appropriate for the approval process being requested. The staff suggests that Section 6 be removed from the EBSEQ Topical Report.

**ISSUE NO. 11: New and replacement equipment**

This issue dealt with the adequacy of qualification of New and Replacement Equipment (NARE) and parts using EBSEQ methodology as presented in Appendix A (including Attachments A and B) to the EBSEQ Topical Report. In its response, SEQUAL still relies on information presented in GIP-2. SEQUAL's response to this issue is not acceptable because the concerns about the issue of equipment class definitions, as described in Issue No. 4, was not resolved in SEQUAL's response.

The staff's position is that accurate descriptions of equipment in each equipment class (such as subassemblies and parts, equipment attributes, physical and dynamic characteristics, etc.) in the database, should be available for more meaningful comparisons between NARE and actual equipment identified in the earthquake experience database.

**ISSUE NO. 12: IEEE 323 test sequence requirements**

In the overall qualification of Class 1E equipment, the IEEE-323-1974 Standard requires that the equipment should be pre-aged before it is subjected to seismic vibration. The concern of this issue is that plants licensed to 10 CFR Part 100 may commit to perform environmental and seismic qualification of equipment in the proper sequence as delineated in Section 6.3.2 of IEEE 323-1974. It is not clear how the EBSEQ methodology will meet this commitment for Class 1E equipment. SEQUAL's response to this issue appears reasonable. However, SEQUAL needs to identify equipment most likely to experience a harsh environment, and to specify that the use of the EBSEQ methodology is not appropriate for equipment in a harsh environment.