August 13, 2001

Mr. Alexander Marion
Director, Engineering
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Dear Mr. Marion:

The staff of the Mechanical and Civil Engineering Branch has completed an acceptance review of the Seismic Experience-based Qualification Owners Group (SEQUAL) topical report, which contains the proposed experience-based seismic qualification (EBSEQ) method. The EBSEQ method is proposed by SEQUAL to be used for the qualification of equipment in nuclear power plants that are not included in the scope of Unresolved Safety Issue (USI) A-46. In contrast to the nuclear power plants that fall within the scope of USI A-46, non A-46 plants are required to meet the analysis and testing methods required by Title 10 Code of Federal Regulations Part 100 (Part 100). Initially, SEQUAL proposed the use of the USI A-46 resolution document, Generic Implementation Procedure, Revision 2 (GIP-2), for the qualification of equipment in non A-46 nuclear power plants. The GIP-2 was developed by the Seismic Qualification Utility Group (SQUG) as a methodology to verify, in-situ, the seismic adequacy of mechanical and electrical equipment installations in lieu of rigorously establishing their seismic qualification using the analysis and testing methods required by Part 100.

In response to the proposed use of the GIP-2 for non A-46 plants, the staff expressed several concerns in a letter from Brian W. Sheron (NRC) to Gregory Ferguson (SEQUAL) dated August 24, 2000 (Reference 1). In its attempt to address the NRC's concerns, SEQUAL submitted a topical report, "Basis for Adoption of Experience-Based Seismic Equipment Qualification (EBSEQ) Methodology by Non-A46 Nuclear Power Plants, Revision (0) dated April 17, 2001. The focus of the staff's review of the SEQUAL Topical Report, which presents the EBSEQ method, is on the disposition of these concerns about the adequacy of the GIP-2 as a method for the use of experiential data for seismic equipment qualification. These concerns about the adequacy of the GIP-2 methodology, for non A-46 plants licensed to Part 100, led the staff to conclude in the above letter (Reference 1), that "the proposed use of the GIP-2 criteria and processes for all equipment in post-USI A-46 plants would be a significant relaxation from the original level of seismic ruggedness that is currently required for equipment in these plants, and is unacceptable in its present form as a method for complying with 10 CFR 100."

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.

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

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.

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 dis-similar 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.

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 0.4 g 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.

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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.

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.

An additional concern regarding the use of earthquake experience data was identified subsequent to the staff August 24, 2000, letter. 10 CFR Part 100 requires that structures, systems and components be designed to withstand the vibratory motion of the operating basis earthquake (OBE) and the safe shutdown earthquake (SSE). Plants licensed to Part 100 criteria typically specify multiple OBEs as part of the design criteria to ensure there is sufficient conservatism in number of earthquake cycles specified for the design of SSCs. The GIP-2 does not adequately address the OBE criteria as implemented by plants licensed to 10 CFR Part 100.

In summary, the staff concludes that SEQUAL has adequately responded to two of the seven concerns, stated in the NRC's August 24, 2000 letter to SEQUAL. We welcome the opportunity to meet with SEQUAL to discuss the remaining issues. These are: (1) lack of clarity concerning the issue of concurrent loading, (2) continued use of the GIP-2 RS, (3) continued use of Method A from the GIP-2, (4) insufficient equipment class definitions, (5) use of GERS in the EBSEQ procedure to establish the seismic adequacy of equipment subassemblies in conjunction with the use of the "rule of the box" concept from the GIP-2 and (6) lack of consideration of fatigue loading requirements. As stated in the staff's letter to SEQUAL (Reference 1), the staff recognizes that properly applied and controlled experiential seismic

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data may be a viable method for seismic qualification of equipment. However, the EBSEQ method does not adequately resolve the staff's concerns regarding the use of the GIP-2 methodology for the seismic qualification of equipment in plants licensed to Part 100.

Please contact me (301-415-3288), if you have any questions.

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