SQUG

December 6, 1991

Mr. James Richardson
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Subject: USI A-46, Comparison of Seismic Capacity to Demand for Housner Plants.

Dear Mr. Richardson:

The purpose of this letter is to transmit our responses to a number of comments and questions raised by the NRC Staff during the meeting we had at your offices on December 2, 1991, on the subject of comparing seismic capacity to seismic demand for those Housner plants which are subject to USI A-46. Enclosure 1 lists the NRC Staff comments and SQUG's response to each of them. Enclosures 2 through 6 contain backup documentation to support SQUG's responses.

SQUG's position is that the GIP reflects the previously established NRC Staff position on this topic as defined in the Generic Letter (GL) 87-02 and the Safety Evaluation Report (SER) on the Generic Implementation Procedure (GIP), Revision 0. Furthermore, we expect that the NRC approach of requiring 2% damped Housner spectra to be compared to 5% damped equipment capacity spectra would result in a significant expenditure of utility resources without a commensurate improvement in plant safety. This issue applies to the majority of SQUG member plants.

Based on the information we presented during the December 2, 1991, meeting and the enclosed responses to certain comments and questions raised by the Staff during that meeting, we ask that you endorse the approach for comparing seismic capacity to demand as given in the GIP, Revision 2 (dated 6/28/91).

Sincerely,

Neil P. Smith

Neil P. Smith, Chairman
Seismic Qualification
Utility Group

Enclosures

cc: G. Bagchi, NRR/NRC
P. Y. Chen, NRR/NRC
J. Conran, CRGR/NRC
B. D. Liaw, NRR/NRC
K. Manoly, NRR/NRC
J. Norberg, NRR/NRC
P. Sears, NRR/NRC

Attachment 3

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Enclosure 1

SQUG Response to NRC Staff Comments on
Comparison of Seismic Capacity to Seismic Demand
for Housner Plants Subject to USI A-46

During the meeting held on December 2, 1991, between the NRC Staff an SQUG representatives, a number of comments and questions were raised by the NRC Staff on the issue of comparing the seismic capacity of equipment to the seismic demand in plants with Housner design spectra for resolution of USI A-46. Given below are the NRC Staff's comments along with SQUG's response.

1. Eastern Plants With Higher Seismic Hazards Include Housner Spectrum Plants.

   Staff Comment:

   The NRC and EPRI Eastern Seismicity Program showed that a group of plants in the eastern U.S. had higher seismic hazards than others. This group included Housner spectrum plants.

   SQUG Response:

   We note that this conclusion is based on comparison of ground motion at these plant sites. However, the issue at hand is the adequacy of the design basis floor response spectra for these plants.

2. Comparison of Seismic Capacity to Seismic Demand in GIP, Revision 0.

   Staff Comment:

   The Staff took issue with the statement made by SQUG representatives that Revision 0 of the GIP called for comparison of seismic demand and capacity at 5% damping. The following paragraph from the GIP, Revision 0, page 4-9, was quoted:

   > The SSE or DBE horizontal ground response spectra together with the damping values to which the utility is committed for the plant license are, by definition, considered to be conservative and are the basis for addressing USI A-46.

   The Staff further indicated that it has always been their understanding and intent that the plant's SSE design spectrum and associated damping values be utilized in determining the demand to be used for A-46 evaluations.

SQUG Response:

Most plants which use Housner spectra do not have clearly defined licensing bases for seismic qualification of equipment. Similarly, most of these plants do not have any damping values specified for seismic qualification of equipment. That's why USI A-46 was instituted. For this reason, the GIP, Revision 0 explicitly sets 5% damping as the value to be used for comparison of seismic capacity to demand as shown on page 4-8 of the GIP, Section 4.2.2, Equipment Seismic Demand. A copy of this portion of the GIP is included as Enclosure 2.

The design basis damping discussed in this portion of the GIP refers to the damping which should be used in the building model for generating floor response spectra, not the damping to be used for equipment qualification.

The NRC's SER endorsed the GIP, Revision 0 and considered it to be acceptable for implementation of USI A-46 provided the open issues listed in the SER are resolved. The SER did not raise any concerns with the use of 5% damping.

We also note that the Generic Letter (GL) 87-02 likewise endorses the use of 5% damped design horizontal ground and floor response spectra for comparison to the Bounding Spectrum and 1.5 times the Bounding Spectrum, respectively. A copy of page 9 of the Enclosure to GL 87-02 is included as Enclosure 3.

3. Consistency With Industry Standard IEEE 344-75

NRC Comment:

The Staff took issue with the statement made by SQUG representatives that comparison of 2% seismic demand spectra with 5% capacity spectra is inconsistent with the industry standard IEEE 344-75. They stated that A-46 plants have not qualified equipment to IEEE 344-75 and therefore, this standard does not apply.

SQUG Response:

The IEEE Standard 344-1975 does not specify the appropriate damping for seismic demand and capacity comparisons. However, it clearly indicates that such comparisons should be made at comparable values of damping. A copy of page 20, Section 6.6.3.1 from this standard is included as Enclosure 4.

While the USI A-46 plants may not have as a part of their licensing basis the requirement to use IEEE 344-75 for seismic qualification of equipment, most of these plants regularly make use of this industry standard since vendors who supply seismically qualified equipment typically use this standard for their products. We have contacted a number of the SQUG plants and found that many of them use this standard for such things as:

- TMI-2 Action Plan Equipment
- Regulatory Guide 1.97 Equipment
- Equipment Upgrades
- New Equipment

4. <u>Number of Plants Using Housner Spectra</u>

NRC Comment:

The NRC Staff questioned the basis of SQUG's count of 43 USI A-46 plants which used Housner ground response spectra as their design basis.

SQUG Response:

The basis for saying that 43 USI A-46 plants use Housner spectra as their design basis comes from two NRC documents. Enclosure 5 is a copy of the list of operating plants to be reviewed to USI A-46 requirements. This list is from NUREG-1211, Enclosure I, and contains 70 units. We note that a few of these units are now no longer operating.

Enclosure 6 is a copy of all the operating plants with their seismic design basis. This list is from an NRC memorandum dated August 8, 1984.

These two enclosures were used to identify those A-46 units which used Housner spectra as their design basis. These units are identified by the letter "H" penciled in the left margin of Enclosure 5 and total 53 units. Eight of these units were evaluated in the Systematic Evaluation Program (SEP) and are identified by the letter "S" in the margin of Enclosure 5. It is our understanding that the NRC has accepted the revised seismic design basis of these SEP plants and therefore would not be subject to the 2% requirement. Two of the USI A-46 Housner plants are no longer operating; these are identified by the letter "X" in the margin of Enclosure 5. Therefore the total number of A-46 plants with Housner spectra which would be affected by the requirement that 2% damped Housner spectra should be compared to 5% damped capacity spectra is (53 - 8 - 2) = 43 units.

Enclosure 2

GIP, Revision 0
Section 4.2.2
Equipment Seismic Demand
Page 4-8

- For Comparison With Bounding Spectrum

  For elevations under about 40 feet above the effective grade(2), the SSE horizontal ground response spectra (demand) for the plant being evaluated, determined at 5 percent critical damping, may be compared directly with the bounding spectrum (capacity) shown in Reference 5.

  For elevations over about 40 feet above the effective grade(2), horizontal floor response spectra (demand) at 5 percent critical damping should be compared with 1.5 times the bounding spectrum (capacity) shown in Reference 5. It is preferable to use realistic mean-centered amplified floor response spectra(3) for this comparison, however, lacking that, conservative floor response spectra(3) can be used.

- For Comparison With GERS (Or Other Seismic Qualification Data)

  One and one-half (1.5) times realistic mean-centered estimates of amplified horizontal floor response spectra(3) (demand) at 5 percent critical damping for an SSE at the plant being evaluated should be compared with the GERS (shown in Reference 6) or other seismic qualification data (capacity). Conservative floor response spectra(3) (demand) at 5 percent critical damping may be compared directly with the GERS or other seismic qualification data (capacity).

  A realistic mean-centered estimate of floor response for elevations below about 40 feet above the effective grade(2) may be determined by using the SSE ground response spectra times 1.5. Therefore the factored in-structure demand spectrum to use for comparison with the GERS (capacity) would be 1.5 x 1.5 = 2.25 times the horizontal SSE ground response spectrum.

The "effective grade" is defined as the average elevation of the ground surrounding the building based on the perimeter of the foundation. However, the "effective grade" is lower than the ground if the building

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(2) "Effective grade" is defined later in this section.

(3) "Conservative" and "realistic mean-centered amplified" floor response spectra are defined later in this section.

SQUG

Enclosure 3

Generic Letter 87-02
Verification of Seismic Adequacy of
Mechanical and Electrical Equipment
in Operating Reactors, Unresolved
Safety Issue (USI A-46)

Enclosure
Seismic Adequacy Verification
Page 9

Equipment Class	Bound
Motor-operated valves with large eccentric-operator-lengths-to-pipe-diameter ratios	Type C
Motor-operated valves (exclusive of those with large eccentric-operator-lengths-to-pipe-diameter ratios) Air-operated valves Horizontal pumps and their motors Vertical pumps and their motors	Type A

These spectrum bounds are intended for comparison with the 5% damped design horizontal ground response spectrum at a given nuclear power plant. In other words, if the horizontal ground response spectrum for the nuclear plant site is less than a bounding spectrum at the approximate frequency of vibration of the equipment and at all greater frequencies (also referred to as the frequency range of interest), then the equipment class associated with that spectrum is considered to be included within the scope of this method. Alternately, one may compare 1.5 times these spectra with a given 5% damped horizontal floor spectrum in the nuclear plant.

The comparison of these seismic bounds with the design horizontal ground response spectrum is judged to be acceptable for equipment mounted less than about 40 feet* above grade (the top of the ground surrounding the building) and for moderately stiff structures. For equipment mounted more than about 40 feet above grade, comparisons of 1.5 times these spectra with the horizontal floor spectrum is necessary. In all cases such a comparison with floor spectra is also acceptable. The vertical component will not be any more significant relative to the horizontal components for nuclear plants than it was for the data base plants. Therefore, it was decided that seismic bounds could be defined purely in terms of horizontal motion levels.

The criteria are met so long as the 5% damped horizontal design spectrum lies below the appropriate bounding spectrum at frequencies greater than or equal to the fundamental frequency range of the equipment. This estimate can be made judgmentally by experienced engineers without the need for analysis or testing.

The recommendation that the seismic bounding spectrum can be compared with the horizontal design ground response spectrum for equipment mounted less than about 40 feet above grade is based upon various judgments concerning how structures respond in earthquakes. However, this 40-foot above grade criterion must be applied with some judgment because some structures may respond in a different manner.

(2) Motor Control Centers

Motor control centers contain motor starters (contactors) and disconnect switches. They also provide over-current relays to protect the system from

*In most cases where numerical values are given in this section they should be considered as either "approximate" or "about," and a tolerance about the stated value is implied.

SQUG

Enclosure 4

IEEE Standard 344-1975
IEEE Recommended Practices for
Seismic Qualification of Class IE Equipment for
Nuclear Power Generating Stations

Section 6.6.3.1
Derivation of Test Input Motion
Page 20

the sweep rate and the damping of the equipment. For sweep rates of 2 octaves per minute or less and for typical equipment damping this percentage exceeds 90 percent. Maximum response is obtained separately at every frequency in the test range. Consequently this test produces the most thorough search for all natural frequencies and it is customarily used for this purpose as an exploratory test, with a low level of input such as 0.2 g.

To qualify an equipment using the sine sweep test the input amplitude must be at least equal to the ZPA of the RRS except at low frequencies where the RRS goes and stays below the ZPA for which the value of the RRS must be met. The TRS may not be a composite of the entire frequency sweep. It must be the response spectrum centered around any instantaneous frequency. The TRS must envelop the RRS according to the criteria described in Sections 6.6.2 and 6.6.2.1. (See Sections 6.6.5 and 6.6.6 for guidance on the time duration and axial relationships for the test.)

6.6.3 *Multiple-Frequency Tests.* When the seismic ground motion has not been strongly filtered, the floor motion retains the broadband characteristics. In this case, multifrequency testing is applicable for qualification. It is applicable as a general qualification method as long as the TRS envelops the RRS. Specific input excitation to the shake table includes time history and random and complex wave shapes.

Multiple-frequency testing provides a broadband test motion which is particularly apt for producing a simultaneous response from all modes of multidegree-of-freedom systems. Multiple-frequency testing provides a closer simulation to a typical seismic ground motion without the requirements to introduce a higher degree of conservatism. Fragility data can thus be obtained by testing equipment under a realistic simulation of the environment.

The shake-table input excitation waveforms described in the following sections can be employed to test an RRS. The degree of conservatism varies from one method to the next. Other inputs which are not specifically referenced here can also be employed providing they excite the equipment being tested.

6.6.3.1 *Derivation of Test Input Motion.* For any waveform employed, the shake-table motion must be adjusted so that the TRS envelops the RRS over the frequency range for which the particular test is designed, and, as a minimum, the shake-table acceleration must equal the ZPA of the RRS. This comparison must be made using comparable values of damping. The adjustment of the table motion to produce enveloping should be made considering the following three factors:

(1) The RRS may have motion amplification over a broad or narrow band of frequencies

(2) The input excitation waveform may be one of several multiple-frequency types

(3) The equipment being tested may have one of many possible dynamic characteristics

For assemblies or devices where the dynamic response results from numerous interacting modes, the shake-table input excitation must be adjusted such that the TRS envelops the RRS over a frequency range which includes all natural frequencies of the equipment up to 33 Hz. In all cases, the TRS must be derived using either justifiable analytical techniques or spectrum analysis equipment.

6.6.3.2 *Time History Test.* A test may be performed by applying to the equipment a specified time history which has been synthesized to simulate the probable input to the equipment. It must be demonstrated that the actual test machine motion was equal to or greater than the required motion.

A time history record can be synthesized to match the RRS using simulation techniques or the required time history can be used. The duration of the input excitation must be sufficient to simulate the effects of a seismic event.

6.6.3.3 *Random Motion Test (Response Spectrum).* A test may be performed by applying to the equipment a random excitation, the amplitude of which is controlled in 1/3 octave, or narrower, frequency bandwidth filters with individual output gain controls. The excitation must be controlled to provide a TRS which meets or exceeds the RRS. The peak value of the input excitation shall equal or exceed the ZPA of the RRS.

The duration of the random excitation should be a minimum of 15 seconds to allow a reasonable probability of occurrence of the expected excitation. (See Section 6.6.5.)

6.6.3.4 *Random Motion with Sine Beat Test.* To meet an RRS which includes a moderately high peak random excitation may re-

Enclosure 5

NUREG-1211
Regulatory Analysis for Resolution of
Unresolved Safety Issue A-4€,
Seismic Qualification of
Equipment in Operating Plants

Enclosure I
Operating Plants To Be Reviewed
To USI A-46 Requirement

X = No longer in commercial operation.

Operating Plants To Be Reviewed To USI A-46 Requirement

This plant list was developed by determining from plant Safety Evaluation Reports whether or not a seismic qualification review has been performed using IEEE Standard 344-1975. Plants not documented as meeting the provisions of IEEE Standard 344-1975 are included on the list.

Alabama

*1. Browns Ferry, Unit 1
*2. Browns Ferry, Unit 2
*3. Browns Ferry, Unit 3
4. Joseph M. Farley, Unit 1

Arkansas

*5. Arkansas Nuclear One, Unit 1
*6. Arkansas Nuclear One, Unit 2

California

*7. San Onofre, Unit 1
*8. Rancho Seco, Unit 2

Colorado

9. Fort St. Vrain

Connecticut

*10. Haddam Neck
*11. Millstone, Unit 1
*12. Millstone, Unit 2

Florida

13. Turkey Point, Unit 3
14. Turkey Point, Unit 4
*15. Crystal River, Unit 3
16. St. Lucie, Unit 1

Georgia

*17. Edwin I. Hatch, Unit 1
*18. Edwin I. Hatch, Unit 2

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*Plant of utility which is a member of SQUG.

Illinois

H+S *19. Dresden, Unit 2
H+S *20. Dresden, Unit 3
H *21. Zion, Unit 1
H *22. Zion, Unit 2
- *23. Quad-City, Unit 1
- *24. Quad-City, Unit 2

Iowa

H *25. Duane Arnold, Unit 1

Maine

H *26. Maine Yankee

Maryland

H *27. Calvert Cliffs, Unit 1
H *28. Calvert Cliffs, Unit 2

Massachusetts

S *29. Yankee Rowe
H *30. Pilgrim, Unit 1

Michigan

S *31. Big Rock Point
H+S *32. Palisades
H *33. Donald C. Cook, Unit 1
H *34. Donald C. Cook, Unit 2

Minnesota

H *35. Monticello
H *36. Prairie Island, Unit 1
H *37. Prairie Island, Unit 2

Nebraska

H *38. Fort Calhoun, Unit 1
H *39. Cooper

New Jersey

H+S *40. Oyster Creek, Unit 1
H *41. Salem, Unit 1
H *42. Salem, Unit 2

New York

*43. Indian Point, Unit 2
*44. Indian Point, Unit 3
*45. Nine Mile Point, Unit 1
*46. R. E. Ginna, Unit 1
*47. James A. Fitzpatrick

North Carolina

*48. Brunswick, Unit 1
*49. Brunswick, Unit 2

Ohio

*50. Davis-Besse, Unit 1

Oregon

51. Trojan, Unit 1

Pennsylvania

*52. Peach Bottom, Unit 2
*53. Peach Bottom, Unit 3
54. Beaver Valley, Unit 1
*55. Three Mile Island, Unit 1

South Carolina

*56. H. B. Robinson, Unit 2
*57. Oconee, Unit 1
*58. Oconee, Unit 2
*59. Oconee, Unit 3

Tennessee

*60. Sequoyah, Unit 1
*61. Sequoyah, Unit 2

Vermont

*62. Vermont Yankee

Virginia

*63. Surry, Unit 1
*64. Surry, Unit 2
*65. North Anna, Unit 1
*66. North Anna, Unit 2

Wisconsin

S 67. LaCrosse
\- *68. Point Beach, Unit 1
\- *69. Point Beach, Unit 2
\- *70. Kewanee

Enclosure 6

NRC Memorandum
Dated August 8, 1984
Updated List of Reactor Design Earthquake Input