

April 27, 2001

Mr. John M. Richards, Chairman
Seismic Qualification Utility Group
Duke Power Company
Mail Code EC09H
P.O. Box 1006
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SUBJECT: REVIEW OF THE SEISMIC QUALIFICATION UTILITY GROUP PROCEDURE
FOR GATHERING AND VALIDATING EARTHQUAKE EXPERIENCE DATA,
REVISION 2 (TAC NO. MA9464)

Dear Mr. Richards:

The U.S. Nuclear Regulatory Commission (NRC) has completed its review of a procedure, submitted by Seismic Qualification Utility Group (SQUG), to estimate a ground motion response spectrum at a selected SQUG database facility site. The procedure was submitted to the NRC in response to an inquiry from the NRC staff to SQUG, dated May 12, 1997, that requested additional information regarding the SQUG procedure for evaluating the acceptability of new earthquake experience data. The first version (Revision 1) of the subject procedure was transmitted in a letter from Neil Smith, SQUG, to Ronald W. Hernan, NRC, dated February 17, 2000. Following this submittal, NRC staff and SQUG representatives had a public meeting at which Revision 1 of the procedure was discussed. A letter from John M. Richards, SQUG, to Ronald W. Hernan, dated June 27, 2000, transmitted Revision 2 of the procedure.

The NRC staff concludes that the procedure to estimate a ground motion response spectrum for nuclear power plants that fall within the scope of Unresolved Safety Issue No. A-46, will provide appropriate facility ground motion estimates at a SQUG database site following an earthquake. Since this procedure will be used to make decisions regarding plant safety, the staff determined that the process for developing database ground motion estimates should be controlled under a quality assurance (QA) program that meets the requirements of Appendix B to Title 10 of the *Code of Federal Regulations*, Part 50 (10 CFR 50). In a letter dated March 22, 2001, to Ronald W. Hernan, NRC, John M. Richards, Chairman of SQUG, stated, "In order to facilitate SQUG's future use of the Procedure to gather earthquake experience data and estimate ground motions without additional formal NRC review, future ground motion estimates will be performed, independently reviewed, and documented in accordance with 10 CFR 50 Appendix B QA quality controls." This NRC staff review pertains only to this SQUG procedure to estimate a ground motion response spectrum at a selected facility site. The staff has not reviewed or approved Electric Power Research Institute Report NP-7149, "Summary of the Seismic Adequacy of the Twenty Classes of Equipment Required for Safe Shutdown of Nuclear Plants," that forms the basis for the SQUG earthquake experience database. Therefore, the staff's review is limited to the procedure for estimating the ground motion at facilities that have experienced earthquakes. The Enclosure contains the Staff Evaluation.

Sincerely,

Ronald W. Hernan, Senior Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Enclosure: Staff Evaluation

cc w/ Enclosure: See next page

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The NRC staff concludes that the procedure to estimate a ground motion response spectrum for nuclear power plants that fall within the scope of Unresolved Safety Issue No. A-46, will provide appropriate facility ground motion estimates at a SQUG database site following an earthquake. Since this procedure will be used to make decisions regarding plant safety, the staff determined that the process for developing database ground motion estimates should be controlled under a quality assurance (QA) program that meets the requirements of Appendix B to Title 10 of the *Code of Federal Regulations*, Part 50 (10 CFR 50). In a letter dated March 22, 2001, to Ronald W. Hernan, NRC, John M. Richards, Chairman of SQUG, stated, "In order to facilitate SQUG's future use of the Procedure to gather earthquake experience data and estimate ground motions without additional formal NRC review, future ground motion estimates will be performed, independently reviewed, and documented in accordance with 10 CFR 50 Appendix B QA quality controls." This NRC staff review pertains only to this SQUG procedure to estimate a ground motion response spectrum at a selected facility site. The staff has not reviewed or approved Electric Power Research Institute Report NP-7149, "Summary of the Seismic Adequacy of the Twenty Classes of Equipment Required for Safe Shutdown of Nuclear Plants," that forms the basis for the SQUG earthquake experience database. Therefore, the staff's review is limited to the procedure for estimating the ground motion at facilities that have experienced earthquakes. The Enclosure contains the Staff Evaluation.

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/RA/

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Enclosure: Staff Evaluation

cc w/ Enclosure: See next page

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U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF
SEISMIC QUALIFICATION UTILITIES GROUP PROCEDURE FOR GATHERING AND
VALIDATING EARTHQUAKE EXPERIENCE DATA, REVISION 2

Background

The “Procedure for Gathering and Validating Earthquake Experience Data” (Revision 2), which the U.S. Nuclear Regulatory Commission (NRC) staff received on June 27, 2000 (Reference 1), provides the method used by the Seismic Qualification Utility Group (SQUG) to gather and validate earthquake experience data for addition to the SQUG Earthquake Experience Database. Earthquake experience data has been used by SQUG for the resolution of Unresolved Safety Issue (USI) A-46 to develop the “Generic Implementation Procedure,” Revision 2 (GIP-2) and by the Boiling Water Reactor Owners Group (BWROG) to verify the seismic adequacy of the alternative leakage treatment path components for main steam isolation valve leakage. The earthquake experience data used for the resolution of these two issues has primarily been from earthquakes that occurred from 1971 through 1985. SQUG, through its contractor, EQE International, has continued to collect earthquake experience data (post-1985) and in May 1998 provided the staff, for information purposes only, a copy of an electronic version of the earthquake experience database (Reference 2). The procedure describes the method to be used to collect and evaluate the data for addition to the electronic earthquake experience database. In addition to general descriptions of the earthquake experience database and the method used for the collection and validation of earthquake experience data, the document contains ground motion estimates that used the proposed procedure at 10 facilities. This NRC staff review pertains only to this SQUG procedure to estimate a ground motion response spectrum at a selected facility site. As stated in the staff’s Supplemental Safety Evaluation Report Number 2 regarding GIP-2 (Reference 3), the staff has not reviewed or approved Electric Power Research Institute (EPRI) Report NP-7149, “Summary of the Seismic Adequacy of the Twenty Classes of Equipment Required for Safe Shutdown of Nuclear Plants,” that forms the basis for the SQUG earthquake experience database. Therefore, the staff’s review is limited to the procedure for estimating the ground motion at facilities that have experienced earthquakes.

Evaluation

Although this review pertains to the SQUG procedure for estimating ground motion at a reference facility (Section 4.0 and Appendix A), since the subject document first presents a description of the seismic experience electronic database (Section 3.0) the staff notes the following concerning the electronic database:

- There is a large variation in the amount and quality of data gathered for each of the equipment items at these facilities. Several key parameters such as the equipment dimensions, weight, configuration, and location within the plant are frequently missing from the equipment descriptions in the database.
- The ground motions presented in the version of the electronic database that the staff received in 1998 are only peak ground acceleration estimates. Peak ground acceleration has a poor correlation with actual earthquake damage. A much better estimate of the ground motion is the ground response spectrum, since the ground

response spectrum provides the maximum level of ground motion over a wide range of frequencies.

- The description of the earthquakes contained in the electronic database states, "The database includes a total of 24 earthquakes ranging in Richter magnitude from 5.7 to 8.1." The Richter magnitude scale saturates at approximately 6.5 and was developed for earthquakes in southern California and, therefore, it is inappropriate to use this magnitude scale. Most of the recently developed ground motion attenuation relationships use the moment magnitude scale, which does not saturate with increasing earthquake size.

Although the staff has not formally reviewed the electronic database that we received in May 1998, in general the staff finds, from a cursory examination of a limited number of equipment entries and facility ground motion estimates, that the electronic database is incomplete, both with respect to the equipment descriptions and the earthquake ground motion estimates. The staff recommends that SQUG develop a standard format for presenting the equipment data and ground motion estimates that will ensure a complete entry for (1) each piece of equipment and (2) reference facility ground motion estimate.

The procedure developed by SQUG for collecting equipment information at facilities after an earthquake is described in Section 4.1. The procedure outlines two phases. The first phase involves an immediate reconnaissance after the earthquake to obtain perishable data and to establish contact with the facility operators. The second phase involves a more detailed site visit conducted a few months after the earthquake to obtain more detailed equipment data and to see if any earthquake-related operational issues have occurred. Information on each database facility is to be obtained through (1) interviews with the facility management, (2) facility operating logs, (3) facility management, (4) an immediate facility survey, and (5) walkdown inspection notes. Information on damaged equipment, as well as nondamaged equipment ("success" data), will be collected at the facility. The staff finds that the equipment data gathering procedure outlined in Section 4.1 provides sufficient information on how the equipment and site data would be collected following an earthquake but lacks sufficient detail on the specific type of equipment data that would be collected and entered into the database. A complete equipment entry into the electronic database should contain, but is not limited to, the following attributes: (1) equipment type; (2) estimated in-structure response spectrum experienced by the equipment; (3) equipment weight, features, dimensions, shape, function, capacity rating, mounting configuration, load path, governing industry standards, materials, natural frequencies, movable sub-assemblies, attached items or components; and (4) any damages or anomalies during or after the earthquake excitation.

The procedure developed by SQUG for estimating the ground motion at sites that have experienced earthquakes is described in Section 4.2 and illustrated in Appendix A. These sample ground motion estimates are divided into four categories or "scenarios" based on the proximity of the actual recordings of the earthquake ground motion to the database facility. These vary from Scenario 1, which is for sites where there is a recording of the ground motion made at the site, to Scenario 4, which is for sites where there are no recordings or only a few distant recordings of the ground motion. For Scenarios 1 and 2, the estimation of the ground response spectrum at the facility is determined from the actual ground motion records, although some adjustment of the ground motion is required for differences in local geologic characteristics between the facility and the recording site. For Scenarios 3 and 4, the estimation of the ground response spectrum at the facility requires the use of appropriate ground motion attenuation relationships to (a) either scale the distant ground motion recordings

or (b) directly estimate the ground motion response spectrum in the absence of ground motion recordings. The staff notes that these four different scenarios together with the procedure presented in Section 4.2.2, which describes potential modifications to the recorded response spectra to account for differences in local site conditions, provide sufficient coverage of the range of possible scenarios for estimating the ground motion at a facility site. If these procedures presented in Section 4.2 are implemented by qualified individuals (as described below), then the staff concludes that the resulting facility ground motion response spectra should adequately estimate the actual ground motion.

Section 4.5 of the procedure contains the qualifications for personnel who will collect and interpret equipment data and for the earth-science professionals who will collect and interpret the strong motion data. Personnel who will collect the equipment data are required to have (1) 5 years of experience in the fields of seismic testing, analysis, structural dynamics, and earthquake effects, (2) experience with equipment design and operations, and (3) working knowledge of SQUG GIP and all SQUG reference documents. The earth-science professionals who will collect and interpret the strong ground motion data are required to have (1) 10 years of experience in the field of earthquake seismology, (2) experience in analyzing and interpreting strong-motion recordings, attenuation relationships, and source rupture characteristics, and (3) an understanding of the impact of local soil conditions on strong ground motion amplification. The NRC staff finds that the qualifications for the equipment data collection engineers and earth-science professionals are adequate.

Of the 10 ground motion estimates provided in Appendix A to the procedure, there is one Scenario 1 estimate, five Scenario 2 estimates, three Scenario 3 estimates, and one Scenario 4 estimate. Except for some problems listed below, the information provided with each of the ground motion estimates is both adequate and consistent. Where appropriate, there are references from either the geologic or seismic literature to support the decisions made by the lead earth-scientist. In addition, the decisions made by the lead scientist regarding (1) the appropriate ground motion recordings for estimating the final response spectrum, (2) the omission of Scenario 4 database sites with very unique soil-response characteristics, and (3) the selection and weighting of the various attenuation relationships demonstrate a conservative approach. Based on the overall quality of these 10 example ground motion estimates, the staff concludes that the procedure developed by SQUG, when implemented by qualified individuals, should provide appropriate facility ground motion estimates. However, since this procedure will be used to make decisions regarding plant safety, the process for developing database ground motion estimates should be controlled under a quality assurance program that meets the requirements of Appendix B to Title 10 of the *Code of Federal Regulations*, Part 50 (10 CFR 50). In addition, a quality assurance program should prevent the errors in previous ground motion estimates that were identified by the staff such as:

- The September 22, 1992, submittal from the BWROG (Reference 4) contained ground motion response spectra for six facilities. Staff review of the six facility ground motion estimates found errors with three of the six estimates. For two facility ground motion estimates, EQE International (consultant to both SQUG and BWROG) used an incorrect damping value (2% critically damped instead of 5%) for the response spectra and the vertical and horizontal components of ground motion were switched for another facility estimate. Mislabeling the 2% of critically damped spectra as 5% gave the appearance that the facilities underwent much larger ground motion than they actually experienced.
- In the SQUG procedure under review, each of the ground motion response spectra plots are labeled incorrectly. The frequency axis units are incorrectly labeled as seconds

instead of Hertz. In addition, Figure A-5 is a repeat of Figure A-4. This resulted in the omission of the response spectra of the ground motion recorded at instrument USC #3 from the 1994 Northridge earthquake.

Conclusions

The June 27, 2000, letter from John M. Richards, SQUG, to Ronald Hernan, NRC, that transmitted Revision 2 of the procedure under review, states that SQUG intends to use the procedure to gather and validate earthquake experience data and add these data to the SQUG earthquake experience database without additional formal NRC review. The estimation of strong ground motion at sites that do not have strong-motion recordings is often dependent on a number of assumptions and decisions that may not be clear-cut and that are critical in making the final ground motion estimate. Therefore, it is important that only appropriately qualified personnel perform these ground motion estimates and that this procedure be controlled under a quality assurance (QA) program that meets Appendix B to 10 CFR 50. In a letter, dated March 22, 2001, to Ronald W. Hernan, John M. Richards, Chairman of SQUG, stated, "In order to facilitate SQUG's future use of the Procedure to gather earthquake experience data and estimate ground motions without additional formal NRC review, future ground motion estimates will be performed, independently reviewed, and documented in accordance with 10 CFR 50 Appendix B QA quality controls." The staff concludes that SQUG has demonstrated that the gathering and validating procedure for earthquake experience data, for nuclear power plants that fall within the scope of USI A-46, will provide appropriate facility ground motion estimates at a selected database site following an earthquake. However, as indicated above (and discussed with James Fisicaro, SQUG, on February 22, 2001), the staff review is limited to facility ground motion estimates.

References

- (1) SQUG (J. Richards) Letter to NRC (R. Hernan), dated June 27, 2000, "Procedure for Gathering and Validating Earthquake Experience Data - Revision 2 to Appendix A Containing Ten Examples of Ground Motion Estimate Derivations."
- (2) EPRI (R. Kassawara) Letter to NRC (P. Chen), dated May 19, 1998, "TR-110781, Rev. 0, 'SQUG Electronic Earthquake Experience Database User's Guide,' May 1998, and the Electronic Database WINSQUG V2.0 (set of two CDROMs)."
- (3) NRC (J. Partlow) Letter to SQUG, dated May 22, 1992, "Supplement No. 1 to Generic Letter (GL) 87-02 that Transmits Supplemental Safety Evaluation Report No. 2 (SSER No. 2) On SQUG Generic Implementation Procedure, Revision 2, As Corrected on February 14, 1992 (GIP-2)."
- (4) BWROG (T. Green) Letter to NRC (T. Liu), dated September 22, 1997, "BWR Owners' Group Response to NRC Comments Regarding Seismic Events Referenced in NEDC-31858, Revision 2."

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