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SUBJECT: NEI Comments On Draft Regulatory Guide Dg-1146, "Performance Based Approach To Define The Site-Specific Earthquake Ground Motion"

PROJECT NUMBER: 689

The Nuclear Energy Institute¹ thanks the NRC for the opportunity to review the subject draft Regulatory Guide. A public meeting has been scheduled on December 14, 2006, to discuss these comments. It may be necessary to supplement the comments based on the December 14 public meeting. In general, Draft Regulatory Guide DG-1146 lays out an acceptable approach for determining the site specific performance based SSE response spectrum consistent with current state of technology and with current regulatory implementation. Specifically it permits:

1. The use of a CAV-based lower bound magnitude cutoff when developing the PSHA - on Page 7
2. Determination of the SSE response spectrum as a free-field spectrum at the ground surface or on the first competent material having shear wave velocity greater than 1000 fps for sites which have thin low shear wave velocity soil layers - in Section 5.3, Page 18
3. Transferring the SSE response spectrum from the control location to foundation levels using the appropriate site response functions obtained from the dynamic site response analysis - in Section 5.4, Page 18

¹ The Nuclear Energy Institute (NEI) is the organization responsible for establishing unified industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all entities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, nuclear materials licensees, and other organizations and individuals involved in the nuclear energy industry.

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4. The use of the ASCE/SEI Standard 43-05 Performance-Goal based approach for determining the SSE response spectrum - in Section 5.1, Page 16

The industry's comments are:

1. On the development of site-specific spectra (Section 4.3), the recommendation for enveloping spectra will give invalid spectra and should be modified. The reason is that the low-frequency earthquake will not have much energy content at high frequencies, so the soil will remain more linear at high frequencies and the amplification factors (soil/rock) will be higher than for the high-frequency earthquake. This means that the low-frequency site amplification applied to the UHRS will control the high-frequency envelope. This is not the intended result. Additionally, it is important to anchor any recommended site spectrum to amplitudes at the frequencies calculated by the PSHA. In recent ESP submittals this has been 7 frequencies (100, 25, 10, 5, 2.5, 1, and 0.5 Hz). A better statement would be:

To determine the UHRS at the free ground surface, examine the mean surface spectra calculated for the high-frequency and low-frequency input motions, and determine over what frequency range each controls the surface motion. At high frequencies, this will be the high-frequency motion, and at low-frequencies, the low-frequency motion. Apply the appropriate (high- or low-frequency) amplification factors for each frequency range to the mean UHRS to calculate the UHRS at the free ground surface. This should be done at the frequencies where the rock PSHA was calculated, using the rock UHRS values, and at intermediate frequencies using appropriate spectral shapes for the high- and low-frequency ranges.
2. Acceptance of the use of the incoherency function as presented in the Task S2.1 reports is very important for utilities to file their COLs. The timeline for making plant siting decisions is critically short, and a common and satisfactory understanding must be reached shortly in order to support already established COL schedules.
3. The draft does not clearly state the acceptability of using post-EPRI (2004) attenuation relation variability estimates developed in EPRI Task G.3, (*"Topical Report 1009684, CEUS Ground Motion Project Final Report"*) nor does the draft provide clarity in regards to acceptable approaches for performing dynamic site response analysis to develop site response functions and obtain the uniform hazard response spectra at the surface or appropriate control location of non-hard rock sites. The industry needs generic resolution of these two issues. It is our judgment that the EPRI Task G.3 sigma estimate has strong technical support and is the appropriate current practice. Also, Approaches 2A, 2B, 3, and 4 described in NUREG/CR-6728 and -6769 all are reasonable methods for

performing the dynamic site response evaluations that represent the site material variability estimates and should be permitted for use in regulatory practice.

4. The draft should provide guidance for ground motion modeling for sites located in the WUS, referencing the PEER Next Generation of Attenuation (NGA) models. As the NGA models apply primarily to California, additional guidance is required for modeling ground motion in the plate boundary subduction region of the Pacific Northwest and in the Basin and Range and Rocky Mountain regions. It would be most appropriate to place general guidance in the Regulatory Guide with reference to detailed guidance on modeling ground motion to be provided in the SRP.
5. The draft states that applicants may use accepted seismic source characterizations as the starting basis for developing inputs for a site-specific PSHA. References to such sources and existing databases are at various places throughout the text. But the draft provides inadequate guidance. The Regulatory Guide should clearly state that seismic source characterizations that have been reviewed either generically (i.e., LLNL, EPRI 1986) or as part of an ESP or COL application and accepted by the NRC are accepted as starting basis for developing inputs for a site-specific PSHA.
6. Additional guidance is needed for Soil Structure Interaction (SSI) analyses using the SSE established in accordance with DG-1146. Industry technical committees are developing guidance for inclusion in a future revision of the ASCE Standards. We recognize NRC plan to include guidance in the update of the Standard Review Plan. The timeline for making these analyses is critically short, and a common and satisfactory understanding must be reached shortly in order to support already established COL schedules. NEI would like to have the opportunity to discuss the recommendations to be included in the Standard Review Plan before the Standard Review Plan is finalized. This subject could be included in the ongoing discussions on incorporation of incoherence in the SSI analyses.
7. The appendices to the draft are more prescriptive than is appropriate for a Regulatory Guide. Appendix F is an example. This detail should be reserved for Standard Review plans.

More detailed comments are provided in the enclosure.

Chief, Rules and Directives Branch

December 7, 2006

Page 4

We look forward to the public meeting to discuss this draft Regulatory Guide and discuss how seismic issues are integrated into the new licensing process for power reactors, 10 CFR Part 52. If you have any further questions regarding these comments, please contact Rick Hill (Project Director) at rahill@erineng.com or me at (202) 739-8094; aph@nei.org.

Sincerely,



Adrian P. Heymer

Enclosure

c: Mr. Stephen O'Connor, NRC
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NRC Document Control Desk

SPECIFIC COMMENTS ON DG-1146

SPECIFIC

1. On pages 3, 8, 15, A-2, E-1, and E-3, the draft refers to computing the PSHA for generic *hard* rock conditions, which are defined on page 14, Sec 4, as "... generic hard surficial hard rock conditions [i.e., rocks with a shear wave velocity (V_s) about 2.8 km/sec (9200ft/sec)]" and in Appendix E as "... usually with a shear wave velocity (V_s) about 2.8 km/sec (9200 ft/sec)." This is the case currently for the CEUS but is not the case for the WUS. It is suggested that the phrase "generic hard rock" be modified to be just "generic rock" and that the discussion on page E-1 of 2.8 km/sec be stated in terms of the current status for CEUS ground motions. It is possible in the future that generic rock ground motion models will be developed for the CEUS for some other commonly found rock condition.
2. On page 4, last paragraph, the draft states, "Under the combined license procedure, these kinds of features [e.g. faults] should be mapped and assessed as to their rupture and ground motion generating potential while the excavations' walls and bases are exposed, and the NRC staff should be notified when excavations are open for inspection." This requirement needs to be clarified relative to how the new information will be handled under the COL process and in a manner that maintains stability in the regulatory process.
3. On page 5, last paragraph, second line, a period is missing between "(Refs. 9, 10)" and "A PSHA."
4. On page 5, last paragraph, the last sentence states, "However, if more up to date information is available, it should be incorporated if significant." This position does not define significant or what is expected of the owner/operator if the more up to date information is identified following design and construction.
5. On page 7, topic "Spectral Frequency Range Considered in the Probabilistic Seismic Hazard Analysis," last sentence should be revised as follows with the underlined portion being an addition to the sentence: "...the hazard assessment should be conducted at a sufficient number of frequencies so that the final grouped motion spectrum can be reliably represented at a minimum of 30 frequencies..." This clarification is needed because ground motion equations do not exist for the CEUS at 30 frequencies. Similarly, on page D-1, section D.2 "Procedure To Determine Controlling Earthquakes," Step 1, third bullet, add between "assessment" and "at" the following words, "at a sufficient number of frequencies so that the final ground motion spectrum can be reliably represented." Also, on page E-3, last paragraph, fourth line, the draft states, "...all 25 points..." The basis for 25 is not provided; however, we assume that it is a misstatement of "a minimum of 30 frequencies." If this is the case, then inserting "sufficient number of frequencies so that the final grouped motion spectrum can be reliably represented" is also appropriate.

6. Also on page 7, topic "Deaggregation of Mean Hazard," first sentence lists 1E-06 as a mean annual probability. This probability is not needed if the ASCE/SEI Standard 43-05 Performance-Goal based approach is used.
7. On Page 7, topic "Choice of Epsilon in Probabilistic Seismic Hazard Analysis," the aleatory uncertainty, sigma, results from the second part of Task G1.3 have been omitted. This paragraph should be expanded to document the reduced values of sigma documented in the Pacific Earthquake Engineering Research Center (PEER) Next Generation Attenuation study and reported in the results for Task G1.3.
8. On page 8, topic "Site Response Analysis," second line, the words "may be" should be inserted prior to "used." A frequency-domain procedure (RVT) can be used for site response, which is just as valid as a time-domain procedure.
9. Also, the time-domain procedure is assumed on pages 57-58 (Pages E-2 and E-3) in the discussion of time histories and required sets of randomized parameters. This discussion should be changed to at least say, "If a time-domain procedure is used to calculate site response...."
10. On page 8, paragraph 5, first sentence, the draft states, "Thus, the performance-based approach combines a conservative characterization of ground motion hazard, with equipment/structure performance (fragility characteristics) to establish risk-consistent SSEs, rather than only hazard-consistent ground shaking, as occurs using the hazard reference probability approach in Appendix B to Regulatory Guide 1.165 (Ref.1)." This sentence provides the basis for having regulatory guide DG-1146 replace Regulatory Guide 1.165 as originally intended in the early meetings of the NEI Seismic Issues Task Force. However, existing applications using RG 1.165 should be allowed based on the date of the applications and the date of the final NRC approval of DG-1146.
11. On page 8, footnote 4 needs to be either deleted or corrected. As written, it imposes HCLPF seismic margin requirements that are more stringent than those imposed by SECY-93-087. There is no need for Footnote 4 so we suggest it be deleted. However, if retained, it should be revised to state that the HCLPF margin factor of 1.67 applies to the overall plant damage states leading to Seismic Core Damage (SCD) or LERF. It should not be necessary to demonstrate a HCLPF margin of 1.67 for every SSC in the plant.
12. On page 11, section C.1.3, the title of the section should be changed to read "Features Discovered During Excavation" rather than "Features Discovered During Construction." This is suggested because excavation is the activity of concern.
13. On page 11, fourth paragraph, third sentence, the draft states, "A commitment should be made, in documents (Safety Analysis Reports) supporting the license application, to geologically map all excavations and to notify the NRC staff when excavations are open for inspection." A commitment, as requested for the major excavation is understandable, but "all excavations" is much too broad a term. For example, at what point does grading or ditching become an excavation? This requirement should be consistent with SRP 2.5.1, Section III, which requests a

commitment to “geologically map all excavations for Seismic Category I structures, as a minimum....” This is a clearer statement.

14. On page 14, section C.3.3, “Conduct a Probabilistic Seismic Hazard Analysis,” next to the last sentence, the word “epsilon” is not the appropriate term and should be replaced with “standard deviation of natural log of ground motion.” Note that on page 7, section titled “Choice of Epsilon in Probabilistic Seismic Hazard Analyses” epsilon is used correctly and is consistent with Reference 15 of DG-1146, i.e., (Electric Power Research Institute (EPRI) and U.S. Department of Energy (DOE), “Program on Technology Innovation: Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States,” Report 1013105, February 2006).
15. On page 14, section C.3.4 “Hazard Assessment,” a proposed re-write of this section is follows. It reflects the fact that hazard analyses can only be performed at structural frequencies for which equations have been developed for the probabilistic seismic hazard program; and the fact that fractile levels of 0.16, 0.5, 0.84, as well as mean are the most meaningful and adequately represent the seismic hazard for a site.

Report fractile hazard curves at the following fractile levels (p) for each ground motion parameter: 0.16, 0.50, 0.85, as well as mean. Report the fractile hazard curves in tabular as well as graphical format. Also, determine the mean UHRS for annual exceedance frequencies of 1 E-04, 1 E-05, and 1E-06 at a minimum of 30 structural frequencies approximately equally spaced on a logarithmic frequency axis between 100 and 0.1 Hz.
16. On page 15, section C.4.1 “Site and Laboratory Investigations and Testing,” first sentence, second line, delete “materials, and their spatial distribution” and replace with “strata.”
17. On page 16, section C.4.3, “Site Amplification Function,” second sentence states “To determine the UHRS..., multiply the rock based UHRS by the high-frequency and low-frequency site amplification functions separately, and envelop the two results.” This appears to be a recommendation for method 2A. Please note that the industry comment in the cover letter provides a recommended rewording of this sentence.
18. On page 16, section C.5.1 “Horizontal Spectrum,” paragraph 3, sentence 1, the draft states, “The performance-based site-specific earthquake ground motion is developed using a method analogous the development of the design response spectrum (DRS)...” Add the word, “to,” after the word, “analogous.”
19. On page 16, section C.5.1 “Horizontal Spectrum” in the explanation of equation 1, there is a reference to Regulatory Position 4.4. It is assumed that this reference should be to Regulatory Position 4.3 since there is no Regulatory Position 4.4.
20. On page 18, section C.5.4, “Determination of Safe Shutdown Earthquake,” first paragraph, “free field motion” at the foundation level should be an “outcrop motion.”

21. Page 18, in order to maintain the nature of the Uniform Hazard and Design Response Spectra for design application, it is suggested that the requirement of 0.10g motion at the foundation level to be separated from development of the design motion. This requirement can be stipulated as a separate seismic analysis to check the design. This would ensure the adequacy of the design and avoid development of multiple SSEs for a plant that may have structures with multiple embedments.
22. On page 22, section C.4, "conclusion," first paragraph, sentence 3, the draft states, "Furthermore, the staff sees no adverse effects with retaining Regulatory Guide 1.165, an acceptable alternative to the new regulatory guide for satisfying the requirements of 10 CFR 100.23." We concur with this statement as represented by our specific comment 10.
23. On page C-6, section C.2.4, "Surface-Fault Rupture and Associated Deformation at the Site," third paragraph last sentence states, "These structures, such as those found in karst terrain, and growth faulting, which occurs in the Gulf Coastal Plain or in other deep soil regions, cause extensive subsurface fluid withdrawal." This appears to be garbled. It does not appear to flow logically from the preceding sentences. It is assumed that the idea is to provide some examples of non-tectonic faulting and to indicate the origin and/or related surface deformation. The link between extensive subsurface fluid withdrawal and surface displacements should be clarified.
24. On page C-8, second paragraph, first sentence, second line, add a space between the word "with" and the word "previous," and add a space between the word "the" and "following."
25. On page D-3, Table D.1, the entries to the cells of the table need to be provided.
26. On page E-1, section E.1 item (2), the words, "If a time-domain procedure is used to calculate site responses," should precede "Performing a suite of site..." This is consistent with our comment 8.
27. On page E-2, section E.3, "Site Response Analysis," fourth paragraph, fifth line, the word "within" should be replaced with the word "outcrop."
28. On page E-3, first paragraph, second sentence states, "When site-specific laboratory data is used, the result should be compared to earthquake recordings on similar soils." It is not clear why this restriction is added on the use of site-specific laboratory data. This restriction could have an important impact on the scope and cost of geotechnical investigations for the next generation nuclear power plants. Clarification is requested.
29. On page E-5, Figure E.2, the ordinate label should be "Response Spectral Ratio" instead of "Response Spectral Rati."
30. On page E-6, section E.4, "Free-Field Ground Surface Uniform Hazard Response Spectra," our comment 19 applies to this paragraph.
31. We recommend that Appendix F be modified to state that if a suite of time histories are being developed for use in site response analysis, that the criteria for spectral matching should be applied to the average response spectra for the suite of time histories.