Screening Analysis for GI-199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants"

DESCRIPTION AND BACKGROUND

In support of Early Site Permits (ESPs) for new reactors, the NRC staff reviewed updates to seismic source and ground motion models provided by applicants. The seismic update information included new models to estimate earthquake ground motion and updated models for earthquake sources in seismic regions such as eastern Tennessee, and around both Charleston, South Carolina, and New Madrid, Missouri. This new data and models resulted in increased estimates of the seismic hazards for plants in the Central and Eastern United States (CEUS), but these estimates remain small in an absolute sense. The staff reviewed and evaluated this new information along with recent U.S. Geological Survey (USGS) seismic hazard estimates for the CEUS, used for building code applications (as opposed to nuclear power plant licensing). From this review, the staff identified that the estimated seismic hazard levels at some current CEUS operating sites might be higher than seismic hazard values used in design and previous evaluations.

The staff of the NRC's Office of Nuclear Reactor Regulation (NRR) compared the new seismic hazard data with the earlier evaluations conducted as part of the Individual Plant Examination of External Events (IPEEE) Program. From this comparison, the staff determined that seismic designs of operating plants in the CEUS still provide adequate safety margins while the staff continues to evaluate new seismic hazard data and models and their potential impact on plant risk estimates. At the same time, the staff also recognized that this new seismic data and models could reduce available safety margins due to increased estimates of the probability associated with seismic hazards at some of the currently operating sites in the CEUS. The licensing basis for these plants does not include a probabilistic assessment of seismic hazards or a probabilistic assessment of their potential impact on plant structures, systems, and components. Rather, the licensing basis for these plants is based on deterministic analysis for design basis loads from the maximum earthquake level that is determined from historical data. However, to help assess potential reduction in available safety margins using a probabilistic approach, the staff of NRR issued a memorandum, dated May 26, 2005, recommending that the new data and models on CEUS seismic hazards be examined under the Generic Issue Program (GIP). This memorandum is available in the NRC's Agencywide Documents Access and Management System (ADAMS), under Accession No. ML051450456.

SAFETY SIGNIFICANCE

The staff's limited evaluation of current seismic data and models results in increased estimates of the probability of seismic events occurring at some currently operating plants in the CEUS. Therefore, this issue has the potential to result in increased seismic core damage frequency estimates for some plants. However, this screening analysis provides a limited evaluation that does not assess the safety response of the plants. The next phase of the analysis under the GIP will assess the risk impact at plants where the increased seismic hazard exceeds previous levels to an extent that might challenge available seismic margins.

POSSIBLE SOLUTION

This issue could result in new or revised NRC regulation, policy, or guidance if further analysis determines that plant structures, systems, and components important to safety meet current plant licensing requirements and yet have insufficient seismic margins to ensure that potential consequences from seismic events are within established regulatory limits. The issue could also result in reviews, analyses, and compensatory or mitigation actions by some plant licensees to ensure and maintain adequate seismic margins.

SCREENING EVALUATION

The NRC's Office of Nuclear Regulatory Research (RES) reviewed the information in NRR's memorandum, and identified the issue as GI-199, as described in the RES response, dated June 9, 2005 (ADAMS Accession No. ML051600272). Given NRR's determination that seismic designs of operating plants in the CEUS still provide an adequate level of protection, RES determined that this issue was lower priority than some of the other issues already being evaluated under the Generic Issues Program (GIP). Then, on November 7, 2005, RES assigned a contractor to perform the initial screening analysis of GI-199 in accordance with the guidelines outlined in Management Directive (MD) 6.4, "Generic Issues Program." In February, 2006, the contractor notified RES of problems obtaining Electric Power and Research Institute (EPRI) Report NP-6395-D, "Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern Untied States: Resolution of the Charleston Issue," dated April 1989, which the contractor needed to perform its task. From March 2006 through February 2007, RES coordinated with the Office of Administration, Division of Contracts; Office of General Counsel; and EPRI to provide EPRI Report NP-6395-D to the contractor. However, the NRC's attempts to provide this copyrighted document to the contractor were unsuccessful.

In the January to March 2007 time frame, two developments led to RES's decision in March 2007 to perform the screening analysis for GI-199 using NRC staff. One development was issuance of SECY- 07-0022, "Status Report on Proposed Improvements to the Generic Issues Program," dated January 30, 2007 (ADAMS Accession No. ML063460239). This paper outlines the seven screening criteria for use to determine whether GIs should proceed to the more detailed safety/risk assessment stage under the GIP. The other development was RES hiring additional seismologists with prior experience involving the assessment of seismic hazards on critical facilities. From April 2007 through September 2007, the NRC staff performed the screening analysis of GI-199 using guidance provided in Management Directive MD 6.4 and SECY-07-0022.

In October 2007, the staff determined that the screening analysis should consider seismic hazard data and models besides those available from the USGS. This determination was based on the staff's ongoing interactions with stakeholders to develop a new performance based approach for assessing seismic hazards for new reactors as described in a memorandum to the Commission, "A Performance-Based Approach to Define the Safe Shutdown Earthquake Ground Motion," dated July 26, 2006 (ADAMS Accession No. ML052360044). The staff's ongoing work on this performance-based approach resulted in issuance of NRC Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," dated March 2007 that endorses the performance-based approach. The staff is currently assessing the various seismic data and models available to complete the preliminary analysis and will identify an approach that is suitable to support the more detailed safety/risk analysis, should GI-199 proceed to that GIP stage.

The discussion under each criterion below provides the screening analysis for GI-199.

1. The issue affects public health and safety, the common defense and security, or the environment.

The estimated risk to public health and safety and the environment associated with the occurrence of seismic events at some NPP sites might have increased from previous estimates. The issue stems from ongoing research being conducted by a number of scientists into the seismic history of the CEUS and the details of wave propagation and attenuation in this region. In particular, information submitted to the NRC by ESP applicants contained updated seismic information that included new models to estimate earthquake ground motion and updated models for earthquake sources in seismic regions such as eastern Tennessee, and around both Charleston, South Carolina, and New Madrid, Missouri. In addition, information summarized by the USGS as part of the National Seismic Hazard Mapping Program indicates that the estimated likelihood of seismic activity (i.e., seismic hazard) in some CEUS locations has increased from previous estimates. Some of these locations are near existing NPP sites. An increase in the seismic hazard at these sites has the potential to adversely impact public health and safety if the estimated increased seismic hazard were to significantly exceed plant design capabilities; substantially reduce perceived safety margins for plant structures, systems, and components important to safety; or appreciably increase the risk associated with the plant's response to a seismic event. From a qualitative perspective, if the increased hazard is significant at sites that have relatively small safety margins for seismic events, then the estimated risk for these sites could increase.

2. The issue applies to two or more facilities and/or licensees/certificate holders or holders of other regulatory approvals.

The updated information described above results in increased estimates of the seismic hazard that could occur at multiple, although not all, NPP sites in the CEUS. Specifically, updated models for earthquake sources in seismic regions such as eastern Tennessee, and around both Charleston, South Carolina, and New Madrid, Missouri indicate the rate of earthquake occurrence in these regions is greater than previously recognized. Since this change applies to several large regions, it has the potential to affect more than one NPP site. Further, new models used to estimate earthquake ground motion have been revised relative to those used in the 1980's. This change also has the potential to affect more than one NPP site. Updated estimates of seismic hazard values at some of the sites could potentially exceed the design basis as well as the review level earthquake spectrum used as part of the IPEEE Program.

3. The issue cannot be readily addressed through other regulatory programs and processes; existing regulations, policies, or guidance; or voluntary industry initiatives.

In a memorandum to RES, dated May 26, 2005, NRR identified this issue and recommended that it be examined under the GIP. In this memorandum the staff concluded that seismic designs of operating plants in the CEUS still provide adequate safety margins while the staff continues to evaluate new seismic hazard data and models and their potential impact on plant risk estimates. At the same time, the staff also recognized that this new seismic data and models could reduce available safety margins due to increased estimates of the probability associated with seismic hazards at some of the currently operating sites in the CEUS. Therefore, to help assess potential reduction in available safety margins using a probabilistic approach, the staff of NRR recommended in memorandum to RES dated May 26, 2005

(ADAMS Accession No. ML051450456), that the new data and models on CEUS seismic hazards be examined under the GIP. Accordingly, at the time of the memorandum, the NRR staff determined that this issue was not sufficiently characterized to address it under existing licensing processes for licensees of plants that might be impacted. In a memorandum dated June 9, 2005, RES informed NRR that the issue would be accepted into the GIP for screening in accordance with MD 6.4.

Based on the limited evaluation of available information, this issue does not appear to be adequately characterized for complete treatment under existing regulatory programs and processes. Examples of regulatory programs and processes that might apply after obtaining additional information and performing further evaluations are listed below. Additional analysis will help determine whether this issue is amenable to these or other regulatory programs or industry initiatives.

- LIC-100, “Control of Licensing Bases for Operating Reactors”
- LIC-105, “Managing Regulatory Commitments Made By Licensees to the NRC”
- LIC-202, “Procedures for Managing Plant-Specific Backfits and 50.54(f) Information Requests”
- LIC-300, “Rulemaking Procedures”
- LIC-400, “Procedures for Controlling the Development of New and Revised Generic Requirements for Power Reactor Licensees”
- LIC-401, “NRR Reactor Operating Experience Program”
- LIC-501, “Program Coordination for Risk-Informed Activities”
- LIC-503, “Generic Communications Affecting Nuclear Reactor Licensees”
- LIC-504, “Integrated Risk-Informed Decision-Making Process for Emergent Issues”

4. The issue can be resolved by new or revised regulation, policy, or guidance.

Further analysis of the risk or safety impact would provide sufficient additional information to properly characterize the issue and its potential impact on CEUS plants and support consideration under other existing regulatory programs or industry initiatives. The regulatory office has authority to take appropriate regulatory action(s) as necessary to protect the public health and safety and the environment. Depending on the outcome of the additional analysis, as well as industry initiatives to address any safety issues, the regulatory office could address this issue through one or more actions involving regulation, policy, or guidance.

5. The issue’s risk or safety significance can be adequately determined (i.e., it does not involve phenomena or other uncertainties that would require long-term studies and/or experimental research to establish the risk or safety significance).

The assessment performed thus far is based on the staff's review of updated seismic data and models submitted by ESP applicants and also updated seismic hazard data and models available from the USGS as part of the National Seismic Hazard Mapping Program. The seismic hazard at CEUS plant sites of interest can be evaluated using an approach like the detailed assessment performed by EPRI (EPRI, 2005,a,b) for 28 of the 29 sites included in Regulatory Guide 1.165 (USNRC, 1997). This study used updated attenuation models and incorporated updates to the EPRI seismic source model developed during the preparation of the Early Site Permits. The risk significance of the updated seismic hazard information can be evaluated for CEUS plant sites of interest by performing a comparison of uniform hazard spectra or other hazard results to the beyond-design-basis review level earthquake or hazard curve used as part of the IPEEE evaluation (USNRC, 2002). The available IPEEE Program results will allow a general assessment of the potential safety impact of increases in seismic hazard at specific sites. This analysis could be performed as part of the safety/risk assessment under the GIP and could also include participation by industry stakeholders, if appropriate.

6. The issue is well defined, discrete, and technical.

The seismic hazard will be adequately defined upon detailed assessment of available updated seismic data and models submitted by ESP applicants and also updated seismic hazard data and models available for other CEUS plant sites of interest using an approach like that performed by EPRI (EPRI, 2005,a,b) for 28 of the 29 sites included in Regulatory Guide 1.165 (USNRC, 1997). This will allow the seismic hazard estimates for CEUS plant sites of interest to reflect the state of current knowledge. As new information and research becomes available, future updates might be warranted. The plants' response to seismic hazards involves technical analyses using established techniques.

7. Resolution of the issue may potentially involve review, analysis, or action by the affected licensees, certificate holders, or holders of other regulatory approvals.

After further characterization of site-specific seismic hazards and an analysis of the plant's response to the increased seismic hazard, some plants may be identified as having a vulnerability that must be addressed to maintain adequate safety margins. Determining a plant's margin and potential need for action to maintain an adequate margin could involve regulatory actions (e.g., requests for information from plant licensees, reviews, additional analysis, mitigation actions, physical enhancements, administrative controls) for some plant licensees or could involve actions by industry stakeholders.

CONCLUSION

The screening analysis shows that the current knowledge of this issue and its potential impact on CEUS plants passes the seven GI screening criteria and, therefore, warrants further analysis under the GIP. The staff recommends that this GI proceed to the safety/risk assessment stage of the GIP in accordance with MD 6.4 and SECY-07-0022.

This screening analysis shows that the estimated increase in spectral acceleration for some existing CEUS plant sites might exceed the design basis and values used for the NRC's review of Individual Plant Examination of External Events (IPEEE) submittals. This translates to an equivalent increase in seismic demand on plant structures, systems, and components. As a result, this issue has the potential to result in increased seismic core damage frequency estimates for some plants. However, this screening analysis provides a limited evaluation that

does not assess the safety response of the plants. The next phase of the analysis under the GIP will assess the risk impact at plants where the estimated increase in seismic hazard exceeds previous levels to an extent that might challenge available seismic margins.

The results from this limited scope screening analysis is that seismic designs of operating plants in the CEUS still provide adequate safety margins while the staff continues to evaluate new seismic hazard data and models and their potential impact on plant risk estimates. Specific reasons for this conclusion include:

- The estimated annual probability of exceedence of seismic hazard is small in an absolute sense.
- Earthquakes cause ground motion over a range of frequencies. Lower frequency motions are more damaging to buildings and equipment than higher frequency motions. Based on the NRC staff's reviews associated with ESPs, the staff is confident that the recent seismic data and models will show that increased estimates of the seismic hazards will occur primarily in the higher ground motion frequencies. Accordingly, the staff anticipates that these increased estimates of seismic hazards would primarily have little impact on previous estimates of the potential damage to buildings and equipment.
- The plants are designed to withstand anticipated earthquakes with substantial design margins. Plants may have seismic margins beyond those reflected in their IPEEE submittals and these could compensate for the increase in estimated seismic load. Such additional seismic margins at plants may be inherent in the design and construction, realized from improved data and analysis methods, or result from plant modifications or enhancements completed since the IPEEE submittals.

REFERENCES

1. Memorandum to F. Eltawila from M. Mayfield, "Identification of a Generic Safety Issue," Dated May 26, 2005 (ADAMS Accession No. ML051450456).

2. Memorandum to M. Mayfield from F. Eltawila, "Generic Issue 199, 'Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States,' Dated June 9, 2005 (ADAMS Accession No. ML051600272).

3. "Preliminary Documentation for the 2007 Update of the United States National Seismic Hazard Maps, By The National Seismic Hazard Mapping Project," Open-file Report 2007—XXXX (viewable from http://earthquake.usgs.gov/research/hazmaps/products_data/2007/).

4. NRC Generic Letter 88-20, Supplement 5, "Individual Plant Examination of External Events for Severe Accident Vulnerabilities," Dated September 8, 1995.

5. EPRI NP-6395-D, "Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Issue," Electric Power Research Institute, April 1989.

6. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Current Revision March 2007.

7. EPRI, 2005a. Program on Technology Innovation: Assessment of a Performance-Based Approach for Determining Seismic Ground Motions for New Plant Sites, V1 (Performance-

Based Seismic Design Spectra), Report No. 1012044, Electric Power Research Institute, Palo Alto, CA.

8. EPRI, 2005b. Program on Technology Innovation: Assessment of a Performance-Based Approach for Determining Seismic Ground Motions for New Plant Sites, V2 (Seismic Hazard Results at 28 Sites), Report No. 1012045, Electric Power Research Institute, Palo Alto, CA.

9. USNRC,1997. Identification and Characterization of Seismic Sources and determination of Safe Shutdown Earthquake Ground Motion, U.S. Nuclear Regulatory Commission, Regulatory Guide 1.165, Washington, D.C.

10. USNRC, 2002. Perspectives Gained from the Individual Plant Examination of External Events, U.S. Nuclear Regulatory Commission, NUREG-1742 (2 vols.), Washington, D.C.