Technical Advisory Committee of the Nuclear Risk Research Center
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SUBJECT: SEISMIC HAZARD AND FRAGILITY EVALUATIONS AT IKATA UNIT 3

Dear Dr. Apostolakis:

During the second meeting of the Technical Advisory Committee of the Nuclear Risk Research Center (NRRC), January 19-23, 2015, we met with representatives of Shikoku Electric Power Company, Ltd. (SEPCO) and the NRRC staff to review seismic hazard and fragility evaluations for the Ikata Unit 3 probabilistic risk assessment (PRA). The SEPCO staff members presented an overview of the Japanese standard related to seismic PRA (Ref. 1) and its implementation at the Ikata site. The NRRC staff members discussed improvements to hazard and fragility evaluations that have been either implemented or are under consideration. Based on our review of the information presented and discussions with the SEPCO and NRRC staff members, this report provides the following recommendations.

RECOMMENDATIONS

1. Consistent with the recent international practice, SEPCO should implement probabilistic seismic hazard analysis (PSHA) using the Senior Seismic Hazard Analysis Committee (SSHAC) procedures (Refs. 2 and 3). In particular, the SSHAC Level 3 or higher procedure should be used for the Ikata Unit 3 site.

2. Because of the complexity, multi-disciplinary nature, and judgments involved in performing a seismic PRA, current practice is to have a formal peer review that can be either a participatory peer review that occurs during the development of a seismic PRA, or a review at the completion of a seismic PRA. A formal peer review consistent with the current international practice should be performed for the Ikata Unit 3 seismic PRA.

3. With respect to fragility improvements, parameters used in fragility models should be re-examined based on available earthquake experience data to the extent possible. The consideration of fragility correlations (dependence) is an important

consideration for the Japanese seismic environment and should be maintained. The proposed simple method (Ref. 5) to identify structures and components that contribute to core damage frequency and containment failure frequency should be further examined for consistency with the established practices before its implementation for the Ikata Unit 3 seismic PRA.

BACKGROUND

The representatives of SEPCO and NRRC made the following presentations related to seismic hazard and fragility evaluations for the Ikata Unit 3 seismic PRA (Refs. 4 and 5):

1. Overview of Implementation of Standards Related to Seismic PRA - (SEPCO) (Note: this presentation concentrated on specific requirements related to seismic hazard evaluation)
2. Status of Seismic Hazard Evaluation at Ikata Unit 3 - (SEPCO)
3. Improvement of Seismic Hazard Evaluation at Ikata Unit 3 - (NRRC)
4. Overview of Implementation of Standards Related to Seismic PRA - (SEPCO) (Note: this presentation concentrated on specific requirements related to fragility evaluations)
5. Status of Fragility Evaluation at Ikata Unit 3 - (SEPCO)
6. Improvement of Fragility Evaluation at Ikata Unit 3 - (NRRC)

The presentations on the seismic PRA standard (Presentations 1 and 4 above) concentrated on standard AESJ-SC-P006:2007 (Ref. 1) which defines the requirements for performing a seismic PRA in Japan. This standard has been revised and a new standard is expected to be published in the spring of 2015. SEPCO, in Presentation 2, discussed the process used for developing the probabilistic seismic hazard for the Ikata Unit 3 site that included information on development of seismic sources, additional geophysical investigations that have been conducted, development of ground motion models, and use of the logic tree approach. The resulting probabilistic hazard curves and uniform hazard spectra were also presented. It appears that the primary purpose of this analysis was for determining the exceedance probability of the design basis ground motion, Ss, that is defined using a deterministic procedure for regulatory review purposes. The planned improvements in the hazard area (Presentation 3) relate to consideration of additional ground motion propagation models and enhancing the logic tree approach that is more consistent with the Japanese standard.

Similarly, in Presentation 5, SEPCO presented the process of fragility evaluation for Ikata Unit 3. Processes used for walkdowns, screening of components, and fragility evaluation methods were presented with results for some components. Among other things, the planned improvements (Presentation 6) include treatment of fragility correlations (dependence), evaluations of various fragility methods and their uses, a simplified method to identify structures and components that contribute to the core damage frequency and containment failure frequency, and a process for fragility evaluation of severe accident measures, such as portable power supply equipment.

DISCUSSION

We requested these briefings to understand the technical processes being used for the hazard and fragility evaluations and how these processes relate to international state-of-practice. Our goal is to provide recommendations to bring the technical processes more in line with the international practices, if necessary.

An objective of any probabilistic seismic hazard analysis is to account for large inherent uncertainties as well as uncertainties related to limited data, differing interpretations, and alternate models. The explicit consideration of uncertainties and differing interpretations is critical in a PSHA to avoid controversies and enhance credibility. Most importantly, the results of a PSHA study, as stated in the SSHAC report (Ref. 2), should *"represent the center, the body, and the range that the larger informed technical community would have if they were to conduct the study."* For a critical facility like a nuclear power plant, the SSHAC Level 3 or Level 4 process, conducted in a well-structured transparent manner, with the participation of several experts under the continuous review of a panel of experienced experts, provides high assurance that uncertainties have been effectively captured. In turn, such a strong hazard study provides a robust technical basis for the PSHA that can be used in a risk study. The use of a SSHAC Level 3 process or higher is referenced in international state-of-practice, and it has been carried out for several sites. The implementation of a full SSHAC Level 3 process for the Ikata Unit 3 seismic PRA will provide high credibility and results that reflect the current scientific knowledge more accurately. It will also serve as a demonstration of the SSHAC application for other nuclear power plant sites. Therefore, we recommend that use of the SSHAC Level 3 process be considered in the Ikata Unit 3 seismic PRA.

In recognition of the complexities, high degree of uncertainty in many input parameters, multi-disciplinary nature, and judgments involved in performing a seismic PRA, formal peer reviews are explicitly incorporated in current international practice. This process greatly enhances the overall credibility of results and provides a more robust technical basis. This is the basis for our recommendation on peer review. Considering the complexity of the tectonic environment and the level of seismicity in Japan along with the public interest in understanding seismic risk, a formal peer review will provide greater transparency and confidence.

In general, the process used for fragility evaluations for Ikata Unit 3 seems to be consistent with the international practice, and more advanced in some cases. For example, the explicit consideration of failure correlations is an important enhancement for the Japanese situation. In order to impart more realism, the use of recent earthquake experience in Japan should be considered in development of fragilities, to the extent possible, for the Ikata Unit 3 seismic PRA. This should also be a part of longer-term research. The presentation and discussion summarized a potential improvement related to a simplified screening process that will identify which structures and components contribute to the risk measures. It was not clear how this process compares with the various international practices and what are the implications of using such a process. The screening at various levels and in the various parts of a seismic PRA is important, and there is considerable current debate on how to apply screening processes in a consistent and technically robust manner.

Therefore, we recommend that standard screening practices be first used in the Ikata Unit 3 seismic PRA and then evaluate applicability of the proposed approach.

Sincerely,

John W. Stetkar
Chairman

REFERENCES

1. "Implementation Standard for Probabilistic Safety Assessment of Nuclear Power Plants: 2007," AESJ-SC-P006:2007, Atomic Energy Society of Japan, September 2007.

2. "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR-6372, Volumes 1 and 2, U.S. Nuclear Regulatory Commission, April 1997.

3. "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," NUREG-2117, Revision 1, U.S. Nuclear Regulatory Commission, April 2012.

4. "Process of Seismic Hazard Evaluation on Ikata Unit 3," Shikoku Electric Power Company, Ltd. and NRRC Staff Presentation to NRRC Technical Advisory Committee, January 20, 2015.

5. "Process of Fragility Evaluation on Ikata Unit 3," Shikoku Electric Power Company, Ltd. and NRRC Staff Presentation to NRRC Technical Advisory Committee, January 20, 2015.