



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

June 28, 2018

MEMORANDUM TO: Brian E. Holian, Acting Director  
Office of Nuclear Reactor Regulation

FROM: Michael F. Weber **/RA/**  
Director of Nuclear Regulatory Research

SUBJECT: CLOSEOUT OF USER NEED REQUEST NRR-2008-001  
"EVALUATION OF LESSONS LEARNED FROM 7/16/2007,  
EARTHQUAKE IN JAPAN"

The Office of Nuclear Regulatory Research (RES) responded to and accepted the Office of Nuclear Reactor Regulation (NRR) subject user need request, (ADAMS Accession No. ML080530080), which was assigned tracking number UNR NRR-2008-001.

Following the July 16, 2007 earthquake at the Kashiwazaki-Kariwa Nuclear Power Plant, User Need NRR 2008-01 requested a detailed analysis and comparison of United States (U.S.) and Japanese seismic standards and analyses, and an evaluation of lessons learned from the event that could be applied to U.S. plants. In response to this request, RES commissioned the following four reports.

**Milestone 1.** Summary of Information on the Effects of the Niigataken Chūetsu-Oki (NCO) Earthquake on the Kashiwazaki-Kariwa Nuclear Power Plant – ML15342A306.

This report summarizes the written and electronic information about the effects of the earthquake available as of December 2010 including seismological information, known plant response, known damage and earthquake-related events, human factors, post-earthquake activities and actions, and International Atomic Energy Agency findings. It contains a summary of meetings conducted to exchange information with international organizations, and serves as a precursor report for the next three reports.

**Milestone 2.** Seismic Design Standards and Computational Methods in the United States and Japan – ML15342A315.

This NUREG/CR attempts to compare conservatism in Japanese and U.S. nuclear power plant (NPP) seismic design analysis and regulations. It acknowledges that the two countries face different challenges with regard to expected seismic activity, and that the purely deterministic Japanese approach is hard to compare with the U.S. approach, which was originally deterministic but is incorporating performance-based, risk-informed elements, particularly with the design analysis of new reactor designs.

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The NUREG/CR reviews NPP seismic design requirements in Japan and in the U.S and how they have evolved over the years. It includes a discussion of the impact of the 2011 Tohoku earthquake and the substantial changes to the overall Japanese regulatory structure that took place in its aftermath.

The NUREG/CR notes that both countries now recognize that, regardless of how the value for a design basis earthquake is established, there is always some probability that a larger earthquake will occur. U.S. regulations and analysis have used a risk-informed approach for this for some time; Japanese regulations were updated in 2006 to recognize and incorporate the concept of “residual risk.”

**Milestone 3.** Impacts of the Niigataken Chūetsu-Oki Earthquake on the Kashiwazaki-Kariwa Nuclear Power Plant, Post-Earthquake Response, and Lessons Learned – ML15342A311.

This report summarizes key findings of the actual performance of KKNPP in the areas of operations, seismic hazard assessment, structure modeling, soil-structure interaction analyses, structural design, subsystem design, and seismic instrumentation. It notes that important to safety structures, systems and components (SSCs) came through the earthquake with no visible damage and in much better condition than might be expected given that the ground motion significantly exceeded the design basis earthquake. This is attributed to very robust design parameters for the NPP that included significant safety margin. It also notes that offsite power remained available throughout the event, despite the fact that this would not be expected given the design and construction of the offsite power infrastructure.

The report looks in-depth at damage to non-safety related SSCs that impacted operator response to the earthquake. These challenges included:

- Seismically-induced fire in the Unit 3 in-house transformer.
- Site-wide soil failures that caused failures of large portions of the fire protection system.
- Significant damage to access roads impeding response from the offsite fire brigade and other emergency responders.
- Soil failures that damaged ducts connected to release pathway stacks, and could have caused radioactive releases at ground level rather than to the atmosphere.
- Sloshing of contaminated spent fuel pool water, which migrated through two leak pathways before being pumped to the sea (note that the total amount of activity was about  $9E4$  Bq, well below authorized limits for exposure to the public).

The report also reviews the common cause failure impact of seismic events. Seismic activity impacting a site may have the same impact on all units on the site, and on redundant trains within each unit. It further notes that with multiple units on the site impacted and responding to the event, there is limited opportunity for assistance between units as would normally occur during an unexpected single-unit shutdown.

The report also provides a detailed examination of the Kashiwazaki-Kariwa Research Initiative Seismic Margin Assessment (KARISMA). The objective of KARISMA was to compare the calculated seismic response based on modeling benchmarks from the countries involved with the actual recorded response of selected SSCs at the plant. This was an international effort involving researchers and support organizations from 11 countries.

**Milestone 4.** Impacts of the Niigataken Chūetsu-Oki Earthquake to the Kashiwazaki-Kariwa Nuclear Power Plant, Post-Earthquake Response, and Lessons Learned: U.S. Perspective ML15342A314.

This report reviews the effects of the NCO earthquake on the KKNPP in order to assess whether the potential for similar behavior (both positive and negative) is expected of U.S. nuclear power plants if subjected to earthquake ground motions exceeding the design bases. The report looks at the actual and potential impacts from KKNPP, including seismic hazard analysis, seismic system interactions (potential for non-safety related equipment to impact safety functions), seismic impact on fire protection, impacts from widespread soil failures on the site, the availability of offsite power, and the ability to cope with common cause events. After reviewing the impact at KKNPP compared to the expected impact based on Japanese regulatory requirements as discussed in detail in the Milestone 3 report, this report reviews applicable U.S. regulations, guidance, and design standards to determine if there are any vulnerabilities revealed by the events at KKNPP. General conclusions and lessons learned for U.S. NPPs include:

- Consideration of a full NPP site review for seismic category II and non-seismic SSCs for the impact of a safe shutdown earthquake (SSE) or beyond design basis earthquake regarding the consequences of surface deformation, seismic system interactions and the potential to impact regarding the safety functions, and fault displacement hazards.
- A revision to Regulatory Guide 1.12, *Nuclear Power Plant Instrumentation for Earthquakes*, to address issues pertaining to the operability of Seismic Data Acquisition Systems for SSE and beyond design basis earthquakes.
- An understanding of the aspects of the offsite power infrastructure and onsite switchyard that ensure high reliability of offsite power even when subjected to significant ground motion and provide insights for improving offsite power reliability.
- Regulatory Guide 1.189, *Fire Protection for Nuclear Power Plants*, to determine whether the guide should clarify that “natural phenomena” include design basis and beyond design basis events, including earthquakes.

It should be noted that the reports for Milestones 1,3, and 4 above are for internal use only due to proprietary information and cannot be released to the public. Milestone 2 does not contain any proprietary information and is published as NUREG/CR-7230.

Further research and documentation of the lessons learned from the NCO earthquake were shed as part of the agency rebaselining initiative in April 2016.

Based on the above actions, RES has completed the activities requested, as modified by rebaselining, and the UNR is closed. Closure of this user need has been discussed with Eric Thomas of your staff and he is satisfied with the actions taken.

RES has established an online quality survey to collect feedback from user offices on the usefulness of RES products and services. This survey can be found online at the hyperlink:

<http://www.internal.nrc.gov/RES/now/res-product-survey/index.html>

I would appreciate it if you would see that this short—about 5 minutes—survey is completed by the responsible manager or supervisor within the next 10 working days to present your office's views of the delivered RES product.

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