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Seismic Reviews at U.S. Nuclear Power Plants

Every U.S. nuclear power plant, even in areas with minimal seismic activity, is designed and built to withstand earthquakes and other natural hazards. The NRC has incorporated updated information and lessons from the 2011 Fukushima accident in asking U.S. plants to reassess their seismic situation.

Background

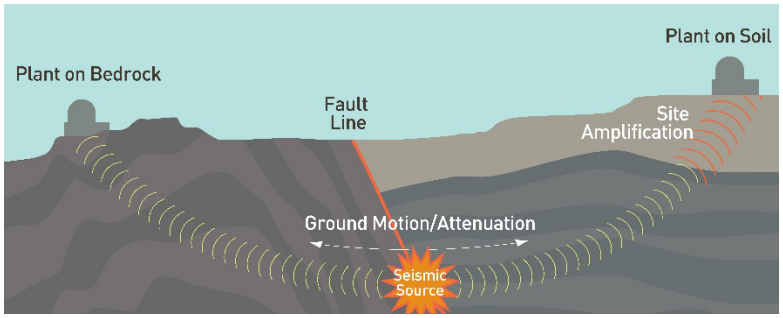
NRC regulations set out design, operation, and maintenance requirements for a nuclear plant's safety-significant structures, systems, and components to keep working after most earthquakes. Plants use traditional engineering practices to add "safety margin" beyond those requirements. The NRC ensures its requirements are satisfied through the licensing, reactor oversight, and enforcement processes.

In the early 2000s the NRC received new reactor-related applications that included updated seismic information and analysis methods. The agency in 2005 began looking broadly at potential changes in earthquake hazards in the Central and Eastern United States (CEUS). Through this effort, the NRC, the Department of Energy and the Electric Power Research Institute developed an updated model for CEUS earthquake sources. This work was later incorporated into the NRC's efforts to implement the lessons learned from the accident at Fukushima Dai-ichi.

Earthquake (or Seismic) Hazard

The NRC requires that everything in a U.S. reactor that can support a safety function must be designed according to:

- the most severe natural phenomena historically reported for the site and surrounding area. This includes a margin for error to account for imprecise historical data;
- appropriately combining the natural event with the effects of the plant's normal and accident conditions; and
- the importance of the safety functions.



An earthquake's energy spreads out from the fault and moves the ground, as well as nuclear power plant structures on or in the ground. The movement's strength and type depends on how the earthquake releases energy and on how the soil around a plant absorbs (or dissipates) the energy. Earthquakes can be measured

by both the frequency of the shaking and how strongly the ground accelerates, or moves at the plant. Different frequencies and strengths affect the plant's buildings as well as the systems and components inside.

An earthquake energy's frequency is measured in cycles per second (or Hz), and the acceleration is typically described as some fraction of the acceleration of Earth's gravity (g), which is about 32.2 feet per second per second (ft/s2). Something accelerating at 0.15 g (15 percent of the acceleration of gravity) is moving at about 5 ft/s2.

Seismic Safety Assessment

Each operating U.S. nuclear power plant determined its expected ground motions with site-specific information from historical earthquake catalogs and examination of local geology. Plant designers examined earthquake sources near a site. They used the largest quake from that sample to determine the site's expected ground motion. The NRC also used the Individual Plant Examination of External Events Program to have existing plants examine potential vulnerability to larger earthquakes. This examination focused on the plants' available safety margins to ensure these margins, together with the plant's accident management programs, continue to protect public health and safety.

These "deterministic" approaches has been replaced with "probabilistic" analysis, which examines how all seismic sources and earthquake types can affect a site. This approach estimates how likely a given ground motion level is for a certain time period (such as the operating life of a reactor). The studies might conclude a site has a 10 percent chance of exceeding ground motion of 0.3 g (a "strong" quake) within 50 years. The study could also estimate the maximum ground motion expected in the next 10,000 years at the site. Any new nuclear plant the NRC licenses will use a probabilistic, performance-based approach to establish the plant's seismic hazard and seismic design limits.

Evolving Knowledge about Earthquakes

The CEUS is generally an area of low to moderate earthquake hazard with few active faults in contrast to the western United States. Even so, in 1811–1812, three major earthquakes (Magnitude 7 to 7.7 on the commonly used Richter Scale) shook much of the CEUS. These earthquakes occurred near the town of New Madrid, Mo. In 1886, a large earthquake (Richter Scale magnitude of about 7) occurred near Charleston, S.C. This earthquake caused extensive damage and was felt in most of the eastern United States. Geologists are aware of these historic occurrences, and knowledge of such earthquakes was taken into account in plant design and analysis.

The NRC regularly reviews new information on earthquake source and ground motion models. For example, the NRC reviewed updated earthquake information provided by applicants in support of Early Site Permits for new reactors. This additional 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 and New Madrid.

Analysis of these updates indicated slight increases to earthquake hazard estimates for some plants in the CEUS. The NRC also reviewed and evaluated recent USGS earthquake hazard estimates for the CEUS that are used for building code applications outside of plant licensing. These reviews showed that the estimated likelihood of earthquakes occurring at some current CEUS operating sites might be slightly higher than what was expected during design and previous evaluations.

NRC Response to Increased Estimated CEUS Earthquake Hazards

The NRC began assessing the safety implications of increased plant earthquake hazards in the CEUS through a May 26, 2005, memorandum (available under Accession No. ML051450456 in the NRC Agencywide Documents Access and Management System) in which the staff recommended examining the new CEUS earthquake hazard information under the Generic Issues Program. The NRC staff identified the issue as GI-199 in a June 9, 2005, memorandum (ADAMS Accession No. ML051600272) and completed the screening analysis for the issue in January 2008. The staff then assessed available earthquake data and models.

The GIP confirmed that operating nuclear power plants were operating safely. The assessment also found that, although still small, some seismic hazard estimates have increased and warrant further attention. In September 2010, the NRC issued a Safety/Risk Assessment report (ADAMS Accession No. ML100270582) and an Information Notice (ADAMS Accession No. ML101970221) to inform stakeholders of the Safety/Risk Assessment results.

Post-Fukushima Seismic Re-Evaluations

Following the events in March 2011 at Japan's Fukushima Dai-ichi plant, the NRC considered how best to incorporate lessons from Fukushima into consideration of U.S. seismic issues. In February 2012, the NRC, DOE and EPRI completed years of CEUS research by publishing an updated understanding of that region's seismic sources. Shortly afterward, the NRC asked all U.S. nuclear power plants to develop a new ground motion response spectrum, or "hazard curve." Western U.S. plants had to develop site-specific source models, while CEUS plants used the regional model.

The plants compared the new hazard curve to their license's original safe shutdown earthquake; if the new hazard was greater, additional actions were required. These actions could include examining if any immediate actions were necessary, determining seismic effects on spent fuel pools, and/or a detailed seismic risk evaluation. The detailed risk evaluations, where appropriate, are underway, and the NRC staff will review the evaluations and any identified corrective actions. More information on the NRC's post-Fukushima seismic re-evaluation work is available on the NRC website.

June 2018