U.S. Nuclear Power Plants Designed and Built to Withstand Earthquakes

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Key Facts

- The U.S. Nuclear Regulatory Commission requires nuclear power plants to be able to withstand the most severe natural phenomena that may occur in the region where they are located, including earthquakes, tsunamis, hurricanes, tornados, fires and floods. The NRC requires additional safety margin to account for any uncertainties and to ensure the plant can remain safe in the event that an accident and a severe natural phenomenon occur at the same time.

- Nuclear power plant designs are based on a detailed evaluation of potential earthquake-induced ground motion at the site. This is followed by thorough analysis, testing and qualification of the plant structures and equipment, using simulated earthquake-induced vibrations. New plants are analyzed using probabilistic seismic hazard assessment techniques that characterize both the ground motion levels and uncertainty at the proposed site.

- Each U.S. nuclear plant has sensitive monitoring instruments systems to detect seismic activity. Plants will shut down if ground motion exceeds a specified level.

- The NRC has required modifications to nuclear plants since they were built to meet increasing safety standards. In addition, the NRC has required plants to have additional redundant equipment and measures to mitigate damage from large fires and explosions.

- The U.S. nuclear energy industry has already started an assessment of the events in Japan and is taking steps to incorporate lessons learned so that U.S. reactors will remain safe even after severe events that may challenge the operation of the facilities.

Designed for Maximum Projected Seismic Event

Engineers and scientists calculate the potential for earthquake-induced ground motion at a site using exacting data and review the impacts of historical earthquakes whose epicenters are up to 200 miles away. Earthquakes that have occurred within 25 miles are studied in greater detail. Engineers use this research to determine the maximum potential earthquake for a particular site.

In addition, experts consider site-specific soil conditions to determine how the maximum earthquake translates into ground motions that could affect plant structures and systems. For example, a site that features clay over bedrock will respond differently to ground motion than a hard-rock site. Taking all of these factors into account, experts determine the maximum ground motion the plant must be designed to withstand. Companies must be capable of achieving and maintaining safe shutdown conditions or preventing/mitigating consequences of reactor accidents that could result in off-site radiation exposures.
The NRC requires plant operators to shut down a reactor even if a seismic event is well within levels the design can accommodate. Each plant has seismic instrumentation to record earthquake-induced motions at the site. The recordings are used to evaluate the level of earthquake vibrations and determine whether the reactor is required to shut down. After shutdown, operators must perform extensive inspections to evaluate the impact of an earthquake at the site and the condition of the plant structures, systems and equipment. NRC approval is required before operators restart the reactor.

Ongoing Study of Seismic Safety at Nuclear Plants

The NRC continues to update its assessments of nuclear plant seismic capability and relevant regulations. In the 1990s, nuclear plant operators assessed the potential for earthquakes that are larger than the design standard as part of a broad examination of external events. After reviewing the assessments, the NRC concluded that nuclear plants have enough safety margins to withstand strong earthquakes.

In 2005, updated seismic hazard estimates by the NRC were higher than previous estimates for some plants in the central and eastern United States. That triggered the NRC to initiate a generic issue (GI-199) to better understand the seismic safety margin at operating plants in those regions.

The NRC issued its safety/risk assessment report on this topic last September. The agency concluded that nuclear power plants are safe, the overall seismic risk estimates remain small, and current seismic designs provide safety margin to withstand potential earthquakes exceeding the original design safety standards. However, the NRC also believes the issue should be further evaluated to better characterize the safety margin. The industry is working with the NRC to develop an efficient method for performing future evaluations of new seismic information.

Nuclear Energy Industry Responds to Fukushima

The nuclear energy industry has started an assessment of the events in Japan and is taking steps to ensure that U.S. reactors can respond to events that may challenge safe operation of the facilities. These actions include:

- Verifying each plant’s capability to manage major challenges, such as aircraft impacts and losses of large areas of the plant due to natural events, fires or explosions. Specific actions include testing and inspecting equipment required to mitigate these events, having the appropriate procedures in place and verifying that qualifications of operators and support staff required to implement them are current.

- Verifying each plant’s capability to manage a total loss of off-site power. This will require verification that all required materials are adequate and properly staged and that procedures are in place, and focusing operator training on these extreme events.

- Verifying the capability to mitigate flooding and the impact of floods on systems inside and outside the plant. Specific actions include verifying that required materials and equipment are properly located to protect them from being flooded.
Performing walk-downs and inspection of equipment needed to respond successfully to extreme events like fires and floods. This work will include analysis to identify any potential for lost equipment functions during seismic events appropriate for the site, and development of strategies to mitigate any potential vulnerability.