

March 11, 2016

The Fifth Anniversary of the Fukushima Daiichi Nuclear Accident-Where We Are Today

The American Nuclear Society (ANS) formed a [Fukushima Special Committee](#) following the nuclear accident that resulted from an unprecedented natural disaster in Fukushima, Japan. The committee evaluated recommendations and lessons learned, based upon an examination of information and data developed over a ten-month timeframe, and provided a clear and concise explanation of what happened during the incident. The ANS findings are contained in [Fukushima Daiichi: A Report by the American Nuclear Society Special Committee on Fukushima \(March 2012\)](#).

“The nuclear energy industry in the United States has always maintained the highest safety standards in the world,” said ANS President Eugene S. Grecheck. “Five years later, our members are continuing to lead innovations based on lessons learned from Fukushima that make nuclear energy production one of the safest processes in the energy industry today.”

ANS Key Points

- The findings of the ANS Fukushima Committee still apply today.
- The industry as a whole is better prepared for a natural disaster due to new strategies and regulations since the Fukushima accident.
- The FLEX program instituted by the NRC is a proactive approach that goes beyond design basis to improve nuclear safety and accident mitigation strategies. This approach takes into account the differences in designs and the most likely risks at each nuclear energy facility so that plants can focus on planning for extreme events that have a greater probability of occurring locally.
- Since 2011, ANS members have been among the key advisors and workers aiding the Japanese with clean-up and planning for the future of the nuclear industry.
- The U.S. nuclear industry has invested more than \$4 billion to comply with new regulations and actively ensure that U.S. reactors can withstand natural events even more severe than those assumed in their original design, upgrade safety equipment, and to train plant workers on new equipment and procedures.

ANS 2012 Report Findings

- The ANS Special Committee on Fukushima found that no aspect of the Fukushima Daiichi accident indicated that the level of safety of nuclear power plants (NPPs) in the United States was unacceptable.
- The tsunami design bases for the Fukushima NPPs were inadequate. A risk-informed regulatory approach would have identified the existing design bases as deficient and was necessary.
- The U.S. Nuclear Regulatory Commission (NRC) should review the scope of reactor safety design

and regulation to consider the adequacy of design bases for natural-phenomenon hazards and the need for extension of the design basis in a graded manner, using a risk-informed approach.

ANS Special Committee on Fukushima Members

Dr. Dale Klein, Co-Chair of the Special Committee

Dr. Michael Corradini, Co-Chair of the Special Committee

Paul Dickman, Study Director and Chairman of the Subcommittee on Risk Communication

Jacopo Buongiorno, Chairman of the Subcommittee on Regulatory Issues

Michael T. Ryan, Chairman of the Subcommittee on Health Physics and Radiation Biology

Craig D. Sawyer, Chairman of the Subcommittee on Accident Sequence Analysis

Amir Shahkarami, Chairman of the Subcommittee on Accident Cleanup and Waste Management

Dr. Hisashi Ninokata, Special Committee member

Dr. Akira Tokuhiro, Special Committee member

Industry Actions Resulting from Fukushima

The NRC issued three Orders in March 2012 requiring U.S. reactors to:

- Obtain and protect **additional emergency equipment**, such as pumps and generators, to support all reactors at a given site simultaneously following a natural disaster.
- Install **enhanced** equipment for monitoring water levels in each plant's spent fuel pool.
- Improve/install emergency venting systems that can relieve pressure **in the event** of a serious accident (only for reactors with designs similar to the Fukushima plant).

The **NRC strengthened the venting Order in 2013**, requiring vents to handle the pressures, temperatures, and radiation levels from a damaged reactor. The revised Order also called for plants to ensure their personnel could operate the vents under those conditions. As part of the same action, the staff used the NRC's rulemaking process to consider filtering methods to prevent radioactive material from escaping containment in an accident, and looked at new filter systems or a combination of existing systems.

Where are we today?

Fukushima Daiichi has gone from crisis, to stabilization, to decommissioning and clean-up.

- Water filtration and a bi-pass system have been in place to reduce the flow of ground water.
- A robust cover has been placed on Unit 3 to support robotics and to protect the environment. Fuel has also been removed.

- Radiation levels in the ocean near Fukushima have decreased.
- Installation of facilities required for constructing the frozen soil wall, designed to block groundwater at Fukushima Daiichi from entering reactor buildings and thereby becoming contaminated, has been completed, leading to the eventual goal of removing water from within the buildings.
- Unit 1, preparations for fuel removal from the spent fuel pool continues.
- Unit 2, plants to clear a path for a robot to explore inside the reactor.
- Unit 3, the large piece of rubble inside the pool has been completely removed.
- Unit 4 fuel has been removed.

Fukushima Daiichi Accident and U.S. Industry Response

Fukushima Talking Points

Source: Nuclear Energy Institute

Background

On March 11, 2011, an earthquake and tsunami in Japan devastated northeast Japan and led to an accident at Tokyo Electric Power Co.'s Fukushima Daiichi nuclear energy facility. The U.S. nuclear energy industry conducted rigorous reviews at the Japanese facility and compiled lessons learned from the event. In the past five years, companies that operate U.S. reactors have taken wide-ranging actions to further enhance the safety of American reactors. The industry has invested billions of dollars to verify that these reactors can withstand natural events even more severe than those assumed in original plant designs, to upgrade safety equipment, and to train plant workers on new equipment and procedures.

Safety is our industry's foremost priority

- In response to the 2011 accident at Fukushima Japan, the companies that operate the U.S. nuclear energy facilities are continuously taking steps to make them even safer.
- The U.S. industry since 2011 has worked through a special committee comprised of chief nuclear officers to catalogue the detailed facts about the Fukushima accident and apply lessons learned from the accident, where relevant, at U.S. reactors.
- Key industry actions include:
 - installation of additional backup safety equipment
 - ongoing training of plant personnel to respond safely to extreme natural events
 - opening two redundant Strategic Alliance for Event Response (SAFER) centers in Memphis and Phoenix that can deliver additional safety equipment and resources to any U.S. nuclear power plant within 24 hours
 - verified seismic and flooding protection at nuclear power plant sites
 - updated and improved the integration of existing emergency operating procedures

- updated a multi-organizational response framework to coordinate industry support
- all sites performed re-evaluations of seismic safety based on revised hazard estimates; 20 facilities are conducting more detailed risk assessments to identify potential safety enhancements, if warranted
- performed re-evaluations of flood safety, and analyses of revised hazard estimates have been completed at 56 plant sites; completion at remaining plant sites is anticipated by May 2016
- installed new instrumentation in used nuclear fuel storage pools
- reinforced containment venting and enhanced accident mitigation procedures to reduce the risk of radiation release.
- The industry will implement almost all of the highest priority enhancements by the end of 2016. Additional safety enhancements (including containment venting enhancements and some detailed seismic and flooding analyses) will be completed after this date.

In response to the accident, the NRC also established a task force to review safety requirements.

- The task force confirmed that all U.S. reactors are safe. America's nuclear power plants fully protect public safety while producing more than 60 percent of our country's carbon-free electricity.

In 2012, the NRC issued three orders to the industry to enhance safety based on its task force findings. In 2013, it changed NRC Order 3.

NRC Order 1: Implement mitigation strategies to maintain reactor and used fuel pool cooling and containment integrity in the event a severe accident that exceeds a facility's design parameters.

Industry response

- The nuclear energy industry developed a tailored, comprehensive strategy called **FLEX** as the centerpiece of its response to Fukushima. **FLEX** is a strategy that relies on adding more backup systems to provide power and cooling for nuclear fuel in the reactor and used fuel storage pools, and to maintain the integrity of reactor containment structures. This equipment, along with actions by highly trained reactor operators, will prevent conditions that may result in an accident.
- **FLEX** addresses the major problem encountered in Japan: The loss of power to maintain effective cooling. This approach builds on existing safeguards to add yet another layer of

protection to the layer upon layer of safety and protection against severe natural events already in place.

- The **FLEX strategy** will maintain backup power after an extreme event by stationing backup emergency equipment—generators, battery packs and chargers—in multiple locations. It also will maintain cooling of reactors and used fuel pools if normal systems fail by stationing additional pumps in multiple locations to provide cooling water to the reactors.
- More than 60 U.S. nuclear plants will have FLEX fully installed in 2015 and the rest will by the end of 2016, in accordance with NRC requirements.

NRC Order 2: Install a second tier of used fuel pool level instrumentation.

Industry response

- Companies that operate nuclear energy facilities are installing an additional tier of reliable spent fuel pool level instrumentation. These instruments will alert operators of changes in the level of water in used fuel storage pools even under extreme conditions. This new instrumentation must be installed by the end of 2016.
- This additional water level monitoring will ensure that operators can respond to keep spent uranium fuel covered with water, which effectively provides a safety barrier cooling the fuel and reducing the release of radiation.

NRC Order 3: Install reliable hardened containment vents for heat removal and pressure control in boiling water reactors with Mark I and II containments capable of operation under severe accident conditions. Twenty-seven U.S. reactors have this type of containment.

Industry response

- In response to the third order, 27 U.S. reactors with Fukushima-style containment structures already had hardened vents upgraded or are installing them. This vent removes heat and pressure, which preserves the integrity of the containment building and can delay fuel damage in the reactor. These vents must remain functional even in severe accident conditions when the reactor fuel is damaged. The industry expects to complete installation of the vents by the end of 2019.

The NRC also required licensees to provide detailed information on flooding and earthquake safety and take additional safety measures to protect against the most extreme flooding and earthquakes that might be experienced at each nuclear power plant site.

Flooding Safety

- The companies that operate America's nuclear power plants are re-evaluating the flooding hazard at their sites using state-of-the-art methods. The current approach for performing such evaluations uses challenging assumptions and methods, including the severity of a storm, events that occur before or during it, warning time and the estimated likelihood of multiple dam failures. Fifty-six facilities completed evaluations by Jan. 31, 2016; evaluations at remaining sites will be completed in mid-2016.
- Combined, these factors produce maximum very conservative estimate of volume of water that potentially could flood a nuclear plant site. Depending on the results of these evaluations, some plants may implement measures to enhance flooding protection.

Seismic Safety

- Seismic experts have re-evaluated earthquake protection at each nuclear power plant using the latest available U.S. Geological Survey data and methodologies and submitted the analysis to the Nuclear Regulatory Commission.
- Based on the results of the studies, some companies will perform more detailed evaluations of their plants' ability to withstand stronger ground motion than they originally expected. The NRC issued a final determination on Oct. 27, 2015, that identified 20 sites in 14 states that will need to perform these evaluations.
- In the meantime, nuclear plant operators evaluated whether and where seismic safety should be enhanced in the near term. The seismic evaluations focused on a limited set of installed plant equipment needed to support implementation of the industry's FLEX strategy. These evaluations confirmed that the plants are able to withstand stronger ground motion than was expected when they were built.
- All of the evaluations will be complete by the end of 2019.

There is a distinct and significant safety and oversight culture associated with the operation of U.S. nuclear power plants.

- The U.S. has an independent federal regulator, the U.S. Nuclear Regulatory Commission. The NRC has at least two inspectors at every U.S. nuclear energy facility who inspect the facility daily and have unfettered access to plant data. The NRC provides independent, quarterly assessments of each reactor, which are available on the agency's website.
- A culture committed to safety, effective industry self-regulation (via the Institute of Nuclear Power Operations), and stringent independent government oversight has resulted in the highest levels of safety. The U.S. industry sets the standard worldwide for

safety and is a model for other nations, including its application of the FLEX strategy in the aftermath of Fukushima.

At the time of the accident at Fukushima, there were significant differences between the U.S. and Japanese nuclear energy industries.

- Japan had multiple regulatory bodies with overlapping responsibilities. The Japanese have transitioned to a single nuclear regulator.
- There were significant differences in plant maintenance, emergency preparedness, reactor operator training and licensing, and plant operations command and control protocols. Over the past four years, with the assistance of the U.S. industry, Japan has been taking actions to close that gap and enhance its safety culture.
- U.S. and Japan chief nuclear officers have held two joint conferences to facilitate sharing of lessons learned and discuss ways to improve safety within the American and Japanese nuclear energy sectors. Topics of discussion include: emergency operating procedures, accident mitigation strategies, safety culture advancement, the U.S. nuclear industry's voluntary implementation of additional safety measures to respond to extreme natural events, and the recovery underway at the Fukushima Daiichi nuclear plant.