Blue Ribbon Commission on America's Nuclear Future

The Department of Energy's
Steps to Review Safety of Nuclear Facilities

Advance Technical Paper Supporting the Statement by

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As requested by the Blue Ribbon Commission, this paper provides a brief summary of the steps that the Department of Energy (DOE) is taking to review the safety of nuclear facilities in light of the events at the Fukushima-Daiichi nuclear power station in Japan. The paper first provides background information on DOE nuclear facilities, including reactors and facilities used for storage of spent fuel and high level wastes that provides context for the actions DOE is taking. The paper supports the remarks that will be made by the DOE Chief, Health, Safety and Security Officer, Mr. Podonsky, to the Blue Ribbon Commission during the May 13, 2011, Open Meeting.

Part 1 - Background Information on DOE Nuclear Facilities

<u>Department of Energy (DOE) Nuclear Facilities</u>

DOE has about 200 nuclear facilities and operations supporting scientific research, nuclear weapons stockpile stewardship, and environmental remediation and waste management functions within 12 states. Of particular interest to this Open Meeting, DOE has:

- Two hazard category 1 (defined below), research reactors:
  - Advanced Test Reactor (ATR) at the Idaho National Laboratory (INL)
  - High Flux Isotope Reactor (HFIR), at the Oak Ridge National Laboratory (ORNL)
- Two other research reactors at DOE laboratories
  - Annular Core Research Reactor at Sandia National Laboratories (SNL)
  - Neutron Radiography Reactor at INL.
- Spent fuel storage facilities at ATR and HFIR and a few other facilities that store significant amounts of spent fuel or other highly radioactive materials including:
  - Several storage facilities at the INL, one of which is a pool
  - The Waste Encapsulation and Storage Facility (WESF) at the Hanford Site.
  - Spent fuel at Hanford is in dry storage with only sludge and debris remaining at the K-West Spent Fuel Storage Basin.
  - The L Reactor Basis at the Savannah River Site (SRS).
- Various facilities where significant quantities of radioactive nuclear materials, including high level waste, are stored and processed. These include a wide range of facilities such as cells, underground storage tanks containing residual high level wastes, secure storage vaults, plutonium and uranium process facilities in support of the defense mission, analytical laboratories, subcritical experiment facilities, facilities used to process nuclear wastes to a safe and stable form, and legacy facilities pending decontamination and decommissioning

<u>Category of Facilities</u>

DOE categorizes its facilities by the level of hazard they present to the public and workers:

- Hazard category 1: A nuclear facility with the potential for significant off-site consequences
- Hazard category 2: A nuclear facility with the potential for significant on-site consequences
- Hazard category 3: A nuclear facility with the potential for only significant in-facility consequences.

DOE is focusing most of its efforts on the higher hazard category 1 and 2 nuclear facilities because these facilities have the higher hazard/risk activities. As noted above, of the nearly 200 DOE nuclear facilities/activities, only two research reactors that meet criteria for a hazard category 1 nuclear facility. DOE has about 150 hazard category 2 nuclear facilities and activities.

<u>Overview of DOE Nuclear Safety Requirements</u>

DOE has established Federal Regulations and DOE Orders that establish requirements for:

- Performing and documenting safety analysis to establish necessary hazard controls (10 CFR 830)
- Designing the nuclear facilities per rigorous safety standards that require multiple layers of protection against the release of hazardous materials (10 CFR 830, DOE Order 420.1B)
- Operating and maintaining its facilities with highly qualified and trained personnel using well-defined procedures; (10 CFR 830, DOE Orders 422.1, 426.2, 433.1B)
- Invoking a rigorous quality assurance program (10 CFR 830 and DOE O 414.1C)
- Establishing emergency plans and procedures (DOE Order 151.1).

Governance Model for DOE Nuclear Safety

Almost all DOE nuclear facilities are government owned and contractor operated. A very few lower hazard category nuclear facilities, such as New Brunswick Laboratory, are government owned and operated. The DOE oversight and regulatory approach has established oversight functions at multiple levels. Major roles and responsibilities for safety of DOE nuclear facilities are:

- Contractors (or Federal site operators) are responsible for developing and implementing safety programs that meet DOE requirements, including development of a safety basis that governs operations at nuclear facilities.
- DOE line management provides programmatic direction to contractors and reviews and approves site safety bases and other documents. DOE line management provides oversight through site offices and program offices, including the Central Technical Authorities functions that focus on nuclear safety and are performed by the Chief of Nuclear Safety or Chief of Defense Nuclear Safety. DOE line management reviews and approves the safety analysis and performs facility reviews to approve facility operations.
- The DOE Office of Health, Safety and Security (HSS) performs independent oversight of safety and security programs at DOE sites, with emphasis on nuclear facilities.

Complementing this internal safety management and oversight, the Defense Nuclear Facilities Safety Board (DNFSB) is an independent agency established by Congress to provide advice and make recommendations to DOE on establishing and operating defense nuclear facilities in accordance with the highest nuclear safety standards. The DNFSB actively reviews and evaluates nuclear safety only at certain sites (those that were involved in national defense).

Similarities and Differences between DOE Nuclear Facilities and Commercial Power Reactors

The accident in Japan involved boiling water nuclear reactors used for generating commercial electric power. These are similar to some of the commercial nuclear reactors in the United States that are licensed by the Nuclear Regulatory Commission (NRC). DOE does not have any reactors that are similar to those in Japan and has no reactors that are used to generate electric power. Further, essentially every DOE nuclear facility is a unique, “one of a kind” facility that is not an instantiation of a common design (unlike US commercial nuclear reactors, which are, in large part, all instantiations of one of the well-analyzed common designs).

There are similarities in the safety requirements and programs between DOE nuclear facilities and those for commercial reactors. DOE has established a nuclear safety policy that has qualitative and quantitative safety goals similar to the NRCs. In addition, DOE develops safety analysis and technical safety requirements, for each of its hazard category 1, 2 and 3 nuclear facilities that are used as the basis for the approval of the operation of the facilities similar to what is used by the NRC to regulate commercial power reactors. However, there are many important differences between DOE nuclear facilities and the commercial power reactors and thus the challenges to safety are very different.

Reactors. One of the most important differences is that DOE reactors operate at much lower power levels than commercial power reactors. Thirty years ago, DOE operated a number of high power reactors that supported the nuclear stockpile program. These production reactors have been shutdown for many years and are largely dismantled.

The highest power DOE reactor – ATR - operates at design thermal power of 250 megawatts, which is about one-fifth the power levels of the smaller commercial power reactors. Further, research reactors are typically run intermittently for experiments rather than continuously and thus do not build up as much of a fission product inventory and do not have a large amount of decay heat when compared to commercial reactors. Commercial power reactors require substantial cooling capability after a shutdown, and a corresponding need for electric power to run pumps. Because of the lower power levels, fission product inventory, and decay heat, DOE reactors are much less susceptible to a reactor meltdown resulting from loss of cooling or electric power.

Spent Fuel Storage. Similar considerations apply to spent fuel storage. At the Fukushima-Daiichi nuclear power station and US commercial nuclear reactors, spent fuel is typically highly radioactive and has significant decay heat that requires cooling to prevent overheating and radioactive releases. For DOE reactors, the challenges to cooling spent fuel are much less because the DOE spent fuel has much less decay heat for a variety of reasons (some of the fuel has been in storage for many years and has cooled considerably).

Other DOE Nuclear Facilities. In addition to reactors and spent fuel storage, DOE has a wide variety of nuclear facilities, such as hot cells and waste treatment facilities. Although not susceptible to nuclear fuel failure events such as what was experienced in Japan, there are other types of accidents (e.g., facility fires, criticality events) that present concerns and warrant high assurance that the safety systems are effective.

Accident Scenarios and Safety Systems. Similar to commercial nuclear reactors, DOE has analyzed and put safety systems in place to prevent and/or mitigate a spectrum of accidents that could impact its nuclear reactors including accidents that are caused by natural phenomena hazards such as tornados and earthquakes. However, for DOE's reactors, because of the significant lower power levels and decay heat loads, the potential accident progression (e.g., boil off of water) and safety system needs (e.g., long term force cooling) are very different and the type of reactor meltdown and spent fuel accident that occurred at the Fukushima-Daiichi nuclear power station is not possible at these reactors and fuel pools. In addition, other types of events that could impact DOE reactors (which have been postulated but are very unlikely) would have significantly less consequences for DOE nuclear reactor facilities because of the lower levels of fission products.

DOE non-reactor nuclear facilities are also thoroughly analyzed and appropriate safety systems put in place. The most important of these system (called safety class systems) are designed to redundancy and quality requirements comparable to safety systems at reactor facilities and are surveilled and tested accordance with technical safety requirements to ensure operability.

Part 2 - DOE Actions in Response to Events at the Fukushima-Daiichi

Safety Bulletin 2011-1

Following the accident at the Fukushima Daiichi nuclear power station, the Secretary of Energy issued Safety Bulletin 2011-1 (Events Beyond Design Safety Basis Analysis) on March 23, 2011, that requested facility operators to do the following:

- Review how beyond design basis events have been considered or analyzed and any controls that have been put in place that could prevent or mitigate them.
- Discuss the ability to safely manage a total loss of power event.
- Confirm safety systems are being maintained in an operable condition.
- Confirm emergency plans, procedures, and equipment are current, functional, and have been appropriately tested, including plans and procedures for response to natural phenomena events that could have site-wide impacts or impacts on regional support infrastructure.

Hazard category 1 facilities responses were due and provided by April 14. Hazard category 2 facilities responses are due by May 13.

Responses to Safety Bulletin 2011-1

The responses were received for the two Hazard Category 1 facilities (ATR and HFIR). Initial analysis of these responses yielded the following observations:

- The reactor designs are significantly different than commercial reactors (much smaller fuel inventory, much lower cooling requirements, different cladding, operations at power are conducted only for short durations).
- All safety systems for accident prevention and mitigation are operable
- The reviews evaluated beyond design basis events (as is called for in 10 CFR 830), including severe natural phenomena events. Some provisions are in place to mitigate these very unlikely events and the associated loss of power events.
- At this point in the review, no risks were identified that warrant immediate action. However, some potential opportunities for improvement were identified including:
  - Developing a comprehensive plan to improve the response to events that impact multiple facilities and site infrastructure and performing a site-wide emergency response exercise to test the new plan.
  - Further, improving seismic capabilities of some systems, structures, and components.

- Revising procedures for improved battery management during prolonged station blackout.
- Improving capabilities to remotely monitor plant equipment status and radiation levels.

As noted, responses for the hazard category 2 facilities are due by May 13. The reviews and submittals are intended to determine whether all beyond design basis events were sufficiently analyzed and that appropriate safety controls were put into place. Based on the reviews, DOE line management will determine whether actions are needed to ensure that the facility safety controls are appropriate and operable and determine the need for any additional measures to control risks or enhance response capability. HSS will also review the site submittals, individually and collectively, to determine whether any improvements are needed in DOE regulations, directives, or guides and to share lessons lesson-learned that can enhance the safety.

Nuclear Safety Workshop

The Deputy Secretary of Energy is sponsoring a workshop June 6 and 7 to bring together the nuclear community to discuss lessons learned from the Japan event and potential actions that could further enhance nuclear safety. Senior leaders and technical staff from DOE, NRC, DNFSB, Institute for Nuclear Power Operations, and Federal Emergency Management Agency are expected to participate. During this meeting, DOE anticipates identifying potential additional actions that may further improve the safety posture at DOE nuclear facilities. These potential actions will be further evaluated to identify enhancements that could further reduce residual risks and/or improve the capability to respond to unlikely but severe conditions. As appropriate, DOE may take action to ensure enhancements are implemented at nuclear facilities, such as incorporating lessons learned into DOE requirements or guidance for nuclear facilities.

Next Steps

In addition to reviewing the submittals for hazard category 1 and 2 facilities, DOE will also monitor lessons learned from the events in Japan. While there is still much about the accident that is unknown and it is premature to draw too many conclusions, some aspects of the accident are reasonably well understood and can serve to guide the review of responses to Safety Bulletin 2011-1 as well as the Department's efforts to continuously improve nuclear safety requirements and guidance. As examples:

- The tsunami wave that exceeded the design basis serves as a reminder that events beyond the design basis are unlikely but not impossible; thus, more attention to beyond design basis events is warranted to identify additional risk-based options to mitigate them.
- The loss of electric power was a major factor in the accident and may have been related to an interruption in fuel supplies as a result of damage caused by the tsunami, and thus additional attention on verifying that safety analyses efforts have not missed credible scenarios that could cause emergency power supplies to fail are prudent. Also, there may be opportunities to improve safety by arranging for contingency measures, such as the use of portable electric generators that could be deployed in the event of loss of station power.
- The tsunami caused multiple concurrent equipment failures and onsite and offsite infrastructure damage (e.g., blocked roads), hindering the response efforts. While common mode failures are examined in safety bases development, additional attention to verifying that potential initiators of common mode and/or infrastructure failures are sufficiently and conservatively analyzed may be prudent. For example, in past independent oversight reviews, DOE has identified potential non-conservatisms in the analysis of common mode failures resulting from a volcano and the associated ash fall that could cause concurrent failures in ventilation systems and emergency power supplies (e.g., blocking filters). The ability to monitor the facility status during an upset condition, such as when access to facilities is hindered by high radiation levels or disasters that impact roads and bridges is also an area that warrants continued review and attention.

As the accident in Japan is analyzed and lessons learned are promulgated, HSS will be working with line management to continually evaluate them. We anticipate that many lessons learned will be developed over the coming months and years and will warrant further evaluation. In addition, information from all sources, including responses to Safety Bulletin 2011-1 and lessons learned from the accident in Japan, will be used to inform us as we look to improve our nuclear safety rules, directives, and guidance and priorities for independent oversight activities.

In conclusion, DOE believes that it is taking prudent actions in response to the accident at the Fukushima Daiichi nuclear power station. These actions are appropriate to the level of risk and we will continue to incorporate lessons learned as appropriate.