TESTIMONY
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UNITED STATES NUCLEAR REGULATORY COMMISSION
TO THE
SUBCOMMITTEES ON ENERGY AND ENVIRONMENT AND
INVESTIGATIONS AND OVERSIGHT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

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Good morning, Chairmen Harris and Broun, Ranking Members Miller and Edwards, and Members of the Subcommittees. I am pleased to appear before you on behalf of the United States Nuclear Regulatory Commission (NRC) to discuss the agency's research program and our current activities in response to the events that have occurred at the Fukushima-Daiichi nuclear power plant site.

My name is Dr. Brian Sheron, and I have been the Director of the NRC Office of Nuclear Regulatory Research for the past five years and have been at the NRC and its predecessor agency, the Atomic Energy Commission, for nearly 38 years.

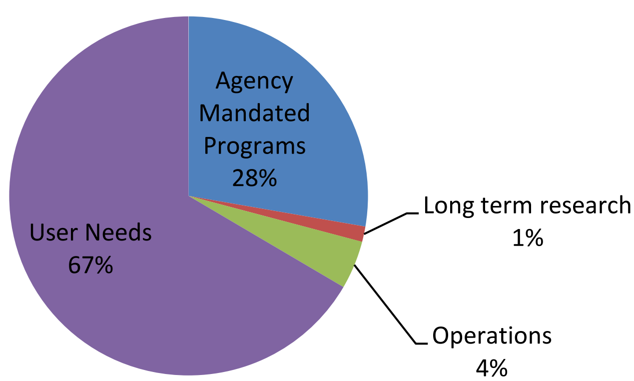
The following testimony is intended to provide an overview of the NRC's Office of Nuclear Regulatory Research (RES) and its current activities, as well as provide a discussion of the agency task force and research activities related to the Fukushima-Daiichi event in Japan.

As you are aware, the NRC is an independent Federal agency established to license and regulate the Nation's civilian use of production and utilization facilities, as well as the use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment. The NRC currently licenses, inspects, and assesses the performance of 104 operating nuclear power plants, as well as many materials licensees, fuel cycle facilities, and research and test reactors.

The Office of Nuclear Regulatory Research (or RES) is a major NRC program office, mandated by Congress and created along with the NRC in 1975. RES is one of the offices that reports to the Executive Director for Operations. RES plans, recommends, and implements programs of nuclear regulatory research, standards development, and resolution of generic safety issues for nuclear power plants and other facilities regulated by the NRC. The Office coordinates research activities within and outside the agency, including NRC participation in national and international volunteer standards efforts. There are currently about 260 staff members in the office, which is organized into three technical divisions: the Division of Engineering, Division of Risk Analysis, and Division of Systems Analysis.

RES is responsible for developing methods, technical expertise and computer codes that are used by the NRC to assess safety and regulatory issues for materials licensees, fuel cycle facilities, operating reactors as well as new and advanced reactor designs. We develop the data needed to assess these codes by conducting experiments at national laboratories, universities, or in collaboration with international organizations.

The NRC regulatory research program addresses issues in the three arenas of nuclear reactors, nuclear materials, and radioactive waste. The research program is designed to improve the agency's knowledge where uncertainty exists, where safety margins are not well-characterized, and where regulatory decisions need to be confirmed in existing or new designs and technologies. Typically, the regulatory offices approach us with an issue, and we determine how to appropriately resolve it through research or analysis. The majority of our work is this user need driven work performed in response to requests from our regulatory offices, as shown in the following chart:



RES coordinates research activities with the other NRC program offices, as appropriate, and leads the agency's initiative for cooperative research with the U.S. Department of Energy (DOE) and other Federal agencies, the domestic nuclear industry, U.S. universities, and international partners. RES coordinates the development of consensus and voluntary standards for agency use, including appointment of agency staff to various standards committees. Based on research results and experience gained, we work with the regulatory offices to develop appropriate regulatory actions to resolve potential safety issues for nuclear power plants and other facilities regulated by the NRC, including those issues designated as Generic Issues (GIs). GIs are technical or security issues that could impact two or more facilities or licensees. RES also develops the technical basis for those areas regulated by the NRC that have risk-informed, performance-based regulations.

RES supplies technical tools, analytical models, and experimental data needed to support the agency's regulatory decisions. RES does not conduct research for the primary purpose of developing improved technologies, a function that is more appropriately that of the Department of Energy or the nuclear industry. Rather, the NRC conducts research to confirm that the methods and data generated by the industry ensure that adequate safety margin is maintained.

In addition to supporting regulation of the commercial use of radioactive materials to protect public health and safety and to protect the environment, RES is responsible for providing the technical basis for regulations to ensure the protection and safeguarding of nuclear materials and nuclear power plants in the interest of national security. Thus, while its primary focus is on supporting the licensing and regulatory process, the research conducted by and for the NRC plays an important role in supporting broad government-wide initiatives associated with national security.

The Office of Research's staff is very well qualified and educated, with 30% of staff holding PhDs, and 33% of staff with master's degrees. The staff continues to reflect diversity in education, demographics, and technical disciplines. The wide range of engineering and scientific disciplines includes expertise in nuclear engineering, materials science, human factors and human reliability, health physics, fire protection, and probabilistic risk assessment, to name a few. It is this diversity in highly technical and specialized disciplines that allows RES to support the licensing offices as they carry out their licensing and regulatory tasks. Given this internal expertise, we perform a significant amount of research in-house. However, because we have more work than RES staff's capacity, we use contractors to supplement our work to perform research that requires special skills or facilities. Our staff develops the work plan and is engaged in the research process with the contractor throughout the entire research effort.

In addition to conducting confirmatory research, RES also conducts forward-looking research. The objectives of forward-looking and long-term research are to develop the technical basis to support related regulatory decision making. We monitor areas where the regulated industry may be moving and determine the technical information needed for future regulatory decisions to prepare the agency to respond to anticipated future industry requests and initiatives.

These activities address new safety technologies or developments in analytical technologies or infrastructure. By their nature, these items span a wide range of disciplines, from risk assessment to structural integrity to fission product transport. Our development of data and assessment tools for these technologies will ensure that the agency is prepared to meet its future regulatory needs.

In addition to our research efforts, the NRC cooperates with professional organizations that develop voluntary consensus standards associated with systems, structures, equipment, or materials used by the nuclear industry. In fiscal year 2010, 184 NRC staff members participated in 325 standards activities, such as membership on a standards-writing committee. The organizations governing these committees include the American Society of Mechanical Engineers (ASME), the National Fire Protection Association (NFPA), the American Nuclear Society, the Institute of Electrical and Electronics Engineers, the American Concrete Institute, and the National Council on Radiation Protection and Measurements.

For example, ASME developed the Boiler and Pressure Vessel Code and the Operations and Management Code which are widely acknowledged as an acceptable set of standards used to design, construct, and inspect pressure-retaining components, including nuclear vessels, piping, pumps, and valves. Similarly, NFPA has developed consensus standards to define acceptable methods to design, install, inspect, and maintain fire protection systems. The NRC has incorporated into its regulations various standards from the groups discussed above.

The NRC's use of voluntary consensus standards is consistent with statutory requirements. Participation by the NRC staff in voluntary consensus standards development is essential because the codes and standards are an integral part of the agency's regulatory framework. The benefits of this active involvement include cost savings, improved efficiency and transparency, and regulatory requirements of high technical quality. The agency acknowledges the broad range of technical expertise and experience of the individuals who belong to the many consensus standards organizations. Thus, participation in standards development minimizes the expenditure of NRC resources that would otherwise be necessary to provide guidance with the technical depth and level of detail of voluntary consensus standards.

Over the past 35 years, RES has developed or sponsored over 40 computer codes for use in its safety analyses. These codes are used in many aspects of the NRC's mission and perform wide ranging tasks including modeling fuel and reactor systems behavior, radiation's health effects, atmospheric dispersion, probabilistic risk assessment and more. They are shared with domestic and international counterparts to capture the value of a larger expert user community, which adds robustness to the codes and certainty to their results.

NRC uses computer codes to model and evaluate fuel behavior, reactor kinetics, thermal-hydraulic conditions, severe accident progression, time-dependent dose for design-basis and beyond design-basis accidents, health effects, and radionuclide release and transport during various operating and postulated accident conditions. Computer codes are validated against scaled tests and actual plan data. Results from such code applications support regulatory decision making in risk-informed activities, confirmatory and exploratory analyses, review of licensees' codes, performance of audit calculations, and resolution of other technical issues to inform the NRC staff on a wide variety of emergent technical questions for ensuring the health and safety of the general public. NRC code development is focused on improving the realism, accuracy and reliability of code results while improving code usability. However, the modeling of some novel systems (e.g., medical isotopes production) and new and advanced reactor design (e.g., Next Generation Nuclear Plant) requires further code development and additional assessment against specific experimental data.

Some specific examples of codes and how they are more specifically used in the regulatory environment are the MELCOR and MACCS2 codes. The MELCOR code models the progression of severe accidents in light-water nuclear power reactors. MELCOR models several phenomena including thermal-hydraulics, core heatup, containment performance, hydrogen production, and fission product release and transport behavior. The MACCS2 code is used to evaluate doses and health risks from the accidental atmospheric releases of radio nuclides. It is also used to confirm license renewal analyses regarding plant specific evaluation of Severe Accident Mitigation Alternatives (SAMAs) that is required as part of the environmental assessment for license renewal. The MACCS2 code is also routinely used in environmental impact statements (EIS) supporting early site permits (ESP).

The agency shares its codes with other organizations under various agreements and has organized user groups for some codes that are widely used. Two such programs are the Code Applications and Maintenance Program (CAMP) and the Cooperative Severe Accident Research Program (CSARP). CAMP, which has existed as a user community for almost 30 years, includes thermal-hydraulic codes, and has members from more than 25 nations. CSARP includes members from 20 nations who focus on the analysis of severe accidents using primarily the MELCOR code. Through the CAMP and CSARP programs, the NRC is able to share some of the codes' development and maintenance cost, while improving their quality and performance.

RES has implemented over 100 international cooperative agreements with other nuclear regulators and international organizations to share information and leverage resources. RES also participates in several International Atomic Energy Agency (IAEA) and Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) committees and working groups that develop safety standards and facilitate the exchange of information between countries on topics such as risk assessment, events and best practices. These include the IAEA Nuclear Safety Standards Committee, the Committee on the Safety of Nuclear Installations, the Working Group on Risk Assessment, and others. In addition, I serve as vice-chair for the Committee on the Safety of Nuclear Installations at the OECD/NEA.

The NRC has a robust reactor operating experience program, and we have taken advantage of the lessons learned from previous operating experience to implement a program of continuous improvement for the U.S. reactor fleet. We have learned from experience across a wide range of situations, including, most significantly, the Three Mile Island (TMI) accident in 1979. As a result of those lessons learned, we significantly revised emergency planning requirements and emergency operating procedures for licensees, and made substantive improvements in NRC's incident response capabilities. We also addressed many human factors issues regarding control room indicators and layouts, added new requirements for hydrogen control to help prevent explosions inside of containment, and created requirements for enhanced control room displays of the status of pumps and valves.

Two particularly significant changes after TMI accident were the expansion of the Resident Inspector Program and the incident response program. Today, there are at least two Resident Inspectors at each nuclear power plant. The inspectors have unfettered access to all licensees' activities, and serve as NRC's eyes and ears at the power plant. The NRC headquarters operations center and regional incident response centers are prepared to respond to all emergencies, including any resulting from operational events, security events, or natural phenomena. Multidisciplinary teams in these centers have access to detailed information regarding licensee facilities, and access to plant status information through telephonic links with the Resident Inspectors, an automated emergency response data system, and directly from the licensee over the emergency notification system. NRC's response would include the dispatch of a site team to supplement the Resident Inspectors on site, and integration with the licensee's emergency response organization at their Emergency Offsite Facility. The program is designed to provide independent assessment of events, to ensure that appropriate actions are taken to mitigate the events, and to ensure that State officials have the information they would need to make decisions regarding protective actions.

The NRC had a Boiling Water Reactor Mark I Containment Improvement Program in the 1990's, which resulted in the installation of hardened vent systems for containment pressure relief, as well as enhanced reliability of the automatic depressurization system.

As a result of the events of September 11, 2001, we identified important pieces of equipment that, regardless of the cause of a significant fire or explosion at a plant, we want licensees to have available and staged in advance, as well as new procedures, training requirements, and policies that would help deal with a severe situation.

As you know, on Friday, March 11, 2011, an earthquake and subsequent tsunami occurred near the northeast coast of Japan, resulting in the shutdown of more than 10 reactors. From what we know now, it appears possible that the reactors' response to the earthquake went according to design. The ensuing tsunami, however, likely caused the loss of emergency alternating current (AC) power to four of the six units at the Fukushima Daiichi site. It is these four units that have received the majority of our attention since that time. Units One, Two, and Three at the site were in operation at the time of the earthquake. Units Four, Five, and Six were in previously scheduled outages.

Our program of continuous improvement based on operating experience will include evaluation of the significant events in Japan and what we can learn from them. We have already begun enhancing inspection activities through temporary instructions to our inspection staff, including the Resident Inspectors at each nuclear power plant and the region-based inspectors in our four Regional offices, to look at licensees' readiness to deal with both the design basis accidents and the beyond-design basis accidents. The information that we gather will be used for additional evaluation of the industry's readiness for similar events, and will aid in our understanding of whether additional regulatory actions need to be taken in the immediate term.

The phenomena associated with the events at Fukushima-Daiichi involve numerous disciplines in which RES has expertise and are in areas where we have already done substantial analysis. I would now like to discuss some of these technical areas that have been raised since the events in Japan and discuss our related existing or planned research activities.

First, the NRC has an extensive seismic research program. Seismic safety in the design and operation of nuclear facilities has been evolving since the development of the first rules and guidance for seismic design by the NRC's predecessor, the Atomic Energy Commission. In 1998, the NRC issued a policy decision to move towards a risk-informed and performance-based regulatory framework. Risk-informed frameworks use probabilistic methods to assess not only what can go wrong, but also the likelihood of going wrong. Over the last decade, significant advances have been made in the ability to assess seismic hazards. The NRC is currently sponsoring several projects in support of both an updated assessment of seismic hazards in the Central and Eastern United States (CEUS) and an enhancement of the overall framework under which the hazard characterizations are developed. The products of these projects will be used in the determination of seismic hazard design levels for new reactors and are being used in a program to reassess seismic hazards at existing plant locations. Although no immediate safety issue has been identified, the NRC will take action if our further analysis shows that safety improvements can be justified.

Since the 2004 Indian Ocean tsunami, significant advances have been made in the ability to assess tsunami hazard globally. The NRC initiated its current tsunami research program in

2006. It focuses on bringing the latest technical advances to the regulatory process and exploring topics unique to nuclear facilities. The tsunami research program focuses on several key areas: landslide-induced tsunami hazard assessments, support activities associated with the licensing of new nuclear power plants in the United States, development of probabilistic methods, and development of the technical basis for new NRC guidance. This program, which includes cooperative work with the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA), has already resulted in several important publications on tsunami hazard assessments on the Atlantic and Gulf Coasts of the United States. The publications and research results help form the basis of NRC review of new license applications. Whether additional work is needed for operating reactors will also be examined.

The NRC has performed extensive research since the TMI accident to understand the phenomena associated with severe accidents and has developed analytical models that predict accident progressions and their consequences. This research includes test programs on zirconium fires, source term analysis, molten core-concrete interactions, and containment analyses.

The NRC is conducting research to estimate the possible public health and safety consequences in the unlikely event that a severe accident occurs at a commercial nuclear power plant in the United States. The State-of-the-Art Reactor Consequence Analysis (SOARCA) program takes maximum advantage of extensive national and international reactor safety research and reflects improved plant design, operation, and accident management implemented over the past 25 years. Using computer models and simulation tools, the NRC is developing a set of realistic consequence estimates of accidents at two U.S. reactor sites representative of different reactor and containment designs used in the United States. The two pilot plants are a General Electric boiling-water reactor (BWR) with a Mark I containment (Peach Bottom) and a Westinghouse pressurized-water reactor (PWR) with a dry, sub-atmospheric containment (Surry). The results of the analyses are showing thus far that analyzed scenarios could reasonably be mitigated, either preventing core damage or delaying or reducing the radiation release. For cases assumed to proceed unmitigated, accidents appear to progress more slowly than previously thought and usually result in smaller and more delayed radiological releases than previously predicted.

A Probabilistic Risk Assessment (PRA) is a structured analytical process that provides estimates of risk by (1) identifying potential initiating event scenarios that can challenge system operations, (2) estimating the likelihood of event sequences that lead to an adverse event such as core damage, containment failure, and offsite radiological effects; and (3) estimating the consequences associated with accident sequences. These rankings are very valuable in the sense that resources can be directed towards the major contributors to risk. There are three levels of PRA for nuclear power plants. Level 1 PRA covers the initiating event to the onset of core damage. Level 2 PRA covers the onset of core damage to radioactive material release to the environment. Level 3 PRA covers radioactive material release to offsite radiological consequences.

The first study to use PRA methods to obtain more realistic estimates of risk associated with severe reactor accidents was completed in 1975. In 1988 the NRC asked the licensees to conduct Individual Plant Examinations to ensure that NRC's regulations were adequate and no undue risk was posed to the public by any plant. In 1990, NRC completed a Level 3 PRA for five commercial nuclear power plants of different reactor and containment designs. Since this last NRC-sponsored Level 3 PRA, the design, operation, maintenance, testing, and inspection of NPPs and the state-of-the-art in PRA technology, and data have evolved considerably. Our staff therefore continues to improve NRC's PRA capability and risk understanding to enhance PRAs role in NRC's current risk-informed regulatory approach.

The NRC has developed independent confirmatory PRA models for operating and new reactor nuclear plants. The NRC maintains Standardized Plant Analysis Risk (SPAR) models that represent the 104 operating commercial plants in addition to 2 SPAR models for new reactor designs. These SPAR models are used to support a variety of NRC regulated activities including the reactor oversight and the accident precursor programs. The SPAR models are updated periodically to reflect plant modifications, new operating experience data, and improved risk modeling capabilities (e.g., support system initiating events, external hazards, and loss of offsite power).

As part of the PRA program, the NRC conducts human reliability analysis (HRA) research to assess the human contribution to risk. We study human performance because it can significantly influence the reliability and safety of nuclear plant operations. HRA research is key to understanding accident sequences and appropriately representing their relative importance to overall risk. Research is conducted both domestically and internationally in cooperation with other organizations. In addition, the NRC participates in and I am the Board Chairman of the OECD/NEA Halden Reactor Project. Halden is a research facility in Norway that advances HRA through research. Several regulatory agencies and private sector companies participate in Halden research activities. NRC continues to study human performance in nuclear power plants and improve the methods for assessing human reliability.

Another PRA based program that measures risk is the Accident Sequence Precursor (ASP) Program. The NRC established ASP in 1979 after the TMI accident. The ASP Program systematically evaluates U.S. nuclear power plant operating experience to identify, document, and rank the operating events most likely to lead to inadequate core cooling and severe core damage (precursors), given the likelihood of additional failures.

The ASP Program provides (1) a comprehensive, risk-informed view of nuclear power plant operating experience and a measure for trending core damage risk; (2) a partial check on dominant core damage scenarios predicted by probabilistic risk assessments; and (3) provides feedback to regulatory activities. The NRC also uses the ASP Program to monitor performance against the safety goal established in the agency's strategic plan and report significant precursors to Congress.

The NRC has previously studied spent fuel pool (SFP) issues and modified licensee requirements in various areas such as an aircraft impact assessment, loss of SFP cooling, modifications to assembly configurations, and additional requirements following the attacks of September 11, 2001. As a result of the recent events in Japan, an updated SFP safety study to estimate the relative consequences of removing older fuel from the SFP and placing it into dry storage versus leaving it in the spent fuel pool is being considered.

Beyond the initial steps to address the experience from the events in Japan, the NRC staff has established a senior level agency task force to conduct a methodical and systematic review of our regulatory processes to determine whether the agency should make any improvements to our regulatory system and to make recommendations to the Commission for its policy direction. This activity will have both near-term and longer-term objectives.

For the near-term effort, we have started a 90-day review. This review will evaluate the currently available information from the Japanese events to identify immediate or near-term operational or regulatory issues potentially affecting the 104 operating reactors in the United States, including their spent fuel pools. Areas of investigation will include: the ability to protect against natural disasters; response to station blackouts; severe accidents and spent fuel accident progression; and severe accident management issues. Over this 90-day period, the task force will develop recommendations, as appropriate, for changes to inspection procedures and licensing review guidance, and recommend whether generic communications, orders, or additional regulations are needed.

This 90-day effort includes a briefing to the Commission after approximately 30 days to provide a snapshot of the regulatory response and the condition of the U.S. fleet based on information it has available at that time. This briefing, which occurred on May 12, also ensured that the Commission is both kept informed of ongoing efforts and prepared to resolve any policy recommendations that surface. However, over the 90-day and longer-term efforts the task force will seek additional stakeholder input. At the end of the 90-day period, a report will be provided to the Commission and to the public in accordance with normal Commission processes, and it will be provided to the Advisory Committee on Reactor Safeguards for its review. The task force's longer-term review will begin as soon as the NRC has sufficient technical information from the events in Japan.

The task force will evaluate all technical and policy issues related to the event to identify additional potential research, generic issues, changes to the reactor oversight process, rulemakings, and adjustments to the regulatory framework that should be pursued by the NRC. The task force is also expected to evaluate potential interagency issues, such as emergency preparedness, and examine the applicability of any lessons learned to non-operating reactors and materials licensees. The task force is expected to seek input from stakeholders during this process. A report with appropriate recommendations will be provided to the Commission within 6 months of the start of this evaluation. Both the 90-day and final reports will be made publicly available in accordance with normal Commission processes. The results of the task force, followed by the Commission's review of the report, will help define which research actions the agency will pursue in the future.

In conclusion, I want to reiterate that the NRC has a very robust research program that supports our regulatory decision making. The NRC has expertise in a multitude of technical disciplines and has performed significant research in the past related to reactors, materials, and waste. In light of the events in Japan, the NRC has initiated a near-term evaluation of the events' relevance to the U.S. nuclear power plants, and we are continuing to gather the information necessary for us to take a longer, more thorough look at the events and their lessons for us. Based on the lessons learned from these efforts, we will pursue additional regulatory actions and research, as needed, to ensure the continuing safety of the U.S. fleet.