UNITED STATES NUCLEAR REGULATORY COMMISSION ACTIONS AS A RESULT OF THE FUKUSHIMA DAI-ICHI ACCIDENT

David L. Skeen and David D. Brown, CHP

U.S. Nuclear Regulatory Commission: 11555 Rockville Pike, Mailstop O-9D02, Rockville, MD 20852 david.skeen@nrc.gov

In light of the accident at the Fukushima Dai-ichi facility on March 11, 2011, the United States Nuclear Regulatory Commission (NRC) has taken many actions to ensure the continued safe operation of U.S. nuclear power plants. These actions include: (1) the performance of inspection activities at all U.S. nuclear power plants to evaluate licensee implementation of procedures and equipment which could mitigate beyond design basis events; (2) the establishment of a Task Force which identified lessons learned which could be implemented to further enhance the safety of U.S. nuclear power plants; and (3) the commencement of a program to identify and take specific near-term and long-term regulatory actions related to these lessons learned. This paper will provide a perspective on all of these phases of the NRC's response to the Fukushima Dai-ichi accident and insights into planned, future NRC actions to address longer-term issues associated with the event.

I. INTRODUCTION

In the days following the Fukushima Dai-ichi nuclear accident in Japan, the NRC established a senior-level agency task force (the Near-Term Task Force, or NTTF) to conduct a methodical and systematic review of the NRC's processes and regulations to determine whether the agency should make additional improvements to its regulatory system and to make recommendations to the Commission for its policy direction.[1] The NTTF completed its review on July 12, 2011, and delivered a report with 12 overarching recommendations to enhance the safety of U.S. commercial nuclear power plants.[2] The purpose of this paper is to describe the immediate actions taken by the agency after the accident, even as the NTTF conducted its review, and the NRC's near-term action items and longer-term evaluations that resulted from recommendations by the NTTF, the NRC's Advisory Committee on Reactor Safeguards (ACRS), the U.S. Congress, the NRC staff, and public stakeholders.

II. NEAR-TERM EVALUATIONS

On March 18, 2011, just one week after the Great Tohoku Earthquake, the NRC issued Information Notice 2011-05, "Tohoku-Taiheiyou-Oki Earthquake Effects on Japanese Nuclear Power Plants."[3] This notice informed power reactor licensees of the effects of the earthquake so that licensees could review the information for applicability to their facilities and consider actions, as appropriate. On May 2, 2011, a similar notice, Information Notice 2011-08, "Tohoku-Taiheiyou-Oki Earthquake Effects on Japanese Nuclear Power Plants-For Fuel Cycle Facilities," was issued to fuel cycle facilities.[4]

On March 23, 2011, the NRC issued temporary instructions (TIs) to its inspectors to assess the adequacy of licensee equipment, capabilities, and strategies to respond to large area fires and explosions, station blackout events, and flooding.[5] On April 29, 2011, the NRC issued another TI that focused on determining whether severe accident management guidelines (SAMGs) are available and how they are being maintained; and to determine the nature and extent of licensee implementation of SAMG training and exercises.[6]

Finally, on May 11, 2011, the agency issued NRC Bulletin 2011-01, "Mitigating Strategies," the objective of which was to require licensees to provide a comprehensive verification of their compliance with the requirements of Title 10, Code of Federal Regulations (10 CFR) Section 50.54(hh)(2).[7] This requirement, which was added after the September 11, 2001, terrorist attacks, pertains to licensee guidance and strategies that are required to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities associated with loss of large areas of the plant due to explosions or fire. The purpose of this bulletin was to determine whether 1) additional assessment of program implementation is needed, 2) the current inspection program should be enhanced, or 3) further regulatory action is warranted.

The results of the near-term evaluations, including licensee reviews, NRC inspections, and bulletin responses, support NRC's finding that a similar sequence of events in the U.S. is unlikely, and that existing mitigation measures could reduce the likelihood of core damage and radiological release. Therefore, there is no imminent risk from continued operation and licensing activities.

However, the inspections did reveal performance issues by licensees to maintain equipment and strategies required to mitigate some design-basis and beyond-design-basis events. As a result of the second TI on SAMGs, the NRC inspectors noted that, while individually, none of the observations posed a significant safety issue, the observations indicated inconsistent implementation of some aspects of the voluntary SAMG program. For example, at some plants, SAMGs were either not available in all expected areas or not properly controlled. These and other observations were made available to the NTTF as part of its review.

III. NEAR-TERM TASK FORCE REVIEW

The NTTF's 12 overarching recommendations are summarized in Table 1. The NTTF provided recommendations for: industry action to enhance safety; NRC action to enhance its programs; and NRC longer-term evaluation.

In response to the NTTF's recommendations, the Commission directed the NRC staff to engage promptly with stakeholders to review and assess the recommendations in a comprehensive and holistic manner, and provide the Commission with fully-informed options and recommendations.[8] The Commission also asked the staff to provide 1) a draft charter for the NRC's longer-term review, and 2) two papers for its consideration. The first paper provided recommendations which the staff, in its judgment, believed should be implemented, in part or in whole, without unnecessary delay.[9] The second paper prioritized all of the NTTF recommendations.[10] The Commission also decided that Recommendation 1 should be pursued independent of any activities associated with the review of the other NTTF recommendations, and directed the staff to provide options and a staff recommendation to disposition this recommendation by February 2013.

On October 19, 2011, the Commission approved the staff's charter for the longer-term review.[11] The charter established the structure, scope, and expectations for the NRC's longer-term review. The longer-term review effort is led by a steering committee of nine senior managers, which reports to the NRC's Executive Director for Operations. The steering committee is supported by the Japan Lessons Learned Project Directorate.

TABLE 1. NTTF Recommendations

1	NRC to establish a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations
2	Require licensees to reevaluate and upgrade as necessary the design-basis seismic and flooding protection
3	Longer-term review: NRC to evaluate potential enhancements to the capability to prevent or mitigate seismically induced fires and floods
4	Require licensees to strengthen station blackout mitigation capability
5	Require licensees to install reliable hardened vents in boiling water reactor facilities with Mark I and Mark II containments
6	Longer-term review: NRC to identify insights about hydrogen control and mitigation inside containment or in other buildings
7	Require licensees to enhance spent fuel pool makeup capability and instrumentation for the spent fuel pool
8	Require licensees to strengthen and integrate onsite emergency response capabilities
9	Require licensees to ensure facility emergency plans address prolonged station blackout and multiunit events
10	Longer-term review: NRC to pursue additional emergency preparedness topics related to multiunit events and prolonged station blackout
11	Longer-term review: NRC to pursue emergency preparedness topics related to decisionmaking, radiation monitoring, and public education
12	NRC to strengthen regulatory oversight of licensee safety performance (i.e., the Reactor Oversight Process)

The charter also directed that all actions items and long-term evaluations are to be completed by the NRC line organization.

IV. PRIORITIZATION OF RECOMMENDATIONS

The staff prioritized the recommendations into three tiers, which are summarized as follows:

Tier 1. Those recommendations which the staff determined should be started without unnecessary delay and for which sufficient resource flexibility, including availability of critical skill sets, exists.

Tier 2. Those recommendations which could not be initiated in the near term due to factors that include the need for further technical assessment and alignment,

dependence on Tier 1 issues, or availability of critical skill sets.

Tier 3. Those recommendations that require further staff study to support a regulatory action, have an associated shorter-term action that needs to be completed to inform the longer-term action, are dependent on the availability of critical skill sets, or are dependent on the resolution of NTTF Recommendation 1.

IV.A. Tier 1 Action Items

The NTTF recommendations that NRC staff assessed and prioritized as Tier 1 include the following, which are listed by the type of regulatory action to be taken:

Orders

NTTF 4.2 Mitigation strategies for beyond-design-basis events
NTTF 5.1 Reliable hardened vents for Mark I and II containments
NTTF 7.1 Spent fuel pool instrumentation

Request for Information (RFI)

NTTF 2.1 Seismic and flood hazard reevaluations
NTTF 2.3 Seismic and flood walkdowns
NTTF 9.3 Emergency preparedness regulatory actions (staffing and communications)

Rulemaking

NTTF 4.1 Station blackout regulatory actions
NTTF 8 Strengthening and integrating on-site emergency response procedures

The Commission approved the Tier 1 orders and RFI on March 9, 2012.[12,13] The orders and RFI were issued to licensees and holders of construction permits on March 12, 2012.

Since establishing the longer-term review organization, the staff has held over 50 public meetings on the development of NRC regulatory products, including the draft guidance for implementation of the orders and RFI. By May 31, 2012, the NRC staff had issued draft guidance for the orders and RFI.[14-19] The schedules for implementation of the orders, and to respond to the RFI, are discussed further in Section VI.

The station blackout and on-site emergency response procedures advance notices of proposed rulemaking (ANPRs) were issued on March 20, 2012, and April 18, 2012, respectively.[20,21] The staff received a number of comments on each ANPR before the comment periods closed. The staff will consider these comments as it prepares the regulatory bases for proposed rules.

IV.B. Tier 2 Action Items

Regulatory actions that were assessed and prioritized as Tier 2 include:

Order

NTTF 9.3 Emergency preparedness regulatory actions (remaining parts of NTTF 9.3, except the Emergency Response Data System capability assessed as Tier 3) [a]

Rulemaking

NTTF 7 Spent fuel pool makeup capability (NTTF 7.2 through 7.5)

All other NTTF recommendations were assessed and prioritized as Tier 3, which is described further in Section V.

IV.C. Additional recommendations and issues

In a paper to the Commission on February 17, 2012, the staff also assessed and prioritized additional recommendations and issues that had arisen since the issuance of the NTTF's report. These issues were assessed and prioritized using the same framework that was used for the NTTF recommendations. This resulted in additional Tier 1 and Tier 2 action items and longer-term evaluations considered Tier 3, as described below.

A recommendation to assess filtration and additional performance requirements for reliable hardened containment vent systems was prioritized as Tier 1. The staff has held a number of meetings with stakeholders and the ACRS as part of its deliberations on this issue.

The staff also developed an additional Tier 1 action item to specifically address ultimate heat sink (UHS) systems in other ongoing Tier 1 action items. The other Tier 1 action items in which loss of UHS will be considered include reevaluations and walkdowns of seismic and flooding hazard protection, station blackout rulemaking, mitigating measures for loss of access to the normal UHS, and, as noted below, consideration of other natural external hazards (other than seismic and flooding) on plant systems.

The ACRS recommended that, in addition to requiring licensees to revaluate seismic and flooding hazards, the NRC should require that licensees also reevaluate other natural hazards against current requirements and guidance and update their design bases.[22] A similar requirement was included in the Consolidated Appropriations Act, 2012.[23] The staff

[a] In July 2012, the staff proposed including this Tier 2 action item among other longer-term evaluations (Tier 3) emergency preparedness in one proposed ANPR.

agrees that this recommendation would improve safety, and prioritized this action as Tier 2. As resources become available, the staff proposes to engage stakeholders on the development of a technical basis and acceptance criteria for reevaluation of external natural hazards and issue a request for information to NRC licensees.

Four additional issues were recommended for longer-term evaluation (i.e., Tier 3): 1) Reconsideration of the basis of the emergency planning zone size; 2) pre-staging of potassium iodide beyond 10 miles; 3) expedited transfer of spent fuel from spent fuel pools to dry cask storage; and 4) consideration of reactor and containment instrumentation withstanding beyond-design-basis events.

V. LONGER-TERM EVALUATIONS

On July 13, 2012, the staff provided its program plans to the Commission for the longer-term evaluations that were prioritized as Tier 3.[24] These plans are the culmination of months of effort by individual working groups led by the steering committee and Japan Lessons Learned Project Directorate. This included several public meetings and meetings with the ACRS. Table 2 lists the eleven NTTF, NRC staff and ACRS recommendations that the staff assessed and prioritized as Tier 3.

VI. FUTURE ACTIONS

The schedule for implementation of the Tier 1 orders calls for NRC staff completion of final guidance by August 31, 2012. By October 31, 2012, licensees (i.e., operating reactor licensees, and holders of combined licenses (COLs) and construction permits) are expected to provide the first of their periodic (every 6 months) updates on implementation of the orders. For operating reactors, the orders must be implemented by no later than two refueling cycles after submittal of the overall integrated plan or December 31, 2016, whichever comes first. COL holders must comply before initial fuel load, and construction permit holders must comply prior to receipt of an operating license.

The last responses to the NRC RFI on emergency preparedness staffing and communication are due October 31, 2012. Licensees are also expected to submit the results of the seismic and flooding walkdowns by the end of February 2013, with most submitting results by November 2012. The results of the walkdowns will inform the reevaluations described below.

The NRC's guidance on seismic and flooding reevaluations is scheduled to be issued by November 30, 2012. Seismic hazard reevaluations will be completed within 18 months of the issuance of the RFI for the Central and Eastern U.S. plants, and within 36 months for Western U.S. plants. The NRC prioritized the due dates for flooding hazard evaluations into one, two, and three year due dates based on the feasibility, potential hazard, and resource considerations.[25] All flooding hazard reevaluations will be completed by March 2015.

The staff will also continue Tier 1 and Tier 2 rulemaking activities on a schedule commensurate with Commission direction.

TABLE 2. Tier 3 program plans

Source	Description
NTTF 2.2	Periodic Confirmation of Seismic and Flooding Hazards
NTTF 3	Potential Enhancements to the Capability To Prevent or Mitigate Seismically Induced Fires and Floods
NTTF 5.2	Reliable Hardened Vents for Other Containment Designs
NTTF 6	Hydrogen Control and Mitigation Inside Containment or in Other Buildings
NTTF 9 – NTTF 11	Emergency Preparedness (EP) Enhancements for Prolonged SBO and Multiunit Events, Emergency Response Data System Capability, Additional EP Topics for Prolonged SBO and Multiunit Events, EP Topics for Decision-making, Radiation Monitoring, and Public Education
NTTF 12.1	Reactor Oversight Process Modifications To Reflect the Recommended Defense-in-Depth Framework
NTTF 12.2	Staff Training on Severe Accidents and Resident Inspector Training on Severe Accident Mitigation Guidelines
Staff	Basis of Emergency Planning Zone Size
Staff	Pre-staging of Potassium Iodide Beyond 10 Miles
Staff	Expedited Transfer of Spent Fuel to Dry Cask Storage
ACRS	Enhanced Reactor and Containment Instrumentation Withstanding Beyond-Design-Basis Conditions

As noted above, the staff is considering, as a Tier 1 priority action item, whether boiling-water reactor (BWR) licensees with Mark I and Mark II containments should install hardened reliable containment vents qualified for severe accident service, which includes consideration of adding filters to reduce offsite releases if the vents were to be used after core damage occurs.

The staff is also considering what new requirements may be required for other regulated facilities, such as research and test reactors, and fuel cycle facilities.

In accordance with the Consolidated Appropriations Act, 2012,[23] the NRC provided $2 million to the National

Academy of Sciences to conduct a study on "Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security at U.S. Nuclear Plants." An initial meeting of the study committee was held on July 19, 2012. The study will be completed by February 2014.

Finally, the staff also plans to undertake activities outlined in the Tier 3 program plans, in accordance with schedules set forth therein. Some of these activities will be started in FY 2013. However, many of the longer-term evaluations that were prioritized as Tier 3 are dependent on lessons learned from implementation of higher priority actions and, therefore, are not expected to start until later years.

VII. CONCLUSION

Following the accident at the Fukushima Dai-ichi nuclear power plant in March 2011, the NRC continues to take decisive regulatory action to enhance safety at U.S. nuclear power plants. The NRC continues to strive to complete the highest priority regulatory actions on a timeframe commensurate with the Commission's five-year goal.

ACKNOWLEDGEMENT

The authors are grateful for the support and diligent efforts of the staff of the U.S. NRC's Japan Lessons Learned Project Directorate.

REFERENCES

1. R. W. BORCHARDT, "Agency Task Force to Conduct Near-Term Evaluation of the Need for Agency Actions Following the Events in Japan," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, March 30, 2011, Agencywide Documents Access and Management System (ADAMS) Accession No. ML11089A050.
2. C. MILLER et al., "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, July 12, 2011, ADAMS Accession No. ML111861807.
3. U.S. NUCLEAR REGULATORY COMMISSION, NRC Information Notice 2011-05: Tohoku-Taiheiyou-Oki Earthquake Effects on Japanese Nuclear Power Plants," March 18, 2011, Washington, DC, ADAMS Accession No. ML110760432.
4. U.S. NUCLEAR REGULATORY COMMISSION, NRC Information Notice 2011-08: Tohoku-Taiheiyou-Oki Earthquake Effects on Japanese Nuclear Power Plants – For Fuel Cycle Facilities," March 31, 2011, Washington, DC, ADAMS Accession No. ML110830824.
5. U.S. NUCLEAR REGULATORY COMMISSION, NRC Inspection Manual, Temporary Instruction 2515/183, "Followup to the Fukushima Daiichi Nuclear Station Fuel Damage Event," March 23, 2011, Washington, DC, ADAMS Accession No. ML11077A007.
6. U.S. NUCLEAR REGULATORY COMMISSION, NRC Inspection Manual, Temporary Instruction 2515/184, "Availability and Readiness Inspection of Severe Accident Management Guidelines (SAMGs)," April 29, 2011, Washington, DC, ADAMS Accession No. ML11115A053.
7. U.S. NUCLEAR REGULATORY COMMISSION, Bulletin 2011-01, "Mitigating Strategies," May 11, 2011, Washington, DC, ADAMS Accession No. ML111250360.
8. A. L. BATES, "Staff Requirements – SECY-11-0093 – Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, August 19, 2011, ADAMS Accession No. ML112310021.
9. R. W. BORCHARDT, "SECY-11-0124 - Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, September 9, 2011, ADAMS Accession No. ML11245A158.
10. R. W. BORCHARDT, "SECY-11-0137 – Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, October 3, 2011, ADAMS Accession No. ML11272A111.
11. A. L. VIETTI-COOK, "Staff Requirements – SECY-11-0117 – Proposed Charter for the Longer-Term Review of Lessons Learned from the March 11, 2011, Japanese Earthquake and Tsunami," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, October 19, 2011, ADAMS Accession No. ML112920034.
12. R. W. BORCHARDT, "SECY-12-0025 – Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, October 3, 2011, ADAMS Accession No. ML12039A103.
13. A. L. VIETTI-COOK, "Staff Requirements – SECY-12-0025 - Proposed Orders and Requests for Information in Response to Lessons Learned from

Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami," U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, March 9, 2012, ADAMS Accession No. ML120690347.
14. U.S. NUCLEAR REGULATORY COMMISSION, JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Washington, DC, Draft Interim Staff Guidance, May 31, 2012, ADAMS Accession No. ML12146A014.
15. U.S. NUCLEAR REGULATORY COMMISSION, JLD-ISG-2012-02, "Compliance with Order EA-12-050, Reliable Hardened Containment Vents," Washington, DC, Draft Interim Staff Guidance, May 31, 2012, ADAMS Accession No. ML12146A371.
16. U.S. NUCLEAR REGULATORY COMMISSION, JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation," Washington, DC, Draft Interim Staff Guidance, May 31, 2012, ADAMS Accession No. ML12144A323.
17. DAVID L. SKEEN, "Endorsement of Electric Power Research Institute (EPRI) Draft Report 1025286, 'Seismic Walkdown Guidance,'" U.S. Nuclear Regulatory Commission, Washington, DC, Correspondence, May 31, 2012, ADAMS Accession No. ML12145A529.
18. DAVID L. SKEEN, "Endorsement of Nuclear Energy Institute (NEI) 12-07, 'Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features,'" U.S. Nuclear Regulatory Commission, Washington, DC, Correspondence, May 31, 2012, ADAMS Accession No. ML12144A142.
19. DAVID L. SKEEN, "U.S. Nuclear Regulatory Commission Review of NEI 12-01, 'Guideline for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities," Revision 0, Dated May 2012,'" U.S. Nuclear Regulatory Commission, Washington, DC, Correspondence, May 15, 2012, ADAMS Accession No. ML12131A043.
20. U.S. NUCLEAR REGULATORY COMMISSION, Washington, D.C., "Station Blackout," Federal Register: Vol. 77 No. 54. pp. 16175-16183. March 20, 2012.
21. U.S. NUCLEAR REGULATORY COMMISSION, Washington, D.C., "Onsite Emergency Response Capabilities," Federal Register: Vol. 77 No. 75. pp. 23161-23166. April 18, 2012.
22. SAID ABDEL-KHALIK, "Initial ACRS Review of: (1) the NRC Near-Term Task Force Report on Fukushima and (2) Staff's Recommended Actions to be Taken Without Delay," U.S. Nuclear Regulatory Commission, Advisory Committee on Reactor Safeguards, Washington, DC, Correspondence, October 13, 2011, ADAMS Accession No. ML11284A136.
23. Consolidated Appropriations Act, 2012, Pub. L 112-74, 125 Stat. 786 (2012).
24. R. W. BORCHARDT, "SECY-12-0095 – Tier 3 Program Plans and 6-Month Status Update in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Subsequent Tsunami." U.S. Nuclear Regulatory Commission, Washington, DC, Memorandum, July 13, 2012, ADAMS Accession No. ML12165A089.
25. DAVID L. SKEEN, "Prioritization of Response Due Dates for Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Flooding Hazards Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident." U.S. Nuclear Regulatory Commission, Washington, DC, Correspondence, May 11, 2012, ADAMS Accession No. ML12097A510.