

Introduction of the U.S. Nuclear Regulatory Commission's Activities to Reflect Lessons Learned from Fukushima Nuclear Accident

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1. Introduction

The combined impact of the earthquake and tsunami on the Fukushima Daiichi nuclear power plant caused a severe nuclear accident. In response to these events, the U.S. Nuclear Regulatory Commission (NRC) established the Fukushima Near-Term Task Force (NTTF) in March 2011 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].

In SECY-11-0093[2], the NTTF provided its recommendations to the Commission [3]. The staff requirements memorandum (SRM) for SECY-11-0093, dated August 19, 2011, directed the staff to recommend a prioritization of the Task Force recommendations by October 3, 2011.

In SECY-11-0137[4], the staff provided its proposed prioritization of the NTTF recommendations in SECY-11-0093 to the Commission. In SRM-SECY-11-0137, dated December 15, 2011, the Commission approved the staff's recommended prioritization, subject to direction provided in SRM-SECY-11-0124, "Staff Requirements-SECY-11-0124 Recommended Actions to be taken without Delay from the Near-Term Task Force Report," dated October 18, 2011.

In SRM-SECY-11-0117[5], dated October 19, 2011, the Commission also approved the staff's proposed "Charter for the Nuclear Regulatory Commission Steering Committee to Conduct a Longer-term Review of the Events in Japan." The Charter requires the staff to highlight potential policy issues for the Commission and provide the Commission every 6 months an update on the review work conducted under the Charter.

The recent status of NRC's activities and related program to reflect the lesson-learned from the Fukushima Daiichi nuclear power plant's severe accident are introduced in this paper.

2. The NTTF Recommendations [2]

The NTTF made 12 recommendations in 5 areas to further enhance the safety of nuclear power plants in the United States of America. These recommendations, taken together, are intended to clarify and strengthen the regulatory framework for protection against natural disasters, mitigation, and emergency preparedness, and

to improve the effectiveness of the NRC's programs. The Task Force's overarching recommendations are:

Clarifying the Regulatory Framework

1) Establishing a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations.

Ensuring Protection

2) Requiring licensees to reevaluate and upgrade as necessary the design-basis seismic and flooding protection of structures, systems, and components for each operating reactor.

3) Evaluating potential enhancements to the capability to prevent or mitigate seismically induced fires and floods, as part of the longer term review.

Enhancing Mitigation

4) Strengthening station blackout mitigation capability at all operating and new reactors for design-basis and beyond-design-basis external events.

5) Requiring reliable hardened vent designs in boiling water reactor facilities with Mark I and Mark II containments.

6) Identifying insights about hydrogen control and mitigation inside containment or in other buildings as additional information is revealed through further study of the Fukushima Daiichi accident, as part of the longer term review.

7) Enhancing spent fuel pool (SFP) makeup capability and instrumentation for the SFP.

8) Strengthening and integrating onsite emergency response capabilities such as emergency operating procedures, severe accident management guidelines, and extensive damage mitigation guidelines.

Strengthening Emergency Preparedness

9) Requiring facility emergency plans to address prolonged station blackout and multiunit events.

10) Pursuing additional emergency preparedness topics related to multiunit events and prolonged station blackout, as part of the longer term review.

11) Pursuing emergency preparedness topics related to decision-making, radiation monitoring, and public education, as part of the longer term review.

Improving the Efficiency of NRC Programs

12) Strengthening regulatory oversight of licensee safety performance (i.e., the Reactor Oversight Process (ROP) by focusing more attention on defense-in-depth requirements consistent with the recommended defense-in-depth framework.

3. Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned [4]

The NRC staff initially prioritized the NTTF recommendations based on its judgment of the potential and relative safety enhancement which could be realized by each. First, the staff considered whether any of the NTTF findings identified an imminent hazard to public health and safety. In SECY-11-0124[6], the staff identified a subset of the NTTF recommendations which should be undertaken without unnecessary delay. These are the recommendations that the staff previously concluded have the greatest potential for safety improvement in the near term, recognizing that the staff does not have sufficient resources to initiate action on all recommendations at this time.

The staff then performed an assessment of each NTTF recommendation to determine the required regulatory activities, an estimated schedule, and associated resource impacts. To further inform this process, the staff conducted a public meeting with representatives of the nuclear industry on September 21, 2011, to better understand their current plans and actions to address the lessons learned from the Fukushima Daiichi event.

As a result of the staff's prioritization and assessment process, the NTTF recommendations were prioritized into three tiers [4]:

- Tier 1
NTTF 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
NTTF 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. These actions do not require long-term study and can be initiated when sufficient technical information and applicable resources become available.
- Tier 3
NTTF 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.

3.1 Tier 1 Action Items [4]

The Tier 1 recommendations are the following:

- (1) Seismic and flood hazard reevaluations (2.1)
- (2) Seismic and flood walkdowns (2.3)
- (3) Station blackout regulatory actions (4.1)
- (4) Equipment covered under 10 CFR 50.54(hh)(2) (4.2)
- (5) Reliable hardened vents for Mark I and Mark II containments (5.1)
- (6) SFP instrumentation (7.1)
- (7) Strengthening and integration of emergency operating procedures (EOPs), severe accident management guidelines (SAMGs), and extensive damage mitigation guidelines (EDMGs) (8)
- (8) Emergency preparedness regulatory actions (staffing and communications) (9.3)

3.2 Tier 2 Action Items [4]

The Tier 2 recommendations are the following:

- (1) SFP makeup capability (7.2, 7.3, 7.4, and 7.5)
- (2) Emergency preparedness regulatory actions (the remaining portions of Recommendation 9.3, with the exception of Emergency Response Data System (ERDS) capability addressed in Tier 3)

3.3 Tier 3 Action Items [4]

The Tier 3 recommendations include all of the items identified for long-term evaluation in the NTTF report. In addition, the staff prioritized the recommendations 2.2, 9.1, 9.2, 9.3, and 12 into Tier 3. The Tier 3 recommendations are as follows:

- (1) Ten-year confirmation of seismic and flooding hazards (2.2)
- (2) Potential enhancements to the capability to prevent or mitigate seismically induced fires and floods (3)
- (3) Reliable hardened vents for other containment designs (5.2)
- (4) Hydrogen control and mitigation inside containment or in other buildings (6)
- (5) Emergency preparedness (EP) enhancements for prolonged station blackout (SBO) and multiunit events (9.1/9.2)
- (6) ERDS capability (9.3)
- (7) Additional EP topics for prolonged SBO and multiunit events (10)
- (8) EP topics for decision-making, radiation monitoring, and public education (11)
- (9) ROP modifications to reflect the recommended defense-in-depth framework (12.1)
- (10) Staff training on severe accidents, resident inspector training on SAMGs (12.2)

4. Implementation Status of Action Items [7]

4.1 Tier 1 Activities

(1) Mitigation Strategies Order EA-12-049

On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events." On August 29, 2012, the NRC staff issued interim staff guidance (ISG) JLD-ISG-2012-01, Revision 0, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events." The ISG endorses, with clarifications, the methodologies described in the Nuclear Energy Institute (NEI) 12-06, "Diverse and Flexible Coping Strategies Implementation Guide," Revision 0. Both the ISG and NEI 12-06 support implementation of the order by the Commission-directed completion date of December 2016.

By February 28, 2013, all licensees submitted their overall integrated plans (OIPs) to the NRC. To accomplish the review of the OIPs on the desired timeline, the Mitigation Strategies Directorate (MSD) was created on August 12, 2013, and it developed supplemental staff guidance for the review of beyond-design-basis external events.

The first operating units are scheduled to comply with the requirements of the Order by the fall of 2014. The NRC staff plans to conduct post-compliance inspections after all units at a site indicate that they are in compliance and an SE is issued for that site.

(2) SFP Instrumentation Order EA-12-051

On March 12, 2012, the NRC issued Order EA-12-051, "Order Modifying Licenses with Regard to Reliable SFP Instrumentation," requiring all U.S. nuclear power plants to install reliable water-level measurement instrumentation in their SFPs. On August 29, 2012, the NRC staff issued its guidance document, ISG JLD-ISG-2012-03, Revision 0, "Compliance with Order EA-12-051, Reliable SFP Instrumentation."

The NRC staff issued ISE's for all plants affected by this Order between September 23, 2013, and December 12, 2013, except for Kewaunee, Crystal River, and SONGS (due to their permanently shut down status). These ISEs included requests for additional information (RAI). Licensees are expected to provide the RAI in their 6-month status update letters as required by the terms of Order EA-12-051, but no later than 6 months before the date when full compliance is required. The licensees for the first affected units are scheduled to complete the required actions by the end of each unit's fall 2014 refueling outage, and the staff has initiated instrument vendor audits for all licensees with compliance due dates this fall. All plants will complete the Order's requirements by December 2016.

(3) Reliable Hardened Containment Vents for BWR Mark I and II Designs (Order EA-12-050 and Order EA-13-109)

The NRC issued Order EA-12-050, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents," on March 12, 2012, requiring all operating boiling-water reactors (BWRs) in the U.S. with Mark I and Mark II containments to install a reliable, hardened vent. After issuing the Order, additional NRC evaluations examined the benefits of venting *after* reactor core damage occurs. SECY-12-0157, "Consideration of Additional Requirements for Containment Venting Systems," was submitted to the Commission on November 26, 2012. In the SRM-SECY-12-0157 on March 19, 2013, the staff was directed to require licensees with Mark I and Mark II containments to "upgrade or replace the reliable hardened vents required by Order EA-12-050 with a containment venting system designed and installed to remain functional during severe accident conditions."

On June 6, 2013, the staff issued the modified Order EA-13-109, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation under Severe Accident Conditions," to ensure that those vents will remain functional in the conditions following reactor core damage.

Since the issuance of the revised Order, the staff issued the ISG for Phase 1 of Order EA-13-109 on November 14, 2013. The ISG endorses, with exceptions and clarifications, the methodologies described in NEI 13-02, Rev. 0, "Industry Guidance for Compliance with Order EA-13-109," that was prepared by NEI. The licensees are required to submit an OIP for NRC review by June 30, 2014, including a description of how compliance with Phase 1 requirements will be achieved. The staff is currently holding public meetings with the industry to develop an acceptable OIP template and resolve most foreseeable licensee questions and reduce staff RAIs through the staff's upfront involvement. The NRC staff will issue ISEs to support implementation of the Phase 1 OIPs.

The Phase 2 portion of Order EA-13-109 builds upon the Phase 1 activities and also takes advantage of studies related to the development of a regulatory basis for the accident management and filtering strategies rulemaking. The staff plans to issue the ISG for Phase 2 by April 30, 2015, barring unforeseen technical issues arising during the guidance development. Licensees are required to submit their OIPs for Phase 2 by December 31, 2015.

(4) Accident Management and Filtering Strategies Rulemaking for Boiling Water Reactors with Mark I and Mark II Containments

After issuing Order EA-12-050, "Order Modifying Licenses with Regard to Reliable Hardened Containment Vents" on March 12, 2012, additional NRC evaluations examined the benefits of venting after reactor core damage occurs. SECY-12-0157, "Consideration of Additional Requirements for Containment Venting Systems," was submitted to the Commission on November 26, 2012. In the SRM for SECY-12-0157, dated March 19, 2013, the Commission

directed the NRC staff to develop the regulatory basis and proceed with a rulemaking for filtering strategies with drywell filtration and severe accident management of BWRs with Mark I and Mark II containments. The Commission directed the staff to provide to the Commission the regulatory basis for the rulemaking on March 19, 2014, the proposed rule and draft staff guidance on March 19, 2015, and the final rule and guidance on March 19, 2017.

Since the issuance of the SRM for SECY-12-0157, the NRC staff has held several public meetings to discuss the Commission's decision and the regulatory basis for the rulemaking. The public meetings included interaction with the public on potential performance measures, probabilistic risk assessments (PRA), and accident progression event trees for the regulatory basis. Currently, the final rulemaking date is in accordance with the schedule provided in SRM-SECY-12-0157.

(5) Seismic Hazard Walkdowns

On March 12, 2012, the NRC staff asked licensees of U.S. nuclear power plants to perform a detailed inspection, or "walkdown," of their currently installed seismic and flooding protection features. Licensees were also asked to verify the current plant configuration with the current seismic licensing basis and to identify, correct, and report any degraded, non-conforming, or unanalyzed conditions. The walkdowns were completed and reports were submitted to the NRC by November 2012.

NRC resident inspectors completed the inspection requirements set forth in TI-2515/188 concurrently with the licensee's walkdown activities, and documented the inspection results in their quarterly reports. Several NRC staff assessments have been issued, and the staff continues to assess the remaining walkdown reports and RAI responses. The staff assessments are scheduled to be completed by May 2014.

Originally, some of the licensees indicated a long timeframe (beyond their next refueling outage) was needed to complete delayed walkdowns on items that were inaccessible. As a result of the staff's interactions with those licensees, the completion for the delayed walkdown items has been improved to be within a 180-day response period. The staff expects that all inaccessible items will have had walkdowns completed by the end of calendar year 2014.

(6) Flooding Hazard Walkdowns

On March 12, 2012, the NRC staff asked licensees for the U.S. nuclear power plants to perform a walkdown of their currently installed flooding protection and mitigation features, including a review of associated manual actions. The industry developed—and the NRC endorsed—NEI 12-07, "Guidelines for Performing Verification Walkdowns of Plant Protection Features," to conduct these walkdowns. The plants completed their walkdowns by November 2012 and the NRC resident inspectors completed their inspections in accordance with TI-2515/187, "Inspection of NTF Recommendation 2.3 Flooding Walkdowns," in parallel

with the performance of the walkdowns. Inspection reports for the staff walkdowns were issued by February 2013. All observations that raised current licensing-basis compliance questions were transitioned into the ROP for significance determination and resolution. The NRC staff has continued to assess each plant's walkdown report. Based on the results of the staff's flooding walkdown audits and review to date of the flooding walkdown reports, the staff requested that all licensees provide additional information regarding the available physical margin methodology. The staff expects most staff assessments to be completed by April 2014, with the timing of a few licensees' responses delaying completion of the staff's assessments until summer 2014.

(7) Seismic Hazard Reevaluations

On March 12, 2012, the NRC staff asked licensees for U.S. nuclear power plant licensees to reevaluate the seismic hazards that could impact their site using current regulations and guidance.

By September 13, 2013, licensees of nuclear plants in the Central and Eastern United States were to have submitted information related to the characterization of their sites in support of performing seismic hazard reevaluations. These submittals are being processed through document control and sensitive unclassified non-safeguards information review, and are expected to be publically available in April 2014.

As planned, if the NRC staff is unable to make a determination of the screening to perform a detailed risk evaluation, the plant will temporarily (or conditionally) screen in, while further staff-licensee interactions take place such that the staff has sufficient information to make a final determination. Until then, sites that temporarily screen in will provide an interim evaluation, and will be informed they should perform and submit the Expedited Approach by December 2014. The Expedited Approach will evaluate equipment and systems at the new seismic hazard level that are necessary for a safe shutdown following a loss of all AC power or ultimate heat sink accidents.

In May 2014, the NRC staff plans to complete the screening and prioritization, and will keep all internal stakeholders apprised of progress to the extent practical. The screening results and prioritization will be shared with applicable stakeholders prior to issuance.

(8) Flooding Hazard Reevaluations

On March 12, 2012, the NRC staff asked all U.S. power reactor licensees and holders of construction permits in active or deferred status to reevaluate the flooding hazards that could impact their site. The NRC staff will review the responses to the request for information and determine whether regulatory actions are necessary to provide additional protection against flooding.

In March 2013, the first set of plants submitted their flooding hazard reports. The second set of flooding hazard reports is due in March 2014, and the third (final) set of reports is due in March 2015. Based on the

first set of hazard submittals, several sites indicated that they will be taking interim actions (e.g., procuring sandbags or other temporary barriers) to address the reevaluated hazard if the reevaluated hazard exceeds the capability of existing flood protection or mitigation.

The NRC staff issued temporary instruction 2515/190, "Inspection of The Licensee's Proposed Interim Actions as a Result of the NTTF Recommendation 2.1 Flooding Reevaluation," to facilitate inspection of those actions.

The majority of sites indicated that they will be performing an integrated assessment following interim staff guidance JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding." The integrated assessments are due to the NRC 2 years after the submittal of the hazard reevaluation. The NRC staff is continuing to work with industry to support the development of several examples applying the new staff guidance. After the integrated assessments are received from the required plants, the staff will use existing NRR processes to document and, if appropriate, take actions based on the information received.

(9) Emergency Preparedness Staffing and Communications

On March 12, 2012, RFI letter asked licensees to assess a large-scale event that causes the loss of all AC power and might affect multiple reactors at their site. It also requested licensees to assess and implement enhancements to help ensure that communications can be maintained during such an event. All licensees submitted their communications assessments by October 31, 2012. Safety assessments were issued documenting the staff's review to each licensee by July 2013, with the exception of SONGS, which has ceased operation.

On April 30, 2013, licensees submitted their staffing assessments based on existing SBO coping strategies with an assumption of multiple reactors being affected concurrently. The NRC staff issued the Phase 1 staffing assessment response letters on October 23, 2013, for the multiunit sites except Arkansas Nuclear One (ANO), Indian Point, and SONGS. The staff intends to issue letters for ANO and Indian Point once it receives and reviews responses to a request for additional information. SONGS, Kewaunee, and Crystal River have ceased operation and notified the NRC staff of their intent to decommission, and have therefore submitted requests for relief from further responding to the obligations of the March 12, 2012, RFI letter. The staff approved these requests on January 22, 2014.

(10) Station Blackout Mitigation Strategies (SBOMS) Rulemaking

The principal objective of the NRC's SBOMS rulemaking effort would be to establish requirements, in the form of mitigation strategies, guidance, and relied-on equipment that provide additional mitigation capability for extreme external events that lead to extended loss of AC power that might also include loss of normal access to the ultimate heat sink. These requirements will reflect the requirements imposed in

Order EA-12-049, issued on March 12, 2012, along with insights gleaned from implementation of the order as well as information on external hazards from the ongoing seismic and flooding reevaluations and stakeholder feedback solicited throughout the rulemaking process.

The advanced notice of proposed rulemaking (ANPR) was published in the *Federal Register* on March 20, 2012, and the comment period on the ANPR closed on May 4, 2012.

On January 25, 2013, the staff submitted COMSECY-13-0002, "Consolidation of Japan Lessons Learned NTTF Recommendations 4 and 7 Regulatory Activities," to engage the Commission in several aspects of the rulemaking, which included combining NTTF Recommendations 4 and 7 and revising the rulemaking schedule to accommodate Commission direction to incorporate the lessons-learned from the mitigation strategies order. The Commission approved the COMSECY-13-0002 proposal on March 4, 2013.

The final SBOMS regulatory basis was issued on July 23, 2013. The Commission's approval of COMSECY-13-0002 resulted in a revised schedule for the rulemaking activity. The revised due date for the proposed rule and the supporting draft guidance is June 30, 2014. Correspondingly, the revised due date for the final rule and supporting guidance is December 27, 2016.

(11) Onsite Emergency Response Capabilities Rulemaking

The NRC's Onsite Emergency Response Capabilities rulemaking effort is expected to strengthen and integrate the various onsite emergency response capabilities at nuclear power plants. The new rule is expected to require plants to improve strategies for large-scale events to promote effective decision-making at all levels.

The new rule is also expected to include training, qualification, and evaluation requirements for the key personnel expected to implement the procedures and strategies. An ANPR was published for this rulemaking in the *Federal Register* on April 18, 2012, and the final regulatory basis was issued on October 25, 2013. The staff issued the rule language on November 11, 2013, and held a public meeting on November 19, 2013, to give the public an opportunity to ask questions about the language. The staff is now developing the proposed rule package and supporting regulatory documents.

The current SECY due date for the proposed rule and supporting guidance is July 25, 2014. The current due date for the final rule and guidance is March 11, 2016. The staff plans to issue supporting guidance for the rule that cites industry guidance currently under development by NEI. If the proposal to consolidate post-Fukushima rulemakings is approved by the Commission, the proposed rule due date to the Commission would change from July 25, 2014, to December 31, 2014; and the final rule due date would change from March 11, 2016, to December 27, 2016.

(12) Enhancements to the Capability To Prevent or Mitigate Seismically Induced Fires and Floods

It is intended to evaluate potential enhancements to the capability to prevent or mitigate seismically induced fires and floods. In SRM-SECY-11-0137, the Commission directed the staff to initiate development of a probabilistic risk assessment (PRA) methodology to evaluate potential enhancements to plants' capability to prevent or mitigate seismically induced fires and floods as part of Tier 1 activities. However, consistent with the program plan for NTTF Recommendation 3 in SECY-12-0095, carrying out the broader evaluation of potential enhancements to the capability to prevent or mitigate seismically induced fires and floods would remain a longer-term Tier 3 activity. In SECY-12-0095, the staff supplied the following schedule and milestones to address Recommendation 3 for seismically induced fires and floods:

1. Continue development of PRA methodology for seismically induced fires and floods. This will include two main subtasks:
 - a) Engagement with PRA standards development organizations to develop the technical elements and standards for the PRA method (ongoing)
 - b) Completion of a feasibility scoping study to evaluate PRA approaches for assessing multiple concurrent events (December 2015)
2. Reevaluate Recommendation 3 based on information obtained from Tier 1 activities and PRA method development activities, as well as recommend further activities (December 2016).

The staff continues engagement with the American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) Joint Committee on Nuclear Risk Management (JCNRM) to leverage external stakeholders' expertise and to better focus future method development efforts.

4.2 Tier 2 Activities

(1) Emergency Preparedness (EP)

Three items related to EP were prioritized as Tier 2. These items are:

- (a) To conduct periodic training and exercises for multi-unit and prolonged SBO scenarios and to practice (simulate) the identification and acquisition of offsite resources, to the extent possible.
- (b) To ensure that EP equipment and facilities are sufficient for dealing with multi-unit and prolonged SBO scenarios.
- (c) To add guidance to the emergency plan that documents how to perform a multi-unit dose assessment (including releases from SFPs) using the licensee's site-specific dose assessment software and approach.

Although items (a) and (b) above are being addressed through the implementation of mitigation strategies, on November 19, 2013, the NRC staff conducted a

combined public meeting with the working group for the Onsite Emergency Response Capabilities rulemaking. This meeting discussed a draft version of the NEI's guidance document NEI 13-06, "Guidance for the Closure of Tier 2 Emergency Preparedness Enhancements from the NTTF Report," which is intended to address emergency-preparedness equipment, facilities, training, drills, and multi-unit dose assessment. Additionally, on March 4, 2014, the staff conducted a combined public meeting with the consolidated rulemaking working group to discuss additional comments on the revised draft NEI 13-06 and the new draft NEI 14-01 "Emergency Response Procedures and Guidelines for Extreme Events and Severe Accidents."

In COMSECY-13-0010, "Schedule and Plans for Tier 2 Order on Emergency Preparedness for Japan Lessons Learned," dated March 27, 2013, the NRC staff informed the Commission that licensees would provide information about their current multi-unit/multi-source capability, or a schedule for implementing such capability for those licensees who do not currently have it, and that implementation of the dose-assessment capability would occur by the end of 2014. The staff has received all licensee submittals on this topic and issued a response letter to the majority of licensees, dated January 29, 2014, that acknowledges that licensees intend to have multi-unit and/or multi-source dose assessment capabilities by December 31, 2014. All response letters note that as part of the implementation of new multi-unit/multi-source dose-assessment capabilities, there is a need for an appropriate level of site procedures and training to ensure adequate integration and licensee staff familiarity, and that implementation of dose-assessment capabilities would be verified through the inspection program.

(2) Consideration of Other Natural External Hazards

The Advisory Committee on Reactor Safeguards (ACRS) recommended expanding Near Term Task Force Recommendation 2.1 to include natural external hazards other than seismic and flooding hazards in a letter dated October 13, 2011. The Consolidated Appropriations Act, Public Law 112-074, directed the NRC to require reactor licensees to reevaluate the external hazards at their sites and to require updates to their design basis, if necessary. Reevaluation of other natural external hazards was prioritized as a Tier 2 activity because of the lack of availability of the critical skill sets for both the NRC staff and external stakeholders, and because the staff considered the seismic and flooding reevaluations to be of higher priority.

The staff plans to develop and issue a request for information to licensees under the 10 CFR 50.54(f) to (1) reevaluate site-specific external natural hazards using the guidance discussed above, and (2) identify actions that have been taken, or are planned, to address plant-specific issues associated with the updated natural external hazards (including potential changes to the licensing or design basis of a plant). Licensee responses

will then be evaluated and appropriate regulatory action taken to resolve issues associated with updated site-specific natural external hazards. The NRC staff expects to begin work on this topic as soon as significant resources become available, following implementation of Tier 1 actions related to seismic and flooding hazard walkdowns and reevaluations.

4.3 Tier 3 Activities

(1) Periodic Confirmation of Seismic and Flooding Hazards

Recommendation 2.2 of the NTTF report suggests that the NRC require licensees to periodically update external hazards based on any new and significant information since the most recent reevaluation. In SECY-11-0137, the NRC staff prioritized Recommendation 2.2 as Tier 3 because it will be developed from Recommendation 2.1, “Seismic and Flooding Reevaluations,” a Tier 1 item requiring licensees to reevaluate flooding and seismic hazards using present-day methodologies and guidance. This recommendation depends on the insights gained from the seismic and flooding reevaluations and, because those evaluations are not complete, no updates are currently available to report. When sufficient insights are gained from the seismic and flooding reevaluations, the NRC staff plans to start the rulemaking process. The staff expects to first develop a technical basis and then engage stakeholders for public participation.

(2) Enhancements to the Capability To Prevent or Mitigate Seismically Induced Fires and Floods

This activity is unique in that it has a Tier 1 aspect and a Tier 3 aspect. The status update for all parts of this activity is included in Tier 1 under the same heading.

(3) Reliable Hardened Vents for Other Containment Designs; and Hydrogen Control and Mitigation Inside Containment or Other Buildings

NTTF Recommendation 5.2 stated a need was to reevaluate hardened vents for containment designs other than boiling-water reactor (BWR) Mark I and Mark II containments (which are being addressed under Tier 1). NTTF Recommendation 6 was to identify insights from Fukushima related to hydrogen control and mitigation inside containment or in other buildings, and to determine whether additional regulatory action is warranted. Additionally, the staff of the Office of Nuclear Regulatory Research is participating as a working group member in a study related to hydrogen generation, transport, and risk management organized by the Organization for Economic Co-operation and Development (OECD).

The NRC staff issued the interim staff guidance (ISG) for Phase 1 (JLD-ISG-2013-02) of Order EA-13-109 on November 14, 2013. The licensees are required to submit an OIP by June 30, 2014. Currently, the staff is holding meetings with the Nuclear Energy Institute industry group to develop an acceptable OIP template for implementation of Order EA-13-109, as well as to

continue development of a technical and regulatory basis for the accident management and filtering strategies rulemaking. The staff will evaluate existing plans for other containment designs (e.g., Mark III, ice-condenser, and large dry containments) and hydrogen control as progress is made with the Mark I and Mark II issues. Once the staff has determined that sufficient insights have been gained from the Mark I and Mark II work and other related activities, it will commence evaluation of other containment designs and hydrogen control to determine whether regulatory action is warranted for either or both activities.

(4) Activities Related to Emergency Preparedness

In SECY-12-0095, the following four Tier 3 items were included within one program plan:

- (a) EP enhancements for prolonged SBO and multi-unit events;
- (b) ERDS capability;
- (c) Additional EP topics for prolonged SBO and multi-unit events;
- (d) EP topics for decision-making, radiation monitoring, and public education.

The program plan outlined in SECY-12-0095 described an approach to collectively address these items using an ANPR. The staff still intends to take this approach for certain Tier 3 EP activities and expects to use the ANPR feedback to help determine if there is a need for rulemaking; and, if so, what its scope and content should be. The staff expects to issue the ANPR in fiscal year 2016. Several of the Tier 3 EP activities could be addressed through a proposed consolidated rulemaking effort.

(5) Reactor Oversight Process Modifications to Reflect Recommended Defense-in-Depth Framework

This lessons-learned activity originated from NTTF Recommendation 12.1 to expand the scope of the annual Reactor Oversight Process (ROP) self-assessment and biennial ROP realignment to include more fully any defense-in-depth considerations that might result from resolution of NTTF Recommendation 1. Therefore, implementation of this activity largely depends on the outcome of work on Recommendation 1, which is ongoing. However, the NRC staff is identifying and incorporating improvements to the ROP based on insights from implementing other lessons-learned activities. For example, NRC inspectors have identified areas for improvement in the inspection program—a key component of the ROP—as a result of conducting inspections to review licensee walkdowns of flooding protection features. These insights are evaluated and incorporated as part of the existing ROP self-assessment and ROP realignment processes. The staff expects that insights from additional lessons-learned activities (i.e., conducting Temporary Instructions to verify Order compliance and responses to requests for information) can be incorporated in the same manner.

(6) NRC Staff Training on Severe Accidents and Severe Accident Management Guidelines

This lessons-learned activity originated from NTF Recommendation 12.2 to enhance NRC staff training on severe accidents, including resident inspector training on SAMGs. Because the Onsite Emergency Response Capabilities rulemaking (Tier 1) is expected to require better integration of emergency procedures, including SAMGs, this activity partially depends on the final outcome of that rulemaking activity.

However, the staff is working toward implementing several potential enhancements related to severe accident training:

1. Increasing the frequency of severe accident courses, including exporting the courses to the regional offices;
2. Updating courses with lessons learned from the Fukushima accident;
3. Modifying existing qualification programs to include requirements for severe accident courses;
4. Adding SAMG courses to qualification program training;
5. Developing new, additional courses that focus on severe accidents.

The NRC staff recognizes that additional changes could be developed as a result of the ongoing State of the Art Reactor Consequence Analysis study, the Level 3 PRA study, and any future Fukushima lessons-learned insights.

(7) Basis of Emergency Planning Zone Size and Pre-Staging Potassium Iodide beyond 10 Miles

Both of these lessons-learned activities originated as “additional issues” in SECY-11-0137. The first activity involves the NRC staff evaluating the basis of the plume exposure pathway emergency planning zone (EPZ) size. In the staff’s early post-Fukushima reviews of the event, it determined that there was no immediate information to suggest that the NRC’s existing basis for EPZ size was inadequate. However, the staff decided to add this activity as an “additional issue” so that it could perform a confirmatory analysis once additional insights were gained from the ongoing Level 3 PRA study and a planned United Nations assessment of Fukushima. The staff expects it will be several years before these other activities are complete.

The second activity involves the NRC staff’s evaluation of whether potassium iodide should be pre-staged beyond the current 10-mile zone. As was the case for the EPZ activity, the staff determined in its early post-Fukushima reviews that there was no immediate information to suggest that the NRC’s existing requirements regarding potassium iodide distribution were inadequate. However, this activity was also added as an “additional issue” to allow a confirmatory analysis to be conducted based on information obtained from studies proposed by the Japanese Government. These studies are expected to take 5 to 7 years before useful data is obtained. Currently, the staff is engaged with the Nuclear Energy Agency, International Atomic Energy

Agency (IAEA), and scientific forums to actively study the impact of releases from Fukushima on public health, the use of KI, and thyroid disease.

(8) Expedited Transfer of Spent Fuel to Dry Cask Storage

On October 9, 2013, the staff provided SECY-13-0112, “Consequence Study of a Beyond-Design-Basis Earthquake Affecting the SFP for a U.S. Mark I Boiling Water Reactor” to the Commission. The purpose of the study was to help the agency determine whether accelerated transfer of spent fuel from the SFP to dry cask storage significantly reduces risks to public health and safety. The study provided consequence estimates of a hypothetical SFP accident initiated by a low-likelihood seismic event at a reference plant based on the Peach Bottom BWR Mark I SFP. On November 12, 2013, the staff provided COMSECY-13-0030, “Staff Evaluation and Recommendation for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel,” to the Commission. In COMSECY-13-0030, the NRC staff completed a regulatory analysis to determine whether additional study of this issue was warranted, after considering a broad history of NRC oversight of spent fuel storage, SFP operating experience (domestic and international), past studies of SFP safety, and the October 2013 SFP study (SECY-13-0112).

In addition, the staff considered international practices related to the transfer of spent fuel from wet to dry storage, as well as stakeholder comments received during two public meetings. The staff concluded that the expedited transfer of spent fuel to dry cask storage would provide only a minor or limited safety benefit (i.e., less than safety goal screening criteria), and that its expected implementation costs would not be justified. The staff recommended to the Commission that additional studies and further regulatory analyses of this issue not be pursued, and that this Tier 3 Japan lessons-learned activity be closed.

At this time, the NRC staff is awaiting further direction from the Commission on whether to pursue any additional activities related to expedited transfer of spent fuel to dry cask storage.

(9) Enhanced Reactor and Containment Instrumentation for Beyond-Design-Basis Conditions

During its review of the NTF recommendations in SECY-11-0124 and SECY-11-0137, the ACRS noted that Section 4.2 of the NTF report discusses how the Fukushima operators faced significant challenges in understanding the condition of the reactors, containments, and SFPs because the existing design-basis instrumentation was either lacking electrical power or providing erroneous readings. As a result, an additional recommendation was developed to address the regulatory basis for requiring reactor and containment instrumentation to be enhanced to withstand beyond-design-basis accident conditions. This activity was prioritized as Tier 3 because it requires further staff study and depends on the outcome of other lessons-learned activities. The NRC staff will continue

work with the standards development organizations to identify criteria for severe accident instrumentation, support IAEA in issuing its document on accident-monitoring instrumentation, and research collaboration with EPRI and DOE. Once the staff has accumulated sufficient knowledge and data, if a safety-significant instrumentation performance gap is identified, regulatory action will be taken through the appropriate mechanism (rulemaking, generic communication, etc.). The NRC staff plans on making a regulatory determination by December 2015.

4.4 Other Activities Not Within a Tier

(1) NTTF Recommendation 1 – Regulatory Framework

In SRM-SECY-11-0093, the Commission directed that NTTF Recommendation 1 be pursued independently of activities associated with the review of the other NTTF Recommendations. On December 6, 2013, the NRC staff sent to the Commission SECY-13-0132, “U.S. Nuclear Regulatory Commission Staff Recommendation for the Disposition of Recommendation 1 of the NTTF Report.” The SECY paper requested the Commission’s approval of the staff’s recommendation to move forward on three potential regulatory improvement activities to disposition NTTF Recommendation 1.

These potential improvement activities were developed after evaluation of the considerations underlying the NTTF’s recommendation and consideration of the Risk Management Task Force’s recommendations for power reactors, and included:

- (a) Establishing a new design-basis extension category of events and requirements and associated internal NRC guidance, policies, and procedures;
- (b) Establishing Commission expectations for defense in depth through the development of a policy statement;
- (c) Clarifying the role of voluntary industry initiatives in the NRC regulatory process.

(2) Other NRC-Regulated Facilities

In the SRM to the Chairman’s tasking memorandum COMGBJ-11-0002, “NRC Actions Following the Events in Japan,” dated March 23, 2011, the Commission directed the NRC staff to consider the applicability of lessons-learned from the event to “non-operating reactor and non-reactor facilities.”

The NRC staff has developed a process to evaluate the potential applicability of lessons-learned activities to non-power reactor facilities. The NRC staff has completed inspections at fuel cycle facilities in accordance with Temporary Instruction 2600/015, “Evaluation of Licensee Strategies for the Prevention and/or Mitigation of Emergencies at Fuel Facilities.”

The process developed to evaluate all types of non-power reactor licensees against the full scope of Fukushima lessons-learned will still be performed for fuel cycle facilities. The evaluations of each type of

facility or licensee are currently underway. The NRC staff will document the results of each evaluation and expects to present the results to the Commission, along with a proposed path forward to address any identified issues, in a paper scheduled for the fourth quarter of fiscal year (FY) 2014.

(3) National Academy of Sciences Study on Fukushima

The National Academy of Sciences (NAS) completed their work on the NRC-funded study entitled, “Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Plants.” The NAS issued the report in the third quarter of FY 2014. The report concluded that the overarching lesson learned from the 2011 Fukushima Daiichi nuclear accident is that nuclear plant licensees and their regulators must actively seek out and act on new information about hazards with the potential to affect the safety of nuclear plants [9].

(4) Comparison Study of U.S. and Japanese Regulations

In SRM-SECY-12-0110, “Consideration of Economic Consequences within the U.S. Nuclear Regulatory Framework,” dated March 20, 2013, the Commission directed the NRC staff to: (a) document its comparison of U.S. and Japanese regulatory requirements that were in effect at the time of the accident, focused on those areas most relevant to the sequence of events and accident mitigation capabilities at Fukushima; and (b) describe how those differences were factored into post-Fukushima actions taken by the NRC. The comparison study was completed in November 2013.

(5) Support of International Activities

The NRC staff continues to be actively engaged in various international activities related to the evaluation and response to lessons-learned from the Fukushima accident. The staff is participating in several working groups within the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) on efforts to better understand the accident and develop appropriate changes in nuclear power plants to improve their ability to cope with severe natural events. One of those working groups is preparing the “IAEA Fukushima Report,” which is expected to be finalized by the end of 2014.

The NRC staff is also participating in the Organization for Economic Co-operation and Development (OECD) NEA Benchmark Study of the Accident at the Fukushima Daiichi (BSAF) nuclear power station project. Additionally, the NRC staff is participating on the OECD Working Group on Analysis and Management of Accidents (WGAMA). In the past year, WGAMA has initiated three coordinated action projects with the objective of developing status reports on filtered containment venting systems (FCVS), hydrogen risk management, and SFP cooling in OECD member countries. Each of these efforts will help inform the NRC’s related lessons-learned activities.

(6) Communications Activities

The NRC staff held over 25 public meetings from

September 2013 to February 2014 related to Japan lessons-learned activities. Most of these meetings enabled wider public participation through webinars, webcasting and teleconferencing. Many of these meetings centered on guidance development or implementation issues related to Tier 1 actions.

Additionally, the NRC Steering Committee has continued to meet publicly with the industry's steering committee approximately once a month to discuss and resolve issues related to lessons-learned activities. The staff expects these meetings and interactions to continue during and after transition of oversight to the line organizations.

In the last 6 months, the Japan Lessons-Learned Project Directorate's (JLD's) strategic communications team has evaluated and implemented tools for enhancing stakeholder understanding of Japan lessons-learned activities. The team's most significant effort was posting on the public website a plain language document explaining the current water situation at Fukushima Daiichi. Additionally, the JLD has used the NRC's public blog to highlight Japan lessons-learned activities. The communications team will continue examining communication needs and developing relevant tools, with a focus on upcoming events and milestones.

5. Conclusions

A wide variety of the U.S. NRC's activities to reflect lessons learned from the Fukushima nuclear accidents was investigated. From the investigation, it was found that most of NRC's activities, based on the Fukushima Near-Term Task Force (NTTF) recommendations, are being implemented in a comprehensive and systematic manner. The NRC staff initially prioritized the NTTF recommendations based on its judgment of the potential and relative safety enhancement which could be realized by each. As a result of the staff's prioritization and assessment process, the NTTF recommendations were prioritized into three tiers (i.e., Tier 1, 2 and 3).

Tier 1 recommendations are 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 recommendations are 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 recommendations are 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.

Through the implementation of each tier activities, existing layers of defense in depth are expected to be gradually bolstered, and such a regulatory approach is much similar in the other countries [10, 11, 12, and 13].

It was also found that public meetings with representatives of the nuclear industry and the public have been frequently held, in order to better understand their current plans and actions to address the lessons learned from the Fukushima Daiichi event.

It is expected that the detail analysis of the above tier activities will be helpful to enhance the safety of domestic operating nuclear power plants.

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