Tier 3 - NTTF Recommendation 3

Purpose

The purpose of this project plan is to evaluate potential safety enhancements for seismically induced fires and floods and determine whether additional regulatory action (e.g., order, rulemaking) is needed.

NTTF Recommendation and other Direction

The Task Force recommended:

> as part of the longer term review, that the NRC evaluate potential enhancements to the capability to prevent or mitigate seismically induced fires and floods[1].

This recommendation was prioritized as Tier 3 in SECY-11-0137 because longer term staff evaluation was required to support a decision on the need for regulatory action. In the SRM to SECY-11-0137, the Commission agreed with the Tier 3 prioritization of Recommendation 3, but directed the staff to initiate a probabilistic risk assessment (PRA) methodology to evaluate potential enhancements to the capability to prevent or mitigate seismically induced fires and floods as part of Tier 1 activities. The Commission indicated that the prerequisite activity to initiate development of an appropriate PRA methodology to support this issue should be started without unnecessary delay, while the remainder of Recommendation 3 activities remained prioritized as Tier 3.

In SECY-12-0025, the staff summarized pre-planning activities necessary to develop a detailed project plan for the development of a PRA method for seismically induced fires and floods. Pre-planning activities would address several key aspects of this activity including the objectives of the methodology, intended users, stakeholder involvement, coordination with other initiatives, resource needs, and proposed schedule.

Regulations and Guidance

GDC 2, “Design Bases for Protection Against Natural Phenomena,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” requires, in part, that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

GDC 3, “Fire Protection,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” requires, in part, that fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on SSCs important to safety and that fire

[1] In the context of Recommendation 3, the term ‘seismically induced floods’ refers only to flooding events initiated by seismically induced failures internal to the reactor plant (e.g., failure of piping systems and tanks). Seismically induced floods initiated external to the plant (e.g., dam failures) are considered to be within the scope of NTTF Recommendation 2. Seismically induced fires external to the reactor plant are also considered to be outside the scope of Recommendation 3 activities. This scope is narrower than initially envisioned in SECY-12-0025, but is better aligned with other ongoing activities and avoids duplication of effort.

fighting systems be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of SSCs.

Appendix R to 10 CFR Part 50, “Fire Protection Program For Nuclear Power Facilities Operating Prior to January 1, 1979,” Section III.O, “Oil Collection System for Reactor Coolant Pump,” requires, in part, that the oil collection system be designed, engineered, and installed that there is reasonable assurance that the system will withstand a safe shutdown earthquake.

10 CFR Part 100, “Reactor Site Criteria,” Appendix A, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” was established to provide detailed criteria to evaluate the suitability of proposed sites and the suitability of the plant design basis established in consideration of the seismic and geologic characteristics of the proposed sites. Appendix A, which applies to stationary reactor site applications before January 11, 1997, provides a deterministic approach for developing the seismic plant design basis. In contrast, 10 CFR 100.23, which applies to applications on or after January 11, 1997 and is being used by new reactor applicants to develop seismic design bases, requires that uncertainties inherent in the estimates of the safe shutdown earthquake be addressed through appropriate analysis, such as probabilistic seismic hazard analysis.

NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 2.4.2, “Floods,” issued November 1975 and updated June 1978, July 1981, April 1989, and March 2007; Section 2.4.10, “Flooding Protection Requirements,” issued November 1975 and updated May 1978, July 1981, and March 2007; and Section 2.5.2, “Vibratory Ground Motion,” issued November 1975 and updated July 1981, August 1989, March 1997, and March 2007 provide general review guidance related to site characteristics and site parameters together with site-related design parameters and design characteristics associated with the ground motion response spectrum and flooding hazards.

RG 1.29, “Seismic Design Classification,” issued June 1972 and updated August 1973, February 1976, September 1978, and March 2007, describes one acceptable method for use in identifying and classifying those features of light-water-reactor (LWR) nuclear power plants that must be designed to withstand the effects of the safe-shutdown earthquake ground motion (SSE).

RG 1.59, “Design Basis Floods for Nuclear Power Plants,” issued August 1973 and updated April 1976 and August 1977, discusses the design basis floods that nuclear power plants should be designed to withstand without loss of capability for cold shutdown and maintenance thereof.

RG 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants,” issued October 1973 and updated December 1973, describes a procedure for defining the response spectra for the seismic design of nuclear power plants.

RG 1.102, “Flood Protection for Nuclear Power Plants,” issued October 1975 and updated September 1976, describes the types of acceptable flood protection for the safety-related SSCs identified in RG 1.29.

RG 1.125, “Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants,” issued March 1977 and updated October 1978 and March 2009, describes the detail and documentation of data and studies that an applicant should include in the preliminary and/or final safety analysis report (PSAR/FSAR) to support the use of physical

hydraulic model testing for predicting the performance of hydraulic structures and systems for nuclear power plants that are important to safety.

RG 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," issued February 2004 and updated March 2009, describes one acceptable approach for determining whether the technical adequacy of the PRA, in total or the parts that are used to support an application, is sufficient to provide confidence in the results, such that the PRA can be used in regulatory decision-making for light-water reactors.

Generic Letter 87-02, "Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue (USI) A-46," February 19, 1987, requested licensees to review the seismic adequacy of certain equipment in operating nuclear power plants against seismic criteria not in use when these plants were licensed.

Generic Letter 88-20, Supplement 4, "Individual Plant Examination Of External Events (IPEEE) for Severe Accident Vulnerabilities," June 28, 1991, and Supplement 5, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," September 8, 1995, requested licensees to perform an IPEEE for plant-specific severe accident vulnerabilities initiated by external events and to submit the results to the NRC.

Staff Assessment

As described in the NTTF Report, seismically induced fires have the potential to cause multiple failures of safety-related SSCs and induce separate fires in multiple locations at the site. It has also been recognized that events such as pipe ruptures (and subsequent flooding) could cause such problems in multiple locations simultaneously. Additionally, seismic events could degrade the capability of plant SSCs intended to mitigate the effects of fires and floods. Although these issues have been examined to a limited degree in the Generic Issues Program (e.g., GSI-172, "Multiple Systems Responses Program") and responses to Generic Letter (GL) 88-20, Supplement 5, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," the NTTF concluded that the staff should reevaluate the potential for common-mode failures of plant safety related SSCs as the result of seismically induced fires and floods.

The staff believes that enhancing the capability to prevent seismically induced fires and floods can be done with traditional deterministic design basis methods. However, the identification of accident sequences and complex dependencies needed to evaluate the mitigation of these events can be done more systematically through probabilistic risk assessments (PRAs). Consequently, the Commission directed the staff to develop a PRA methodology for seismically induced fires and floods as a necessary prerequisite for the implementation of NTTF Recommendation 3.

As described in SECY 12-0025, the staff has initiated activities to develop a PRA method to address seismically induced fires and floods. There are significant technical challenges associated with this effort including, but not limited to the following:

- hazard definition and characterization
    - quantification of site-specific seismically induced fire ignition frequencies
    - quantification of site-specific seismically induced flooding frequencies
    - seismic fragilities for SSCs, including fire protection components
    - treatment of uncertainties
- modeling concurrent and subsequent initiating events

- treatment of systems interactions
- human reliability analysis methodologies suitable for seismically induced hazards
- multiunit risk considerations

There are no current state-of-practice PRA methods that are capable of supporting a quantitative assessment of seismically induced fires and floods. Although the RG 1.200 regulatory positions for an acceptable approach for defining PRA technical adequacy does include consideration of seismic/fire interactions, only a qualitative assessment is needed. Specifically, RG 1.200 states that a qualitative assessment should be performed to verify that such seismically induced fires have been considered and that steps are taken to ensure that the potential risk contributions are mitigated. Current PRA standards do not specifically address seismically induced fires and floods. However, the American Society of Mechanical Engineers (ASME) and the American Nuclear Society (ANS) Joint Committee on Nuclear Risk Management recently formed a working group to investigate approaches for quantitatively addressing multiple concurrent hazards (including seismically induced fires and floods).

The issue of concurrent external hazards is closely related to several other NTTF Tier 1 recommendations associated with external hazard evaluation, seismic risk evaluation, and various plant modifications pertinent to external hazard mitigation capability. Specifically, the following orders and information requests were issued on March 12, 2012:

- EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012

- EA-12-050, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents," March 12, 2012

- EA-12-051, "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," March 12, 2012

- 10 CFR 50.54(f) Letter, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1,2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," March 12, 2012

Collectively, these activities will serve to improve the characterization of the unique external hazards for each nuclear plant site. However, these orders and information requests are likely to result in plant licensing basis changes over the next several years, some of which cannot be fully defined at this time. Therefore, in order to gain a more complete understanding of plant-specific hazards, vulnerabilities, mitigation capabilities, and potential post-Fukushima licensing basis changes, it will be necessary to monitor the progress in these Tier 1 areas before substantial resources should be dedicated to evaluation of seismically induced fires and floods.

The timing of some of these Tier 1 activities is also dependent on the results of initial evaluations and the associated NRC staff evaluation. For example, the Recommendation 2.1 hazard evaluations associated with seismic and flooding events will be implemented using a two-phase multi-year process[2]. During the first phase, licensees will complete a seismic and flooding hazard

[2] Recommendation 2.1 considers seismic and flood hazards separately and does not address seismically induced flooding.

Table1, Timeline for Tier 1 NTTF Recommendations Related to Recommendation 3

Recommendation	Activity	Priority[(1)]	Timeline	Comments
2.1, Seismic Hazard and Risk Evaluation for Central and Eastern US (CEUS) Plants	CEUS Plants Complete Seismic Hazard Evaluation	n/a	September 2013	
	CEUS Plants Complete Risk Evaluation	High	October 2016	Seismic PRA is to be performed
		Low	October 2017	Seismic PRA or Seismic Margins Analysis is to be performed
2.1, Seismic Hazard and Risk Evaluation for Western US (WES) Plants	Western US Plant Complete Seismic Hazard Evaluation	n/a	March 2015	
	WUS Plants Complete Risk Evaluation	High	April 2018	Seismic PRA is to be performed
		Low	April 2019	Seismic PRA or Seismic Margins Analysis is to be performed
2.1, Flooding Hazard Evaluation	Complete Flooding Hazard Reevaluation Report	Variable	March 2013 – March 2015	If higher flooding hazards relative to the design basis are identified, licensees to also provide interim evaluation and actions taken or planned to address the higher flooding hazard.
	Flooding Integrated Assessment Report	Variable	March 2015 – March 2017	Only required if higher flooding hazards relative to the design basis are identified
2.3, Seismic and Flooding Walkdowns	Complete walkdowns	n/a	February 2013	Assumes walkdown procedures issued in August 2012 (does not include inaccessible areas)
4.2 Mitigation Strategies for Beyond Design Basis External Events	Integrated Plan	n/a	February 2013	Addresses requirements for maintaining or restoring core cooling, containment and spent fuel pool (SFP) cooling using installed equipment or resources, using portable onsite equipment and consumables, and offsite equipment. Requires providing sufficient, portable, onsite equipment and consumables, and offsite resources.
	Full implementation		No later than December 31, 2016	
5.1, Hardened Containment Vents	Integrated Plan	n/a	February 2013	Requires reliable hardened vent to remove decay heat and maintain control of containment pressure for BWR Mark 1 and Mark 2 containments
	Full implementation		No later than December 31, 2016	
7.1, Reliable Spent Fuel Instrumentation	Integrated Plan	n/a	February 2013	Requires reliable indication of the water level in spent fuel storage pools
	Full implementation		No later than December 31, 2016	

(1) The strategy for screening and prioritizing the site-specific seismic hazard (Recommendation 2.1) is currently under development. Once finalized, the prioritization strategy will be used to determine if a seismic margins analysis or a seismic PRA is needed to support the seismic risk evaluation.

evaluation and perform a risk evaluation, if necessary. During the second phase, the staff will determine if additional regulatory actions are necessary (e.g., changes to the design and licensing basis) based on the results of the first phase. Based on the summary timeline provided in Table 1, substantially new information from licensees on flooding assessments (e.g., submittal of integrated flooding assessment report) will not be available until 2015. Similarly, new seismic risk evaluations for high priority plants in the central and eastern US will not be available until 2016. As stated in SECY 12-0025, the staff anticipates collecting sufficient information to make a regulatory decision for most plants by 2017. Although the Recommendation 2.3 seismic and flooding walkdown results may be available in early 2013, this information will need to be evaluated within the context of the associated plant-specific external hazards. The timeline for full implementation of the orders related to beyond design basis mitigation equipment (Recommendation 4.2), hardened vents (Recommendation 5.1), and spent fuel instrumentation (Recommendation 7.1) will be completed no later than December 31, 2016. Although activities associated with Recommendations 2.1 and 2.3 will be most relevant to resolution of Recommendation 3, design and licensing basis changes associated with beyond design basis external hazard mitigation equipment, BWR venting capability, and spent fuel pool instrumentation have the potential to impact plant-specific responses to seismically induced fires and flooding. Therefore, the staff believes that information needed to support a thorough evaluation of the Tier 3 issue for seismically induced fires and floods will not be available until the [ ] time frame.

A complete evaluation of seismically induced fires and floods requires technical staff with significant expertise in the areas of seismic hazard evaluation, fire protection, flooding evaluation, and accident analysis. Additionally, development of a supporting PRA method requires staff with experience in seismic, fire, and flooding PRA methods. These technical areas represent critical skill sets within the staff and the availability of resources within this area is limited. Currently, staff with the requisite expertise are engaged in other higher priority work such as NFPA 805 licensing review and implementation support, external hazard Standardized Plant Analysis Risk (SPAR) model development, and the resolution of other Tier 1 and Tier 2 NTTF recommendations. Similarly, available contractors capable of supporting this work are also engaged in higher priority work activities. Therefore, staffing and contractor availability to address NTTF Recommendation 3 will be very limited over the next four years.

Staff Plan for Addressing NTTF Recommendation 3

Because of staffing limitations and that significant plant-specific information related to seismic and flooding hazard evaluations will not be received for several years, the staff intends to complete the evaluation of NTTF Recommendation 3 in [ ]. However, the staff also believes that some supporting information to facilitate this evaluation can be developed during the next several years. The staff proposes to engage in the following activities during FY[ ] through FY[ ] to address NTTF Recommendation 3:

- Initiate the development of a PRA methodology for addressing seismically induced fires and floods. A detailed plan for developing this method is described in SECY 12-0025, Enclosure 8. It should be noted that the staff has limited resources available to support new fire and external hazard PRA activities. Therefore, until sufficient information is obtained from ongoing activities supporting NTTF Recommendation 2.1, 2.3, and 4.2, the staff plans to dedicate resources to this method development activity at a level that will not preclude accomplishment of other high priority work in the fire and external hazard area (e.g., development of new NFPA-805 fire and external hazard Standardized Plant Analysis Risk models). The staff plans to focus method development activites in two areas:

  - Coordination with standards development organizations (e.g., ASME and ANS) and developing more generalized approaches for assessing concurrent hazards. This will help identify the technical elements and associated high level and supporting requirements for a suitable PRA method, and will suggest specific areas where detailed guidance is needed.
  - Perform a feasibility scoping study to identify issues associated with the risk assessment of multiple concurrent hazards and evaluate available PRA methods within this context. This study would provide information regarding the capabilities of traditional and advanced risk assessment methods (e.g., linked event tree-fault tree, dynamic simulation-based approaches) for accident scenarios where issues such as event timing, dependencies, and concurrency can influence risk significance. This study would also include an evaluation of the current state-of-the-art for addressing seismically induced fires and floods and, more generally, concurrent hazards.

- Once sufficient information has been obtained from the Tier 1 activities identified in Table 1, the staff will re-evaluate NTTF Recommendation 3. This evaluation will be based on experience gained in developing a PRA methodology for seismically induced fires and floods and insights derived from Recommendation 2.1, 2.3, and 4.2 activities. It is expected that this re-evaluation will result in one of the following outcomes (along with the supporting technical and regulatory basis):

  - Recommendation for regulatory action (e.g., rulemaking, order);
  - Recommendation for no regulatory action; or
  - Recommendation for further research to support future regulatory decision-making.

- The staff noted that the initial basis for identifying this Tier 3 Recommendation was associated with the limited ability of the NTTF to fully assess the basis for closure of GSI-172, “Multiple System Responses Program,” due to variability or omission of critical information in the IPEEE submittals and the NTTF schedule to complete their activities. The staff considered performing a near-term activity to re-evaluate the basis for closure of GSI-172, but concluded that this historical review would add limited value toward the future safety of the nuclear power plant fleet. Additionally, given the potential for design and licensing basis changes to address external hazards over the next several years, it is likely that this historical information would no longer represent the as-built, as-operated nuclear plant fleet. Therefore, the staff does not plan to review of the closure of GSI-172 in order to allow these resources to be utilized for higher priority work.

Staff Recommendation

The staff recommends that the Commission approve this plan for addressing NTTF Recommendation 3.

Schedule and Milestones

- Continue development of PRA methodology for seismically induced fires and floods as described. This will include two main subtasks:
  - Engagement with PRA standards development organizations to develop the technical elements and requirements for the PRA method (ongoing); and

    - Completion of a feasibility scoping study to evaluate PRA approaches for assessing multiple concurrent events
- Re-evaluation of Recommendation 3 based on information obtained from Tier 1 activities and PRA method development activities and provide recommendation for further activities