

The response to Fukushima Daiichi in the United States

By E. Michael Blake

The kind of natural disaster that caused the accident at Fukushima Daiichi is not considered plausible in the vicinity of any nuclear power plant in the United States, but the events that occurred in Japan on and after March 11, 2011, prompted the Nuclear Regulatory Commission and power reactor licensees to look more closely at long-standing policies and assumptions related to external events. A consensus has emerged that some modifications to equipment and procedures are warranted, but there is some disagreement between the NRC and the industry over how extensive such changes should be and how soon they should be made.

Essentially all of the responses to Fukushima Daiichi arise from the report by the NRC's Near-Term Task Force, *Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Daiichi Accident*, issued in July 2011. Apart from laws and formal regulations, this may be the single most influential document in the NRC's history, with the agency's subsequent actions either addressing the report's 12 recommendations and its more detailed subtasks or aiming to achieve effects considered to be in the spirit of the recommendations and subtasks. Some of the recommendations have already led to a great deal of work on the part of staffers and licensees. Others, requiring rulemaking, are still in the early stages. And the one that was listed first in the report is just now being addressed for the first time. This is in keeping with the commissioners' directive in late 2011 that

The recommendations of the Near-Term Task Force are in various stages of implementation by the Nuclear Regulatory Commission and its licensees.

priorities be set for the recommendations to emphasize the work that is considered most vital and to conserve NRC resources.

What follows is an overview of the response to Fukushima Daiichi in the United States, based on the recommendations and subtasks from the Near-Term Task Force report. (To reduce repetition, the word "recommendation" is replaced by the letter R for designations such as R1, R2, etc.)

Recommendation I

The Task Force recommends establishing a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations.

R1 is essentially an assertion that NRC regulations are a "patchwork" of regulatory requirements and safety initiatives based on decades of modifications to the agency's inheritance from the Atomic Energy Commission, and that the public would be better served by a new framework established from the ground up. A new framework could eliminate duplications and contradictions and make better use of the accumulation of knowledge of nuclear science and technology.

The commissioners were taken aback by this assertion and directed the staff to take some time to figure out how to proceed. The agency is just now developing a path forward. At a meeting with the commissioners



on January 10, the staff proposed three "improvement activities":

- Create a "design-basis extension" category of events, requirements, and internal NRC guidance, with the latter specifying how to write design-basis extension requirements in a consistent, logical, and complete manner and the need to address points such as performance goals and change processes.
- Develop a policy statement regarding the agency's expectations for defense-in-depth. This would include definitions, objectives,

and principles; implementation guidance, including decision criteria to ensure the adequacy of defense-in-depth; and conforming guidance to ensure the integration of defense-in-depth with risk.

■ Clarify the role of voluntary industry initiatives in the NRC's regulatory process by specifying when these initiatives can be credited and providing guidance regarding the type and level of licensee documentation and NRC oversight that would be appropriate for future industry initiatives.

The staff has projected that these activities will be pursued from now through fiscal year 2018.

Recommendation 2

The Task Force recommends that the NRC require licensees to reevaluate and upgrade, as necessary, the design-basis seismic and flooding protection of structures, systems, and components for each operating reactor.

To date, there has been more activity on the part of staffers and licensees related to R2 than on any other recommendation. In response to a request for information (three of which were issued in March 2012, along with three orders addressing other tasks), flooding- and seismic-related walkdowns were carried out at every licensed reactor in order to generate a knowledge base and, in effect, determine how well the reactors would endure external events. In general, the results of the walkdowns could not confirm that plant conditions, equipment, and procedures are sufficient in terms of satisfying the staff's vision of R2 compliance. The next step is an integrated assessment, which is a much more detailed licensee study of what does not measure up and what must be done to meet the NRC's ideal. It appears likely that the NRC will request such an assessment for most, or perhaps all, power reactors.

The flooding portion of the R2 effort is farther advanced than the seismic portion, which requires the services of a relatively small pool of suitably qualified consultant geologists. In August 2013, the NRC stated that all licensees had submitted letters stating whether they would use NRC guidance to reassess seismic hazards or adopt an alternative approach. One such alternative, developed by the Electric Power Research Institute, was endorsed by the NRC in February 2013, but soon after, the staff stated that some seismic walkdown reports did not appear to follow the EPRI guidance.

The three tasks included in R2 refer to both seismic and flooding hazards, but the flooding work and the seismic work are different activities, so references to tasks 2.1 (reevaluations) and 2.3 (walkdowns) must be identified as either seismic- or flooding-related activities. The commissioners have placed task 2.2, rulemaking for 10-year hazard reassessment, in Tier 3, the group of tasks with the least-urgent priority.

Recommendation 3

The Task Force recommends, 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.

R3 has also been placed in Tier 3, and the report's authors clearly expected, as indicated by their use of the phrase "as part of the longer-term review," that this would not be an immediate effort. Some of the work for R2 that is being done now (and will be done later as more seismic information is collected) will feed into the actions that are ultimately taken to address R3.

Recommendation 4

The Task Force recommends that the NRC strengthen station blackout mitigation capability at all operating and new reactors for design-basis and beyond-design-basis external events.

R4 is in Tier 1, and task 4.2 was the focus of one of the three orders issued by the NRC in March 2012. For the most part, the NRC accepts the Nuclear Energy Institute's FLEX strategy for the storage and deployment of equipment and materials—to be warehoused in Memphis, Tenn., and Phoenix, Ariz.—that would be made available to licensees to bolster their response to extreme external events. As the NRC staff has stated in its evaluations of plant compliance, "stakeholder input influenced the NRC staff to pursue a more performance-based approach" than that initially specified in R4.

Task 4.1 is for rulemaking that would, among other things, require all reactors to cope with the loss of all alternating current power for at least eight hours and to provide for extended coping time of at least 72 hours through the use of extra resources and operator actions. The proposed rule has not yet been published for comment, and a final rule is not expected to go into effect until 2016 at the earliest.

Recommendation 5

The Task Force recommends requiring reliable hardened vent designs in boiling water reactor facilities with Mark I and Mark II containments.

R5 was the subject of another March 2012 order, which was revised in June 2013 to require licensees to ensure that their venting systems can withstand severe accident conditions and can be operated safely even if the reactor core is damaged. The NRC staff had also sought to require external filters

(rather than just filtration through the suppression pool), but the commissioners instead directed the staff to develop a technical basis for vent filtration by March of this year and a proposed rule on filtration strategies by March 2015.

To some extent, the NRC uses interim staff guidance (ISG) documents to regulate under changed conditions, before the same principles are put through the rulemaking process and become requirements. Hence the term "interim." (This has an odd effect on semantics: Once an ISG is modified to adopt public comment on the draft version, the document becomes "final interim staff guidance.")

The NRC has completed the final ISG on compliance with the June 2013 order; at this writing, it had not yet been published in the *Federal Register*. The ISG endorses, with clarifications, industry guidance in NEI 13-02.

Recommendation 6

The Task Force recommends, as part of the longer-term review, that the NRC identify 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.

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While the tsunami caused the Fukushima Daiichi accident, the hydrogen explosions may have had the most significant impact in terms of interfering with recovery efforts. Hydrogen control, however, has been a concern in the United States since the accident at Three Mile Island-2 in 1979, and because "further study" of Fukushima could go on indefinitely, the ongoing hydrogen-control efforts of the NRC and its licensees have not been noticeably altered by R6.

Recommendation 7

The Task Force recommends enhancing spent fuel pool makeup capability and instrumentation for the spent fuel pool.

Spent fuel pool instrumentation was the subject of a March 2012 order, and licensees have either shown that their installed equipment is sufficient or have begun the process of upgrading it. Tasks related to makeup water are being treated in rulemaking. In No-

vember 2011, the Natural Resources Defense Council, an environmental group, petitioned for safety-related power for the makeup system, one train of on-site emergency electrical power available to support the pool whenever it contains irradiated fuel, and a seismically qualified spray system with an accessible connection to an outside power source. In July 2013, the NRC stated that these points would be considered in the rulemaking.

Recommendation 8

The Task Force recommends strengthening and integrating on-site emergency response capabilities such as emergency operating procedures, severe accident management guidelines, and extensive damage mitigation guidelines.

This recommendation is to be carried out through rulemaking, although there is some overlap between R8 tasks and those of other recommendations. While R8 is in the high-priority Tier 1, the development process for rule language may allow for the results of other tasks to be used in the rulemaking to avoid duplication of effort and to achieve coherence. As with the other Tier 1 rules, this work may lead to a final rule by early 2016.

Recommendation 9

The Task Force recommends that the NRC require that facility emergency plans address

prolonged station blackout and multiunit events.

Parts of R9, including wide-ranging task 9.3, have been spread across all three tiers. Also, the NRC determined last spring that licensee work in response to the R4 order is already addressing areas such as training and exercises for multiunit plants, prolonged station blackout, and equipment and facilities for emergency preparedness (such as through FLEX), and so the staff decided not to issue an order that had been under development.

Recommendation 10

The Task Force recommends, as part of the longer-term review, that the NRC pursue additional emergency preparedness topics related to multiunit events and prolonged station blackout.

To the extent that work under R10 will actually be needed, it will be developed after work has been carried out in areas such as R4 and R9. Because it depends on the completion of other tasks, R10 is in Tier 3.

Recommendation 11

The Task Force recommends, as part of the longer-term review, that the NRC should pursue emergency preparedness topics related to decision making, radiation monitoring, and public education.

As with R10, this is an effort that will de-

pend on the results from other tasks, mainly from R9, and it is also in Tier 3.

Recommendation 12

The Task Force recommends that the NRC strengthen regulatory oversight of licensee safety performance (the Reactor Oversight Process) by focusing more attention on defense-in-depth requirements consistent with the recommended defense-in-depth framework.

One of the two tasks in R12, expanding the scope of the Reactor Oversight Process, will be addressed only after the commissioners decide what to do with R1. The other task, on enhancing the training of NRC personnel on severe accident mitigation guidelines, must await the completion of R8. And so, even though the task force did not state this as part of the “longer-term review,” the commissioners placed R12 in Tier 3.

It is worth noting that the task force endorsed the certification and licensing of two new reactor models, Westinghouse’s AP1000 and GE Hitachi’s ESBWR, and that post-Fukushima work on these models has been minimal. Also, no specific mention was made of small modular reactors, which at the time the report was written were still in the early stages of development. It is clear, however, that lessons learned from the Fukushima Daiichi accident will factor into all new reactor development, in the United States and elsewhere. **■**