

# RECOMMENDATIONS FOR ENHANCING REACTOR SAFETY IN THE 21<sup>ST</sup> CENTURY

THE NEAR-TERM TASK FORCE  
REVIEW OF INSIGHTS FROM THE  
**FUKUSHIMA DAI-ICHI ACCIDENT**



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REVIEW OF INSIGHTS FROM THE  
FUKUSHIMA DAI-ICHI ACCIDENT

JULY 12, 2011

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## DEDICATION

This report is dedicated to the people of Japan and especially to those who have responded heroically to the nuclear accident at Fukushima. It is the fervent hope of the Near-Term Task Force that their hardships and losses may never be repeated.

Throughout its tenure, the Near-Term Task Force has been inspired by the strength and resilience of the Japanese people in the face of the inconceivable losses of family and property inflicted by the Great East Japan Earthquake and tsunami of 2011 and exacerbated by the ongoing radioactive releases from the Fukushima Dai-ichi Nuclear Power Plant. The heroes of Fukushima shouldered the emotional impacts of the devastation around them and labored on in the dark, through the rubble, with increasing levels of radiation and contamination. They undertook great efforts to obtain power and cooling to prevent the unthinkable from occurring. The outcome—no fatalities and the expectation of no significant radiological health effects—is a tribute to their efforts, their valor, and their resolve. It is our strong desire and our goal to take the necessary steps to assure that the result of our labors will help prevent the need for a repetition of theirs.

## ACKNOWLEDGMENT

Over the past 4 months, the Near-Term Task Force has devoted many long hours and an extensive amount of thought, deliberation, and collaboration to produce this report. The recommendations presented herein will likely require the same by those who will make decisions as to whether they should be endorsed or not. That is as it should be. The Task Force members comprise over 135 years of regulatory experience as a collective body. I have valued greatly their wisdom and dedication in completing this task. It has been my privilege to serve as their leader. So to:

Amy Cabbage  
Cynthia Davidson  
Dan Dorman  
Jack Grobe  
Gary Holahan  
Nathan Sanfilippo

I say thank you,  
Dr. Charles L. Miller

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## EXECUTIVE SUMMARY

The Near-Term Task Force was established in response to Commission direction to conduct a systematic and methodical review of U.S. Nuclear Regulatory Commission 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, in light of the accident at the Fukushima Dai-ichi Nuclear Power Plant. The Task Force appreciates that an accident involving core damage and uncontrolled release of radioactive material to the environment, even one without significant health consequences, is inherently unacceptable. The Task Force also recognizes that there likely will be more than 100 nuclear power plants operating throughout the United States for decades to come. The Task Force developed its recommendations in full recognition of this environment.

In examining the Fukushima Dai-ichi accident for insights for reactors in the United States, the Task Force addressed protecting against accidents resulting from natural phenomena, mitigating the consequences of such accidents, and ensuring emergency preparedness.

The accident in Japan was caused by a natural event (i.e., tsunami) which was far more severe than the design basis for the Fukushima Dai-ichi Nuclear Power Plant. As part of its undertaking, the Task Force studied the manner in which the NRC has historically required protection from natural phenomena and how the NRC has addressed events that exceed the current design basis for plants in the United States.

In general, the Task Force found that the current NRC regulatory approach includes:

- requirements for design-basis events with protection and mitigation features controlled through specific regulations or the general design criteria (Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, “Domestic Licensing of Production and Utilization Facilities,” Appendix A, “General Design Criteria for Nuclear Power Plants”)
- requirements for some “beyond-design-basis” events through specific regulations (e.g., station blackout, large fires, and explosions)
- voluntary industry initiatives to address severe accident features, strategies, and guidelines for operating reactors

This regulatory approach, established and supplemented piece-by-piece over the decades, has addressed many safety concerns and issues, using the best information and techniques available at the time. The result is a patchwork of regulatory requirements and other safety initiatives, all important, but not all given equivalent consideration and treatment by licensees or during NRC technical review and inspection. Consistent with the NRC’s organizational value of excellence, the Task Force believes that improving the NRC’s regulatory framework is an appropriate, realistic, and achievable goal.

The current regulatory approach, and more importantly, the resultant plant capabilities allow the Task Force to conclude that a sequence of events like the Fukushima accident is unlikely to occur in the United States and some appropriate mitigation measures have been implemented, reducing the likelihood of core damage and radiological releases. Therefore, continued operation and continued licensing activities do not pose an imminent risk to public health and safety.

However, the Task Force also concludes that a more balanced application of the Commission’s defense-in-depth philosophy using risk insights would provide an enhanced

regulatory framework that is logical, systematic, coherent, and better understood. Such a framework would support appropriate requirements for increased capability to address events of low likelihood and high consequence, thus significantly enhancing safety. Excellence in regulation demands that the Task Force provide the Commission with its best insights and vision for an improved regulatory framework.

The Task Force finds that the Commission's longstanding defense-in-depth philosophy, supported and modified as necessary by state-of-the-art probabilistic risk assessment techniques, should continue to serve as the primary organizing principle of its regulatory framework. The Task Force concludes that the application of the defense-in-depth philosophy can be strengthened by including explicit requirements for beyond-design-basis events.

Many of the elements of such a regulatory framework already exist in the form of rules regarding station blackout, anticipated transient without scram, maintenance, combustible gas control, aircraft impact assessment, beyond-design-basis fires and explosions, and alternative treatment. Other elements, such as severe accident management guidelines, exist in voluntary industry initiatives. The Task Force has concluded that a collection of such "extended design-basis" requirements, with an appropriate set of quality or special treatment standards, should be established.

The Task Force further sees this approach, if implemented, as a more comprehensive and systematic application of defense-in-depth to NRC requirements for providing "adequate protection" of public health and safety. Implementation of this concept would require strong Commission support for a clear policy statement, rule changes, and revised staff guidance.

The Task Force notes that, after the attacks of September 11, 2001, the Commission established new security requirements on the basis of adequate protection. These new requirements did not result from any immediate or imminent threat to NRC-licensed facilities, but rather from new insights regarding potential security events. The Task Force concluded that the Fukushima Dai-ichi accident similarly provides new insights regarding low-likelihood, high-consequence events that warrant enhancements to defense-in-depth on the basis of redefining the level of protection that is regarded as adequate. The Task Force recommendation for an enhanced regulatory framework is intended to establish a coherent and transparent basis for treatment of the Fukushima insights. It is also intended to provide lasting direction to the staff regarding a consistent decisionmaking framework for future issues.

The Task Force has considered industry initiatives in this framework and sees that these could play a useful and valuable role. The Task Force believes that voluntary industry initiatives should not serve as a substitute for regulatory requirements but as a mechanism for facilitating and standardizing implementation of such requirements.

The Task Force applied this conceptual framework during its deliberations. The result is a set of recommendations that take a balanced approach to defense-in-depth as applied to low-likelihood, high-consequence events such as prolonged station blackout resulting from severe natural phenomena. 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. The Task Force recommends establishing a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations. (Section 3)

### ***Ensuring Protection***

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. (Section 4.1.1)
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. (Section 4.1.2)

### ***Enhancing Mitigation***

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. (Section 4.2.1)
5. The Task Force recommends requiring reliable hardened vent designs in boiling water reactor facilities with Mark I and Mark II containments. (Section 4.2.2)
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 Dai-ichi accident. (Section 4.2.3)
7. The Task Force recommends enhancing spent fuel pool makeup capability and instrumentation for the spent fuel pool. (Section 4.2.4)
8. The Task Force recommends strengthening and integrating onsite emergency response capabilities such as emergency operating procedures, severe accident management guidelines, and extensive damage mitigation guidelines. (Section 4.2.5)

### ***Strengthening Emergency Preparedness***

9. The Task Force recommends that the NRC require that facility emergency plans address prolonged station blackout and multiunit events. (Section 4.3.1)
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. (Section 4.3.1)
11. The Task Force recommends, as part of the longer term review, that the NRC should pursue emergency preparedness topics related to decisionmaking, radiation monitoring, and public education. (Section 4.3.2)

### ***Improving the Efficiency of NRC Programs***

12. The Task Force recommends that the NRC strengthen regulatory oversight of licensee safety performance (i.e., the Reactor Oversight Process) by focusing more attention on defense-in-depth requirements consistent with the recommended defense-in-depth framework. (Section 5.1)

The Task Force presents further details on its recommendations in this report and an implementation strategy in Appendix A. The strategy includes several rulemaking activities to establish new requirements. Recognizing that rulemaking and subsequent implementation typically take several years to accomplish, the Task Force recommends interim actions to enhance protection, mitigation, and preparedness while the rulemaking activities are conducted.

These recommendations are based on the best available information regarding the Fukushima Dai-ichi accident and a review of relevant NRC requirements and programs. The Task Force concludes that these are a reasonable set of actions to enhance U.S. reactor safety in the 21<sup>st</sup> century.