POLICY ISSUE
INFORMATION

February 28, 2014 SECY-14-0027

FOR: The Commissioners

FROM: James T. Wiggins, Director
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SUBJECT: REVIEW OF ANALYSIS CODES USED DURING THE FUKUSHIMA INCIDENT

PURPOSE:

This memorandum provides the Commission with information on the staff's review of lessons learned and analyses regarding the use of codes during the Fukushima incident in Japan. This paper does not address any new commitments or resource implications.

BACKGROUND:

In SRM-SECY-12-0092, "State-of-the-Art Reactor Consequence Analyses (SOARCA)—Recommendation for Limited Additional Analyses" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12341A349), the Commission directed the staff to provide it with an information paper on its complete review of lessons learned and analyses with regard to use of codes during the Fukushima incident, and to explain in detail how this performance obviates the need for the rapid analysis tool described in SECY-05-0233, "Plan for Developing State-of-the-Art Reactor Consequence Analyses (SOARCA)" (ADAMS Accession No. ML11228A232).

The U.S. Nuclear Regulatory Commission's (NRC's) Japan Incident Response After Action Report (ADAMS Accession No. ML112580203) provides a broad, agencywide assessment of the NRC's response to the Fukushima Dai-ichi incident in Japan over the 9-week period from March 11 to May 16, 2011. The purpose of the NRC response team's efforts during the Fukushima incident was to assist the response by trying to understand the incident, predict plant

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response and suggest corrective actions, assess Japanese protective actions, and make recommendations for protection of United States (U.S.) citizens in Japan. The NRC used its technical expertise, including its analytic codes, to support the U.S. team's response.

Radiological Assessment System for Consequence Analysis (RASCAL) was the main code used by the NRC in support of its Fukushima response activities and is the focus of this paper. The NRC also used the results of SOARCA based on the MELCOR accident progression analysis to develop a source term estimate. The SOARCA analysis for the Peach Bottom Atomic Power Station was used because it is a boiling-water reactor with a Mark I containment, the same class of plant as the Fukushima units. However, this additional assessment was of limited use because information about the Fukushima plants was difficult to obtain during the incident. Given the limited nature and use of MELCOR during the Fukushima incident, MELCOR is not discussed in detail in this paper.

DISCUSSION:

NRC Incident Response

A primary goal of the NRC during a response to a radiological incident within the U.S. is to evaluate the adequacy of the licensee's Protective Action Recommendations and to monitor and, if requested, provide assistance to State and local officials in their evaluation of Protective Actions. To perform this function, the NRC uses a suite of analytical codes, supplemented by technical analysis and coordination with other Federal partners.

The NRC's primary analysis code for incident response, RASCAL, was designed to predict where evacuation or sheltering might be needed for radiological incidents at U.S. facilities prior to the availability of field measurements. RASCAL models an incident's release pathways and atmospheric dispersion to estimate radiological doses to persons downwind of the facility. The U.S. Department of Energy's National Atmospheric Release Advisory Center (NARAC) provides additional support by importing RASCAL source terms to provide short- and long-range high-resolution plume modeling. For events in the U.S., the Emergency Response Data System (ERDS) would be a source of input data to RASCAL that enables the code to more accurately assess ongoing events. In the unlikely case that ERDS is not available for an incident involving a U.S. plant, staff is also able to obtain data directly from the licensee through the Emergency Notification System communicator. Assessment of a potential radiological release with RASCAL provides the NRC with a reliable, rapid prediction to inform recommendations regarding protection of public health and safety.

Enhancements to RASCAL after the Fukushima Incident

The Fukushima event presented many challenges to NRC responders regarding how to best utilize the RASCAL code. RASCAL was primarily designed to analyze incidents at U.S. facilities where verifiable data would be readily available to the NRC. Because of the lack of verifiable data from the Fukushima Dai-ichi site, many assumptions were made about source-term input parameters, such as core damage, leak rates, and release pathways, needed for RASCAL dose calculations.

The Incident Response After Action Report included feedback on the use of RASCAL during the Fukushima incident and identified limitations of the code. Enhancements to RASCAL version 4.3 addressed these limitations by improving source-term parameters, providing multi-unit dose-assessment capabilities, and increasing release distance and calculation time. The update includes many additional improvements to the user interface and the ability to share source term information with other assessment codes.

Improvement of Source Term Characterizations
At the time of the Fukishima event, RASCAL did not have a method for calculating reactor source terms for long-term station blackout scenarios because RASCAL was based on reactor core release fractions and accident progression timing representative of large-break loss of coolant accidents, as described in NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants” (Soffer et al. 1995). In comparison, long-term station blackout accidents have longer accident progression time frames and different reactor core release fractions. RASCAL now includes a long-term station blackout option that incorporates reactor core release fractions and accident progression timings for pressurized water reactors and boiling water reactors based on information obtained from SOARCA studies of representative plants. Also, RASCAL is now capable of tracking radionuclide inventories, providing perspective on radionuclide movement within the plant and to the environment.

Addition of Multi-unit Assessment Capability
The Fukushima incident demonstrated that RASCAL did not support the creation of a single impact plot from multiple source terms. Source terms from multiple reactor units and spent fuel pools were manually combined to model a single aggregate source term. A source term merge option has since been added to RASCAL version 4.3 to allow source terms for two or more reactors or spent fuel pools on a single site to be compiled into a common source term. Users can now assess the dose consequences from multiple releases at a single site.

Increase to 50-mile Capability
RASCAL was not designed to project dose consequences beyond 50 miles. Previously, the NRC staff concluded that modeling atmospheric releases to 50 miles was adequate for purposes of informing protective actions during the initial response phase of an accident. NRC staff procedures call for coordination with NARAC for their independent assessment of atmospheric transport and dispersion of the radiological source terms generated by RASCAL. This approach enables comparisons of RASCAL projected doses with NARAC, and provides the U.S. the capability to model atmospheric releases well beyond 50 miles. While dose consequence models provide one source of information, State and local decisions about Protective Actions take into consideration plant conditions, field measurement readings, and other factors. Given a desire to maintain flexible code capabilities, RASCAL was enhanced so it could calculate dose projections out to 100 miles. This change in the RASCAL calculation distance did not change the procedures for coordinating with NARAC on the atmospheric transport and dispersion of the radiological source terms generated by RASCAL.

Increase to 96-hour Calculation Period
The RASCAL code originally included a maximum calculation period (release duration) of 48 hours. While this time period allowed adequate analysis of plume-phase protective actions, it was observed that a longer calculation period would expand the analysis capabilities. RASCAL version 4.3 extends the maximum release duration to 96 hours.

Improvements to Weather Download and File Transfer
Other RASCAL improvements since the Fukushima response include the ability to automatically download large quantities of meteorological observations and forecasts from the National Weather Service, resulting in more accurate modeling of offsite impact for sites located in the U.S. RASCAL version 4.3 also contains a standardized interface for sharing and importing source terms from other codes. This allows more efficient transfer of technical information between external counterparts.

Future RASCAL Improvements
The staff is participating in domestic and international benchmarking studies of RASCAL that involve comparisons to Fukushima and SOARCA data. The staff plans to continue making technical improvements to RASCAL as part of its code development and maintenance program. The staff also assesses and collects feedback from responders and external sources continuously through exercise evaluation and working groups to improve the NRC Incident Response program.

Path Forward for Response Codes
The staff has informed its consideration of the need for the rapid analysis tool described in SECY-05-0233 with insights gained from the Fukushima incident. A MELCOR-based rapid analysis tool could calculate dose projections like those made during Fukushima. Development of such a tool was identified as one of four SOARCA objectives in SECY-05-0233, “an integrated, faster than real-time, computer-based tool to assist decision making in the event of a severe reactor accident.” The intent of developing the tool was to provide a more precise source term estimate by using specific pre-analyzed scenarios. Subsequent evaluation of the proposal determined that development of a fast-running tool was cost-prohibitive, as discussed in SECY-12-0092, “State-of-the-Art Reactor Consequence Analyses - Recommendation for Limited Additional Analysis.” Most importantly, such a rapid analysis tool would likely not provide improved response capability because of the number, complexity, and assumptions of inputs and the overall time required to generate results. Furthermore, developing plant-specific models would be cost-prohibitive, would require plant-specific information from each licensee, and would be difficult keep up to date. Ultimately, dose projections with such a tool would still include the significant uncertainties inherent in atmospheric dispersion models due to the uncertainty in input and boundary conditions.

The staff recognizes that severe accidents involve conditions that make the prediction of source terms and dose projections difficult and uncertain. The NRC has long provided guidance to its licensees that places emphasis on the use of plant conditions, rather than dose calculations, to formulate initial Protective Action Recommendations. To help the NRC responders quickly analyze these plant conditions, a computer-based version of NUREG/BR-0150, “Response Technical Manual 96,” now called Response Technical Tools, has been developed to assist the technical analysts in determining core damage using the available input parameters. The

Response Technical Tools package provides a dozen standalone assessment tools that allow analysts to predict, recognize, and initially estimate the degree of core damage using a limited set of input parameters. The staff considers these new tools progress toward the SECY-05-0233 objective to have rapid analysis capabilities.

CONCLUSION:

The staff has determined that existing analytical codes and capabilities, including RASCAL version 4.3, the electronic Response Technical Tools, and support from NARAC, enable the NRC to adequately analyze emergency conditions for the duration of an accident. Given the capabilities of current analytical codes, the staff has determined that the resources and effort associated with developing "an integrated, faster than real-time, computer-based tool to assist decision making in the event of a severe reactor accident" are not justified at this time.

COORDINATION:

The Office of the General Counsel reviewed this paper and has no legal objection.

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