POLICY ISSUE
(Information)

October 6, 2014 SECY-14-0107

FOR: The Commissioners

FROM: Brian W. Sheron, Director
Office of Nuclear Regulatory Research

SUBJECT: STATUS OF THE ACCIDENT SEQUENCE PRECURSOR PROGRAM AND THE STANDARDIZED PLANT ANALYSIS RISK MODELS

PURPOSE:

To inform the Commission of the status, accomplishments, and results of the Accident Sequence Precursor (ASP) Program, including quantitative ASP results, and to communicate the status of the development and maintenance of the Standardized Plant Analysis Risk (SPAR) models. This paper does not address any new commitments or resource implications.

BACKGROUND:

In a memorandum to the Chairman dated April 24, 1992, the staff of the U.S. Nuclear Regulatory Commission (NRC) committed to report periodically to the Commission on the status of the ASP Program. Subsequently in SECY-02-0041, "Status of Accident Sequence Precursor and SPAR Model Development Programs," the staff expanded the annual ASP status report to include: (1) the evaluation of precursor data trends and (2) the development of associated risk models (e.g., SPAR models).

The ASP Program systematically evaluates U.S. nuclear power plant (NPP) operating experience to identify, document, and rank the operating events most likely to lead to inadequate core cooling and severe core damage (i.e., precursors[1]). The ASP Program provides insights into the NRC's risk-informed and performance-based regulatory programs and

CONTACT: Keith M. Tetter, RES/DRA
301-251-7605

[1] Enclosure 1 provides background on the process used by the staff to identify precursors.

monitors performance against safety measures in the agency's Congressional Budget Justification (see NUREG-1100, Volume 30, "FY15 Congressional Budget Justification," issued March 2014).

Under the SPAR Model Program, the staff develops and maintains independent risk-analysis tools and capabilities to support NPP-related risk-informed regulatory activities. The staff uses

SPAR models for the Reactor Oversight Process (ROP) Significance Determination Process (SDP); the ASP Program; Management Directive (MD) 8.3, "NRC Incident Investigation Program," event assessment process; and MD 6.4, "Generic Issues Program," resolution process. In addition, the staff uses SPAR models to risk-inform inspection activities.

DISCUSSION:

This section summarizes the status, accomplishments, and results of the ASP Program and SPAR Model Program since the previous status report, SECY-13-0107, "Status of the Accident Sequence Precursor Program and the Standardized Plant Analysis Risk Models," dated October 4, 2013.

ASP Program

The staff continues to review operational events from licensee event reports and inspection reports to identify potential precursors to a core damage event. Operational events that exceed the threshold mentioned previously are considered precursors in the ASP Program. *Significant* precursors have a conditional core damage probability (CCDP[2]) or a change in core damage probability (ΔCDP[3]) greater than or equal to 1×10^{-3}. The staff has identified twelve precursor events for fiscal year (FY) 2013. The staff did not identify any *significant* precursors for FY 2013, and has not identified any potentially *significant* precursors for FY 2014 to date, although detailed evaluations of some FY 2014 events are still in progress.

The ASP Program evaluates the trend for all precursors as an input to the agency's Industry Trends Program (ITP). The ITP provides an input to the agency's safety performance measure that is part of the Congressional Budget Justification of no significant adverse trend in industry safety performance. For the period of FY 2004 through FY 2013, the staff found no statistically significant trend for all precursors.

In addition to the trend analysis of all precursors provided for the ITP, the staff performs trend analyses on other precursor subgroups for additional insights. These subgroups include:

- Precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-4}
- Precursors involving an initiating event
- Precursors involving degraded conditions
- Precursors involving a complete loss of offsite power

---

2 The term CCDP is the probability of the occurrence of core damage given that an initiating event has occurred.

3 The term ΔCDP is the increase in probability of core damage (from the baseline core damage probability) due to a failure of plant equipment or an identified deficiency during the time the failure or deficiency existed.

- Precursors that occurred at boiling-water reactors (BWRs)
- Precursors that occurred at pressurized-water reactors (PWRs)

For the period of FY 2004 through FY 2013, the staff found a statistically significant increasing trend in precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-4}; no statistically significant trends were identified for the other subgroups during this same period. This increasing trend results from the occurrence of seven precursors in this subgroup in the past four years after zero events were identified in the previous six years.[4] The staff reviewed these events for risk-informed insights, looking at the systems causing the events, the dominant risk sequences, and the plant types affected by the events. The most common similarity was that seven of the eight events were caused by multiple electrical failures. These electrical failures varied from failures of electrical equipment (such as circuit breakers) to losses of offsite power. Regulatory actions taken as a result of these events included the issuance of several enforcement actions, five information notices, and a bulletin (see Table 3 in Enclosure 1). However, no changes to the NRC's regulations were deemed necessary.

Enclosure 1, "Results, Trends, and Insights of the Accident Sequence Precursor Program," provides additional details on results and trends of the ASP Program.

SPAR Model Program

The staff continued to maintain and update the 79 SPAR models representing 104 commercial nuclear power reactors[5]. The scope of every SPAR model includes internal events, at power, through core damage (i.e., Level 1 model). In addition, the staff continued to expand SPAR model capability beyond internal events at full-power operation. For example, 20 of these 79 SPAR models, representing 24 nuclear power reactors, include other hazard groups and are referred to as SPAR All Hazard (SPAR-AHZ[6]) models. Currently, 17 of the SPAR-AHZ models include hazards such as fires, internal floods, and seismic events based on the results of the assessments conducted for Supplement 5, "Individual Plant Examination of External Events for Severe Accident Vulnerabilities," to Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," and other readily available information. The staff has also recently completed incorporation of internal fire scenarios from the fire probabilistic risk assessments (PRAs) done in compliance with National Fire Protection Association (NFPA) 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," for the Shearon Harris Nuclear Power Plant and the Donald C. Cook Nuclear Power Plant. In addition to more detailed fire PRA modeling, the SPAR models for Harris and Cook include improved external hazard modeling and model validation. The staff has also leveraged the ongoing Level 3 PRA project for the Vogtle Electric Generating Plant, Units 1 and 2, to develop improved external hazard and fire modeling for the

---

[4] No precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-4} were identified in FY 2013. However, the seven precursors identified in the previous three years (FYs 2010-2012) combined with no precursors being identified for the preceding six years (FYs 2004-2009) still cause a statistically significant trend over the 10-year period for this subgroup.

[5] Three of the 79 SPAR models are associated with nuclear power plants that have permanently shut down (Kewaunee, San Onofre, and Crystal River). While these SPAR models are no longer being updated, they remain available for agency use.

[6] These models were formerly named SPAR external event (SPAR-EE) models, but have been renamed SPAR-AHZ to reflect recent improvements in external hazard modeling efforts and for consistency with the ASME PRA Standard model scope.

Vogtle SPAR model. In the new reactor area, the staff has developed SPAR models for the AP1000, Advanced Boiling Water Reactor (ABWR) (for both the Toshiba and General Electric-Hitachi designs), U.S. Advanced Pressurized Water Reactor (US-APWR), and the U.S. Evolutionary Power Reactor (U.S. EPR). The staff is expanding the capability of the AP1000 SPAR model to include hazards such as seismic, fire, flooding, and low-power shutdown events. The Office of Nuclear Regulatory Research staff continues to work with the Office of Nuclear Reactor Regulation and the Office of New Reactors to identify future enhancements to the SPAR models, including continuing the development of new all-hazard SPAR models.

In FY 2010, the staff completed PRA standard-based peer reviews of a representative BWR SPAR model and a representative PWR SPAR model. These peer reviews were performed in accordance with American Society of Mechanical Engineers (ASME)/ American Nuclear Society (ANS) RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," and Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities." The peer-review teams concluded that, within the constraints of the program, the SPAR models provide an appropriate tool to conduct an independent check on the technical adequacy of utility PRAs. The teams also identified a number of facts and observations related to areas where enhancements could be implemented on the SPAR models and supporting documentation. The staff prioritized these enhancements and is addressing high-priority issues as available resources permit. Major activities undertaken to address these peer-review items in FY 2014 include the following:

- Structuring the SPAR model documentation to more closely align with the structure of ASME/ANS PRA standard.

- Incorporating improved loss of offsite power modeling and support system initiating events modeling into the SPAR models (e.g., loss of service water or component cooling water).

The pace of these activities was significantly reduced during FY 2013 because of sequestration-related budget cuts. With funding restored in FY 2014, the staff continued the resolution of peer-review items, including documentation enhancements and model upgrades. The staff plans to complete the PWR and BWR SPAR Model peer-review enhancements in August 2015.

The staff continues to maintain and improve the Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) software to support the SPAR Model Program. SAPHIRE is a personal-computer-based software application used to develop PRA models and to perform analyses with SPAR Models. During FY 2014, significant SAPHIRE activities included the following:

- Oversight of the SAPHIRE software quality-assurance program, including performance of an annual audit of software quality-assurance activities, tools, and documents in accordance with NUREG/BR-0167, "Software Quality Assurance Program and Guidelines."

- Implementation of new SAPHIRE features, including: a truncation convergence function, a results editor feature to assist users in reviewing and analyzing model results, the

ability to use an external PRA-solving engine that is widely used by U.S. utilities, and improved Level 2 PRA modeling capabilities.

- Continued research on advanced quantification methods to improve accuracy and calculation speeds.

Enclosure 2, "Status of the Standardized Plant Analysis Risk Models," provides a detailed status of SPAR models and related activities.

Planned ASP and SPAR Model Activities

- The staff will continue the screening, review, and analysis (preliminary and final) of potential precursors for FY 2014 and FY 2015 events to support the monitoring of the agency's safety measures.

- The staff will continue to assess the ASP Program screening criteria for enhancement considering lessons learned from the performance of initiating event analyses.

- The staff will continue to implement enhancements to the internal event SPAR models for full-power operations. Planned enhancements include incorporating new models for support-system initiators, revised success criteria based on insights from ongoing thermal-hydraulic analyses, and a periodic parameter data update.

- The staff will continue quality-assurance activities for both the agency SPAR models and the SAPHIRE code. This will ensure that agency risk tools continue to be of sufficient quality for performing SDP, ASP, and MD 8.3 event assessments in support of the staff's risk-informed regulatory activities.

- The staff will continue to evaluate the need for additional SPAR model capability (beyond full-power internal events) based on experience gained from SDP, ASP, and MD 8.3 event assessments and feedback from user offices.

- The staff will continue development of new SPAR-AHZ models, including incorporation of modeling derived from the NFPA 805 application process. The staff will continue to develop new all-hazard SPAR model capabilities for operating reactors.

SUMMARY:

Under the ASP Program, the staff continues to evaluate the safety significance of operating events at NPPs and to provide insights into the NRC's risk-informed and performance-based regulatory programs. The staff identified no *significant* precursors in FY 2014 for events evaluated to date. A statistically significant increasing trend in precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-4} was observed. There is an increase of precursors in this subgroup with seven events in the past four years after zero events were identified in the previous six years. Six of the seven events were caused by various types of electrical failures (ranging from failures of electrical equipment such as circuit breakers to losses of offsite power). The SPAR Model Program is continuing to develop and improve independent risk-analysis tools and capabilities to support the use of PRA in the agency's risk-informed regulatory activities.

COORDINATION:

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

/RA/

Brian W. Sheron, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Results, Trends, and Insights of the ASP Program
2. Status of the SPAR Models

COORDINATION:

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

/RA/

Brian W. Sheron, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Results, Trends, and Insights of the ASP Program
2. Status of the SPAR Models

ADAMS Accession No.: ML14230A084 **WITS 199200101**

OFFICE	RES/DRA/PRB	SUNSI Review	RES/DRA/PRAB	RES/DRA/PRB	Tech Editor
NAME	K. Tetter	K. Tetter	K. Coyne	J. Nakoski	J. Dougherty
DATE	8/22/14	8/22/14	8/26/14	8/26/14	8/23/14
OFFICE	RES/DRA	NRO	NRR	OGC	RES
NAME	R. Correia	G. Tracy	D. Dorman	B. Jones	B. Sheron
DATE	9/24/14	9/14/14	9/10/14	9/9/14	10/06/14

OFFICIAL RECORD COPY