

POLICY ISSUE

(INFORMATION)

September 30, 2011

SECY-11-0138

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 of the Accident Sequence Precursor (ASP) Program, provide the annual quantitative ASP results, and 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. In SECY-02-0041, the staff expanded the annual ASP SECY paper to include evaluation of precursor data trends and to summarize the continuing 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 (precursors). The ASP Program provides insights to NRC's risk-informed and performance-based regulatory programs and monitors performance against safety measures established in the agency's Congressional Budget Justification (see NUREG-1100, Volume 27, "Congressional Budget Justification: Fiscal Year 2012," issued February 2011). The SPAR Model Program develops and maintains independent risk-analysis tools and capabilities to support the use of probabilistic risk assessment (PRA) in the agency's risk-informed regulatory activities.

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The staff uses SPAR models to support the Significance Determination Process (SDP), the ASP Program, the Incident Investigation Program event assessment process, and the Generic Issue Program resolution process. In addition, the staff uses SPAR models to inform licensing and 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-10-0125, "Status of the Accident Sequence Precursor Program and the Standardized Plant Analysis Risk Models," dated September 29, 2010.

ASP Program

The staff has completed the probabilistic analyses of all precursor events that were identified in fiscal year (FY) 2010 (11 precursors). Precursors are events with a conditional core damage probability (CCDP) for initiating event analyses or an increase in core damage probability (Δ CDP) for equipment deemed unavailable or degraded that is greater than or equal to 1×10^{-6} . In addition, the staff has completed the screening of FY 2011 events for *significant* precursors. *Significant* precursors have a CCDP or Δ CDP greater than or equal to 1×10^{-3} . Based on completed analyses, no *significant* precursors were identified in FY 2010, and based on screening and analyses in progress, no *significant* precursors have been identified in FY 2011. However, the staff will continue to evaluate the flooding situation at Fort Calhoun and the recent earthquake at North Anna and inform the Commission if *significant* precursors are identified.

The one event that was evaluated as a potential *significant* precursor in FY 2010 involved an electrical fire at H. B. Robinson Steam Electric Plant, Unit 2 that led to a plant trip with a subsequent loss of reactor coolant pump seal cooling and additional complications. The potential for the event to be a significant precursor was identified after new information became available in December 2010 during follow-up inspection activities. A preliminary ASP analysis was issued by NRC staff and transmitted to the licensee in accordance with established procedures. This prompted the licensee to perform some additional thermal-hydraulic analysis, which resulted in changes to modeling assumptions and reduced the CCDP of the event to 4×10^{-4} , which is lower than the CCDP threshold value of a *significant* precursor. Enclosure 1 presents additional details of the event analysis.

The staff evaluated precursor data during the period of FY 2001 through FY 2010 to identify statistically significant adverse trends for the Industry Trends Program (ITP). No statistically significant trend was detected for all precursors during this 10-year period. The ASP Program results are trended in the ITP to provide an input to the agency's safety performance measure of no significant adverse trend in industry safety performance.

In addition to the trend analysis of all precursors, the staff performs trend analyses on precursor subgroups. These subgroups include precursors with a high safety significance (i.e., CCDP or Δ CDP greater than or equal to 1×10^{-4}), initiating events, degraded conditions, loss of offsite power initiating events, precursors at boiling-water reactors (BWRs), and precursors at pressurized-water reactors (PWRs). Statistically significant decreasing trends were detected for

two subgroups of precursors—precursors corresponding to high safety significance (i.e., CCDP or Δ CDP greater than or equal to 1×10^{-4}) and precursors that occurred at PWRs. No statistically significant trends were observed in other precursor subgroups. Enclosure 1 provides additional details on results and trends of the ASP Program.

SPAR Model Program

The staff continued to maintain and update the 78 SPAR models representing the 104 operating commercial NPPs during FY 2011. In addition to routine model updates, in October 2010, the staff completed an evaluation of the potential core damage risk reduction associated with the extensive damage mitigation strategies and guidance required by 10 CFR 50.54(hh). This was forwarded to the Office of Nuclear Reactor Regulation (NRR) to support an assessment of the effectiveness of the 10 CFR 50.54(hh) security enhancements implemented by licensees and the potential credit of these enhancements in the SDP.

In FY 2010, the staff, in cooperation with the Electric Power Research Institute (EPRI) and the Pressurized Water Reactor and Boiling Water Reactor Owner's groups, completed peer reviews of a representative PWR SPAR model and BWR SPAR model in accordance with American National Standard, ASME RA-S-2002, "Standard for 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 included individuals experienced with the peer review process used for licensee PRAs and NRC staff familiar with the agency's use of risk tools. The peer review teams concluded that, within the constraints of the program, the SPAR models provide an appropriate tool to provide an independent check on the technical adequacy of utility PRAs. The teams also identified a number of areas where enhancements could be made to the SPAR models and supporting documentation. The staff has evaluated the peer review comments and has initiated projects to address these comments, where appropriate. The staff plans to complete this effort in 2013.

The staff continued to expand the SPAR model capability beyond internal events at full-power operation. Currently, a total of 16 SPAR external event (EE) models exist (e.g., fires, floods, and seismic events). Three of the integrated SPAR models (which include both internal and external hazards) were previously used in identifying and evaluating severe accident sequences for the consequential steam generator tube rupture (SGTR) project in support of the closure of the Steam Generator Action Plan. Consequential SGTR events are potentially risk significant because of the possibility of a severe core damage event leading to failure of the steam generator tubes and reactor coolant bypass of the containment building. In addition, the SPAR-EE models have been used to provide background information to NRR on the impact of assessing external hazard risk in 10 CFR 50.65 maintenance risk assessments. This study concluded that including consideration of fire and external hazards in pre-maintenance risk assessments could prompt beneficial changes in maintenance configurations and result in lower cumulative plant risk. The staff also plans to incorporate internal fire scenarios from the National Fire Protection Association (NFPA) 805, "Performance-Based Standard for Fire Protection for Light-Water Reactor Electric Generating Plants," pilot applications into two SPAR models. The Office of Nuclear Regulatory Research (RES) staff continues to work with NRR and the Office of New Reactors (NRO) to identify future enhancements to the SPAR-EE models.

The staff has continued the development and enhancement of the shutdown template models, resulting in a total of eight shutdown SPAR models available to support the Reactor Oversight Process evaluations of shutdown events and degraded conditions during shutdown conditions. The staff also developed a preliminary new reactor SPAR model for the Advanced Boiling Water Reactor (ABWR) Toshiba design and a preliminary model for the AP1000 design including a seismic analysis. Quality assurance and internal review activities are ongoing for these models. A SPAR model for the ABWR/GE design was completed in May 2011. These new reactor SPAR models allow confirmation of PRA results presented in licensing submittals, evaluation of risk-informed license applications prior to plant operation, and assessment of operational findings and events once operation commences. Enclosure 2 provides a detailed status of SPAR models.

The staff continues to maintain and improve the Systems Analysis Program for Hands-On Integrated Reliability Evaluations (SAPHIRE) Version 8 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 2011, the new features, capabilities, and user support activities that have been implemented for SAPHIRE Version 8 include:

- Effective use of multi-core computers to decrease overall analysis time.
- User-friendly links to SPAR model documentation and new risk insights reports.
- Training to NRC resident inspectors participating in the piloting of a new process for SDP Phase 2 analyses using SPAR models.
- Completion of NUREG/CR-7039, Volumes 1 through 7, the companion documentation for the SAPHIRE Version 8 software.

On September 19, 2011, the Office of the Inspector General (OIG) issued audit report OIG-11-A-18, "Memorandum Report: Audit of NRC's SAPHIRE 8 System." Although the OIG concluded that SAPHIRE 8 meets its operational capabilities and there is limited security risk to the software, the OIG recommended several additional measures relating to software distribution policies and website access controls to ensure that the software was properly managed. The staff is currently evaluating the need for corrective actions to address the three recommendations identified by the OIG in the audit report.

Planned Activities

- The staff will continue the screening, review, and analysis (preliminary and final) of potential precursors for FY 2011 and FY 2012 events.
- The staff will continue to implement enhancements to the internal event SPAR models for full-power operations as needed. Anticipated enhancements include incorporating new models for support-system initiators and revised success criteria based on insights from thermal-hydraulic analyses. The staff also is working with industry representatives through a memorandum of understanding with EPRI to resolve other PRA technical issues common to

both licensee PRAs and NRC SPAR models. In support of this effort, the memorandum of understanding addendum on PRA with EPRI had been previously extended through 2016.

- The staff has reviewed the SPAR model peer review comments. A project plan has been developed to address peer review comments, where appropriate, and is planned to be completed in 2013. The main objective of this effort is to ensure the SPAR models continue to be of sufficient quality for performing SDP Phase 3, ASP, and Management Directive (MD) 8.3 event assessments in support of the staff's risk-informed activities.
- The staff will use information obtained as part of the NFPA-805 application process to create new SPAR fire models with updated fire scenarios.
- 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.
- The staff will continue the development of SPAR models for new reactors to allow confirmation of PRA results presented in licensing submittals, evaluation of risk-informed applications prior to plant operation, and assessment of operational findings and events once operation commences.
- The staff will develop about one new all-hazards SPAR model per year as well as perform validation activities for about two existing all hazards models per year.
- SPAR Model development efforts will be leveraged to the extent practical to support the full-scope Site Level 3 PRA described in Staff Requirements Memorandum (SRM) SECY-11-0089.
- The staff will continue to maintain and improve the SAPHIRE Version 8 software to support the SPAR Model Program. In addition, the staff plans to address the three recommendations contained in audit report OIG-11-A-18 in FY2012.

SUMMARY:

The ASP Program continues to evaluate the safety significance of operating events at NPPs and to provide insights to NRC's risk-informed and performance-based regulatory programs. The analyses of FY 2010 events and the screening of FY2011 events are complete, and the analysis of FY 2011 events is in progress. The staff identified no *significant* precursors in FY 2010 or FY 2011. No statistically significant trend was detected for all precursors during the FY 2001 through FY 2010 period. 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.

The Commissioners

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COORDINATION:

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

/RA/

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Enclosures:

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

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