POLICY ISSUE
(Information)

March 31, 2003 SECY-03-0049

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations /RA/

SUBJECT: STATUS OF THE ACCIDENT SEQUENCE PRECURSOR (ASP) AND THE DEVELOPMENT OF STANDARDIZED PLANT ANALYSIS RISK (SPAR) MODELS

PURPOSE:

To inform the Commission of the status of the Accident Sequence Precursor (ASP) Program and the development of the Standardized Plant Analysis Risk (SPAR) models.

SUMMARY:

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 efforts to improve the ASP Program. In SECY-94-268, dated October 31, 1994, the staff made two significant changes to the report. First, the staff committed to provide the report annually, and second, the staff began providing annual quantitative ASP results.

This report discusses the following activities, which the staff has performed since the last status report (SECY-02-0041), dated March 8, 2002:

- The screening and analyses of events for fiscal year (FY) 2002 to identify "significant" precursors, defined as those with a conditional core damage probability (CCDP) or change in core damage probability (ΔCDP) that is greater than or equal to 1×10^{-3}.

- Analysis of the FY 2001 and FY 2002 events to identify precursors (i.e., events with a CCDP or ΔCDP that is greater than or equal to 1×10^{-6}).

CONTACTS: Don Marksberry, RES, 301-415-6378 (ASP Program)
Patrick O'Reilly, RES, 301-415-7570 (SPAR Model Development Program)

- Evaluation of precursor data to identify statistically significant adverse trends for the Industry Trends Program.

- Revision of SPAR models for all plants for internal initiating events during full-power operation, completion of SPAR models for three lead plants for internal initiating events during low-power and shutdown operations, and initiation of development of SPAR models for the calculation of large early release frequency (LERF).

BACKGROUND:

The attachment to this paper presents a brief background summary of the ASP and SPAR Model Development Programs and their uses in risk-informed regulation. The staff has not made any significant changes to the programs and their uses since the last status report.

DISCUSSION:

This section summarizes the program status, accomplishments, and results for this reporting period.

Identification of Significant Precursors

The ASP Program provides the basis for one of five performance measures, "no more than one event per year identified as a *significant* precursor of a nuclear accident," for the performance goal to maintain safety in the reactor safety arena of the NRC's Strategic Plan. The Strategic Plan defines a *significant* precursor as an event that has a 1 in 1000 (10^{-3}) or greater probability of leading to a reactor accident.

During this reporting period, the staff completed its screening and review of events in FY 2002 for potential *significant* precursors. As reported in the last status report, no *significant* precursors were identified in FY 2001. The staff did, however, identify three events in FY 2002 as having the potential to be *significant* precursors. One condition, discovered at the Davis-Besse Nuclear Power Station, involved reactor vessel head degradation and cracking of the control rod drive mechanism (CRDM) housing. The analysis of the condition at Davis-Besse is still ongoing. The second condition, which affected both units at Point Beach Nuclear Plant (counted as two precursors), involved a potential common-mode failure of all auxiliary feedwater (AFW) pumps as a result of a design deficiency in the pumps' air-operated minimum flow recirculation valve. Preliminary results show that the condition at Point Beach Units 1 and 2 does *not* meet the *significant* precursor criteria. Moreover, the preliminary analyses indicates that the performance measure (defined above) was not exceeded for FY 2002. The status of both analyses is as follows:

- *Davis-Besse.* The NRC staff expects to issue its preliminary ASP analysis for peer review in July 2003, with the schedule contingent on the completion of the licensee-sponsored laboratory analysis of vessel head material. The NRC's Office of Nuclear Regulatory Research (RES) has initiated a project to use the laboratory characterization of the degraded vessel head material and analytic models to estimate the probability of a loss-of-coolant accident from the vessel head degradation and cracking of the CRDM housing. In addition, the NRC's Office of Nuclear Reactor Regulation (NRR) is currently analyzing a

recently discovered condition involving a sump degradation which will be included in this ASP analysis.

- *Point Beach Units 1 and 2.* The preliminary ASP analysis shows that the condition which affected both units at Point Beach has a mean ΔCDP of about 7×10^{-4} with a 90% confidence that the ΔCDP is between 2×10^{-4} and 1×10^{-3}. Consistent with previous ASP Program practices, the mean ΔCDP represents the best estimate, and the significance of the precursor is determined using the mean value of the uncertainty distribution. This is the ASP Program's first application of recently developed methods for characterizing parameter and modeling uncertainties associated with the estimated CCDP. The preliminary analysis was recently issued to the NRC staff and the licensee for peer review.

FY 2001 and 2002 Event Analyses

The analyses of FY 2001 and 2002 events are ongoing. The current status is as follows:

- For FY 2001, the NRC staff screened and reviewed 238 events for potential precursors. These activities were completed in 2001. Of the 48 events selected for analysis, the staff completed 26 analyses and rejected the associated events as precursors. These analyses were completed during the past year. The analyses of 22 additional events are undergoing internal reviews before being issued for peer review. As previously mentioned, the staff did not identify any *significant* precursors for FY 2001.

- For FY 2002, the NRC staff screened and reviewed 154 events for potential precursors. Of those events, the staff has identified 24 for analysis. The staff issued the preliminary analysis involving two precursors (Point Beach Units 1 and 2); the peer review is ongoing. The staff is currently analyzing one potential *significant* precursor (Davis-Besse) and the other selected events.

- Eight of the potential precursors for FY 2001 and 2002 include through-wall cracks in the CRDM housing. The staff is currently analyzing these potential precursors in conjunction with characterizing the probability of failure of the as-found crack conditions at Davis-Besse.

- Several of the identified potential precursors involve complex analyses, which have required more than the normal amount of time to analyze. These analyses include the potential common-mode failure of all AFW pumps at Point Beach Units 1 and 2, the reactor pressure vessel head degradation at Davis-Besse, the emergency service water debris clogging condition at D.C. Cook, and CDRM cracking events.

Delays in issuing preliminary analyses of FY 2001 events are the result of the program's focus on the more complex and potentially risk-important events described above. In addition, in-house resources were assigned to initiate the following improvements in ASP analysis methods to address internal and external stakeholder comments on characterization of precursor events:

- Develop and implement methods for characterizing parameter and modeling uncertainties associated with the estimated CCDPs.

- Use the Revision 3i SPAR models in ASP analyses. Toward that end, the staff has reanalyzed several preliminary analyses of FY 2000 and 2001 events using the Revision 3i SPAR models and uncertainty analysis capability. This capability will be part of the preliminary ASP analyses of all events occurring after FY 2001.

- Develop and implement methods for external event initiators (e.g., fires, seismic events, tornadoes, and internal flooding). These methods are developed on an event-specific basis.

- Develop a more structured method for using engineering insights to determine system or component functionality given a degradation in performance.

Based on an evaluation of the delays experienced during the past year, the staff has initiated two efforts to streamline the analysis and review process in the ASP Program. During the next year, the staff is developing a plan to prioritize and, where appropriate, scale back efforts on events with lower CCDPs and events that are non-controversial. In the longer term, to improve efficiency, NRR and RES are planning to improve consistency between ASP approaches and those used in the Significance Determination Process (SDP), where possible. This effort is part of NRR's SDP improvement initiative.

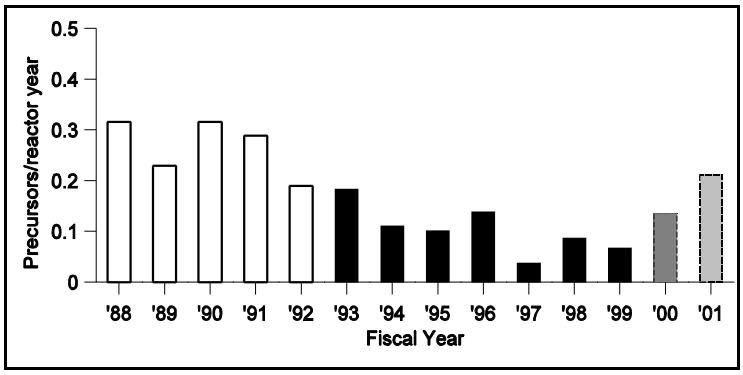
Industry Trends

The NRC's Industry Trends Program (ITP) provides the basis for addressing the performance goal measure of "no statistically significant adverse industry trends in safety performance," which is one of the five measures in the NRC's Strategic Plan for the performance goal of maintain safety. One of the indicators that NRR uses to assess industry performance against this measure is the trend of all precursors identified by the ASP Program. The method used for trending precursors is consistent with the analysis used for trending the other indicators in the Industry Trends Program.

Consistent with last year's trending analysis, the trend is based on the number of all precursors since FY 1993.[1] Analyses for FY 2000 are preliminary, with final analyses nearing completion (pending resolution of peer review comments). The data for FY 2001 are based on ongoing analyses that have undergone internal staff review.

Results. The staff did not observe any statistically significant trend in the occurrence rate of precursors (CCDP or ΔCDP $\geq 10^{-6}$) during the 1993–2001 period. The following figure shows the occurrence rate (number of precursors per reactor year) for all precursors by fiscal year. The staff did not use data prior to FY 1993 in the trending analysis; however, the figure shows those data for information and to provide perspective. Although the staff did not detect a trend based on data for 1993 through 2001 (shaded bars in the figure), data for the 5-year period from 1997 through 2001 show an increasing number of precursors.

[1] Consistent with the previous years' trending analyses, the trend is based on the number of precursors since FY 1993. Beginning in 1992, the staff transmitted each preliminary analysis to the responsible licensee for review and comment. As a result of comments received from the licensees, the staff's analyses incorporated credit for additional equipment and recovery procedures.



All precursors—occurrence rate, by fiscal year. No trend detected during the FY 1993–2001 period. A trend line is not shown in the figure because the slope is not statistically significant.

The staff will investigate the nature of the precursors to determine whether there is an explanation for the relatively low number of precursors between 1997 and 1999, and an increasing number of potential precursors in 2000 and 2001. This evaluation will occur after the staff completes its FY 2001 preliminary analysis. The evaluation of trends is the subject of a joint project between NRR and RES as part of the Industry Trends Program.

Availability of ASP Analyses and Analysis Details and Results

Issuance of ASP analysis reports. In SECY-02-0041, the staff indicated that the issuance of preliminary and final precursor analyses was suspended following the terrorist attacks on September 11, 2001. The staff resumed its issuance of ASP analyses and SPAR models to the licensees in June 2002, based on guidance provided in a Staff Requirements Memorandum on COMSECY-02-0015, "Withholding Sensitive Homeland Security Information from the Public," dated April 4, 2002. Guidance for issuing results of risk analyses to the public is being coordinated between RES, NSIR, and NRR.

Posting ASP results on the World Wide Web. The staff is currently implementing two initiatives to make precursor analyses and results available to NRC staff, our contractors, and the public:

- The staff has upgraded its database of ASP analysis results and reports since 1969. The staff is currently beta testing the ASP database before making it available to NRC staff through the agency's internal Web site. However, given the sensitivity of information contained in the analysis reports, the agency will not make this database available through the public Web site at this time.

- The staff will make its report of results, trends, and insights from the ASP Program available to the public in a more timely manner. The staff will update this information after completing all preliminary analyses for a fiscal year. After the necessary internal reviews, the staff will then make this report available to the public through the Agencywide Documents Access and Management System (ADAMS) and on the NRC's public Web site in accordance with agency guidelines on withholding sensitive information.

SPAR Model Development

The SPAR Model Users Group (SMUG) is composed of representatives from each of the organizations within the agency's program and regional offices that use risk models in regulatory activities. The SMUG meets on a regular basis to provide technical guidance for the SPAR Model Development Program consistent with the approved Integrated SPAR Model Development Plan. This plan conforms to the modeling needs that the SMUG members and their management identified for performing risk-informed regulatory activities.

In accordance with this plan, the staff completed the following activities in model and methods development in the past year:

- SPAR models for internal initiating events during full-power operation

  – Maintained Revision 2QA SPAR models on an as-needed basis (e.g., added plant features not previously modeled, corrected errors).

  – Produced the last 12 Revision 3i SPAR models; this completed the set of 72 models. These models, which the staff uses in performing risk-informed regulatory activities (see attachment for examples), replaced Revision 2QA SPAR models that were gradually phased out in 2002.

  – Completed the onsite quality assurance review of 33 Revision 3i SPAR models, in conjunction with NRR's benchmarking of the SDP Plant Notebooks. The staff conducted each review at the licensee's probabilistic risk assessment (PRA) office. This review consisted of reviewing the SPAR model with the licensee's PRA staff and benchmarking the SPAR model against the licensee's PRA. A total of 53 of the 72 Revision 3i models have undergone onsite review.

- SPAR models for internal initiating events during low-power and shutdown (LP/SD) operations

  – Completed interim low-power/shutdown SPAR models (interim models have not yet undergone an on-site QA review) for Byron 1 & 2, Millstone 2, and Millstone 3 as the lead plants in the pressurized-water reactor (PWR) plant categories.

  – Conducted an onsite quality assurance review of the LP/SD SPAR model for Surry 1 and 2.

  – Transmitted the LP/SD SPAR models for Byron 1 & 2, Millstone 2, Millstone 3, and Grand Gulf to the respective licensees in anticipation of the onsite quality assurance reviews of these models.

  – Met with the Advisory Committee on Reactor Safeguards to discuss development of LP/SD SPAR models. Comments from the committee were favorable, and they requested that the staff keep them informed about the progress of this model development effort.

- SPAR models for the calculation of large early release frequency (LERF)
  - Completed an evaluation of existing capabilities for modeling LERF sequences.
  - Prepared a program plan for developing LERF SPAR models using input provided by model users.
  - Obtained approval of the LERF SPAR Model Development Program Plan from management of model user organizations.
  - Began implementing the approved plan to develop a LERF SPAR model for the first lead plant (a PWR with a large dry containment).
  - Developed draft bridge trees (logic trees to utilize Revision 3 SPAR model results as inputs to the LERF model) and LERF event trees for the lead plant.
  - Transmitted draft bridge trees and LERF event trees to members of the SPAR Model Users Group, key users, and management of user organizations for internal review/acceptance regarding the draft trees and technical approach for developing LERF SPAR models.

UPCOMING ACTIVITIES

The staff currently plans to engage in the following activities during the next 12 months:

- Identify and complete the preliminary analysis of significant precursors for FY 2003.
- Issue the preliminary analysis of events for FY 2001 and 2002.
- Issue the final analysis of events for FY 2000, 2001, and 2002.
- Continue the screening, review and analysis (preliminary and final) of events for FY 2003.
- Evaluate trends in precursors.
- Work with NRR to develop guidance for issuing ASP analysis results to the public; post the report of results, trends, and insights from the ASP Program on the NRC's public Web site; and provide access to the precursor database on the agency's internal Web site.
- Continue to coordinate efforts to improve consistency between the ASP Program and the SDP.
- Complete the onsite quality assurance review of Revision 3i SPAR models.
- Continue developing SPAR models for internal events during low-power/shutdown operations and LERF in accordance with the approved Integrated SPAR Model Development Plan.

- Begin developing external events analysis capability in accordance with the approved Integrated SPAR Model Development Plan.

- Develop an improved user interface for use with Revision 3 SPAR models in response to user feedback.

/RA/

William D. Travers
Executive Director
for Operations

Attachment: Background and Uses of the Accident Sequence Precursor (ASP) Program and the Standardize Plant Analysis Risk (SPAR) Model Development Program

SECY PAPER DATED: / /03

SUBJECT: STATUS OF THE ACCIDENT SEQUENCE PRECURSOR (ASP) AND THE DEVELOPMENT OF STANDARDIZED PLANT ANALYSIS RISK (SPAR) MODELS

Distribution (w/attch):

OERAB RF
DRAA RF
OEDO RF
(WITS NO 9200101)
Public
File Center
MCunningham, RES
DO'Neal, RES
MMayfield, RES
FEltawila, RES
JFlack, RES
BSheron, NRR
GHolahan, NRR
RBarrett, NRR
RWBorchardt, NRR
WDean, NRR
DMatthews, NRR
LMarsh, NRR
MJohnson, NRR
MReinhart, NRR
PWilson, NRR (SRA)
RRasmussen, NRR (SRA)
CCarpenter, NRR
DCoe, NRR
SWong, NRR (SRA)
RGibbs,NRR (SRA)
PWilson, NRR (SRA)
WLanning, RI
ECobey, RI (SRA)
WSchmidt, RI (SRA)
CCasto, RII
RBernhard, RII (SRA)
WRogers, RII (SRA)
CPederson, RIII
MParker, RIII (SRA)
SBurgess, RIII (SRA)
AHowell, RIV
DLoveless, RIV (SRA)
RBywater, RIV (SRA)
MRunyan, RIV (SRA)
MFields, NRR
PO'Reilly, RES
TBoyce, NRR
DRasmuson, RES
EChelliah, RES
GDeMoss, RES
CHunter, RES
JHoughton, RES
EGoldfiez, RES
MCaruso, NRR
IJung, NRR

DOCUMENT: A:ML030800173.wpd

***See previous concurrence**

To receive a copy of this document, indicate in the box "C" copy w/o attach/encl "E" copy w/attach/encl "N" no copy

OFFICE	OERAB*	E	OERAB*	E	OERAB*	E	OERAB*	E	DRAA*	E
NAME	DMarksberry		PO'Reilly		MCheok		PBaranowsky		SNewberry	
DATE	3/05/03		3/05/03		3/05/03		3/05/03		3/05/03	

OFFICE	NRR*	E	RES*	E	DEDR		EDO	
NAME	SCollins		AThadani		CPaperiello		WTravers	
DATE	3/14/03		3/20/03		3/ /03		/ /03	

OFFICIAL RECORD COPY

OAR in ADAMS? (Y or N)	Y	**Publicly Available? (Y or N)**	No*

* To be issued to the public by SECY

Template Number: SECY-012 Accession Number: ML030800173 RES File Code: 2C-3

BACKGROUND AND USES OF
THE ACCIDENT SEQUENCE PRECURSOR (ASP) PROGRAM AND
THE STANDARDIZE PLANT ANALYSIS RISK (SPAR) MODEL DEVELOPMENT PROGRAM

The discussion below provides a brief background of the Accident Sequence Precursor (ASP) Program, the Standardized Plant Analysis Risk (SPAR) Model Development Program, and the uses of ASP results and SPAR models in risk-informed regulatory activities.

ASP Program

The U.S. Nuclear Regulatory Commission (NRC) established the ASP Program in 1979 in response to the Risk Assessment Review Group report (see NUREG/CR-0400, September 1978). The primary objective of the ASP Program is to systematically evaluate U.S. nuclear plant operating experience to identify, document, and rank the operating events that were most likely to lead to inadequate core cooling and severe core damage (precursors), if additional failures had occurred.

To identify potential precursors, the NRC staff reviews events and conditions from licensee event reports, inspection reports, and special requests from NRC staff. The staff then analyzes any identified potential precursors and calculates a conditional core damage probability (CCDP) by mapping failures observed during the event onto accident sequences in risk models. An event with a CCDP or a condition with a change in core damage probability (ΔCDP or importance) greater than or equal to 1.0×10^{-6} is considered a precursor in the ASP Program.

The ASP Program has the following secondary objectives:

- Categorize the precursors by their plant-specific and generic implications.
- Provide a measure for trending nuclear plant core damage risk.
- Provide a partial check on dominant core damage scenarios predicted by probabilistic risk assessments (PRAs).

The NRC also uses the ASP program to monitor performance against the Strategic Plan performance goal to maintain safety in the reactor safety arena (see Volume 2, Part 1, of NUREG-1614, September 2000). The program provides input to the following performance measures:

- No more than one event per year identified as a significant precursor of a nuclear reactor accident (i.e., CCDP or importance greater than or equal to 1×10^{-3}).
- No statistically significant adverse industry trends in safety performance.[2]

[2] The ASP Program provides one industry trend indicator used in this performance measure.

SPAR Model Development Program

The Standardized Plant Analysis Risk (SPAR) models are the analysis tools used by staff analysts in many regulatory activities, including the ASP Program and Phase 3 of the Significance Determination Process (SDP). The SPAR models have evolved from two sets of simplified event trees that were initially used to perform precursor analyses in the early 1980s. Today's Level 1, Revision 3 SPAR models for internal events are far more comprehensive than their predecessors.

The Level 1, Revision 3 SPAR models comprise a standardized, plant-specific set of PRA-based risk models that use the event tree/fault tree linking methodology. They also use an NRC-developed standard set of event trees and standardized input data for initiating event frequencies, equipment performance, and human performance. These input data can be modified to be more plant- and event-specific, where needed. The system fault trees contained in the SPAR models are not as detailed as those contained in licensees' PRA models. However, benchmarking performed with the SPAR models during the onsite quality assurance review of these models indicates that the models capture 80–85% of the total overall core damage frequency.

Revision 3 of the SPAR models includes uncertainty analysis capability through the propagation of uncertainties at the equipment and human performance levels. The SPAR models use results from studies sponsored by the NRC's Office of Nuclear Regulatory Research (RES) to provide an independent validation of input parameters used in a licensee's PRA. These studies include system and component reliability studies, initiating event studies, and a human reliability analysis method.

In 1999, the SPAR Model Users Group (SMUG) assumed coordination of model development efforts that support the ASP Program and other risk-informed regulatory processes. This group is composed of representatives from RES and the Office of Nuclear Reactor Regulation (NRR), and regional offices that use reactor plant risk models in regulatory activities. In August 2000, the SMUG completed the SPAR Model Development Plan, which conforms to the modeling needs that SMUG members and their management identified for performing risk-informed regulatory activities. This plan addresses the following models:

- internal initiating events during full power operation (Revision 3 SPAR models)
- internal initiating events during low-power and shutdown operations
- external initiating events (including fires, floods, seismic events)
- calculation of large early release frequency (LERF)

Uses

The NRC staff uses the ASP methodology, SPAR models, and ASP analysis results to perform the following risk-informed regulatory activities:

- Promptly assess the risk significance of operational events to support regulatory decisions by senior management.

- Evaluate the significance of inspection findings as part of the agency's Reactor Oversight Process (ROP) in Phase 3 of the Significance Determination Process (SDP).

- Establish plant-specific, risk-informed thresholds to support the development of enhanced performance indicators for the ROP.

- Develop risk-informed thresholds for industry-level indicators in the Industry Trends Program.
- Evaluate the change in risk associated with licensing amendments submitted by licensees requesting changes in surveillance frequencies or allowed outage times.
- Support decisions to develop generic communications.
- Systematically screen, review, and analyze operational experience data for accident sequence precursors.
- Evaluate the generic implications of precursors, trend industry performance, and compare results against PRAs.
- Perform regulatory analyses to resolve generic issues.