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JAN 3 1 1991

MEMORANDUM FOR: Edward L. Jordan, Director
Office for Analysis and Evaluation
of Operational Data

FROM: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER NUMBER 168;
RISK-BASED PERFORMANCE INDICATORS

REFERENCE: Memorandum from S. J. Chilk to V. Stello,
"Staff Requirements - SECY-88-103, "Status of
Performance Indicator Program," June 24, 1988.

This letter summarizes the results of research in support of AEOD to develop an indicator of the unavailability of selected, risk-significant safety-systems.

The candidate indicator is the product of the fractions of time during the previous quarter when the trains of the selected system would not have functioned on demand. For example, the indicator of unavailability of a two-train system is the product of the fraction of time during the quarter when train 1 would not have functioned on demand during plant operation, times a similar fraction for train 2. Thus, when the indicator is calculated from data that contains all contributors to unavailability (e.g., component failures, human errors, and maintenance outages), the indicator is a rough measure of the probability that, during reactor operation in the previous quarter, the system would not have functioned on demand, provided that the contributors to unavailability are independent of each other.

By using train or component failures (instead of complete safety-system failures, used in the existing indicator) the candidate indicator provides a more rapidly responding and more risk-significant indication of safety-system unavailability.

Regulatory Issue

In 1988, SECY-88-103 reported the status of this research to the Commission. In response, the Commission asked the staff to: (1) validate the indicator by retrospective analysis with actual plant data, and (2) explore alternative methods of getting data for this candidate indicator without rulemaking (Reference 1). In 1989, SECY-89-066 reported the status of research on the first issue, validation.

FOS

Now we have completed research both on validation and on an alternative data base. This letter provides a summary of the technical basis for a joint AEOD/RES SECY paper to inform the Commission of these research results (WITS follow-up Item 8800080). Also, AEOD may wish to include in the SECY paper staff views and recommendations regarding implementation of the indicator.

Conclusions

This research has led us to the following conclusions.

1. When the indicator is calculated from data that contains all contributors to unavailability, the indicator is a rough measure of the unavailability of the system.

2. The indicator can help to flag instances of degraded or degrading availability of the following, risk-significant safety systems:

   - o For PWRs: EDGs, AFW, & HPI;
   - o For BWRs: EDGs, RHR, and HPSI/RCIC.

3. Retrospective analysis with data from plant logs from three sites provided empirical evidence that:

   - o the indicator can identify high, low, and changing unavailability, and
   - o these results appear reasonable in light of other (qualitative) measures of plant performance, such as inspection reports.

4. Uncertainty in this indicator is inherent in the evaluation of operational data regarding component failures and other outages to determine:

   - o whether a component could not perform its safety function, and,
   - o if so, how long was the fault exposure time.

   These uncertainties, however, are common to all risk analyses and reliability data bases, including PRAs and the Nuclear Plant Reliability Data System (NPRDS). Even with these uncertainties, the candidate indicator, based on component or train failures responds more rapidly than the existing indicator, which is based on less frequent, complete system failures.

5. The major problem with the candidate indicator is that NRC does not collect the input data. (Licensees, however, collect most of these data from plant operating logs to calculate an INPO indicator of safety system performance.)

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WASHINGTON, D. C. 20555

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   These uncertainties, however, are common to all risk analyses and reliability data bases, including PRAs and the Nuclear Plant Reliability Data System (NPRDS). Even with these uncertainties, the candidate indicator, based on component or train failures responds more rapidly than the existing indicator, which is based on less frequent, complete system failures.

5. The major problem with the candidate indicator is that NRC does not collect the input data. (Licensees, however, collect most of these data from plant operating logs to calculate an INPO indicator of safety system performance.)

6. NPRDS contains fault-exposure time and repair time due to component failures. Such component failures are often, but not always, the major contributor to increases in unavailability of safety systems in the historical data we studied. Other contributors to safety-system unavailability, that NPRDS does not include, are: scheduled preventive maintenance, some support-system failures, and human errors.

7. When the indicator is calculated from the smaller scope of data in NPRDS, the result is simply a relative indication of the system unavailability. Therefore, when the indicator is calculated from NPRDS, outliers are identified by statistical analysis, instead of by comparison with a benchmark of expected unavailability. Also, the smaller scope of NPRDS data makes indicator trends less reliable than when based on more complete data.

   Nevertheless, this relative indication from NPRDS provides useful information. The reason behind this is that the fault-exposure times and repair times in NPRDS are for component failures, which are major contributors to increases in safety-system unavailability.

8. Outliers identified by statistical analysis of this NPRDS-based indicator correlate with the number of precursors (excluding precursor events that did not involve failures).

9. Software is available for automated calculation of this indicator from NPRDS data.

Regulatory Applications

The research was conducted to develop a candidate indicator that could potentially supplement or replace the number of safety system failures in NRC's set of plant performance indicators.

An indication that a plant is operating with high likelihood that important safety systems would not function on demand (e.g., high unavailability) reflects one aspect of risk.

Furthermore, indications of increased unavailability of safety systems can indicate that maintenance has been ineffective in preventing safety-systems from degrading. Therefore, the indicator may provide useful feedback in a reliability-based approach to maintenance.

The indicator might also provide useful information to help focus NRC inspections. Also, when problems have been identified, the indicator might subsequently help staff confirm whether licensee improvement programs have proven effective.

Restrictions on Application

Alternatives for collecting the data could involve:

- o changing licensee reporting requirements to include data on train or component unavailability,
- o collecting the data that licensees use to calculate the INPO indicator of safety system performance, or
- o using NPRDS data to calculate the indicator.

Using NPRDS data would limit the capability of the indicator by excluding contributions to unavailability from scheduled preventive maintenance, some support-system failures, and human errors. Also, the delay time in reporting data to NPRDS would make an NPRDS-based indicator two or more quarters behind the data for other NRC indicators. Furthermore, since NPRDS is a voluntary system, licensees could be tempted not to report failures, and thereby avoid indicating potential problems to NRC.

Nevertheless, even with these limitations, using NPRDS to calculate the indicator can provide useful information that is not available otherwise. For example, the analysis of ten reactors with NPRDS identified half of the instances of high unavailability of AFW and EDGs that were identified from the more complete plant-log data.

Finally, we want to make clear that this indicator is not a "risk-meter" which integrates many factors to estimate overall plant risk. Instead, this indicator includes just one aspect of risk, e.g., the probability that during the quarterly time period, selected safety systems would not have functioned on demand.

Unresolved Questions and Further Work

A closely related aspect of risk management is prevention of multiple (e.g., dependent) failures such as occurred in the 1985 loss of feedwater at Davis Besse. One potential improvement in this area could be a way to analyze component failure data to flag increasing susceptibility of safety systems to dependent failures. This type of dependent-failure indicator could complement the unavailability indicator described in this letter, and could increase both the flexibility and risk-effectiveness of surveillance testing.

Also, longer-range research to further develop technology for dynamic PRA eventually could transform PRAs into time-varying models of risk. We plan to discuss with AEOD and NRR the potential usefulness of research in these areas to further enhance the technical basis for risk management.

Additional references

Two BNL reports describe the technical basis for the indicator and automated analysis of NPRDS data as one way to calculate the indicator:

1. NUREG/CR-5652, "System Unavailability Indicators and Potential Extension to Operational Risk Management," to be published in 1991.

2. BNL Report A3295-12-5-90, "Automated use of NPRDS for Construction of System Unavailabilities and Aggregate Component Failures," by Azarm, Hsu, Carbonaro, Elkins, and Vesely, dated December 5, 1990.

Recommendations

With respect to the indicator of unavailability of safety systems, we recommend:

(1) that AEOD proceed with trial use of the indicator of safety system unavailability. The indicator could be based on NPRDS, initially. Both NPRDS data and software for analysis of NPRDS data are available to NRC. The results could help to identify outliers with high unavailability of safety systems.

(2) that AEOD explore ways to collect more complete data on unavailability of safety systems, possibly through INPO or through changes in reporting requirements.

We plan to work with AEOD to jointly develop a SECY paper that informs the Commission of these research results and, if appropriate, AEOD's views and recommendations regarding implementation.

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

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Eric S. Beckjord, Director
Office of ~~Nuclear Regulatory~~ Research

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Subject File No. R-2000,03
RIL NO. 168
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Recommendations

With respect to the indicator of unavailability of safety systems, we recommend that:

(1) AEOD proceed with trial use of the indicator of safety system unavailability. This could be based on NPRDS, initially.

(2) AEOD explore with industry ways to get the data that licensees use to calculate the INPO indicator of safety system performance

We look forward to working with AEOD to develop a SECY paper that informs the Commission of these research results and AEOD's plans regarding implementation.

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