June 19, 2001

Dr. William D. Travers
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Dr. Travers:

SUBJECT: RISK-BASED PERFORMANCE INDICATORS: PHASE 1 REPORT

During the 483rd meeting of the Advisory Committee on Reactor Safeguards, June 6-8, 2001, we completed our review of the staff's report on the results of the Phase 1 effort to develop risk-based performance indicators (RBPIs). We also discussed this matter with representatives of the NRC staff and the Nuclear Energy Institute (NEI) during our 482nd meeting, May 10-11, 2001. Our Subcommittee on Reliability and Probabilistic Risk Assessment discussed this matter on April 17, 2001. We had the benefit of the documents referenced.

Conclusions and Recommendations

Although the scope of the Phase 1 study was limited to the technical feasibility of developing RBPIs, our letter addresses some of the questions that might arise in the implementation of these candidate PIs.

1. A rational framework has been established for evaluating RBPIs and handling the relevant aleatory and epistemic uncertainties in evaluating PIs from available data.

2. The staff should continue to develop RBPIs as part of the ongoing effort to make the reactor oversight process (ROP) more objective and scrutable.

3. The staff should develop methods for assessing tradeoffs between introducing new PIs versus reducing baseline inspections.

4. The staff should investigate establishing thresholds that depend on the baseline core damage frequency (CDF) of the plant.

5. The Phase 1 report states that the green/white thresholds used in the current ROP correspond to changes in CDF (ΔCDF) that vary by more than an order of magnitude among plants. The green/white thresholds in the ROP should be reevaluated.

6. The derivations of decision rules (thresholds for RBPIs) given in Appendix F to the RBPI Phase 1 report should be expanded to include plant- or design-specific prior distributions.

7. The staff should continue to explore "alternative" RBPIs.

8. The potential for unintended impacts of RBPIs on plant performance is a concern and should be carefully considered in the development of the RBPIs.

9. The staff does not have the up-to-date risk information needed to develop RBPIs for shutdown operations; therefore, the staff's work should focus on full-power operations until such information is developed.

10. There should be a publicly available peer review of the SAPHIRE code and, eventually, the Standardized Plant Analysis Risk (SPAR) models.

11. It is premature to initiate a pilot program for RPBIs.

Discussion

PIs and baseline inspections constitute major elements of the ROP whose objective is to verify that reactor facilities are operated safely and to provide early warning of adverse trends and deteriorating licensee performance. The PI values are determined based on statistical evidence from actual plant performance and, therefore, remove some of the subjectivity that is inherent in the inspection and assessment processes. Even though inspection findings are related to risk metrics through the significance determination process (SDP), the PIs are less subjective. Both PIs and inspection findings provide input to the action matrix in determining the need for increased NRC involvement in addressing plant performance issues. RBPIs have the advantage that their relation to risk is direct and more transparent than that of other types of PIs.

Although the evaluation of PIs appears to be a straightforward and objective process, it is important to distinguish between aleatory and epistemic uncertainties to ensure that the calculated values are statistically meaningful. The practical questions in the evaluation of PIs are: How long should the observation period be and how many occurrences over this period (the aleatory variable) will lead to the conclusion that the average frequency (the epistemic variable) has shifted? Statistical methods for handling these questions are available and have been employed appropriately by the staff in Appendix F. We encourage the staff to continue this work.

It is important that PIs and inspections complement each other and that the collection of redundant information be avoided. Introducing additional PIs should be justified either on the basis that some important aspects of plant performance are not addressed well in the current ROP or that information previously collected via inspections can now be better obtained through the new PIs, thereby allowing reduced inspection. In order to evaluate the potential for increased regulatory burden associated with additional PIs, the staff should develop methods for evaluating the tradeoffs between introducing new PIs and reducing inspections.

In the Phase 1 study, the thresholds between green and white (GW), white and yellow (WY), and yellow and red (YR) performance bands are chosen to correspond to ΔCDF. The GW threshold corresponds to a ΔCDF of 10^{-6}/reactor-year. The ΔCDF values for the WY and YR thresholds are10^{-5}/reactor-year and 10^{-4}/reactor-year, respectively. These values are claimed to be consistent with the acceptance guidelines in Regulatory Guide 1.174. We note, however, that in Regulatory Guide 1.174 the acceptance limits on ΔCDF are 10^{-5}/reactor-year when the baseline CDF is smaller than 10^{-4}/reactor-year and10^{-6}/reactor-year when the baseline CDF is greater than 10^{-4}/reactor-year. The staff should investigate establishing thresholds that correspond to ΔCDF values that are functions of the baseline CDF.

In contrast to the Phase 1 report, the GW thresholds in the ROP are defined in terms of the 95th percentiles of the plant-to-plant variability distributions for a specified reference period. It is noted in the report that, due to the large plant-to-plant variability in the importance of systems, the thresholds in the ROP correspond to ΔCDFs in excess of 10^{-5}/reactor-year for some plants, a value that is an order of magnitude greater than the GW threshold used in the SDP. The choice of the GW threshold in the ROP should be revised so that the ΔCDFs are consistent from plant to plant.

The statistical analyses in Appendix F provide very useful insights into a number of decision rules for determining the thresholds. Appendix F shows that using generic industry information for the occurrence of transients as the prior distribution leads to unrealistic results. For example, for the transient "loss of heat sink," the number of events in a three-year period that must occur to exceed the thresholds are: GW = 19.5, WY = 335.2, and YR = 3,461. Furthermore, regarding component unavailability, it is concluded in Appendix F that only site-specific data are appropriate for estimating the variability of unavailability data at a plant. From this, it is evident that industry-wide prior distributions should not be used.

In addition, two sets of “noninformative” prior distributions are considered in Appendix F. Using these distributions means that, before collecting the data, the analysts assume that they have no knowledge regarding the distribution of the RBPI values. This is too strong an assumption and inconsistent with the information provided in Individual Plant Examinations. As the report states, the RBPIs should reflect *changes* in licensee performance that are logically related to risk. To evaluate these changes, one must start with the existing distributions of the RBPIs (i.e., use the anticipated plant performance as prior distributions) and then incorporate the collected data to determine whether undesired changes have occurred.

To date, PIs have been defined individually. In other words, the thresholds have been set in such a way that, when exceeded, the PI alone indicates unacceptable performance. It is possible, however, that several PIs may increase in such a way that the change in CDF is significant even though each PI remains below its corresponding threshold. The questions are, then: What is an appropriate set of PIs and by how much should they deviate from their expected values to suspect that the licensee performance is indeed deteriorating and that increased regulatory attention is warranted? We commend the staff for raising this very important issue and encourage the staff to pursue what it denotes as "alternative approaches for RBPI determination."

For shutdown modes, the staff is proposing to consider four risk-significant states, depending on reactor-cooling conditions, time after shutdown, and the availability of mitigating system

trains. The RBPIs are, then, defined as the times spent in each of these states. NEI raises an important issue regarding an unintended impact of these shutdown RBPIs: thresholds based on time spent in each state could discourage licensees from exercising caution when warranted. For example, a situation may arise while in the "medium" risk state that would call for a deliberate approach, resulting in a longer time in this state. Knowing that this extension of time may move a performance indicator to the white performance band may have an adverse impact on the licensee's decision. There is a similar problem with the unavailability RBPI, which is also based on time (the duration of planned and unplanned outages). These and other unintended impacts should be investigated.

A more fundamental problem with the development of shutdown RBPIs is the lack of adequate risk information. The Phase 1 report had to rely on available results that were based on assumptions that could not be evaluated. The PRA knowledge base for shutdown modes is much weaker than for power operations. In light of this observation and the NEI concern noted above, the staff's work should focus on the development of RBPIs for power operations until sufficient risk information is developed for shutdown modes.

The development of RBPIs uses computerized SPAR models. At this time, about 30 such models have been developed and reviewed by the licensees. We believe that the underlying computer code (SAPHIRE) should be subjected to the Office of Nuclear Regulatory Research process for reviewing computer codes that has been used for SCDAP, CONTAIN, MELCOR, and VICTORIA. Peer review of the SAPHIRE code is a necessary first step that should lead eventually to peer review of the SPAR models.

The Phase 1 report is a good step toward the development of RBPIs. As noted in our recommendations, significant work remains to be done before a pilot program is initiated. We look forward to working with the staff on this important matter in the future.

Sincerely,

/RA/

George E. Apostolakis
Chairman

References:

1. U. S. Nuclear Regulatory Commission, draft report entitled, Risk-Based Performance Indicators: Results of Phase-1 Development, and Associated Appendices A-G, January 2001.
2. Memorandum dated June 28, 2000, from William D. Travers, Executive Director for Operations, NRC, to the Commissioners, Subject: SECY-00-0146, "Status of Risk-Based Performance Indicator Development and Related Initiatives."
3. Memorandum dated May 7, 2001, from Hossein G. Hamzehee, Office of Nuclear Regulatory Research, NRC, to Patrick W. Baranowsky, Office of Nuclear Regulatory Research, NRC, Subject: Summary of April 24, 2001 Public Meeting on Draft Phase-1 Risk-Based Performance Indicator Development Report.
4. Memorandum dated March 9, 2001, from Hossein G. Hamzehee, Office of Nuclear Regulatory Research, NRC, to Patrick W. Baranowsky, Office of Nuclear Regulatory Research, NRC, Subject: Summary of February 21, 2001 Public Meeting on Draft Phase 1 Risk-Based Performance Indicator Development Results.

5. Memorandum dated December 1, 2000, from William M. Dean, Office of Nuclear Reactor Regulation, NRC, to Thomas L. King, Office of Nuclear Regulatory Research, NRC, Subject: Comments on Draft Phase-1 Risk-Based Performance Indicator Report (Predecisional Draft).
6. Memorandum dated November 30, 2000, from Farouk Eltawila, Office of Nuclear Regulatory Research, NRC, to Thomas L. King, Office of Nuclear Regulatory Research, NRC, Subject: Review of Report - Results of Phase-1 Risk-Based Performance Indicator Development (Predecisional Draft).
7. Memorandum dated November 20, 2000, from James Wiggins, NRC Region I, to William Dean, Office of Nuclear Reactor Regulation, NRC, Subject: Regional Comments on Report, "Results of Phase-1 Risk-Based Performance Indicator Development" (Predecisional Draft).
8. Memorandum dated November 27, 2000, from Michael E. Mayfield, Office of Nuclear Regulatory Research, NRC, to Thomas L. King, Office of Nuclear Regulatory Research, NRC, Subject: Review of Report - Results of Phase-1 Risk-Based Performance Indicator Development (Predecisional Draft).
9. Letter dated May 12, 2001, from Stephen D. Floyd, Nuclear Energy Institute, to Michael T. Lesar, Acting Chief, Rules and Directives Branch, NRC, Subject: Comments on "Risk-Based Performance Indicators: Results of Phase-1 Development."
10. Letter dated May 11, 2001, from J. M. Kenny, Chairman, Boiling Water Reactor Owners' Group, to Michael T. Lesar, Division of Administration, NRC, Subject: BWROG Comments on Risk-Based Performance Indicators: Results of Phase-1 Development.
11. Letter dated May 14, 2001, from R. M. Krich, Exelon Generation Company, to Michael T. Lesar, Acting Chief, Rules and Directives Branch, NRC, Subject: Response to Request for Public Comments on Risk-Based Performance Indicators: Results of Phase-1 Development.
12. Letter dated March 9, 2001, from Mark J. Burzynski, Tennessee Valley Authority, to Chief, Rules and Directives Branch, NRC, Subject: Risk-Based Performance Indicators: Results of Phase 1 Development.
13. Memorandum dated January 8, 1999, from William D. Travers, Executive Director for Operations, to the Commissioners, Subject: SECY-99-007, "Recommendations for Reactor Oversight Process Improvements."
14. Memorandum dated March 22, 1999, from William D. Travers, Executive Director for Operations, to the Commissioners, Subject: SECY-99-007A, "Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007)."
15. U. S. Nuclear Regulatory Commission, Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," July 1998.