UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555

October 31 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Jackson:

SUBJECT: Application of Probabilistic Risk Assessment Methods to Performance Assessment in the NRC High-Level Waste Program

This letter provides the Commission with the Advisory Committee on Nuclear Waste's (ACNW's) observations and recommendations on the application of probabilistic risk assessment (PRA) methods to performance assessment (PA) in the High-Level Radioactive Waste (HLW) Program. We believe our recommendations enhance the Commission's policy of increasing the use of risk-informed, performance-based approaches in waste management. The Committee considers this issue a high-priority item because of the need for transparency and clarity[1] in the decision-making process, not only for the NRC's prelicensing and licensing activities for the proposed HLW repository at Yucca Mountain, but also for other waste-related activities, such as decommissioning, low-level waste management, and management of uranium mill tailings. The complexity of the proposed repository system at Yucca Mountain and the models that are intended to represent its performance over time necessitates some method for presenting the results that clearly indicates to the decision makers and to the public what the expected performance will be and what the main subsystem components are that contribute to that performance. The Committee firmly believes that certain PRA approaches can be successfully applied to the PA results for waste management.

Summary and Recommendations

In general, the Committee is impressed with the methods employed by both the NRC and the Department of Energy (DOE) in their work on PA. Analytically characterizing the performance of the proposed Yucca Mountain repository involves an unprecedented application of physical process modeling and probability methods. The progress in abstracting site characterization and facility design information into probabilistic PA (PPA) models has been extensive.

[1] By "transparency" we mean the ability to see through the entire process, to understand the process; by "clarity" we mean the ability to discern the key elements in the analyses.

Despite this considerable progress, the Committee does have some concerns about the staff's PA program. These concerns center around two primary issues. The Committee believes that PAs should follow the intent and spirit of the risk-assessment philosophy of developing realistic models with uncertainties included, as opposed to developing bounding or worst-case calculations. We also believe the assessments should enable unraveling the results into rank-ordered contributors to the overall risk or to the performance of the repository. The latter provides a solid basis for developing confidence in the design and meaningful risk-management practices.

Therefore, we recommend the following:

- To as great an extent as possible, realistic models and parameters should be used so that the results of the PAs represent the full range of values (i.e., upper and lower bounds, central tendency parameters, and the values in between) that realistically can be supported by the evidence.

- Bounding analysis and worst-case calculations should be used primarily to screen out issues of little or no concern, i.e., to scope the analysis, but not to be the basis for generating results that are clearly out of context with reality and, thus, that do not produce a framework for judging reality.

- The NRC Total Performance Assessment code, version 3.1 (TPA-3), should be reviewed for unrealistic results that arise from bounding calculations embedded in the code. Ultraconservative model assumptions and parameter values should be replaced with more realistic assumptions and probability distributions.

- An event tree or a similar approach for evaluating the TPA-3 model results emphasizing the systematic and efficient unraveling of results into specific contributors to performance should be developed and applied.

- Appropriate importance measures should be developed. We understand that staff from both the NRC and the Center for Nuclear Waste Regulatory Analyses (CNWRA) are currently working on this issue. The Committee encourages the continuation of this effort.

- Subsystem performance measures at specific pinch points[2] in the analysis, such as the flux of radionuclides released from the repository into the geosphere, should be defined. These performance measures might include the integrated release of radionuclides over time, or the release rate as a function of time. Both the NRC and DOE have indicated that their respective models are capable of providing intermediate results (e.g., source term output to the geosphere). Hence, the approach can take advantage of the existing model subsystem output capabilities.

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[2] Pinch points occur where outputs (material, energy, or information flow) from one module of the total system model become the inputs to another module.

Background

The comments in this letter have been developed, in part, on the basis of a working group meeting on the application of PRA methods to PA during the 93rd ACNW Meeting at the CNWRA in San Antonio, Texas, on July 24, 1997. Participants included representatives from: the PRA field; the Electric Power Research Institute; the DOE's Yucca Mountain Project; the Waste Isolation Pilot Plant PA Project; and the NRC staff. The Committee benefited from detailed NRC staff presentations on the HLW PA program and the NRC's TPA-3 code during the previous day's ACNW meeting on HLW PA capability. The Committee members and staff also observed the NRC/DOE technical exchange on DOE's Total System Performance Assessment activities and NRC's iterative performance assessment (IPA) efforts on July 21-22.

Accomplishments

The NRC staff's work on the revised TPA-3 code represents a pivotal effort. The staff has made longstanding, extraordinary efforts to ensure that appropriate site characterization information is collected and to understand the processes that ultimately may determine the performance of an HLW repository at Yucca Mountain. As part of the IPA program, the staff has developed approaches for abstracting site and design information and process models that have been incorporated into the TPA-3 model. The Committee commends this effort and notes that the recommendations previously presented are aimed primarily at developing more realistic models, mainly with respect to assumptions and scope, and improvements in processing the information that is the current output of the TPA-3 model. In particular, the Committee is not suggesting basic changes in the model but is encouraging more realistic assumptions and improvements in the methods for analyzing the results of the PAs.

Realistic Models

Probabilistic concepts have their greatest value in communicating confidence in the outcome of an event or process. They provide the tool for analysts to express their full state of knowledge about how likely an event or process is. The introduction of probabilistic analysis does not replace the deterministic models; rather, it allows a richer interpretation of results. Of course, the probabilities must be supported with appropriate evidence, and to the extent that the evidence is weak, the uncertainties are greater. Such communication is the essence of probabilistic analysis. Thus, the aim of PPA should be to "tell it like it is" on the basis of all the evidence available. The result is what the experts and, with public participation, society believes is likely to happen. A logical framework then exists to make decisions as conservative as desired, but within a framework that defines the level of conservatism.

Interpretation of the Results

Although there are clear differences between nuclear power plant PRAs and waste system PAs (which have been discussed with the Commission by both the NRC staff and the ACNW), a number of key similarities makes it possible to consider the use of PRA methods, such as the top-down event tree approach, to facilitate interpretation of PA results. Both PRAs and PAs

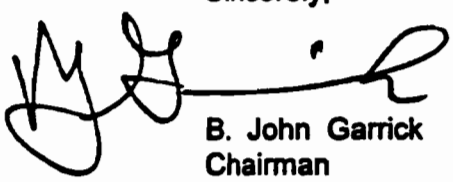
begin with a set of initial conditions (in PRAs these are called initiating events). In PAs, the initial conditions may consist of such phenomena as climate conditions, volcanic events, seismic events, or human intrusion. Both PRA and PAs use a modular approach to the analysis (in PRAs, this includes level-I, -II, and -III analyses; in PAs this includes analyses for infiltration, engineered barriers, source term, geosphere transport, biosphere uptake, and dose to the critical group). Both methodologies can be decomposed into logical pinch points for which specific performance measures can be developed (such as core damage for PRA and integrated release of radionuclides into the geosphere for PA). The goal is to develop a systematic and efficient method for identifying different inputs and outputs of the various modules that make up the full PA model in terms of their individual contribution to the overall performance of the repository. To do this may require a different approach in the way that scenarios are structured for PA.

At our workshop, candidate methods were presented for systematically and efficiently interpreting the results from PAs using a post-processing tool, such as an event tree approach. The postprocessor could make the results more transparent and sharpen our understanding of the total system model. The Committee believes that these techniques should be explored for TPA-3.

An important benefit of the proposed approach to interpreting PA results should be with respect to the program for evaluating key technical issues (KTIs). The postprocessor should greatly facilitate the task of determining the importance of individual KTIs to the overall performance of the repository. This will allow staff to allocate already scarce resources to the KTI program so that the focus is on the most important KTIs and subissue areas. The approach will also prove useful in determining where uncertainties are important to demonstrating compliance and where they do not really matter, even if they are large. Sometimes there is a tendency to focus only on the relative magnitude of the uncertainty in a model or parameter (large uncertainty is considered bad and small uncertainty is considered good), rather than on whether that uncertainty makes any significant difference to the bottom-line result, which is ultimately the health and safety of the public. The goal in the near term would be to avoid spending large resources on trying to reduce uncertainties that do not matter to the result. In the longer term, the goal is to be able to defend in a licensing hearing the specific staff positions in the safety evaluation report vis-a-vis the magnitudes of the uncertainties for different subsystems and for total system performance.

The Committee looks forward to following the staff's program in PA, and we are particularly interested in its progress on the two issues of transparency of results and the use of realistic models.

Sincerely,



B. John Garrick
Chairman