UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

ACRSR-2247

April 23, 2007

The Honorable Dale E. Klein
Chairman
U.S. Nuclear Regulatory Commission
Washington DC 20555-0001

SUBJECT: HUMAN RELIABILITY ANALYSIS MODELS

Dear Chairman Klein:

In a November 8, 2006 Staff Requirements Memorandum (SRM), resulting from the October 20, 2006 meeting with the Advisory Committee on Reactor Safeguards (ACRS), the Commission requested that the ACRS "work with the staff and external stakeholders to evaluate the different Human Reliability models in an effort to propose either a single model for the agency to use or guidance on which model(s) should be used in specific circumstances." During the 541st meeting of the ACRS, April 5-7, 2007, we discussed proposed plans by the NRC staff and the Electric Power Research Institute (EPRI) for moving forward to evaluate several human reliability analysis (HRA) models used by staff and industry. Our Subcommittee on Reliability and Probabilistic Risk Assessment also reviewed this matter on March 22, 2007. During these meetings, we had the benefit of discussions with representatives of the NRC staff and EPRI, and of the documents referenced.

CONCLUSION

The staff and EPRI are making progress in developing a plan to evaluate several human reliability analysis models.

DISCUSSION

Insights and results from probabilistic risk assessments (PRAs) and models for human performance provide valuable input to many regulatory decisions. NUREG-1842, "Evaluation of Human Reliability Analysis Methods Against Good Practices," lists several different methods for HRA in support of PRAs. Even within the agency, the staff uses multiple approaches to human reliability analysis for actions following an initiating event.

ATHEANA (A Technique for Human Event Analysis) is the result of a multi-year research effort supported by the Office of Nuclear Regulatory Research. Its underlying premise is that significant human errors occur as a result of a combination of influences associated with plant conditions and specific human-centered factors that may lead plant personnel to perform unsafe acts. ATHEANA provides a systematic process for the identification of these combinations of influences (the "error-forcing contexts"). Given an error-forcing context, ATHEANA requires that a group of experts develop the probabilities of unsafe acts.

In 1994, an NRC HRA model was developed to support the Accident Sequence Precursor (ASP) Program. This is the Accident Sequence Precursor /Standardized Plant Analysis Risk (ASP/SPAR) HRA Model. This model was updated in 1999 and renamed SPAR-H. NRC staff analysts use it for risk-informed regulatory activities such as: the Significance Determination Process Phase 3, the development of an integrated risk-informed performance measure for the Reactor Oversight Process, and the analysis of operating experience data to identify precursors to severe accident sequences. SPAR-H relies on eight performance shaping factors (PSFs) that are deemed to be capable of influencing human performance. These include available time for action, stress level, and experience and training. An error probability is provided that corresponds to all the PSFs being at their nominal values. Adjustment factors for this baseline probability are given for PSF values other than nominal.

During the discussion of draft NUREG-1852, “Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire,” the staff presented another approach for evaluating human actions. This approach is “deterministic” in the sense that it requires a demonstration that the sum of the time to detect the fire and the time to implement actions to control it is less than the available time (i.e., before an undesirable consequence occurs) by a “time margin.” This time margin accounts for the unquantified uncertainties. Besides being “deterministic,” this approach focuses on time in contrast with the ATHEANA and SPAR-H models, which treat time as one of the PSFs.

EPRI has developed an HRA Calculator, which is a software tool designed to facilitate a standardized approach to HRA. The HRA methodologies implemented in the Calculator follow the framework established in EPRI's Systematic Human Action Reliability Procedure (SHARP), the Cause-Based Decision Tree Method (CBDTM), Human Cognitive Reliability/Operator Reactor Experiments (HCR/ORE), the Accident Sequence Evaluation Program (ASEP) Human Reliability Analysis Procedure, and the Technique for Human Error Rate Prediction (THERP). The EPRI models focus on the available time for action to a greater extent than ATHEANA and SPAR-H.

Evaluations of extended power uprate amendments have shown that the most significant impact on core damage frequency is the reduction of the time available for operator action. Estimates are made of the changes in human error probabilities as a result of the shorter times. We understand that these estimates are usually produced using the EPRI Calculator, which, to our knowledge, has not been evaluated by the staff.

Analysts can obtain widely different results for human error probabilities. In mid 1980s, the Ispra Joint Research Center of the European Commission organized a benchmark exercise in which 15 teams from 11 countries used a number of HRA models available at the time to estimate the probability of the crew not responding correctly to a transient. The results produced by the teams using the same HRA model differed by orders of magnitude. The results produced by a single team using a number of HRA models also differed by orders of magnitude. Although these results are fairly old now, it is important to understand whether they are still representative of the model uncertainties present in HRA.

The staff and EPRI are in the process of developing a plan that is intended to lead to an integrated approach to evaluate various HRA models. The goals and important milestones of the project will need to be clearly articulated.

The staff should compare the NRC and EPRI models with respect to their basic assumptions and intended use. An evaluation of the validity of these assumptions and the supporting evidence should be performed. The objective should be to develop a common understanding of the relative importance of factors affecting human performance and ways in which they could be integrated into analyses. Achieving this objective will allow the staff to develop guidance on which model(s) should be used for specific regulatory applications.

The staff is currently organizing an HRA Empirical Study whose objective is to perform model-to-model comparisons to assess the strengths and weaknesses of HRA models. Various operator crews will run scenarios, similar to those appearing in PRAs, at the simulator in Halden, Norway. Teams of analysts will then analyze the human actions appearing in these scenarios using HRA models of their choice. The results will be compared to produce insights with respect to the assumptions the teams made and how the models were applied.

We view this Empirical Study as part of the broader effort to collect evidence regarding the validity of HRA models. Its anticipated benefits should be defined carefully. The study may provide useful qualitative information on crew performance and the factors that influence it. However, the Empirical Study by itself will probably not be sufficient to develop meaningful quantitative estimates of the probability of errors.

Additional evidence should be collected from operating experience, especially the Augmented Inspection Team reports on past incidents. The staff is already evaluating the operating experience in the Human Event Repository and Analysis System (NUREG/CR-6903). These sources of information should be used to enhance the insights gained from the Empirical Study. A large amount of data can be collected from licensee simulators. These data could complement the Halden results. It may also be beneficial to compare the Halden results against data from similar experiments at a U.S. plant simulator.

We look forward to working with the staff in formulating the details of the plan and its implementation.

Sincerely,

William J. Shack
Chairman

References:

1. Memorandum dated November 8, 2006, from Annette L. Vietti-Cook, Secretary, NRC to John T. Larkins, Executive Director, ACRS, Subject: Staff Requirements - Meeting With Advisory Committee on Reactor Safeguards, 2:30 P.M., Friday, October 20, 2006, Commissioners' Conference Room, One White Flint North, Rockville, Maryland (Open to Public Attendance)

2. "Evaluation of Human Reliability Analysis Methods Against Good Practices," NUREG-1842, Final Report, September 2006.

3. "Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire," NUREG-1852, Draft for Public Comment, September 2006.

4. "Human Event Repository and Analysis (HERA) System, Overview," NUREG/CR-6903, July 2006.

5. A. Poucet, "The European Benchmark Exercise on Human Reliability Analysis," Proceedings of International Topical Meeting on Probability, Reliability, and Safety Assessment, PSA '89, Pittsburgh, PA, April 2-7, 1989.

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/RA/

William J. Shack
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