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

February 23, 2009

Mr. R. W. Borchardt
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DRAFT FINAL NUREG-1855, "GUIDANCE ON THE TREATMENT OF UNCERTAINTIES ASSOCIATED WITH PRAs IN RISK-INFORMED DECISIONMAKING," AND DRAFT APPENDIX A, "EXAMPLE IMPLEMENTATION OF THE PROCESS FOR THE TREATMENT OF PRA UNCERTAINTY IN A RISK-INFORMED REGULATORY APPLICATION"

Dear Mr. Borchardt:

During the 559th meeting of the Advisory Committee on Reactor Safeguards (ACRS), February 5-7, 2009, we reviewed the draft final NUREG-1855, "Guidance on the Treatment of Uncertainties Associated with Probabilistic Risk Assessments in Risk-Informed Decisionmaking," and draft Appendix A, "Example Implementation of the Process for the Treatment of PRA Uncertainty in a Risk-Informed Regulatory Application," (Reference 1). Our Subcommittee on Reliability and Probabilistic Risk Assessment (PRA) reviewed NUREG -1855 on December 19, 2007, and on September 30, 2008. During these reviews, we had the benefit of discussions with representatives of the NRC staff, the Electric Power Research Institute (EPRI), Brookhaven National Laboratory, Sandia National Laboratories, and ERIN Engineering and Research, Inc.

CONCLUSIONS AND RECOMMENDATIONS

1. NUREG-1855 is a valuable contribution to the management of uncertainty in risk-informed regulatory applications. It should be published.

2. Draft Appendix A should not be published until it is revised.

3. The staff should develop methods for the quantification and integration of model uncertainties in risk-informed decisions.

4. Additional examples illustrating applications of the diverse aspects of the guidance should be developed and published separately.

DISCUSSION

A long-standing issue in the process of making risk-informed regulatory decisions is the proper assessment of the impact of uncertainties on these decisions. The relevant regulatory documents, e.g., Regulatory Guide 1.174 (Reference 2), require the use of mean values in the comparison of risk metrics such as core damage frequencies with acceptance guidelines. These are the means of the risk metric distributions. These distributions are the result of the propagation of the probability distributions of the epistemic uncertainties in the basic events (component failure rates, human error rates) through the logic models. These are generally called parametric uncertainties as they refer to uncertainties in the parameters of probabilistic models of failure.

Parametric uncertainties are only one source of uncertainty in PRAs. For some basic events, e.g., human error rates, the models require assumptions and approximations, which themselves, are sources of uncertainty. In addition, the decision maker has to always be concerned about the completeness of the analyses (the "unknown unknowns"). Typically, PRA results, i.e., the derived risk metrics, do not include these uncertainties.

NUREG-1855 provides excellent discussions on epistemic uncertainties (due to parameters, models, and incompleteness) and places them in the context of risk-informed decisionmaking. The guidance for the identification of sources of model uncertainty is a significant advance and will enhance the quality of regulatory decisionmaking. It should be published.

Although NUREG-1855 provides good guidance for the identification of sources of model uncertainty, it stops short of providing meaningful guidance on quantification of these uncertainties and integrating them into the overall PRA results or risk-informed decisions. The report heavily emphasizes sensitivity studies. Such studies can be useful in gaining insight into the impact of uncertainties, but often involve implicit judgments as to the adequacy of the range of variables examined.

The issue of quantification of model uncertainty has long been of interest to the Nuclear Regulatory Commission (NRC) and the ACRS (Reference 3). The agency sponsored a workshop dedicated to this issue 16 years ago (Reference 4) in which several ideas regarding quantification were debated. On a more practical level, two major NRC-sponsored studies addressed this issue. They both employed expert judgments. In NUREG-1150 (Reference 5), the experts assigned weights to alternative hypotheses (models). In NUREG/CR-6372 (Reference 6), the experts combined the results of alternative models and sensitivity analyses subjectively without assigning weights explicitly.

Both of the NRC studies mentioned above (References 5 and 6) dealt with issues of major importance and had the appropriate amounts of resources. This is not the case for most risk-informed regulatory decisions. For example, requiring that the PRA be performed using a number of alternative human reliability models and then having experts evaluate the results would impose a major burden and would be impractical. There is a great need for appropriate guidance on these matters. It will be a challenge to develop guidelines that will help the analysts incorporate model uncertainties into PRAs efficiently and perform meaningful sensitivity studies. The staff should undertake such an effort.

In addition, NUREG-1855 deals with PRAs that consist primarily of binary events (sometimes called PRA Level 1+). Although many regulatory decisions focus primarily on Level 1+ PRA results, consequence analyses and the Safety Goals require risk information and assessments of the uncertainties in Level 2 and 3 PRAs. Significant model uncertainties may arise in modeling physical and chemical phenomena that are addressed in these PRAs. Guidance on handling these uncertainties should be part of the follow-on work[1]. Appendix A to NUREG-1855 is intended to provide an example implementing the guidance given in the draft report. The example is a hypothetical License Amendment Request to revise the Technical Specification Allowed Outage Time from 3 days to 7 days for the Residual Heat Removal/Suppression Pool Cooling system at a representative Boiling Water Reactor, Mark II plant. The Appendix begins with important illustrations of how to break down PRA results into hazard groups identifying the impact of proposed changes at a detailed level. It uses this information to develop lists of contributors that are potential sources of uncertainty that could impact results.

A number of problems exist in the analysis, particularly the sensitivity studies, that require improvement before the Appendix is suitable for publication:

- Results are presented in ways that may be misinterpreted as general conclusions, when they are applicable only to the specific situation modeled. For example, in the fire risk analysis, the ignition frequency is identified as a key source of uncertainty but the fire models are not. No justification is provided.

- Important dependencies are not described in ways that make it clear that the user will need to identify and model them properly. For example, the coupling between seismically induced loss of offsite power and loss of coolant accident is not adequately described.

- There is a serious problem in the use of arbitrary sensitivity analyses to evaluate model uncertainties. It is recognized in NUREG-1855 and the Appendix that human error probabilities (HEPs) are a source of model uncertainties. A sensitivity analysis is presented in Table A.3-19 in which "All HEP events [are] set to their 95th percentile value[s] to approximate use of different method[s]." No evidence, discussion, or references are provided to justify an implicit assumption that the 95th percentile of the method employed in the PRA encompasses the results of other models.

These sensitivity analyses are intended to guide the analysts in identifying compensatory measures that would increase our level of confidence that the acceptance guidelines are met. This is a very worthwhile objective. However, its achievement requires more discussion of the sufficiency of the analyses to identify key uncertainties. In addition, guidance would be needed on the quantitative evaluation of the impact of these compensatory measures.

Finally, there is a pervasive view in this Appendix, borrowed from the EPRI document that it cites heavily (Reference 8), that the current PRAs typically contain significant conservatisms. Not enough attention is paid to the possibility that there may be significant non-conservative assumptions.

Appendix A should not be published in its present form. Revision of the Appendix will avoid many difficulties for users implementing the guidance and for staff reviewing analyses based on the report. The issuance of the revised Appendix will add to the value of draft final NUREG-1855.

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[1] The agency is sponsoring a significant effort to quantify the uncertainties in the results of fire models (Reference 7).

At a later time, it would be useful to publish a report with additional examples illustrating more diverse evaluations of the kinds of uncertainty described in the report. These examples should be less influenced by the assumptions and numerical analyses from a single plant-specific PRA. We look forward to future interactions with the staff on these important matters.

Sincerely,

/RA/

Mario V. Bonaca
Chairman

References:

1. Draft NUREG-1855, "Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decisionmaking," and draft Appendix A, "Example Implementation of the Process for the Treatment of PRA Uncertainty in a Risk-Informed Regulatory Application," 02/02/2009 (ML090300541)

2. Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Revision 1, 11/29/2002 (ML023240437)

3. Letter Report from Mario V. Bonaca, Chairman, ACRS, to Nils J. Diaz, Chairman, U. S. Nuclear Regulatory Commission, "Improvement of the Quality of Risk Information for Regulatory Decisionmaking," 05/16/2003 (ML031420832)

4. A. Mosleh, N. Siu, C. Smidts, and C. Lui, Editors, "Model Uncertainty: Its Characterization and Quantification," Proceedings of Workshop I on Advanced Topics in Risk and Reliability Analysis, Annapolis, Maryland, Oct. 20-22, 1993, pp. 167-186, NUREG/CP-0138, Nuclear Regulatory Commission, Washington, DC, 10/31/1994

5. NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," 12/31/1990 (ML040140729)

6. Senior Seismic Hazard Analysis Committee (SSHAC), "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," NUREG/CR-6372, 04/30/1997 (ML080090003 & ML080090004)

7. NUREG-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications," 05/31/2007 (ML071650546)

8. Electric Power Research Institute, "Treatment of Parameter and Model Uncertainty for Probabilistic Risk Assessments," EPRI Report 1016737, Palo Alto, CA, 2008

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