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

December 10, 2004

The Honorable Nils J. Diaz
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: ESTIMATING LOSS-OF-COOLANT ACCIDENT FREQUENCIES THROUGH THE ELICITATION PROCESS

Dear Chairman Diaz:

During the 518th meeting of the Advisory Committee on Reactor Safeguards on December 2-4, 2004, we reviewed the draft NUREG Report, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies through the Elicitation Process," (Reference 1). Our Subcommittee on Regulatory Policies and Practices reviewed this matter during a meeting on November 16, 2004. During these reviews, we had the benefit of discussions with the NRC staff and of the documents referenced.

RECOMMENDATION

The draft NUREG Report should be revised prior to being issued for public comment.

DISCUSSION

In a staff requirements memorandum (SRM) dated March 31, 2003 (Reference 2), the Commission directed the staff to develop a risk-informed alternative to the current requirements in 10 CFR 50.46 related to the analysis of the performance of emergency core cooling systems (ECCS) during LOCAs. The focus of this effort is the selection of a risk-informed transition break size (TBS) for the alternative design-basis LOCA. In an SRM dated July 1, 2004 (Reference 3), the Commission directed the staff to use LOCA frequencies derived from an expert-opinion elicitation process, supported by historical data and fracture mechanics and other relevant information to determine an appropriate alternative break size. This alternative break size could be the break size that has a mean frequency of occurrence of 10^{-5} per reactor year.

Expert-opinion-based probability distributions of uncertain quantities have been used extensively in probabilistic risk assessments (PRAs) starting with WASH-1400 (Reference 4). The NUREG-1150 studies (Reference 5) formalized the process of elicitation and utilization of expert judgments. Later, major studies sponsored by both government and industry refined the process and applied it to seismic risk assessments (References 6 and 7).

Generating distributions from expert opinions involves the selection of the experts, elicitation of their judgments, and the processing of the individual judgments to produce a composite distribution.

An important question is what kinds of sources of uncertainties the expert-opinion produced distribution of LOCA frequencies should represent. Ideally, this distribution should reflect the uncertainties due to all scenarios and mechanisms with the potential of causing or contributing to a LOCA. Plant-to-plant variability is an important source of uncertainty. In addition, these uncertainties should reflect the opinions of the expert community at large (i.e., the composite distribution should represent the uncertainties in the state of the art).

Of course, this ideal situation is very difficult to achieve. It is impossible to elicit the opinions of the whole community of experts and the analysts have to rely on a group of experts that is representative of the range of the community's views. The expert panel in this study was selected carefully to represent a broad range of expertise.

In the elicitation process, it is very important that the analysts ask the experts questions that will lead to the development of a composite distribution useful to the decisionmakers. The experts must fully understand the questions and the underlying assumptions. In this context, we have identified several issues that must be addressed.

The Report does a good job describing the limitations of the results with respect to the scenarios and mechanisms considered. The elicitation process assumed normal plant operational cycles and did not consider the effects of operating profile changes (e.g., due to power uprates). The effects of "rarer" transients, such as seismic events, were also not considered.

It is unclear to what extent the experts considered plant-to-plant variability. The Report states that the elicitation was focused on developing generic, or average, values for the fleet of plants. The panelists were instructed to account for broad plant specific factors. It states further that "the uncertainty bounds do not represent LOCA frequency estimates for individual plants that deviate from the generic values." We conclude that plant-to-plant variability may not be fully reflected in the composite distribution. This conclusion is consistent with the statement in Section H-1 that "Several panelists expressed that safety culture deficiencies at a single plant could increase the LOCA frequencies at that plant by a factor of 10 or more."

The decisionmakers will have to compensate for the uncertainties created by these limitations by evaluating their impact and resorting to structuralist defense-in-depth measures (e.g., by adding conservatism to the ultimate results of the study). The Report should include a better explanation of what a generic frequency value for the fleet of plants means and to what extent plant-to-plant variability affected the results.

The LOCA size categories are defined by determining an effective break size using correlations that relate break size to the flow rate associated with the break. We were told that some experts assumed that the calculated break size corresponded to double the flow rate while others did not. The question is whether one uses the flow rate from one end of the severed pipe or this flow rate is doubled to include coolant loss from both ends. The analysts should correct the results to make them consistent. The Report should state clearly what the understanding of the experts was when they answered questions about the LOCA size categories.

The Report acknowledges that possible ways for correcting the individual expert opinions to compensate for potential biases and the method of aggregation of these opinions can have a

significant impact on the results. Sensitivity analyses are presented to show the impact of a number of approaches.

The aggregation method chosen is what the Report calls "geometric" averaging, e.g., the group's 95th percentile is taken to be the nth root of the product of the 95th percentiles provided by n experts. The results from "arithmetic" averaging are also presented as a sensitivity analysis. This means that the group's estimate is taken to be the sum of the individual estimates divided by n. We note that these averaging methods deal with the characteristic values of the individual distributions directly [i.e., the group median and the group 95th percentile are the geometric (or arithmetic) average of the individual medians and 95th percentiles, respectively]. This practice is at variance with the methods employed in References 5-7, in which the arithmetic averaging method is applied to the probability distributions of the experts.

As we stated above, the analysts performed numerous sensitivity analyses. Yet, the Executive Summary lists only the "baseline" results and states: "This study does not recommend whether the LOCA frequency estimates corresponding to the baseline or a particular sensitivity analysis should be used in applications." By not stating what, in their judgment, the most appropriate distribution is, the analysts place an extraordinary burden on the users of the results who are generally not familiar with the intricacies of expert opinion elicitation and aggregation. The final distribution reported in the Executive Summary should be the composite distribution that the analysts, based on the sensitivity analyses, believe represents the expert community's current state of knowledge regarding LOCA frequencies.[1] Providing such a distribution would also be consistent with PRA practice, which utilizes epistemic distributions for the frequencies of initiating events (in this case, LOCA frequencies) and not confidence intervals for individual percentiles. Thus, the results would be useful to a broader class of applications than just the selection of the TBS.

During our December, 2004 meeting, the analysts presented to us results from the aggregation method that averages probability distributions (what they called a "mixture distribution"). They also provided us with a revised chapter of the Report. It is evident that this work is still in progress and is not ready for public comment.

We look forward to reviewing the Report after the staff responds to our comments.

Sincerely,

/RA/

Mario V. Bonaca
Chairman

[1]This means that the analysts should act as a Technical Facilitator/Integrator, a concept described in detail in NUREG/CR-6372 (Reference 7).

References:

1. Memorandum dated November 4, 2004, from Michael E. Mayfield, Director, Division of Engineering Technology, RES, to John T. Larkins, Executive Director, ACRS, Subject: Transmittal of Draft NUREG on Passive System LOCA Frequency Development for use in Risk-Informed Revision of 10 CFR 50.46, Appendix K to Part 50, and GDC and Appendices (Pre-Decisional For Internal ACRS Use Only).
2. Staff Requirements Memorandum dated March 31, 2003, from Annette L. Vietti-Cook, SECY, NRC, to William D. Travers, EDO, NRC, Subject: SECY-02-0057 - Update to SECY-01-0133, "Fourth Status Report on Study of Risk-Informed Changes to the Technical Requirements of 10 CFR Part 50 (Option 3) and Recommendations on Risk-Informed Changes to 10 CFR 50.46 (ECCS Acceptance Criteria)."
3. Staff Requirements Memorandum dated July 1, 2004, from Annette L. Vietti-Cook, SECY, NRC, to Luis A. Reyes, EDO, NRC, Subject: Staff Requirements - SECY-04-0037, "Issues Related to Proposed Rulemaking to Risk-Inform Requirements Related to Large Break Loss-of-Coolant-Accident (LOCA) Break Size and Plans for Rulemaking on LOCA With Coincident Loss-of-Offsite Power".
4. U.S. Nuclear Regulatory Commission, Reactor Safety Study, an Assessment of Accident Risks in U.S. Nuclear Power Plants, Report NUREG-75/014 (WASH-1400), 1975.
5. U.S. Nuclear Regulatory Commission, Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants, Report NUREG-1150, 1990.
6. Electric Power Research Institute, *Seismic Hazard Methodology for the Central and Eastern United States*, EPRI Report NP-4726, 1988.
7. R.J. Budnitz, G. Apostolakis, D.M. Boore, L.S. Cluff, K.J. Coppersmith, C.A. Cornell, and P.A. Morris, *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance and Use of Experts*, Report NUREG/CR-6372, 1997.