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

ACRSR-2276

December 20, 2007

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

SUBJECT: DRAFT FINAL NUREG-1829, "ESTIMATING LOSS-OF-COOLANT ACCIDENT (LOCA) FREQUENCIES THROUGH THE ELICITATION PROCESS," AND DRAFT NUREG-XXXX, "SEISMIC CONSIDERATIONS FOR THE TRANSITION BREAK SIZE"

Dear Chairman Klein:

During the 548th meeting of the Advisory Committee on Reactor Safeguards, December 6-8, 2007, we reviewed the draft final NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process," and draft NUREG-XXXX, "Seismic Considerations for the Transition Break Size." Our Reliability and Probabilistic Risk Assessment Subcommittee reviewed this matter during a meeting on November 27, 2007. During these reviews, we had the benefit of discussions with representatives of the NRC staff. We also had the benefit of the documents referenced.

RECOMMENDATIONS

1. NUREG-1829 on estimating LOCA frequencies through the expert elicitation process, and the NUREG report on seismic considerations for the transition break size (TBS) should be published.

2. Regulatory decisions should be based on the totality of the results from the sensitivity studies rather than the results from individual methods of expert judgment aggregation.

3. A set of consistent guidelines should be established for the elicitation and aggregation of expert judgments including the performance of sensitivity studies. These guidelines should be used throughout the agency.

DISCUSSION

The Transition Break Size

An essential element of the proposed risk-informed alternative to the existing 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear reactors," is the concept of "transition break size." In a Staff Requirements Memorandum dated July 1, 2004, the Commission directed the staff to define the TBS as that break size that has a frequency of occurrence of about 10^{-5} per reactor year. Loss-of-coolant accidents due to breaks smaller than the TBS are expected to have frequencies of occurrence greater than 10^{-5} per reactor year and would remain design-basis accidents (DBAs). They would be analyzed using the methods,

assumptions, and criteria currently prescribed in 10 CFR 50.46. Accidents due to breaks larger than the TBS are expected to have lower frequencies of occurrence and would become beyond design-basis accidents. Consequently, they would be analyzed without the additional conservatisms associated with DBAs.

The size of the transition break cannot be determined from operating experience or mechanistic calculations alone. We must rely on expert judgment supported by the available evidence and analyses. The resulting uncertainty is managed by selecting a conservative TBS and by ensuring that breaks greater than the TBS can be mitigated, i.e., by invoking a structuralist defense-in-depth principle for this range of break sizes.

The staff has produced two reports, NUREG-1829 and NUREG-XXXX, which help to provide the basis for selecting a conservative TBS. NUREG-1829 presents the results of a formal expert evaluation of the state of the art and NUREG-XXXX focuses on the impact of seismic events on TBS.

The authors of NUREG-1829 acknowledge the limitations of expert opinion elicitation processes as well as the fact that one could use several ways to aggregate these opinions. The study provides the results of a series of sensitivity studies that help decisionmakers understand the magnitude of the uncertainties in the TBS. As expected, many public comments addressed issues associated with individual aggregation methods. Although the authors of NUREG-1829 have provided reasonable answers to these comments, it is the totality of results from the sensitivity studies that shapes our state of knowledge rather than the results from individual methods.

NUREG-XXXX provides additional insights by investigating seismically induced failures in unflawed piping, flawed piping, and indirect piping failures caused by the failure of other components and supports. The results of the study indicate that, for Pressurized-Water Reactors (PWRs) east of the Rocky Mountains, the likelihood of seismically induced failures in unflawed piping of size greater than the TBS is very low for earthquakes with 10^{-5} and 10^{-6} annual probabilities of exceedance. Even for pipes with long surface flaws, the depths of these flaws must be greater than 30-40% of the wall thickness for a high likelihood of failure during such earthquakes. Inspection programs, leak detection systems, and other measures taken to eliminate failure mechanisms such as stress corrosion cracking should make the likelihood of such cracks very low.

Both of these NUREG reports provide results and insights that can form the basis for the selection of the TBS. They should be published.

Expert Judgment

Using expert judgments to evaluate the state-of-the-art in issues that cannot be resolved by statistical or mechanistic methods is an approach that has been pioneered by the NRC. These issues usually involve rare events and divergence of opinions among knowledgeable investigators and practitioners.

The Senior Seismic Hazard Analysis Committee (SSHAC) investigated the paralyzing differences in probabilistic seismic hazards between the NRC and the Electric Power Research Institute (EPRI) (NUREG/CR-6372). SSHAC stated: “The Committee's most important conclusion is that differences in PSHA [Probabilistic Seismic Hazard Analysis] results are due to procedural rather than technical differences. Thus, in addition to providing a detailed

documentation on state-of-the-art elements of a PSHA, this report provides a series of procedural recommendations." These recommendations dealt with the use of expert judgments. It is worth pointing out that the SSHAC work was sponsored by the NRC, DOE, and EPRI. It was reviewed by a National Research Council Panel, which stated: "The panel believes that the SSHAC report makes a solid contribution to the methodology of hazard analysis, especially in the use of expert opinion."

The goal of the SSHAC guidance is to develop a probability distribution representing the state of knowledge of the informed technical community. To achieve this, the SSHAC guidance recommends that the appropriate method for aggregating expert estimates is one that encourages complete sharing of information and full consideration and discussion of the evidence supporting each expert's judgment. The approach asks the experts to state their own opinions first and then defend their positions, based on all the evidence at their disposal. This sharing of evidence puts the experts on equal footing and ensures that they understand the bases for the judgments of others. The approach then asks each expert to take on a new role, that of evaluator.

Under this reframing of the problem, the experts, acting as evaluators, propose probability distributions reflecting the state of knowledge of the informed technical community. This is done after significant interaction has taken place among them. Ideally, the experts agree upon a consensus distribution. The SSHAC report recommends that the results of any mechanistic aggregation of opinions be scrutinized and modified if they are inconsistent with the overall judgment of the experts and the study integrators. The National Research Council Panel agrees and states: "Do not accept the results of a mechanical combination rule unless they are consistent with judgment."

We note that this elicitation process gives considerable attention to the extreme values of the distribution, challenging each evaluator to consider all factors that could drive the results higher or lower. We acknowledge that this approach requires very effective control of bias and the interaction among experts, but that is true of all elicitation efforts.

For their baseline methodology, the authors of NUREG-1829 take the geometric average of each set (lower, median, and upper bound) of the expert supplied percentiles. This averaging is performed after the experts have exchanged views and their opinions have been adjusted for possible bias by the study integrators. The authors subscribe to the view that a group estimate should be defined as a value near the center of the group opinion; i.e., their approach focuses on getting the center value of the estimate right. In this study, the geometric mean does produce a value near the center of the group estimates[1].

The method called "Mixture Distribution Aggregation" in NUREG-1829 is the mechanistic aggregation approach recommended by SSHAC and was used by the team that developed NUREG-1150. In this method, the composite probability distribution of the frequency of a break of a certain size is the arithmetic average of the panelists' probability distributions (not of the percentiles).

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[1] It is important to recognize that the geometric average of percentiles can be controlled by a very low outlier. Similarly, the arithmetic average of percentiles can be controlled by a high outlier. In the current study, there are no extreme low outliers for the final evaluations; therefore, the geometric mean gives a fair estimate of the *center* of the distributions.

In response to comments provided during the ACRS Subcommittee meeting, the authors of NUREG-1829 also produced results using the Mixture Distribution Aggregation method. The panelists went through a significant exchange of views. They were not asked, however, to act as evaluators, i.e., to produce distributions that reflect the views of the informed technical community; their distributions represented their own uncertainties. The authors of NUREG-1829 state: "The mixture distribution approach does not attempt to develop aggregated estimates that represent the central group opinion as does the baseline methodology, but rather attempts to exhibit the full range of variability among the panelist responses." We believe that employing a method that "exhibits the full range of variability among the panelist responses" is important and useful for a study whose results will form the basis of regulations. In these cases, understanding the breadth of informed opinion is more important than central estimates.

There is no compelling mathematical reason supporting a particular aggregation method[2]. Each requires assumptions that may or may not be justified. We find the attempt to develop a consensus distribution that represents the technical community's views intellectually appealing. To help the experts develop consensus, sensitivity studies need to be conducted including possible adjustment for bias and various aggregation schemes.

The elicitation of expert judgments is a process that the NRC will continue to use to inform regulatory decisionmaking involving important matters. The method employed to process these judgments cannot be left up to the discretion of the team performing each new study. The Office of Nuclear Regulatory Research should investigate the existing methods and propose a set of consistent guidelines to be used throughout the agency.

Sincerely,

/RA/

William J. Shack
Chairman

REFERENCES

1. U.S. Nuclear Regulatory Commission, NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process," and associated Appendixes A through M, 2005.

2. U.S. Nuclear Regulatory Commission, NUREG-XXXX, "Seismic Considerations for the Transition Break Size," 2005.

3. U.S. Nuclear Regulatory Commission, NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," 1990.

4. U.S. Nuclear Regulatory Commission, NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," [Prepared by Senior Seismic Hazard Analysis Committee (SSHAC)], 1997.

[2] The theoretically correct method for combining expert judgments is to treat them as evidence in a Bayesian framework. To date, this approach is impractical. Development of a consensus distribution reflecting the breadth of concerns of the technical community is an excellent way to select an informed prior distribution for later Bayesian analysis.

5. Staff Requirements Memorandum from Annette L. Vietti-Cook, Secretary, U.S. Nuclear Regulatory Commission, to Luis A. Reyes, Executive Director for Operations, U.S. Nuclear Regulatory Commission, “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,” dated July 1, 2004.

5. Staff Requirements Memorandum from Annette L. Vietti-Cook, Secretary, U.S. Nuclear Regulatory Commission, to Luis A. Reyes, Executive Director for Operations, U.S. Nuclear Regulatory Commission, "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," dated July 1, 2004.

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