March 4, 2003

MEMORANDUM TO: Gary M. Holahan, Director
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

FROM: Farouk Eltawila, Director ***Original signed by R. Eltawila***
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH USER NEED IN SUPPORT OF RECOMMENDATIONS ON RISK INFORMING 10CFR50.44 AND GSI -189

Attached for your information is a draft report describing follow-on analyses performed in conjunction with our activities to address Generic Safety Issue -189, Susceptibility of Ice Condenser and Mark III Containments to Early Failure From Hydrogen Combustion During a Severe Accident. This work was identified in our May 17, 2001 responses to the NRR User Need dated April 19, 2001 and later described in our memorandum dated December 27, 2001. The attached report describes the analyses to formally address the uncertainty in the evaluation of the hydrogen release used to assess the risk from hydrogen combustion during a postulated station blackout in an ice condenser plant. The uncertainty in the hydrogen release, addressed in this study, has been factored into the GSI -189 evaluation of the ice condenser containment performance. Other analyses can be found on Adams ML022880554.

As we move to a risk informed regulatory approach the reliance on risk analysis and its underlying level 2 PRA severe accident analysis of the reactor and containment systems response take on greater significance. While mean estimates of plant response are valuable in assessing risk and comparing risks among plants, decisionmaking for specific design enhancements and risk reduction is buttressed by an understanding of the uncertainty in the fundamental quantities that drive the specific risk concern.

The objective of this study is to characterize the uncertainly in the predicted in-vessel and ex-vessel hydrogen production in station blackout accident in an ice condenser plant. For this analysis we used the MELCOR code itself to characterize that uncertainty. In this study, we have primarily focused on the uncertainty associated with the state of knowledge of phenomenological behavior related to hydrogen generation. Other analyses performed to assess the containment systems performance addressed the uncertainty in combustion phenomena, e.g., ignition and propagation concentrations.

The approach taken was to select the modeling parameters in MELCOR which correspond to the phenomenological models of major processes known from past experience and other studies (e.g., Siemens study of German PWRs) to affect hydrogen generation predictions. For those selected model parameters distributions were then developed based on experimental data (e.g., Phebus) and analysis, TMI experience, physical limits and engineering judgement. In this study we have addressed such areas as oxidation rate models, material holdup and fuel failure criterion, heat transfer and material relocation modeling (11 model parameters total).

LHS (Latin Hypercube Sampling) was then used to statistically sample from the distributions and create the MELCOR input files which were run.

The results indicate a relatively narrow spread (from 5% to 95% confidence limits) in the predicted hydrogen generation. The early in-vessel (up to vessel failure) hydrogen generation had a range of 145 kg around a mean value of 450 kg (+/-16%). The mean value corresponds to a 50% equivalent metal water reaction of the cladding. The total in-vessel hydrogen generation, including post vessel failure oxidation of remnant metal, had a range of 260 kg around a mean of 578 kg (+/-23%); the mean corresponding to an equivalent 65% metal water reaction. Hydrogen generation calculations include, where appropriate, non cladding and stainless steel components as well. In general, no individual parameter was seen to have a dominant influence on the predicted hydrogen generation. Ex-vessel hydrogen generation was large in all cases, primarily because the ice condenser geometry, for these scenarios, limited flooding of the lower cavity. Thus, sensitivity to ex-vessel debris heat transfer was limited by water flooding or lack thereof. Ex-vessel hydrogen generation is not particularly troublesome from a combustion standpoint however, because its generation rate is slow in comparison to early in-vessel generation rates which are typically limiting.

We believe these analyses indicate a promising direction for the examination of severe accident analysis uncertainty and risk uncertainty. It is also reasonable that this approach could be used to address stochastic uncertainties as well and we are pursuing this under other venues.

Attachment: As stated

cc w/att.:
R. Palla, NRR

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