May 13, 2002

MEMORANDUM TO: John T. Larkins, Executive Director
Advisory Committee on Reactor Safeguards

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

SUBJECT: RES PROPOSED RECOMMENDATION FOR RESOLVING GENERIC SAFETY ISSUE 189: "SUSCEPTIBILITY OF ICE CONDENSER AND MARK III CONTAINMENTS TO EARLY FAILURE FROM HYDROGEN COMBUSTION DURING A SEVERE ACCIDENT"

RES has developed the technical basis for resolving the subject Generic Safety Issue (GSI) 189. This issue was established from the on-going effort to risk-inform 10 CFR 50.44, "Standards for Combustible Gas Control System in Light-Water-Cooled Power Reactors." In SECY-00-0198, "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 50.44 (Combustible Gas Control)," the staff recommended that safety enhancements that have the potential to pass the backfit test be assessed for mandatory application through the generic issue program. The Commission has indicated in a SRM dated December 31, 2001, that the staff should work to expeditiously resolve GSI-189. Subsequently, in February 2002, GSI-189 passed the generic screening criteria and the technical assessment stage began. This document summarizes the technical assessment. Since the dominant portion of this evaluation is a straight-forward cost-benefit analysis and we were able to extract much of the needed information from already completed studies, we believe that this issue can quickly move forward. RES plans to brief the ACRS in early June 2002, on the issue resolution process and RES' proposed recommendation to NRR.

GSI-189 addresses the adequacy of power supplied to igniter systems installed in PWR ice condenser and BWR Mark III containments. These systems consist of AC-powered igniters (distributed judiciously throughout the containment airspace) which are intended to initiate burning in relatively small volumes and at lean gas mixtures. For station blackout (SBO) events in which neither preferred AC nor backup AC power provided by the emergency diesel generators would be available, the igniters would not be functioning and containment integrity could be challenged. The proposed system enhancement is the addition of back-up power to igniters. This is a mitigative fix and as such does not affect the frequency of postulated SBO events and CDF. Therefore, the proposed enhancement does not add a significant benefit for averted on-site costs. Initiating events, core damage frequencies and release categories were extracted from existing studies. This technical assessment focused on assessing containment performance for ice condensers and Mark IIIs, i.e., quantifying the reduction in the conditional containment failure probability *with* igniters being available during SBO events. The reduction in probability was converted to a dollar value for averted offsite property damage and public risk, and compared against the overall cost for the implementation and maintenance of the igniter

system enhancement to determine if there is a potential cost beneficial back-fit. We also performed an independent cost analysis to determine the cost of implementing other potential enhancements.

In a separate but related issue, as part of the license renewal process, applicants are required to consider severe accident mitigation alternatives (SAMAs) in their environmental assessment. Duke Energy Corporation has submitted an assessment of SAMAs for the Catawba and McGuire plants which included consideration of an alternate power supply for the igniter system to address SBO sequences. The staff's review concluded that this alternative is cost beneficial under certain assumptions, which are being examined in connection with the resolution of this GSI. The staff's review further concluded that the SAMA did not relate to adequately managing the effects of aging during the period of extended operation and need not be implemented as part of license renewal pursuant to 10 CFR Part 54 (refer to Draft NUREG-1437, Supplements 8 & 9). Since these plants are ice condenser plants and represent the licensee's latest plant analysis, we extracted relevant information from this assessment for comparative purposes. Mark III licensees have not yet submitted corresponding analyses.

In addition, for ice condenser plants, an earlier containment analysis (NUREG/CR-5586, October 1990) concluded that in order to improve containment performance, the air return fans should be operational with the igniters during postulated SBO events. If air return fans as well as igniters are needed, the costs will be substantially higher. Therefore, as part of this GSI evaluation, a new ice condenser containment analysis was performed to investigate the feasibility of the igniters functioning without the use of the air return fans. Besides up-dating the containment modeling, the new hydrogen release source terms were used which were being developed in support of the on-going effort to risk-inform 10 CFR 50.44. As demonstrated in Attachment 3, during a postulated representative SBO event, the new ice condenser containment analysis finds that igniters alone are effective in controlling hydrogen build-up.

Ice Condenser Plants:

Cost Analysis:

As reflected in Attachment 1, the base case is a modest but permanent modification that can provide backup power to igniters under SBO conditions. This modification will include a prestaged diesel generator sized to power either one of the two trains of igniters. Due to ventilation, radiation and fire protection concerns as well as space limitations for location of the alternate power supply in the auxiliary building, the diesel generator would be located outside in an area that can be accessed by an operator. Because the alternate power supply is assumed not to be safety-related nor qualified for external events, the generator will not be housed in a separate structure. However, it is assumed that it will be designed for normal outdoor conditions, i.e., will be protected by a weather enclosure.

A lower cost option to provide backup power was also considered. This option considered the use of a portable diesel generator which would require limited permanent modifications to the plant, and for example, would not require a concrete pad nor a weather enclosure. It is assumed that this low cost option has a slightly lower functional reliability level than the prestaged option. However in response to SBO external events, there is a greater likelihood that this option could function more reliably. Because of its less permanent nature, the low cost option provides for more flexibility to react to the initiating event.

There are nine domestic PWR plants with an ice condenser containment design; four dual unit sites (McGuire, Catawba, D.C. Cook, and Sequoyah) and one single unit site (Watts Bar). It was estimated that the base case would cost $294K for a dual unit site (i.e., $147K for each unit) and $191K for a single unit site. The low cost option is estimated to cost $138K for a dual unit site (i.e., $69K for each unit) and $89K for a single unit site. Also in Attachment 1, other cost options and sensitivities are discussed, including the operability of the air return fans in which the cost would be more than twice the base case value. Moreover, there is a similar difference when the base case is qualified for external events.

Benefits (Averted Costs):

In Attachment 2, estimates of averted costs were developed for Catawba and Sequoyah. This study estimated benefits of about $540K per unit for the Catawba plant to about several million dollars per unit for the Sequoyah plant. This Catawba estimate is comparable to the Catawba SAMA estimate of $300K which was developed by Duke based on its plant specific PRA. Moreover, the McGuire SAMA estimate was about $250K. It appears that the Sequoyah estimated benefit is higher because the assessment assumes a much higher value for the conditional containment failure probability. Note that in Attachment 2, the ice condenser averted cost estimates used relevant information from NUREG/CR-6427, and it appears to provide upper bound estimates as compared to plant-specific best estimates.

[Regarding Attachment 2, the following adjustments were made to the estimated benefits for both the ice condenser and Mark III analysis. Even with the addition of an independent power supply for hydrogen control, the probability of containment failure in SBO events will not be totally eliminated. For example, late failures due to long-term containment over-pressure could still occur. Also, the non-safety related, non-seismic back-up power supply may have a functional reliability and performance effectiveness of about 0.8 - 0.9, and may only be available for a modest subset of external events. More realistically, most of the early and some of the late releases would be eliminated. Therefore, a reasonable benchmark of the risk reduction benefit is assumed that hydrogen control would eliminate all early failures due to internal events and half the early failures due to external events.]

Mark III Plants:

Cost Analysis:

As reflected in Attachment 1, a base case cost estimate, similar to that discussed above was developed for Mark III plants. There are four domestic BWR plants with a Mark III containment design at four separate sites (Grand Gulf, Perry, Clinton and River Bend). It was estimated that the base case would cost $206K per unit. And the low cost option is estimated to cost $91K per unit. Also, in Attachment 1, other cost options and sensitivities are discussed.

Benefits (Averted Costs):

In Attachment 2, estimates of averted costs for Grand Gulf were developed, and based on differences between Grand Gulf and the other Mark IIIs, e.g., differences in plant specific SBO frequencies and site population, estimates of averted costs were extrapolated for the other Mark III units. Considering these factors, the Mark IIIs benefits range from $30K to about $180K with an average estimate of about $100K.

Reasons why it appears that Mark IIIs show a relatively small benefit to include:

1. The Mark III design embodies a strong drywell structure and a suppression pool that interfaces between the drywell airspace and the primary containment airspace, thereby providing an effective means for fission product scrubbing.

2. For SBO events, high pressure RCS at vessel breach is a significant fraction of the risk profile; thereby, the availability of igniters does not change the conditional containment failure probability.

Summary & Recommendation

Based on our technical assessment as summarized above and described in the attachments, we conclude:

(1) Focusing on the plant specific averted cost estimates for ice condenser plants, the low cost equipment option is clearly cost beneficial and provides for more overall flexibility in response to external events. Moreover, the new ice condenser containment analysis finds that igniters alone are effective in controlling hydrogen build-up.

(2) For some Mark III plants, the low cost back-up power supply option is marginally cost-beneficial.

(3) Since the proposed mitigative enhancement passes the back-fit cost beneficial test, we recommend that further regulatory action is warranted.

RES plans to transmit its proposed recommendation to the Director, NRR, by the end of July 2002. Accordingly, the lead for GSI-189 will be formally transferred from RES to NRR, and GSI-189 will move from Technical Assessment (Stage 3) to Regulation and Guidance Development (Stage 4) of the MD 6.4 generic issue process. RES welcomes comments and advice from the ACRS, and will consider them in the development of final recommendations that will be sent to NRR.

Attachments: **ADAMS Package ML021340238**

1. ISL REPORT ADAMS ML021340149
2. BNL REPORT ADAMS ML021340170
3. SNL REPORT ADAMS ML021340284

cc: S. Uttal, OGC

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