August 9, 2004

MEMORANDUM TO: John W. Craig, Deputy Director
Office of Nuclear Regulatory Research

FROM: Michael E. Mayfield, Director ***/RA/***
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: CLOSURE OF STEAM GENERATOR ACTION PLAN ITEMS 3.1j) AND 3.4i)

The purpose of this memorandum is to record the completion of task milestones in the Steam Generator Action Plan (SGAP). The first milestone is Item Number 3.1j), "Conduct analyses similar to above with refined load estimates, if necessary." These analyses are in conjunction with the development of a better understanding of the potential for damage progression of multiple SG tubes due to depressurization of the SGs during a main steam line break (MSLB) or other type of secondary side design basis accident. The second milestone is Item Number 3.4i), "Use existing international data and develop analyses for predicting leak rates of degraded tubes in restricted areas under design basis and severe accident conditions."

During the closure of SGAP Items 3.1d) to 3.1h), as reported in Adams Accession No. ML030230822, it was concluded that there is little need to conduct additional thermal-hydraulic analyses due to the low loads calculated as a result of the transients that were analyzed. Therefore, it was concluded that additional analyses would not be required and that Item Number 3.1j) can be closed. This item should have been closed out as part of the close out of Items 3.1d) to 3.1h) but was not included in that close out.

SGAP Item Number 3.4 addresses ACRS comments on the previous risk assessments and develops a better understanding of the reactor coolant system (RCS) conditions and corresponding component behavior (including SG tubes) under severe accident conditions in which the RCS remains pressurized. Item Number 3.4 involves the improved modeling methods for the evaluation of steam generator tube integrity and requires the integration among three disciplines: probabilistic risk assessment (PRA) for assessing risk significance; thermal hydraulics (T/H) for addressing the fluid conditions within the primary system; and materials engineering (ME) for work concerning steam generator tube and other primary system components' integrity. Item Number 3.4i) is part of the ME work for Item Number 3.4. The first objective of the work in Item Number 3.4i) was to analytically predict flaw opening areas at MSLB pressure and to calculate the expected leak rate from a single crack, both for axial and circumferential cracks under the tube support plate (TSP). The second objective was to calculate the flaw openings and leak rates from similarly situated cracks during severe accidents as a function of time.

Item Number 3.4i) is being closed by issuance of a report titled, "Technical Letter Report: Develop Analyses for Predicting Leak Rates of Degraded Tubes in Restricted Areas Under Design-Bases and Severe Accident Conditions," by Saurin Majumdar dated May, 2004 (Attached). A finite element analysis for a SG tube containing axial cracks within the TSP with no deposits present showed that the controlling leakage area during MSLB and severe accidents is the ID crack opening area for short cracks $\leq$ 0.5 inches and the gap area between the OD surface and the TSP hole for longer cracks. At longer times during a severe accident, axial cracks undergo creep and eventually, short cracks make contact with the TSP and the contact length of longer cracks increases with time. A similar analysis for a SG tube containing circumferential cracks within the TSP with no deposits present showed that circumferential cracks undergo less bulging compared to axial cracks during a MSLB. During severe accidents, circumferential cracks deform very little by creep and, therefore, crack opening areas and gap areas change very little with time during the severe accident. The leak rate models presented in this report provide upper bound leak rates assuming no crevice deposits are present.

Leak rates in restricted areas depend on many factors. The highest rates occur from crevices with no deposits which would restrict flow. Test results on intact tube-to-tube support plate junctions containing crevice deposits showed that the leak rates could be reduced by as much as a factor of 1000 compared to calculated leak rates with no deposits. Tests on several tube-to-tube sheet junctions that contained crevice deposits that were removed from the retired McGuire SG showed wide variability in leak rates. Three of the McGuire samples contained through wall circumferential outside diameter stress corrosion cracks and three contained 60-70 percent through wall circumferential cracks. One of the samples with a through wall crack started leaking at 5100 psi at 0.15 gpm and a second started leaking at 7300 psi at 0.08 gpm. A third sample did not leak at 7500 psi even though it contained a through wall circumferential crack. None of these samples with part through wall circumferential cracks leaked at the maximum test pressure of 7500 psi. The combination of the model results for crevices with no deposits and the two sets of test data for crevices with deposits provides a range of potential leak rates for consideration when developing the PRA models.

If you have any questions, please contact Dr. James A. Davis at 301-415-6987 or jad@nrc.gov.

Attachment: As stated

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