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JUN 1 4 1979

NOTE TO: R. J. Mattson

FROM: R. J. Bosnak

SUBJECT: TMI-2 STEAM GENERATOR B

Reference: Note to R. J. Bosnak from R. J. Mattson of June 1, 1979 on TMI-2 Steam Generators

A baseline eddy current inspection of steam generator B at TMI-2 during December 1977 revealed approximately 400 tubes with defects ranging from minor dents to 95% through wall penetrations.1 Thirty five tubes with defects greater than 40% of the wall thickness required plugging. A majority of the eddy current signals (ECT) were indicative of a dimple (ding) i.e., reduction of inside diameter without detectable reduction in wall thickness. These defects presumably occurred during the fabrication process. Other ECT signals were indicative of scab type defects. Circumferential cracks can initiate at such locations under conditions of high cycle fatigue. It is surmized that excessive flow induced vibrations may have caused high cycle fatigue failures at other B&W plants notably Oconee 1, 2, and 3. Concern about excessive tube vibration at TMI had been raised after the baseline inspection in December 1977.2 A test was designed to investigate the reduction in alternating stress by installation of tube sleeves at two locations of concern and addition of intermediate supports at two different locations at the upper most tube span. It is possible that during the period between the December 1977 baseline inspection and the accident at TMI-2 in March 1979, circumferential cracks may have been initiated at locations of high flow induced vibrations. It is estimated that a circumferential crack with a depth which had progressed to greater than seventy percent through wall would be unable to withstand the pressure and thermal loads imposed during the March 1979 transients. Such a crack would then be expected to pop through the remaining wall resulting in primary to secondary leakage.

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The bending and thermal stresses in the tubes during pressure and thermal transients similar to those that occurred during the TMI-2 accident were evaluated by B&W recently.3 In the analysis of the postulated transient, primary system pressure builds to the maximum value associated with the safety valve setpoint. Since primary flow is unavailable, a steam environment exists on the primary side of the tubes. On the secondary side, the steam generator is completely depressurized, boiled dry. A temperature differential of approximately 450oF may exist across the steam generator tube walls under such conditions. Initiation of auxiliary feedwater flow to the steam generator at this stage results in a rapid cooling of the tubes which in turn produces significant tensile loads in the axial direction. The bending stress on the tube outer wall due to a temperature differential, ΔT, of 450oF across the tube wall can be as high as 80 ksi tension which will cause plastic deformation of a portion of the tube. A circumferential crack of depth seventy percent through wall or more located in this region is likely to penetrate the tube wall and the crack opening is likely to increase resulting in a primary to secondary leak. During a decrease in ΔT across the tube wall and a consequent reduction in bending stress, the circumferential crack would tend to close up, resulting in either a decrease or complete stoppage of the primary to secondary leak, depending on the size of the crack.

Other possible sources of primary to secondary leakage were also examined. These include:

a. Leakage due to failure of the welds, attachments or other modifications made in the TMI Unit 2 steam generators to install instrumentation for monitoring vibration flow and pressure data.4

b. Leakage as a result of other design modifications made in the steam generators for example: (1) Tube sleeving modifications, (2) Lane flow blockers (3) Auxiliary feedwater nozzle modifications, and (4) Secondary side, lane tube stiffness.

674 350

JUN 14 1979

c. Failure of steam generator tube plugs installed after the initial baseline inspection of 1977.

d. Leakage of the tubes due to other types of damage viz. wear, stress-corrosion cracking or erosion/pitting.

While the possibility of leakage due to these mechanisms cannot be ruled out, the most probable cause appears to be high cycle fatigue cracking discussed earlier.

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674 351

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References:

1. Letter from H. Silver to Metropolitan Edison Company - Summary of Meeting on Steam Generator Tube Inspection June 30, 1978.

2. Letter from Metropolitan Edison Company - Steam Generator Tube Sleeve Qualification Program, Dec. 22, 1977 to S. A. Varga, NRC.

3. B&W Report of May 7, 1979, "Evaluation of Transient Behavior and Small Reactor Coolant System Breaks in the 177 Fuel Assembly Plant Appendix 2 (Steam Generator Tube Thermal Stress Evaluation)

4. B&W Report of Dec. 22, 1972 "Once Through Steam Generator Instrumentation Program for Three Mile Island #2." Report No. 773570139

671 352