NOVEMBER 9, 2001

MEETING WITH AMERGEN ENERGY COMPANY, LLC

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

STEAM GENERATOR SEVERED TUBE ROOT CAUSE

NRC STAFF FOLLOW-UP QUESTIONS

1. Please provide a montage of high magnification fractographs to augment the fracture surface map provided to the NRC staff on November 15, 2001 (which is attached as an addendum to the meeting handout in Enlosure 2). The fractographs should be annotated, including magnification and orientation, and should describe the significant features of the fracture surface. The fractographs should demonstrate examples of the features identified on the fracture surface map (e.g., IGA, fatigue striations, pueblo structure, flowed metal, ductile tearing and smeared metal). Provide a discussion of the fracture surface features as they relate to the postulated failure sequence of events, i.e., outer diameter (OD) IGA as points of origin for fatigue propagated by flow induced vibration, followed by ductile tearing.

2. Summarize the results of the metallography, hardness measurements, and mechanical testing that have been completed on the severed tube and other harvested tubes. Describe the locations of the test specimens (or hardness tests) relative to the fracture surface location. Relate these results to the postulated failure mechanism.

3. What alternating stress level is suggested by the striations at the various stages of fatigue crack development? What was the number of alternating stress cycles to failure?

4. Discuss your plans for stabilization of swelled tubes (i.e., full length stabilization) and the purpose of these actions.

5. Has TMI-1 experienced any denting at the tube sheets or tube support plates? If so, summarize the extent and magnitude.

6. Describe the adaptation of PORTHOS to once-through steam generators (OTSGs). Assess the uncertainty of the velocity predictions from PORTHOS. Discuss the ability of PORTHOS to predict local cross flow velocities for the actual tube array geometry. For example, does PORTHOS model the differences in flow resistance for radial flow parallel to the bundle Y-axis, versus that for radial flow 30, 60, and 90 degrees from the Y-axis?

7. Nominally, what is the mechanism for flow-induced vibration (FIV) in areas such as the peripheral zone of the upper span (Region 1) the lane region of the upper span (Region 2) and peripheral zone of the lower most span (Region 3)? Describe the supporting evidence or basis.

Enclosure 4

8. Describe the analytical models for evaluating the OTSG tube bundle for FIV and their justification or basis. Describe the model boundary conditions and their justification or basis. Describe the applied loadings, including cross flow velocities and axial load and their justification or basis. Describe the other model input parameters (e.g., damping coefficients) and various model coefficients and constants and their justification or basis. Discuss the source and magnitude of model uncertainties.

9. Discuss the qualification of the FIV model and supporting empirical data, both for cross flows involving saturated water in the lower bundle region and super heated steam in the upper bundle region.

10. Describe nominal FIV response (e.g., stability ratios or some other figure of merit) under normal operating conditions at key locations in the bundle, including Regions 1, 2, and 3. Are these nominal FIV responses high enough to contribute to fatigue usage factors? What is the associated alternating stress and mean stress level?

11. Describe changes in FIV responses in these regions for plugged tubes. Discuss all revisions to boundary conditions, applied loadings, and other model inputs and basis for these revisions compared to nominal conditions.

12. For plugged tubes, describe changes in FIV response in these regions for plugged tubes if tubes become swelled. Discuss all revisions to boundary conditions, applied loadings, and other model inputs and basis for these revisions.

13. Assess FIV response of plugged, swelled tube which has undergone axial failure or fish mouth in each of the regions. Discuss all revisions to boundary conditions, applied loadings, and other model inputs and basis for these revisions. Discuss the potential for the tips of such axial failures to propagate under continued FIV to circumferential failure.

14. Given a probability of detection of 50/50, how shallow a wear indication (through-wall) would the bobbin probe inspection be expected to find?

15. During the November 9, 2001, meeting, a slide was provided to the staff titled "Severed Tube Wear on Adjacent Tubes." (This slide has been attached as an addendum to Enclosure 2 to this meeting summary.) The slide indicates that an "actual wear rate of 62 mils/EFPY [effective full power year]" was utilized in your associated analysis. Provide a discussion of the origin of this wear rate and any uncertainties associated with the use of this wear rate.