January 25, 2002

Alex Marion
Nuclear Energy Institute
1776 I Street NW, Suite 400
Washington, DC 20006-3708

SUBJECT: GENERIC IMPLICATIONS OF THE TMI STEAM GENERATOR TUBE SEVERANCE ISSUE

Dear Mr. Marion:

During a public meeting on November 28, 2001, the NRC requested the industry submit an assessment of the generic implications of the Three Mile Island Unit 1 (TMI-1) tube severance event which is discussed in NRC Information Notice 2002-002, "Recent Experience with Plugged Steam Generator Tubes (ML013480327)." By letter dated December 21, 2001, (ML020180014), you provided two reports containing this assessment. One of these reports was prepared by the Electric Power Research Institute (EPRI) Steam Generator Management Project (SGMP) and concerns generic implications for recirculating steam generators. The other report was prepared by the B&W Owners Group (BWOG) and concerns generic implications for the once-through steam generators. The industry concludes in each of these reports that the TMI tube severance issue is not of immediate concern and that it is acceptable to continue with its in-depth investigation concurrent with continued operation.

The NRC staff plans to meet with NEI and other industry representatives on January 31, 2002, to discuss this issue (ML020170464). To prepare for this meeting, the NRC staff developed the enclosed questions and comments with the intent that they would be discussed during the meeting. Although the NRC staff has questions and comments as indicated in the enclosed, the NRC staff believes adequate justification exists to support continued operation in the near term. The NRC staff and industry will meet on January 31, 2002, to discuss the technical aspects of this issue in further detail. It is anticipated that this discussion will include near- and long-term actions along with the schedule for achieving these actions.

If you have any questions or comments, please contact Emmett Murphy of my staff on (301) 415-2710.

Sincerely,

/ra/

William H. Bateman, Chief
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Enclosure: As stated

Questions and Comments
Industry Reports Regarding Generic Implications of the
TMI Steam Generator Tube Severance Issue

Reference: NEI letter, dated December 21, 2001, enclosing industry reports (ML020180014)

Electric Power Research Institute (EPRI) Steam Generator Management Program (SGMP) Report for Recirculating Steam Generators

1. On pages 2 to 4 of the EPRI SGMP report, operating experience with swelled and ruptured tubes is provided; however, the operating experience appears to be limited to row 1 tubes. Clarify whether this observation reflects that visual inspections are only typically performed for row 1 tubes (and perhaps some peripheral tubes) rather than a comprehensive examination of the tube bundle. Discuss the extent to which visual inspections are performed in the interior of the bundle. In the absence of visual inspections in the interior of the bundle, discuss the extent to which swollen or pulled tubes were observed during plug replacement activities, secondary side maintenance, etc.

2. As evidenced by the Westinghouse evaluation of the North Anna 1 steam generator tube rupture event in 1987 (Reference: WCAP-11601 (Proprietary) and -11602 (Non-Proprietary)), it can take several to many years to initiate a fatigue crack. In addition, radial constraint of swelled tubes at tube support plate locations could potentially create sufficient stress to induce circumferential stress-corrosion cracking (SCC) years following the plugging of a tube. Circumferential SCC would enhance the potential for subsequent fatigue. The fatigue failure at TMI initiated at a site with outside diameter initiated degradation although it is not known whether this degradation occurred prior to, or after, plugging of the tube. Also, the stress induced by the radial constraint at the tube support plate is a “mean stress” which can further enhance the susceptibility to fatigue, as was the case at North Anna. Given the above, address the likelihood that a plugged tube may sever over the long term.

B&W Owner’s Group (BWOG) Report

1. The BWOG report concludes that the population of plugged tubes most susceptible to severance are those with alloy 600 rolled plugs that have been repaired or replaced. This conclusion is based primarily on experience at TMI-1 and at Oconee 3. At TMI-1, tubes with alloy 690 plugs were deplugged and inspected whereas at Oconee 3 tubes with alloy 690 plugs were not. Broader industry experience, as documented in the EPRI SGMP report for recirculating steam generators, indicates that tubes with non-repaired, non-replaced plugs of various designs can experience swelling and burst. In fact, the EPRI report concludes that it is not possible to eliminate the plug diode effect (which can result in tube swelling and burst) by a review of plug types. Given this broader industry experience, additional technical justification is needed to support the BWOG conclusion that the tube swelling and burst/severance phenomenon is only applicable to tubes with repaired/replaced alloy 600 plugs.

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2. Provide a discussion of the types and numbers of plugs installed at B&W plants including the dates of installation and the dates of repair or replacement, as applicable.

3. In Table 1, the BWOG report divides plugged tubes into those which were more than 50% filled with water. Discuss the basis for the 50%. Does this represent the minimum volume to cause swelling?

4. On page 3 of the BWOG report, it was indicated that no tubes which were originally plugged with alloy 690 rolled plugs on both ends had more than 50% water. Given the limited number of tubes in this category (i.e., 87 tubes), the limited operating experience with this plug type (e.g., length of time tube has been plugged compared to the other categories), and the relative frequency of tube swelling and burst, the basis for not deplugging and inspecting such tubes is not clear.

5. On page 5, the BWOG report states that the fluid-elastic stability margin (FSM) for a swollen <u>outermost</u> peripheral tube is estimated to be 1.1. This value was calculated using a lower bound damping value. A value greater than 1.0 indicates the actual velocity is less than the critical velocity and the tube is stable.

   a) Provide the estimated FSM at tube locations B66-130 and A2-24?

   b) The report states that B66-130 failed because it was "near instability (indicated by an FSM <1.0), which caused amplitudes of vibration in excess of those that would be predicted if the tube were completely stable." Clarify this discussion.

   c) If the FSMs for tubes B66-130 and A2-24 are not less than 1.0, the basis for the screening criteria for determining which tubes are susceptible to flow-induced vibration (and subsequently fatigue) is not evident.

      As discussed in the EPRI SGMP report for recirculating steam generators, fluid velocities just exceeding the critical velocity would not necessarily increase the vibration amplitudes sufficiently to cause fatigue. That is, an FSM $\leq$ 1 does not necessarily equate to imminent fatigue failure. Rather, amplitude increases with increasing velocity above the critical velocity until, at some point, the tube begins undergoing fatigue damage. A key issue to be addressed is what relative improvement in FSM is needed with respect to B66-130 to ensure that a tube will not sever.

   d) Given that lower bound input parameters (i.e., damping values for a swollen tube) were used in these calculations, it appears that the FSM prediction model may be somewhat non-conservative. Please discuss. This discussion should include the results from calculations performed if nominal input parameters were used in the FSM calculations.

6. The B&WOG generic risk assessment is based on the risk associated with the specific amount of wear observed in the TMI-1 tubes. The most worn tube at TMI-1 would have been susceptible to failure only during relatively infrequent steam-side depressurization events that exceed the design-basis challenge. However, the wear rate estimated by the B&WOG is sufficiently high that the full tube thickness could be worn away during a fraction of an operating cycle, which would result in tube leakage or rupture during operation. Therefore, the B&WOG risk assessment does not appear to adequately address the risk associated with the generic issue.

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