May 31, 2001

MEMORANDUM TO: William H. Bateman, Chief
Materials and Chemical Engineering Branch
Division of Engineering

FROM: Edmund J. Sullivan, Chief ***/ra/***
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SUBJECT: SUMMARY OF MAY 10, 2001, TELEPHONE CONFERENCE BETWEEN NRC AND NEI REGARDING STEAM GENERATOR ISSUES RELATED TO NEI 97-06

On May 10, 2001, a telephone conference was held between Emmett Murphy, Edmund Sullivan, and Bob Tjader of the NRC, Jim Riley of NEI, and other industry representatives. The telephone conference was held to address the following topics: proposed technical specification (TS) and TS Bases for the NEI 97-06 revised steam generator (SG) regulatory framework, SG Action Plan items (see Attachment 8 from the summary of the April 26, 2001, meeting with NEI on SGs, bases description of the accident induced leakage criterion, and condition monitoring.

Much of this telephone conference relied on the draft documents from NEI that are contained in Attachment 1 to this memo. Attachment 1 contains a markup of the proposed TS and TS Bases for the NEI 97-06 revised SG regulatory framework. Comments made on these documents during the telephone conference are marked on Attachment 1. The NEI representative was generally receptive to the comments or indicated the he would consider the NRC comment and proposed specific revisions.

During the discussions, the staff noted that the primary-to-secondary operational leakage TS bases clarify that leakage measurements are based on room temperature conditions. These TS bases note that this is consistent with the EPRI guidelines on primary-to-secondary operational leakage. The staff pointed out that it is not aware of a documented historical position on the temperature of primary-to-secondary operational leakage measurements. In addition, it was noted that leakage measurements made at room temperature conditions and at reactor conditions will substantially differ. The staff requested that industry develop a “white paper” that describes the basis for the industry position that operational leakage measurements be made based on room temperature conditions. This is an item for NEI followup.

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Regarding the SG Action Plan items provided by NEI, NRC representatives indicated that they had not had adequate time to review and comment on the paper in detail but that the organization of the writeups appears to be appropriate. This is an item for NRC followup.

The third topic relates to a request by NEI for assistance in developing a bases document description of the accident induced leakage criterion. The suggestions provided by the NRC are contained in Attachment 2.

The fourth topic relates to recently expressed NRC concerns regarding condition monitoring. Two elements, among many, involved in condition monitoring are in-situ testing and the frequency of inservice examinations. NRC representative discussed basic concerns that have arisen over the adequacy of industry guidelines related to these two elements. NRC representative also indicated that these concerns are not technical concerns alone in that they relate to the NEI 97-06 regulatory framework.

At the conclusion of the telephone conference, NRC indicated that it would develop a preliminary description of its concerns related to the last topic discussed and provide it to NEI. Information provided to NEI on this topic subsequent to the meeting is contained in Attachment 3. NEI indicated that after receiving this information, they would work with NRC to schedule the next meeting.

Attachments: As stated

cc: J. Riley, NEI

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cc: J. Riley, NEI

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Limiting Accident Induced Leakage to [1 gpm] per SG

Initial technical specifications limited that amount of OPERATIONAL LEAKAGE to 1 gpm from all steam generators, with [xxx gpd] from the worst generator. Initial safety analyses assumed that leakage under accident conditions would not exceed the limit on the operational leakage. More recent experience with degradation mechanisms involving tube cracking have revealed that leakage under accident conditions can exceed the level of operating leakage by orders of magnitude. Therefore, a separate performance criterion for ACCIDENT INDUCED LEAKAGE was established. The numerical limit for the accident induced leakage criterion is initially established at the original value for operational leakage. The ACRS has concluded [9] that, except for alternative repair criteria granted in accordance with the provisions of Generic Letter 59-05, probabilistic safety assessments should be performed to address the effects of tube leakage on risk before regulatory action is taken that would permit increases in accident leakage. The NRC has concluded that additional research is needed to develop an adequate methodology for fully predicting the effects of leakage on the outcome of some accident sequences. As a result, LEAKAGE greater than the initial design basis or 1 gpm per steam generator (whichever is less) is not allowed unless the NRC has approved greater leakage rates as part of an Alternate Repair Criterion or a plant-specific or generic change to the Accident Induced Leakage Limit. Application of increased Accident Induced Leakage rates in conjunction with Alternate Repair Criteria are limited to the specific criteria and type of degradation for which they are granted.

[9] "Voltage-Based Alternative Repair Criteria, A Report to the Advisory Committee on Reactor Safeguards by the Ad Hoc Subcommittee on a Differing Professional Opinion," NUREG-1740, U.S. Nuclear Regulatory Commission, February 2001.

Condition Monitoring Issue (draft)

The proposed administrative technical specifications will require that condition monitoring be performed during each outage during which steam generator (SG) tubes are inspected, plugged, or repaired to confirm that the performance criteria are met. NEI 97-06 specifies that tube integrity assessments, including condition monitoring, account for all significant uncertainties such as to provide a conservative assessment of the condition of the tubing relative to the performance criteria.

It is the staff's position that the regulatory standard for what constitutes an acceptable condition monitoring program is 10 CFR 50, Appendix B, Criterion 16. Specifically, measures (i.e., condition monitoring) shall be established to assure that conditions adverse to quality (i.e., conditions outside the performance criteria) are **promptly** identified.

The implementation details for condition monitoring concerning methodology and frequency are to be defined in the SG Program. Licensees will commit to developing the SG program in accordance with NEI 97-06 which references detailed sub-tier industry guidelines. Sub-tier industry guidelines pertinent to condition monitoring include the SG Examination Guidelines, SG Tube Integrity Assessment Guidelines, and the In Situ Pressure Test Guidelines.

The staff is reviewing NEI 97-06 with the hope of being able to endorse these guidelines. However, it has not been the staff's intention to review the sub-tier industry guidelines for endorsement. There have been three reasons for this. One, the staff and the industry have not reached a consensus position on what many of the details should be. Two, the sub-tier guidelines exhibit varying degrees of maturity, and these guidelines can be expected to evolve over time as additional experience is gained and additional technical insights are developed as a result of industry and/or NRC studies. Industry flexibility to adjust these guidelines to reflect such developments is desirable. Three, consensus on the details of the sub-tier guidelines isn't needed to ensure tube integrity, given the new performance-based technical specifications that would be in place and the licensee commitments to develop their SG programs in conformance with NEI 97-06.

The effectiveness of the new regulatory framework for ensuring tube integrity is predicated on condition monitoring being capable of promptly identifying tubing conditions which fail to meet the performance criteria; that is, condition monitoring fulfills its Appendix B obligation. However, recent developments have caused the staff to be concerned that the sub-tier guidelines do not provide sufficient guidance to ensure that condition monitoring programs will meet these objectives. This, in turn, raises the issue of whether critical elements of an effective condition monitoring assessment need to be elevated to NEI 97-06, or even beyond NEI 97-06 (e.g., to the administrative technical specifications), to ensure that the needed effectiveness of condition monitoring can be enforced.

The recent developments prompting the staff's concern include the following:

1. Staff observations from recent SG inspections indicate that a number of condition monitoring assessments of stress corrosion cracking mechanisms are based exclusively on eddy current testing with no or minimal in situ testing. In each instance, the licensee felt it was meeting the intent of the tube integrity assessment guidelines and the in situ pressure

test guidelines. However, the staff has no information that the NDE flaw sizing capability and uncertainty in these instances had been characterized through an appropriate, site-applicable performance demonstration. Further, the sub-tier guidelines do not clearly define what is an appropriate performance demonstration for purposes of determining NDE flaw sizing performance. The staff needs to be assured that condition monitoring will rely exclusively on NDE flaw size measurements only if sizing measurement uncertainty has been characterized through an appropriate performance demonstration and accounted for in the condition monitoring assessment. Where an appropriate performance demonstration has not been performed, the staff needs to be assured that supplemental measures (e.g., in situ pressure testing) will be performed as necessary to ensure that condition monitoring is capable of fulfilling its Appendix B obligation. Additional comments and the staff's position on the critical elements of an appropriate performance demonstration are discussed in Enclosure 1.

2. In-situ pressure tests may be terminated prior to reaching the target pressure in instances where tube leakage occurs and exceeds test system capacity. RIS 2000-22, Issue 7, describes a recent such experience where the licensee performed an engineering assessment in lieu of a retest with a bladder to support a conclusion that the subject tube was capable of meeting the burst pressure performance criterion. The staff reviewed the licensee's assessment and found the licensee did not have an adequate basis to conclude that the tube satisfied the criterion (Accession No. ML003710343).

   The staff believes that the in situ pressure guidelines do not provide sufficient guidance to ensure a rigorous, engineering assessment when in situ testing must be terminated due to leakage. The preferred approach is to retest with a bladder installed. Where this is not possible, the guidelines suggest that the margin against burst be verified by visual or eddy current examination, or by extrapolation of leakage data obtained during the test. There is little specific guidance on how to use visual or NDE results for this purpose. Treatment of uncertainties in accordance with NEI 97-06 is not sufficiently addressed. Again, assumed NDE sizing uncertainties should reflect the results of an appropriate performance demonstration. Leakage extrapolation methods suggested in the guidelines can lead to non-conservative results because leak rates for actual cracks can vary by orders of magnitude from the rates indicated by predictive models. The staff needs to be assured that in the event of an incomplete pressure test, a retest with a bladder will be performed. Where this is not possible (e.g., in the u-bends), a conservative engineering assessment is performed to determine if the performance criteria have been met. The engineering assessment must be objective, consistent with all observable information. Uncertainties in predictive models and input parameters shall be accounted for such as to ensure a conservative assessment.

3. The proposed revision 6 of the examination guidelines contain prescriptive criteria that would permit inspection intervals for replacement SGs and, thus, the frequency of condition monitoring, to be stretched to 6 EFPY (600-TT) and 7 EFPY (690-TT) in the absence of active degradation during the previous inspection. Proposed performance based criteria would permit inspection and condition monitoring intervals well beyond these values. The bases for inspection and condition monitoring intervals beyond two fuel cycles have not been discussed with the staff. The staff is concerned that the proposed guideline revisions

may not ensure **prompt** detection of conditions adverse to quality. Additional comments concerning Revision 6 are discussed in Enclosure 2. The staff needs to be assured that intervals beyond the two fuel cycles permitted by Revision 5 will not be contrary to prompt detection of tubing conditions which do not satisfy the performance criteria.

Potential Resolution Path

The following provision would be added at the appropriate regulatory level (perhaps a supplement to NEI 97-06 or the administrative technical specifications).

Supplemental Criteria:

1. For each defect type (refers to defect mechanism (e.g., ODSCC, PWSCC) and circumstances (e.g., freespan, u-bends, TSP, etc), condition monitoring shall include a sample of in situ pressure tests unless the NDE flaw sizing measurement capability and associated uncertainty have been characterized by a performance demonstration applicable to site-specific conditions.

2. Performance demonstrations shall include the following attributes:

   - Quantify flaw sizing performance of the total NDE system (technique, personnel, data analysis resolution procedure) relative to ground truth. Where voltage is the pertinent flaw size parameter, sizing performance refers to the variability (repeatability) of the NDE system voltage measurement for a given flaw.

   - Include a statistically significant number of flawed tube specimens over the full range of flaw sizes of interest.

   - Utilize flawed tube specimens which are representative of conditions at the site in terms of flaw morphology, tube and support geometry, flaw signal response, noise, and signal to noise.

3. For flaw types for which a site-applicable performance demonstration does not exist, a minimum of the five most limiting flaws of each flaw type shall be tested. If there are fewer than five indications of a given flaw type, then each of the indications shall be tested. If there are more than 25 indications of a given flaw type, then a 20% sample shall be tested. If one or more of the tests results in failure or significant leakage, the test sample shall be expanded as described in the in situ test guidelines.

4. Tubes shall be retested with a bladder inserted should an in-situ pressure test be terminated due to leakage above the system capacity (not involving burst) prior to reaching the target pressure. If such a retest cannot be performed, the test shall be deemed to have failed to demonstrate that the applicable performance criteria has been met. Alternatively, an engineering assessment shall be provided to the NRC within X days demonstrating that the tube does satisfy the applicable performance criteria.

5. No steam generator shall be operated for more than two fuel cycles between SG inspection and condition monitoring unless reviewed and approved by the NRC.

Condition Monitoring Methodology Issues

Existing industry guidelines for tube integrity assessment, including in situ pressure testing, should be upgraded to provide guidance on how condition monitoring programs can be made compliant with Part 50, Appendix B. Needed upgrades include the following:

1. In situ pressure testing should be performed for each flaw type for which the NDE system sizing performance, including the associated sizing error, have not been adequately characterized through a site-applicable performance demonstration. Under these circumstances, the guideline sampling strategy should be followed; namely a minimum of the five most limiting flaws of each flaw type should be tested. If there are fewer than five indications of a given flaw type, then each of the indications should be tested. If there are more than 25 indications of a given flaw type, then a 20% sample should be tested. If one or more of the tests results in failure or significant leakage, the test sample should be expanded as described in the in situ test guidelines.

2. Detailed guidelines should be developed for characterizing NDE sizing capabilities and uncertainties on the basis of prior in situ pressure test results. The test data set must include a statistically significant number of data samples with burst pressures above and below the burst pressure performance criteria. In the absence of such guidelines, NDE sizing measurement capabilities and uncertainties should only be established on the basis of an appropriate NDE performance demonstration.

3. A site applicable performance demonstration should:

    - quantify flaw sizing performance of the total NDE system (technique, personnel, data analysis resolution) relative to ground truth. Where voltage is the pertinent flaw size parameter, sizing performance refers to the variability (repeatability) of the NDE system voltage measurement for a given flaw.

    - include a statistically significant number of flawed tube specimens over the full range of flaw sizes of interest

    - utilize flawed tube specimens which are representative of conditions at the site in terms of flaw morphology, tube and support geometry, flaw signal response, noise, and signal to noise.

Regarding the application of the screening criteria, as discussed in the Appendices of the in situ guidelines, when determining whether in situ pressure is needed, we believe the following upgrades are needed:

1. Section B.1 of the guidelines state that the multi-tiered sequential approach to screening indications (described in Appendix B) is often functionally accurate enough to separate limiting defects even in cases where measurement uncertainty is not fully characterized.

The staff agrees that such an approach may be sufficient for prioritizing the tubes for in situ pressure testing, but it is not sufficient to justify not performing in situ pressure tests of a sample of tubes in cases where measurement uncertainty is not fully characterized through performance demonstration.

2. Appendix B.2.C of the guidelines state that total measured crack length is conservative due to probe lead in lead out effects and need not be adjusted for measurement error. The staff notes there is ample evidence from Appendix H qualifications and from operating experience indicating that this statement, as a general statement, is incorrect. The screening process must account for length measurement uncertainty as determined from a performance demonstration.

3. Appendix B.2.F states that the maximum measured depth may be applied to the limiting depth criterion with no adjustment for depth. This is not valid as a general statement. For example, it may not be valid if there are significant uncertainties associated with the depth measurement and/or if the crack depth profile is relatively uniform.

4. Appendix B.2.H should be upgraded to reflect the needed attributes of an appropriate performance demonstration (see above) necessary to quantify the sizing performance of NDE systems, including uncertainties.

Note, the above comments relate to Appendix B of the guidelines with respect to axial cracks. Similar comments may apply to the other defect types discussed in Appendix B.

Frequency of Inspection and Condition Monitoring
Issues Relating to Proposed Revision 6 of the Examination Guidelines

Comments Concerning Prescriptive Criteria for Alloy 690 TT Tubing

1. The definition of “active damage mechanism” needs to tightened up such as to ensure active degradation is considered “active.” Under the existing definition, the u-bend cracking mechanism at Indian Point 2 would be considered non-active. Note, only one tube at Indian Point exhibited an indicated growth rate greater than 10% (in terms of average depth) and the maximum growth rate was 11%. In terms of maximum depth growth rate, only 4 tubes exhibited a growth rate exceeding 10%, and none exceeded 24%.

   An average growth rate above zero would seem to imply active degradation. The inspection interval should not exceed that supported by the performance demonstration.

2. The guideline states that the SGs shall be examined with sequential periods of 144, 108, 72, and 60 EFPM. We gather that the 144 can only be applied to the period of operation immediately following the first inservice inspection. We assume it is not the intent of the guidelines to suggest that SGs which have already operated for twelve years could now be permitted to begin the above mentioned sequence starting with 144 EFPM. All this needs to be clarified.

3. The guideline states that 50% of the tubes in each SG should be inspected by the mid-point of the period. Does this permit the initial 50% sample to be taken after say only 18 EFPM with the remaining inspections to be performed at the end of the 144 EFPM period. The minimum period Between SG inspections needs to be clarified.

4. What is the basis for the proposed inspection and condition monitoring intervals? What is the basis for ensuring that these intervals ensure the “prompt” detection (see criterion 16 of Appendix B, Part 50) of tube conditions exceeding the performance criteria?

5. How will degradation experience at similar units be considered? Under what circumstances might this experience dictate that a shorter inspection interval is appropriate? Would one revise the inspection schedule mid-way through the interval in response to such experience? What are the specific criteria to this effect?

6. What are the criteria defining the actions to be taken in the event of a water chemistry excursion to determine whether the inspection schedule should be revised?

7. The staff has similar comments pertaining to SGs with 600 TT tubing.

Comments Concerning Performance Based Inspections

8. The staff has not looked at the proposed guidelines for performance based and risk informed inspections. The staff does not have a copy of EPRI Report TR-114736-V1 describing key details of the methodology.

Enclosure 2