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Date: 5/18/01 5:42PM
Subject: Condition Monitoring/Operational Assessment

OK, here they are. These are draft. Hopefully these will be helpful at your meetings next week in terms of getting ready to meet with us. Emmett

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Condition Monitoring Issue (draft)

The proposed administrative technical specifications will require that condition monitoring be performed during each outage during which 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. Licensee's 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 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 are not sufficient 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 proposal on the critical elements of an appropriate performance demonstration are discussed in Attachment 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 Attachment 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 on a generic or plant specific basis.

Attachment 1

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.

Attachment 2

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.

Staff Oversight of Operational Assessments (Draft)

The staff's oversight of operational assessments is discussed herein for each of the following areas:

1. NRR review of license amendment requests for new ARCs

2. NRR monitoring of SG operating experience

3. NRC Reactor Oversight Program

NRR Review of License Amendment Requests For New ARCs

License amendment requests for new ARCs are submitted for NRC review and approval. It is the staff's expectation that new ARC proposals will be part of an overall SGDSM strategy pertaining to the subject degradation mechanism. It is possible that ARC proposals may include the use of alternative performance criteria for accident induced leakage. The SGDSM strategy would generally be expected to include an operational assessment methodology. The staff would likely review the operational assessment in detail with an expectation of a high degree of rigor in assuring that tube integrity performance can be conservatively assessed relative to approved performance criteria. This would include an expectation of a high degree of rigor in the treatment of input parameter uncertainty. It should be noted that the staff has not reviewed or endorsed the industry guidelines for performing operational assessments. Development of operational assessment methodologies consistent with the industry guidelines may or may not be sufficient to gain staff approval. Finally, proposed ARC and performance criteria may have potential risk implications. The staff will consider any potential risk implications as part of its review of the license amendment request in accordance with NRC Regulatory Guide 1.174. The staff recommends that license amendment requests for new ARCs address risk considerations.

NRR Monitoring of SG Operating Experience

NRR monitoring of SG operating experience includes review of the 120 day reports required by the technical specifications in the event that one percent of the tubes are found to be defective. It also includes SG outage phone calls between NRC staff and the licensee. The purpose of this oversight is to keep abreast of the general condition of the steam generators including the types of degradation mechanisms which are active, the extent and severity of the degradation, and the type and scope of inspections being performed to manage the degradation. In addition, this monitoring will allow the staff to keep abreast of any emerging trends in terms of operating experience and licensee SG programs.

These monitoring activities are not intended to constitute a detailed review of the licensee's implementation of it's SG program including operational assessment. These activities will have as an initial premise that licensees are meeting applicable regulatory requirements (e.g., technical specifications, 10 CFR 50, Appendix B) and their written commitment to establish and implement their SG Programs in accordance with NEI 97-06.

However, these routine monitoring activities may lead to follow up questions concerning operational assessments in the form of phone calls and/or RAIs. Such follow up questions may occur for a variety of reasons:

1. The detection of a degradation mechanism not previously observed at the plant. Depending on the nature and circumstances of this mechanism, the staff may wish additional information concerning the licensee's root cause assessment, the corrective actions being taken, and the licensee's basic strategy for predicting how the degradation mechanism may evolve prior to the next scheduled inspection. For example, how is the potential crack growth rate distribution being determined. What is the basis for POD and flaw sizing performance being assumed.

2. The finding of significantly more and/or larger indications than were predicted by the previous operational assessment. The staff may wish additional information on whether the reason is understood and whether appropriate adjustments have been made to the operational assessment methodology.

3. The licensee is planning to increase the inspection interval relative to past intervals. Depending on the most recent inspection results, the staff may wish to better understand the rationale for proceeding with the longer inspection interval.

4. Questions of current topical interest, based on industry experience trends or as the result of operational events. Recent examples include various lessons learned from the IP-2 event, including whether licensees are implementing appropriate data quality criteria.

Follow up questions could also address aspects of the SG program other than operational assessments. The staff will discuss any areas of concern its has with the respective licensee. Such areas of concern may involve details of the SG program beyond the level addressed in technical specifications or in NEI 97-06. These details are developed in accordance with the detailed sub-tier industry guidelines. The staff believes that some of these sub-tier guidelines, such as the tube integrity assessment guidelines, represent a work in progress. The staff recognizes that the guidelines will be updated on a continuing basis to reflect an improving knowledge base, operating experience, and changing technology. Nevertheless, generic guidelines can't be expected to anticipate every situation or plant specific condition. Therefore, licensees have a responsibility to critically examine all elements of their SG programs for their site-specific conditions to ensure that these programs will effectively maintain tube integrity in accordance with the performance criteria. In particular, licensees are responsible for ensuring that conditions adverse to quality are promptly identified and corrected in accordance with Part 50, Appendix B. Operational assessments are an integral part of meeting these objectives. Depending on the situation, it may be necessary for the staff to understand how licensees are addressing their site-specific conditions. The staff may also discuss these concerns with industry representatives to the extent these concerns are potentially generic and whether revisions to industry guidelines are necessary to address these concerns.

Any plant-specific issues stemming from the NRR monitoring of SG operating experience relating to potential regulatory non-compliance or failure to meet written commitments will be addressed with the Region as part of the Reactor Oversight Program. Enforcement action and regulatory response, if warranted, would be taken commensurate with the safety and risk significance of the staff's findings. This is discussed in additional detail in the next section below. In addition, the NRC has the authority under existing regulations (e.g., 50.54(f), 50.109) to go outside the reactor oversight process as necessary to remedy immediate, significant safety issues of either a generic or plant-specific nature. The staff has seldom found it necessary to exercise this authority with respect to SG tube integrity issues.

Reactor Oversight Process

From an SG tube integrity standpoint, the reactor oversight process (ROP) is intended to monitor performance in avoiding accidents involving a loss of SG tube integrity and reducing the consequences of such accidents should they occur. SG tube integrity involves two ROP reactor safety "cornerstones;" initiating event and barrier integrity.

In general, the ROP monitors performance through a combination of objective performance indicators and by the NRC inspection program that focuses on those plant activities which have the greatest impact on safety and overall risk. The NRC baseline inspection program is intended to address important safety areas not covered by performance indicators or for which a performance indicator does not fully cover the inspection area, to verify the accuracy of information provided by a licensee's performance indicators, and to comprehensively review the licensee's effectiveness in finding and resolving problems.

At present, the ROP does not employ performance indicators relevant to SG tube integrity. Tube integrity performance, therefore, is monitored as part of the NRC baseline inspection program.

The staff has drafted a revised baseline inspection program for inservice inspection activities, including steam generators. A general description of these revisions is contained in a memorandum from Jack Strosnider to B. Sharon and R. Borchardt dated April 30, 2001. The draft baseline inspection program will be finalized after receipt of comments from the Regions. Additional revisions will be necessary once the staff approves new technical specifications accommodating the industry's NEI 97-06 initiative. Once the new technical specifications are approved, it is expected that these inspections will focus primarily on the effectiveness of the licensee's SG program to ensure that the SG tube integrity performance criteria are maintained in accordance with the new administrative technical specifications. The level of inspection effort will be at the discretion of the Region depending on such items as the SG design and materials, operating experience, and industry trends. A key focus of a full baseline inspection will be to ensure that condition monitoring is capable of prompt identification of conditions adverse to quality (i.e., not meeting the SG performance criteria). This includes focusing on the NDE tube inspections and supplemental tests such as in situ testing. The inspection would also verify that the performance criteria, repair criteria, and repair methods utilized were as reviewed and approved by NRC and that the licensee is satisfying its commitments to the NRC on matters relating to tube integrity (e.g., NEI 97-06, generic letters 95-05, 97-06).

The baseline inspection will typically not focus on operational assessment details, absent an identified performance issue. This is not absolute, however. The baseline inspection will make observations about the outcome of condition monitoring compared to what had been predicted by operational assessment. To the extent that operational assessment under-predicted conditions actually found, NRR may be requested by the Region to follow up on the causes and corrective actions. As discussed in the previous section (NRR oversight of SG operating experience), NRR may request information concerning operational assessments to better understand the licensee's rationale supporting its planned inspection interval. Issues relating to lack of regulatory compliance or failure to meet written commitments will be referred to the Region for consideration under the ROP as described below.

Regulatory requirements, under the new framework, will not specifically address operational assessment, although licensees will have written commitments to perform such assessments as part of the SG program required by the technical specifications. However, any operational assessment shortcomings can cause the overall SG program to be ineffective in maintaining SG tube integrity in accordance with the licensing basis and, in addition, can cause conditions adverse to quality to not be identified promptly (through condition monitoring). Thus, operational assessment inadequacies can lead to instances of regulatory non-compliance.

Should the baseline inspection identify that a licensee is violating NRC requirements (e.g., technical specifications, Appendix B of Part 50) or is not in conformance with written commitments, this finding will be subject to a significance determination process (SDP). If the violation is thought to be of low safety significance, it will be discussed in the inspection report with no formal enforcement action. The licensee is expected to deal with the violation through its corrective action program, correcting the violation, and taking steps to prevent a recurrence. The issue may be reviewed during future NRC inspections.

While a formal Notice of Violation will usually not be issued for violations of low safety significance, such a formal notice will be made should the licensee fail to correct the problem in a reasonable time period or does not put the problem into its corrective action program. A Notice of Violation will also be issued if the violation is found to be willful.

If the SDP reveals that the violation has higher safety significance, a Notice of Violation will be issued. The performance assessment process will be used to establish the appropriate regulatory response for the violation.

Failure to satisfy SG tube integrity performance criteria (the performance criteria referenced in the technical specifications) may or may not lead to a Notice of Violation. This will depend on the root cause and the results of the SDP. In terms of root cause, a key consideration will be whether there were significant shortcomings in the licensees SG program in terms of its effectiveness for ensuring that the tube integrity performance criteria are maintained. That is, was the condition something that the licensee should reasonably have anticipated and prevented. A relevant question to this effect may be whether operational assessment properly evaluated all the pertinent, available information affecting the projected condition of the tubing with reasonable allowance for uncertainties. The staff's review of the operational assessment may be detailed, depending on the safety and risk implications of the occurrence. As part of the NRC oversight process, supplemental regional inspections may be performed, consistent with the outcome of the risk significance determination process. NRR may potentially may participate in these supplemental inspections.