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SUBJECT: Forwards response to NRC 980623 RAI re proposed amend 156 to plant TS,changing F* & elevated F* SG tubesheet region alternate repair criteria.

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July 14, 1998

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Supplemental Information for Proposed Amendment 156 to the Kewaunee Nuclear Power Plant Technical Specifications: Changes in the F* and Elevated F* Steam Generator Tubesheet Region Alternate Repair Criteria

References:

1) Letter from C. R. Steinhardt (WPSC) to Document Control Desk (NRC) dated June 1, 1998.

2) Letter from W.O. Long (NRC) to M.L. Marchi (WPSC) dated June 23, 1998.

3) WCAP-14677, Rev. 0, "F* and Elevated F* Tube Alternate Repair Criteria for Tubes with Degradation within the Tubesheet Region of the Kewaunee Steam Generators," 6/96.

4) WCAP-14677, Rev. 1, "F* and Elevated F* Tube Alternate Repair Criteria for Tubes with Degradation within the Tubesheet Region of the Kewaunee Steam Generators," 5/98.

5) WCAP-14679, Rev. 0, "Qualification of Additional Roll Expansion for the Kewaunee Nuclear Power Plant Steam Generators," 6/96.

6) Letter from M.L. Marchi (WPSC) to Document Control Desk (NRC) dated September 6, 1996.

7) Letter from R.J. Laufer (NRC) to M.L. Marchi (WPSC) dated October 2, 1996.

A001

On June 1, 1998, Wisconsin Public Service Corporation (WPSC) submitted a proposed Technical Specification (TS) amendment to revise the minimum roll expansion distances for the F* and elevated F* (EF*) steam generator tubesheet region repair criteria; reference 1. By letter dated June 23, 1998, reference 2, the NRC staff requested additional information (RAI) in order to complete the review of the proposed TS amendment. Attachment 1 to this letter contains both WPSC and Westinghouse responses to the NRC request.

We appreciate the timely NRC staff review of this proposed TS amendment and will continue to support this review effort by providing any needed additional information. Please contact Lynne Gunderson of my staff at (920) 388-8294, if you have any further questions or require additional information.

Sincerely,

Mark L. Marchi
Site Vice President - Kewaunee Plant

LMG/jmf

Attach.

cc - US NRC Senior Resident Inspector
US NRC Region III

ATTACHMENT 1

Letter from M. L. Marchi (WPSC)

To

Document Control Desk (NRC)

Dated

July 14, 1998

Response to Request for Additional Informatiou Related to Proposed Technical Specification Amendment 156: Changes in the F* and Elevated F* Steam Geuerator Tubesheet Region Alternate Repair Criteria

This attachment provides responses to the NRC staff request for additional information (RAI) dated June 23, 1998.

NRC Question 1

Discuss the differences between the original analysis and revised analysis in which the primary to secondary differential pressure was increased from 1565 psi to 1600 psi; e.g., what were the assumptions applied to the SG tubing in the revised analysis that were different from the original analysis?

Response to Question 1

The differences between the reference 3 and reference 4 analyses are primarily numerical changes resulting from the difference in the primary-to-secondary ΔP. Tables 2-3 and 2-4 of references 3 and 4 list the steam generator normal operation (N.O.) and faulted condition pressures and temperatures, tube joint design dimensions, fabrication results, analysis features and calculated F* lengths. Similarly, Table 3-1 of these references lists the same information for EF*. For both analyses, only the normal operating calculation for F* and EF* are affected by the ΔP change from 1565 to 1600 psi; the faulted condition was not affected, as the pressure differential is unchanged at 2650 psi.

The methodology and assumptions for calculating the normal operating F* and EF* lengths based on the tabulated contact pressure values are the same in references 3 and 4. In both analyses, numerical values for the contact pressures due to internal pressure, differential thermal expansion between the tube and the tubesheet, residual preload from the hardroll process, and (in the case of EF* only) loss of contact pressure due to tubesheet bending above the neutral (bending) axis (NBA) are used to calculate the required F* and EF* lengths. The change in normal operating pressure differential causes changes in the numerical values for the contact pressures due to pressure and tubesheet bending which are reflected in the values tabulated in reference 4. In reference 3, the contact pressure due to the normal operating pressure differential term was 876 psi. In reference 4, it increased to 1057 psi. While this appears to be a substantial increase in contact pressure for a relatively small increase in the normal operating ΔP term, this is because it was discovered during the calculation of contact pressures for input to reference 4 that the methodology for calculating the tube-to-tubesheet contact pressure due to the normal operating ΔP across the tube wall had an inherent error at the time the calculations supporting reference 3 were performed. This was subsequently corrected for reference 4. This error, and its resolution, are discussed in greater detail in the response to Question 5, below. The error has been corrected in the analysis to determine contact pressures for reference 4. Otherwise, the assumptions and equations used to calculate F* and EF* (based on the given contact pressures) in references 3 and 4 remain unchanged.

NRC Question 2

Confirm that F* and EF* distances, including nondestructive examination (NDE) uncertainty of 0.20 inches, will be 1.31 inches and 1.71 inches, respectively. Confirm that the F* and EF* criteria will not be applied to any non-sleeved hardroll whose length is less than F* and EF* distances of 1.31 inches and 1.71 inches, respectively. Discuss the changes, if any, to the eddy current technique (e.g., probe design) to reflect the proposed changes to the distances. Discuss in detail how the NDE uncertainty of 0.20 inches was derived.

Response to Question 2

The F* distance will be 1.31 inches and the EF* distance will be 1.71 inches, which are inclusive of NDE uncertainty (uncertainty of 0.20 inch applied to the F* and EF* structural limits of 1.11 and 1.51 inches respectively). The F* and EF* criteria may be applied to degradation in any non-sleeved hardroll, regardless of the length of the original factory hardroll. In cases of degradation in tubes where the original factory hardroll is less than 1.31 inches, an additional roll expansion will be fabricated to meet the minimum F* distance of 1.31 inches. Similarly, an additional roll expansion above the mid-thickness of the tubesheet will be fabricated to meet the minimum EF* distance of 1.71 inches.

It is our intent to apply the same eddy current technique as that used for our current F* and EF* alternate repair criteria. This technique consists of a rotating coil examination to confirm no detectable degradation within the F* and EF* regions, as well as a bobbin coil examination to confirm that the minimum F* and EF* distances (1.31 inches and 1.71 inches, respectively) are met.

The following information on the Westinghouse test program to determine the NDE measurement uncertainties was originally transmitted to the NRC as a response to a request for additional information for the original F* and EF* amendment in a letter dated September 6, 1996 (reference 6). The information was accepted by the NRC in a letter dated October 2, 1996 (reference 7). The information in the following paragraphs is being repeated for your convenience.

An eddy current uncertainty of 0.20 inch will continue to be applied to the F* and EF* structural limits of 1.11 and 1.51 inches respectively. Testing completed by Westinghouse in support of WPSC's original F*/EF* amendment demonstrated that 0.20 inches is a conservative value. The purpose of the Westinghouse test program was to determine the NDE measurement uncertainties for both the F* and L* applications. The hardware configuration was typical of a field system. The primary test frequencies used for locating the bottom of the hardroll transition (BRT) and the crack tip were 400 kHz on the bobbin probe, 300 kHz on the mid-range pancake, and 600 kHz on the high frequency pancake. These frequencies are either contained in, or span those which are to be used for the upcoming Kewaunee inspection. A series of 57 measurements were made on specimen samples. The uncertainties determined by the measurements are tabulated below. The recommended uncertainty is based on applying two times the standard deviation in the most conservative direction.

Coil	Location of BRT	Length of Sound Roll	Recommended Uncertainty
Bobbin	Avg. Error: 0.13" Std. Dev.: 0.04"	Avg. Error: -0.18" Std. Dev.: 0.18"	0.18"
Mid-Range Pancake	Avg. Error: 0.10" Std. Dev.: 0.03"	Avg. Error: -0.07" Std. Dev.: 0.12"	0.17"
High Frequency Pancake	Avg. Error: 0.08" Std. Dev.: 0.03"	Avg. Error: -0.08" Std. Dev.: 0.12"	0.16"

Based on this testing, the application of the 0.20 inch uncertainty committed to in the basis section of the Technical Specification is conservative. The Kewaunee analysis guidelines for application of the F*/EF* alternate repair criteria will continue to incorporate the 0.20 inches NDE uncertainty value, which takes into consideration the results of the testing program described above. Therefore, no differences are expected between the analysis procedure and the qualification testing.

NRC Question 3

TS 4.2.b.6.b specifies that the EF* region is located a minimum of 4 inches below the top of the tubesheet. Discuss the technical basis of the 4-inch distance.

Response to Question 2

Theoretically, the projected elevation of the elevated additional roll expansion (EARX) and the associated EF* length could range from the tubesheet's NBA to the top of the tubesheet. However, the top of the EF* region was selected as approximately 17 inches above the tubesheet bottom, i.e., four inches below the top of the tubesheet (TTS). The selection of the maximum elevation of the elevated retrofit joint was based on the potential of denting corrosion. It is expected that if denting corrosion is present, it would occur primarily at the top of the tubesheet, probably affecting retrofit roll expansion there. For this reason, the maximum elevation of 17 inches (4 inches below the TTS) was selected for the top of the EARX joint. It is expected that most tubesheet region degradation in the Kewaunee tubes would be below the NBA. In cases where the elevation of degradation requires a length of undegraded tubing and application of the EARX above the NBA, selection of a minimum distance of 4 inches below the TTS for the top of the EF* length was used to facilitate the application of the EF* criterion in such tubes while keeping the EF* length in a region with minimal potential for denting corrosion.

NRC Question 4

In the footnote on Page 2-1 of WCAP-14677, Revision 1, "F* and Elevated F* Tube Alternate Repair Criteria for Tubes With Degradation In The Tubesheet Region of the Kewaunee Steam Generators," an attachment to the June 1, 1998, application, it is stated that based on NDE, the factory hardrolls in the hot leg tubesheet of SG A in Kewaunee range from about zero to about 2.25

inches in axial length. It is also stated that the typical length is 1.25 inches. The staff understands that the licensee has repaired the undersized, non-sleeved, factory hardrolls by installing additional roll expansion joints directly above the factory hardrolls. However, it is not clear that the average length of the existing non-sleeved hardrolls is 1.25 inches. Provide the average length of the existing non-sleeved hardrolls. Provide the number of non-sleeved hardrolls that have length shorter than the F* distance of 1.31 inches and assess their structural and leakage integrity.

Response to Question 4

The average length of the non-sleeved factory hardrolls in the A steam generator hot leg is approximately 1.25 inches. There are currently 880 open (non-sleeved, non-plugged) tubes in the A steam generator hot leg which contain short factory hardrolls. None of these tubes have been repaired by installing additional roll expansion joints directly above the factory hardrolls. In 1988, when the short factory hardrolls were identified, additional rolling steps were performed only for those tubes scheduled for sleeving. No action was taken in performing an additional roll expansion of all short hardrolls since the short factory hardrolls were found to be acceptable.

As stated in the previous paragraph, the short factory hardrolls were and remain acceptable. The steam generator structural analysis considered only the tube-to-tubesheet weld in meeting the ASME Code stress allowables (no credit was given for the original factory hardroll). The tube-to-tubesheet weld also provides the leakage barrier for the tube-to-tubesheet joint. The factory hardrolls were provided only as a means to help prevent any primary to secondary leakage. Therefore, the factory hardrolls are structurally not required and there are no structural or leakage integrity issues associated with short factory hardrolls.

NRC Question 5

On page 3 of Attachment 1 to the June 1, 1998, letter, it is stated that Westinghouse corrected a minor error in the original calculation of F* and EF* distance. Discuss the error in detail: (1) Discuss whether the error affects F* and EF* criteria in existing technical specifications in plants other than Kewaunee; (2) Discuss whether Westinghouse investigated the error under 10 Code of Federal Regulation Part 21, "Reporting of Defects and Noncompliance." (3) By removing the error, the F* distance would decrease from 1.12 inches to 1.10 inches and the EF* distance would increase from 1.44 inches to 1.49 inches. Why did the error cause an increase in one case and a decrease in another case?

Response to Question 5

The following response on 10 CFR Part 21 was provided by Westinghouse. If the NRC requires further clarification or information on the status of the potential issue investigation, please contact Westinghouse directly. The Westinghouse licensing representative is Hank Sepp, Manager of Regulatory and Licensing Engineering. He can be reached at (412) 374-5282.

General Response to Question 5

There were two errors and both involved the effect of the secondary side pressure on tubesheet hole enlargement for normal operation. For conservatism, it is assumed that the steam generator secondary pressure penetrates the interface between the tube outer diameter (OD) and tubesheet hole surface of the expanded region. In the calculations made to isolate the contribution of pressure and differential thermal expansion (thermal expansion preload) to the tube-to-tubesheet contact pressure, the secondary pressure was incorrectly applied to the tubesheet (TS) hole surface. The other error occurred in the calculations for the contact pressures above the tubesheet neutral bending axis due to pressure, temperature and tubesheet bow. In this case, the secondary pressure was not applied to the surface of the tubesheet hole.

Response to Part (1) Question 5:

Westinghouse is currently determining the plant applicability list.

Response to Part (2) Question 5:

The issue of "errors in F*/EF* lengths for Kewaunee" has been identified as a potential condition adverse to safety and is currently being evaluated by Westinghouse under 10 CFR Part 21. Potential Issue number PI-98-019 has been assigned to follow this issue.

Response to Part (3) Question 5:

In the calculations made to isolate the contribution of pressure and differential thermal expansion to the tube-to-tubesheet contact pressure, the secondary pressure was incorrectly applied to the tubesheet (TS) hole surface, resulting in a contact pressure that was low by approximately 150 psi. This resulted in F* values which were slightly larger than required, i.e., conservative. This error did not affect the EF* calculation. Credit for increased contact pressure in the bottom half of the tubesheet due to upward bowing of the tubesheet during normal operation was conservatively not taken in the F* calculation.

In the EF* calculations for the contact pressures due to pressure, temperature and tubesheet bow, the secondary pressure was not applied to the surface of the tubesheet hole as had been intended. This resulted in contact pressures that were too high, by approximately 120 psi. This yielded an EF* that was slightly shorter than necessary, i.e., slightly nonconservative.

NRC Question 4

Discuss whether the revised F* and EF* distance, which were calculated by theory, can be supported by the tensile test results in WCAP-14679, "Qualification of Additional Roll Expansion for the Kewaunee Nuclear Power Plant Steam Generators," which was submitted on July 3, 1996, as a part of license amendment 129.

Response to Question 6

The F* and EF* distances are based on semi-empirical data, i.e., tests and analyses, and are supported by the tensile (pullout) test results in reference 5. The basis of the use of the tensile test results of reference 5, for the field-applied roll expansion process, interchangeably with the factory-applied test results of references 3 and 4, will be discussed first. After that, the determination of F* and EF* as supported by the tensile test results will be discussed.

Comparison of Room Temperature Preload from F* Tests and from Additional Roll Expansion Tests:

During the qualification of the field-applied (additional roll expansion - ARX) process, it was necessary to determine if the tube-to-tubesheet hole surface mechanical interference fit pressure, "Net Preload" from references 3 and 4 (Table 3 - 1), projected for the field was adequate over reasonable axial lengths. The field conditions were different from factory conditions, such as different types and quantities of sludge between the tube OD and tubesheet surface for the field case. In the program, the field process was shown to provide conservatively the same strength, i.e., resistance to pullout, as the factory process. The factory results are shown in references 3 and 4, in Tables 2-1 and 2-2 and the result, a factory-installed room temperature preload (RTP) of 3854 psi, is used in Tables 2-3 and 2-4.

The ARX, i.e., field-projected, "tensile forces", results are shown in Table 4-5 of reference 5. Based on these test data, it can be shown that the minimum, as-installed RTP, i.e., mechanical interference fit (MTF) contact pressure, between the tube OD and tubesheet hole surface is approximately 5033 psi. This conservatively exceeds 3854 psi. The minimum pullout load of 3124 lbs in the table and used in the calculation was based on a conservative $\Delta P_{\text{primary-to-secondary-N.O.}}$ and it enveloped the Kewaunee $\Delta P_{\text{primary-to-secondary-N.O.}}$. All of the other pullout loads ("tensile forces" in Table 4-5 of reference 5) recorded in the test and within the required tube ID change limits, were greater than 3124 lbs. The largest force exceeded 9000 lbs. Therefore, the corresponding RTPs would also exceed 5033 psi.

Determination of F* and EF* as Supported by the Tensile Test Results:

F* Criterion:

Reference 5 states that the F* alternate plugging criterion may be applied in two locations below the neutral (bending) axis (NBA) of the tubesheet: within the factory roll expansion and within the field-applied, additional roll expansion adjacent to the factory roll expansion. The term F* is used in the lower half of the tubesheet, i.e., below the NBA.

References 3 and 4 (Tables 2-1 and 2-2) show the determination of RTP pressure between the tube OD and tubesheet hole surface for the factory, as-installed, condition. Projecting this as-installed condition to other plant conditions such as normal operation is performed by calculating two effects. These are 1) the thermal expansion preload in references 3 and

4, between the tube and tubesheet, caused by the two parts having different coefficients of thermal growth and 2) pressure preload in references 3 and 4. (Tubesheet upward bending during the two limiting conditions, normal operating and FLB/SLB, gives rise to increasing the MIF pressure below the NBA. This effect is beneficial to a varying extent below the NBA, but it is conservatively neglected for all tubes.)

EF* Criterion:

The criterion EF* is applied by a field-installed roll expansion process above the tubesheet NBA- the mechanical interference fit (MIF) pressure acting over an area and determined in references 3, 4 and 5, i.e., 3854 psi, as changed by operation, is used. The thermal expansion preload and differential pressure preload effects are calculated for EF* using the same method as used for F*. Added to this is a third effect, tubesheet bow loss, in references 3 and 4, for applications for EF*, i.e., above the tubesheet NBA, for the limiting plant conditions, normal operating and FLB/SLB. Tubesheet bow loss results from the tubesheet holes dilating during tubesheet upward bending due to the primary side pressure exceeding the secondary side pressure during these plant conditions. The radial location of a tube in the tubesheet from the tubesheet vertical centerline, at a given elevation, determines the extent of the dilation, and therefore, the reduction in the "net preload." The tubesheet bow loss at the radius of greatest reduction is conservatively applied to tubes at all radii. Refer to Table 3-1.

Conclusion for Question 6:

The value of RT Preload as determined for the field-applied (ARX) process is conservative to the value of RT Preload determined in the F* program, 3854 psi. For convenience, 3854 psi is used for both F* and EF* calculations. Therefore, the results from reference 5 support the F* and EF* distances.

The F* and EF* joint strength, i.e., tensile force projections, in going from the as-installed condition to the operating condition, for thermal expansion preload, differential pressure preload and tubesheet bow loss are the same regardless of whether the process is the factory or field process.