FPL Energy
Seabrook Station

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August 8, 2006

Docket No. 50-443
SBK-L-06157

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Seabrook Station
Facility Operating License NPF-86
Response to Request for Additional Information Regarding
License Amendment Request 05-08
"Limited Inspection of the Steam Generator Tube Portion within the Tubesheet"

References:

1. FPL Energy Seabrook, LLC letter SBK-L-05185, License Amendment Request 05-08, Limited Inspection of the Steam Generator Tube Portion within the Tubesheet, September 29, 2005.

2. FPL Energy Seabrook, LLC letter SBK-L-05186, Proprietary Information to Support License Amendment Request 05-08, Limited Inspection of the Steam Generator Tube Portion within the Tubesheet, September 29, 2005.

3. NRC letter to FPL Energy Seabrook, LLC, Draft Request for Additional Information (TAC NO. MC 8554), February 23, 2006.

By letters dated September 29, 2005, (References 1 and 2) FPL Energy Seabrook, LLC (FPL Energy Seabrook) submitted License Amendment Request 05-08, Limited Inspection of the Steam Generator Tube Portion within the Tubesheet.

In Reference 3, the NRC requested additional information in order to complete its evaluation. The information requested and the FPL Energy Seabrook responses are provided in Enclosure 1 to this letter. Westinghouse Electric Company LLC (Westinghouse) was contracted to provide analysis support for this response. Westinghouse has identified that portions of its technical evaluation, SG-SGDA-06-19 P, "Response to NRC Request for Additional Information License Amendment Request 05-08 Limited Inspection of the Steam Generator Tube Portion within the Tubesheet (TAC No. MC8554) Seabrook Station," contains proprietary information and is requesting this proprietary information be withheld from public disclosure. The proprietary information will be provided under separate cover and is not included in Enclosure 1.

A001

In response to item #3 in the request for information, FPL Energy Seabrook will include in the 12-month Special Report required by Technical Specification (TS) 4.4.5.5 the operational primary to secondary leakage rate observed (greater than one gallon per day) in any steam generator (if it is not practical to assign the leakage to an individual steam generator, the entire primary to secondary leakage should be conservatively assumed to be from one steam generator) during the cycle preceding the inspection which is the subject of the report. Based on a discussion with the NRC reviewer on July 13, 2006, the threshold for reporting this observed leakage will be leakage greater than one gallon per day. The response to item #3 in Enclosure 1 differs slightly from that provided in the Westinghouse analysis based on the discussion with the NRC reviewer.

Enclosure 2 contains a new markup of the proposed change based on the responses to the RAIs. The changes are administrative and do not alter the conclusion discussed in Reference 1 that the proposed change does not involve a significant hazard consideration pursuant to 10 CFR 50.92. A copy of this letter has been forwarded to the New Hampshire State Liaison Officer pursuant to 10 CFR 50.91(b). The Station Operation Review Committee and the Company Nuclear Review Board have reviewed the proposed changes.

The Enclosure 2 markup of the proposed change replaces the markup submitted with Reference 1. Retyped pages of the proposed change will be provided at a later date when requested.

Should you have any questions regarding this information, please contact Mr. James Peschel, Regulatory Programs Manager, at (603) 773-7194.

Very truly yours,

FPL Energy Seabrook, LLC

[signature] for Gene St. Pierre

Gene St. Pierre
Site Vice President

Enclosures (2)

cc: S. J. Collins, NRC Region I Administrator
G. E. Miller, NRC Project Manager, Project Directorate I-2
G. T. Dentel, NRC Resident Inspector

Mr. Bruce G. Cheney, ENP, Director, Division of Emergency Services
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OATH AND AFFIRMATION

I, Michael Kiley, Station Director of FPL Energy Seabrook, LLC, hereby affirm that the information and statements contained within this response to the request for additional information to License Amendment Request 05-08 are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

Sworn and Subscribed
before me this

8 **day of** August **, 2006**

Michael Kiley
Station Director

Notary Public

MICHAEL D. O'KEEFE
MY COMMISSION EXPIRES FEB. 5, 2008
NOTARY PUBLIC
NEW HAMPSHIRE

Enclosure 1 to SBK-L-06157

License Amendment Request 05-08
Limited Inspection of the Steam Generator Tube Portion within the Tubesheet
Response to NRC Requests for Additional Information

Response to Requests for Additional Information (RAIs)

RAI #1

LAR 05-08 proposes to add a new requirement "d." under TS 4.4.5.2, "Steam Generator Tube Sample Selection and Inspection". This proposed new requirement would define minimum sampling requirements to be performed with a rotating probe in the tubesheet region. The TSs are normally non-specific with respect to the types of eddy current test probes to be used. As stated in NRC Generic Letter (GL) 2004-01, once licensees determine that specific degradation mechanisms may be present at various locations along the tube (as part of the degradation assessment), it is the staff's position that they should use probes capable of detecting these forms of degradation. The GL states that, to not do so raises questions about whether the tube inspection practices ensure compliance with the TSs in conjunction with Title 10 of the *Code of Federal Regulations* Part 50, Appendix B. Please justify the need to specifically define the type of probe to be used.

FPL Energy Seabrook Response to RAI #1

FPL Energy Seabrook agrees with the staff that the new requirement "d" under TS 4.4.5.2, "Steam Generator Tube Sample Selection and Inspection" is unnecessary and has deleted the new requirement from the proposed TS change.

RAI #2

LAR 05-08 proposes to add items 10) and 11) under TS 4.4.5.4, "Acceptance Criteria." These new terms would define the words "bulge" and "overexpansion," respectively. These new definitions support the use of these terms in the proposed new requirement. "d." under TS 4.4.5.2. In connection with question 1, if there is no need to specifically define the type of probe used, please describe the need for the proposed definitions.

FPL Energy Seabrook Response to RAI #2

FPL Energy Seabrook agrees with the staff position and has deleted the definitions for the words "bulge" and "overexpansion."

RAI #3

Please justify why TS 4.4.5.5, "Reports," item "b.", pertaining to the 12-month Special Report does not have a proposed addition of informational requirements for the reports. Specifically, the NRC staff notes other amendment requests proposing similar changes as LAR 05-08 also included a proposed revision to the requirements for the 12-month report, expanding it to include:

a. The number of indications and location, size, orientation, and whether initiated on primary or secondary side of each indication detected in the upper 17-inches of the tubesheet thickness.

b. The operational primary-to-secondary leakage rate observed in each steam generator (SG) during the cycle preceding the inspection which is the subject of the report, and the corresponding, calculated accident leakage rate from the lower-most 4 inches of tubing for the most limiting accident, in the most limiting SG. In addition, if the calculated accident leakage rate for the most limiting accident is less than two times the maximum operational primary to secondary leakage rate, the 12-month report should describe how it was determined.

FPL Energy Seabrook Response to RAI #3

FPL Energy Seabrook will revise TS 4.4.5.5 as follows:

- TS 4.4.5.5.b.4) The number of indications and location, size, orientation, and whether initiated on primary or secondary side of each indication detected in the upper 17-inches of the tubesheet thickness.

- TS 4.4.5.5.b.5) The operational primary to secondary leakage rate observed (greater than one gallon per day) in any one steam generator (if it is not practical to assign the leakage to an individual steam generator, the entire primary to secondary leakage should be conservatively assumed to be from one steam generator) during the cycle preceding the inspection which is the subject of the report and (2) the corresponding, calculated accident leakage rate from the lowermost 4-inches of tubing for the most limiting accident in the most limiting steam generator. In addition, if the calculated accident leakage rate from the most limiting accident is less than 2 times the maximum operational primary to secondary leakage rate, the 12-month report should describe how it was determined.

RAI #4

Provide a copy of WCAP-16053, which is listed as a reference in the technical attachment to Reference 2, above.

FPL Energy Seabrook Response to RAI #4

WCAP 16053, Rev. 1 Reference 5 in the technical attachment to Reference 2 provides no additional technical details than those already included in the technical attachment to Reference 2. It is referenced for historical perspective only, that is, to document the historical evolution of the H* concept. The requested report is essentially the same as other H* reports that the staff has received and partially reviewed in the past (e.g., WCAP-15932-P. The information from WCAP-16053 required for the technical justification attached to Reference 2 has been included in the technical justification provided. Examples are Figure 5 and Figure 6 and Appendix A. That the current technical justification is a freestanding report, independent of WCAP-16053 is clearly stated in the introduction to the current technical document which states "The structural analysis of the Seabrook SG tube-to-tubesheet joints is provided in Appendix A to this report. The content is the same as that in Reference 5 and permits the review of the structural analysis to be performed independent of the Reference 5 information".

The following paragraphs address the specific references to WCAP 16053 in the technical justification attached to Reference 2:

- In the Abstract, reference is made to "structural analysis of the tube-to-tubesheet joint first documented in WCAP-16053 and repeated in Appendix A of this report." This statement notes that the necessary analysis is include in the technical justification LTR-CDME-170-P.

- List of Figures, Figure 5 and Figure 6: Both figures are reproduced in LTR-CDME-170-P; reference is made to their original source.

- Introduction: Reference 5 is mentioned in a statement that the recommendation of LTR-CDME-170-P is not part of an attempt to license the H* methodology. Since the H* methodology is the subject of Reference 5, this statement makes clear that Reference 5 leakage methodology is not the subject of LTR-CDME-170-P.

- Reference 5 is further cited (5 times) as the basis for the inspection depth necessary to meet the structural performance criteria. The structural analysis of Reference 5 has been repeated in LTR-CDME-170-P in Appendix A. Two of the references appear in a statement that the "... content is the same as that in Reference 5 and permits for the review of the structural analysis to be performed independent of the Reference 5 information."

- In Section 2, Summary Discussion, the reference to WCAP-16053 appears several times.

  - In paragraph 1, the reference is in regard to the inspections depths to ensure structural integrity. A noted above, the necessary structural calculations are contained in Appendix A to the technical justification document, LTR-CDME-170-P.

  - In the first bullet of the summary, the reference is again called out in regard to the structural integrity performance criteria. The structural analysis is repeated in Appendix A to LTR-CDME-170-P.

  - Fourth paragraph, the reference is to the leak rate methodology in WCAP-16053. The paragraph concludes that "...the method was not pursued for evaluation and implementation."

  - Fifth paragraph, the reference is to structural analysis to show the relationship between leak resistance and tube-to-tubesheet contact pressure. The relationship between contact pressure and flow resistance is provided in LTR-CDME-06-170-P as Figure 5.

  - Sixth paragraph: The reference is again called out in regard to structural analysis to define the H* depths. The structural analysis is provided in the LTR-CDME-06-170-P, Appendix A.

In summary, the information which is referred to is information contrasted to the current LAR. For example, H* distances are referenced followed by a statement that the current LAR does not utilized the H* distances but is for a fixed distance of 17-inches, much greater than H*. Further, the leak rate methodology discussed in WCAP-16053 is not used in the current analysis.

- Section 5 refers to structural analysis and test data documented in WCAP-16053 regarding the tube pullout forces for Model F SGs. The test data are summarized in Appendix A to the current technical justification. The source of figure 5 in LTR-CDME-170-P is referenced as WCAP-16053. Since the test data and structural analyses are included in Appendix A of LTR-CDME-06-170-P, the current technical justification is a freestanding document in this respect. The references to WCAP-16053 simply provide a historical perspective of where the results were first reported.

- Section 6 describes the leak rate methodology discussed in WCAP-16053, which also originally defined the term "bellwether". However, the current technical justification does not utilize the leak rate methodology of WCAP-16053, but relies on first principle structural analysis to develop ratios for the leak rate at accident conditions to the normal operating leak rate.

  - The second paragraph of Section 6.1 states "These results were not included in the final versions of the document because of concerns associated with the accuracy of the approach above the neutral plane of the tubesheet where the tube-to-tubesheet contact pressure would usually be expected to diminish during faulted conditions.

  - Figure 6 of LTR-CDME-170-P is referenced as being taken from WCAP-16053.

  - Section 6.2 discusses the development of leak rate prediction methodology as presented in WCAP-16053 for axial and circumferential cracks in the tube-end welds. It is noted that this discussion is provided for information only because the recommended inspection depth excludes the tube-end weld. Section 6.2 concludes that the leak rate methodology of WCAP-16053 "...has been demonstrated to be conservative to, and obviated by, the application of the bellwether principle and the selection of an inspection depth of 17-incheses below the top of the tubesheet."

- Section 7 states that the use of the information in WCAP-16053 "for assessing the bounding leak rate from non-detected indications in the un-inspected range below H*...is not recommended ..." for Seabrook for indications above the 17-inch inspection depth.

- Section 8- Conclusions: The reference to WCAP-16053 simply points out that the source of Appendix A to LTR-CDME-06-170-P is WCAP-16053. Discussion, as noted above, shows that the same information is included in LTR-CDME-06-170-P.

- Section 9, item 1 notes that the inspection depths, i.e., H*, are described in WCAP-16053. Prior discussion, as noted above, shows that the same information is included in LTR-CDME-06-170-P.

- References: WCAP-16053-P, Revision 1 (called WCAP-16053 in this response) is Reference 5 of LTR-CDME-06-170-P.

- Figure 5: The source of Figure 5 in LTR-CDME-06-170-P is WCAP-16053.

- Figure 6: The source of Figure 6 in LTR-CDME-06-170-P is WCAP-16053.

- Appendix A: WCAP-16053-P, Revision 1 (called WCAP-16053 in this response) is Reference A-1 in Appendix A of LTR-CDME-06-170-P.

In summary, the current technical justification provided as an attachment to Reference 2 is a freestanding document which utilizes some of the concepts of WCAP-16053, but includes all of the necessary information for the current LAR. If WCAP-16053 were provided, it is believed that no new information would be provided and that the review process may become unnecessarily more confusing. Further, deletion of Reference 5 (WCAP-16053) from LTR-CDME-06-170-P, although technically acceptable and without impact to the technical justification, would require a revision to LTR-CDME-06-170-P without added technical value, while potentially delaying the review process

RAI #5

Under the proposed 17-inch tubesheet inspection zone, LAR 05-08 contends that the accident leakage integrity of the tubing below the 17-inch inspection zone is ensured by the bell-weather principle. The NRC staff requests that the licensee submit a leakage sensitivity study to support the conservatism of the bell-weather approach. That is, leakage during accidents will not exceed two times that observed during normal operating conditions. It is requested that this study consider axial and circumferential flaws located at the bottom of the tubesheet at three tubesheet radial locations (i.e., at the zero radius, mid-radium, and peripheral locations). For each crack type at each location, leakage under normal operating and accident conditions should be evaluated considering only the crack leakage resistance, considering only the tube-to-tubesheet annual resistance and, lastly, considering the total resistance of the crack and annulus to leakage. Please note that the staff is not so much interested in the absolute values of the leakage predictions as it is in the relative values of the predictions between normal operating and accident conditions. As LAR 05-08 has not requested that the staff review the leakage prediction models, the NRC staff would not be in a position to approve these models until the accuracy of these models has been validated by test for prototypic situations. Notwithstanding that, the NRC staff believes that these models, which are based on standard engineering principles, should at least be capable of providing a qualitative demonstration supporting the bell-weather approach.

FPL Energy Seabrook Response to RAI #5

The basis for the development of the 17-inch tubesheet inspection zone with regard to leak rate is the ratio of the potential leak rate during a steam line break (SLB) event to that during normal operation (NOp) using the results of data from leak rate tests of the tube-to-tubesheet interface, a.k.a. crevice. Westinghouse had historically developed a computer model for a crevice in series with a crack using the crevice data and independent data for free-span cracks. The NRC staff expressed concerns regarding the model because of a lack of test data from physical specimens which contained a crack in series with a crevice; hence, the discussion in the last section of the RAI. Westinghouse data obtained from separate testing of the tube-to-tubesheet crevice and axial cracks within a tubesheet with a zero length crevice above the crack demonstrated the resistance of the crack to be comparable to the resistance of the crevice for a larger tube size. The implication from the latter being that an analysis that neglected the effect of the crack would be valid because the effect on the numerator and denominator of the SLB:NOp leak rates ratio would be the same. Other considerations were also made, e.g., for indications within about 56

inches from the center of the tubesheet, the effect of tubesheet bow induced crack closure would be to increase the resistance of the crack.

It is also worth noting the expectations from the analysis based on the crack opening area formulation and the geometries of the model. The opening of circumferential cracks is resisted by the stiffness of the material above and below the crack flanks and by friction on the OD of the tube. For all practical purposes the tube is infinitely long in the axial direction, although, the resistance to opening due to shear increases rapidly. The geometry of the tubesheet does not restrict crack opening in the axial direction. The opening of axial cracks is more restricted owing to the geometry of the problem. For example, there is a line of symmetry 180° from the crack flanks; hence the tube is stiffer in the hoop direction at that location. There is also friction associated with the interface of the tube with the tubesheet. Finally, the confinement provided by the tubesheet means that an axial crack cannot open more than the dilation of the tubesheet hole, which is very small on the periphery. Thus, the effects reported from the DENTFLO analyses would be expected to indicate more effect for circumferential cracks than for axial cracks.

In trying to use the Westinghouse computer model to provide a qualitative demonstration of the veracity of the B* analysis, a significant potential shortcoming associated with the approach must be recognized. The crack flow leak rate model portion of the code was based on a freespan axial crack, not a crack with flanks constrained by the tubesheet hole. Thus, the crack opening area computation could be significantly biased. In order to perform the requested studies the code was modified as follows:

1) The crack opening area model for circumferential cracks of Appendix C of WCAP-15932 was included in the DENTFLO code.

2) A crack opening area model for axial cracks constrained in the tubesheet was derived accounting for the constraints added to the problem by the presence of the tubesheet and included in the DENTFLO code.

The new model for the axial crack opening that takes into account the guidance and constraint provided by the surrounding tubesheet is described in what follows. See Figure 1 below for a sketch of the model configuration.

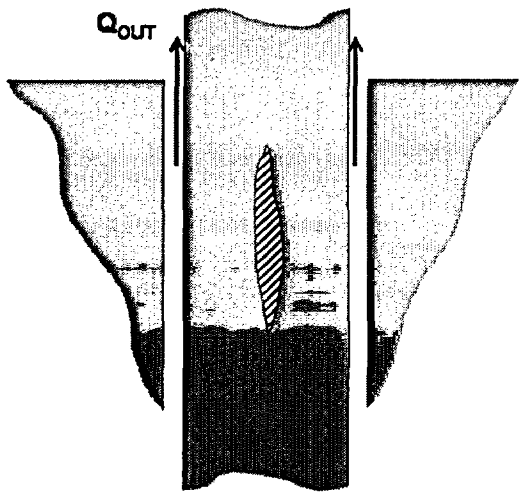

Figure 1: Sketch of Cracked Tube in Tubesheet Leading to Leakage Flow-rate, Q_{OUT}.
Note that the gap shown between the tube and the tubesheet is for illustration purposes only.

Using these models, a sensitivity study was performed which consisted of a series of analyses to demonstrate the conservatisms of the bellwether approach. These analyses considered the locations and conditions specified in the RAI, i.e., crack only, crevice only and combined crack and crevice.

The models developed for these analyses were for qualitative comparisons only (i.e., not for absolute prediction of leak rates) and were not verified and/or validated beyond that "information only" status

Constrained Axial Crack Opening Area Calculations

A literature search of the significant fracture mechanics texts and journals, e.g. Journal of Engineering Fracture Mechanics, International Journal of Fracture Mechanics, Reference 9, etc., did not yield any previously published models for the crack opening area (COA) for a central axial crack that is circumferentially constrained in an internally pressurized tube. A mathematical model was developed to calculate the crack opening area for a constrained SG tube under these conditions. The general form of the equation for the crack opening area in an infinite plate is [2]:

$$\text{COA} = 2\pi a^2 \frac{\sigma}{E}$$

where σ is the far-field stress resulting in the crack opening, E is the Young's Modulus of the tube and a is the half-length of the crack. In the absence of empirical evidence, the general form for the crack opening area can be modified by a functional to deal with the tube configuration. The functional can include the important details regarding the boundary conditions and other effects relative to the constrained and cracked tube. Let $H(\ F(n)\ )$ be the modifying functional for the crack opening area, where n represents the influential parameters of the geometry and

loading. Then the model for the crack opening area becomes,

$$\text{COA} = H\left(F(n) \right) 2\pi a^2 \frac{\sigma}{E}$$

Given the general constitutive form for the crack opening area it remains to define the modifying functional. The crack opening area for the axial crack will be affected by the interactions of the internal pressure on the crack flanks and the contact pressure between the tube and the tube sheet, see Reference 3. The largest effect on the crack flanks that can affect the flow rate through the crack will be the radial flexing of the flanks due to the internal pressure in the event that the contact pressure between the tube and the tube sheet decreases, although, as previously noted, the amount of opening can never be greater than the change in the circumference of the hole in the tubesheet.

<u>Comparison against Established Methods</u>

The resulting model for the crack opening area in an internally pressurized and constrained tube with an axial crack is shown below,

a,c,e

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where ζ is a scalar coefficient that describes the local effect of the crack in a tube on an equivalent finite flat plate area and ϕ is a parameter that accounts for the change in resistance to radial flexing of the crack flanks due to the change in tube to tubesheet contact pressure and crack length. This model was compared against several established models for unconstrained internally pressurized tubes with axial cracks. These comparison models include published work by Zahoor [4] and empirical models employed by the American Petroleum Institute (API) and developed by Anderson [7].

Figure 2, below, shows the results that each model predicts for the crack opening area for cracks ranging from 0.02 to 2.00 inch.

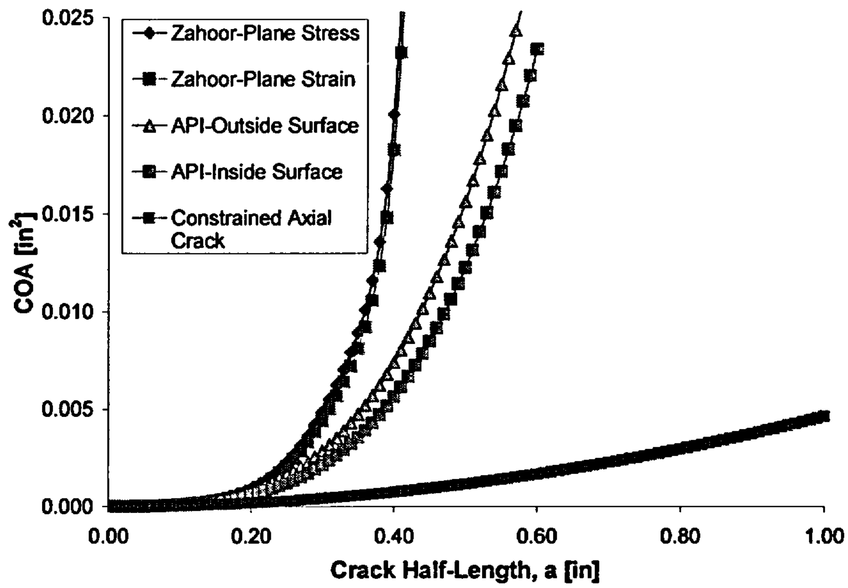

Figure 2: Comparison of Models for Calculating the Crack Opening Area

The comparison above shows that the results for the new model, for a constrained internally pressurized tube, are reasonable in comparison to the other established models for unconstrained tubes. Specifically, the new model predicts a smaller crack opening area as a function of crack length than the unconstrained axial cracks with a smaller rate of increase in the crack opening area. This is an expected result because the other models assume a free span for the tube with no constraining effects. The COA should be come asymptotically linear with increasing length because the constraint from the tubesheet hole will restrict the opening to some maximum amount. Therefore, it is reasonable to use the new model for further calculations to estimate the crack opening area of a constrained and internally pressurized tube with a central axial crack.

Analysis of Circumferential Cracking

A model for a constrained circumferential crack in an internally pressurized tube was developed [3]. This model is appropriate to use for a circumferential crack that occurs in a tube within the tubesheet. A maximum crack half angle of 90°, or a maximum circumferential crack equal to half of the circumference of the tube, was used in this analysis as a simplifying assumption. The model for constrained circumferential cracks was implemented in the code DENTFLO to determine the trend of the leakage rate ratios for normal operating and steam line break conditions. See References 3 and 6 for more details on the model and its application.

DENTFLO Analysis Methodology

The program DENTFLO was run to determine the trend of the leak rate ratios of a damaged tube at the bottom of the tubesheet at different radii. There are 36 different cases of interest with respect to the leak rate ratio analysis, i.e., combinations of: 2 thermal-hydraulic conditions (NOp and SLB), 2 crack orientations (axial and circumferential), 3 radial locations (near, mid, and peripheral) and 3 conditions of interest (crack, crevice, and combined crack and crevice). The

Normal Operation – Maximum Temperature (NOp-MAX) and the Steam Line Break (SLB) were chosen for the analysis because of the largest change in temperature and pressure between the two cases. The tubesheet radii for each range are: Near (2.0774 In), Mid (33.101 In), Peripheral (60.2475 In). The contact pressures used in the DENTFLO analysis were taken at each tubesheet radius at several elevations in the tubesheet (Reference 10). The tubesheet material below 4 inches from the bottom of the tubesheet and any contact pressure generated by that material was conservatively neglected. The loss coefficients for the analysis were taken as a numerically integrated average over the length of the crevice, i.e., from 4 inches above the bottom of the tubesheet to the top of the tubesheet, based on the contact pressure distribution in the tubesheet [8]. The axial and circumferential crack orientation cases used the models discussed above. The crevice only cases use a model for an unconstrained axial crack based on the work of Paris and Tada [2] because it gives less resistance to flow through a crack than the other models available in DENTFLO. The crack length is also large in the crevice only case in order to best represent a situation where the crack cannot contribute significantly to the flow resistance.

DENTFLO Analysis Results

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]a,c,e

a,c,e

Figure 3: Leak Rate Ratio as a Function of Axial Crack Length for a Tubesheet Radius of 60.248 inches at the Bottom of the Tubesheet.

a,c,e

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Figure 4: Leak Rate Ratio as a Function of Circumferential Crack Length for a Tubesheet Radius of 60.248 inches at the Bottom of the Tubesheet

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Table 1: Summary of Near Radius Leak Rate Ratio Results

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Table 2: Summary of Mid Radius Leak Rate Ratio Results

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]a,c,e This is despite the sharp decrease contact pressure at the periphery between the tubes and the tubesheet.

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]a,c,e

Table 3: Summary of Peripheral Radius Leak Rate Ratio Results

[ ]a,c,e

The results of the DENTFLO analysis indicate that the bellwether trend is valid for all tubesheet radii and is bounded by a factor of 2. Therefore, the bellwether principle for the leak rate ratio approach is valid.

References

1. NSD-RMW-91-026, "An Analytical Model for Flow Through an Axial Crack in Series with a Denting Corrosion Medium," M.J. Sredzienski. 02/05/1991.

2. H. Tada, The Stress Analysis of Cracks Handbook, 2nd Ed., Del Research Corporation, 226 Woodburne Dr., St. Louis, Missouri, USA, 1985.

3. WCAP-16053-P, Revision 1, "Improved Justification of Partial Length RPC Inspection of Tube Joints of Model F Steam Generators of Seabrook Station," June 2004.

4. NP-6301-D, "Ductile Fracture Handbook," Volume 1, EPRI, 3412 Hillview Avenue, Palo Alto, CA, June 1989.

5. CN-SGDA-03-85, Revision 1, "Input Data for the H*/P* Effort pertaining to both Model D-5 and Model F Steam Generators," 09/30/2003.

6. Steam Generator Degradation Specific Management Flaw Handbook, EPRI, Palo Alto, CA, USA: 2006. 1001191.

7. T.L. Anderson, "Stress Intensity and Crack Growth Opening Area Solutions for Through-Wall Cracks in Cylinders and Spheres," WRC Bulletin 430, Welding Research Council, January, 2003.

8. TH-98-37, Revision 0, "Vogtle/Yonggwang Tubesheet Crevice Leakage," J.H. Lilly, 10/30/1998.

9. R.J. Sanford, Principles of Fracture Mechanics, Prentice Hall, Upper Saddle River, NJ, 2003.

10. CN-SGDA-03-99, Revision 0, "Evaluation of the Tube/Tubesheet Contact Pressures for Wolf Creek, Seabrook, and Vogtle 1 & 2 Model F Steam Generators," A.L. Thurman, 09/26/2003.

RAI #6

The bell-weather principle maintains that the increase in primary-to-secondary leakage, when going from normal operating to accident conditions, is bounded by a factor of two. This is based, in part, on an assumed main steamline break (MSLB) and main feed line break (MFLB) pressure differential of 2560 and 2650 psi, respectively, and a temperature of 600 degrees F. Provide the rationale which supports the conservatism of the 600-degree F assumption. This rationale should consider the time history of primary and secondary pressure and temperature during the accident. The NRC staff's purpose in asking this question is to ensure the time integrated leak rate is bounded by the bell-weather principle factor of two increase relative to normal operating leakage. Provide the primary pressure and temperature curves as a function of time for the MSLB and MFLB accidents under consideration. Also, provide the rationale supporting the conservatism of the bell-weather principle for a large break loss-of-coolant accident.

FPL Energy Seabrook Response to RAI #6

The calculation of the leak rate during a postulated SLB event is not based on a temperature of 600°F, but on the temperature obtained from an examination of the equipment specification curves for the transient. In addition, the calculation of conditions during normal operation is based on a set of umbrella values resulting in considering primary fluid temperatures of 604.3 and 621.4°F for secondary side pressures of 782 and 947 psig respectively. Both conditions are used.

The SLB transient is assumed to initiate while the plant is at hot standby conditions, i.e., 557°F. The primary temperature drop is 139°F leading to an analysis temperature of 418°F. The secondary temperature drop is 307°F leading to a shell temperature of 260° for the analysis. The design specification pressure changes are illustrated on Figure 5 and the actual pressures for Seabrook are shown on Figure 6. The design specification temperature history during a postulated SLB event is shown on Figure 7. The superposed curves are shown on Figure 8. It is readily seen that the most limiting differential pressure, 2575 psi, occurs when the temperature is at a relatively steady state for both the hot and cold legs. The analyses were performed for the conditions at about 600 seconds into the transient and found to be less limiting than when the pressure difference is at a maximum. The H* engagement length required to resist the SLB differential pressure with a margin of 1.4 is about 0.15 inch greater for the latter condition. The B* length to restrict the SLB leak rate to a factor of 2 relative to that during NOp, based on the method of calculation, is about 7% longer for the conditions at 4200 seconds relative to those at 600 seconds. Examination of Figure 8 leads to the conclusion that the differential pressure is the controlling factor and the value at 4200 seconds will bound any value in between the two.

RAI #7

It is stated on page 20 of the attachment to Reference 2 that if the leak rate during normal operation was 0.1 gallons per minute (gpm) (150 gallons per day (gpd)), the postulated accident condition leak rate would be 0.2 gpm (using the D'Arcy equation), versus the allowable limit of 0.347 gpm when only considering the change in differential pressure. In accordance with the Electric Power Research Institute primary-to-secondary leak guidelines, operating leakage versus the TS limit is evaluated under room temperature conditions. Presumably, this adjustment is based on water density at room temperature versus operating temperature, which means that if the operational leakage measurement is 0.1 gpm, then actual leakage under hot operating conditions is about 0.15 gpm. Assuming a factor of two increase in leak rate during postulated accidents, the actual leak rate under hot accident conditions is 0.3 gpm, which is still less than the "allowable limit" of 0.347 gpm. Please clarify what is the appropriate comparison to make here; 0.2 gpm (accident leakage adjusted for room temperature conditions) versus the 0.347 gpm "allowable limit," or 0.3 gpm (accident leakage for actual accident temperature) versus the 0.347 "allowable limit." In other words, does the accident analysis consider the 0.347 gpm "allowable limit" to be an adjusted value for room temperature conditions or does it treat it as a hot value?

FPL Energy Seabrook Response to RAI #7

Based on a review by FPL Energy Seabrook of the basis of the allowable accident leak rate, the allowable limit of 0.347 gpm is at room temperature conditions. The comparison is appropriate as written.

RAI #8

The TS primary-to-secondary leakage limit is 500 gpd per SG, and 1 gpm for all SGs. These limits appear inappropriate since the 500 gpd limit is equal to the amount assumed in the accident analyses. If operational leakage is just below 500 gpd, the expected leakage during a postulated accident may significantly exceed the amount assumed in the MSLB accident analysis. Please justify how this TS limit is supported by the accident analyses given the previously-discussed possibility of an increase in leakage following the onset of an event.

FPL Energy Seabrook Response to RAI #8

FPL Energy Seabrook has submitted LAR 06-02, the Generic Licensing Change Package for TSTF – 449 to the NRC for approval. As part of that submittal, the operational leakage in TS 3.4.6.2 was changed from 500 gallons per day to 150 gallons per day per steam generator.

RAI #9

WCAP-15932-P, Revision 1, Section 6.5 (submitted on the Callaway docket, NRC Agencywide Documents Access and Management System (ADAMS) Accession No. ML022910436) provides a justification for why ligament tearing of circumferential cracks is not a significant concern. Provide a justification for why ligament tearing of axial cracks at the bottom of the tubesheet at the periphery is similarly not a significant concern.

FPL Energy Seabrook Response to RAI #9

One of the concerns to address when dealing with cracks in SG tubes is the potential for ligament tearing. Ligament tearing may occur during a postulated accident when the differential pressure is significantly greater than during normal operation. The approach to dealing with the question is the same as that for circumferential cracks, that is, what is the ligament that will not tear during NOp conditions compared to the ligament that will tear during a postulated SLB event. The stress that is applied to the crack flanks during normal operation is the 2250 psi primary pressure. The stress during a SLB event is the 2560 psi pressure associated with the set point of the relief valves. The net difference is only 310 psi, hence the affect is expected to be small. The following evaluation considers the potential for ligament tearing of postulated axial cracks and to what extent such tearing would affect the technical basis for the LAR. For the depth of concern, at 17-inches from the top of the tubesheet, the contact pressure between the tube and the tubesheet, at the periphery, is never less than 800 psi for NOp or 900 psi for SLB.

The tube area required to resist tearing due to an axially oriented crack can be calculated using traditional mechanics. The axial orientation of the damage in the tube means that the required area of the tube cross section to resist tearing and damage should be based on the local strength of the material around the crack. It is conservative, in this case, to neglect the forces in the

tubesheet at the periphery that would act to keep a crack closed and compress the flanks in the ligament so that tensile tearing would become unlikely. This includes the far field axial stress on the tube cross section generated by internal pressure end cap loads which would act to close the ligament and any cracks below the H* depth (the depth required to prevent tube pullout). This is in contrast to the typical method used to compare what percent of the area is required to resist ligament tearing in circumferentially damaged tubes based on the amount of force applied to the damaged tube cross section.

The results shown in the table below were obtained using the ASME code minimum material properties [1] and the nominal dimensions of the Seabrook steam generator tubes. The method of evaluation was to determine the minimum wall thickness necessary to resist tearing due to the internal pressure in each condition and then define what range of pre-crack flaw thickness would result in a tear under the accident conditions but not tear under normal conditions. [

]a,c,e The results for the calculated minimum wall thicknesses to resist tearing under either NOp or SLB at the periphery are summarized in the table below.

a,c,e

[ ]

The results of the axial ligament tearing calculations are [

]a,c,e

Another check can be made by looking at the dilation of the TS hole with the change in pressure. The increase in circumference would be equal to π times the diameter change. This is roughly a change in crack opening displacement (COD) and use the linear approximation to determine the thickness that would lead to ligament tearing, i.e., a ligament of 3 mils can withstand a COD of 3 mils. For example, the flexibility of the tubesheet is about 6.44E-8 in/psi at 600°F. If 2250 psi acts on the inside of the hole, the circumference increases by 0.345 mils. The corresponding change is 0.392 mils for the SLB pressure, an increase of a little less than 0.05 mils. So, the probability of having cracks that are not torn during NOp, but would tear during a SLB is very small.

Considering the worst-case scenario, the likelihood of ligament tearing from axial cracks at the periphery resulting from an accident pressure increase is [

]a,c,e The potential for axial ligament tearing is considered to be a secondary effect of essentially negligible probability and is not expected to affect the results and conclusions reported for the B* evaluation. The leak rate

model does not include provisions for predicting ligament tearing and subsequent leakage. Increasing the complexity of the model to attempt to account for axial or circumferential ligament tearing is not considered necessary.

1. ASME Boiler and Pressure Vessel Code Section III, Rules for Construction of Nuclear Power Plant Components," 1989 Edition, The American Society of Mechanical Engineers, New York, NY.

2. "Improved Justification of Partial Length RPC Inspection of Tube Joints of Model F Steam Generators of Ameren-UE Callaway Plant", WCAP-15932, Revision 1, May 2003.

3. Steam Generator Degradation Specific Management Flaw Handbook, EPRI, Palo Alto, CA: 2006. 1001191

RAI #10

Are there any tubes in the Seabrook SGs which were not fully expanded (per nominal) within the tubesheet? If so, please describe the extent of this condition and justify why the amendment request is sufficient to ensure the structural and leakage integrity of the affected tube joints.

FPL Energy Seabrook Response to RAI #10

Based on a review of Seabrook RF09 and earlier outage data, there are no known tubes in the Seabrook Steam Generator's that are not fully expanded. Unexpanded tubes, or partially unexpanded tubes, are given the code NTE (no tube expansion) or PTE (partial tube expansion) during Eddy Current (EC) inspection. No tubes were identified in any of the steam generators with either of these codes.

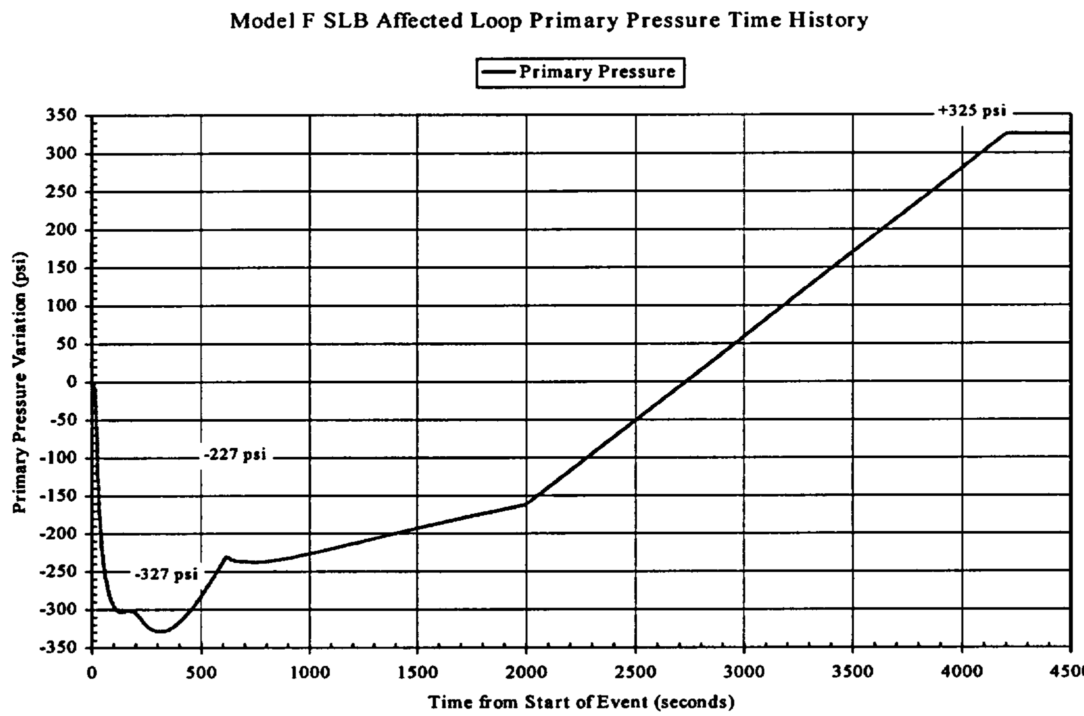

Figure 5: SLB Design Pressure Change History

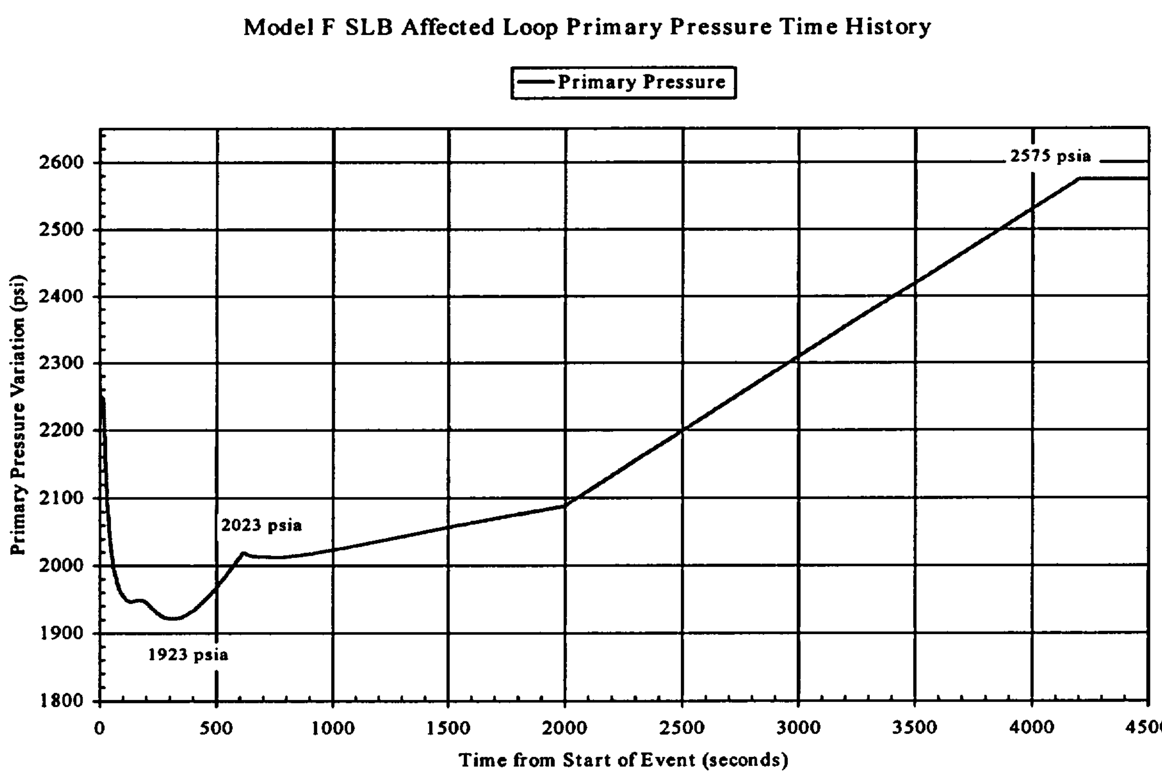

Figure 6: SLB Design Pressure History

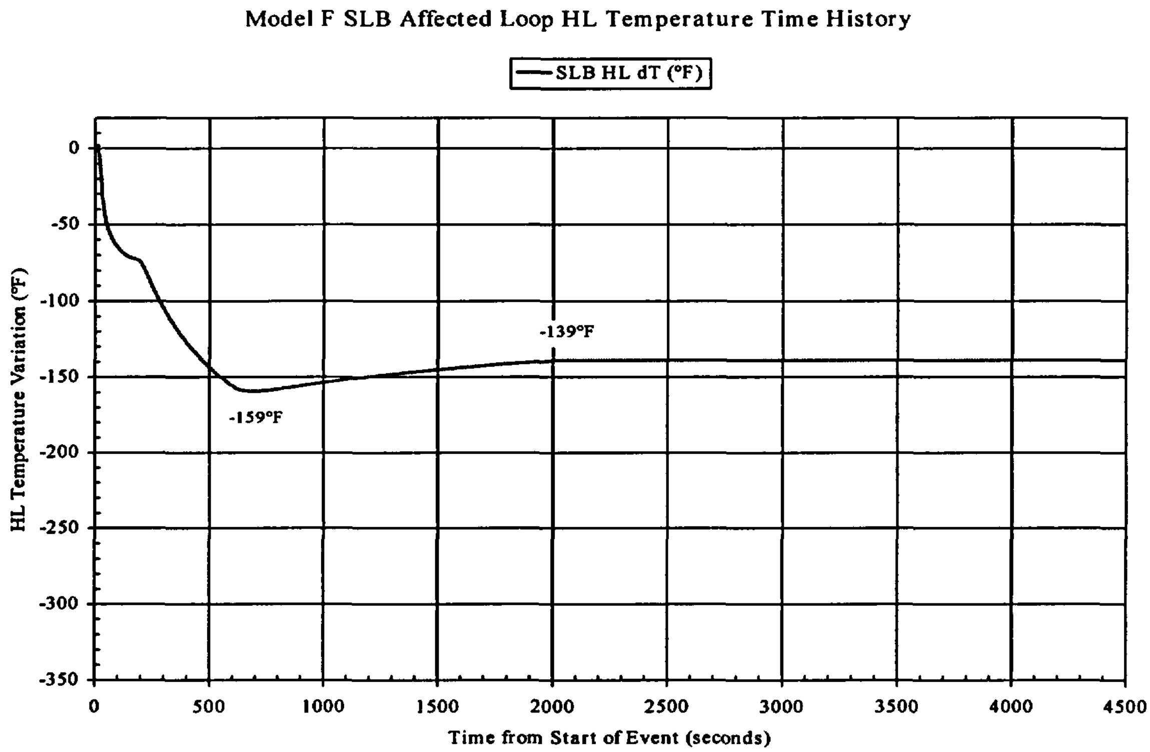

Figure 7: SLB Design Temperature Change History

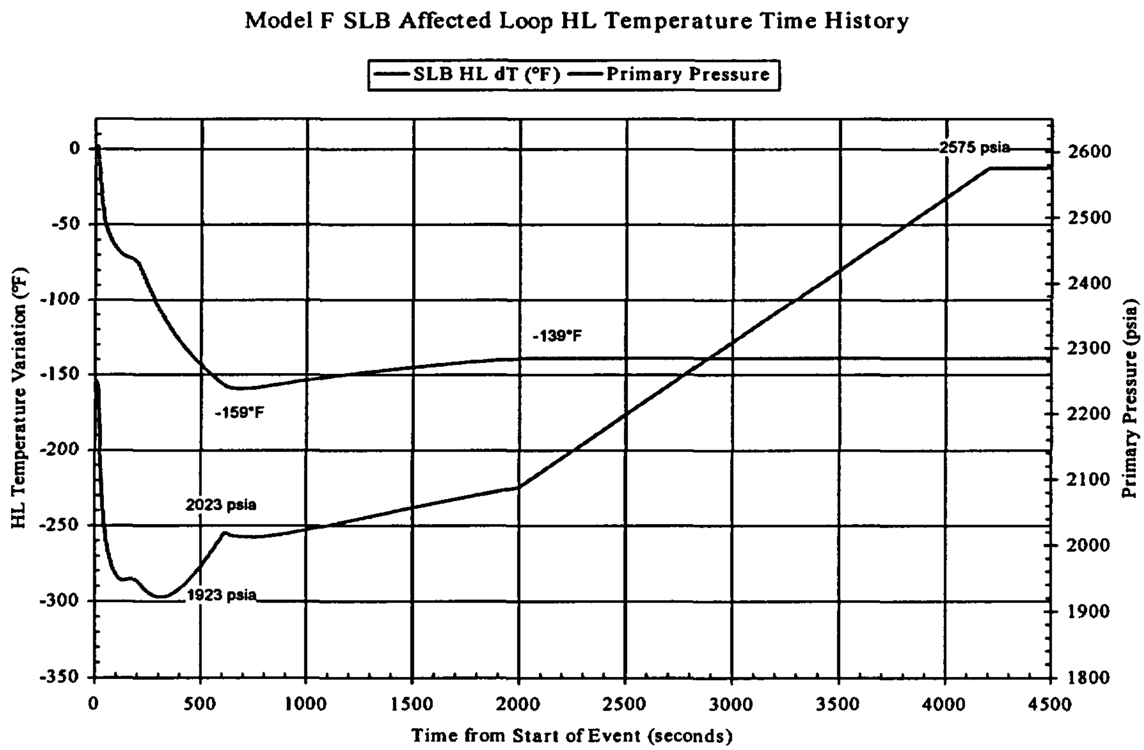

Figure 8: Superimposed SLB Design Pressure and Temperature History

Enclosure 2 to SBK-L-06157

Proposed Technical Specifications Changes (markups)

The following TS are included in this enclosure:

Technical Specification	Title	Page
4.4.5.4	Acceptance Criteria	3/4 4-16
4.4.5.5	Reports	3/4 4-17

SURVEILLANCE REQUIREMENTS

4.4.5.4 Acceptance Criteria

a. As used in this specification:

1) Imperfection means an exception to the dimensions, finish, or contour of a tube from that required by fabrication drawings or specifications. Eddy-current testing indications below 20% of the nominal tube wall thickness, if detectable, may be considered as imperfections;

2) Degradation means a service-induced cracking, wastage, wear, or general corrosion occurring on either the inside or outside of a tube;

3) Degraded Tube means a tube containing imperfections greater than or equal to 20% of the nominal wall thickness caused by degradation;

4) % Degradation means the percentage of the tube wall thickness affected or removed by degradation;

5) Defect means an imperfection of such severity that it exceeds the plugging limit. A tube containing a defect is defective;

INSERT A

6) ~~Plugging Limit means the imperfection depth at or beyond which the tube shall be removed from service and is equal to 40% of the nominal tube wall thickness;~~

7) Unserviceable describes the condition of a tube if it leaks or contains a defect large enough to affect its structural integrity in the event of an Operating Basis Earthquake, a loss-of-coolant accident, or a steam line or feedwater line break as specified in Specification 4.4.5.3c., above;

INSERT B

8) ~~Tube Inspection means an inspection of the steam generator tube from the point of entry (hot-leg side) completely around the U-bend to the top support of the cold leg; and~~

9) Preservice Inspection means an inspection of the full length of each tube in each steam generator performed by eddy-current techniques prior to service to establish a baseline condition of the tubing. This inspection shall be performed prior to initial POWER OPERATION using the equipment and techniques expected to be used during subsequent inservice inspections.

SURVEILLANCE REQUIRMENTS

4.4.5.4 (Continued)

b. The steam generator shall be determined OPERABLE after completing the corresponding actions (plug all tubes exceeding the plugging limit and all tubes containing through-wall cracks) required by Table 4.4-2.

4.4.5.5 Reports

a. Within 15 days following the completion of each inservice inspection of steam generator tubes, the number of tubes plugged in each steam generator shall be reported to the Commission in a Special Report pursuant to Specification 6.8.2;

b. The complete results of the steam generator tube inservice inspection shall be submitted to the Commission in a Special Report pursuant to Specification 6.8.2 within 12 months following the completion of the inspection. This Special Report shall include:

1) Number and extent of tubes inspected,

2) Location and percent of wall-thickness penetration ~~for each~~ indication of an imperfection, and

3) Identification of tubes plugged. INSERT C

c. Results of steam generator tube inspections which fall into Category C-3 shall be reported in a Special Report to the Commission pursuant to Specification 6.8.2 within 30 days and prior to resumption of plant operation. This report shall provide a description of investigations conducted to determine cause of the tube degradation and corrective measures taken to prevent recurrence.

Technical Specification Mark-up Inserts

INSERT A

Plugging Limit means the imperfection depth at or beyond which the tube will be removed from service and is equal to 40% of the nominal tube wall thickness. This criterion does not apply to degradation identified in the portion of the tube below 17 inches from the top of the hot leg tubesheet. Degradation found in the portion of the tube below 17 inches from the top of the hot leg tubesheet does not require plugging. Tubes with degradation identified in the portion of the tube within the region from the top of the hot leg tubesheet to 17 inches below the top of the tubesheet shall be removed from service;

INSERT B

Tube Inspection means an inspection of the steam generator tube from the point of entry (hot-leg side) completely around the U-bend to the top support on the cold leg. The portion of the tube below 17 inches from the top of the hot leg tubesheet is excluded; and

INSERT C

4) The number of indications and location, size, orientation, and whether initiated on primary or secondary side of each indication detected in the upper 17-inches of the tubesheet thickness.

5) The operational primary to secondary leakage rate observed (greater than one gallon per day) in any one steam generator (if it is not practical to assign the leakage to an individual steam generator, the entire primary to secondary leakage should be conservatively assumed to be from one steam generator) during the cycle preceding the inspection which is the subject of the report and (2) the corresponding, calculated accident leakage rate from the lowermost 4-inches of tubing for the most limiting accident in the most limiting steam generator. In addition, if the calculated accident leakage rate from the most limiting accident is less than 2 times the maximum operational primary to secondary leakage rate, the 12-month report should describe how it was determined.