Northern States Power Company

Prairie Island Nuclear Generating Plant

1717 Wakonade Dr. East
Welch, Minnesota 55089

NSP

February 25, 2000

U S Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket Nos. 50-282 License Nos. DPR-42
50-306 DPR-60

Response to Request for Additional Information for Steam Generator Tube EF Star Criterion Prairie Island Units 1 and 2 Supplement 1 to License Amendment Request Dated November 10, 1999

By letter dated November 10, 1999, Northern States Power Company submitted for staff review a license amendment request (LAR) for the Technical Specifications (TS) for Prairie Island Nuclear Generating Plant, Units 1 and 2. The LAR proposed to change the Elevated F-star (EF*) distance of 1.62 inches to 1.67 inches in TS 4.12, "Steam Generator Tube Surveillance." The proposed change is the result of corrections made to tubesheet bending calculations and is documented in the Westinghouse report, "F* and Elevated F* Tube Plugging Criteria for Tubes with Degradation in the Tubesheet Region of the Prairie Island Units 1 and 2 Steam Generators," WCAP-14255, Revision 2.

In a telephone conference conducted on January 24, 2000, representatives of NSP, the NRC, and Westinghouse discussed questions developed by the NRC during the review of NSP's November 10, 1999 LAR. The NSP responses to these questions are as follows:

Question:
1). The licensee stated that the proposed change to EF distance is the result of the corrections made to the original tubesheet calculations. A description of the original error was not clearly discussed in WCAP-14255, Revision 2, although numerical changes were shown in Table 3-1 of the report. In the November 10, 1999 letter, the*

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licensee described the errors briefly. The licensee needs to describe the errors and corrections in detail. (1) Discuss where were the errors made in the original calculations, and (2) Discuss the corrections made in terms of loading data in Table 3-1 of WCAP-14255, Revision 2 (use the case of 1.67-inch EF distance). In addition, we are interested in obtaining an explanation if the errors present generic implications regarding EF* distance calculations for other nuclear plant applications in structural analyses of sleeves and tubes.*

Response:

See Attachment 1 for the Westinghouse response to this question.

Question:
2) If the EF criteria of 1.62 inches in the current technical TS have been applied to tubes in service, the licensee needs to determine if those EF* tubes that are in service have sufficient structural integrity to satisfy the margins of Regulatory Guide 1.121.*

Response:

There are 19 EF* tubes in service. They are installed in 11 steam generator with a 2.0 inch elevated additional roll expansion. The additional hard roll expansion was examined post installation with rotating coil technology. There are no indications present in the additional hard roll expansion. Length of the hard roll expanders is checked prior to installation. Therefore, each EF* tube has 2.0 inches of additional hard roll expansion. Two inches is greater than 1.67 inches and therefore meet the structural integrity requirements as defined in WCAP-14225, Revision 2.

Question:
During our review of the proposed amendment, the staff noticed in the current TS wording that EF distance do not account for eddy current measurement uncertainty (F* distance does not include the eddy current uncertainty also). That is, the TS states "EF* Distance is the distance from the bottom of the upper hardroll transition toward the bottom of the tubesheet that has been conservatively determined to be 1.62 inches (not including eddy current uncertainty)...."*

The staff has approved the current TS wording in previous safety evaluation and understand that the eddy current measurement uncertainty is not part of the proposed changes. However, upon close examination, the staff found that questions remain regarding the measurement uncertainty issue. The licensee stated previously that the reason for excluding eddy current uncertainty is because the reroll tool is fixed to 2 *inches and F* and EF* distances are less than 2 inches; therefore, the measurement uncertainty does not need to be included. The staff would appreciate a clarification on how the eddy current measurement uncertainty is applied in practice and why the TS wording should not state that the EF* distance is 1.62 inch plus eddy current measurement uncertainty.*

Response:

A study by ZETEC for Northern States Power was conducted of the F* and EF* measurement using rotating coil technology. The resultant data documented uncertainty using machined notches and actual additional roll expansions. The conservative maximum analysts deviation (measured defect free hard roll region minus actual defect free hard roll region was -0.32 inches. All analysts measurements were less than the actual distance from the bottom of the hard roll transition to the crack tip. Thus, the measured distance of defect free hard roll region is always less than the actual distance of defect hard roll region. This is due to the eddy current coil sensing the anomaly some distance prior to the coil physically reaching that point, or in the case of the roll transition, also, after passing that point. This always gives a conservative measurement of the length of defect hard roll. In practice, we apply a 0.2 inch conservative uncertainty to the F* and EF* measurement.

For example, our procedures require 1.3 inch of defect free original hard roll between the original hard roll transition and the defects found near the tube ends. In practice, if a defect exists anywhere in the additional hard roll, we have repaired or plugged the tube. A combination bobbin coil and rotating coil probe has also been qualified for higher accuracy, but is not currently in use at Prairie Island. The wording as is in the technical specification requires an eddy current measurement uncertainty be applied to the F* or EF* distance to leave the tube in service.

A revised Safety Evaluation, Significant Hazards Determination, and Environmental Assessment have not been submitted since these evaluations, as originally presented in the November 10, 1999 submittal, continue to bound the proposed license amendment as supplemented.

In this letter we have made no new Nuclear Regulatory Commission commitments. Please contact Jeff Kivi (651-388-1121) if you have any questions related to this letter.

Joel P. Sorensen
Site General Manager
Prairie Island Nuclear Generating Plant

c: Regional Administrator - Region III, NRC
Senior Resident Inspector, NRC
NRR Project Manager, NRC
J E Silberg

Attachments:

1. Westinghouse Electric Company Letter, NSP-00-007, from S. Swigart, to R. Pearson (NSP), dated February 18, 2000.

UNITED STATES NUCLEAR REGULATORY COMMISSION

NORTHERN STATES POWER COMPANY

PRAIRIE ISLAND NUCLEAR GENERATING PLANT DOCKET NO. 50-282
50-306

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION FOR STEAM GENERATOR TUBE EF STAR CRITERION PRAIRIE ISLAND UNITS 1 AND 2 SUPPLEMENT 1 TO LICENSE AMENDMENT REQUEST DATED NOVEMBER 10, 1999

Northern States Power Company, a Minnesota corporation, by this letter dated, February 25, 2000, provides supplemental information in support of the license amendment request dated November 10, 1999.

This letter contains no restricted or other defense information.

NORTHERN STATES POWER COMPANY

By Joel P. Sorensen
Joel P. Sorensen
Site General Manager
Prairie Island Nuclear Generating Plant

On this 25 day of February 2000 before me a notary public in and for said County, personally appeared Joel P. Sorensen, Site General Manager, Prairie Island Nuclear Generating Plant, and being first duly sworn acknowledged that he is authorized to execute this document on behalf of Northern States Power Company, that he knows the contents thereof, and that to the best of his knowledge, information, and belief the statements made in it are true and that it is not interposed for delay.

JEFFREY L. KIVI
NOTARY PUBLIC-MINNESOTA
My Commission Expires Jan. 31, 2005

ATTACHMENT 1

Westinghouse Letter NSP-00-007

February 18, 2000

Northern States Power Company
Prairie Island Units 1 and 2
Response to RAI on F*/EF* WCAP

NOTE: Although labeled "Westinghouse Proprietary" per telecon between NSP (Jeff Kivi) and Westinghouse (Stephen Swigart) of 2/21/00, Westinghouse does not expect Attachment 1 to be withheld from public disclosure.

WESTINGHOUSE PROPRIETARY

Westinghouse Electric Company

Box 355
Pittsburgh Pennsylvania
15230-0355

NSP-00-007
February 18, 2000

Mr. Richard Pearson
Northern States Power Company
Prairie Island Nuclear Generating Plant
1717 Wakonade Drive East
Welch, MN 55089

Subject: **Northern States Power Company**
Prairie Island Units 1& 2
RESPONSE TO RAI ON F*/EF* WCAP

Reference:
1. NSP Purchase Order No. PN7803SQ/ 000
2. Westinghouse General Order No. MKD78027/000
3. Steam Generator Engineering Services Blanket Order Task Authorization No. 9
4. Email, R.Pearson, NSP to H.Lagally, EFSTARRJan00, 1/7/00 (RAI - attached)
5. WCAP-14225 Rev. 2, F* and Elevated F* Tube Plugging Criteria for Tubes with Degradation in the Tubesheet Region of the Prairie Island Units 1 and 2 Steam Generators, 3/99
6. Telephone call, NRC (J.Tsao, E.Murphy, et.al.), NSP, R.Pearson, et.al. and Westinghouse, J.Houtman, A.Thurman and L.Nelson, Clarification of NRC request in Ref. 1, 1/24/00

Dear Mr. Pearson:

Reference 4 transmitted the NRC Request for Additional Information (RAI) relating to Ref. 5. Northern States Power is seeking a response to Question 1 of Ref. 4. In connection with that request, the NRC in Ref. 6 stated a clarification request.

Question 1-1 of Ref. 4: "Discuss where were the errors made in the original calculations"

Answer:

In the EF* calculations made to isolate the contribution of pressure, differential thermal expansion and tubesheet bow 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 slightly high. The secondary pressure was not applied to the surface of the tubesheet hole as had been intended. This yields an EF* that is slightly shorter than desired, i.e., slightly nonconservative by approximately 0.050 inch for the "2.00 to 4.00 inches down from the tubesheet top" case. This is approximately 3 percent of the intended value. (Note: This case is also discussed below, in response to a request in Ref. 6.)

It should be noted that there is margin in the EF* calculation which more than offsets the 0.050 inch. For instance, the tubesheet bow loss of 1993 psi, listed in Table 3-1 (attached) at the elevation 2.0 inches below the tubesheet top was applied to the entire 2.00 inch axial length from the "two-inch-down" elevation to the "four-inch-down" elevation. Similarly at the latter elevation, the tubesheet bow loss was 1572 psi, per Table 3-1 in Ref. 5. Logically, the bow loss at the midpoint of the two inch axial length could be used in the calculation for the field roll expansion that is centered at the "three-inch-down" elevation. In approximate terms, this average bow loss would be 1783 psi and this would provide a net preload which would be approx. 210 psi, or 6 percent higher than the 3,471 psi listed. This translates into about a 6 percent decrease in EF* length. Therefore, this unclaimed margin more than offsets the approximately 3 percent effect due to the secondary side pressure assumption.

The equations used by Westinghouse to calculate tubesheet bending were requested in Ref. 6. These equations are provided in an attachment. (Title: Sleeve/Tube Contact Pressures)

Question 1-2A (Ref. 6): "Discuss the corrections made in terms of loading data in Table 3-1 of WCAP-14255, Revision 2 (use the case of 1.67-inch EF* distance).

Answer:

Those calculations are shown in Table 3-1 (1.67 inch EF* Case).

Question 1-2B: "In addition, we are interested in obtaining an explanation if the errors present generic implications regarding EF* distance calculations for other nuclear plant applications in structural analyses of sleeves and tubes."

Sleeves: These were surveyed and only one plant was affected. In this case, the margin against pullout in the joint was approximately 300 percent, versus the several percent effect for the lack of the secondary side pressure intrusion assumption.

Tubes: No other tube applications were affected.

If you have any questions, Please contact me at 412 374-6119 or Larry Nelson at 724 722-5689

Sincerely,

Stephen P. Swigart

Stephen P. Swigart
Customer Projects Manager

cc R.Kittle Downers Grove FS

♣Table 3-1
Evaluation of Required Engagement Length[1], EF*, for Prairie Island Units 1 and 2

15% Plugging Level

ELASTIC ANALYSIS	EF* (Applies when top of elevated additional roll expansion is 2.0 to 4.0 inches down from top of tubesheet, and conservatively at any lower elevation above or below NBA[2])	**Explanation of terms in previous column, beginning with "Net Preload"
RT Preload (LTL), psi	3,854	
Thermal Expansion Preload, psi	560	
Pressure Preload, psi	1050	
Tubesheet Bow Loss, psi	-1,993	
Net Preload, psi	3,471	$\Sigma_{\text{Preceding 4 values}}$ This is the net mechanical interference fit radial contact pressure acting at the field roll at N.Op.
Net Radial Force, lbs/inch	9,705	Net Preload (from above) times tube/tubesheet interface area per inch axial. The interface circumferential length is $(\pi)(D)$, i.e., the typical expanded tube OD of 0.890 inch: 3471 psi(π x 0.890) = 9705
Net Axial Resistance, lbs/inch	1941	9705 (μ = 0.2) = 1941 Note: μ = Coef. of friction
Applied Load, lbs	991	$\Delta P_{N.Op.}$(Area) =(1593psi)[($\pi D^2/4$)] = 991 lbs This is the maximum pullout load acting during N.Op.
Analysis Load, lbs (N.Op.: SF=3; FLB: SF=1.43)	2,973[3]	$3\Delta P_{N.Op.}$ (Area) =(3)(1593psi)[(π)(D^2/4 in^2)] = 2973 lbs Note: This uses the factor of 3 times the ΔP (separation) load specified for the free span
End Effect Resistance, lbs	416	(0.616)(0.348)(1941) = 416 lbs (for 2 ends)

♣Table 3-1

Evaluation of Required Engagement Length(1), EF*, for Prairie Island Units 1 and 2

15% Plugging Level (Cont'd)

ELASTIC ANALYSIS	EF* (Applies when top of elevated additional roll expansion is 2.0 to 4.0 inches down from top of tubesheet, and conservatively at any lower elevation above or below NBA(2))	**Explanation of terms in previous column, beginning with "Net Preload"
Net Analysis Load, lbs.	2,557	Net analysis load = 2973 – 416 = 2557 lbs. Note: This is the load which needs to be resisted by the non-end effect portion of the roll expansion (EF*)
End Effect Length, inch (x 2 for total)	0.174	When summing the components of EF*, both end effect portions, i.e., 2 x 0.174 = 0.348 inch are used.
Additional Length Req'd, inch	1.317	The non-end effect portion of EF* is 2557 lb/1941 lb/inch or 1.317 inch
Total Length Req'd, EF*, inches	1.67	This is the sum of the two end effect portions (0.348 inch) plus the non-end effect, or "central" portion of EF* axial length

Notes from table:
♣ This table from WCAP-14225 Rev. 2, (Page 3-4), 3/99
(1) EF* distances determined do not include NDE uncertainty for elevation of ECT indications.
(2) Neutral bending axis (NBA) is 10.515 inches below top of tubesheet, or approximately 10.665 inches above bottom of tubesheet cladding (10.885 inches above tube end).
(3) Limiting EF* is determined by Normal Operation condition.
** These terms are also defined in Section 2.0 of WCAP-14225 Rev. 2

Sleeve/Tube Contact Pressures

If sleeves are to be installed in the upper half of the tubesheet, tubesheet bow during operation tends to increase the diameter of the holes drilled in the tubesheet. This diameter increase will result in a decrease in the contact pressures between the sleeve/tube and tube/tubesheet produced by system pressures and differential thermal expansions among the sleeve, tube, and tubesheet. This section determines the effect of tubesheet rotations on the sleeve/tube and tube/tubesheet contact pressures.

Loads are imposed on the tube as a result of tubesheet rotations under pressure and temperature conditions. A 2-D axisymmetric finite element analysis of the Series 51 tubesheet, channel head, and lower shell was performed previously. This yielded displacements throughout the tubesheet for the two pressure and three thermal unit loads.

Previous calculations performed with a 3-D finite element model of this region of a Model D-4 steam generator (which is identical to the Series 51 except for the hole drilling pattern in the tubesheet) showed that, when the divider plate is included the displacements at the center of the tubesheet are 0.76 of the displacements without the effect of the divider plate. Although the reduction in the displacement components throughout the tubesheet is a more complex function of the reduction in the vertical displacements at the center due to the divider plate, applying the same 0.76 factor to all the displacement components is a reasonable approximation since all displacement components will decrease when the maximum displacement decreases. This is supported by the 3-D analysis of the Model E channel head complex documented previously. The radial displacements produced by the thermal unit loads are unaffected by the divider plate.

The radial deflection at any point within the tubesheet is found by scaling and combining the unit load radial deflections at that location according to:

$$\begin{aligned} U_R &= (0.76)(U_R)_{Prim}(\text{Primary Pressure}/1000) \\ &+ (0.76)(U_R)_{Sec}(\text{Secondary Pressure}/1000) \\ &+ (U_R)_{Tubesheet}[(\text{Tubesheet Temperature} - 70)/500] \\ &+ (U_R)_{Shell}[(\text{Shell Temperature} - 70)/500] \\ &+ (U_R)_{Channel\ Head}[(\text{Channel Head Temperature} - 70)/500] \end{aligned}$$

This expression is used to determine the radial deflections along a line of nodes at a constant axial elevation (e.g. top of the tubesheet) within the perforated area of the tubesheet.
The expansion of a hole of diameter D in the tubesheet at a radius R is given by:

Radial: $\Delta D = D\{dU_R(R)/dR\}$

Circumferential: $\Delta D = D\{U_R(R)/R\}$

U_R is available directly from the finite element results. dU_R/dR may be obtained by numerical differentiation.

The maximum expansion of a hole in the tubesheet is in either the radial or circumferential direction. Typically, these two values are within 5% of each other. Since the analysis for calculating contact pressures is based on the assumption of axisymmetric deformations with respect to the centerline of the hole, a representative value for the hole expansion must be used that is consistent with the assumption of axisymmetric behavior. A study had been performed previously to determine the effect of hole out-of-roundness on the contact pressures between the sleeve and tube, and between the tube and tubesheet. The equation used for the hole ΔD is:

$$\Delta D = (SF)(\Delta D_{max}) + (1 - SF)(\Delta D_{min})$$

where SF is a scale factor between zero and one. For the eccentricities typically encountered during tubesheet rotations, SF is usually between 0.50 and 0.60. These are listed in the table below:

Initial Eccentricity	Scale Factor (SF)
0.0000	0.50
0.0002	0.53
0.0004	0.55
0.0006	0.57
0.0008	0.60

This hole expansion includes the effects of tubesheet rotations and deformations caused by the system pressures and temperatures. It does not include local effects produced by interactions between the sleeve, tube, and tubesheet hole. Thick shell equations in combination with the hole expansions calculated from the finite element model displacements are used to calculate the contact pressures between the sleeve and tube, and between the tube and tubesheet.

The unrestrained expansion of the sleeve O.D. is given by:

Thermal: $$\Delta R_s^{th} = b\,\alpha_s(T_s - 70)$$

Pressure: $$\Delta R_s^{pr} = \frac{P_i b}{E_s}\left[\frac{2a^2}{b^2 - a^2}\right] - \frac{P_o b}{E_s}\left[\frac{b^2 + a^2}{b^2 - a^2} - \nu\right]$$

Where

P_i = Internal pressure, psi

P_o = External pressure, psi

a = Inside radius of sleeve, in.

b = Outside radius of sleeve, in.

α_s = Coefficient of thermal expansion of sleeve in/in °F

E_s = Modulus of Elasticity of sleeve, psi

ν = Poisson's Ratio

The unrestrained expansion of the tube I.D. is given by:

Thermal: $$\Delta R_{ti}^{th} = b\,\alpha_t (T_t - 70)$$

Pressure: $$\Delta R_{ti}^{pr} = \frac{P_i b}{E_t}\left[\frac{c^2+b^2}{c^2-b^2}+\nu\right] - \frac{P_o b}{E_t}\left[\frac{2c^2}{c^2-b^2}\right]$$

Where

b = Inside radius of tube, in.

c = Outside radius of tube, in.

α_t = Coefficient of thermal expansion of tube in/in °F

E_t = Modulus of Elasticity of tube, psi

ν = Poisson's Ratio

The unrestrained expansion of the tube O.D. is given by:

Thermal: $$\Delta R_{to}^{th} = c\,\alpha_t (T_t - 70)$$

Pressure: $$\Delta R_{to}^{pr} = \frac{P_i c}{E_t}\left[\frac{2b^2}{c^2-b^2}\right] - \frac{P_o c}{E_t}\left[\frac{c^2+b^2}{c^2-b^2}-\nu\right]$$

The expansion of the hole I.D. produced by pressure is given by:

Pressure: $$\Delta R_{TS}^{pr} = \frac{P_i c}{E_{TS}}\left[\frac{d^2+c^2}{d^2-c^2}+\nu\right]$$

Where

E_{TS} = Elastic modulus of the tubesheet, psi

d = Equivalent outside radius of a tubesheet unit cell, in.

ν = Poisson's Ratio

If the unrestrained expansion of the sleeve O.D. is greater than the expansion of the I.D. of the tube, then the sleeve and the tube are in contact. The thick cylinder equations above can be used to determine the contact pressure between the sleeve and the tube. The inward radial displacement of the outside surface of the sleeve produced by the contact pressure between the sleeve and tube is given by:

$$\delta_s = \frac{P_1 b}{E_s}\left[\frac{b^2+a^2}{b^2-a^2}-\nu\right]$$

The radial displacement of the inside surface of the tube is given by:

$$\delta_{ti} = \frac{P_1 b}{E_t}\left[\frac{c^2+b^2}{c^2-b^2}+\nu\right]-\frac{P_2 b}{E_t}\left[\frac{2c^2}{c^2-b^2}\right]$$

Where

P_1 = Contact pressure between sleeve and tube, psi

P_2 = Contact pressure between tube and tubesheet, psi

One equation for the contact pressures P_1 and P_2 is thus obtained from:

$$\delta_s + \delta_{ti} = \Delta R_s - \Delta R_{ti}$$

If the unrestrained expansion of the tube O.D. is greater than the expansion of the tubesheet hole, then the tube and the tubesheet are in contact. The inward radial displacement of the outside surface of the tube produced by the contact pressures is given by:

$$\delta_{to} = -\frac{P_1 c}{E_t}\left[\frac{2b^2}{c^2-b^2}\right]+\frac{P_2 c}{E_t}\left[\frac{c^2+b^2}{c^2-b^2}-\nu\right]$$

The radial displacement of the inside surface of the tubesheet hole produced by the contact pressure between the tube and hole is given by:

$$\delta_{TS} = \frac{P_2 c}{E_{TS}}\left[\frac{d^2+c^2}{d^2-c^2}+\nu\right]$$

The second equation for the contact pressures P_1 and P_2 is obtained from:

$$\delta_{to} + \delta_{TS} = \Delta R_{to} - \Delta R_{TS}$$

Where

ΔR_{TS} = Hole expansion produced by tubesheet rotations obtained from finite element results

For conservatism, the secondary pressure is assumed to act on the outside of the tube and the inside of the tubesheet hole. For an intact tube, the δ's become:

$$\delta_s = \frac{P_1 b}{E_s}\left[\frac{b^2+a^2}{b^2-a^2}-\nu\right]$$

$$\delta'_{ti} = \frac{P_1 b}{E_t}\left[\frac{c^2+b^2}{c^2-b^2}+\nu\right]-\frac{P_2 b}{E_t}\left[\frac{2c^2}{c^2-b^2}\right]-\frac{P_{sec} b}{E_t}\left[\frac{2c^2}{c^2-b^2}\right]$$

$$\delta'_{to} = -\frac{P_1 c}{E_t}\left[\frac{2b^2}{c^2 - b^2}\right] + \frac{P_2 c}{E_t}\left[\frac{c^2 + b^2}{c^2 - b^2} - \nu\right] + \frac{P_{sec} c}{E_t}\left[\frac{c^2 + b^2}{c^2 - b^2} - \nu\right]$$

$$\delta'_{TS} = \frac{P_2 c}{E_{TS}}\left[\frac{d^2 + c^2}{d^2 - c^2} + \nu\right] + \frac{P_{sec} c}{E_{TS}}\left[\frac{d^2 + c^2}{d^2 - c^2} + \nu\right]$$

With separated tubes, the secondary pressure is assumed to act on the outside of the sleeve and inside of the tube as well as between the tube and tubesheet. With the additional modifications the δ's become:

$$\delta'_s = \frac{P_1 b}{E_s}\left[\frac{b^2 + a^2}{b^2 - a^2} - \nu\right] + \frac{P_{sec} b}{E_s}\left[\frac{b^2 + a^2}{b^2 - a^2} - \nu\right]$$

$$\delta'_{ti} = \frac{P_1 b}{E_t}\left[\frac{c^2 + b^2}{c^2 - b^2} + \nu\right] - \frac{P_2 b}{E_t}\left[\frac{2c^2}{c^2 - b^2}\right] + \frac{P_{sec} b}{E_t}\left[\frac{c^2 + b^2}{c^2 - b^2} + \nu\right] - \frac{P_{sec} b}{E_t}\left[\frac{2c^2}{c^2 - b^2}\right]$$

$$\delta'_{to} = -\frac{P_1 c}{E_t}\left[\frac{2b^2}{c^2 - b^2}\right] + \frac{P_2 c}{E_t}\left[\frac{c^2 + b^2}{c^2 - b^2} - \nu\right] - \frac{P_{sec} c}{E_t}\left[\frac{2b^2}{c^2 - b^2}\right] + \frac{P_{sec} c}{E_t}\left[\frac{c^2 + b^2}{c^2 - b^2} - \nu\right]$$

$$\delta'_{TS} = \frac{P_2 c}{E_{TS}}\left[\frac{d^2 + c^2}{d^2 - c^2} + \nu\right] + \frac{P_{sec} c}{E_{TS}}\left[\frac{d^2 + c^2}{d^2 - c^2} + \nu\right]$$

The resulting equations are of the form:

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{Bmatrix} P_1 \\ P_2 \end{Bmatrix} = \begin{Bmatrix} b_1 \\ b_2 \end{Bmatrix}$$

For a given set of primary and secondary side pressures and temperatures, the contact pressure equations are solved for selected elevations in the tubesheet to obtain the contact pressures as a function of radius between the sleeve and tube and the tube and tubesheet. The elevations selected were the neutral axis of the tubesheet and three elevations spanning the section from the bottom of the ETS to two inches from the top surface of the tubesheet.

REQUEST FOR ADDITIONAL INFORMATION
FOR STEAM GENERATOR TUBE EF STAR CRITERION
PRAIRIE ISLAND UNITS 1 AND 2

By letter dated November 10, 1999, Northern States Power Company submitted for staff review an amendment request for the technical specifications (TS) for Prairie Island Nuclear Generating Plant, Units 1 and 2. The licensee proposed to change the elevated F-star (EF*) distance of 1.62 inches to 1.67 inches in TS 4.12, "Steam Generator Tube Surveillance." The proposed change is the result of corrections made to tubesheet bending calculations and is documented in the Westinghouse report, "F* and Elevated F* Tube Plugging Criteria for Tubes with Degradation in the Tubesheet Region of the Prairie Island Units 1 and 2 Steam Generators," WCAP-14255, Revision 2. In order to continue its review, the staff requests the following information:

1). The licensee stated that the proposed change to EF* distance is the result of the corrections made to the original tubesheet calculations. A description of the original error was not clearly discussed in WCAP-14255, Revision 2, although numerical changes were shown in Table 3-1 of the report. In the November 10, 1999 letter, the licensee described the errors briefly. The licensee needs to describe the errors and corrections in detail. (1) Discuss where were the errors made in the original calculations, and (2) Discuss the corrections made in terms of loading data in Table 3-1 of WCAP-14255, Revision 2 (use the case of 1.67-inch EF*distance). In addition, we are interested in obtaining an explanation if the errors present generic implications regarding EF* distance calculations for other nuclear plant applications in structural analyses of sleeves and tubes.

2) If the EF* criteria of 1.62 inches in the current technical TS have been applied to tubes in service, the licensee needs to determine if those EF* tubes that are in service have sufficient structural integrity to satisfy the margins of Regulatory Guide 1.121.

During our review of the proposed amendment, the staff noticed in the current TS wording that EF* distance do not account for eddy current measurement uncertainty (F* distance does not include the eddy current uncertainty also). That is, the TS states "EF* Distance is the distance from the bottom of the upper hardroll transition toward the bottom of the tubesheet that has been conservatively determined to be 1.62 inches (not including eddy current uncertainty)...."

The staff has approved the current TS wording in previous safety evaluation and understand that the eddy current measurement uncertainty is not part of the proposed changes. However, upon close examination, the staff found that questions remain regarding the measurement uncertainty issue. The licensee stated previously that the reason for excluding eddy current uncertainty is because the reroll tool is fixed to 2 inches and F* and EF* distances are less than 2 inches; therefore, the measurement uncertainty does not need to be included. The staff would appreciate a clarification on how the eddy current measurement uncertainty is applied in practice and why the TS wording should not state that the EF* distance is 1.62 inch plus eddy current measurement uncertainty.