Northern States Power Company
Prairie Island Nuclear Generating Plant
1717 Wakonade Dr. East
Welch, Minnesota 55089

February 28, 1996

Prairie Island
Technical Specification 4.12

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

Steam Generator Inspection Reports

In accordance with Technical Specification 4.12.E.1, the following steam generator tube plugging information is provided to the NRC Staff:

> Following the recent inservice inspection of the Unit 1 steam generators, eighty three (75) tubes were plugged for the first time. Two hundred fifty three (253) sleeves were successfully installed, and fifty five (55) tubes were returned to service. The percentage of tubes plugged is 2.80% in steam generator 11. The percentage of tubes plugged is 5.26% in steam generator 12. The inspection results are summarized in Attachment 1.

In accordance with Technical Specification 4.12.E.2, this information will be expanded upon in the Inservice Inspection Report for Unit 1 which will be submitted within 90 days of the end of the current refueling outage. Also Table 4.3-13 of the Prairie Island Updated Safety Analysis Report will be updated in the next revision.

The results of the inspection of steam generator 11 and steam generator 12 were classified as Category C-3 in accordance with Technical Specification 4.12 because more than 1% of the inspected tubes in each Steam Generator were defective. The NRC Staff was informed of the Category C-3 classification by telephone on January 16, 1996. In accordance with Technical Specification 4.12.E.3, a 30 day special report on the Category C-3 steam generator inspection is provided as Attachment 2 to this letter.



A001

The F-Star (F*) Alternate Repair Criteria and Additional Roll Expansion was implemented under Prairie Island Modification 95L486. There are 6 tubes classified as F* tubes. In accordance with Technical Specification 4.12.E.4, the identification of F* tubes by Row and Column and the location and extent of degradation are included in Attachment 3 to this letter.

Attachment 4 is the 10CFR50.59 safety evaluation that establishes the criteria and bases for leaving tubes in service that contain indications in welded tubesheet sleeve upper welds. Also, Attachment 7 provides the plugging criteria for these indications in a logic diagram format. The process of determining whether to plug with these indications utilized eddy current examinations to locate flaws with respect to the centerline of the welds. We believe this use of eddy current examination is appropriate and definitive. *During the next Unit 1 operating cycle, we will pursue formal qualification of eddy current examination for this application.* Because of concerns regarding uncertainties in characterizing indications in the upper sleeve weld area, we have pulled 5 sleeves for metallurgical examination in order to correlate non-destructive examination results with the metallurgical data. We will not have the results of the metallurgical analysis and correlations determined prior to the startup of Unit 1.

*We will begin a mid-cycle shutdown for inspection of sleeves in 12 steam generator no later than eight operating months following the startup of Unit 1.* We have chosen eight months because of our concern that a shutdown too early could result in a very costly evolution with insufficient inservice time to provide informative results and because the existing examination results indicate no growth in the indications. The justification for eight months is contained in the Operational Assessment section of the Prairie Island Unit 1 Steam Generator Startup Report (Attachment 5). *Subsequent to receipt of the results of the metallurgical analysis, we will determine whether a Unit 1 mid-cycle shutdown is required to perform examinations of the sleeves in 12 steam generator. Mid-cycle shutdown will be determined unnecessary if the metallurgical analysis conclusively shows that the upper sleeve weld area indications are not service related or the analyses indicate that service related indications do not present flaw sizes of magnitudes great enough to present structural or leak hazards during the expected fuel cycle length. Within 90 days of startup, we will submit the results of the metallurgical analysis and our conclusions for NRC review and concurrence.*

Included for your information is the plan for removal and examination of sleeved tube samples from a Prairie Island Unit 1 Steam Generator (Attachment 6).

This letter contains new NRC commitments indicated above by the statements in italics. If you have any questions concerning this letter, please call Jack Leveille at 612-388-1121, Ext. 4662.

Michael D Wadley
Plant Manager
Prairie Island Nuclear Generating Plant

c: Regional Administrator - Region III, NRC
Senior Resident Inspector, NRC
NRR Project Manager, NRC
J E Silberg
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Attachments:
1. Steam Generator Plugged Tube and F-Star Tube Summary (TS required 15-day report)
2. Prairie Island Unit 1 Steam Generators Category C-3 Tube Inspection Special Report (TS required 30-day report)
3. F* Tube Report (TS required 15-day report)
4. Safety Evaluation, SE No. 436, Eddy Current Indications in Welded Tubesheet Sleeve Upper Weld Region
5. Prairie Island Unit 1 Steam Generator Startup Report
6. Program Outline for Removal and Examination of Sleeved Tube Samples from a Prairie Island Unit 1 Steam Generator, January 1996
7. Plugging Criteria for Eddy Current Indications at the Upper Weld in Combustion Engineering Welded Tubesheet Sleeves
8. 2 Letters from Asea Brown Boveri Inc. to Richard Pearson (NSP) Regarding the Minimum Weld Height
9. Radiographs of Preproduction Samples 2B and 13B

ATTACHMENT 1

Steam Generator Plugged Tube and F* Tube Summary

# 11 Steam Generator Plugged Tube and F* Tube Summary

## Summary

| | |
|---|---|
| New Indications Plugged this Outage: | 18 |
| Old Indications Returned to Service by ET | 6 |
| Total Plugged Tubes: | 95 |
| Total F* Tubes: | 32 |
| 11 Steam Generator % Plugged: | 2.80% |

## Inspection Scope

All open tubes were examined full length, except for Rows 1 and 2 U-bends with the bobbin coil.

All Rows 1 and 2 U-bends were examined with rotating probes.

All hot leg tubes were examined with rotating probe technology (including +Point ™) from the tube end to 6 inches above the top of the tubesheet.

## New Indications

Fifty tubes were identified with the following types of degradation:

1. Wastage:

   Eleven tubes were plugged for thinning at the cold leg tube support plate.

2. Secondary Side IGA/SCC in Hot Leg Tubesheet Region

   Three tubes contained single axial indications in the tubesheet crevice region indicative of secondary side IGA/SCC occurring in the tubesheet region and were plugged. An additional tube, containing a single axial indication at TSH -.1 to +.2, was plugged.

3. Primary Water Stress Corrosion Cracking (PWSCC) at Hot Leg Roll Transition Zone

   Five tubes contained single or multiple axial indications at the Roll Transition Zone. Three tubes became F* tubes after successful Additional Roll Expansions. Two PWSCC tubes were plugged due to unsuccessful Additional Roll Expansion.

4. Cause Uncertain

   Twenty nine tubes contained short axial indications near the hot leg tube end. These tubes were all classified as F* tubes. One tube was plugged which contained an inside diameter single axial indication 2 inches above the first support plate in the cold leg side..

## Average Length of Roll Transition Zone Indications

The average length of the indications in the Roll Transition Zone was 0.1 inches.

## 11 Steam Generator Plugged Tube and F* Tube Summary (continued)

### Tube Plug Inspection

A visual inspection was done of all installed tube plugs. There were no unusual indications found.

### Tube Plug Removal

Forty three (43) Westinghouse Alloy 600 mechanical tube plugs were removed in response to Addendum 3 to Revision 3 of Westinghouse WCAP-12244 in accordance with the commitment to remove the remaining hot leg plugs in NSP letter to the NRC dated January 31, 1995. In addition, sixty three (63) Westinghouse Alloy 600 mechanical tube plugs were removed from the cold leg. There are now no Westinghouse Alloy 600 mechanical plugs in 11 Steam Generator.

### Rotating Probe Inspections

In order to best identify those tubes which have minor degradation in the tubesheet region and which could leak during the next fuel cycle, and in accordance with the requirements of Generic Letter 95-03, a complete examination of the hot leg tubesheet region of all inservice tubes was conducted using a Rotating Coil Probe which contained three different coils. These coils were a 0.115 inch pancake coil, a 0.080 inch pancake coil for discrimination of inside versus outside diameter signals and the + Point coils.

This probe was also used to resolve distorted signals called by the bobbin probe eddy current inspection and all dents greater than 5 volts were inspected.

### Circumferential Indications

No circumferential indications were found.

The results of this inspection program of Steam Generator 11 were classified as Category C-3 by Technical Specification 4.12 because more than 1% (including rotating probe indications) of the inspected tubes in Steam Generator 11 were defective. The NRC staff was informed of the Category C-3 classification by telephone on January 16, 1996.

# 12 Steam Generator Plugged Tube and F* Tube Summary

## Summary

| | |
|---|---|
| New Indications Plugged This Outage: | 57 |
| New Indications Sleeved This Outage: | 206 |
| Old Indications Restored To Service by Sleeving: | 47 |
| Old Indications Restored to Service by ET: | 2 |
| Old Sleeved Tubes Plugged This Outage: | 9 |
| Total Plugged Tubes: | 154 |
| Total Sleeved Tubes: | 680 |
| Total F* Tubes: | 3 |
| 12 Steam Generator % Plugged and % Sleeved Equivalent | 5.26% |

## Inspection Scope

All open tubes were examined full length, except for Rows 1 and 2 U-bends, with the bobbin coil.

All Rows 1 and 2 U-bends were examined with rotating probes including + Point ™.

All hot leg tubes were examined with rotating probe technology from the tube end to 6 inches above the top of the tubesheet.

All sleeves were examined full length with the +Point rotating coil.

## New Indications

Two hundred fifty four tubes and 9 sleeves were identified with the following types of degradation:

1. Wastage

   One tube was plugged for thinning at the cold leg tube support plate.

2. Secondary Side IGA/SCC in Hot Leg Tubesheet Region

   One hundred ninety seven tubes were plugged or sleeved for axial indications in the hot leg tubesheet crevice region. These single or multiple axial indications in the lower half of the tubesheet crevice region are associated with the secondary side IGA/SCC corrosion occurring in the tubesheet of 12 steam generator. Fifteen of these tubes also contained single or multiple axial indications at the roll transition zone. One of these tubes in the sludge pile region, had a single axial indication at 0.3 inch long at TSH +.5.

3. Primary Water Stress Corrosion Cracking (PWSCC) at Hot Leg Roll Transition Zone

   Fifty seven tubes contained single or multiple axial indications at the Roll Transition Zone. Three tubes became F* tubes after successful Additional Roll Expansions. The remainder were sleeved or plugged due to unsuccessful Addition Roll Expansions.

**12 Steam Generator Plugged Tube and F* Tube Summary (continued)**

4. Sleeves

Four sleeves contained circumferential indications at the upper weld. One sleeve showed leakage. Two sleeves had unusual volumetric indications. Two sleeves had boron deposits from unidentified sources. The types of degradation, if any, are unknown at this time.

Average Length of Roll Transition Zone Indications

The average length of the indications in the Roll Transition Zone Indications was 0.16 inches.

Tube Plug Inspection

A visual inspection was done of all installed tube plugs. There were no unusual indications found.

Sleeve Visual Inspection

A visual inspection of all sleeve ends was done. One sleeve leaked 1 drop per 6 minutes under 750 psig secondary side pressure. This sleeve R7C63 was removed for examination. Source of leakage is unknown at this time, but did not appear to be from the upper weld.

Tube Plug Removal

Sixteen Westinghouse Alloy 600 mechanical tube plugs were removed in response to Addendum 3 to Revision 3 of Westinghouse WCAP-12244 in accordance with the commitment to remove the remaining hot leg plugs in NSP letter to the NRC dated January 31, 1995. In addition forty one Westinghouse Alloy 600 mechanical plugs were removed from the cold leg. There are now no Westinghouse Alloy 600 mechanical plugs in 12 Steam Generator.

Rotating Probe Inspections

In order to best identify those tubes which have minor degradation in the tubesheet region and in accordance with the requirements of Generic Letter 95-03, a complete examination of the hot leg tubesheet region of all inservice tubes was conducted using a Rotating Coil Probe which contained three different coils. These coils were a 0.115 inch pancake coil, a 0.080 inch pancake coil for discrimination of inside versus outside diameter signals and the +Point coils. This probe was also used to resolve distorted signals called by the bobbin probe inspection and all dents greater than 5 volts were inspected.

All old and new sleeves were inspected full length by + Point coil. Ten sleeves were plugged due to circumferential indications. Fourteen sleeves were plugged due to volumetric indications. Further details are in Attachment 5.

Circumferential Indications

No circumferential indications were found in the in-service tubes. Three tubes which had been plugged earlier for tubesheet IGA/SCC and which were examined when the Alloy 600 plugs were removed had circumferential indications at the roll transition zone. This phenomenon has only been seen in tubes plugged for several years.

The results of this inspection program of Steam Generator 12 were classified as Category C-3 by Technical Specification 4.12 because more than 1% (including rotating probe indications) of the inspected tubes in Steam Generator 12 were defective. The NRC staff was informed of the Category C-3 classification by telephone on January 16, 1996.

ATTACHMENT 2

Prairie Island Unit 1 Steam Generators
Category C-3 Tube Inspection
Special Report

# Prairie Island Unit 1 Steam Generators
# Category C-3 Tube Inspection
# Special Report

## Purpose

This report fulfills the special reporting requirements of Prairie Island Technical Specification 4.12.E.3. This report is required whenever the steam generator tube inservice inspection finds more than 10 % of the total tubes inspected are degraded tubes or more than 1% of the inspected tubes are defective.

## Summary

An inservice inspection consisting of 100% full length bobbin coil and 100% of hot leg tubesheet region mechanical rotating probe with + Point™ coil was conducted on Unit 1 Steam Generators from January 10, 1996 through January 17, 1996. As a result of the eddy current inspection 1.5% (50 of 3305) of the inspected tubes in Steam Generator 11 contained defects requiring repair. Eighteen (18) of these tubes were plugged and the remaining 32 tubes were left in service using Additional Roll Expansion and the F-Star (F*) alternate repair criteria. Repairs were completed on February 1, 1996.

As a result of the eddy current inspection 8.0% (259 of 3242) of the inspected tubes in Steam Generator 12 contained defects requiring repair. Fifty-seven of these tubes were plugged and 3 tubes were left in service using Additional Roll Expansion and the (F*) alternate repair criteria. The remaining 206 tubes were repaired by installing welded tubesheet sleeves. Repairs were completed on February 18, 1996.

In 1980 and 1985, tube samples were removed to characterize indications at cold leg tube support plates and in the hot leg tubesheet region. In February 1996, five (5) tube/sleeve samples were removed from 12 Steam Generator to characterize eddy current indications located at the sleeve upper weld.

## Background

Table 1 provides data on the Prairie Island Nuclear Generating Plant which is significant for the steam generators.

## Table 1: PRAIRIE ISLAND PLANT DATA

**Location:** On Mississippi River near Red Wing Minnesota

**Nuclear Steam Supply System:** Westinghouse 2-Loop 560 MWE

**Steam Generators:** Westinghouse Model 51
Mill-Annealed Alloy 600 Tubing
Open Tubesheet Crevices - 2.75 inch hard roll at bottom of tube

**Circulating Water:** Mississippi River/Cooling Towers

**Secondary Systems Tubing:** Stainless Steel/Carbon Steel

**Startup Dates :** Unit 1 - December 16, 1973
Unit 2 - December 21, 1974

**Effective Full Power Days as of December 31, 1995:**
Unit 1 - 6600 EFPD's

**HOT LEG TEMPERATURE:** 590 degrees Fahrenheit

The current status of each steam generator at Prairie Island is shown in the attached Table 2: "Prairie Island Steam Generator Tube Degradation and Repair Status."

Cause of Tube Degradation

The major cause of the degradation of tubes in Steam Generator 12 is secondary side intergrannular attack and stress corrosion cracking (IGA/SCC or ODSCC). This cause was identified by metallurgical examination of three hot leg sections of the Inconel 600 tubing removed from Steam Generator 12 in January 1985 (Reference 1). The degradation is characterized as single or multiple axial indications. Except for the early years, these axial indications are located in the lower one-half of the tubesheet crevice region.

Rotating pancake coil (MRPC) of the tube samples and experience gained from other utilities provides tools to confirm the type of degradation occurring in the tubesheet region. MRPC examinations of all tubes with non-quantifiable indications in the tubesheet region have been done routinely since February, 1987. The MRPC results have confirmed the type of degradation as secondary side IGA/SCC.

Also, tubes with indications representative of primary water stress corrosion cracking (PWSCC) at the roll transition region have also been identified.

Indications at Sleeve Welds

Eddy current circumferential and volumetric indications at sleeve welds are discussed in Attachment 5.

Remedial Actions

Northern States Power has participated in utility funded research on steam generator related issues beginning with the Steam Generator Owners Group II in 1982 and continuing to the present EPRI funded Steam Generator Management Project. Remedial actions to reduce and/or prevent tube degradation due to primary water stress corrosion cracking and secondary side IGA/SCC have been used by the industry with only limited success. Prairie Island has evaluated, and in most cases, implemented the following remedial actions:

Reduced Operating Temperature: Prairie Island has been a low temperature plant, having operated with $T_{hot}$ at 590 $^{o}$F since startup. This has slowed, but not eliminated, growth of PWSCC and IGA/SCC in the Prairie Island steam generators. Additional temperature reduction has not been warranted.

Chemistry Control: Prairie Island has used state of the art analytical equipment since startup and has followed both the original equipment manufacturer's water chemistry guidelines as well as the EPRI secondary water chemistry guidelines. (2)

The amounts of material found from hideout return tests during shutdowns have been small. Steam generators are sludge lanced every other outage on a rotating basis with less than 80 pounds of sludge removed during each outage. The PWSCC degradation is relatively independent of chemistry and occurs in regions of high residual stress.

High Hydrazine and Molar Ratio Control: These two remedial actions have been used with success in Japan. For a US plant, Prairie Island has maintained relatively high hydrazine levels for a long time. Since May, 1992, hydrazine control has been 125 +- 25 ppb.

Molar ratio control to reduce secondary side corrosion: Molar ratio control is still being evaluated. The object of molar ratio control is to maintain the cation to anion ratio (sodium to chloride) at less

than one so that free sodium hydroxide can not form in the crevice regions. Hideout return evaluations indicate crevice conditions may be acidic.

Conduct Crevice Flushing Operations with Boric Acid: Prairie Island started crevice flushing in 1986 using two days of time. Since then we have added boric acid to the crevice flushing procedure. The time has been reduced to 24 hours since only a small amount of contaminants are being removed.

On-line addition of Boric Acid: Following the report of favorable laboratory results in 1986, Prairie Island began on-line addition of boric acid in unit 1 in March 1987. The effectiveness of this remedial action remains controversial within the industry (EPRI IGA/SCC workshops in May 1991 and December 1992). Improvements in the eddy current technology can make these comparisons difficult, however, since a different set of tubes would have been identified for everyone if RPC inspections had been available and/or used in the past. Prairie Island will continue to use boric acid until such time as an inhibitor of equal or greater effectiveness is justified for on-line use. One of the recommended boric acid practices, low power soaks, has not been implemented at Prairie Island.

Use of other chemical inhibitors: At the present time, NSP supports EPRI research for other chemical inhibitors. Our current evaluations centers around the use of titanium compounds to inhibit the growth of IGA/SCC. A titanium chelate, TYZOR LA Titanate has been added since January 1994 to Unit 1 steam generators.

Preventive sleeving is one method of reducing the probability of tube leak outages. The down side of preventive sleeving is the inability to follow the degradation mechanism and the reduction in the ability to examine tube support plate intersection above the sleeves. NSP has made the strategic decision to sleeve on an as-needed basis, to insure that we are able to best follow the tube support plate problems and to reduce our overall cost of steam generator repair and maintenance.

The F-Star Alternate Repair Criteria allows tube to remain in service with indications below the F* distance. Additional Roll Expansion adds a new F* distance to the steam generator tubing and allows additional tubes to remain in service which have degradation in the lower ~1/3 of the tubesheet crevice region.

Detailed Inspection Plans: Although not a recommendation for remedial actions, but rather a current inspection guideline, 100% of the full length of all tubes in service are routinely examined at Prairie Island . This was started in 1982. In addition, all tubes with indications which can not be quantified, such as UDI's, DSI's, MBM's (in the tubesheet) are examined with the rotating coil probe due to its higher sensitivity. Repair decisions, in those cases, are based on the RPC results. The full length of the tubesheet crevice region is examined by + Point™ coil.

References

(1) EPRI NP-4745-LD, Examination of Tubes R4C19HL, R6C18HL, and R16C33HL from Steam Generator 12 of the Prairie Island Nuclear Station Unit 1.
(2) EPRI TR102134, PWR Water Chemistry Guidelines, Rev. 3

## Prairie Island Steam Generator Tube Degradation and Repair Status

| Type of Degradation | 11 SG | 12 SG | 21 SG | 22 SG |
|---|---|---|---|---|
| Cold Leg TSP Thinning | 41 | 18 | 67 | 126 |
| Antivibration Bar Wear | 24 | 3 | 9 | 30 |
| Tubesheet Sec Side IGA/SCC Only | 8 | 651 | 20 | 2 |
| Roll Transition PWSCC Only | 5 | 105 | 310 | 121 |
| RTZ PWSCC and Sec Side IGA/SCC | 1 | 26 | 6 | 0 |
| Hot Leg Tube Support Plate | 0 | 1 | 0 | 0 |
| U-Bend PWSCC | 1 | 1 | 0 | 0 |
| Loose Parts | 7 | 0 | 2 | 2 |
| Free Span & Top of Tubesheet | 7 | 1 | 2 | 1 |
| Tube End Axial Indications | 29 | 0 | 22 | 26 |
| Other | 4 | 5 | 4 | 3 |
| **Total Tubes Defective** | **127** | **811** | **442** | **311** |

| Type of Repair | | | | |
|---|---|---|---|---|
| Tubes Plugged | 95 | 154 | 132 | 172 |
| Tubesheet Sleeves (IGA/SCC)* (1) | 0 | 680 | 0 | 0 |
| F*0 Alternate Repair Criteria | 29 | 0 | 22 | 26 |
| F*1 & F*2 ARC w/ Additional Roll Expansions | 3 | 3 | 288 | 113 |
| Total Tubes Repaired | 127 | 837 | 442 | 311 |
| **% Equivalent Plugged** | **2.80%** | **5.26%** | **3.90%** | **5.08%** |
| ***% Equivalent Plugged per Unit*** | ***4.03%*** | | ***4.49%*** | |
| (1)Includes 26 preventive sleeves in 12 SG, *28 Sleeves = 1 plug | | | | |

Table 2

Attachment 2
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As of February 18, 1996

TUBESTAT.XLS 9601

# ATTACHMENT 3

F* Tube Report

## 11 Steam Generator F*0 Tubes, 9601

| ROW | COL | INDICATION | LOCATION | | | | REMARK |
|---|---|---|---|---|---|---|---|
| 1 | 27 | MAI | TEH | + | 0.1TO+ | 0.4 | F*0 |
| 6 | 27 | SAI | TEH | + | 0.0TO+ | 0.2 | F*0 |
| 1 | 29 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 30 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 31 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 35 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 13 | 36 | MAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 21 | 36 | SAI | TEH | + | 0.2TO+ | 0.3 | F*0 |
| 2 | 37 | MAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 13 | 38 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 39 | MAI | TEH | + | 0.1TO+ | 0.3 | F*0 |
| 7 | 39 | SAI | TEH | + | 0.1TO+ | 0.3 | F*0 |
| 1 | 40 | MAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 41 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 18 | 41 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 20 | 41 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 21 | 42 | SAI | TEH | + | 0.0TO+ | 0.2 | F*0 |
| 1 | 43 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 44 | SAI | TEH | + | 0.2TO+ | 0.2 | F*0 |
| 17 | 44 | SAI | TEH | + | 0.0TO+ | 0.1 | F*0 |
| 1 | 45 | SAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 48 | SAI | TEH | + | 0.1TO+ | 0.4 | F*0 |
| 1 | 55 | SAI | TEH | + | 0.1TO+ | 0.3 | F*0 |
| 1 | 56 | SAI | TEH | + | 0.1TO+ | 0.3 | F*0 |
| 19 | 60 | MAI | TEH | + | 0.1TO+ | 0.2 | F*0 |
| 1 | 70 | SAI | TEH | + | 0.0TO+ | 0.4 | F*0 |
| 1 | 76 | SAI | TEH | + | 0.1TO+ | 0.3 | F*0 |
| 1 | 78 | SAI | TEH | + | 0.1TO+ | 0.3 | F*0 |
| 1 | 87 | SAI | TEH | + | 0.1TO+ | 0.3 | F*0 |

Total Tubes = 29

F*0 = Fstar Tube Without Additional Roll Expansion

## 11 Steam Generator F*1 Tubes, 9601

| ROW | COL | INDICATION | LOCATION | | | | REMARK |
|---|---|---|---|---|---|---|---|
| 23 | 17 | MAI | TEH | + | 0.8TO+ | 2.4 | F*1 |
| 23 | 17 | SAI | TRH | + | 0.1TO+ | 0.4 | F*1 |
| 5 | 56 | SAI | TEH | + | 2.7TO+ | 2.7 | F*1 |
| 8 | 78 | MAI | TEH | + | 0.8TO+ | 1.3 | F*1 |

Total Tubes = 3

## 12 Steam Generator F*1 Tubes, 9601

| ROW | COL | INDICATION | LOCATION | | | | REMARK |
|---|---|---|---|---|---|---|---|
| 37 | 38 | MAI | TEH | + | 2.7TO+ | 2.9 | F*1 |
| 34 | 31 | MAI | TEH | + | 2.9TO+ | 3.0 | F*1 |
| 4 | 71 | MAI | TEH | + | 2.6TO+ | 2.8 | F*1 |

Total Tubes = 3

MAI = Multiple Axial Indication
SAI = Single Axial Indication
TEH = Tube End Hot Leg
TRH = Top of Roll Hot Leg

ATTACHMENT 4

Safety Evaluation, SE No. 436, Eddy Current Indications in Welded Tubesheet Sleeve Upper Weld Region

## Safety Evaluation 436
## Eddy Current Indications in Welded Tubesheet Sleeve Upper Welds

**Background of Welded Tubesheet Sleeves**

The steam generator tubing at Prairie Island is made from low temperature mill-annealed Alloy 600 tubing and is, therefore, susceptible to both primary and secondary side stress corrosion cracking. The Prairie Island steam generator tubing is degrading both at the roll transition zone due to primary water stress corrosion cracking (PWSCC) and at the tubesheet crevice region due to intergrannular attack and stress corrosion cracking from the secondary side.

License Amendments Nos. 76 and 69 amended the Prairie Island Technical Specifications to allow tubesheet sleeving as a method for repairing steam generator tubes instead of plugging the defective tubes[1].

Modification 86L958 implemented the use of Combustion Engineering welded tubesheet sleeves in the Prairie Island Steam Generators. [2] Post weld heat treatment of the upper sleeve weld joint region was implemented under Prairie Island Safety Evaluation 280 in February 1990[3]. Modification 95SG01 implemented the use of a straight sleeve configuration, a new process sequence, and the use of state of the art eddy current technology for the baseline examination. [4]

During the 9601 in-service and baseline eddy current examinations of the sleeves, indications have been identified at the upper sleeve weld region. Table 1 gives the results for the 9601 examination of installed sleeves.

Table 1: Sleeve ET Indications

| Installation Date | Number Inspected | Volumetric Indications | Circumferential Indications |
|---|---|---|---|
| Prior to 1996 | 436 | 25 | 4 |
| 9601 | 271 | 26 | 7 |

Table 2 lists the sleeve installation history. The original four sleeves which had been plugged were plugged due to welding defects.

Table 2: 12 SG Sleeve History

| Date | Sleeves Required | Tubes Restored | Preventive Sleeves | Outage Total | Sleeves Plugged | Sleeves in Service | Sleeves Heat Treated |
|---|---|---|---|---|---|---|---|
| Apr-87 | 27 | | | 27 | | 27 | 0 |
| Aug-88 | 48 | | 26 | 74 | 1 | 100 | 0 |
| Jan-90 | 37 | 26 | | 63 | 0 | 163 | 16 |
| Jun-91 | 0 | 0 | | 0 | 1 | 162 | 0 |
| Sep-92 | 0 | 0 | | 0 | 0 | 162 | 0 |
| Oct-92 | 158 | 0 | | 158 | 1 | 319 | 158 |
| May-94 | 118 | 0 | | 118 | 1 | 436 | 117 |
| Jan-96 | 240 | 45 | | 285 | 41 | 680 | 253 |
| **Totals** | **628** | **71** | **26** | **725** | **45** | | **550** |

In February 1996, due to the uncertainty in the source of eddy current indications in the sleeve upper weld region, 5 sleeves were removed for metallurgical examination.

**Evaluation**

The eddy current indications found in the sleeve welds have been either volumetric or circumferential in nature. The circumferential indications appear crack like in nature. However, there has been controversy as to whether or not they are due to the welding process (e.g. weld geometry). Because of the inability to size circumferential indications, especially in the weld joint region, all circumferential indications shall be plugged. This position is supported by industry experiences as outlined in NRC Generic Letter 95-03. [5]

Technical Specification 4.12 D.1.(f) defines the repair limit for degraded tubes. Repair limit means the imperfection depth at or beyond which the tube shall be removed from service by plugging or repaired by sleeving because it may become unserviceable prior to the next inspection and is equal to 50% of the nominal tube wall thickness. If significant general tube thinning occurs, this criteria will be reduced to 40% wall penetration.

Technical Specification 4.12 D.1.(g) defines the unserviceable condition. 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.

Technical Specification 4.12.D.1.(e) defines defect.
Defect means an imperfection of such severity that it exceeds the repair limit. A tube containing a defect is defective.

It is possible to make some assessments on the extent of degradation or welding artifacts present in the sleeve weld for volumetric indications. Laboratory specimens exhibiting volumetric indications have been metallurgically examined. The source of these indications has been found to be small cavities at either edge of the sleeve weld. When these cavities are at the upper edge of the weld, there is no effect on the pressure boundary integrity of the sleeve weld. [6]

**Regulatory Guide 1.121 Evaluation**

1) From Reg. Guide 1.121, it is required that the margin of safety against tube rupture under normal operation conditions should not be less than 3. The required thickness is determined as follows.

Primary Pressure $P_{pri}$=2235 psig
Differential Pressure $\Delta P$=1530 psi
Inner Radius of sleeve $R_i$=.333
Secondary Pressure $P_{sec}$=705 psig
Average Pressure $P_{avg}=0.5(P_{pri}+P_{sec})$=1470 psi
Minimum tensile strength $S_u$=90 ksi

nominal thickness of sleeve t = .040 in.
$t_{min}$ = minimum thickness

$$t_{min} = \frac{3\,\Delta P\,R_i}{S_u - P_{avg}} = \frac{3(1530)(.333)}{90{,}000-1470} = .017 \text{ in.}$$

$$\%\text{ allowable degradation} = \frac{(.040-.017)100}{.040} = 57\%$$

3) Also, from Reg. Guide 1.121, it is required that the margin of safety against tube failure under postulated accidents (Service level D) should be consistent with the margin of safety determined from the stress limits specified in NB3225 of Section III of the ASME B & PV code. NB3225 leads to Appendix F which specifies a allowable stress of $0.7S_u$ for level D Service limits
Pa = pressure differential for accident = 2485 psi

$$t_{min} = \frac{P_a R_i}{0.7S_u - 0.5P_a} = \frac{(2485)(.333)}{0.7(90{,}000)-0.5(2485)} = .013 \text{ in.}$$

$$\%\text{ allowable degradation} = \frac{(.040-.013)100}{.040} = 67\%$$

Thus the limit comes from the three times normal operating differential pressure and is 57%.

**Plugging Criteria**
Plugging criteria have been established for indications at the weld zones using input from all of the available examination techniques.
1. Visual examination of the weld surface interior diameter by Combustion Engineering sleeve installation procedures: [7]

The weld is considered visually acceptable if it is found to be free of imperfections that could be detrimental to the integrity of the weld. Detrimental imperfections are blow holes at the lower edge of upper welds, blow holes extending through the sleeve into the tube, porosity, incomplete or partial welds, and lack of fusion. Nondetrimental qualities are weld roughness, down slope weld tail, and weld ripple.
2. Ultrasonic examination of the sleeve weld.

The weld shall be considered to have acceptable fusion of the weld for 360 degrees at any single elevation, or any combination of elevation positions. A continuous indication of lack of fusion across the entire width of the weld (i.e., a leak path) shall be cause for rejection. Welds noted on a Weld Scan Data Sheet as possibly being defective due to blow holes shall be visually examined. [8]

3. Eddy Current Examination using bobbin coil probe:

Welds are considered defective if an indication is greater than 40% through wall.

4. Eddy current examination using rotating coil technology such as +Point™ coils and pancake coils both with and without magnetic biasing.

+Point calls shall be verified by magnetic biased +Point coils. Any indications which are crack like are unacceptable. This includes single and multiple axial and circumferential indications.

Any volumetric signals require further analysis. Those volumetric indications which are in the lower half of the weld region are defective. Those indications which are at the top of the weld are acceptable. [6] When available, additional ultrasonic testing can be used to substantiate the eddy current analysis.

5. Ultrasonic Examination using Shear Waves. [9]

The ultrasonic examination of 12 Steam Generator sleeve weld volumetric indications was done using a 3 channel probe head which contains an axially aimed transducer for circumferential indications, a circumferentially aimed transducer for detection of axial indications and a zero degree beam for inside diameter profiling and wall thickness or bond quality measurements included 56 tubes. The UT-360 System configured for zero degree is typically accurate to .001 inch (depth) and .010 inch (length) for volumetric indications. The zero degree data was responsible for detection and identification of ID surface anomalies such as blow holes, weld sag, suck back, and general wall thickness measurements for the sleeve and weld zone. Applications for shear wave mode include the detection of axial cracks, circumferential cracks, stress corrosion cracking (i.e., planar type indications) and volumetric type indications with sharp edges.

The results of the ultrasonic examination were used to reject indications which were in the lower half of the weld and to assist in the final disposition of eddy current indications using the location and depth capability of the ultrasonic system.

Volumetric indications left in service were acceptable by visual examination, installation UT, bobbin coil, physical location at upper weld edge, and less than 0.012 inches wall loss (< 30%) by UT-360 measurements. In addition, all welds left in service with volumetric indications, had an average weld height of greater than 0.080 inch which meets the structural analysis (by a factor of 4) for the CE welded tubesheet sleeve pull out forces. [10]

10CFR50 Appendix B Section IX, Special Processes, requires that special processes including welding, heat treating, and nondestructive testing be controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The nondestructive examination techniques met these requirements.

**Growth Assessment**

There were 26 volumetric indications and 4 circumferential indications identified in old sleeves. When the 1994 eddy current examination data was compared to the 1996 data, there were no changes in the volumetric indications. (There was a small change in one circumferential indication). This data comparison was made with I-coil data and 3 coil RPC data. There was a small change in circumferential indication.

Section 14 of the USAR was reviewed for impact. The function of the steam generator tubing is to 1) maintain the primary system pressure boundary and to 2) transfer heat from the reactor coolant system to the secondary side. This safety evaluation does not change the failure modes or failure impact of the Steam Generator tubing. No impact on the USAR Section 14 accidents was identified.

This Safety Evaluation supports leaving volumetric indications in service using the evaluation criteria established above and the fact that no growth was found in the old volumetric indications.

**Future Inspections**

Technical Specification 4.12 B.2.(a) requires all tubes that previously had wall penetrations >20% that have not been plugged or sleeve repaired in the affected area to be included in the first sample set of tubes selected for each in-service inspection of each steam generator. All sleeves with volumetric indications will be inspected at each 12 steam generator tubing inspection.

**Determination of Unreviewed Safety Question**

1. Does the proposed activity increase the consequences of an accident previously evaluated in the USAR or in a pending USAR submittal?

   Those accidents which could be affected by this change are:
   - Rupture of a Steam Pipe or Feedwater Line Break (USAR Section 14.5.5).
   - Steam Generator Tube Rupture (USAR Section 14.5.4).
   - Large Break Loss of Coolant Accident (USAR Section 14.6)

No. The repair limit per Technical Specification 4.12 D.1.(f) of 50% has been analyzed for consequences of an accident. The sleeve indications which are circumferential or which are in the lower half of the sleeve weld will be plugged. Sleeve failure results in the same consequences as tube failure. Therefore, this activity will not increase the consequences of an accident previously evaluated in the USAR.

2. May the proposed activity increase the probability of occurrence of an accident previously evaluated in the USAR or in a pending USAR submittal?

No. The sleeve weld volumetric indications are not growing. Sufficient sleeve weld exists to ensure the integrity of the sleeve joint. Therefore, this activity will not increase the probability of occurrence of an accident previously evaluated in the USAR.

3. May the proposed activity increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the USAR or in a pending USAR submittal?

No. The structural integrity of the sleeve weld is maintained. Reexamination of the old volumetric indications shows no breach of leakage integrity. Therefore, this activity does not increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the USAR.

4. May the proposed activity increase the consequences of a malfunction of equipment important to safety previously evaluated in the USAR or in a pending USAR submittal?

No. If any of the steam generator sleeves do fail, the malfunction, Steam Generator Tube Rupture, of the sleeve has been previously evaluated. Accident leakage is bounded by the current analysis for steam generator tube rupture and main steam pipe rupture. Therefore, this activity will not increase the consequences of a malfunction of equipment important to safety previously evaluated in the USAR.

5. May the proposed activity create the possibility of an accident of a different type than previously evaluated in the USAR or in a pending USAR submittal?

No. Failure of a sleeve is bounded by the tube rupture accident. Therefore, this activity will not create the possibility of an accident of a different type than previously evaluated in the USAR.

6. May the proposed activity create the possibility of a different type of malfunction of equipment important to safety than any previously evaluated in the USAR or in a pending USAR submittal?

No. The failure mode for a steam generator tube leakage or rupture is bounded by current analyses. Therefore, this activity will not create the possibility of a different

type of malfunction of equipment important to safety than previously evaluated in the USAR.

7. Does the proposed activity reduce the margin of safety as defined in the basis for any Technical Specifications?

No. The repair limit of 50% through wall degradation (40% for general thinning) is met by the criteria established for sleeve evaluations, The sleeve repair criteria is more limiting than the Technical Specification criteria. Therefore, leaving tubes in service with the sleeve volumetric indications does not reduce the margin of safety as defined in the basis for any Technical Specifications.

Since all of the above answers are No, there is no Unreviewed Safety Question.

Prepared by: Richard P Pearson Date: 2-19-96

Reviewed by: M R Heller Date: 2/19/96

[1] Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Amendment Nos. 76 and 69 to Facility Operating License Nos. DPR-42 and DPR-60 for NSP's Prairie Island Nuclear Generating Plant
[2] Modification 86L958: Steam Generator Sleeving using Welded Sleeves
[3] Safety Evaluation 280: Post Weld Heat Treatment of Steam Generator Tube Sleeve Upper Welds
[4] Modification 95SG01: Changes to the ABBCE Steam Generator Welded Tubesheet Sleeve Process
[5] NRC Generic Letter 95-03: Circumferential Cracking of Steam Generator Tubes
[6] ABB Combustion Engineering letter from David Stepnick to Richard Pearson, dated February 5, 1996: Sleeve Weld at Location R14/C64 with a Volumetric Indication

[7] ABB Combustion Engineering Procedure STD-400-157 Rev. 0, Visual Examination of Steam Generator Tube Sleeve and Sleeve Plug Welds
[8] ABB Combustion Engineering Procedure 00000-NSS-062 Rev. 10, Procedure for Ultrasonic Examination of Steam Generator Tube Sleeve Upper Welds.
[9] Framatome Procedure 54-ISI-97-06, PQ# 54-PQ-197-03, Rev 1/30/96: Ultrasonic Examination of Steam Generator Tubing with Shear Waves using UT-360
[10] Prairie Island Steam Generator Tube Repair using Leak Tight Sleeves, ABB Combustion Engineering Report CEN-294-P Revision 3-P, Section 8.2.1

ATTACHMENT 5

Prairie Island Unit 1 Steam Generator Startup Report

# Prairie Island Unit 1 Steam Generator Startup Report
# Refueling Cycle 18 Startup
# February 28, 1996

This report discusses the sleeve indications and sleeve examination program, evaluates the as-found condition (Condition Monitoring) of the Unit 1 steam generators, and assesses the condition of the steam generators during the next operating cycle (Operational Assessment).

## 1. 12 Steam Generator Sleeve Examination Program

All in-service and new sleeves were examined with rotating eddy current technology. Three different probes were used:

1. +Point™ rotating coil
2. Magnetically biased +Point™ and pancake rotating coils of all Sleeve Weld Indications (SWIs), except historical volumetric indications
3. 3 Coil RPC of all sleeve volumetric, circumferential or axial indications, except in-service SWIs

All in-service and new sleeves with volumetric indications were examined with bobbin coil, visual, and ultrasonic testing techniques.

## 2. Status of Sleeves with Circumferential Eddy Current Indications

Circumferential indications were identified in 4 old sleeves and 7 new sleeves at the upper sleeve weld. One of these new sleeve welds had already been rejected by visual examination. Four of these sleeves were pulled for metallurgical examination. The other 7 sleeves were plugged. No sleeves with eddy current circumferential indications were left in service.

## 3. Review of the eddy current indications identified in in-service sleeves

During the 9601 Prairie Island Unit 1 Steam Generator Refueling Inspection of steam generator tubing, circumferential indications were identified in the upper sleeve (ATS) weld of 11 (1 was a visual reject) sleeved tubes and volumetric indications in the ATS weld of 51 sleeved tubes. The history of sleeve examination and comparisons follow.

### 3.1. 10/92 Examination

The sleeves were examined with the X-wound probe which reduces the effects of the expansion transition. This probe also contained a regular bobbin coil configuration. The general consensus of the eddy current examiners is that this probe is not sensitive to small indications and would not detect the indications that are being reported with the new technology probes, such as +Point™. No indications were found in the cross wound bobbin coil probe baseline examination in 1992.

### 3.2. 5/94 Examination

The sleeves were examined with the I-coil (.250" axial coil and .230" circumferential coil). Indications from the I-coil were reported as either Sleeve Weld Indication (SWI), or a Possible Weld Anomaly (PWA), with the SWI code assigned to larger indications and the PWA code to smaller indications. The SWI and PWA indications were then examined with the 3 Coil RPC probe and classified as either volumetric (VOL), circumferential (MCI/SCI) or axial (SAI/MAI). During this outage the only 3 Coil indications called were volumetric. None of these volumetric indications were identified by 5/94 cross-wound bobbin coil examination. The indications were all located at the sleeve upper weld. Four of these sleeves were installed

in the April 1987 outage and fifteen were installed in October 1992 outage. Five were installed in the 5/94 outage.

At that time, the sleeves with the welding artifacts, as identified by eddy current RPC probes, were accepted for continuing service based on acceptable visual examination, ultrasonic examination, and indication location. There is currently no known primary side degradation which is volumetric in nature. In addition, since these indications were found in the both the oldest and newest sleeve welds, they were evaluated to not be a result of corrosion.

### 3.3. 1/96 Examination

During this year's examination, the +Point™ coil was used to examine all in-service and new sleeves. The entire sleeve length was examined on the push with a .180" +Point™ probe designed for sleeve examinations. If an indication was observed in the sleeve weld, it was reported as an SWI. An SWI required additional examination by a magnetically biased .127" +Point™ probe and a 3 Coil probe to provide additional definition and evaluation.

The magnetically biased .127" +Point™ probe also had a magnetically biased .115" pancake coil. These coils were used to screen out possible permeability variation indications. This examination did eliminate some of the SWI indications. If the indication was still observed with the magnetically biased probes, these were classified as volumetric, circumferential or axial.

The 3 Coil probe contained a .115" pancake coil ( sensitive to all indications), a .110" circumferentially wound coil (sensitive to axial indications) and a.110" axial wound coil (sensitive to circumferential indications). During the 3 Coil examination the indications are reported as either volumetric, circumferential, or axial.

### 3.4. 1/96 Results

| Examinations | SWI Indications | VOL Indications | SCI/MCI Indications |
|---|---|---|---|
| 436 Inservice Sleeves | 15 | 25 | 4 |
| 271 Pre-service Sleeves | 50 | 26 | 7 |
| Total Sleeve Indications | 65 | 51 | 11 |

Note: One SCI Indication was from a Visual Reject weld

The location of these indications is in the weld itself and at the parent tube/sleeve interface or towards the inside diameter of the sleeve.

### 3.5. Circumferential Flaw Comparison

The tubes with circumferential indications and their eddy current indications are:

| Row | Col | Eddy Current Indication at ATS Weld | Date Installed |
|---|---|---|---|
| 5 | 48 | Single Circumferential Indication | 9210 |
| 7 | 52 | Multiple Circumferential Indications | 9405 |
| 2 | 56 | Single Circumferential Indication | 9210 |
| 9 | 57 | Single Circumferential Indication | 9210 |

These sleeve upper joints were all examined with the ZETEC I-coil rotating probe in May, 1994. Previous to that, the sleeves had been examined with the cross-wound bobbin coil. The eddy current indications identified in each sleeve since installation are listed below:

| Row | Col | 9210 | 9405 | 9601 |
|---|---|---|---|---|
| 5 | 48 | NDD | SWI | SCI |
| 7 | 52 | N/A | SWI | MCI |
| 2 | 56 | NDD | NDD | SCI |
| 9 | 57 | NDD | NDD | SCI |

NDD = No Detectable Degradation
SWI = Single Weld Indication
MCI = Multiple Circumferential Indication
SCI = Single Circumferential Indication

The four circumferential sleeve indications that were reported this outage (1/96) were compared to the data collected last outage (5/94). The pancake coil was used for comparison of two tubes, and four tubes were compared with I-Coil probe data. It is the opinion of a Steam Generator Level III Eddy Current Qualified Data Analyst that the I-coil data did not change. One tube, R5C48, did show a small change on the 3 Coil probe. This tube has been pulled for metallurgical examination.

### 3.6. Volumetric Flaw Comparison

The 24 volumetric sleeve indications that were identified last outage (5/94) were compared to the data collected this outage (1/96). The pancake coil was used for the comparison. It is the opinion of a Steam Generator Level III Eddy Current Qualified Data Analyst that the indications have the same appearance and that no measurable change has occurred during the last operational cycle (545 days on-line).

## 4. Pre-production Sample Metallurgical Examination

The metallurgical examination of the pre-production upper sleeve weld samples with volumetric indications has identified weld suck back (hemispherical cavity in the sleeve wall) above the upper edge of the weld about .090 inch in diameter. There is no effect on the structural integrity of the weld due to the location of the weld suck back.

Pre-Production Sample 2A: Sample 2A had a sleeve weld indication by +Point™ and volumetric indication by 3 Coil RPC. Upon metallurgical examination, a void was found at the top of the upper edge of the weld extending upward away from the weld about 0.3" in circumferential extent.

Pre-Production Sample 13B: Sample 13B had a volumetric indication by +Point™ and 3 Coil RPC very similar to those found in 12 Steam Generator. Visual examination identified a blow hole at the location of the volumetric indication. Metallurgical examination identified a lower void at the bottom of the weld extending about 45 degrees in circumference.

Pre-Production Sample X3: Radiography performed on this sample revealed that a void existed above the weld approximately 180 degrees around the circumference. A very small void exists below the weld for less than 0.05". Ultrasonic testing by Framatome Technologies did not identify this indication. Sectioning will be done based on the ET and RT results. Sectioning has not yet been done.

These voids in the pre-production welds appear to have no effect on structural integrity. Evaluation is continuing.

## 5. Sieeve Pull Program

### 5.1. Pulled Tubes

In order to characterize the eddy current indications identified in sleeve welds, 5 sleeved tube samples were removed from 12 Steam Generator Hot Leg. The tubes/sleeves removed from 12 Steam Generator Hot Leg are:

| Row | Col | Eddy Current Indication at ATS Weld | Year | # of Welds |
|---|---|---|---|---|
| 5 | 48 | Single Circumferential Indication | 9210 | 1 |
| 7 | 52 | Multiple Circumferential Indications | 9405 | 4 |
| 9 | 57 | Single Circumferential Indication | 9210 | 1 |
| 7 | 63 | Volumetric Indication | 9210 | 2 |
| 5 | 74 | Multiple Circumferential Indications | 9601 | 2 |

### 5.2. NDE Estimates of Degradation

Circumferential extents were estimated for the circumferential indications. The estimated circumferential extents in degrees are:

| Row | Col | +Point™ | +Pt Mag Bias | .115PC MgBias |
|---|---|---|---|---|
| 5 | 48 | 185 | 86 | 108 |
| 7 | 52 | 278 | 149 | 146 |
| 2 | 56 | 266 | 173 | 107 |
| 9 | 57 | 243 | 227 | 124 |
| 5 | 74 | 157 | 157 | 136 |

No depth estimates have been made, nor are expected to be made, from the eddy current data. Without knowing the origination of the indications, it is not possible to set a proper calibration curve. In addition, analysts are reluctant to assign depth measurements to circumferential indications in the presence of geometry changes.

### 5.3. Objectives of the Sleeve Examination

1. Identify physical condition which is source of ET indications
2. Evaluate effect on structural integrity

3. Identify the root cause of the degradation or weld defects

### 5.4. Metallurgical Examination Plan

The metallurgical examination plan was previously supplied to the NRC on January 29, 1996. The metallurgical plan, ABB Combustion Engineering letter WO-96-016, is submitted as Attachment 6. There are three additional comments:

1. An additional tube was pulled, R7C63, a possible volumetric indication (leaking tube).
2. Examination of the hydraulic expansion transition zones will be done.
3. The radiography and some of the ultrasonic testing will not be Quality Class 1.

## 6. Primary to Secondary Leak Monitoring Program

The primary-to-secondary leakage monitoring program will be based on EPRI Report TR-104788, PWR Primary-to-Secondary Leak Guidelines. Full implementation of this program will be completed by March 31, 1996. Radiation monitors for leak monitoring are located at the condenser air ejector exhaust and on the steam generator blowdown system. The current administrative primary to secondary leak limit is 0.1 GPM, a normal shutdown commences at >0.1 GPM.

## 7. Regulatory Guide 1.121 Evaluation

### 7.1. Prairie Island Safety Evaluation 436: Eddy Current Indications in Welded Tubesheet Sleeve Upper Welds.

Safety Evaluation 436 (Attachment 4) provides a detailed discussion for the repair criteria used for leaving volumetric indications in service. It also states that circumferential eddy current indications shall be removed from service due to inability to size those indications. Also, the source of the circumferential indications is not known at this time. The source of the volumetric indications is now believed due to weld cavities or voids due to blowholes, weld suck back, or possibly weld undercut (i.e., weld process induced indications). Analytical evaluation is continuing on the effects of these voids on weld integrity, particularly when located in the lower half of the weld. The structural integrity of the sleeve weld with volumetric indications is maintained by location and depth estimate. In addition, there is no evidence of growth in the volumetric indications and no evidence that they are due to service-related degradation.

### 7.2. Additional Regulatory Guide 1.121 Considerations

The Combustion Engineering welded tubesheet sleeve joint has been mechanically tested for both burst and pull-out loads.[1]

- The force calculated to shear the upper sleeve weld is 4,716 lbs. In mechanical test, the upper weld yielded at 4,500 lbs and failed at 9020 lbs . The maximum load under Main Steam Line Break accident is 1172 lbs. This gives a safety factor of 3.8. Weld height is maintained in the sleeves left in service providing sufficient safety margin to pull-out forces.
- In burst tests, fixture leakage occurred at 7800 lbs with no sleeve failure.

Allowances for growth of indications cannot be made at this time since all data shows no growth has occurred over a 20 month operating cycle in the in-service sleeves.

Combinations of loading conditions for the postulated accident conditions are not considered since, for the sleeve location below the first tube support plate, the LOCA + SSE bending stresses in the sleeves are quite small.[ii]

## 8. Condition Monitoring

Although the as-found condition of the 4 circumferential indications and 12 volumetric indications has lead to conservative decisions to plug these tubes, original acceptance criteria for the sleeves using visual inspection, ultrasonic examination, and installation parameter controls are still met. There is no sign of a leakage path through the weld joint. Sufficient weld height exists to meet structural requirements. Therefore, sleeve burst and leakage integrity were met during the previous operating cycle. (This will also be evaluated following destructive examination)

Cold leg tube support plate thinning indications did not exceed limits with maximum through wall observed of 49%.

The two free span crack-like indication had free span length of 0.2 inches which will not rupture.

## 9. Operational Assessment

Since there is no indication of growth in any of the indications, except R5C48 (which appears to be small), there is little justification for establishing any cycle length other than the full operating cycle. However, since it is not know what the indications represent, a mid cycle inspection at less than 8 effective full power months is proposed until the characterization of the indications is complete and further analysis has been done. It is possible that the appropriate inspection cycle length could decrease or increase based on the metallurgical examination findings.

## 10. Expectations for Inconclusive Data

The possibility exists that the metallurgical examination results may be inconclusive. If this is the case, then the following plan is proposed:

Additional attempts to duplicate field indications in the laboratory using expanded parent tube parameters (such as wall thickness, material strength, outside diameter conditioning with sludge).

Additional attempts to duplicate field indications by varying welding parameters and welding conditions (such as multiple repairs, contaminated argon, high humidity conditions).

Further development of ultrasonic tests based on the data acquired by the state of the art ultrasonic examination of the installed sleeves.

Development of eddy current probes which might better map the indications.

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[i] Combustion Engineering Report CEN-294-P Rev. 2-P: Prairie Island Steam Generator Tube Repair Using Leak Tight Sleeves

[ii] WCAP-10756: Prairie Island Units 1 and 2 Steam Generator Sleeving Report

# ATTACHMENT 6

Program Outline for Removal and
Examination of Sleeved Tube Samples
from a Prairie Island Unit 1 Steam Generator
January 1996

ABB
ASEA BROWN BOVERI

January 28, 1996

WO-96-016

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

**SUBJECT: PRAIRIE ISLAND REMOVED SLEEVED TUBE SAMPLE EXAMINATION**

Dear Mr. Pearson:

Based on our meeting of January 26th, it is our understanding that, barring any unexpected developments, the attached scope of work would be acceptable to NSP as a method for evaluating the recent Plus Point eddy current examination indications reported in the ABB CENO welded steam generator tube sleeves. The work required to pull the samples and perform on-site eddy current testing would be performed by others at NSP's direction with ABB's concurrence.

Our intent would be to provide preliminary NDE information within one week of receipt of the samples and preliminary destructive evaluation data within the second week. A complete report of the evaluation would then be provided in six weeks time.

Please review the attached plan and provide me with any comments you may have.

Sincerely,

W. R. Gahwiller

W. R. Gahwiller
Consulting Engineer

xc: J. Hall
J. Rogers
D. Stepnick
G. Stevens
J. M. Westhoven

Attachment



Combustion Engineering, Inc
1201 Riverfront Parkway
Chattanooga, Tennessee 37402
Telephone (423) 752-2390
Toll Free 1-800-872-8836
Fax (423) 752-2449

# PROGRAM OUTLINE

# FOR

# REMOVAL AND EXAMINATION

# OF

# SLEEVED TUBE SAMPLES

# FROM A

# PRAIRIE ISLAND UNIT 1

# STEAM GENERATOR

**JANUARY 1996**

## I. OBJECTIVE

The objectives of this sleeved tube removal and examination program are to:
(1) identify the physical condition(s) present in the sleeve joints which have resulted in the eddy current test indications observed.
(2) verify that, if as suspected, the indications are a result of installation, the condition is not detrimental to the structural integrity of the sleeve.
and
(3) in the unlikely event service induced degradation is the cause, identify the factors affecting that degradation mechanism.

## II. SLEEVED TUBE SAMPLES

The sleeved tube sample set will consist of six (6) sleeve/tube upper weld sections as shown in Figure 1. Two (2) samples are pre-production samples, one (1) is a sleeve installed during the current January 1996 outage, and three (3) are sleeves that have been in service. Specifically these samples are:

1. 1996 Preproduction Sample 13B : a possible volumetric indication
2. 1996 Preproduction Sample 2A: an indeterminate volumetric/SCI indication
3. 1996 Installed Sleeve in Tube (TBD): possible multiple circumferential indications
4. 1992 Installed Sleeve in Tube R5 C48: a possible single circumferential indication
5. 1992 Installed Sleeve in Tube R9 C57: a possible single circumferential indication
6. 1994 Installed Sleeve in Tube R7 C52: possible multiple circumferential indications

## III. PRE-REMOVAL TASKS AND FIELD EXAMINATION

ABB-CENO will ensure that all samples will have been in-generator straight beam ultrasonically and visually tested during the present outage in accordance with the approved sleeving installation procedures. During the VT operation, orientation of the weld tailoff will be established with relation to the divider plate.

Rockridge will perform the in- and ex-generator Plus Point ECT examination. During the in-generator ECT, orientation of the signals within the tube will be made by placing a magnet in an adjacent tube.

Frametome will perform the sleeve removal process and the in-generator ultrasonic examination.

## IV. LABORATORY TASKS

Once the assemblies have been received at the ABB-CENO laboratory in Windsor, Connecticut, the following NDE and destructive examinations will be performed in accordance with the logic diagram shown in the Figure 2.

**Non-Destructive Examination**

1. A 0° mark will be placed on each sample at the location of the weld tail off from which all NDE and destructive examination orientation descriptions will be made.

2. Any loose deposits will be collected from the tube O.D. surface. Macro-visual examination and photography will be performed of the tube expansion area at 1-20x.

3. Using a magnetic marker or similar method, the samples will be Plus Point ECT'd to establish the azimuthal orientation of any specific indications.

4 Using an O.D. coil, the samples will be magnetically saturated and re-ECT'd using the Plus Point coil.

6. The tube diameter profile will be measured along its length.

7. Silastic molds will be made of the sleeve I.D. in the weld/expansion region to replicate and measure their profiles.

8. Radiography of sample welds or preproduction samples will be attempted. Should this approach prove to be acceptable each sample will be similarly examined.

9. A shear wave UT will be performed on the welds/tubes in the steam generator, should this prove to be beneficial an additional test will be performed in the laboratory.

**Destructive Examination**

Based on the consensus that the indications are circumferentialy oriented, the following steps will be taken to characterize the ECT indications. Prior to cutting, a detailed sectioning diagram will be submitted to NSP for approval. Unless subsequent data suggests otherwise, the sectioning of the preproduction samples and the newly installed sleeve will be performed first followed by each of the in-service sleeves as determined by data obtained to that point.

1. The samples will be first cut axially such that one cut surface is adjacent to the maximum signal shown on the ECT terrain map.

2. Any loose I.D. deposit will be collected. A macro (10-20x) visual exam will be performed on the sleeve/weld I.D. and the surfaces photographed.

3. In the case of the preproduction and newly installed sleeves only, the I.D. and O.D. surfaces will be fluorescent penetrant tested. Penetrant testing will not be performed on the in-service sleeve samples.

4. The sample edges will be polished and examined metallographically in the unetched condition. In the absence of any defect, the samples will be incrementally ground in the circumferential direction until a defect is discovered.

5. Depending on the location and orientation of defects that may be uncovered by the incremental grinding, the tube, sleeve, or weld would be cut away and sections bent to observe the surface from which the defects originate. Additional grinds would be made to reveal the extent of internal defects.

6.. Upon opening the tube/sleeve annulus, the surfaces of interest will be macro/micro examined and photographed using scanning electron as well as light microscopy, to determine the defect's morphology, size and frequency.

7. Any deposit associated with the defects will be analyzed using energy dispersive spectroscopy (EDS), electron spectroscopy for chemical analysis (ESCA) or other appropriate analysis technique.

8. Should the circumferential grinding fail to find any defects, half of the remaining 180° section of the sleeve/tube sample containing the ECT signal will be sectioned transversely to determine whether any defects are orientated in the axial direction.

   Unless required for this examination, the second sample half will be reserved for additional characterization of the defects, mechanical testing if required, and any further deposit analysis.

**Quality Assurance**

Laboratory examinations shall be performed in accordance with ABB Combustion Engineering Nuclear Operation Quality Program as a Class 1 Safety Related program.

**Deliverables**

A interim progress report will be provided to NSP two (2) weeks following receipt of the subject samples.

A report describing the results of the examination and effect on the status of the Prairie Island steam generator welded sleeves will be provided to NSP within six (6) weeks of receipt of the samples.

FIGURE 2
PRAIRIE ISLAND SLEEVE SAMPLE EXAMINATION
LOGIC NETWORK

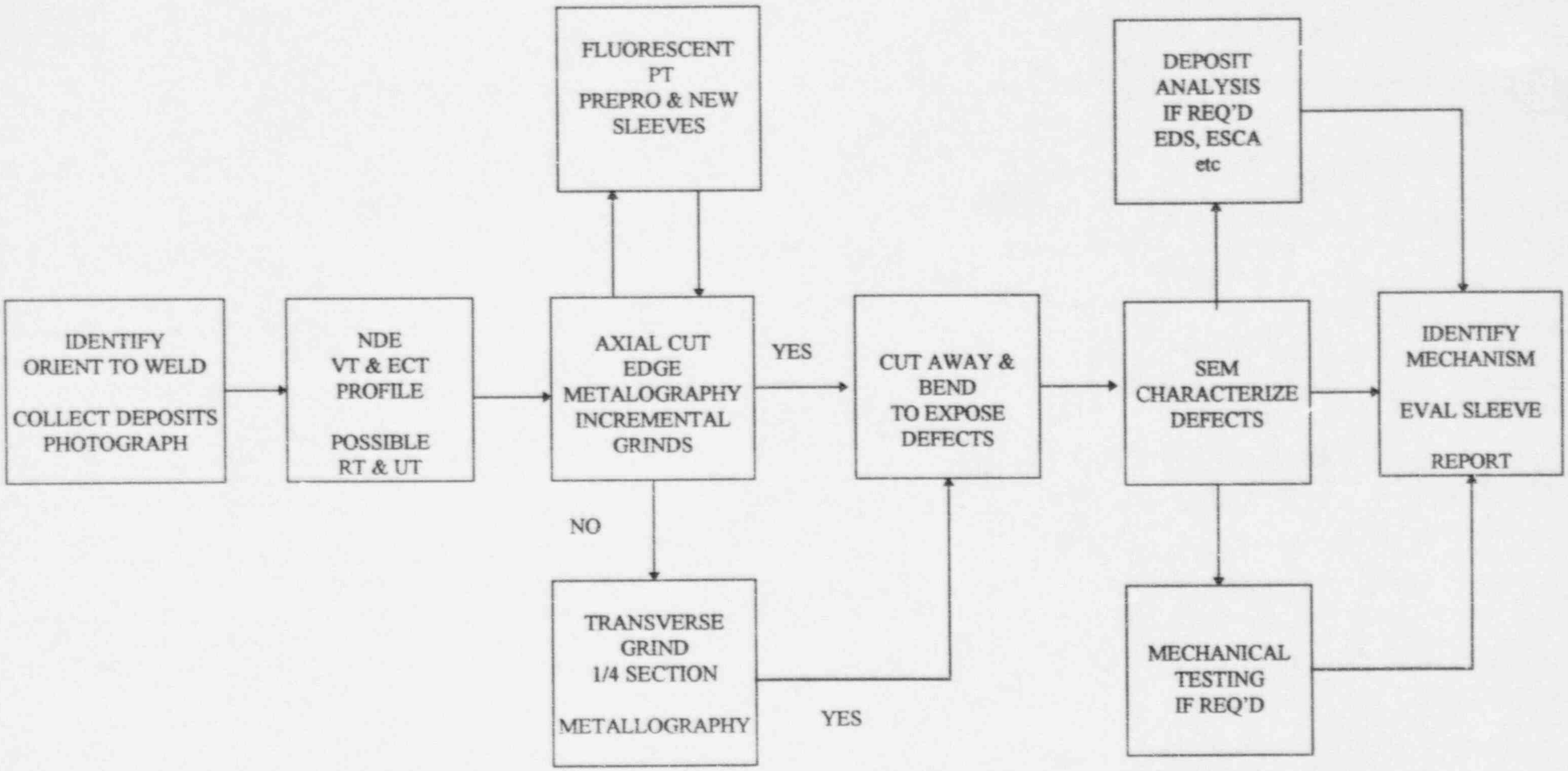
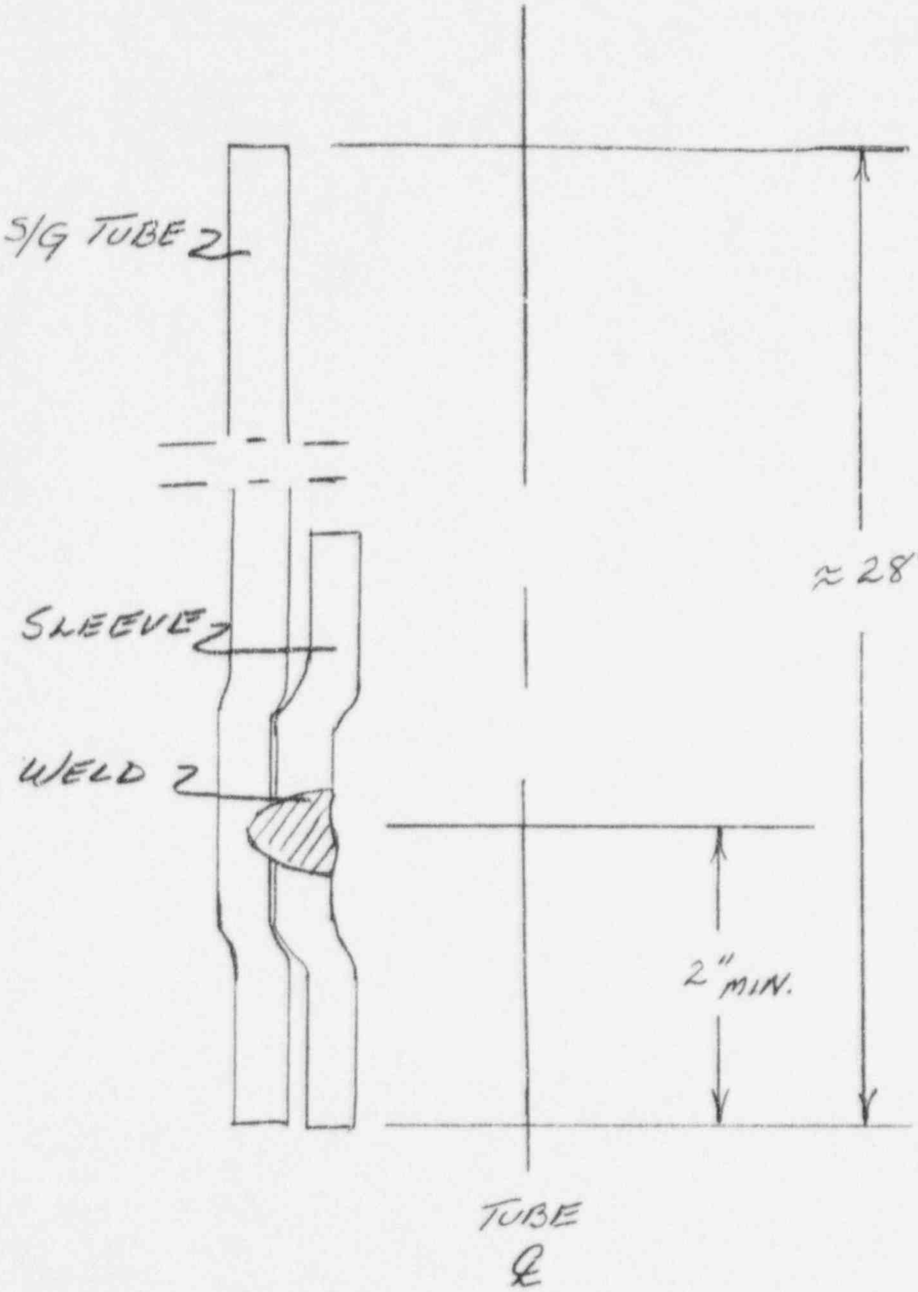


FIGURE 1

REMOVED STEAM GENERATOR
TUBE-SLEEVE
SAMPLE




NOT TO SCALE

# ATTACHMENT 7

Plugging Criteria for Eddy Current Indications at the Upper Weld in Combustion Engineering Welded Tubesheet Sleeves

# Prairie Island Nuclear Generating Plant
# Plugging Criteria for Eddy Current Indications at the Upper Weld in Combustion Engineering Welded Tubesheet Sleeves

During the Unit 1 9601 steam generator inspection, both in-service and baseline eddy current examinations of all the sleeves in 12 steam generator (there are none in 11 steam generator) were done using rotating coil eddy current technology which included the +Point™ coil. Both circumferential and volumetric indications were identified at the upper sleeve weld region. Ten sleeves which had passed installation inspection acceptance criteria contained circumferential eddy current indications. Fifty one sleeves contained volumetric indications.

Plugging criteria were established for upper weld eddy current indications using input from all of the available examination techniques. The flow path for these determinations is shown in the attached "Prairie Island Upper Sleeve Weld Plugging Criteria." Since an advanced ultrasonic examination system was mobilized for tube sample removal, the tubes with volumetric indications were examined using this system, also. The entire acceptance process is described below.

1. Visual examination of the upper sleeve weld:

   Visual examination of the weld surface interior diameter is done by Combustion Engineering after completion of the weld and before ultrasonic testing in accordance with the sleeve installation procedures.[1] The weld is considered visually acceptable if it is found to be free of imperfections that could be detrimental to the integrity of the weld. Detrimental imperfections are blow holes at the lower edge of upper welds, blow holes extending through the sleeve into the tube, porosity, incomplete or partial welds, and lack of fusion. Nondetrimental qualities are weld roughness, down slope weld tail, and weld ripple.

2. Installation ultrasonic examination of the sleeve weld (Combustion Engineering zero degree).

   The weld shall be considered to have acceptable fusion of the weld for 360 degrees at any single elevation, or any combination of elevation positions. A continuous indication of lack of fusion across the entire width of the weld (i.e., a leak path) shall be cause for rejection.

3. Eddy current examination using rotating coil technology such as +Point™ coils and pancake coils both with and without magnetic biasing.

   The initial eddy current examination used unbiased +Point ™ coils. If an eddy current indication was found, it was classified as a Sleeve Weld Indication and required further examination by magnetically biased rotating +Point™ and pancake coils

   Initial +Point™ calls shall be examined by magnetic biased +Point™ coils. Any indications which remain and are crack like are unacceptable. This includes single and multiple axial and circumferential indications.

   Any Sleeve Weld Indications which remain in the magnetically biased +Point™ data and are volumetric require disposition. Those volumetric indications which are in the lower half of the weld region are unacceptable. Those indications which are at the top of the weld are acceptable. Even though indications at the top of the weld may proceed into the weld (possibly to the centerline), the leaktightness criteria and minimum average weld height are still met (determined by UT as discussed in Items 2 and 7). The eddy current signatures of the pre-production samples (see Attachment 9) 2B (volumetric) and 13B (blow hole) were used to evaluate the sleeve weld indications.

4. Eddy Current Examination using bobbin coil probe:

Welds are considered defective if an indication is greater than 40% through wall. (Bobbin coil data is not normally taken when rotating coil probes are used, but was done this outage for all of the volumetric indications).

5. Advanced Ultrasonic Examination by Framatome Technologies (FTI).

The advanced ultrasonic examination of 12 Steam Generator sleeve weld volumetric indications was done using a 3 channel probe head which contains an axially aimed transducer for circumferential indications, a circumferentially aimed transducer for detection of axial indications and a zero degree beam for inside diameter profiling and wall thickness. The UT-360 System configured for zero degree is typically accurate to .001 inch (depth) and .010 inch (length) for volumetric indications. The zero degree data was responsible for detection and identification of ID surface anomalies such as blow holes, weld droop, suck back, and general wall thickness measurements for the sleeve and weld zone. Applications for shear wave mode include the detection of axial cracks, circumferential cracks, stress corrosion cracking (i.e., planar type indications) and volumetric type indications with sharp edges. The advanced UT was valuable in defining indications at the top of the weld and in confirming eddy current indications. In addition, where evaluated, the depth of the indication by ultrasonic examination needed to be less than about 30% through wall. The more conservative of the UT and eddy current evaluations was used for plugging decisions when there was not agreement.

6. Final Decision:

After considering all of the input data, the eddy current indications were used to make a final assessment for leaving volumetric indications in service.

7. Average Sleeve Weld Height:

Sleeve weld height was evaluated from the Combustion Engineering ultrasonic examination (performed earlier as Item 2 for each volumetric indication to be left in service. Each weld with a volumetric indication had at least an average of 0.080 in. of weld height (see Page 5 for a tabulation of the measured average weld heights for the 51 welds with volumetric indications) which is the basic height used for analysis in the sleeve licensing report.

Conclusion:

Volumetric indications left in service were acceptable by visual examination, installation UT, bobbin coil, physical location at upper weld edge by ET, and less than 0.013 inches wall loss by UT-360 measurements. In addition, all welds left in service with volumetric indications had an average measured weld height of 0.090 in. or greater which meets the structural analysis (by a factor of 4) for the CE welded tubesheet sleeve pull out forces. [2]

NOTES:

1. Additional Information on the Combustion Engineering Ultrasonic Examination:

The Combustion Engineering ultrasonic examination is designed to determine the presence of weld fusion between the sleeve and tube. However, the UT data also provides information about the height of the sleeve weld at the sleeve tube interface. The sleeve weld UT examination uses a transducer beam width of 0.03 to 0.035 inches at the inside diameter of the sleeve. Data is taken every 1 to 2 degrees in a complete 360 degree circumferential scan. Then the transducer is moved up 0.020 inch

and the circumferential scan repeated. The ultrasonic signal locates the back wall of the sleeve. The weld is identified when the sleeve back wall signal is lost. The scan is conducted over the height of the weld so that the weld boundaries are detected as well as the leak tightness of the weld. Because the transducer continues to see the back wall of the sleeve when it is partially over the weld, the actual weld height will be greater than the measured weld height by zero to one beam diameters. The UT examination system calibration is performed prior to and at the completion of examinations. In addition, calibration checks are performed on the entire system at least every 12 hours.

A small comparison of field UT data to metallurgical data has been done. The exact location of the transducer could not be correlated to the metallurgical sectioning, but the capabilities can be assessed (See Attachment 9 for radiographs of the below mentioned samples).

- Sample 2B: UT height was 0.12 to 0.16 inches. The metallurgical heights were 0.13 inches and 0.16 inches.
- Sample 13B: UT height was 0.14 inches to 0.18 inches. The metallurgical heights were 0.15 inches and 0.18 inches.

The axial indexing of the UT probe is accurate to ± 0.005 inches. The fact that the probe moves is verified by the distance encoder readout and by observing markings on the UT probe shaft.

2. Location of Indication by Eddy Current:

A volumetric weld defect, such as the weld suck back in preproduction sample 2B, will be seen by the rotating coil over several helical scans of the coil. This tends to smear the volumetric indication and cause it to show up on several scans into the upper part of the weld. Judgment of the analyst when evaluating the steam generator data is aided by comparison to the known sample. In addition, there are cases where a volumetric defect will extend into the top of the weld. This is illustrated by the attached ultrasonic examination data for R8C48 which has a "lack of fusion" protruding into the top of the weld. This weld is acceptable since the average weld height is 0.11 inches and there is a continuous band of fusion completely around the sleeve.

3. Licensing Basis:

The licensing basis for the Combustion Engineering welded tubesheet sleeve upper weld specifies an average weld height of 0.080 inches and leak tightness of the weld. There is no requirement to measure the weld height which is controlled by process parameters.

> "...the minimum average height of the weld is 0.080 inches at the sleeve-tube interface." [3]

The reason 0.080 was selected for analysis was that it was close to the actual height of the welds being produced. However, there is no requirement in the licensing report to actually measure this weld height.

Structural requirements have been reviewed by Combustion Engineering and it is shown that the minimum height needed for structural integrity both from design and Regulatory Guide 1.121 is 0.027 inches. Thus there is a wide margin for safety in the weld height.

Leak tightness of the weld is determined form ultrasonic examination.

> "A minimum of three scans are performed and if one or more of these scans shows fusion for the whole 360 degrees, the weld is considered acceptable." [4]

Because of the eddy current volumetric indications, average weld heights were evaluated from the

Combustion Engineering ultrasonic examination to ensure that structural integrity requirements were met. The minimum average weld height was 0.090 inches which together with the ±0.005 inch uncertainty establishes that the welds with volumetric indications left in service met the licensing basis.

[1] ABB Combustion Engineering Procedure STD-400-157 Rev. 0, Visual Examination of Steam Generator Tube Sleeve and Sleeve Plug Welds

[2] Prairie Island Steam Generator Tube Repair using Leak Tight Sleeves, ABB Combustion Engineering Re port CEN-294-P Revision 3-P, Section 8.2.1

[3] Combustion Engineering Report CEN-294-P, January 15, 1985 "Prairie Island Steam Generator Tube Repair Using Leak Tight Sleeves", Section 4.3

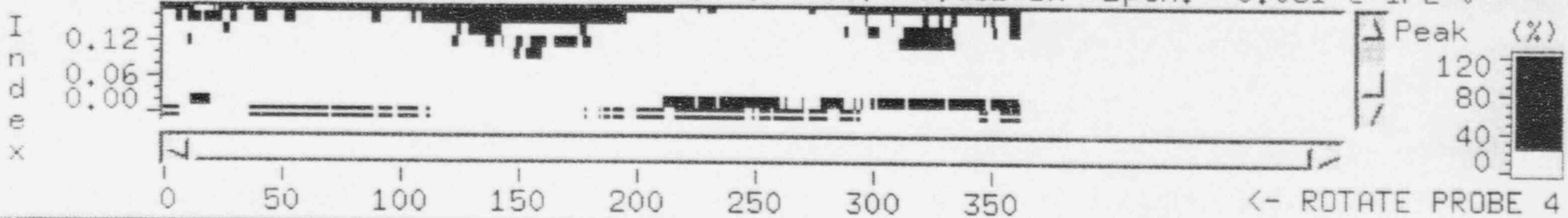
[4] Combustion Engineering Report CEN-294-P, January 15, 1985 "Prairie Island Steam Generator Tube Repair Using Leak Tight Sleeves", Section 5.1.1

| Prairie Island 12 SG Volumetric Sleeve Indications | | | | | |
|---|---|---|---|---|---|
| ROW | COL | Weld Height | Plugged? | # of Welds | Installed |
| 9 | 59 | 0.16 | Plugged | 1 | 8704 |
| 15 | 50 | 0.10 | Plugged | 1 | 9405 |
| 17 | 23 | 0.09 | Plugged | 1 | 9601 |
| 3 | 40 | 0.11 | Plugged | 1 | 9601 |
| 6 | 53 | 0.11 | Plugged | 2 | 9601 |
| 16 | 28 | 0.14 | Plugged | 1 | 9601 |
| 5 | 36 | 0.14 | Plugged | 2 | 9601 |
| 6 | 20 | 0.15 | Plugged | 2 | 9601 |
| 7 | 82 | 0.15 | Plugged | 1 | 9601 |
| 20 | 40 | 0.16 | Plugged | 1 | 9601 |
| 17 | 36 | 0.17 | Plugged | 2 | 9601 |
| 9 | 20 | 0.19 | Plugged | 1 | 9601 |
| 13 | 32 | 0.19 | Plugged | 1 | 9601 |
| 12 | 49 | 0.20 | Plugged | 2 | 9601 |
| 7 | 63 | 0.12 | Removed | 1 | 9210 |
| 8 | 57 | 0.09 | | 1 | 8704 |
| 23 | 67 | 0.09 | | 1 | 8704 |
| 8 | 48 | 0.11 | | 1 | 8704 |
| 3 | 56 | 0.22 | | 2 | 8704 |
| 8 | 41 | 0.09 | | 1 | 9210 |
| 4 | 43 | 0.10 | | 1 | 9210 |
| 10 | 41 | 0.12 | | 1 | 9210 |
| 16 | 43 | 0.12 | | 1 | 9210 |
| 16 | 64 | 0.12 | | 1 | 9210 |
| 3 | 36 | 0.13 | | 1 | 9210 |
| 10 | 43 | 0.13 | | 1 | 9210 |
| 4 | 47 | 0.13 | | 1 | 9210 |
| 3 | 41 | 0.15 | | 1 | 9210 |
| 14 | 50 | 0.15 | | 2 | 9210 |
| 21 | 51 | 0.15 | | 1 | 9210 |
| 3 | 11 | 0.16 | | 1 | 9210 |
| 8 | 16 | 0.22 | | 1 | 9210 |
| 7 | 65 | 0.10 | | 1 | 9405 |
| 6 | 39 | 0.11 | | 1 | 9405 |
| 13 | 40 | 0.11 | | 2 | 9405 |
| 6 | 66 | 0.11 | | 1 | 9405 |
| 3 | 44 | 0.12 | | 1 | 9405 |
| 17 | 65 | 0.14 | | 1 | 9405 |
| 3 | 46 | 0.09 | | 1 | 9601 |
| 17 | 31 | 0.10 | | 1 | 9601 |
| 7 | 68 | 0.10 | | 1 | 9601 |
| 17 | 18 | 0.12 | | 1 | 9601 |
| 12 | 55 | 0.12 | | 1 | 9601 |
| 7 | 61 | 0.12 | | 1 | 9601 |
| 4 | 75 | 0.12 | | 1 | 9601 |
| 25 | 16 | 0.13 | | 1 | 9601 |
| 23 | 41 | 0.13 | | 1 | 9601 |
| 6 | 55 | 0.13 | | 1 | 9601 |
| 17 | 22 | 0.14 | | 1 | 9601 |
| 5 | 80 | 0.14 | | 1 | 9601 |
| 19 | 25 | 0.15 | | 1 | 9601 |
| Total | 51 | | | | |

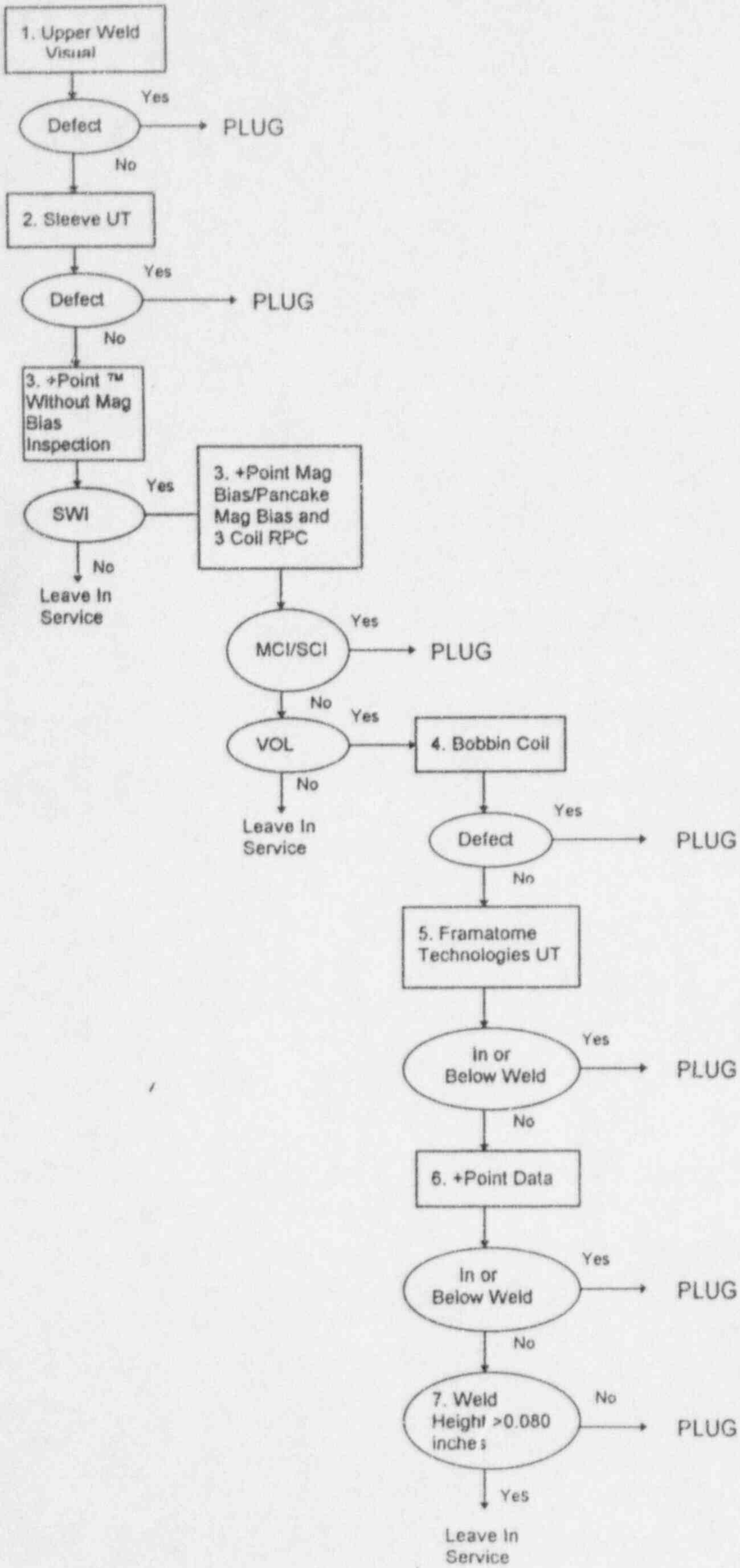
File Channel Gate C-Scan B-Scan A-Scan Tools Settings Help

File: r8c48old Exam Date: 02/04/96 Time: 12:58 - 13:01
Channel: 1 Gate: SW 1 Mode: Max Video Mode: Off Video Filter: 2
Gain: 71.0 dB Dac: OFF Offset: 0.0 db Pulser Voltage: 400
Pulse Width: 80 Pulser Type: Sq. Wave Damping: 100 Filters LP: 5 HP: 2.0
Adly: 0.00 us Awdth: 3.00 us Cdly: 0.40 us Cwdth: 0.18 us Cthrsh: 20.0%
Compression: OFF Thresh: 19% I-Gate: ON AD Rate: 100 Msps
Transducer Ang: 0.00 deg Freq: 15.00 MHz Skew Ang: 0.00 deg S/N: K71802
Operator: MJD
Component: Steam Generator Sleeved Tube Ser No: N/a
Scan Axis: ROTATE PROBE 4 From: 0.000 To: 362.000 Intv: 1.000 Offset: 0
Index Axis: Index From: 0.000 To: 0.300 Intv: 0.020 Offset: 0.00
This Weld has been: ______Accepted ______Rejected
..................................MJ Dashukewich UT Level III

ROTATE PROBE 4: 0.000, Index: 0.000
AMP: 61% TOF: 0.530 us dB: 3.7 MP: 0.061 in Dpth: 0.061 @ 1/2 V



# PRAIRIE ISLAND UPPER SLEEVE WELD PLUGGING CRITERIA



ATTACHMENT 8

2 Letters from Asea Brown Boveri Inc. to Richard Pearson (NSP) Regarding the Minimum Weld Height

ABB

Mr. Richard Pearson
Prairie Island Nuclear Power Plant
1717 Wakonade Drive
Welch, MN 55089

February 23, 1996

Dear Mr. Pearson,

CE has reviewed the Prairie Island sleeve licensing report with regard to sizing requirements for the upper tube weld. The licensing report indicates significant margins available in the calculations using the upper weld length = .080".

The attached calculations determine the required length of the upper weld for DESIGN and FAULTED conditions. The required length is shown to be .019" for design conditions and .013" for faulted conditions. These required sizes satisfy the ASME Code requirements. In addition the ASME Code requires a minimum weld size of 2/3 t in the qualification requirements for similar type welds. In this case 2/3t = .027" would be a conservative limit.

Sincerely,

W. R. [signature]
for Dave Stepnick
Mgr, Primary Side Repair

w/ attachment
WO96034.DS

Combustion Engineering Nuclear Operations

Combustion Engineering, Inc
P.O. Box 500
1000 Prospect Hill Road
Windsor, CT 06095-0500
Telephone (203) 285-2841
Fax (203) 285-9530

Attachment to W096034.DS

UPPER TUBE WELD REQUIRED THICKNESS

<u>Design Condition</u>

Allowable Shear Stress $S_{allow} = .6\,(S_m) = .6\,(26.6) = 16$ ksi

Design Pressure Load $P_D = 1600\,Pi\,R^2 = 1600\,(PI)\,(.3875)^2 = .755$ kips

Req'd Weld Shear Area $A_S = P_D / S_{allow} = .047\ in^2$

Req'd Weld Thickness. $tw_{Req} = A_S / 2\,PiR_W = \underline{.019\ in}$

<u>Faulted Condition (Main Steam Line Break)</u>

Allowable Shear Stress $S_{allow} = .6\,(.7\,S_U) = 33.6$ ksi

Main Steam Line Break Load $P_{MSLB} = P_{PRI}\,(Pi\,R^2) = (2235)\,Pi\,(.3875)^2$

$= 1.054$ kips

Required Weld Shear Area $A_S = P_{MSLB} / S_{allow} = .031\ in^2$

Required Weld Thickness $tw_{Req} = A_S / 2PiR_W = \underline{.013\ in}$

ASEA BROWN BOVERI

February 26, 1996

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

Subject: Minimum Sleeve Weld Height

Reference: ABB Letter WO96034.DS, D. G. Stepnick to R. Pearson, February 23, 1996.

Dear Mr. Pearson:

With regards to the question posed by the NRC during our call last Friday concerning sizing of the subject weld in accordance with the requirements of Regulatory Guide 1.121 we offer the following explanation.

The upper tube weld required thickness calculations contained in the referenced letter are in accordance with the ASME Code and are consistent with the requirements of Reg. Guide 1.121.

In the calculation for design conditions the allowable stress is based on the design stress intensity, Sm which is 1/3 of the ultimate strength, Su. The calculation is equivalent to using a pressure load of 3 times the normal pressure and an allowable stress Su. This margin is consistent with the margin required by Reg. Guide 1.121. Since Sm = 2/3 Sy the calculation using Sm will also satisfy the yield requirement of the Reg. Guide.

The ASME Code allowables used in the calculation for main steam line break provide the same margin of safety required by Reg. Guide 1.121 for faulted conditions.

If you have any further questions with respect to this matter please do not hesitate to call me.

Sincerely,

David Stepnick

David G. Stepnick
Mgr. Primary Side Repair

xc: W. Gahwiller
P. Anderson

WO96036.DS

Asea Brown Boveri Inc.

1000 Prospect Hill Road
Post Office Box 500
Windsor, Connecticut 06095-0500

Telephone:
(203) 688-1911

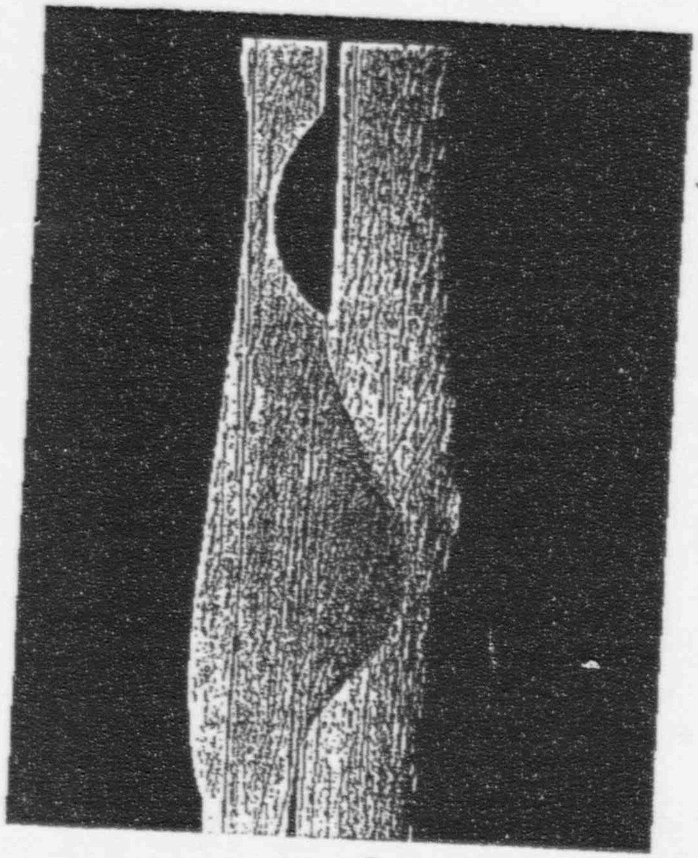
Telex:
90297

# ATTACHMENT 9

Radiographs of Preproduction Samples 2B and 13B

PREPRO SAMPLE 2B (PI 2A)

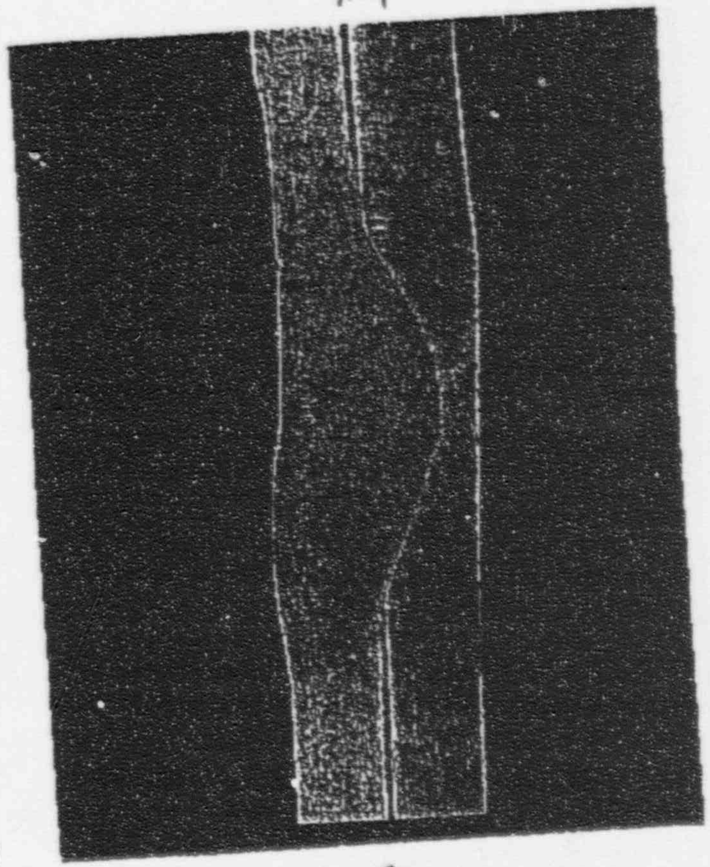
TOP



270°

Location of ET Val

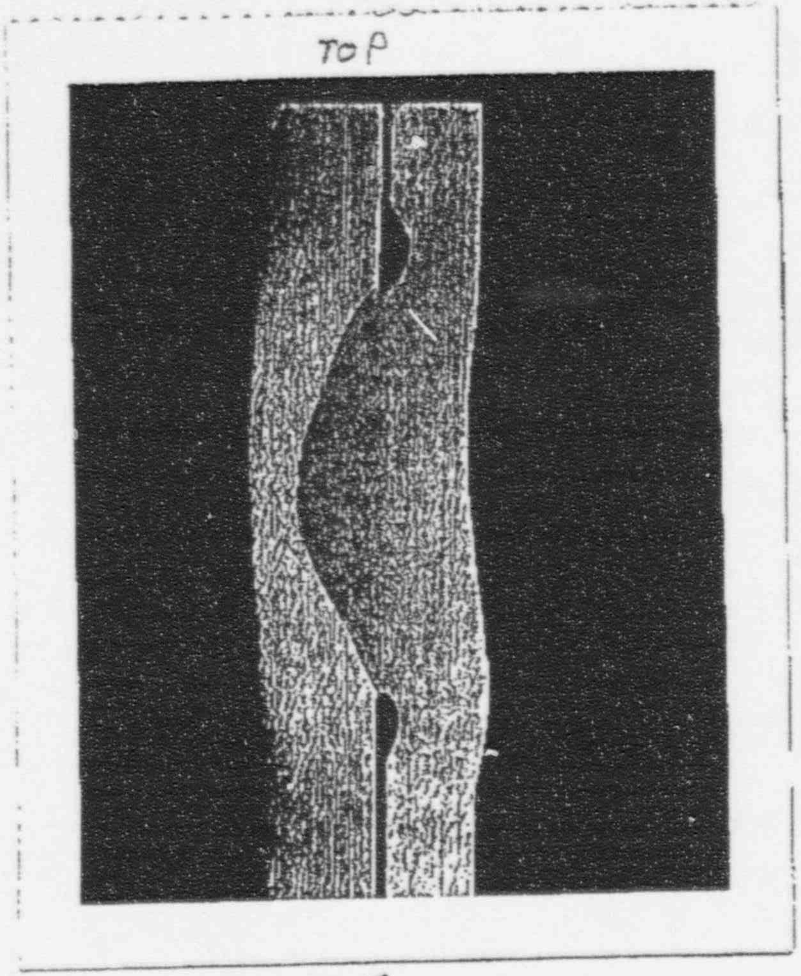
TOP



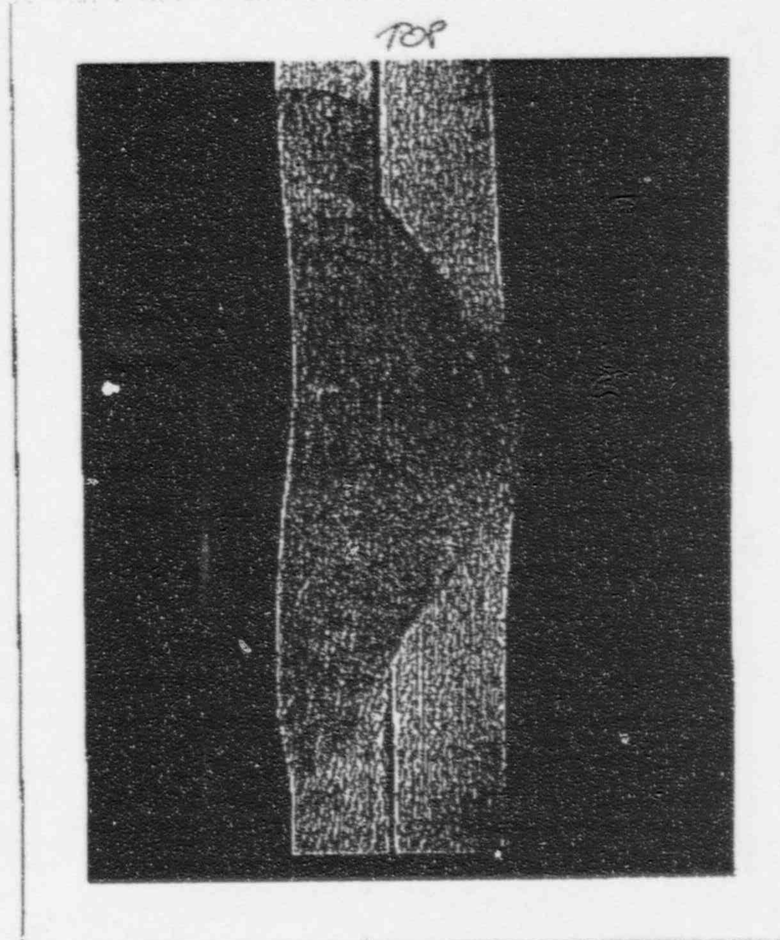
90°

13.5X

PREPRO SAMPLE 13B




90°




270°
(EDGE NEAR THE BLOW HOLE)

13.5X

No loss in [illegible]

Trouble shoot [illegible]