Public Service
Electric and Gas
Company

Steven E. Miltenberger
Vice President -
Nuclear Operations

Public Service Electric and Gas Company P.O. Box 236, Hancocks Bridge, NJ 08038 609 339-4199

March 28, 1988
NLR-N88045

Mr. W. T. Russell, Administrator
United States Nuclear Regulatory Commission
Region I
475 Allendale Road
King of Prussia, PA 19406

Gentlemen:

RESPONSE TO NRC BULLETIN 88-02
SALEM GENERATING STATION
UNIT NOS. 1 AND 2
DOCKET NOS. 50-272, 50-311

Public Service Electric and Gas Company (PSE&G) has received the subject NRC Bulletin regarding the potential for rapidly propogating fatigue cracks in steam generator tubes such as that which occurred at North Anna Unit 1 on July 15, 1987. The information requested by this bulletin as related to the Salem Generating Station is provided in the enclosure to this letter.

Should you have any questions with regard to this transmittal, please do not hesitate to contact us.

Sincerely,

Steven E Miltenberger

Enclosure

IE11 1/1

C Mr. D. C. Fischer
USNRC Licensing Project Manager

Mr. R. W. Borchardt
USNRC Senior Resident Inspector

Mr. W. T. Russell, Administrator
USNRC Region I

Mr. D. M. Scott, Chief
Bureau of Nuclear Engineering
Department of Environmental Protection
380 Scotch Road
Trenton, NJ 08628

USNRC
Document Control Desk
Washington, DC 20555

Ref: RESPONSE TO NRC BULLETIN 88-02

STATE OF NEW JERSEY)
) SS.
COUNTY OF SALEM)

Steven E. Miltenberger, being duly sworn according to law deposes and says:

I am Vice President and Chief Nuclear Officer of Public Service Electric and Gas Company, and as such, I find the matters set forth in our letter dated March 28, 1988 , concerning our response to NRC Bulletin 88-02, are true to the best of my knowledge, information and belief.

Steven E Miltenberger

Subscribed and Sworn to before me
this 28th day of March, 1988

Eileen M. Ochs
Notary Public of New Jersey

My Commission expires on EILEEN M. OCHS
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires July 16, 1992

ENCLOSURE

RESPONSE TO NRC BULLETIN 88-02
SALEM GENERATING STATION, UNIT NOS. 1 AND 2
DOCKET NOS. 50-272 AND 50-311

The responses to each of the questions presented in NRC Bulletin 88-02, Rapidly Propogating Fatigue Cracks in Steam Generator Tubes, regarding the implementation of actions to minimize the potential for a steam generator tube rupture such as that which occurred at North Anna Unit 1 on July 15, 1987, are presented below.

A. The most recent steam generator inspection data should be reviewed for evidence of denting at the uppermost tube support plate. Inspection records may be considered adequate for this purpose if at least 3% of the total steam generator tube population was inspected at the uppermost support plate during the last 40 calendar months. "Denting" should be considered to include evidence of upper support plate corrosion and the presence of magnetite in the tube-to-support plate crevices, regardless of whether there is detectable distortion of the tubes. The results of this review shall be included as part of the initial Bulletin response. Where inspection records are not adequate for this purpose, inspections of at least 3% of the total steam generator tube population at the uppermost support elevation should be performed at the next refueling outage. The schedule for these inspections shall be included as part of the initial Bulletin response and the results of the inspection shall be submitted within 45 days of their completion. Pending completion of these inspections, an enhanced primary-to-secondary leak rate monitoring program should be implemented in accordance with paragraph C.1.

RESPONSE

The most recent steam generator inspection data for Salem Units 1 and 2 were reviewed for evidence of denting at the uppermost tube support plate. Attached to this response are maps, generated by Westinghouse, showing the locations of magnatite build up or dents at the uppermost tube support plate for Steam Generator Nos. 12, 13 & 14 of Salem Unit 1 and Steam Generator Nos. 21, 23 & 24 of Salem Unit 2.

Dented tubes with deformation (dent signal > 3V) were determined from Eddy Current (EC) evaluation of tubes at the top tube support plate. The NRC definition of "denting" as provided in Bulletin 88-02 was used for determining denting of tubes which were not supported by Anti-Vibration Bars (AVBs). Since the North Anna Unit 1 scenario is limited to tubes not supported by AVBs in rows 9 through 12, the denting information provided in the maps is limited to the tubes in rows 8 through 12 only.

Mapping of Steam Generator No. 11 of Salem Unit 1 was not performed as the pre-service baseline EC tapes were single frequency and judged not adequate for identification of dent locations. At the next refueling outage on Salem Unit 1, Steam Generator No. 11 will be EC inspected to determine denting at the uppermost tube support plate locations. PSE&G anticipates that the results of this inspection will be similar to those of the other three steam generators as Steam Generator No. 11 has historically been the best performer of the four Unit 1 steam generators in terms of EC inspection results. Also, the mapping of dent locations for Steam Generator No. 22 is not included due to noise present in the EC data making interpretation difficult. This steam generator will be EC inspected at the next scheduled refueling outage for Salem Unit 2.

The Westinghouse maps showing locations of denting were generated from the latest EC data available. Eddy current data on Steam Generator Nos. 12 and 14 and Steam Generator Nos. 21 and 23 do not meet the 40 calendar month data requirement stated in NRC Bulletin 88-02. However, efforts are underway to define the need for and scope of future eddy current examinations. Future EC inspection to determine denting will be limited to tubes where analysis demonstrates that the tube is susceptible to the failure mode addressed by this bulletin and other corrective action (e.g. plugging) is not taken.

An enhanced primary to secondary leak rate monitoring program is in place and being implemented at both Salem Units. Details of this monitoring program are discussed later in this Bulletin response.

B. For plants where no denting is found at the uppermost tube support plate, the results of future steam generator tube inspections should be reviewed for evidence of denting at the uppermost support plate. If denting is found in the future, the provisions of Item C below should be implemented. Commitments to implement these actions shall be submitted when the results of A above are submitted.

RESPONSE

Both Salem units exhibit some denting at the uppermost tube support plate. As such, the provisions of Item C of the Bulletin are being addressed.

C. For plants where denting is found, the NRC staff requests that the following actions be taken:

1. Pending completion of the NRC staff review and approval of the program described in C.2 below or completion of inspections specified in item A above to confirm that denting does not exist, an enhanced primary-to-secondary leak rate monitoring program should be implemented as an interim compensatory measure within 45 days of the date

of receipt of this bulletin.* Implementation of this program shall be documented as part of the initial Bulletin response. The enhanced monitoring program is intended to ensure that if a rapidly propagating fatigue crack occurs under flow-induced vibration, the plant power level would be reduced to 50% power or less at least 5 hours before a tube rupture was predicted to occur. The effectiveness of this program should be evaluated against the assumed time-dependent leakage curve given in Figure 1 of the Bulletin.

This program should consider and provide the necessary leakage measurement and trending methods, time intervals between measurements, alarms and alarm setpoints, intermediate actions based on leak rates or receipt of alarms, administrative limits for commencing plant shutdown, and time limitations for (1) reducing power to less than 50% and (2) shutting down to cold shutdown. Appropriate allowances for instrument errors should be considered. Finally, the program should make provision for out of service radiation monitors, including action statements and compensatory measures.

*While this bulletin was being prepared, licenses for a few plants (including Salem Unit 1) committed to an enhanced primary-to-secondary leak rate monitoring program at the staff's request. These plants had been identified on a preliminary basis by Westinghouse as being potentially susceptible to rapidly propagating fatigue cracks. These enhanced programs should be upgraded as necessary to comply with this paragraph. However, no relaxation from current commitments should be made without prior approval by the NRC staff.

RESPONSE

An enhanced primary to secondary leakage rate monitoring program is in place and being implemented at both Salem Units. This program involves close scrutiny of both on-line radiation monitors and radiochemistry results and has proven its capability to detect and trend low levels of primary to secondary leakage. This program was presented to the NRC staff in a meeting on November 24, 1987 in Bethesda, MD and was committed to in our letter dated December 16, 1987 in response to a verbal NRC staff request. This program is similar to the leakage rate monitoring program suggested in the Bulletin with one exception. Instead of providing a specific directive to reduce power to 50% as a function of predetermined leak rate value, the Salem program commits to make a management decision when a projected leak rate exceeds 288 gallons per day (gpd).

This is, in fact, an improvement over the leakage rate monitoring program suggested in the Bulletin because a decision to reduce power will be called for based on a leakage rate projection rather than a measured leakage rate.

The Salem enhanced primary to secondary leakage rate monitoring program is briefly summarized below.

If the primary to secondary steam generator leakage rate reaches 42 gpd (0.03 gpm), the leakage rate will be calculated and graphically recorded with a 24-hour projection. This will be done once every 8 hours. The Air Ejector and Steam Generator Blowdown Radiation Monitors will be checked every two hours. If any of these instruments indicates a rapidly increasing leak, a leak rate calculation together with a 24-hour projection will be performed at that time. Upon reaching the 42 gpd (0.03 gpm) level, the Senior Shift Supervisor and the Operations Manager will be immediately notified.

If the 24-hour projections indicate that a 288 gpd (0.2 gpm) leakage rate will be reached, the personnel indicated above and the Station General Manager will be notified immediately. Two additional primary to secondary leakage rate calculations will be performed along with Air Ejector Monitor and Steam Generator Blowdown Monitor readings. If the above three 24-hour projections indicate that 288 gpd would be reached, station management will review the need for a power reduction or shutdown.

The detailed program is included in Salem Chemistry Procedure CH-3.3.018, "Detection and Determination of Primary to Secondary Leakage" and in Salem Radiation Protection Procedure RP-603, "Routine and Special RMS Monitoring." Provisions for out of service radiation monitors are followed in accordance with the Salem Units 1 and 2 Technical Specification requirements and the required preplanned alternate methods of monitoring required by the Technical Specifications are in place.

Training in the implementation of the enhanced leakage rate monitoring program has been provided to all appropriate personnel.

C.2 A program should be implemented to minimize the probability of a rapidly propagating fatigue failure such as that which occurred at North Anna Unit 1. The need for long-term corrective actions (e.g., preventive plugging and stabilization of potentially susceptible tubes, hardware, and/or operational changes to reduce stability ratios) and/or long-term compensatory measures (e.g., enhanced leak rate monitoring program) should be assessed and implemented as necessary. An appropriate program would include detailed analyses, as described in subparagraphs (a) and (b) below, to assess the potential for such a failure. Alternative approaches and/or compensatory measures implemented in lieu of the actions in subparagraphs (a) or (b) below should be justified.

Although the initial Bulletin response shall provide a clear indication of actions proposed, including their status and schedule, a detailed description of this program and the results of analyses shall be submitted subsequently, but early enough to permit NRC staff review and approval prior to the next scheduled restart from a refueling outage. Where the next such restart is scheduled to take place within 90 days, staff review and approval will not be necessary prior to restart from the current refueling outage. An acceptable schedule for submittal of the above information should be arranged with the NRC plant project manager by all licensees to ensure that the staff will have adequate time and resources to complete its review without adverse impact on the licensee's schedule for restart.

(a) The analysis would include an assessment of stability ratios (including flow peaking effects) for the most limiting tube locations to assess the potential for rapidly propagating fatigue cracks. This assessment would be conducted such that the stability ratios are directly comparable to that for the tube which ruptured at North Anna.

(b) The analysis would include an assessment of the depth of penetration of each AVB. The purpose of this assessment is twofold: (1) to establish which tubes are not effectively supported by AVBs and (2) to permit an assessment of flow peaking factors.

(NOTE: Most steam generators have at least two sets of AVBs. This applies only to the set that penetrates most deeply into the tube bundle). The methodology used to determine the depth of penetration of each <u>individual</u> AVB shall be described in the written report. The criteria for determining whether a tube is effectively supported by an AVB shall also be identified. (Note: An AVB that penetrates far enough to produce an eddy current signal in a given tube may not penetrate far enough to provide a fully effective lateral support to that tube).

RESPONSE

As presented below, Salem Generating Station intends to accomplish the program proposed by the Bulletin to minimize the probability of a rapidly propagating fatigue failure such as that which occurred at North Anna Unit 1.

The stability ratio assessment analysis as required by C.2(a) is expected to be completed in time for Salem Unit 2's next refueling outage scheduled to start in September 1988. Westinghouse has been authorized to perform the analysis for fatigue failure of the steam generator tubes due to vibration caused by fluid-elastic instability. This assessment will be conducted such that the stability ratios are directly comparable to that for the tube which ruptured at North Anna Unit 1. Necessary preventive plugging measures will be finalized when the detailed Westinghouse analysis performed in accordance with Item C.2(a) has been completed.

The assessment of depth of penetration for each AVB as required by C.2(b) has been completed for all the steam generators except Steam Generator No. 11 of Salem Unit 1 and Steam Generator No. 22 of Salem Unit 2. Steam Generator No. 11 will be EC inspected at the next Salem Unit 1 refueling outage, tentatively scheduled for April 1989, and the AVB depth penetration will be assessed at that time. AVB depth penetration for Steam Generator No. 22 could not be determined satisfactorily due to electronic noise present in the EC tapes. As noted previously, this steam generator will be EC inspected and evaluated at the next scheduled refueling outage for Salem Unit 2, tentatively scheduled for September 1988.

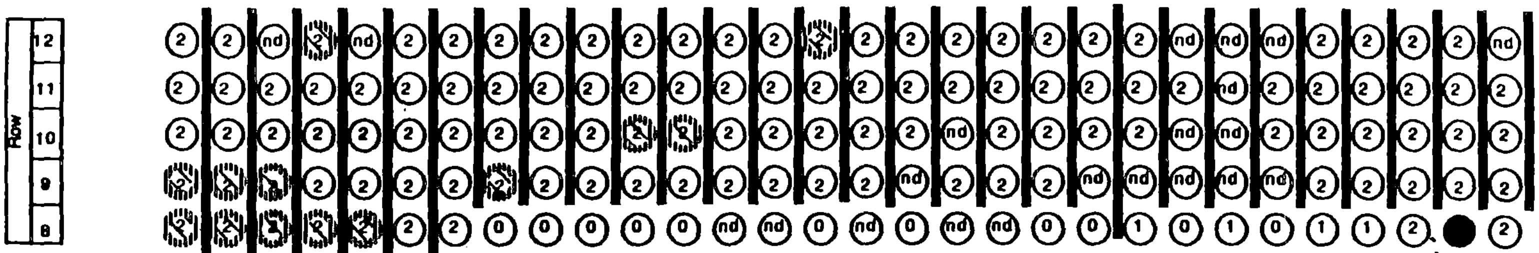
The Westinghouse maps in Attachment 1 provide the assessment of AVB penetrations for the Steam Generator Nos. 12, 13, 14, 21, 23 and 24. The methodology and criteria for determining the depth of penetration and the effectiveness in supporting the tube is provided in Attachment 2.

Attachment 3 identifies tubes in the steam generator which are not considered adequately supported and will be subject to the analyses discussed in C.2(a).

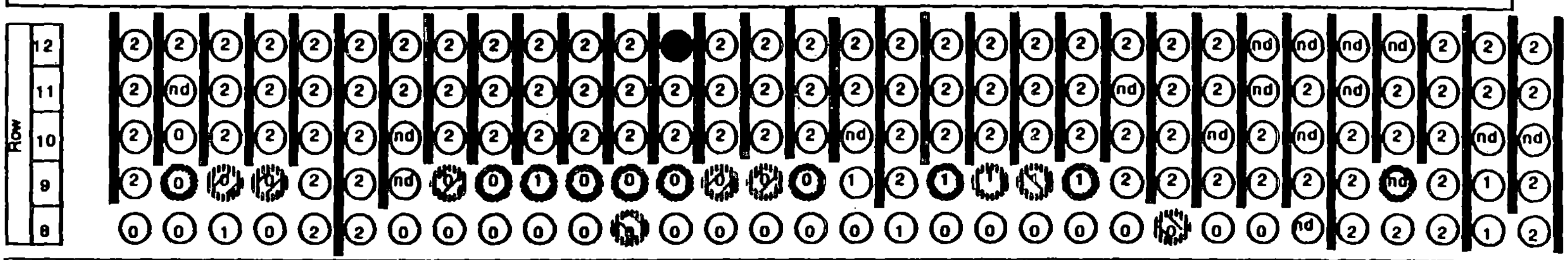
The need and schedule for long term corrective actions and/or compensatory measures will be determined on completion of Westinghouse analysis for Item C.2(a) and on completion of the remaining work in response to Item C.2(b).

Attachment 1	Westinghouse maps showing denting information and AVB locations for steam generators 12, 13 and 14 of Salem Unit 1 and steam generators 21, 23 and 24 of Salem Unit 2.
Attachment 2	Westinghouse Methodology and Criteria for AVB Depth Determination
Attachment 3	Summary listing of unsupported tubes in Rows 9-12

Salem 1 : S/G - 12
AVB Positions



Column	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64
Projection																		8.4				7.9	8.1	8.5	8.9	8.6					



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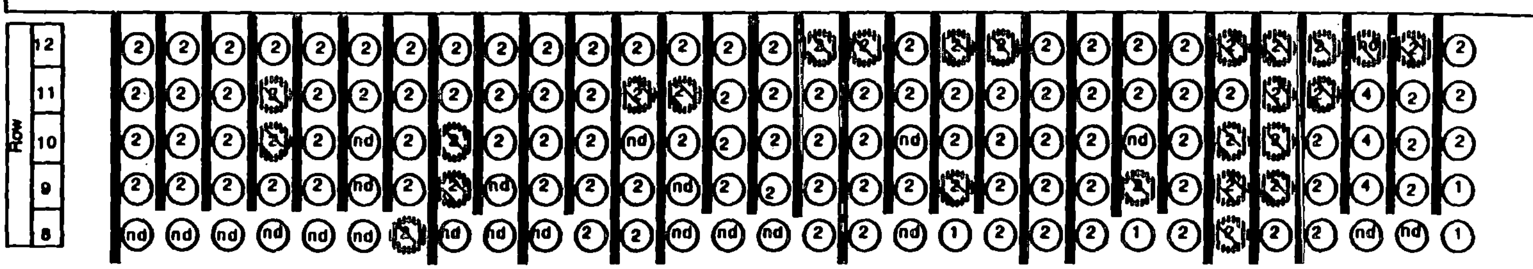
Projection		9.3					8.9										8.8					9.5					8.5		9.3		8.8	7.3



Column	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Projection				8.4					7.9				7.0															8.5		8.6	

NOTES:

- Numbers in tubes indicate AVBs visible.
- Projections are based on centerline of AVB relative to centerline of the tubes

(nd) Noisy data ; inconclusive; inconclusive data

Fixture - No data

Tube inspected and found dented with deformation at TSP 7

Tube inspected and found corroded with magnatite at TSP 7

Tube inspected and found to have no detectable degradation at TSP 7

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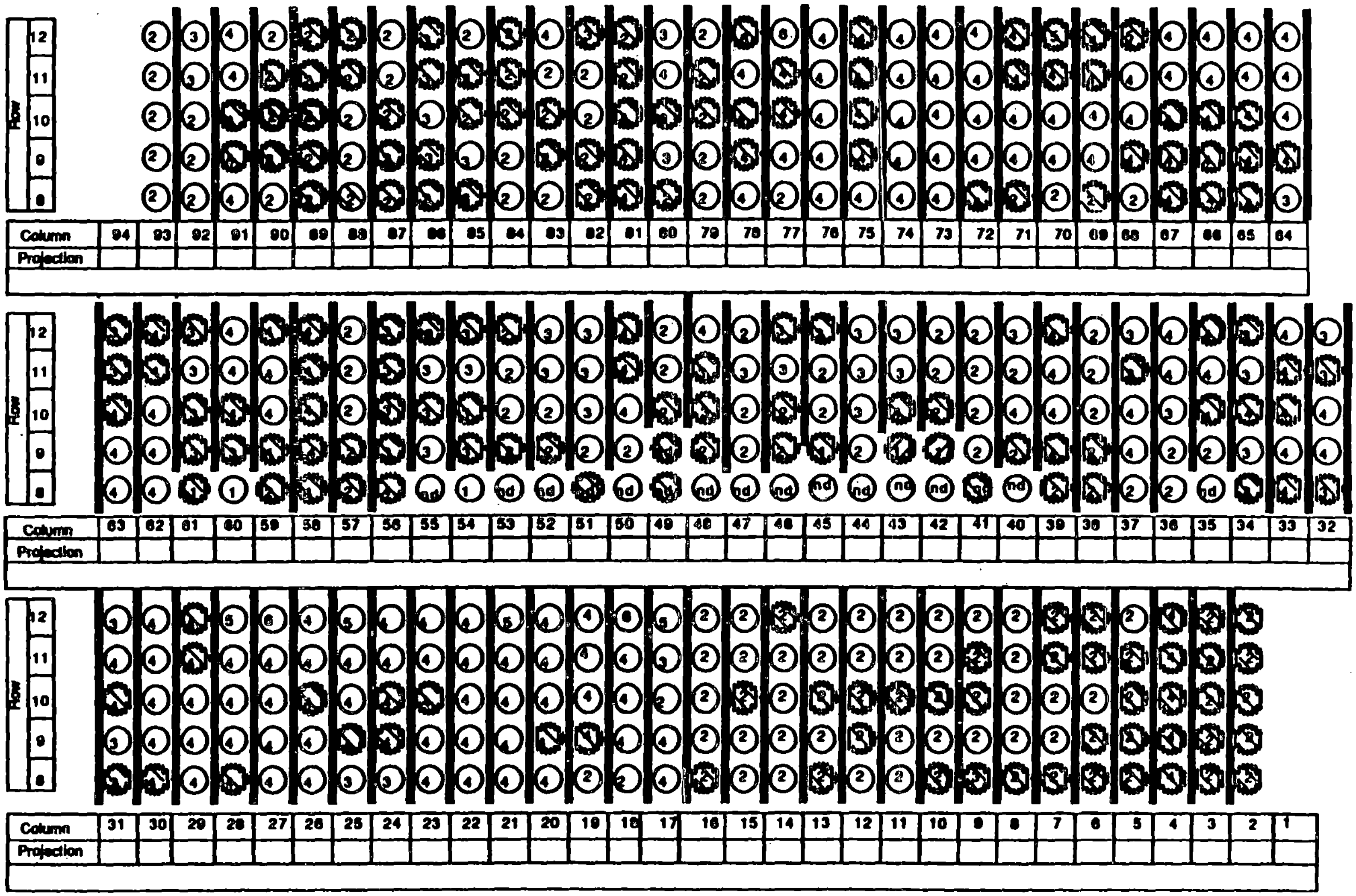
Salem Unit 1, Steam Generator 12, AVB Positions

ATTACHMENT 1

Salem 1 : S/G - 13
AVB Positions



Salem Unit 1, Steam Generator 13, AVB Positions

NOTES:

Numbers in tubes indicate AVBs visible.

(nd) Noisy data; inconclusive data

Tube inspected and found dented with deformation at TSP 7

Tube inspected and found corroded with magnetite at TSP 7

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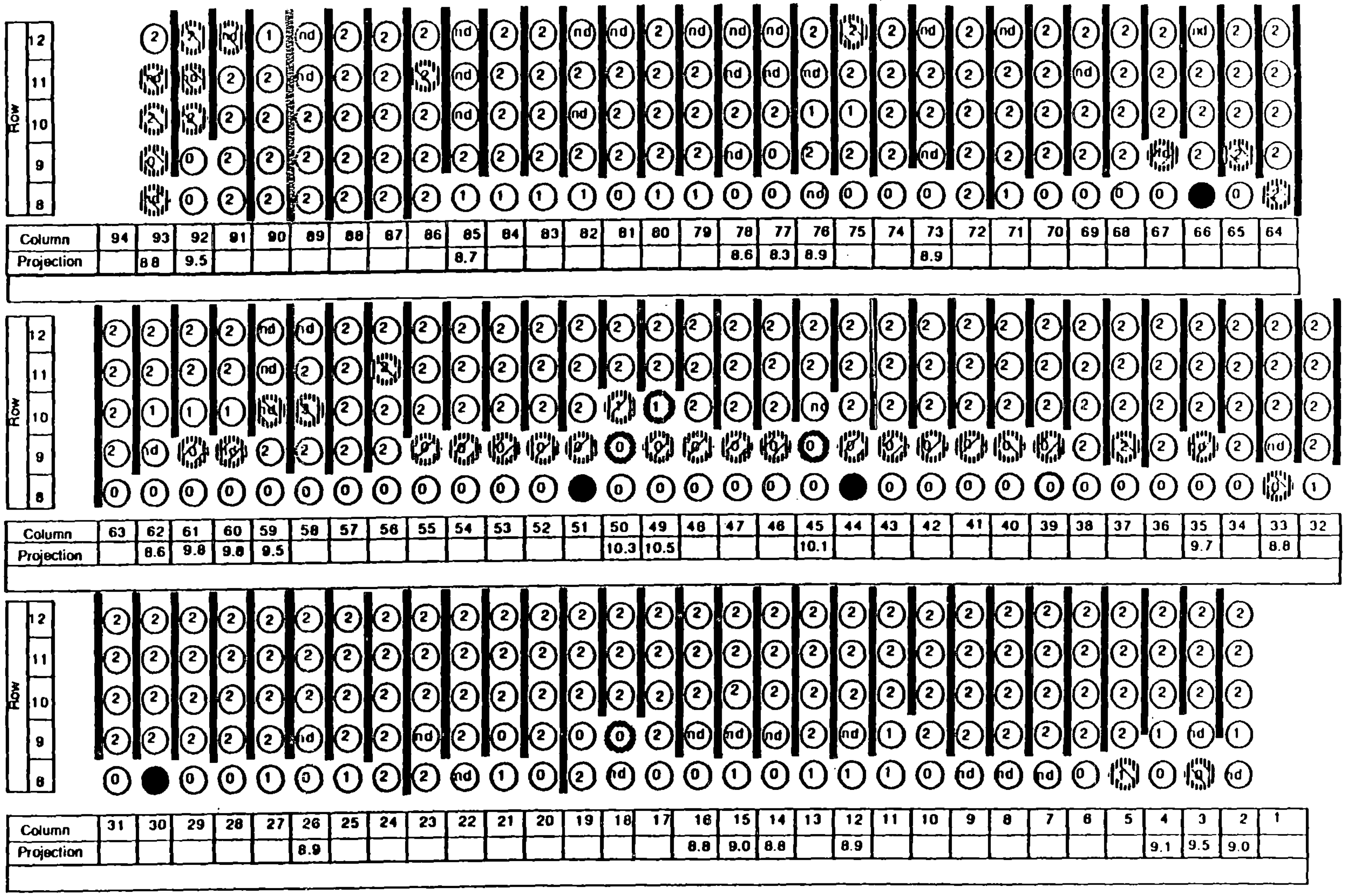
ATTACHMENT 1

Salem -1 : S/G - 14
AVB Positions



Column	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64
Projection		8.8	9.5							8.7							8.6	8.3	8.9			8.9									

Column	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
Projection		8.6	9.8	9.8	9.5									10.3	10.5				10.1										9.7		8.8	

Column	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Projection						8.9										8.8	9.0	8.8		8.9								9.1	9.5	9.0	

NOTES:
Numbers in tubes indicate visible AVB's
Projections are based on centerline of AVB relative to tube centerline.

Tube Not Inspected

(nd) Noisy data; Inconclusive data

Tube inspected and found dented with deformation at TSP 7

Tube inspected and found corroded with magnatite at TSP 7

Tube inspected and found to have no detectable degradation at TSP 7

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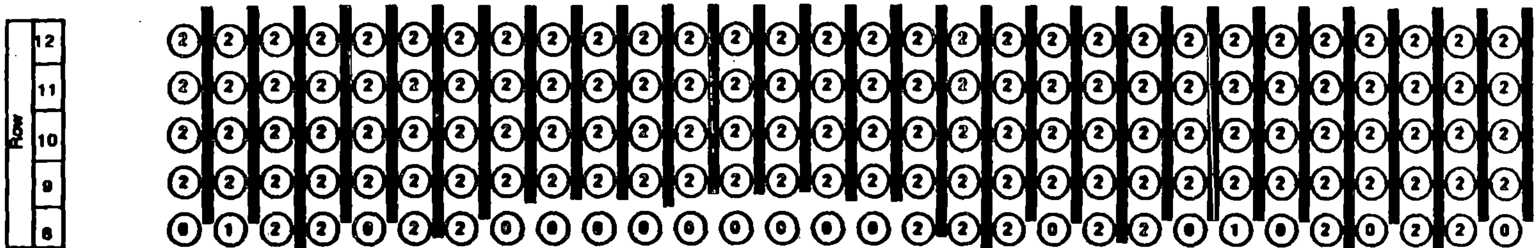
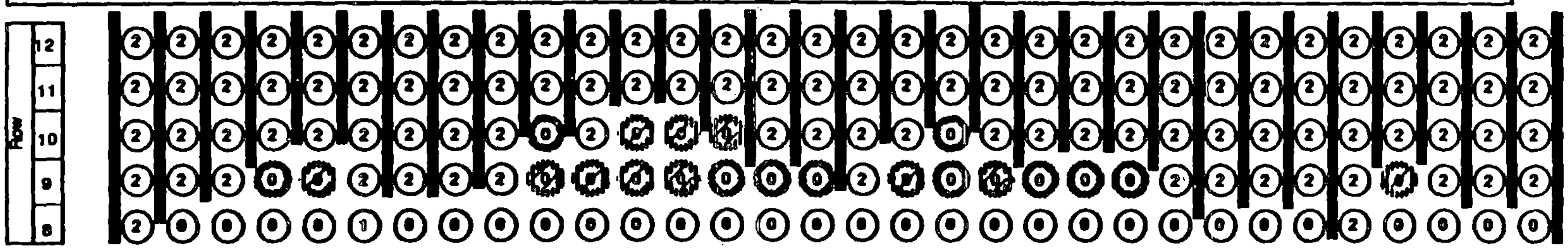
Salem Unit 1, Steam Generator 14; AVB Positions

ATTACHMENT 1

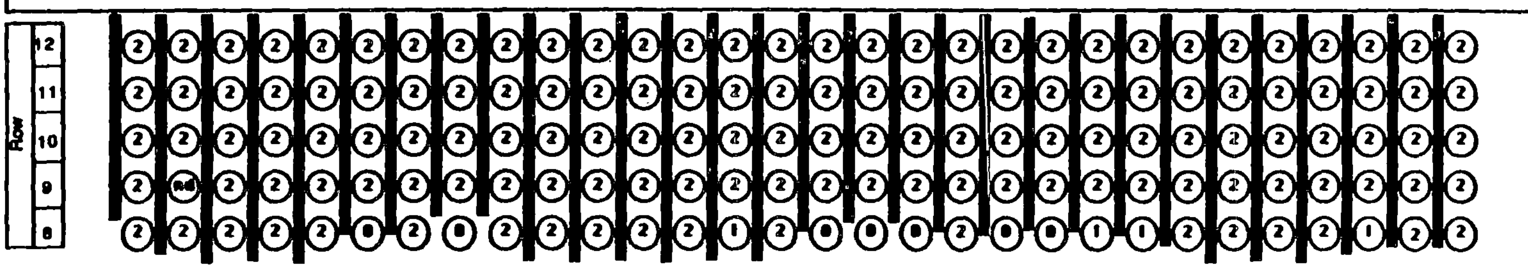
51 Series Steam Generator
Salem # 2
SG - 21



Column		93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64
Projection		8.3	8.2	7.6	7.5	8.3	7.8	7.8	8.3	8.6	8.7	8.6	8.6	8.8	8.8	8.8	8.6	7.8	7.4	7.2	8.2	7.2	7.7	8.3	7.8	8.3	7.3	8.2	7.4	7.4	8.4



Column	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
Projection	7.8	8.1	8.6	9.4	9.8	8.1	8.6	8.7	8.9	10.0	8.8	10.7	10.0	9.2	9.4	9.3	8.7	9.9	10.2	9.4	9.4	9.8	9.2	8.2	8.2	8.4	8.2	7.6	9.5	8.4	8.1	8.4



Column	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	
Projection	7.6	7.3	7.5	7.3	7.2	8.0	7.4	8.6	7.3	7.1	7.2	7.9	8.6	7.8	7.4	8.2	8.3	8.2	7.9	8.1	8.2	8.0	7.7	7.4	7.5	7.4	7.2	7.6	7.7	7.4	

NOTES:

Numbers indicate 'visible' AVB's

If no number is given, no data exists

Projections are based on centerline of AVB relative to centerline of tube

Tube inspected and found dented with deformation at TSP # 7

Tube inspected and found corroded with magnetite at TSP # 7

Tube inspected and found to have no detectable degradation at TSP # 7

nd Noisy data; inconclusive data

Salem Unit 2 Steam Generator 21 - AVB Positions

ATTACHMENT 1

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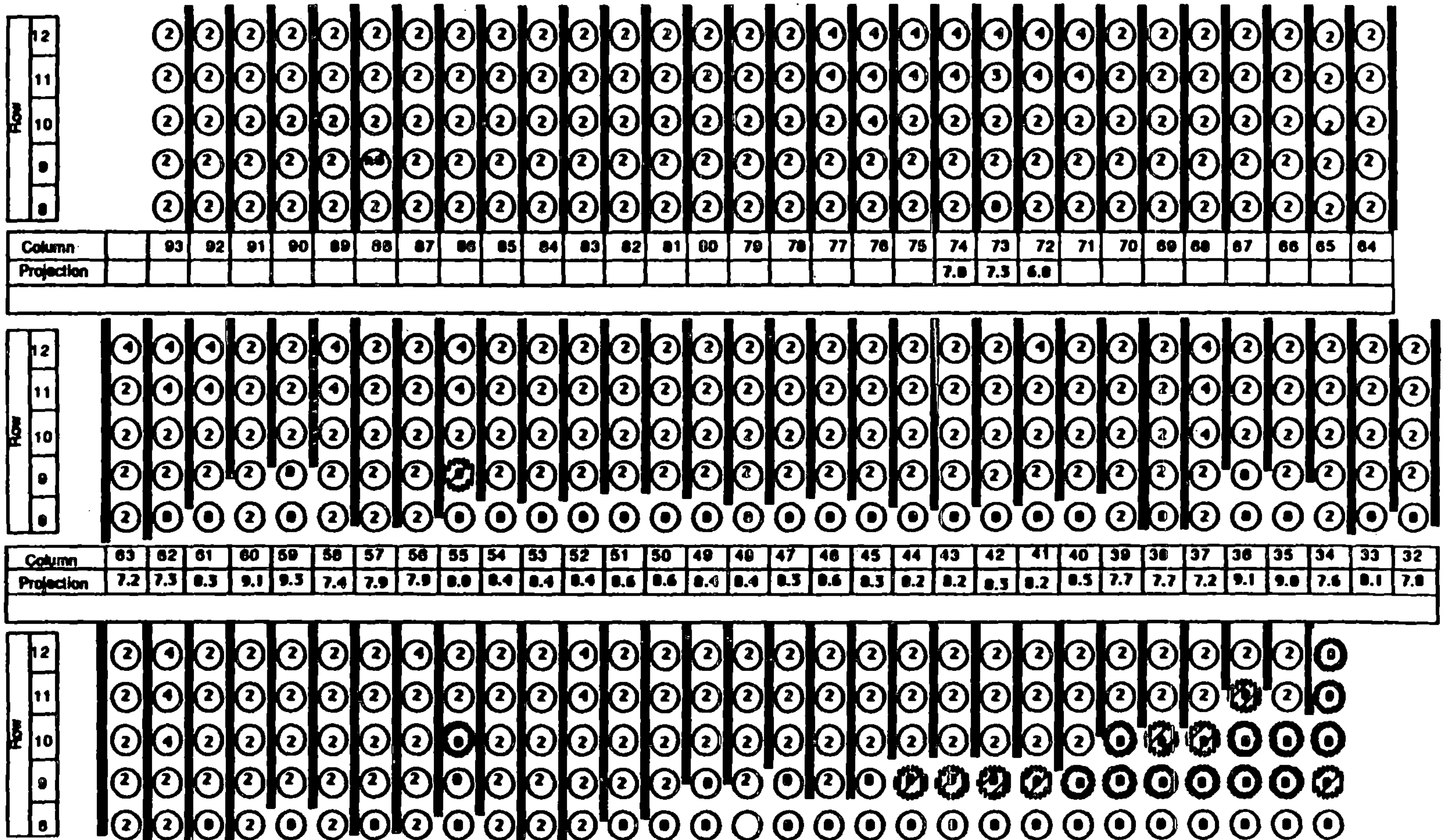
51 Series Steam Generator
Salem # 2
SG - 23

Salem Unit 2 Steam Generator 23 - AVB Positions



Column		93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64
Projection																					7.8	7.5	6.8								

Column	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
Projection	7.2	7.3	8.3	9.1	9.3	7.4	7.9	7.9	8.8	8.4	8.4	8.4	8.6	8.6	8.4	8.4	8.5	8.6	8.3	8.2	8.2	8.3	8.2	8.5	7.7	7.7	7.2	9.1	9.8	7.6	8.1	7.8

Column	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	
Projection	7.4	6.9	7.7	7.6	8.4	7.9	7.9	7.7	8.2	7.1	6.9	7.8	8.1	8.1	9.8	8.7	9.4	8.7	9.3	9.6	9.6	9.6	9.4	9.4	10.1	10.3	10.1	11.3	9.8		

NOTES:

Numbers indicate 'visible' AVB's

If no number is given, no data exists

Projections are based on centerline of AVB relative to centerline of tube

Tube inspected and found dented with deformation at TSP # 7

Tube inspected and found corroded with magnetite at TSP # 7

Tube inspected and found to have no detectable degradation at TSP # 7

nd Noisy data; inconclusive data

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ATTACHMENT 1

51 Series Steam Generator
Salem # 2
SG - 24

Salem Unit 2 Steam Generator 24 - AVB Positions

Row \ Column	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64
12		2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	4	4	3	3	3	3	3	3	3	3	4	3	4	4	3
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10		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	2
9		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	4	4	2
8		2	2	2	2	2	2	2	2	1	1	1	1	1	2	2	2	3	2	3	3	2	2	2	2	2	2	2	3	4	2
Projection																															

Row \ Column	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32
12	2	2	3	4	2	2	2	2	2	2	2	3	2	3	4	2	2	2	2	2	2	3	3	2	2	3	3	3	2	3	3	2
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8	0	1	2	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	0	0	2	2
Projection	8.3	7.7	7.7	10.3	7.1	7.1	8.3	8.4	8.7	9.1	9.4	9.2	9.2	8.9	9.8	9.1	9.1	9.2	9.3	9.1	8.7	8.6	8.7	8.6	8.2	7.7	7.1	7.8	9.7	8.6	7.8	

Row \ Column	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
12	3	3	2	3	3	3	3	3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
9	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
8	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	
Projection						7.3	7.8	7.1																							
L1																															

NOTES:

Numbers indicate 'visible' AVB's

If no number is given, no data is available

Projections are based on centerline of AVB relative to centerline of tube

Tube inspected and found dented with deformation at TSP # 7

Tube inspected and found corroded with magnetite at TSP # 7

Tube inspected and found to have no detectable degradational Tsp #7

(nd) Noisy data; inconclusive data

03/15/88 HWY

ATTACHMENT 1

ATTACHMENT 2

WESTINGHOUSE METHODOLOGY AND CRITERIA
FOR AVB DEPTH DETERMINATION

1. Eddy Current Data and AVB Positions

Eddy current data was used as the source of input in locating the AVBs and determining the condition of the tube support plate interface. Analysis of the ECT tapes was performed principally by the SG Inspection and Analysis group of Westinghouse STD. Subsequent to the analysis of the ECT tapes, the data analysis results were evaluated and plotted by the Steam Generator Design and Development group of Westinghouse STD.

2. Eddy Current Data for AVB Positions

The AVB insertion depths were determined on the basis of interpretation of the eddy current data. To locate the AVBs, the ECT data traces were searched for the characteristic peaks seen in the signals, which indicate the intersection of an AVB (or a tube support plate) with the tube. The number of these intersections detected between the tube support plate indications; and the spacing between signal was logged for each tube to indicate the presence or absence of AVBs. Where only a single intersection was indicated by the data, the length of this intersection was recorded to provide additional information to assess the adequacy of support for the tube. The analysis results for tubes in rows 8 through 12 for Salem Unit 1, Salem Generator Nos. 12, 13 and 14 are presented in Attachment 1. Steam Generator No. 11 was not evaluated. Similar information is presented in Attachment 1 for the equivalent tubes in Salem Unit 2, Steam Generator Nos. 21, 23 and 24.

Since ambiguity can occur in the interpretation of the ECT data, due to inability of ECT to differentiate at which side of a tube a "visible" AVB is located, other information was used to assist in establishing the location of the AVBs. This includes evaluation for consistency with the design of the AVB assembly, consistency of data between adjacent columns, and verification by projection to determine the depth of insertion which was plotted.

3. AVB Assembly Design

The design of the AVB assembly for the Model 51 Steam Generator includes a lower AVB between successive columns from 2/3 through 92/93; and an upper AVB between successive columns from 4/5 through 90/91. No AVBs are installed outside column 2 or column 93. The retainer ring, to which all of the lower AVBs are welded, crosses the peripheral tube in columns 2 and 93, and projects into the space between columns 1 and 2, and 93 and 94. The minimum design depth of insertion of the lower AVBs is to row 11, while the minimum design depth of insertion of the upper AVBs is to row 13. Review of the eddy current data for the Salem Units 1 and 2 shows that with the exception of Steam Generator No. 23, only in the middle third of the tube bundle, do the lower AVBs not extend as far inward as row 8 or row 9, and typically less than 20 row 10 tubes are not supported (Steam Generator No. 22 is not included in this conclusion because its data is so ambiguous).

Eddy current data sometimes indicate the presence of AVBs in columns 2 and/or 91. Since no AVBs are in these columns by design, the data indications are interpreted as the retainer ring which projects between columns 2-3 and 90-91. The retainer ring is approximately the same size as the AVBs and may be in close enough proximity to the tube to be "seen" by ECT. However, support of these tubes cannot be assured on the basis of this signal.

4. AVB Insertion Depths

AVB position maps for the Steam Generator Nos. 12, 13, 14, 21, 23 and 24 are given in Attachment 1. The number of visible AVB indications per tube, projections of AVB insertion and the condition of the tube to TSP interface are shown on the Attachment 1 figures.

The direct observation data (the number of AVB intersections seen by the eddy current probe) are the principal basis for determining the AVB positions. Where the direct observations were ambiguous or there is a conflict between observations and projections, the more conservative data are used to determine the AVB positions. Since direct observation gives a 'yes-no' type of answer, the projection method is used to 'interpolate' AVB insertion depths between rows of tubes. The visual images thus produced being more easily understood when fluid flow peaking situations are evaluated.

Greater conservatism is generally interpreted as the AVB being less inserted, although consideration must also be given to the resulting flow peaking factors. No attempt was made to inflate the flow peaking factors through conceptually possible, but unreasonable, interpretation of the data.

5. AVB Projection

The projection technique is useful where noisy ECT signals prevent direct observation of the AVBs, where testing is impossible due to plugged tubes, and in some instances to resolve ambiguities in the ECT data. Since the included angle and the apex radius of the AVB are known, relatively simple geometrical calculations may be performed to locate the AVB apex with respect to neighboring tubes. These calculations are based on the spacing between intercepts of that AVB with the tubes located higher in the same column. Projection is never the method of choice where direct, unambiguous data for the tubes in rows 8 through 12 are available.

In the case where the AVB characteristic signals cannot be confidently determined due to a noisy signal or pre-existing plugged tubes, location data for the AVBs is provided for higher rows in the same columns. The data input to the calculation are the arc lengths to AVBs 1 and 4 measured from the centerline of the top tube support plate, and the total U-bend length from the hot leg to the cold leg. These data are then used to calculate the insertion depth of the AVB in that column, based on the known dimensions of the AVB. The projected positions appear on the respective maps as fractional values of pitch. For example, the value 10.5 indicates the tangent point of the apex of the centerline of the AVB to be midway between the centerlines of tube rows 10 and 11.

The use of data for multiple tubes in the same column provides a consistency check of the projection based on any single tube. However the projected positions shown on the AVB maps are based on the nearest "two contact" signal to the apex of the AVB. Some additional conservatism results from the assumption used in the projection method that the included angle between the two legs of the AVB is constant at the drawing value, regardless of the position along the AVB. It can be demonstrated that for the range of tube rows for which the projection calculations are made, the included angle of the AVB can be smaller than the drawing value, and that this results in calculated projected AVB positions which are slightly higher than the true positon.

6. Position Map Interpretation

The following definitions provide an interpretation key for the position maps in Attachment 1:

1. <u>2 AVBs Visible</u>

° EC evaluation shows well defined presence of both legs of at least one AVB

- If EC reading is doubtful or if data is inconsistent with adjacent tubes (such as adjacent tubes showing no AVBs), AVB support is determined by projection techniques.

- "2 AVBs" is normally reported for the case of staggered adjacent lower AVBs for which the presence of 4 AVB legs might be expected. When separation of the two adjacent AVBs is necessary to tube support evaluation, the EC data is reevaluated to separate the two adjacent AVB signals for use in projection methods. AVB maps still report 2 AVBs as an indication of "assured" tube support.

° 2 AVBs visible assures that the tube is supported by at least one AVB at the tube centerline (subject to above noted consistency checks) and the tube needs not be evaluated for tube fatigue.

2. <u>1 AVB Visible</u>

- EC evaluation shows presence of 1 AVB and the length and location of the AVB signal should be reported. Normally this corresponds to the bottom apex of the AVB at or near to the tube centerline.

- Tube support cannot be assured by the EC data only.

- Projection methods are used to determine AVB depth of penetration and tube support conditions.

3. <u>No AVB Visible</u>

- EC evaluation clearly shows that no AVBs are visible.

- Tube is not supported by an AVB.

4. <u>Undefined AVBs</u>

- EC evaluation for AVBs cannot be made due to noisy data or deposits. The tube has been probed.

- Projection methods should be used if the EC signal is noisy or AVBs not determinable due to deposits.

5. <u>No Data</u>

- No EC inspection data is available.

- Projection techniques are required.

6. <u>AVB Projections</u>

- Insertion depth projections are based on EC analysis determination of distances from top TSP centerline to the centerline for each AVB. Closely spaced AVBs must be separated for accurate projections.

  Projected insertion distances (10.1, 9.2, etc.) are based on the <u>centerline of the AVB</u> to the tube centerline. For example, a 10.2 projection indicates the AVB apex centerline is 0.2 tube pitches above the tube centerline. A projection of 10.1 means the nominal estimate indicates that the tube is supported.

ATTACHMENT 3

Summary Listing of Unsupported Tubes in Rows 9 through 12
Salem Unit 1

Steam Generator '12'

Row 12	None
Row 11	None
Row 10	None
Row 9	C35, C42, C43, C44, C45, C48, C49, C50, C51, C52 C53, C54, C55, C56, C60, C61, C62

Steam Generator '13'

Row 12	None
Row 11	None
Row 10	None
Row 9	C42, C43

Steam Generator '14'

Row 12	None
Row 11	None
Row 10	C49, C50
Row 9	C18, C35, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C60, C61, C67

All of the tubes listed should be evaluated. The underlined tube locations are the most likely to have high flow peaking factors as preliminarily evaluated by Westinghouse.

Summary Listing of Unsupported Tubes in Rows 9 through 12
Salem Unit 2

Steam Generator '21'

Row 12	None
Row 11	None
Row 10	C45, C50, C51, C52
Row 9	C35, C41, C42, C43, C44, C45, C46, C48, C49, C50 C51, C52, C53, C54, C59, C60

Steam Generator '23'

Row 12	C2
Row 11	C2, C4
Row 10	C2, C3, C4, C5, C6
Row 9	C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C59

Steam Generator '24'

Row 12	None
Row 11	None
Row 10	C60
Row 9	C35, C53, C60

All of the tubes listed should be evaluated. The underlined tube locations are the most likely to have high flow peaking factors as preliminarily evluated by Westinghouse.