WESTINGHOUSE PROPRIETARY CLASS 3

WCAP-12688 SG-90-07-016 Rev. 2

INDIAN POINT UNIT 2
TUBE FATIGUE REEVALUATION

ISSUE DATE: AUGUST 1990

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FOREWORD

Introduction

The initial assessment for Indian Point #2 small radius tube fatigue was performed in 1987 (Reference 1). The Indian Point #2 tube fatigue evaluation was later revised for changes in operating conditions associated with power uprating, (References 2 and 3). This revision was based on Anti-Vibration Bar (AVB) maps from the 1987 evaluation. The initial evaluation made in Reference 1 identified two tubes which required action. The evaluation for operation at uprated conditions identified four more tubes which required action to support long term operation at the uprated condition.

The NRC has requested that Westinghouse re-evaluate the AVB positions and associated flow peaking factors for all steam generators evaluated prior to 1989. Indian Point #2 is included in this set since the evaluation was performed in late 1987 and early 1988. In addition, the presence of extensive copper deposits on the tubes complicated the identification of AVB positions from eddy current data. Initial efforts using projections of AVB depths from outer rows (typically Row 15 and higher) were undertaken by EPRI in their review of eddy current data from Indian Point #2 steam generators 22 and 24, (Reference 1). This was done to avoid the copper deposits which typically were more prevalent on the smaller radius tubes. Later [

]a,c For both these reasons, the effort described here to remap the AVB positions in all four Indian Point #2 steam generators and perform the related flow peaking factor, tube vibration, and tube fatigue analysis has been undertaken.

Eddy Current Data Interpretation and AVB Position Mapping

The eddy current data taken during the 1984 Refueling Outage of steam generators 22 and 24 which were reviewed by EPRI have been completely re-reviewed by Westinghouse eddy current specialists. This review took advantage of recently developed techniques to aid in distinguishing eddy current signals due to AVBs from signals due to copper deposits on the tubes.

The eddy current data from all four steam generators were entered into projection programs and the AVB positions were projected from each tube which had eddy current data. The projections were examined row by row [

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In some cases the data were sparse and good data from higher rows were not available. In those cases, only the [

]a,c In over [

]a,c

As expected from [ ]a,c the AVB projections made from the inner rows (Rows 9-13) went deeper than projections made from outer rows (Row 15 and above). In the original evaluation (Reference 1) the projections were based on [

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The AVB location maps for the four steam generators are shown in Figures 1 thru 4. It should be noted from the map of S/G 24 (Figure 4) that the four tubes (R9C65, R10C71, R11C45, and R11C46) which had been identified in References 2 and 3 as requiring preventive action prior to operating at the uprated power are shown to be supported (R9C65 and R10C71) or as not being flow peaked (R11C45 and R11C46) on the new map. Thus, they do not now require any preventive action.

Allowable and Actual Flow Peaking Ratios at the Uprated Power Condition

The analytical methods used to evaluate the susceptibility to vibration induced fatigue of the small radius U-bend tubes are the same as those used in the original and uprated analyses (References 1, 2, and 3) and the detailed description of the methods will not be repeated here.

The AVB insertion maps (Figures 1 thru 4) were used to determine flow peaking factors and all unsupported tubes having flow peaking factors greater than 1.0 are listed in Table 1. Table 1 also lists the type of AVB insertion pattern attributed to each tube with a peaking factor greater than 1.0. The AVB insertion patterns and associated flow peaking factors and peaking ratios are shown in Figure 5. The peaking ratio is the peaking factor divided by the peaking factor for North Anna R9C51.

The results of the thermal hydraulic and tube stability evaluation are given in a slightly different form than in the previous analyses of Indian Point #2. The maximum allowable peaking ratio (the peaking ratio which causes the stress ratio to be unity after operation over the design basis period) is given in Figure 6 as a function of tube row and column. The maximum allowable peaking ratio is also given in the last column of Table 1 for the tubes included in that table.

Inspection of the last two columns of Table 1 shows that the following tubes have peaking ratios large enough to cause the stress ratio to be greater than unity and thus may require preventive action prior to operation at the uprated power condition.

<u>Unsupported Tubes With Stress Ratios Greater than Unity at the Uprated Power Condition</u>

S/G 21	No tubes
S/G 22	No tubes
S/G 23	R11C48
S/G 24	No tubes

Operation Over the Current Cycle and Future Uprated Cycles

The operating conditions for the current cycle, which started on June 23, 1990, are shown in Table 2 and are more limiting than the original conditions considered in Reference 1 and less limiting than the uprated conditions considered in References 2 and 3. Therefore the tube listed above, which would have a stress ratio greater than unity operating at the uprated conditions, has been evaluated for the design basis period of the plant with the historical operating conditions through February 1990, current cycle conditions from June 1990 to February 1991, and uprated values after February 1991.

Conclusions

All but one tube in the four steam generators at Indian Point Unit 2 could operate for the design basis operating period without exceeding the tube fatigue criterion. This tube, SG-23 R11C48, however, does meet the criteria for design basis operation at the current cycle conditions through the end of the current cycle. Therefore no action is required prior to the end of the current operating cycle. However, tube SG-23 R11C48 should receive preventive action at the end of the current cycle.

Table 1
Velocity Peaking Factors and Peaking Ratios for Indian Point 2 U-Bend Flow
-- Original AVBs for Indian Point 2 --

Steam Generator	Row No.	Col. No.	Type of AVB Insertion	Peaking Factor	Peaking Ratio	Allowable Peaking Ratio*
21	9	65, 64				
	10	77				
		70				
		34				
		20				
		12, 11				
	11	86				
22	9	84				
	10	87				
		78				
		74				
		68				
		65, 64				
		14				
	11	88				
23	9	61, 60				
	10	81				
		53				
		37				
	11	48				
		3				
24	8	73				
		64				
		33				
		28				
	9	38				
		10				
	10	54				
		6				
	11	51, 50				
		44				
		2				

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* Based upon uprated conditions.

† Exceeds allowable flow peaking (but does not exceed 1.0 fatigue usage factor during current cycle).

Table 2
Indian Point #2 Steam Generator Operating Conditions
Used as Input for ATHOS Analysis

Quantity	Original Value[1]	Uprated Value[1]	Current Cycle Value[2]
Thermal Power (MWt)	694	770.8	754
Primary Flowrate (GPM)	89,700	89,100	92,600
Primary Inlet Temp. (°F)	579	591.4	586.7
Primary Outlet Temp (°F)	525	525.3	531
Feedwater Flow (lbm/hr)	2.93×10^6	3.31×10^6	3.23×10^6
Feedwater Temp. (°F)	416	430	424
Outlet Nozzle Steam Press. (psia)	690	641	735
Circulation Ratio	[		]

NOTES:
1. Data taken from Reference 3.
2. Data as per Reference 5. These data apply to the cycle starting June 23, 1990, and running to February, 1991.

References

1. Indian Point Unit 2 Evaluation for Tube Vibration Induced Fatigue, WCAP-11811, May 1988

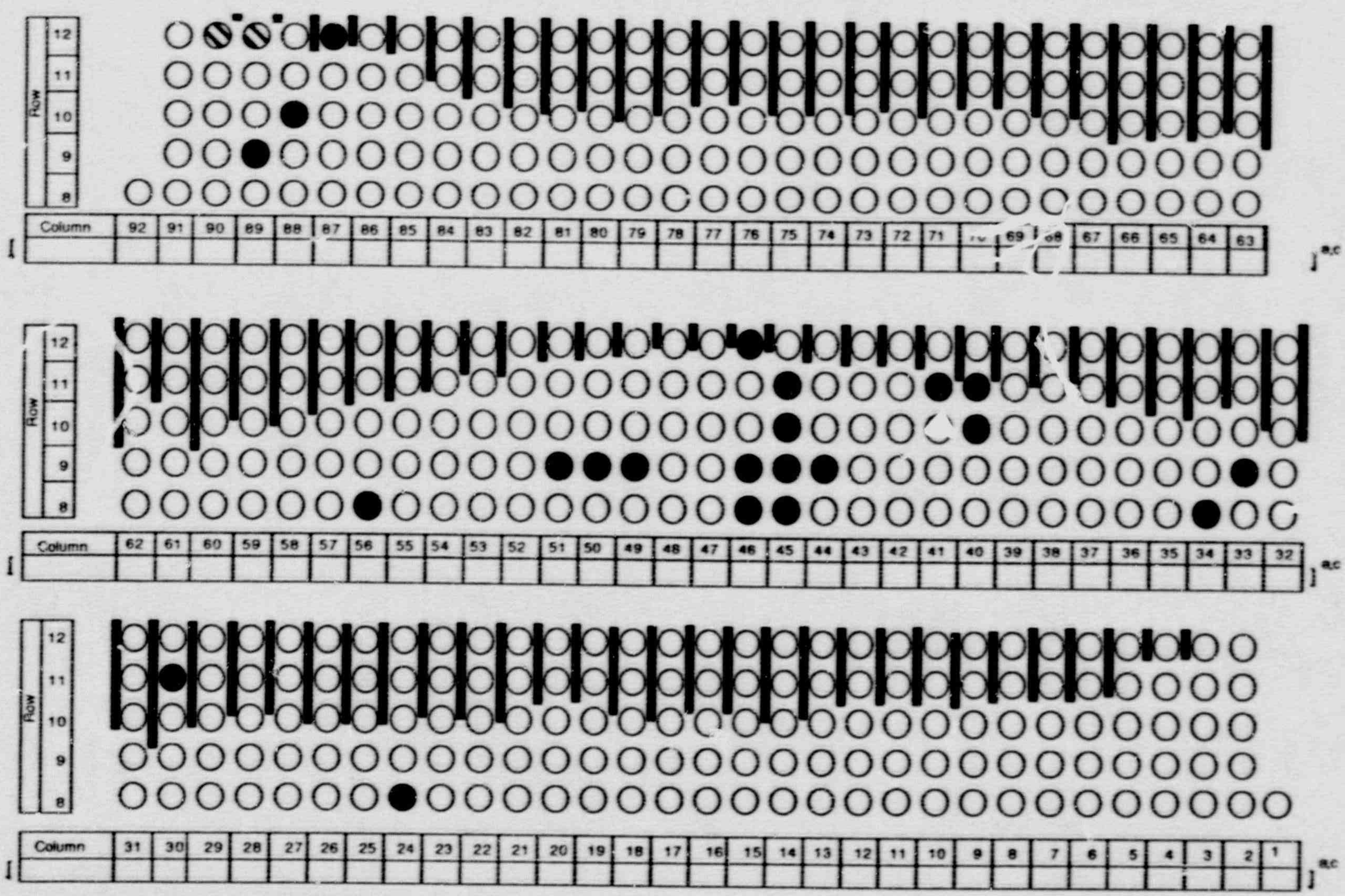
2. Consolidated Edison Co. of New York, Inc. Indian Point Unit 2 3083.4 Mwt Stretch Rating Engineering Report, WCAP-12187, March 1989

3. Transmittal of T/H and FIV Report for IPP DCRP Removal, NSD-SGT-SM-9074, May 24, 1989

4. WCAP-11811 - Clarifications on IPP Tube Vibration Induced Fatigue, IPP 90-513, January 17, 1990

5. Indian Point #2 Rapifax Transmittal dated July 17, 1990, 4:22 pm

Figure 1
Indian Point -2: S/G -21
AVB Positions



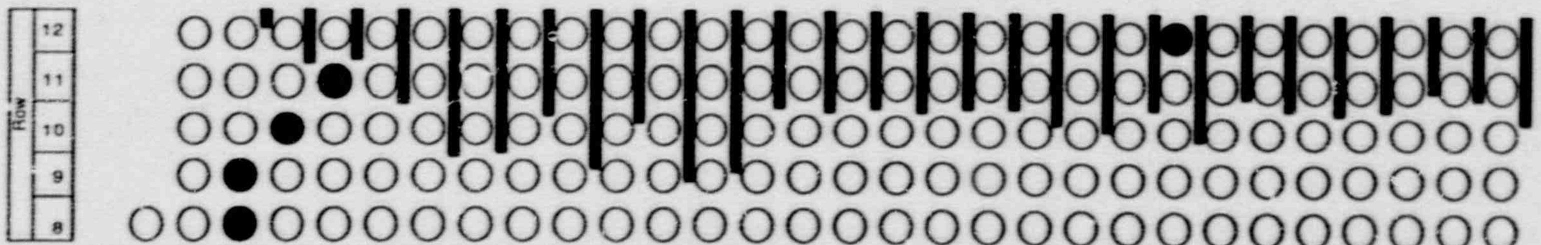
NOTE:
Projections are based on AVB centerline relative to tube centerline.

● Tube Plugged for Indication

⊘ Sentinel Plugged Tube

2 Aug 90
NJC/RMW

Figure 2
Indian Point - 2 : S/G - 22
AVB Positions



[

Column	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	63
Projection																														

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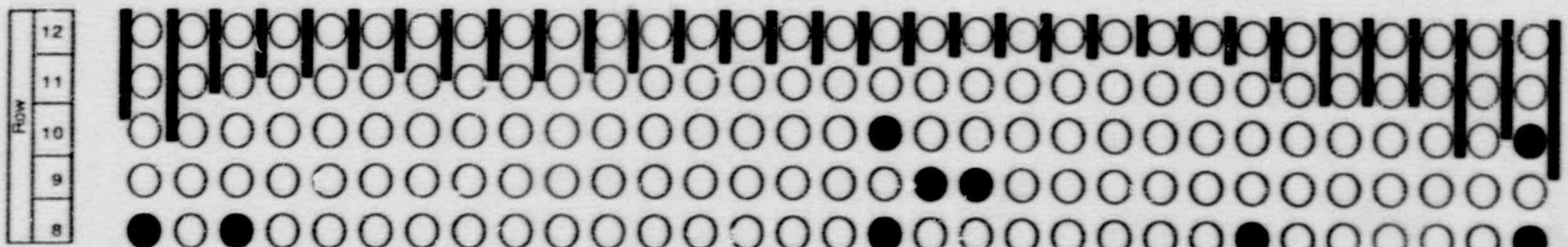

[

Column	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																															

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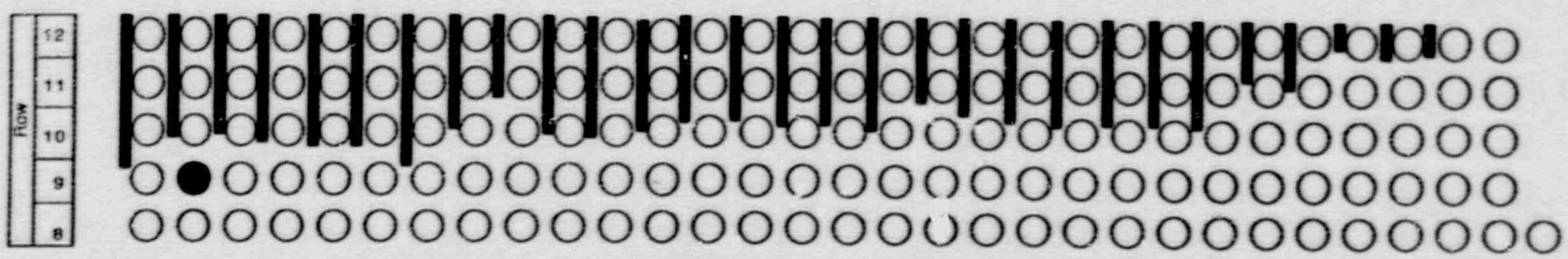

[

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																															

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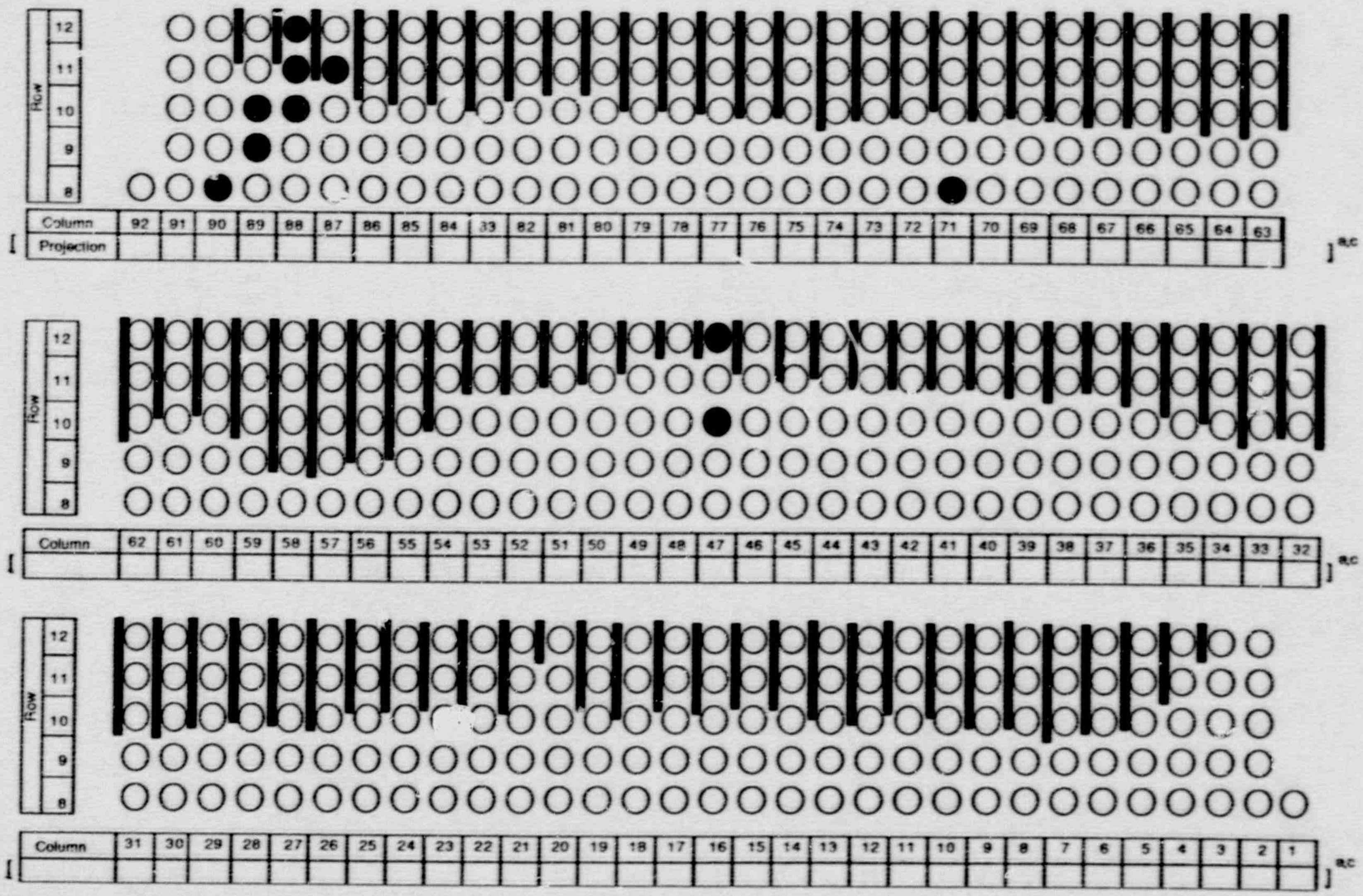
NOTE:

Projections are based on AVB centerline relative to tube centerline.

● Plugged Tube

2 Aug 1990
NJC/RMW

Figure 3
Indian Point - 2: S/G - 23
AVB Positions



NOTE:
Projections are based on AVB centerline relative to tube centerline.

● Plugged Tube

2 Aug 1990
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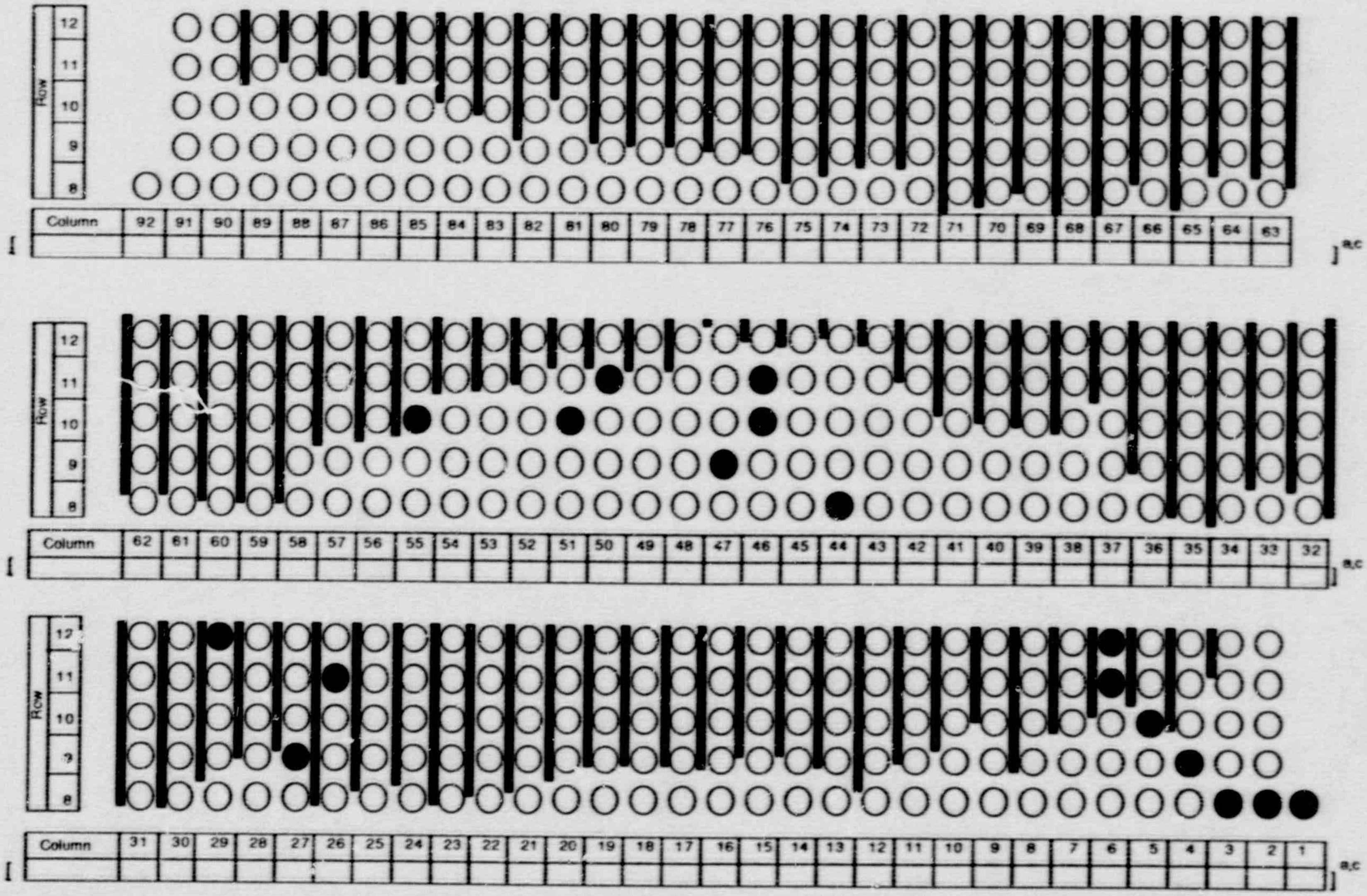
Figure 4
Indian Point - 2 : S/G -24
AVB Positions



NOTES:

Projections are based on AVB centerline relative to tube centerline.

● Plugged Tube

2 Aug 1990
NJC/RMW

TYPE OF AVB INSERTION	PEAKING FACTOR	TYPE OF AVB INSERTION	PEAKING FACTOR
[ ]a,c		[ ]a,c	

Figure 5 Final Peaking Factor for Indian Point 2

Figure 6

IPP–MAX ALLOW REL FPEAK – UPR w/o DCRP

(UPRATED CONDITION)

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