REPORT OF STEAM GENERATOR INSPECTION AND TUBE REPAIR

TURKEY POINT UNIT 4

JULY 1982 OUTAGE

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION - EVENT DESCRIPTION

On July 6, 1982, existing primary to secondary leakage in steam generator B at Turkey Point No. 4, began to show signs of increasing. Over the next approximately 36 hours the rate of leakage increased from about 1.2 gallons/hour to an estimated 5 to 10 gallons/hour. Florida Power and Light Company elected to shut the plant down to locate and repair the source of leakage.

After entry into the Steam Generator B was effected, the source of leakage was identified as tube R44 C57, hot leg. Eddy current (EC) testing detected the presence of an apparent through wall penetration at the top of the tubesheet in the leaking tube. A similar signal, uncharacterized due to its complexity, was detected on the adjacent tube, R44 C58, hot leg.

Since the neighboring tubes did not exhibit dents at the top of the tubesheet, and since a similar leakage event had occurred the previous month in Steam Generator B at R44 C36, cold leg, a program including secondary side visual inspection and selected tube EC testing was established.

2.0 RESULTS OF STEAM GENERATOR INSPECTION PROGRAM

2.1 Steam Generator Annulus Search

2.1.1 Preface

The purpose of this review is to describe the technique used to visually inspect and record the nature and location of certain foreign material(s) found in the secondary side of the Turkey Point Unit 4 Steam Generators. This method was also used to provide pictorial data for the evaluation of associated tube anomalies.

2.1.2 Fiberoptics

Introduction

The fiberscope used by Westinghouse for steam generator inspection is a current "state-of-the-art" viewing device. It is a bundle of glass fibers in which the light necessary for viewing travels through some of the fibers while the remainder transmit the image. A cable through the center provides a means of tip angulation to increase the range of view. The apparatus is flexible and can be directed to almost any accessable location within the working length.

The equipment used for the steam generator annulus search is an Olympus 1F11D3 Industrial Fiberscope; Olympus ILK-4 Light Source; and Olympus OM-1 35mm camera with fiberscope adaptor. The fiberscope has a working length of 108 in. and a depth of field ranging from 10mm to infinity. The field of view is 65° and is enhanced by angulation of the viewing tip which can be turned in any direction. This scope affords the optimum view provided size is not a constraint. A 35mm camera can be attached to the scope to document any viewed condition. The best "feel" or picture of the situation is seen through the eyepiece of the operator.

2.1.3 Operation

To prepare for an inspection, the handhole covers and tube lane blocking devices are removed. Water on the tubesheet should be removed. The fiberscope is hand fed into the generator. The inspector scans every tube, photographing any abnormal conditions. A 360° inspection can be obtained through the two penetrations on opposite ends of the tube lane.

A search requires about one ten hour shift per generator, if no abnormal conditions exist.

2.1.4 Video Camera

A. Introduction

The video camera system used by Westinghouse NSD is made especially for dark tight areas in a radiation field. It uses a low light level camera tube which is radiation tolerant and operated remotely from a control unit. Except where constrained by its size (21 in. x 1.25 in.) the camera can reach most areas of the generator.

B. Description

At present the system in use is the Westinghouse ETV 1250 Miniature Underwater TV Camera. In addition, a right angle rotator capable of 360° rotation, and video recorder are used. The camera has a 125 ft. cable allowing the control unit to be in a lower radiation area. The focus range is from 1 in. to infinity limited only by light which reaches approximately 16 inches above the tubesheet.

C. Operation

Scan and documentation of the steam generator require the tube lane blocking device and any water on the tubesheet be removed. A track is set up in the generator bundle to shell annulus to guide the camera and a control station is set up.

This initial preparation time is 4 shifts. It is anticipated that each scan would then take 4 shifts per generator.

2.1.5 Comparison of Techniques

Fiberoptics is the preferred method of inspection whereas the video camera provides an all inclusive record documentation. The operator of the fiberscope can obtain a better understanding of the total conditions since the image is three-dimensional; is in color; and is quite clear with minimum glare, a condition which video has trouble controlling. The fiberscope can

look from unlimited angles and distances whereas the video camera cannot. The video documentation takes about five times as long, which results in more radiation exposure to personnel. Documentation through the fiberscope provides clearer results but 100 percent documentation would require thousands of pictures. Consequently, unless 100 percent documentation is necessary, fiberoptics is the preferred method.

2.1.6 Recent Experience at Another Plant Location

The initial inspection with the fiberscope of a steam generator at another plant, where it was determined that the damage was extensive, resulted in a decision that 100 percent documentation would be required. All efforts were therefore directed to a video camera inspection. Problems associated with the video results at this site were poor lighting, glare or burnout, and lack of clarity.

2.1.7 Determination of Visual Technique Used in Turkey Point Unit 4 Steam Generators

Based upon the initial fiberscope inspection of Turkey Point Unit 4 Steam Generator B, it was determined that a fiberscope was the inspection equipment which would provide the optimum data for a technical evaluation of the tube anomalies.

In accordance with this determination, the fiberoptics technique was used for the visual inspection of the annulus region in each steam generator, and for the photographic recording of foreign objects observed in these steam generators.

2.1.8 Results of Fiberoptics Annulus Search

As a result of the fiberoptics inspection of the steam generator annuli, a number of foreign objects were observed and photographically recorded. A list of the objects observed in each steam generator is provided in Table 1. A photographic record of the objects has been prepared and has been presented in

TABLE 1

Inventory and Disposition of Foreign Objects Observed in Secondary Side of Turkey Point Unit No. 4 Steam Generators - July, 1982 Outage

Steam Generator	Item	Size	Location	Position	Remo
4A	1. Weld Rod	8" long	Outlet, R43-44, C33	Protruding from bundle	Yes
	2. Flat Bar	1" x 2"	Inlet R35-36, C18	Protruding from bundle	Yes
	3. Coiled wire or strip	Very Small Mass about 1/32"x1/4" x 2"	Originally R45 now unknown	Between Tubes	No
	4. Coiled Wire	Very Small about 1"long	Unknown, sighted first day of inspection only	Between tubes	No
4B	1. Bolt	0.375"x1.0"	Outlet, R42, C31-32	Wedged on Tubesheet	Yes
	2. Flat Stock	0.5"x2"x6"	Outlet, R43, C32-33	Wedged at an angle	Yes
	3. Stainless Steel Tube with wing nut	0.375"x6"	Inlet, R44, C57-58	Wedged between tubes	Yes
	4. Pin	1.0" diam x2" long	Inlet, R45, C48-50	Loose on tubesheet adjacent to tubes	Yes
	5. Weld Rod	8"	Inlet, R44-45, C53-54	Standing, adjacent to tubes	Yes
	6. "Glob"	1.0"	Inlet, R44, C55	Wedged on Tubesheet	No
	7. Flat Stock	0.375"x1.5" x 2"	Outlet, R43, C33-34	Between tubes	Yes
	8. Piece of metal/slag	.5" x 1.0"	Outlet, R42-43, C32-33	Between tubes	No
	9. Wire	0.32"x5" long	Inlet, R44,C56-58	Loose, on tubesheet	Yes
	10. Deepwell Socket	11/16" x 1/2" drive	Near manway side tube-lane blocking device	Loose, on tubesheet	Yes
4C	1. Pin	1" diam x 2" long	Inlet, R45, C50-54	Loose on tubesheet	Yes
	2. Weld Rod	8" long	Inlet, R45, C54-55	Standing between tubes	Yes
	3. Tapered Plug	1.0"x1.5"long	Outlet, R44, C34-35	Wedged, on tubesheet	Yes
	4. Piece of Metal	0.5" diam.	Outlet, R44, C55-56	Wedged on tubesheet	Yes
	5. Wire	3/16"x10"long	Inlet, R45,C53-54	Located in bundle	Yes
	6. Wire	App. 1/16" x 10" long	Inlet, R45, C53-54	Leaning into bundle	Yes

album form to the NRC staff at the joint NRC/Florida Power and Light Co./Westinghouse Electric Corporation meeting on the subject outage on Friday, July 23, 1982 in Bethesda, Maryland.

2.2 Steam Generator Eddy Current Inspection Program

2.2.1 Description of Eddy Current Inspection Program

A limited multifrequency eddy current inspection program was performed in the inlet and outlet loop of each of the three Turkey Point Unit 4 steam generators as a result of the July 1982 primary-to-secondary leakage event. (The primary frequencies were 400Khz and 100 Khz, both in the differential mode.)

In general, the program consisted of the eddy current inspection of unplugged tubes in the periphery of the tube bundle plus additional tubes in the vicinity of observed foreign objects. The locations of the tubes inspected in this program are shown for each leg of each steam generator in Figures 1 to 6, inclusive. The numbers of tubes inspected are summarized in Table 2. In Steam Generator B inlet, where the tube leak was found, the tubes were inspected through the uppermost support plate (tube support plate No. 6). In addition, any tubes restricting passage of the standard 0.700-inch diameter probe for this plant were gauged with probes of successively smaller diameter (0.650 and 0.610-inch) as required until clearance was realized. Additional tubes, surrounding those found with 0.650-inch or smaller restrictions or surrounding tubes with reported eddy current indications, were added to the original program as required.

In Steam Generator B outlet, as well as in both legs in each of Steam Generators A and C, the tubes were inspected only through the first support plate, and gauging was not performed.

TABLE 2

TURKEY POINT UNIT 4

JULY 1982 OUTAGE

NUMBER OF STEAM GENERATOR TUBES INSPECTED

Steam Generator	Number of Tubes Inspected	Extent of Inspection
A inlet	201	First Support Plate
A outlet	171	First Support Plate
B inlet	167	Sixth Support Plate
B outlet	106	First Support Plate
C inlet	148	First Support Plate
C outlet	163	First Support Plate

A	33	9/74; TUBES PLUGGED
B	63	6/75; TUBES PLUGGED
C	1	DATE NOT KNOWN; TUBES PLUGGED
D	1	SHOP WELD
E	2	5/76; TUBES PLUGGED
F	92	11/76; TUBES PLUGGED
G	131	7/77; TUBES PLUGGED
H	1	7/77; WELD REPAIR HL, E/P CL
I	169	2/78; TUBES PLUGGED
J	86	8/78; TUBES PLUGGED
K	2	SHOP WELD, HL MISDRILLED
L	79	4/79; TUBES PLUGGED
M	72	5/80; MECH PLUGGED
N	27	11/80; MECH PLUGGED
P	36	11/81;MECH PLUGGED

SERIES 44

FLA-A

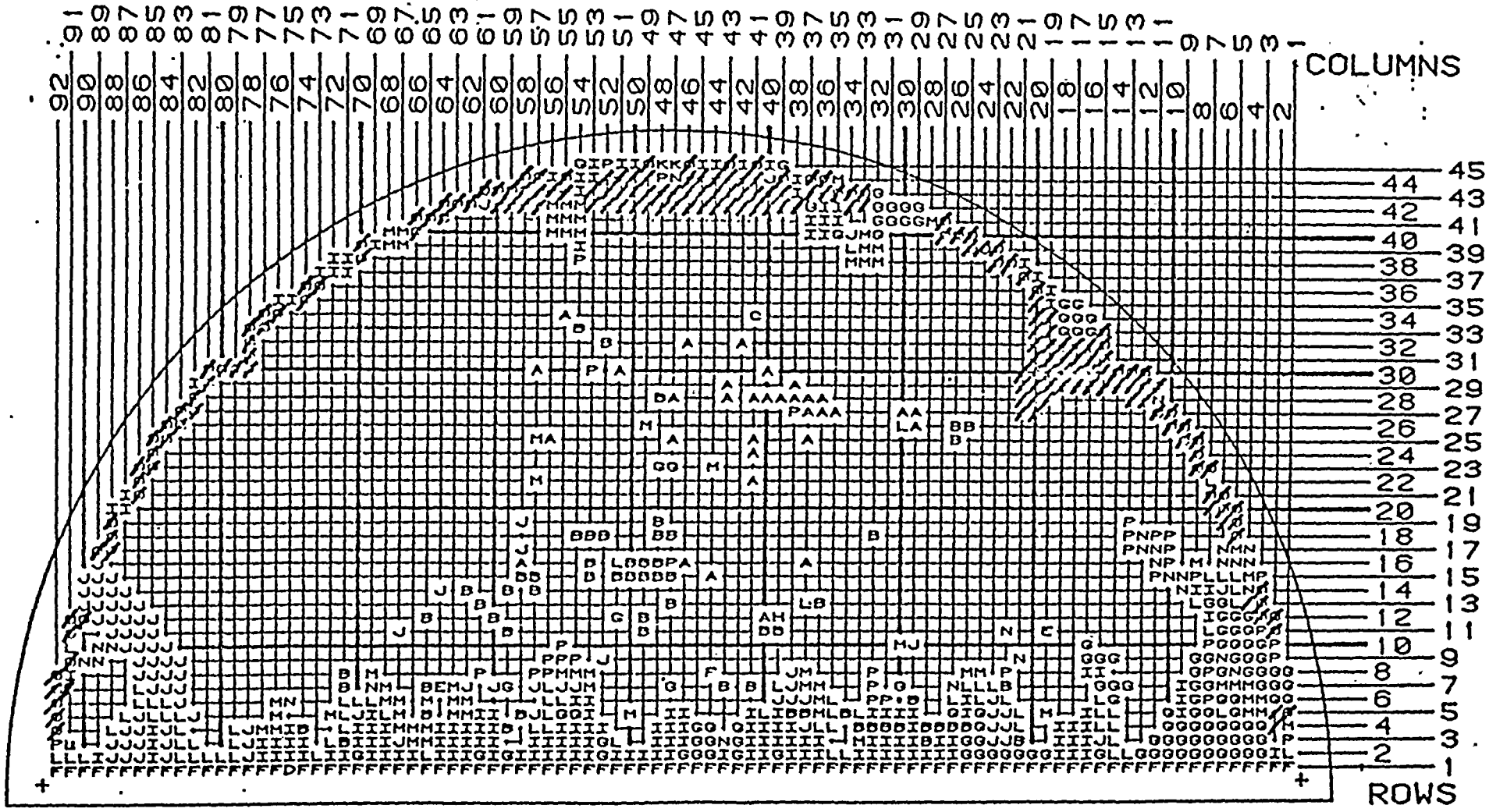


FIGURE 1
TURKEY POINT UNIT 4
STEAM GENERATOR A INLET
JULY, 1982 OUTAGE

A	33	9/74; TUBES PLUGGED	I	168	2/78; TUBES PLUGGED
B	63	6/75; TUBES PLUGGED	J	86	8/78; TUBES PLUGGED
C	1	DATE NOT KNOWN; TUBES PLUGGED	K	2	SHOP WELD, HL MISDRILLED
D	1	SHOP WELD	L	79	4/79; TUBES PLUGGED
E	2	5/76; TUBES PLUGGED	M	72	5/80; MECH PLUGGED
F	92	11/78; TUBES PLUGGED	N	27	11/80; MECH PLUGGED
G	131	7/77; TUBES PLUGGED	P	36	11/81;MECH PLUGGED
H	1	7/77; WELD REPAIR HL, E/P CL			

SERIES 44

FLA-A

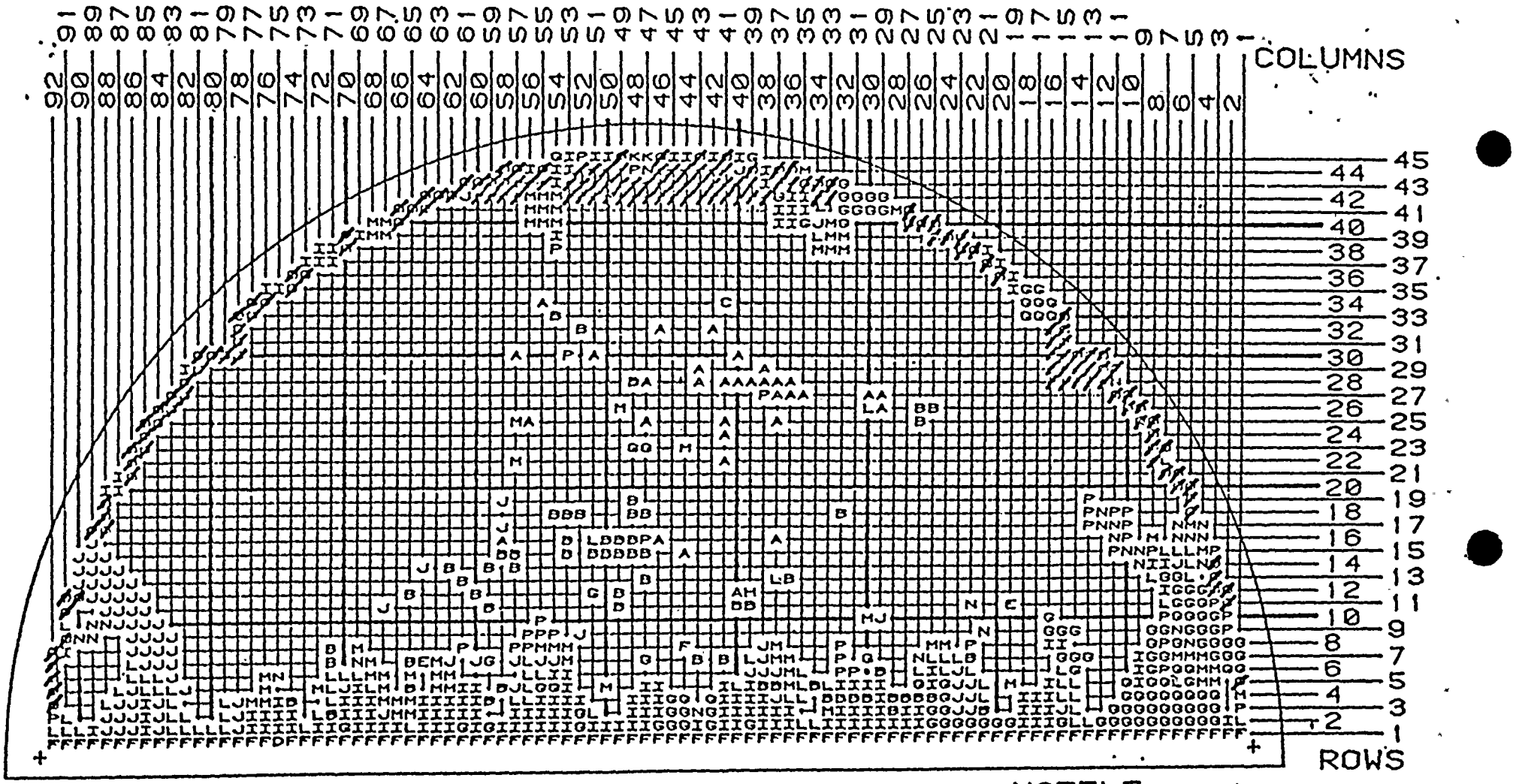


FIGURE 2

TURKEY POINT UNIT 4
STEAM GENERATOR A OUTLET
JULY, 1982 OUTAGE

[illegible]	TUBES PLUGGED PRIOR TO 10/75	M	9	10/77; TUBES PLUGGED
[illegible]	8/75, BARE HOLE PLUG HL-E/P CL	N	79	2/78; TUBES PLUGGED
1	SLEEVE WELD	P	28	8/78; TUBES PLUGGED
1	8/75; BARE HOLE PLUGS—HL,CL	R	52	4/79; TUBES PLUGGED
3	8/75, TUBES PLUGGED	S	48	5/80; MECH PLUGGED
45	8/75, TUBES PLUGGED	T	56	11/80; MECH PLUGGED
60	11/76; TUBES PLUGGED	U	42	11/81;MECH PLUGGED
1	7/77; WELD REPAIR	V	1	11/81;W/P HL ONLY
324	7/77; TUBES PLUGGED	W	5	6/82; MECH PLUGGED

SERIES 44

FLA-B

COLUMNS

ROWS

← MANWAY

NOZZLE →

FIGURE 3

TURKEY POINT UNIT 4
STEAM GENERATOR B INLET
JULY, 1982 OUTAGE

122	TUBES PLUGGED PRIOR TO 10/75	M	9	10/77; TUBES PLUGGED
1	8/75; BARE HOLE PLUG HL-E/P CL	N	79	2/78; TUBES PLUGGED
1	SHOP WELD	P	28	8/78; TUBES PLUGGED
1	9/75; BARE HOLE PLUGS—HL,CL	R	52	4/79; TUBES PLUGGED
3	5/76; TUBES PLUGGED	S	48	5/80; MECH PLUGGED
45	9/75; TUBES PLUGGED	T	56	11/80; MECH PLUGGED
68	11/76; TUBES PLUGGED	U	42	11/81; MECH PLUGGED
1	7/77; WELD REPAIR	V	1	11/81; W/P HL ONLY
324	7/77; TUBES PLUGGED	W	5	6/82; MECH PLUGGED

SERIES 44

FLA-B

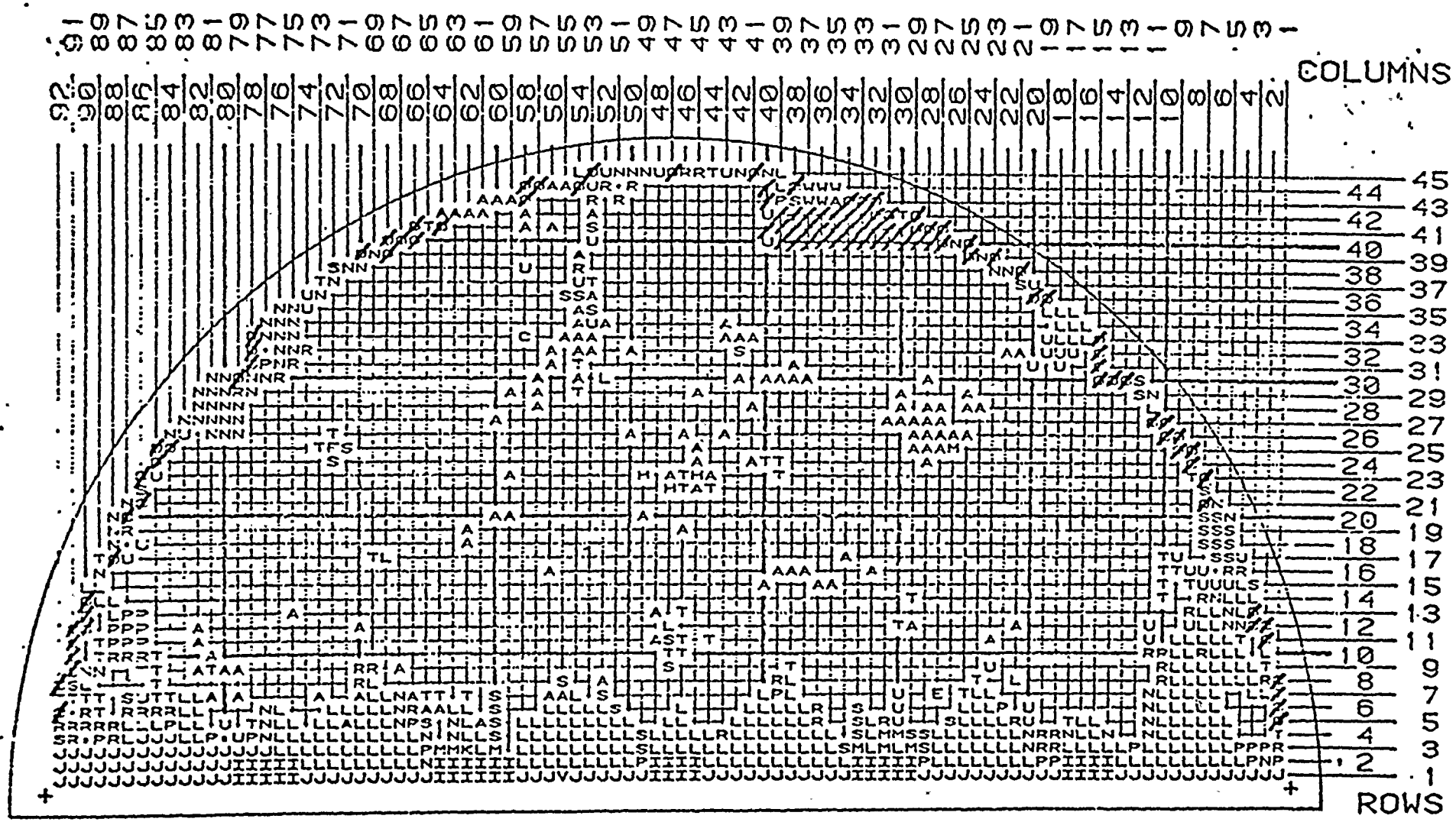


FIGURE 4

TURKEY POINT UNIT 4
STEAM GENERATOR B OUTLET

A	8	8/74; TUBES PLUGGED	K	166	7/77; TUBES PLUGGED
B	80	8/75; TUBES PLUGGED	L	118	2/78; TUBES PLUGGED
C	2	1/76; TUBES PLUGGED	M	62	8/76; TUBES PLUGGED
D	6	5/76; TUBES PLUGGED	N	54	4/79; TUBES PLUGGED
E	2	8/76; TUBES PLUGGED	P	1	8/76; EP 6/76, VR HL
F	83	11/76; TUBES PLUGGED	R	56	5/80; MECH PLUGGED
G	5	1/77; TUBES PLUGGED	S	48	11/80; MECH PLUGGED
H	2	3/77; TUBES PLUGGED	T	26	11/81; MECH PLUGGED
I	8	4/77; TUBES PLUGGED	U	1	11/81; W/R HL ONLY
J	2	7/77; BARE HOLE HL, E/P OUTLET			

SERIES 44

FLA-C

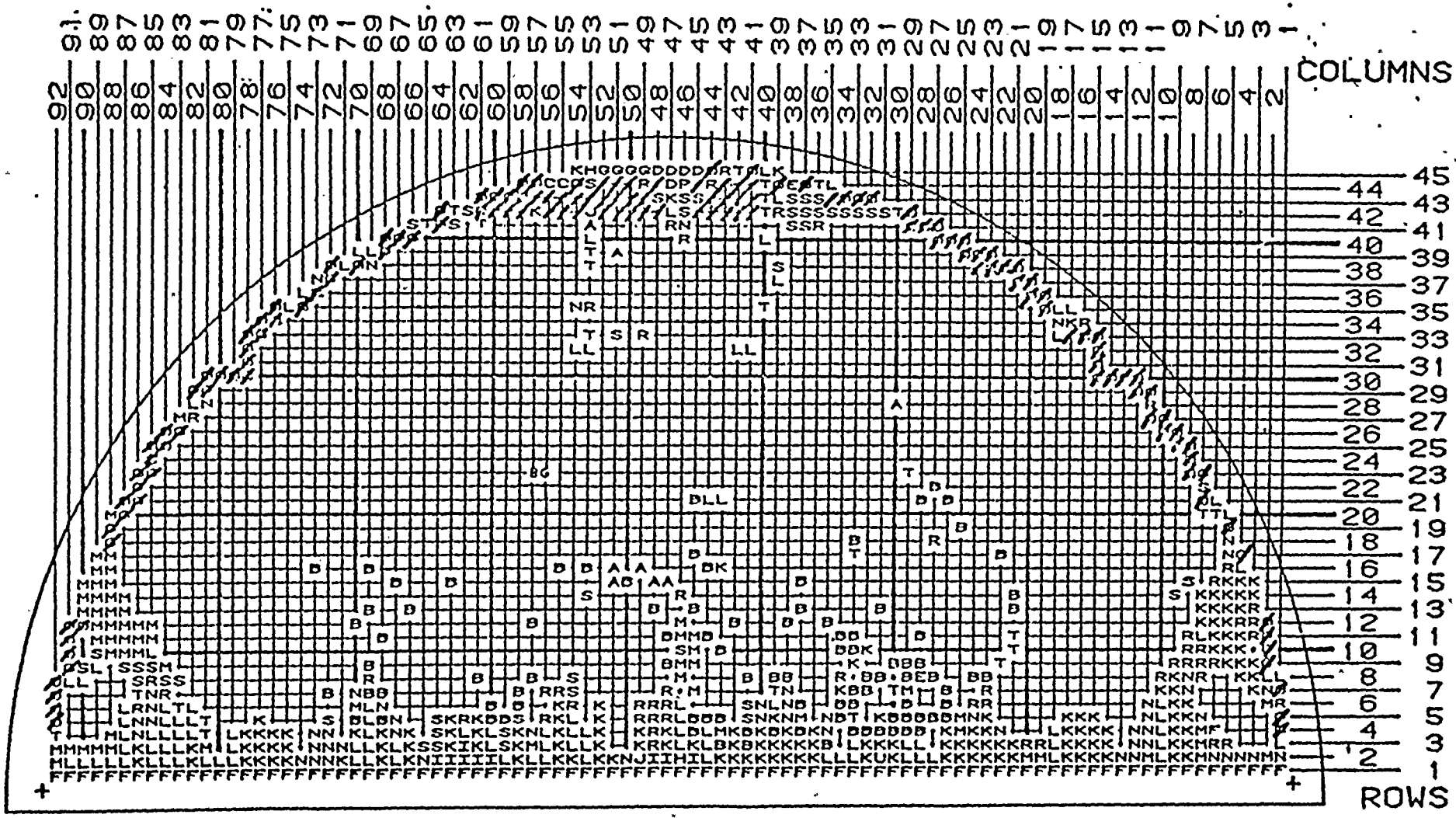


FIGURE 5

TURKEY POINT UNIT 4
STEAM GENERATOR C INLET
JULY, 1982 OUTAGE

A	8	8/74; TUBES PLUGGED	K	158	7/77; TUBES PLUGGED
B	93	8/75; TUBES PLUGGED	L	118	2/78; TUBES PLUGGED
C	2	1/76; TUBES PLUGGED	M	82	8/78; TUBES PLUGGED
D	5	5/76; TUBES PLUGGED	N	54	4/79; TUBES PLUGGED
E	2	8/76; TUBES PLUGGED	P	1	8/78; EP 5/76, VR HL
F	83	11/76; TUBES PLUGGED	R	58	5/80; MECH PLUGGED
G	5	1/77; TUBES PLUGGED	S	48	11/80; MECH PLUGGED
H	2	3/77; TUBES PLUGGED	T	28	11/81; MECH PLUGGED
J	8	4/77; TUBES PLUGGED	U	1	11/81; V/R HL ONLY
	2	7/77; BARE HOLE HL, E/P OUTLET			

SERIES 44

FLA-C

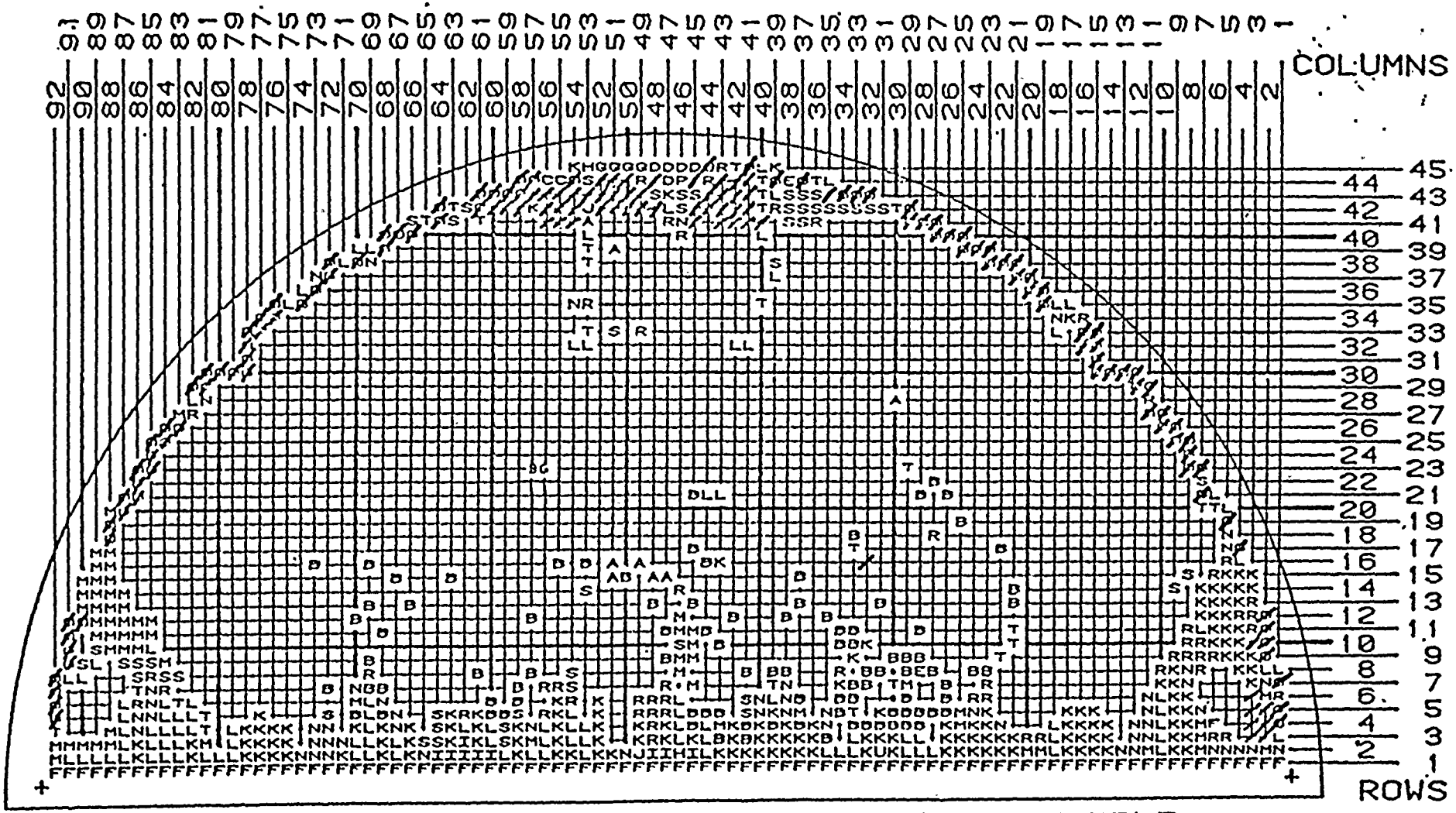


FIGURE 6

TURKEY POINT UNIT 4
STEAM GENERATOR C OUTLET
JULY, 1982 OUTAGE

2.2.2 Results of the Eddy Current Inspection

2.2.2.1 Eddy Current Indications

Eddy Current (wall loss) indications were observed only in Steam Generator B. The reported indications are listed in Table 3.

TABLE 3

TURKEY POINT UNIT 4 - JULY 1982 OUTAGE

EDDY CURRENT INDICATIONS REPORTED

Steam Generator	Row-Column	Eddy Current Indications	Elevation
B inlet	44-57 (leaker)	99 percent	Top of tubesheet
B inlet	44-58	99 percent	Top of tubesheet
B inlet	44-56	56 percent	10" above tubesheet
B outlet	42-31	29 percent	5" above tubesheet
B outlet	42-32	29 percent	5" above tubesheet
B outlet	43-32	32 percent	4" above tubesheet
B outlet	43-33	25 percent	4" above tubesheet
B outlet	43-34	38 percent	4" above tubesheet
B outlet	41-32	<20 percent	25" above tubesheet
B outlet	41-32	<20 percent	40" above tubesheet

With the exception of the tube at R41-C32, the observed indications were at tube locations and elevations which have been correlated directly or approximately with the locations of foreign objects (See Section 2.8, Table 1.)

2.2.2.2 Tube Restrictions

Restrictions to the passage of the eddy current probe were noted in each of the steam generator loops tested. As noted above, gauging with smaller-diameter probes, as required, was accomplished only in Steam Generator

B inlet, since the eddy current inspection was initiated in this leg, where the leaker was located, prior to the availability of results of the secondary-side visual examinations. As these results were made available and it became evident that the leak as well as other reported indications and tube damage were associated with foreign objects observed at or near tube sheet elevations, further EC inspections were made only in the region of interest i.e., up to the first tube support plate, in order to reduce unnecessary exposure. The numbers of tubes restricted to the various-sized probes are listed in Table 4. The locations of the 0.650 and 0.610 inch restrictions in Steam Generator B inlet are shown in Figure 7.

2.3 Results of Profilometry Inspection

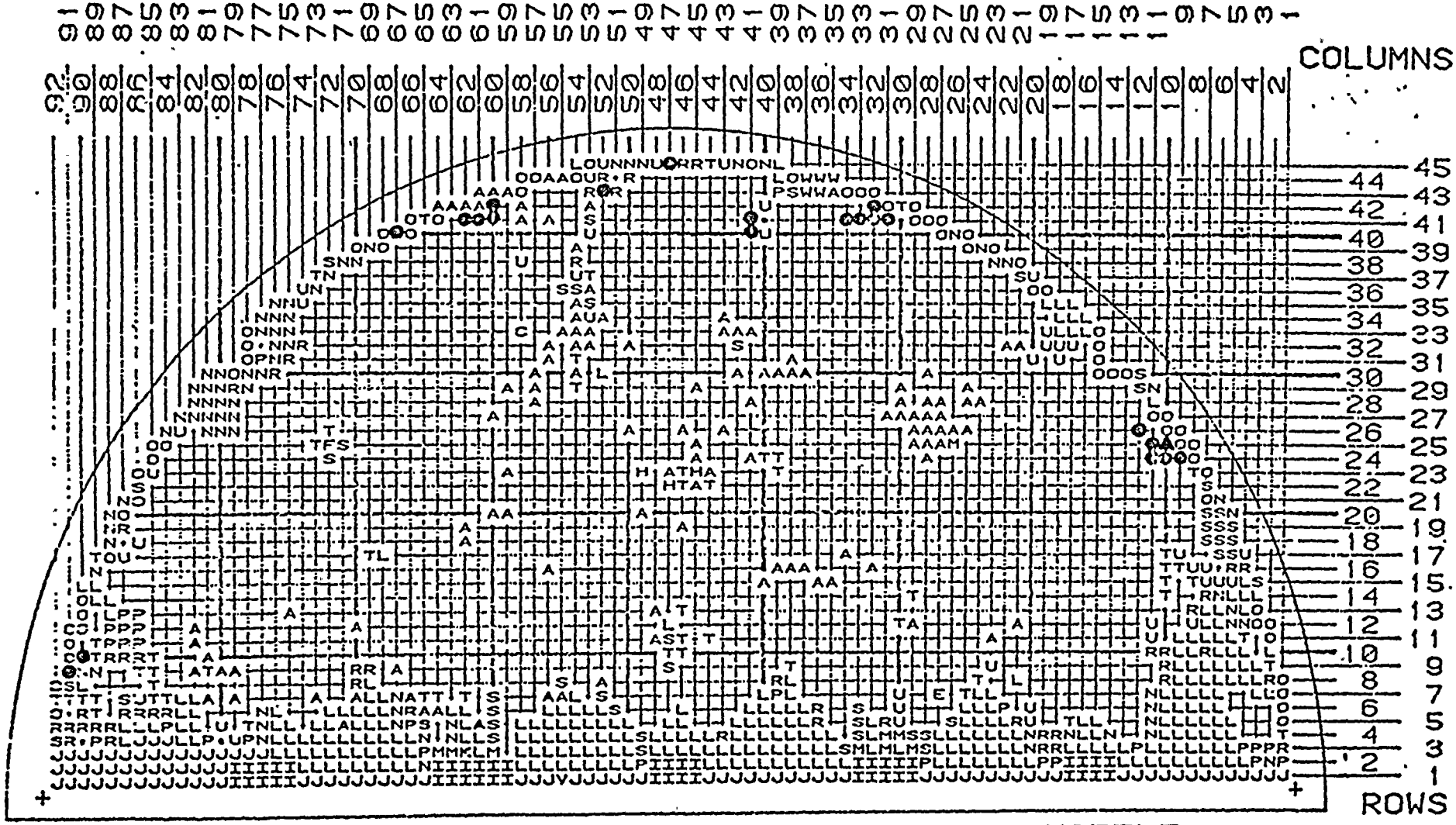
Two (2) tubes in Steam Generator B and thirteen (13 tubes in Steam Generator C were reported as possibly having bulges (detected visually or by the eddy current inspection). A special inspection of these tubes, and three (3) adjacent tubes in S/GB was performed using special probes designed to provide data on the profile of the tubes inner diameters. The purpose of this study was to verify and map the contours and orientation of the reported bulges.

The five (5) tubes inspected by this method in Steam Generator B were the leaker (R44-C57) and four adjacent tubes (R44-C58, and R43-C55, 57, 58). Evaluation of the profilometric data clearly shows bulges in Tubes R44-C57 and 58, where the largest bulges were observed visually, but does not show bulges in the other three tubes in Steam Generator B. In tube R44-C57, the maximum bulge size (inner diameter) was measured as 0.799 inches. This is 24 mils in excess of the nominal tube I.D. of 0.775 inches. In tube R44-C58, the maximum I.D. of the bulge was measured as 0.802 inches. This is 27 mils in excess of the nominal tube I.D. The orientation of the bulges was in the direction of the tube bundle periphery, where one of the foreign objects was observed lying on the tubesheet. Plots of the resulting data for these two tubes along eight radii at the elevation of the maximum bulge radius are shown in Figures 8 and 9.

A	122	TUBES PLUGGED PRIOR TO 10/75	H	9	10/77; TUBES PLUGGED
C	1	6/75; BARE HOLE PLUG HL-E/P CL	N	79	2/78; TUBES PLUGGED
E	1	SHOP WELD	P	28	8/78; TUBES PLUGGED
F	1	9/75; BARE HOLE PLUGS--HL,CL	R	52	4/79; TUBES PLUGGED
H	3	5/75; TUBES PLUGGED	S	48	5/80; MECH PLUGGED
I	45	9/75; TUBES PLUGGED	T	58	11/80; MECH PLUGGED
J	69	11/76; TUBES PLUGGED	U	42	11/81; MECH PLUGGED
K	1	7/77; WELD REPAIR	V	1	11/81; W/P HL ONLY
L	304	7/77; TUBES PLUGGED	W	5	6/82; MECH PLUGGED

SERIES 44

FLA-B



←---- MANWAY

NOZZLE ---→

TURKEY POINT UNIT 4
GAUGING RESULTS-JULY, 1982

TUBE RESTRICTIONS

X = .540 PROBE

NO. OF TUBES

None

1

FIGURE 7

TABLE 4

TURKEY POINT UNIT 4

JULY 1982 OUTAGE

NUMBER OF TUBES RESTRICTING PASSAGE OF PROBE LISTED

S/G	Probe Diameter	Number of Restrictions
A Inlet	.700 - inch	46
A Outlet	.700 - inch	3
B Inlet	.700 - inch	57
	.650 - inch	21
	.610 - inch	1
	.540 - inch	none
B Outlet	.700 - inch	13
C Inlet	.700 - inch	28
C Outlet	.700 - inch	4

Results of the profilometric inspection of the thirteen tubes in steam generator C selected on the basis of bulge-type signals detected in the normal EC inspection at the top of the tubesheet in the outlet leg were inconclusive inasmuch as evidence of bulges (if present) could not be definitely established. Tubes R4-C1; R5-C1; R7-C1; R9-C2; R10-C2; R33-C15; R42-C41, 42, 55; R43-C32, 33, 34; and R44-C37 were the locations thus identified.

2.4 Review of Prior EC Data for R44-C57, R44-C58

Table 5 provides an independent analysis of the eddy current data from Steam Generator B, R44-C57, 58. These data encompass the period from the 1976 inspection to the present. Also included as Figures 10 and 11 are photographs of the oscillographic display of the eddy current signals. These data show incipient wall loss in 1977. The 1981 and 1982 photos indicate a strong tube distortion (bulge) influence at the point of tube penetration.

R 44 C 58

TUBE NOMINAL DIAMETER= .775: NOMINAL RATIO= .388
PROBE DIAMETER= .700: CALIBRATION VOLTS=4.0: STEP= .020

	BULGE RADIUS
R1	.411
R2	.410
R3	.406
R4	.395
R5	.390
R6	.388
R7	.389
R8	.394

	DIAM
D1-5	.800
D2-6	.797
D3-7	.788
D4-8	.799
MAX	.002

MAXIMUM BULGE IN TUBE IS .802 OCCURING AT BULGE
PLOTS OF THIS BULGE ARE SHOWN BELOW

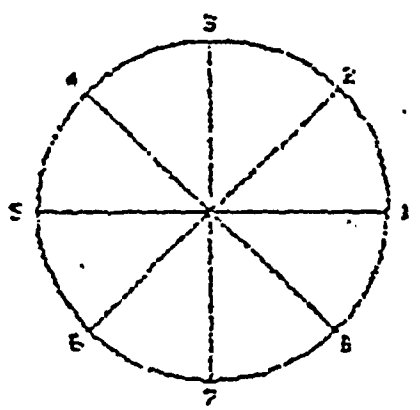


FIGURE 8
TURKEY POINT UNIT 4
RESULTS OF PROFILOMETRY INSPECTION
OF TUBE R44-C57, STEAM
GENERATOR B, INLET

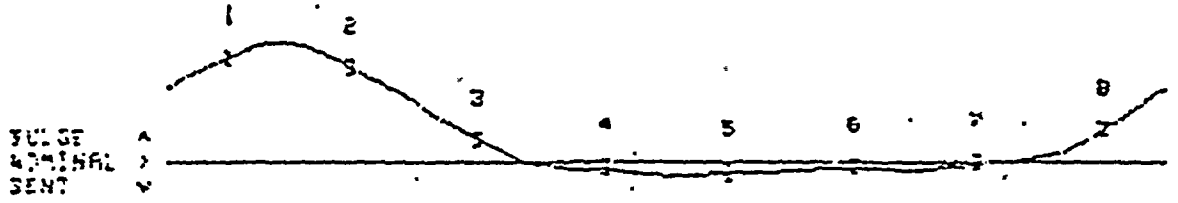
R 44 C 57

[illegible] NOMINAL DIAMETER= .775 [illegible] FACTOR= .0
PROBE DIAMETER= .700 CALIBRATION VOLTS=4.0 STEP= .024

	BULGE RADIUS
R1	.410
R2	.408
R3	.399
R4	.386
R5	.385
R6	.365
R7	.387
R8	.354

	DIAM.
D1-5	.795
D2-6	.784
D3-7	.779
D4-8	.788
MAX	.799

MAXIMUM BULGE IN TUBE IS .799 OCCURING AT BULGE
PLOTS OF THIS BULGE ARE SHOWN BELOW



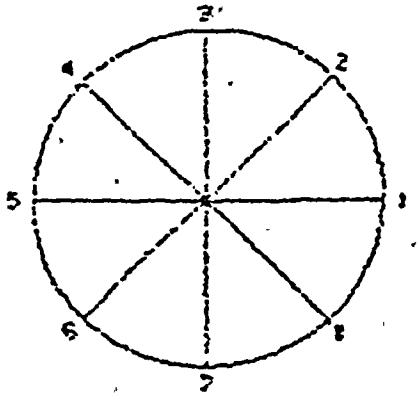


FIGURE 9
TURKEY POINT UNIT 4
RESULTS OF PROFILOMETRY INSPECTION
OF TUBE R44-C58, STEAM GENERATOR B, INLET

TABLE 5

EDDY CURRENT DATA ANALYSIS

STEAM GENERATOR B

ROW 44 COLUMNS 57 AND 58

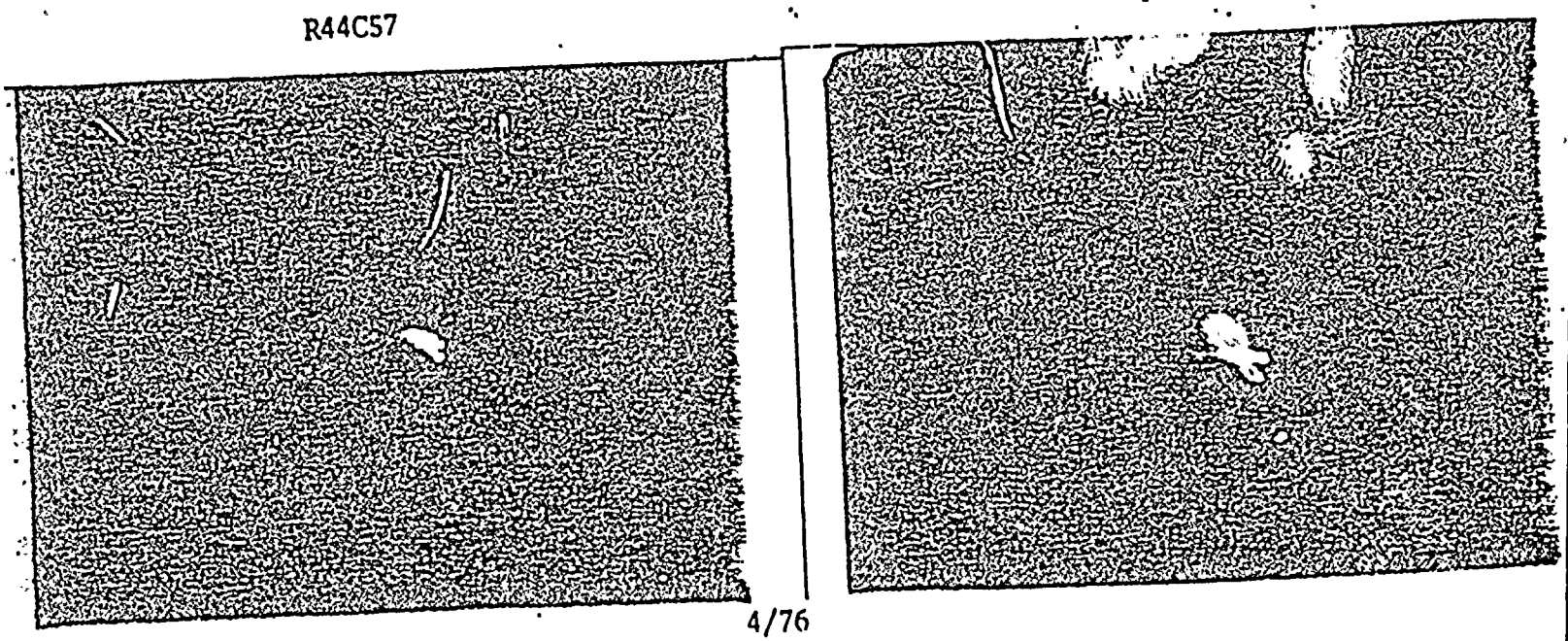
Row 44 Column 57		Row 44 Column 58
April 1976	- Some distortion of the tubesheet but nothing to indicate loss-of-wall or any denting or bulging.	April 1976 - Same as R44-C57
May 1977 and April 1979	Change in distorted tubesheet signal with some indication of loss-of-wall at and above the top of the tubesheet.	May 1977 and April 1979 - Same as R44-C57
May 1980	- Signal starts in the direction of a bulge (to right) but is rapidly drawn back to the left. This could be caused by loss of wall in that area.	May 1980 - Same as R44-C57
July 1981	- Complete saturation of the 400 Khz and the 400/100 Khz mix. No information available other than that there is a fairly large bulge. However, the 100 Khz signal indicates 60 percent - 80 percent loss-of-wall in that area.	July 1981 - Same as R44-C57 f 400 Khz and 400/1 mix. The 100 Khz nal shows the pre of bulging but is torted by a verti component probabl to loss of tubewa
July 1982	- Same as above for 400 Khz and 400/100 Khz mix. Phase angle of 100 Khz signal has rotated further clockwise to the thru-wall area.	July 1982 - Same as R44-C57 f 400/100 Khz mix. 100 Khz signal i at face value wo an I.D. indicati However, it is b that the bulge (goes horizontall the right and th left) combined w O.D. loss-of-wal (which goes down then up) has rot a real O.D. loss wall into the I. plane.

TURKEY POINT #4 (FLA)
STEAM GENERATOR B HL

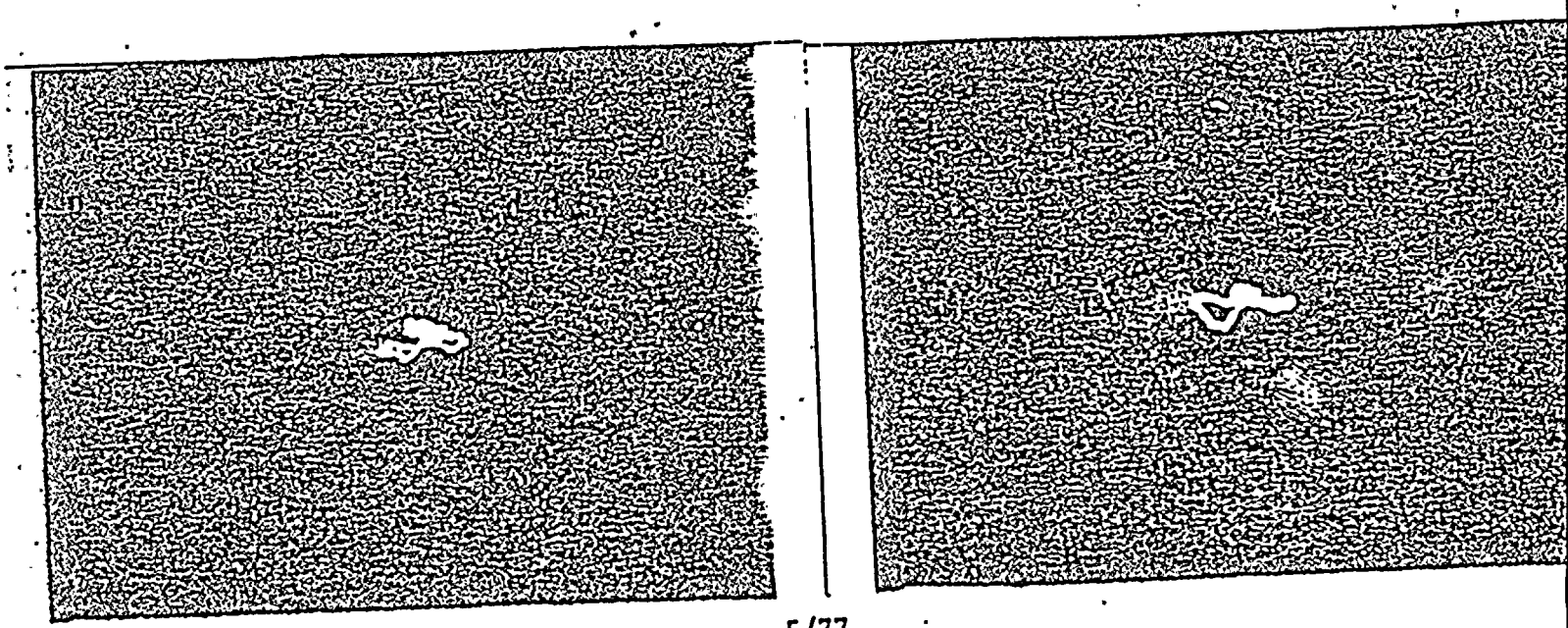
FIGURE 10

R44C57

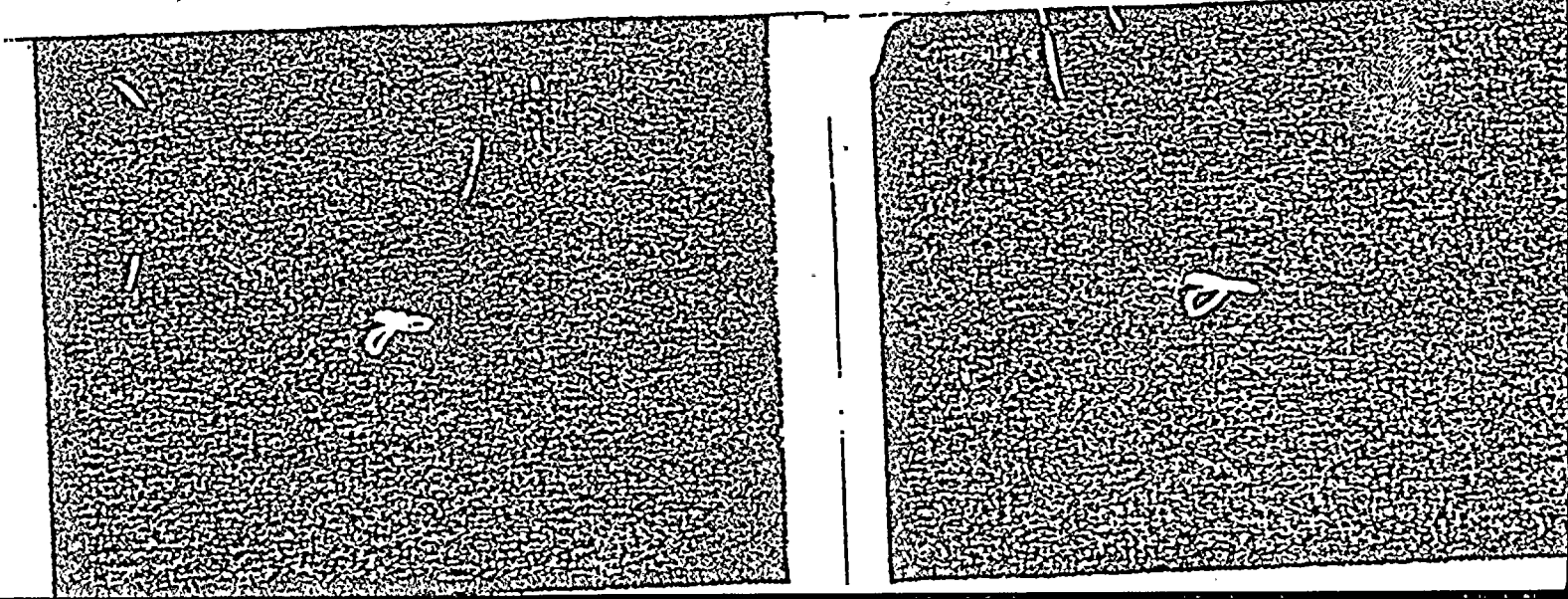
R44C58



4/76



5/77

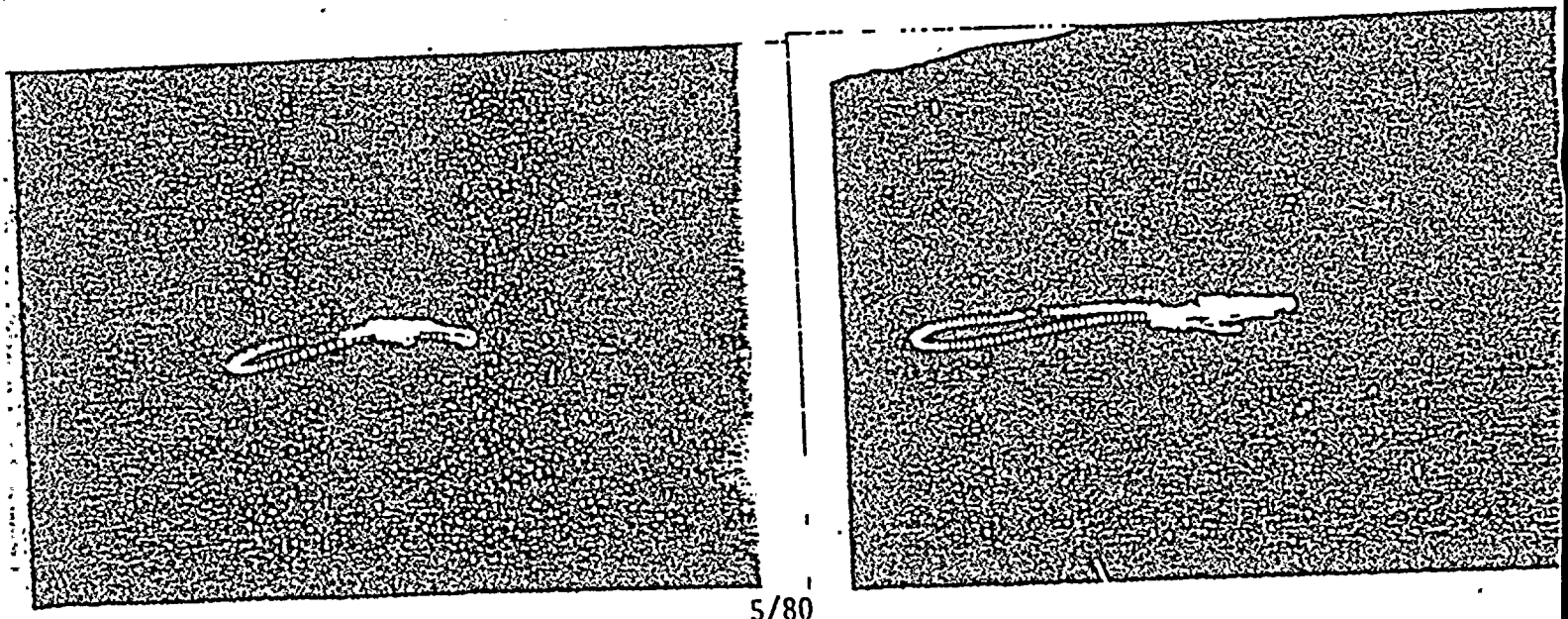


TURKEY POINT #4 (FLA)
STEAM GENERATOR B HL

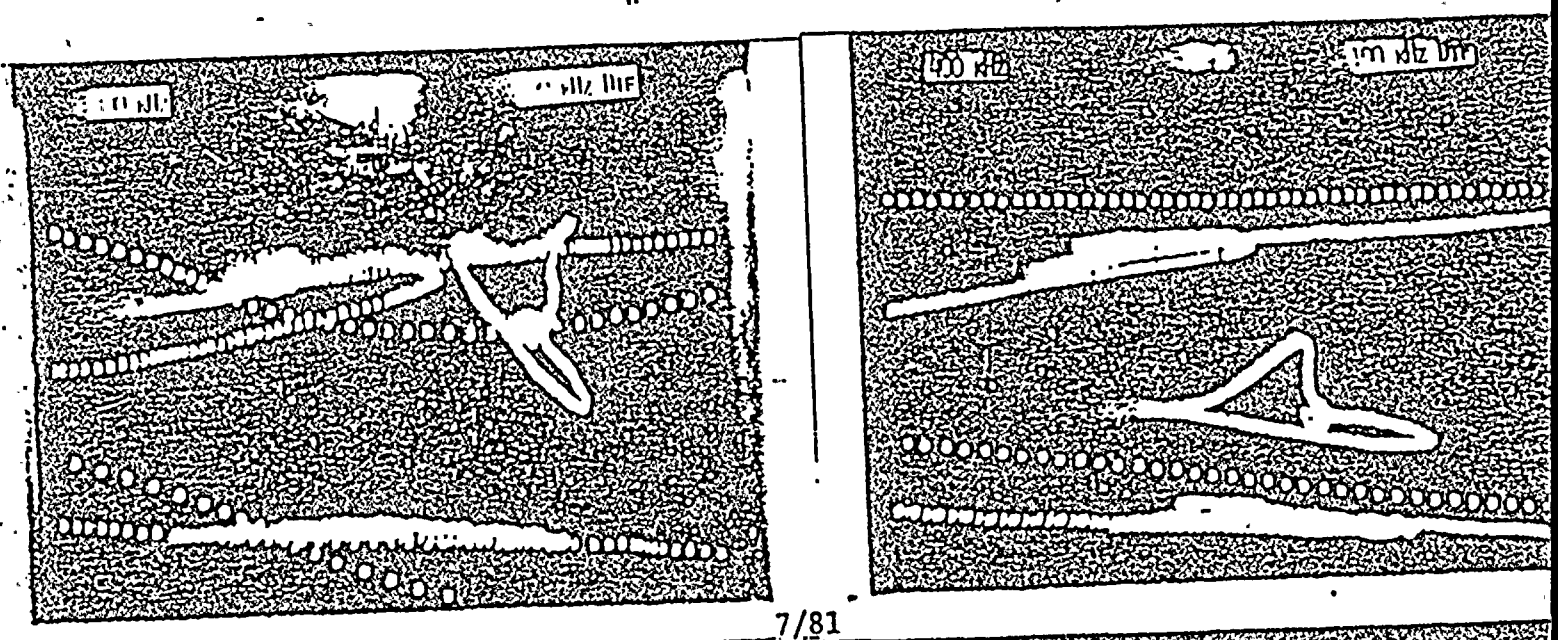
FIGURE 11

R44C57

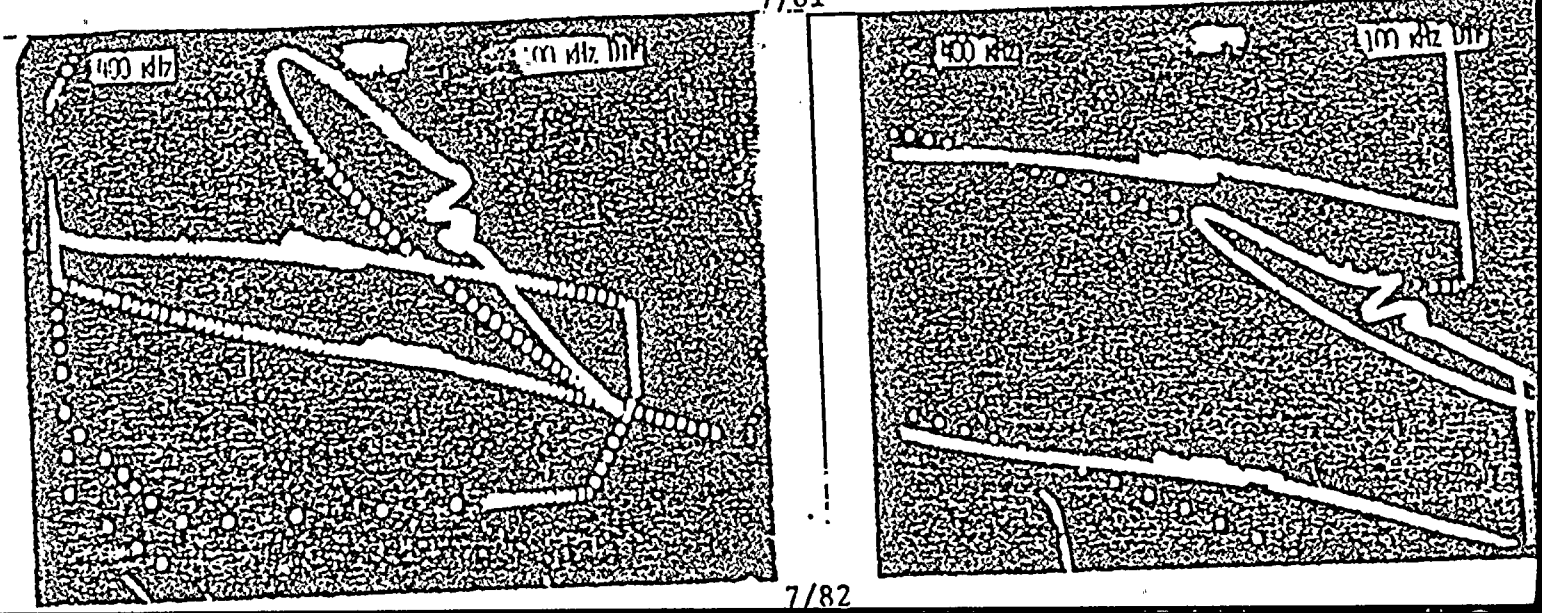
R 44C58



5/80



7/81



7/82

3.0 TUBE DAMAGE ASSESSMENT AND RECOMMENDED SAFEGUARDS

Peripheral tubes in both the hot-and cold-legs of all three steam generators have been examined visually from the secondary side using fiberoptics as well as EC probes through the primary side. Additionally, profilometry was completed on selected tubes which appear to have bulges from the fiberscope examination. The following assessment of tube damage is based primarily on the results of visual examination and supplemented, where applicable, by EC and profilometry data.

The major concern with tube damage on peripheral tubes is the potential of large leakage due to:

(1) Impact/wear damage to an active tube by a loose foreign object, and

(2) Severance near the tubesheet of a structurally degraded plugged tube and its interaction with an active tube, resulting eventually in a large leak due to impact/wear damage.

Based on previous experience, a tube must undergo a significant (visible) structural degradation before it could precipitate any large leak due to either of the above failure paths. The logic to safeguard against any major tube failure is, therefore, to isolate the active tube bundle from all structurally degraded tubes and loose foreign objects. The most positive approach would be to physically remove all foreign objects and structurally unstable tubes if present (and/or segments thereof). However, another acceptable approach would be to create a picket fence around all identified foreign objects and structurally degraded tubes along with a monitoring system to forewarn of any progression of damage through the picket fence towards the active bundle, so as to assure a safe and orderly plant shutdown for any corrective action.

The sentinel plug concept* is recommended for use in tubes forming the picket fence. Since the observed tube damage is primarily to the peripheral tubes and the failure paths for a potential large leak are also associated mainly with these tubes, the sentinel plugs are appropriate next to the damaged peripheral tubes only. Any other areas of concern are recommended to be picket fenced with conventional (mechanical) plugs.

Table 6 summarizes the tube damage assessment and recommended picket tubes with sentinel plugs.

*Sentinel plugs are standard mechanical plugs with a small, built-in leak path, installed in the unit into the inlet side of tubes not known to be damaged but located adjacent to tubes where foreign objects were wedged, or where known tube damage had been established. The purpose of these plugs is to provide early warning in the form of controlled leakage of about 0.15 gallon per minute, in the unlikely event of a damaged peripheral tube severing at the tubesheet and damaging the neighboring tube plugged with the sentinel plug through impact/wear interaction, resulting in a through-wall penetration of the sentinel fence.

TABLE 6

TURKEY POINT UNIT NO. 4 STEAM GENERATORS

SUMMARY OF TUBE DAMAGE ASSESSMENT AND RECOMMENDED SENTINEL PLUGGING*

1. S/G-A

Tubes R43-C32, R44-C35: Local wear marks near tubesheet due to loose weld rod: wear pattern about 3/8" long axially and deepest penetration may be approaching through-wall. Both tubes are structurally stable and were previously plugged.

Sentinels: R44-C36, R43-C33-36, R42-C33 (6 total).

2. S/G-B

Tubes R45-C54: Locally indented over 3/8 to 1/2" near tubesheet
R44-C55-58: Locally bulged near tubesheet, axial length, about 1/4", maximum bulge ~30 mils. (Profilometry on R44-C57-58 shows bulges to extend over 60 to 120 degrees around circumference with maximum bulge size of ~25 mils.)

R45-C53, R43-C59-61: show polishing, peening and small ding marks.
All tubes are structurally stable and with the exception of R44-C57-58, all were previously plugged.

Sentinels: R43-C54-58 (5 total)

3. S/G-C

Tubes R45-C51-54, R44-C55: Indented locally due to impacting by a loose pin; damage somewhat more severe than R45-C54 in S/G-B, with possible thru-wall penetrations on R45-C52 and 53.
All tubes are structurally stable and were previously plugged.

Sentinels: R44-C50-52, R44-C54 (4 total)

* Fence is completed by tubes plugged in previous outages and additional neighboring tubes plugged conventionally at the present outage. Tube R44-C57 in S/G-B was a leaker and was plugged conventionally.

4.0 SAFETY EVALUATION

4.1 Continued Operation with Foreign Objects Present in Steam Generators

All three steam generators have been visually inspected on the secondary side utilizing fiber optic techniques. These techniques allow the inspection of the entire periphery of the tube bundle. The inspection results have cataloged and located observable foreign objects around the periphery of the steam generators. These objects as well as observable tube damage have been documented with photographs. All loose objects have been removed. Three small foreign objects still remain wedged between tubes in the bundle. On the basis of their apparent mass, these objects have been assessed as presenting no potential for tube damage in the event they may become dislodged. An eddy current inspection has been performed around the wedged foreign objects to determine the condition of the tubes adjacent to foreign objects. A review of previous EC inspection tapes has been performed to attempt to determine if wedged foreign objects are in fact wedged and have been in their present locations for a period of time.

The following actions were taken to assure the integrity of the steam generator tubes during the next period of operation: (a) A conservative tube plugging program including preventive plugging and the use of sentinel plugs was developed during the foreign object retrieval operations as a contingency position in the event that the larger, more significant of these objects could not be removed. As the retrieval efforts continued, all of the significant objects were successfully removed. However, the planned plugging program has been implemented in full to maintain conservatism. All the tubes surrounding the wedged foreign objects have been plugged and sentinel plugs have been installed around potentially degraded tubes. Sentinel plugs are standard mechanical plugs with a small leak path built into the plug. The sentinel plug will alert the operator in the unlikely event that a tube adjacent to potentially degraded tube has started to leak, will limit the postulated leak and will allow the plant to respond to the situation in a normal controlled manner, (b) A metal impact monitoring system has been installed on the secondary side of each steam generator as a means of detecting wedged foreign objects which may become dislodged or any additional foreign objects which may

intrude into the steam generators. The detection of significant impacts will allow the plant to undergo an orderly shutdown for steam generator inspection.

The proposed period of operation for the unit is until approximately mid-October 1982 at which time it is planned to shut down for steam generator replacement.

Completion of the above actions and the short operating interval allow operation of this plant with known foreign objects in the steam generator without presenting undue risk to the health and safety of the public.

4.2 Tube Plugging

As a result of the eddy current and visual inspections, a number of tubes were plugged for various reasons. In each steam generator, several tubes were considered to be pluggable due to their proximity to observed foreign objects, the presence of a bulge in the tubes, or both. Additionally, in Steam Generator B, the leaker (R44-C57), an adjacent tube with a 56 percent eddy current indication (R44-C54), and three tubes with restrictions at the tube support plates were designated for plugging. In the case of the restricted tubes, one was a 0.610 inch restriction, a size which had been plugged in earlier inspections in this unit, and the others were 0.650 inch restrictions, plugged conservatively because of their peripheral locations.

Sentinel plugs were installed into fifteen of the tubes, as described in Section 3.0 above.

The location of the tubes plugged is shown in Figures 12, 13, and 14 for Steam Generators A, B, and C respectively.

A list of the tubes plugged, including the location of the sentinel plugs, is given in Table 7.

A	33	9/74; TUBES PLUGGED	I	169	2/78; TUBES PLUGGED
B	63	6/75; TUBES PLUGGED	J	86	8/78; TUBES PLUGGED
C	1	DATE NOT KNOWN, TUBES PLUGGED	K	2	SHOP WELD, HL MISDRILLED
D	1	SHOP WELD	L	79	4/79; TUBES PLUGGED
E	2	5/76; TUBES PLUGGED	M	72	5/80; MECH PLUGGED
F	92	11/76; TUBES PLUGGED	N	27	11/80; MECH PLUGGED
G	131	7/77; TUBES PLUGGED	P	36	11/81; MECH PLUGGED
H	1	7/77; WELD REPAIR HL, E/P CL			

SERIES 44

FLA-A

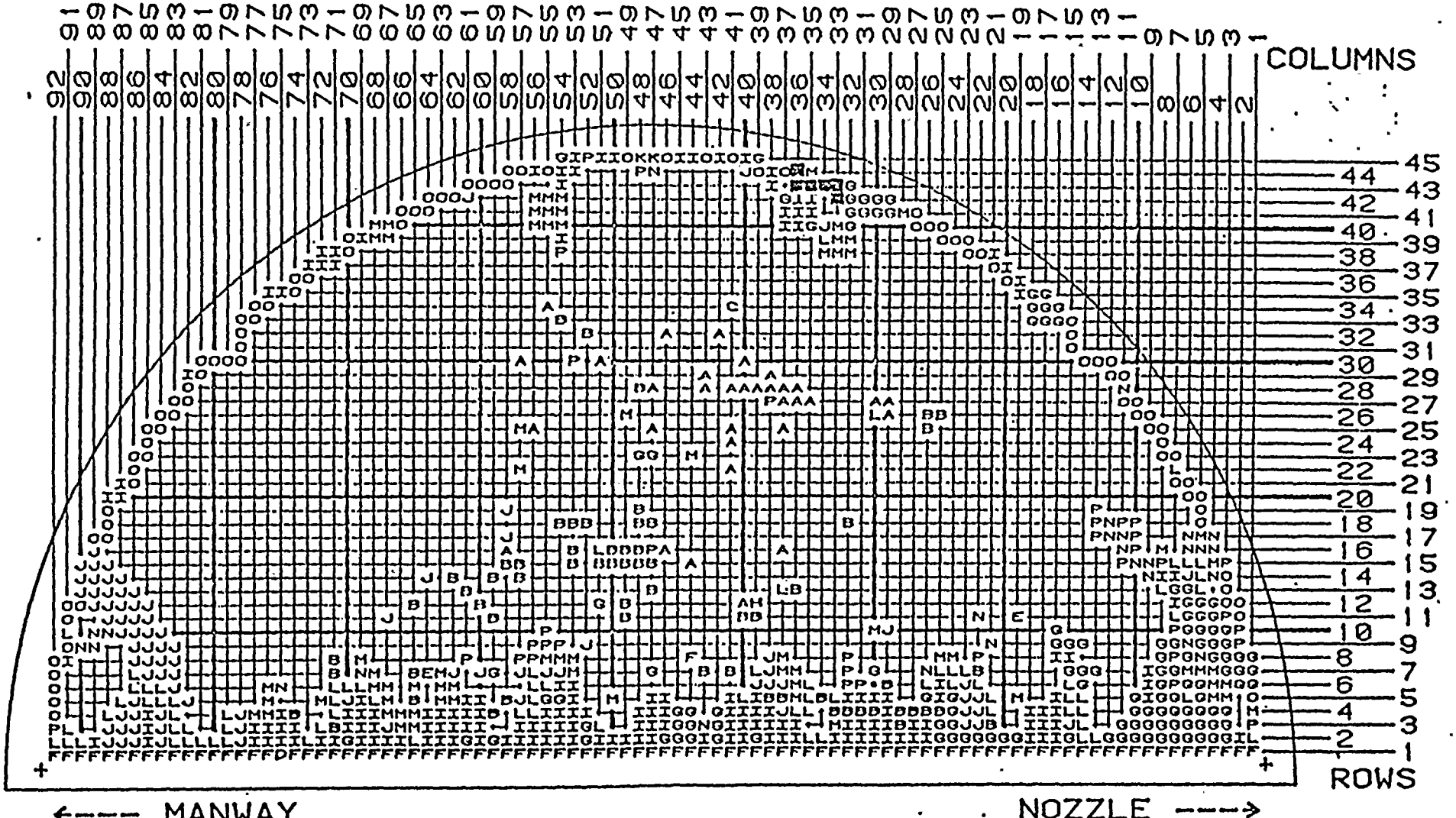
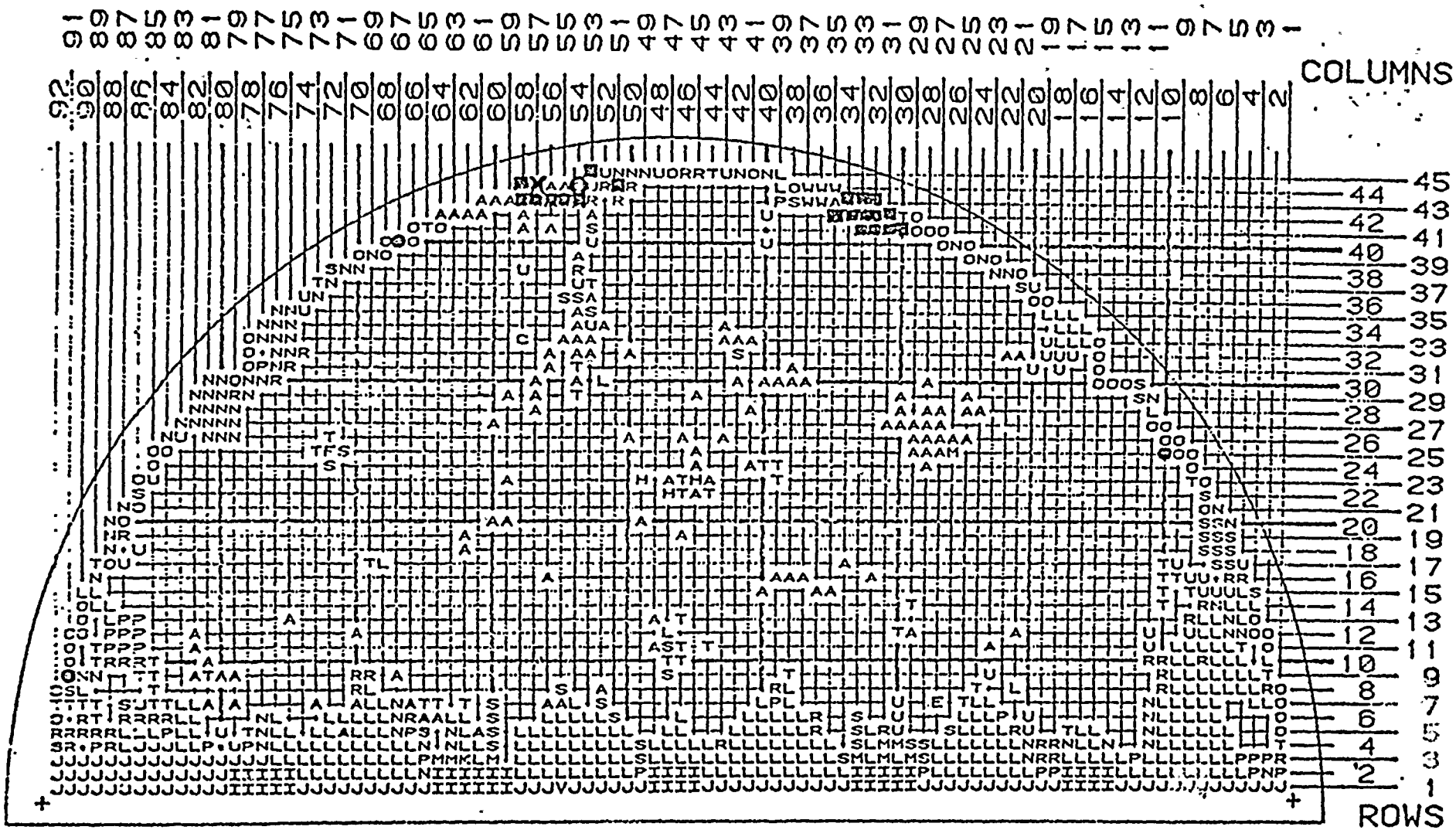


FIGURE 12
TURKEY POINT UNIT 4
STEAM GENERATOR A
JULY, 1982 OUTAGE
RECOMMENDED PLUGGING

A	120	TUBES PLUGGED PRIOR TO 10/75	H	9	10/77; TUBES PLUGGED
C	1	8/75; BARE HOLE PLUG HL-E/P CL	N	79	2/78; TUBES PLUGGED
E	1	SHOP WELD	P	28	8/78; TUBES PLUGGED
F	1	9/75; BARE HOLE PLUGS--HL,CL	R	52	4/79; TUBES PLUGGED
H	3	5/75; TUBES PLUGGED	S	48	5/80; MECH PLUGGED
I	48	9/75; TUBES PLUGGED	T	56	11/00; MECH PLUGGED
J	69	11/76; TUBES PLUGGED	U	42	11/81;MECH PLUGGED
K	1	7/77; WELD REPAIR	V	1	11/01;W/P HL ONLY
L	304	7/77; TUBES PLUGGED	W	5	6/02; MECH PLUGGED

SERIES 44

FLA-B



TURKEY POINT UNIT 4
STEAM GENERATOR B
JULY, 1982 OUTAGE

RECOMMENDED PLUGGING

X LEAKING TUBE (1)

PREVENTIVE PLUGGING DUE TO FOREIGN OBJECT (20)

o PREVENTIVE PLUGGING FOR EDDY CURRENT INDICATION (1)

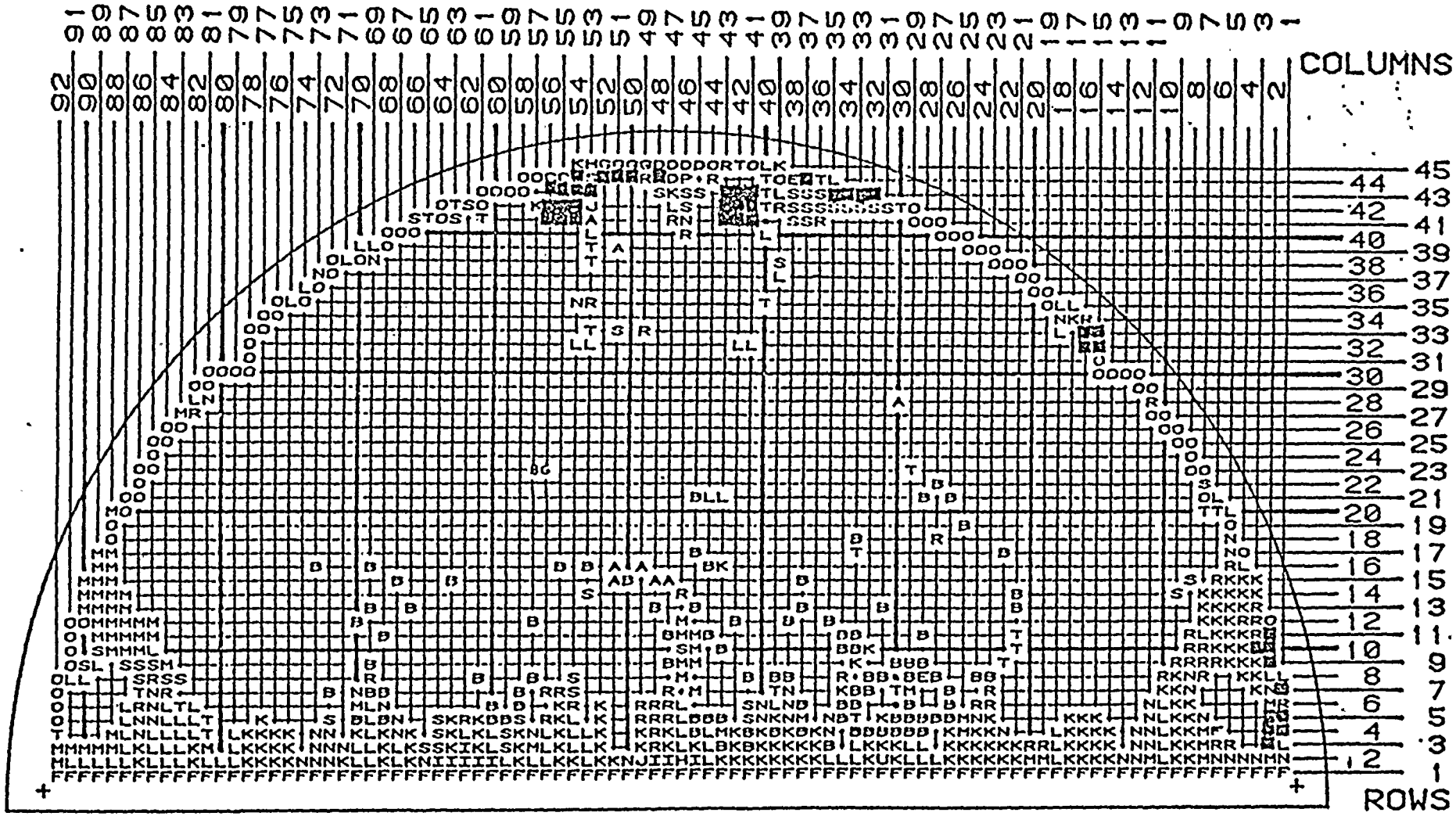
● PREVENTIVE PLUGGING FOR RESTRICTIONS (3)

FIGURE 13

A	8	9/74; TUBES PLUGGED
B	96	6/76; TUBES PLUGGED
C	2	1/76; TUBES PLUGGED
D	6	6/76; TUBES PLUGGED
E	2	9/76; TUBES PLUGGED
F	83	11/76; TUBES PLUGGED
G	6	1/77; TUBES PLUGGED
H	2	3/77; TUBES PLUGGED
I	8	4/77; TUBES PLUGGED
J	2	7/77; BARE HOLE HL. E/P OUTLET
K	166	7/77; TUBES PLUGGED
L	119	2/78; TUBES PLUGGED
M	62	8/78; TUBES PLUGGED
N	54	4/79; TUBES PLUGGED
P	1	8/76; EP 6/76, WR HL
R	56	5/80; MECH PLUGGED
S	48	11/80; MECH PLUGGED
T	28	11/81; MECH PLUGGED
U	1	11/81; W/R HL ONLY

SERIES 44

FLA-C



TURKEY POINT UNIT 4
STEAM GENERATOR C
JULY, 1982 OUTAGE

RECOMMENDED PLUGGING

▩ PREVENTIVE PLUGGING DUE TO FOREIGN OBJECTS OR BULGE (43)

FIGURE 14

TABLE 7
TURKEY POINT UNIT 4
JULY 1982 OUTAGE

RECOMMENDED TUBE PLUGGING

The following tubes are recommended for plugging:

Steam Generator "A": (6 tubes)

Preventive Plugging due to proximity to foreign objects:

R42 - C33*
R43 - C33*, 34*, 35*, 36*
R44 - C36*

Steam Generator "B": (25 tubes)

Preventive Plugging due to proximity to foreign objects:

R41 - C30, 31, 32, 33
R42 - C31, 32, 33, 34, 35
R43 - C32, 33, 34, 54*, 55*, 56*, 57*, 58*
R44 - C51, 58
R45 - C53

Leaking Tube:
R44 - C57

Plugging for Eddy Current Indications:
R44 - C54 (56 percent)

(*) Denotes sentinel plugs installed on the inlet side, normal plug to be installed on the outlet side of the designated tubes.

TABLE 7 (CONTINUED)

RECOMMENDED TUBE PLUGGING

Preventive Plugging for Restrictions:

R 9 - C91
R25 - C10
R40 - C67

Steam Generator "C": (43 tubes)

Preventive Plugging due to presence of tube bulges or proximity to foreign objects:

R 3 - C 2
R 4 - C 1, 2
R 5 - C 1, 2
R 7 - C 1
R 9 - C 2
R10 - C 2, 3
R11 - C 2
R32 - C15, 16
R33 - C15, 16
R41 - C41, 42, 43, 54, 55, 56
R42 - C41, 42, 43, 54, 55, 56
R43 - C32, 33, 34, 35, 41, 42, 43, 53, 54, 55, 56
R44 - C37, 48, 50*, 51*, 52*, 54*

(*) Denotes sentinel plugs installed on the inlet side, normal plugs to be installed on the outlet side of the designated tubes.

APPENDIX 1

Foreign Object Retrieval Operations Performed in Secondary Side of Turkey Point Unit No. 4 Steam Generators July, 1983 Outage

The techniques used in retrieving the objects required the use of electromagnets, horseshoe magnets, grabbers, electricians snake and a special tool used to move objects out into the annulus from between the tubes. The special tool sends a piece of banding material down the tube lane and bends it 90° to go between the tubes and ease the objects into the annulus.

Extreme care was taken when pushing the objects into the annulus to prevent damage to the tube bundle. There is usually no contact with the tubes when retrieving objects in the annulus. Most of the retrieval tools are wrapped with heat shrink tubing to prevent scratching tubes.

APPENDIX 2

UNIT 4 STEAM GENERATOR LOOSE PARTS MONITOR

DISCUSSION:

The steam generator MIM system is a 6 channel system. Each channel consists of a detector, a 932 Amplifier Module and a 1432 Impact Detector Module. The 6 channels feed a 1433P Control Module and a 1433C Audio Monitor. A system alarm is indicated on the 133A alarm module and on Annunciator Panel G where the alarm is combined with the Reactor Vessel Metal Impact Alarm.

Each 932 Amplifier module has two controls. One sets the low pass filter upper frequency limit. It is normally set at 50KHZ and should not require any resetting. The second switch determines the amplifier gain. It is set at a value of 50 and should not require adjustment. Higher settings will overload the amplifier as indicated by the amplifier monitor light turning from green to red. A lower setting will reduce gain and system sensitivity. An excessive number of spurious system alarms can be reduced by lowering the gain setting. It should however remain at a value of at least 20. If the gain is adjusted to reduce the number of spurious alarms I & C should be notified.

The 1432 Impact Detector modules have no front panel adjustments. The module uses a filter arrangement to establish a reference background noise signal, it then looks for a transient noise signal at a given level above background. When this occurs, a channel alert will occur and be indicated by a red light on the 1432 module.

The 1433P control module is activated when any of the six impact channels gives an alert. The control module will display the number of the first channel that signals an alert. It will also start a timed counter. If 5 channel alerts on a given module occur in a 10 second period, a system alarm will occur. If 5 alerts in 10 seconds are not detected, then the system will automatically reset. The module has two controls. The alarm reset switch is used to reset a system alarm. It must be depressed to clear the system after an alarm condition has occurred. The second switch is the Auto Reset Period Switch. It is normally in the enable position. When placed in disable, it eliminates the 10 second time period requirement for a system alarm.

The 133 Alarm module has a red indicator light that indicates a system alarm and an alarm test push button.

The 1433 C Audio Monitor module has a speaker and a selector switch that can be used to monitor the audio on any one of the six channels. All other controls are used for an internal test simulator and should not be used for normal system operation.

A listing of channel numbers and detector locations is attached as enclosure (1). The system sensitivity is set so that it will detect a 0.048 ft-lbf impact 1 foot from the detector. Because of this high value of sensitivity alarms can be expected during any evolution which changes the status of the plant. An actual metal impact will be a very loud metalic clank on the audio speaker.

STEAM GENERATOR LOOSE PARTS MONITOR DETECTOR LOCATION

Channel Number	Location	1432 Module Label
1	4A S/G Lower Level Tap	A
2	4A S/G Tube Sheet Drain	AA
3	4B S/G Lower Level Tap	B
4	4B S/G Tube Sheet Drain	BB
5	4C S/G Lower Level Tap	C
6	4C S/G Tube Sheet Drain	CC

Enclosure (1)