Docket

REGULATORY DOCKET FILE COPY

Docket No. 50-206

AUGUST 0 8 1980

LICENSEE: Southern California Edison Company

FACILITY: San Onofre Unit No. 1

SUBJECT: REPORT OF JULY 10, 1980 MEETING TO DISCUSS THE RESULTS OF STEAM GENERATOR INSPECTIONS AND CORRECTIVE ACTIONS FOR SAN ONOFRE UNIT 1

NRC and Southern California Edison Company representatives met in Bethesda, Maryland, on July 10, 1980, to discuss the ongoing steam generator tube inspections at San Onofre Unit No. 1. The meeting attendees are listed in Attachment 1.

SCE requested the meeting to present the results of their inspections and discuss additional investigations. The results of their investigations with a more sensitive eddy current probe indicate about 1/4 of the tubes examined have indications of cracking above the 50% penetration plugging limit. Less than 150 man rem exposure was accumulated since the steam generator inspection began during this current outage. The additional investigations will include further eddy current testing, removal of five additional tubes for more detailed examination, primary and secondary side pressure testing of the tube bundles, and an investigation (including secondary water chemistry) of operating conditions. It is expected that the facility will remain shut down through August.

The licensee provided handouts of the presentation; this is included in Attachment 2.

Original signed by

Stanley J. Nowicki, Project Manager
Operating Reactors Branch #5
Division of Licensing

Enclosures:
1. List of Attendees
2. Presentation

cc w/encl:
See next page

8009020448

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SURNAME	SNowicki:lb					
DATE	8/7/80					

NRC FORM 318 (9-76) NRCM 0240 ☆U.S. GOVERNMENT PRINTING OFFICE: 1979-289-369

50-206

LIST OF ATTENDEES

NRC

G. Lainas
D. Crutchfield
B. D. Liaw
W. J. Collins
A. Burger
E. J. Brown
V. Benaroya
E. Murphy
D. T. Huang
R. Emch
B. Turovlin
L. Frank
V. Noonan

BNL

J. Weeks
D. van Rooyen

Westinghouse

T. R. Timmons
W. D. Fletcher
R. T. Beglen
D. D. Malinowski
E. P. Morgan
C. Lissenden, Jr.
J. L. Houtman
C. W. Hiast

Southern California Edison

B. L. Curtis
H. L. Ottoson
R. W. Krieger
M. P. Baskin

OFFICE ▶						
SURNAME ▶						
DATE ▶						

Meeting Summary Distribution
Southern California Edison
July 10, 1980 Meeting

Docket File
NRC PDR
Local PDR
ORB#5 Reading
NRR Reading
H. R. Denton
E. G. Case
D. G. Eisenhut
R. A. Purple
J. Olshinski
T. Novak
R. Tedesco
G. Lainas
G. Zech
J. Heltemes, AEOD
S. Varga
T. Ippolito
R. Reid
R. Clark
B. J. Youngblood
A. Schwencer
J. R. Miller
Licensing Branch #3
D. Crutchfield
Systematic Evaluation Program Branch
Operating Reactors Assessment Branch
S. Nowicki
OELD
OI&E (3)
H. Smith
ACRS (16)
NSIC
TERA
NRC Participants

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

August 8, 1980

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Stanley J. Nowicki

Stanley J. Nowicki, Project Manager
Operating Reactors Branch #5
Division of Licensing

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2. Presentation

cc w/encl:
See next page

Attachment 1

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H. L. Ottoson
R. W. Krieger
K. P. Baskin

Attachment 2

SCE - NRC

MEETING ON STEAM GENERATORS

JULY 10, 1980

•	INTRODUCTION	SCE
•	BACKGROUND-CHRONOLOGY-ACTIONS	SCE
•	INSPECTIONS AND FINDINGS	W
•	TUBE SAMPLE EXAMINATIONS	W
•	PRESSURE TESTS	W
•	SUMMARY	SCE

I. CHRONOLOGY

A. June, 1979 - Maintenance Outage

1. Primary to secondary leakage identified in steam generator A going into outage.

2. Eddy current inspection performed in steam generators A and C.

(A) 639 tubes in steam generator A hot leg inspected through first support plate - 21 plugged due to tube sheet area indications.

(B) 215 tubes in steam generator C hot leg inspected through first support plate - no pluggable indications

B. August, 1979

1. Westinghouse evaluation of June, 1979 eddy current inspection received.

2. Recommendations included:

(A) Cycle VIII refueling outage eddy current inspection program in steam generators A, B, and C.

(B) Steam generator secondary chemistry control modifications.

(C) Suggested tube pulling during Cycle VIII refueling outage.

C. February - April, 1980

1. Steam generator leakage observed steady at 40-60 GPD following TMI outage

2. Steam generator leakage begins to accelerate, reaches approximately 260 GPD on April 8, 1980.

D. April 8, 1980

Unit shutdown due to steam generator primary to secondary leakage.

E. April 13, 1980 - Steam Generator Secondary Side Hydro.

1. Steam generator C - 5 leaking tubes indentified.

2 Steam generator B - 3 possible leaking tubes identified.

3. Steam generator A - 1 possible leaking plug identified.

4. Steam generator C - 5 leakers plus 2 adjacent tubes eddy current tested by hand. All tubes indicated 99%-100% through wall degradation at top of tube sheet (TTS).

F. April 28, 1980 - Westinghouse/SCE Meeting in Pittsburgh

1. TTS experiencing apparent corrosive attack to extent not previously detected

2. Eddy current inspection program expanded to include all tubes through first support plate on hot legs of steam generators A, B, and C.

3. Selection of tubes to be pulled for examination dependent upon eddy current results.

G. June 18, 1980 Meeting with NRC Staff and Westinghouse/SCE personnel to present findings of chemistry program review, eddy current data evaluation, removed tube metallurgical examinations and revised inspection program

H. July 10, 1980 Meeting with NRC staff and Westinghouse/SCE personnel to present revised inspection program

II. FINDINGS

A. Chemistry Program Evaluation

Evidence of high ratio phosphates and possible free caustic intermittently since mid-1978.

B. Eddy Current Inspections

1. Extensive confirmed tube wall degradation at TTS in hot legs of all steam generators (~400 pluggable tubes).
2. Possible extensive unconfirmed tube wall degradation at TTS in each steam generator (complex eddy current signals for ~130 tubes).

C. Metallurgical Examinations of Removed Tube Specimens

1. Caustic induced intergrandular attack (IGA) occuring nearly through wall in specimens from tubes R24C71 (95% TTS indication, 26% indication ~11" above TTS) and R31C28 (complex eddy current indication at TTS).

2. IGA and cracking observed in tube sheet crevis of tube R17C52 (95% indication ~4" below TTS in tube sheet crevis).

3. IGA not readily detected and quantified by standard eddy current coil.

4. IGA at TTS not previously observed in domestic and foreign PWR's.

D. Revised Inspection Program

1. Eddy current inspections with new surface coil (pancake) probe.

   (A) Inspect 4 tubes selected for removal from steam generator C with pancake probe to provide correlation data prior to tube removal.

   (B) Inspect additional ~2200 tubes in steam generator A to determine suitability of new probe.

2. Remove tubes R13C67, R11C69, R14C70, and R32C71 from steam generator C from below the first support plate in order to:

   (A) Establish condition of tubes near and away from regions of the tube sheet being affected by apparent IGA at the TTS.

(B) Correlate existing eddy current data with actual condition of tubes.

(C) Correlate eddy current data from new probe with actual condition of tubes.

3. In-situ pressure tests.

(A) Perform in-situ pressure tests.

(1) Establish that tubes "Leak Before Break" to reduce safety concern.

(2) Establish margins of structural integrity of tubes affected by IGA.

(3) Determine the fracture mode of tubes affected by IGA (i.e., axial rupture or circumferential rupture).

(B) Tubes which experience rupture will be visually examined by fiberscopic technique to determine fracture mode.

(C) Data obtained will be useful, if not essential, in justifying continued operation in the absence of knowledge of the rate at which IGA corrosion is occurring.

III. RESULTS FROM REVISED INSPECTION PROGRAM

A. Eddy Current Inspections with New Probe in Steam Generator A.

1. Technique is sensitive to IGA whenever grain boundary sparation is present (IGA cannot be reliably detected and quantified otherwise).

2. Technique detects IGA in tubes not previously detected using conventional eddy current probe.

3. Quantity of tubes requiring plugging based on the 50% plugging limit has increased.

   (A) Conventional probe - 178 out of 3,699 inspected.

   (B) New probe - 299 out of 1179 inspected.

B. Visual and Non-Destructive Examinations of Removed Tube Specimens.

1. R13C67

   This tube had a slighty distorted large dent signal using the conventional eddy current probe. Hand probing prior to removal using the new probe yielded a 54% indication. The tube fractured at TTS on removal. Visual examination showed nearly through wall IGA at certain locations on the fracture face.

2. R11C66 and R32C71

   These tubes each had non-distorted, large dent signals using the conventional eddy current probe. Hand probing using the new probe prior to removal yielded no indication of IGA. Both tubes fractured at TTS during removal. Visual examination showed IGA at various locations and depths around the fracture face.

3. R14C70

   This tube had no indication of either a dent on IGA using both the conventional eddy current probe and the new probe prior to removal. The tube did not fracture upon removal. Visual and radiographic examination disclosed the presence of circumferentially oriented cracks at TTS. Estimated depth of penetration is 35% to 45% through wall. Tube will be subjected to laboratory pressure test to burst pressure followed by metallurgical examinations.

ACTIONS

- CONTINUE RPC EDDY CURRENT TESTING
- INDIVIDUAL PRESSURE TEST 5 LEAKERS IN SG-C
- INDIVIDUAL PRESSURE TEST TUBES (TEST FIRST WITH RPC)
- PULL TUBES (TEST FIRST WITH RPC)
- RCS PRESSURE TEST OF BUNDLE
- SS PRESSURE TEST OF BUNDLE
- PLUG TUBES
- CHEMISTRY FLUSHING
- INSTITUTE CHANGES IN CHEMISTRY CONTROL
- REDUCED CONDITIONS OPERATIONS
- REPAIR

SAN ONOFRE #1

STEAM GENERATOR TUBE INSPECTION
EDDY CURRENT DATA ANALYSIS
FOR THE
APRIL, 1980 OUTAGE

SAN ONOFRE #1

STEAM GENERATOR TUBE INSPECTIONS

BACKGROUND

- DENTING

  Successive inspections since 1977 demonstrated that no significant progression of denting was occurring.

- ANTI-VIBRATION BAR WEAR

  Tube degradation due to wear prior to 1977 was arrested by the insertion of an additional set of square, Inconel (chromium plated) bars.

- THINNING

  Tube degradation due to phosphate thinning in the sludge pile region at or above the tubesheet had been progressing at a low rate through October, 1978.

- CRACKING

  Prior to June, 1979, no tube cracking had been reported in the SONGS #1 steam generators.

SAN ONOFRE #1

EDDY CURRENT DATA EVALUATION

JUNE, 1979 OUTAGE

- Outage due to tube leaks in steam generator A.
- Leak check showed 2 tubes leaking in SG/A.
  - One in tubesheet crevice
  - One at top of the tubesheet
- EC Program in SG/A: 639 hot leg tubes to #1 support plate @ 400 kHz.
  - 21 tubes with EC $\geq$ 50%
  - 37 tubes with EC > 20% < 50%
  - 10 tubes with EC < 20%
- Tubes plugged - 21
  - 19 for EC indications at top of the tubesheet.
  - 2 for EC indications in the tubesheet crevice.
- SG/C inspection program: 215 hot leg tubes to #1 support plate @400 kHz.
  - No quantified indications
  - No tubes plugged
  - 52 tubes reported with distortions of the tubesheet signals include R12C36 which leaked in April, 1980.

SAN ONOFRE #1

SG TUBE LEAKAGE: APRIL, 1980

Low level tube leakage (approx. 50 gpd) reported during February-March, 1980 after outage for maintenance.

Increased tube leakage apparent in early April reached approx. 250 gpd.

Shutdown April 8 was three (3) days in advance of refueling outage schedule.

Hydro test of SG's confirmed tube leakage in SG/C (5 tubes); possible tube leakage in SG/B.

Hand probing of leakers and 2 other tubes showed deep penetration EC signals at the top of the tubesheet in SG/C.

The EC program was modified to encompass all hot leg tubes to at least the #1 support plate.

SAN ONOFRE #1

SG FLOW SLOT INSPECTION

Central flow slot in all 3 SG's have been photographed in each scheduled inspection beginning in October, 1976.

Initial photos revealed flow slot hourglassing and ligament cracks in SG's A and C; the flow slots in SG/B appeared normal.

Inspection of the upper flow slots(#3 and #4 support plates) through a 3" inspection port in SG/C indicated no distortion.

The absence of hourglassing in the upper plates of SG/C and all the plates in SG/B coincided with the absence of significant denting in those plates; by inference SG/A has no hourglassing in the #3 and #4 plates.

Measurement of average flow slot width reduction has shown no significant change through 5 inspections (10/76, 9/77, 4/78, 10/78 and 4/80) .

SAN ONOFRE #1

SG TUBE GAUGING INSPECTION

APRIL, 1980 OUTAGE

Evaluation of denting progression is also accomplished by review of tube ID restriction data.

522 tube inspections in SG/A and 362 in SG/C were extended through the #4 support plate in addition to the U-bend scope in each to provide data on tube ID restrictions.

Only 2 tubes in each SG blocked passage of a 460 mil diameter probe.

2 cold leg tubes in SG/A were not previously tested.
2 hot leg tubes in SG/C passed 460 mil probe in prior inspections.

19 other tubes blocked passage of smaller probes than in previous inspections.

Overall conclusion: No significant change in denting status has occurred.

SAN ONOFRE #1

APRIL, 1980 OUTAGE

STEAM GENERATOR "A" GAUGING

Summary of Inspection Results

		INLET	OUTLET
TUBES GAUGED		398	179
Tube Restrictions	≤.400	0	2
	.400 - .460	0	0
	.460 - .500	19	11
	.500 - .560	50	26
	.560 - .580	109	21
TOTAL RESTRICTED TUBES		178	60

SAN ONOFRE #1

APRIL, 1980 OUTAGE

STEAM GENERATOR "C" GAUGING

Summary of Inspection Results

		INLET	OUTLET
TUBES GAUGED		461	69
Tubes Restricted	<.400	0	0
	.400 - .460	2	0
	.460 - .500	6	2
	.500 - .560	95	17
	.560 - .580	82	6
TOTAL RESTRICTED TUBES		185	25

SAN ONOFRE #1

STEAM GENERATOR EC INSPECTION

APRIL, 1980 OUTAGE

Phase I EC testing was accomplished using multiple frequency eddy current equipment.

Four frequencies were multiplexed to provide simultaneous readout.

- 400 kHz Differential - comparison to all prior inspection data.
- 340 kHz Differential - optimal frequency for inspection of 55 mil wall, 0.750" Inconel-600 tubes.
- 100 kHz Differential - O. D. sensitivity enhancement and tubesheet response for signal mixing.
- 100 kHz Absolute - Heighten response to gradual changes.

SAN ONOFRE #1

APRIL, 1980 OUTAGE

EC INSPECTION PROGRAM

	A		B		C	
	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
TOTAL TUBES	3794	3794	3794	3794	3794	3794
PREVIOUSLY PLUGGED	95	95	50	50	124	124
REMAINING IN-SERVICE	3699	3699	3744	3744	3670	3670
ACTUAL INSPECTION						
Through U-Bend	475	16	754	12	592	39
Through 4th Support	343	179			346	16
Through 1st Support	2881	1803	2990	640	2732	305
TOTAL	3699	1998	3744	652	3670	360

SAN ONOFRE #1

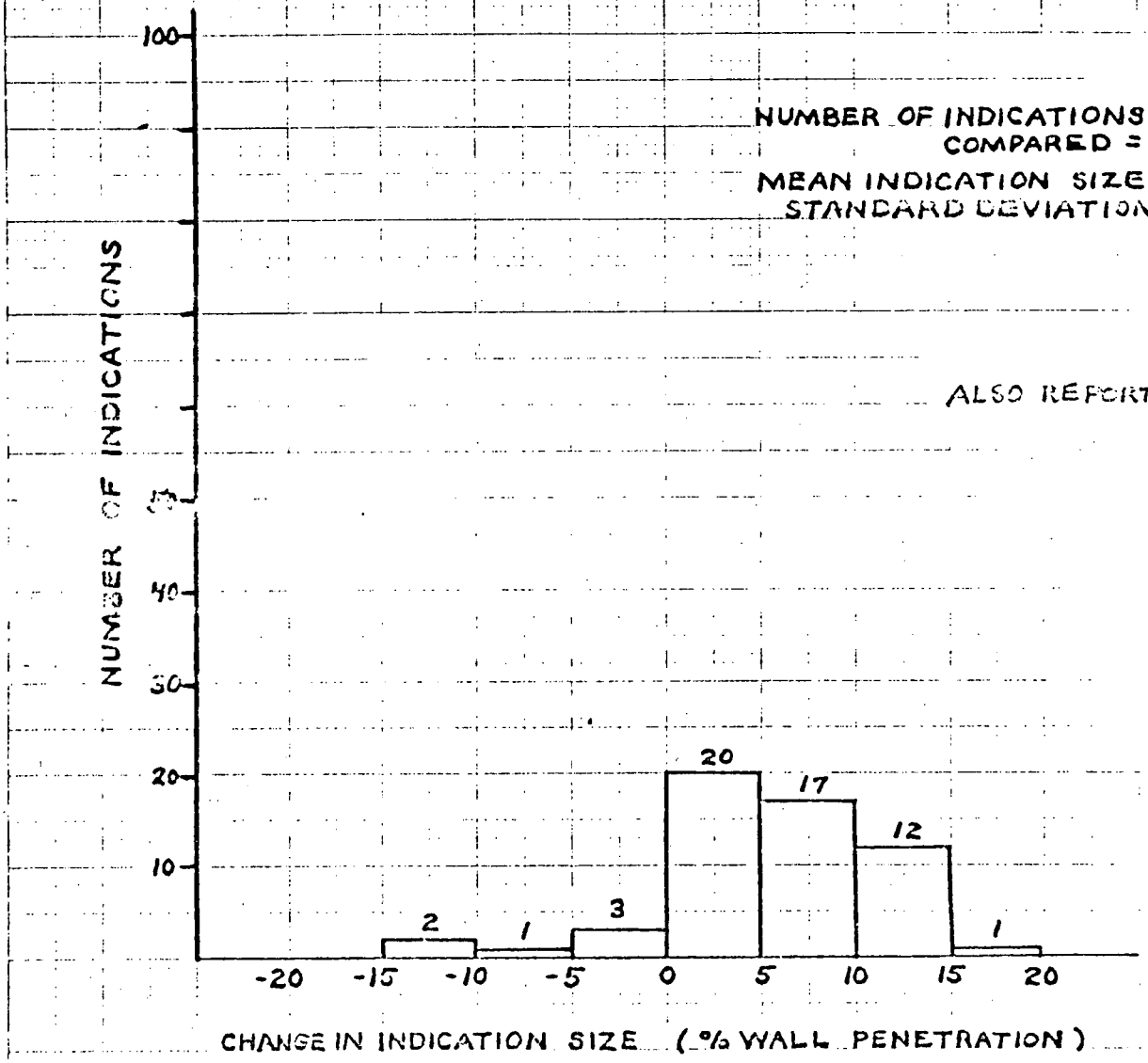
SUMMARY OF EC INDICATIONS 20%
CONVENTIONAL EC TESTING

	A		B		C	
LOCATION OF INDICATION	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
At Anti-Vibration Bars	279	0	472	0	363	0
Above Tubesheet	393	249	146	95	128	35
At Top of Tubesheet	139	3	48	0	156	0
Below Tubesheet	1	0	0	0	0	0
TOTAL	812	252	666	95	647	35

DISTRIBUTION OF THE CHANGE IN AVB WEAR INDICATIONS RECORDED AS ≥ 20% AT BOTH THE 10/78 AND 5/80 INSPECTIONS

SAN ONOFRE UNIT 1

STEAM GENERATOR A



NUMBER OF INDICATIONS COMPARED = 56

MEAN INDICATION SIZE = 4.79

STANDARD DEVIATION = 5.85

ALSO REPORTED:

<20% = 13

<30% = 114

<[illegible]% = 0

46 1320

DISTRIBUTION OF THE CHANGE IN AVB WEAR INDICATIONS RECORDED AS ≥ 20% AT BOTH THE 10/78 AND 5/80 INSPECTIONS

SAN ONOFRE UNIT 1

STEAM GENERATOR B

NUMBER OF INDICATIONS COMPARED = 129

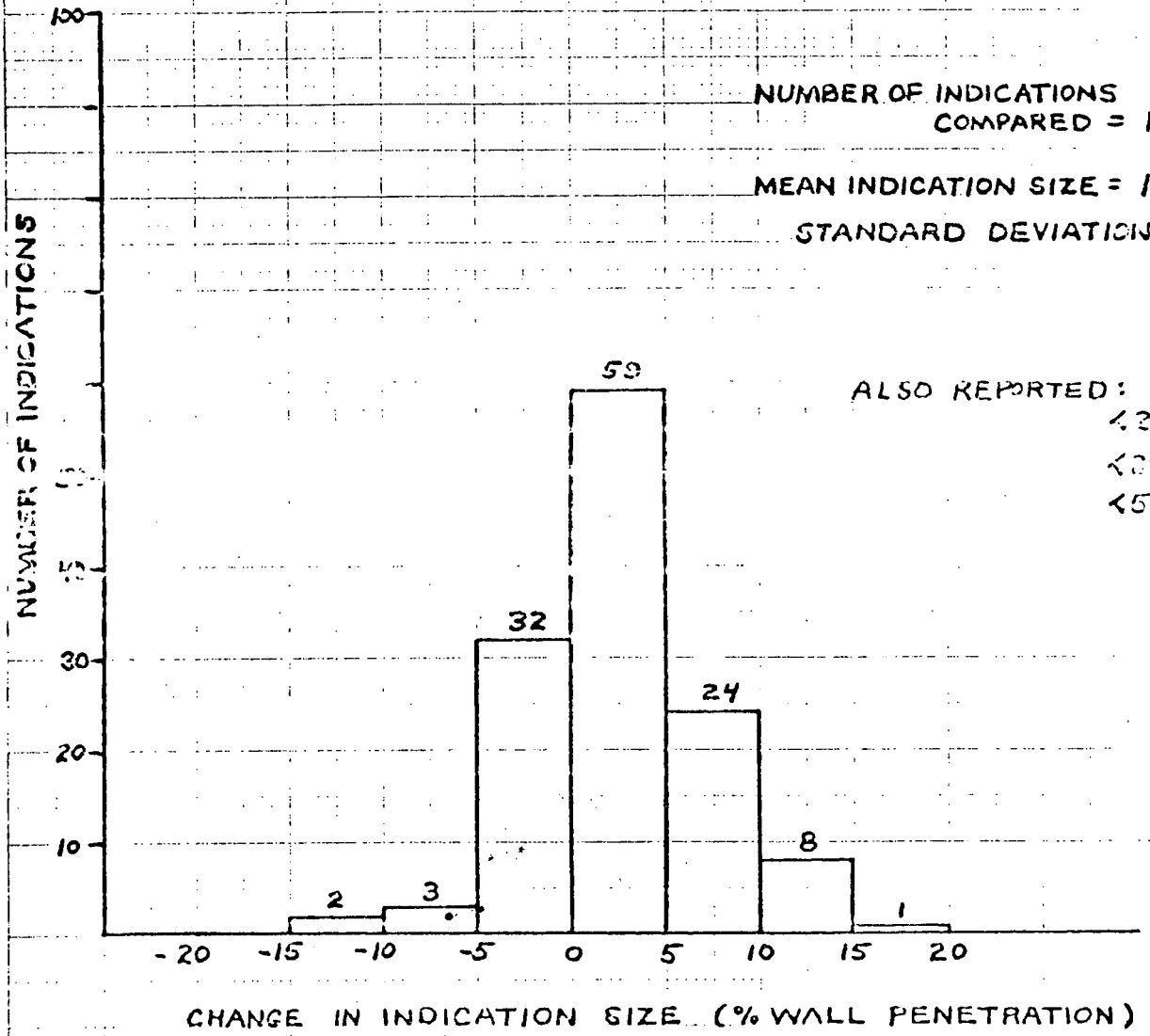
MEAN INDICATION SIZE = 1.98 %

STANDARD DEVIATION = 4.02

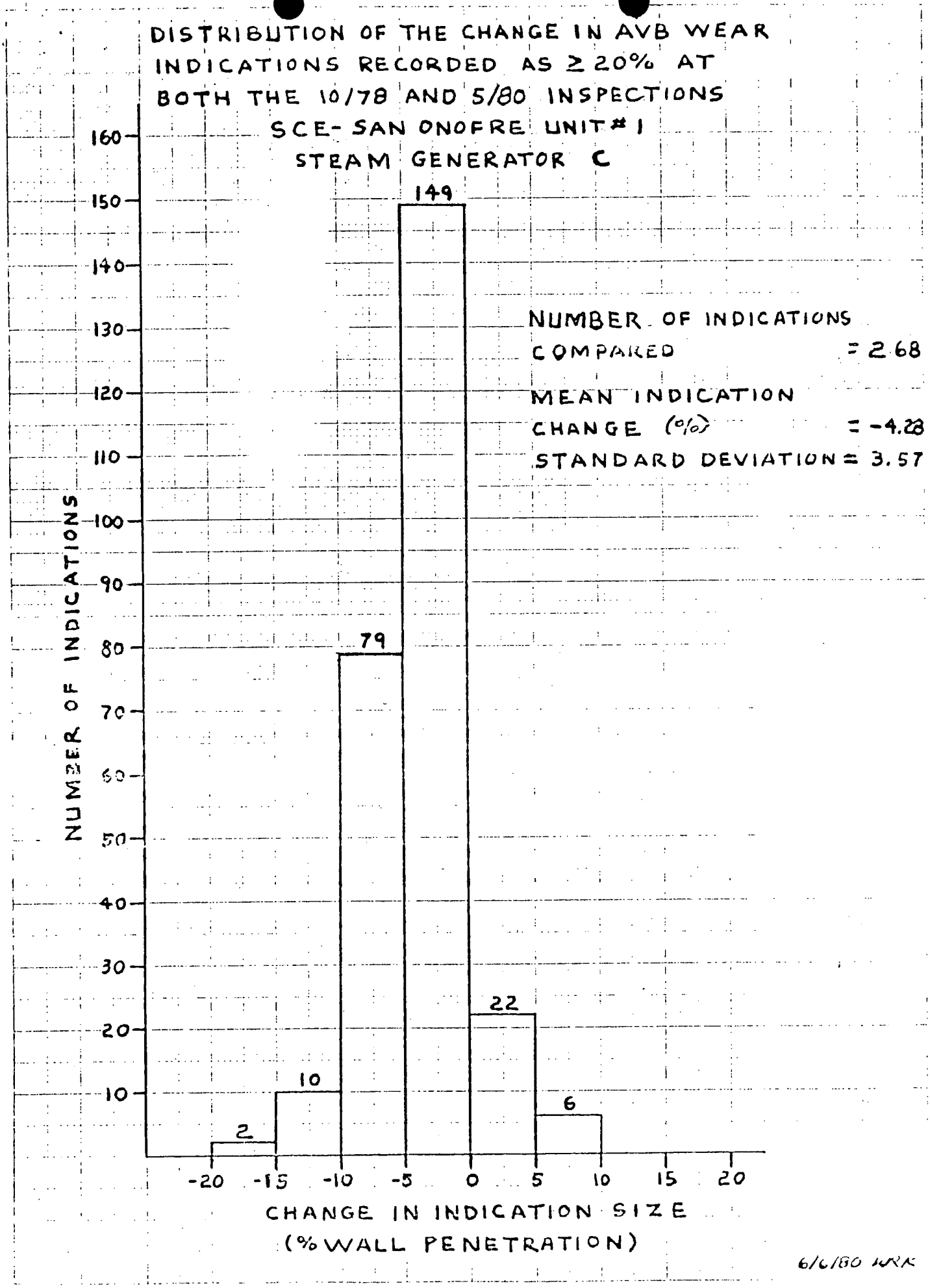
ALSO REPORTED:

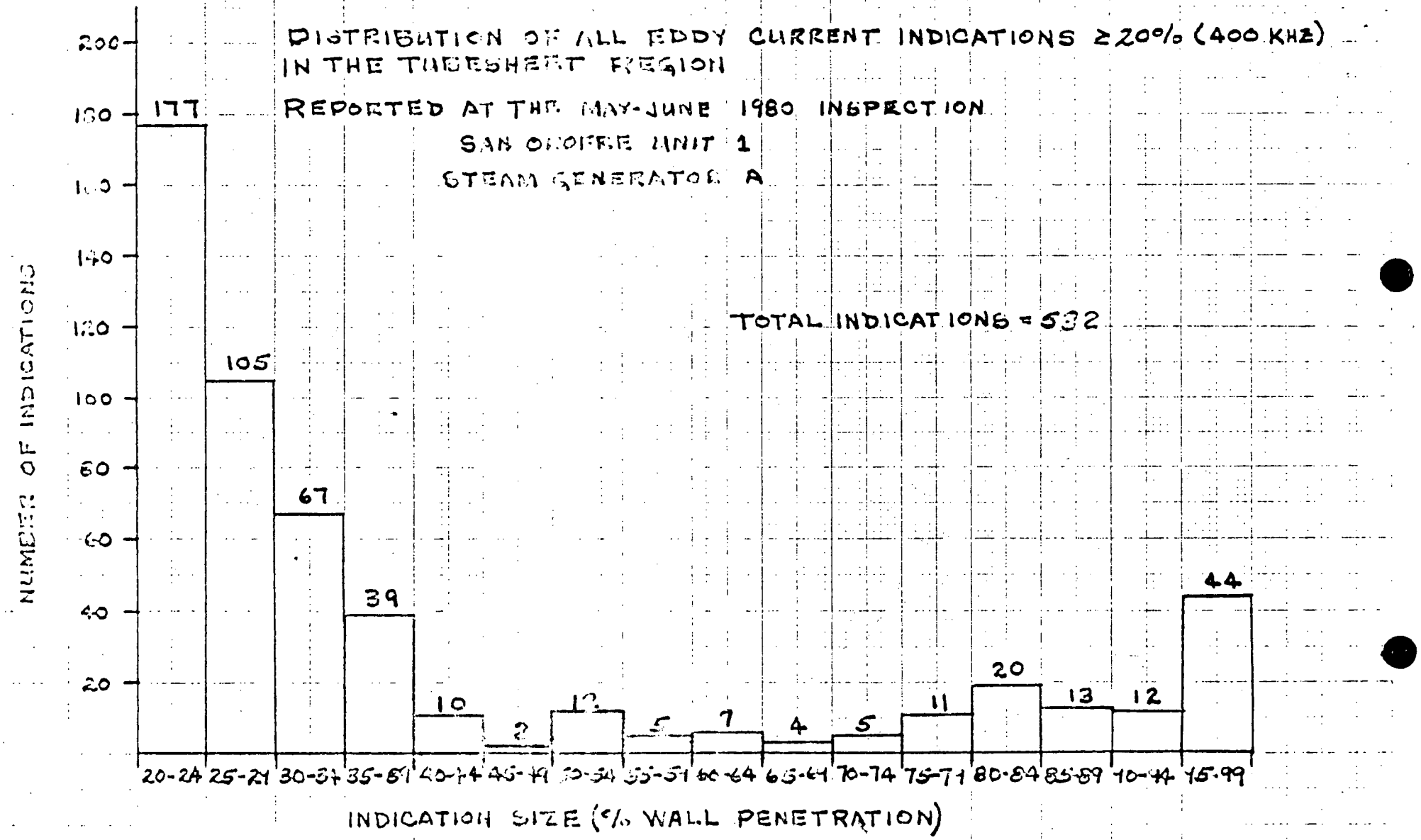
<20% = 63

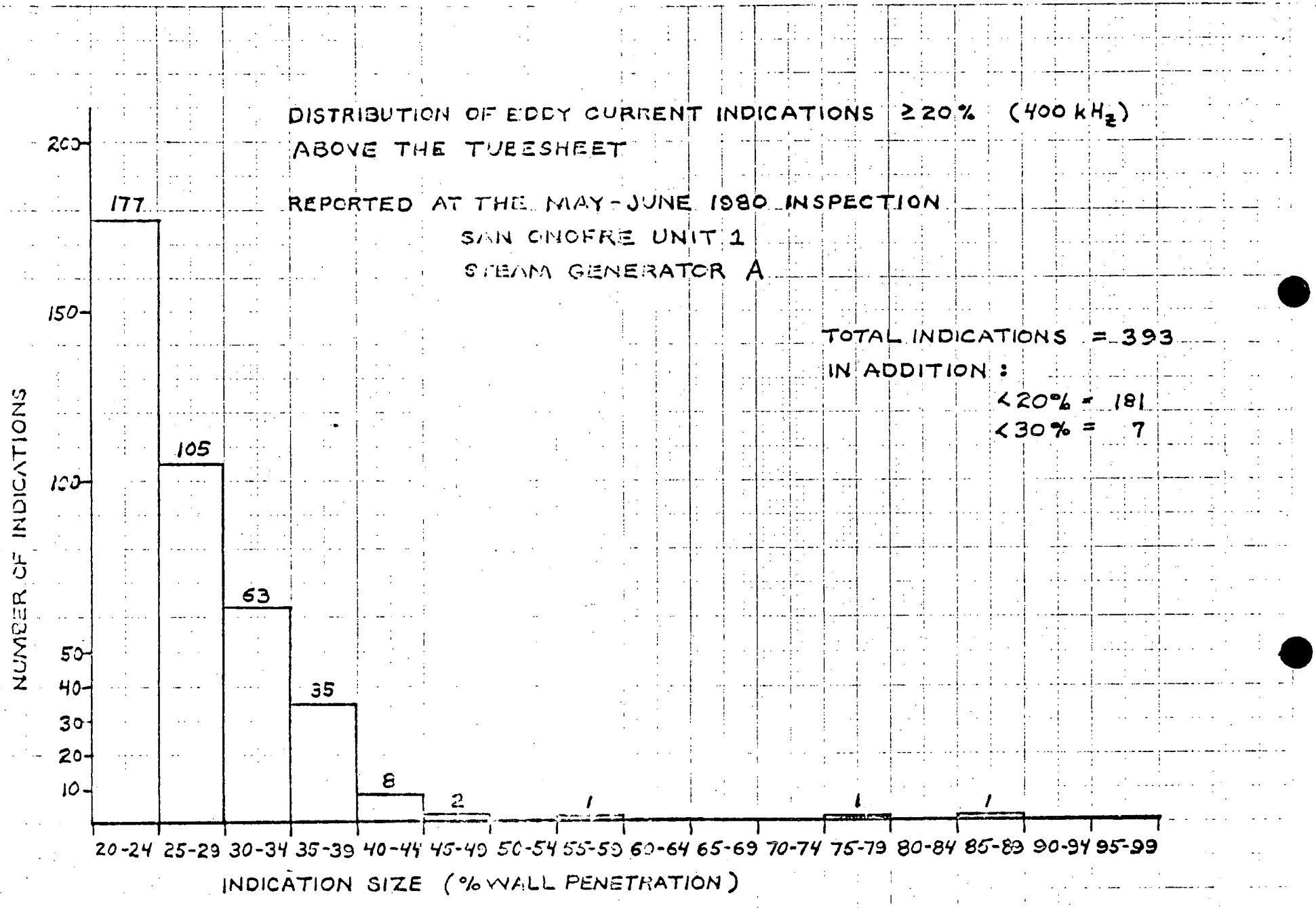
<50% = 12



46 1320

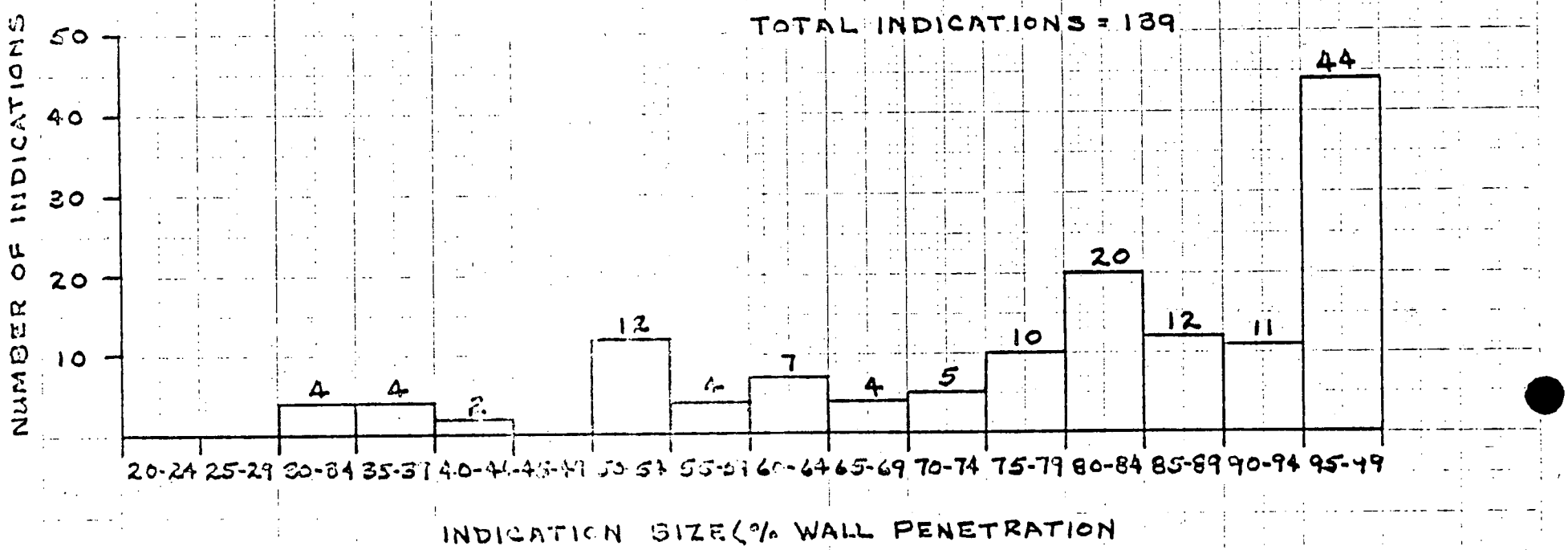

DISTRIBUTION OF THE CHANGE IN AVB WEAR INDICATIONS RECORDED AS ≥ 20% AT BOTH THE 10/78 AND 5/80 INSPECTIONS
SCE- SAN ONOFRE UNIT # 1
STEAM GENERATOR C
NUMBER OF INDICATIONS COMPARED = 268
MEAN INDICATION CHANGE (%) = -4.28
STANDARD DEVIATION = 3.57
NUMBER OF INDICATIONS
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
149
79
22
10
6
2
-20
-15
-10
-5
0
5
10
15
20
CHANGE IN INDICATION SIZE
(% WALL PENETRATION)
6/6/80 WRK

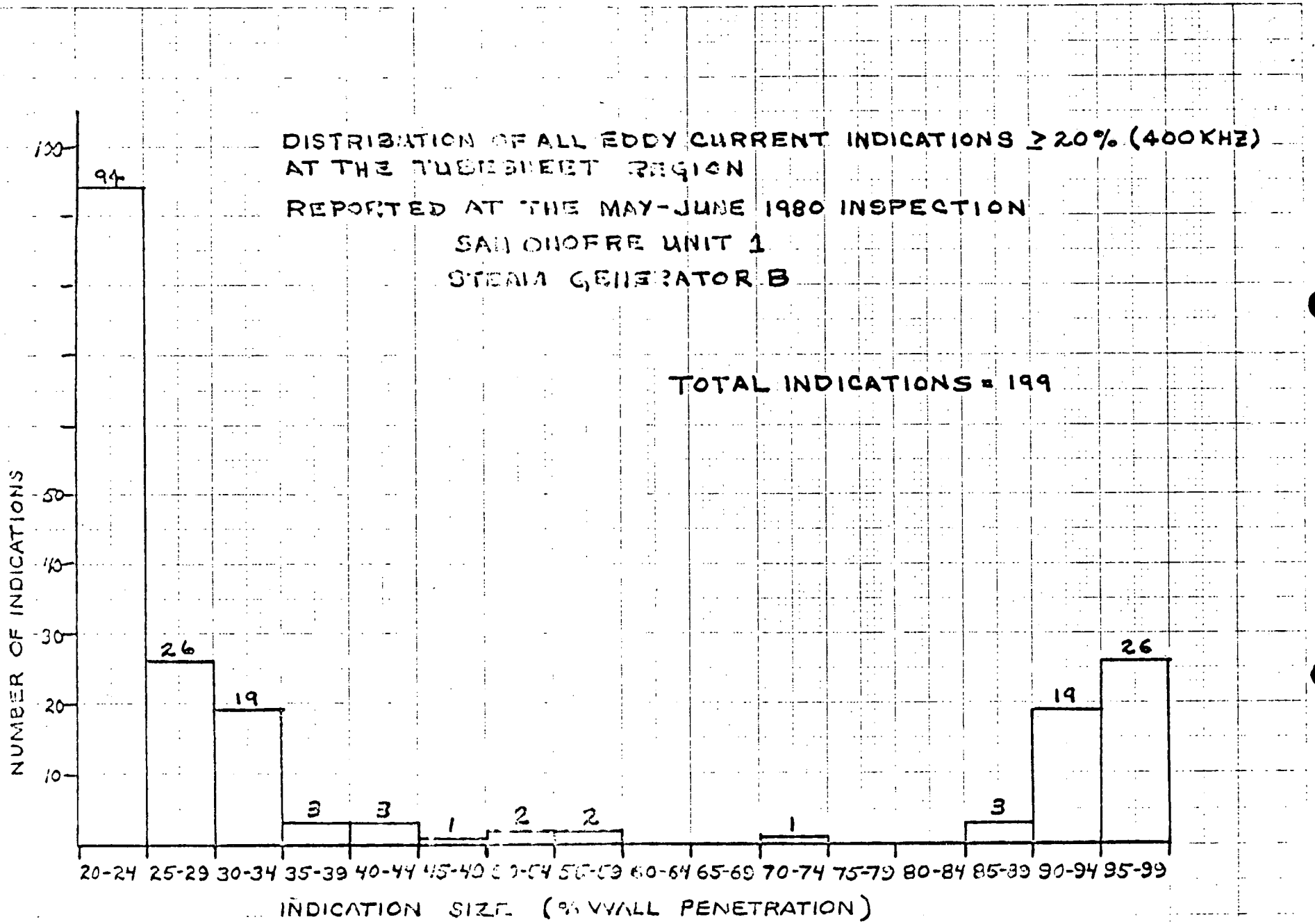

DISTRIBUTION OF ALL EDDY CURRENT INDICATIONS ≥20% (400 KHZ)
IN THE TUBESHEET REGION
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR A
TOTAL INDICATIONS = 532
NUMBER OF INDICATIONS
200
180
160
140
120
100
80
60
40
20
177
105
67
39
10
2
12
5
7
4
5
11
20
13
12
44
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
INDICATION SIZE (% WALL PENETRATION)

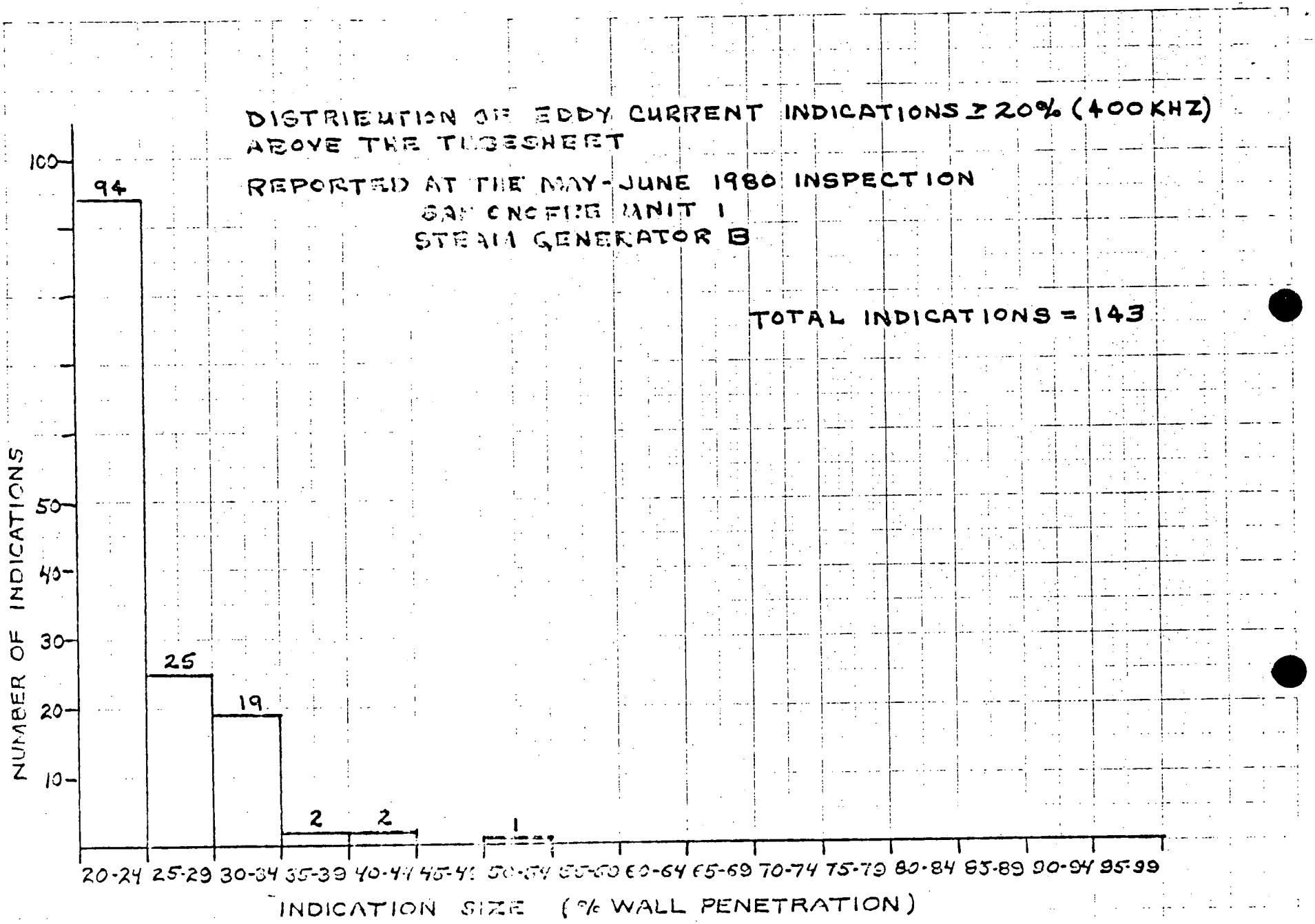

DISTRIBUTION OF EDDY CURRENT INDICATIONS ≥20% (400 kHz)
ABOVE THE TUBESHEET
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR A
TOTAL INDICATIONS = 393
IN ADDITION :
<20% = 181
<30% = 7
NUMBER OF INDICATIONS
200
150
100
50
40
30
20
10
177
105
63
35
8
2
1
1
1
20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75-79 80-84 85-89 90-94 95-99
INDICATION SIZE (% WALL PENETRATION)

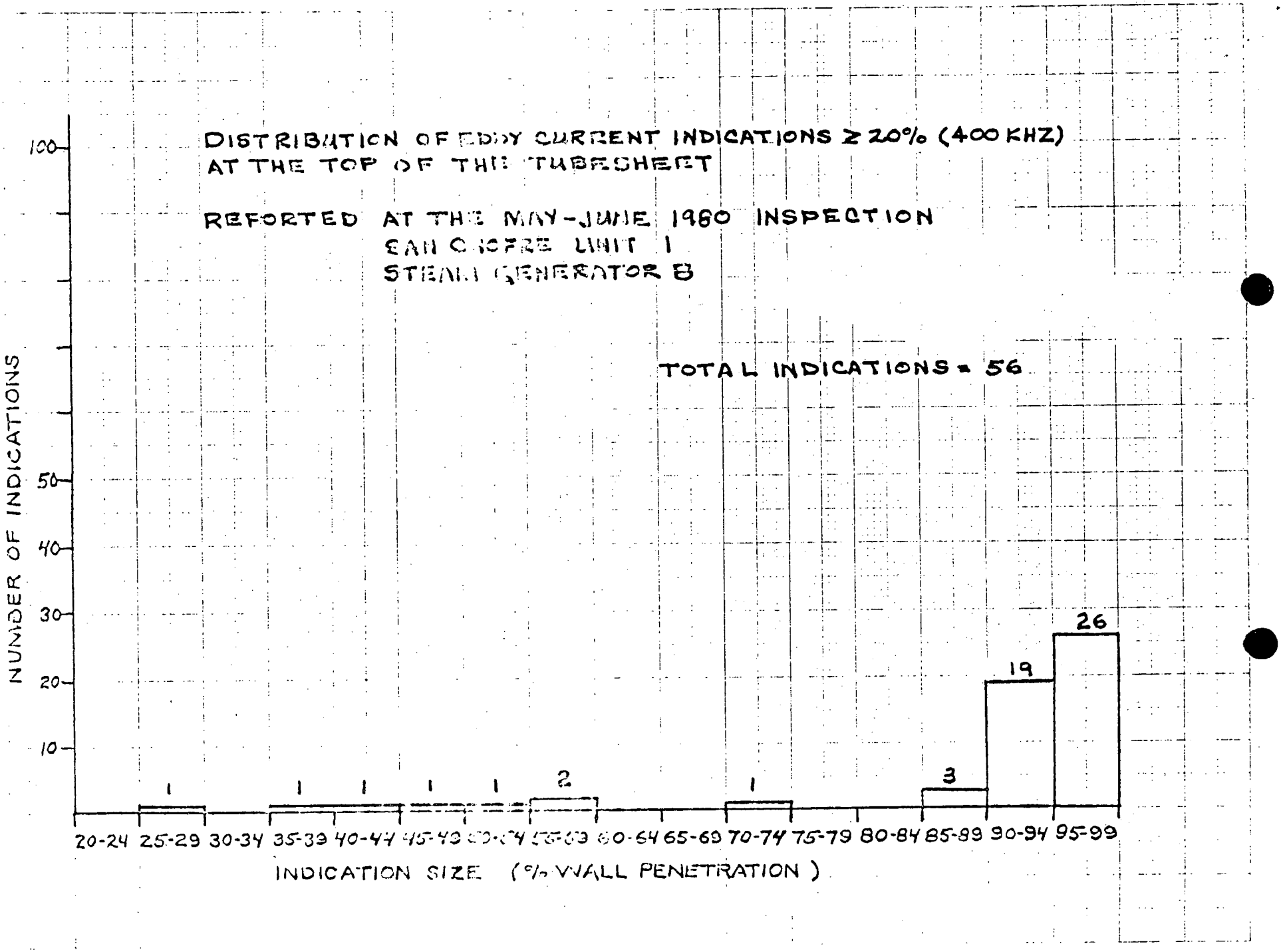
DISTRIBUTION OF EDDY CURRENT INDICATIONS ≥ 20% (400 KHZ)
AT THE TOP OF THE TUBESHEET

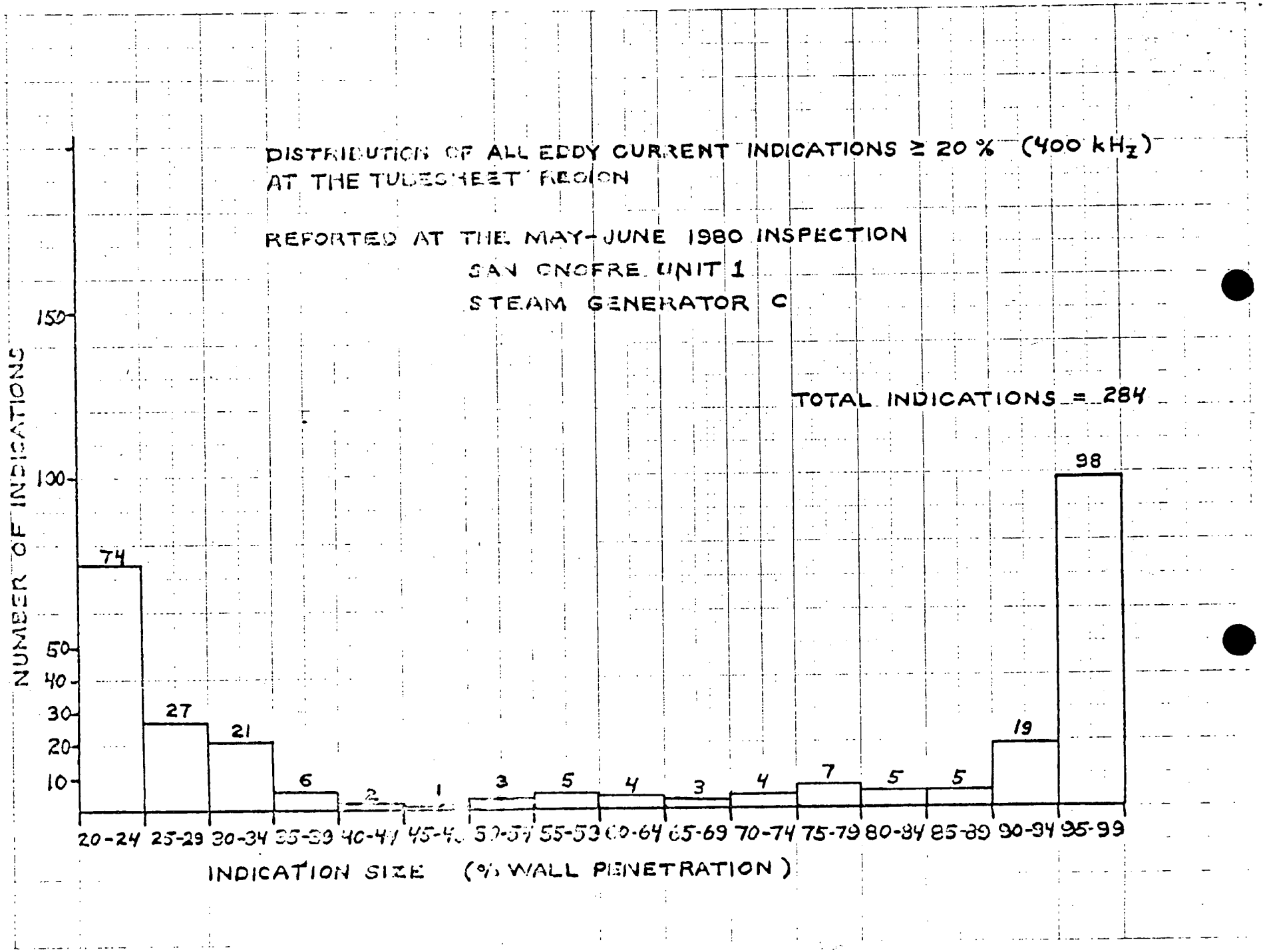
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR A




DISTRIBUTION OF ALL EDDY CURRENT INDICATIONS ≥ 20% (400KHZ)
AT THE TUBESHEET REGION
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR B
TOTAL INDICATIONS = 199
NUMBER OF INDICATIONS
100
50
30
20
10
94
26
19
3
3
1
2
2
1
3
19
26
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
INDICATION SIZE (% WALL PENETRATION)

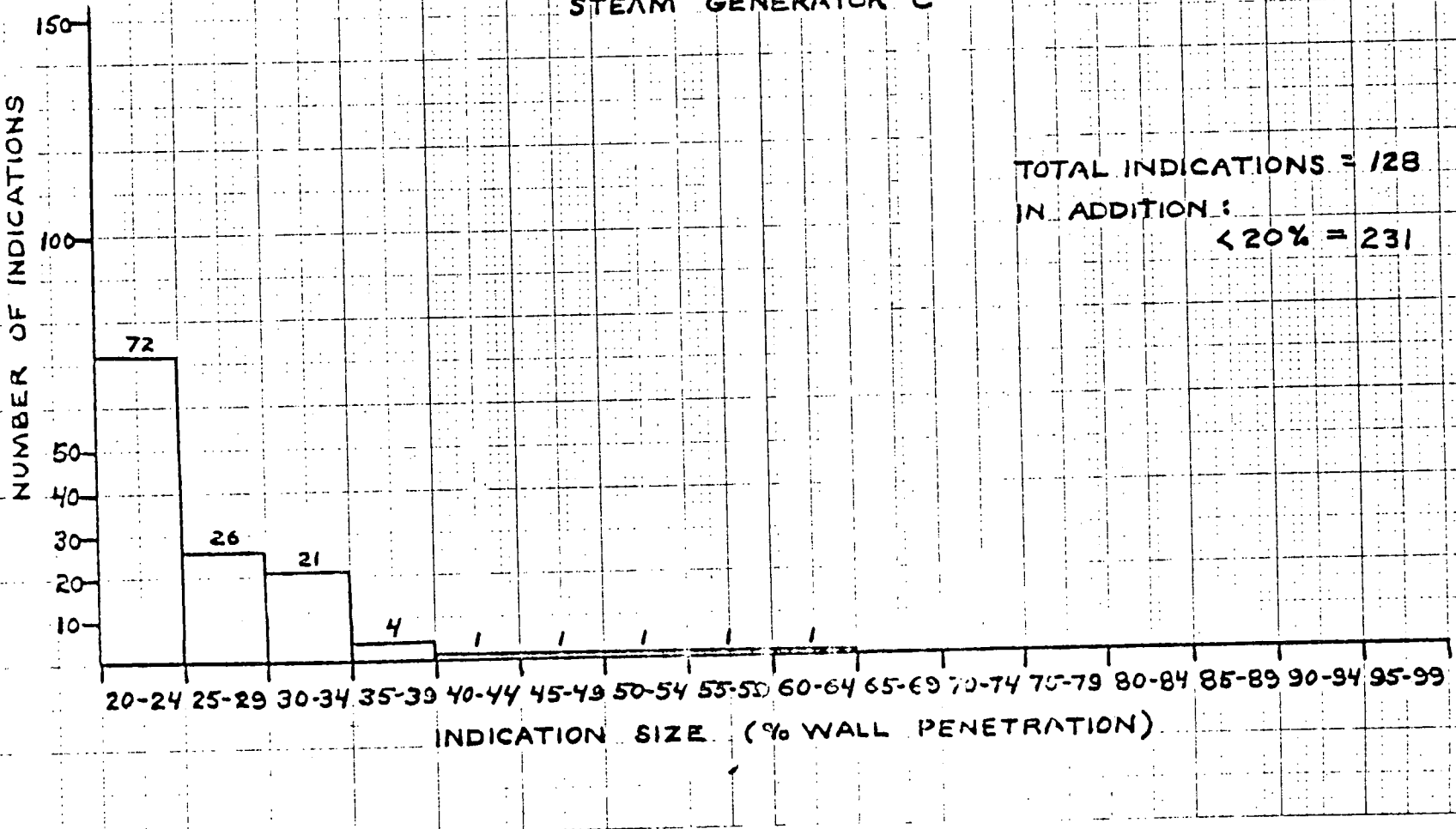

DISTRIBUTION OF EDDY CURRENT INDICATIONS ≥ 20% (400 KHZ)
ABOVE THE TUBESHEET
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR B
TOTAL INDICATIONS = 143
NUMBER OF INDICATIONS
100
50
40
30
20
10
94
25
19
2
2
1
20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75-79 80-84 85-89 90-94 95-99
INDICATION SIZE (% WALL PENETRATION)


DISTRIBUTION OF EDDY CURRENT INDICATIONS ≥ 20% (400 KHZ)
AT THE TOP OF THE TUBESHEET
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR B
TOTAL INDICATIONS = 56
NUMBER OF INDICATIONS
100
50
40
30
20
10
1
1
1
1
1
2
1
3
19
26
20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75-79 80-84 85-89 90-94 95-99
INDICATION SIZE (% WALL PENETRATION)


DISTRIBUTION OF ALL EDDY CURRENT INDICATIONS ≥ 20 % (400 kHz)
AT THE TUBESHEET REGION
REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR C
TOTAL INDICATIONS = 284
NUMBER OF INDICATIONS
150
100
50
40
30
20
10
74
27
21
6
2
1
3
5
4
3
4
7
5
5
19
98
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
INDICATION SIZE (% WALL PENETRATION)

DISTRIBUTION OF EDDY CURRENT INDICATIONS ≥20% (400 kHz)
ABOVE THE TUBESHEET

REPORTED AT THE MAY-JUNE 1980 INSPECTION
SAN ONOFRE UNIT 1
STEAM GENERATOR C



TOTAL INDICATIONS = 128

IN ADDITION:

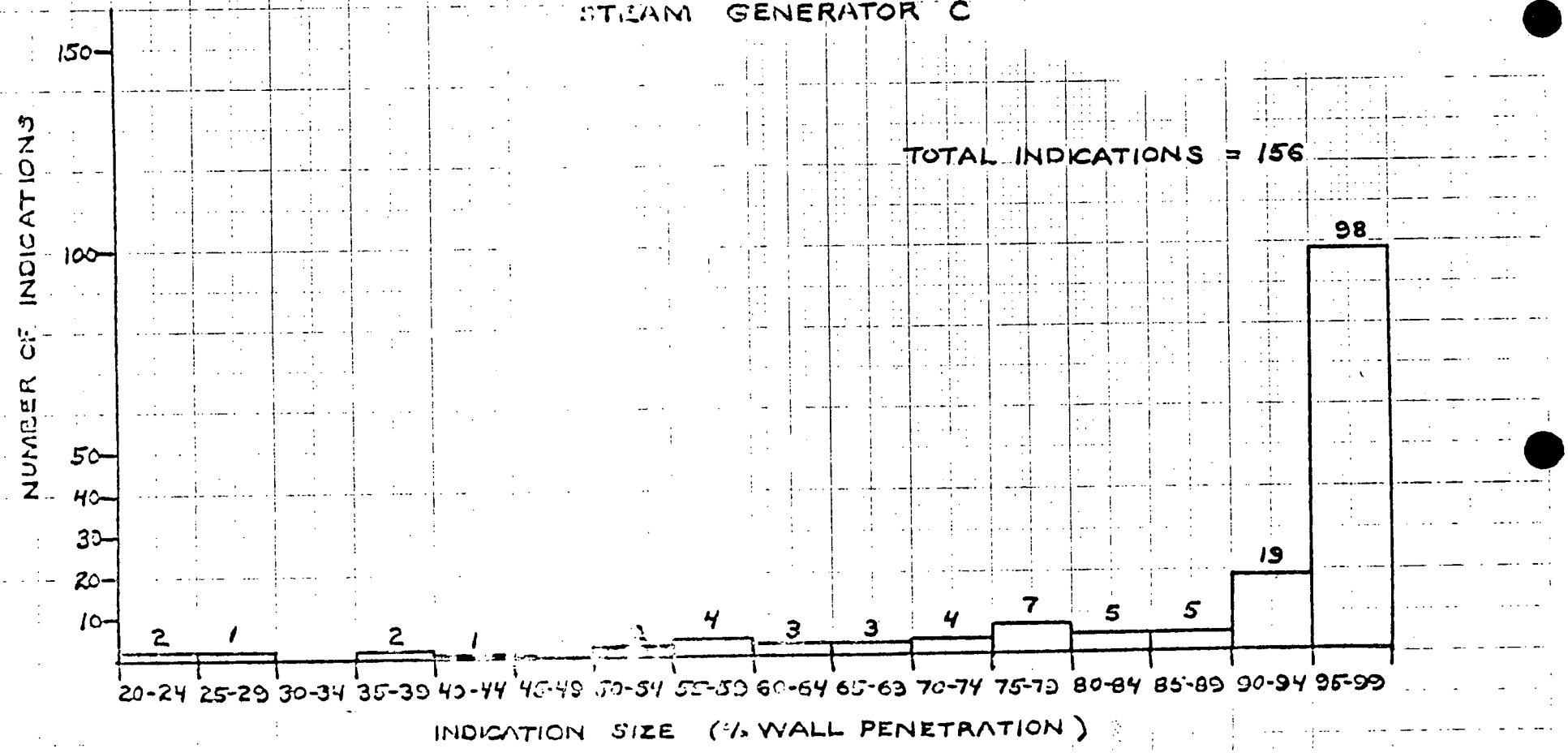
<20% = 231

DISTRIBUTION OF EDDY CURRENT INDICATIONS ≥ 20% (400 kHz) AT THE TOP OF THE TUBESHEET

REPORTED AT THE MAY-JUNE 1980 INSPECTION

SAN ONOFRE UNIT 1

STEAM GENERATOR C



SAN ONOFRE # 1

APRIL, 1980 OUTAGE

CONVENTIONAL EC DATA INTERPRETATIONS

- AVB SIGNALS SHOW NO SIGNIFICANT CHANGE
- NO SIGNIFICANT CHANGE IN TUBE DENTING
- SLIGHT INCREASE IN APPARENT THINNING BETWEEN TUBESHEET AND FIRST TSP
- ONLY ONE TUBESHEET CREVICE INDICATION (TUBE SAMPLE REMOVED FOR EXAMINATION)
- SIGNALS AT TOP OF TUBESHEET ARE COMPLEX
  - THREE CATEGORIES
    1. TUBESHEET ENTRY SIGNAL ONLY
    2. DENTING + TUBESHEET ENTRY
    3. DENTING + TUBESHEET ENTRY+ CORROSION
- EVALUATIONS OF COMPLEX SIGNALS ARE IN PROGRESS

SAN ONOFRE #1

SG TUBE REMOVAL DATA

STEAM GENERATOR A

Laboratory evaluation of three tubes was deemed necessary to determine the nature of tube degradation exhibited by the EC data and the tube leakage events.

- R24C71 HL - Section from #1 TSP down.
  In-plant EC data: 95% at tubesheet.
  26% 12" above tubesheet.

  Tube fractured at 95% indication on pulling.

- R31C28 HL - Section from #4 TSP down.
  In-plant EC data: Complex signal at tubesheet.

  Tube fractured at complex signal on pulling.

- R17C52 HL - Section from 2" below top of tubesheet down.
  In-plant EC data: 95% 4" below top of tubesheet.

  Tube cutter lodged at #3 TSP; surrounding tubes to be plugged.

SAN ONOFRE #1

EXPANDED SCOPE SG INSPECTIONS

Apparent tube degradation on tube with complex signal indicated need for more specialized NDE techniques and additional tube pulls.

Additional EC testing with probes optimized for locating circumferentially-oriented degradation.

- Multiple, series-wired pancake coils on a straight pull probe did not produce significant improvement over original equipment.

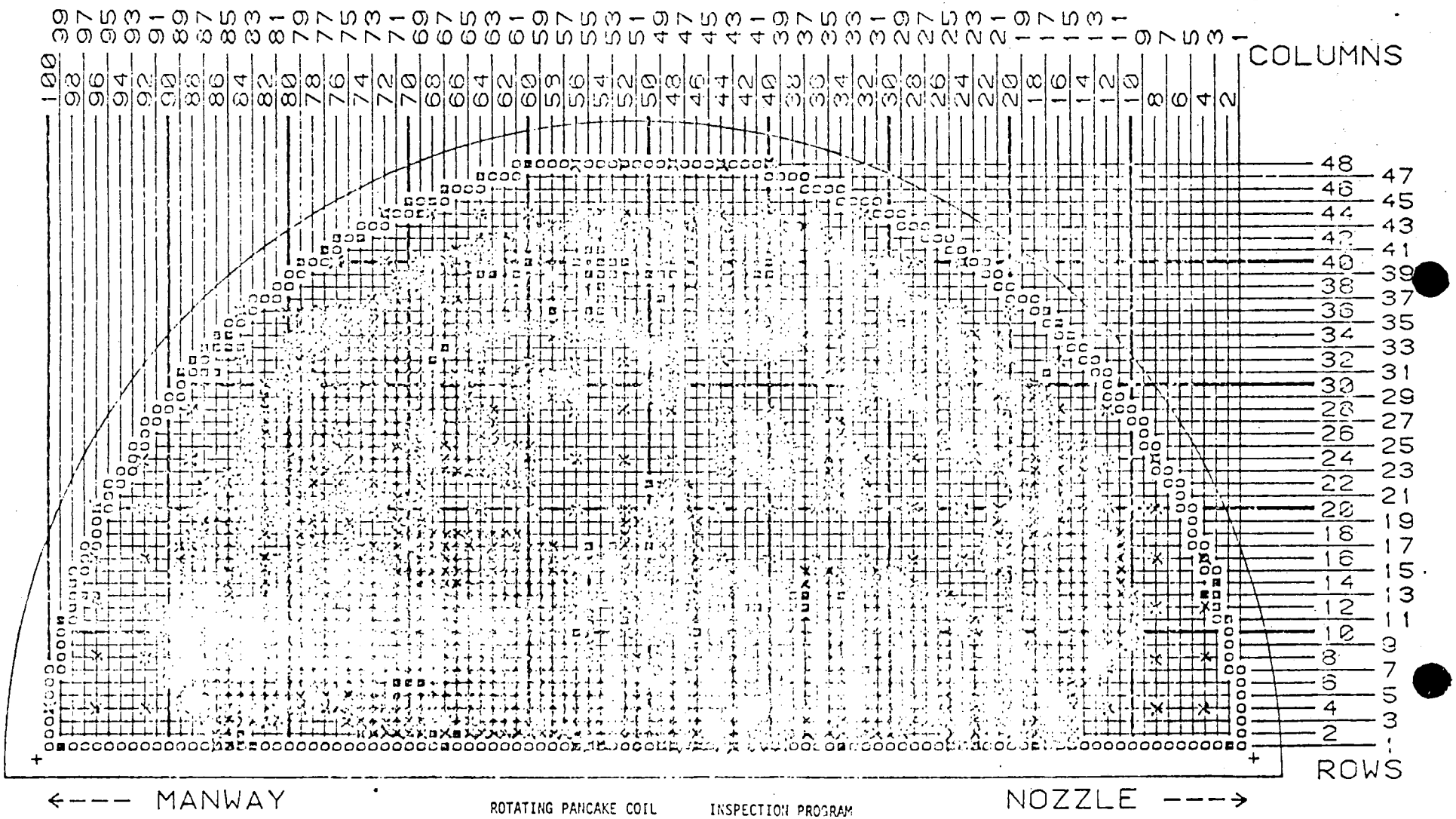
- Backup - a single, rotating pancake coil probe did provide increased sensitivity and circumferential extent of apparent degradation.

Inspection program based on non-routine 100 kHz signal patterns from conventional EC data plus one apparently normal tube around the "red dots" calls for 2270 tubes to be tested with the Rotating Pancake Coil (RPC) probe in Steam Generator A.

SERIES 27

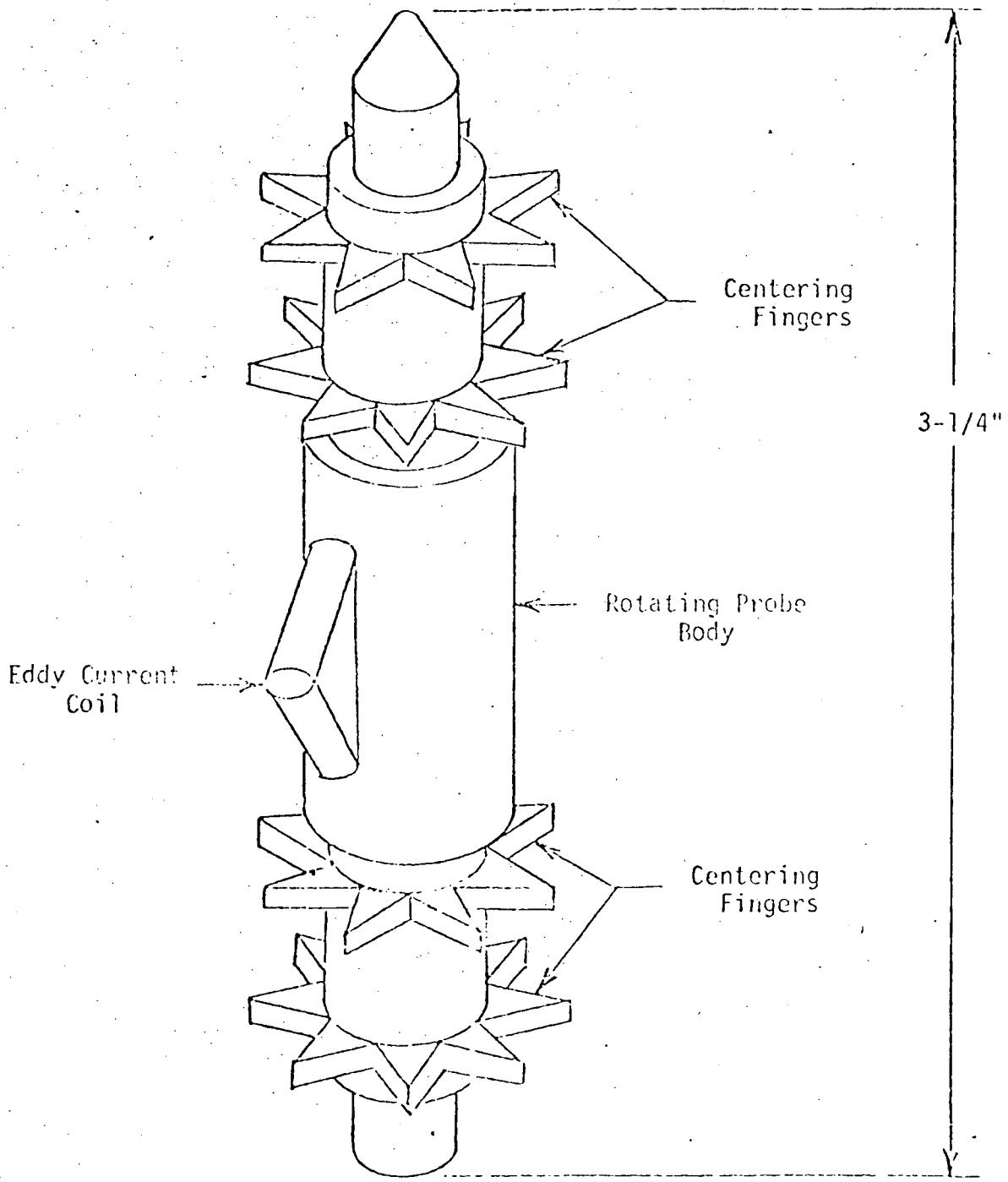
SCE-A

INLET



ROTATING PANCAKE COIL INSPECTION PROGRAM

HELICAL SCAN EDDY
CURRENT PROBE



SAN ONOFRE #1

APRIL, 1980 OUTAGE

SECOND PHASE TUBE PULLS

STEAM GENERATOR C

Four additional tubes identified for removal to characterize the tube condition corresponding to the EC data in the original data base. All were hand-probed with the RPC prior to removal.

1.	R13C67 HL	Apparent large dent signal with slight distortion; 45% and 55% RPC indications.
2.	R11C69 HL	Apparent large dent signal; No RPC indication.
3.	R32C71 HL	Apparent large dent signal; No RPC indication.
4.	R14C70 HL	Apparently normal tubesheet entry signal; No RPC indication.

Tubes (1), (2), and (3) fractured upon pulling at the position corresponding to the dent-like signals; IGA evident at the fracture faces of each tube.

Tube (4) removed intact but slightly stretched; exhibits visible circumferentially-oriented cracks measured between 40% and 50% by O.D. surface probe.

SAN ONOFRE #1

STEAM GENERATOR A INLET

ROTATING PANCAKE COIL INSPECTION RESULTS

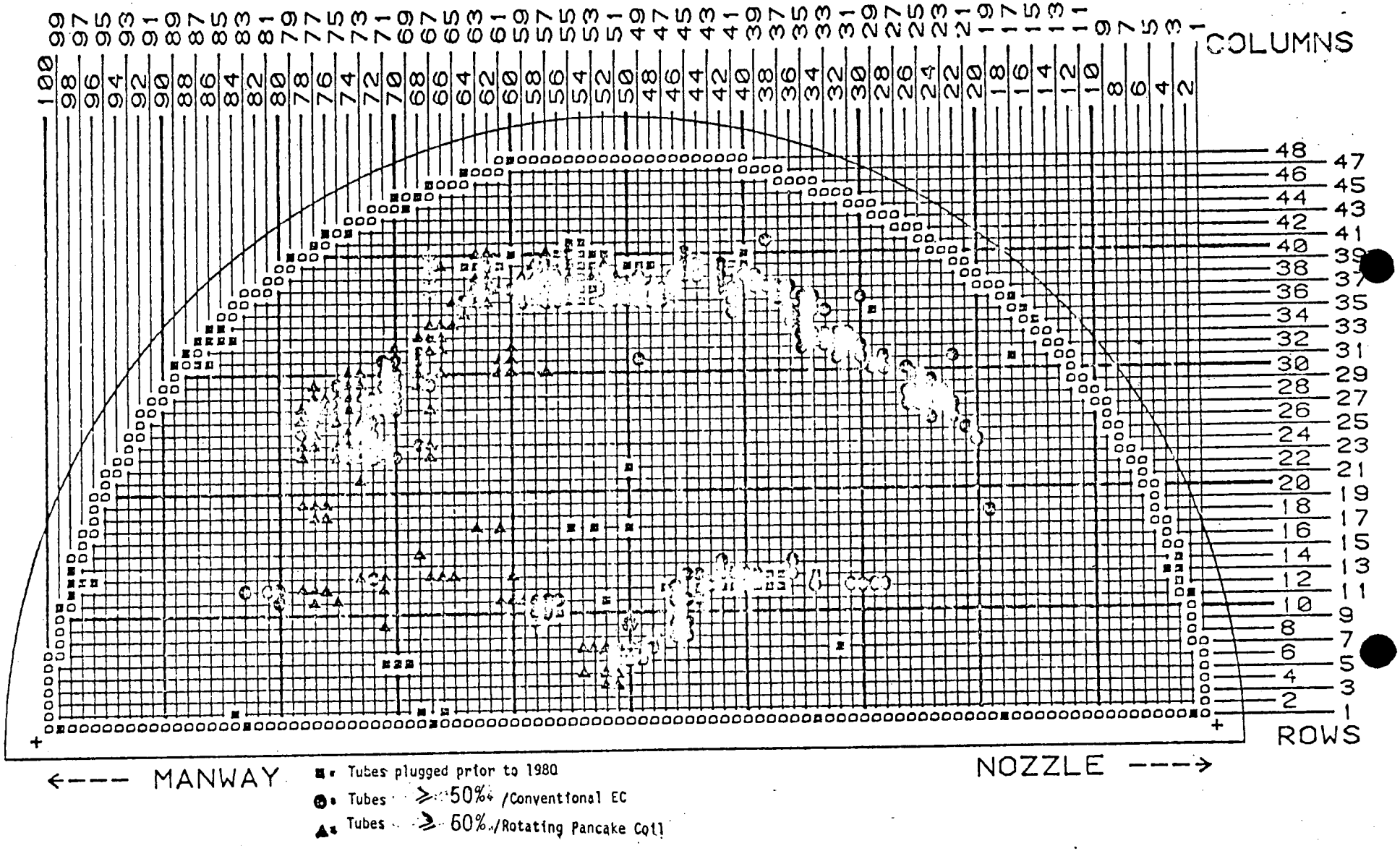
JULY, 1980

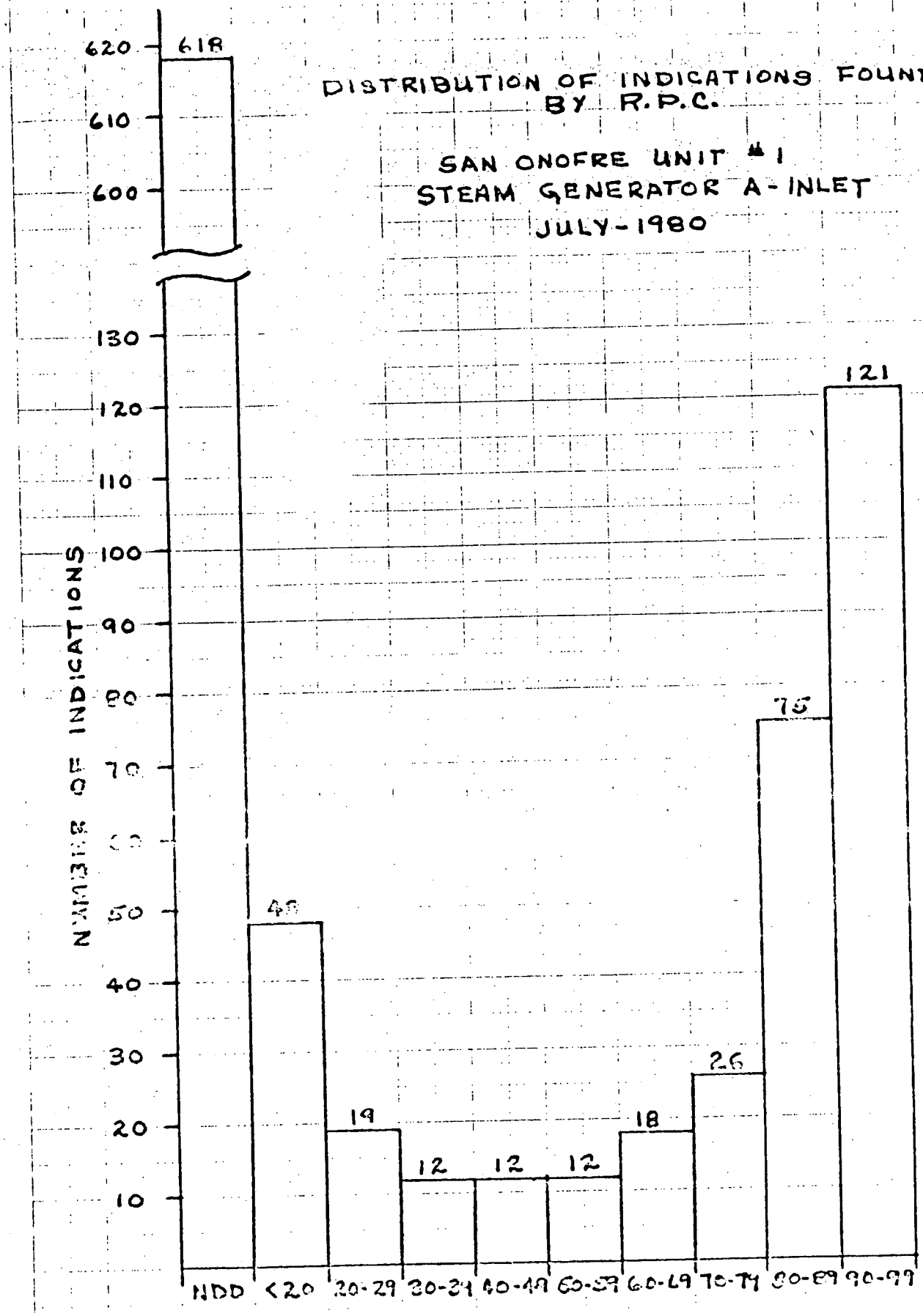
Tubes evaluated (0800, 7/9/80)	1179
Results	
No detectable Indications	772
< 20% Indications	76
≥ 20% <50% Indications	61
≥ 50% Indications	270
Number of New Indications	248
Number of New ≥ 50% Indications	122

SAN ONOFRE #1 APRIL, 1980 OUTAGE

SERIES 27

SCE-A




DISTRIBUTION OF INDICATIONS FOUND BY R.P.C.
SAN ONOFRE UNIT #1
STEAM GENERATOR A-INLET
JULY-1980
NUMBER OF INDICATIONS
620
610
600
130
120
110
100
90
80
70
40
30
20
10
618
49
19
12
12
12
18
26
76
121
NDD
<20
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
INDICATION SIZE (% WALL PENETRATION

46 1320

SAN ONOFRE #1

JULY, 1980

SELECTION OF TUBE PULL CANDIDATES

OBJECTIVES

1. Maximize identification capability of pluggable tubes.

   Bobbin (conventional) probe EC data.

   - 100 kHz
   - Mixed signals

   • Rotating Pancake Coil EC data comparison

   • Pull tubes

SG CANDIDATE	BOBBIN			RPC	EXPECTED METALLOGRAPHY	EXPECTED CONCLUSION
	400 kHz	100 KHz	MF			
A 24-43	Normal Dent	Yes	Dist. Dent	Dent + NDD	< 60%	OK
A 20-58	" Entry	NDD	NDD	NDD	< 60%	OK

2. Verify RPC Data Calibration

   Pull Tubes

SG CANDIDATE	BOBBIN			RPC	EXPECTED METALLOGRAPHY	EXPECTED CONCLUSION
	400 kHz	100 kHz	MF			
A 12-70	Small Dent	Yes	Small Dent	≤20%	≤ 20%	OK
A 15-70	Small Dist. Dent	Yes	Small Dist. Dent	35%	≤ 35%	OK
A 17-61	Small Dent	Yes	Dist. Dent	62%	≤ 62%	OK

SCE UNIT NO. 1

PRESSURE TESTS

OBJECTIVE:

CONFIRM LEAK-BEFORE-BREAK AND SUBSTANTIATE BUNDLE STRUCTURAL INTEGRITY

- EXAMINED PROFILES ARE NOT UNIFORM
- WE HAVE LEAKERS
- A SMALL UNIFORM THICKNESS (5 MILS) WILL CARRY SUBSTANTIAL PRESSURE (2000 PSI)

SCE UNIT NO. 1

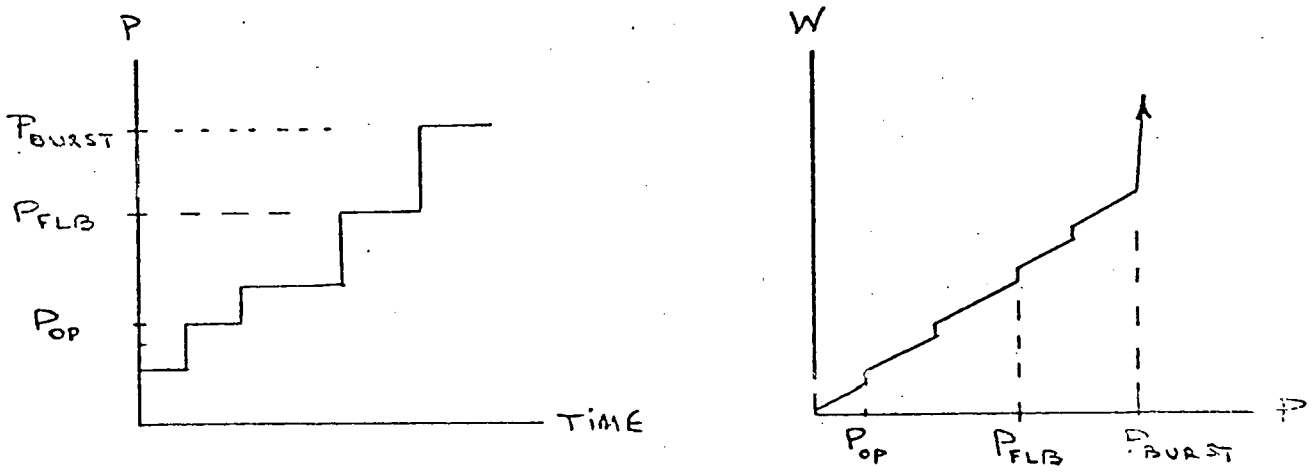
MINIMUM TUBE WALL REQUIREMENTS

- DEGRADATION MODE - UNIFORM THINNING (IGA)
- DEGRADATION LENGTH = .5 INCH
- SAFETY REQUIREMENT - NO TUBE RUPTURE

PLANT CONDITION	Δp, psi	MIN. REQ'D. WALL	
		MILS	% OF NOMINAL
• 100% STEADY-STATE	1350	3.5	6.4%
• LOSS-OF-LOAD ACCIDENT	1715	4.4	8.0%
• FLB ACCIDENT	2560	6.3	11.5%

PRESSURE TESTS FOR LEAK-BEFORE-BREAK VERIFICATION

SINGLE TUBES - LEAK RATE AND MARGIN TO BURST



$$P_M = P_{BURST} - P_{FLB} \ (\sim 2000 \text{ PSI})$$

PRIMARY HYDRO - ESTABLISH MINIMUM BUNDLE CAPABILITY, P_{MIN}

$$P_{MIN} = P_{HYDRO} + P_M,$$

$$P_{HYDRO} \sim 2000 \text{ PSI}$$

SECONDARY HYDRO -VALIDATE LEAK-BEFORE-BREAK BY PLUGGING ALL LEAKERS.

CONTINUED OPERATION

- CORROSION ARREST

SINGLE TUBE PRESSURE TESTS

OBJECTIVE: - SPECIFICATION OF ACCEPTABLE LEAK RATE, $\dot{W}$

- DERIVATION OF MARGIN TO BURST, P_M

TUBE SELECTION

BASIS: ACTIVE REGION

LEAKERS

CONVENTIONAL ECT

TEST CANDIDATES

- LEAKERS (5) IN SG-C

  R11C45, R12C36-38-48-51

- NON-LEAKERS (9) IN SG-A

R-C	RPC	CONV. ECT
13-36	85% - 180°	60%
13-40	94% - 210°	99%
13-41	89% - 180°	96%
13-42	86% - 240°	80%
10-45	74% - 210°	89%
11-41	-	DENT
14-39	-	"
12-55	-	"
14-40	-	"

PRELIMINARY RESULTS FROM SCE UNIT # 1

LEAKING TUBE PRESSURE TESTS

- FOUR TUBES TESTED TO MAXIMUM PRESSURE OF 5500 TO 6000 PSI WITH APPARENT CRACK OPENING BASED ON FIBRE SCOPE OBSER - VATIONS

- MAXIMUM FLOW RATE UNDER MAXIMUM PRESSURE WAS < 1 GPM

- FLOW RATES UNDER NORMAL PRESSURE WERE APPROXIMATELY 0.02 - 0.03 GPM