ENCLOSURE 6

WESTINGHOUSE CLASS 3

SAN ONOFRE #1

STEAM GENERATOR TUBE SLEEVING

INDEPENDENT REVIEW BOARD

PRESENTATION

INTRODUCTION

D. D. MALINOWSKI
STEAM GENERATOR DATA ANALYSIS
WESTINGHOUSE ELECTRIC CORPORATION

WESTINGHOUSE CLASS 3

SAN ONOFRE #1

SONGS #1

SONGS #1 is a 1347 MWt (450 MWe) PWR plant supplied by Westinghouse.

There are three (3) vertical, U-tube steam generators (SG's) of the recirculating type.

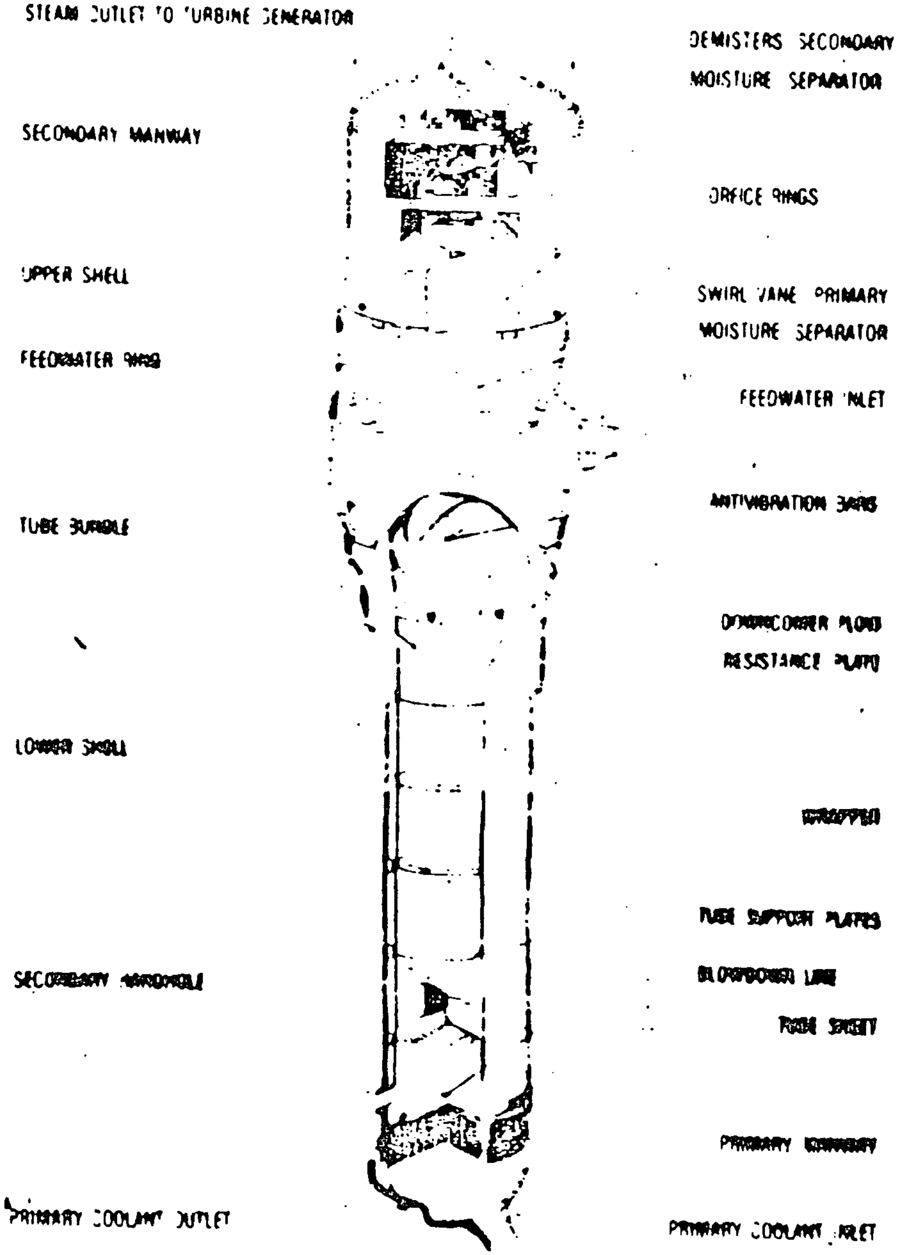
Tubing: Mill annealed Inconel 600 0.750", 0.055" wall tubing, partially expanded (approx. 2 1/2") at the base of the tubesheet; 3794 tubes per SG.

Startup: Initial criticality June, 1967
Commercial Operation Jan. 1968

Secondary Chemistry Control Regime

Initial treatment with sodium phosphate, maintained throughout life except for approx. 5 months during 1970 - 1971.

WESTINGHOUSE CLASS 3



STEAM GENERATOR

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.

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SG TUBE LEAKAGE: APRIL, 1980

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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.

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STEAM GENERATOR TUBE PLUGGING

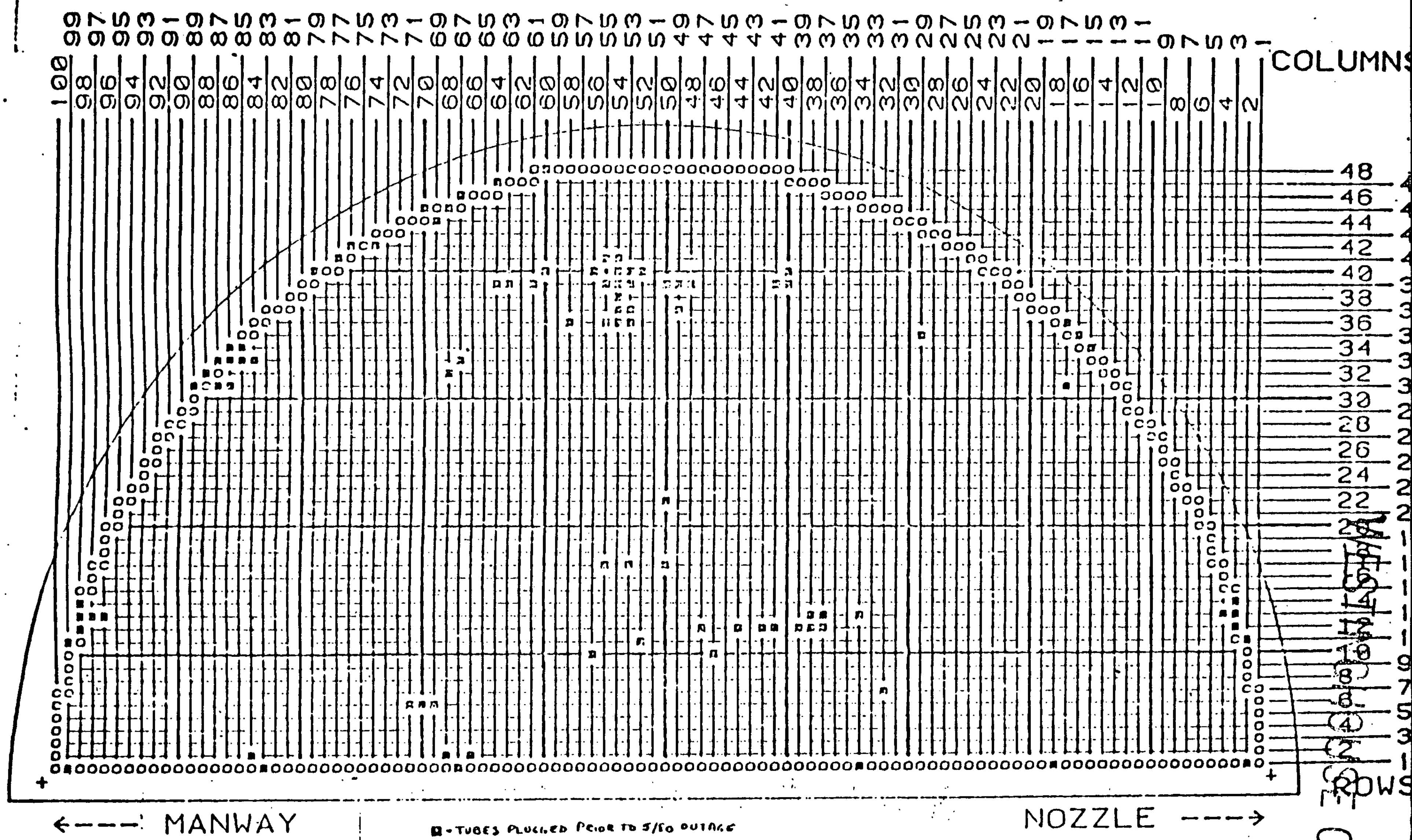
Prior to April, 1980

	SG/A	SG/B	SG/C
Number	95	50	124
%	2.50	1.32	3.27

Total = 269 (2.36%)

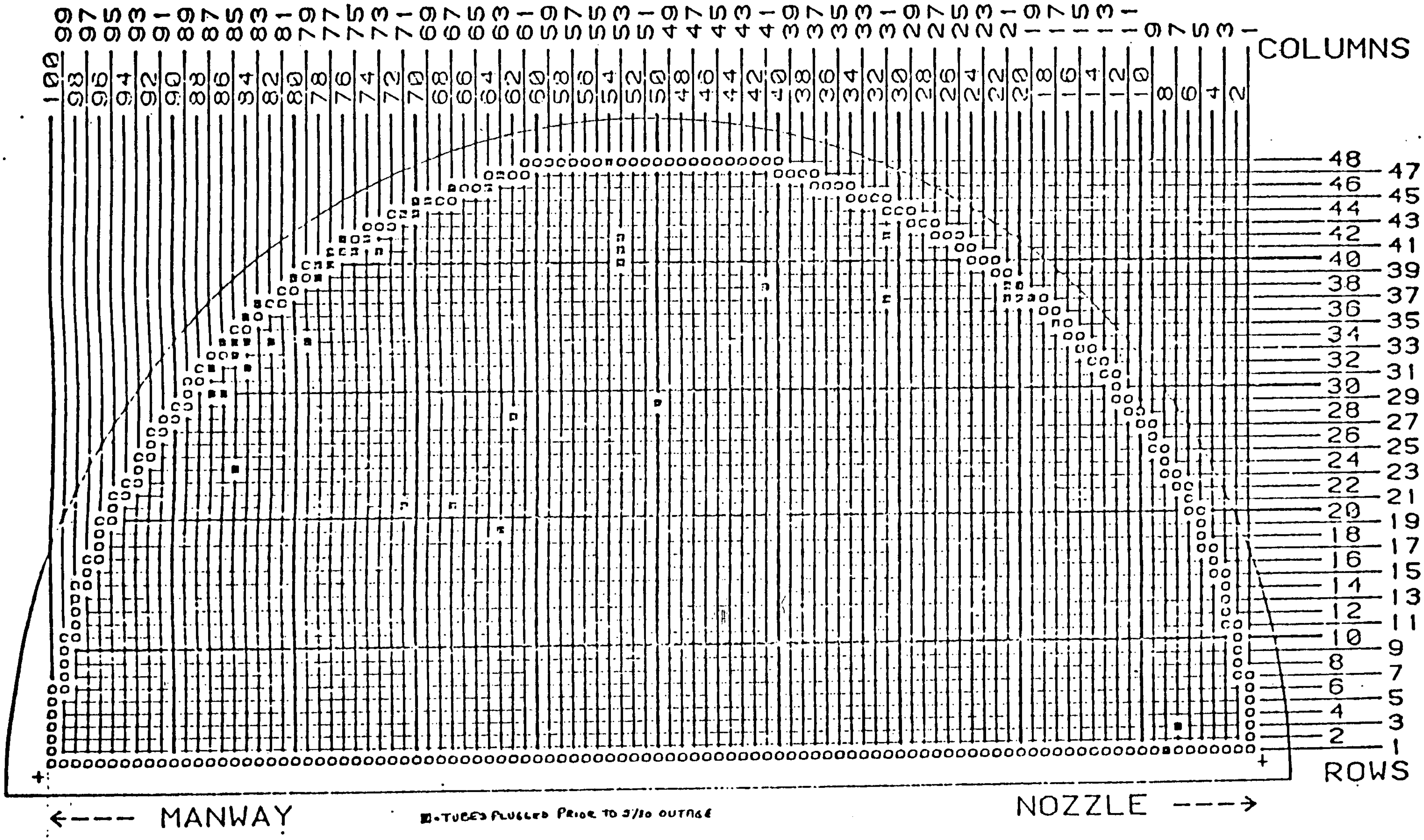
SERIES 27

SCE-A



SERIES 27

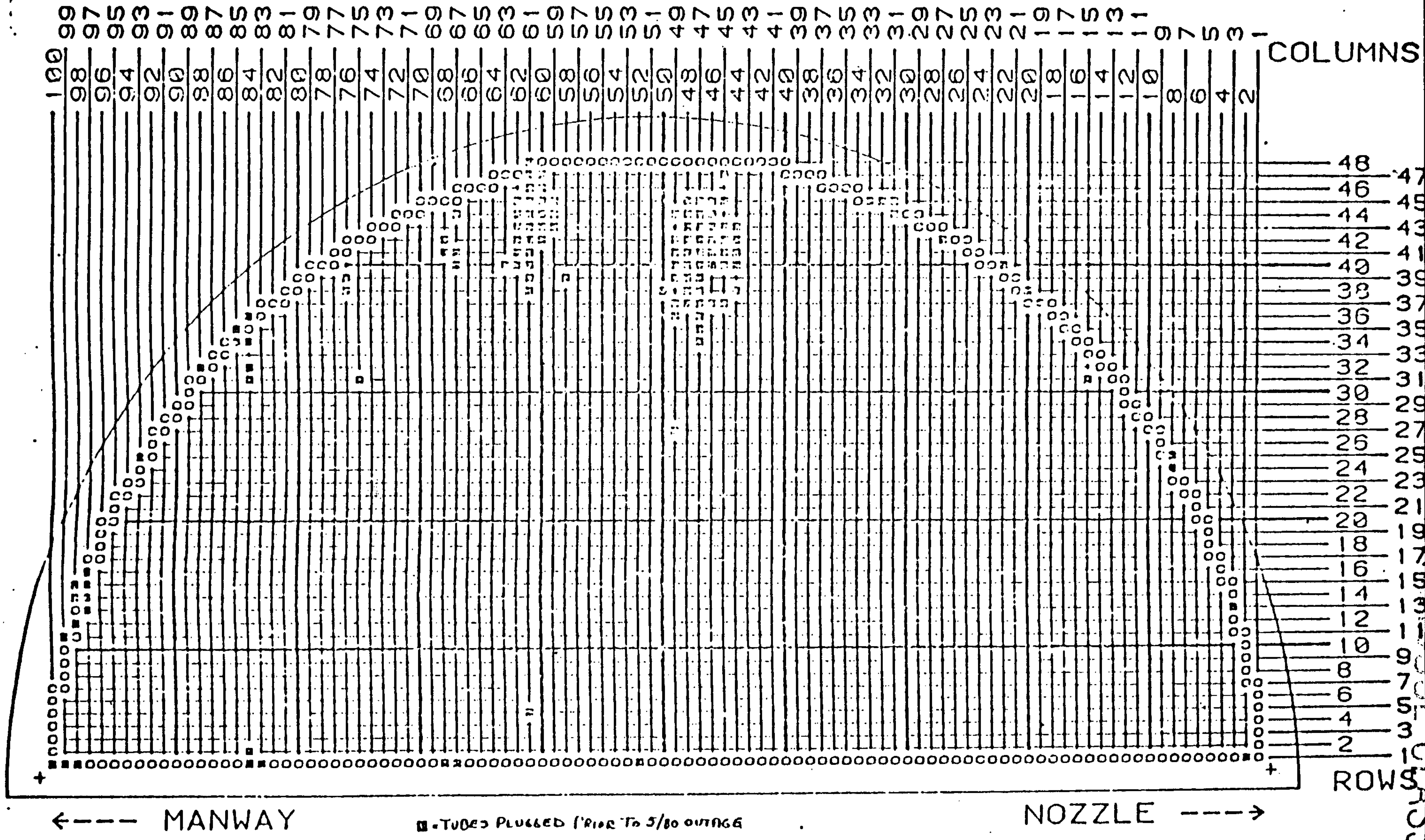
SCE-B



WESTINGHOUSE CLASS 3

SERIES 27

SCE-C



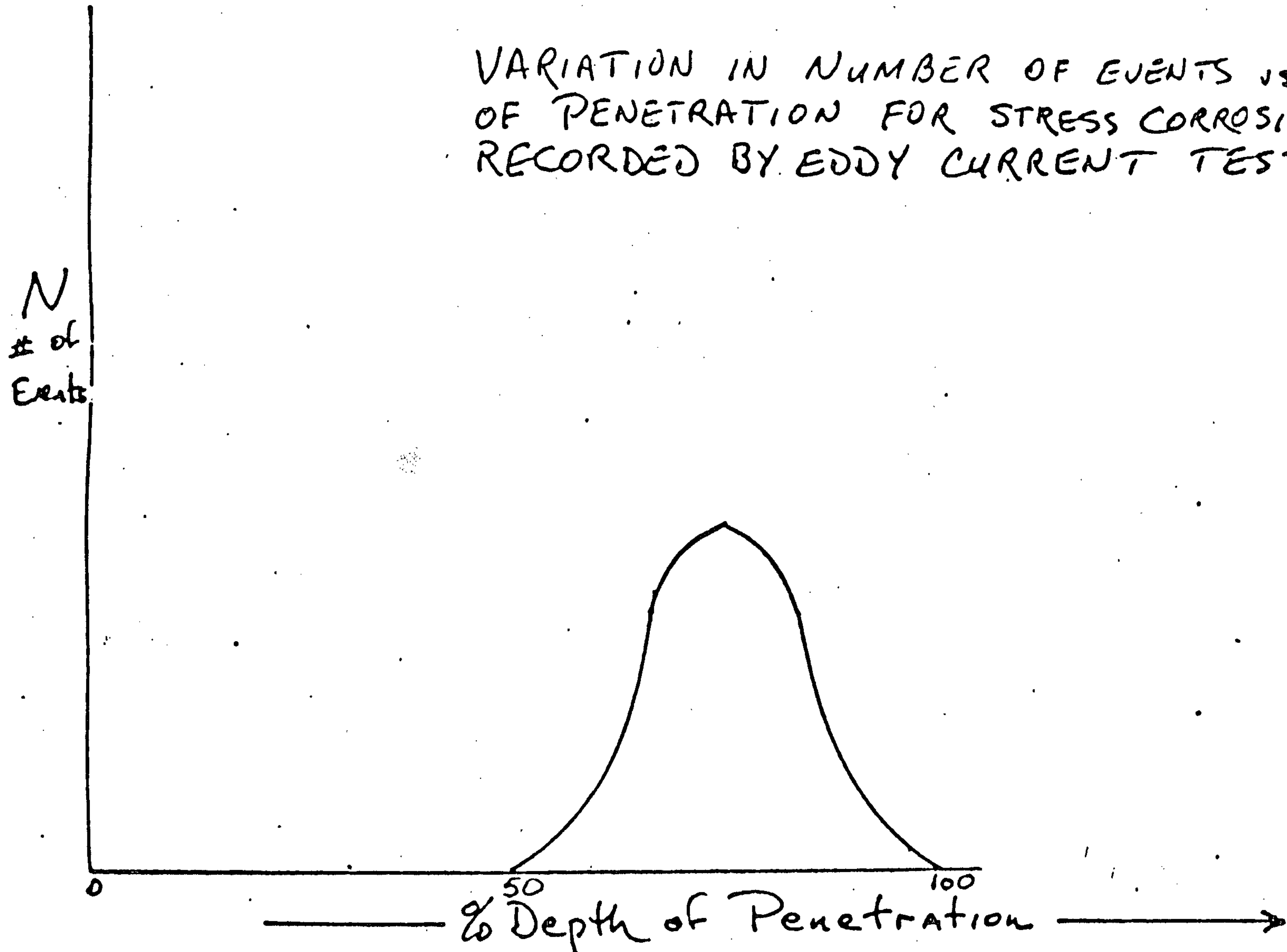
■ = TUBES PLUGGED PRIOR TO 5/80 OUTAGE

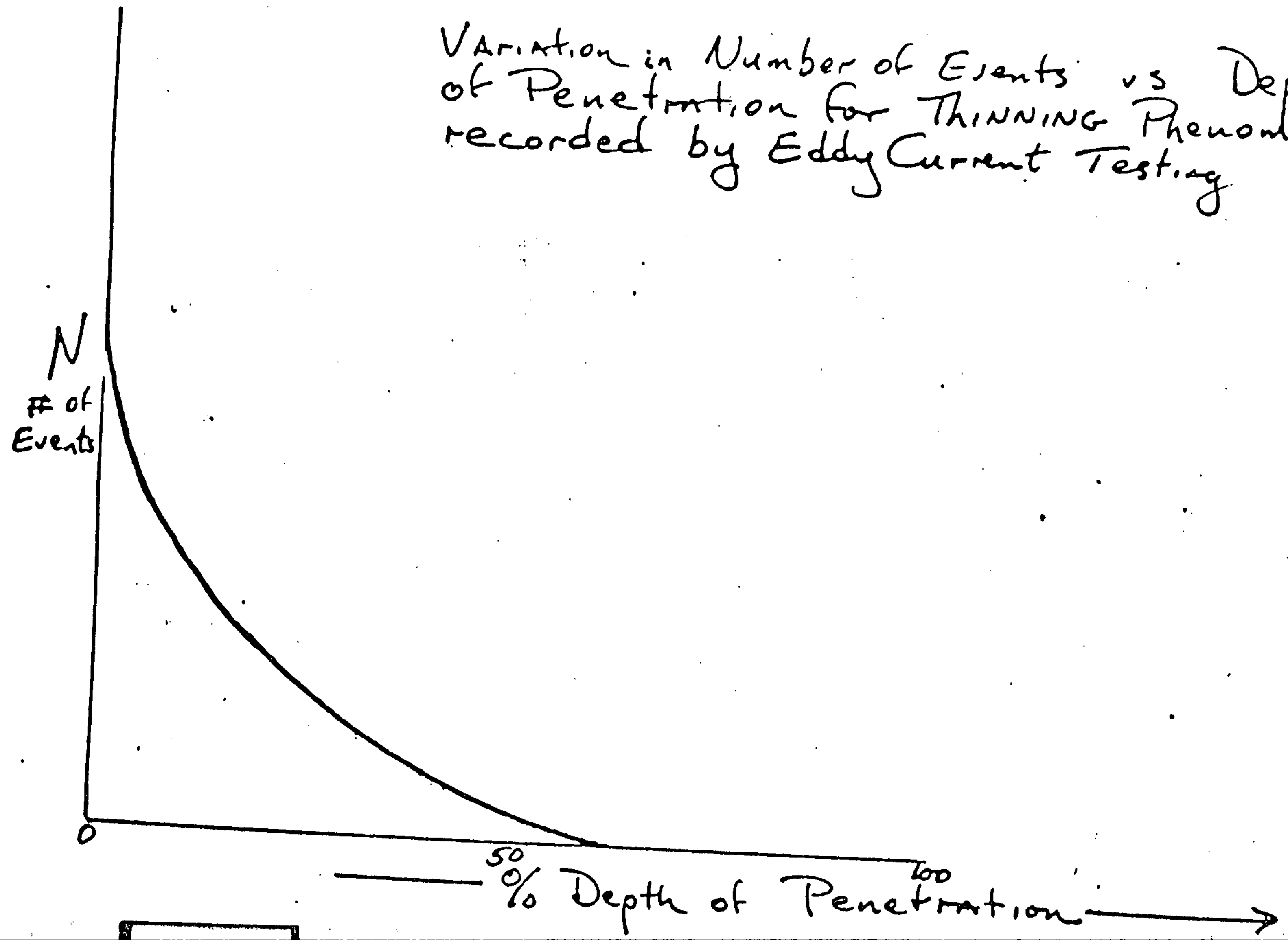
SUMMARY OF CONVENTIONAL EDDY CURRENT EXAMINATION (BOBBIN COIL)

TYPE OF INDICATION (≥ 20%)	S/G A Inlet	S/G A Outlet	S/G B Inlet	S/G B Outlet	S/G C Inlet	S/G C Outlet	REMARKS
At Anti-Vibration Bars							
Total (tubes)	148	-	215	-	209	-	Old indications;
Pluggable (≥ 50%)	4	-	7	-	2	-	No significant gr
Above Tubesheet							
Total ECI's	415	629	148	96	245	39	Old indications;
ECI's ≥ 50%	4	2	1	0	7	0	No significant gr
At Top of Tubesheet							
Total ECI's	145	3	56	0	156	0	Previously unrepo indications; real apparent growth.
ECI's ≥ 50%	128	0	52	0	148	0	
Below Top of Tubesheet							
Total ECI's	1	0	0	0	0	0	Only one apparent indication.
ECI's ≥ 50%	1	0	0	0	0	0	
Tube Support Plate Elevations							
Total ECI's	0	6	1	0	2	0	Limited number of indications; Minor impact.
ECI's ≥ 50%	0	0	0	0	0	0	
Restricted Tubes							
Total Tubes	178	60	-	-	185	25	Manifestation of damage previously shown to be arres
Pluggable	0	2	0	0	2	0	
Other (1)	23	0			4		
Tubes Requiring Plugging	125	1	60	0	16		

(1) Tubes to be plugged because of tube pulling operations.

VARIATION IN NUMBER OF EVENTS vs DEPTH OF PENETRATION FOR STRESS CORROSION CRACKING RECORDED BY EDDY CURRENT TESTING



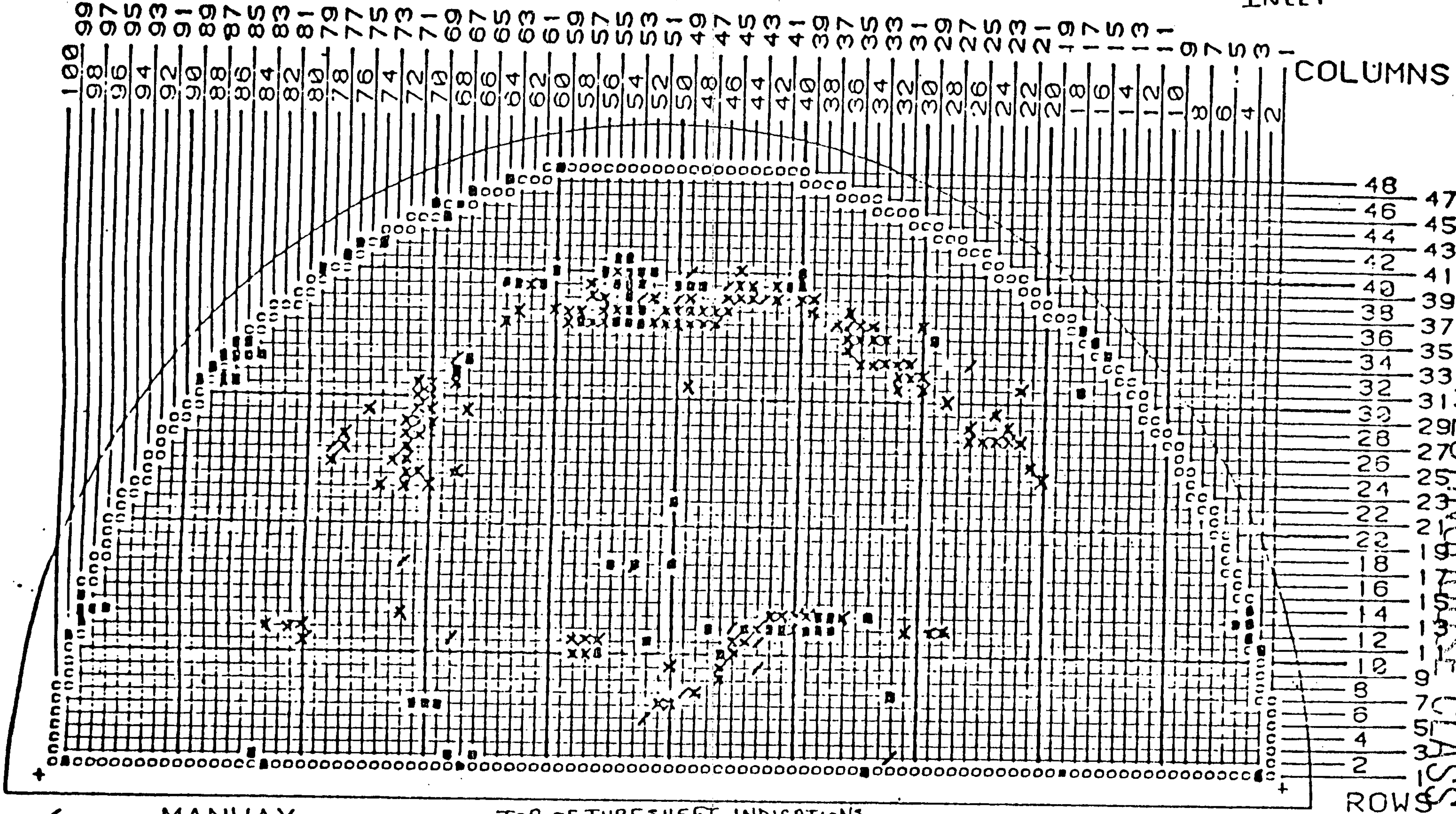


Variation in Number of Events vs Depth of Penetration for THINNING Phenomena recorded by Eddy Current Testing

SERIES 27

SCE-A

INLET



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←--- MANWAY

NOZZLE --->

TOP OF TUBESHEET INDICATIONS

X = ≥ 50% - 123 TUBES

/ = 20% - 49% - 17 TUBES

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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: 98% 4" below top of tubesheet.

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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.

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Tube Examinations: Metallography vs RPC

Third Phase

Tube No.	RPC Result	Tube Condition
A-R20C60H	No detectable degradation	<5 mil thinning; No crack indications
A-R22C84H	"	<5 mil thinning; 15 mil penetration at top of tubesheet
A-R23C83H	"	<10 mil thinning; <15 mil penetration at top of tubesheet
A-R17C61H	62%	Circumferential indication just below top of tubesheet
A-R20C85H	38%	80% max. penetration
A-R12C70H	<20%	50% max. penetration
A-R41C46C	73%	<17% thinning; no apparent cracking

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SCE IN-SITU TUBE PRESSURE TESTS - LEAKERS

- TESTED FIVE (5) LEAKERS IN SG-C

TUBE NO.	MAX. TEST PRESSURE	MAX. LEAK RATE
R11C45	5600 PSI	0.17* GPM
R12C36	5900 PSI	0.43 GPM
R12C38	5800 PSI	0.91 GPM
R12C48	6000 PSI	0.25 GPM
R12C51	5600 PSI	0.22 GPM

- FIBEROPTICS INSPECTION AFTER TESTS

  LARGE CIRCUMFERENTIAL SEPARATIONS AT TTS ON ALL 5 TUBES

- INFERENCES
  - LEAK RATES ARE IMPEDED BY THE PRESENCE OF SLUDGE PILE
  - LEAKERS TESTED IN-SITU MEET THE MAXIMUM OPERATING-BASIS STRENGTH REQUIREMENT

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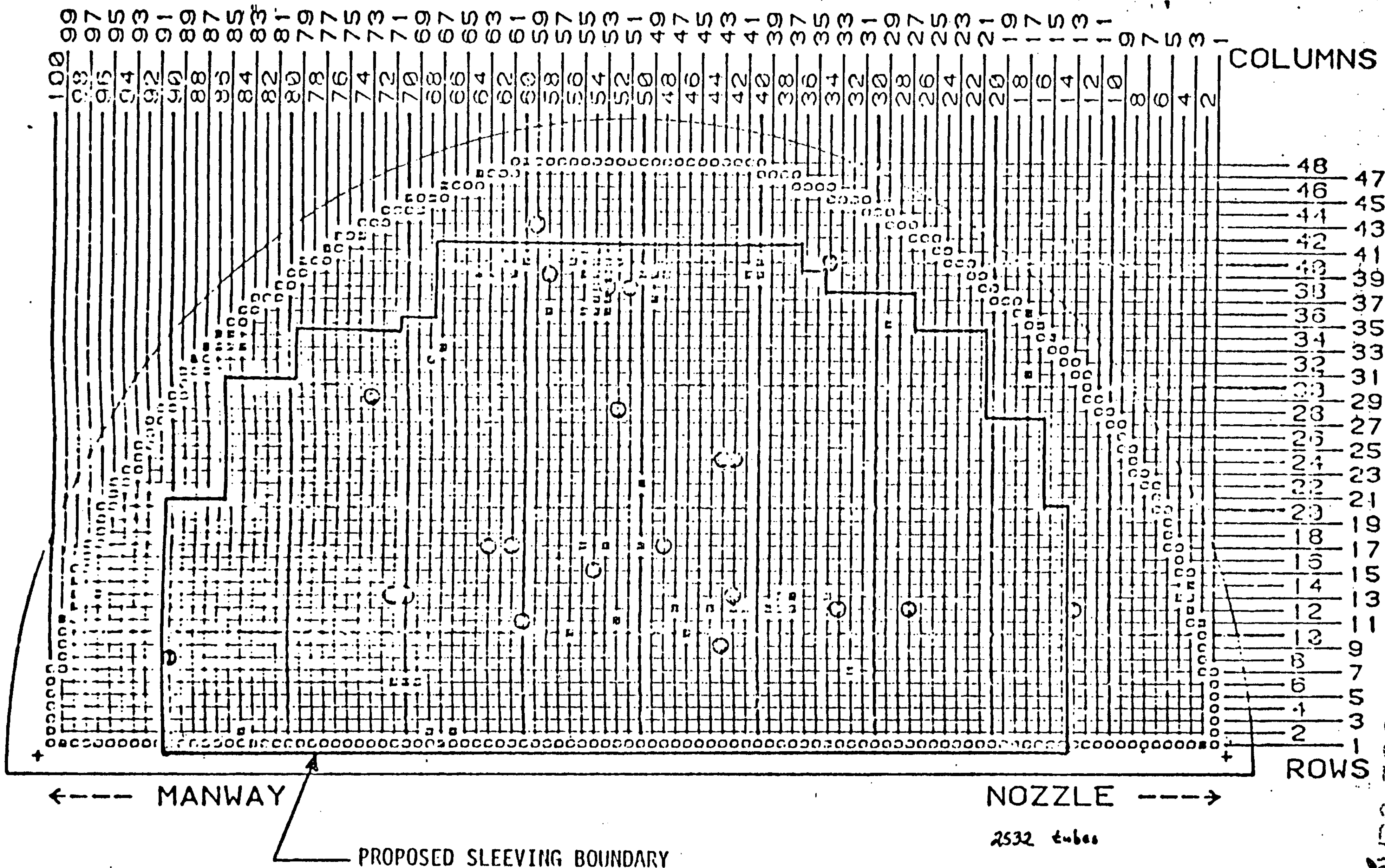
* LEAK RATES, ALTHOUGH SMALL, FLUCTUATED WIDELY OVER THE ENTIRE TEST PRESSURE RANGE

SERIES 27

SCE-A

WESTINGHOUSE CLASS 3



2532 tubes

● TUBES PRESSURE-TESTED IN-SITU TO 3000 PSI.

SCE IN-SITU TUBE PRESSURE TESTS - NONLEAKERS

- TESTED TWENTY-TWO (22) NONLEAKERS IN SG-A WESTINGHOUSE CLASS 3

R-C	RPC %	RPC Arc°	CONV. ECT	SLUDGE HEIGHT	TUBESHEET ZONE
A-13-70	55%	220°	NDD	6 in.	SLUDGE-LANCE ACCESSIBLE ON MANWAY SIDE
13-71	89%	240°	NDD	6 in.	
11-60	97%	350°	NDD	8 in.	
17-61	62%		NDD	12 in.	
A-12-33	50%	180°	NDD	8 in.	SLUDGE-LANCE ACCESSIBLE ON NOZZLE SIDE
13-42	86%	240°	80%	11 in.	
9-43	97%	180°	45%	7 in.	
12-27	<20%	90°	NDD	9 in.	
A-15-54	NDD	---	NDD	12 in.	CENTRAL, RELATIVELY QUIET
28-52	NDD	---	NDD	19.5 in.	
24-43	64%	150°	NDD	16 in.	
24-42	83%	120°	NDD	16 in.	
17-63	96%	180°	NDD	12 in.	
17-48	94%	210°	NDD	17 in.	
A-38-51	88%	210°	NDD	9 in.	RELATIVE ACTIVE BETWEEN ROWS 34-40 AND COLS. 40-60
38-53	91%	180°	33%	9 in.	
39-58	96%	150°	NDD	8 in.	
29-73	96%	360°	NDD	14 in.	
A-43-59	NDD	---	NDD	0 in.	OUTER PERIPHERAL
40-34	NDD	---	NDD	6 in.	
12-13	NDD	---	NDD	5 in.	
8-90	NDD	---	NDD	4 in.	

- PRESSURIZED TO 3000 PSI
- NO LEAKAGE
- FIBEROPTICALLY INSPECTED R17C61 - NO INDICATIONS
- INFERENCE - NONLEAKERS TESTED IN-SITU MEET THE MAXIMUM OPERATING-BASIS STRENGTH REQUIREMENT

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IN-SITU PRESSURE TESTS
OF
NON-LEAKING TUBES

- Twenty-two (22) tubes in SG/A were tested.

  16 RPC indications
  6 No detectable degradation

- Pressurized to 3000 psi.

- No Leakage.

- Fiber optics inspection of R17C61 revealed no indications at the top of the tubesheet.

- Inference: Non-leakers tested in-situ meet the maximum operating basis strength requirements.

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CORROSION RATE ESTIMATE

Examination of eddy current signals from prior inspections indicates the presence of signal distortions in 1973 data.

Best estimates on data from 10/76, 9/77, 9/78 and 6/79 inspections permits rough corrosion rate calculation.

39 tubes in SG/A

Average Growth Rate: 13% per year

CONVENTIONAL EDDY CURRENT
INSPECTION PROGRAM
April, 1980 Refueling Outage

	A INLET	A OUTLET	B INLET	B OUTLET	C INLET	C 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
PLANNED INSPECTIONS						
Through U-Bend	491		586		452	
Through 4th Support	380	16				
Through 1st Support	2828	1480	3158	386	3218	279
ACTUAL INSPECTIONS						
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

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PERSONNEL EXPOSURE (MAN-REM)

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DECON PROCESS DEVELOPMENT
FOR STEAM GENERATOR
CHANNELHEAD MAINTENANCE ACTIVITIES

[ ] a,c,e

WESTINGHOUSE CLASS 3

EXPERIENCE

a, c, e

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TECHNICAL ISSUES

1. CLAD CONDITION AFTER DECON
2. RESIDUAL GRIT
   - CHEMISTRY COMPATIBLE
   - R.C. PUMP SEALS/CRDM
3. DILUTION
4. WASTE HANDLING

a, c, e

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WESTINGHOUSE CLASS 3

a, c, e

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HEALTH PHYSICS PROGRAM

FOR

STEAM GENERATOR REPAIR

I. ORGANIZATION

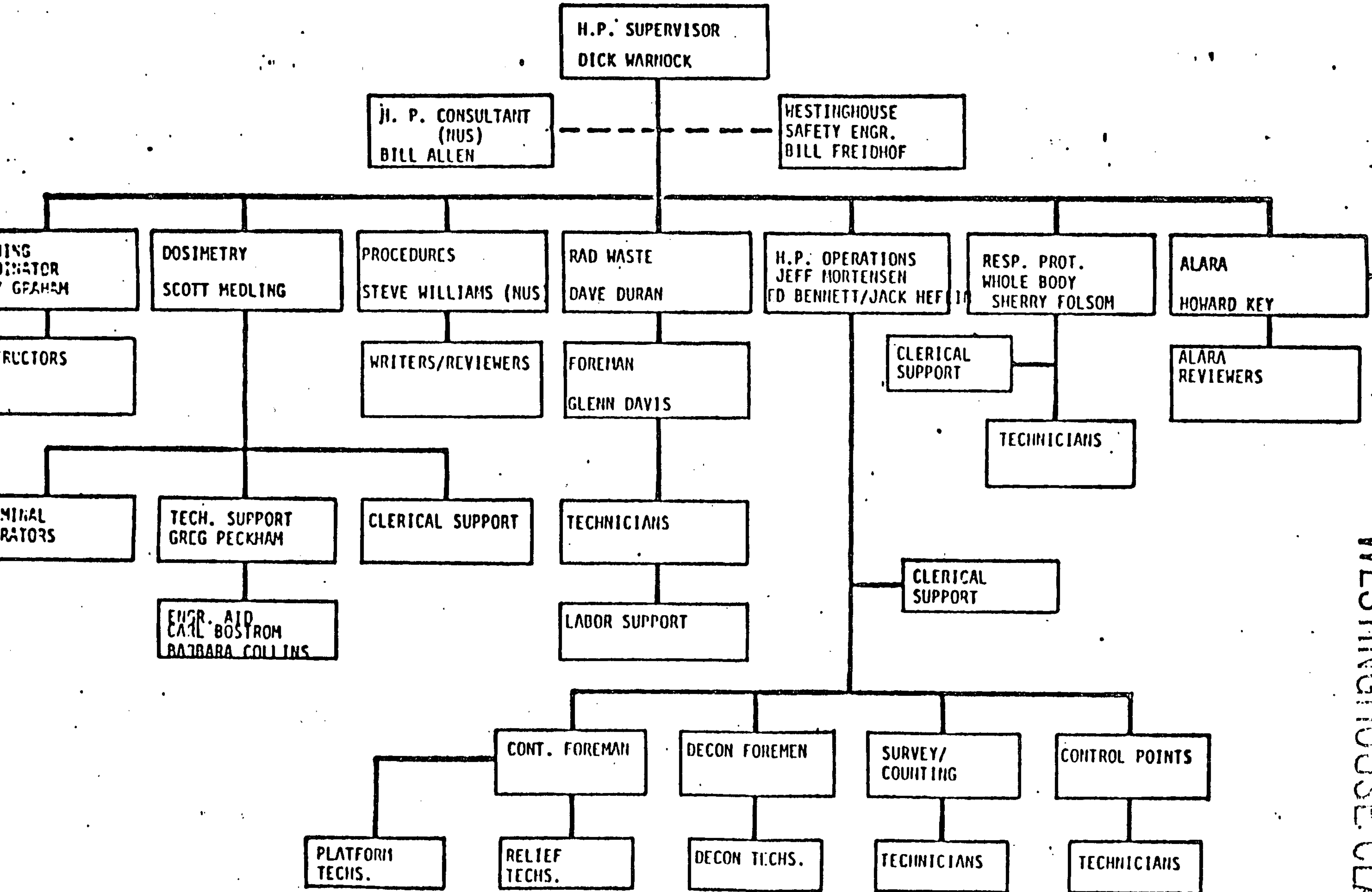
A. A HEALTH PHYSICS ORGANIZATION DEDICATED TO S/G REPAIR IS DEVELOPED TO PROVIDE:

1. SHIFT COVERAGE IN THE FUNCTIONAL AREAS
2. ADEQUATE STAFF TO SUPPORT ACTIVITIES IN 3 STEAM GENERATORS
3. ASSURANCE OF CONTAMINANTION CONTROL AND RAD WASTE HANDLING

B. STAFFING SUPPLEMENT SUMMARY

1. 64 HEALTH PHYSICS TECHNICIANS ARE CONTRACTED AS OF 10/15/80
2. 16 DECON TECHNICIANS ARE AVAILABLE FOR SHIFT COVERAGE
3. 12 SCE PERSONNEL ARE DEDICATED TO S/G REPAIR.

Revision
9/9/80



WESTINGHOUSE CLASS 3

WESTINGHOUSE CLASS 3

I. TRAINING

A. THE EXISTING STATION RADIATION PROTECTION TRAINING PROGRAM IS UTILIZED TO QUALIFY CERTAIN PERSONNEL FOR UNESCORTED ACCESS.

1. SCE SUPPORT
2. WEC
3. ANS SUPERVISORS & ESCORTS

B. CONTRACTED HEALTH PHYSICS PERSONNEL RECEIVE:

1. UNESCORTED ACCESS TRAINING
2. STATION HEALTH PHYSICS PROCEDURE TRAINING

C. STEAM GENERATOR ENTRANTS TRAINING SEQUENCE:

1. DAY ONE
   - A. FOUR + HOURS CLASSROOM INSTRUCTION RELATED TO 10CFR19-12
   - B. EXAMINATION
   - C. WHOLE BODY COUNT

2. DAY TWO
   - A. FULL PHYSICAL EXAM
   - B. DRESS UP/OUT IN FULL PROTECTIVE CLOTHING
   - C. RESPIRATORY PROTECTION CLASS AND EXAM

3. DAY THREE
   A. MOCK UP TRAINING IN CIVILIAN CLOTHES/TOOLING USE
   B. FULL DRESS AND JUMP IN SIMULATED PLATFORM ENVIRONMENT
      1. STEP OFF PADS
      2. H.P. COVERAGE
   C. SEQUENCE ABOVE IS REPEATED AT LEAST ONCE WITH TIMING ON BOTH FOR PROFICIENCY (RECORDED)

4. REFRESHER CLASSES ARE HELD AS NECESSARY FOR PROCEDURE OR EQUIPMENT CHANGES

5. JOB SPECIFIC TRAINING HAS 15 SEPARATE QUALIFICATIONS

D. SYSTEM TRAINING FOR OTHER PERSONNEL

1. SYSTEM REVIEWS & WALK THROUGHS
   A. DECON, HONING, SLEEVING (ENGINEER SHIFT COORDINATORS)

2. HEALTH PHYSICS PERSONNEL
   A. FOUR HOURS INSTRUCTION ON EQUIPMENT PLUS MOCKUP/JUMPER OBSERVATION

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II. PROCEDURES

A. THE FOLLOWING PROCEDURES HAVE BEEN DEVELOPED AND APPROVED TO SUPPORT S/G ACTIVITIES:

1. ALARA PROGRAM FOR S/G DECON & REPAIR
2. RESPIRATORY PROTECTION PROGRAM FOR S/G DECON & REPAIR
3. PACKAGING AND TRANSFERRING DECON FILTERS TO RADWASTE STORAGE AREA
4. EMERGENCY PROCEDURES FOR S/G DECON & REPAIR
5. USE, CLEANING AND MAINTENANCE OF THE BIOMARINE BIOPAK 60P RESPIRATOR
6. TRANSFER AND PREPARATION OF HONES FROM S/G PLATFORMS TO RADWASTE AREA
7. PACKAGING AND TRANSFERRING FLEXIHONE WATER FILTERS TO RADWASTE STORAGE AREA

B. A "HEALTH PHYSICS PROGRAM FOR STEAM GENERATOR REPAIR" PROCEDURE IS NEAR COMPLETION

1. STANDARDIZE APPROACH AND AS APPLIED TO S/G REPAIR WILL ADDRESS AREAS SUCH AS:
   a. DOSIMETRY
   b. ACCESS & EGRESS
   c. TRAINING
   d. RESPIRATORY PROTECTION
   e. EXPOSURE LIMITS

IV. ACCESS CONTROL

A. A SEPARATE ENTRANCE FOR WEC PERSONNEL HAS BEEN ACTIVATED AND MANNED.

* B. AN ENTRANCE/EXIT FACILITY HAS BEEN CONSTRUCTED ON THE TURBINE DECK.

1. A COMPUTER TERMINAL WILL BE ACTIVATED TO ASSURE ACCURATE WORK FUNCTION AT TIME OF ENTRY

C. PROTECTIVE CLOTHING SEQUENCE

1. INGRESS
   A. TWO LAYERS OF PROTECTIVE CLOTHING, HEAD COVER, COTTON GLOVES AT OUTER ACCESS
   B. THROW AWAY BOOTIES, RUBBERS AND PLASTIC GLOVES AT EQUIPMENT HATCH ACCESS
2. EGRESS
   A. RUBBERS ARE REMOVED AT FIRST STEP OFF PAD
   B. COVERALLS, GREEN GLOVES REMOVED PRIOR TO PERSONNEL HATCH EXIT
   C. PLASTIC BOOTIES ARE REMOVED ON TURBINE DECK AND SHOES FRISKED
   D. FULL BODY FRISK PRIOR TO EXIT TURBINE DECK
   E. UNDER LAYER OF COVERALLS REMOVED AT ACCESS TRAILER

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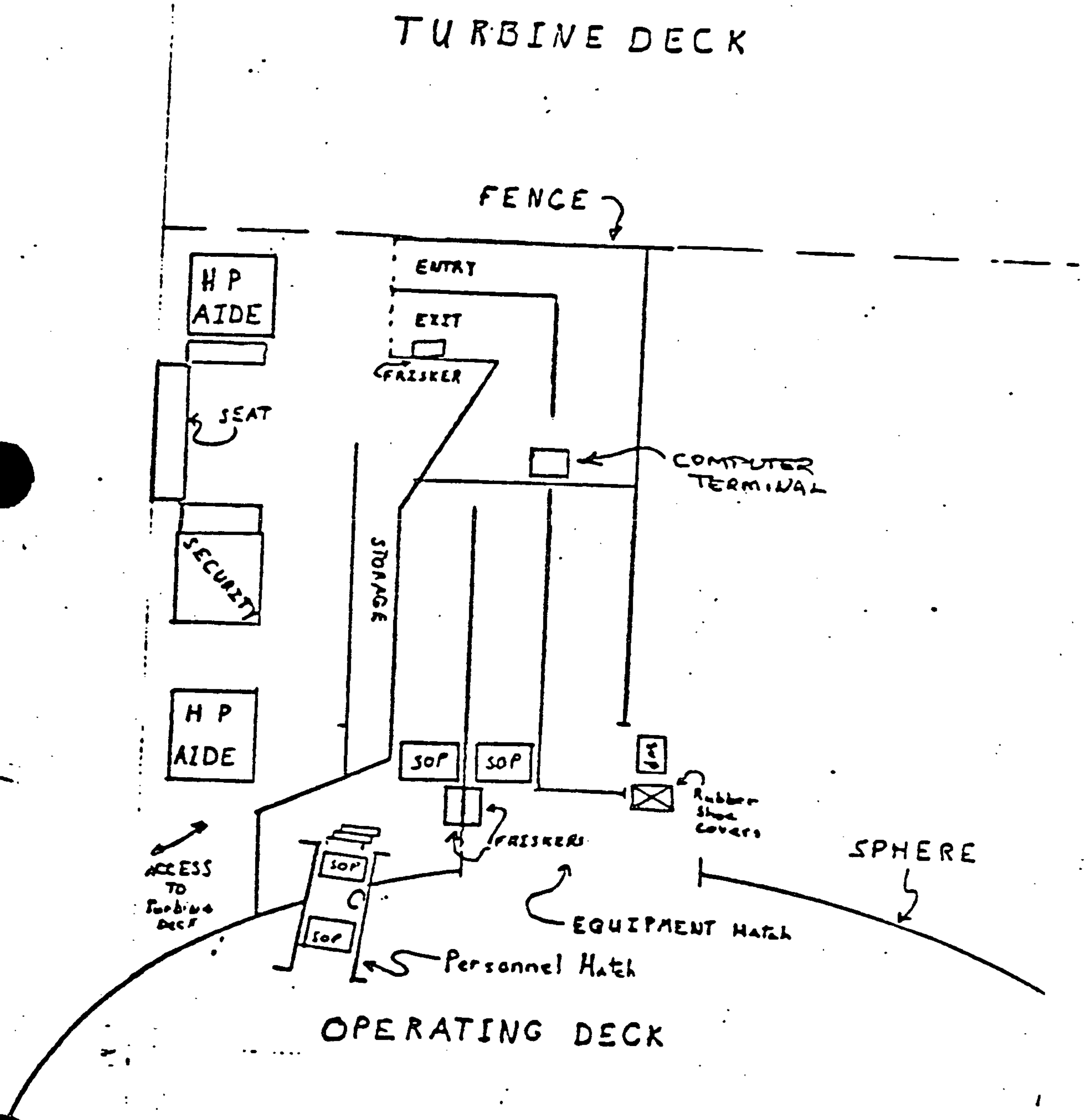


V. ALARA

A. DOSE REDUCTION EFFORTS

1. EXTENSIVE SURVEYS AND POSTING OF HOT SPOTS AND IDENTIFICATION OF "COOL AREAS"
* 2. TEMPORARY SHIELDING AT ALL PRACTICABLE LOCATIONS
3. ERECTION OF SHIELDED "DOG HOUSES" FOR HIGH OCCUPANCY AREAS
4. SUIT UP FOR STEAM GENERATOR ENTRY ON TURBINE DECK WHENEVER PRACTICABLE

B. DOSE ASSESSMENT

* 1. BLANKET REP's RELATED TO WORK FUNCTION HAVE BEEN ESTABLISHED TO ALLOW EVALUATION OF ACTIVITY BY STEAM GENERATOR

C. MANAGEMENT ATTENTION

1. SHIFT COVERAGE TO SEARCH FOR IMPROVEMENTS AND RECORD DISCREPANCIES THAT NEED RESOLUTION
* 2. DAILY EXPOSURE UPDATES TO ASSURE KNOWLEDGE OF EXPOSURE STATUS AND TRENDS

D. TRAINING

1. ALARA BRIEFINGS FOR PERSONNEL INVOLVED IN PROJECT
2. USE OF MOCK UP WITH FULL DRESS FOR VARIOUS TOOLING QUALIFICATIONS
   A. PERSONNEL ARE TIMED FOR PROFICIENCY. RECORDS ARE MAINTAINED SO THE BEST AVAILABLE MAN-POWER MAY BE USED.

E. 10CFR20.201 - SURVEYS

1. CONTAMINATION ONCE PER SHIFT (20.103)
2. RADIATION LEVELS ONCE PER SHIFT (20.101, 20.203)
3. SITE PERIMETER RADIATION SURVEYS ONCE PER DAY (20.105)
4. AIR SAMPLING - CONTINUOUS ON PLATFORMS AND NEAR DECON PROCESS EQUIPMENT - GRAB SAMPLES DURING CHANNEL HEAD WORK IN C/H, ON CATWALKS AND PLATFORM (20.103)

F. 10CFR20.202 - PERSONNEL MONITORING

1. ALL ACCESS TO SPHERE REQUIRES CHEST BADGE AND 0-200 MR AND 0-1R DOSIMETRY
2. HEAD AND EXTREMETIES ARE REQUIRED FOR PLATFORM AND CHANNEL HEAD WORK

G. 10CFR20.203 - POSTING & LABELING

1. CONTAINMENT AREAS ARE POSTED TO ASSURE COMPLIANCE AND INFORM WORKER DURING ACCESS WORK ACTIVITIES AND EGRESS

H. 10CFR19.12

1. EXISTING PLANT TRAINING PROGRAMS ARE UTILIZED FOR UNESCORTED ACCESS
2. CLASSROOM INSTRUCTION FOR CHANNEL HEAD WORKERS SUPPLEMENTED BY REALISTIC MOCK UP ACTIVITY QUALIFICATION (REG GUIDE 8.8)

I. 10CFR20.103 (REG GUIDE 8.15)

1. CLASSROOM INSTRUCTION AND EXAMINATION SUPPLEMENTED BY HANDS ON USE IN MOCK UP SITUATION

WESTINGHOUSE CLASS 3

INDEPENDENT
THIRD PARTY REVIEW
PRESENTATION

SLEEVE DESIGN
SLEEVE CRITERIA
STRESS ANALYSIS

P. P. DEROSA
October 23, 1980

VP/013

WESTINGHOUSE CLASS 3

TUBE REPAIR AND SLEEVING HISTORY

a,c,e,f

WESTINGHOUSE CLASS 3

a, c, e, f

VP/013

SLEEVE DESIGN CRITERIA

- REPLACES THE TUBE AS PRESSURE BOUNDARY
  - STRUCTURAL INTEGRITY
  - PRESSURE CONTAINING
- MEETS ASME CODE REQUIREMENTS
  - SECTION II MATERIAL
  - SECTION III DESIGN & ANALYSIS
  - [ ] a,c,e,f
  - SECTION XI INSERVICE INSPECTION
- ACCOMODATES TUBES IN "FIELD-CONDITION"
  - OXIDIZED/RADIOACTIVE
  - DENTED
  - NON-STRAIGHT/NON-PERPENDICULAR
  - DISTORTED TUBE ENDS
- MINIMAL EFFECT ON PRIMARY FLOW RESISTANCE
  - ENTRANCE AND EXIT LOSSES
  - FRICTION LOSSES
- SPANS THE SECTION OF AFFECTED TUBE
- MATERIAL SELECTION QUALIFIED WITH CORROSION TESTS

TABLE 3.1

ASME CODE AND REGULATORY REQUIREMENTS

Item	Applicable Criteria	Requirement
Sleeve Design	Section III	NB-3200, Analysis NB-3300, Sizing Test
	Westinghouse Equipment Specification 675161 Rev 3, Dated 10/28/64	Analysis Conditions
	Reg. Guide 1.83	S/G Tubing Inspectibility
	Reg. Guide 1.121	Plugging Margin
Sleeve Material	Section II	Material Composition
	Section III	NB-2000, Identification, Tests and Examinations
	Code Case 1484-3	Mechanical Properties
[ ] a,c,e,f Material	Section II	[ ] a,c,e Material Composition
	Section III	[ ] a,c,e Identification
[ ] a,c,e,f Joints	Section III	NB-4000, Configuration and Testing
	Section IX	Process Qualification
	Section XI	Inspection Pressure Testing

WESTINGHOUSE CLASS 3

a,c,e,6

Figure 4.5 Sleeve Design

a,b,c,e,f

WESTINGHOUSE CLASS 3

Figure 3.1 Sleeve Configuration

WESTINGHOUSE CLASS 3

a,c,e,6

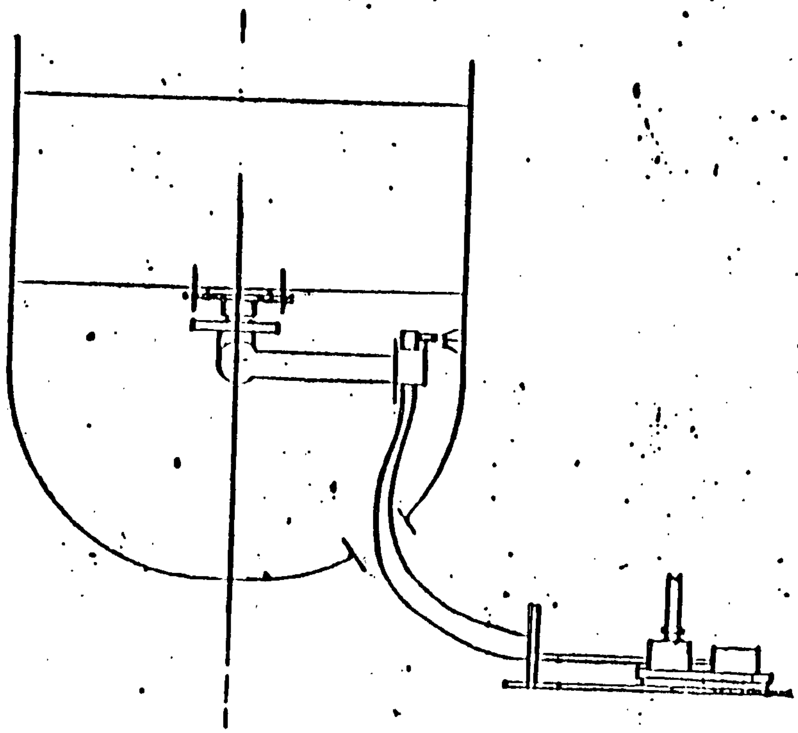
[ ]

Figure 3.2 PHOTO SLEEVE [ ]a, c, e, 6

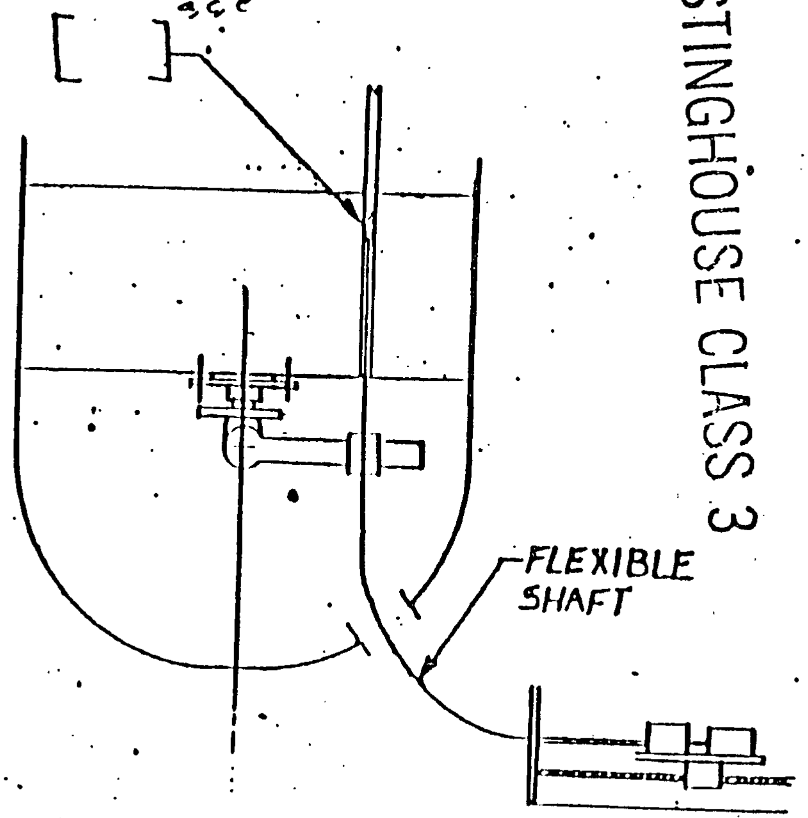
WESTINGHOUSE CLASS 3

a,c,e

WESTINGHOUSE CLASS 3



DECONTAMINATE



CLEAN TUBES

[ ]a,c,e

Figure 4.2

[ ]a,c,e

WESTINGHOUSE CLASS 3

a,c,f

WESTINGHOUSE CLASS 3

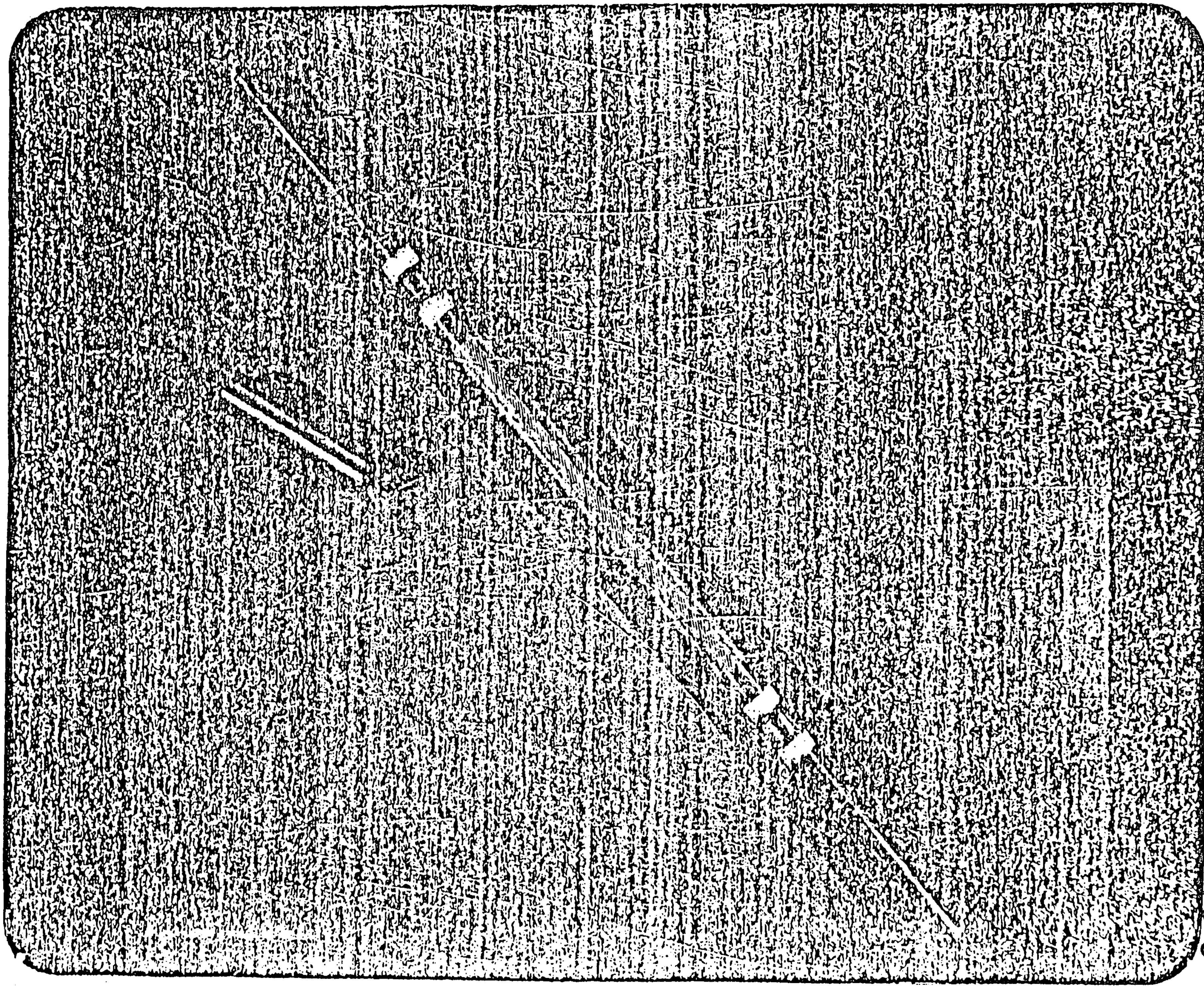
WESTINGHOUSE CLASS 3

a,c,e

WESTINGHOUSE CLASS 3

a,c,e

RIGID MANDREL For Sleeving



WESTINGHOUSE CLASS 3

a,c,e

18

WESTINGHOUSE CLASS 3

a,c,e

a,c,f

[ ]

a,c,f

Figure 4.8 [ ] System

WESTINGHOUSE CLASS 3

a,c,f

Figure 4.9 [ ] Cycle

a,c,f

a, c, e, f

WESTINGHOUSE CLASS 3

SLEEVE LOWER JOINT QUALIFICATION TESTS

ACCEPTANCE CRITERIA

- ZERO LEAK RATE (LESS THAN $\frac{1}{10,000}$ GPM PER JOINT)
- STRUCTURAL INTEGRITY

TESTS

a, c, e, f

[
-
-
-
]

a,c,e

a,c,e

WESTINGHOUSE CLASS 3

e

a,c,e,f

a,c,e

WESTINGHOUSE CLASS 3

SLEEVE-TO-TUBE [ ]a,c,e JOINT TESTING

OBJECTIVE

- DEMONSTRATE AND VERIFY THE LEAK-TIGHTNESS OF [ ]a,c,e JOINT

TEST SPECIMEN

[ ]a,c,e

PRELIMINARY RESULTS

[ ]a,c,e

WESTINGHOUSE CLASS 3

SLEEVE ANALYSIS

- DESIGN AND CODE CRITERIA
- SLEEVE DESIGN
- ASME SECTION III ANALYSIS
  - EQUIPMENT SPECIFICATION REQUIREMENTS AND LOADS
  - METHOD OF ANALYSIS
  - SECTION III RESULTS
  - SPECIAL CONSIDERATIONS

WESTINGHOUSE CLASS 3

CODE AND DESIGN CRITERIA

REQUIREMENT	CRITERIA	VERIFICATION
I. CODE		
• SLEEVE STRUCTURAL INTEGRITY	SECTION III SECTION XI	ANALYSIS TESTING
[•		] a,c,e
• PLUGGING CRITERIA	REG. GUIDE 1.121	ANALYSIS
II. DESIGN		
• DESIGN LIFE = REMAINING LIFE		ANALYSIS

a, c

Figure 6.2.1 Geometry Analyzed

WESTINGHOUSE CLASS 3

CONDITIONS EVALUATED

- DESIGN
- TEST
- FAULTED
- NORMAL AND UPSET
  - PRIMARY PLUS SECONDARY STRESS RANGE
  - FATIGUE
- SPECIAL AND IN-FIELD CONDITIONS
  - FLOW SLOT HOURGLASSING
  - TUBE/SLEEVE VIBRATION
  - FLOW VELOCITY IN SLEEVE

TABLE 6.2.3

DESIGN, FAULTED AND TEST CONDITIONS

Conditions	Reference	Sleeve Pressure Loading (psig)	
		Primary	Secondary

a, c

WESTINGHOUSE CLASS 3

a,c

[ ]

Figure 6.2.11 Secondary Pressure Unit Loading [ ]a,c

a,c

Figure 6.2.8 Primary Pressure Unit Loading [ ]a,c

a,c

Figure 6.2.6 Finite Element Model
Sleeve Lower End

a, c

[ ]

Figure 6.2.7 Finite Element Model [ ] a,c,f

a,c

Figure 6.2.2 Analysis Cross-Sections

WESTINGHOUSE CLASS 3

DESIGN CONDITIONS

ISSUE

- NB-3324, REQUIRED THICKNESS
- NB-3221, DESIGN LIMITS
- NB-3133, EXTERNAL COLLAPSE PRESSURE

LOADING

	PRESSURE (P_P/P_S), PSIG
WITH PERFORATED TUBE	2485/985
WITH UNPERFORATED TUBE	2485/0

METHOD OF ANALYSIS

- FINITE ELEMENT AND HAND CALCULATIONS
- CONSIDERED TUBE SERVERED AND UNSEVERED (NON-LEAKING)

RESULTS

a,c,e

[
-
-
-
]

WESTINGHOUSE CLASS 3

TEST CONDITIONS

ISSUE

- NB-3226, TESTING LIMITS
- NB-3133, EXTERNAL COLLAPSE PRESSURE
- CYCLES INCLUDED IN FATIGUE ANALYSIS

LOADING

	CRITERIA	PRESSURE(P_P/P_S), PSIG
PRIMARY TEST	SECTION XI (1.10P_O)	2295/0
PRIMARY LEAK	SECTION XI (P_O)	2085/0
SECONDARY TEST	SECTION XI (1.25P_D)	0/1235
SECONDARY LEAK	SECTION XI (P_O)	0/695

METHOD OF ANALYSIS

- FINITE ELEMENT AND HAND CALCULATIONS

RESULTS

- MAXIMUM STRESS VS. ALLOWABLE RATIO OF .53 AT SECTION EE
- MINIMUM COLLAPSE PRESSURE OF 1308 PSIG (PER CODE)

WESTINGHOUSE CLASS 3

FAULTED CONDITIONS

ISSUE

- NB-3225, LEVEL D SERVICE LIMITS
- NB-3133, EXTERNAL COLLAPSE PRESSURE
- APPENDIX F
- REGULATORY GUIDE 1.121

LOADING

	PRESSURE (P_P/P_S), PSIG
SLB/FLB	2085/0
LOCA	0/710

METHOD OF ANALYSIS

- FINITE ELEMENT AND HAND CALCULATIONS

RESULTS

- MAXIMUM STERSS VS. ALLOWABLE RATIO OF .31 SECTION EE
- MINIMUM COLLAPSE PRESSURE OF 1146 PSIG
- MINIMUM REQUIRED WALL TO MEET REGULATORY GUIDE 1.121 IS .013 INCHES (36% OF WALL)

WESTINGHOUSE CLASS 3

NORMAL AND UPSET CONDITIONS

ISSUE

- NB-3222, LEVEL A SERVICE LIMITS
- NB-3223, LEVEL B SERVICE LIMITS
- REGULATORY GUIDE 1.121

LOADING

(SEE TABLE)

METHOD OF ANALYSIS

- FINITE ELEMENT ANALYSIS
- THERMAL STRESSES INCLUDE TUBE/SLEEVE INTERACTION
- PRESSURE STRESSES CONSIDER TUBE SEVERED AND UNSEVERED
- ASSUMES REMAINING LIFE
- SECONDARY STRESS EVALUATION INCLUDES BENDING DUE TO FLOW SLOT HOURGLASSING

RESULTS

- PRIMARY PLUS SECONDARY STRESS RANGE - 45 KSI $< 3\ S_M$ AT WW (79.8KSI)
- FATIGUE USAGE FACTOR CALCULATIONS - .063 AT WW (OF)
- MINIMUM REQUIRED WALL TO MEET REGULATORY GUIDE 1.121 IS .011 INCHES (30% OF WALL)

WESTINGHOUSE CLASS 3

SPECIAL CONSIDERATIONS

- EFFECT OF FLOW SLOT HOURGLASSING
- EFFECT OF SLEEVE ON TUBE/SLEEVE VIBRATION
- EROSION OF SLEEVE AT [ ]a,c,e JOINT TRANSITIONS
- EFFECT OF TUBE SUPPORT PLATE DENTING

WCM

WESTINGHOUSE CLASS 3

TABLE 6.1.1

MAIN ASPECTS OF THE CORROSION/MATERIAL PROGRAM FOR [ ] JOINTS

a,c,f

[ ]

TABLE 6.1.2

CORROSION/MATERIAL ISSUES AND TESTS CONDUCTED

Issue	Test

a,c,e

TABLE 6.1.2 (continued)

CORROSION/MATERIAL ISSUES AND TESTS CONDUCTED

a,c,e

Issue	Test

6.1.5 Acceptance Criteria for Verification and Qualification Tests of SCE Sleeving - The following lists each criterion, the justification for the selection of the criterion and the specific Task which addresses each criterion.

a,c,f

CRITERA	JUSTIFICATION	TASK

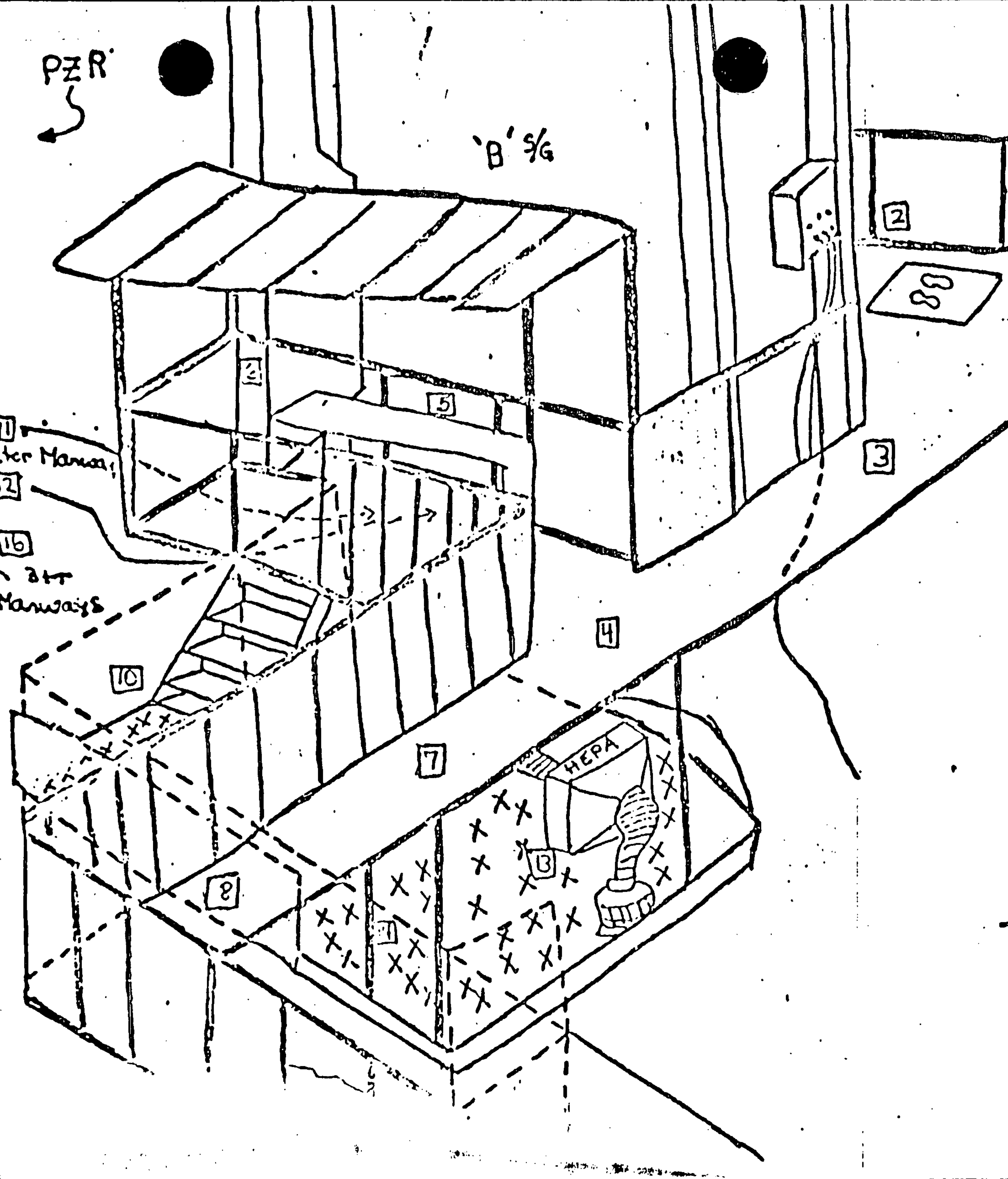
WESTINGHOUSE CLASS 3

CRITERA	JUSTIFICATION	TASK
		a,c,e

WESTINGHOUSE CLASS 3

CONCLUSIONS TO DATE

Issue	Findings
1. Effect of high temperature braze cycle on:	[ ]a,c,e
a. Mechanical properties of tube and sleeve	
b. Micro-structure	
c. Corrosion resistance of tube and sleeve	
d. Possible diffusion of OD contaminants	
e. Possible sensitization of tube or sleeve	
2. Effect of [ ]a,c,e in primary side crevice	
3. Compatibility of [ ]a,c,e	
4. Effect of outer tube leak and exposure of sleeve to secondary side contaminants	
5. Structural integrity of [ ]a,c,e assembly	



- - - - - Cut Away section of overhead shielding

XXX Leaded Generator Platform Floor

WESTINGHOUSE CLASS 3

100 SERIES -- STEAM GENERATOR DECON OPERATIONS 1980 OUTAGE

100	RESERVED
101	EQUIPMENT SETUP/TEST
102	NOZZLE PLUG INSTALLATION
103	AUTOMATIC DECON
104	MANUAL DECON
105	INSTALL NOZZLE SHIELDING
106	CHANNELHEAD INSPECTION/SURVEY
107	EQUIPMENT MOVEMENT/REMOVAL
108	TOUR OF DECON EQUIP
109	SHIELDING SUPERVISION
110	ALARA INSPECTION
111	REPAIR/MAINT CHANNELHEAD
112	REPAIR/MAINT OTHER
113	FILTER CHANGE
114	RADWASTE REMOVAL
115	SUPERVISORY REVIEW
116	HP SURVEILLANCE
117	HOUSEKEEPING
118	SHIELDING
119-148	RESERVED
149	OTHER DECON IN STEAM GENERATORS

150 SERIES-- STEAM GENERATOR SLEEVING OPERATIONS 1980-81

151	R-THETA SETUP/FIXTURE CHG
152	TUBE HONING
153	SLEEVE INSERTION/EXPANSION
154	BRAZE
155	END PREP & ROLL

156	TUBE SHEET WELD/HARD ROLL
157	TUBE REWORK & REPAIR
158	INSPECTION & TESTING
159	TOOLING INSTALL/CHANGE
160	TUBE PLUGGING
161	MAINT - CHANNEL HEAD
162	MAINT - OTHER
163	H.P. SURVEILLANCE
164	SUPERVISORY REVIEW
165	HOUSEKEEPING
166	SHIELDING
167-179	(RESERVED)
180	OTHER SLEEVING OPERATIONS

WESTINGHOUSE CLASS 3

VALIDATION IS COMPLETE - DATA FIELDS WITH INPUT SHOWN IN HIGH INTENSITY:

```
.P. NO.- 07103          LAST UPDATED: Z5A  09/22/80 ·· ·5
IRATION TIME: 09:00     EXPIRATION DATE: 12/31/80
 LOC     07 - U1 STEAM GEN B              MPC- 00.80
 DESC  002 - ROUTINE MAINTENANCE
K DESC 103 - AUTOMATIC DECON
 CLASS 002 - BLANKET
 QUAL   00
M     EMPLOYER DESC  OR                  WORKER DESC  OR
GE    NAME                               QTR     REM    7-MPCH
04   WESTINGHOUSE                       MAINTENANCE WORKER
03   WESTINGHOUSE                       INSTRUMENT TECHNICIA
01   WESTINGHOUSE                       ADMIN, SUPERVISR, CL
03   OTHER                              INSTRUMENT TECHNICIA
06   WESTINGHOUSE                       ENGINEER
01   ·UMPER (R&M OR PROTR               ADMIN, SUPERVISR, CL
04   ·MPER (R&M OR PROTR                MAINTENANCE WORKER
06   ·UMPER (R&M OR PROTR               ENGINEER
NO CHANGES - DEPRESS PF 7 KEY
NT REQUESTED BY Z5D FROM TERMINAL 4902 ON 10/03 AT 18:30
```

ALARA UPDATE

WESTINGHOUSE CLASS 3

TO:

SUBJECT: ALARA UPDATE INFORMATION

DATE: October 18, 1980

EXPOSURE SINCE 9-8-80

	INSIDE SECONDARY	A STEAM GEN.	B STEAM GEN.	C STEAM GEN.	SPHERE TOTAL
MAN-REMS	32.141	13.630	92.649	0.545	*139.160

	MAN-REMS ACTUAL	MAN-REMS PROJECTION DECON	HONING	SLEEVING	% COMPLETION	% EXPOSURE
SCE	3.315	-	36.00	-	17	9.21
WESTINGHOUSE	14.085	-	61.00	-	17	23.09
TOTAL	17.400	-	97.00	-	17	17.94

REMARKS:

SIGNED: [signature]
ALARA ENGINEER

VI. CONTAMINATION CONTROL

A. AIR EXHAUST

1. FILTERED EXHAUST BLOWER ON OPPOSITE MANWAY TO CONTROL AIRBORNE CONCENTRATIONS

B. STEP OFF PADS

1. LOCATED AT PLATFORM EXIT TO CONFINE HIGHEST SOURCE TO A LOCAL AREA
2. ESTABLISHED WITHIN SPHERE TO CONFINE LOWER SOURCES WITHIN CONTAINMENT

C. PLATFORMS

1. COVERED WITH MULTIPLE LAYERS OF PLASTIC
   - A. ALLOWS DECON AND PROTECTS GRATING AND LOWER ELEVATIONS
   - B. LAYER MAY BE REMOVED IF LEVELS OR DECON TIME BECOME PROHIBITIVE

D. ROUTINE DECONTAMINATION

1. WALKWAYS FROM PLATFORMS OUT ARE WIPED DOWN ON A SHIFT BASIS
2. STEP OFF PADS ARE ROUTINELY CHANGES
3. THREE SHIFT COVERAGE IS SUPPLIED TO ASSURE POSITIVE CONTROL OF CONTAMINATION SPREAD

VII. COMPLICANCE SUMMARY

WESTINGHOUSE CLASS 3

A. 10CFR20.101 - EXPOSURE OF INDIVIDUALS

1. FILM APPLIED HEAD AND CHEST TLD RINGS FOR EXTREMITIES FOR PLATFORM AND CHANNEL HEAD WORK
2. MOST RESTRICTIVE SELF READING DOSIMETER RESULT IS ENTERED UPON EACH EXIT FOR LIVE TIME EXPOSURE UPDATE

B. 10CFR20.102 - DETERMINATION OF ACCUMULATED DOSE

1. FORMS NRC 4 EQUIVALENT ARE COMPLETED PRIOR TO FILM ISSUANCE AND APPROPRIATE LIMITS ARE ESTABLISHED

C. 10CFR20.103 - EXPOSURE OF INDIVIDUALS TO CONCENTRATIONS OF RADIOACTIVE MATERIAL IN RESTRICTED AREAS

1. USE OF SUPPLIED AIR HOODS FOR PLATFORM AND CHANNEL HEAD WORK
2. EXHAUST AND FILTRATION OF THE OPPOSITE LEG
3. USE OF PROTECTIVE CLOTHING AND EQUIPMENT TO PREVENT INADVERTENT INTAKE OF RADIOACTIVE MATERIAL
4. CONTINUOUS AND GRAB AIR SAMPLES

D. 10CFR20.105 - PERMISSIBLE LEVELS OF RADIATION IN UNRESTRICTED AREAS

1. CONTROLLED STORAGE OF RADIOACTIVE MATERIAL AND SURVEYS

WESTINGHOUSE CLASS 3

TASK C4

MODEL BOILER TESTS

OBJECTIVE:

[a,c,e

o

o

o

]

APPROACH:

[ ] a,c

TEST SETUP:

Refer to Figure 6.1.3

ENVIRONMENT:

[a,c

o

o

]

STATUS:

[a,c

]

WESTINGHOUSE CLASS 3

BOILER OPERATING CONDITIONS

Primary Loop Temperature	$620^{\circ}F \pm 5^{\circ}F$
Primary Loop Pressure	2200 psi
Primary Boiler Inlet Temperature	$615^{\circ}F \pm 5^{\circ}F$
Primary Boiler Outlet Temperature	$595^{\circ}F \pm 5^{\circ}F$
Steam Bleed	8 cc/min for 1 hour/day
Blowdown (Initial)	10 cc/min for 23*/hours day

*The blowdown is shut off for 1 hour/day while the steam bleed is turned on.

a,c,f

Figure 6.1.3. Single Tube Model Boiler Test Setup

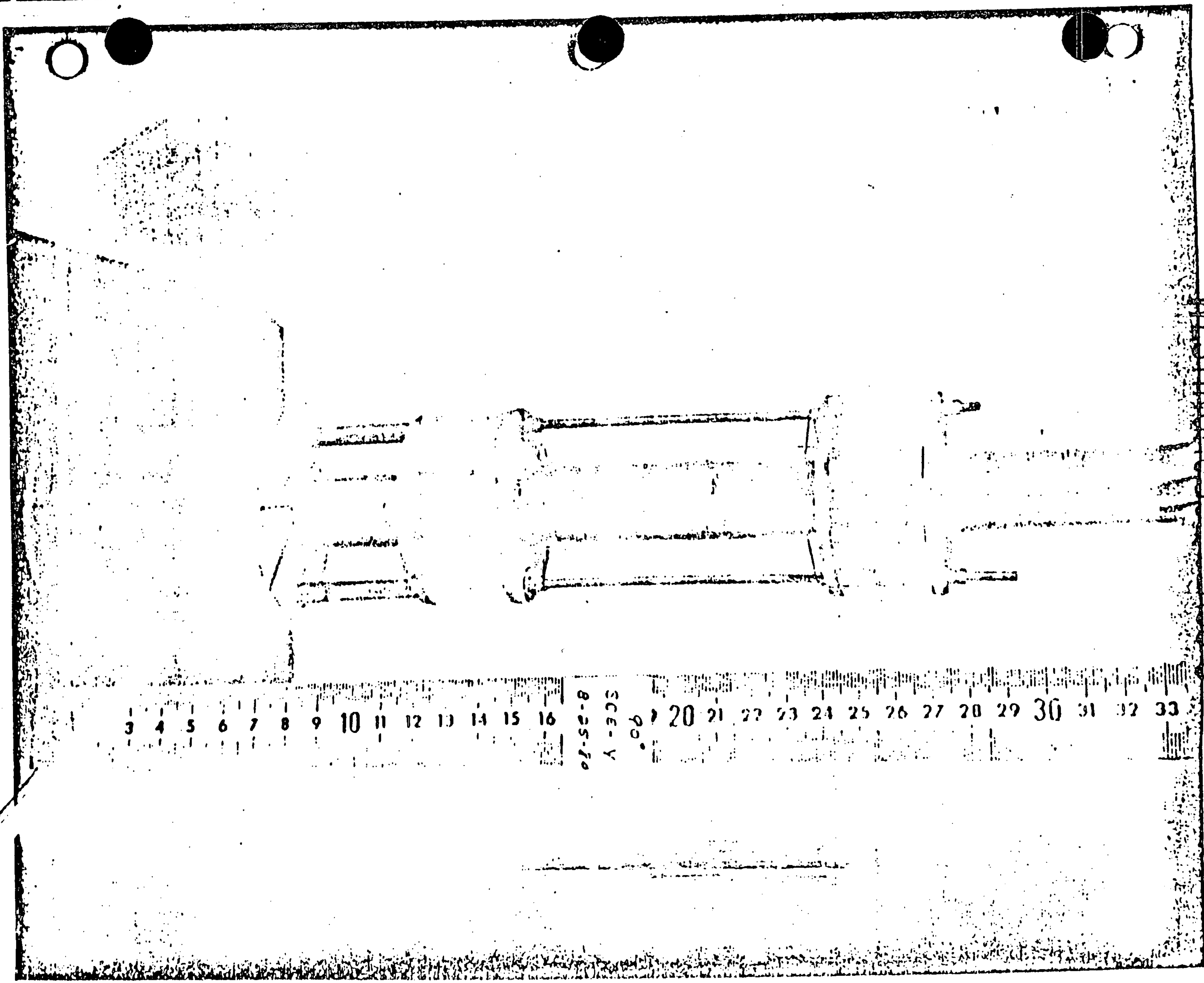

WESTINGHOUSE TYPE CLASS 3
SCE-Y
8-25-70
90°

TABLE 6.1.15

RESULTS OF DESTRUCTIVE EXAMINATION

[ ] a,c

Conclusions

[ ] a,c

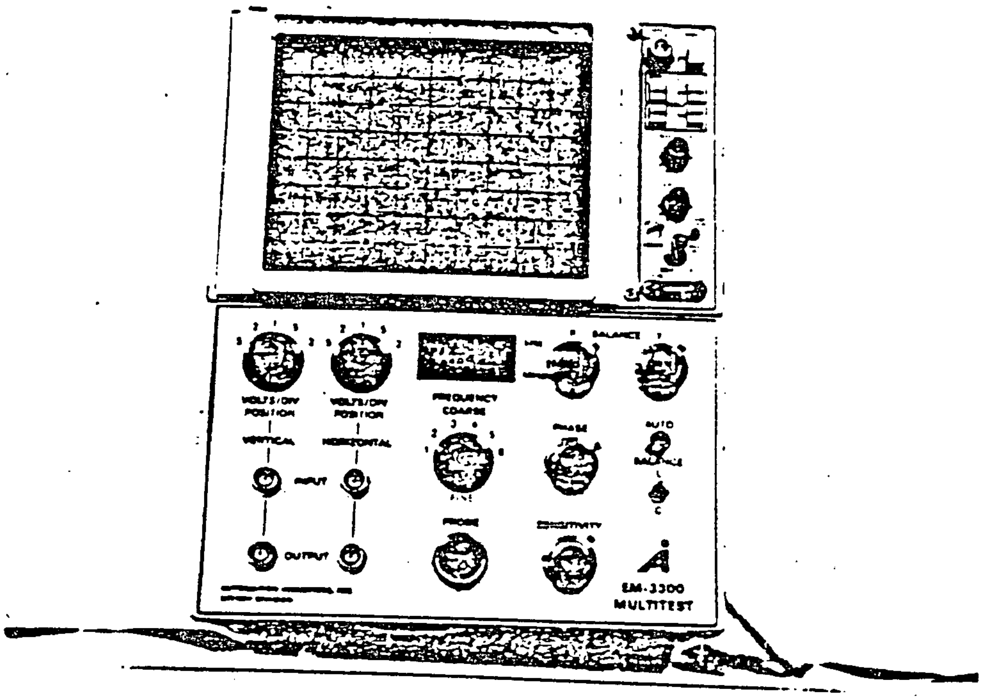
wcm

ISI [ ] [a,c]

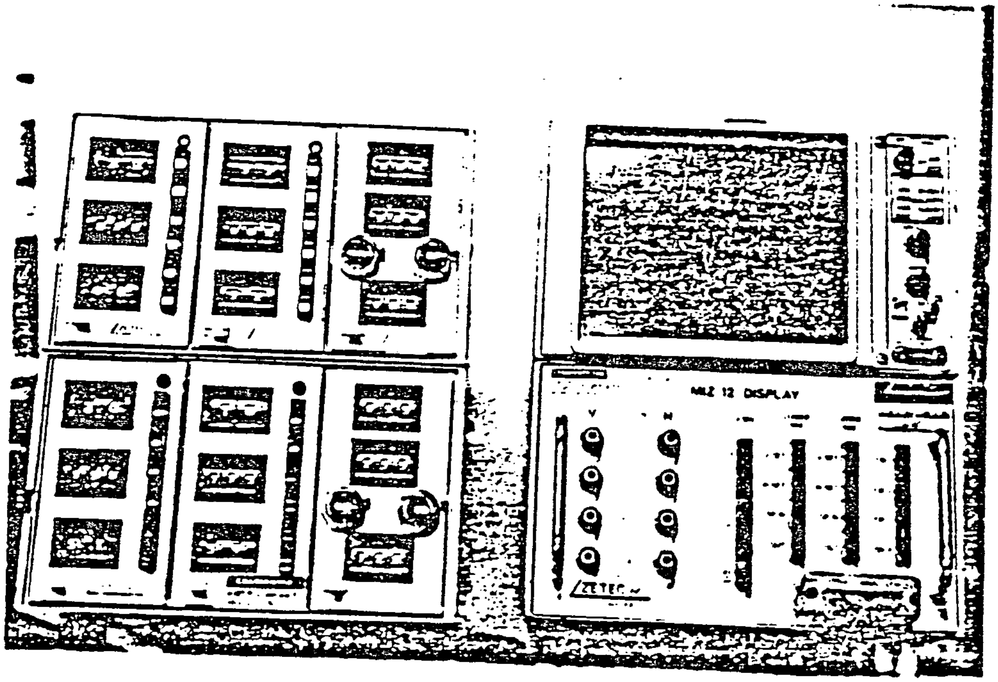
[ ] [a,c]

EDDY CURRENT INSTRUMENTATION

Single frequency



Multiple frequency



a,c

[ ]

a,c

Figure 7.10 [ ]

a, c

[ ]

Figure 7.11 [of Tube With [ ] Sleeve] a, c

a, c

[ ] a,c

Figure 7.12 [With [ ] Sleeve] of Tube
a,c a,c

WESTINGHOUSE CLASS 3

[ ]a,c

Figure 7.13 [of Sleeve with [ ]a,c Tube]a,c

a,c

[ ]

Figure 7.14 [of Sleeve with [ ] Tube] a,c

a,c

a, c, f

[ ]

Figure 7.15 [ ] a, c

a,c

[ ]

Figure 7.16 [ ] a,c

a,c

[

]

Figure 7.17 [ ] a,c

Figure 7.19

[ ]a,c Signatures of the [ ]a,c,f Region

[ ]a,c,f

Figure 7.18

[ ]a,c Signatures of the [ ]a,c,f Region

a,c,f

[ ]

Figure 7.20

[ ]a,c,f

[ ]a,c,f

Figure 7.21(a)

[ ] a,c,f

a,c,f

[ ]

WESTINGHOUSE CLASS 3

Figure 7.21(b)

[ ]a,c,f

[ ]a,c,f

a,c

[ ]

a,c,f

Figure 7.1 [ ] Testing of the [ ] Joint

a,c,f

[

]

WESTINGHOUSE CLASS 3

a,c,f

WESTINGHOUSE CLASS 3

a,c

ULTRASONIC PROBE
FOR BRAZE EVALUATION

a,c

[ ]

Figure 7.3 [Region Sample M5]

Figure 7.5 [DOUBLE WALL RADIOGRAPH OF CALIBRATION SPECIMEN] a,c

[ ] a,c

a, c

Figure 7.4 [a,c,f
Region Sample M8]

FIGURE 7.6 [DOUBLE WALL RADIOGRAPH OF CALIBRATION SPECIMEN M8]a,c

a,c

Figure 7.8
Ultrasonic System Resolution

Reference

a,c

WESTINGHOUSE CLASS 3

Figure 7.2

Response of Focused Ultrasonic Transducer

a,c

[ ]

[ ] a,c

WESTINGHOUSE CLASS 3

PROCESS INSPECTION SAMPLING PLAN

a,c,e

[ ]

WESTINGHOUSE CLASS 3

a, c

WESTINGHOUSE CLASS 3

[ ]^{a,c}

a,b,c

Figure 4.12 FLOW CHART OF PROPOSED SAMPLING PLAN

WESTINGHOUSE CLASS 3

ACCEPTANCE CRITERIA

[ ]a, c

a, c

[ ]

ACCEPTANCE CRITERIA
[ ]a,c

[ ]a,c

INSERVICE INSPECTION PLAN FOR SLEEVED TUBES

a, c

[ ]

SAN ONOFRE #1

STEAM GENERATOR

SLEEVING BOUNDARY

PLOT OF RPC INDICATIONS

FOR

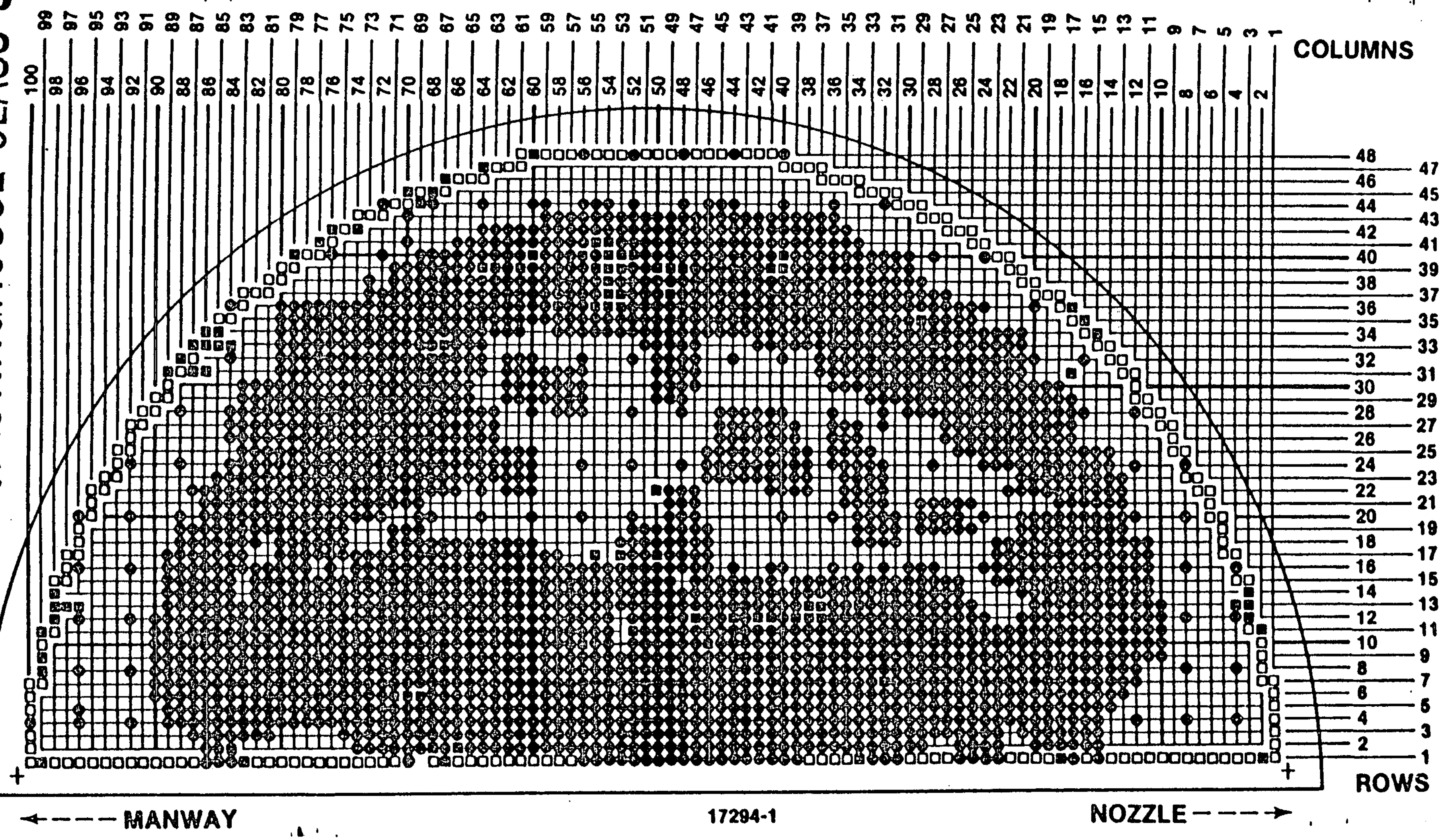
SAN ONOFRE #1

STEAM GENERATOR A

WESTINGHOUSE CLASS 3

SERIES 27
SCE-A
INLET

- Inspected Pancake Coil- No TTS Indications
- Inspected Pancake Coil- <50% Indications
- Inspected Pancake Coil- >50% Indications



17294-1

WESTINGHOUSE CLASS 3

PLOT OF INDICATIONS

FOR

SAN ONOFRE #1

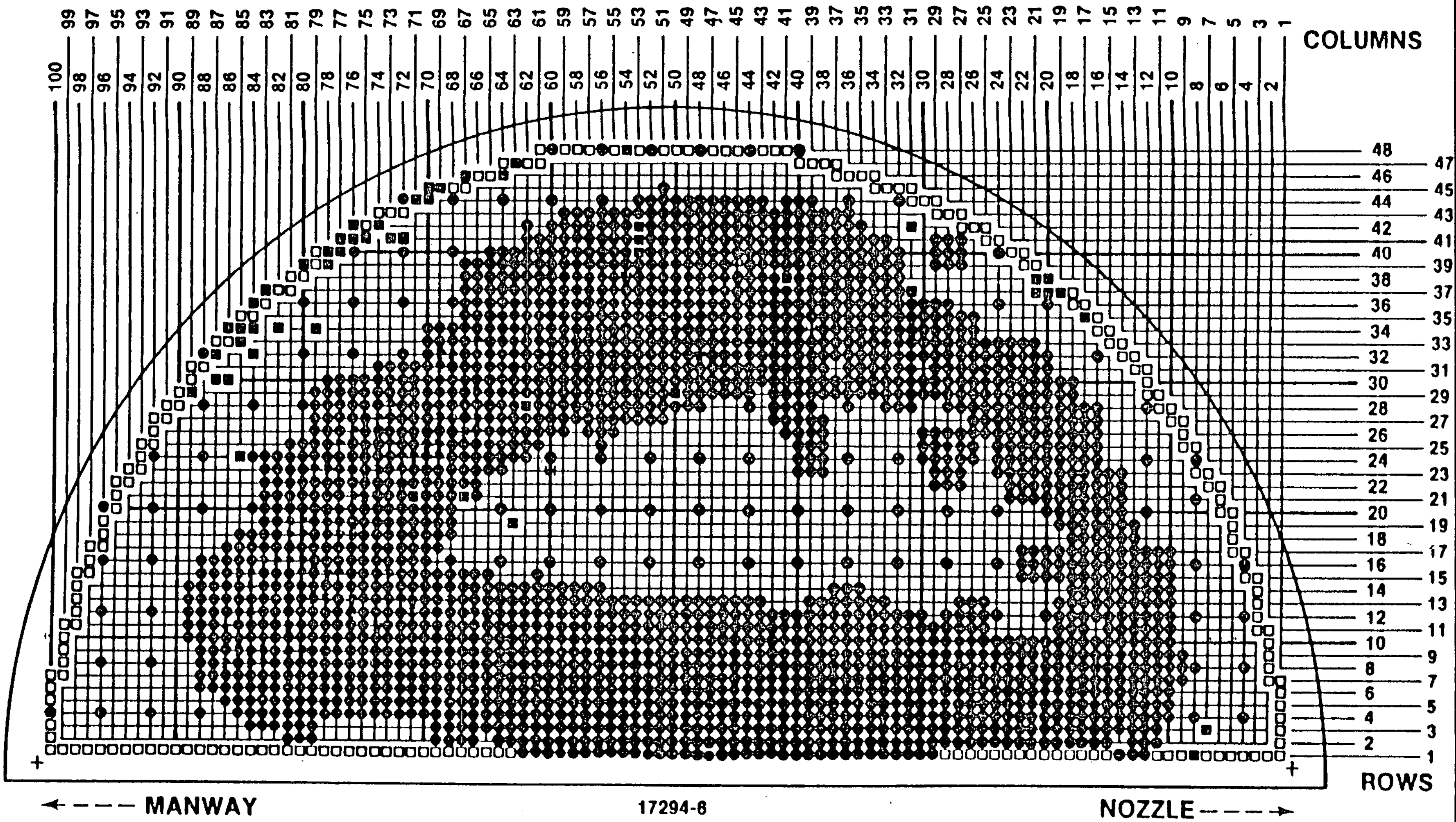
STEAM GENERATOR B

SERIES 27

SCE-B

WESTINGHOUSE CLASS 3

- ● Plugged 6/80 After Conventional Testing- TTS Indications
- ■ Plugged 6/80 After Conventional Testing- ATS, AVB Indications
- ● Inspected Pancake Coil- No TTS Indications
- ● Inspected Pancake Coil- <50% Indications
- ● Inspected Pancake Coil- >50% Indications



WESTINGHOUSE CLASS 3

PLOT OF INDICATIONS

FOR

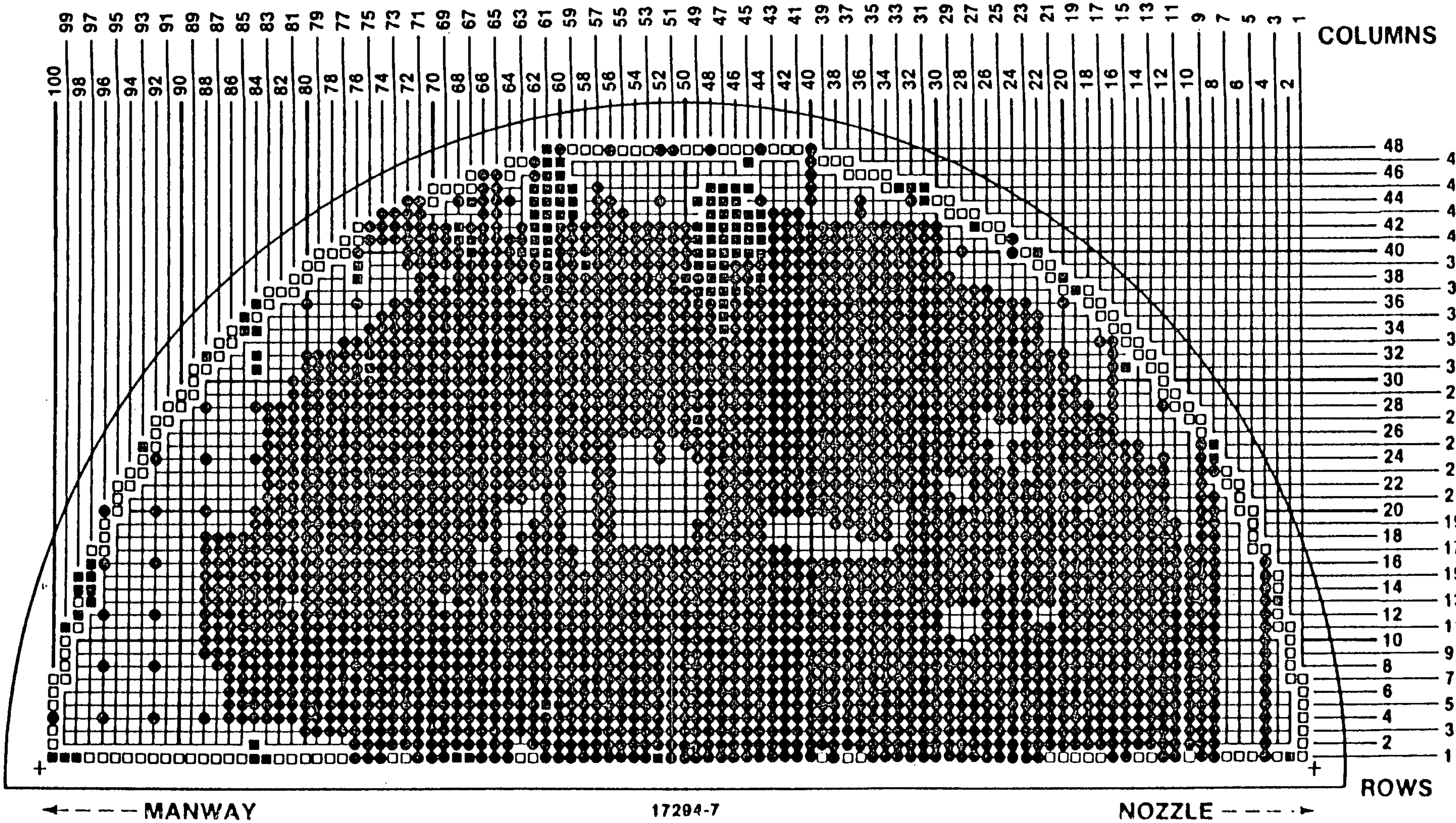
SAN ONOFRE #1

STEAM GENERATOR C

WESTINGHOUSE CLASS 3

SERIES 27
SCE-C
INLET

- Inspected Pancake Coil- No TTS Indications
- Inspected Pancake Coil- <50% Indications
- Inspected Pancake Coil- >50% Indications
- Tubes Plugged Prior To Pancake Inspection



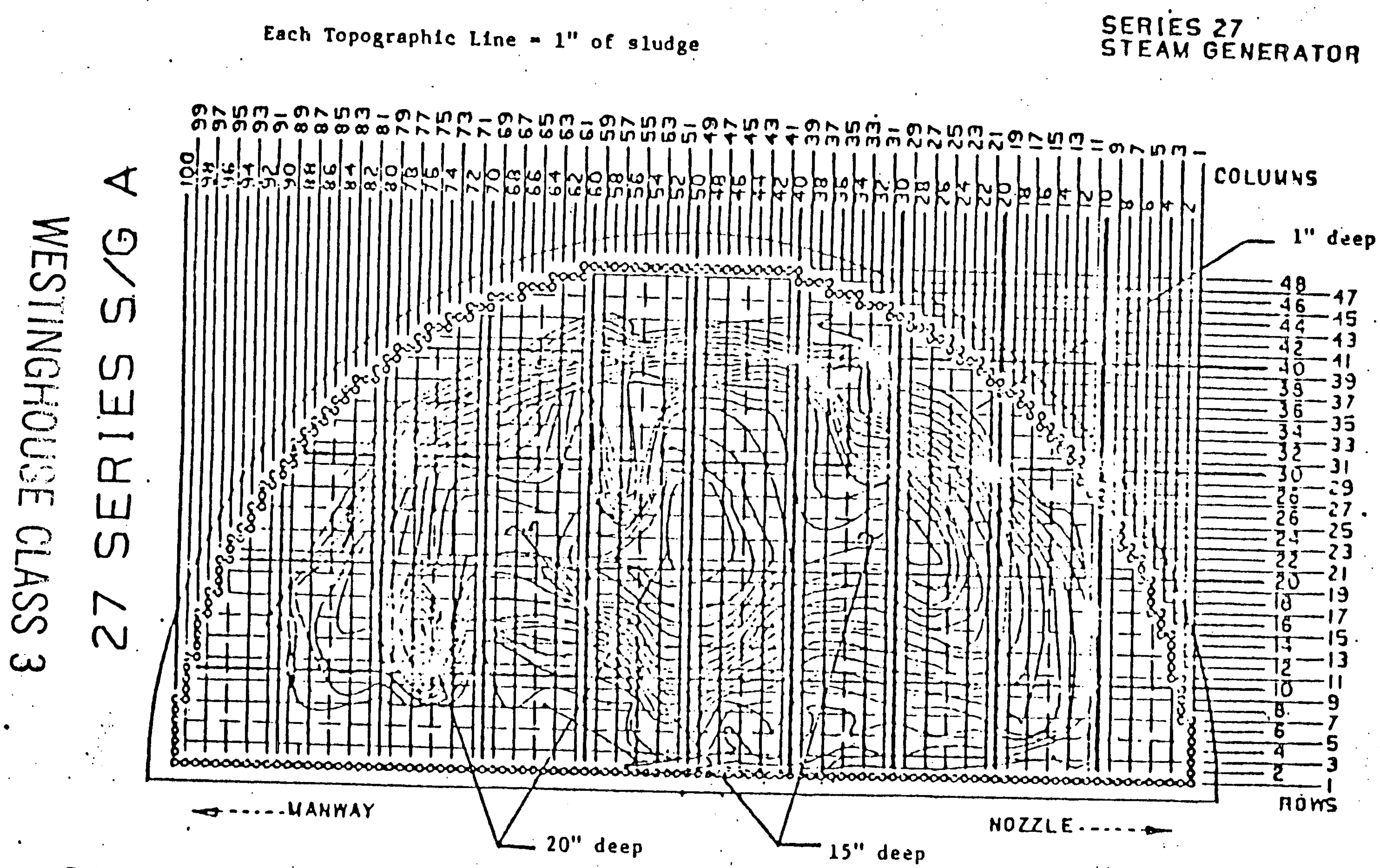

WESTINGHOUSE CLASS 3
27 SERIES S/G A
Each Topographic Line = 1" of sludge
SERIES 27
STEAM GENERATOR
COLUMNS
1" deep
ROWS
MANWAY
NOZZLE
20" deep
15" deep

Figure 1

SAN ONOFRE #1

STEAM GENERATOR TUBE SLEEVING

CRITERIA FOR TUBE SELECTION

All tubes with RPC - detectable indications at the top of the tube sheet are to be sleeved or plugged.

Any tube immediately adjacent to an RPC indication ≥ 50% will also be sleeved or plugged.

All accessible tubes within the broad boundary formed by tubes identified above will be sleeved.

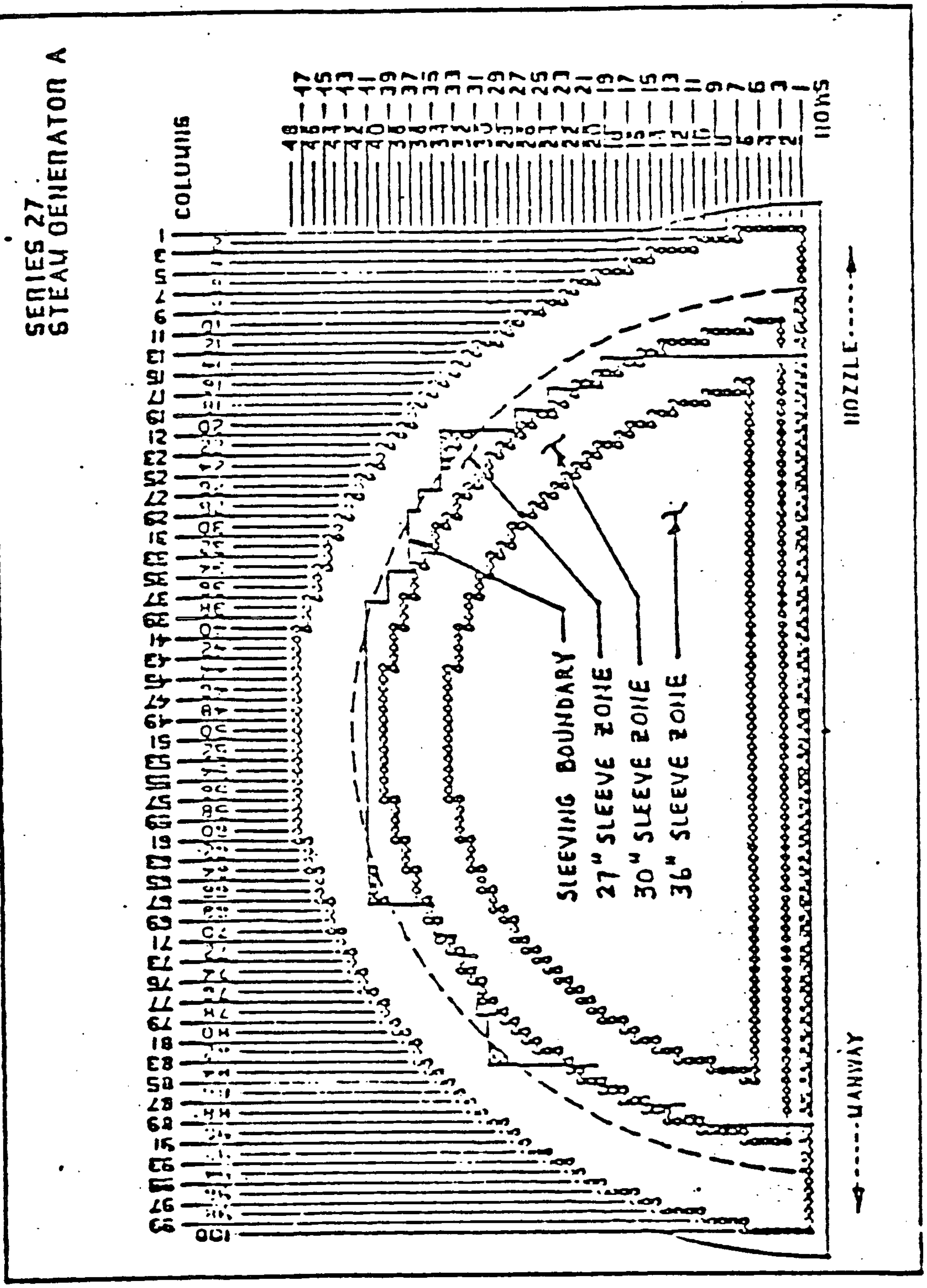

SERIES 27
STEAM GENERATOR A
COLUMNS
ROWS
SLEEVING BOUNDARY
27" SLEEVE ZONE
30" SLEEVE ZONE
36" SLEEVE ZONE
NOZZLE
MANWAY

Figure 4

WESTINGHOUSE CLASS 3

SAN ONOFRE #1

SG TUBE SLEEVING BOUNDARY

	SG/A	SG/B	SG/C	
Tubes within boundary	2527	2371	2343	
Tubes previously plugged (prior to 1980)	54	8	17	
Tubes plugged in 1980	131	60	4	
Tubes in pattern not to be sleeved	15	14	7	
Tubes to be sleeved	2327	2289	2315	≏ 6930

SAN ONOFRE #1

SG TUBE SLEEVING BOUNDARY

PERIPHERAL TUBES

- RPC testing was performed at least one tube beyond last indication found in pattern and the peripheral region was sampled on a 4 x 4 basis.

- Results in peripheral region - beyond sleeving boundary - are free from indications.

- This region corresponds to zone of high tubesheet flow velocities and to area of little or no sludge.

- Corrosion observations on peripheral tubes on these and other SG's are generally much lower than found in the sludge-covered central area.

- Given the absence of detectable indications, an upper bound of 49% applied to these tubes yields plausible corrosion estimate of approximately 4% per for life of the plant.

WESTINGHOUSE CLASS 3

SAN ONOFRE #1

OVERALL PERSPECTIVE ON PLANT OPERABILITY WITH SLEEVING REPAIR

- Tubes not repaired generally are free from both bobbin probe or RPC probe eddy current indications.
- Even if those tubes have degradation less than 50%, tests show strength close to virgin tubing.
- The peripheral zone and low row area are usually low corrosion zones due to tubesheet velocities; demonstrated by sludge distribution.
- Sludge distribution correlates strongly with location of tube corrosion.
- In the unlikely event of tube leakage on tubes close to boundary some reinforcement can be expected from sludge, limiting leakage.
- Leak before break expected based on corrosion seen on tubes examined.
- Whole bundle hydro will demonstrate strength.

WESTINGHOUSE CLASS 3

MATERIAL CORROSION
TESTING

BY

A. R. VAIA
A. W. KLEIN
STRATEGIC OPERATIONS DIVISION
WESTINGHOUSE ELECTRIC CORPORATION

MATERIAL AND CORROSION PROGRAM

a,c,e

[ ]

WESTINGHOUSE CLASS 3

MATERIAL CORROSION PROGRAM

ASSURE THAT THE [ ]^{a,c,e} HAS NOT AFFECTED THE INHERENT CORROSION RESISTANCE OF THE TUBING WHEN EXPOSED TO ACCELERATED CORROSION TESTS IN VARIOUS PRIMARY AND SECONDARY ENVIRONMENTS.

ENVIRONMENT	TEST TECHNIQUE	ACCELERATED CONDITIONS	NORMAL CONDITIONS
CAUSTIC	IMMERSION (C-RINGS)	TEMPERATURE: 650°F STRESS: > 50KSI CONCENTRATION: 10%	593°F INLET 549°F OUTLET 15/20 KSI –
	CONTROL POTENTIAL (C-RINGS)	STRESS: > 50KSI CONCENTRATION: 10% POTENTIAL: ACTIVE/PASSIVE	15/20 KSI – –
PURE WATER	IMMERSION (U-BENDS)	TEMPERATURE: 680°F STRESS: > Y.S.	593°F INLET 549°F OUTLET 15/20 KSI
PRIMARY WATER	PRESSURIZED CAPSULE	TEMPERATURE: 650°F	593°F INLET 549°F OUTLET
$OH^- + Cl^-$ $PO_4 + Cl^-$	MODEL BOILER	NONE	–

WESTINGHOUSE CLASS 3

a, c, f

EFFECT OF BRAZE CYCLE ON MECHANICAL PROPERTIES, MICROSTRUCTURE AND CORROSION RESISTANCE OF INCONEL 600

WESTINGHOUSE CLASS 3

a,c,e

0.2% Yield Strength (KSI)

Ultimate Strength (KSI)

WESTINGHOUSE CLASS 3

PEAK BRAZE TEMPERATURE (°F)

Figure 6.1.4 Results of [ ]a,c Tests For Single Tubes [ ]a,c,e

TABLE 6.1.5

a,c,f

HARDNESS, TEMPERATURE AND GRAIN SIZE VARIANCE
ALONG BRAZE HEAT-AFFECTED-ZONE
(SCE SIZE TUBING)

WESTINGHOUSE CLASS 3

a,c,f

Micro-structure

TABLE 6.1.6

RESULTS OF SENSITIZATION STUDIES
FOR BRAZED HEAT-AFFECTED-ZONE

a,c,f

WESTINGHOUSE CLASS 3

TABLE 6.1.8

CONTROL POTENTIAL

a,c,f

WESTINGHOUSE CLASS 3

TASK C3

a,c,f

TABLE 6.1.13

RESULTS OF TESTS TO DETERMINE THE EXTENT OF [ ]a,c,e

[ ]a,c,e

WESTINGHOUSE CLASS 3

SECONDARY SIDE

BLOWDOWN CHEMISTRY

PHOSPHATE	20 PPM (RANGE 15 - 30)
SODIUM	11.6 PPM (RANGE 8.4 - 18.9)
NA/PO_4 (M.R.)	2.4 (RANGE 2.3 - 2.6)
pH AT 25°C	9.8 (RANGE 9.4 - 10.2)
CHLORIDE	0.5 PPM MAXIMUM

MAKE UP WATER

MAKE UP EVAPORATOR SHOULD BE MONITORED CLOSELY TO PREVENT CARRY OVER OF HARDNESS IMPURITIES TO CONDENSATE STORAGE TANK.

A SAMPLING SCHEDULE OF THE STORED CONDENSATE SHOULD BE MAINTAINED TO PRESERVE THE QUALITY OF THE CONDENSATE MAKE UP.

WESTINGHOUSE CLASS 3

SCE SLUDGE SIMULANT

MATERIAL	WT %
Na_3PO_4	15
Cu	19
Fe_3O_4	60.9
MgO	1.7
NiO	2.2
ZnO	1.2

SAN ONOFRE SLUDGE ANALYSES

ELEMENT	1975	1976	1978	1980
CU WT %	16.7	16.0	17.0	31
FE WT %	32.3	34.0	42.7	53
NI WT %	2.4	4.7	3.3	2.5
ZN WT %	2.6	0.2	2.0	1.4
NA WT %	0.6	0.01	1.0	3.2
P WT %	2.2	0.1	0.13	4.9
CA WT %	0.6	0.3	0.2	0.7
MG WT %	1.0	0.3	1.0	1.2
CL PPM	-	41	37.0	45.6
SO_4 PPM	-	73	36.2	36.2
C WT %	-	0.05	0.45	0.31
PH FROM FILTERED LIQUID	-	-	-	11.00

WESTINGHOUSE CLASS 3

SAN ONOFRE STEAM GENERATOR SLUDGES

JUNE 1980

		S.G. A	S.G. B	S.G. C
FE	WT.%	34	38	45
CU	"	17	11	11
ZN	"	2.2	2.9	2.4
NI	"	1.3	1.1	1.4
NA	"	1.1	1.7	2.3
PO_4	"	8.8	1.3	2.0
CA	"	0.6	1.2	0.9
MG	"	1.2	2.2	1.5
MN	"	0.4	0.6	0.5
CR	"	0.3	0.2	0.3
TI	"	< 0.1	< 0.1	0.1
PB	"	< 0.05	0.05	0.05
K	"	< 0.001	< 0.001	< 0.001
LI	"	< 0.002	< 0.002	< 0.002
CL	PPM	< 40	< 32	< 43
SO_4	PPM	< 140	< 160	< 160

WESTINGHOUSE CLASS 3

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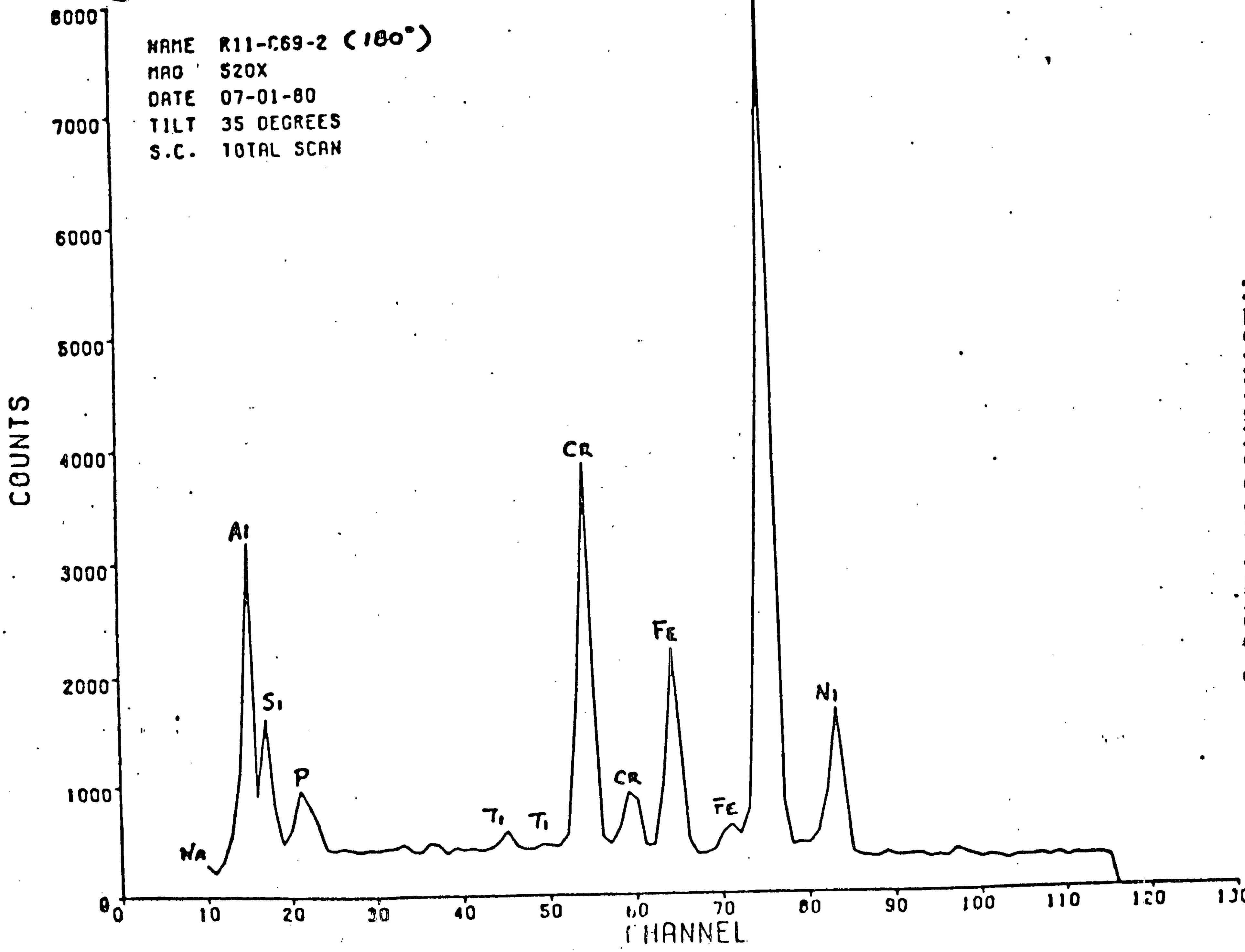
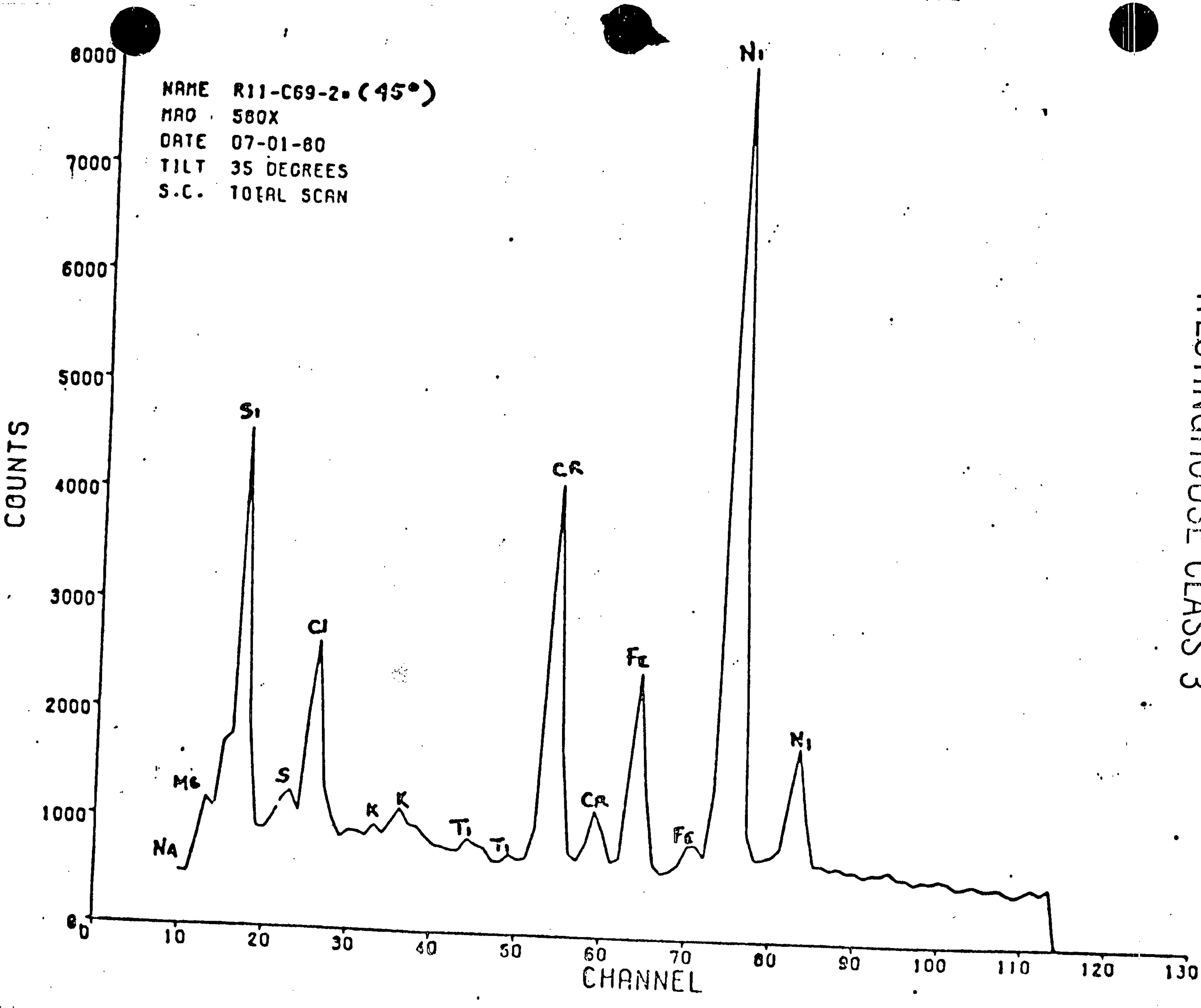


WESTINGHOUSE CLASS 3

FRACTURE SURFACE OF TUBE REMOVED FROM SAN ONOFRE



WESTINGHOUSE CLASS 3

WESTINGHOUSE CLASS 3

PREOPERATIONAL PRIMARY SIDE CHEMISTRY PROGRAM TO REMOVE MAGNETITE

- INITIALLY CLEAN THE MAGNETITE IN THE PIPE BY RECIRCULATION-FILTRATION CLEANING PRIOR TO PLANT SYSTEM REFILL OR IN COMBINATION WITH PICKUP BY ELECTROMAGNET.
- START-UP WITH ONE MIX BED CHARGED WITH A NEW CHARGE OF HOH RESIN.
- OPERATE THE CVCS FILTRATION (HOH BED PLUS RCS FILTER) WITH 2 MICRON SIZE FILTERS UNTIL WESTINGHOUSE RECOMMENDED LIMITS ARE MET.
- CLEAN-UP PRIOR TO HEAT-UP ABOVE 150°F.
- DO NOT OPERATE (CRDM) MECHANISM PRIOR TO CLEAN-UP.
- ASSURE THAT RCP SEAL INJECTION IS OPERATING AT TIME OF CLEAN-UP.
- FOLLOWING CLEAN-UP OPERATION AT 150°F TO PREVENT SOLUBILITY OF THESE IMPURITIES, CHECK CHEMISTRY FOR ALUMINUM AND SiO_2 CONCENTRATION TO CONFIRM THAT WESTINGHOUSE CHEMISTRY SPEC. IS NOT VIOLATED FOR IMPURITIES.
- IF IMPURITIES ARE BEYOND LIMITS, COMMENCE RCS BLEED AND FEED.

WESTINGHOUSE CLASS 3

INITIAL OPERATION

- HYDROSTATIC TESTING
- IN-SERVICE INSPECTION PROGRAM
- INITIAL OPERATING PERIOD
- PRIMARY TO SECONDARY LEAKAGE LIMIT

WESTINGHOUSE CLASS 3

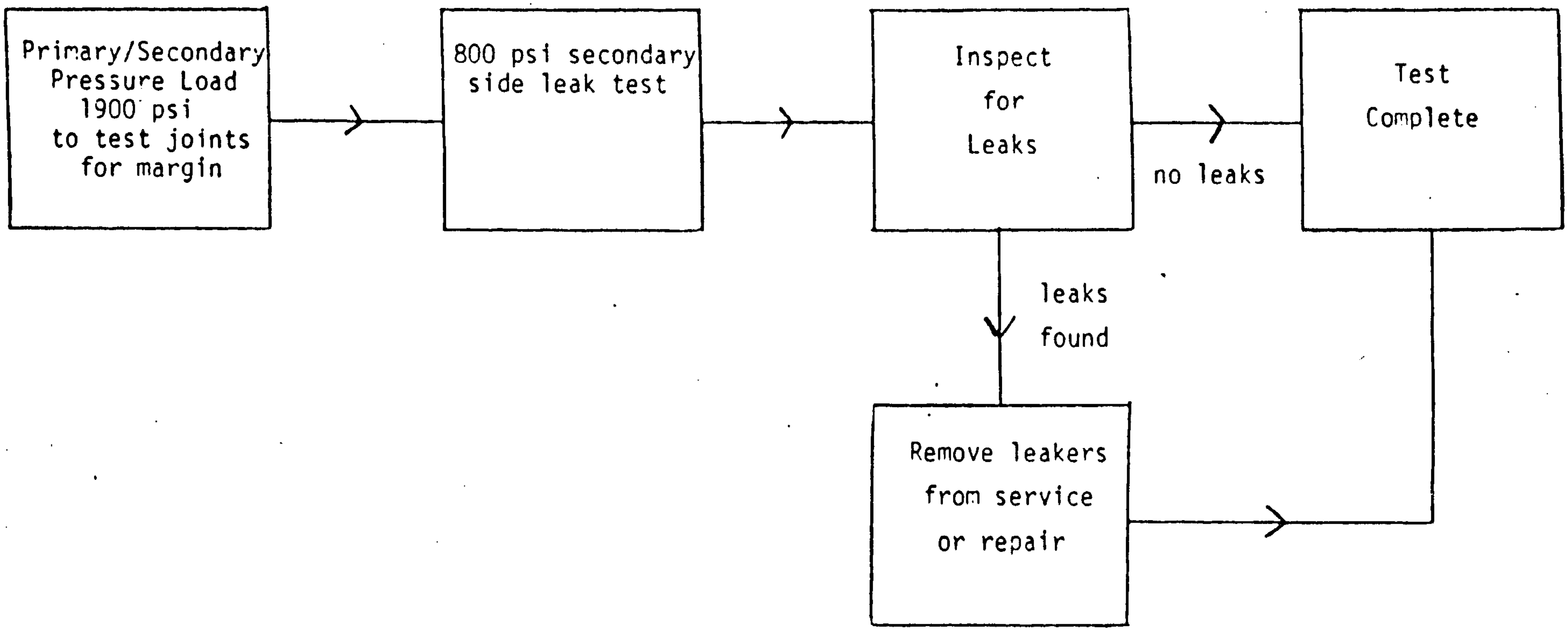
HYDROSTATIC PRESSURE TESTING

OBJECTIVE: TO TEST INTEGRITY OF BRAZED JOINT/SLEEVE SYSTEM AND THE PERIPHERAL TUBES.

CRITERIA: LEAK (OR) NO LEAK
AT MAXIMUM ACHIEVABLE PRIMARY TO SECONDARY ΔP

TECHNIQUE: WHOLE BUNDLE PRIMARY TO SECONDARY (S.L.B.) AND SECONDARY TO PRIMARY (L.O.C.A.) PRESSURE LOADINGS.

FIGURE 9.1 . PERIODIC TUBE/SLEEVE [illegible] MARGIN TEST



WESTINGHOUSE CLASS 3

INSERVICE INSPECTION PROGRAM

OBJECTIVE: TO ASSURE CONTINUED RELIABILITY OF SLEEVED AND NON-SLEEVED TUBES.

CRITERIA: PROVIDE ASSURANCE OF FURTHER NONDEGRADATION BY SECONDARY WATER OF THE TUBE BUNDLE. THAT IS NO INDICATIONS >50% FOR NON-SLEEVED TUBES AND NO DEGRADATION >50% FOR THE SLEEVES.

TECHNIQUE: "E.C. TESTING"

(A) E.C. SIGNATURES WILL BE OBTAINED ON ALL TUBES PRIOR TO OPERATION.

(B) FIRST E.C. PROGRAM WILL INCLUDE AT LEAST 3% OF TUBES IN EACH SG AND WILL BE CONSISTENT WITH REG. GUIDE 1.83.

(C) SUBSEQUENT E.C. PROGRAMS WILL BE CONDUCTED CONSISTENT WITH REG. GUIDE 1.83.

"LEADER TUBES"

(A) FOUR REPRESENTATIVE TUBES IN EACH SG WILL BE PERFORATED JUST ABOVE THE TUBESHEET IN ORDER TO EXPOSE THE [ ] a,c TO THE SECONDARY SIDE ENVIRONMENT.

(B) DURING FUTURE OUTAGES ONE OF THESE TUBES WILL BE REMOVED FROM EACH SG AND EXAMINED.

(C) FROM THESE EXAMINATIONS A DEGRADATION RATE FOR THE TUBE/SLEEVE JOINT CAN BE INFERRED AND FACTORED INTO CONTINUED OPERATING CONSIDERATIONS.

WESTINGHOUSE CLASS 3

INITIAL OPERATING PERIOD

OBJECTIVE: RETURN THE UNIT TO FULL POWER CONSISTENT WITH SAFE OPERATION.

BASIS : THE FIRST INSERVICE INSPECTION WILL OCCUR AFTER THE SLEEVES HAVE SEEN 6 MONTHS OF EFFECTIVE FULL POWER OPERATION.

THIS NUMBER IS CONSERVATIVE SINCE A REVIEW OF PAST E.C. DATA SHOW THIS PHEOMENA PROGRESSING AT A RATE OF ~15%/YR (OR) ~8 MILS/YR.

CONSIDER THESE CONDITIONS:

UNSLEEVED PERIPHERY: (MILL ANNEALED I-600)

- 40% (OR) 22 MILS PENETRATION
- 6 MONTHS OPERATION = 4 MILS ADDITIONAL PENETRATION
- TOTAL PENETRATION = 26 MILS (OR) 46% PENETRATION

SLEEVED TUBE: (THERMALLY TREATED I-600)

- VIRGIN MATERIAL FOR SLEEVE
- 6 MONTHS OPERATION = 4 MILS PENETRATION

RESIDUAL STRENGTH PROPERTIES OF TUBES SUBJECT TO IGA.

SUBSEQUENT INSPECTIONS WILL BE CONDUCTED DURING STANDARD REFUELING OUTAGES AND TUBES PLUGGED (OR) SLEEVED AS NECESSARY.

TECHNIQUE: MULTI-FREQUENCY E.C. SAMPLING LEADER TUBE PROGRAM

STATUS:

[ ] a,c,b

CONCLUSIONS:

[ ] a,c

TASK C2

[ ] a,c EVALUATION OF [ ] a,c,e JOINTS

[ ] a,c,e

TABLE 6.1.9

a,c,e

RESULTS OF METALLOGRAPHIC EXAMINATION OF U-BENDS FROM BRAZED JOINTS AFTER EIGHT - WEEKS EXPOSURE TO HIGH PURITY WATER AT 680°F

(TASK C2)

TABLE 6.1.10

[ ][a,c] TEST

[a,c,d]

[ ]

TABLE 6.1.11

[ ]a,c,e

[ ]

TABLE 6.1.11 (Cont.)

[ ]a,c

[ ]a,c

TABLE 6.1.12

CAPSULE EXPOSURE OF BRAZED JOINTS TO FLOWING HIGH PURITY WATER

a,c,f

WESTINGHOUSE CLASS 3

a,c,f

WESTINGHOUSE CLASS 3

SUMMARY OF SYSTEMS CHEMISTRY OPERATIONS AT SAN ONOFRE UNIT ONE

M. J. WOOTTEN, MANAGER
CHEMISTRY OPERATIONS AND FIELD DEVELOPMENT

- CHEMISTRY HISTORY
- PROPOSED PROGRAM

- CHEMISTRY DURING START-UP
- CHEMISTRY DURING SUBSEQUENT OPERATION

WESTINGHOUSE CLASS 3

STEAM GENERATOR CHEMISTRY REVIEW

SINCE OCTOBER 1974, SECONDARY SIDE WATER TREATMENT HAS BEEN AIMED AT $NA/PO_4 = 2.6$ WITH $[PO_4] = 5$ TO 10 PPM.

RATIOS AS LOW AS 2.4 AND IN SOME CASES EXCEEDING 3.0 REPORTED.

WHEN DEVIATIONS FROM 2.6 OCCURRED, CORRECTIVE TREATMENT BY CHEMICAL MEANS OR CONDENSER MAINTENANCE IMPLEMENTED.

CAUSE OF FLUCTUATIONS ATTRIBUTED TO SEA WATER INGRESS FROM CONDENSER LEAKAGE. AT TIMES WHEN pH OF THE STEAM GENERATOR BULK SOLUTION WENT BELOW 7.0, SODIUM HYDROXIDE WAS ADDED.

WESTINGHOUSE CLASS 3

CHLORIDE BUILD-UP IN STEAM GENERATOR PROVIDES INDICATION OF CONDENSER LEAKAGE

- 1974 AND 1975, CHLORIDE CONCENTRATIONS BETWEEN 0.3 AND 0.5 PPM AND GREATER WERE PRESENT FOR 90% OF OPERATING TIME.

- IN 1976, CHLORIDE LEVELS ABOVE 0.5 PPM REDUCED TO 65% OF OPERATING TIME.

- IN 1977 AND 1978, FURTHER REDUCTIONS MADE AS EVIDENCED BY LEVELS AT ONLY 25 TO 30% OF OPERATING TIME.

- IN 1979 THROUGH TO MARCH 1980, SEVERAL OCCURRENCES OF SALT WATER IN-LEAKAGE AT LOW LEAKAGE RATES WHICH CONTINUED FOR SEVERAL WEEKS. CHLORIDE LEVELS GENERALLY RANGED FROM 0.5 TO 1.5 PPM.

WESTINGHOUSE CLASS 3

LOAD FOLLOW CAUSED FLUCTUATIONS IN CHEMISTRY CONTROL

- DURING MAY AND JUNE 1978, WHEN SAN ONOFRE WAS BEING USED TO LOAD FOLLOW, FLUCTUATIONS IN MARCY-HALSTEAD RATIO OBSERVED.
- SIGNIFICANT TIME PERIODS WHEN RATIO EXCEEDED 3.0.
- DIFFICULT TO STABILIZE DUE TO EFFECTS OF HIDEOUT AND HIDEOUT RETURN DURING TRANSIENT PERIODS.

WESTINGHOUSE CLASS 3

SODIUM/PHOSPHATE RATIO HAS TRENDED UPWARD IN RECENT TIMES

- FROM OCTOBER 1979 THROUGH TO SHUTDOWN IN SPRING 1980, MARCY-HALSTEAD PATIO HAS SLOWLY INCREASED. AVERAGE RATIO OF 3.0 DURING FIRST QUARTER OF 1980.

- ANALYTICAL RATIO NOT SO CLEAR ALTHOUGH SPIKES OF GREATER THAN 3.0 WERE SEEN AT TIMES.

WESTINGHOUSE CLASS 3

CHEMICAL ADDITIONS DO NOT EXPLAIN UPWARD MARCY-HALSTEAD RATIO TREND

1/79 TO 5/79 (5 MONTHS)

769 POUNDS Na_3PO_4

616 POUNDS Na_2HPO_4

57 POUNDS NaOH

Σ = 372 POUNDS NA AT Na/PO_4 = 2.54

8/79 TO 12/79 (5 MONTHS)

388 POUNDS Na_3PO_4

912 POUNDS Na_2HPO_4

Σ = 366 POUNDS NA AT Na/PO_4 = 2.13

APART FROM 4/79 AND 5/79, NO APPRECIABLE DIFFERENCE IN CONDENSER INLEAKAGE. CAUSTIC ADDITIONS STOPPED FROM 9/79 ONWARDS.

WESTINGHOUSE CLASS 3

SHUTDOWN AND START-UP OPERATIONS RELEASE PHOSPHATES :

- Shutdown And Cooldown Apparently Cause Low Ratios To Return to Solution.

- Start-up Operations Tend To Release High Ratios. High Ratio Return Was Not Controllable By Blowdown. Treatment With Mono Sodium Phosphate Required.

- Continuing Hideout Return Inventories Indicate That Steam Generator Crevices And Sludge Continue To Harbor Appreciable Quantities Of Phosphate Chemicals.

WESTINGHOUSE CLASS 3

ANALYSIS OF WASHINGS FROM SIX TUBESHEET HOLE DEPOSITS FROM SAN ONOFRE INDICATIVE OF FREE CAUSTIC.

	AVERAGE	RANGE	
		MIN.	MAX.
NA PPM	49.2	18.0	108
PO_4 PPM	38.0	8.8	162
RATIO NA/PO_4	5.3	2.9	18.0
SO_4 PPM	3.8	<2.0	11.8
CL PPM	14.6	0.8	35.0
K PPM	0.7	0.1	1.4
MG PPM	0.2	0.01	0.3
CA PPM	0.3	<0.05	1.7
SIO_2 PPM	0.3	<0.1	0.5

WESTINGHOUSE CLASS 3

MAKE UP WATER SOURCE CHANGED IN RECENT YEARS

- FROM PLANT START-UP UNTIL RECENT YEARS, SEAWATER EVAPORATED FOR MAKE UP.
- TWO OR THREE YEARS AGO, RAW WATER SOURCE CHANGED TO SAN CLEMENTE CITY WATER (COMES FROM COLORADO AND FEATHER RIVERS).
- 1978 - 1980 DATA SUGGESTS AN INCREASE IN HARDNESS OF MAKE UP. PRECIPITATION OF HARDNESS ELEMENTS WITH PHOSPHATE COULD LEAD TO DIFFICULTIES IN CONTROL AND INCREASE IN HIDDEN OUT PHOSPHATES.

WESTINGHOUSE CLASS 3

SUMMARY OF CHEMISTRY HISTORY

- REVIEW OF OPERATING PLANT CHEMISTRY SHOWS EVIDENCE OF FREE CAUSTIC PRESENT IN BULK WATER.
- ADDITION OF SODIUM HYDROXIDE FOR pH CONTROL WAS DISCONTINUED IN MID 1979.
- SHUTDOWN/START UP/POWER OPERATION CHEMISTRY CYCLED FROM LOW RATIO TO HIGH RATIO PHOSPHATES.
- PHOSPHATE INVENTORIES NOT REMOVED COMPLETELY DURING HIDEOUT RETURN SITUATIONS.
- CONDENSER LEAKAGE (LOW RATES) CONTINUED FOR A NUMBER OF WEEKS.
- MAKE UP WATER SOURCE CHANGED TO CITY WATER.

WESTINGHOUSE CLASS 3

SAN ONOFRE UNIT I

STEAM GENERATOR CHEMISTRY PROGRAM

OBJECTIVE:

TO REDUCE THE CONCENTRATION OF CONTAMINANTS WHICH HAVE LED TO CORROSION OF THE STEAM GENERATOR TUBES. THESE CONTAMINANTS ARE CONTAINED WITHIN STEAM GENERATOR DEPOSITS AND SLUDGES.

A PROGRAM DESIGNED TO MAXIMIZE THE REDUCTION IN CONCENTRATION OF CORRODENT AND PROVIDE BUFFERING WITH 2.4 RATIO SODIUM PHOSPHATE IN LOCALIZED REGIONS AT THE TUBE SHEET; EXPECTED TO REDUCE THE POTENTIAL FOR TUBE CORROSION, CONSISTS OF THE FOLLOWING MINIMUM OPERATIONS:

COLD WATER SOAKS
HOT WATER SOAK
PLANT START UP

ANOTHER OEPRATION, PRESENTLY UNDER DEVELOPMENT WHICH INVOLVES DEPRESSURIZATION, MAY ALSO BE BENEFICIAL. THIS WILL BE CONSIDERED AT A LATER TIME WHEN OPTIMUM PROCEDURES FOR CONTAMINANT REMOVAL ARE IDENTIFIED.

WESTINGHOUSE CLASS 3

COLD WATER SOAK 70°F

RATIONALE — REVIEW OF PAST DATA SHOWS THAT EVEN AT COLD SHUTDOWN SIGNIFICANT RETURN OF PHOSPHATES EXPERIENCED. THIS SOAK WILL BE FIRST ATTEMPT TO REMOVE MORE ACCESSIBLE SOLUBLE MATERIAL.

TIMING — IMMEDIATELY FOLLOWING THE COMPLETION OF THE SLEEVING OPERATION. THE SOAKS ARE NOT ON THE CRITICAL PATH. SECONDARY HYDRO CAN BE ACHIEVED DURING THIS TIME.

PROCEDURE — FILL STEAM GENERATOR WITH PURE H_2O TO COVER TUBE BUNDLE.

SAMPLE AND ANALYZE FOR pH, CONDUCTIVITY, SODIUM, PHOSPHATE, CHLORIDE, SILICA. ANALYZE LATER FOR SULFATE, POTASSIUM, MAGNESIUM, CALCIUM, IRON, COPPER, NICKEL, LEAD.

NUMBER OF SOAKS AS PRACTICABLE PRIOR TO HOT SOAK.

WESTINGHOUSE CLASS 3

HOT WATER SOAK 350 - 400°F

RATIONALE — LABORATORY DATA SHOWS THAT 300 - 400°F IS TEMPERATURE RANGE FOR OPTIMUM SOLUBILITY OF SODIUM PHOSPHATE. SOLUBILITY DROPS OFF WITH HIGHER TEMPERATURES. HIGHER TEMPERATURE IS MORE KINETICALLY FAVORABLE. EXPECT THIS SOAK TO HAVE GREATER PENETRATION THAN FIRST SOAK.

PROCEDURE — FILL STEAM GENERATOR WITH PURE H_2O (PLUS N_2 SPARGING) TO THE PRIMARY SEPARATOR LEVEL.

HEAT TO 350 - 400°F USING PUMP HEAT.

SOAK FOR UP TO 48 HOURS (CONVECTION MIXING).

FOLLOW CONCENTRATION INCREASE. IF CONCENTRATION PLATEAU REACHED BEFORE 48 HOURS, STOP SOAK.

SAMPLE AND ANALYZE AS IN COLD SOAK.

FEED AND BLEED TO ~100TH DILUTION AND A $Na/PO_4 < 2.8$.

WESTINGHOUSE CLASS 3

CHEMISTRY CONTROL DURING HEATUP FOR RESTART

- HEAT TO HOT STANDBY, APPLY MAXIMUM BLOWDOWN AND MONITOR CHEMISTRY, HOLD UNTIL BLOWDOWN CHEMISTRY IS STABILIZED FOR AT LEAST 24 HOURS (RESIDUAL NA/PO_4 RATIO TO BE <2.8)

- PROCEED TO 25% POWER. HOLD FOR CHEMISTRY STABILITY AS ABOVE. MONITOR TRANSPORT OF CONTAMINANTS AND CORROSION PRODUCTS FROM THE CONDENSATE/FEEDWATER SYSTEMS.

- IF NO HIGH RATIO PHOSPHATE HIDEOUT RETURN IS EXPERIENCED (PO_4 <2 PPM, NA/PO_4 <2.8), COMMENCE PO_4 INJECTION TO REACH PO_4 LEVEL OF 50 PPM AND NA/PO_4 = 2.3. HOLD FOR AT LEAST 24 HOURS.

- RAMP TO 50%, 75% AND 100% WITH AT LEAST 24 HOUR HOLDS TO MAINTAIN STABILITY.

- REDUCE PO_4 LEVEL TO 20 PPM WITH LIMITS OF 15 TO 30 PPM AND TARGET RATIO OF 2.4 (LIMITS 2.3 TO 2.6) DETERMINED USING THE MARCY/HALSTEAD RATIO.

WESTINGHOUSE CLASS 3

CHEMISTRY CONTROL DURING HEATUP FOR RESTART (CONTINUED)

- IF HIGH RATIO PHOSPHATE HIDEOUT RETURN IS OBSERVED AT 25% POWER, CONTINUE BLOWDOWN AND HOLD FOR CHEMISTRY STABILITY FOR AT LEAST 24 HOURS.

- RAMP TO 50% POWER. IF NO HIGH RATIO PHOSPHATE HIDEOUT RETURN IS OBSERVED, COMPLETE ADDITION OF PHOSPHATE AS DESCRIBED ABOVE. IF HIGH RATIO PHOSPHATE IS EXPERIENCED, CONTINUE TO BLOWDOWN AND HOLD FOR CHEMISTRY STABILITY. INCREASE POWER TO 75% TO ESTABLISH IF RETURN OCCURS THERE.

- ONCE STEAM GENERATOR IS UNDER 2.4 NA/PO_4, PO_4 = 20 PPM CONTROL, MAINTAIN CHEMISTRY FOLLOW ON 4 HOUR FREQUENCY.

- WHEN BLOWDOWN CHEMISTRY HAS STABILIZED FOR AT LEAST 24 HOURS, RETURN TO NORMAL ANALYTICAL SCHEDULE.

WESTINGHOUSE CLASS 3

CHEMISTRY DURING OPERATION

PRIMARY SIDE

CONDUCTIVITY	DETERMINED BY THE CONCENTRATION OF BORIC ACID AND ALKALI PRESENT.
pH	AS FOR CONDUCTIVITY. EXPECTED VALUES RANGE BETWEEN 4.2 AND 10.5 AT 25°C.
OXYGEN	0.005 PPM MAXIMUM
CHLORIDE	0.15 PPM MAXIMUM
FLUORIDE	0.5 PPM MAXIMUM
HYDROGEN	25 - 50 CC (STP)/KG H_2O
SUSPENDED SOLIDS	1.0 PPM MAXIMUM
pH CONTROL AGENT (Li^7OH)	0.7 - 2.2 PPM AS LI
BORIC ACID	VARIABLE FROM 0 - 4000 PPM AS B
SILICA	0.2 PPM MAXIMUM
ALUMINUM	0.05 PPM MAXIMUM
CALCIUM	0.05 PPM MAXIMUM
MAGNESIUM	0.05 PPM MAXIMUM

WESTINGHOUSE CLASS 3

SECONDARY SIDE

BLOWDOWN CHEMISTRY

PHOSPHATE	20 PPM (RANGE 15 - 30)
SODIUM	11.6 PPM (RANGE 8.4 - 18.9)
NA/PO_4 (M.H.)	2.4 (RANGE 2.3 - 2.6)
pH AT 25°C	9.8 (RANGE 9.4 - 10.2)
CHLORIDE	0.5 PPM MAXIMUM

MAKE UP WATER

MAKE UP EVAPORATOR SHOULD BE MONITORED CLOSELY TO PREVENT CARRY OVER OF HARDNESS IMPURITIES TO CONDENSATE STORAGE TANK.

A SAMPLING SCHEDULE OF THE STORED CONDENSATE SHOULD BE MAINTAINED TO PRESERVE THE QUALITY OF THE CONDENSATE MAKE UP.

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WESTINGHOUSE CLASS 3

SAN ONOFRE STEAM GENERATOR SLUDGES

JUNE 1980

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Fe	WT.%	34	38	45
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PO_4	"	8.8	1.3	2.0
Ca	"	0.6	1.2	0.9
Mg	"	1.2	2.2	1.5
Mn	"	0.4	0.6	0.5
Cr	"	0.3	0.2	0.3
Ti	"	< 0.1	< 0.1	0.1
Pb	"	< 0.05	0.05	0.05
K	"	< 0.001	< 0.001	< 0.001
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Cl	PPM	< 40	< 32	< 43
SO_4	PPM	< 140	< 160	< 160

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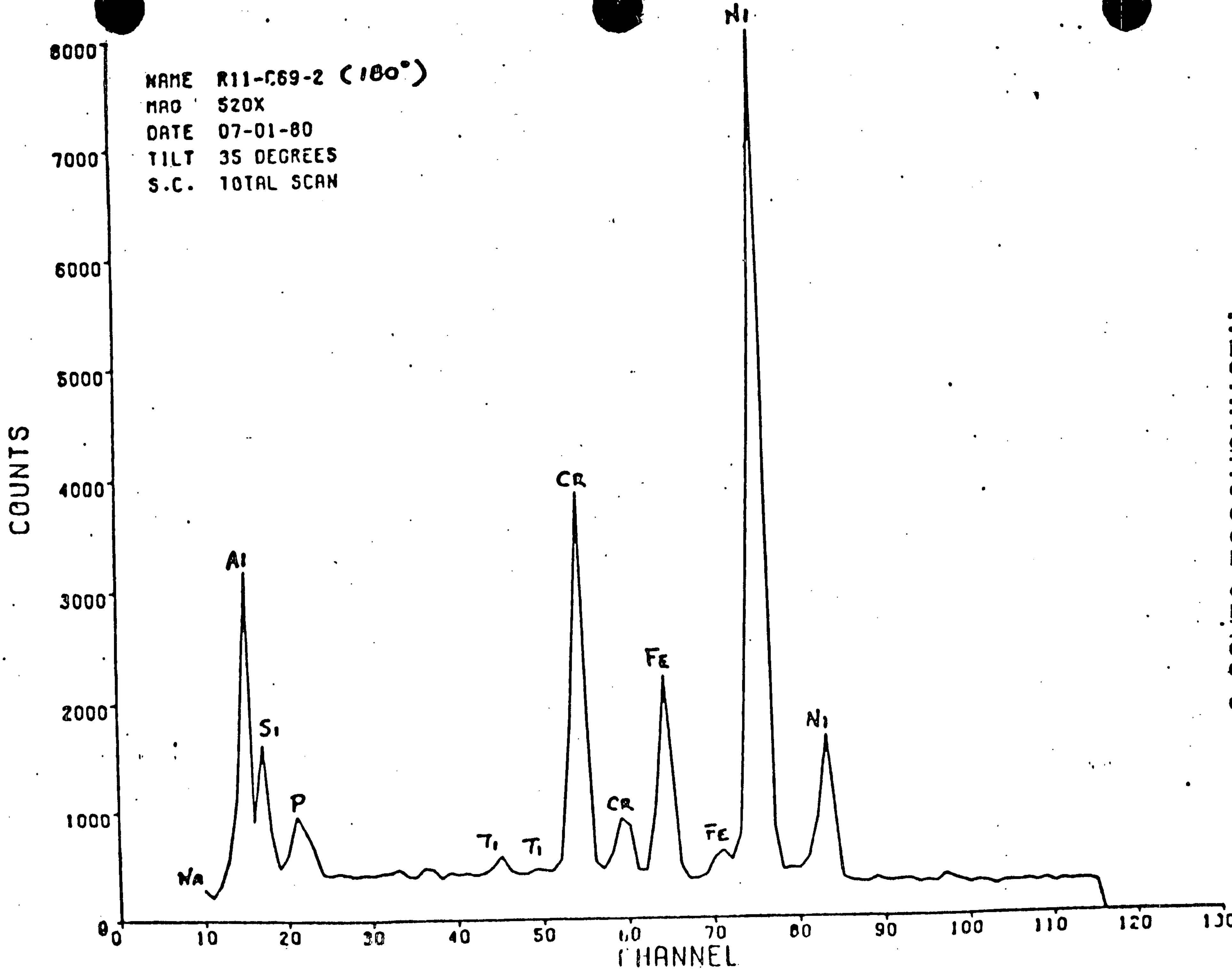
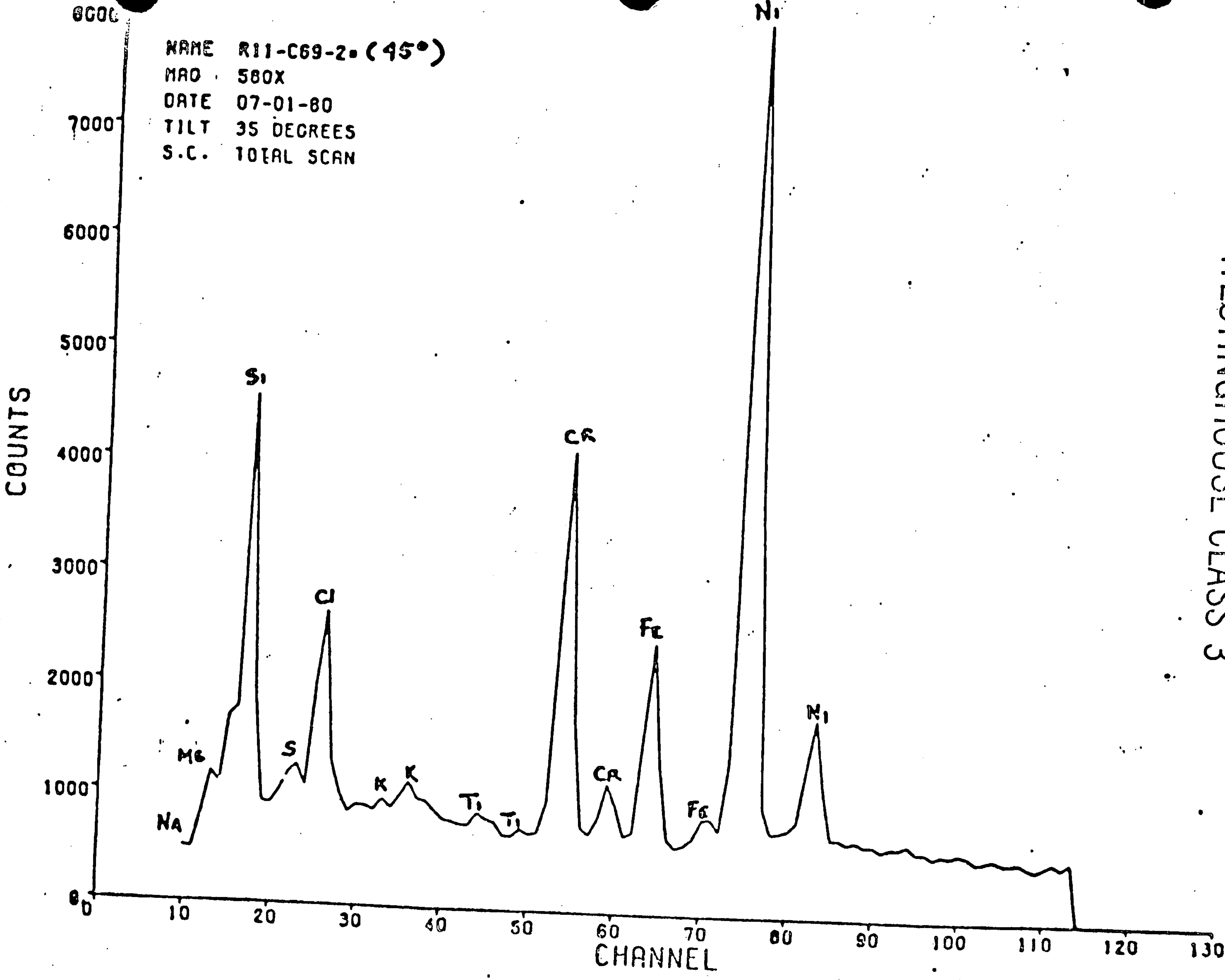


WESTINGHOUSE CLASS 3

EDAX OF FRACTURE SURFACE OF TUBE REMOVED FROM SAN ONOFRE



WESTINGHOUSE CLASS 3

WESTINGHOUSE CLASS 3

PREOPERATIONAL PRIMARY SIDE CHEMISTRY PROGRAM TO REMOVE MAGNETITE

- INITIALLY CLEAN THE MAGNETITE IN THE PIPE BY RECIRCULATION-FILTRATION CLEANING PRIOR TO PLANT SYSTEM REFILL OR IN COMBINATION WITH PICKUP BY ELECTROMAGNET.
- START-UP WITH ONE MIX BED CHARGED WITH A NEW CHARGE OF HOH RESIN.
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- DO NOT OPERATE (CRDM) MECHANISM PRIOR TO CLEAN-UP.
- ASSURE THAT RCP SEAL INJECTION IS OPERATING AT TIME OF CLEAN-UP.
- FOLLOWING CLEAN-UP OPERATION AT 150°F TO PREVENT SOLUBILITY OF THESE IMPURITIES, CHECK CHEMISTRY FOR ALUMINUM AND SiO_2 CONCENTRATION TO CONFIRM THAT WESTINGHOUSE CHEMISTRY SPEC. IS NOT VIOLATED FOR IMPURITIES.
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WESTINGHOUSE CLASS 3

INITIAL OPERATION

- HYDROSTATIC TESTING
- IN-SERVICE INSPECTION PROGRAM
- INITIAL OPERATING PERIOD
- PRIMARY TO SECONDARY LEAKAGE LIMIT

WESTINGHOUSE CLASS 3

HYDROSTATIC PRESSURE TESTING

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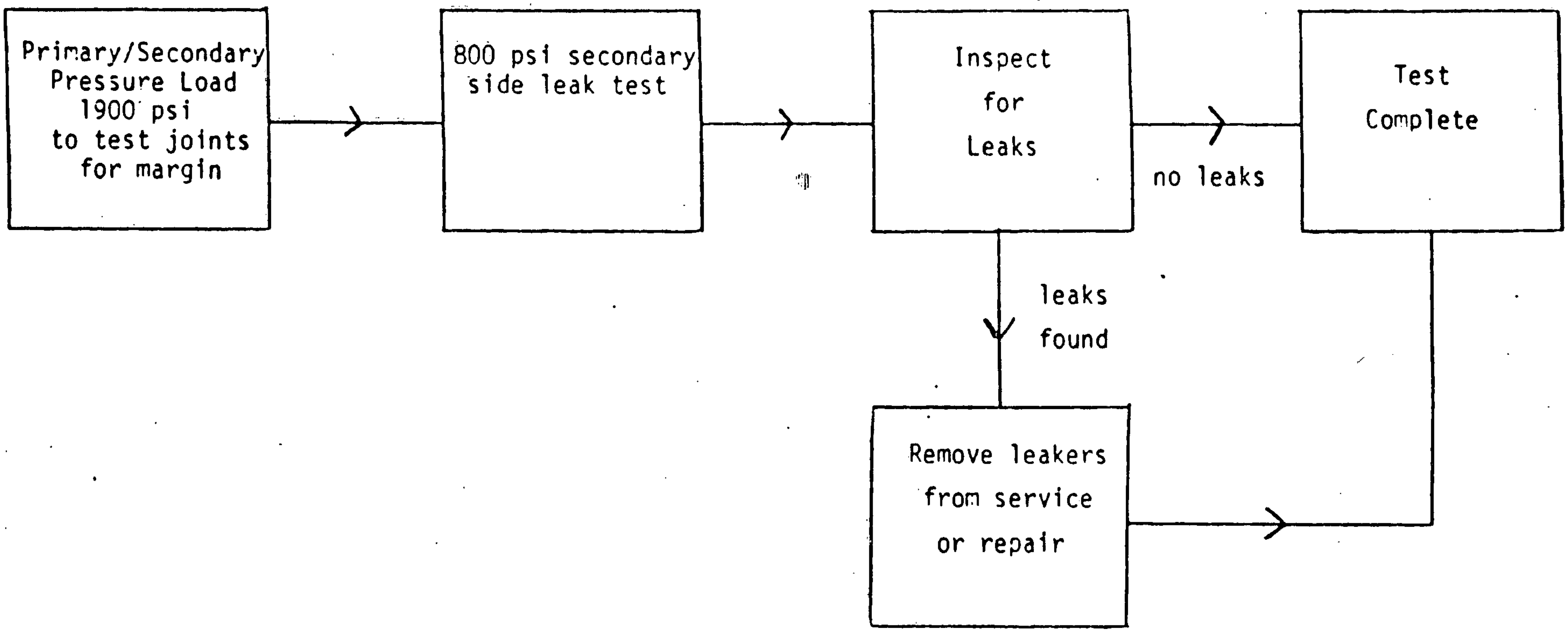
FIGURE 9.1 . PERIODIC TUBE/SLEEVE [illegible] MARGIN TEST



WESTINGHOUSE CLASS 3

INSERVICE INSPECTION PROGRAM

OBJECTIVE: TO ASSURE CONTINUED RELIABILITY OF SLEEVED AND NON-SLEEVED TUBES.

CRITERIA: PROVIDE ASSURANCE OF FURTHER NONDEGRADATION BY SECONDARY WATER OF THE TUBE BUNDLE. THAT IS NO INDICATIONS >50% FOR NON-SLEEVED TUBES AND NO DEGRADATION >50% FOR THE SLEEVES.

TECHNIQUE: "E.C. TESTING"

(A) E.C. SIGNATURES WILL BE OBTAINED ON ALL TUBES PRIOR TO OPERATION.

(B) FIRST E.C. PROGRAM WILL INCLUDE AT LEAST 3% OF TUBES IN EACH SG AND WILL BE CONSISTENT WITH REG. GUIDE 1.83.

(C) SUBSEQUENT E.C. PROGRAMS WILL BE CONDUCTED CONSISTENT WITH REG. GUIDE 1.83.

"LEADER TUBES"

(A) FOUR REPRESENTATIVE TUBES IN EACH SG WILL BE PERFORATED JUST ABOVE THE TUBESHEET IN ORDER TO EXPOSE THE [ ]a,c TO THE SECONDARY SIDE ENVIRONMENT.

(B) DURING FUTURE OUTAGES ONE OF THESE TUBES WILL BE REMOVED FROM EACH SG AND EXAMINED.

(C) FROM THESE EXAMINATIONS A DEGRADATION RATE FOR THE TUBE/SLEEVE JOINT CAN BE INFERRED AND FACTORED INTO CONTINUED OPERATING CONSIDERATIONS.

WESTINGHOUSE CLASS 3

INITIAL OPERATING PERIOD

OBJECTIVE: RETURN THE UNIT TO FULL POWER CONSISTENT WITH SAFE OPERATION.

BASIS : THE FIRST INSERVICE INSPECTION WILL OCCUR AFTER THE SLEEVES HAVE SEEN 6 MONTHS OF EFFECTIVE FULL POWER OPERATION.

THIS NUMBER IS CONSERVATIVE SINCE A REVIEW OF PAST E.C. DATA SHOW THIS PHEOMENA PROGRESSING AT A RATE OF ~15%/YR (OR) ~8 MILS/YR.

CONSIDER THESE CONDITIONS:

UNSLEEVED PERIPHERY: (MILL ANNEALED I-600)

40% (OR) 22 MILS PENETRATION

6 MONTHS OPERATION = 4 MILS ADDITIONAL PENETRATION

TOTAL PENETRATION = 26 MILS (OR) 46% PENETRATION

SLEEVED TUBE: (THERMALLY TREATED I-600)

VIRGIN MATERIAL FOR SLEEVE

6 MONTHS OPERATION = 4 MILS PENETRATION

RESIDUAL STRENGTH PROPERTIES OF TUBES SUBJECT TO IGA.

SUBSEQUENT INSPECTIONS WILL BE CONDUCTED DURING STANDARD REFUELING OUTAGES AND TUBES PLUGGED (OR) SLEEVED AS NECESSARY.

TECHNIQUE: MULTI-FREQUENCY E.C. SAMPLING LEADER TUBE PROGRAM

WESTINGHOUSE CLASS 3

PRIMARY TO SECONDARY LEAKAGE LIMIT

MONITOR PRIMARY TO SECONDARY LEAKAGE

SHUTDOWN FOR TUBE PLUGGING ON DETECTION AND CONFIRMATION OF ANY OF THE FOLLOWING:

- SUDDEN PRIMARY TO SECONDARY LEAKAGE OF 140 GPD (0.1 GPM) IN ANY STEAM GENERATOR
- ANY PRIMARY TO SECONDARY LEAKAGE IN EXCESS OF 215 GPD (0.15 GPM) IN ANY STEAM GENERATOR
- MEASURED INCREASE IN PRIMARY TO SECONDARY LEAKAGE IN EXCESS OF 15 GPD (0.01 GPM) PER DAY, WHEN MEASURED PRIMARY TO SECONDARY LEAKAGE IS ABOVE 140 GPD

SHUTDOWN FOR TUBE PLUGGING AND EDDY CURRENT INSPECTION ON DETECTION AND CONFIRMATION OF THE FOLLOWING:

- PRIMARY TO SECONDARY LEAKAGE IN EXCESS OF 430 GPD (0.3 GPM) IN ANY STEAM GENERATOR

WESTINGHOUSE CLASS 3

SUMMARY AND CONCLUSIONS

- PROGRAM OF STEAM GENERATOR INSPECTION HAS SHOWN:
  - SIGNIFICANT CAUSTIC INDUCED IGA OCCURRING AT TOP OF TUBESHEET FOR TUBES IN INTERIOR REGIONS OF STEAM GENERATORS A, B, AND C.
  - PERIPHERAL TUBES IN EACH STEAM GENERATOR NOT SIGNIFICANTLY DEGRADED.
- EVIDENCE OF OPERATIONS WITH FREE CAUSTIC AND OTHER OFF-NORMAL CHEMISTRY BASED ON SECONDARY SIDE CHEMISTRY REVIEW.
- SLEEVING PROGRAM RESTORES INTEGRITY OF STEAM GENERATOR TUBE BUNDLES.
  - PERMITS FULL POWER OPERATION CONSISTENT WITH PLANT SAFETY REQUIREMENTS.
  - PROGRAM VALIDATED BY EXTENSIVE TESTING, ANALYSES AND DESIGN REVIEWS
  - PROGRAM IMPLEMENTED WITH REGARD FOR OPERATIONAL ALARA GUIDELINES
- CHEMISTRY PROGRAM FOR STARTUP AND OPERATION REDUCES CONCENTRATION OF CONTAMINANTS AND POTENTIAL FOR CONTINUING IGA.

WESTINGHOUSE CLASS 3

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WESTINGHOUSE CLASS 3

- HYDROSTATIC PRESSURE TEST DURING INITIAL STARTUP CONFIRMS BUNDLE INTEGRITY.

- INSERVICE INSPECTION PROGRAM MONITORS INTEGRITY OF SLEEVED AND UNSLEEVED TUBES.
  - EDDY CURRENT TESTING
  - LEADER TUBE REMOVAL/INSPECTION PROGRAM

- PRIMARY TO SECONDARY LEAKAGE LIMITS ARE CONSERVATIVE AND PROVIDE PROMPT REMEDIAL ACTION CONSISTENT WITH SAFE OPERATION.
  - TUBES AFFECTED BY IGA STILL RETAIN SIGNIFICANT RESIDUAL PROPERTIES
  - LEAK BEFORE BREAK MECHANISM APPLIES TO DUCTILE INCONEL 600 TUBING
  - MARGIN IS APPLIED TO EXISTING TECHNICAL SPECIFICATION LEAKAGE LIMITS

- COMPREHENSIVE PROGRAM OF STEAM GENERATOR DIAGNOSTICS, SLEEVING, OPERATIONAL MONITORING AND INSERVICE INSPECTIONS ASSURES THAT SAN ONOFRE UNIT 1 CAN RETURN TO FULL POWER OPERATION WITH ADEQUATE SAFETY MARGIN.

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