

January 24, 1991

Docket Nos. 50-348
and 50-364

LICENSEE: Alabama Power Company

FACILITY: Joseph M. Farley Nuclear Plant, Units 1 and 2

SUBJECT: MEETING SUMMARY OF NOVEMBER 6, 1990

A meeting was held with Alabama Power Company (APCO) on November 6, 1990, in Rockville, Maryland, to discuss alternative tube plugging criteria for the Joseph M. Farley Nuclear Plant (Farley), Unit 2, steam generators. During the meeting, APCO presented information to support a proposed future request for approval of the following:

1. Allow 65 tubes to remain in service with known axial, primary water stress corrosion cracks in the expansion zone region of the tube sheet. These cracks exceed the requirements of the Farley, Unit 2, Technical Specifications for tube plugging. APCO's justification for the request was based on a limited application of a new plugging criteria being submitted to the NRC by the Electric Power Research Institute (EPRI).
2. Continue to apply the 1.75 volt criteria for tube plugging previously applied by APCO for the outside diameter (OD) stress corrosion cracks in the tube support plate region. APCO's justification, as described at the meeting, was based on Farley operating history and industry data that, at this voltage, even through-wall cracks demonstrated no leakage, and on a current program by EPRI to develop new plugging criteria for OD cracks in the tube support plate region.

The NRC staff indicated that it would evaluate the information presented and would respond to APCO's proposed request.

Handouts from the meeting are contained in WCAP-12803 (Proprietary) and WCAP-12804 (Non-Proprietary), "Steam Generator Tube Plugging Limits Presentation Materials." Enclosure 1 contains a copy of WCAP-12804. Enclosure 2 contains a list of attendees.

Original Signed By:

9102070174 910124
PDR ADOCK 05000348
P PDR

Stephen T. Hoffman, Project Manager
Project Directorate II-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosures: As stated

cc w/enclosures:
See next page

OFC	: PM:PD21:DRPR	: D:PD21:DRPR	:	:	:
NAME	: SHoffman, dt	: EAdensam	:	:	:
DATE	: 1/24/91	: 1/24/91	:	:	:

OFFICIAL RECORD COPY
Document Name: FARLEY MTG ON NOV. 6

DISTRIBUTION FOR MEETING SUMMARY DATED: November 6, 1990

Facility: Farley

Docket File

NRC PDR	
Local PDR	
T. Murley	12-G-18
F. Miraglia	12-G-18
S. Varga	
G. Lainas	
E. Adensam	14-B-20
P. Anderson	14-B-20
S. Hoffman	14-B-20
OGC	15-B-18
E. Jordan	MNBB-3302
K. Desai	8-E-23
E. Murphy	7-D-4
C. Cheng	7-D-4
B. Liaw	9-A-2
H. Conrad	7-D-4
K. Wichman	7-D-4
J. Richardson	7-D-24
ACRS (10)	P-315
B. Borchardt	17-G-21

Meeting Summary

Joseph M. Farley Nuclear Plant

cc:

Mr. R. P. McDonald
Executive Vice President
Nuclear Operations
Alabama Power Company
P. O. Box 1295
Birmingham, Alabama 35201

Mr. B. L. Moore
Manager, Licensing
Alabama Power Company
P. O. Box 1295
Birmingham, Alabama 35201

Mr. Louis B. Long, General Manager
Southern Company Services, Inc.
Houston County Commission
P. O. Box 2625
Birmingham, Alabama 35202

Mr. D. N. Morey
General Manager - Farley Nuclear Plant
P. O. Box 470
Ashford, Alabama 36312

Mr. J. D. Woodward
Vice-President - Nuclear
Farley Project
Alabama Power Company
P. O. Box 1295
Birmingham, Alabama 35201

Resident Inspector
U.S. Nuclear Regulatory Commission
P. O. Box 24 - Route 2
Columbia, Alabama 36319

Regional Administrator, Region II
U.S. Nuclear Regulatory Commission
101 Marietta Street, Suite 290C
Atlanta, Georgia 30323

Chairman
Houston County Commission
Dothan, Alabama 36301

Claude Earl Fox, M.D.
State Health Officer
State Department of Public Health
State Office Building
Montgomery, Alabama 36130

James H. Miller, III, Esq.
Balch and Bingham
P. O. Box 306
1710 Sixth Avenue North
Birmingham, Alabama 35201

Mr. W. G. Hairston, III
Senior Vice President
Alabama Power Company
40 Inverness Center Parkway
Post Office Box 1295
Birmingham, Alabama 35201

WESTINGHOUSE PROPRIETARY CLASS 3

WCAP-12804

STEAM GENERATOR TUBE PLUGGING LIMITS
PRESENTATION MATERIALS

December 1990

G. W. Whiteman

WESTINGHOUSE ELECTRIC CORPORATION
Energy Systems
P. O. Box 355
Pittsburgh, Pennsylvania 15230

(C) 1990 Westinghouse Electric Corporation, all rights reserved.

9101220058

WESTINGHOUSE PROPRIETARY CLASS 3

This proprietary report bears a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in this report which are necessary for its internal use in connection with generic and plant specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.790 regarding restrictions on public disclosure. Copies of this report or part thereof made by the NRC must include the copyright notice and the proprietary notice.

A meeting was held on November 6, 1990, between Alabama Power Company, Westinghouse, and the NRR to discuss alternate steam generator tube plugging criteria for the Farley Unit 2 steam generators.

The following topics were discussed by Westinghouse:

1. Overview of the Farley Unit 2 Assessment
2. Farley 2- Specific Tube Plugging Criteria for Expansion Zone Primary Water Stress Corrosion Cracking in the Roll Transitions
3. Steam Line Break Leakage Limits for Farley Unit 2
4. Farley Unit 2 Eddy Current Inspection Summary
5. Farley Unit 2 Tube Support Plate Criteria

ODSCC AT TSPs FARLEY-2 PLAN

TUBE PLUGGING FOR FARLEY-2 1990 OUTAGE

o PLUG TUBES EXCEEDING 1.75 VOLT AMPLITUDE

o BASIS

- PREVIOUSLY APPLIED FOR DIS IN 4 FARLEY - 1, 2
OUTAGES

o NO LEAKAGE ATTRIBUTABLE TO INDICATIONS AT
TSPs

- SUPPORTED BY PULLED TUBE, FIELD LEAKAGE
EXPERIENCE AND LABORATORY TESTING AS A
CONSERVATIVE, NO LEAKAGE TUBE PLUGGING
LEVEL

- SMALL GROWTH RATE FOR INDICATIONS AT TSPs

SUPPORTING DATA

o CURRENT EPRI PROGRAM TO DEVELOP PLUGGING CRITERIA FOR OD
TSPs

ODSCC AT TSPs

EPRI ALTERNATE TUBE PLUGGING CRITERIA

- 0 DEMONSTRATE EITHER OR BOTH OF:
 - TSP CONSTRAINT TO PREVENT TUBE RUPTURE IS PRESENT AT SLB CONDITIONS
 - PLUGGING LIMITS PROVIDE ADEQUATE MARGIN AGAINST TUBE RUPTURE EVEN IF TSP CONSTRAINT IS NOT PRESENT

- 0 TWO PARAMETER PLUGGING CRITERIA
 - BOBBIN COIL VOLTAGE AND DEPTH INDEX LIMITS MUST BOTH BE EXCEEDED FOR TUBE PLUGGING
 - VOLTAGE APPLIED AS A CRACK SEVERITY INDEX BASED UPON VOLTAGE DEPENDENCE ON CRACK LENGTH, DEPTH AND LIGAMENTS (VOLUMETRIC FACTORS)
 - VOLTAGE, DEPTH INDEX LIMITS ESTABLISHED BASED ON CORRELATION WITH POTENTIAL FOR TUBE LEAKAGE
 - 0 LABORATORY INDUCED CRACK SPECIMENS, PULLED TUBE DATA AND FIELD LEAKAGE EXPERIENCE USED TO ESTABLISH LIMITS

- 0 PLUGGING LIMIT
 - TUBE PLUGGING IF: $V > V_L - V_{NDE} - V_{CG}$
AND $D > D_L - D_{NDE} - D_{CG}$

APC FOR ODSCC AT TSPs
VOLTAGE / DEPTH INDICES

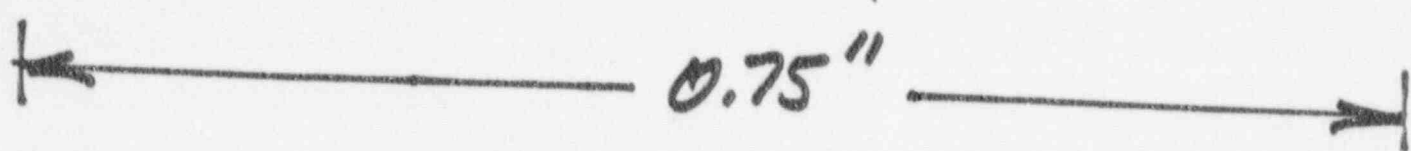
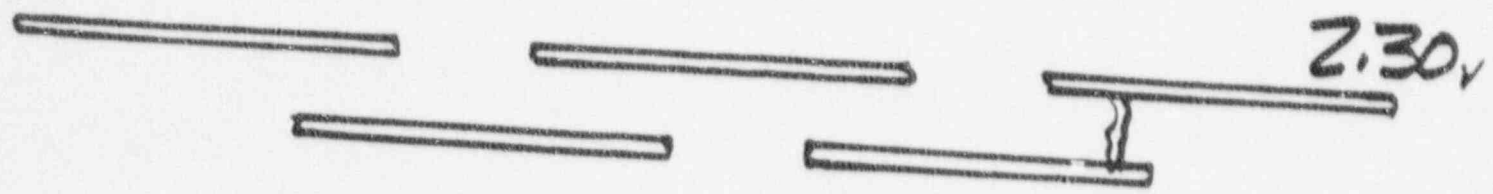
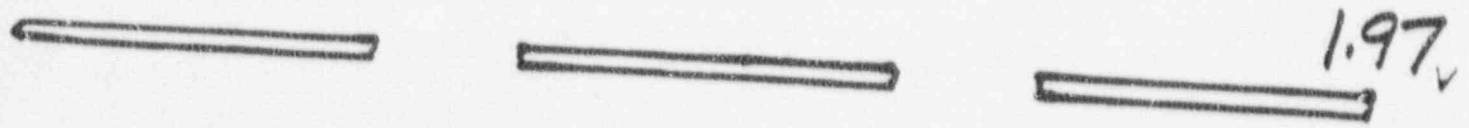
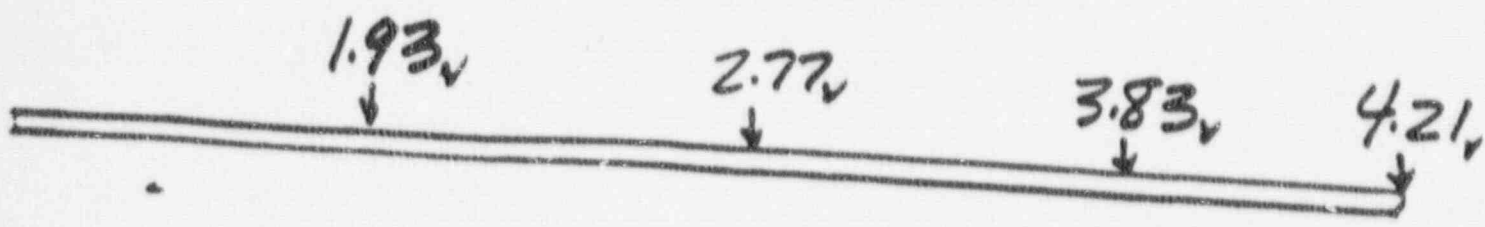
VOLTAGE - CRACK SEVERITY INDEX

- FEASIBILITY EC TESTS PERFORMED
- VOLTAGE INCREASES WITH CRACK SEVERITY
 - WITH INCREASING CRACK LENGTH
 - WITH INCREASING NUMBER OF CRACKS OF SIMILAR LENGTH
 - WITH INCREASING NUMBER OF CRACKS AROUND TUBE CIRCUMFERENCE
 - WITH LOSS OF LIGAMENTS

AVERAGE DEPTH INDEX

- AVERAGE DEPTH (PHASE ANGLE) USED TO SIMPLIFY INTERPRETATION AND IMPROVE CONSISTENCY BETWEEN ANALYSTS

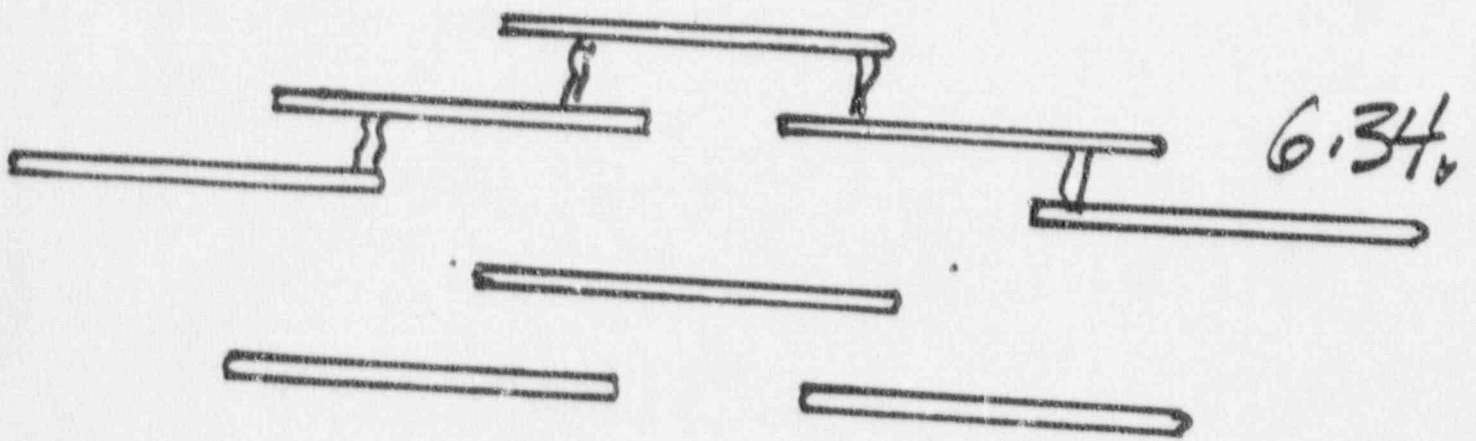
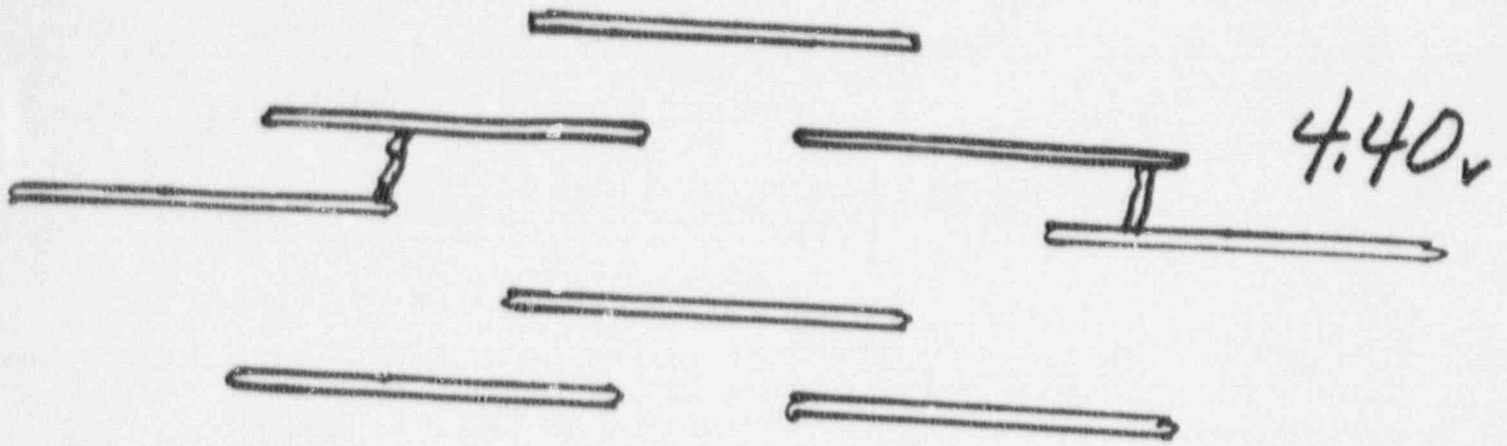
AVERAGE CRACK DEPTH AND CRACK NETWORK LENGTH (VOLTAGE)
CONTROL LIGAMENT FRACTURE AND THUS LEAKAGE UNDER SLB
CONDITIONS



2.00

2.54

3.09



EPRI PROGRAM
APC FOR ODSCC AT TSPs

NDE EVALUATION

- MODEL BOILER SPECIMENS
- DOPED STEAM SPECIMENS
- AVAILABLE PULLED TUBE DATA

ALTERNATE PLUGGING CRITERIA

- MODEL BOILER SPECIMENS
- PULLED TUBE DATA
- FIELD DATA FOR LEAKING TUBES

INFLUENCE OF TUBE DENTING ON LEAKAGE

- FATIGUE SPECIMENS
- DOPED STEAM SPECIMENS

BURST TESTING

- MODEL BOILER SPECIMENS
- DOPED STEAM SPECIMENS
- EDM NOTCH SPECIMENS

EPRI PROGRAM
APC FOR ODSCC AT TSPs

PULLED TUBE AND FIELD DATA

- PULLED TUBE DATA SUPPORTS []^g VOLTS (UP TO 100% DEPTH) AS ACCEPTABLE (NO LEAKAGE)
- FIELD LEAKAGE EXPERIENCE (3 TUBES) ABOVE []^g VOLTS
- INADEQUATE DATA IN []^g VOLT RANGE
 - RANGE OF DATA NEEDED FROM MODEL BOILER SPECIMENS

LEAK RATE TESTING OF LABORATORY SPECIMENS

- CURRENTLY INSUFFICIENT MODEL BOILER SPECIMENS TO CONFIDENTLY ESTABLISH VOLTAGE CRITERIA
 - DIFFICULTY IN GENERATING MODEL BOILER SPECIMENS WITH THRU-WALL CRACKS AND []^g VOLTS (LOWER BOUND OF MB LEAKERS)
- SLB TO NORMAL OPERATING LEAK RATE RATIO BOUNDED BY FACTOR OF []^g VOLTS)
 - INDICATIVE OF INSIGNIFICANT CRACK DEFORMATION UNDER SLB CONDITIONS
- TUBES CRACKED []^g SHOW NO LEAKAGE EVEN AT SLB CONDITIONS (8 SPECIMENS)
- MAGNETITE PACKED CREVICES REDUCE LEAK RATE COMPARED TO OPEN CREVICES (3 SPECIMENS)

TABLE 5.1
PULLED TUBE DATA - BURST PRESSURE

Plant	Robbin Coil			Destructive Exam		Burst Pressure (psi)		
	Volts	Depth	Phase	Max Depth	Length ⁽¹⁾	No Leak	Burst	
A-2								- 9
B-1								
D-2								

1. Crack network lengths with through-wall crack lengths in parentheses - destructive exam shows many, small axial cracks
2. N.M. = Not Measured
3. Values in parentheses are estimated tube burst pressures based upon crack morphology obtained from destructive examination metallography. This pressure would be required to obtain a large leak at SLB conditions for these tubes with no leakage at normal operating conditions.
4. Thin, peripheral ligament remaining leads to an effective through-wall length of 0.1".

TABLE 5.3-1

FIELD EXPERIENCE
SUSPECTED TUBE LEAKAGE FOR ODSCC AT TSPs

<u>Plant</u>	<u>Inspection</u>	<u>Volts</u>	<u>Bobbin Coil</u> <u>Depth</u>	<u>Comments</u>
B-1	Outage before suspected leak	-	-	-
	Outage following suspected leak			
E	Outage following suspected leakage	-	-	-
	Outage following			

* EC calibration data needed to confirm voltage level.

Notes:

1. Reported voltages were adjusted to normalization in this report of []^g

Figure 5-1
 Pulled Tube and Field Bobbin Coil Inspection Data

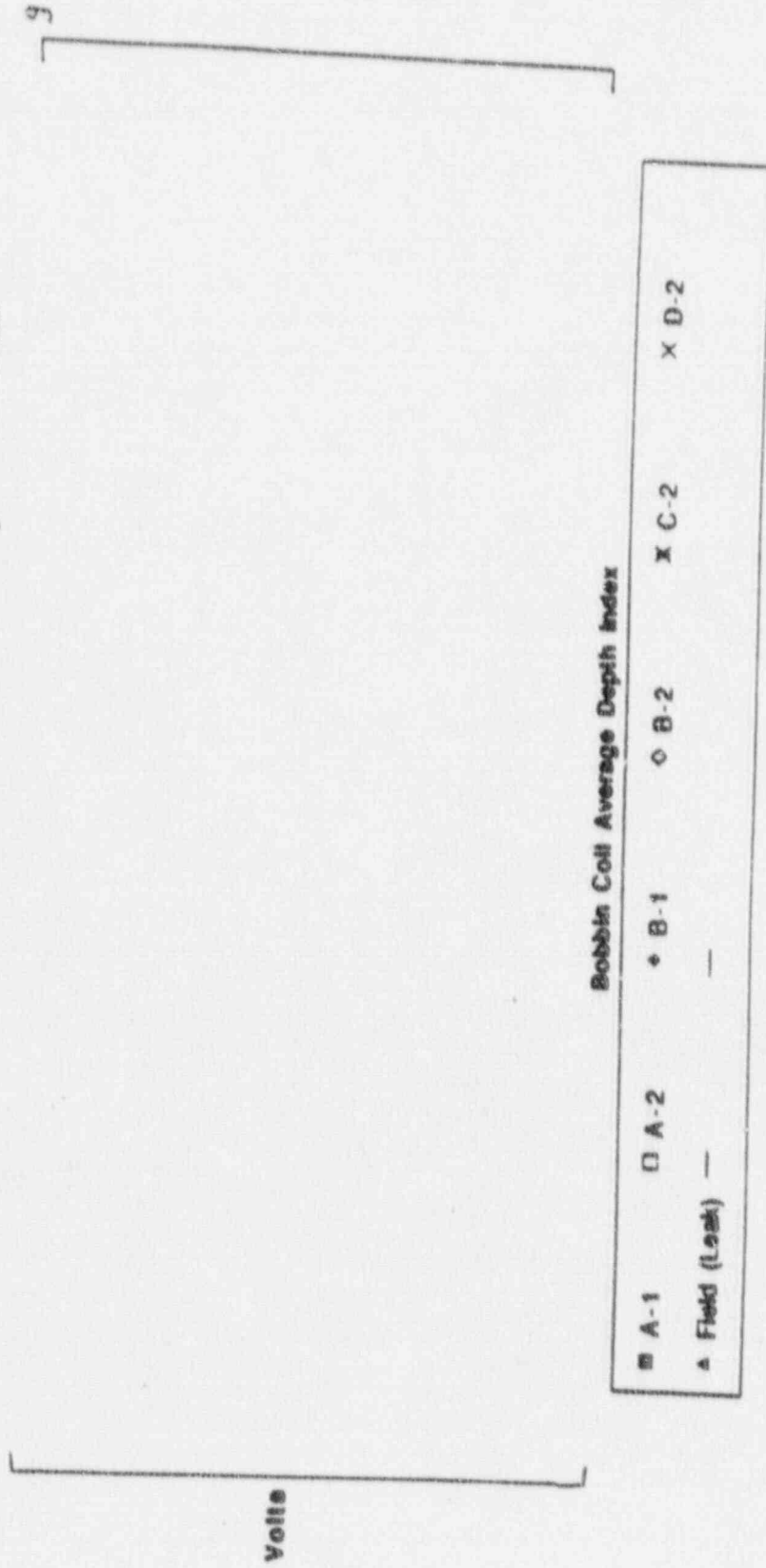
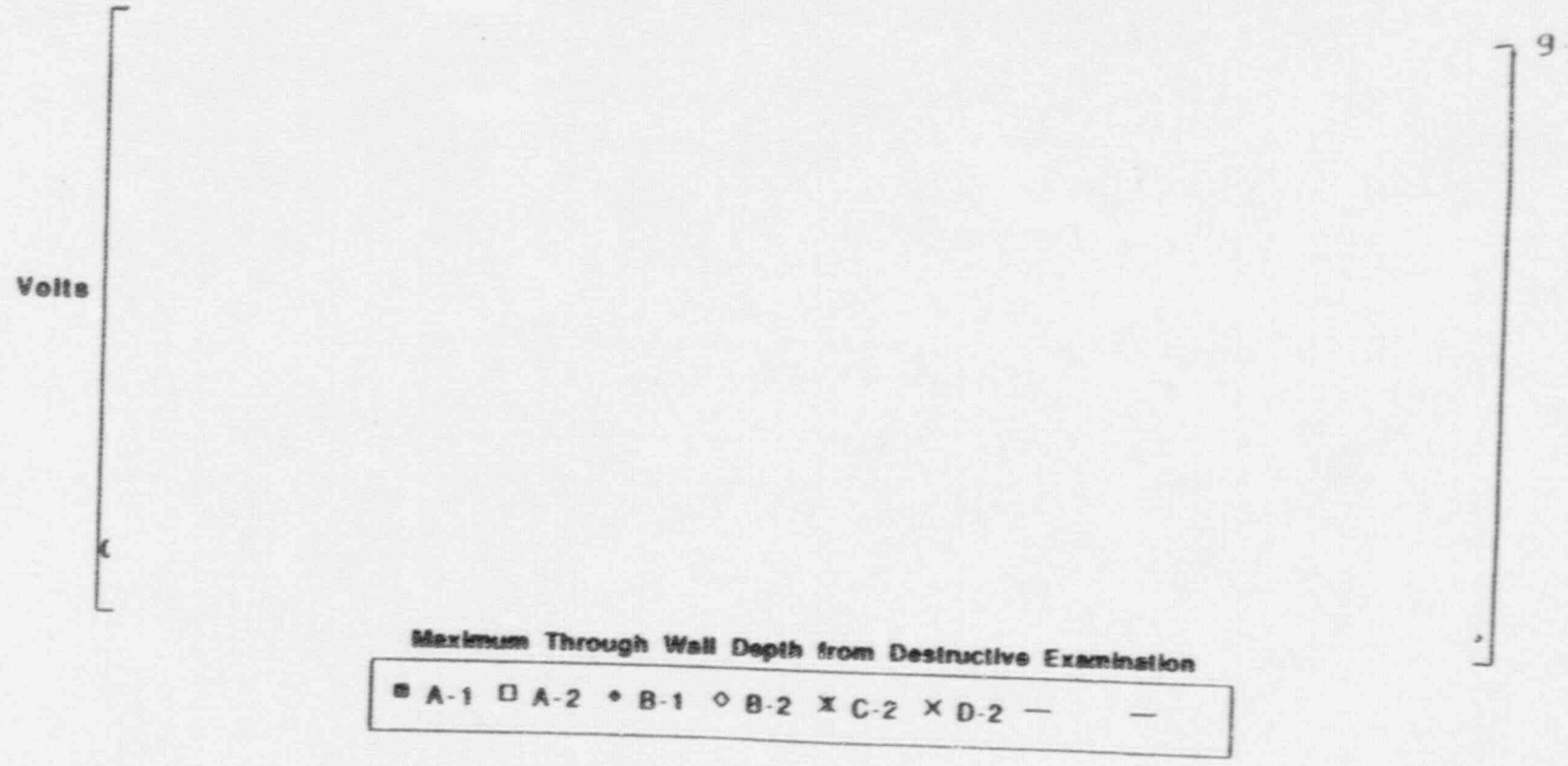


Figure 5-2
Pulled Tube Destructive Examination Data



Normal Operating ΔP Leak Rate Data Base

Volts

9

- MB-Small Leak
- MB-Large Leak
- MB-No Leak
- Field-Leakage
- X Pulled Tubes (No Leakage)

Bobbin Coil Average Depth Index

SIGNAL PARAMETERS FOR CRACKING

SIGNAL AMPLITUDE (VOLTS)

THROUGH-WALL PENETRATION (PERCENT)

Normal Operating ΔP Leak Rate Data Base

Volts

- MB-Small Leak
- MB-Large Leak
- MB-N^o Leak
- Field-Leakage
- X Puffed Tubes
- △ Field -No Leak (No Leakage)

Bobbin Coil Average Depth Index

TABLE 11.2
LEAK RATE TEST DATA FOR DENTED
TUBE/TSP INTERSECTIONS

<u>Sample I.D.</u>	<u>Dent Size</u>	<u>Dent Volume</u>	<u>Thru-Wall Crack (In.)</u>	<u>Open Crevice Leak Rate (Vhr)</u>	<u>Measured Leak Rate (Vhr)</u> <u>Normal Oper.</u> <u>SLE</u>
Fatigue Specimens					
FAT1	[] 9
FAT2					
FAT3					
FAT4					
FAT5					
FAT6					
FAT7					
FAT8					
FAT9					
FAT10					
FAT11					
FAT12					
ODSCC Specimens					
BW1	[] 9
BW3(3)					
BW9					
BW14					

Notes:

1. Fatigue specimen leak rates are calculated leak rates. [
2. Crack network length (includes ligaments)] 9
3. Through wall crack length extended approx. 1/8" outside TSP.

EZPWSCC IN ROLL TRANSITIONS

FARLEY 2 SPECIFIC PLUGGING CRITERIA

TUBE RUPTURE CONSIDERATIONS

ALLOWABLE AXIAL CRACK LENGTH

COMBINED ACCIDENT EVALUATION

LEAKAGE RATE CALCULATION

OPERATING LEAKAGE RATE LIMIT

EZPWSCC IN ROLL TRANSITIONS

ALLOWABLE AXIAL CRACK LENGTH

EPRI NP-6864-L BASIS

CRITICAL CRACK LENGTHS

BURST PRESSURE (PSI)	<u>CRITICAL CRACK LENGTH</u>	
	<u>NO TSC*</u> (INCH)	<u>WITH TSC*</u> (INCH)
1457	0.99	0.99
2650	0.64	0.72
4371	0.35	0.52

* TSC IS TUBE SHEET CONSTRAINT.

EZPWSCC IN ROLL TRANSITIONS
ALLOWABLE AXIAL CRACK LENGTH

EPRI NP-6864-L BASIS

NORMAL OPERATION PRESSURE DIFFERENTIAL

① LIMITING CASE WITH FACTOR OF 3

- $3 \Delta P = 3 (2250-793)$
= 3 (1457)
= 4371 PSI

- REFERENCE CRACK LENGTH = 0.35 INCH

ALLOWABLE AXIAL CRACK LENGTH, A

① ACCOUNTS FOR GROWTH, EC UNCERTAINTY AND
SYSTEMATIC ERROR, AND TUBESHEET (TS)
CONSTRAINT WHERE APPLICABLE

- A = 0.37 INCH WITH TS CONSTRAINT
- A = 0.20 INCH WITHOUT TS CONSTRAINT

EZPWSCC IN ROLL TRANSITIONS
ALLOWABLE AXIAL CRACK LENGTH

COMBINED ACCIDENT EVALUATION

- o SSE PLUS LOCA OR SLB/FLB

PRIMARY STRESS AT TOP OF TUBESHEET

- o PRESSURE DIFFERENTIAL

- NORMAL OPERATION (1457 PSI)
- SLB/FLB (2650 PSI AFTER BLOWDOWN)
- LOCA (-793 PSI AFTER BLOWDOWN)

- o CROSS-SECTION BENDING STRESS



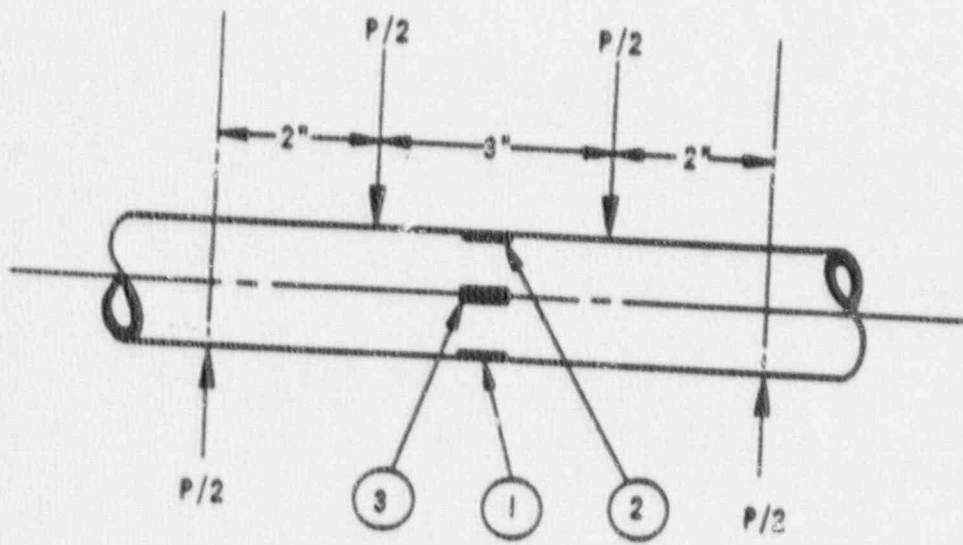
CROSS-SECTION BENDING STRESS IS WELL BELOW THE
MAGNITUDE REQUIRED TO HAVE AN EFFECT ON BURST
PRESSURE (WCAP 7832-A)



ALLOWABLE AXIAL CRACK LENGTH DETERMINED ON THE
BASIS OF INTERNAL PRESSURE ONLY IS JUSTIFIED

COMBINED BENDING AND INTERNAL PRESSURE BURST TESTS
ON TUBES WITH THROUGH WALL SLOTS

a, b, c



Externally Applied Bending Load and Locations of Through Wall Penetrations

EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

OVERVIEW

PROBABILISTIC TECHNIQUES ARE COMBINED WITH A DETERMINISTIC MODEL FOR LEAKAGE FROM A SINGLE AXIAL CRACK TO DETERMINE THE LEAKAGE RATE FOR THE DISTRIBUTION OF AXIAL CRACK LENGTHS.

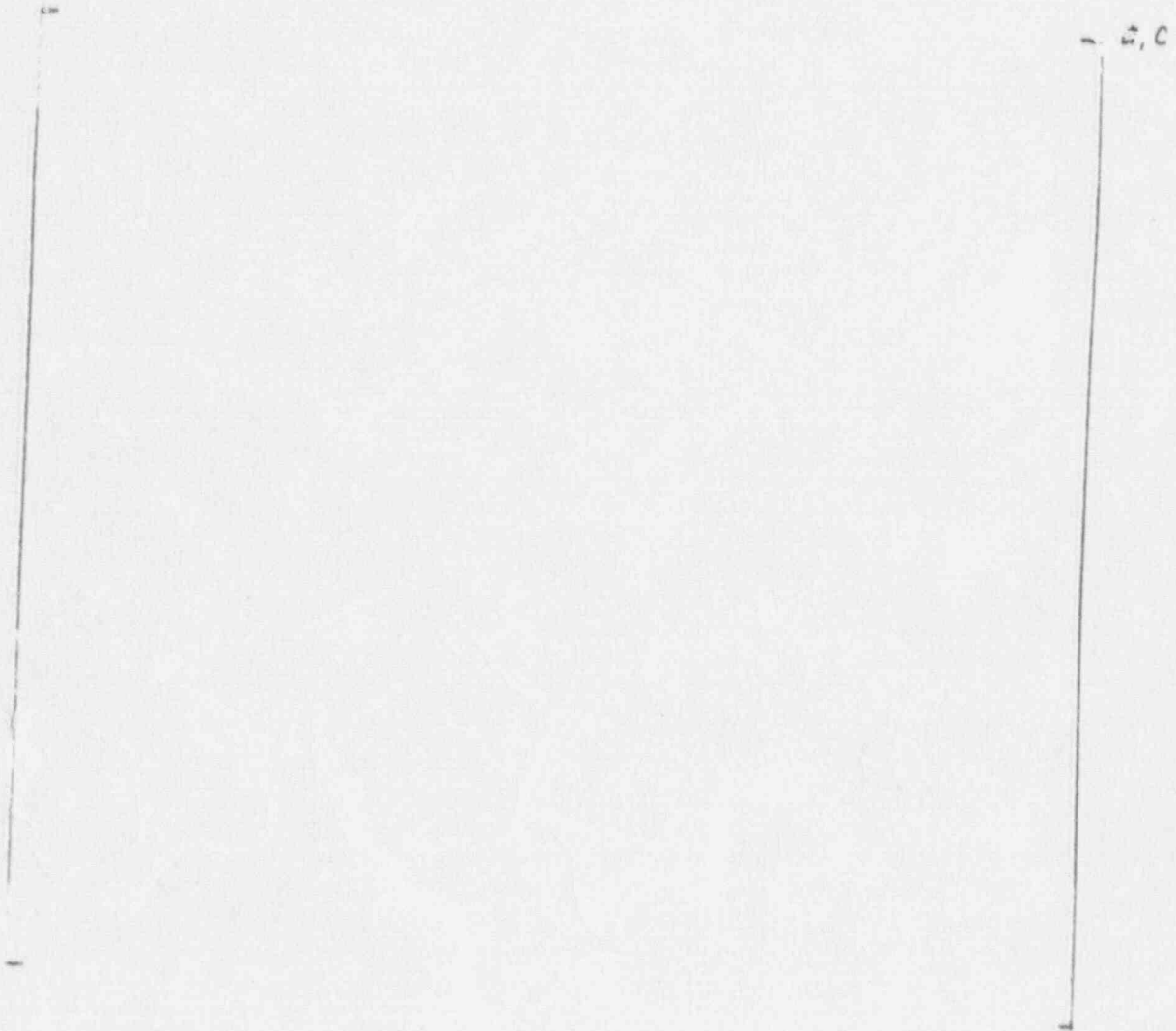
POTENTIAL LEAKAGE IS OBTAINED FOR ALL AXIAL CRACKS DETECTED BY RPC INSPECTION ABOVE THE F^* DISTANCE WITH CRACK LENGTH LESS THAN ALLOWABLE.

EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

AXIAL CRACK FLOW MODEL
(CRACKFLO)

ASSUMPTIONS

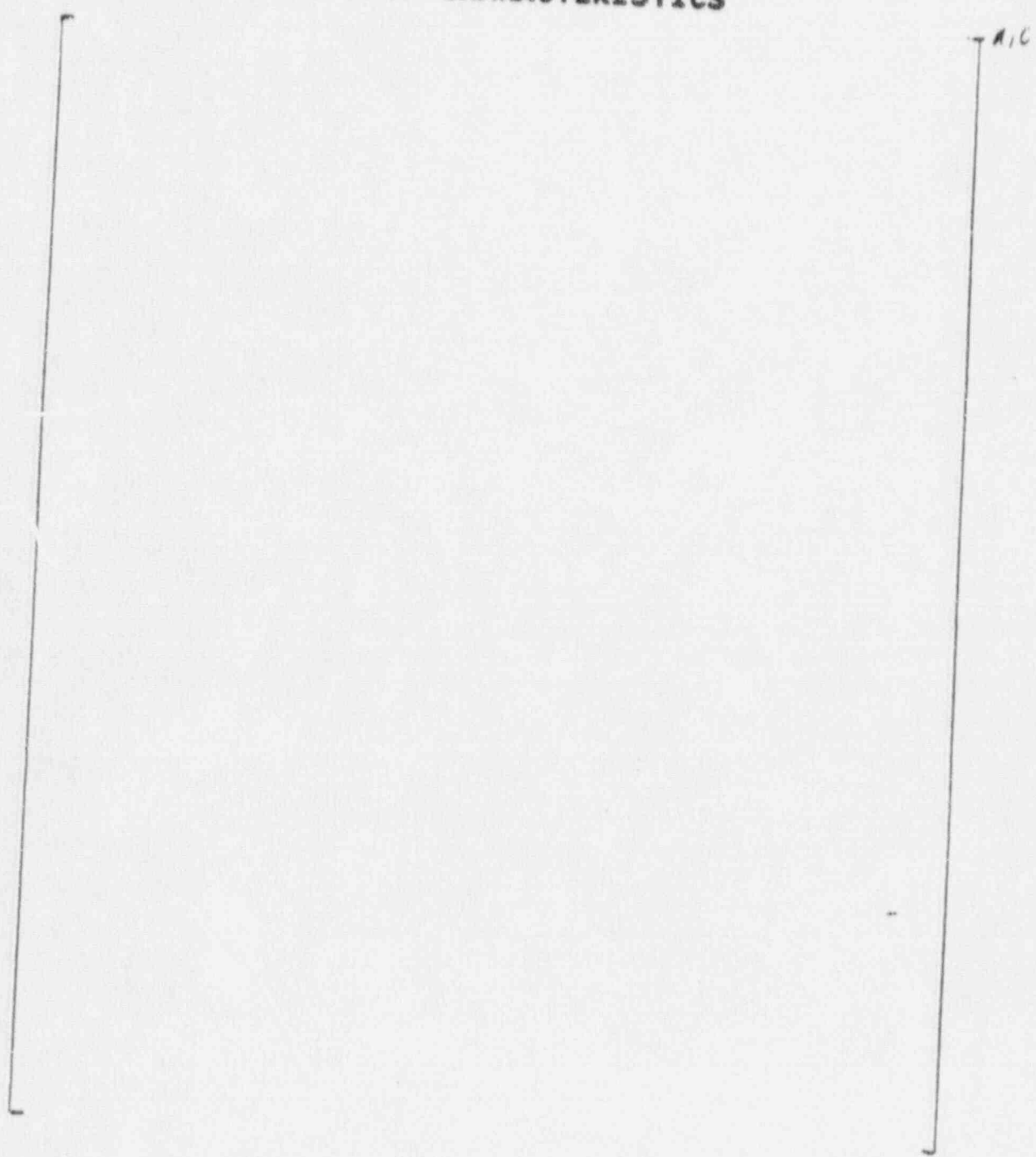


EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

AXIAL CRACK FLOW MODEL
(CRACKFLO)

FLUID AND PRESSURE DROP CHARACTERISTICS



EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

AXIAL CRACK FLOW MODEL
(CRACKFLO)

AXIAL CRACK OPENING AREA MODEL



EZPWSCC IN ROLL TRANSITIONS
LEAKAGE RATE CALCULATION

AXIAL CRACK FLOW MODEL
(CRACKFLO)

SOLUTION PROCEDURE



EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

COMPARISON WITH EXPERIMENTAL RESULTS

NORMAL PLANT OPERATION

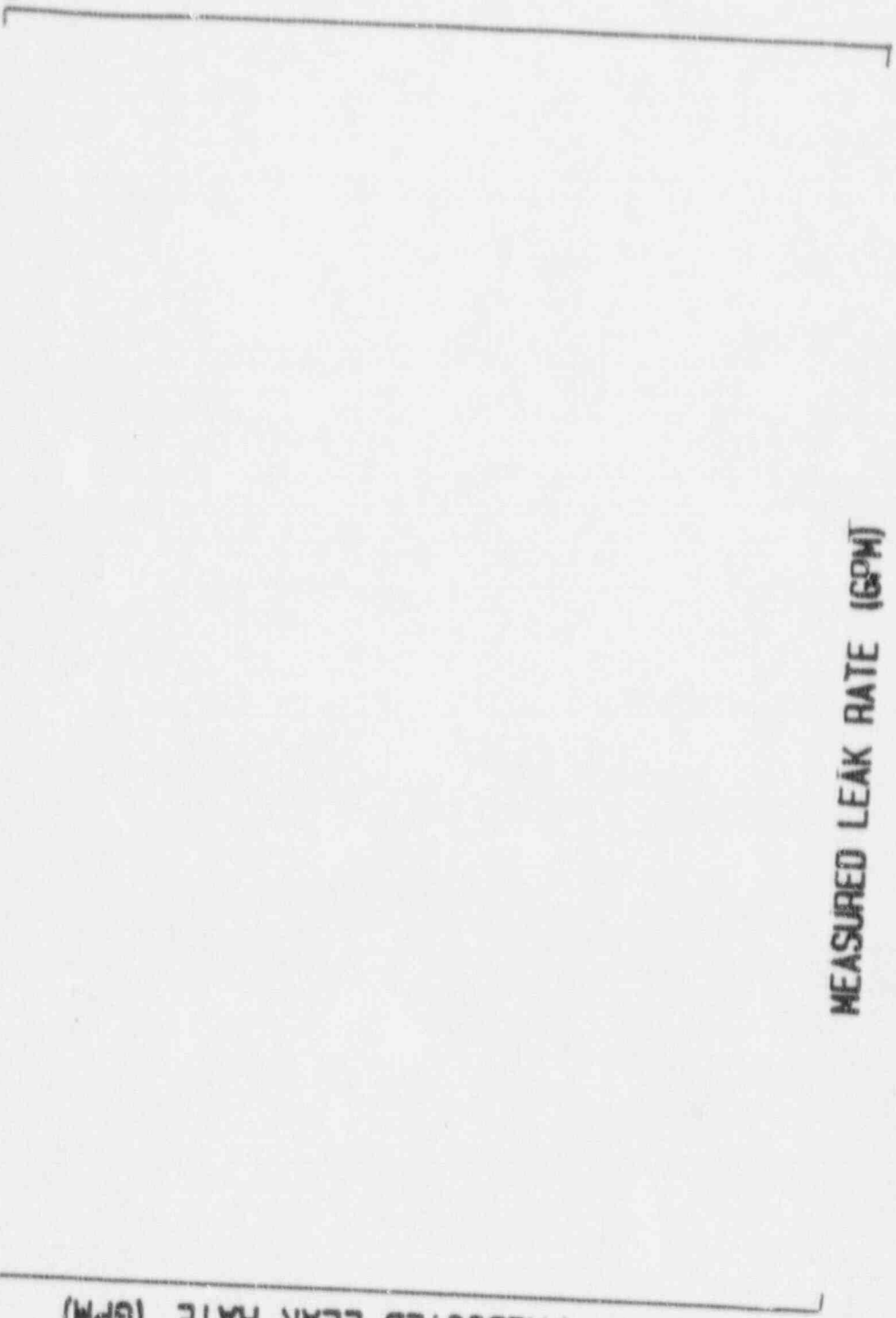
- IN GENERAL, MODEL YIELDS A GOOD PREDICTION FOR THE TREND OF LEAK RATE WITH CRACK LENGTH.
- EXCELLENT AGREEMENT BETWEEN PREDICTED AND MEASURED LEAK RATES IS SHOWN FOR FATIGUE CRACKS.
- FOR STRESS CORROSION CRACKS, GREATER DATA SCATTER IS SHOWN.
 - SCC CRACKS ARE CHARACTERISTICALLY SMALL ~ 0.1" LONG
 - DIFFICULT TO DEFINE GEOMETRICALLY
 - SUSCEPTIBLE TO PLUGGING

COMPARISON BETWEEN PREDICTED & MEASURED LEAK RATES

a, b, c

PREDICTED LEAK RATE (GPM)

MEASURED LEAK RATE (GPM)



EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

COMPARISON WITH EXPERIMENTAL RESULTS

STEAM-LINE BREAK CONDITIONS

- IN GENERAL, THE MODEL OVER PREDICTS LEAK RATES FOR SLB.
- IN ORDER TO IMPROVE PREDICTION CAPABILITY, EMPIRICALLY BASED ADJUSTMENTS ARE MADE TO THE MODEL.

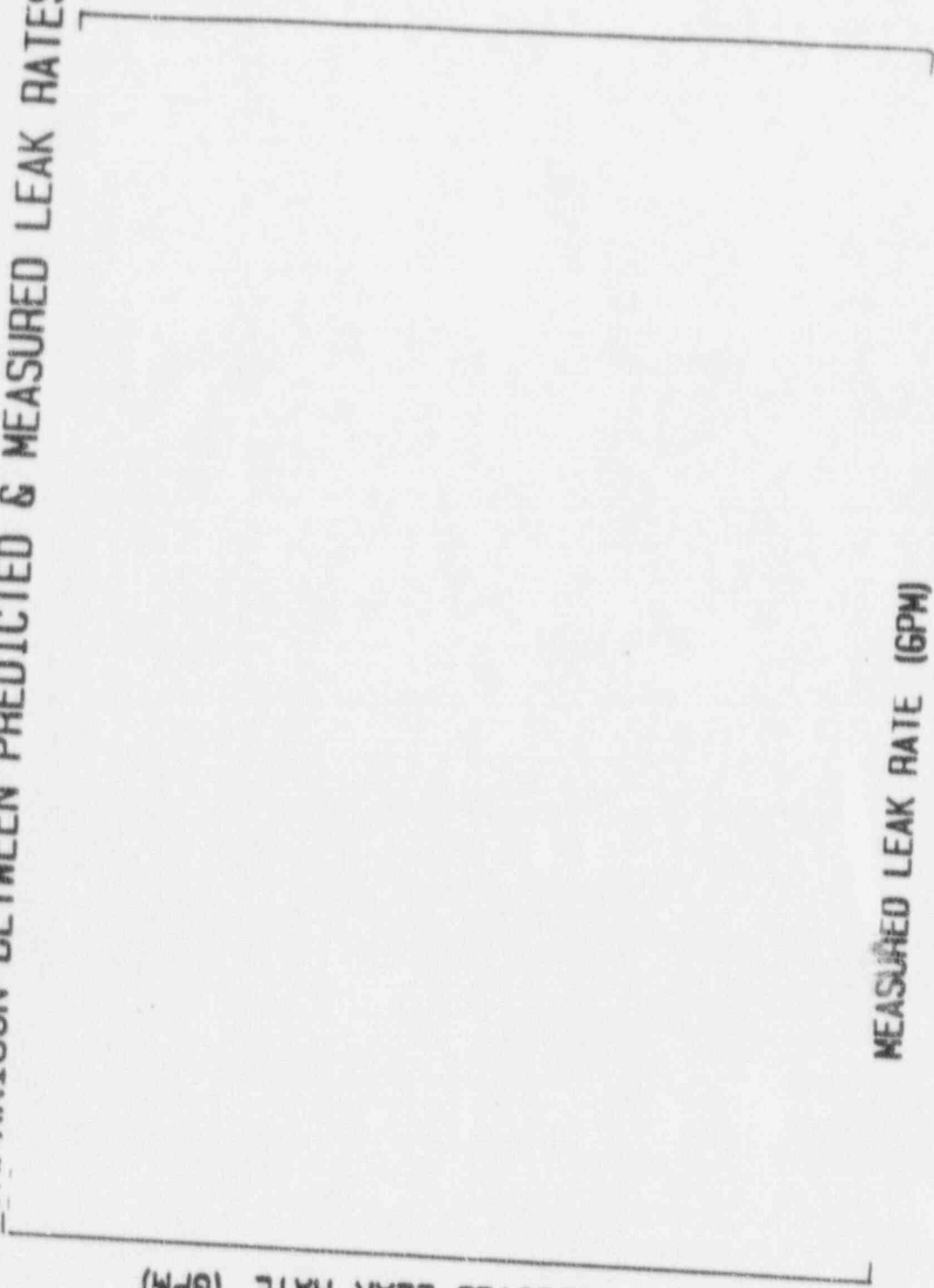
[]^{A,C}

COMPARISON BETWEEN PREDICTED & MEASURED LEAK RATES

a, b, c

PREDICTED LEAK RATE (GPM)

MEASURED LEAK RATE (GPM)



EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

PROBABILISTIC METHODOLOGY

A MONTE CARLO TYPE EVALUATION IS PERFORMED BY SAMPLING CRACK LENGTH FROM A GIVEN POPULATION TOGETHER WITH EACH OF THE FOLLOWING NORMALLY DISTRIBUTED STATISTICAL PARAMETERS:

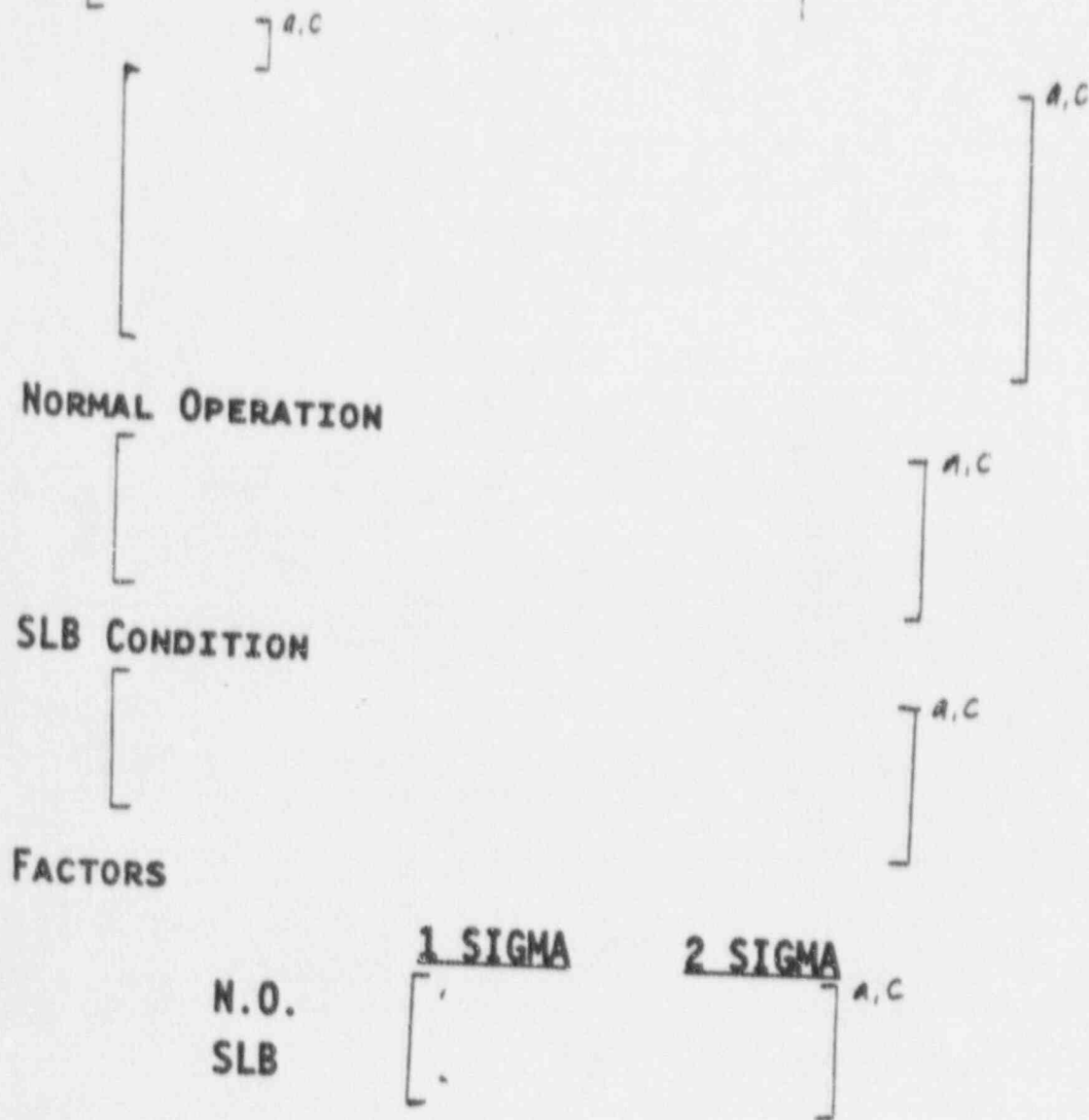


EZPWSCC IN ROLL TRANSITIONS LEAKAGE RATE CALCULATION

UNCERTAINTY ANALYSIS

MEASURED VERSUS PREDICTED VALUES (M VS. P) ARE FIT

BY [



MEASURED VS PREDICTED LEAK RATES

MEASURED LEAK RATE (GPM)

PREDICTED LEAK RATE (GPM)

a, b, c

MEASURED VS PREDICTED LEAK RATES

- a, b, c

MEASURED LEAK RATES, GPM

PREDICTED LEAK RATES, GPM

EZPWSCC IN ROLL TRANSITIONS

LEAKAGE RATE CALCULATION

SLB LEAKAGE RATE COMPARISON FOR EPRI DISTRIBUTIONS

1000 CRACKS FROM 0 TO 0.394 INCH (10 MM) IN LENGTH

CALCULATION <u>MODEL</u>	LEAK RATE <u>(GPM)</u>	
	A	B
EPRI/LABORELEC K CURVE 1 K CURVE 2	[]
CRACKFLO NOMINAL NOMINAL + 2 SIGMA NOMINAL + N SIGMA	[]

EZPWSCC IN ROLL TRANSITIONS
OPERATING LEAKAGE RATE LIMIT

EPRI NP-6864-L BASIS

REASONABLE ASSURANCE OF LEAK BEFORE BREAK IS
ACHIEVED WITH A []^g GPM LEAKAGE RATE LIMIT.

HISTORICALLY, AXIAL CRACKS IN ROLL TRANSITIONS HAVE
EXHIBITED LOW LEAKAGE, EVEN NO LEAKAGE IN SOME
CASES. ACCORDINGLY 100% EC INSPECTION IS PERFORMED
WITH MRPC PROBES TO COMPLETELY CHARACTERIZE THE
CONDITION OF THE BUNDLE IN AFFECTED REGIONS.

THE COMBINATION OF 100% MRPC INSPECTION AND THE []^g
GPM LEAKAGE RATE LIMIT CONSTITUTE A DEFENSE IN
DEPTH AND ASSURE CONTROL OF TUBE BUNDLE STRENGTH
AND LEAKAGE INTEGRITY.

EZPWSCC IN ROLL TRANSITIONS
OPERATING LEAKAGE RATE LIMIT

LEAK BEFORE BREAK

ASSUMING []⁹ GPM LEAK RATE LIMIT AND MINIMUM BURST
CAPABILITY

NOMINAL RT LEAKAGE VS CRACK LENGTH

- 0 WITH TS CONSTRAINT, 3 P BURST CAPABILITY IS ASSURED; 0.52 INCH VS 0.40 INCH, BURST VS LEAK.

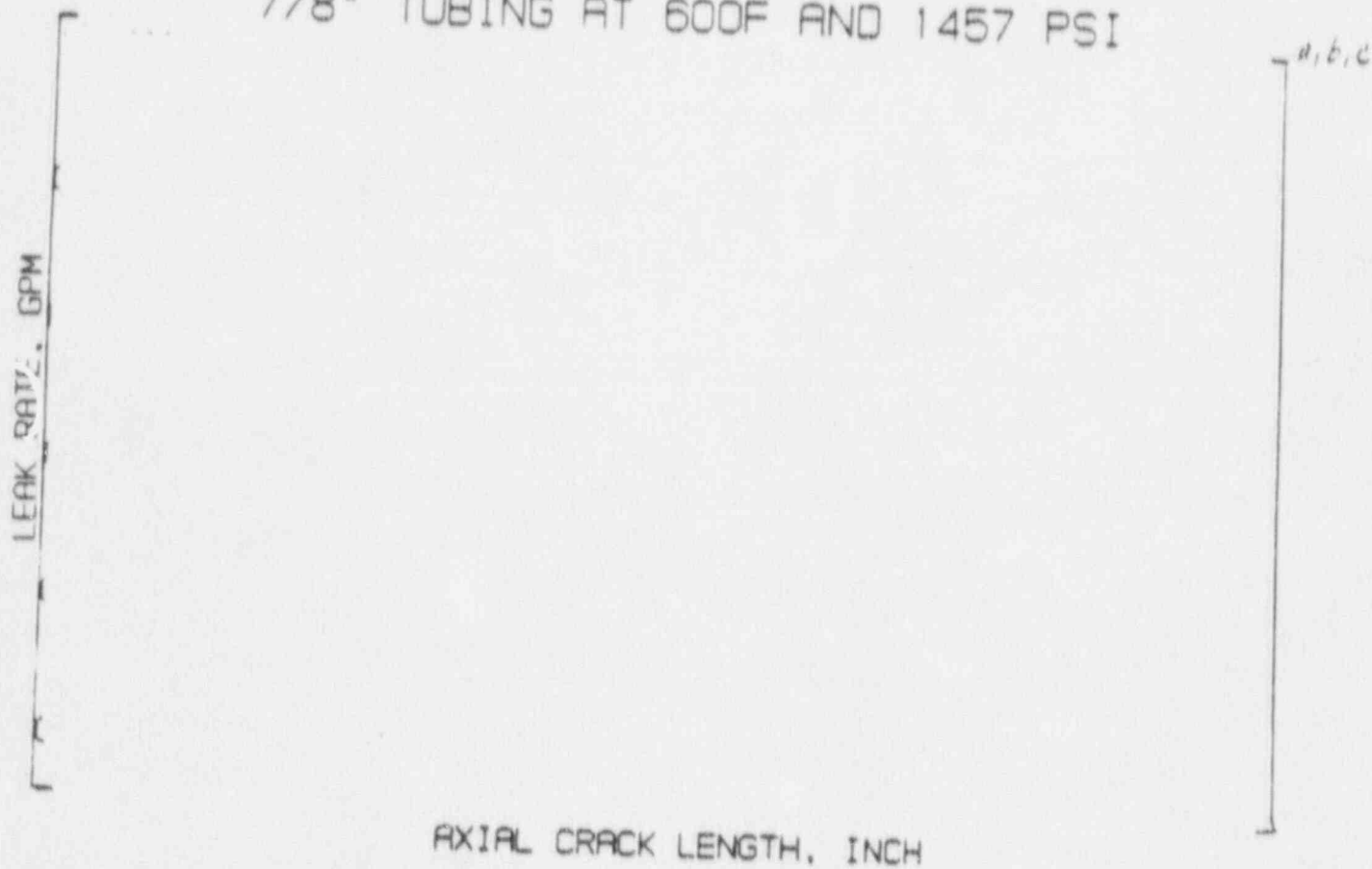
-2 SIGMA RT LEAKAGE VS CRACK LENGTH

- 0 WITH TS CONSTRAINT, SLB BURST CAPABILITY IS ASSURED; 0.72 INCH VS 0.60 INCH, BURST VS LEAK.

WITHOUT TS CONSTRAINT

- 0 SLB BURST CAPABILITY IS ASSURED FOR -2 SIGMA RT LEAKAGE VS CRACK LENGTH; 0.64 INCH VS 0.60 INCH, BURST VS LEAK.
- 0 GROWTH AND UNCERTAINTY ALLOWANCES LIMIT THIS CONDITION TO AN EOC LENGTH OF 0.35

LEAK RATE VS AXIAL CRACK LENGTH
EXPANSION ZONE ROLL TRANSITION
7/8" TUBING AT 600F AND 1457 PSI



FARLEY UNIT 2

SALIENT ASSUMPTIONS USED TO DETERMINE ALLOWABLE PRIMARY-TO-SECONDARY LEAK RATE FOLLOWING A STEAMLINE RUPTURE

- o PRIMARY COOLANT INITIAL IODINE ACTIVITY:
1% DEFECTS
- o SECONDARY COOLANT INITIAL ACTIVITY:
0.1 MICRO Ci/GM D.E. I-131
- o LOCATION OF POTENTIAL TUBE LEAKS:
TUBE SHEET
- o PARTITION COEFFICIENTS:
SG IN RUPTURED LOOP - 1.0
SG's IN INTACT LOOPS - 0.1
- o STEAM RELEASE FROM INTACT LOOPS (0-2
HRS.)
479,000 LBM
- o SITE BOUNDARY λ/α : 7.6 E-4 SEC/M³

FARLEY UNIT 2

RESULTS OF ALLOWABLE LEAK RATE EVALUATION

DOSE ACCEPTANCE CRITERIA:

2 HOUR SITE BOUNDARY THYROID
DOSE LESS THAN 30 REM

ALLOWABLE LEAK RATE:

40 GPM PER GENERATOR

FARLEY UNIT 2
STEAM GENERATOR OPERATING HISTORY

PRESENTED BY
D. D. MALINOWSKI
MANAGER, STEAM GENERATOR DIAGNOSTICS
NUCLEAR SERVICE DIVISION
WESTINGHOUSE ELECTRIC CORPORATION

ALABAMA POWER COMPANY/U.S.N.R.C./
WESTINGHOUSE ELECTRIC CORPORATION
MEETING

ROCKVILLE, MD
NOVEMBER 5, 1990

FARLEY UNIT 2

PRIOR S/G OPERATING HISTORY

J. M. FARLEY UNIT 2
TUBE PLUGGING CHRONOLOGY
BY CAUSE

DATE	CAUSE	S/G A	S/G B	S/G C	TOTAL
PRESERVICE		3	1	-	4
6/81	VISUAL LEAKER	1	0	0	1
10/82	ROW 1 (PREV.)	92	94	94	280
	F. O.	3	0	0	3
	TOTAL	95	94	94	283
9/84	LEAK (HL) BELOW TSP 7	1	0	0	1
	F. O.	0	2	0	2
	TOTAL	1	2	0	3
1/85	AVB-WEAR	8	0	0	8
	TUBE PULL	1	0	0	1
	PREV.	3	0	0	3
	TUBESHEET PWSCC	1	0	0	1
	OTHER	0	0	0	0
	TOTAL	13	1	0	14
4/86	AVB-WEAR	1	1	0	2
	TUBESHEET PWSCC	8	5	27	40
	O.D. TSP SCC	2	5	17*	28
	TOTAL	11	15	44	70
				*(2 PULLED)	
11/87	TUBESHEET PWSCC	4	9	16	29
	O.D. TSP SCC	6	24	44	74
	FREE-SPAN	3	0	0	3
	AVB-WEAR	0	2	0	2
	ABOVE TUBESHEET	0	0	1	1
	TOTAL	13	35	61	109
4/89	TUBESHEET PWSCC	11	3	2	16
	O.D. TSP SCC	0	8	2*	10
	AVB-WEAR	0	1	0	1
	TOTAL	11	12	4	27
				*(2 PULLED)	

J. M. FARLEY UNIT 2
STEAM GENERATOR
TUBE PLUGGING SUMMARY

PLUGGING DATE	TUBES PLUGGED			TOTALS	
	S/G A	S/G B	S/G C	INCREMENTAL	CUMULATIVE
PRE-SERVICE	1	1	0	2	2
8/80	2	0	0	2	4
6/81	1	0	0	1	5
10/82	95	94	94	283	288
9/84	1	2	0	3	291
1/85	13	1	0	14	305
4/86	11	15	44	70	375
11/87	13	35	61	109	484
4/89	<u>11</u>	<u>12</u>	<u>4</u>	<u>27</u>	<u>511</u>
TOTALS	148 (4.4%)	160 (4.7%)	203 (6.0%)		511 (5.0%)

FARLEY UNIT 2

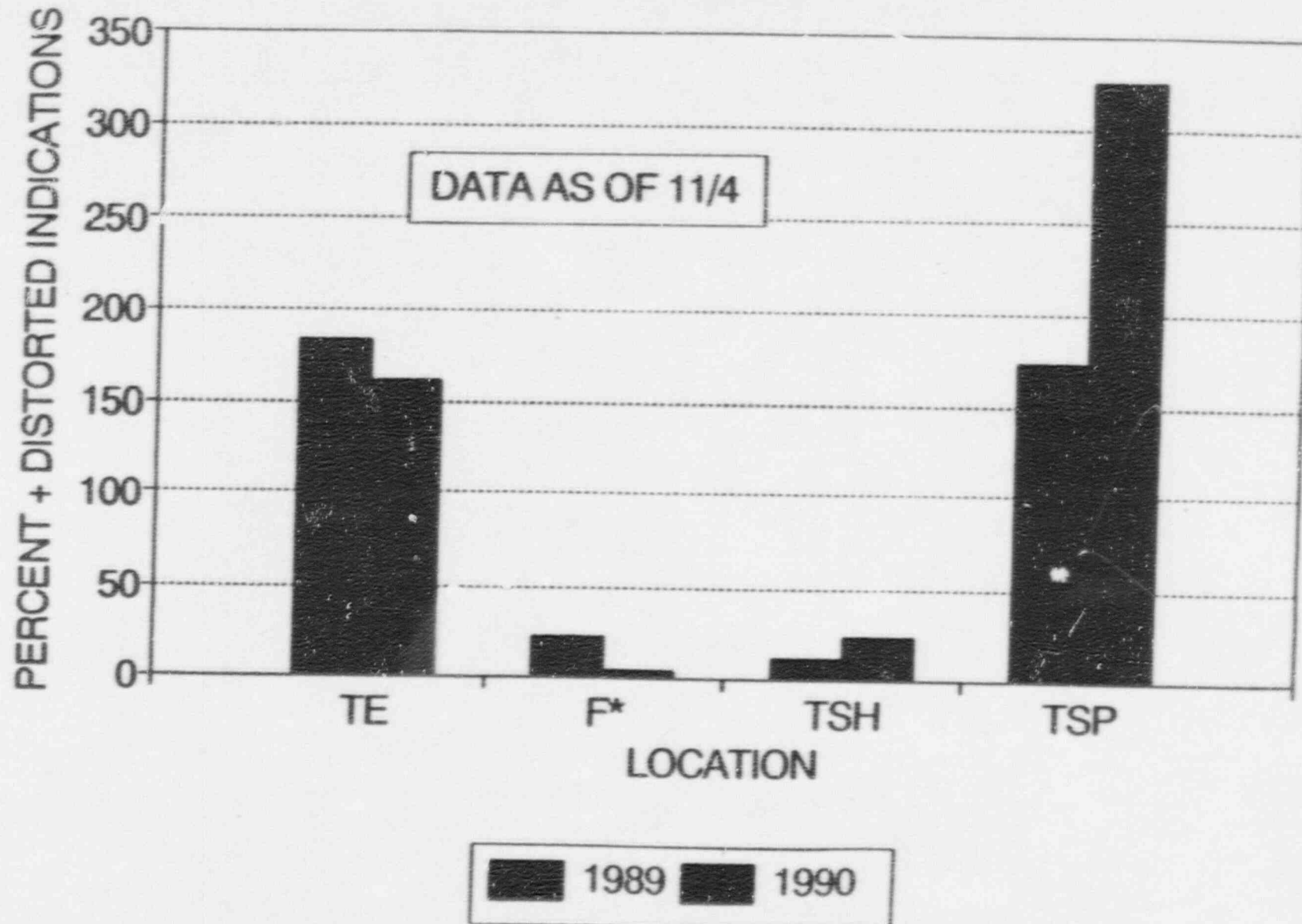
CURRENT INSPECTION RESULTS

FARLEY UNIT 2

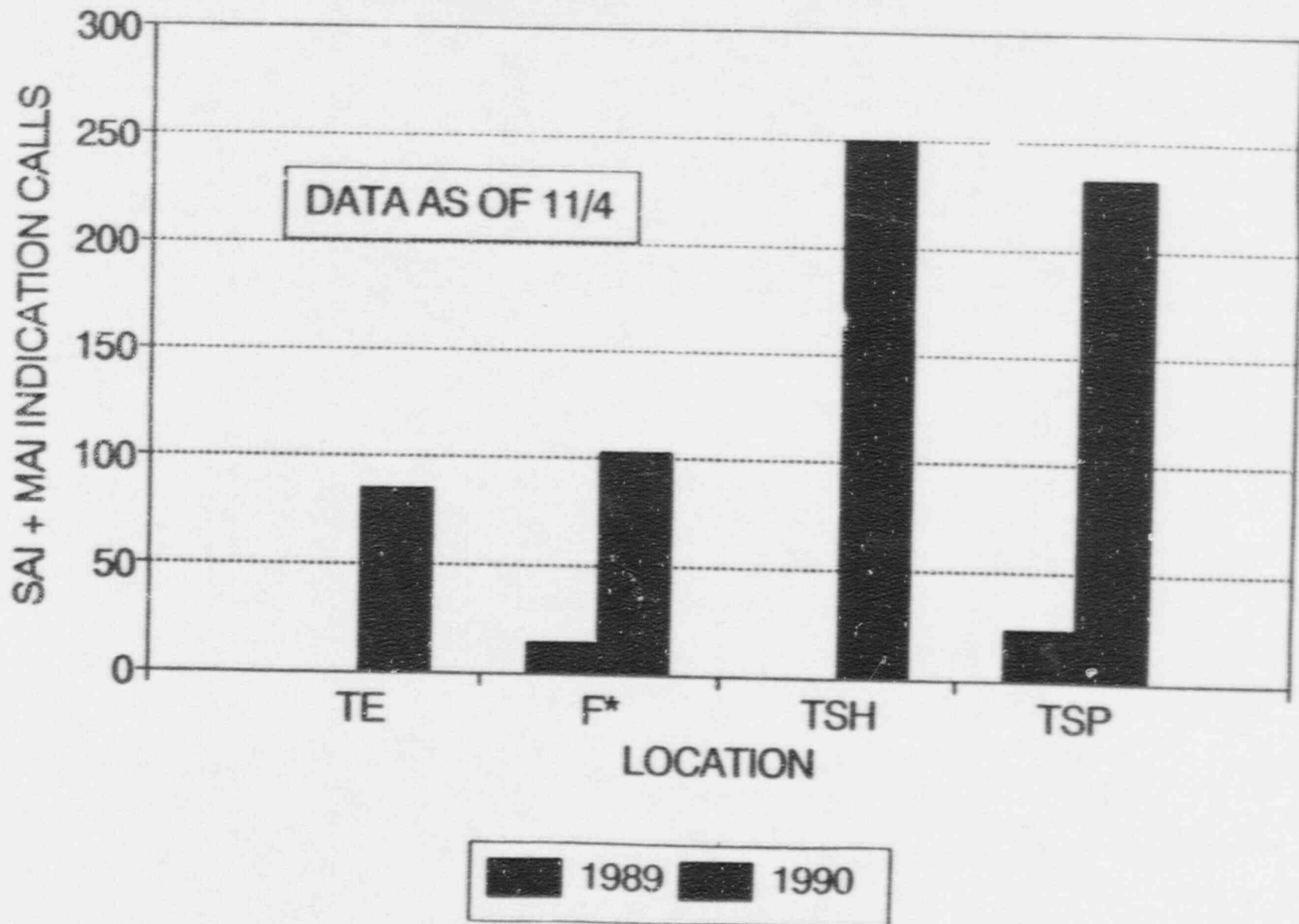
S/G EDDY CURRENT INSPECTION PROGRAM OCTOBER 1990 OUTAGE

PROBE AND EXTENT	TUBES INSPECTED					
	S/G A		S/G B		S/G C	
	HL	CL	HL	CL	HL	CL
BOBBIN						
FULL LENGTH	3240	274	3228	276	3185	279
RPC						
TUBESHEET	3240	-	3228	-	3185	-
RPC AT TSPs	82	-	81	2	195	-
RPC U-BEND	92	-	92	-	94	-
BOBBIN U-BEND (POST HEAT TREAT)	92	-	92	-	94	-

FARLEY UNIT 2 BOBBIN INDICATION CALLS ALL STEAM GENERATORS

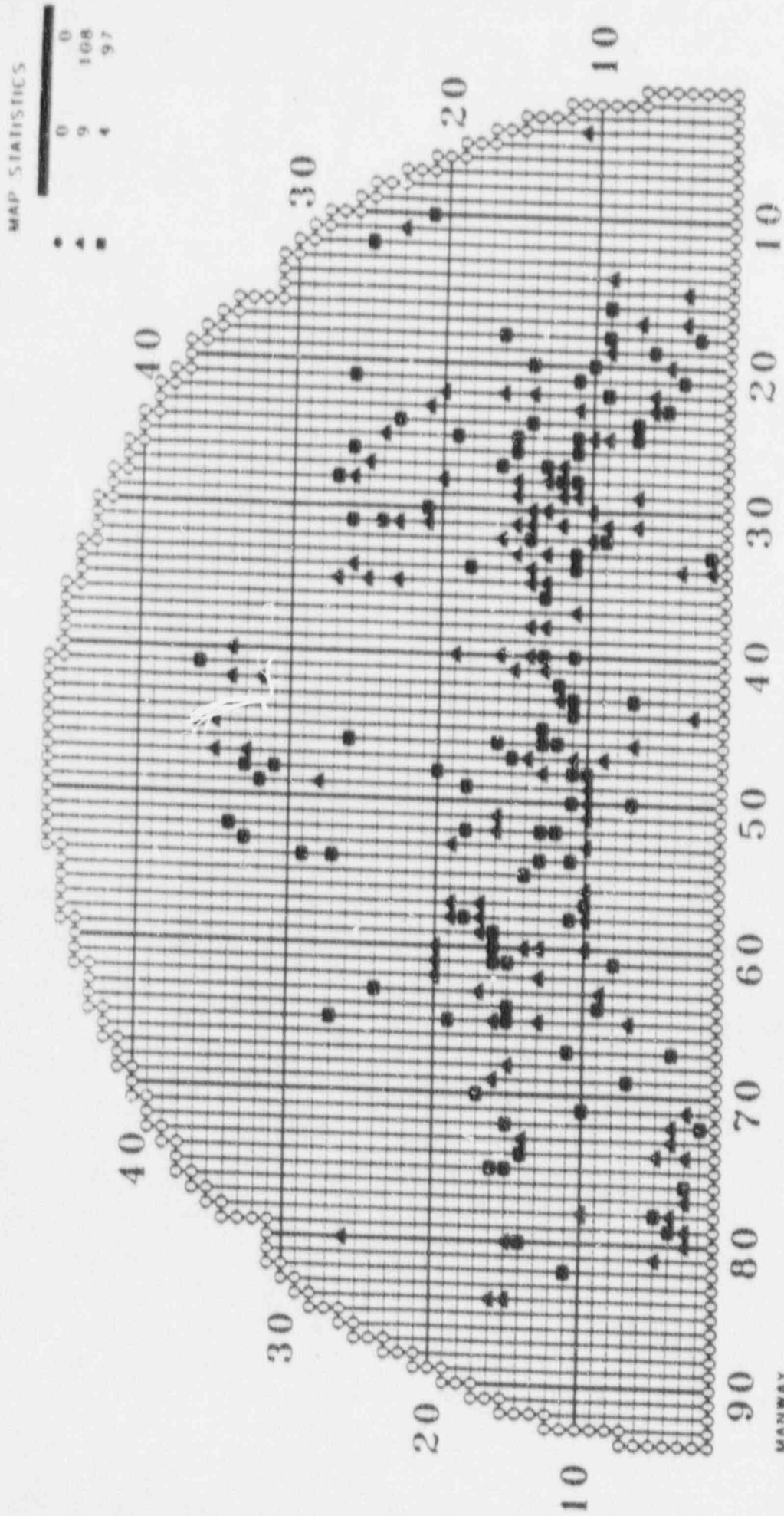


FARLEY UNIT 2 RPC INDICATION CALLS ALL STEAM GENERATORS



FARLEY UNIT 2 S/G A 11/2 (0400) DATA

TUBESHEET INDICATIONS



○ > = 40%

■ f.

△ MAI

□ SAI

■ Top of Tubesheet

STEAM GENERATOR INFORMATION SYSTEM (S) WESTINGHOUSE ELECTRIC CORP 1990

DATE PLOTTED 11/2/1990

FARLEY UNIT 2 DETERMINATION OF AXIAL CRACK LENGTHS

SOURCE OF DATA: RPC RESULTS

APPLICATION: TUBE/TUBESHEET ROLL TRANSITION

METHOD:

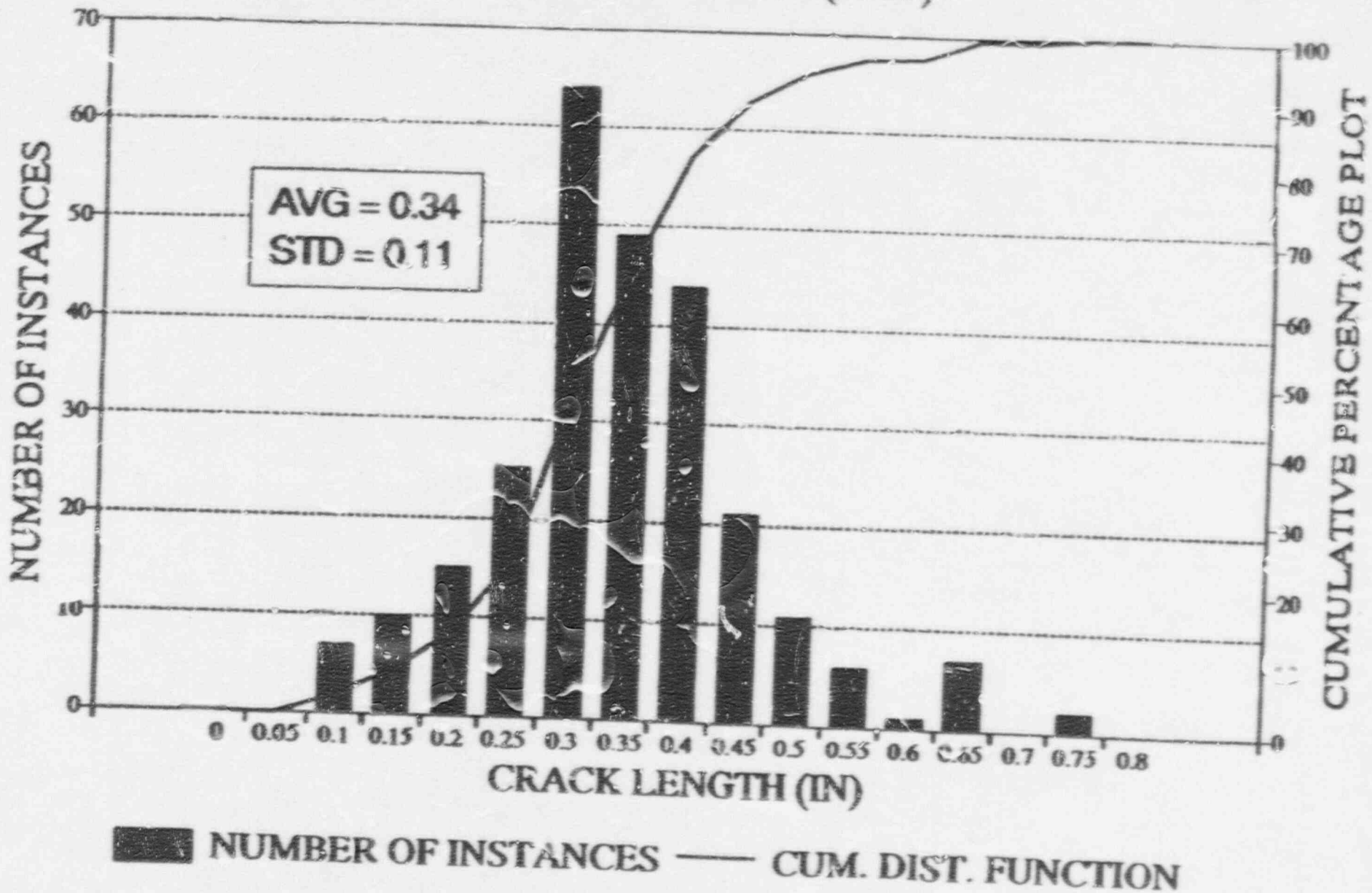
- 1 ESTABLISH ROTATIONAL PITCH - USE MACHINED NOTCHES ON CALIBRATION STANDARD
- 2 DETERMINE NUMBER OF "HITS" (VERTICAL DEPARTURE FROM NULL EXHIBITING FLAW LIKE FEATURES. USE MOST ACCURATE OF PSEUDO-ISOMETRIC RPC PLOT, EXPANDED STRIP CHARTS OR LIS-SAJOUS FIGURES)
- 3 CALCULATE AXIAL LENGTH - MULTIPLY ROTATIONAL PITCH BY NUMBER OF "HITS". IMPLICITLY ADDS 1/2 PITCH TO BEGINNING AND END OF EACH INDICATION

ADDITIONAL CONSIDERATION:

CORRECTION FOR ELECTROMAGNETIC FIELD SPREAD OF COIL IS NOT APPLIED AT PRESENT SINCE MORPHOLOGIES OF INDICATIONS ARE NOT KNOWN ACCURATELY.

FARLEY 2 CRACK LENGTH STATISTICS

DATA AS OF 11/5 (1500)



**CRACK LENGTH MEASUREMENT
UNCERTAINTY a_{NDE}
(EPRI Report No. 6864-L Draft)**

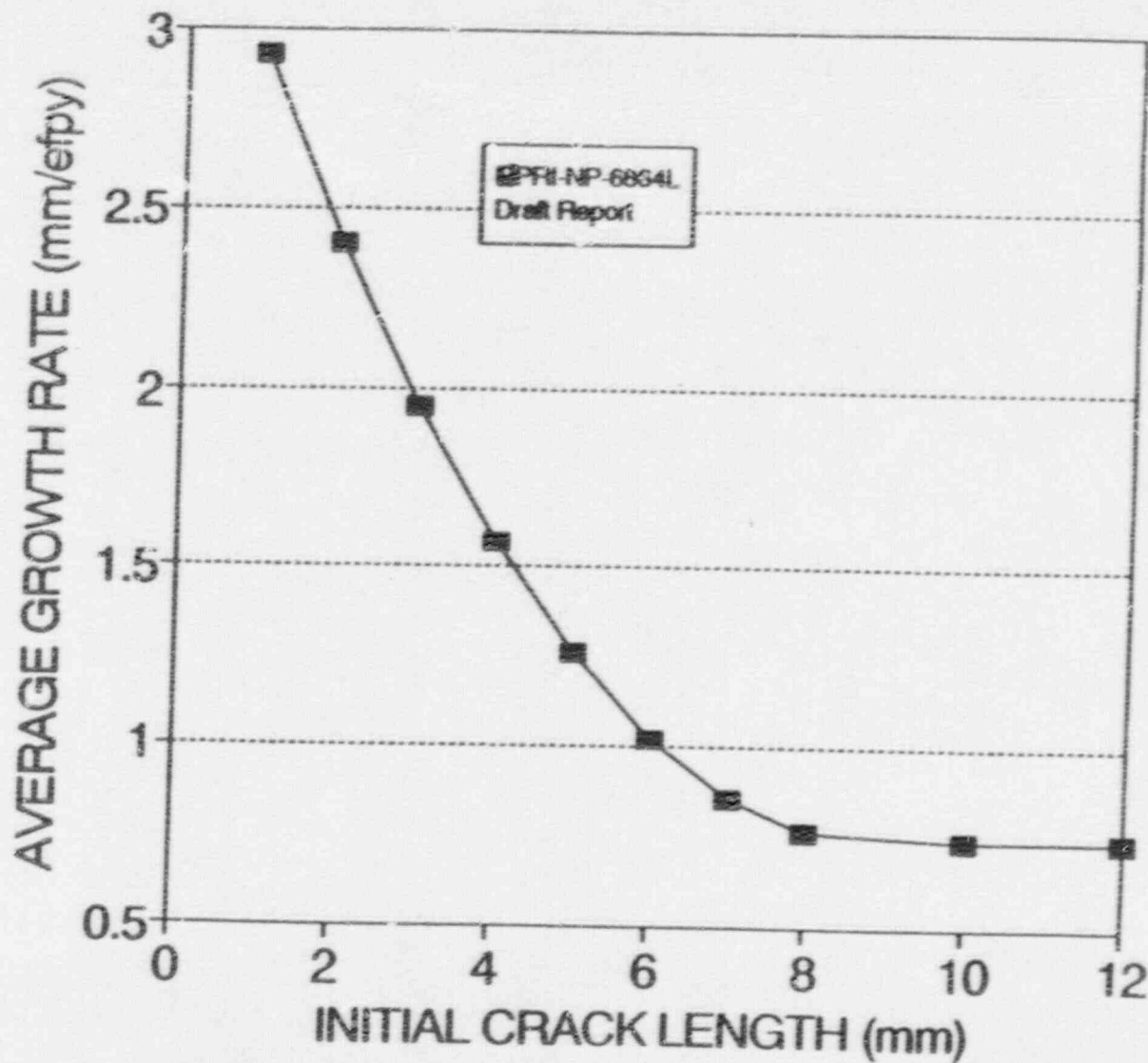
EPRI crack length measurement is the sum of the systematic error and the random error.

Systematic Error = True crack size - NDE crack size
(True crack size measured by metallography or other acceptable method.)

Random Error = Expected NDE crack size - lower bound NDE crack size

$a_{NDE} = 0.12''$ (3.04 mm) for
7/8" tubing

AVERAGE CRACK GROWTH RATES BASED ON KISS-ROLL DATA



Consecutive measurements of crack lengths divided by the time elapsed between measurements yields an estimate of the rate of crack length growth.

Farley 2 results from RIPC data in 1990 cannot be compared to prior results since tubes with visible cracks in the area of interest were plugged in prior outages.

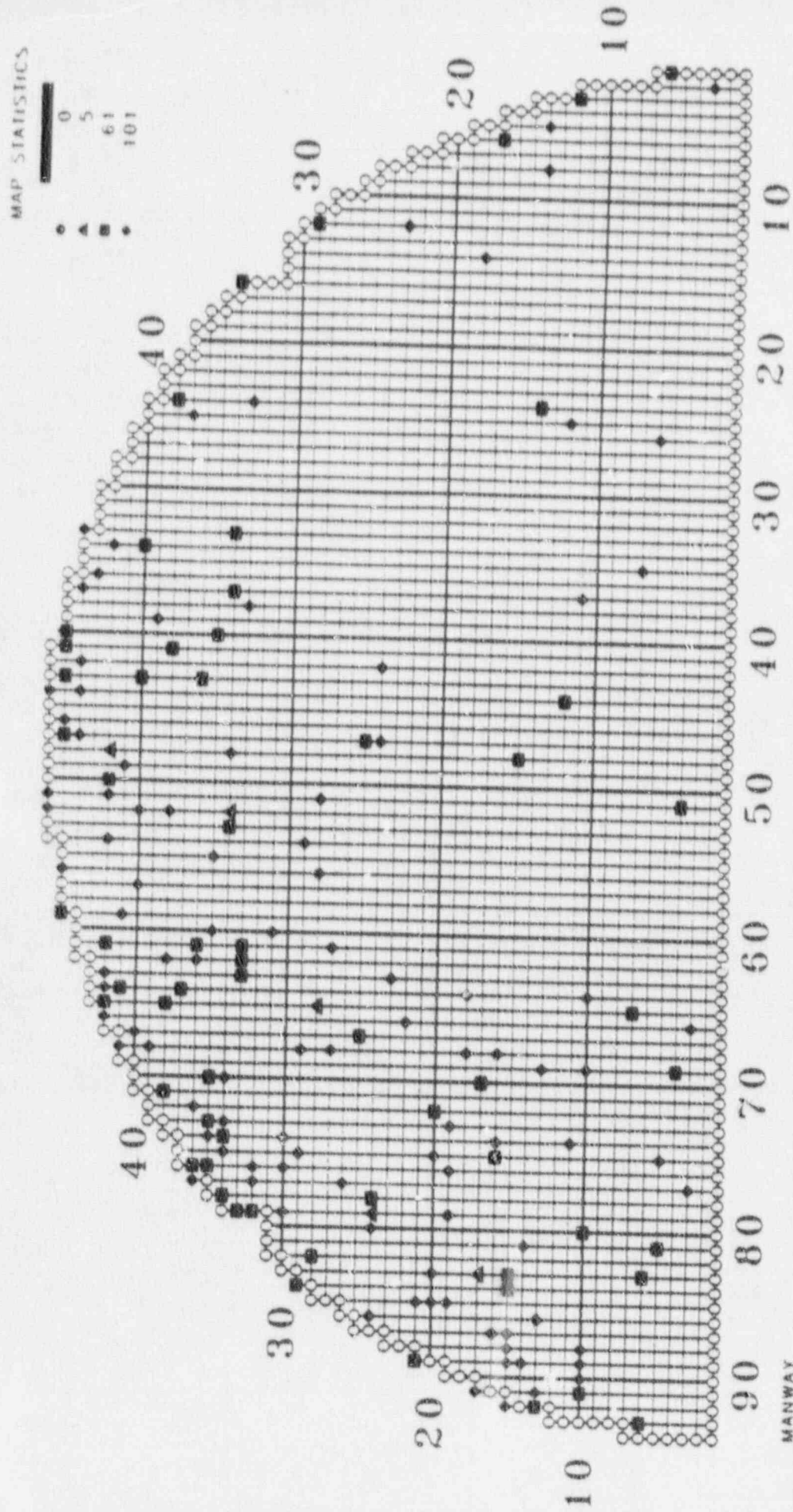
EPRI study provides an estimate of average crack growth rates for various observed lengths in the base inspection.

Growth rate is observed to have an inverse relationship to crack length.

EPRI/CRACK/02

FARLEY UNIT 2 S/G C 11/4 (0400) DATA

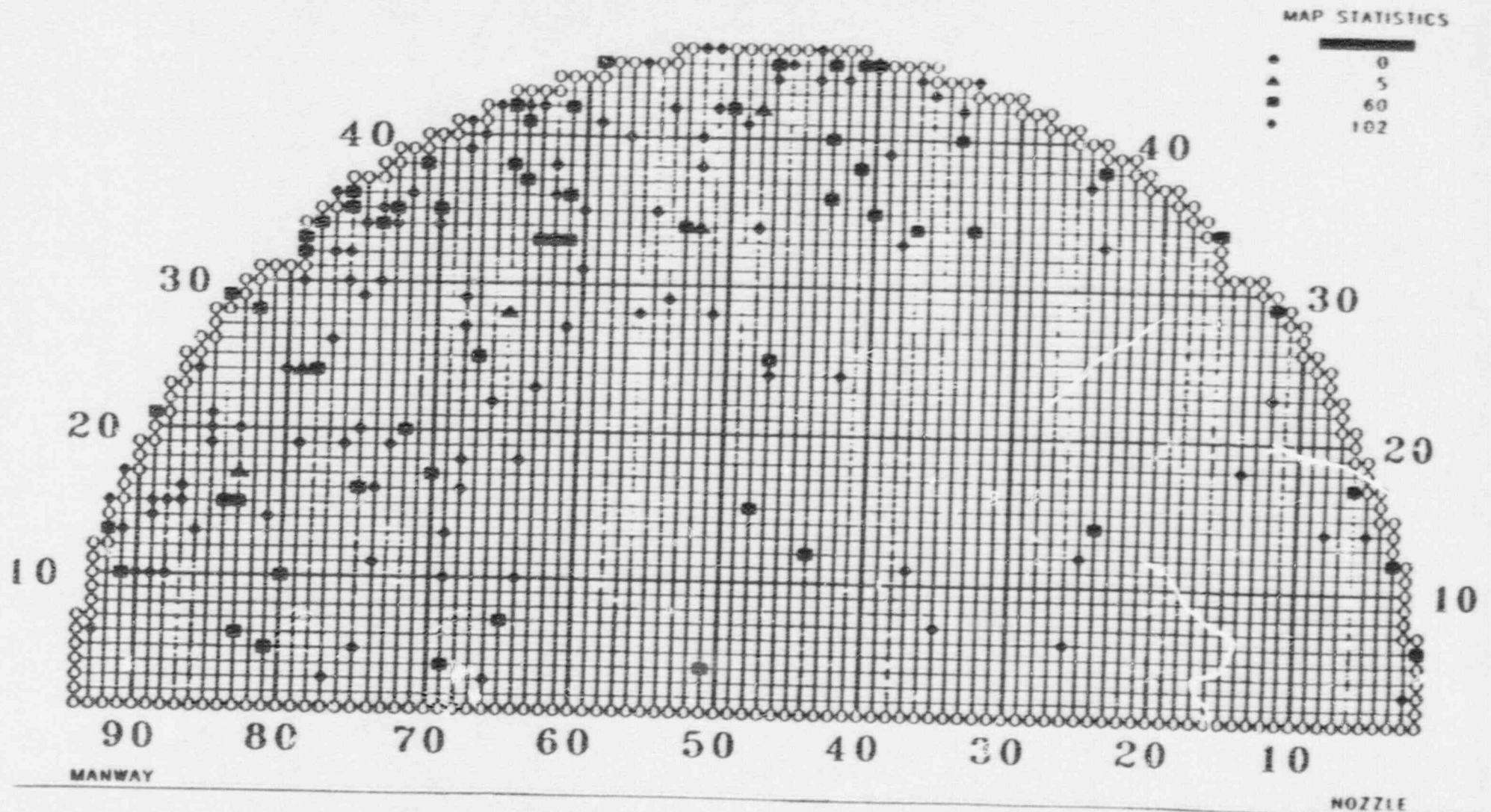
SUPPORT PLATE/AVB INDICATIONS



- 20%
- △ 20% to 39%
- Support Plates
- ▨ Antivibration Bars
- 40% to 100%
- Distorted Indications

FARLEY UNIT 2 S/G C 11/5 DATA

SUPPORT PLATE/AVB INDICATIONS

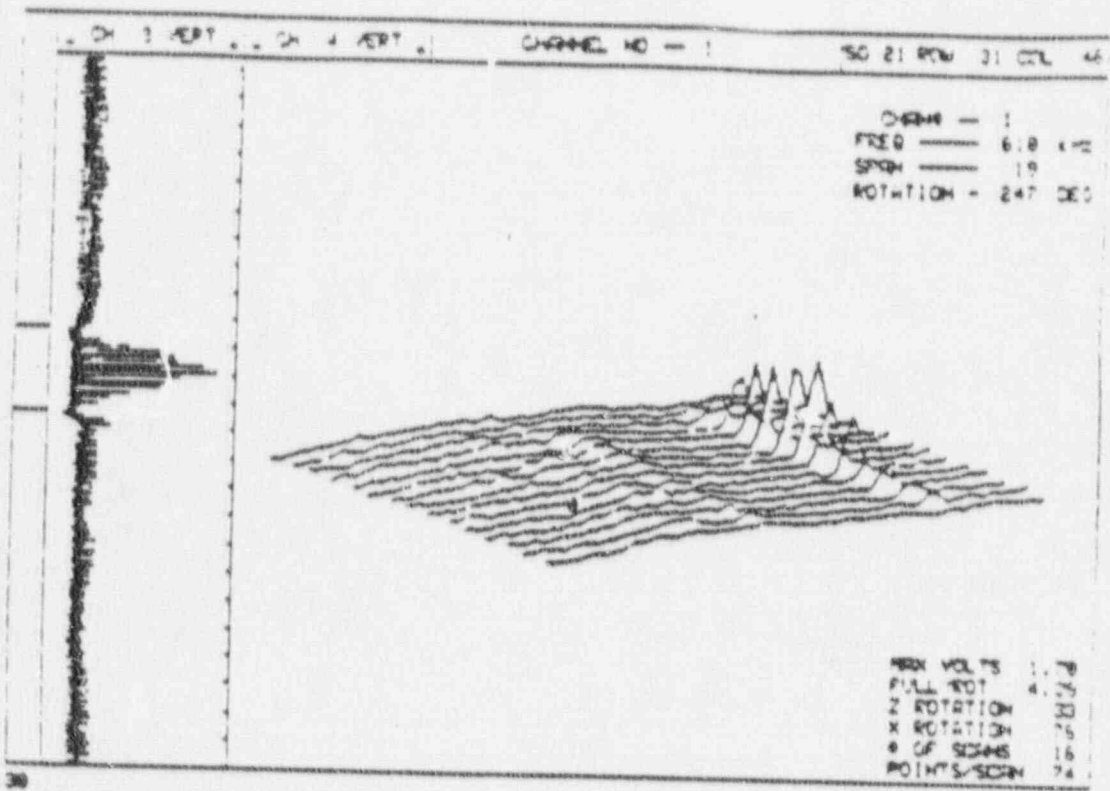


- | | | | |
|------------------|----------------------|---------------|-------------------------|
| ○ 20% | △ 20% to 39% | □ 40% to 100% | ○ Distorted Indications |
| ■ Support Plates | ■ Antivibration Bars | | |

Table IIa

Summary of Examination Results on Farley Unit 2 SG C Tube Removal 4th R

<u>Tube/Location</u>	<u>Field (Bobbin)</u>	<u>Destructive Examination Results</u>
R31C46 1st Sp	81%	OD surface intergranular axial crack. 83% throughwall in one cross section and 100% in another. Some secondary more shallow cracks on OD periphery away from primary crack.



RPC Display for Tube R31C46 Steam Generator C

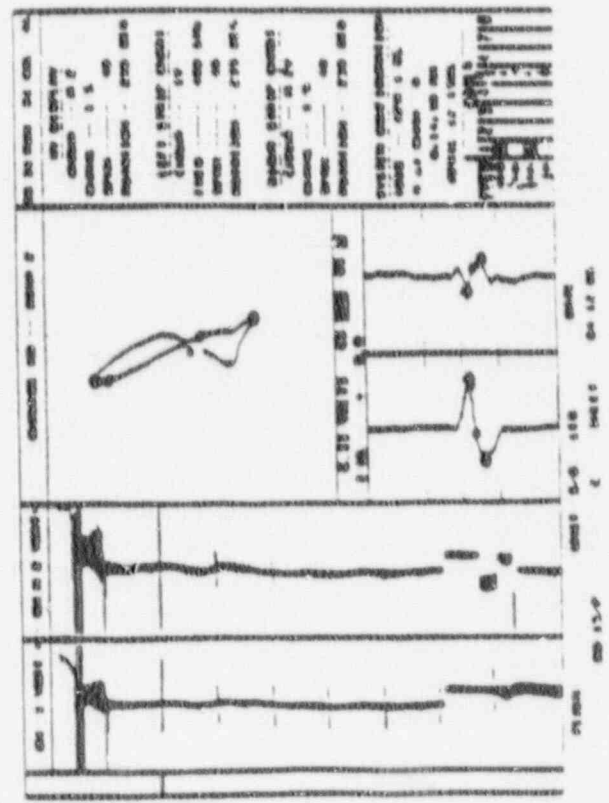
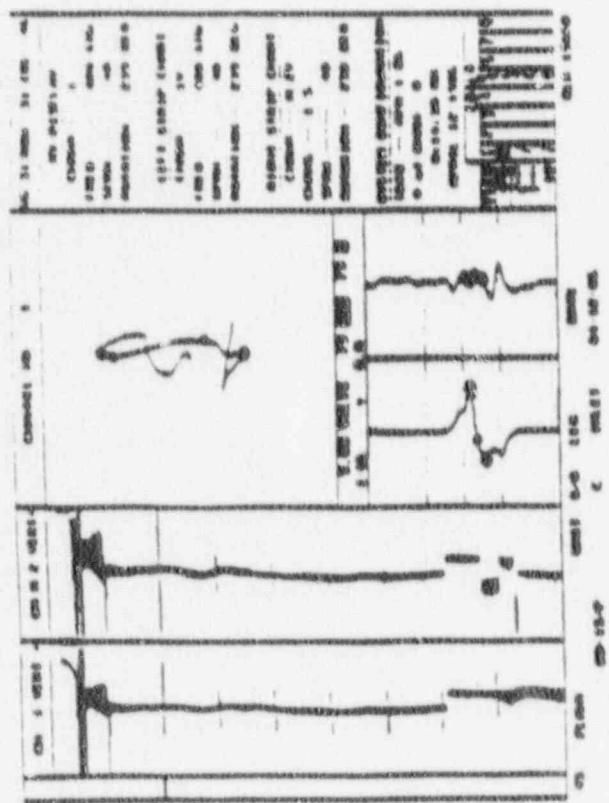


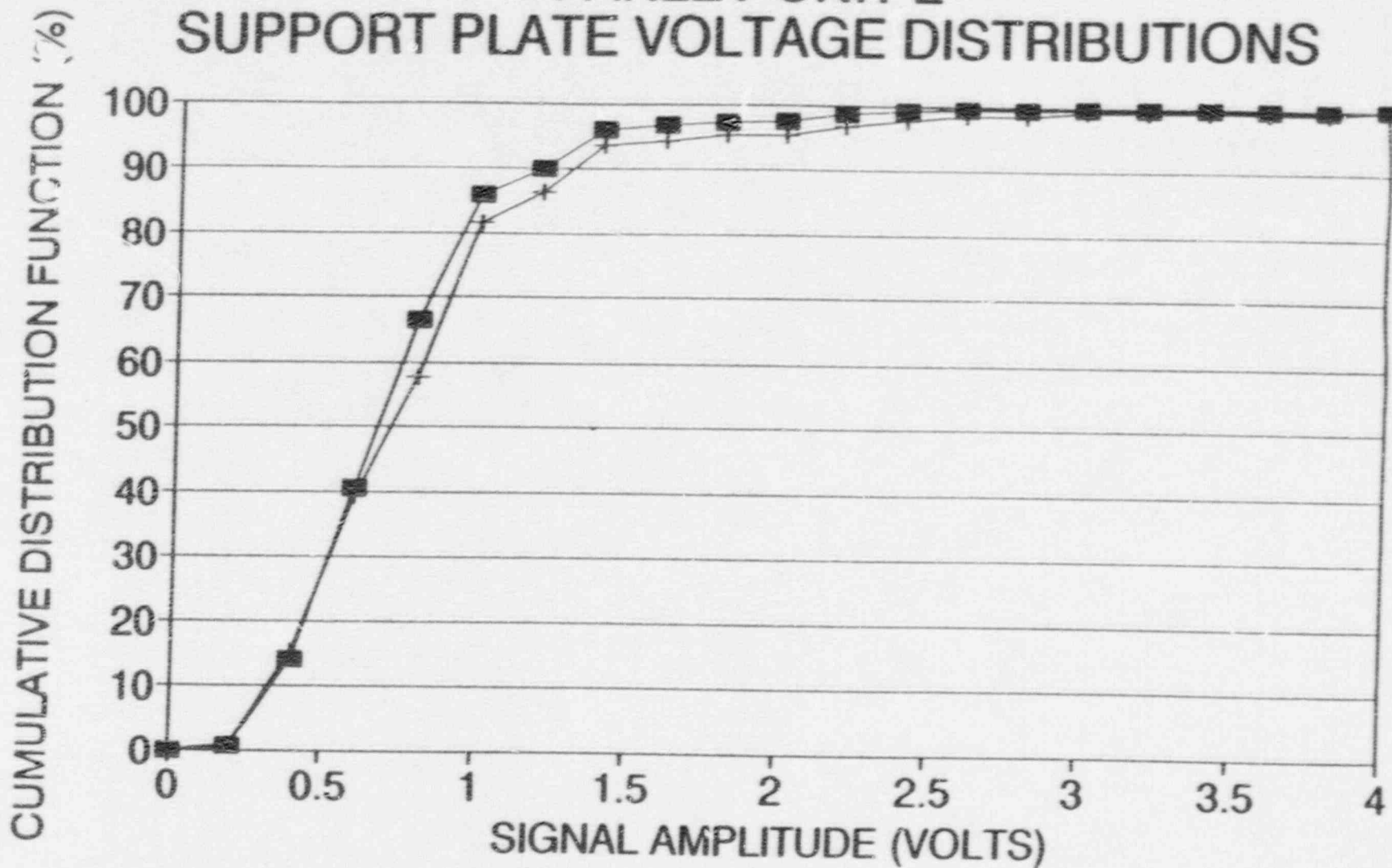
Figure — Major crack in tube Section 6 (first support plate region). Crack here extends approximately 200 through wall. It is branched and intergranular. Stress corrosion are missing. Crack profile is one of stress corrosion.

Tube R31C46 ISP IM 4/86
Metallography Deeper Penetration is 100X

79X

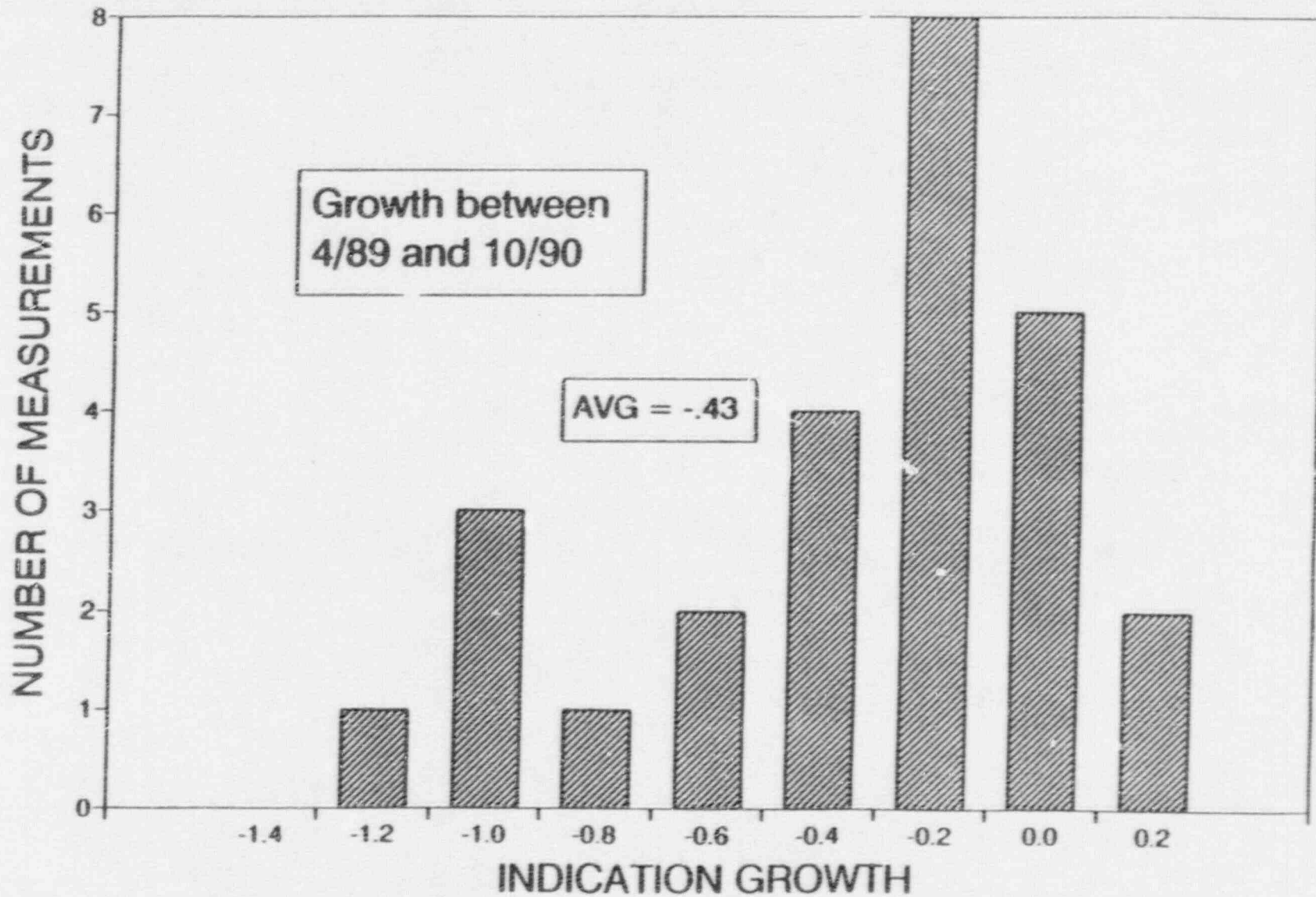
81X

FARLEY UNIT 2 SUPPORT PLATE VOLTAGE DISTRIBUTIONS

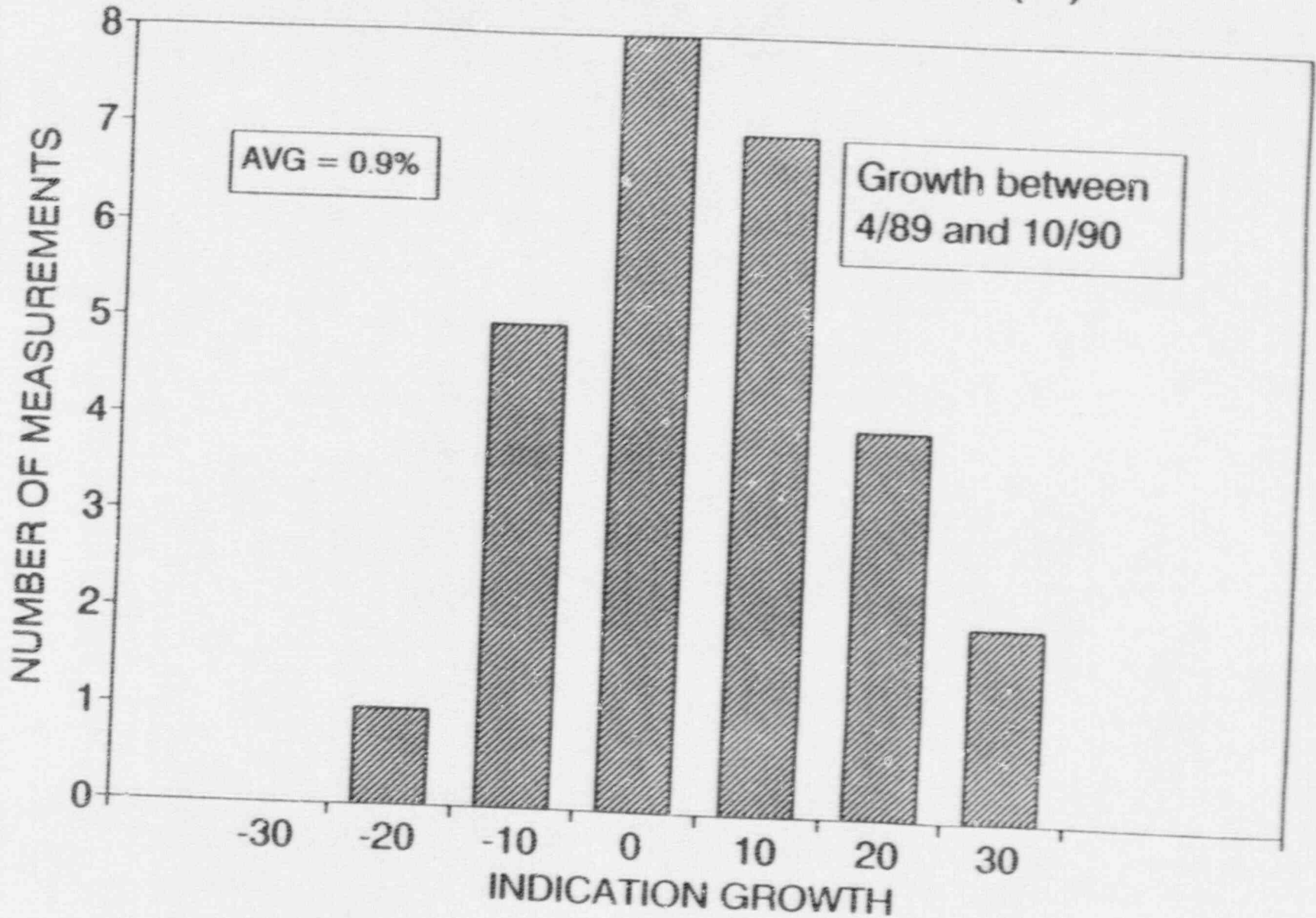


—■— ALL DATA —+— CLEAR IND. ONLY

FARLEY UNIT 2 S/G A SUPPORT PLATE INDICATION GROWTH RATE (V)



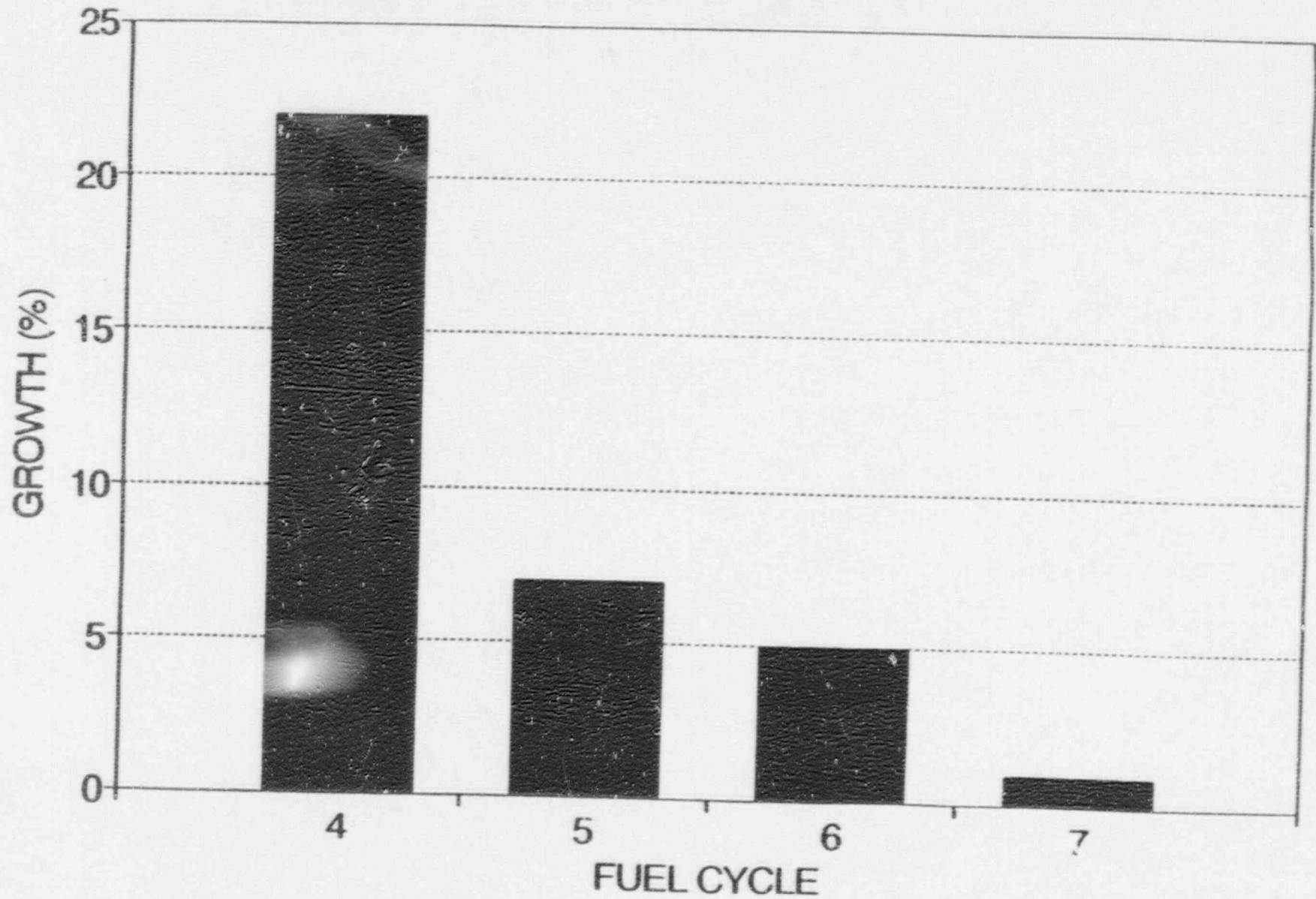
FARLEY UNIT 2 S/G A SUPPORT PLATE INDICATION GROWTH RATE (%)



FARLEY UNIT 2 GROWTH RATES FOR TSP LEVEL ODSCC

OPERATING PERIOD	CYCLE	ECI GROWTH
1985-1986	4	22%
1986-1987	5	7%
1987-1989	6	5%
1989-1990	7	<1%

FARLEY UNIT 2 GROWTH RATES FOR TSP ODSCG



FARLEY -2 1990 OUTAGE PROPOSED BASES FOR TUBE PLUGGING

PWSCC AT ROLL TRANSITIONS

o LIMITED APPLICATION OF EPRI PROGRAM PLUGGING CRITERIA

- DEMONSTRATION TO DEVELOP OPERATING EXPERIENCE
WITH CRACK LENGTH BASED CRITERIA

o PROPOSED DEMO OF EPRI CRITERIA

- LEAVE IN SERVICE A LIMITED NUMBER OF TUBES
THAT MEET EPRI CRITERIA

o 50 TUBES WITH SINGLE AXIAL INDICATIONS ABOVE TOP OF TUBESHEET

o TUBES WITH AXIAL CRACKS CONFINED TO WITHIN THE TUBESHEET AND ABOVE F* LENGTH

- CONSERVATIVELY EVALUATED ON
CRITERIA FOR CRACKS EMANATING
FROM THE TUBESHEET

**FARLEY -2 1990 OUTAGE
PROPOSED BASES FOR TUBE PLUGGING**

OD SCC AT TSPs

**O CONTINUE TO APPLY 1.75 VOLT CRITERIA FOR
TUBE PLUGGING**

**- APPLIED FOR DI RESOLUTION IN LAST 2 OUTAGES AT FARLEY
-1 AND 2**

**- NO LEAKAGE ATTRIBUTABLE TO ODSCC AT TSPs
FOUND AT FARLEY-1 AND 2**

**O NEGLIGIBLE GROWTH RATES FOUND FOR INDICATIONS
AT TSBS**

**O SUPPORTING DATA INDICATES 1.75 VOLTS IS A
CONSERVATIVE, NO LEAKAGE CRITERIA**

**- PULLED TUBE, FIELD EXPERIENCE AND
LABORATORY TESTS APPLIED IN
EPRI PROGRAM TO DEVELOP PLUGGING
CRITERIA FOR ODSCC AT TSPs**

PLUGGING LIMITS FOR PWSCC IN ROLL TRANSITIONS

INSPECTION REQUIREMENTS

- o 100% NDE OVER $\sim \pm 2''$ OF TOP OF TUBESHEET (1)
- o QUALIFIED NDE TECHNIQUE FOR PWSCC IN RT
 - NDE QUALIFIED FOR DETECTION OF PWSCC IN ROLL TRANSITIONS BY ACCEPTABLE DETECTABILITY THRESHOLD AND DEMONSTRATED CRACK LENGTH MEASUREMENT UNCERTAINTY
 - RPC APPLIED FOR 1990 FARLEY-2 OUTAGE (1)

(1) REQUIREMENT CONSISTENT WITH EPRI REPORT

PLUGGING LIMITS FOR PWSCC IN ROLL TRANSITIONS

DEFINITIONS

- o AXIAL CRACK (1)
 - AN AXIAL CRACK NETWORK LENGTH WITH MAXIMUM INCLINATION FROM THE TUBE AXIS SUCH THAT THE CIRCUMFERENTIAL PROJECTION IS [1]⁹
- o ROLL TRANSITION (1)
 - TUBE AXIAL REGION OVER WHICH TUBE DIAMETER CHANGES FROM FULL EXPANSION IN THE TUBESHEET TO THE NOMINAL TUBE DIAMETER
- o F* REGION (1)
 - THE DISTANCE FROM THE BOTTOM OF THE ROLL TRANSITION TO THE F* LENGTH
- o CRACK LENGTH CHARACTERIZATION (1)
 - CRACKS EMANATING FROM TOP OF TUBESHEET
 - CRACKS INITIATING ABOVE TOP OF TUBESHEET

(1) DEFINITION CONSISTENT WITH EPRI REPORT.

PLUGGING LIMITS FOR PWSCC IN ROLL TRANSITIONS

DEFINITIONS (CONT'D.)

- 0 CRACK GROWTH ALLOWANCE - A_{CG} (1)
 - ALLOWANCE FOR AVERAGE CRACK GROWTH BETWEEN INSPECTIONS BASED UPON GROWTH OF MAXIMUM TO MAXIMUM CRACK LENGTHS BETWEEN INSPECTIONS
 - FARLEY-2 1990 OUTAGE CRACK GROWTH BASED ON EPRI REPORT NP-6864-L
 - CRACK GROWTH AT SUBSEQUENT INSPECTIONS TO BE BASED UPON FARLEY-2 GROWTH RATES FROM 50 TUBES LEFT IN SERVICE

- 0 CRACK LENGTH MEASUREMENT UNCERTAINTY - A_{NDE} (1)
 - DEMONSTRATED UNCERTAINTY ON CRACK LENGTH MEASUREMENT BY NDE INSPECTION TECHNIQUE BASED UPON QUALIFICATION OF FIELD NDE AGAINST ACTUAL CRACK LENGTHS FROM PULLED TUBES

- 0 MAXIMUM ALLOWABLE CRACK LENGTH (1)
 - MAXIMUM CRACK LENGTH THAT CAN BE LEFT IN SERVICE BUT SUBJECT TO CONSTRAINT THAT PREDICTED SLB LEAK RATE IS LESS THAN ACCEPTANCE LIMIT

(1) DEFINITION CONSISTENT WITH EPRI REPORT.

PLUGGING LIMITS FOR PWSCC IN ROLL TRANSITIONS

CRACK LENGTH LIMITS (1)

- o CRACKS EMANATING FROM TOP OF TUBESHEET
 - MAXIMUM ALLOWABLE: $A_1 = 0.52'' - A_{CG} - A_{NDE}$
 $A_1 = 0.35''$
 - o INCLUDES TUBESHEET CONSTRAINT EFFECT ON ALLOWABLE LENGTH
- o AXIAL CRACKS INITIATING ABOVE TOP OF TUBESHEET
 - MAXIMUM ALLOWABLE: $A_2 = 0.35'' - A_{CG} - A_{NDE}$
 $A_2 = 0.20''$
 - o DOES NOT INCLUDE TUBESHEET CONSTRAINT AFFECT ON ALLOWABLE LENGTH
- o CRACKS WITHIN F* REGION
 - CONSERVATIVELY GROUPED WITH AXIAL CRACKS EMANATING FROM TOP OF TUBESHEET

(1) DEFINITION CONSISTENT WITH EPRI REPORT.

PLUGGING LIMITS FOR PWSCC IN ROLL TRANSITIONS

SLB LEAK RATE EVALUATION REQUIREMENTS

- 0 THE PREDICTED SLB LEAK RATE BASED ON THE DISTRIBUTION OF CRACK LENGTHS LEFT IN SERVICE AFTER EACH INSPECTION SHALL NOT EXCEED 40 GPM PER S/G

- 0 CRACK LENGTHS FOR LEAKAGE CALCULATION

$$A_L = A_M + A_{CG} + A_{NDE}$$

$$A_M = \text{MEASURED CRACK LENGTH}$$

- 0 METHOD FOR LEAK RATE ANALYSIS

- THE METHOD USED TO CALCULATE LEAK RATES SHALL BE DEMONSTRATED TO BE APPROXIMATELY A PLUS 2-SIGMA CONFIDENCE LEVEL RELATIVE TO LEAK RATE MEASUREMENTS ON PULLED TUBE ROLL TRANSITION CRACKS AND LABORATORY INDUCED AXIAL CRACKS

NOVEMBER 6, 1990FARLEY STEAM GENERATOR ALTERNATIVE TUBE PLUGGING CRITERIAMEETING ATTENDEES

<u>NAME</u>	<u>ORGANIZATION</u>
Steve Hoffman	NRC/NRR/DRP
J. A. Miller	Alabama Power Company
R. E. Mullins	Alabama Power Company
J. Begley	Westinghouse
Richard J. Morrison	Westinghouse
Ken Rubin	Westinghouse
Gary Whiteman	Westinghouse
Dan Mayes	Duke Power
Steve Brown	EPRI
Chuck Welty	EPRI
Kulin D. Desai	NRC/SRXB
Brad Moore	Alabama Power Company
Jack Woodard	Alabama Power Company
John C. Blomgren	Commonwealth Edison
John L. Houtman	Westinghouse NSD
T. A. Pitterle	Westinghouse NSD
C. D. Pugh	Alabama Power Company
Dan Malinowski	Westinghouse NSD
C. Eichelinger	Westinghouse
Emmett Murphy	NRC/DET/EMCB
Fred Anderson	Northeast Utilities
R. P. McDonald	Alabama Power Company
Donald E. Mansfield	Alabama Power Company
John F. Garlington	Alabama Power Company
C. Y. Cheng	NRC/DET/EMCB
B. D. Liaw	NRC/NRR/DRIS
E. G. Adensam	NRC/NRR/DRP
G. C. Lainas	NRC/NRR/DRP
H. F. Conrad	NRC/DET/EMCB
Keith Wichman	NRC/DET/EMCB
S. Varga	NRC/NRR/DRP
J. Richardson	NRC/DET/EMCB