WEC PROPRIETARY CLASS 3

Westinghouse Energy Systems

WESTINGHOUSE CLASS 3

WCAP-13256
Revision 1

SG-92-04-017

North Anna Unit 1
Steam Generator Startup Approval Meeting
Presentation Materials

April 1992

Approved by: _____

M. J. Wootten, Manager
Steam Generator Technology & Engineering

WESTINGHOUSE ELECTRIC CORPORATION
Nuclear Services Division
P.O. Box 355
Pittsburgh, PA 15230-0355

A meeting was held on March 2, 1992 between Virginia Power Company, Westinghouse and the NRR at One White Flint Building, Rockville, MD, to discuss the status of the North Anna Unit 1 steam generators. The meeting agenda included discussions on:

1. Basis for Startup Approval (Virginia Power)
2. Summary of SG Tube Eddy Current Inspection Program and Results (Virginia Power)
3. Detailed Discussion of Inspection Results (Westinghouse)
4. Tube Integrity Evaluation (Westinghouse)
5. Operational Considerations (Virginia Power)
6. Startup Basis Summary and Schedule (Virginia Power)

This document presents a compilation of the presentation materials used by Westinghouse. Section 1 presents the materials used for the "Detailed Discussion of Inspection Results". Section 2 presents the "Tube Integrity Evaluation" presentation materials. Section 3 contains information which was not included directly in the presentations to the NRC on March 2, 1992, but which was provided to supplement the materials presented in Sections 1 and 2 of this report, as follows:

Pages 3-2 to 3-7 provide supplementary data for the evaluation of tubes with mixed mode degradation at the TSPs. Pages 3-2 and 3-3 show eddy current data from the 2-coil RPC for tube R8C33-2H (SG C), which is one of 7 tubes shown on page 1-18 with mixed mode indications at the same edge of the TSP. Pages 3-4 to 3-7 show EC data from 2-coil and 3-coil RPC probes for tube R14C10-2H (SG C), which had axial and circumferential indications at opposite edges of the TSP (see page 2-27); the figures indicate that the 3-coil RPC did not improve resolution of potential mixed mode indications at the same elevation relative to the 2-coil RPC.

Page 3-8 shows a plot of burst pressure vs. crack angle for single throughwall and segmented cracks. Page 3-9 shows burst pressure vs. crack angle for single cracks with 50% deep circumferential degradation beyond the throughwall region of the crack. These figures supplement the tube burst capability summary on page 2-13.

Pages 3-10 to 3-12 provide supplementary eddy current data on the tubes with the largest circumferential indications presented on page 2-14.

Pages 3-13 to 3-15 provide supplementary eddy current data for the assessment of WEXTEX and TSP MCIs on page 2-21.

Pages 3-16 and 3-17 show eddy current data for tube R29C16-1H of SG C, supplementing the data for potential mixed mode cracking presented on pages 2-24 to 2-26.

Page 3-18 provides eddy current data for tube R25C8 of SG B, which had the largest WEXTEX circumferential indication in Zone 1 for the tube vibration assessment (page 2-31).

Page 3-19 provides eddy current data for tube R45C50-1H of SG A, which had the largest TSP circumferential indication in Zone 1 for the tube vibration assessment (page 2-33).

Page 3-20 supplements the summary of the EOC SLB leakage evaluation presented on page 2-36.

Westinghouse

Detailed Discussion of Inspection Results

D. D. Malinowski

North Anna #1
February 1992

Tube Plugging Summary

	A	B	C
Through 1991	463	425	650
WEXTEX (HL) (RPC)	15	10	11
TSP (HL) (RPC)	143	148	178
Other (Bobbin)	1	0	2
Preventive	7	2	10
Total 1992	166	160	201
Cumulative	629	585	851
% Plugged	18.6%	17.3%	25.1%

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North Anna #1
February 1992

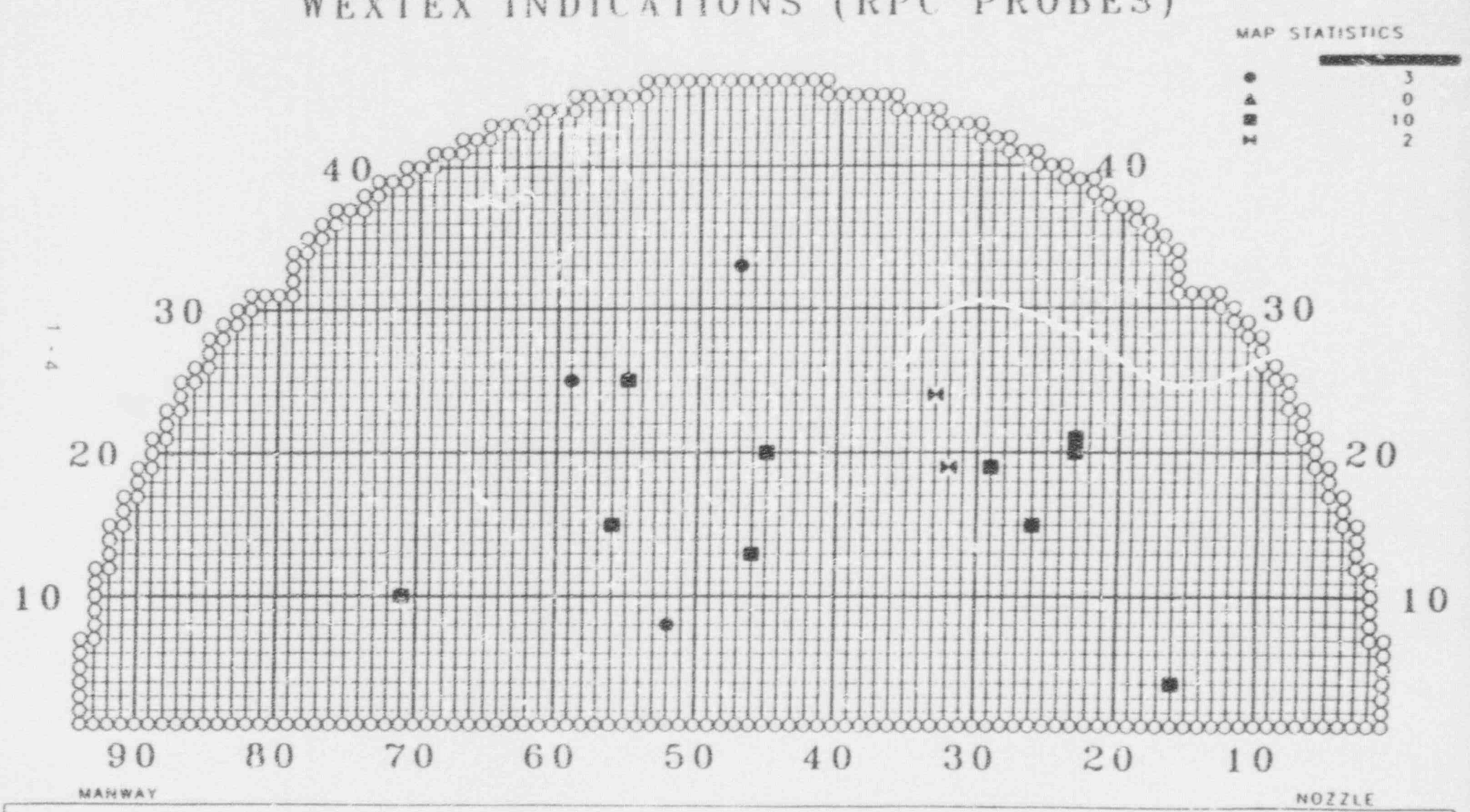
WEXTEX Inspection Results

# Tubes	Steam Generator A	B	C
Single Axial	3	0	2
Multiple Axial	0	0	0
Single Circumferential	10	9	7
Multiple Circumferential	2	1	2

* There were 0 tubes with mixed mode degradation identified in the WEXTEX transitions.

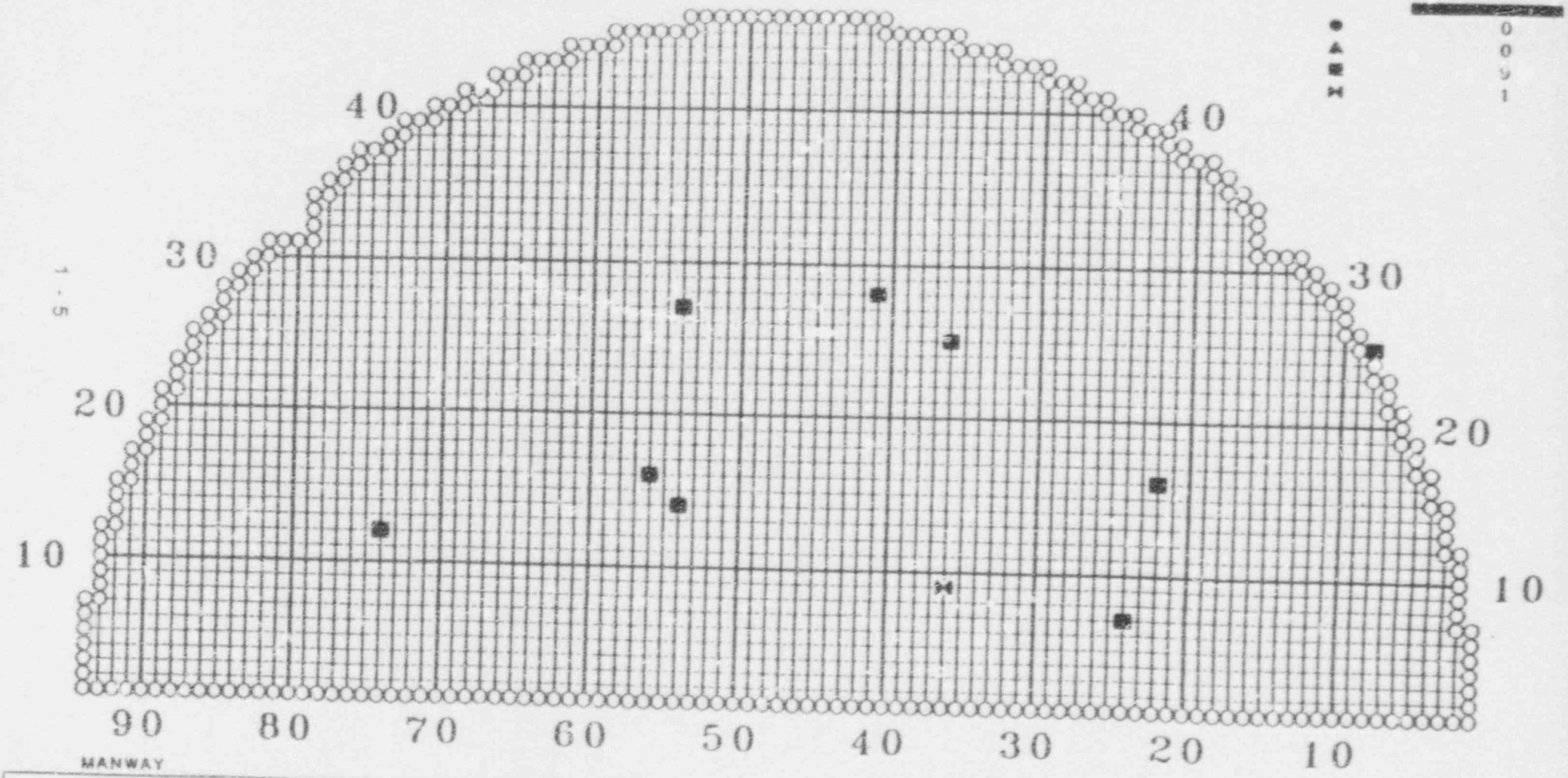
NORTH ANNA UNIT 1 S/G A 2/27 PLUG LIST

WEXTEX INDICATIONS (RPC PROBES)



NORTH ANNA UNIT 1 S/G B 2/27 PLUG LIST

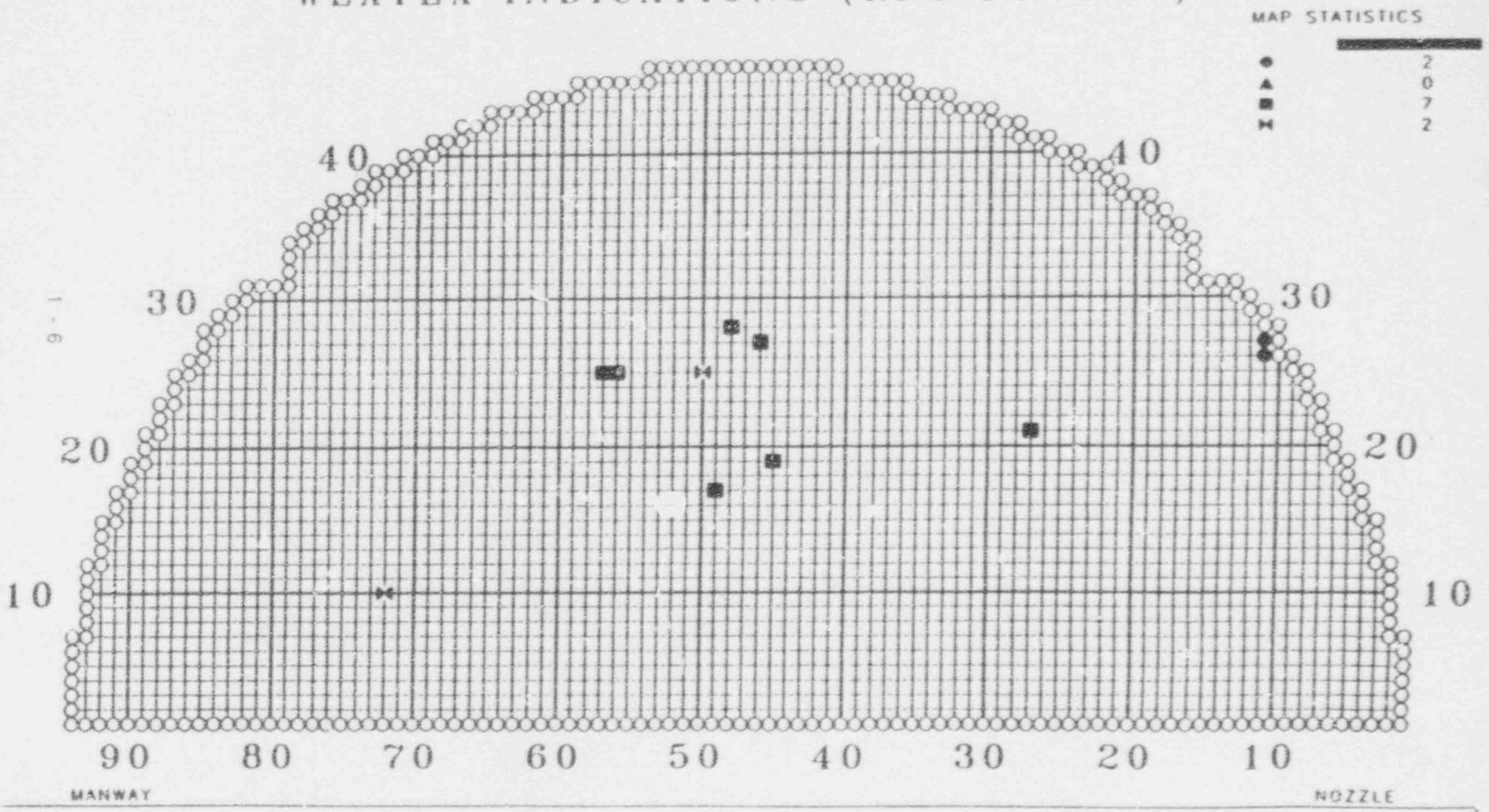
WEXTEX INDICATIONS (RPC PROBES)



STEAM GENERATOR INFORMATION SYSTEM (C) WESTINGHOUSE ELECTRIC CORP. 1990

NORTH ANNA UNIT 1 S/G C 2/27/92 PLUG LIST

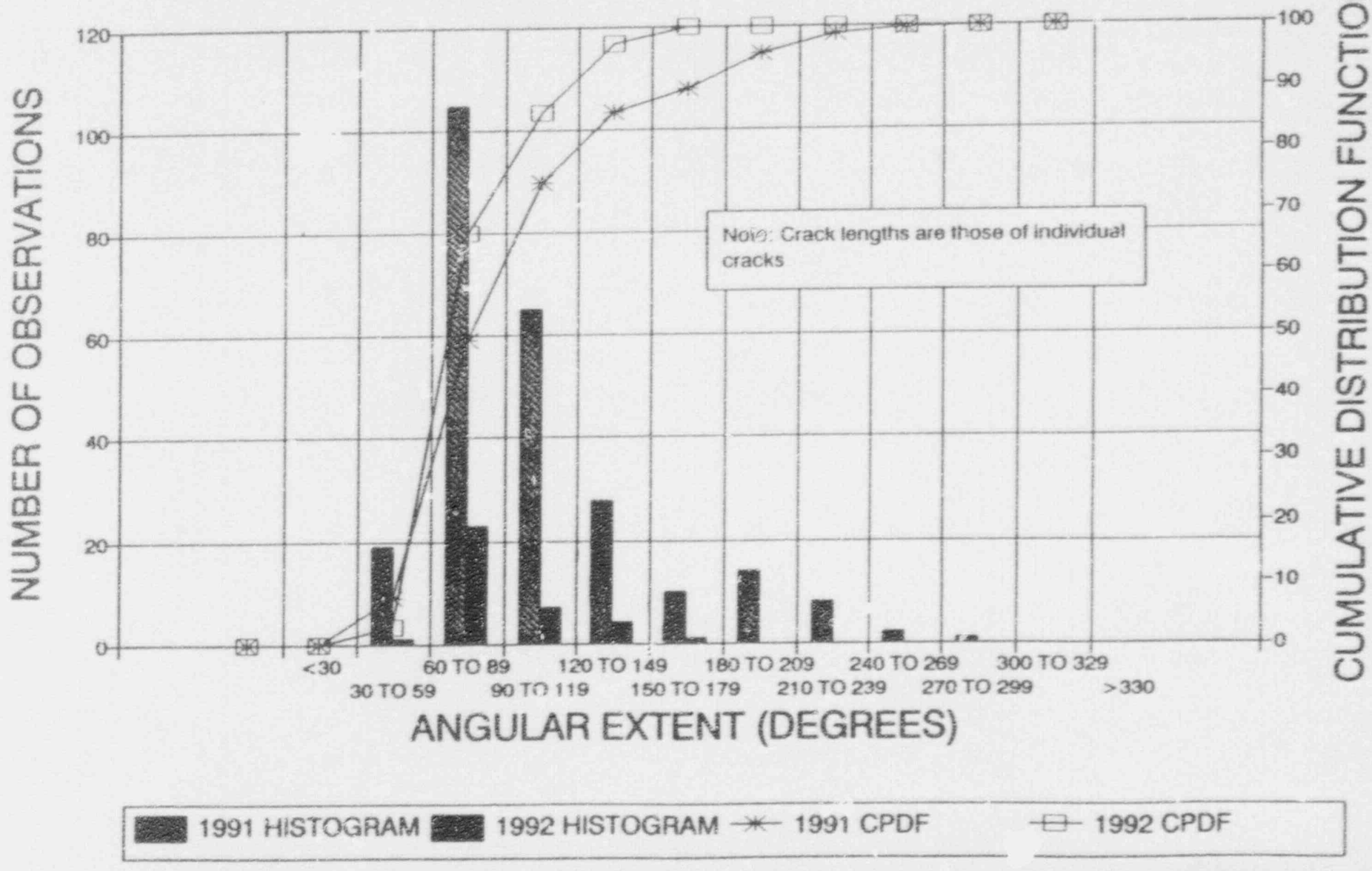
WEXTEX INDICATIONS (RPC PROBES)



STEAM GENERATOR INFORMATION SYSTEM (C) WESTINGHOUSE ELECTRIC CORP.

NORTH ANNA UNIT 1 ALL S/G's

WEXTEX CIRCUMFERENTIAL INDICATIONS



North Anna #1
February 1992

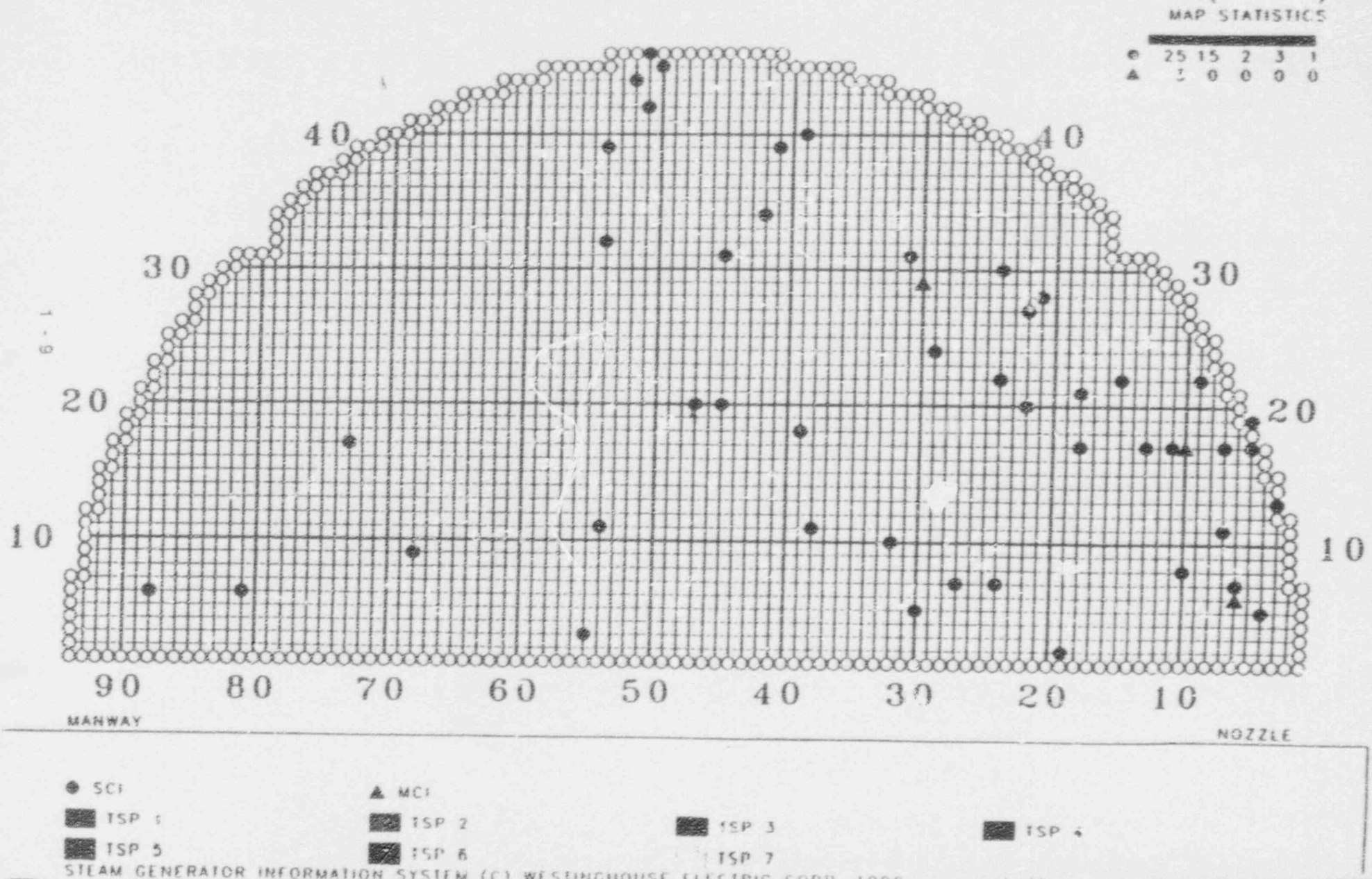
TSP Circumferential Cracks

Elevation	Steam Generator		
	A SCI/MCI	B SCI/MCI	C SCI/MCI
1H	25/3	22/0	27/0
2H	15/0	33/3	42/3
3H	2/0	7/2	19/1
4H	3/0	0/0	3/0
5H	1/0	0/0	1/0
6H	0/0	0/0	0/0
7H	0/0	0/0	0/0

SCI - SINGLE CIRCUMFERENTIAL INDICATION
MCI - MULTIPLE CIRCUMFERENTIAL INDICATIONS

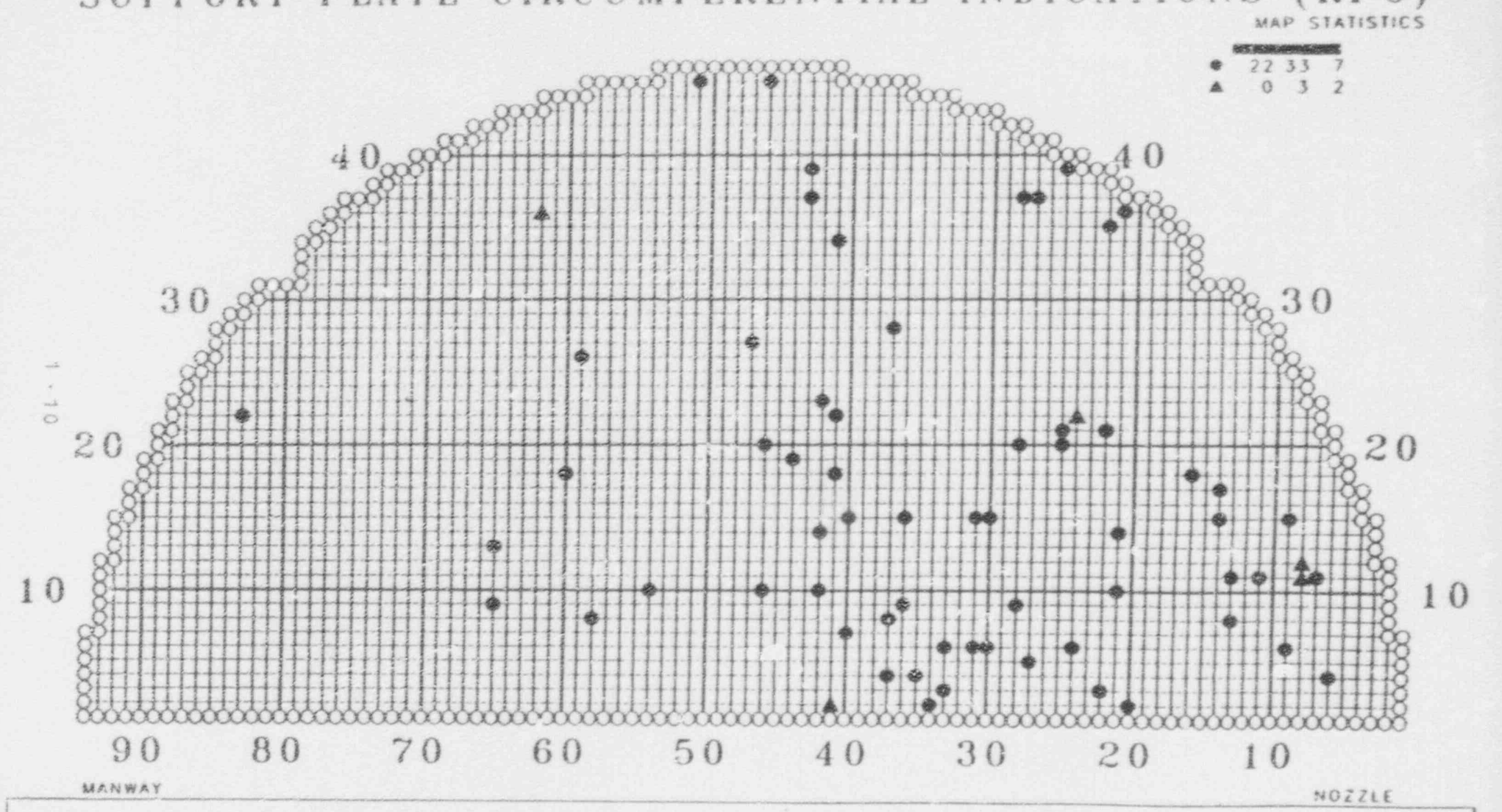
NORTH ANNA UNIT 1 S/G A 2/27 PLUG LIST

SUPPORT PLATE CIRCUMFERENTIAL INDICATIONS (RPC)



NORTH ANNA UNIT 1 S/G B 2/27 PLUG LIST

SUPPORT PLATE CIRCUMFERENTIAL INDICATIONS (RPC)

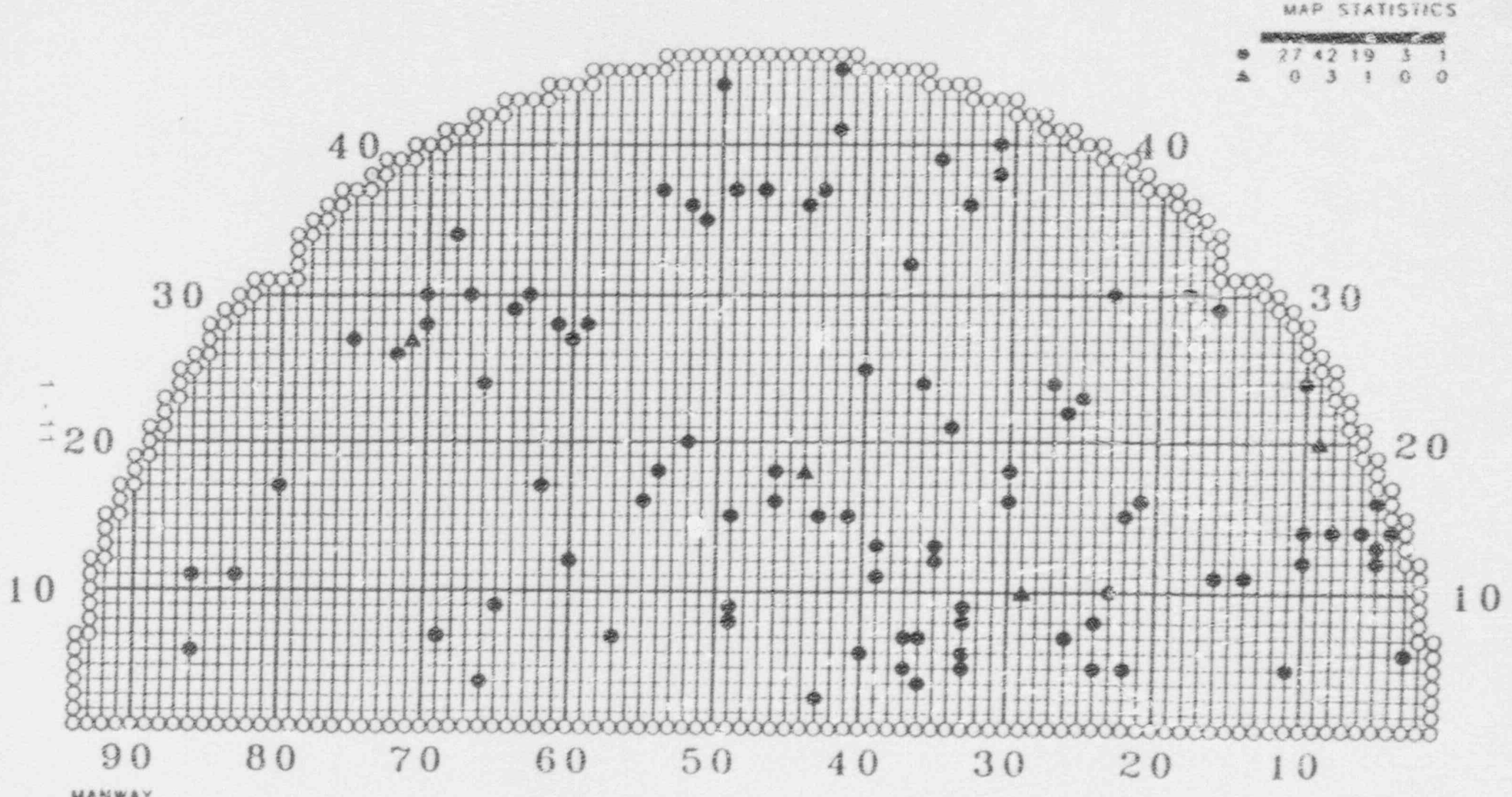


STEAM GENERATOR INFORMATION SYSTEM (C) WESTINGHOUSE ELECTRIC CORP 1990

DATE PLOTTED 2/27/1991

NORTH ANNA UNIT 1 S/G C 2/27/92 PLUG LIST

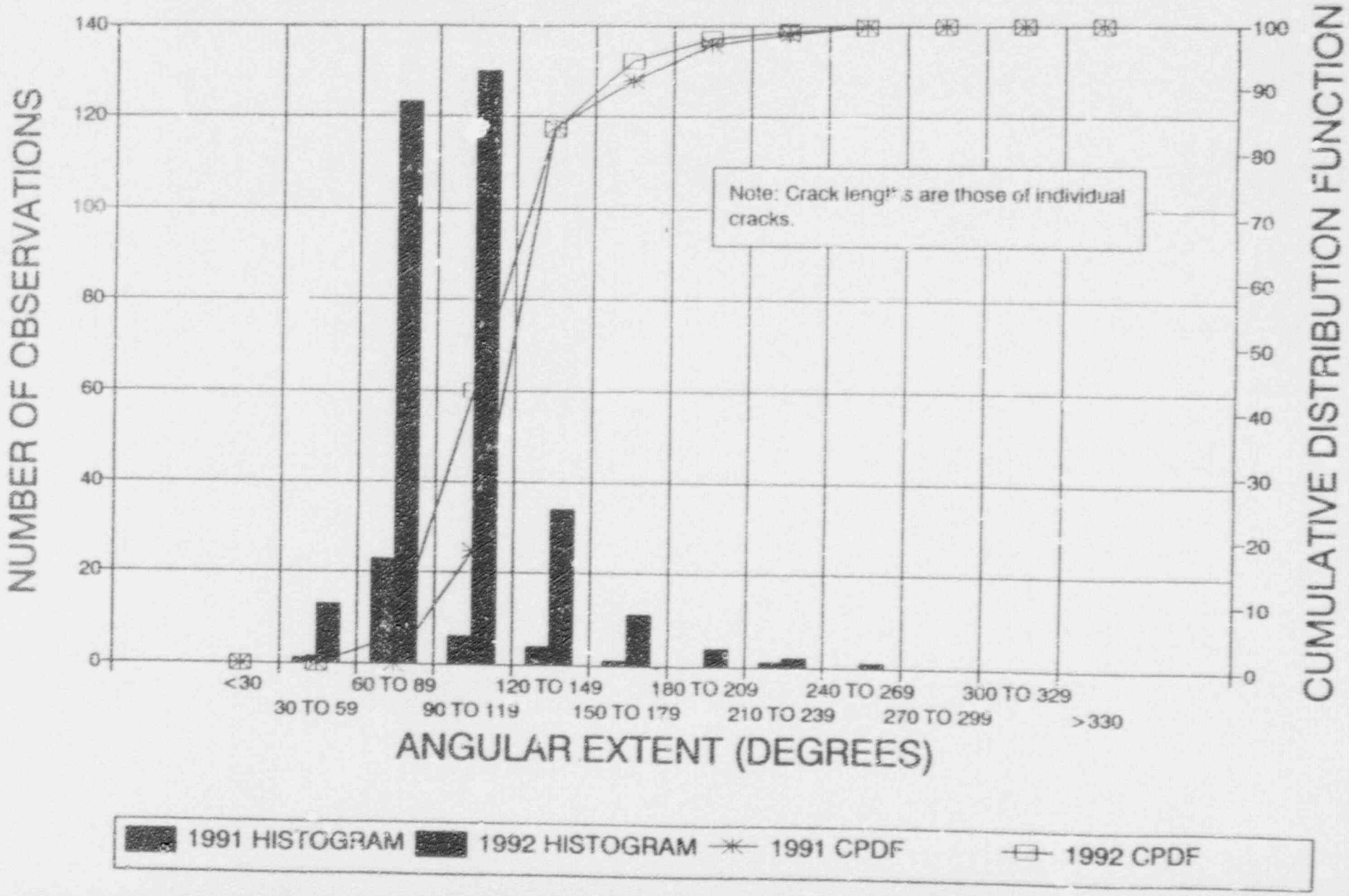
SUPPORT PLATE CIRCUMFERENTIAL INDICATIONS (RPC)



STEAM GENERATOR INFORMATION SYSTEM (C) WESTINGHOUSE ELECTRIC CORP 1990

DATE PLOTTED 2/27/1992

NORTH ANNA UNIT 1 ALL S/G's
SUPPORT PLATE CIRCUMFERENTIAL IND.



North Anna #1
February 1992

TSP Axial Cracks

Elevation	Steam Generator A SAI/MAI	B SAI/MAI	C SAI/MAI
1H	36/0	53/4	37/5
2H	24/2	14/3	41/1
3H	7/0	6/0	5/1
4H	5/0	5/0	8/0
5H	21/0	1/0	1/0
6H	3/0	1/0	2/0
7H	0/0	0/0	0/0

SAI - SINGLE AXIAL INDICATION
MAI - MULTIPLE AXIAL INDICATIONS

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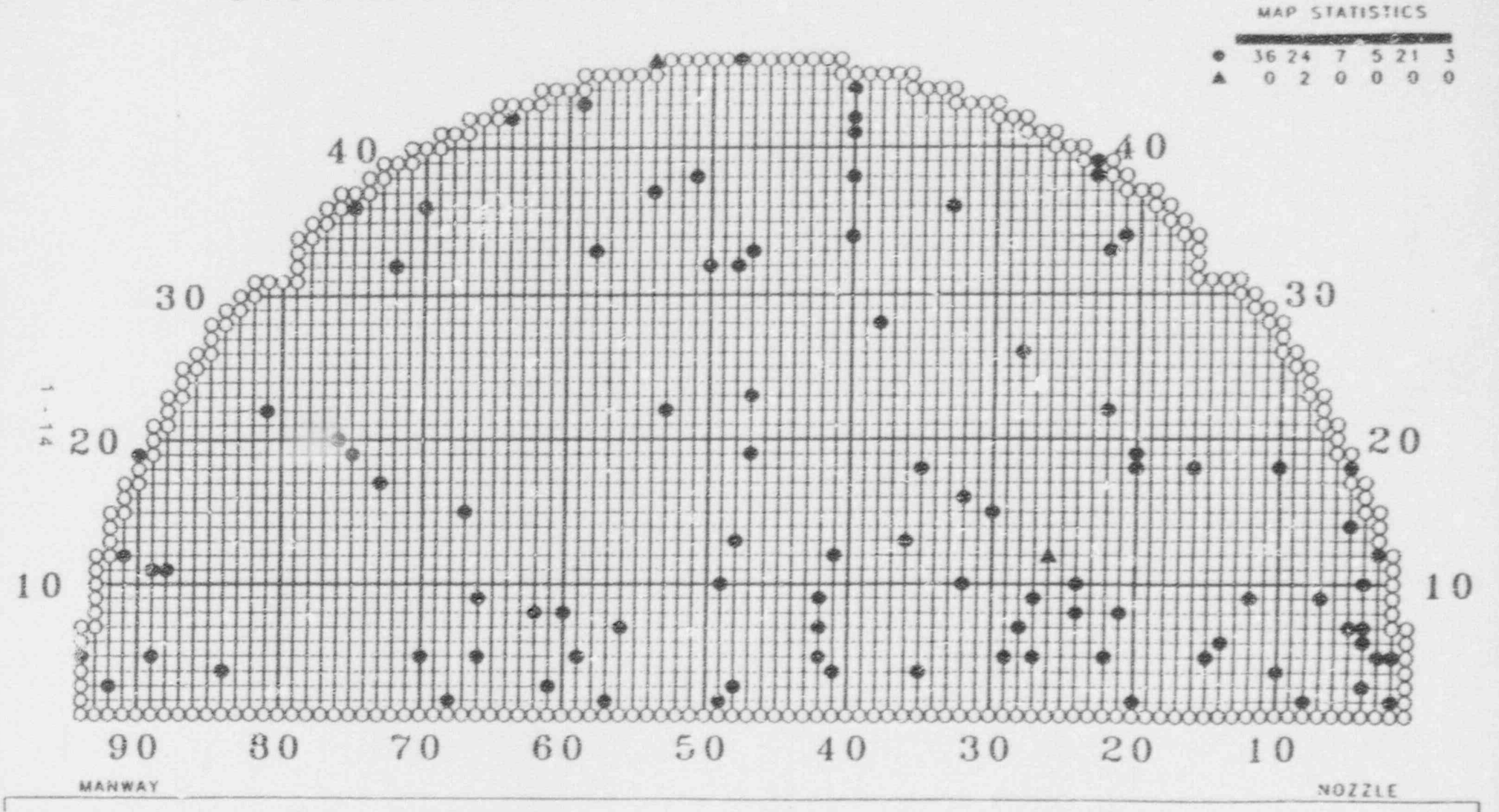
NORTH ANNA UNIT 1 S/G A 2/27 PLUG LIST

SUPPORT PLATE AXIAL INDICATIONS (RPC)



DATE PLOTTED: 2/27/96

NORTH ANNA UNIT 1 S/G B 2/27 PLUG LIST

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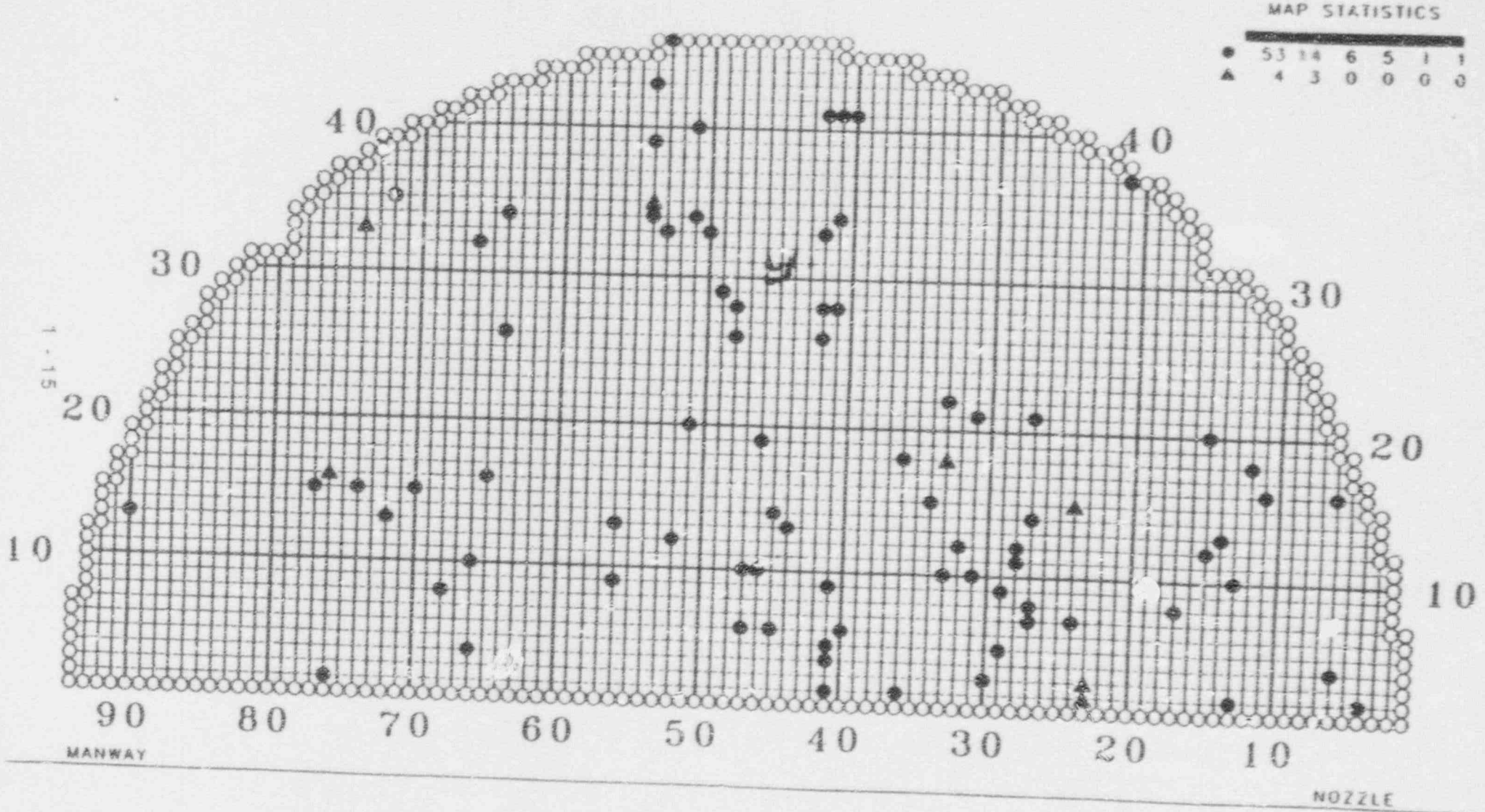
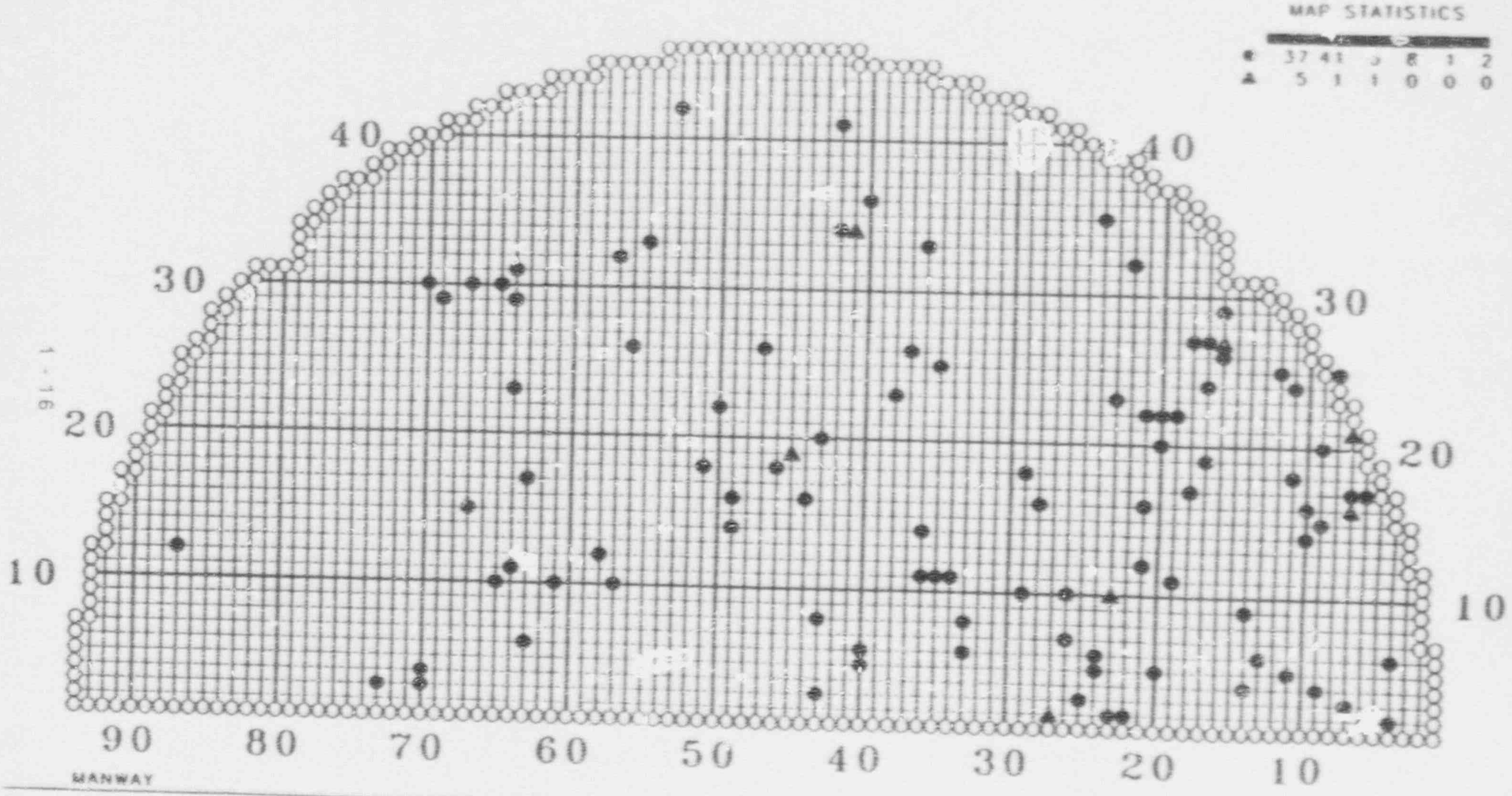


NORTH ANNA UNIT 1 S/G C 2/27/92 PLUG LIST

SUPPORT PLATE AXIAL INDICATIONS (RPC)



NORTH ANNA #1
FEBRUARY 1992

WEXTEX CIRCUMFERENTIAL CRACK GROWTH

24 WEXTEX CIRCUMFERENTIAL CRACKS WERE EVALUATED FOR GROWTH FROM 1991 TO 1992 USING RPC DATA.

AVERAGE CHANGE*: $12.8^{0} \pm 12.2^{0}$

SUPPORT PLATE CIRCUMFERENTIAL CRACK GROWTH

23 TSP CIRCUMFERENTIAL CRACKS COULD BE EVALUATED FOR GROWTH FROM 1991 TO 1992 USING RPC DATA.

AVERAGE CHANGE*: $10.5^{0} \pm 12.2^{0}$

*ALL NEGATIVE CHANGES SET TO ZERO.

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NORTH ANNA #1
FEBRUARY 1992

TSPs WITH BOTH CIRCUMFERENTIAL
AND AXIAL CRACKS

NO CASES OF MIXED MODE DEGRADATION WERE DETECTED IN S/G A AND S/G B.

SEVEN (7) LOCATIONS WITH MIXED MODE DEGRADATION AT THE SAME TSP EDGE WERE OBSERVED IN S/G C.

ELEVATION	TUBE EDGE*	CIRCUM.	MINIMUM SEPARATING LIGAMENT
TSP #1:	R29C16 +	75°	> 25°
	R3C43 +	73°	> 39°
	R18C46 +	69°	> 69°
TSP #2:	R10C29 -	119°	>113°
	R8C33 +	76°	> 37°
	R29C64 -	91°	> 27°
	+	63°	> 17°
	R30C67 +	133°	> 20°

DATA WAS ACQUIRED WITH 2X RPC PROBE; FOR CLOSEST AXIAL-CIRCUMFERENTIAL PROXIMITY 3 COIL ZETEC PROBE WAS USED; NO APPARENT IMPROVEMENT IN RESOLUTION.

ALL THESE INTERSECTIONS WERE JUDGED TO BE ACCEPTABLE AGAINST TUBE BURST CRITERIA.

* + UPPER EDGE
- LOWER EDGE

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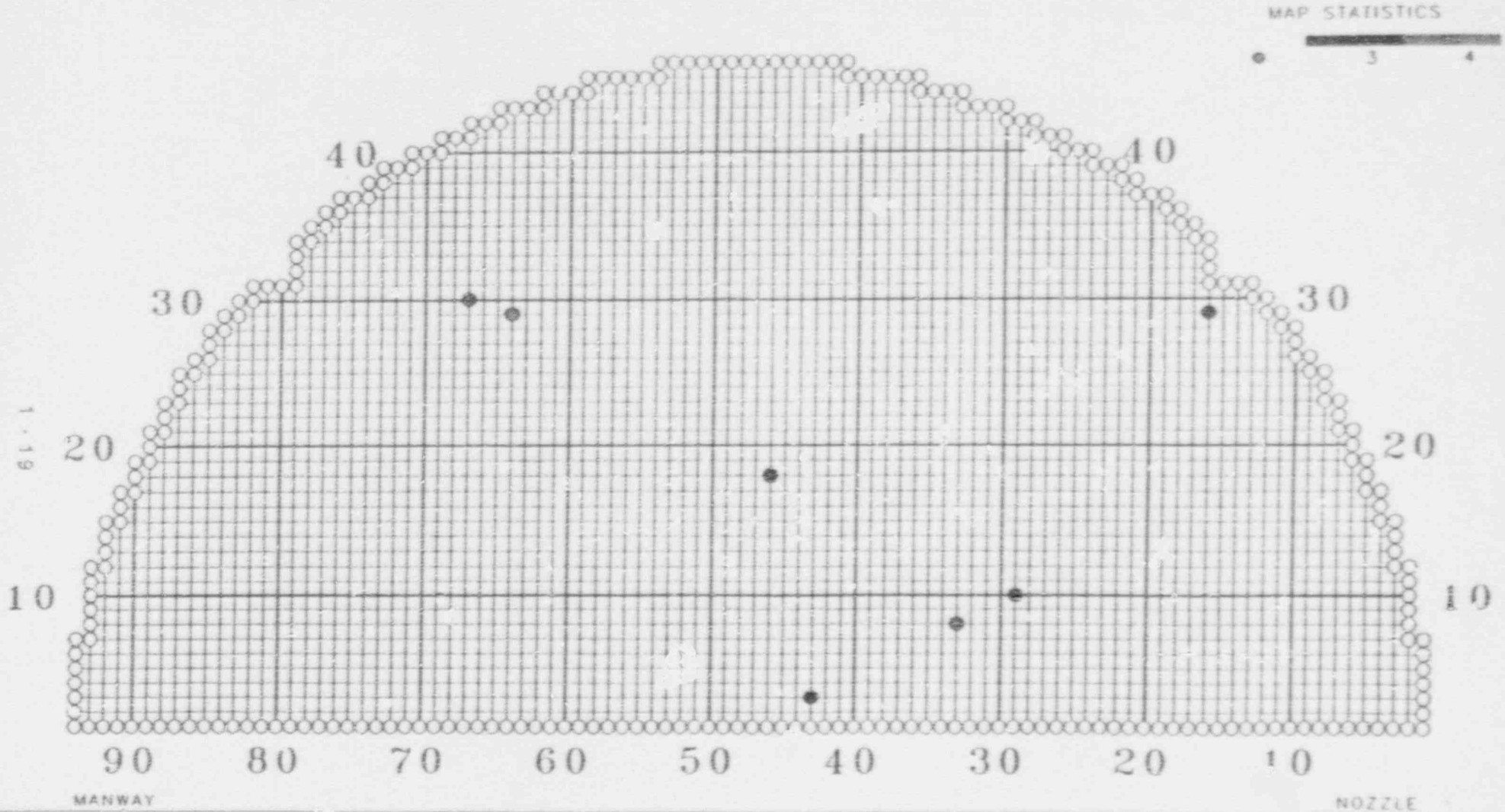
NORTH ANNA UNIT 1 S/G C FEB 1992 INSPECTION

POTENTIAL MIXED MODE INDICATIONS



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North Anna Unit 1
Steam Generator Mid-Cycle Inspection Outage
NRC Startup Approval Meeting

March 2, 1992

Westinghouse

Tube Integrity Evaluation

T. A. Pitterle

Tube Integrity Assessment

Discussion Topics

Growth Rates: '92 RPC vs '91 8X1

"Inspection Transient" and Operations

Acceptable Indications for Burst and Vibration (WCAP-13034)

Tube Integrity Evaluation

- Largest SCI and SAI Assessment
- Multiple Circumferential Indication Assessment
  - Tube Burst Tests
  - Assessment
- Potential Combined Circ. & Axial Assessment
- Susceptability to Tube Vibration
- EOC SLB Leak Rates

Growth Rate Comparisons

	RPC: '92-'91*		8X1: '91-'89	
	WEXTEX	TSPs	WEXTEX	TSPs
Average	26°	21°	30°	31°
90% Cum. Probability	57°	47°	60°	54°
95% Cum. Probability	66°	63°	73°	67°

* Measured growth for short cycle (254 vs 506 EFPD) multiplied by factor of two for full cycle comparison

- 24 WEXTEX Indications in '92 vs 112 Ind. in '91
- 23 TSP Ind. in '92 vs 77 Ind. in '91

WEXTEX Cumulative and Interval Crack Growth Distributions

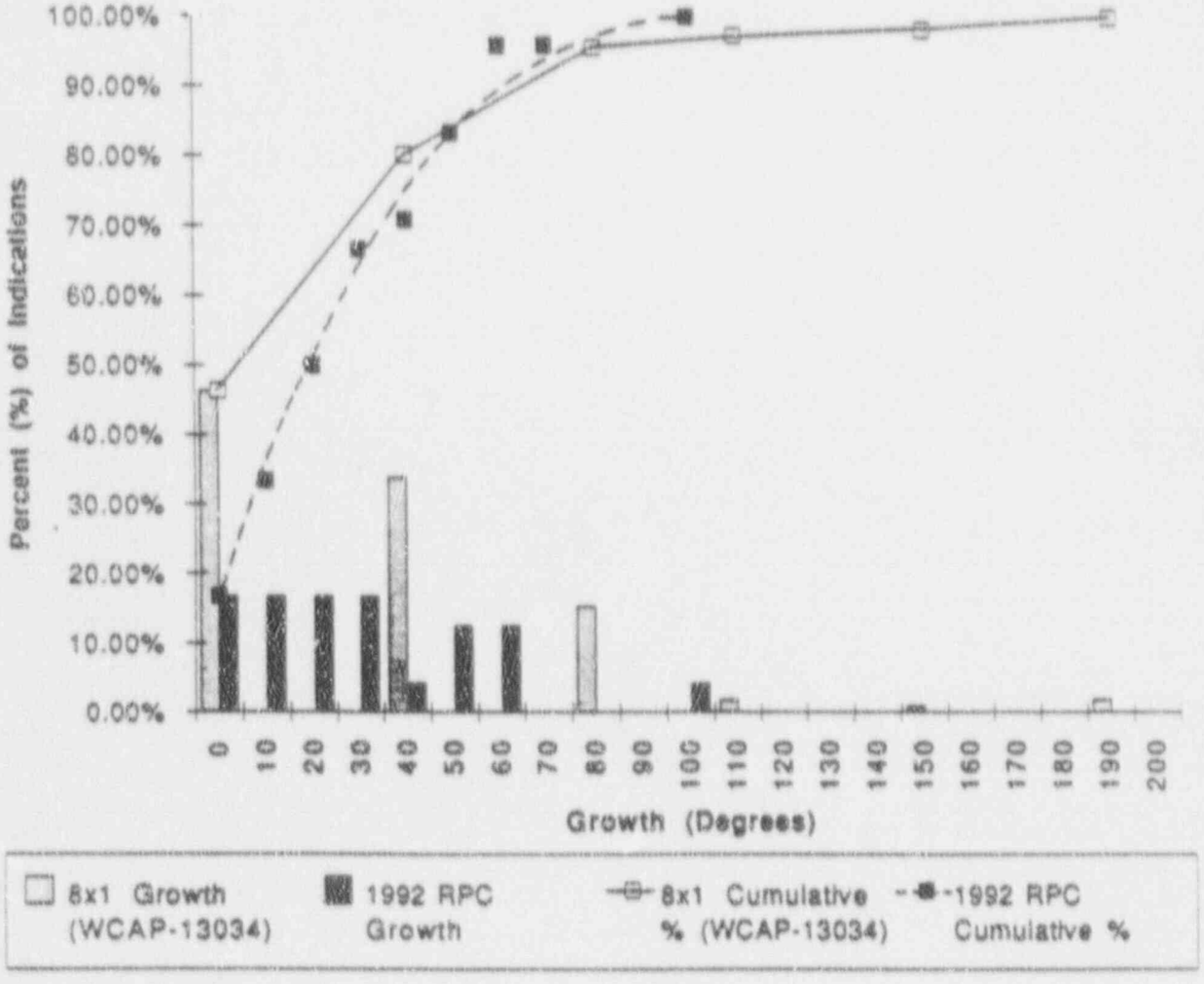


Chart WEXTEX Growth Rates 2/27/92

TSP Cumulative and Interval Crack Growth Distributions

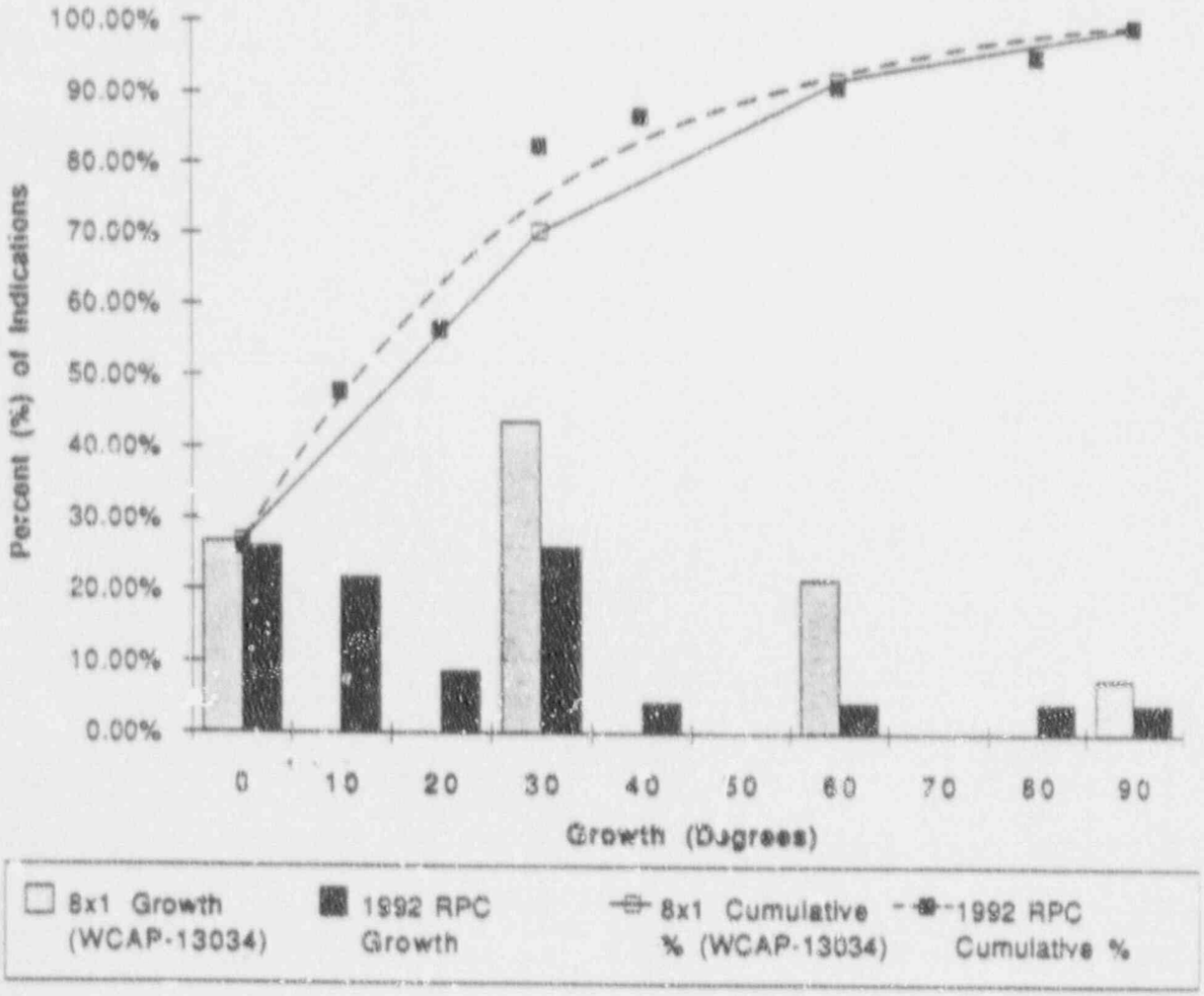


Chart TSP Growth Rates 2/27/92

"Inspection Transient" Considerations

Projections (18 mo.) of WCAP-13034

- WEXTEX Projections
  - Projections based on 8x1 inspection history significantly overestimated number and size of indications
  - Typical of cycle following an "inspection transient" (first application of more sensitive, RPC probe)
- TSP Projections
  - Projections based on 8x1 history underestimated number and size of indications
  - Typical of cycle having an "inspection transient"
  - Fewer indications would be anticipated next cycle

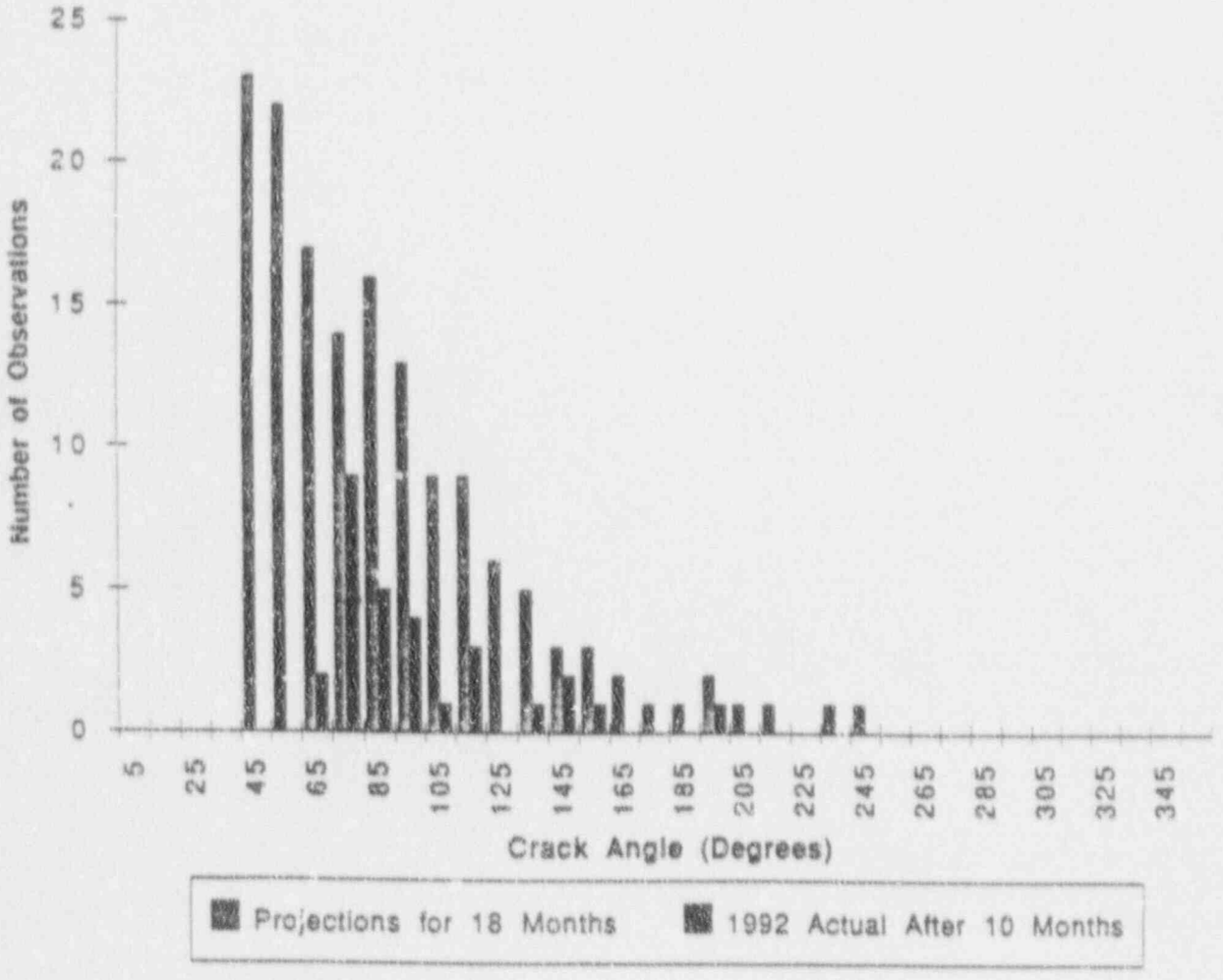


Chart WEXTEX '92 Proj 18 Mo 2/25/92

TSP 1992 EOC Projections vs. Actual

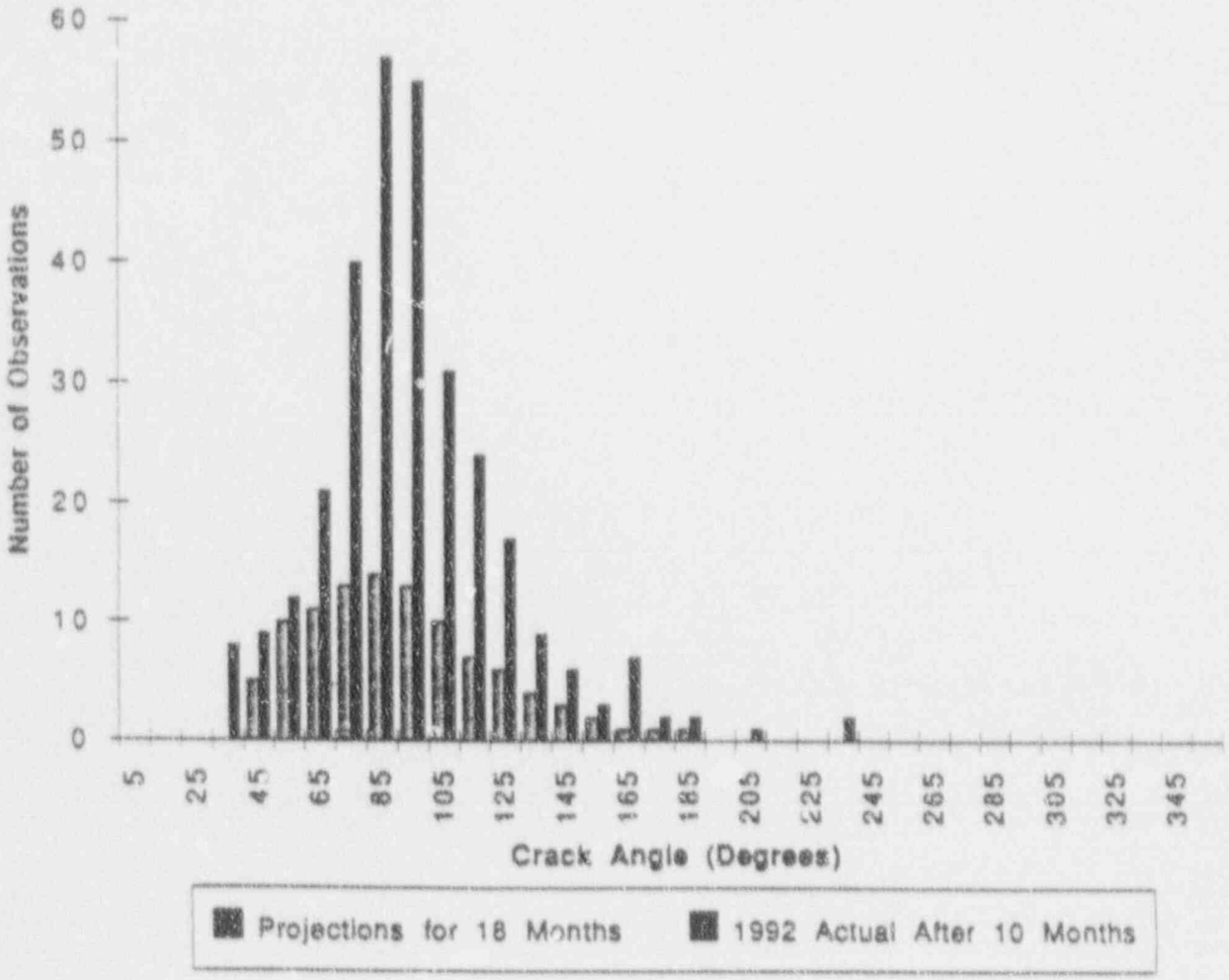


Chart TSP '92 Proj 18 Mo 2/25/92

Example of "Inspection Transients"

	North Anna-1		Plant A
	WEXTEX	TSP	WEXTEX
Cycle Before RPC	28	110	0
RPC "Inspection Transient"	216	212	56
Cycle After RPC	31	TBD	2

REG. GUIDE 1.121
CRITERIA FOR THRU-WALL CIRCUMFERENTIAL CRACKS

TUBE BURST CAPABILITY OF THREE TIMES NORMAL OPERATING PRESSURE DIFFERENTIAL

ADEQUATE MARGIN AGAINST RAPID CRACK PROPAGATION AND TUBE RUPTURE UNDER ACCIDENT CONDITIONS

- CRACK PROPAGATION FROM TUBE VIBRATION UNDER NORMAL OPERATING CONDITIONS INCLUDED IN THE EVALUATION

LEAK RATE LIMIT THAT PROVIDES LEAK BEFORE BREAK

ALLOWANCE IN ACCEPTABLE CRACK LENGTHS FOR EC UNCERTAINTY AND GROWTH (PLANT SPECIFIC) BETWEEN INSPECTIONS

CONFIRM ACCEPTABLE LEAKAGE DURING LIMITING ACCIDENT CONDITION

- STEAM LINE BREAK IS TYPICALLY LIMITING

Tube Integrity Assessment

Approach

2/92 Inspection Results Typical of Expected at End of Next Cycle

- Cycle Lengths
  - 254 EFPD prior cycle
  - 252 EFPD next cycle

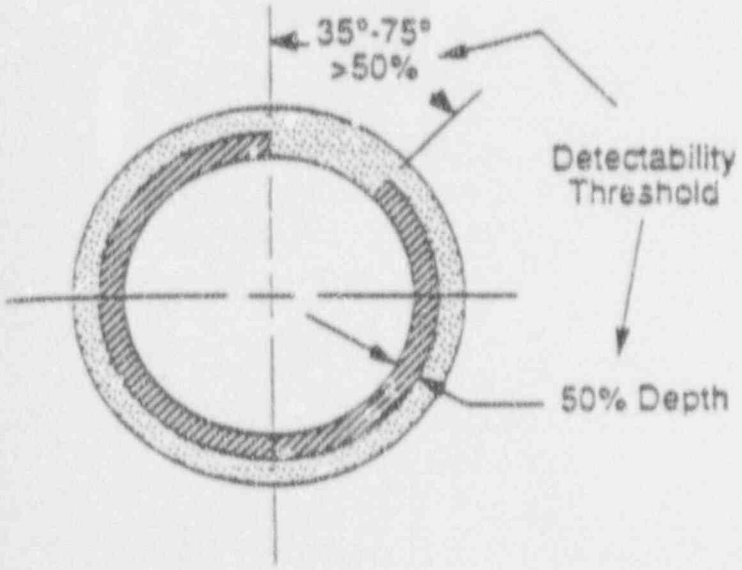
Perform Tube Integrity Assessment for 2/92 Inspection Results

- Conservative for Next EOC
  - 100% RPC inspection of H.L. TSP intersections
- Tube Burst Assessments
  - Single Cracks
  - MCIs
  - Potential mixed mode
- Susceptibility to Tube Vibration
- SLB Leak Rates

Crack Growth Models for ODSCC and PWSCC

ODSCC

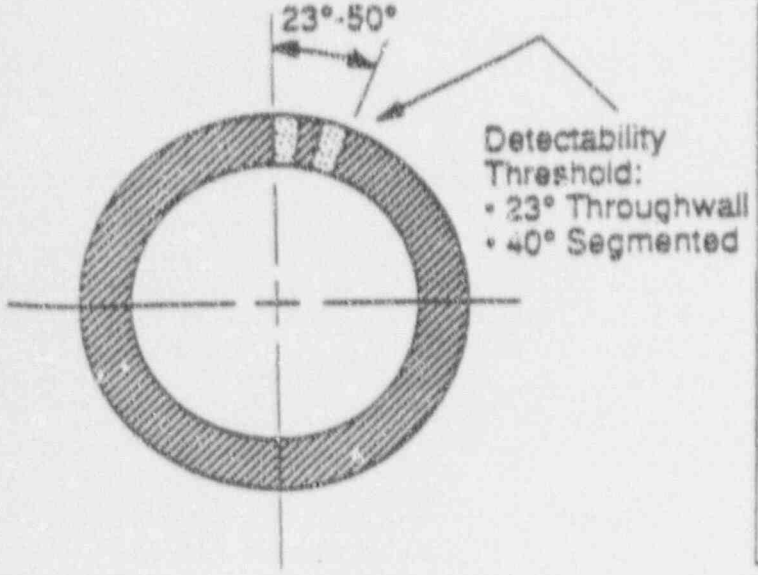
BOC



a,c

PWSCC

BOC



a,c

Circumferential and Axial Crack Tube Burst Capability Summary

Crack Morphology	$3\Delta P_{N.O.}$	ΔP_{SLB}
Circumferential Crack Angles		
Segmented Cracks	[b,c	] b,c
Single Crack		
Single Crack with 50% Deep Crack		
Axial Crack Lengths - inch		
Segmented Cracks	[b,c	] b,c
Single Cracks		

Burst Capability Assessment

WEXTEX Circumferential Indications

- 199° largest WEXTEX circumferential indication
  - S/G B, R25C36
- All indications meet 3△P Burst Capability
  - [ ]^{b,c} for expected segmented crack morphology
  - [ ]^{b,c} for throughwall crack

TSP Circumferential Indications

- Two indications have RPC crack angles exceeding [ ]^{b,c} for 3△P for uniform, throughwall crack
- 240° @ S/G A, R34C42, 2H
  - Deepest part of crack ~134°
- 239° @ S/G A, R18C39, 1H
  - Deepest part of crack ~ 96°
- All indications expected to meet 3△P burst capability

Burst Capability Assessment

Axial Indications Extending Outside TSP

- Maximum length of 0.54" less than prior outages of ~0.9"
  - RPC lengths shorter than bobbin lengths used previously due to reduced lead-in and lead-out effects for RPC compared to bobbin
  - Westinghouse roll transition studies indicate measured RPC lengths should be reduced by 0.1 inch.
  - EPRI NP-6368-L also shows good agreement of RPC lengths with pulled tube data.
- Crack length of 0.72" meets 3$\triangle$P burst capability for expected segmented crack morphology
- Axial indications at TSPs meet 3$\triangle$P burst capability

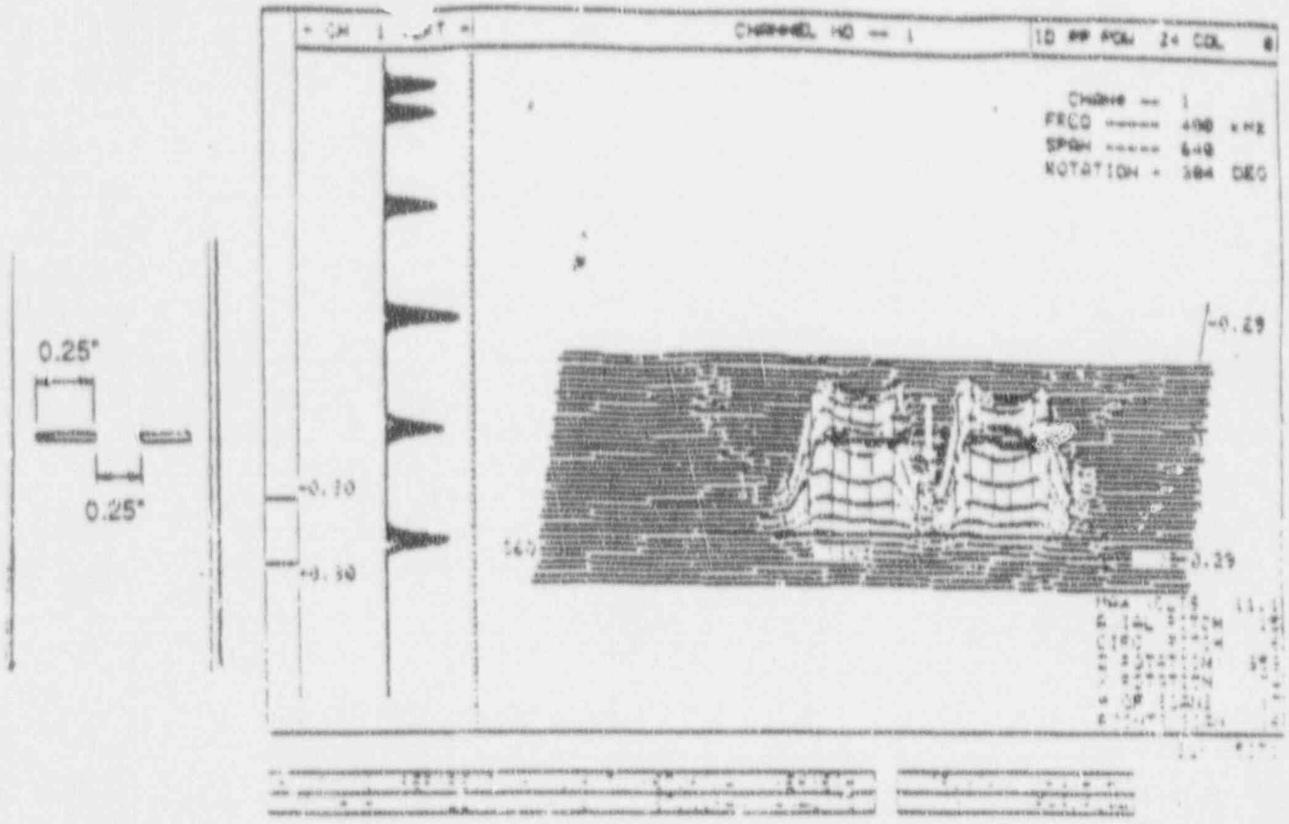
MCI Burst Capability Assessment

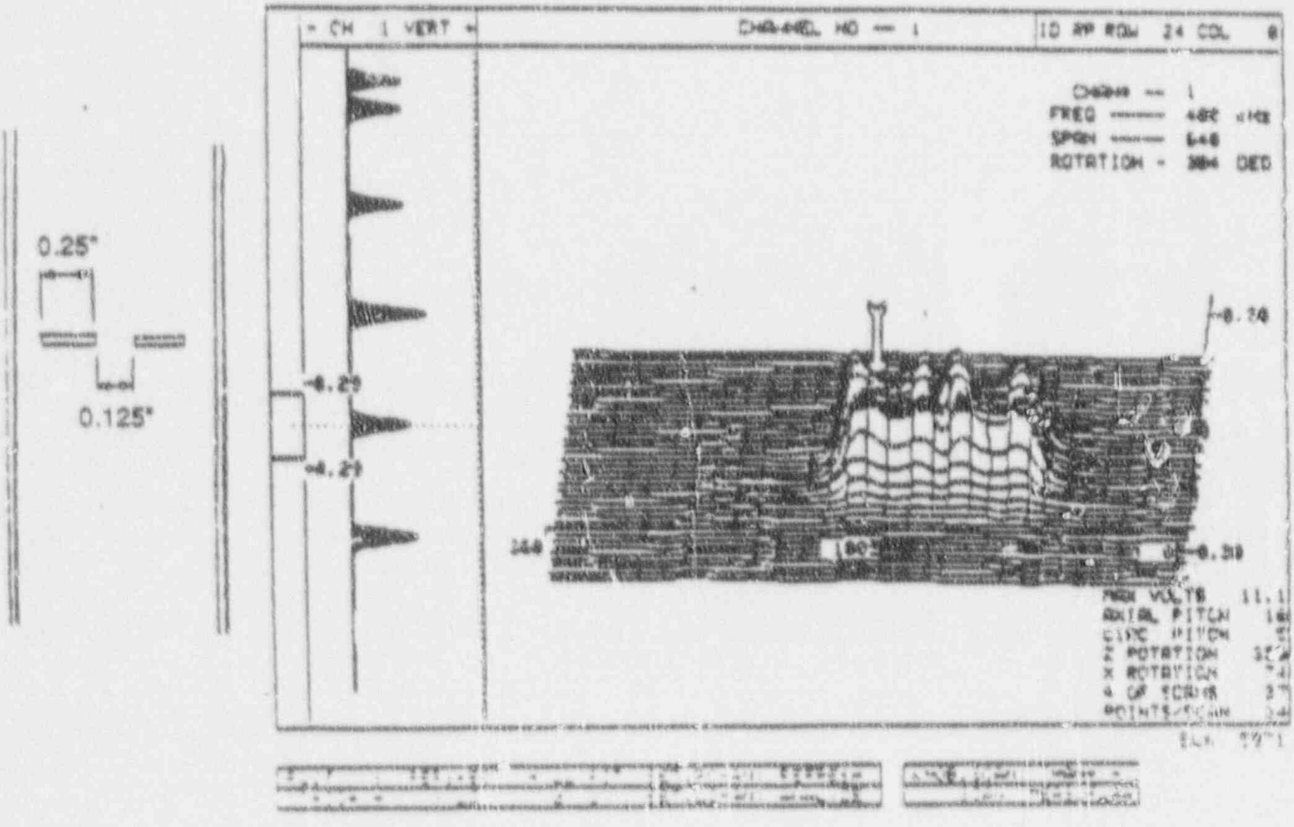
Minimum Ligament Between Circumferential Indications

- RPC ligament call requires return to null point (background) between circumferential cracks
- TPC ligament requires 30^{0}-35^{0} (0.2"-0.25") between deep circumferential cracks due to resolution (coil lead-in and lead-out effects) limitations
  - Confirmed by measurements of EDM notches
- Minimum ligament in MCIs = RPC ligament angle + 30^{0}

RPC measurements of throughwall cracks overestimated by ~30^{0}

- 8^{0} reduction in angle can be conservatively applied at each end of crack


0.25"
0.25"
CHANNEL NO -- 1
CHANNEL -- 1
FREQ ------ 400 kHz
SPAN ------ 640
ROTATION - 384 DEG
-0.29
-0.10
-0.30
360
0.29


0.25"
0.125"
CH 1 VERT
CHANNEL NO -- 1
CHANNEL -- 1
FREQ ------ 402 kHz
SPAN ------ 640
ROTATION - 384 DEG
-0.20
-0.29
-0.29
360
80°
0.30
MAX VOLTS 11.1

Burst Tests for Multiple Circumferential Indications

Burst Tests

B,C

[ ]

Objective

- Confirm acceptable ligaments for MCIs to meet structural integrity requirements

Results

- MCI burst capability with minimum acceptable ligaments exceeds burst pressure of SCI having same total crack angle
  - Minimum acceptable ligament = 30^0-35^0 full thickness
  - Minimum acceptable ligament = 60^0-70^0 with 50% deep crack

Tube Burst Test Results for MCIs

Single Circumferential Slot

[b,c]

Multiple Symmetric Circumferential Slots

[b,c]

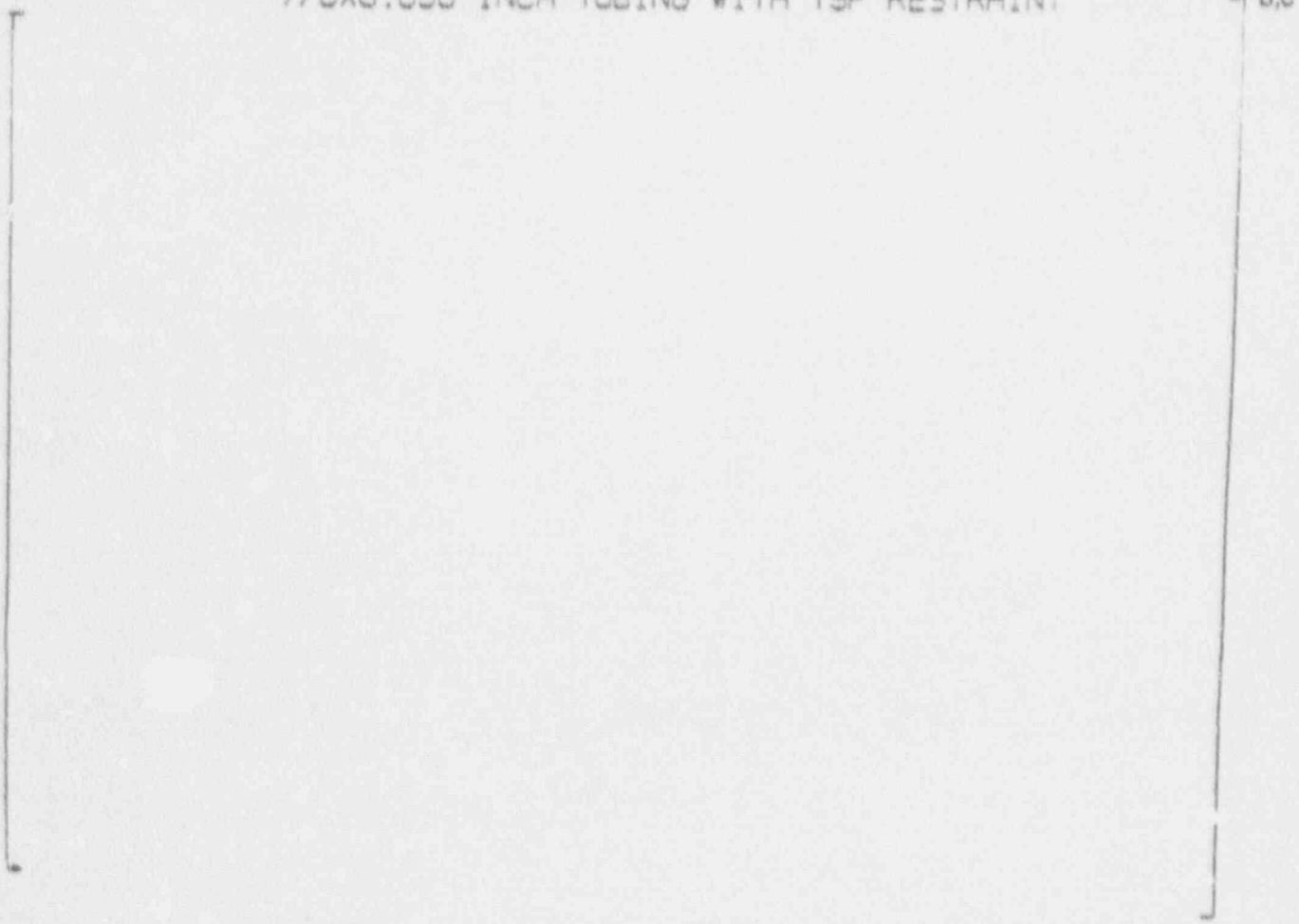
Multiple Non-Symmetric Circumferential Slots

[b,c]

BURST PRESSURE VERSUS TOTAL CRACK ANGLE

7/8X0.050 INCH TUBING WITH TSP RESTRAINT

b,c



MCI Burst Capability Assessment

WEXTEX MCIs

- 5 MCIs identified
- Smallest RPC ligament = 12° (S/G A, R24C33)
- Minimum ligament ~42° and sum of crack angles <218° after RPC resolution adjustment
- All MCI ligaments exceed 30-35° ligament size required for MCI burst capability to exceed that of single crack with a 70° ligament
- All WEXTEX MCIs meet 3△P burst capability

TSP MCIs

- 15 MCIs identified
- Minimum RPC ligament for all 15 MCIs ~41°
  - Minimum ligament ~71° after RPC resolution adjustment
  - Ligaments exceed 60-70° ligament size required for MCI 3△P burst capability
- All TSP MCIs meet 3△P burst capability

North Anna-1
WEXTEX MCIs

Tube	Location	Circ.1	Lig.1	Circ.2	Lig.2	Total Circ.
			Steam Generator A			
R1[illegible]32	TS-.12	102°	24°(54°)(1)	82°	152°	184°
R24C33	TS-.08	149°	114°	85°	12°(42°)(1)	234°(218°)
			Steam Generator B			
R9C36	TS+.00	81°	17°(47°)(1)	82°	180°	163°
			Steam Generator C			
R10C72	TS-.02	76°	38°	76°	170°	151°
R25C50	TS-.04	67°	46°	59°	178°	126°

Note 1. RPC measured ligament increased by 30° for resolution limitations (coil lead-in and lead-out effects).

TAP2023:022992

North Anna-1
TSP Multiple Circumferential Indications (MCIs)

Tube	Location	Circ. 1	Lig. 1	Circ. 2	Lig. 2
			Steam Generator A		
R6C6	1H+.39	81°	91°	78°	110°
R17C10	1H+.50	90°	86°	95°	- 89°
R29C30	1H+.26	131°	75°	87°	- 67°
			Steam Generator B		
R11C8	2H-.21	114°	68°	117°	61°
	2H+.23	108°	65°	81°	106°
R12C8	3H+.23	128°	75°	98°	59°
R22C24	2H-.30	132°	73°	101°	54°
R2C41	3H+.29	138°	66°(96°)(1)	115°	41°(71°)(1)
	3H-.25	91°	88°	101°	80°
R36C62	2H-.23	83°	69°	107°	101°
			Steam Generator C		
R20C9	3H-.27	130°	64°	79°	87°
R24C10	3H+.28	105°	92°	88°	- 75°
R10C29	2H+.35	80°	83°	107°	90°
R18C44	2H+.35	99°	90°	109°	- 62°
R27C71	2H-.30	79°	96°	82°	103°

Note 1. RPC measured ligament angles based on return of signal amplitude to background or null point. For deep circumferential indications, the actual ligament exceeds the measured ligament by about 30° or more (Figure 4-2, WCAP-13034) due to RPC coil lead-in and lead-out resolution limits on crack angles.

TAP2023:022992

Evaluation for Potential Mixed Mode Cracking

14 Occurrences in S/G C of Circ. and Axial Ind. at Same TSP

- 7 occurrences with axial on opposite edge or inside TSP compared to circumferential crack
  - Not a concern for mixed mode considerations
- 7 occurrences with axial at same edge as circumferential
  - Evaluated for ligament between axial and circ.

Minimum RPC ligament is 20° for R30C67, 2H

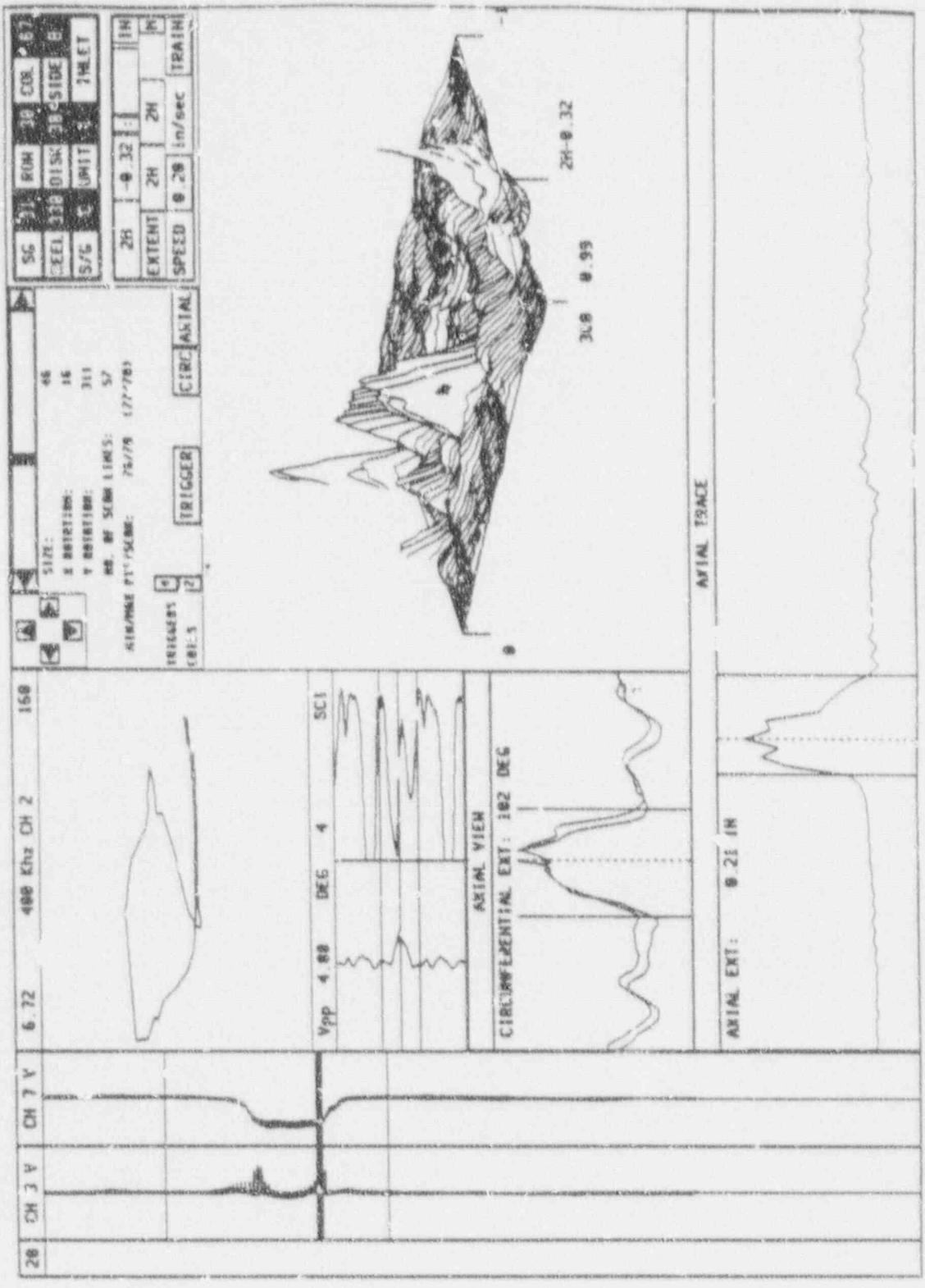
- Minimum ligament of 28° after adjustment for RPC resolution
- Minimum ligament requirement

[redacted] 9

- All lig[redacted]s for potential mixed mode crack exceed[redacted] and would meet 3△P burst capability

TAP2026:022692

NORTH ANNA_____ 02/10/92 INLET UNIT: 1_ SG: C REEL: 330 RES



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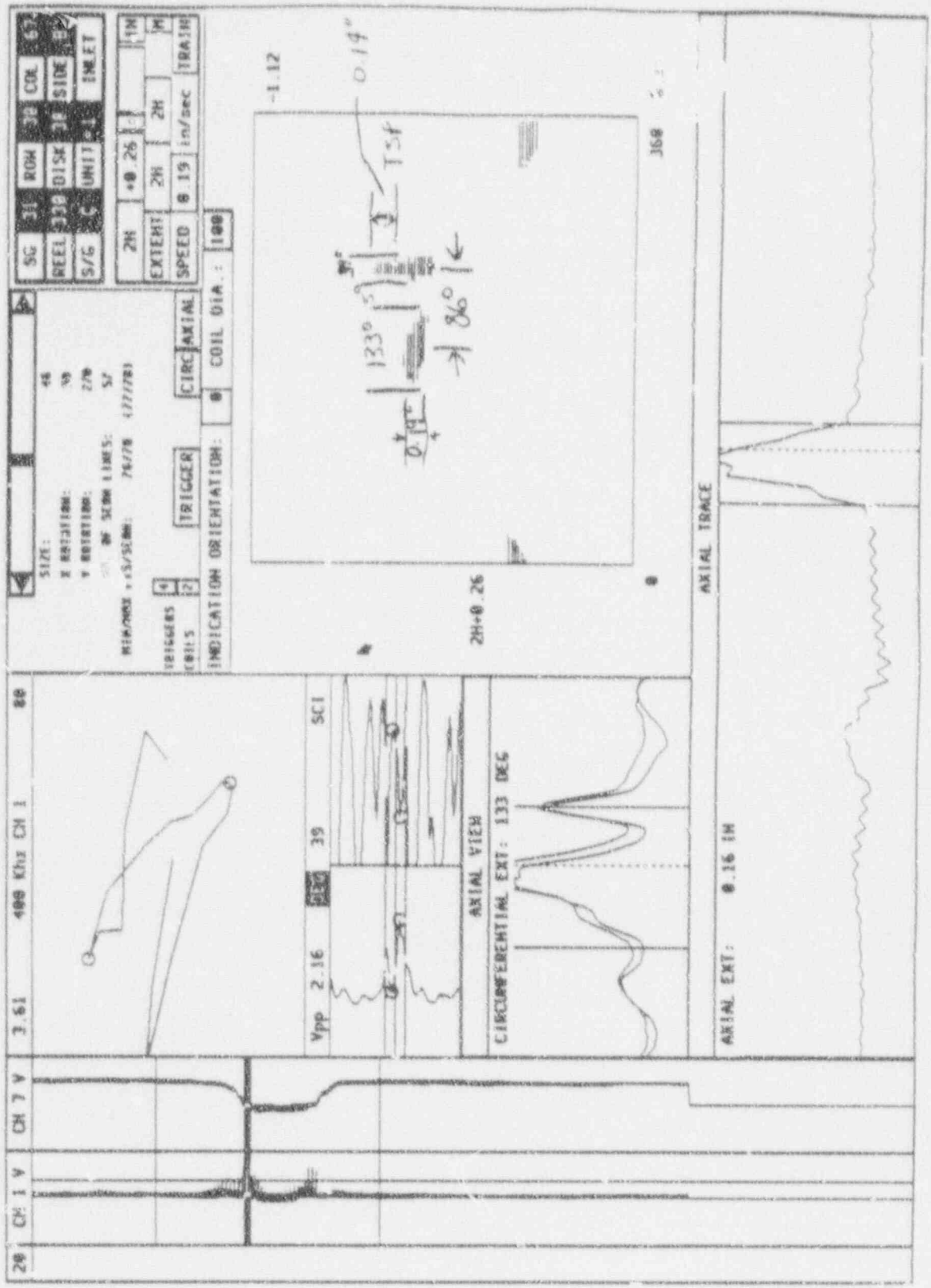


North Anna-1

Mixed Mode Evaluation

Tube	Location	Circ. Angle	C.I. to C.I.	Derived[1] Lig.Angle	Measured[2] Lig.+ 0.5 Axial θ	Resolution[3]
				Steam Generator C		
R20C9	3H-.27	$130^0/79^0$				Opposite Edges,No Concern
R14C10	2H+.20	101^0				Opposite Edges,No Concern
R5C11	1H-.27	96^0				Axial Inside TSP,No Concern
R29C16	1H+.26	75^0	62^0	25^0	6^0+28^0	Acceptable,large ligament
R10C29	2H-.29	119^0			90^0+23^0	Acceptable,large ligament
R6C3[illegible]	1H-.30	85^0				Opposite Edges,No Concern
R8C33	2H+.18	76^0	82^0	44^0	10^0+27^0	Acceptable,large ligament
R6C40	3H-.26	104^0				Opposite Edges,No Concern
R3C43	1H+.31	73^0	75^0	39^0	17^0+20^0	Acceptable,large ligament
R18C46	1H+.33	69^0			36^0+33^0	Acceptable,large ligament
R29C64	2H-.33	91^0	75^0	30^0	10^0+17^0	Acceptable,large ligament
	2H+.47	63^0				Opposite Edges,No Concern
R30C67	2H+.26	$133^0(117^0)^3$	86^0	$20^0(28^0)^3$	5^0+19^0	Acceptable,large ligament
R30C70	2H+.31	96^0				Opposite Edges,No Concern

Notes:

1) Ligament angle obtained as circumferential crack centerline to axial crack centerline distance minus on-half the circumferential angle.
2) Ligament angle obtained as the measured ligament angle plus one-half the axial crack angle.
3) RPC measurements adjusted for resolution (coil lead-in and lead-out) in measuring deep crack angles. Resolution typically ~1 coil diameter (0.105", 15^0) at each end of crack. Conservativeiy applying 8^0 at each crack end.

Zones for Tube Vibration Assessment

WEXTEX Zones for Initiation of Crack Propagation

- Zone 1: Initiation at TW angles of [ ]b,c
  - 620 tubes
- Zone 2: Initiation at TW angles of [ ]b,c
  - 344 tubes
- Zone 3: Initiation at TW angles of [ ]b,c
  - 940 Tubes
- Zone 4: Initiation requires TW angles [ ]b,
  - 1484 tubes
  - 90% of WEXTEX circumferential indications occur in Zone 4.

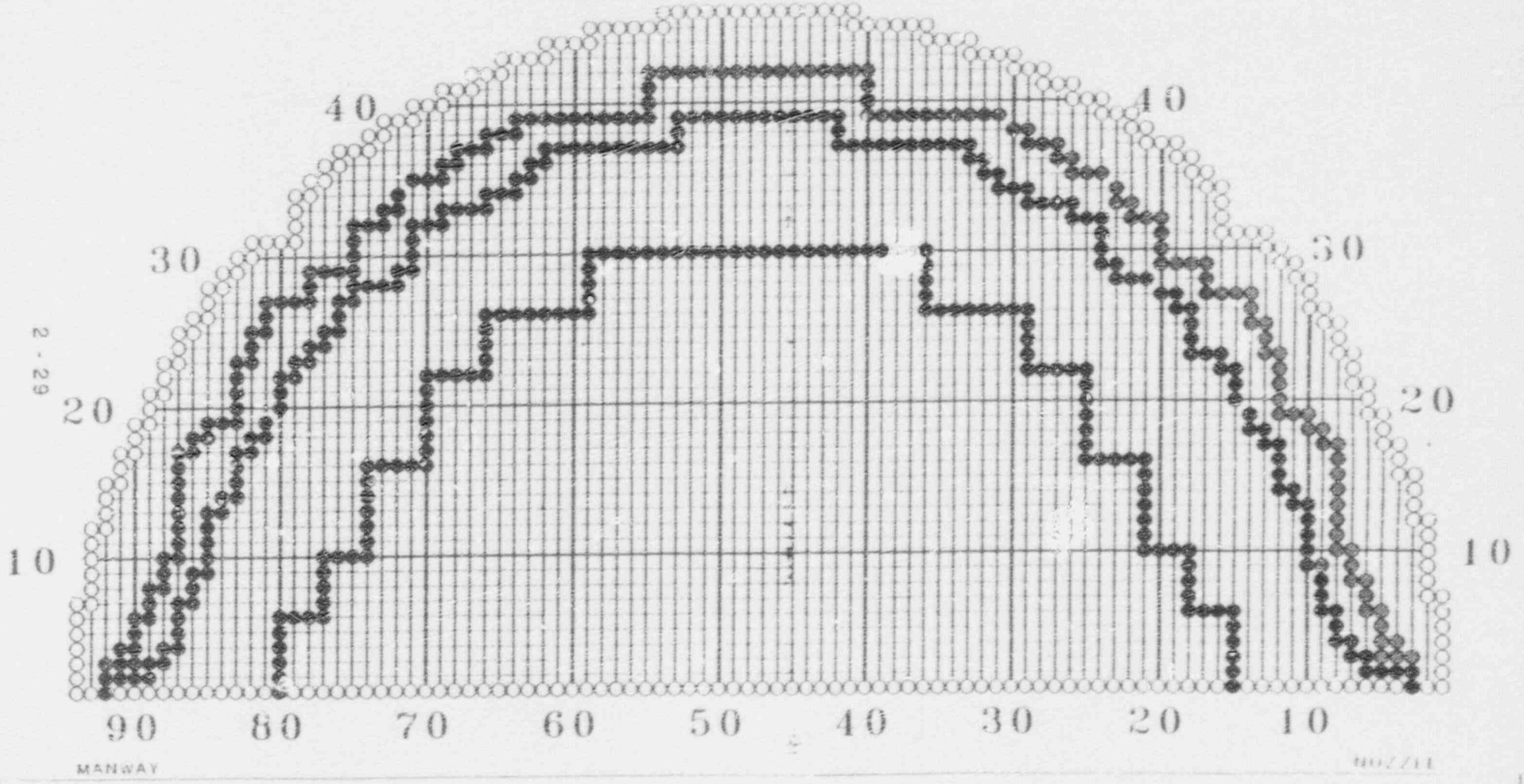
Zones also envelope crack propagation for circumferential indications at bottom of 1st TSP

- Turbulence initiation at [ ]b,c in Zone 1

Minimum angles for crack propagation in each zone apply to only a few tubes in the zone.

INSPECTION BOUNDARIES

BOUNDARY TUBE MAP



2-29

● TUBES FORMING BOUNDARY

ZONE 1 ZONE 2 ZONE 3 ZONE 4

Acceptable RPC Crack Angles for Tube Vibration

	WEXTEX PWSCC	TSP ODSCC(1)	
		TW Only	TW+ 50%(2)
Conservative TW Cracks			
o Peripheral Region	[		] b,c
- Turbulence			
- Fluidelastic			
o Central Region			
- Turbulence			
- Fluidelastic			
Expected Crack Morphology			
o PWSCC Segmented Cracks	[	] b,c	
- Turbulence			
- Fluidelastic			
o ODSCC Model			
- Peripheral:	[		] b,c
Turbulence			
Fluidelastic			
- Central:			
Turbulence			
Fluidelastic			

Notes:

1. Limiting crack angles at TSPs applicable to bottom of 1st TSP only. Higher elevations to bottom of top TSP require TW crack angles [ ] b,c evaluated for crack propagation due to vibration.
2. Throughwall crack [ ] a,c
3. Most limiting peripheral tube locations
4. ODSCC Model assumes [ ] a,c

Tube Vibration Assessment

WEXTEX Circumferential Indications

Crack propagation due to vibration does not occur for expected segmented PWSCC crack morphology even for [ ]^{b,c} crack network angles

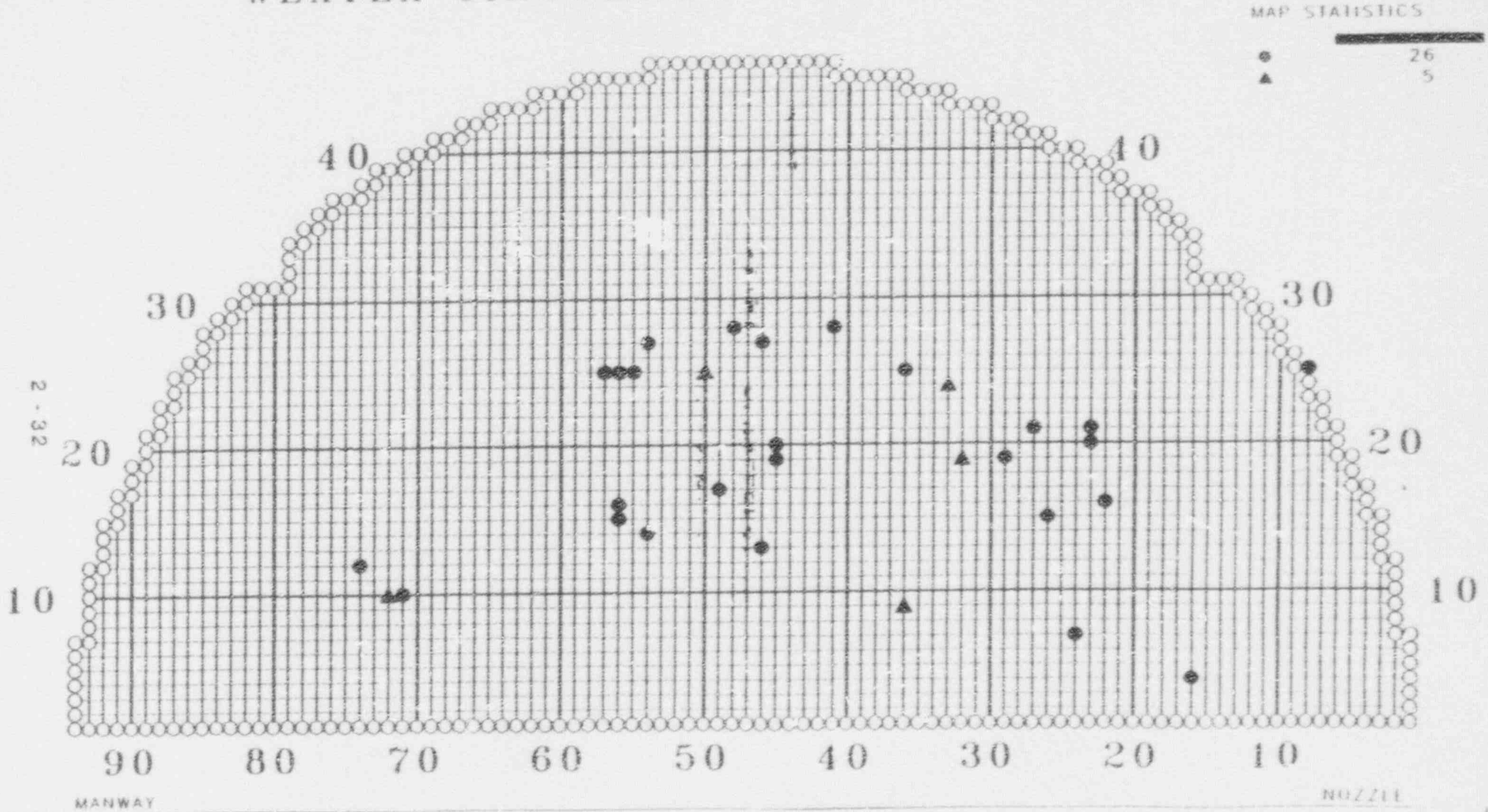
Largest Crack Angles

- Zone 1: S/G B, R25C8 - 157° (Field-142°)
  - Well defined crack angle ~107°
  - Possible TW angle [ ]^{b,c} minimum Zone 1 or [ ]^{b,c} at R25C8 necessary for turbulent crack propagation at this location
  - Only 1 WEXTEX circ. indication in Zone 1
- Zone 2: No circumferential indications
- Zone 3: S/G A, R21C23 - 118°
  - Two WEXTEX circ. indications in this zone have RPC crack angles [ ]^{b,c} minimum TW angle for crack propagation
- Zone 4: S/G B, R25C36 - 199°
  - All WEXTEX circ. indications in this zone have RPC crack angles [ ]^{b,c} minimum TW angle for crack propagation

Conclusion

- No WEXTEX indications subject to crack propagation due to tube vibration.

NORTH ANNA UNIT 1 ALL GENERATORS
WEXTEX CIRCUMFERENTIAL INDICATIONS



Tube Vibration Assessment

TSP Circumferential Indications

Potential for Crack Propagation Exists Only for TSP Circ. Indications at Bottom of 1st TSP

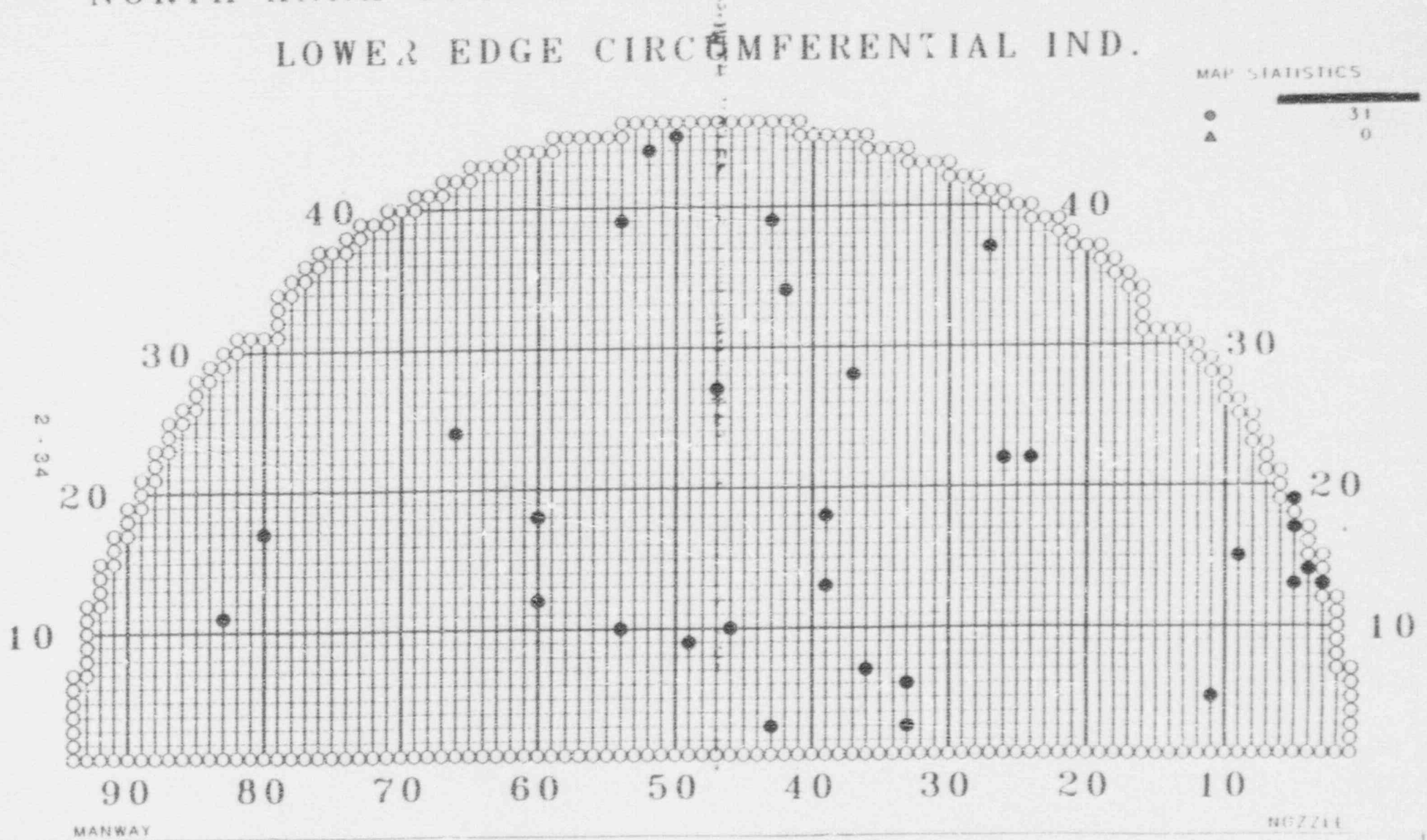
- No circumferential indications found above 5th TSP
- 31 circ. indications of bottom of 1st TSP

Largest Crack Angles at Bottom of 1st TSP

- Zone 1: S/G A, R45C50 - 167°
  - Well defined, deep crack angles ~93°
  - Possible TW angle [ ]b,c minimum in Zone 1 or [ ]b,c at R45C50 necessary for turbulent crack propagation
  - Remaining 6 circ. indications <104° RPC angle
- Zone 2: S/G B, R15C9 - 121°
  - All 3 indications in Zone 2 are [ ]b,c minimum TW crack necessary for propagation
- Zone 3: S/G C, R17C80 - 173°
  - All 6 indications in Zone 3 are [ ]b,c minimum TW crack necessary for propagation
- Zone 4: S/G A, R18C39 239°
  - All 15 indications in Zone 4 are [ ]b,c minimum TW crack analyzed for crack propagation

NORTH ANNA UNIT 1 ALL GENERATORS 2/27 DATA

LOWER EDGE CIRCUMFERENTIAL IND.



Tube Vibration Assessment
MCI and Mixed Mode

MCIs

- WEXTEX
  - All MCIs in Zone 4
  - No tube vibration concern even at sum of crack angles
- TSPs
  - No occurrences of MCIs at bottom of 1st TSP

Mixed Mode

- WEXTEX
  - No occurrences
- TSPs
  - No occurrences of circ. + axial at bottom edge of 1st TSP

EOC SLB Leakage Evaluation

Methods of Analysis Per WCAP-13034

[a,c]

EOC SLB Leakage

- 0.43 gpm: WEXTEX Circumferential
- 20.4 gpm: TSP Circumferential
- 3.40 gpm: TSP Axial
- 24.2 gpm: Total

North Anna-1 Tube Integrity Assessment

Overall Conclusions

Operation to End of Next Planned Operating Cycle (252 EFPD) is acceptable and meets R.G. 1.121 Guidelines

Tube Burst Requirements ($3\Delta P$) are met at EOC for SCIs, MCIs and potential mixed mode considerations

The potential for propagation of circumferential cracks due to tube vibration is negligible

Growth Rates of circumferential cracks are modest

- Average of 21^{o}-26^{o} per 18 month cycle

The estimated EOC SLB leak rate is ~24 gpm

- 100% RPC inspection at TSPs likely to reduce TSP indications and potential leakage for next cycle

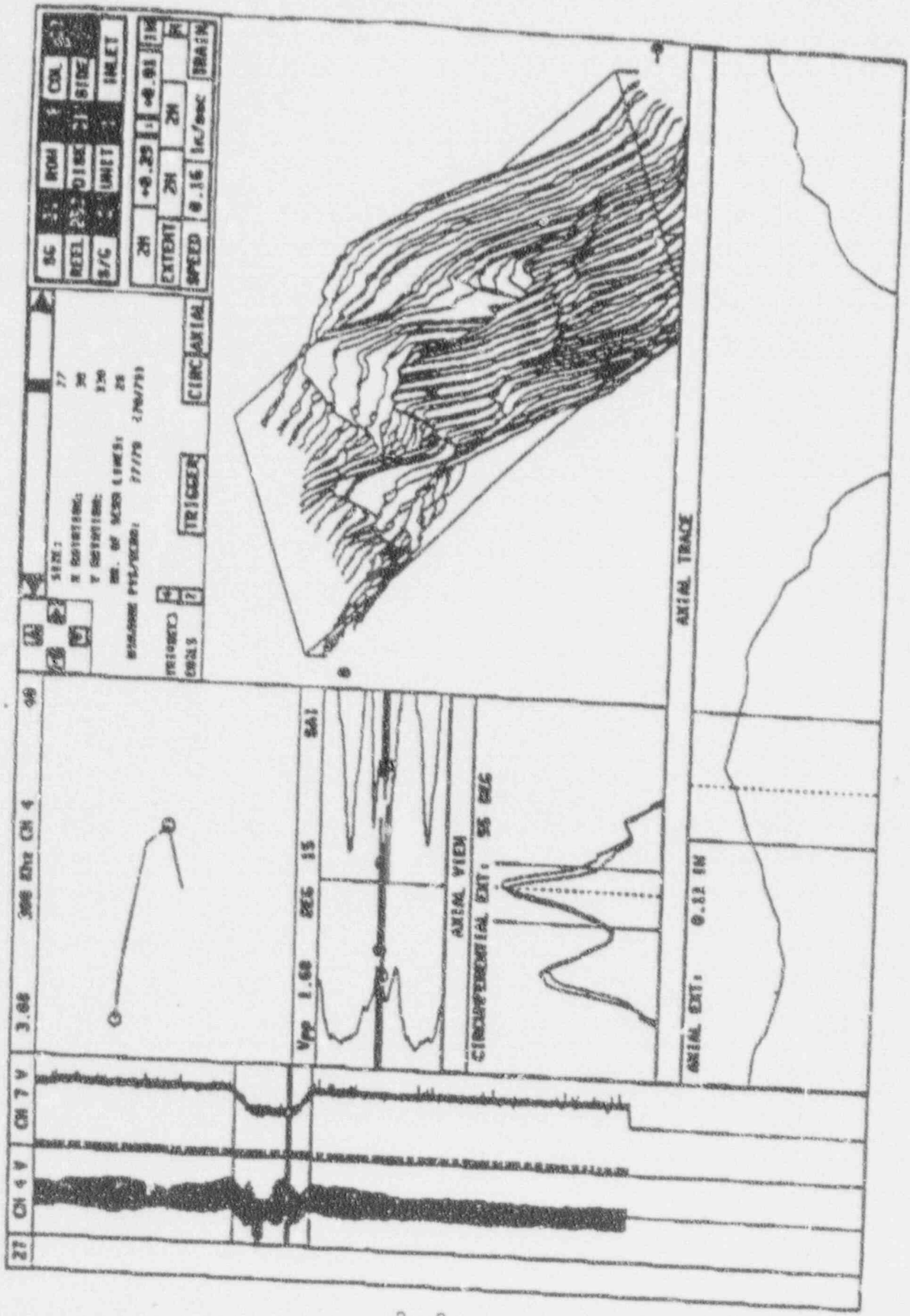
North Anna Unit 1
Steam Generator Mid-Cycle Inspection Outage
NRC Startup Approval Meeting

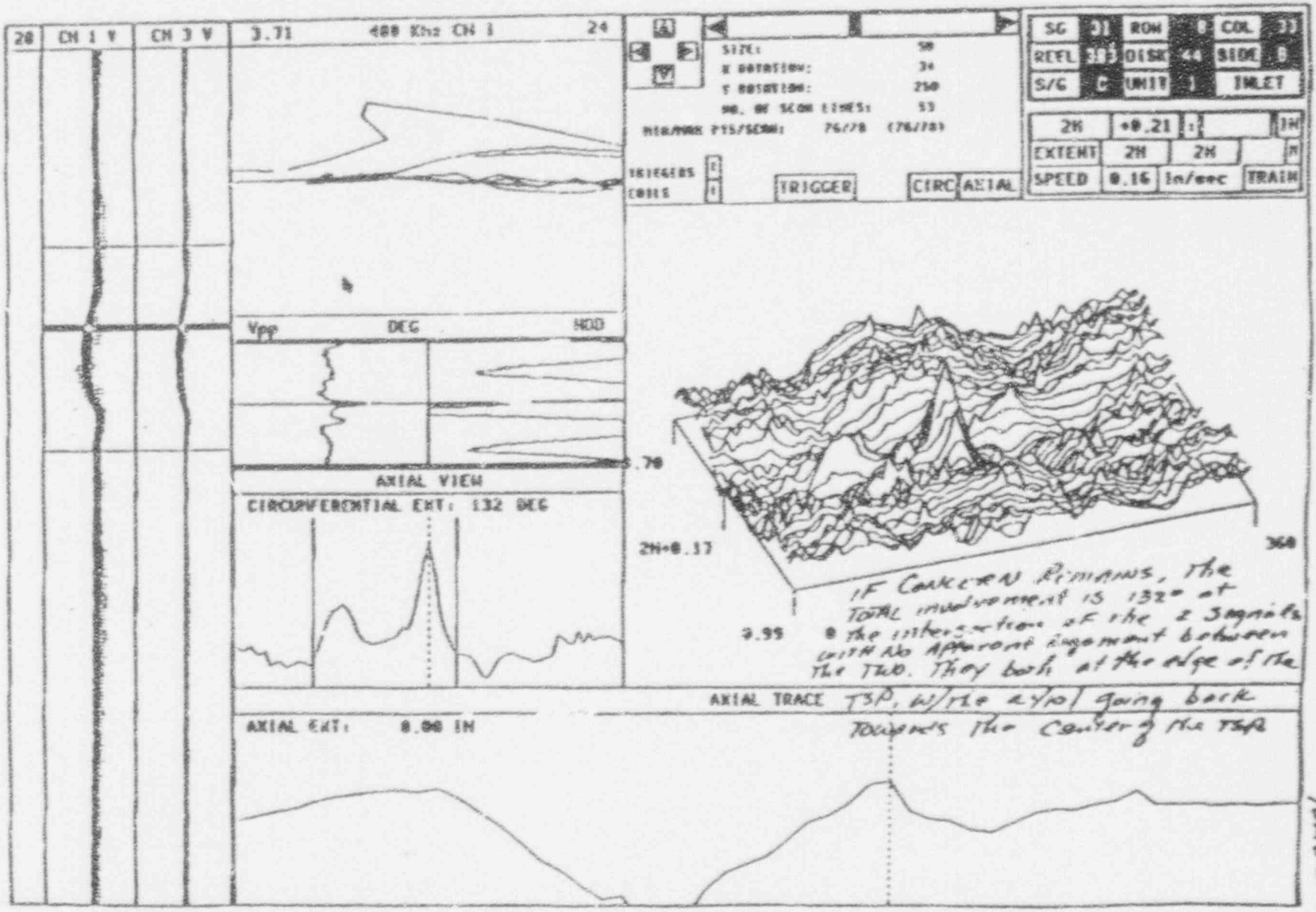
March 2, 1992

Westinghouse

Supplemental Information Package

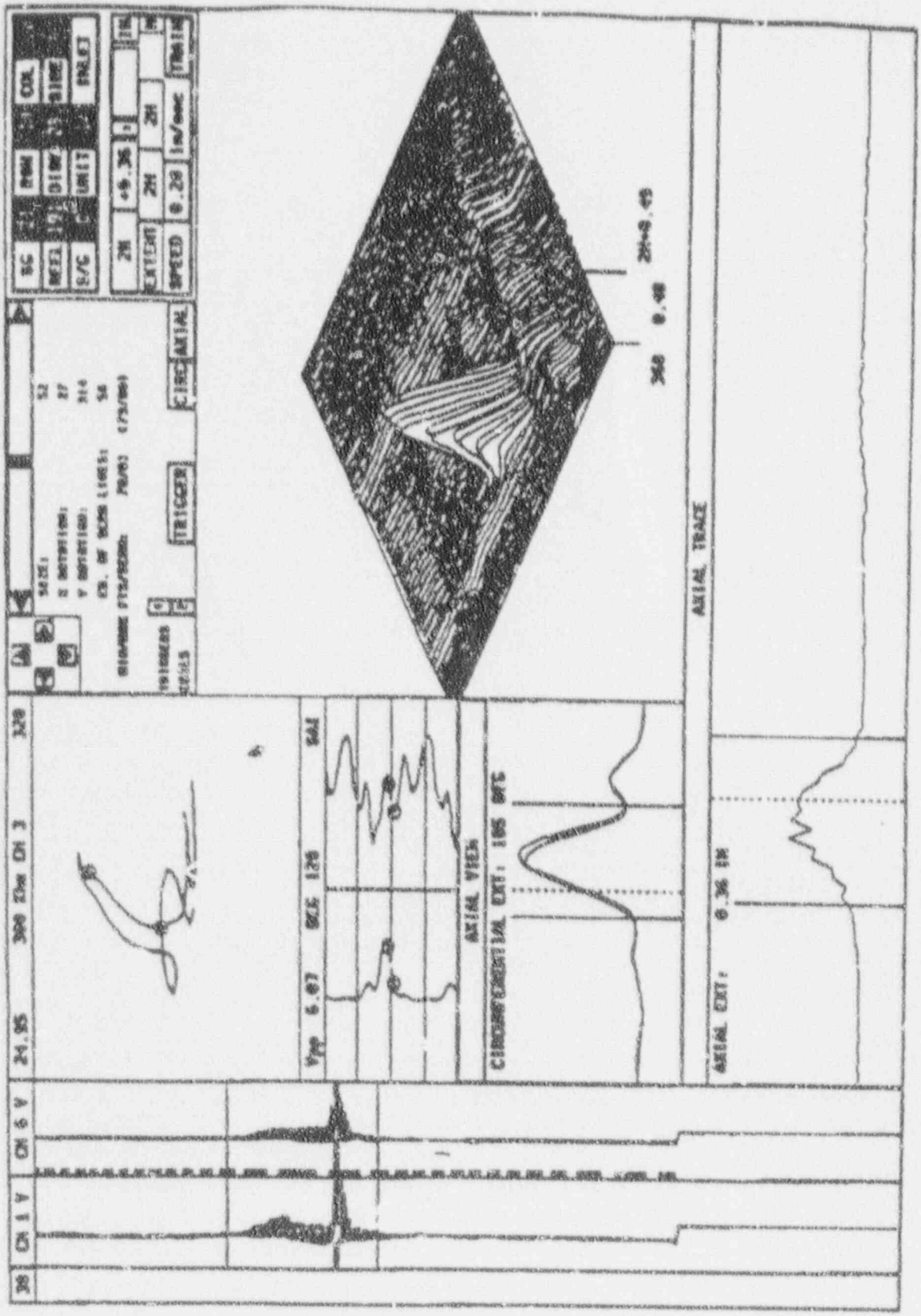
NORTH ANNA_____ 01/29/92 INLET UNIT. 1_ SG: C R _L: 253 PRI

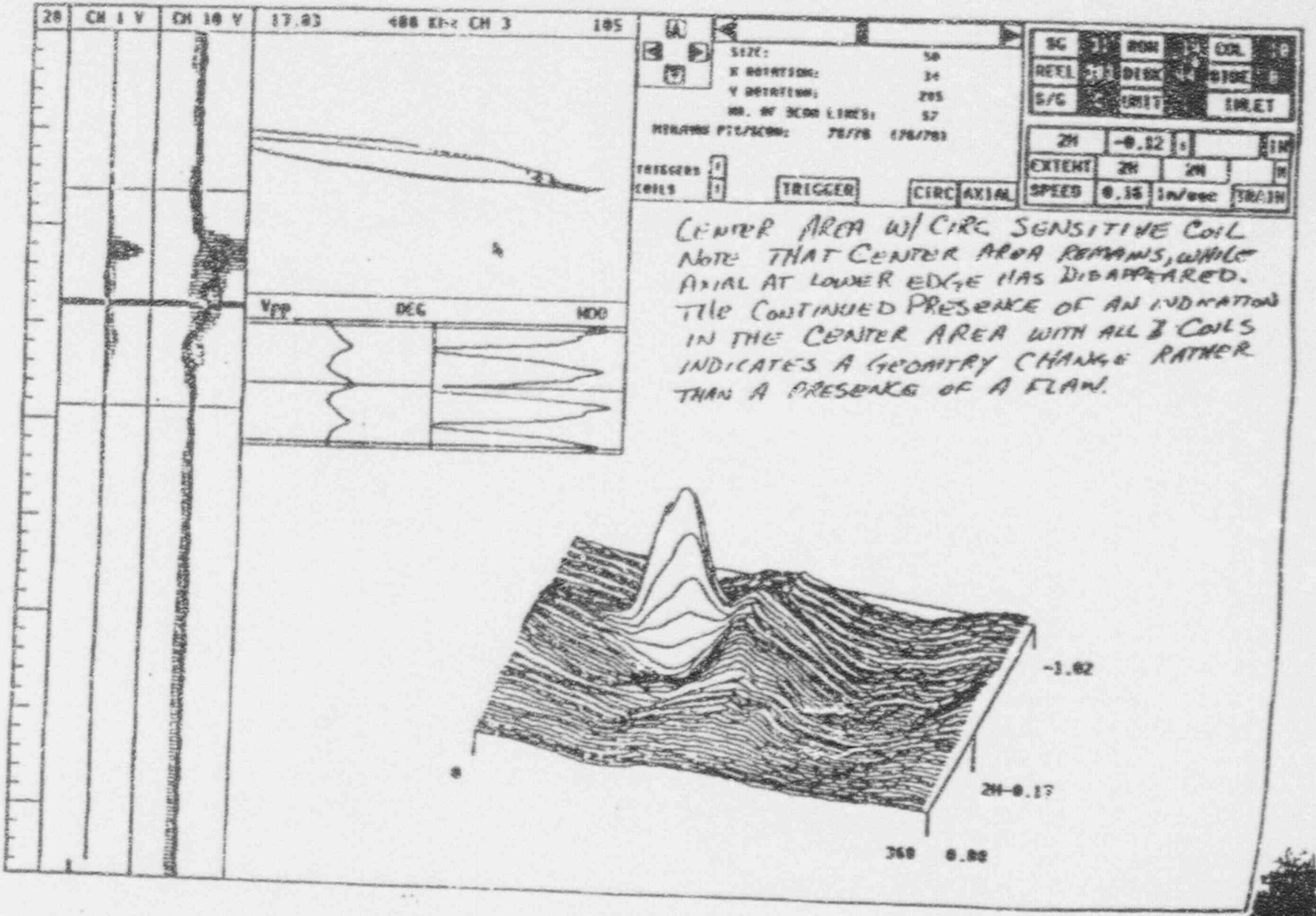



28
CH 1 V
CH 3 V
3.71
488 Khz CH 1
24
SIZE:
50
X ROTATION:
34
Y ROTATION:
250
NO. OF SCAN LINES:
53
76/78
(76/78)
TRIGGERS
COILS
TRIGGER
CIRC
AXIAL
SG
01
ROW
0
COL
33
REEL
333
DISK
44
SIDE
0
S/G
C
UNIT
1
INLET
2H
+0.21
1H
EXTENT
2H
2H
H
SPEED
0.16
in/sec
TRAIN
Vpp
DEG
HOD
.70
AXIAL VIEW
CIRCUMFERENTIAL EXT: 132 DEG
2H+0.17
360
0.99
IF CORROSION REMAINS, THE
TOTAL involvement IS 132° at
the intersection of the 2 signals
WITH NO APPARENT segment between
THE TSP. They both at the edge of the
AXIAL TRACE TSP, W/the a/p/ going back
AXIAL EXT: 0.00 IN
Represents the Center of the TSP

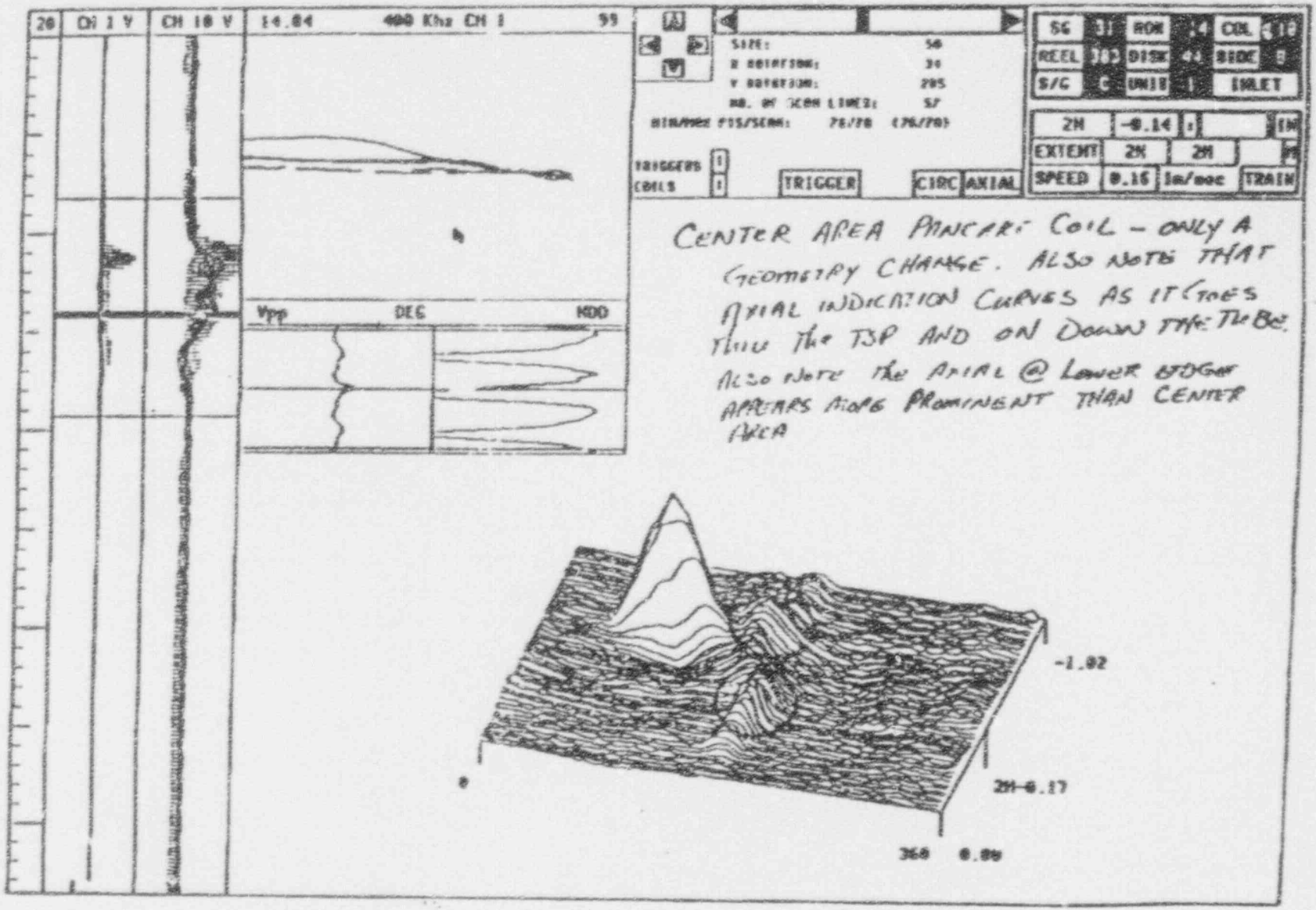
PS 4 Remarks

NORTH ANNA_____ 01/19/92 INLET UNIT: 1_ SG: C REEL: 191 SEC





CENTER AREA W/ CIRC SENSITIVE COIL NOTE THAT CENTER AREA REMAINS, WHILE AXIAL AT LOWER EDGE HAS DISAPPEARED. THE CONTINUED PRESENCE OF AN INDICATION IN THE CENTER AREA WITH ALL 3 COILS INDICATES A GEOMETRY CHANGE RATHER THAN A PRESENCE OF A FLAW.

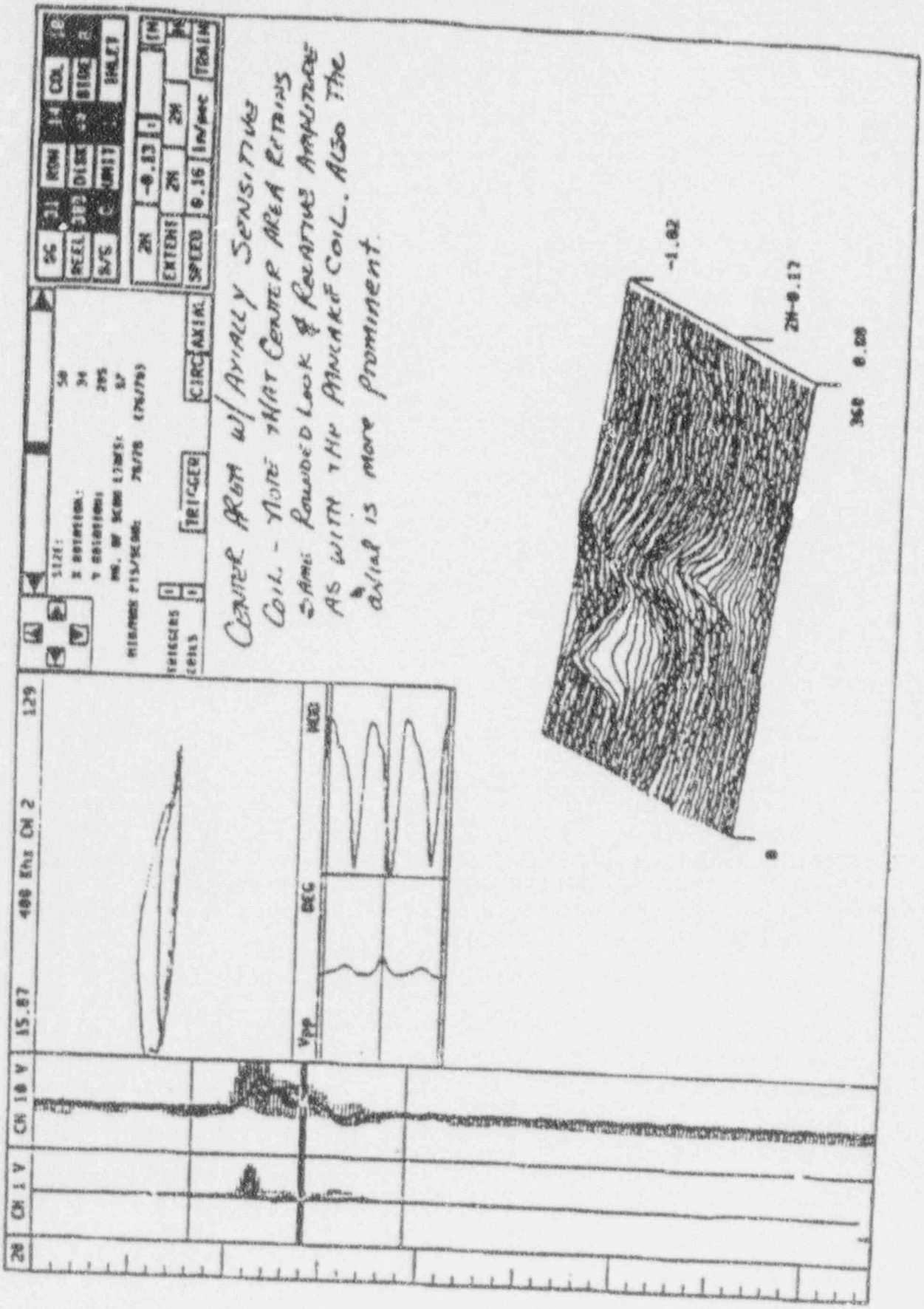


CENTER AREA PANCAKE COIL - ONLY A GEOMETRY CHANGE. ALSO NOTE THAT AXIAL INDICATION CURVES AS IT GOES THRU THE TSP AND ON DOWN THE TUBE. ALSO NOTE THE AXIAL @ LOWER EDGE APPEARS MORE PROMINENT THAN CENTER AREA

02/19/92 INLET UNIT: 1 SG: C REEL: 383 PRI

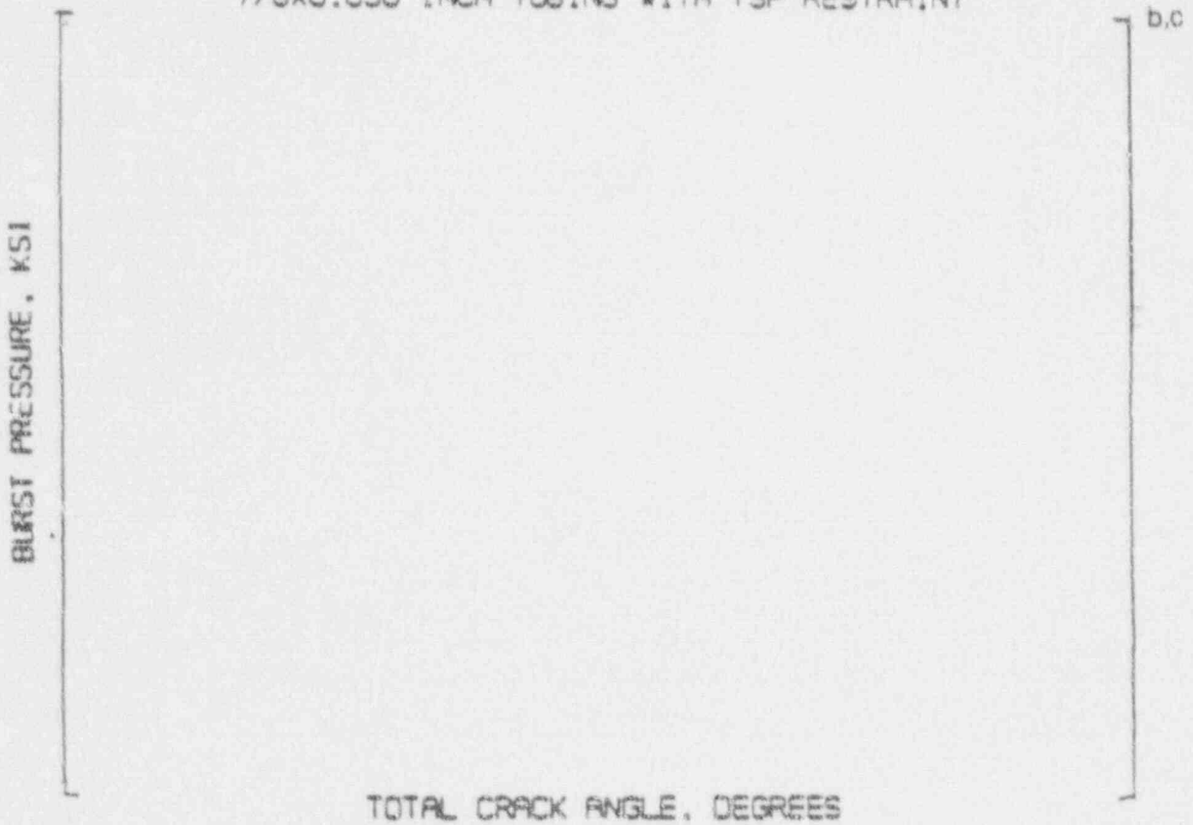
3.6

NORTH ANNA_____ 03/19/92 INLET UNIT: 1_ SG: C REEL: 383 PRI



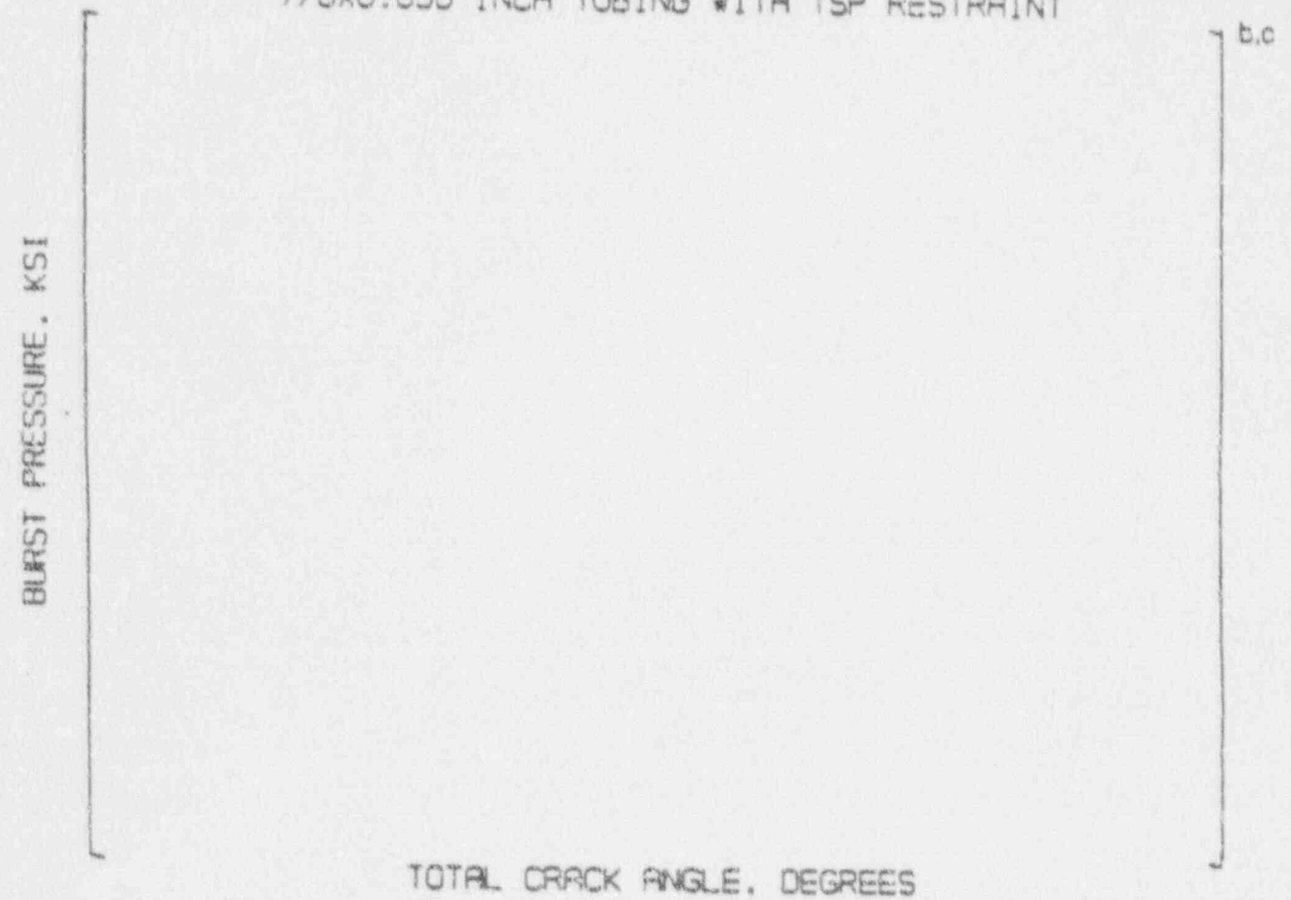
BURST PRESSURE VERSUS TOTAL CRACK ANGLE

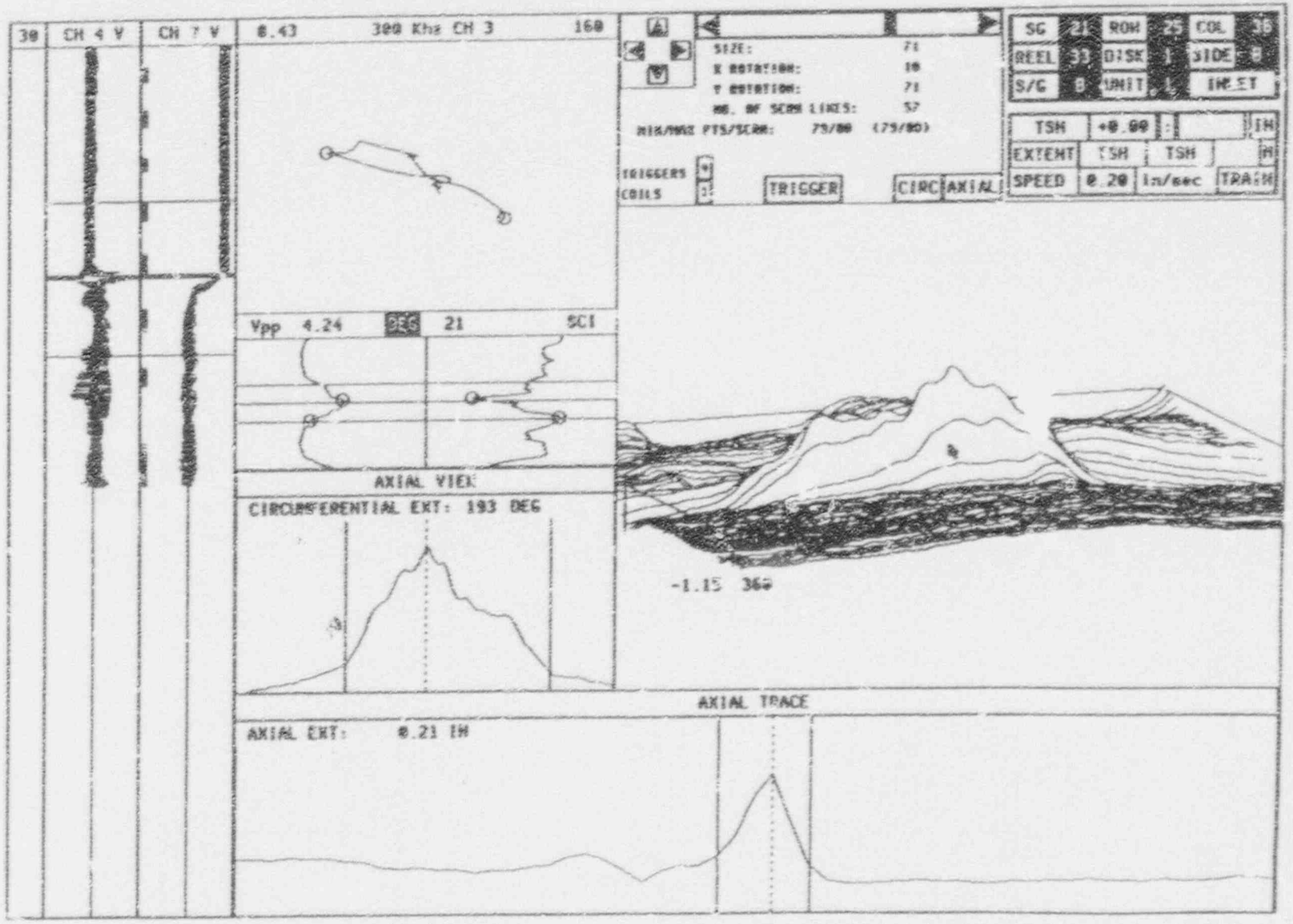
7/8X0.050 INCH TUBING WITH TSP RESTRAINT



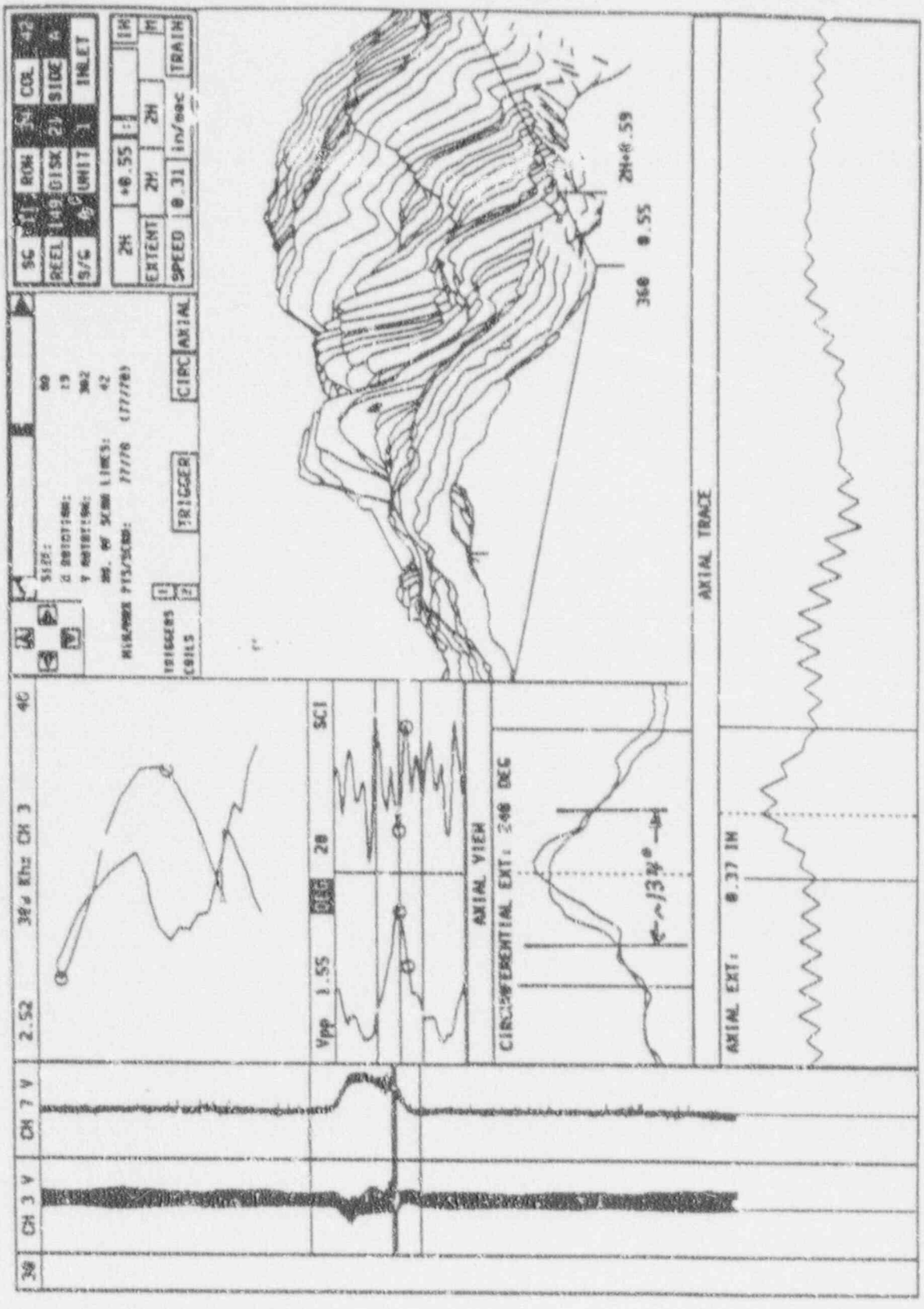
BURST PRESSURE VERSUS TOTAL CRACK ANGLE

7/8X0.050 INCH TUBING WITH TSP RESTRAINT




39
CH 4 V
CH 7 V
8.43
300 Khz CH 3
160
SIZE:
71
X ROTATION:
18
Y ROTATION:
71
NO. OF SCAN LINES:
57
MIN/MAX PTS/SCAN:
79/80 (79/80)
TRIGGERS
COILS
TRIGGER
CIRC
AXIAL
SG
21
ROW
25
COL
36
REEL
33
DISK
1
SIDE
0
S/G
8
UNIT
1
INLET
TSH
+0.00
IN
EXTENT
TSH
TSH
IN
SPEED
0.20
in/sec
TRAIN
Vpp 4.24
DEG
21
SCI
AXIAL VIEW
CIRCUMFERENTIAL EXT: 193 DEG
-1.15
360
AXIAL TRACE
AXIAL EXT:
0.21 IN

NORTH ANNA_____ 01/18/92 INLET UNIT: 1_ SG: A REEL: 149 PRI



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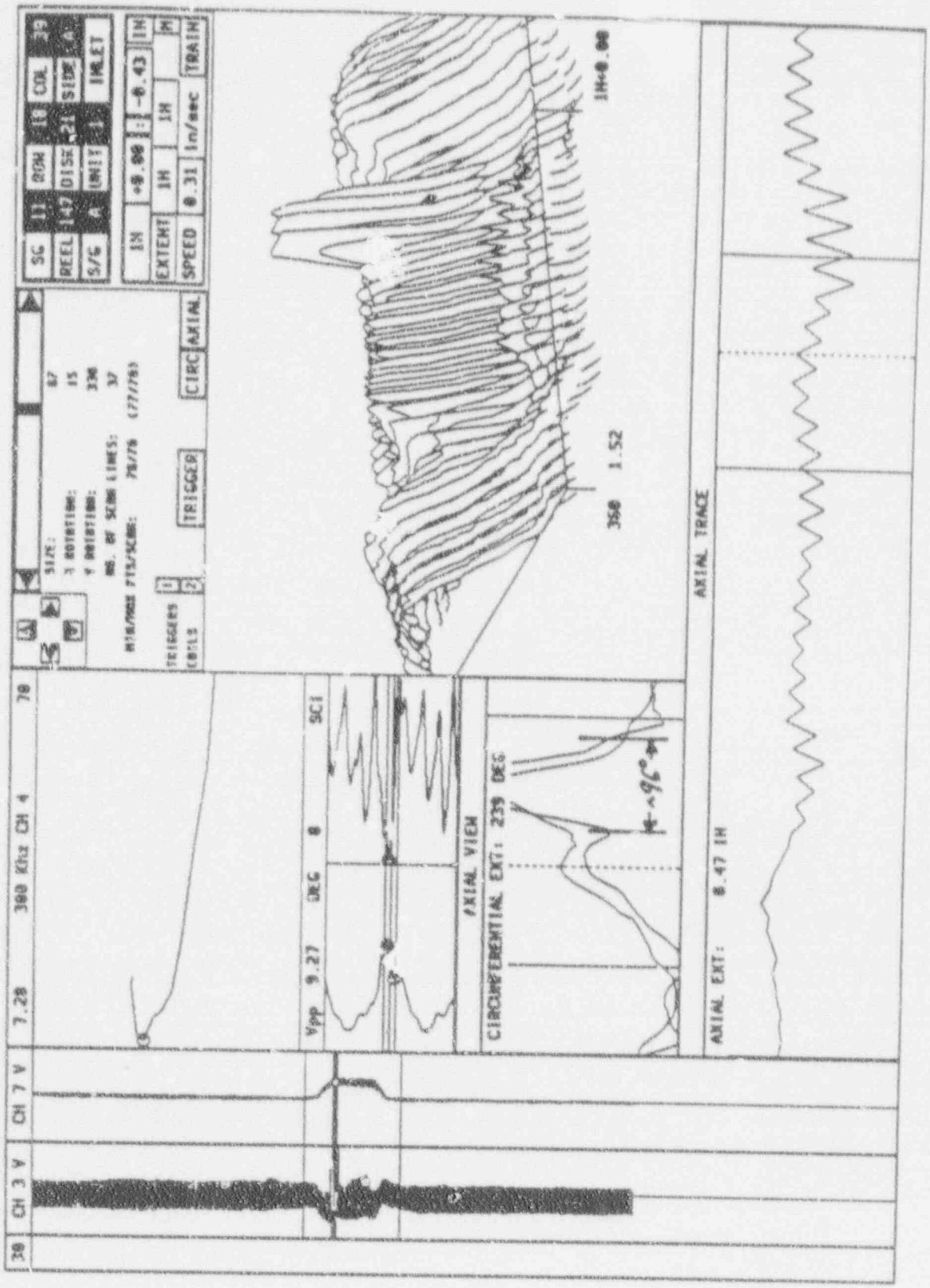

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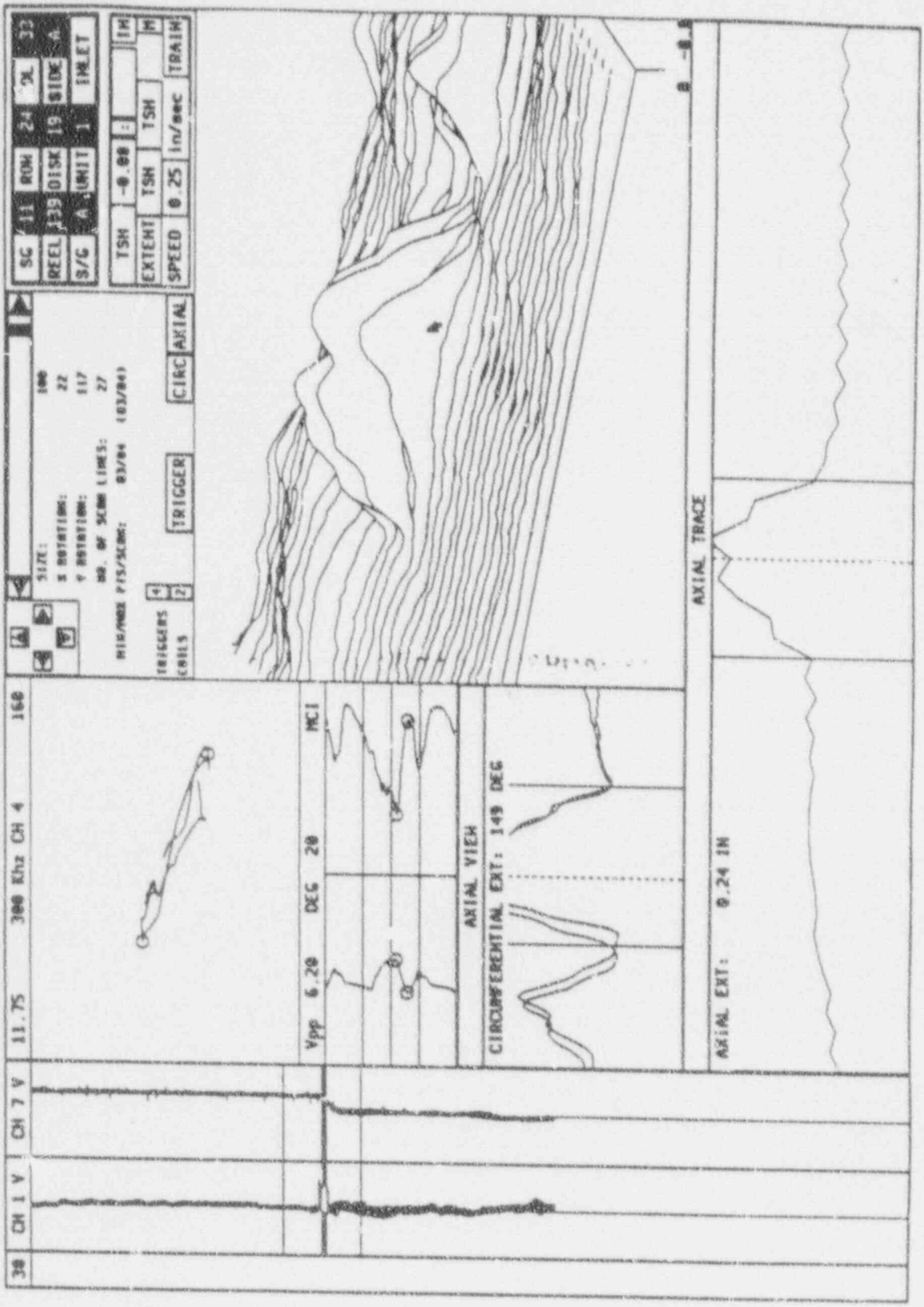

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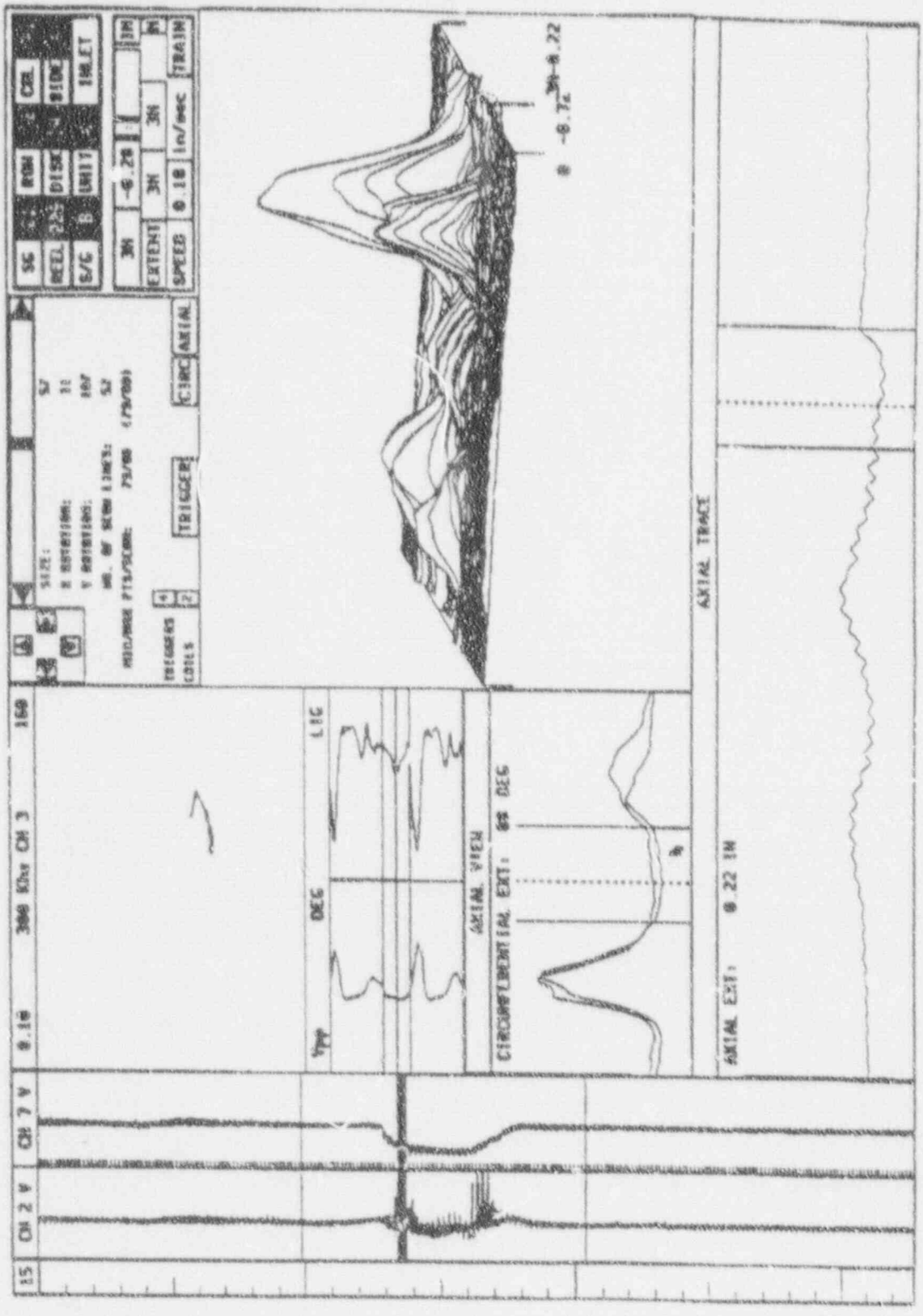

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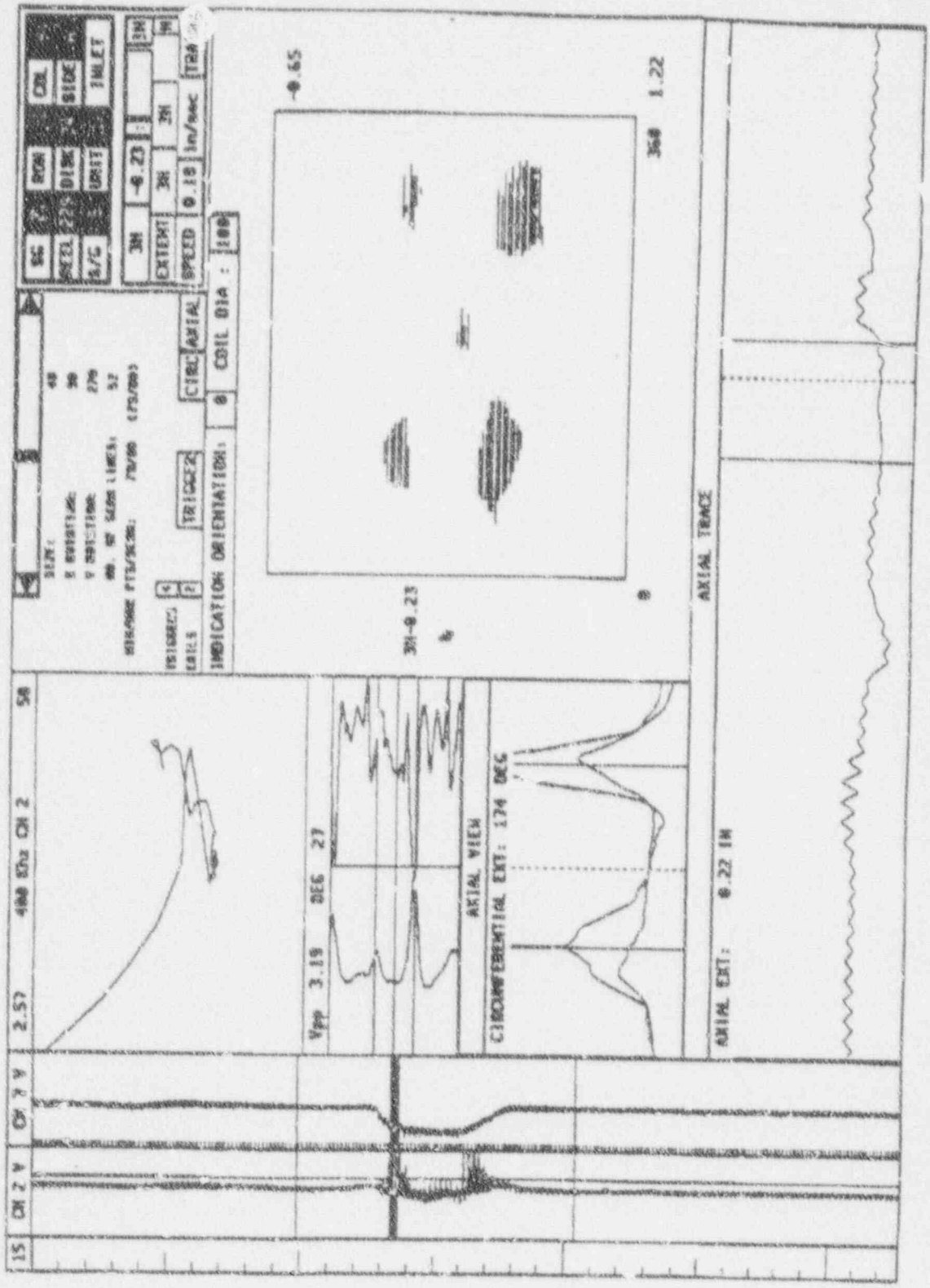

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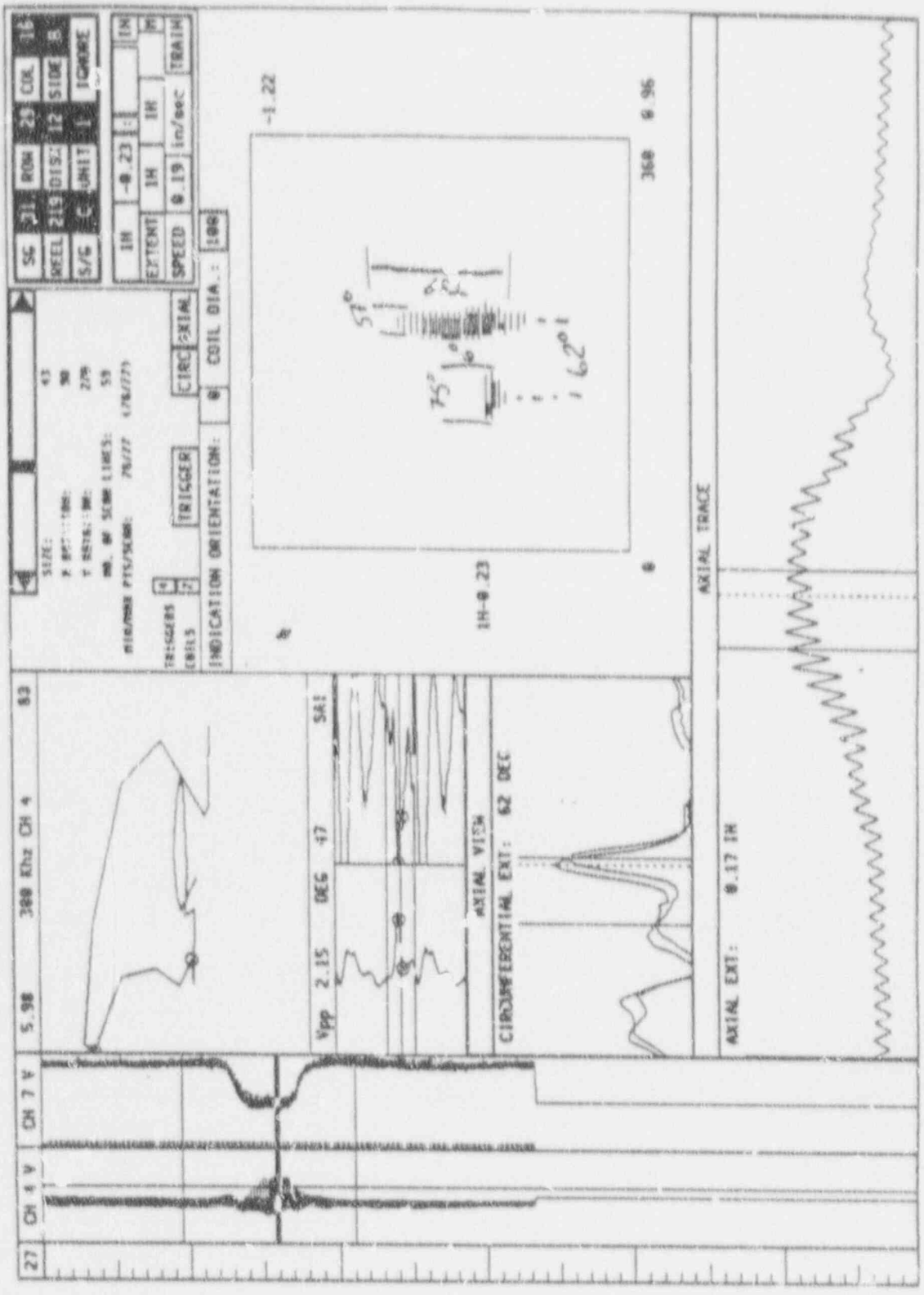

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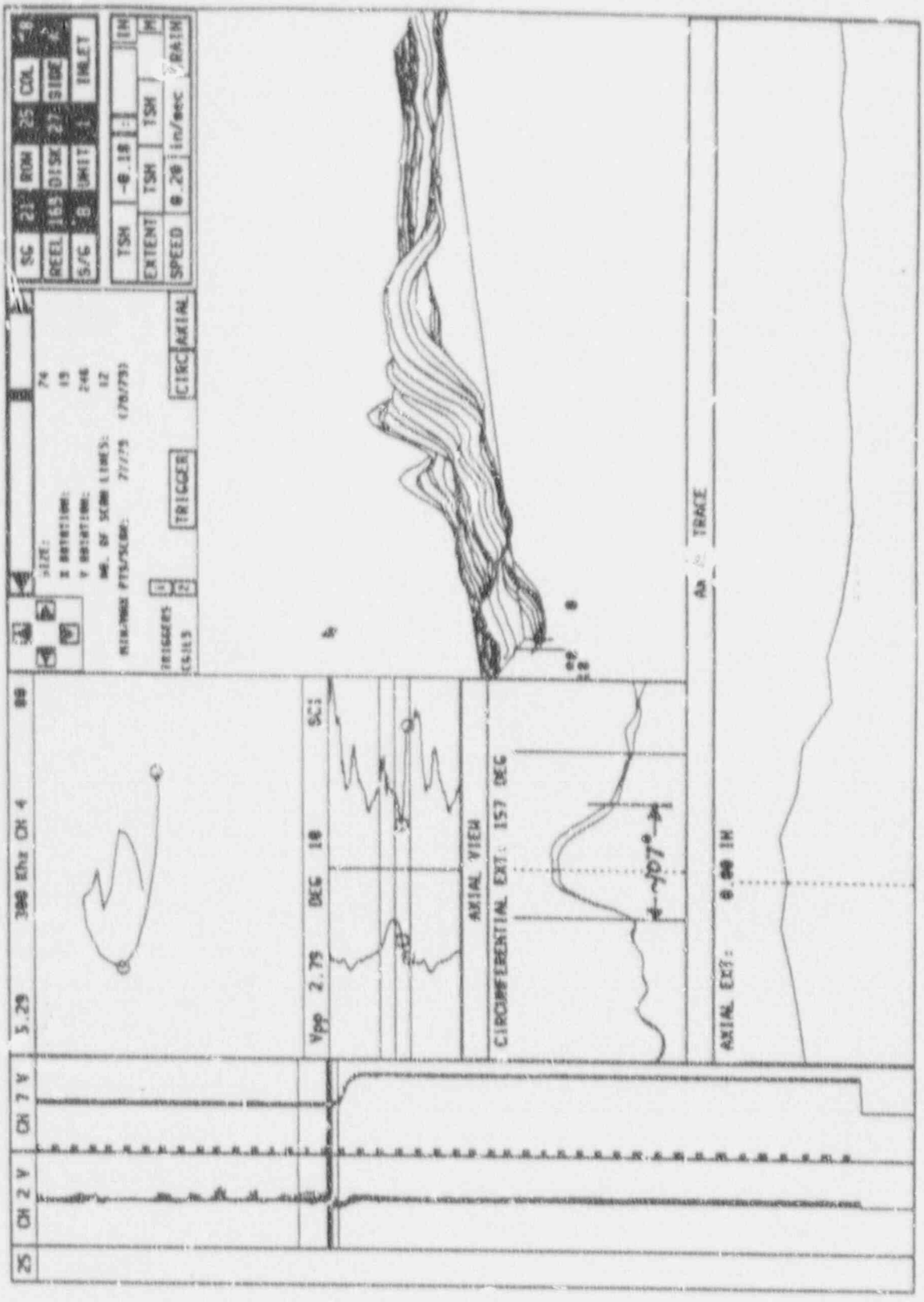

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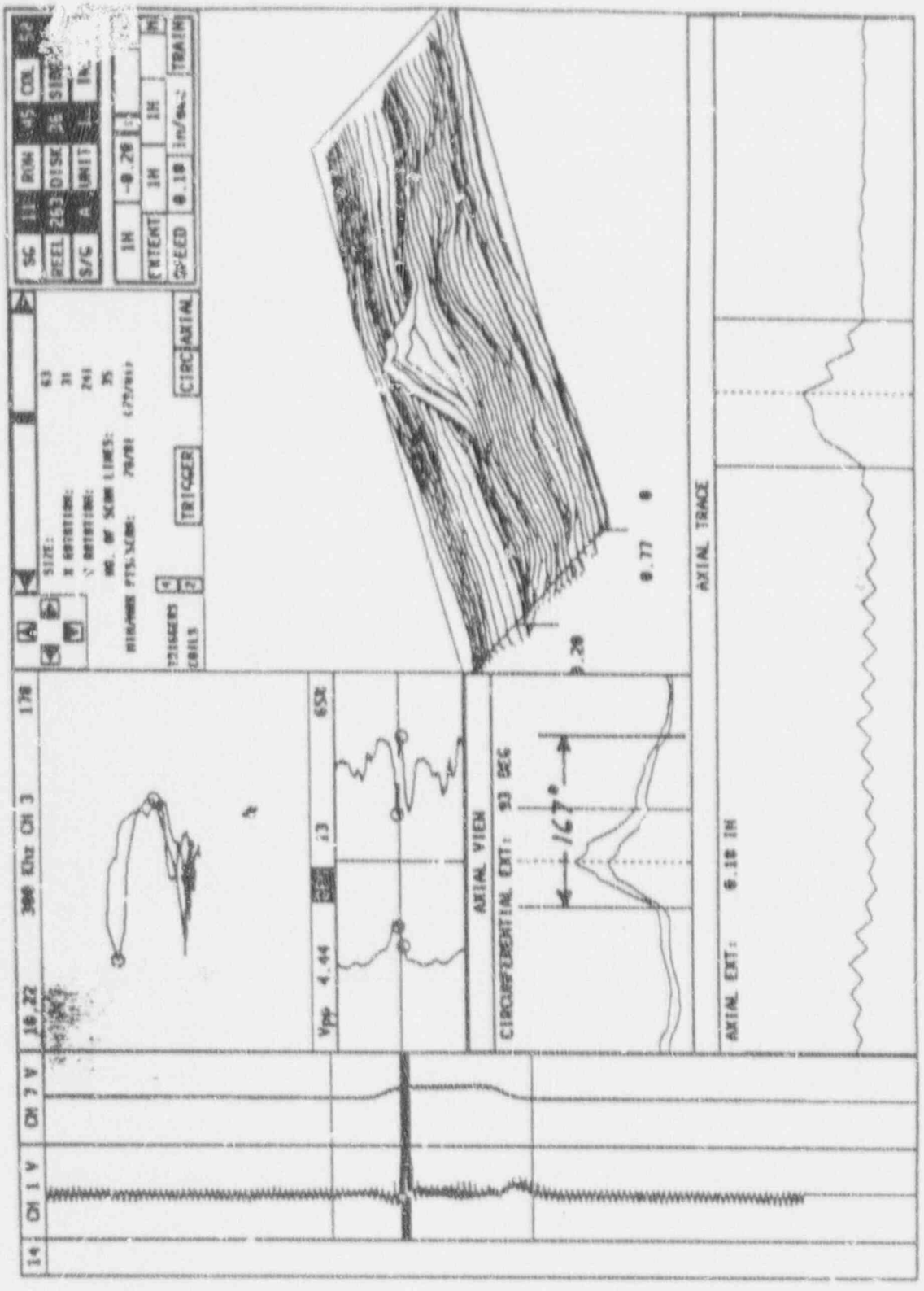

LEAK RATE VERSUS CIRCUMFERENTIAL CRACK ANGLE

SEGMENTED CRACKS IN 7/8X0.050" TUBING