ENCLOSURE

SEQUOYAH NUCLEAR PLANT

TVA INNER RADIUS U-BEND PROGRAM

TVA Inner Radius U-Bend Meeting Agenda

Introduction and Review of Row 1 U-Bend Problem.
David F. Goetcheus (TVA)

Overview of TVA Inner Radius U-Bend Program.
David F. Goetcheus (TVA)

Evaluation of Sequoyah U-2 Row 1 Tubing (Manufactured by Westinghouse and Huntington Alloys) Mechanical Properties Compared to Mechanical Properties Associated with Failed Inner Radius Tubes.
David F. Goetcheus (TVA)

Quantitative Assessment of Stresses Associated with Row 1 U-Bend Tube Failures.
J. Ed Wilson (TVA)

Review of Calibration Tubes Simulating Variations of "Opposite Side Transitions" Defects Associated with Row 1 U-Bend Leakage.
David F. Goetcheus (TVA)

Eddy Current Testing to Characterize Sequoyah U-2 Row 1 U-Bends to Determine the Presence and Degree of "Opposite Side Transition" Defects and Baseline Eddy Current Test.
Shozo Narita (C&L Eng. TVA Contractor)

Summary of TVA Inner Radius Program.
David F. Goetcheus (TVA)

INTRODUCTION AND REVIEW OF ROW 1 U-BEND PROBLEM

DAVID F. GOETCHEUS (TVA)

STEAM GENERATOR EXPERIENCE

ROW 1 U-BEND LEAKAGE

Leakage in Row 1 U-Bend sections has occurred in two locations:

1. Apex
2. Tangent

Apex Leaks

Three plants.

One dent-related: hourglassing, leg displacement (140 gpm).

Two in tubes manufactured by Mannesman (up to 150 gpm).

Tangent Le s

Six plants with tangent leaks; all 51 series steam generators.

Leakage starts very low (~10 gpd).

Maximum leakage ~ 0.7 gpm

With one exception (Surry #2 - Apex leak), denting is not an influence in the occurrence of U-Bend leakage.

DDM

12/10/80

ROW 1 U-BEND LEAKS HAVE OCCURRED IN EIGHT PLANTS DURING RECENT YEARS

PLANT	YEAR	LOCATION
FARLEY 1	1978, 1980	TANGENT
RINGHALS 2	1979, 1980	TANGENT
DOEL 2	1979	APEX
TAKAHAMA #1	1977, 1978, 1980	TANGENT
TROJAN	1978, 1979, 1980	TANGENT
NORTH ANNA 1	1979	TANGENT
BEZNAU 2	1980	UNKNOWN
COOK 2	1980	NOT CONFIRMED

Nov. 3 1980

Dwg. ?235A ?7

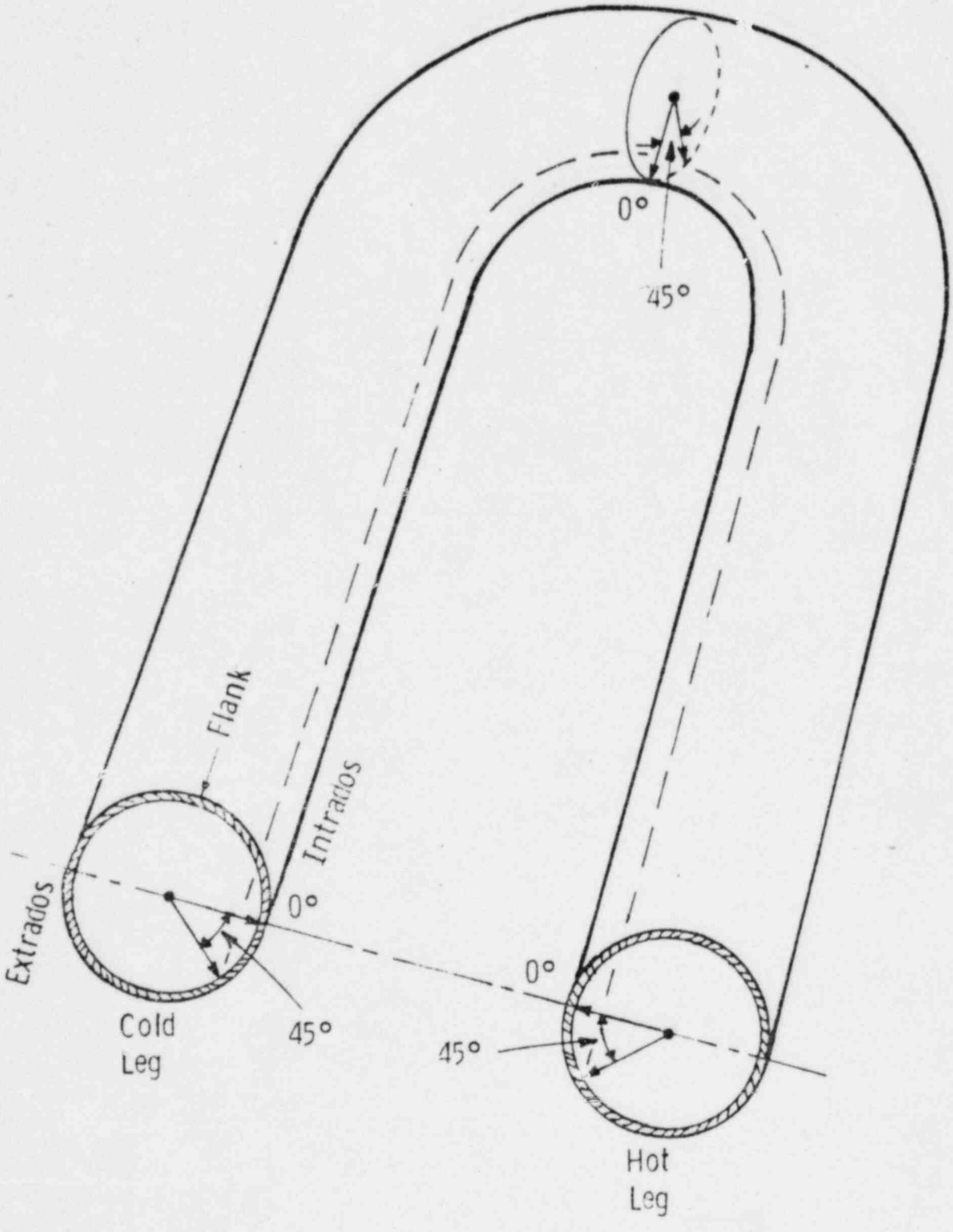
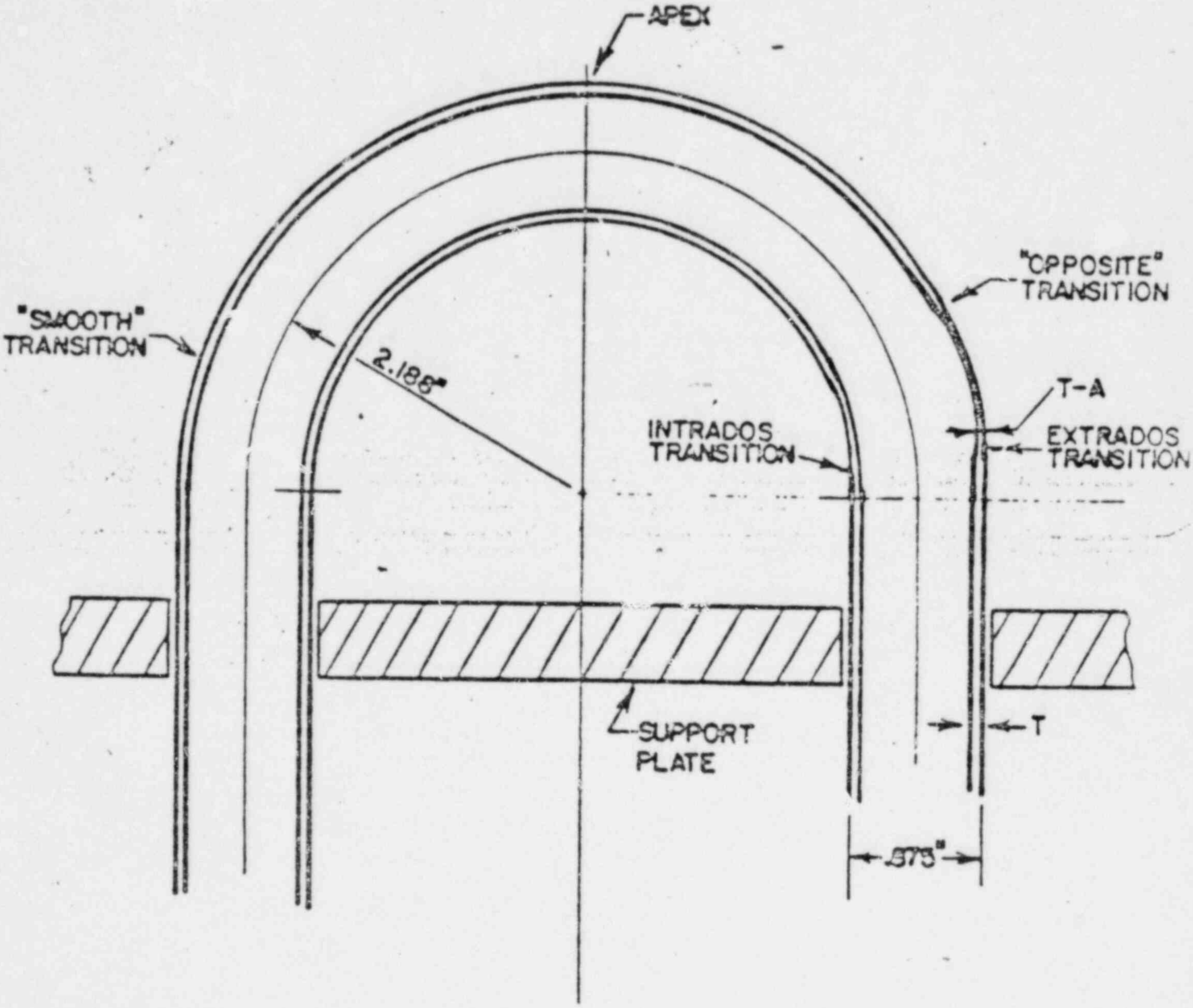
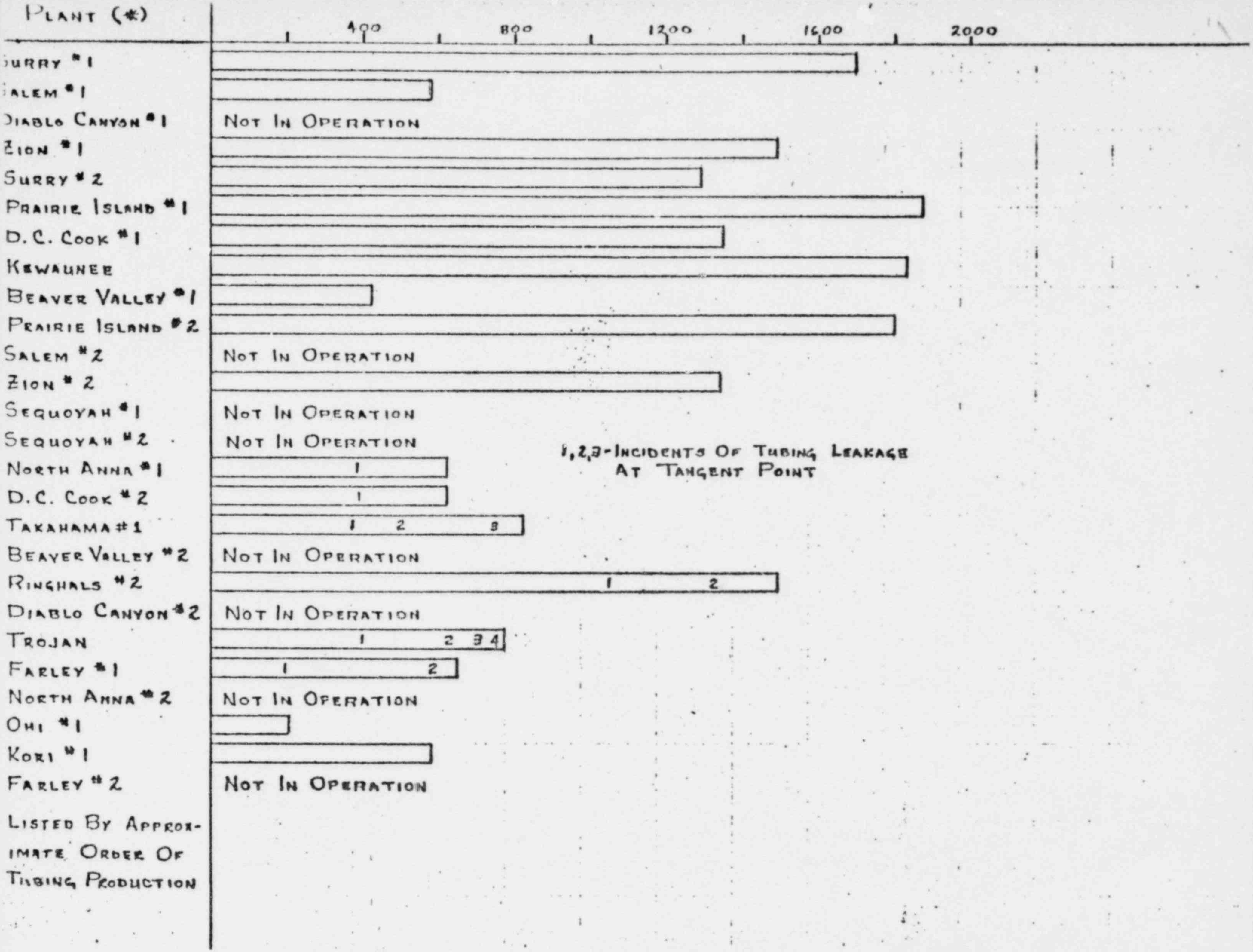


Fig. — Definition of angular positions



T = .050" NOM. WALL
A = .010"
= .007"
= .005"
= .003"



(*) Listed By Approximate Order Of Tubing Production

ROW 1 U-BEND LEAKAGE
EXPERIENCE SUMMARY

All tangent point leakers have occurred in Series 51 steam generators (SG's).

Tangent point leakage has been confirmed in 3 domestic plants (6 of 10 SG's) of 14 plants in commercial operation (45 SG's). A leak in another plant has not been confirmed to have occurred in the tube with a Row 1 tangent point EC indication.

Tangent point leakage in domestic plants has been well below Tech. Spec. allowable limits; none higher than 0.1 gpm. Maximum observed tangent point leakage 0.7 gpm.

The population experiencing tangent point leakage occurred in tubes in SG's shipped in 1972...

First leakage events have occurred after approx. 400 effective full power days operation. (Exception: Ringhals 2 @1050 EFPD but 216/282 Row 1 tubes were plugged at approx. 420 EFPD).

SUMMARY OF REVIEW OF TUBE MANUFACTURING RECORDS

1. PLANT EXPERIENCE SHOWS CERTAIN SETS OF TUBES, MANUFACTURED BY W, HAVE SHOWN LEAKAGE IN SOME HEATS OF MATERIAL.

2. CERTAIN HEATS APPEAR MORE SUSCEPTIBLE TO U-BEND LEAKAGE THAN THE GENERAL POPULATION, AND ARE CHARACTERIZED, STATISTICALLY, WITH HIGHER YIELD STRENGTHS AND HARDNESS VALUES.

3. MODELS 44, D and F TUBING REPRESENT POPULATIONS WHICH, STATISTICALLY, DIFFER FAVORABLY FROM THE AFFECTED MODEL 51 HEATS.

4. THE STATISTICAL ANALYSES ARE NOT INTENDED AS A MEANS FOR SPECIFIC TUBE DISCRIMINATION BUT ONLY AS A DIAGNOSTIC TOOL TO HELP EXPLAIN THE PHENOMENON.

Plant	S/G No.	Tubing Supplier	Set No.
PNT: Salem Unit 2	1201	SMD	28,29,30
	1202	SMD	28,29,30,31
	1203	Row 1: HAPD, SMD (27 tubes)	30,31
		Row 2: HAPD, SMD (22 tubes)	30,31
	1204	SMD	28,32,33
TVA: Sequoyah Unit 1	1221	SMD	34,37,38
	1222	SMD	31,32,35,37,38, 39,40
	1223	SMD	31,32,40,41
	1224	SMD	37,38,39,40,41
TEN: Sequoyah Unit 2	1321	SMD	29,31,39,40, 41,42
	1322	SMD	39,41,42,43,44
	1323	Row 1: HAPD, SMD (24 tubes)	35,39,41,42
		Row 2: HAPD	-
	1324	HAPD	-
VPA: Surry Unit 1	1021	HAPD	-
	1001	HAPD	-
	1002	HAPD	-
VIR: Surry Unit 2	1063	SMD	16
	1081	HAPD	-
	1082	SMD	18

GEOMETRIC CONCERNS

RELATED TO ROW 1 U-BEND LEAKAGE

Apex leakage shows some correlation with tube ovality.

Surry 2 > 12%
Doel 2 > 15%
Obrigheim

Tangent point leakage and indications appear related to presence of "opposite" transition at extrados tangent.

Trojan - laboratory examinations
Eddy current data interpretation from Trojan, North Anna #1, Farley #1, Cook #2

DDM
12/10/80

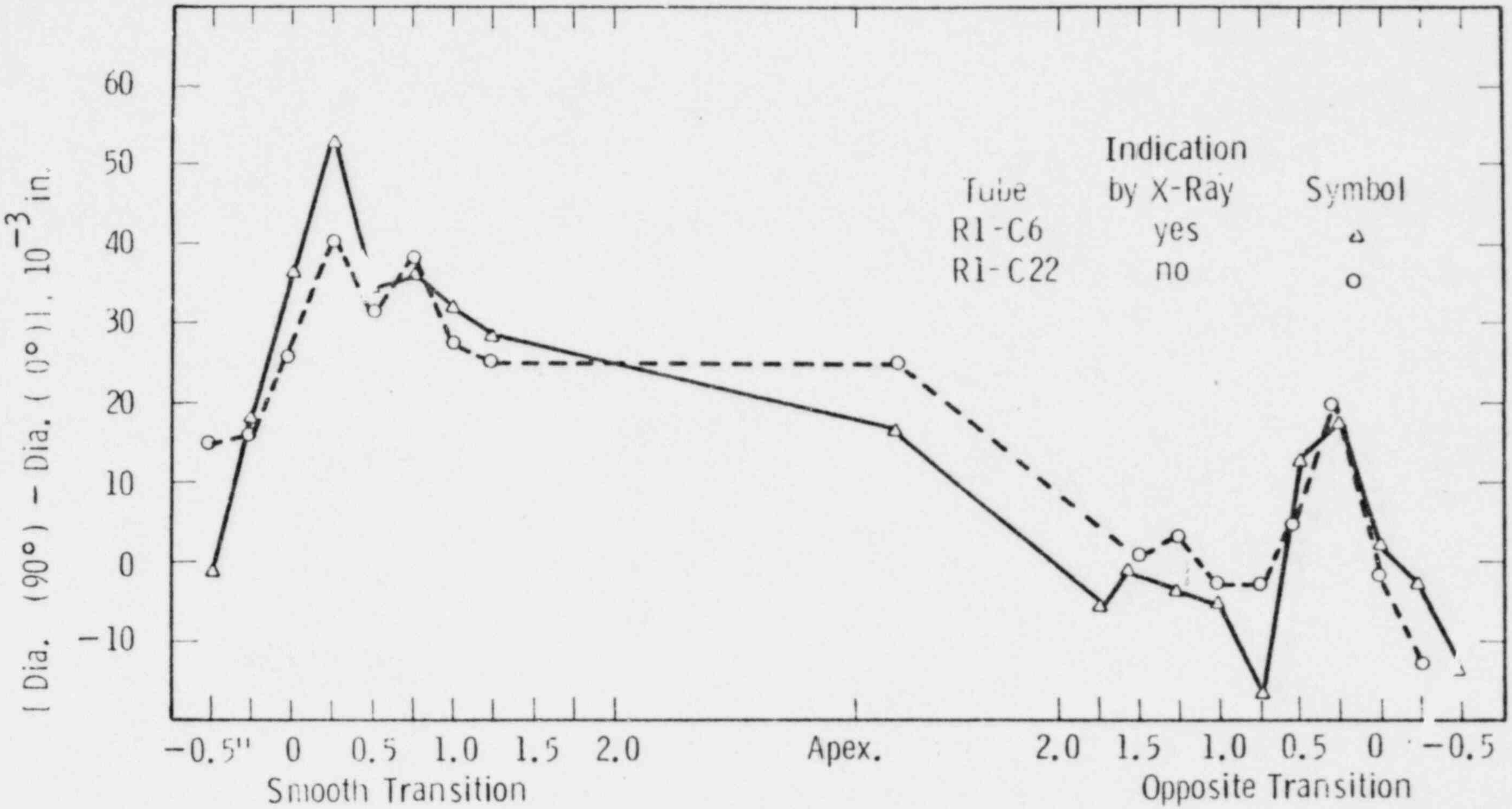


Fig. 2 — Ovality data for Trojan tubes R1-C6 and R1-C22 at the smooth transition, apex, and opposite transition. Zero positions correspond to intrados transitions

SUMMARY OF THE PRINCIPAL FACTS (9-30-80)

1. DOUBLE WALL X-RAY RADIOGRAPHS IDENTIFIED THREE TUBES WITH INDICATIONS OUT OF 26 ROW 1 TUBES.

2. THESE INDICATIONS OCCURRED AT THE TRANSITION WITH WELL DEFINED EXTRADOS AND INTRADOS TRANSITIONS AND ON THE EXTRADOS JUST BELOW THE EXTRADOS TRANSITION AND IN THE STRAIGHT LENGTH SECTION.

3. THE INDICATION ON TUBE R1-C6 CONSISTED OF INTERGRANULAR CRACKS WHICH RESULTED FROM MULTIPLE INITIATIONS ON THE I.D.

4. THE HARDNESS OF R1-C6 TUBE WAS HIGHER THAN FOR TWO OTHER TUBES WITH INDICATIONS AND FOR THREE OTHER TUBES WITH NO INDICATIONS.

WESTINGHOUSE METALLURGICAL

Summary

1. Trojan row 1 U-bends were characterized by a smooth transition with only a well defined intrados transition and by an opposite transition with well defined intrados and extrados transitions.

2. At the opposite transition, the extrados transition was ~0.6" above the intrados transition and closer to the apex.

3. Three of 26 tubes had cracks which occurred at the opposite transition between the intrados and extrados transitions and at the extrados.

4. These cracks resulted from multiple initiations on the ID and intergranular penetration.

5. No consistent and significant relationship could be established between cracking and ovality, grain size, carbide distribution, minor element chemistries, and hardness.

6. No cracking or opposite transition was found on the row 2 tube studied.

7. Row 1 bends from Surry 1 and Turkey Point No. 4 had only smooth transitions (no opposite transitions), and no cracking at the transitions was observed.

8. Surry 2 row 1 tubes had opposite transitions like the Trojan tubes and had ID multiply initiated cracks (aspect ratio of ~4) at the same location as the Trojan tubes.

9. On a virgin tube, strain gages and a layer removal technique were used to measure residual stresses where cracking had been encountered, they were compressive.

SUMMARY OF U-BEND DISCUSSIONS

U-BEND LEAKAGE TANGENT POINT EVENTS ARE CONFINED TO 51 SERIES STEAM GENERATORS MANUFACTURED IN APPROXIMATELY THE 1972 PERIOD.

TUBE LEAKAGE AND E.C. INDICATIONS ARE CONFINED TO ROW 1 TUBES.

PLANT EXPERIENCE SHOWS THAT CERTAIN TUBES MANUFACTURED BY WESTINGHOUSE HAVE LEAKED.

LEAKAGE AND E.C. INDICATIONS APPEAR AT ONLY ONE TANGENT POINT.

TANGENT POINT LEAK RATES HAVE BEEN RELATIVELY SMALL AND WELL BEHAVED - ORDERLY SHUTDOWN IN EACH CASE.

CRACKS APPEAR TO BE SHORT AND TIGHT WITH LOW ASPECT RATIO.

LEAKAGE EVENTS APPEAR IN PLANT OPERATIONS AT APPROXIMATELY 400 EFPD.

Overview of TVA Inner Radius U-Bend Program.

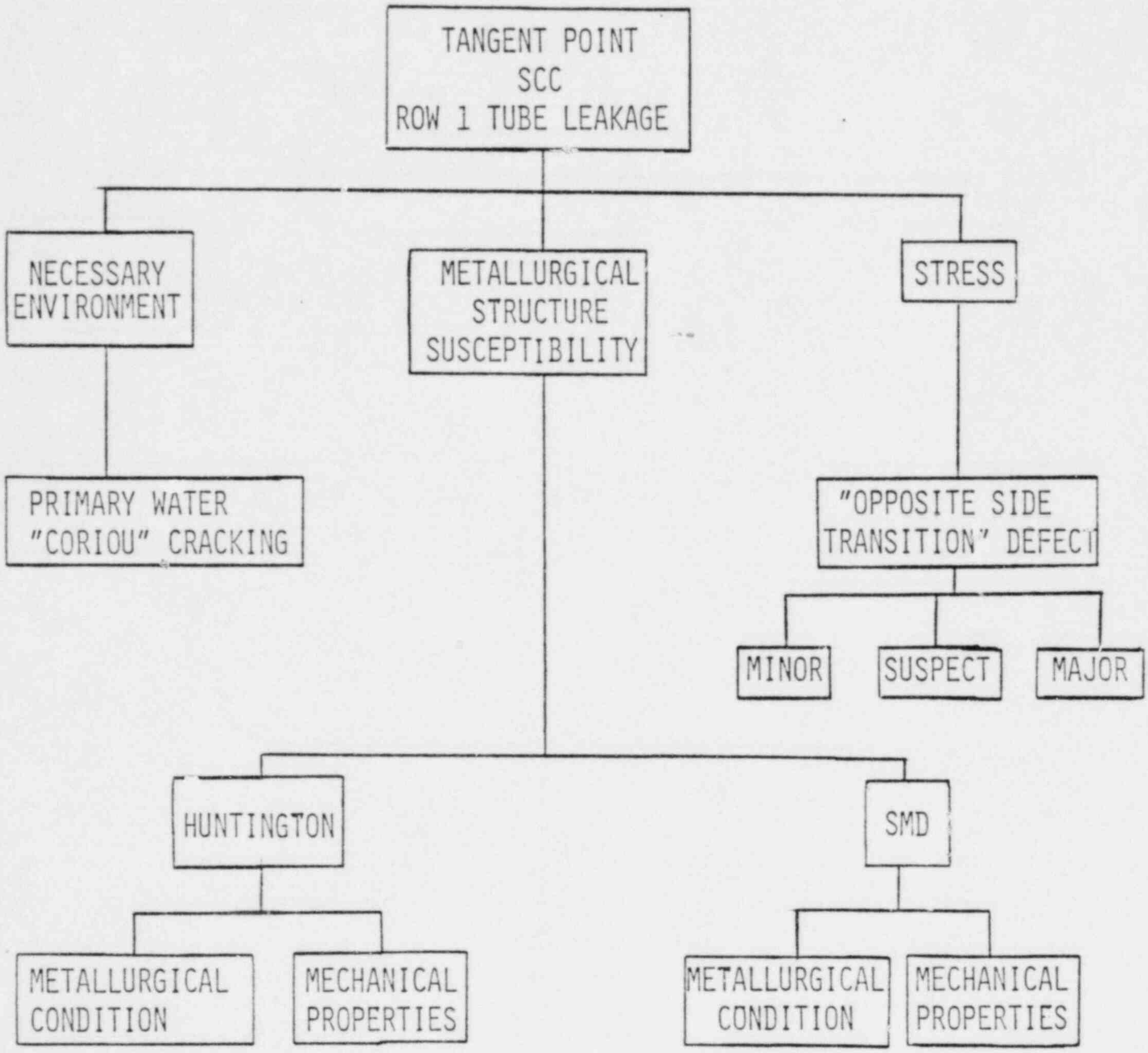
David F. Goetcheus (TVA)

TVA INNER RADIUS U-BEND PROGRAM

THE FOLLOWING PROGRAM HAS BEEN INITIATED AS A RESULT OF NRC ACTION. THE PROGRAM OBJECTIVE IS TO PROVIDE THE NRC WITH SUFFICIENT INFORMATION AND DOCUMENTATION TO JUSTIFY NOT PLUGGING SEQUOYAH, ROW 1, STEAM GENERATOR TUBES.

A. DEVELOP A TEST METHOD TO CHARACTERIZE INNER RADIUS U-BENDS TO DETERMINE THE PRESENCE AND DEGREE OF "OPPOSITE SIDE TRANSITION" DEFECTS, AND TO PROVIDE A BASELINE EDDY CURRENT TEST FOR FUTURE EXAMINATIONS.

B. DEVELOP IMPROVED TEST METHODS TO BETTER DETECT STRESS CORROSION CRACKING AT THE OPPOSITE SIDE TRANSITION.


TANGENT POINT
SCC
ROW 1 TUBE LEAKAGE
NECESSARY ENVIRONMENT
METALLURGICAL STRUCTURE SUSCEPTIBILITY
STRESS
PRIMARY WATER "CORIOU" CRACKING
"OPPOSITE SIDE TRANSITION" DEFECT
MINOR
SUSPECT
MAJOR
HUNTINGTON
SMD
METALLURGICAL CONDITION
MECHANICAL PROPERTIES
METALLURGICAL CONDITION
MECHANICAL PROPERTIES

Row 1 IN-600 Inner Radius U-Bend Tubes prone to stress corrosion cracking can be characterized by:

1. The presence of a major "Opposite Side Transition".
2. Susceptible Inconnel 600 metallurgical condition.
3. Physical properties of Inconel 600 (i.e., hardness).
4. Manufactured by Westinghouse Specialty Metals Division.

Evaluation of Sequoyah U-2 Row 1 Tubing (manufactured by Westinghouse and Huntington Alloys) mechanical properties compared to mechanical properties compared to mechanical properties associated with failed inner radius tubes.

David F. Goetcheus (TVA)

Table 2. Comparison of wall thickness (mils) and Knoop Hardness (500g) for three tubes with x-ray indications and three without at various approximate angular positions on a straight leg.

Tube/Leg		Wall Thickness				Hardness (mid-wall)					
		135°	180 (Extrados)	225	Avg.	90	135	180 (Extrados)	225	270	Avg.
R1-C6 Cold*	x-ray indication	57	55	54	55.3	219.8	233.9	245.0	234.7	216.7	230.0 (Rb = 93)
R1-C7 Hot**	x-ray indication	57	57	55	56.3	186.7	187.3	178.2	178	183.2	182.7 (Rb=83)
R1-C26 Hot**	x-ray indication	56	57	56	56.3	199.6	190.4	185.2	201.8	206.3	196.6 (Rb=87)
R1-C10 Cold*	no x-ray indication	59	60	57	58.66	179.1	186.4	183.1	180.4	186.1	183.0 (Rb=83)
R1-C13 Hot**	no x-ray indication	52	52	54	52.7	187.8	183.1	187.8	186.5	190.8	187.2 (Rb=85)
R1-C22 Cold**	no x-ray indication	59	57	55	57.0	181.3	185.2	183.5	176.8	181.3	181.6 (Rb = 83)

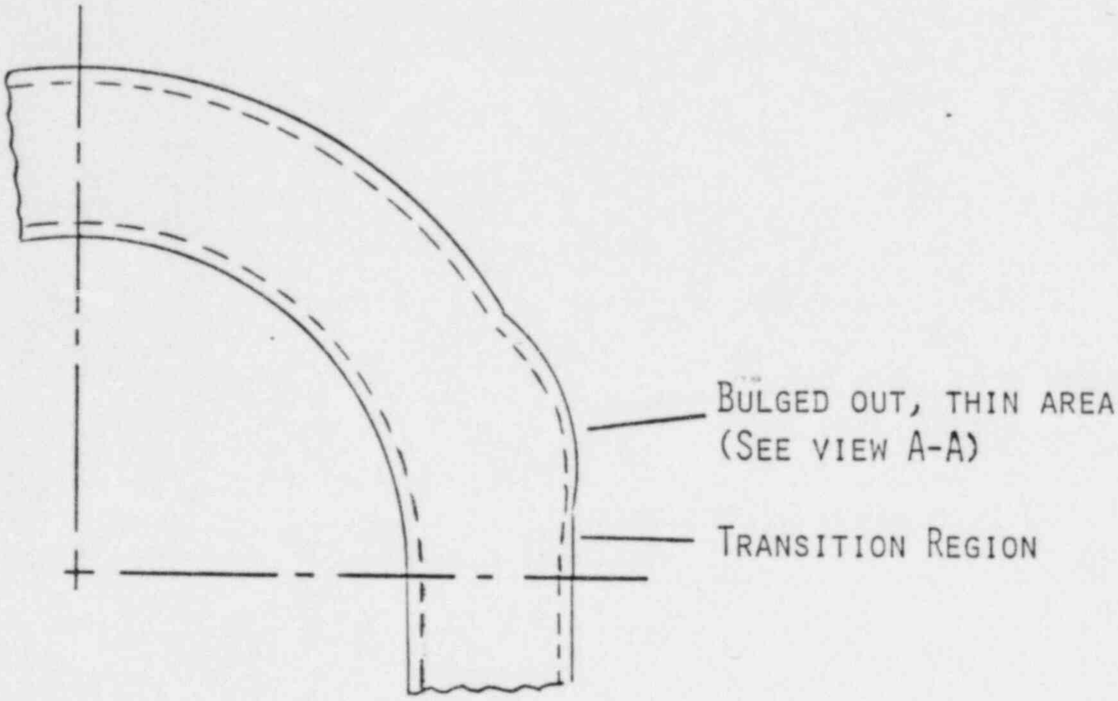
* Opposite Transition
** Smooth Transition

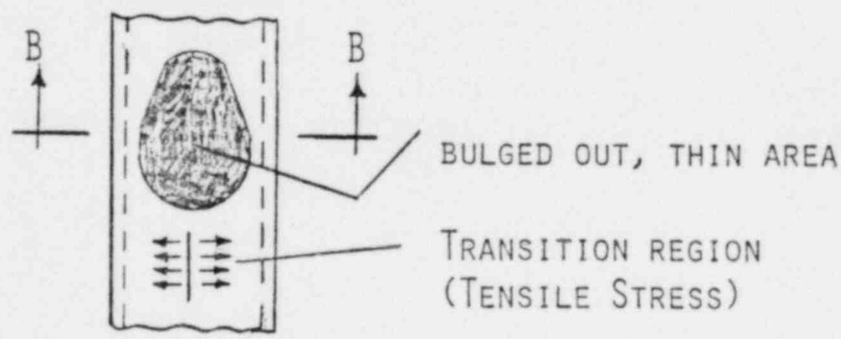
Mechanical Property Analysis
For Trojan, Westinghouse Manufactured,
Huntington Alloy Manufactured, and Model 51 Tubes

Population	Ultimate Strength (Ksi)	Yield Strength (Ksi)	Elongation (%)	Carbon W/O	Hardness R_B
Model 51 Tubing (800 heats)	101.7	55.2	39.5	0.035	85.7
Affected Trojan tubing (18 heats)	104.3	58.6	38.4	0.037	87.6
Sequoyah Huntington tubing (avg. of 15 heats)	101.7	56.0	37.8		86.3 (range 81-91)
Sequoyah Westinghouse Tubing (avg. of 41 heats)	102.7	57.0	38.4		87.1 (range 81-91)
<u>Removed Trojan Tubes</u>					
X-Ray Indication:					
RIC 6 Cold					93.0
RIC 7 Hot					83.0
RIC 26 Hot					87.1
No X-Ray Indication:					
RI-C10 Cold					83.0
RI-C13 Hot					85.5
RI-C22 Cold					83.0

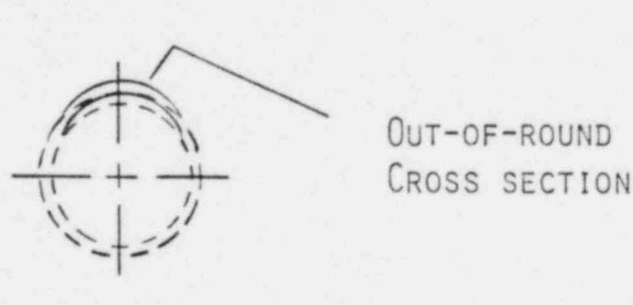
Quantitative Assessment of Stresses Associated with Row 1
U-Bend Tube Failures.

J. Ed Wilson (TVA)





VIEW A-A



SECTION B-B

Quantitative Assessment of the Stresses Associated With Row 1 U-Bend Tube Failures

1. Spring back of the bulged out, thin region after releasing the mandrel ball pressure results in compressive residual stresses in this area. Tensile residual stresses then occur at the transition region to maintain equilibrium. This is where most tube failures are known to initiate.

2. Differential pressure loading across the tube wall tends to round up the cross section at the bulged out, thin region. This results in the nearly round transition region being the strong back which picks up more of the tensile load in the hoop direction.

3. The magnitude of the tensile residual stress and the tensile pressure stress at the transition region where most tube failures are known to initiate is directly related to the degree of out-of-roundness and thinning of the bulged out area.

Review of Calibration Tubes Simulating Variations of "Opposite Side Transitions" Defects Associated with Row 1 U-Bend Leakage.

David F. Goetcheus (TVA)

INNER RADIUS U-BEND TEST PROGRAM CALIBRATION TUBES

1.0 Percent Reduction in Wall Thickness
1.1 Tube 1019-1
1.2 Tube 1019-2
1.3 Tube 1019-3
1.4 Tube 1019-4
1.5 Tube UB-I
1.6 Tube UB-III

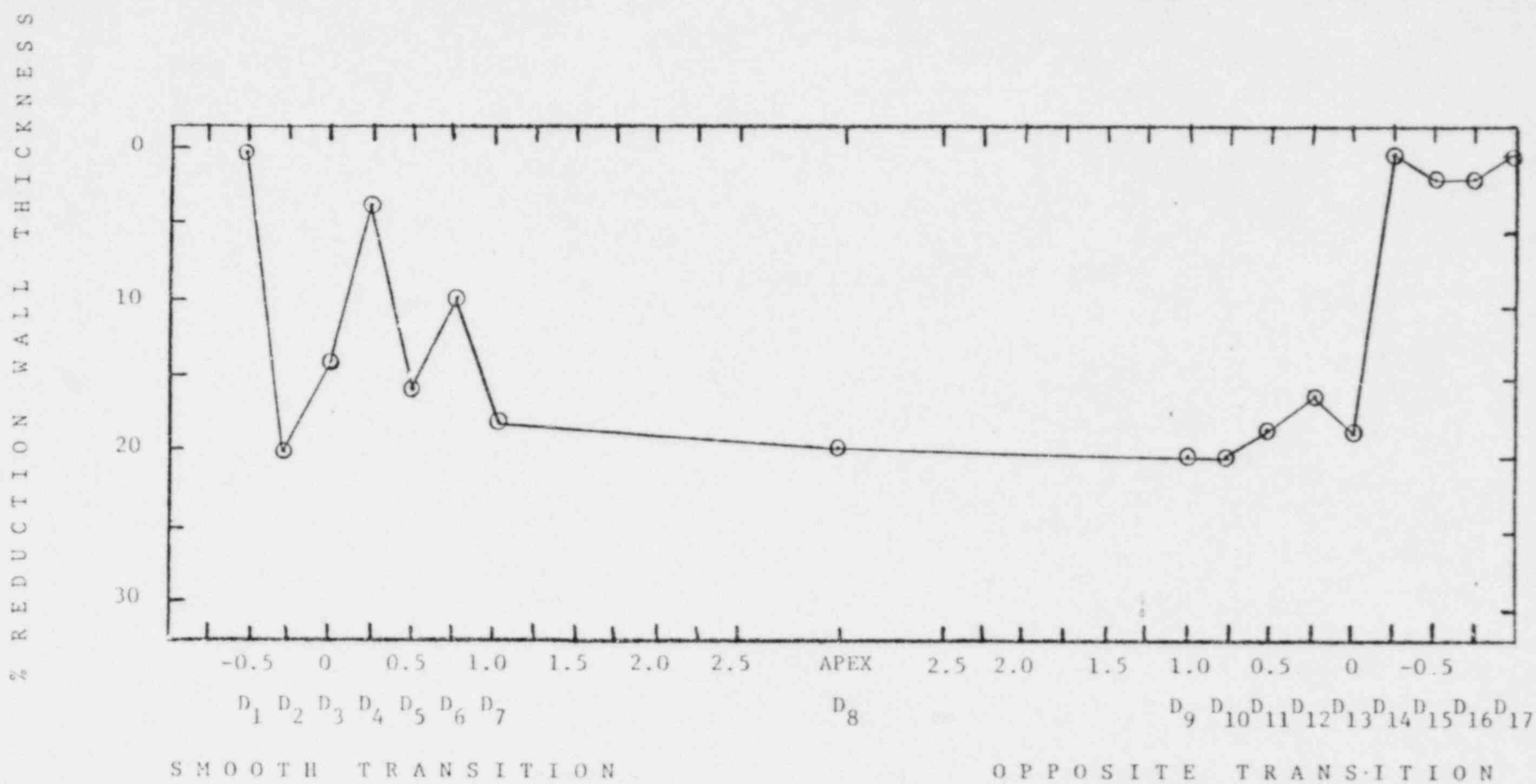
2.0 Ovality Data
2.1 Tube 1019-1
2.2 Tube 1019-2
2.3 Tube 1019-3
2.4 Tube 1019-4
2.5 Tube UB-I
2.6 Tube UB-III

3.0 EDM Notches
3.1 Tube 1019-1
3.2 Tube 1019-2
3.3 Tube 1019-3
3.4 Tube 1019-4
3.5 Tube UB-I
3.6 Tube UB-III

INNER RADIUS U-BEND TEST PROGRAM CALIBRATION TUBES

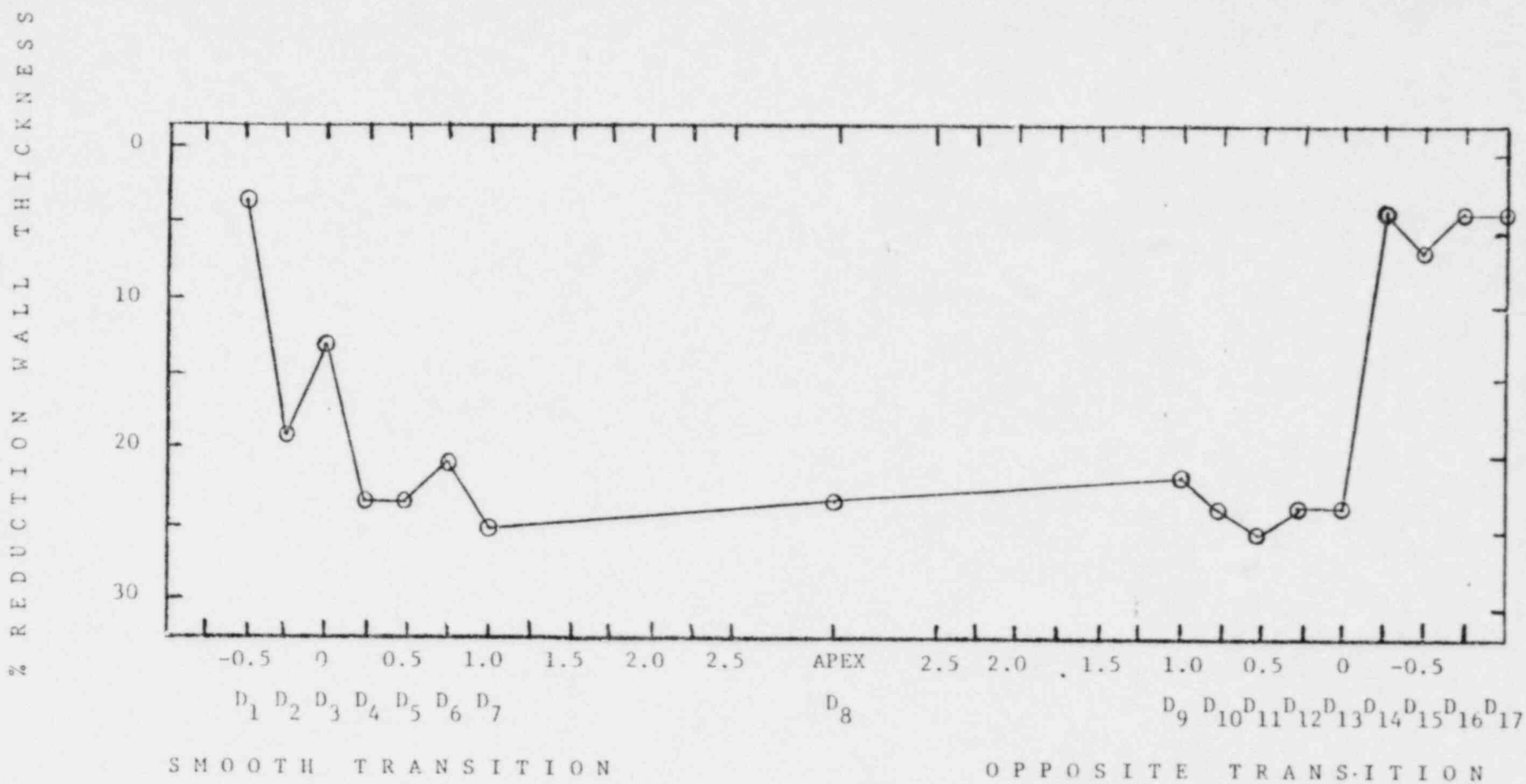
1.0 Percent Reduction in Wall Thickness

PERCENT REDUCTION IN WALL THICKNESS
CALIBRATION TUBE 1019-1



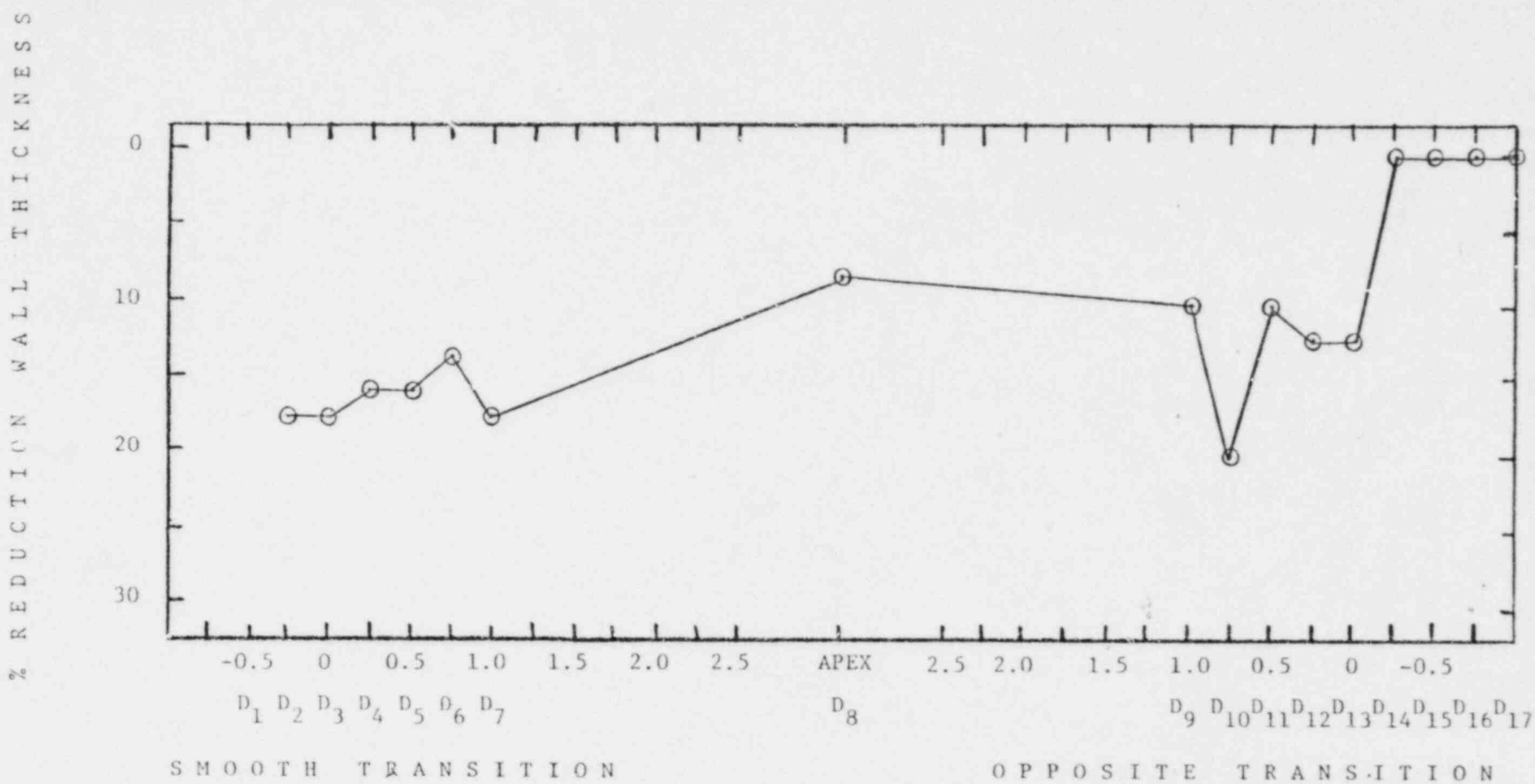
Percent reduction in wall thickness at the extrados (180°C) for the smooth transition, apex, and opposite transition. Zeros correspond to extrados transitions.

PERCENT REDUCTION IN WALL THICKNESS
CALIBRATION TUBE 1019-2



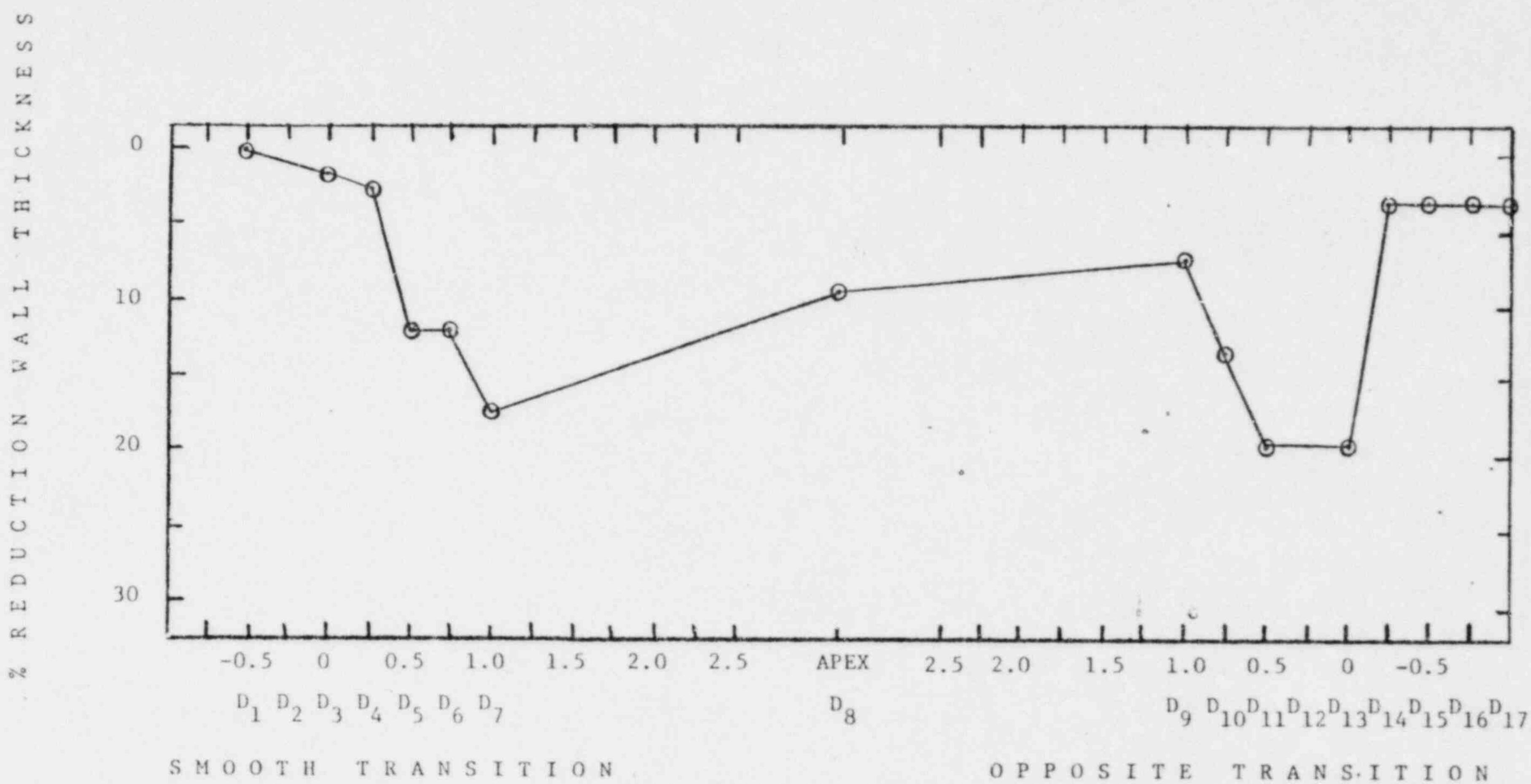
Percent reduction in wall thickness at the extrados (180°C) for the smooth transition, apex, and opposite transition. Zeros correspond to extrados transitions.

PERCENT REDUCTION IN WALL THICKNESS
CALIBRATION TUBE 1019-3



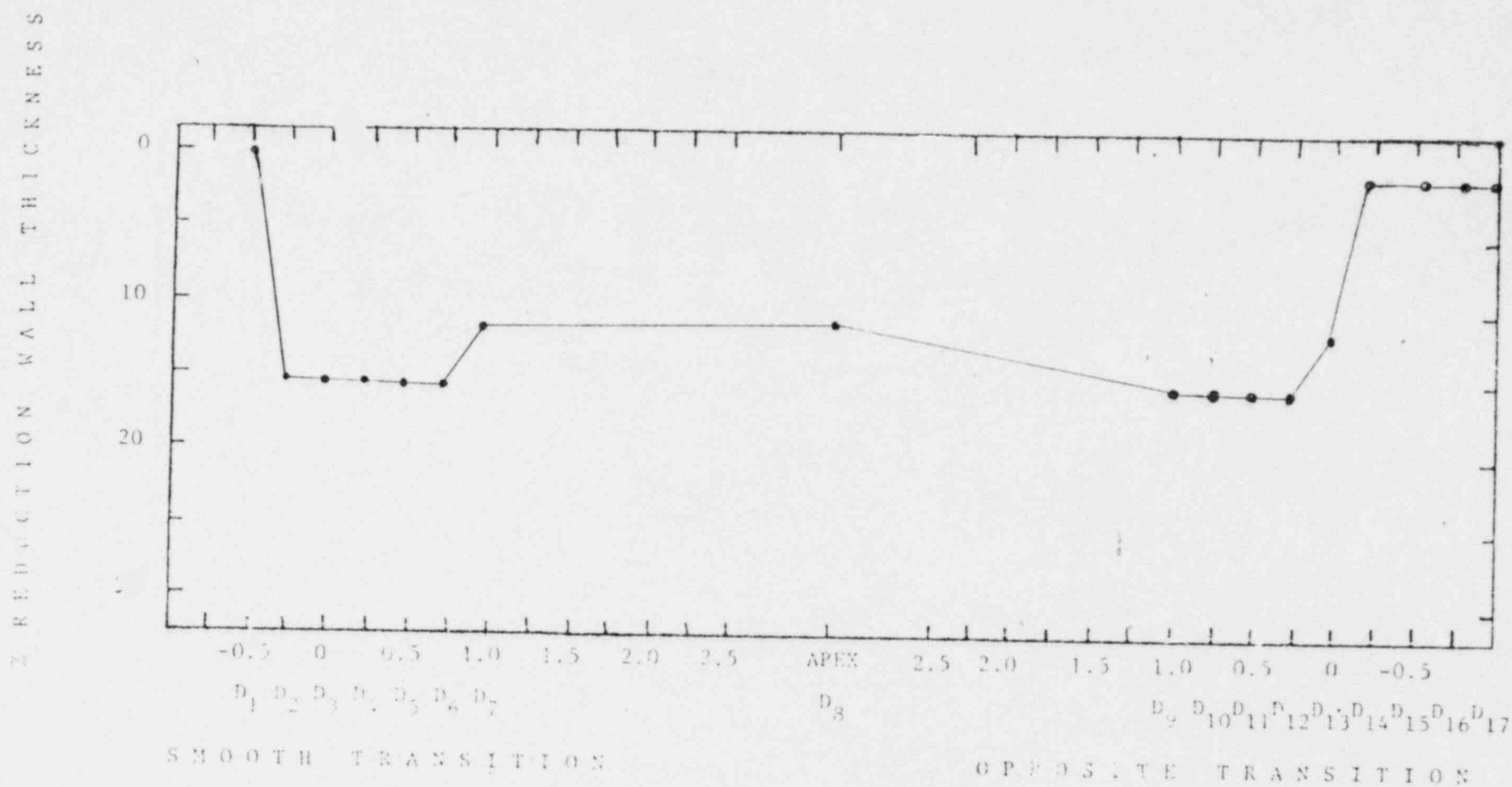
Percent reduction in wall thickness at the extrados (180°C) for the smooth transition, apex, and opposite transition. Zeros correspond to extrados transitions.

PERCENT REDUCTION IN WALL THICKNESS
CALIBRATION TUBE 1019-4



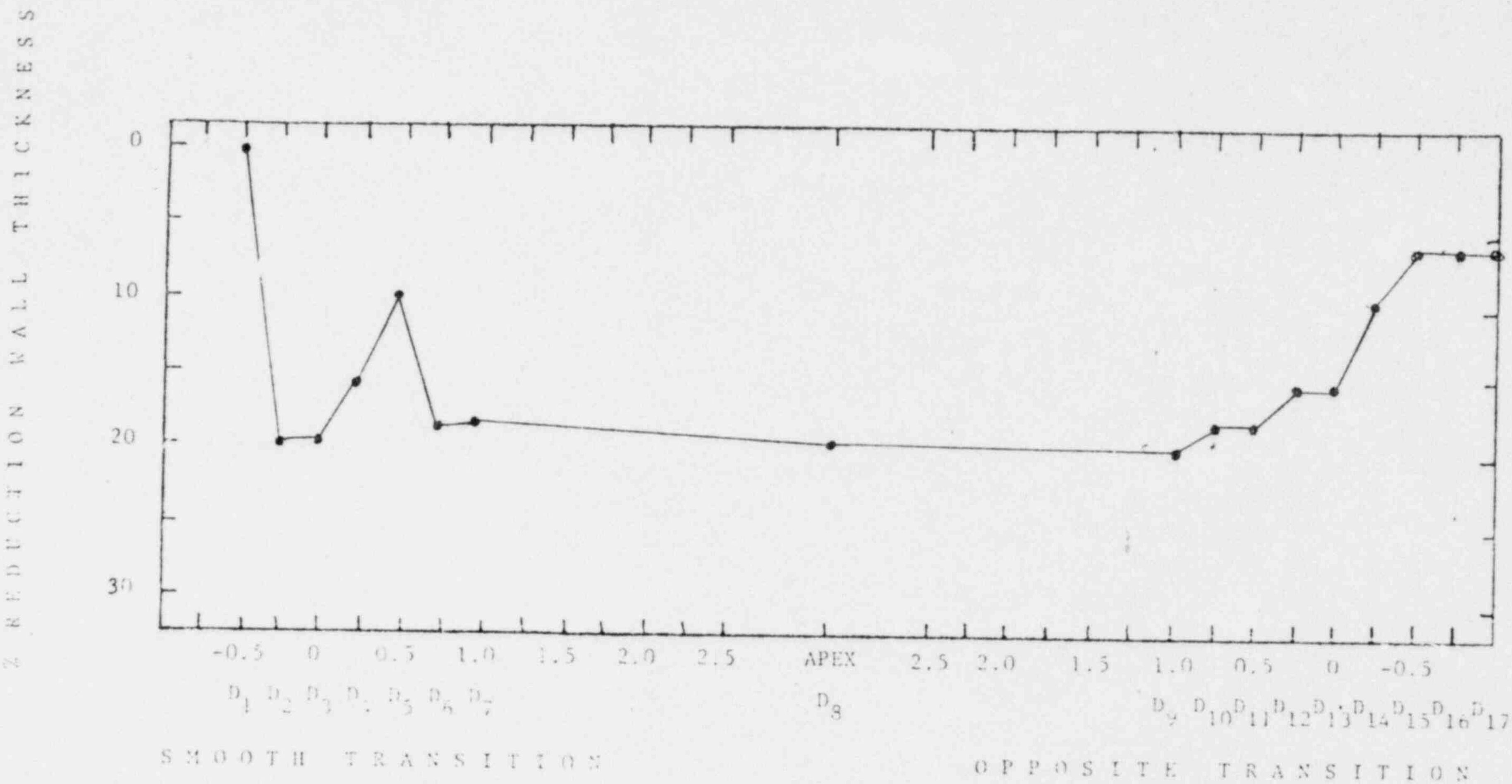
Percent reduction in wall thickness at the extrados (180°C) for the smooth transition, apex, and opposite transition. Zeros correspond to extrados transitions.

PERCENT REDUCTION IN WALL THICKNESS
CALIBRATION TUBE 1019-JB1



Percent reduction in wall thickness at the ext.ados (180°C) for the smooth transition, apex, and opposite transition. Zeros correspond to extrados transitions.

PERCENT REDUCTION IN WALL THICKNESS
CALIBRATION TUBE 1019-UB3

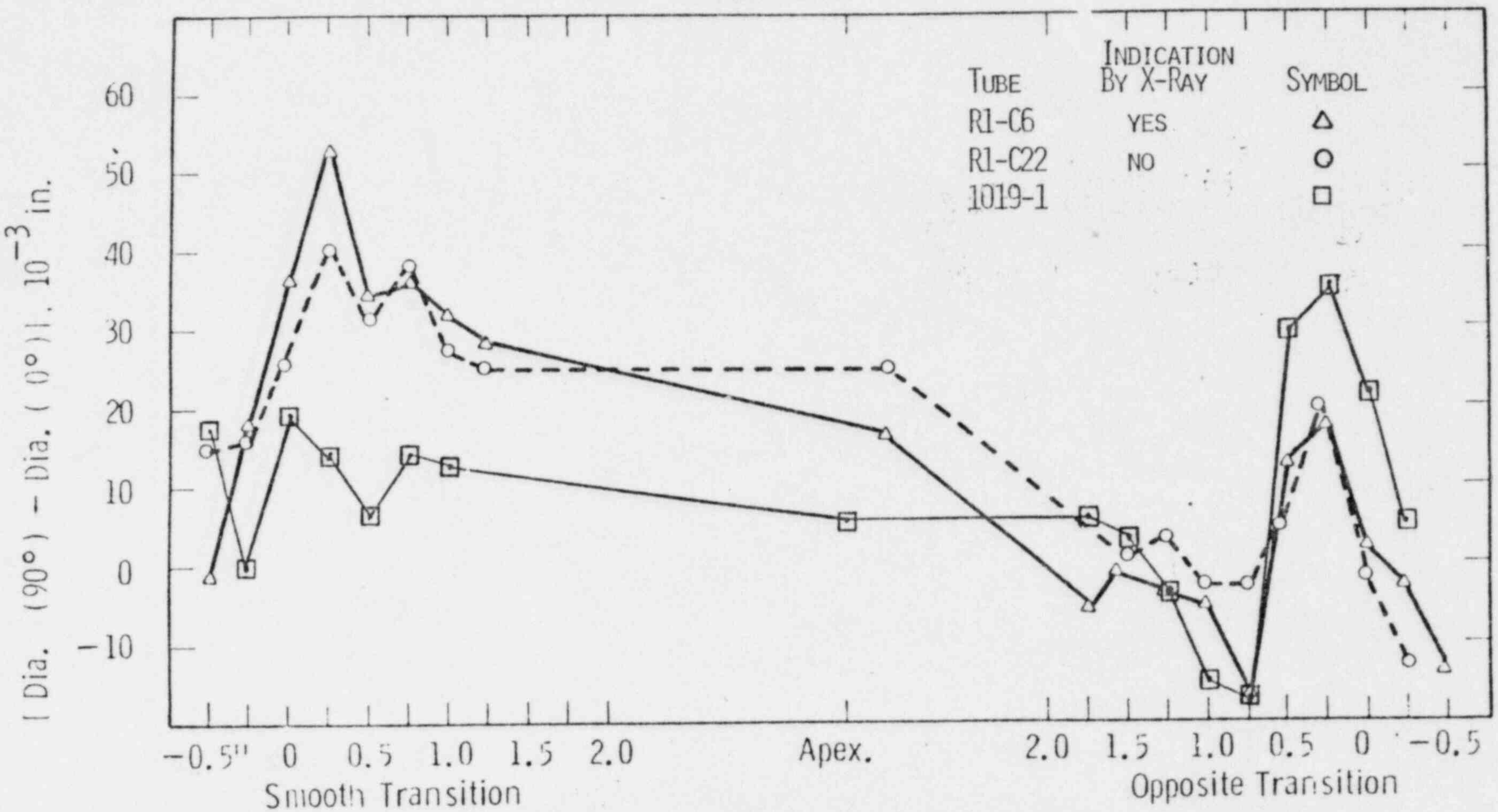


Percent reduction in wall thickness at the extrados (180^{o}C) for the smooth transition, apex, and opposite transition. Zeros correspond to extrados transitions.

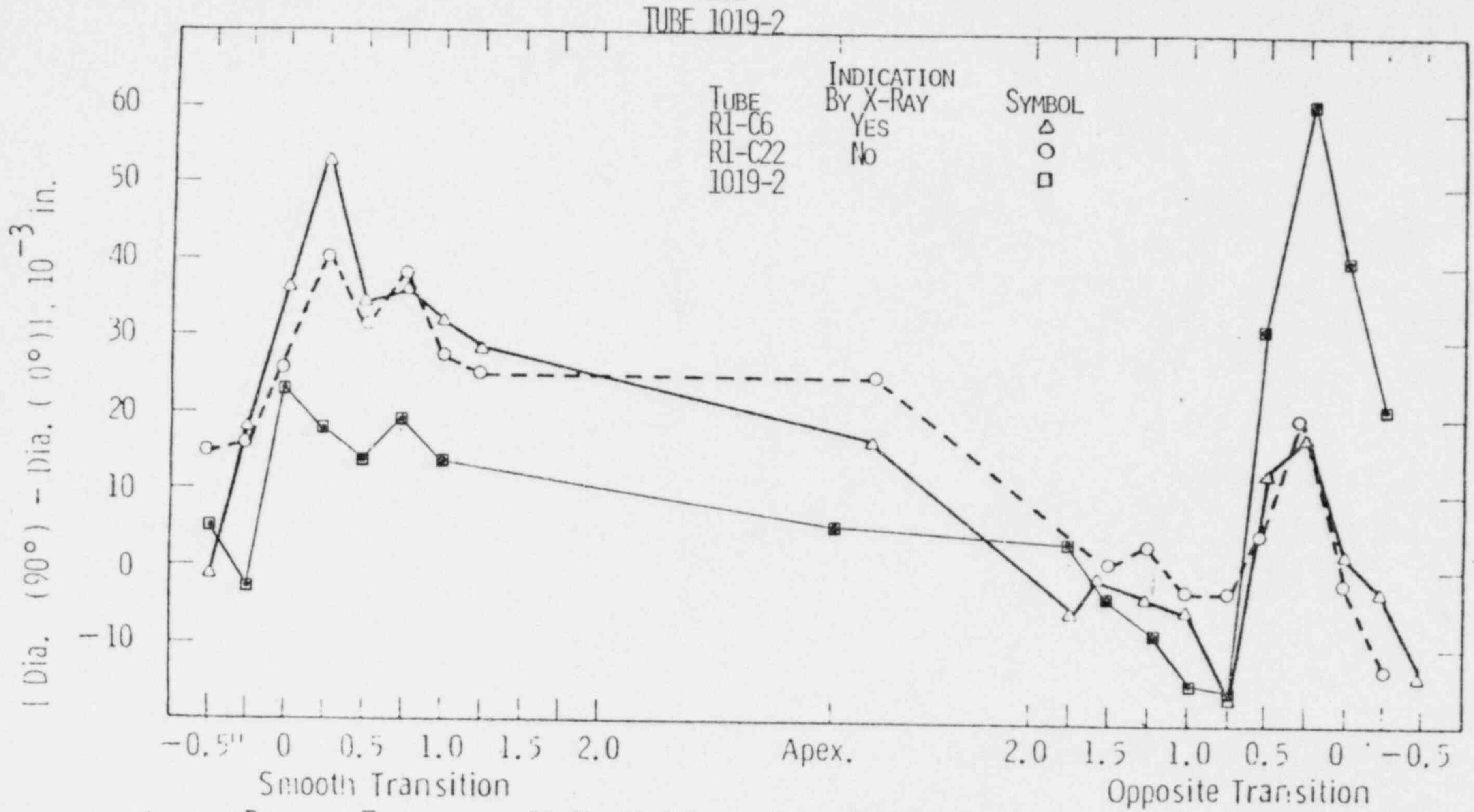
INNER RADIUS U-BEND TEST PROGRAM CALIBRATION TUBES

2.0 Ovality Data

TUBE 1019-1

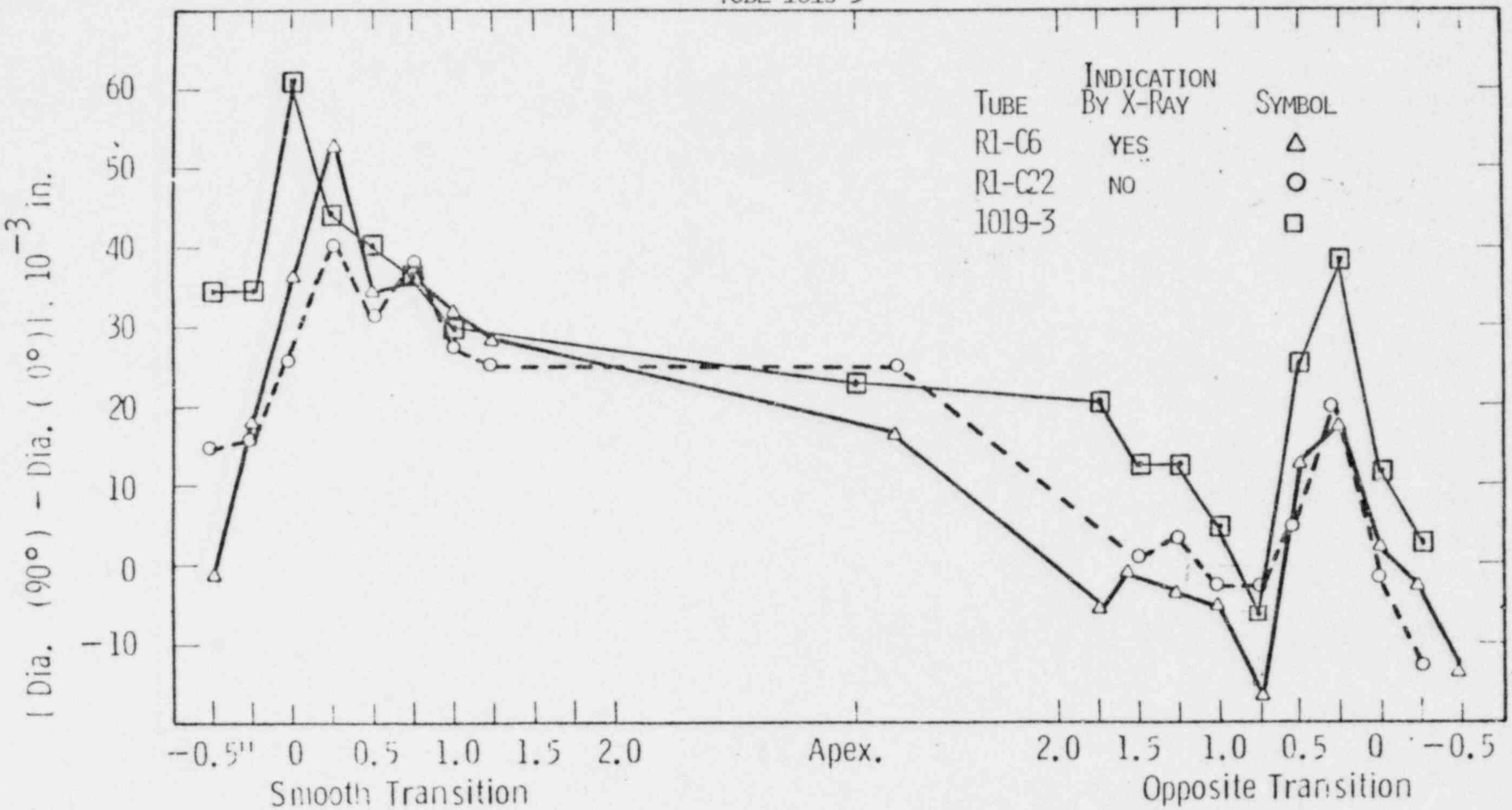


Ovality data for Trojan tubes R1-C6, R1-C22, and TVA Calibration Tube 1019-1 at smooth transition, apex, and oposite transition. Zero positions correspond to intrados transitions



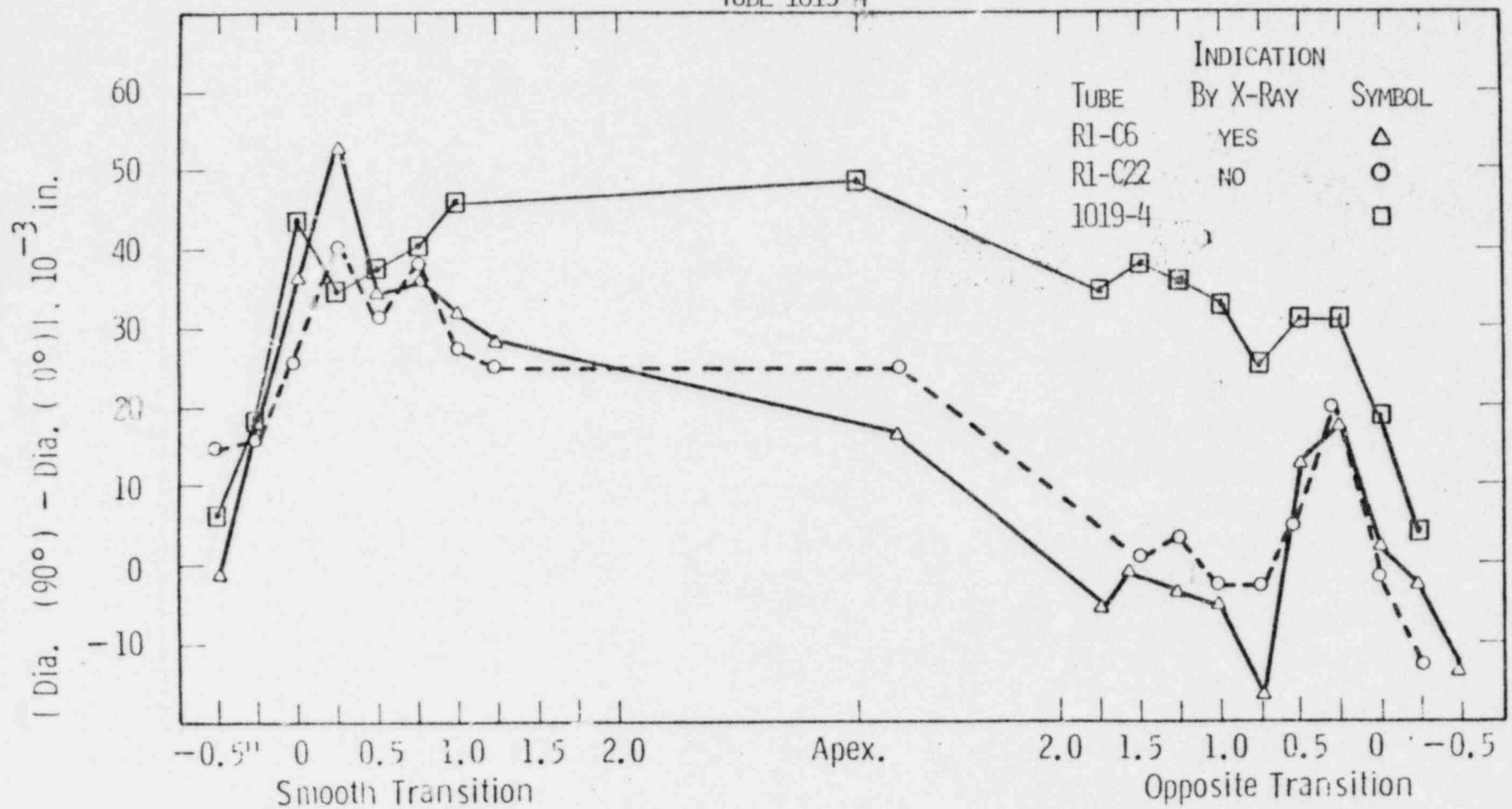
OVALITY DATA FOR TROJAN TUBES R1-C6, R1-C22, AND TVA CALIBRATION TUBE 1019-2 AT SMOOTH TRANSITION, APEX, AND OPPOSITE TRANSITION. ZERO POSITIONS CORRESPOND TO INTRADOS TRANSITIONS.

TUBE 1019-3

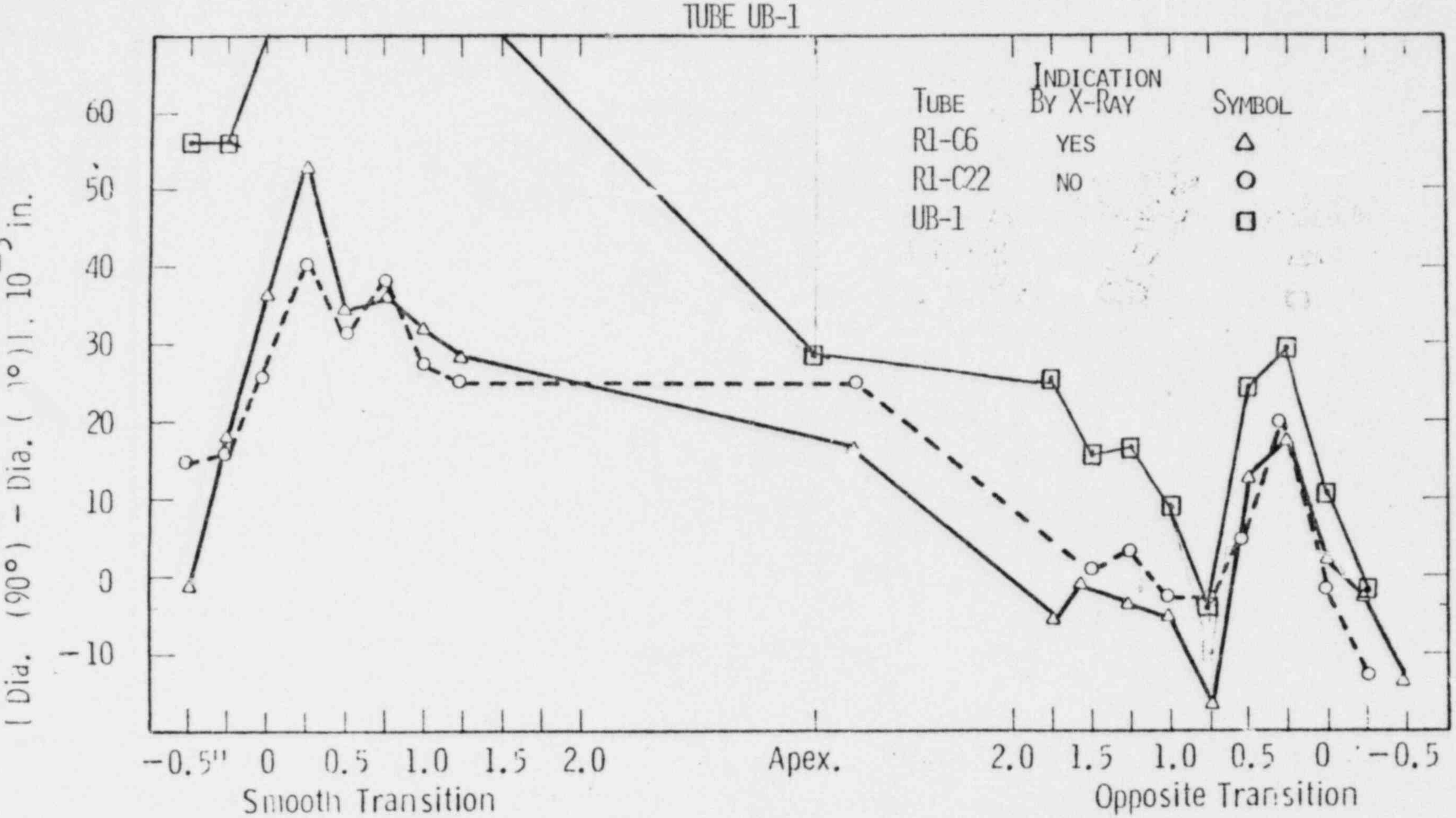


OVALITY DATA FOR TROJAN TUBES R1-C6, R1-C22, AND TVA CALIBRATION TUBE 1019-3 AT SMOOTH TRANSITION, APEX, AND OPPOSITE TRANSITION. ZERO POSITIONS CORRESPOND TO INTRADOS TRANSITIONS

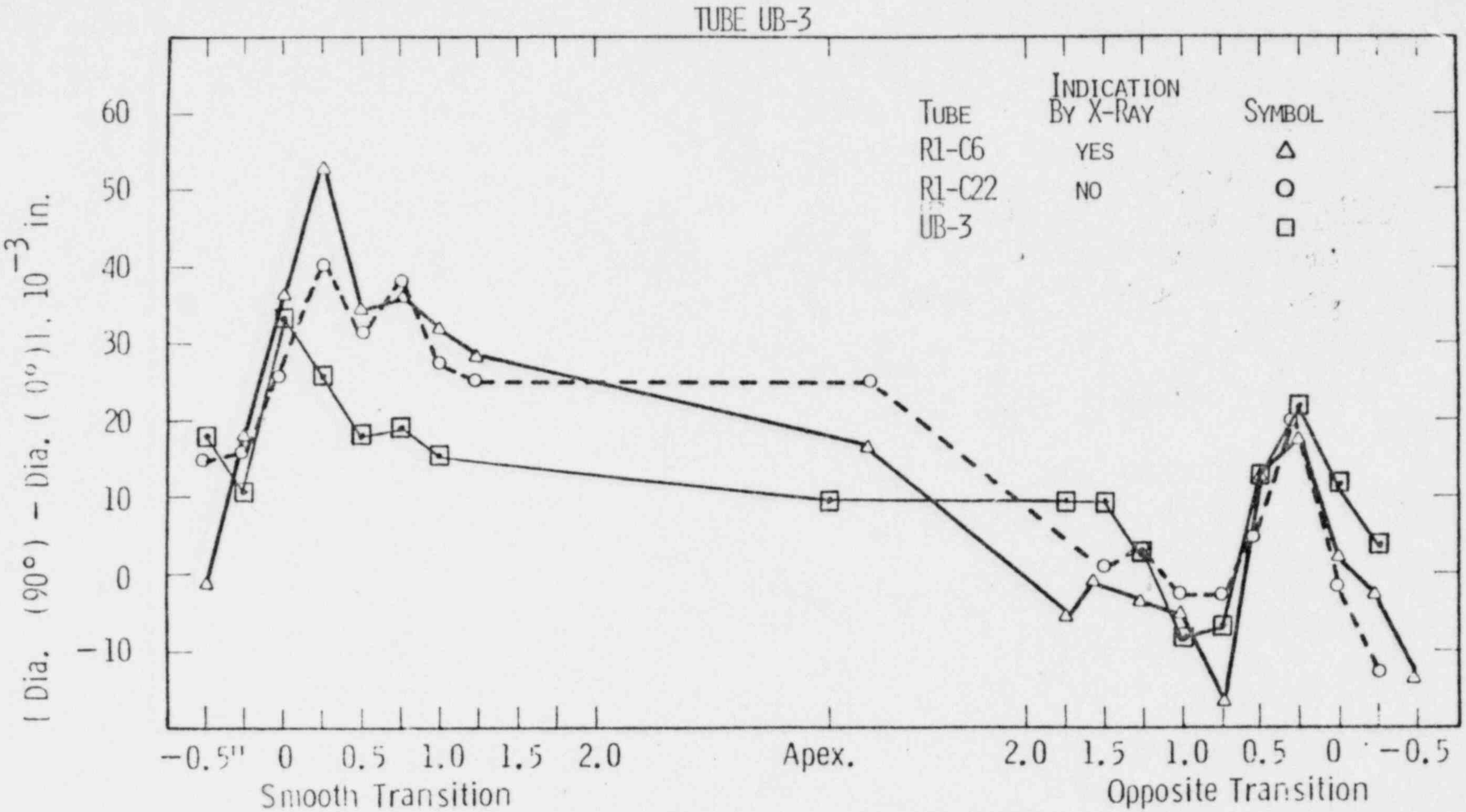
TUBE 1019-4"



Ovality data for Trojan tubes R1-C6, R1-C22, and TVA Calibration Tube 1019 at smooth transition, apex, and opposite transition, Zero positions correspond to intrados transitions



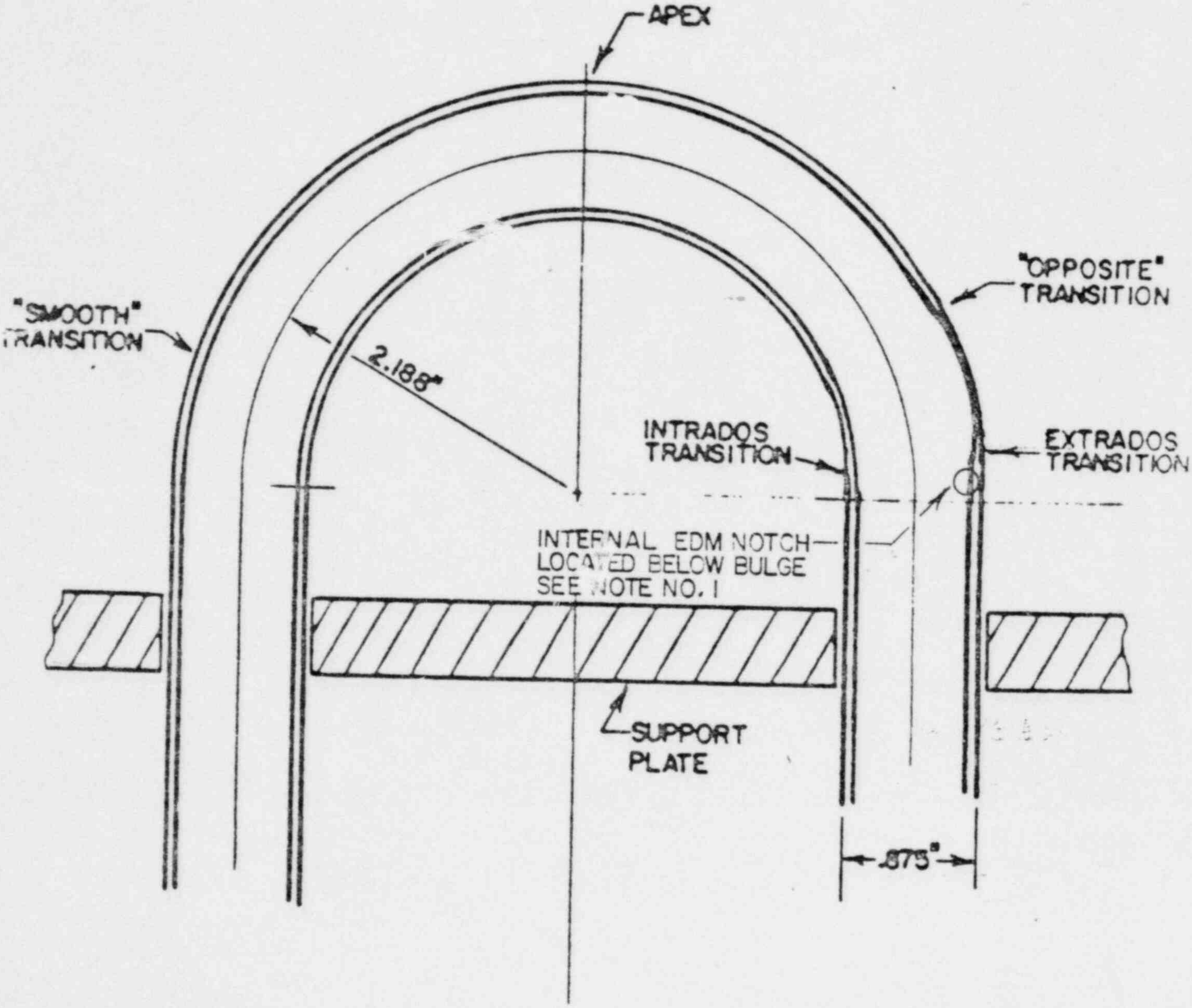
OVALITY DATA FOR TROJAN TUBES R1-C6, R1-C22, AND TVA CALIBRATION TUBE UB-1 AT SMOOTH TRANSITION, APEX, AND OPPOSITE TRANSITION. ZERO POSITIONS CORRESPOND TO INTRADOS TRANSITIONS



Ovality data for Trojan tubes R1-C6, R1-C22, and TVA Calibration Tube UB-1 at smooth transition, apex, and opposite transition. Zero positions correspond to intrados transitions

INNER RADIUS U-BEND TEST PROGRAM CALIBRATION TUBES

3.0 [illegible]M Notches



NOTES

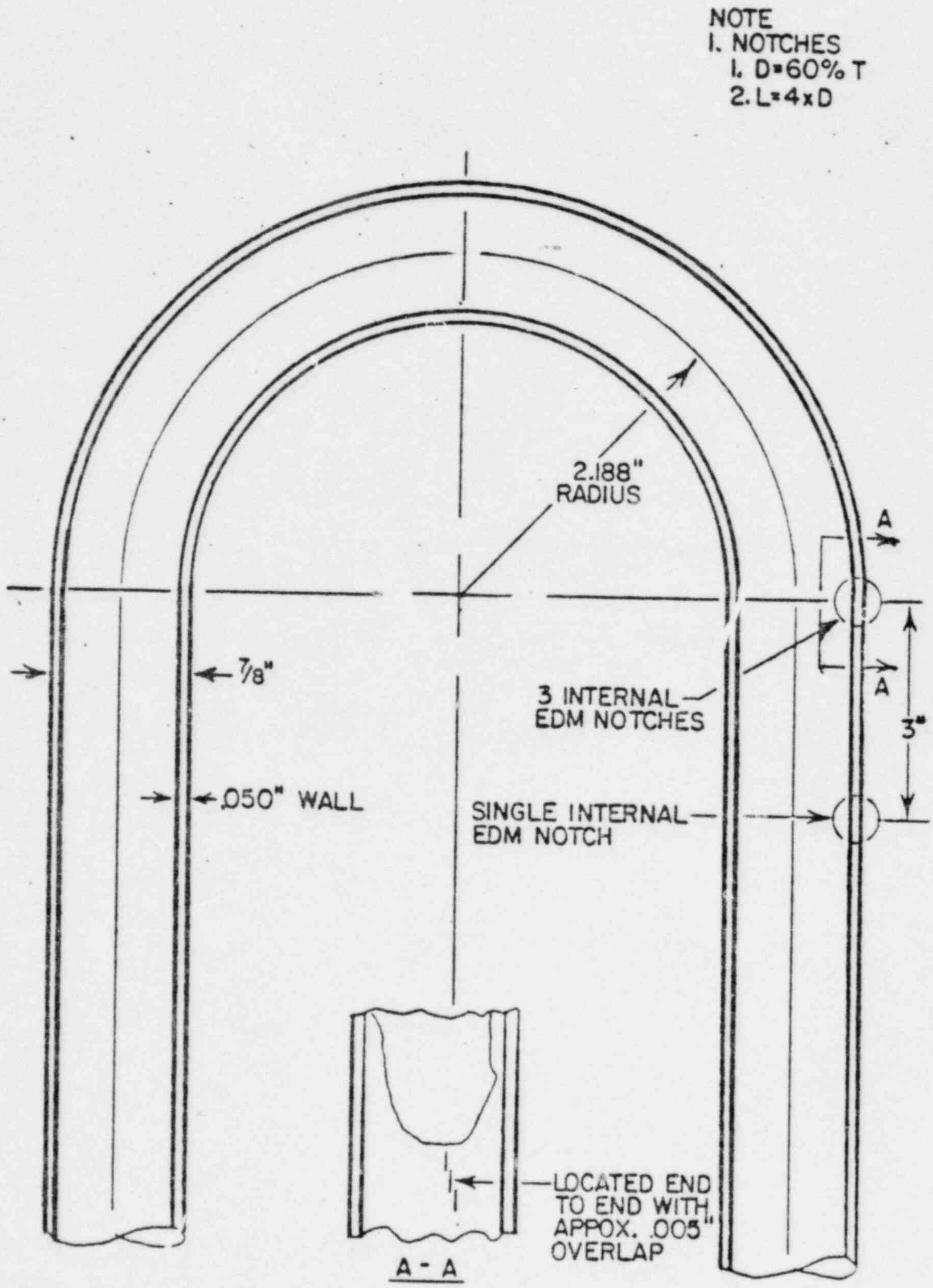
1. TUBE D(NOTCH DEPTH)

3.1 1019-I 40%T
3.2 1019-II 30%T
3.3 1019-III 50%T
3.4 1019-IV 60%T

L=4xD
W=.005

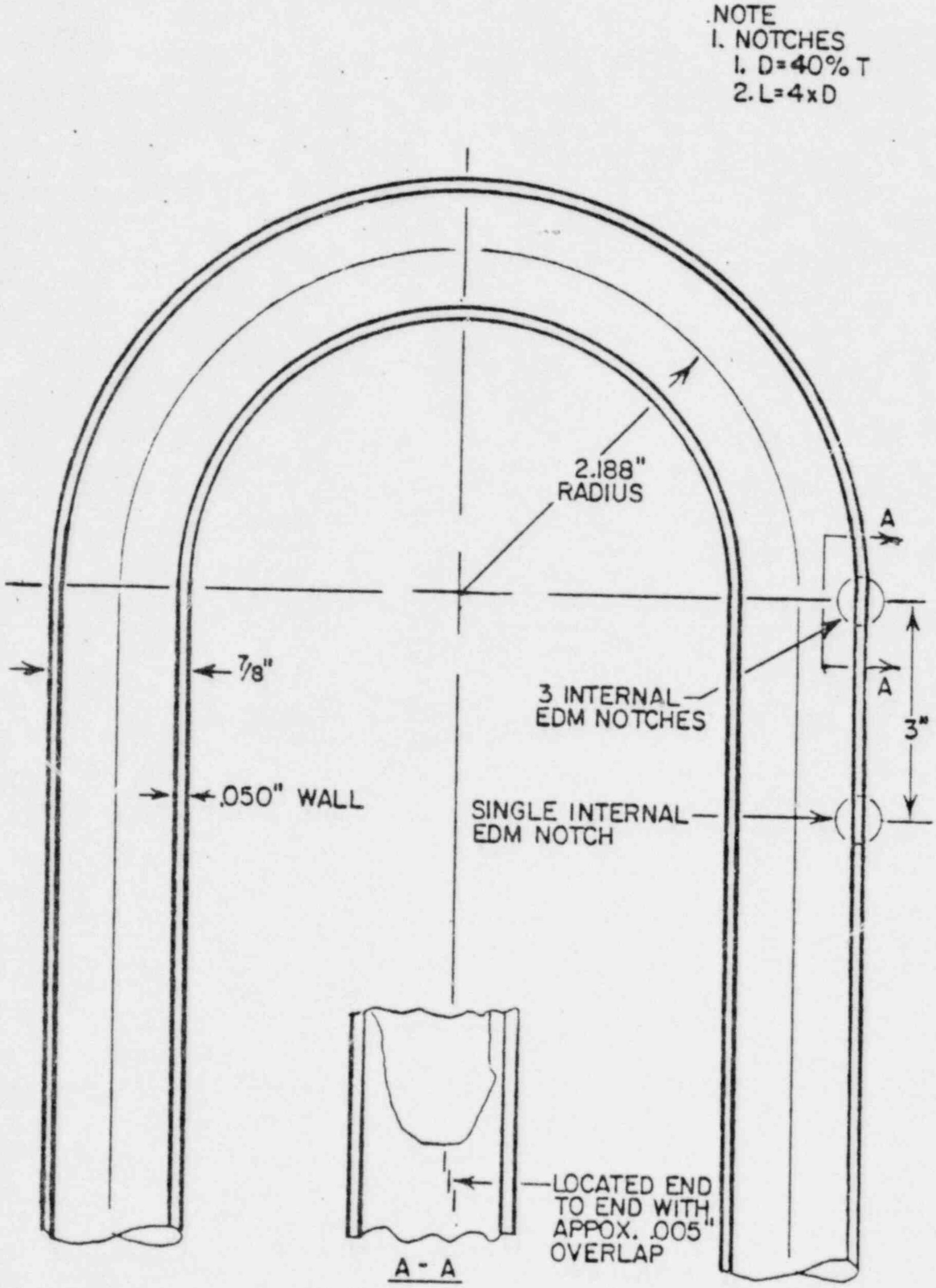
3.5

TUBE 1019-UB-I



3.6

TUBE 1019-UB-III



[illegible] MATERIAL CERTIFICATION

(W) Order Number T10-00731 Customer Order No. 0607 MT It. Nos.

Heat Number	C	Mn	Fe	S	Si	Cu	Ni	Cr	Al	Ti	Co	P	B	Ultimate Strength PSI	Yield Strength PSI	% Elong.	Rb Hardness
NX-1019	.047	.26	9.00	.001	.18	.28	74.49	15.74	.24	.23	.04	.008	.005	96,000 (Item 1	55,000 .875" O.D.)	34.0	88
NX-1748	.032	.25	8.75	.001	.19	.27	75.36	15.15	.21	.16	.03	.008	.004	109,000 (Item 2	59,000 .750" O.D.)	37.0	87

RECEIVED
APR 27 19[illegible]1
[illegible]

TVA - SEQUOYAH #2
CALIBRATION TUBES [signature]

SUMMARY OF CALIBRATION TUBES

EDDY CURRENT TEST CALIBRATION TUBES DEVELOPED BY TVA SIMULATE ACCURATELY THE FOLLOWING VARIABLES:

1. ACTUAL MODEL 51 STEAM GENERATOR ROW 1 BEND RADIUS 2.188 IN.

2. ACTUAL MODEL 51 OUTSIDE DIAMETER

3. SIMULATE VARIATIONS OF "OPPOSITE SIDE TRANSITION" OVALITY CONSISTANT WITH FAILED TUBES REMOVED FROM TROJAN NUCLEAR PLANT

4. PERCENT REDUCTION IN AREA ASSOCIATED WITH OPPOSITE SIDE TRANSITIONS WAS 16% - 20%. TVA CALIBRATION TUBES HAVE 15% - 25% REDUCTION IN AREA.

MAJOR DIFFERENCE IN TVA CALIBRATION TUBES

1. WALL THICKNESS OF TVA CALIBRATION TUBES HAVE .050 IN. AND WESTINGHOUSE STATES THE MINIMUM WALL THICKNESS USED ON MODEL 51 STEAM GENERATORS WAS .052 IN.

EDDY CURRENT TESTING TO CHARACTERIZE SEQUOYAH U-2 ROW 1 U-BENDS TO DETERMINE THE PRESENCE AND DEGREE OF "OPPOSITE SIDE TRANSITION" DEFECTS AND BASELINE EDDY CURRENT TEST.

SHOZO NARITA (C&L ENGR. TVA CONTRACTOR)

OBJECTIVES

1.]- DETECT AND CHARACTERIZE SEVERITY OF OPPOSITE SIDE TRANSITIONS

2.]- DETECT AND CHARACTERIZE DEPTH OF CRACKING AT AN OPPOSITE SIDE TRANSITION

APPROACH

USING MULTIFREQUENCY EDDY CURRENT INSTRUMENTATION:

1.]- DETECT AND CHARACTERIZE OPPOSITE SIDE TRANSITION WITH SINGLE FREQUENCY (100 KHZ)

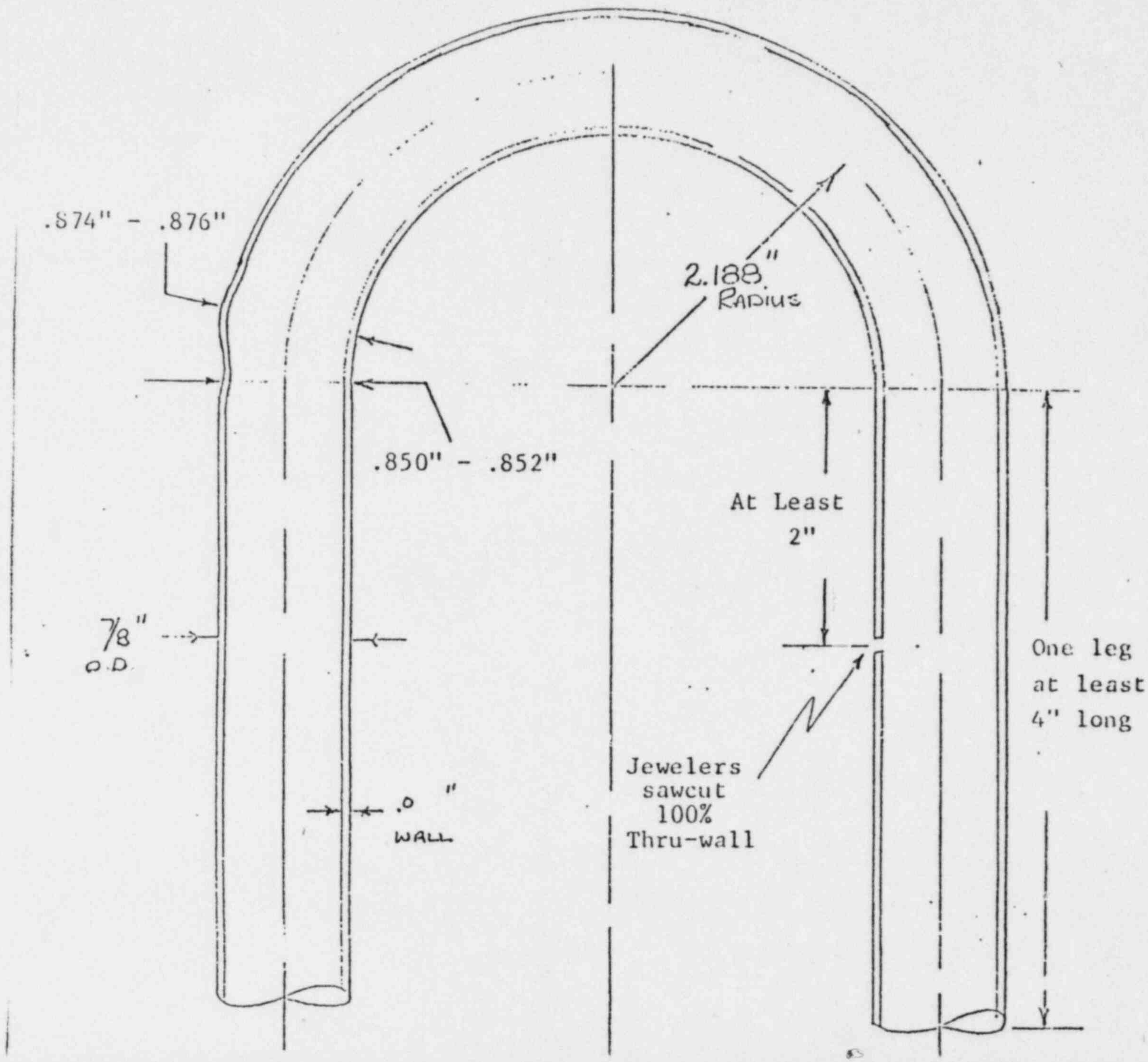
2.]- SUPPRESS OPPOSITE SIDE TRANSITION SIGNAL BY MIXING TWO DIFFERENT FREQUENCIES (240 KHZ AND 100 KHZ). DETECT AND CHARACTERIZE CRACKING WITH MIXED SIGNAL.

RESULTS

1.- GOOD DETECTION AND CHARACTERIZATION OF OPPOSITE SIDE TRANSITION.

2.- POOR CRACK DETECTABILITY, NO CHARACTERIZATION OF CRACK DEPTH.

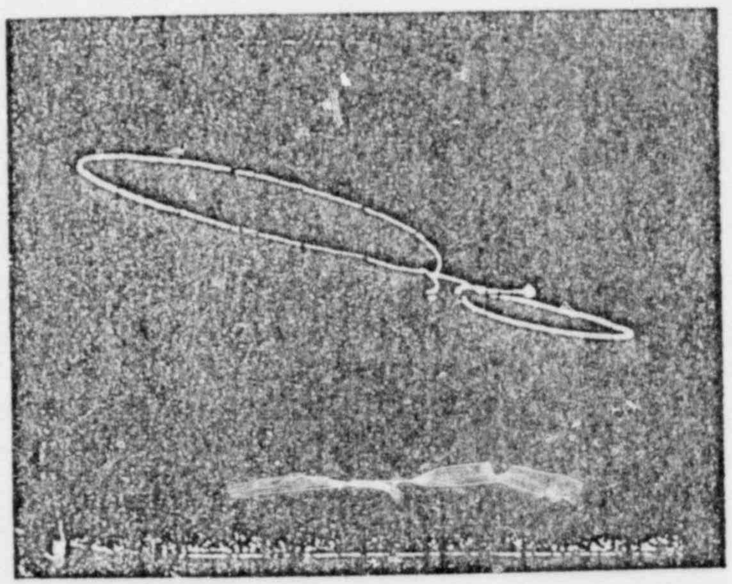
MOCK-UP OF SHORT RADIUS U-BEND



U-BEND CALIBRATION TUBE SIGNALS

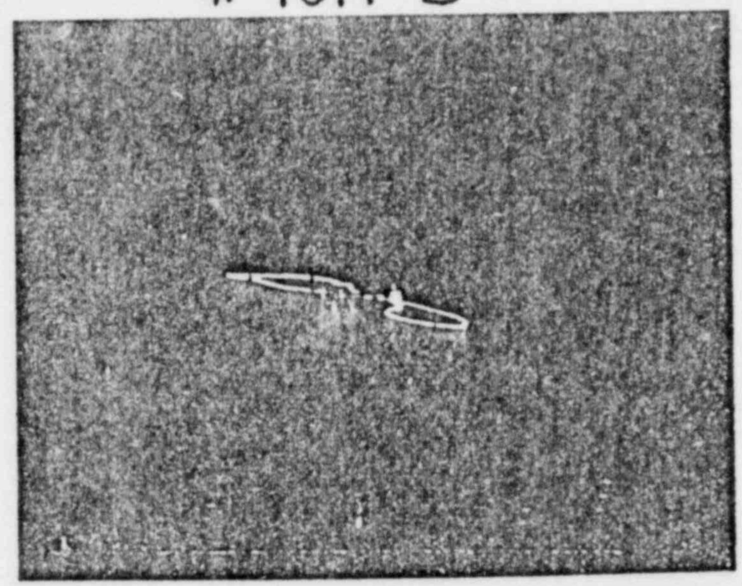
100 KHZ

1019-1



LARGE LOOP AMPLITUDE
1.35 VOLTS

1019-5



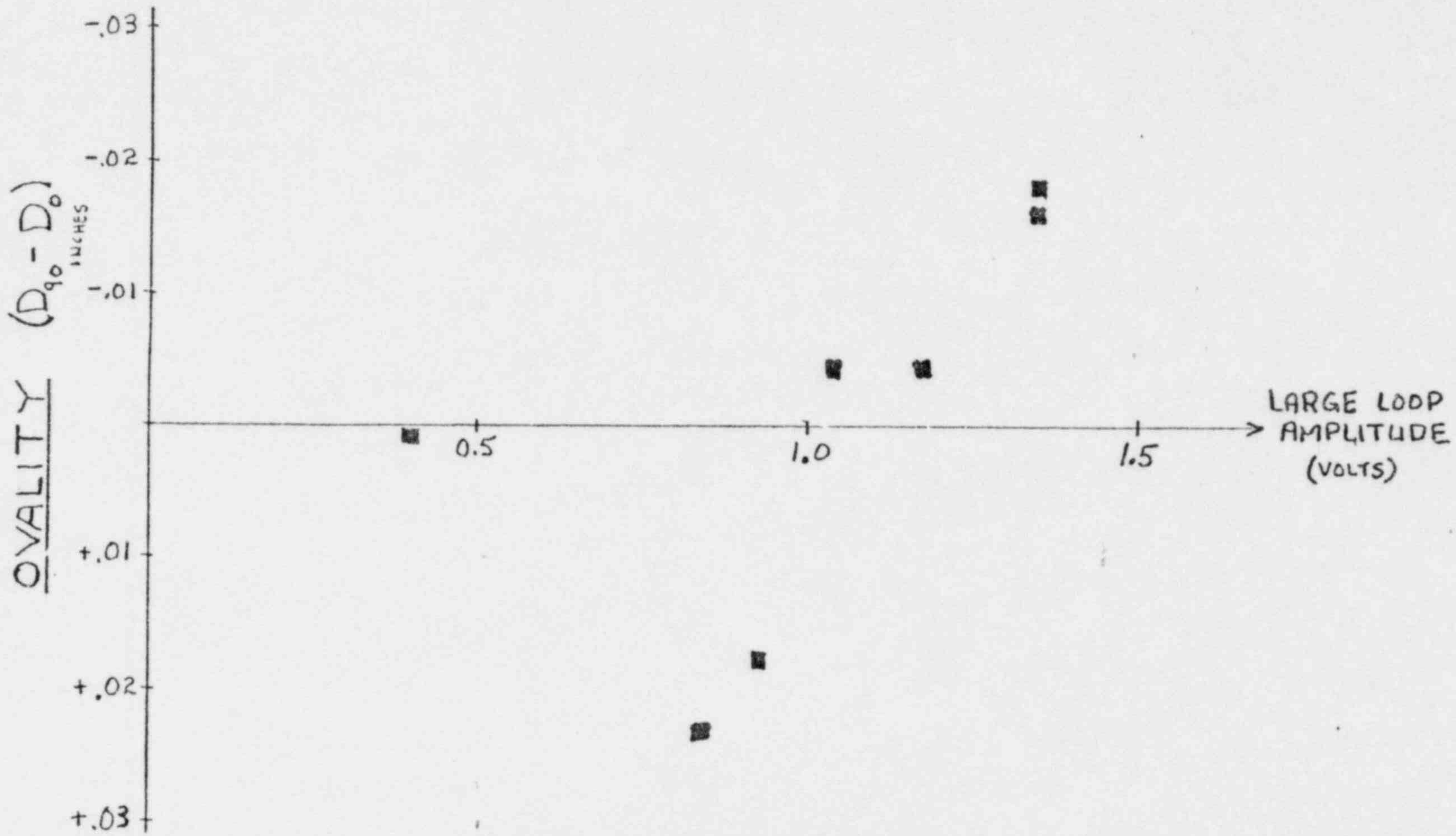
LARGE LOOP AMPLITUDE
0.40 VOLTS

OVALITY VERSUS LARGE LOOP AMPLITUDE

U-BEND SAMPLE	100KHz LARGE LOOP AMPLITUDE (VOLTS)	OVALITY $D_{90} - D_0$ (IN.)
1019-1	1.35	-.018
1019-2	1.35	-.016
1019-3	1.03	-.006
1019-4	0.82	+.024
1019-UB-2	1.18	-.005
1019-UB-5	0.90	+.001
1019-UB-6	0.93	+.018

REV. 1

CORRELATION CURVE



CLASSIFICATION OF OPPOSITE SIDE TRANSITIONS

LARGE LOOP AMPLITUDE (VOLTS)	CLASSIFICATION
1.0 ≤ AMPLITUDE < 1.1	MINOR OPPOSITE SIDE TRANSITION
1.1 ≤ AMPLITUDE < 1.3	SUSPECT OPPOSITE SIDE TRANSITION
AMPLITUDE ≥ 1.3	MAJOR OPPOSITE SIDE TRANSITION

MULTIFREQUENCY MIX FOR U-BEND INSPECTION

400 KHZ

Comparison With Other S.G. Inspections Per ASME Boiler Code

240 KHZ and **100 KHZ**

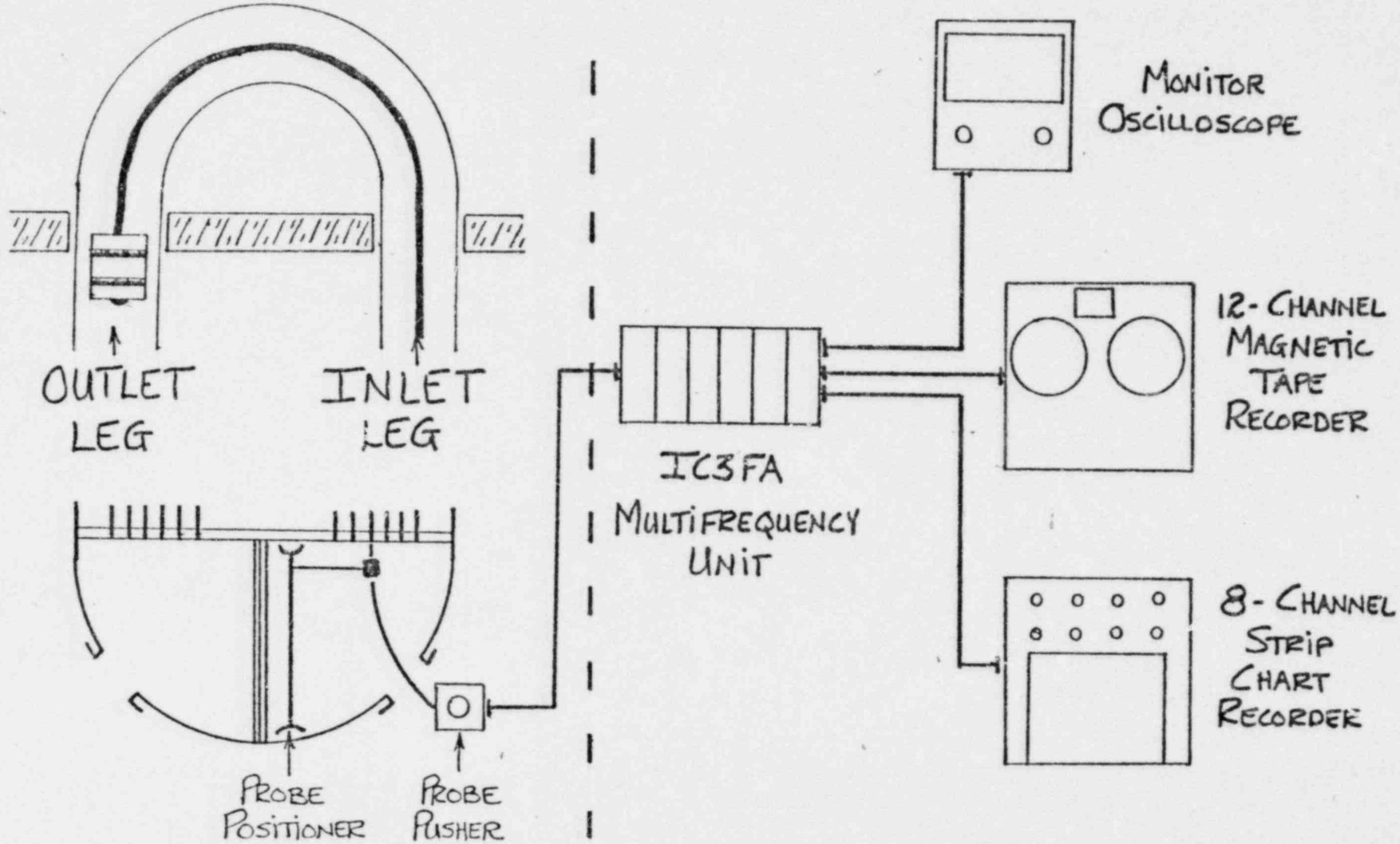
Mix To Suppress U-Bend Signal

Crack Detection

100 KHZ

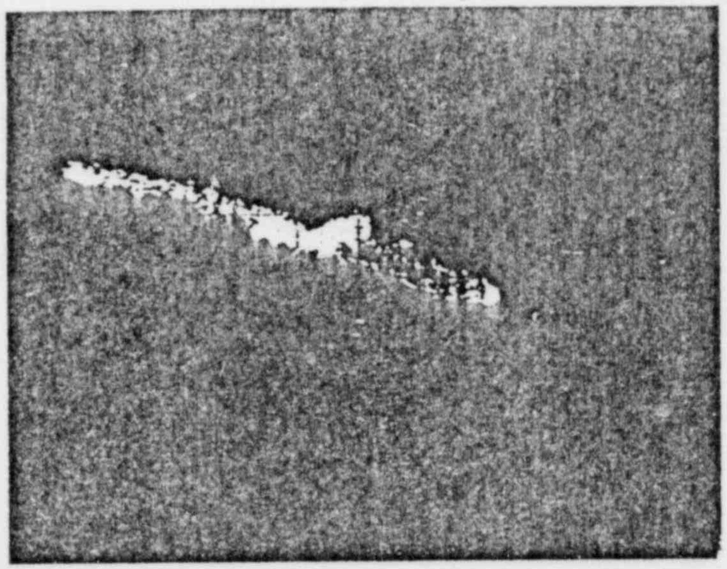
Single Frequency To Detect And Characterize Opposite Side Transition

DATA ACQUISITION SYSTEM



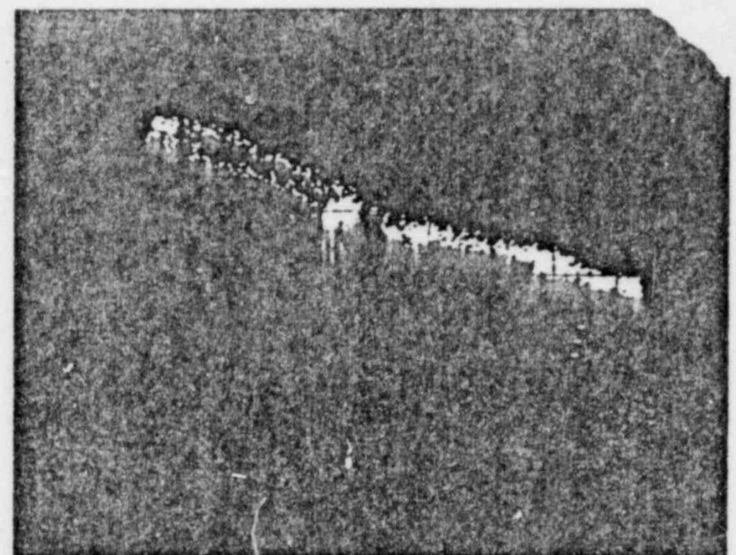
TYPICAL TRANSITION SIGNALS
S.G. #2

TUBE R1-C4, I7



LARGE LOOP AMPLITUDE
0.80 VOLTS

TUBE R1-C30, O7



LARGE LOOP AMPLITUDE
1.24 VOLTS

DATA ANALYSIS RECORD

DATE 2/8/81 PAGE 1

S.G. #2 SIDE INLET

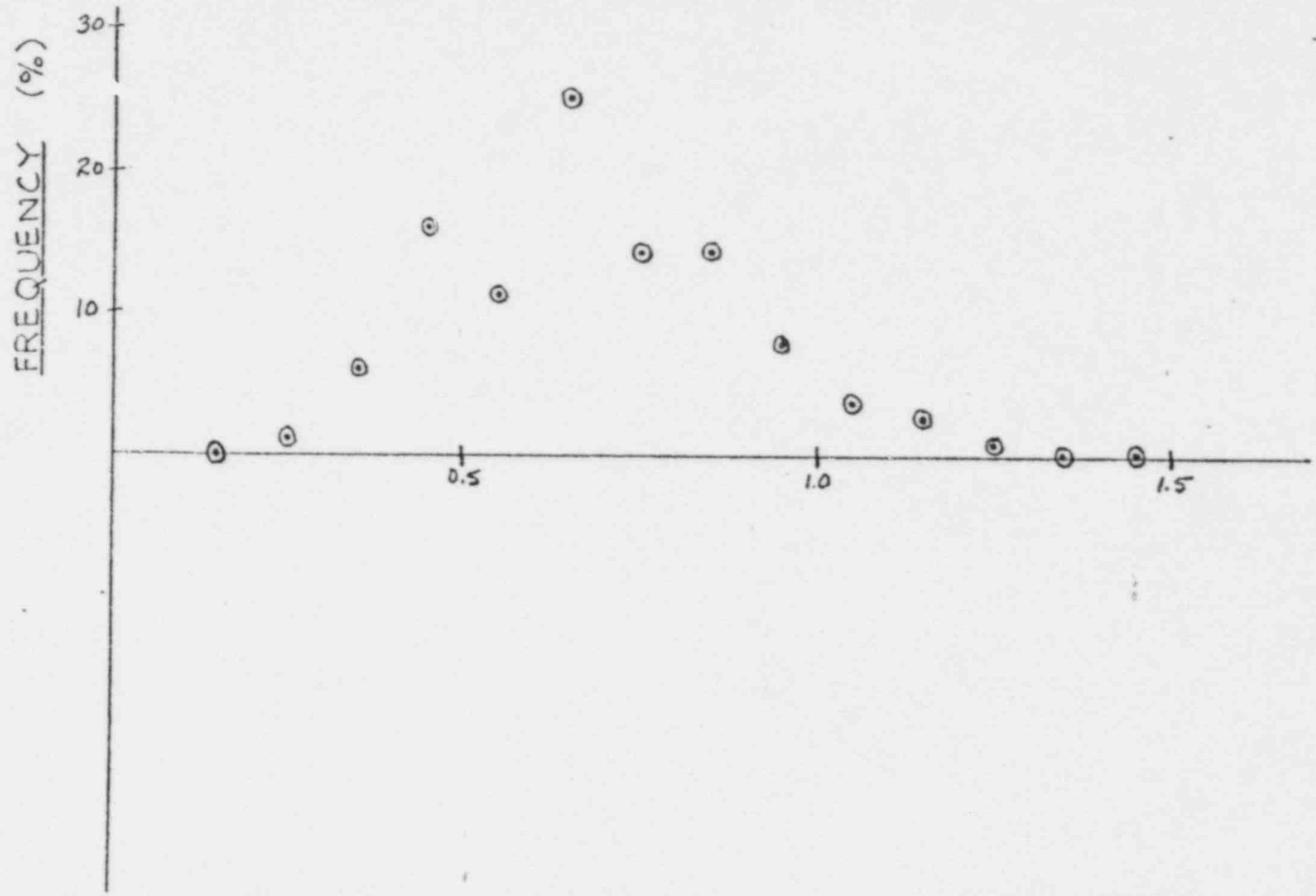
DATA ANALYST R. FERRIS / S. NARITA

REVIEWED

Tube # R	Tube # C	Record: Strip Chart	Record: Mag Tape	F3 100 KHZ 1st Loop: Magnitude Divisions	F3 100 KHZ 1st Loop: Quadrant	F3 100 KHZ 2nd Loop: Magnitude Divisions	F3 100 KHZ 2nd Loop: Quadrant	F3 100 KHZ: Voltage	F3 100 KHZ: Phase Angle Degrees	Photo #	FA: Vector Magnitude Divisions	FA: Phase Angle	C1 MIX: Total Magnitude	C1 MIX: Phase	C1 MIX: Starting Quadrant	C1 MIX: Quadrant	Location	Comment
1	1	1	1-036	3.1	2	1.2	4	.62	16		3.4	55	3.2	30	1-2		07	
1	1			3.3	2	3.3	4	.66	16		3.7	68	3.2	02	1-2		I7	
1	2	1	1-049	4.4	2	3.4	4	.88	19		5.1	62	4.8	27	1-2		07	
1	2			2.4	2	2.3	4	.48	19		2.9	59	3.4	25	2-1		I7	
1	3	1	1-072	3.2	2	1.2	4	.64	19		3.2	59	3.4	16	1-2		07	
1	3			3.3	2	2.4	4	.66	18		3.6	69	4.2	189	3-1-4-2	PHOTO # 3	I7	
1	4	1	1-082	3.2	2	2.2	4	.64	12	1	3.4	55	4.2	18	4-2		07	
1	4			4.0	2	3.4	4	.80	17	2	3.6	66	4.0	189	3-1-4-2		I7	
1	5	1	1-094	2.1	2	1.4	4	.42	17		3.1	54	3.2	30	1-2		07	
1	5			3.4	2	2.4	4	.68	17		3.6	66	3.2	189	3-1		I7	
1	6	1	1-105	3.1	2	2.1	4	.62	17		3.4	57	3.2	31	2-1		07	
1	6			4.0	2	3.0	4	.80	17		3.8	67	3.2	185	1-3		I7	
1	7	1	1-116	2.1	2	1.4	4	.42	17		2.9	55	3.0	208	4-2		02	
1	7			4.1	2	3.1	4	.82	17		3.8	69	3.2	189	4-2		I2	
1	8	1	1-126	2.0	2	1.3	4	.40	17		2.6	56	3.2	26	4-2		07	
1	8			3.4	2	3.1	4	.63	17		3.8	68	3.2	182	2-1		I7	
1	9	1	1-136	2.0	2	1.4	4	.40	17		3.0	58	3.2	35	4-2		07	
1	9			3.4	2	3.1	4	.68	17		3.6	69	3.2	187	1-3		I7	
1	10	1	1-146	2.2	2	1.4	4	.44	17		3.2	54	3.2	206	2-4		07	
1	10			3.3	2	2.4	4	.66	17		3.2	71	3.2	182	2-1		I7	
1	11	1	1-156	2.2	2	1.3	4	.44	17		3.2	58	3.2	208	2-4		07	
1	11			3.3	2	3.1	4	.66	17		3.2	71	3.2	186	2-4		I7	

U-BEND SIGNAL FREQUENCY DISTRIBUTION

SG #2



INSPECTION SUMMARY

SEQUOYAH UNIT #2 FIRST ROW U-BENDS

LARGE LOOP AMPLITUDE (VOLTS)	CLASSIFICATION	STEAM GENERATOR 1	2	3	4	TOTAL
$1.0 \leq A < 1.1$	MINOR TRANSITION	17	11	3	1	32
$1.1 \leq A < 1.3$	SUSPECT TRANSITION	8	10	0	0	18
$A \geq 1.3$	MAJOR TRANSITION	4	1	0	0	5

Summary of TVA Inner Radius Program.

David F. Goetcheus (TVA)

Summary and Recommendations

1. Two necessary conditions for Row 1 Tangent Point SCC can be identified. The degree of "Opposite Side Transition" and manufacture by SMD can be used to identify the susceptibility of tubes to failure. Identification of tubes by this method would be conservative, since the metallurgical structure cannot be characterized as to its susceptibility to SCC. Tubes may be identified that have a metallurgical structure immune to SCC.

2. Row 1 Tangent Point Tube Failure Morphology is associated with the degree of "Opposite Side Transition" and the associated stresses.

3. Commercially available ECT methods can be used to characterize Row 1 tubes' propensity to SCC.

4. ECT methods are currently being developed by EPRI and TVA to improve crack detection at U-Bent Tangent Points. These improved techniques will be available for Sequoyah Units 1 and 2 at the first refueling outage.

5. Testing of Sequoyah Unit 2 Row 1 tubes has identified:

5 Major "Opposite Side Transistions"
18 Suspect "Opposite Side Transitions"
32 Minor "Opposite Side Transitions"

All major "Opposite Side Transitions" will be inspected at the first refueling outage for SCC. If SCC is detected, then all suspect transitions will be inspected.

6. At the first refueling outage Sequoyah Unit 1 Row 1 tubes will be characterized and major "Opposite Side Transitions" will be inspected. This additional testing will be accomplished provided this work does not enter into critical path time and/or infringe on section eleven required testing.

7. The addition of inspection ports will not provide pertinent information to the Row 1 leakage problem. Degradation of generator internals is not a necessary condition for Row 1 tangent point leakage events. Generator internals can best be monitored by one or a combination of the following methods:

   Eddy Current Test Data Analysis
   Profilometry Data Analysis
   Flow Slot Measurements
   Remote TV Camera Inspection

8. Since all Row 1 tubes do not have the required conditions for SCC then plugging all Row 1 tubes is not justified.

   Essential variables for tangent point SCC are known and can be used to identify specific tubes to be monitored to control potential leakage events.