

Babcock & Wilcox

EPRI/BABCOCK & WILCOX COOPERATIVE PROGRAM

ON

PWR FUEL ROD PERFORMANCE

(RP-711-1)

DALLAS-FT. WORTH, TEXAS

APRIL 6, 1977



THIS HAND-OUT IS A COMPILATION OF VIEWGRAPHS AND
INFORMATION PRESENTED AT THE SECOND EPRI CONTRACTORS'
OVERVIEW MEETING HELD IN DALLAS - FT. WORTH, TEXAS,
ON APRIL 6, 1977. ALL DATA PRESENTED HEREIN ARE
CONSIDERED PRELIMINARY.

PHASE 1

CREEP COLLAPSE TESTS

OBJECTIVES:

LONG-TERM IN-REACTOR DATA ON

- COMPRESSIVE CREEP**
- IRRADIATION GROWTH**

(NO FUEL INTERACTION EFFECTS)

EPRI/B&W

COOPERATIVE PROGRAM

ON

PWR FUEL ROD PERFORMANCE

RP-711-1

PHASE 2

PWR DEMONSTRATION IRRADIATIONS

OBJECTIVES:

DETERMINE EFFECTS OF DIFFERENT;

- MATERIAL PROPERTIES
- DESIGN PARAMETERS

ON FUEL ROD PERFORMANCE

(FUEL INTERACTION EFFECTS)

**EPRI/B&W COOPERATIVE PROGRAM ON
PWR FUEL ROD PERFORMANCE**

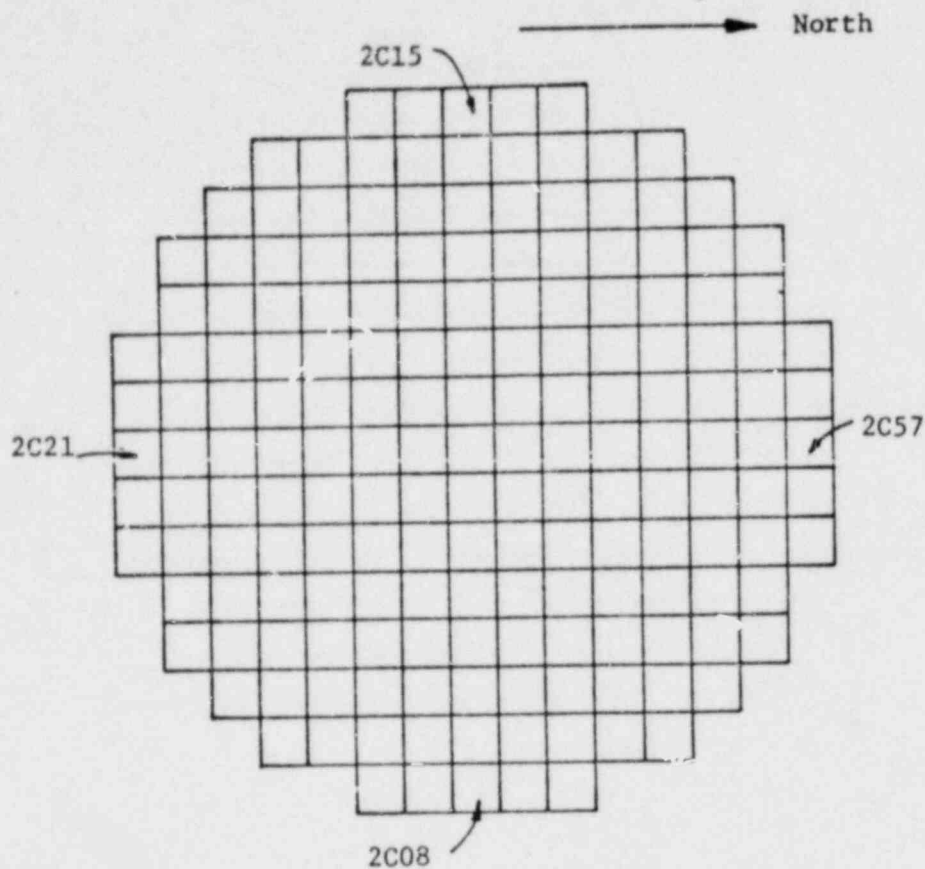
(RP 711-1)

PHASE I

"CREEP COLLAPSE"

EOC 1

DESTRUCTIVE EXAMINATION



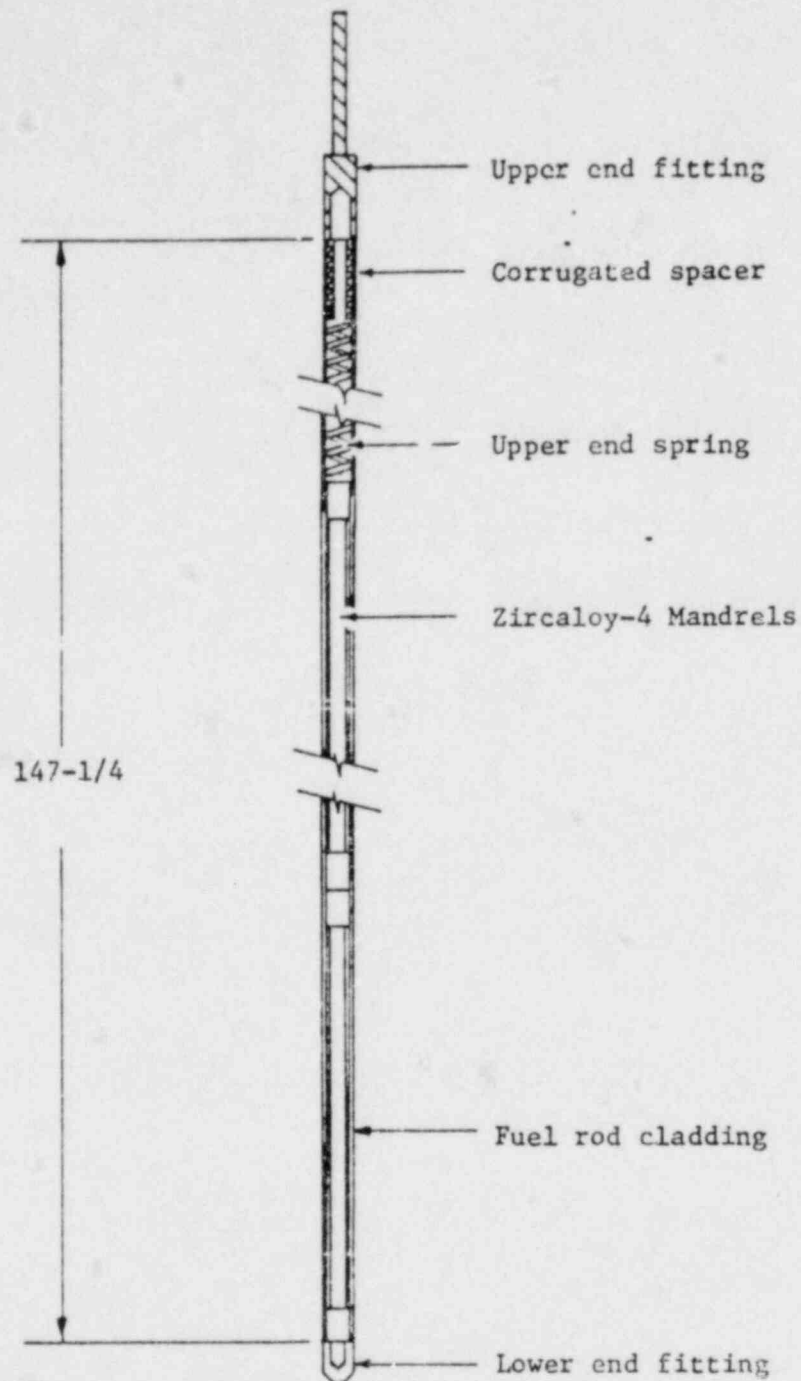
Fuel Assembly Number:	2C15	2C57	2C08	2C21
Test Assembly Number:	118	115	117	116

Oconee II, Cycle 1 Core Locations of Experimental Cladding Test Assemblies

ASSEMBLY 118

ROD S/N	CLADDING TYPE	COMPRESSIVE HOOP STRESS
80004	V-1	12.5
80005	V-1	10
80013	V-2	12.5
80018	V-2	0
80025	S-2	15
80026	S-2	15
80030	S-2	12.5
80035	S-2	0
80042	S-1	15
80043	S-1	15
80050	S-1	12.5
80051	S-1	12.5
80058	S-1	10
80059	S-1	10
80067	S-1	0
80068	S-1	0
80069	S-1	0

(ARCHIVE)



Dimensions in Inches

NOTE:

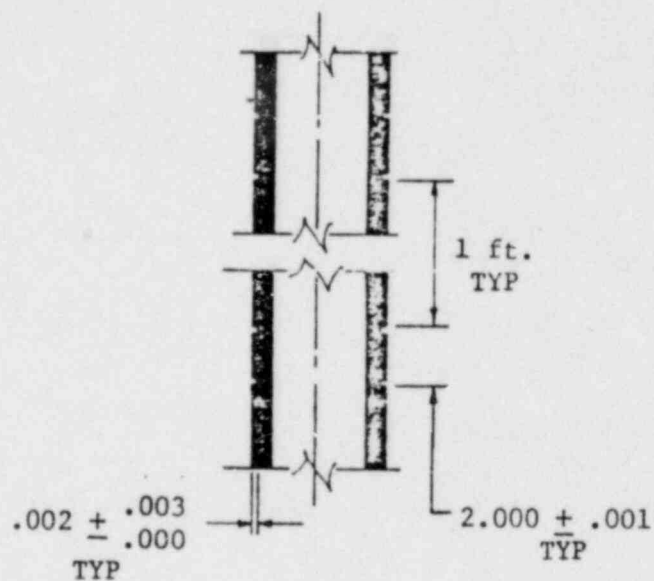
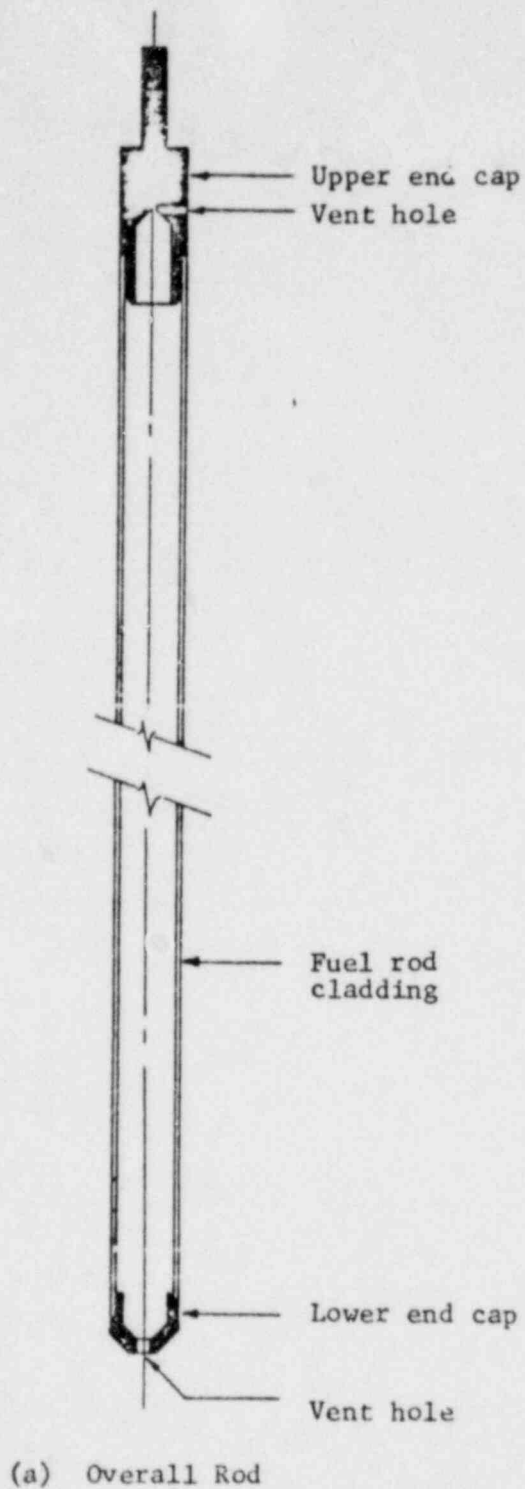
Cladding O.D. = 0.430 ± 0.002

I.D. = 0.377 ± 0.002

Creep Collapse Specimen Rod

HOT CELL EXAMINATION EOC 1

- 1. VISUAL**
- 2. PROFILOMETRY**
- 3. WALL THICKNESS**
- 4. GROWTH**
- 5. BOW**
- 6. RADIOCHEMISTRY**
- 7. UNIAXIAL TENSILE**
- 8. BIAXIAL TENSILE**



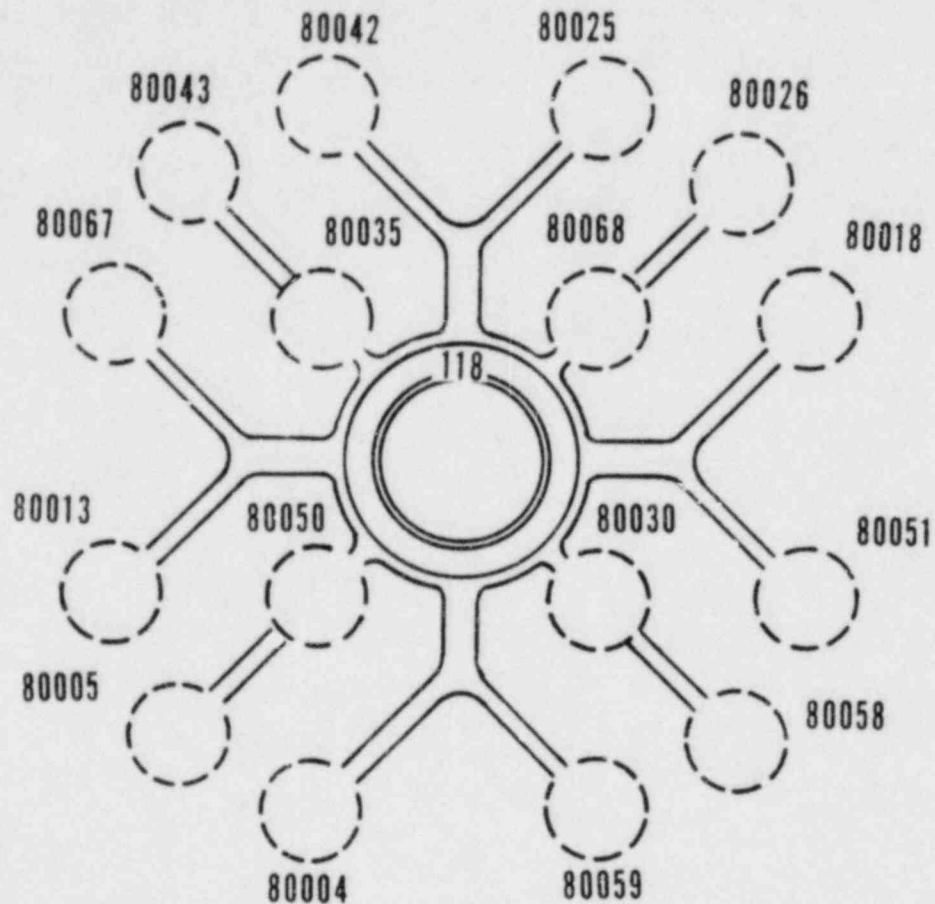
Dimensions in inches

Irradiation Growth Specimen Rod

GROWTH

- ARCHIVE ROD
- CALIBRATE SSM TRACES
- CALIBRATE LRC TRACES

CORE CENTER



ROD ORIENTATION OF CLADDING TEST

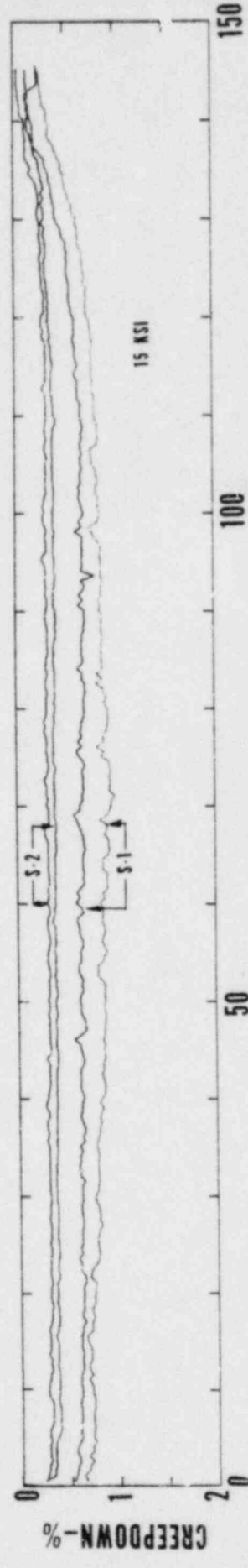
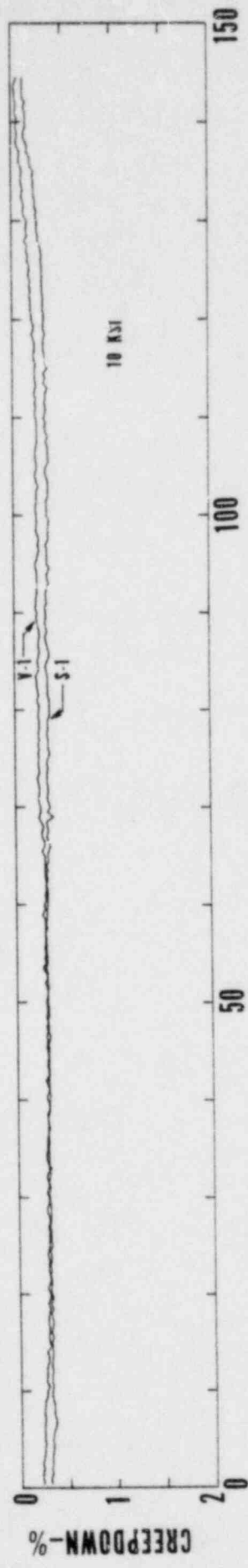
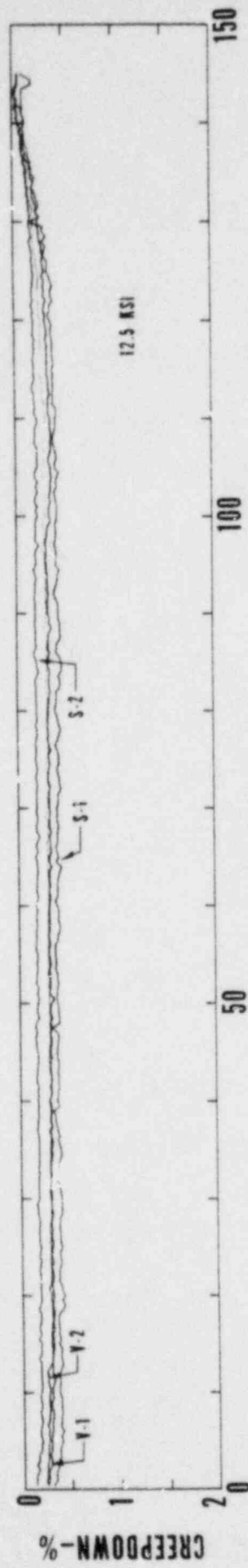
ASSEMBLY 118 (VIEWED FROM TOP)

UNIAXIAL TENSILE

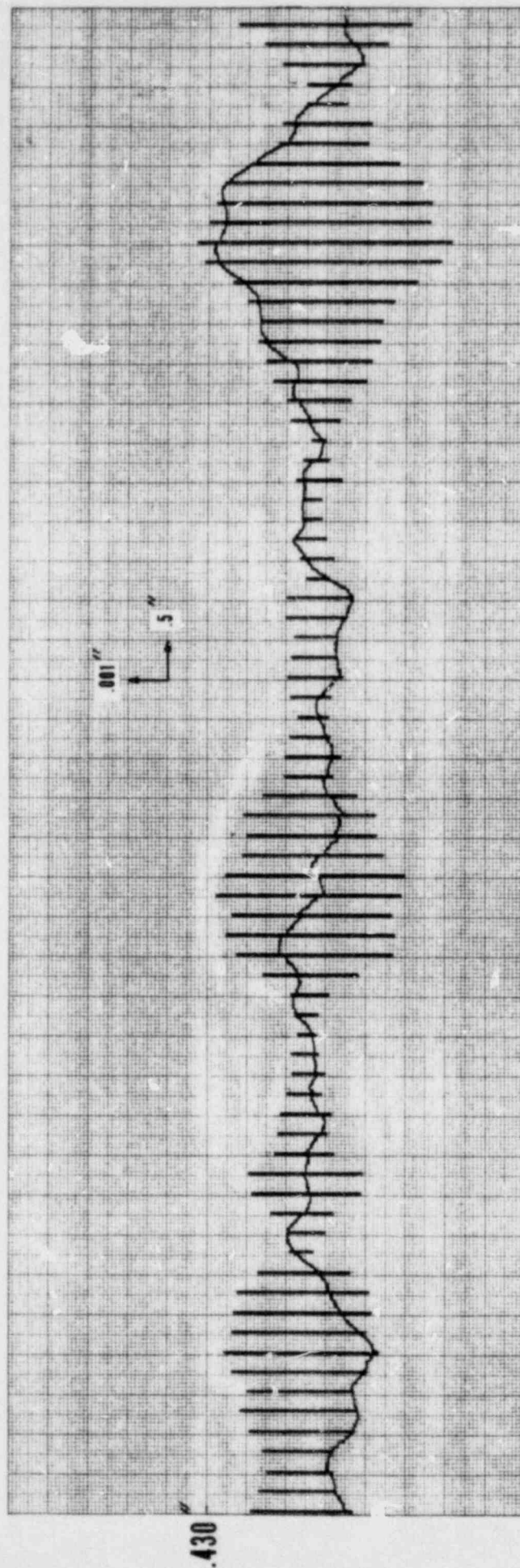
- .650°F
- $\pm 5^{\circ}\text{F}$ OVER 3 INCHES
- 30 MINUTE HEATING
- 7 INCH SPECIMEN
- 2 INCH GAGE LENGTH
- 5 INCH UNSUPPORTED
- 0.005/MINUTE STRAIN RATE
- PHOTOGRAPHY

VISUAL EXAMINATION

- 2X AND 10X PERISCOPE**
- UNIFORM LIGHT CRUD LAYER**
- NO ABNORMALITIES**



EFFECT OF CLADDING TYPE (AT EQUIVALENT STRESS) ON CREEPDOWN VERSUS
DISTANCE FROM THE BOTTOM OF THE ROD (IN INCHES)



ON-LINE TRACE OF ONE SECTION OF A DIAMETER STEP SCAN

Irradiation Growth of Experimental Rods

<u>Rod S/N</u>	<u>Cladding Type</u>	<u>Preirradiation Gage Length (inches)</u>	<u>Postirradiation Length (inches)</u>	<u>Length Change (inches)</u>	<u>Growth (%)</u>
80059	S-1	127.97	127.97	0	0
80068	S-1	127.75	128.24	+ 0.49	+ 0.38
80067	S-1	127.38	128.28	+ 0.90	+ 0.71
80035	S-2	127.82	128.91	+ 1.09	+ 0.85
80018	V-2	130.14	128.39	- 1.75	- 1.34

DISTORTION (BOW)

- FIXED I/T TRANSDUCER**
- ONE RPM ROTATION**
- AUDIBLE ALARM**
- ONE FOOT STEPS**
- CALIBRATION**
- DATA REDUCTION**

**MAXIMUM BOW AND ANGLE
Z/Ø' PLANE**

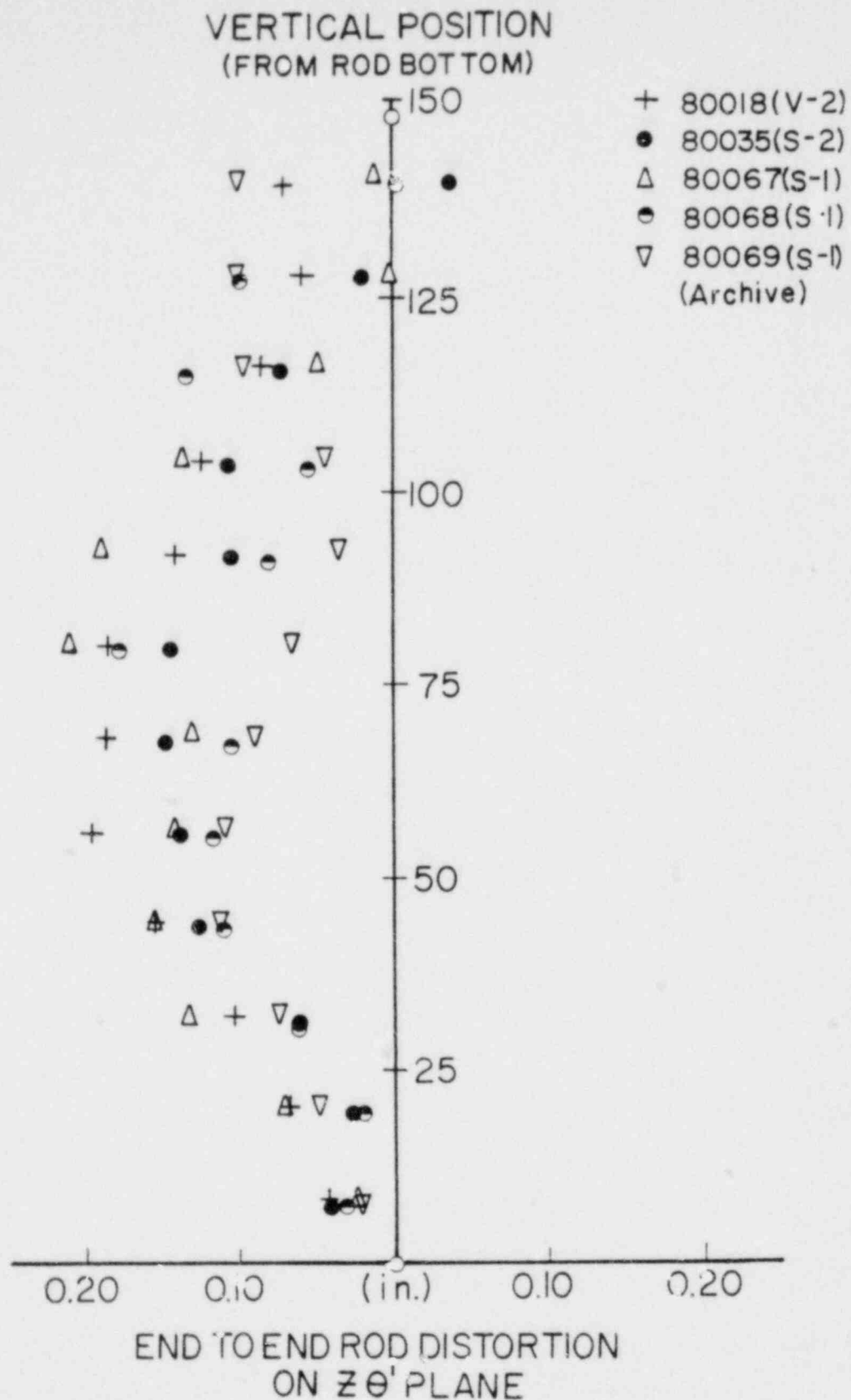
**ROD CENTERLINE
VERTICAL TO ACTUAL
VERTICAL SHIFT**

650°F UNIAXIAL TENSION

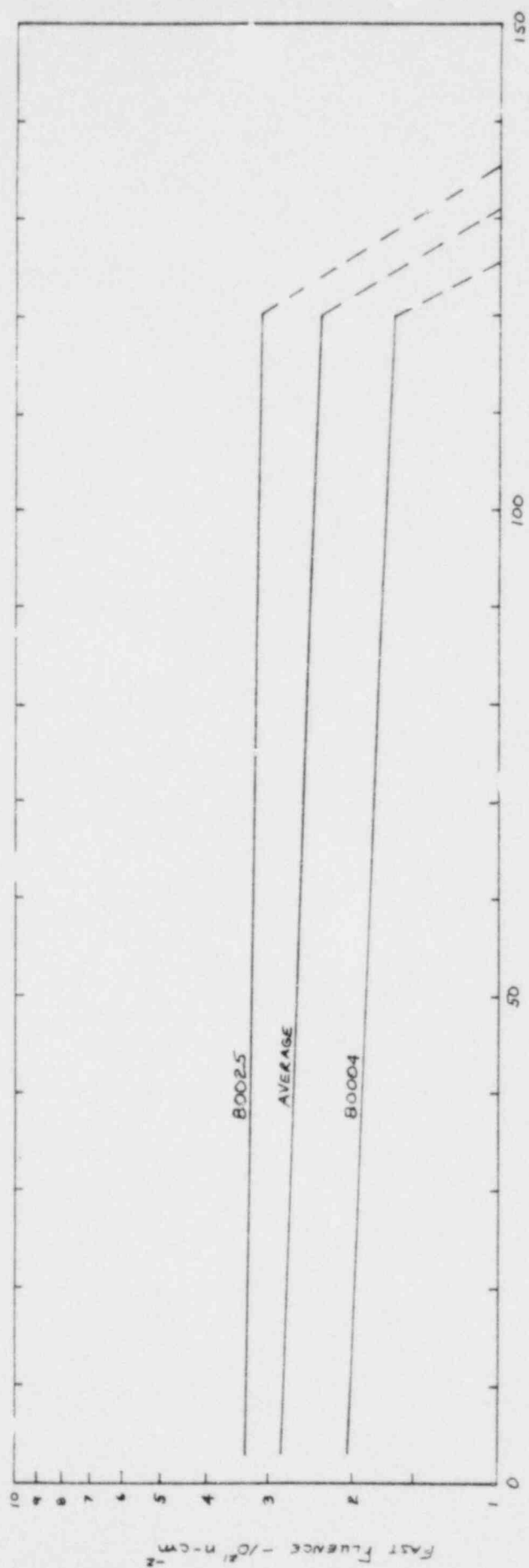
		UTS	0.2%YS	UE	TE
S-1	PRE	70.5	54.7	3.3	23.1
	POST	94.0	81.2	2.7	20.7
	%	+33	+49	-17	-11
S-2	PRE	36.2	20.6	17.2	54.6
	POST	79.1	76.2	0.7	10.0
	%	+119	+269	-96	-82
V-1	PRE	66.4	488.3	3.0	15.4
	POST	79.6	74.9	1.4	11.0
	%	+20	+55	-53	-28
V-2	PRE	58.2	45.1	4.3	16.4
	POST	78.9	75.3	1.1	9.9
	%	+36	+67	-75	-40

BIAXIAL TENSILE

- CLOSED END 2:1
 - 650°F
 - +/- 5°F OVER 3 INCHES
 - 45 MINUTE HEATING
 - 7 INCH SPECIMEN
 - 2000 PSI /MIN
 - HEISE GAGE
 - PHOTOGRAPHY
- .1% TCE RESOLUTION



**END-TO-END ROD DISTORTION OF TYPES V-2, S-2
AND S-1 CLADDING VERSUS DISTANCE FROM
THE BOTTOM OF THE ROD (IN INCHES)**



650°F BIAXIAL TENSION

		UHS	TCE
S-1	PRE	86.1	8.9
	POST	120.3	5.4
	%	+40	-39
S-2	PRE	53.2	53.9
	POST	99.2	15.7
	%	+86	-71
V-1	PRE	74.0	21.1
	POST	100.7	6.0
	%	+36	-71
V-2	PRE	70.0	30.3
	POST	100.4	14.3
	%	+43	-53

**EPRI/B&W COOPERATIVE PROGRAM ON
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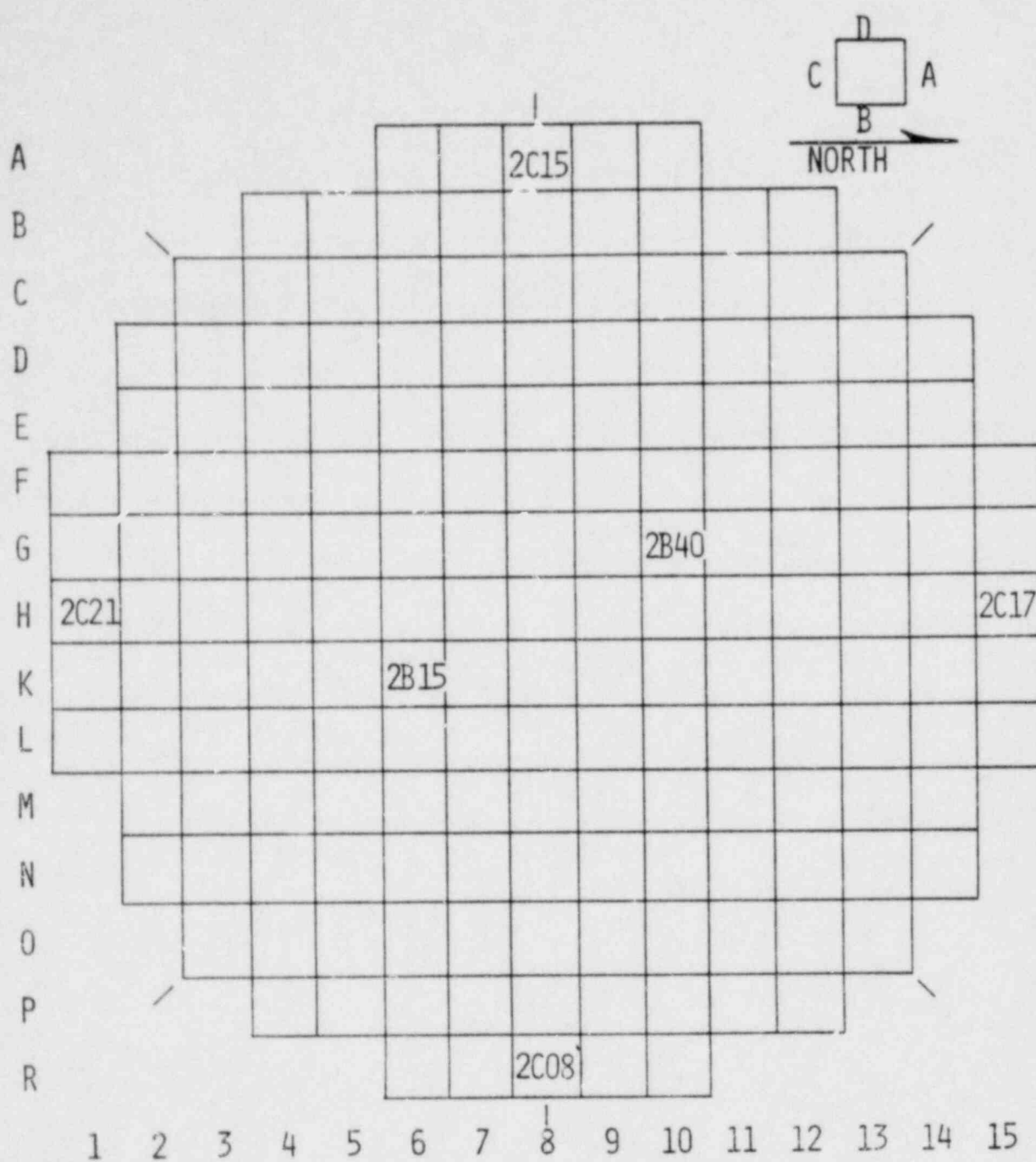
(RP 711-1)

PHASE II

"PWR"

EOC 1

POOLSIDE EXAMINATION



- 2B15 - LBP
- 2B40 - LBP
- 2C08 - CCS-117
- 2C15 - CCS-118
- 2C17 - CCS-115
- 2C21 - CCS-116

FACE A

	4	3	2					1			24	23			
4	V2C		V1L		V1C					V1L		V1C	V1L	23	
49	S1C												V2C	22	
5	S2L												S1L	21	
50	S1C														
6	S2C														
51	S1C														
7	S2L														
FACE D														FACE E	
8	S2C														
													S2C	20	
9	S2L												S1L	19	
													S2C	18	
													S1L	17	
													V2C	16	
52	S1C				V2C					V2L	V1C	V2L	V1C	V2L	15
	52				10					11	12	13	14	15	
															FACE C

POOLSIDE TESTS

- **VISUAL EXAMINATION**

PERISCOPE - PHOTOGRAPHY

TV - VIDEO TAPE

- **GROSS GAMMA SCANNING**

- **DIMENSIONAL MEASUREMENTS**

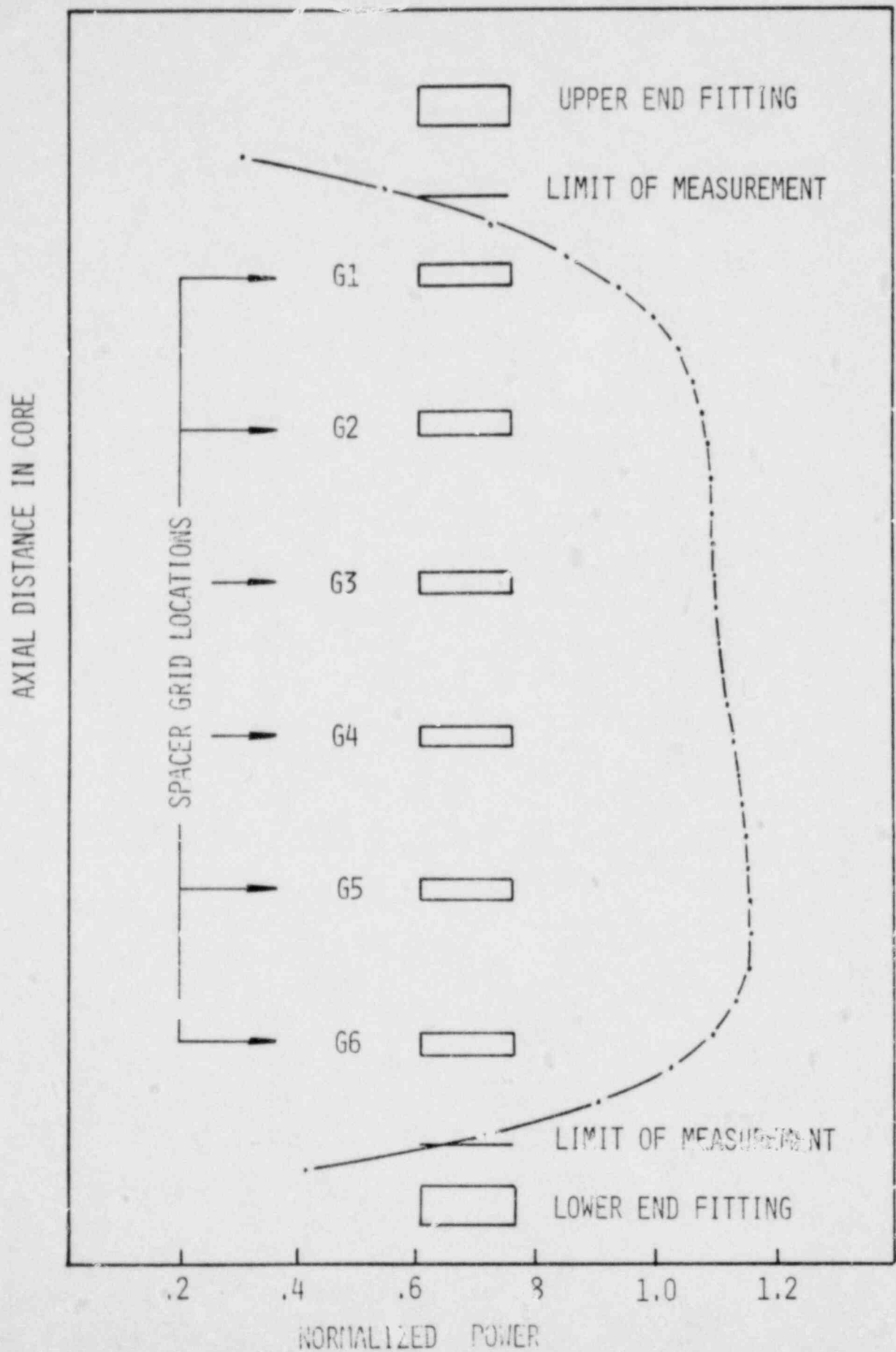
DIAMETER PROFILOMETRY

ASSEMBLY BOW

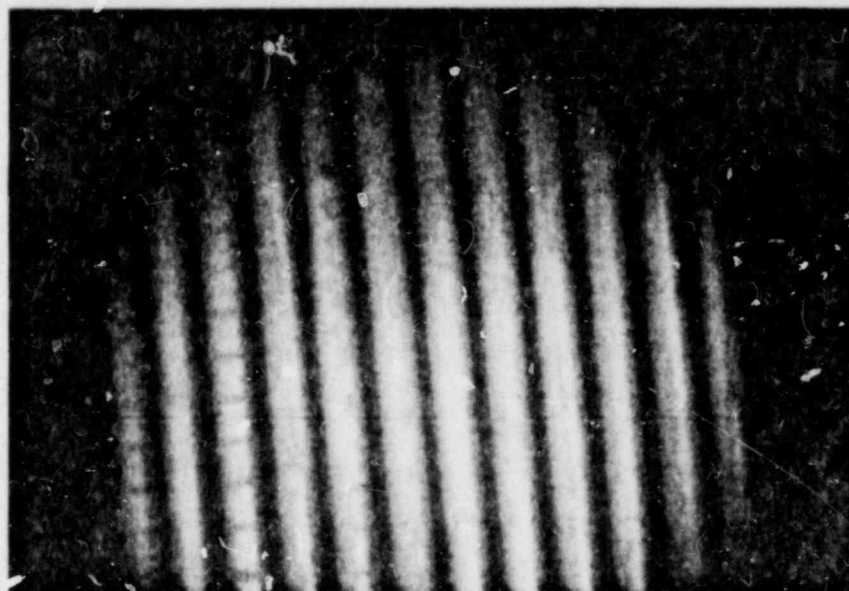
ROD BOW

WATER CHANNEL SPACINGS

AXIAL POWER DISTRIBUTION



F/A 2B40 FACE A G6-L/SK



GAMMA SCANS



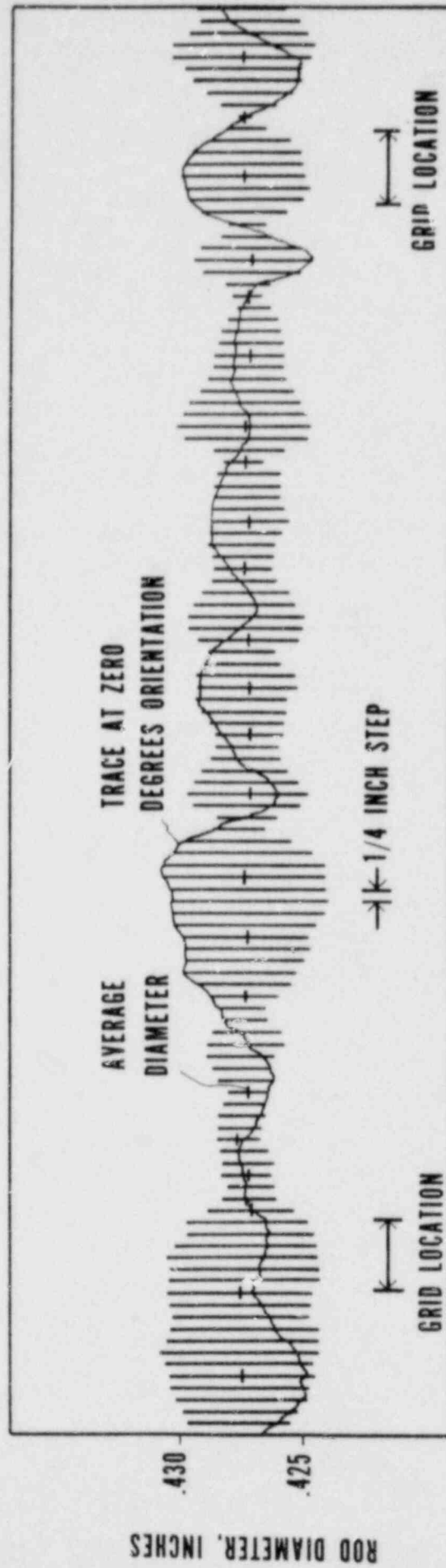
ROD 39 - TYPE L FUEL

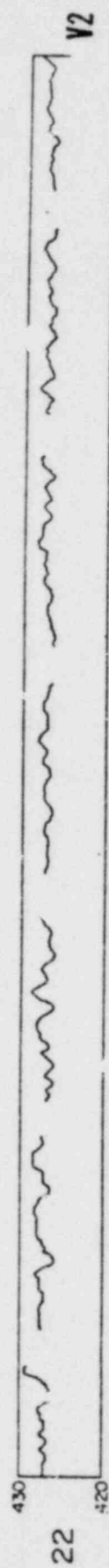
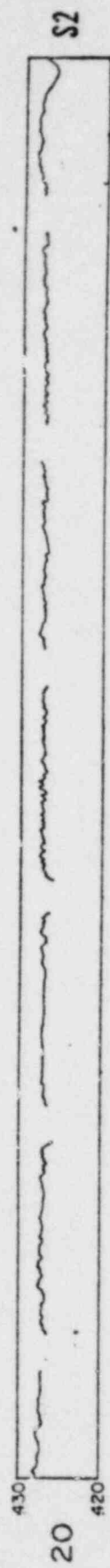


ROD 56 - TYPE C FUEL

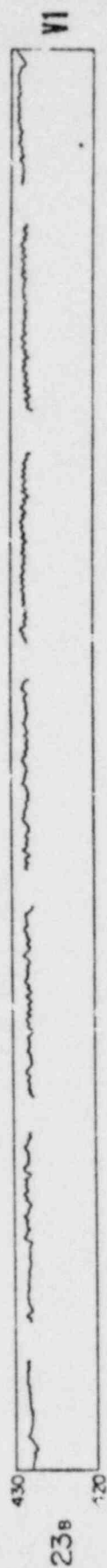
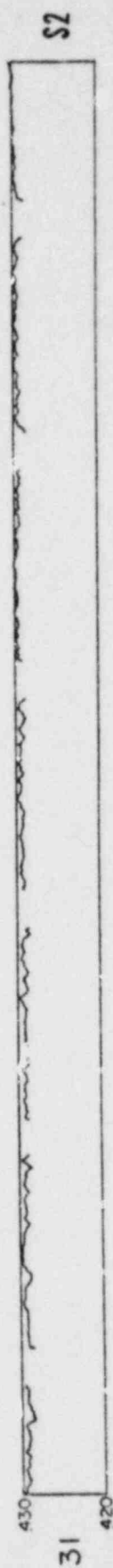
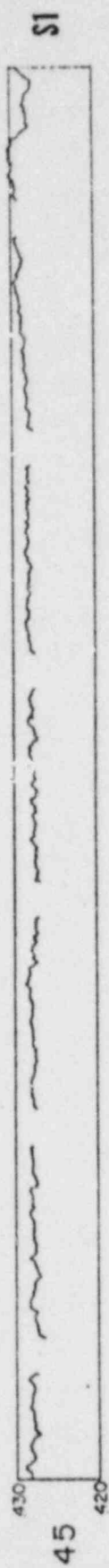


STEP-SCAN PROFILOMETRY WITH 180° ROTATION AT EACH STEP





DIAMETER PROFILOMETRY - TYPE C FUEL



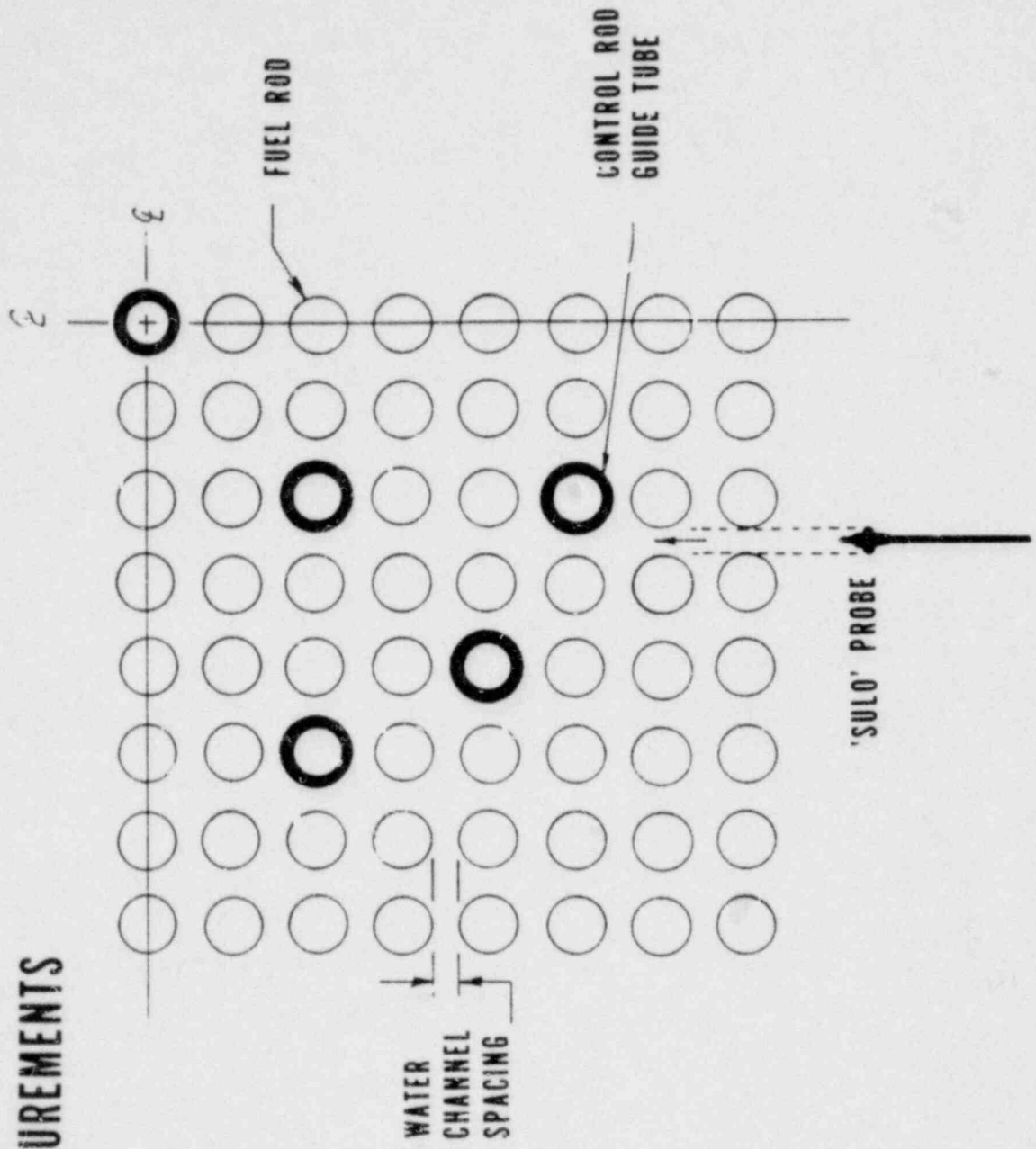
DIAMETER PROFILOMETRY - TYPE L FUEL

DIAMETER PROFILOMETRY RESULTS

<u>FUEL</u>	<u>CLAD</u>	<u>ROD NUMBERS</u>	<u>MEAN DIAMETER</u>	<u>AVG. MAX. OVALITY</u>
KM	S1	49, 50, 51, 52*53, 54, 55, 56, 57, 58	.4269"	7.7 mils
	S2	6, 8, 18, 20, 30, 32, 42, 44	.4287"	1.7 mils
	V1	2, 12, 14, 24, 26, 36, 38, 48	.4278"	3.3 mils
	V2	4*10, 16, 22, 28*34, 40, 46	.4280"	2.6 mils
LRC	S1	17, 19, 21, 41, 43, 45	.4278"	1.4 mils
	S2	5, 7, 9, 29, 31	.4290"	1.2 mils
	V1	1, 3, 23*25, 27, 47*	.4284"	1.2 mils
	V2	11, 13, 15*35, 37, 39*	.4287"	1.1 mils

* Corner Rods With Orthogonal Traces Obtained

WATER CHANNEL MEASUREMENTS

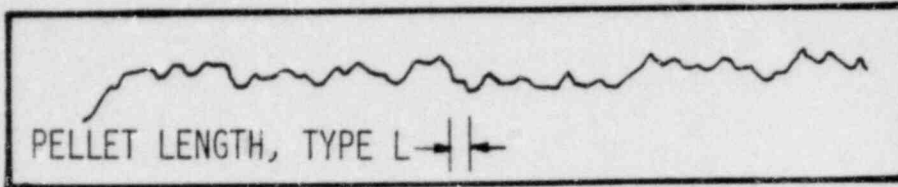


DIAMETER SCAN SEGMENTS

FUEL ROD DIAMETER, INCHES

.430

.425



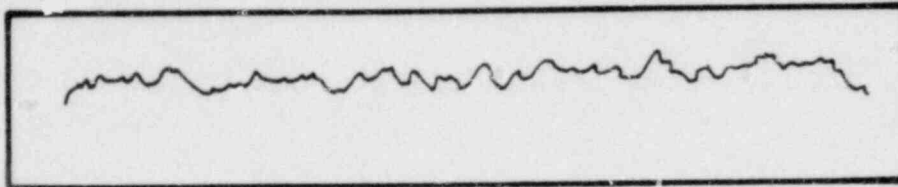
19

L

S1

.430

.425



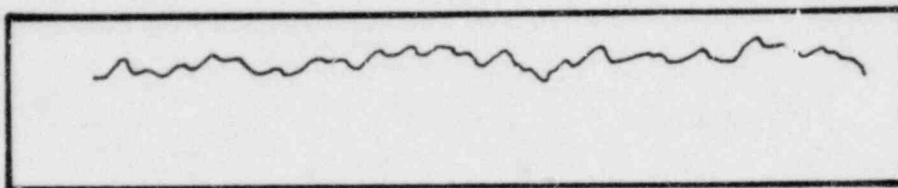
23

L

V1

.430

.425



15

L

V2

.430

.425



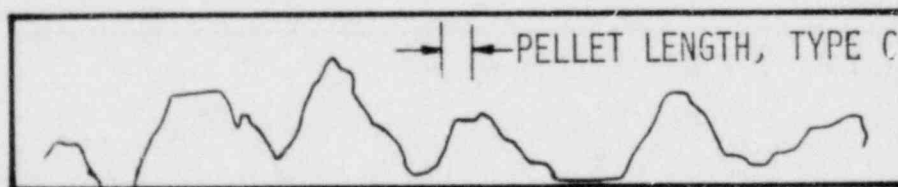
49

C

S1

.430

.425



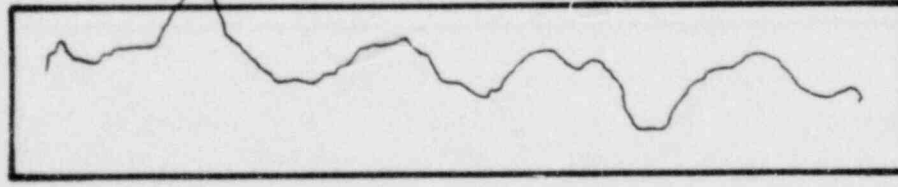
12

C

V1

.430

.425

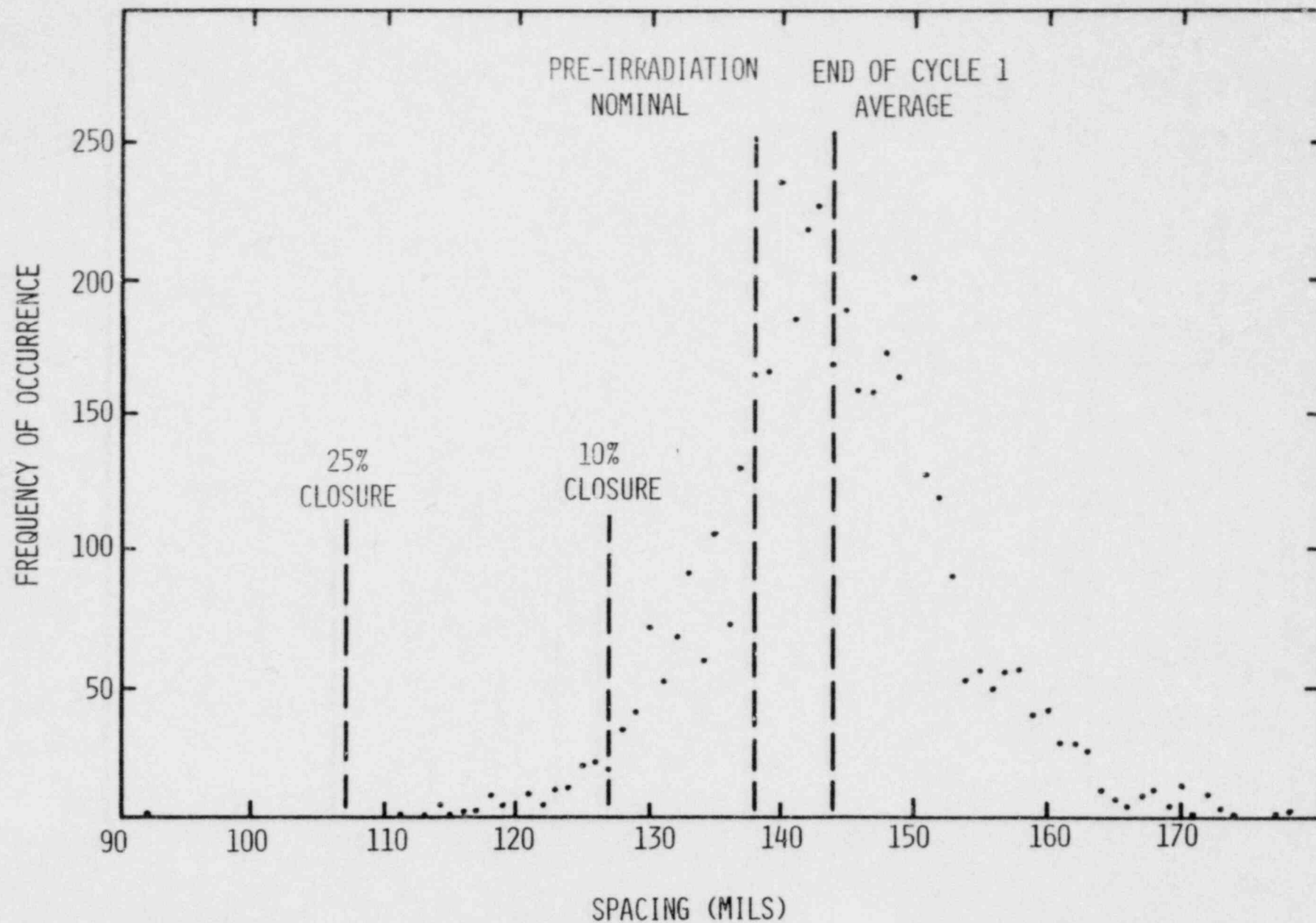


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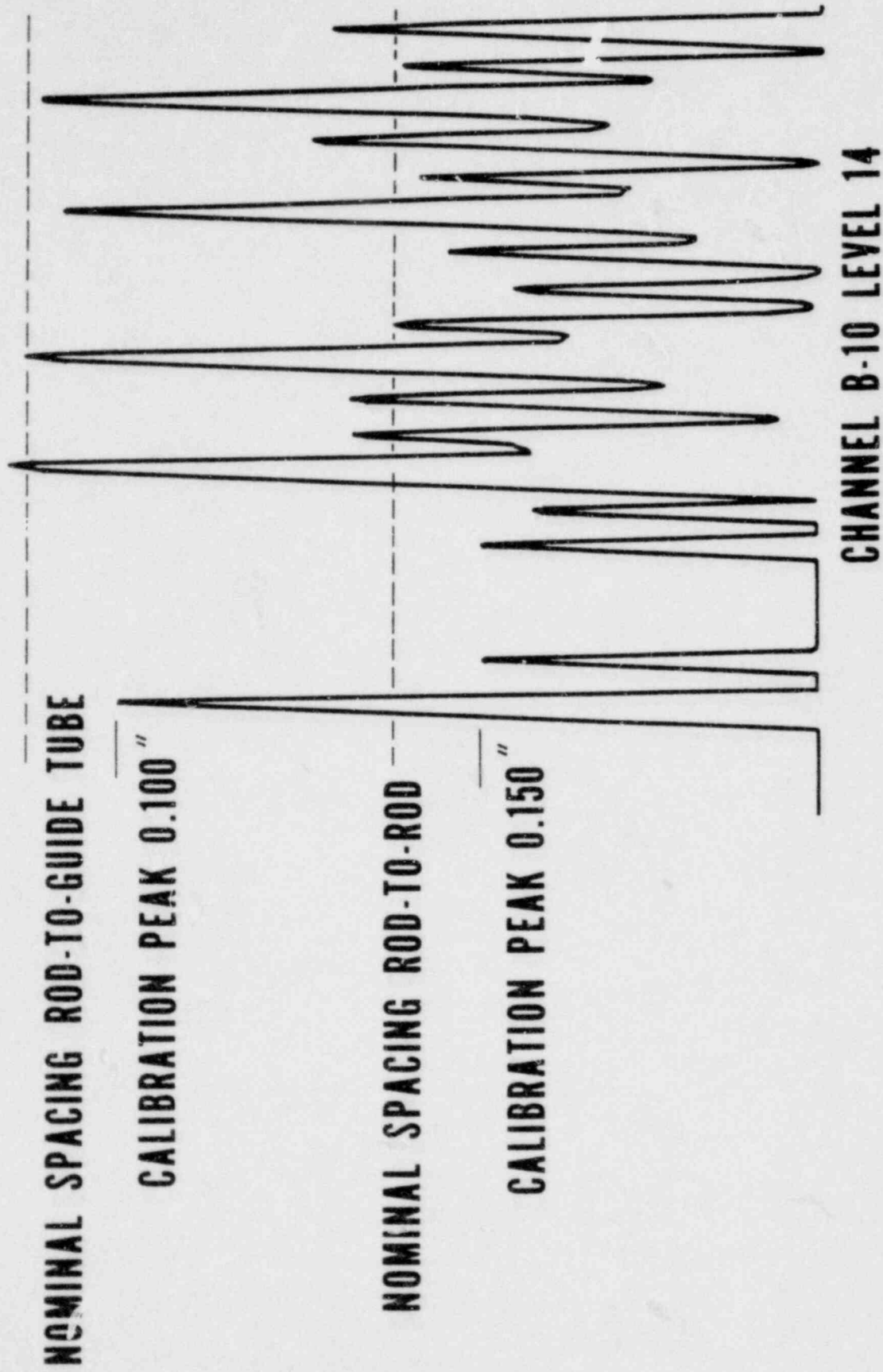
C

V2

ROD-TO-ROD SPACING DISTRIBUTION



WATER CHANNEL SPACINGS



ROD BOW VS BURNUP

