# Wolf Creek EOC-8 Fuel Assembly/RCCA Inspection Program

**Contributors:**

**D. J. Colburn**
**D. D. Davis**
**J. R. Halligan**
**A. S. Konzel**
**H. Kunishi**

**May 3, 1996**

Inspection work was conducted at the site by NSD under the supervision of WCNOC personnel and PPE Engineers Tom DiMuzio, John Bury, and Howard Pendley. Responsibility for the reduction and verification of individual portions of the inspection program was assigned to various PPE Engineers. Their signatures on this document attest that (1) they have independently verified the sections assigned to them; and (2) they concur with the results documented herein.

A listing of the individual data reduction and verification assignments is given below:

| | Inspection Program Section | Originating Engineer | Verifying Engineer |
|---|---|---|---|
| 1.0 | Background & Objectives | J. Halligan | D. Colburn |
| 2.0 | Full Length RCCA Drag Tests | J. Halligan/A. Konzel | D. Colburn |
| 3.0 | Short RCCA Drag Tests | J. Halligan | D. Colburn |
| 4.0 | Guide Thimble Plug Gage Exams | D. Davis | J. Halligan |
| 5.0 | F/A Bow Measurements | D. Davis | D. Colburn |
| 6.0 | F/A Length Measurements | H. Kunishi | A. Konzel |
| 7.0 | Rod Growth Measurements | H. Kunishi | A. Konzel |
| 8.0 | T/N Gap Measurements | H. Kunishi | A. Konzel |
| 9.0 | Guide Thimble Borescope Exams | A. Konzel | H. Kunishi |
| 10.0 | Overall Summary | A. Konzel | D. Colburn/J. Halligan |

**Signatures On File**

_____
**D. J. Colburn**
Product Performance Engineering

_____
**D. D. Davis**
Product Performance Engineering

_____
**J. R. Halligan**
Product Performance Engineering

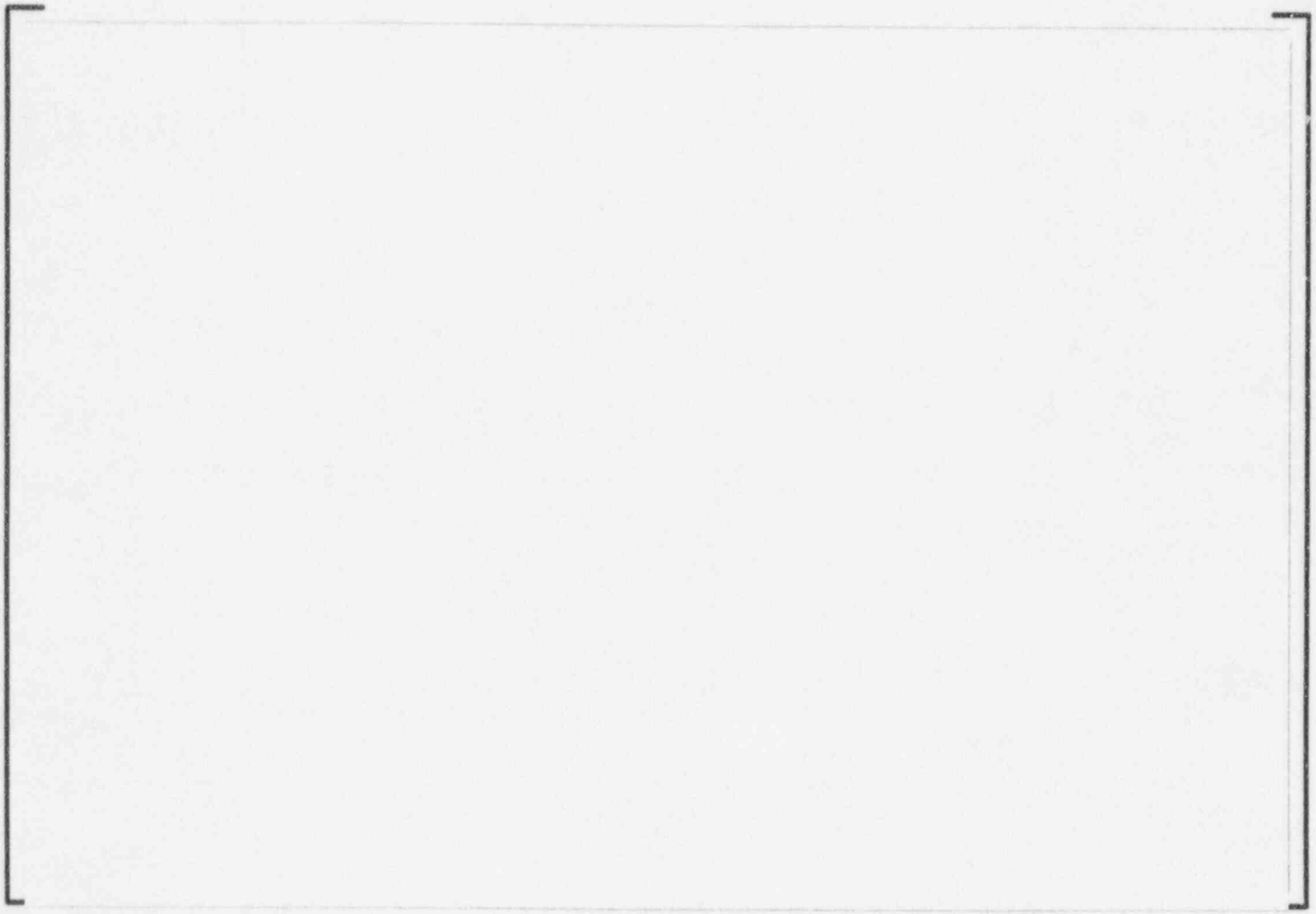
_____
**A. S. Konzel**
Product Performance Engineering

_____
**H. Kunishi**
Product Performance Engineering

## 1.0 Background and Objectives

An RCCA insertion anomaly was experienced at Wolf Creek near the end of Cycle 8. The reactor tripped resulting in a SCRAM. During this SCRAM, five RCCAs failed to fully insert. Wolf Creek conducted cold drop tests after the anomaly, and three additional RCCAs did not fully insert. The objective of this investigation was to determine, to the fullest extent possible, the nature of these anomalies. A decision tree for the investigation was developed and issued under PPE-96-043 prior to the initiation of testing, to be used as a guide in the investigative process.

a,b,c



## 2.0 Full Length RCCA Drag Tests

The following RCCA drag tests were conducted in an effort to better understand the anomaly.

- Drag test with upper internals in place
- Drag test of RCCA in mating fuel assembly in spent fuel pool
- Drag test of RCCA in a reference fuel assembly

The objectives of these tests were to determine:

(1) The location of the interference causing the anomaly (F/A, RCCA, or Upper Internals); and

(2) Determine the magnitude on interference.

## 2.1 Drag Test with Upper Internals in Place

A total of 27 RCCA positions were selected for drag testing with the upper internals in place. They included assemblies which failed to fully insert, and a sample of assemblies with various burnups. Fuel assemblies H03, H16, H53 and H59 also failed to fully insert, however, these assemblies were not selected because of the risk that they may not be reinsertable.

### 2.1.1 General Test Procedure

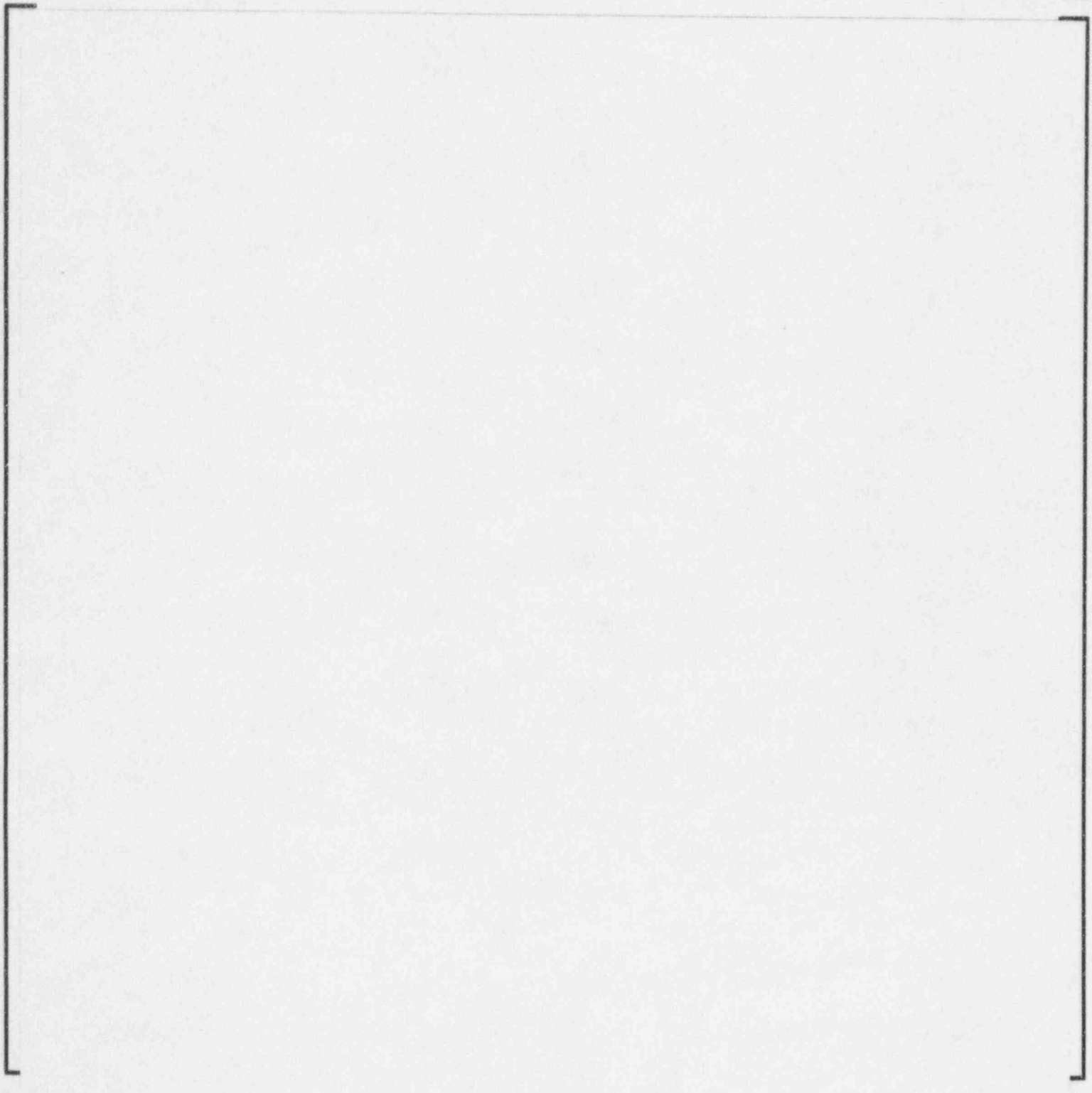
The reactor head was previously removed. The RCCA drive shafts remain attached to the RCCAs. A load cell and strip chart recorder are used in conjunction with the crane to withdraw the RCCA from the fuel assembly while recording total weight as a function of axial position of the RCCA in the fuel assembly.

### 2.1.2 Test Results

a,b,c

[ ]

a,b,c



## 2.2 Drag Tests in the Spent Fuel Pool

Sixteen fuel assemblies were selected for this test based on the results of the in core tests. The assemblies were as follows.

a,b,c

[

]

### 2.2.1 General Procedure

The selected RCCAs were latched with a handling tool and withdrawn approximately 108 inches, then reinserted back into the fuel assembly. These tests were performed in the same fuel assemblies in which the RCCAs were used in Cycle 8.

## 2.2.2 Test Results

a,b,c

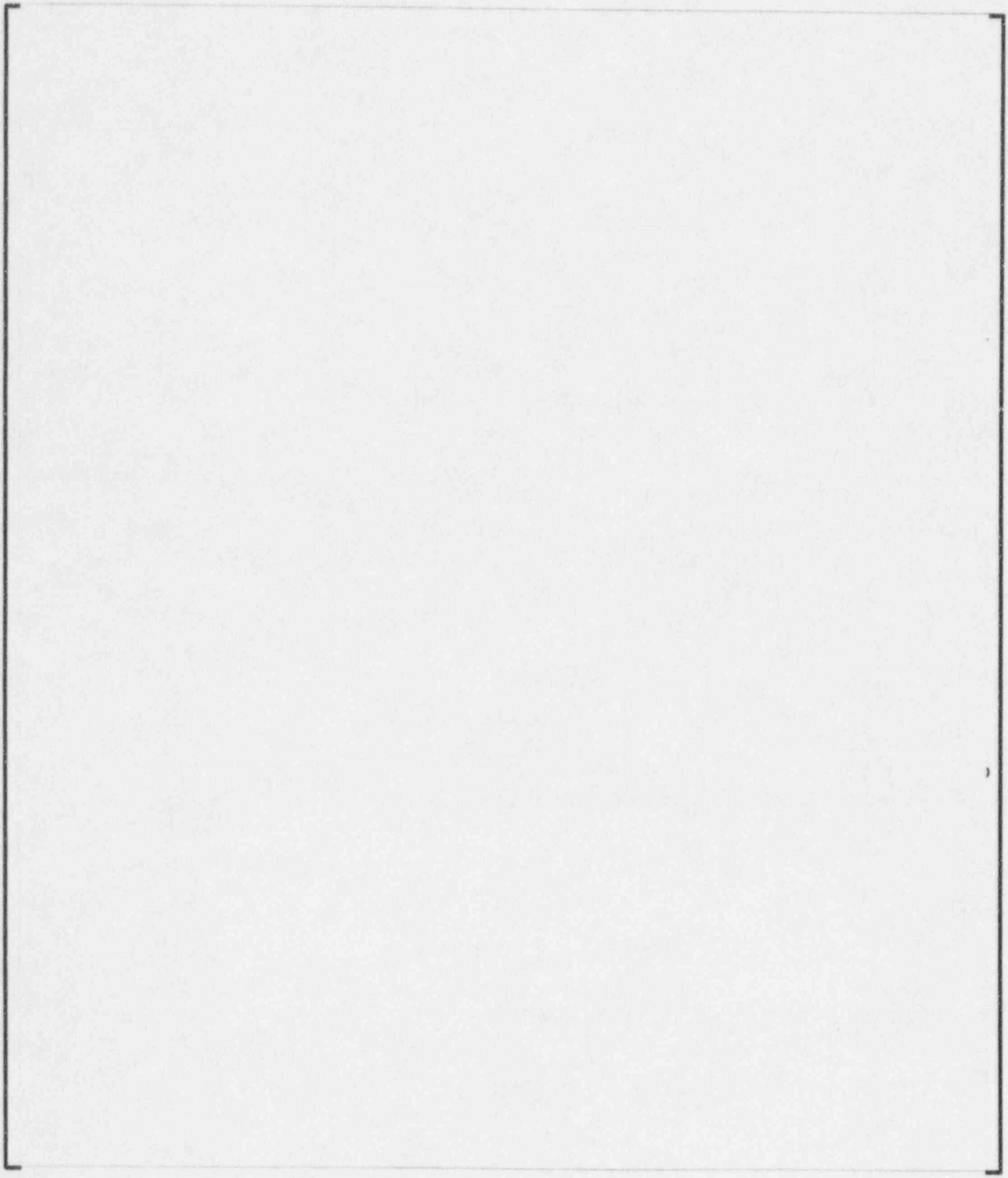


Table 2.3 provides a summary of spent fuel pool drag forces at selected elevations.

a,b,c

## 2.3 Drag Tests of RCCAs in Reference Fuel Assembly

Each of the RCCAs listed in Section 2.2 above were drag tested in a new fuel assembly (L54) using the same test procedure. In all cases, including hafnium RCCA R27, the drag observed was less than 20 lbs. This drag is judged to be insignificant.

## 2.4 Conclusions

The results of the above drag tests indicate that a binding interference exists between the thimble tubes and the RCCAs, causing the high drag. Based on the test of the RCCAs in a reference fuel assembly, the RCCAs show no indications of damage or deformation. The problem appears to reside within the fuel assembly.

# 3.0 Drag Test with Mock RCCA (Short Rodlets)

A drag test was performed on seven fuel assemblies with a mock RCCA with 13 inch rodlets. The objective of this test was to determine the condition of the thimble tubes at the top of the fuel assembly and the top nozzle alignment.

## 3.1 Test Procedure

The procedure for this test was similar to the full length RCCA drag test. The mock RCCA was attached to the handling tool and lowered into the test fuel assembly, then withdrawn. The total load was measured and recorded during insertion and withdraw.

## 3.2 Test Results

a,b,c

[

]

### 3.4 Conclusions

The twice and thrice burned assemblies displayed a higher drag than the once burned (control) assembly. In all cases the drag measured with the mock (short) RCCA was significantly a,b,c

[

]

## 4.0 Single Tube Probe

Fuel assemblies that show relatively high drag in the RCCA test have been selected for this test. Therefore, it is known there is an interference between the RCCA rodlets and thimble tubes. It was the objective of this test to determine the condition of the thimbles with respect to the following:

- Are the dashpots and/or major diameters distorted?
- Are the distortions "bows" or "kinks"?
- Are the distortions localized at a particular elevation?
- Are all the thimble tubes within an assembly distorted?

Fuel assemblies with low and intermediate drag were also selected for this test. The objective for these assemblies was to establish a baseline and observe the progression of single tube results as compared to RCCA drag test results.

### 4.1 General Procedure

a,b,c

[

]

## 4.3 Test Results

### 4.3.1 Go/ No-Go Summary - # of Tubes Passed/ # of Tubes Tested

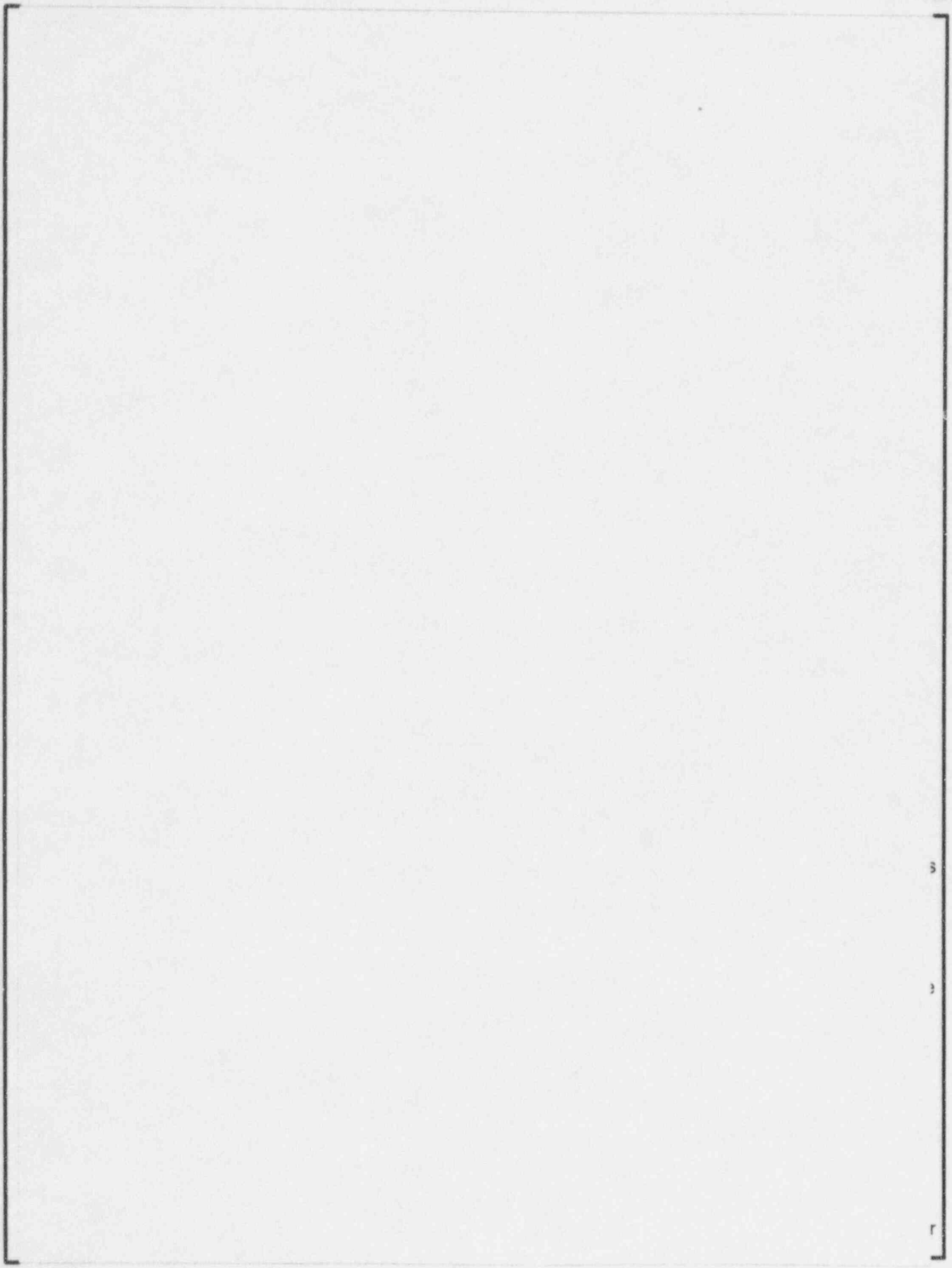
[ a,b,c ]

[ a,b,c ]

### 4.3.2 Thimble Tube Drag Test Summary

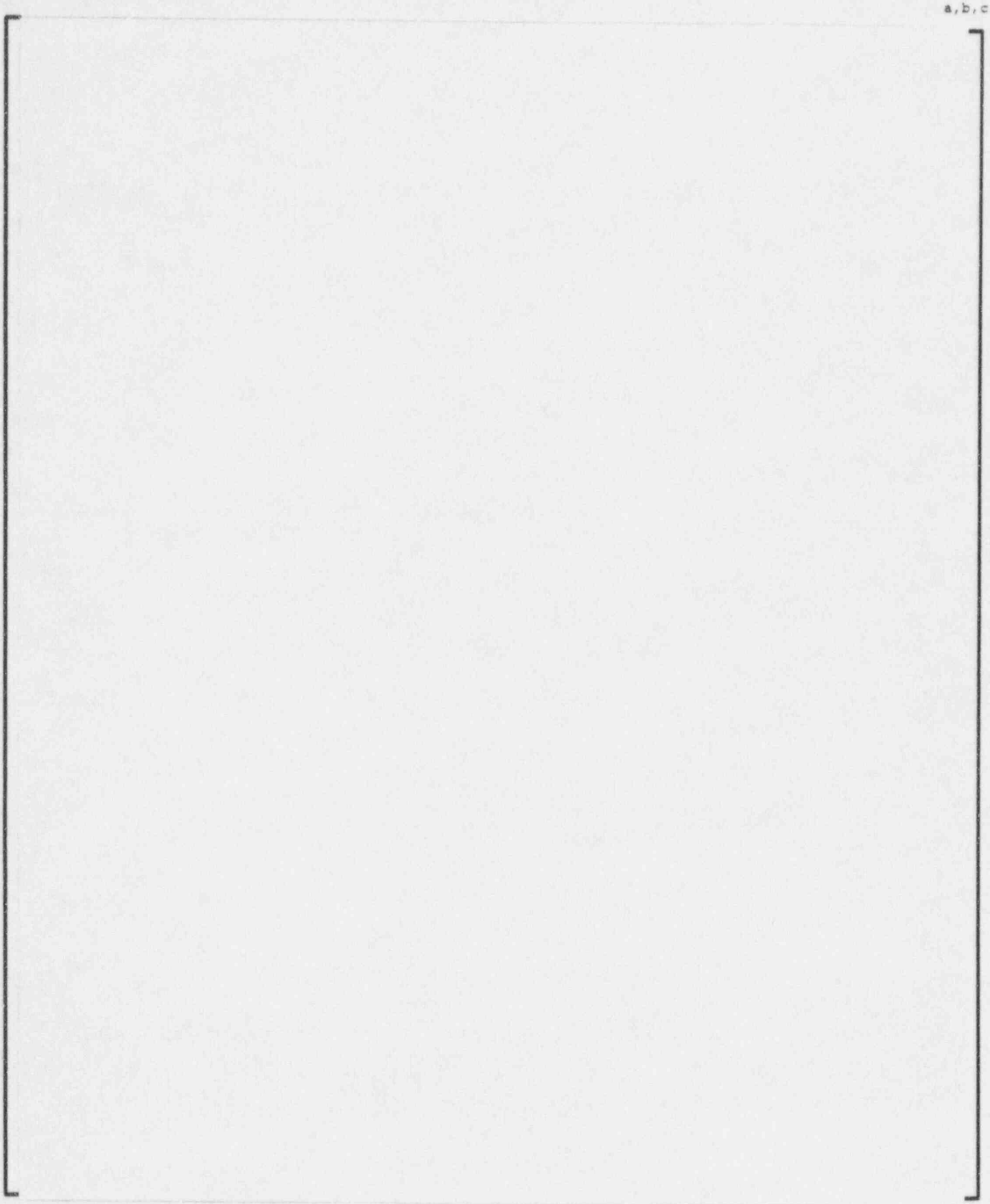
[ a,b,c ]

a,b,c



a,b,c

a,b,c



## 4.4 Conclusions

a,b,c

[

]

## 5.0 Fuel Assembly Bow

a,b,c

[

]

## 5.1 Measured Bow Shape

a,b,c

[

]

a,b,c

## 5.2Measured Bow Change

a,b,c

[

]

a,b,c

[

]

a,b,c

[

]

## 6.0Fuel Assembly Growth

a,b,c

[

]

a,b,c

## 7.0Fuel Rod Growth

For selected F/As, the axial gap between each peripheral rod and the F/A top nozzle was manually measured from the low magnification TV tapes obtained during the EOC-8 fuel examination. When combined with the F/A growth information previously obtained, a value for fuel rod growth can subsequently be derived.

Conversion factors from the measured gaps to the actual gaps were obtained by measuring the TV image of several grid spring heights on the outer straps in the top and bottom grids on each assembly face and by comparing the measured spring height to the corresponding manufacturing drawing nominal dimension. This assumes a negligible change of the inconel grid dimensions during irradiation.

A total of 11 assemblies were measured for the rod-to-nozzle gaps. They are G18, G35, G46, H07, H43, H50, H62, J29, J46, J61, and K46. The cladding material used in the "G" assemblies was standard Zircaloy-4. The cladding material used for the "H", "J", and "K" assemblies was Improved Zircaloy-4. Almost all peripheral rods in the "H" and "J" assemblies were seated on the bottom nozzle. It was also observed that the top gaps in most of the assemblies were fairly even, except that some interior rods in assemblies J29, H62, and H43 appeared higher than the exterior rods. These rods may be experiencing breakaway growth, or simply may not be seated on the bottom nozzle.

a,b,c

[

]

## 8.0Top Nozzle Gap Measurements

An attempt was made to measure the distance between the bottom of the top nozzle and the top of the top grid at the two opposite sides on the same assembly face to determine if there is any detectable cocking of the top nozzle. The distance was measured at the two opposite sides of Face 3 of F/A J03. Considering the large uncertainty involved in the measurement, no significant difference in the two distances was detected, and no additional measurements were peformed on the other assemblies.

## 9.0Guide Thimble Borescope Examinations

Borescope examinations were conducted on all guide thimbles in the following Wolf Creek fuel assemblies: H16, H38, H81, J03, and K06. The assemblies were chosen based upon the results of their RCCA drag force measurements and their burnup.

Every guide thimble in the selected assemblies was examined to determine:

- The presence of obvious physical anomalies and the general condition of the tube;
- The presence of debris or debris-related scarring on the thimbles; and
- The quantity and severity of wear marks believed to be present in the guide thimbles based upon their drag force results.

a,b,c

a,b,c

## 10.0 Overall Summary

a,b,c

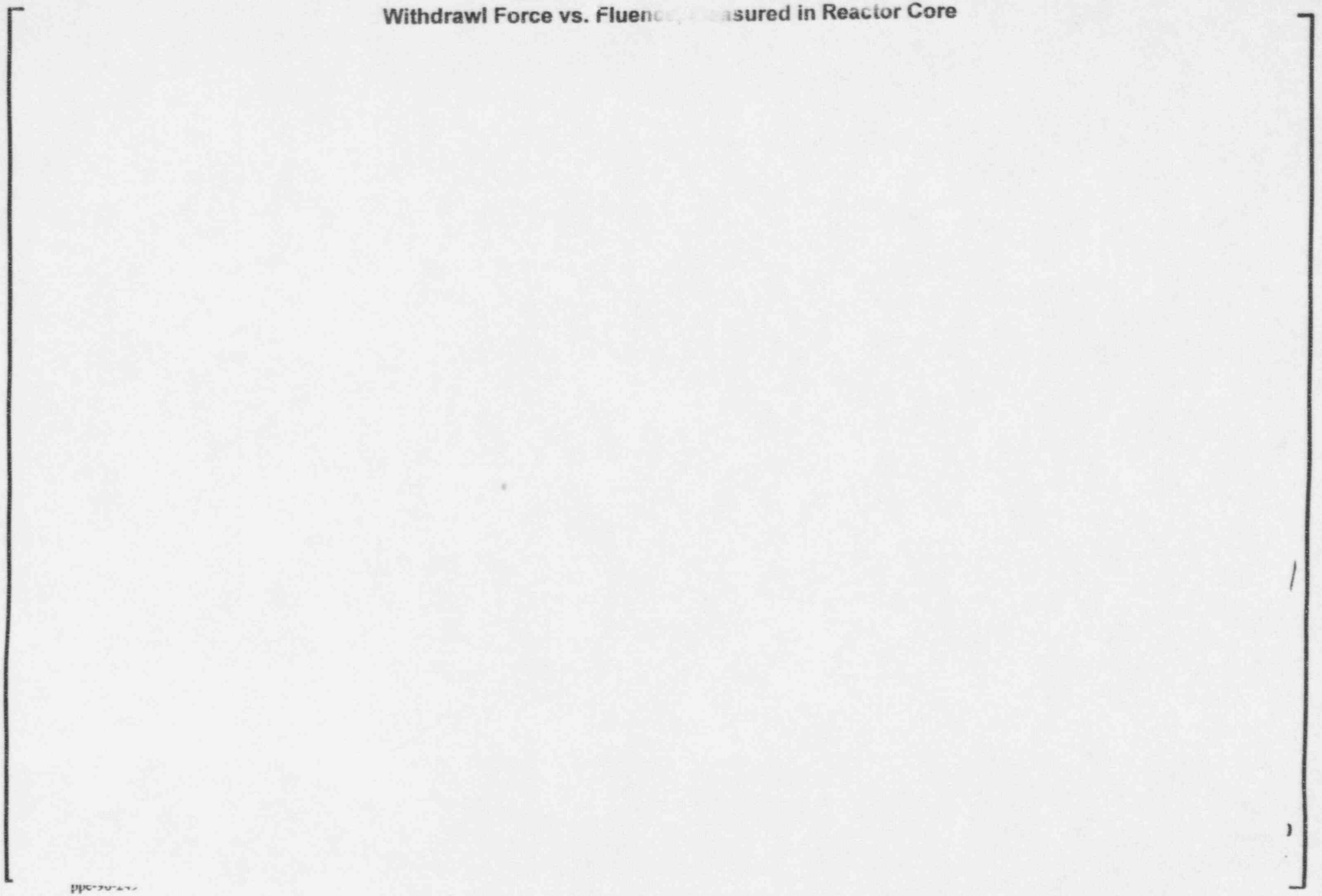
# Appendix 'A'

## Supporting Charts & Graphs

## Figure 2.1: Wo eek EOC-8

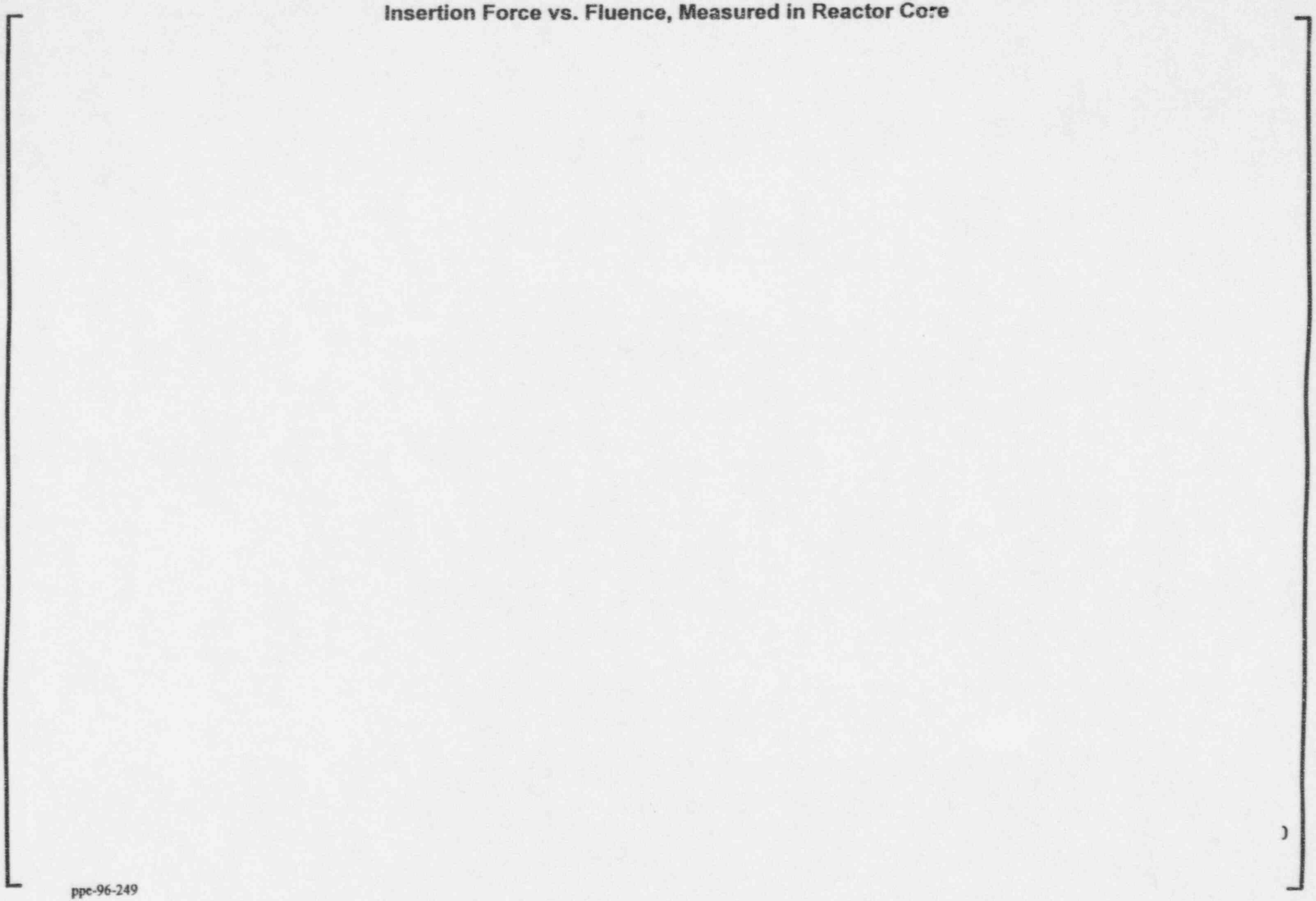
a,b,c

Withdrawl Force vs. Fluenc asured in Reactor Core

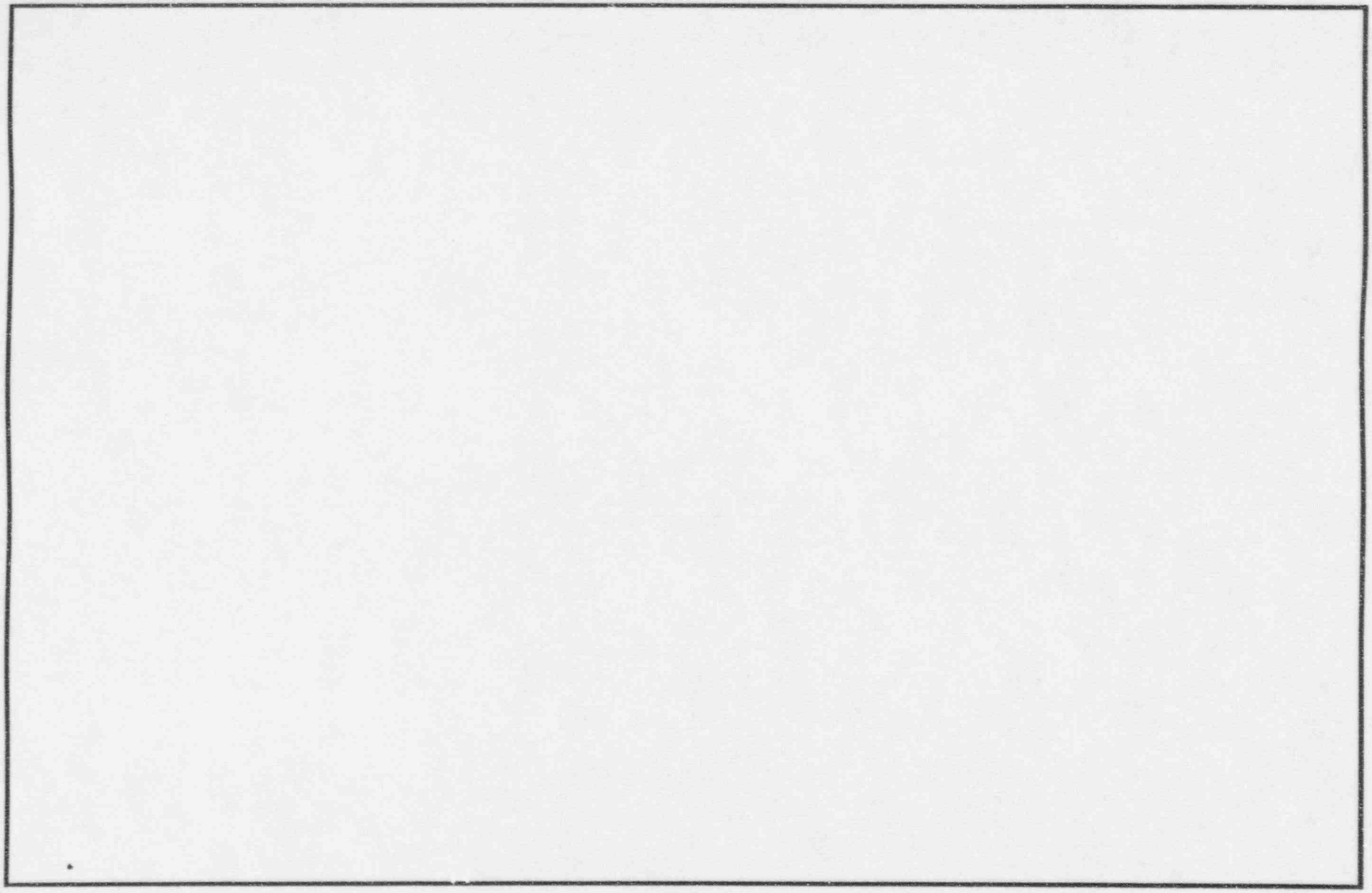


## Figure 2.2: Wolf Creek EOC-8
### Insertion Force vs. Fluence, Measured in Reactor Core

a,b,c

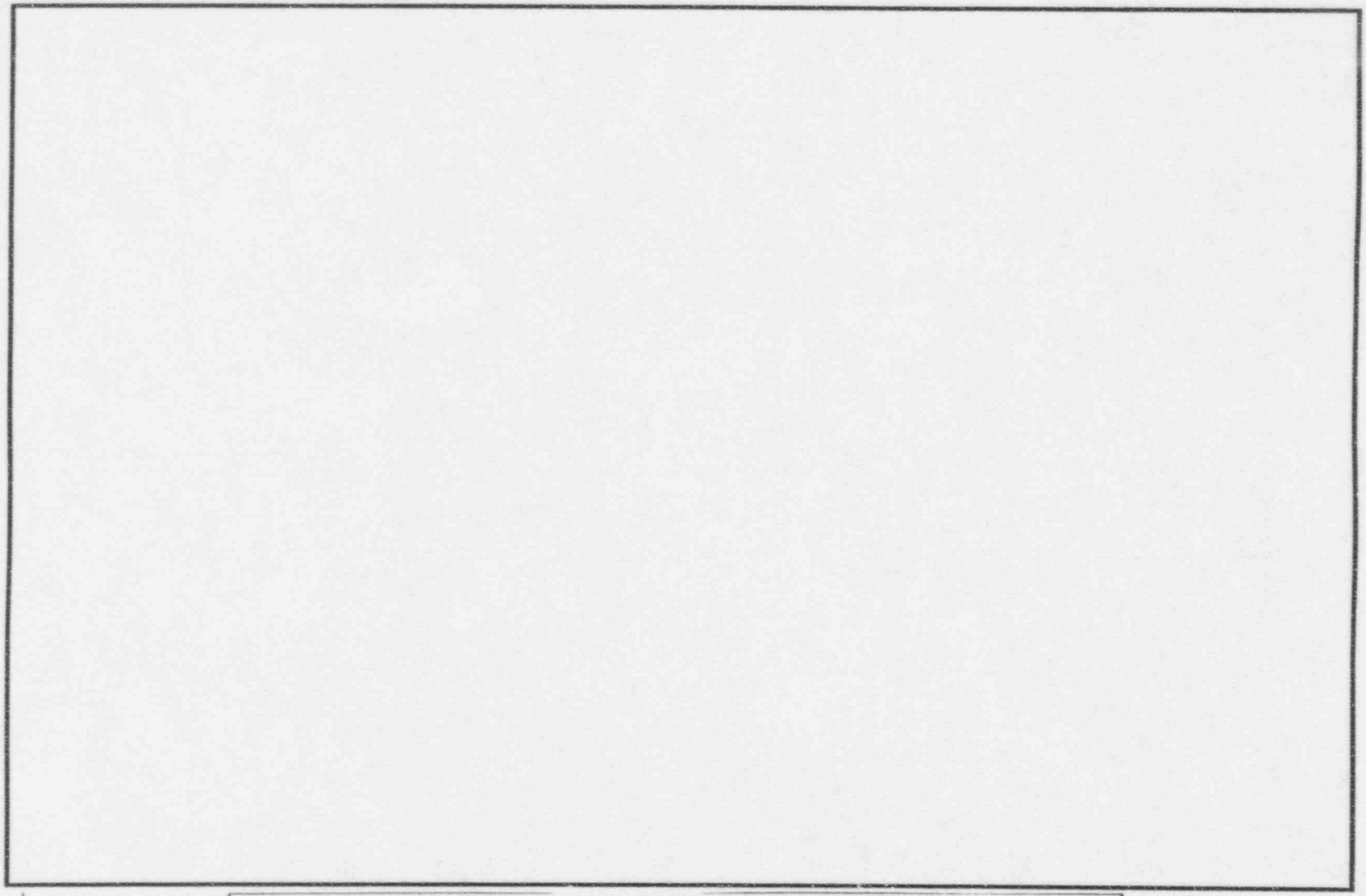


)



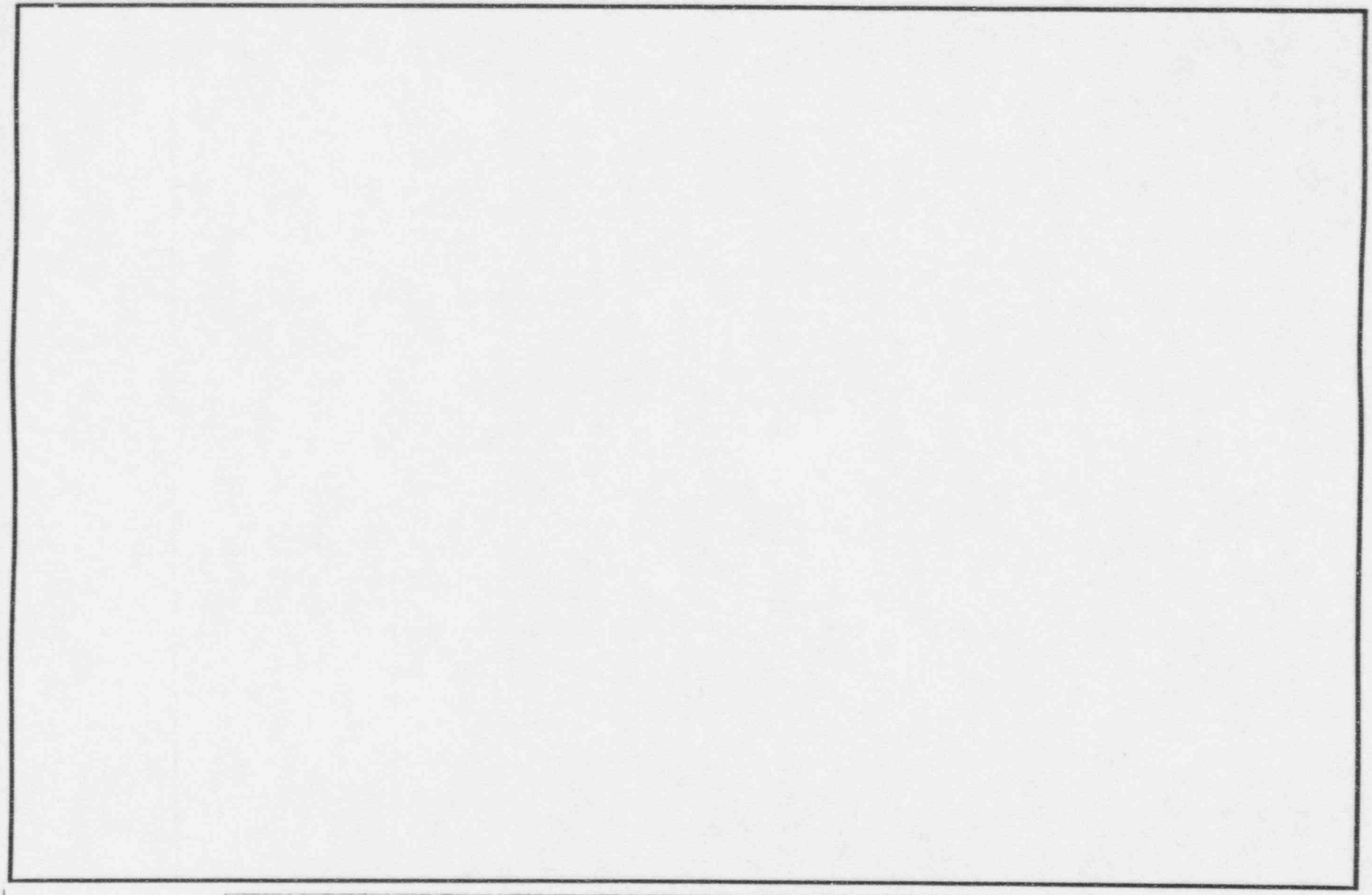
a,b,c

Figure 4.1.1: Wolf Creek EOC-8 Assembly K06 Thimble Tube Go/ No-Go Probe Data



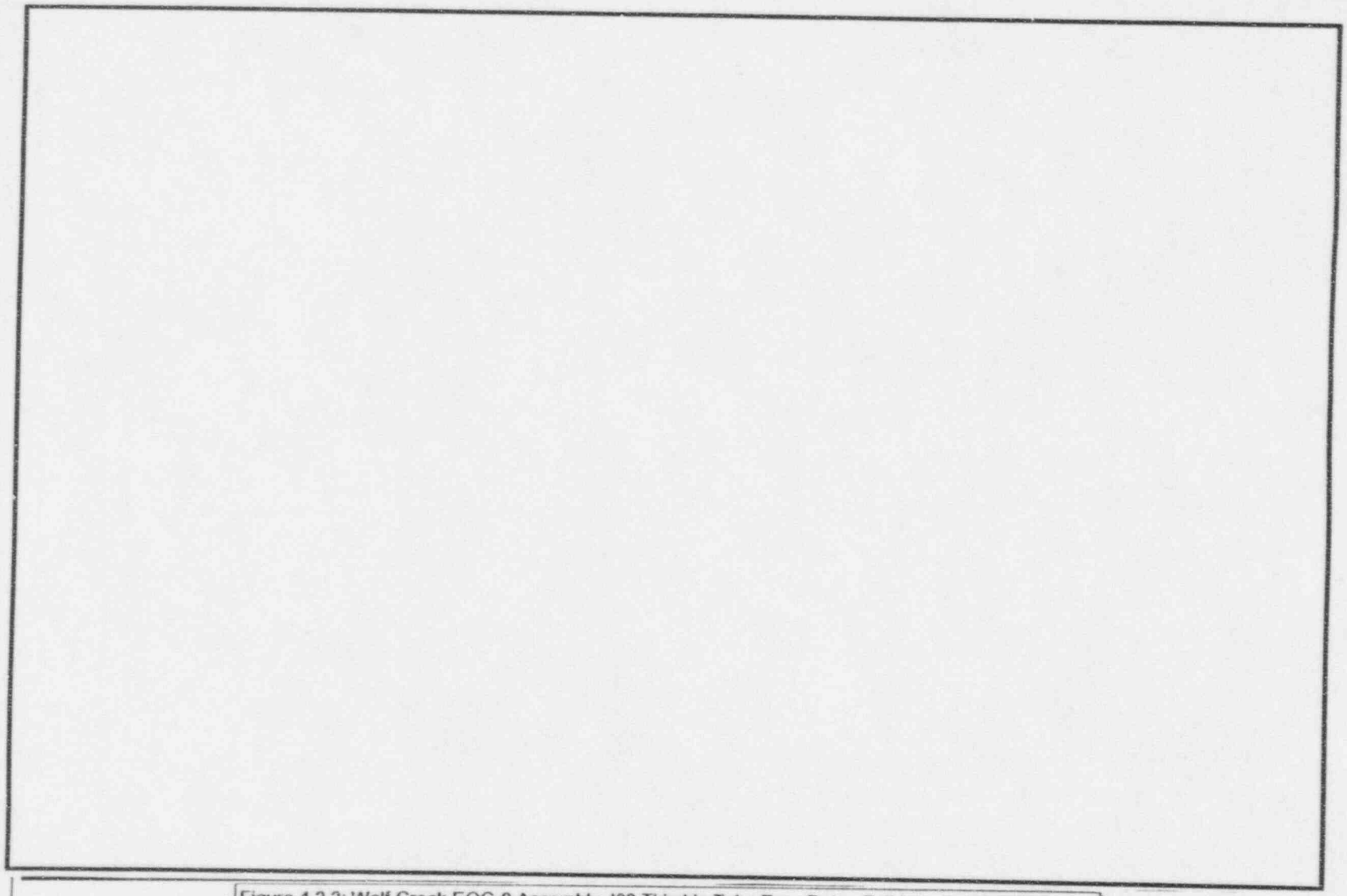
a,b,c

Figure 4.1.2: Wolf Creek EOC-8 Assembly K06 Thimble Tube Drag Data - Probe H02 (>393" OD, 12"L)
Probe P8534C14, Rev. 2



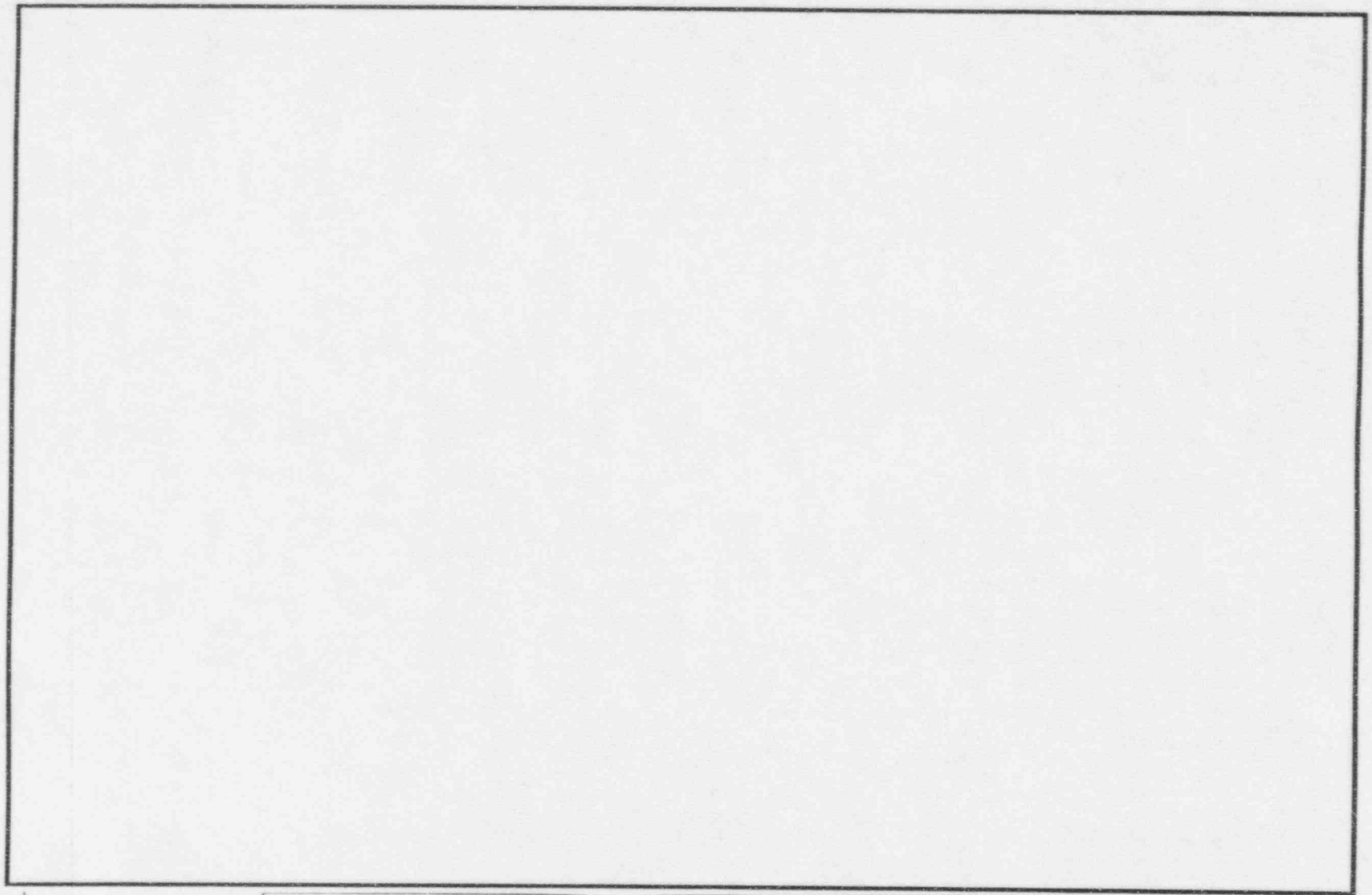
a,b,c

Figure 4.2.1: Wolf Creek EOC-8 Assembly J03 Thimble Tube Go/ No-Go Probe Data



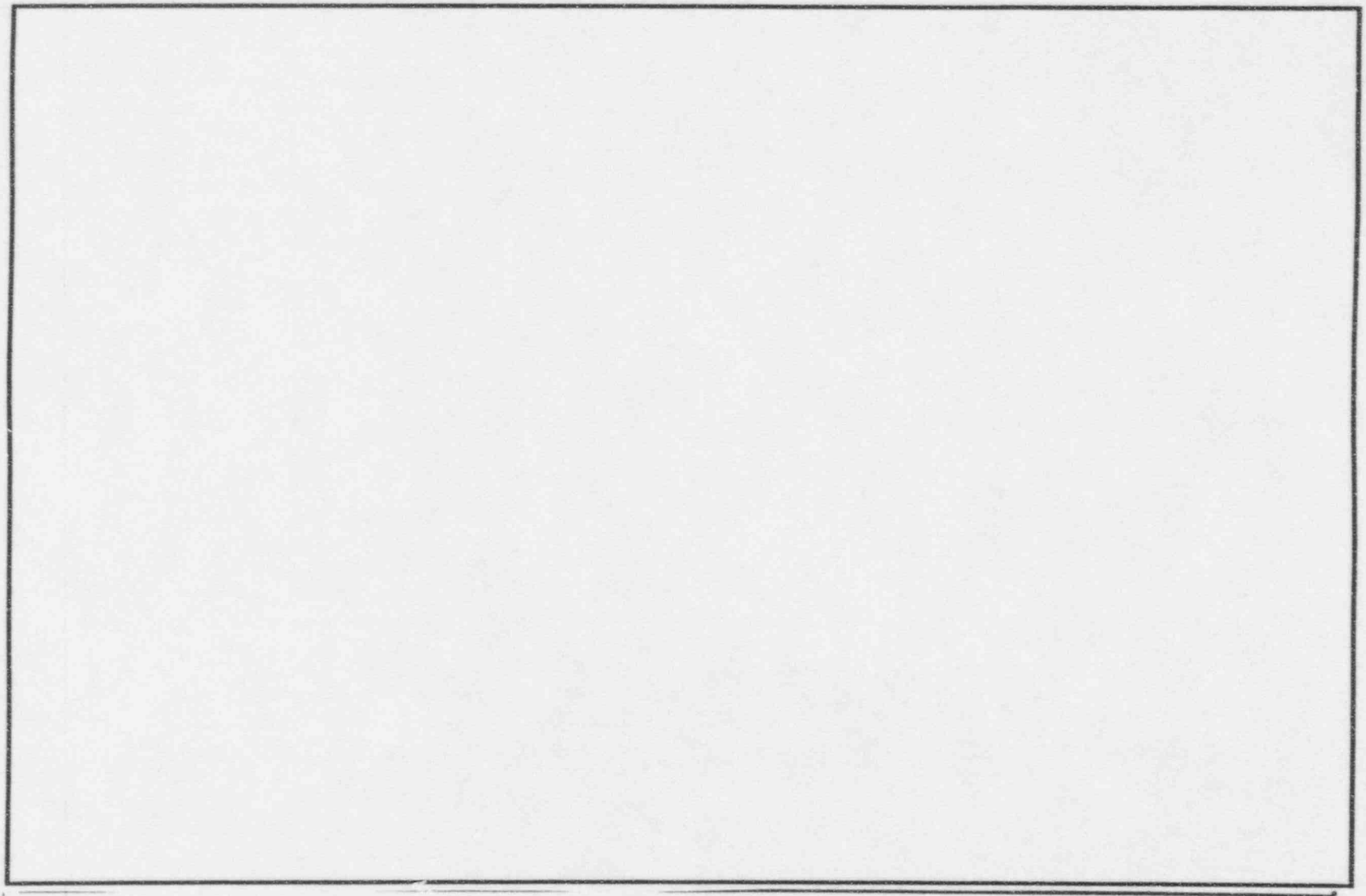
a,b,c

Figure 4.2.2: Wolf Creek EOC-8 Assembly J03 Thimble Tube Drag Data - Full Length .381"OD Rodlet Probe Drawing P6664E34, Rev. 1



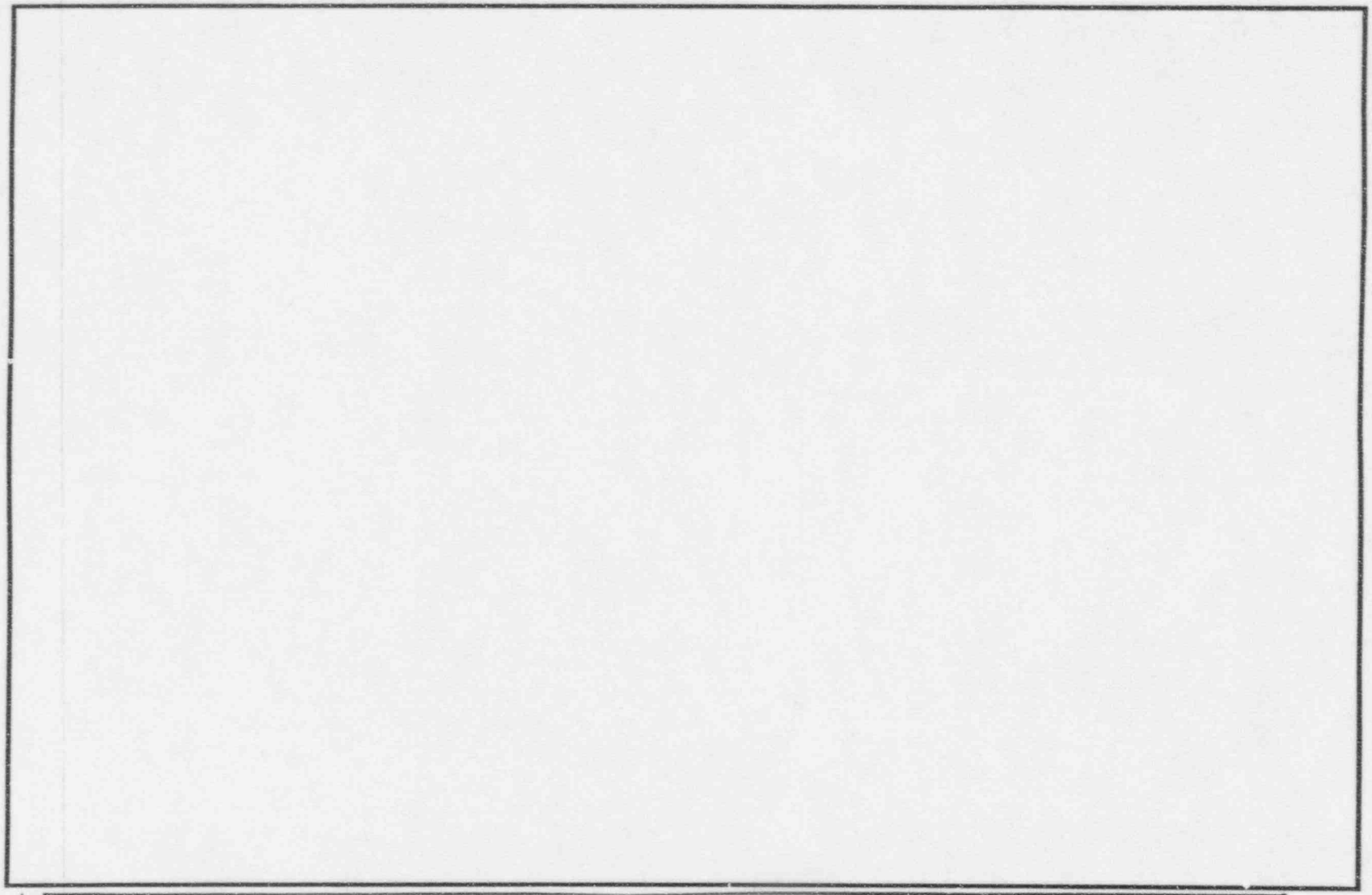
a,b,c

Figure 4.2.3: Wolf Creek EOC-8 Assembly J03 Thimble Tube Drag Data - Probe H04 (.434"OD, 3"L)
Probe Drawing 8534C14, Rev. 2



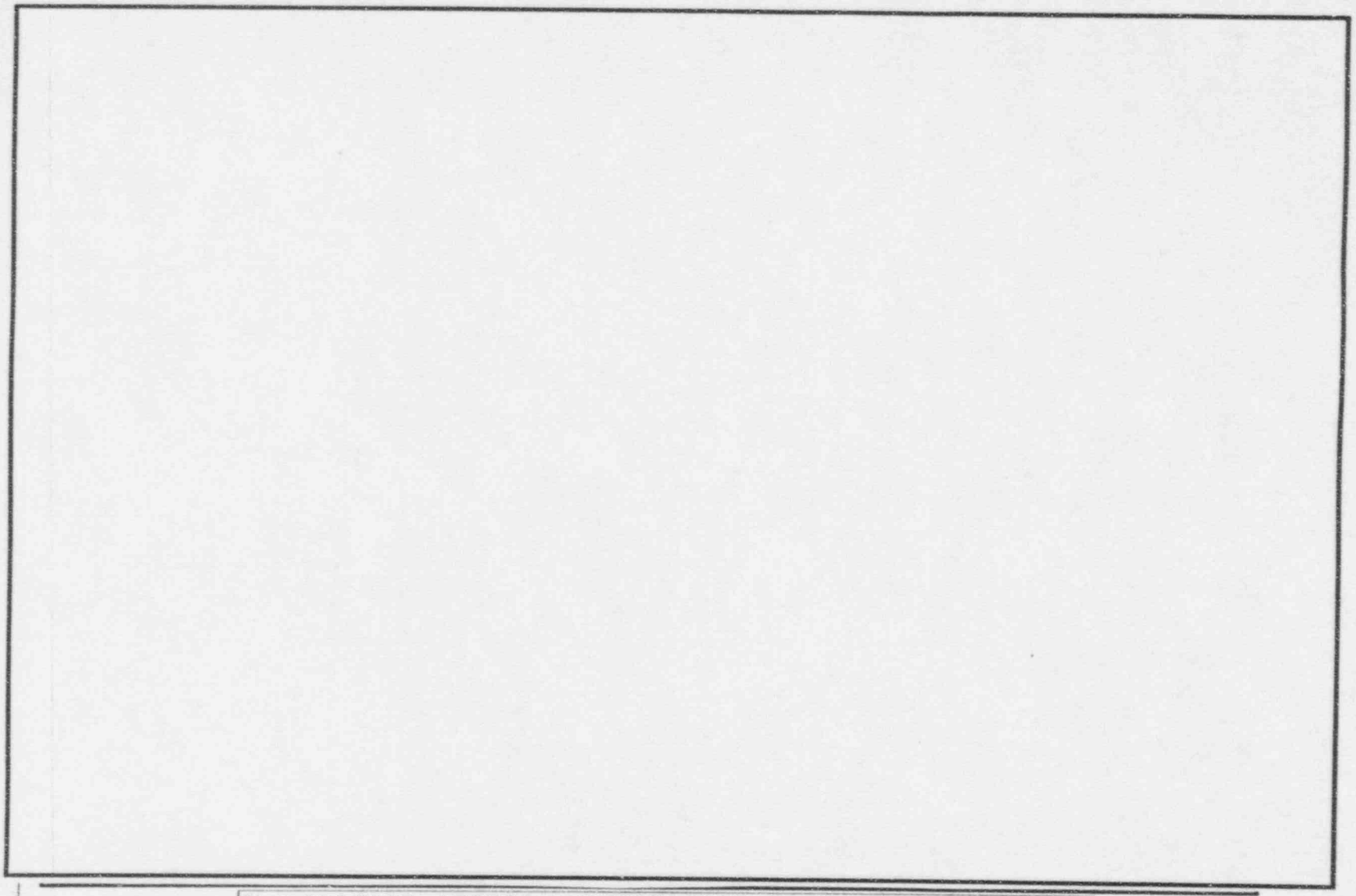
a,b,c

Figure 4.3.1: Wolf Creek EOC-8 Assembly H16 Thimble Tube Go/ No-Go Probe Data



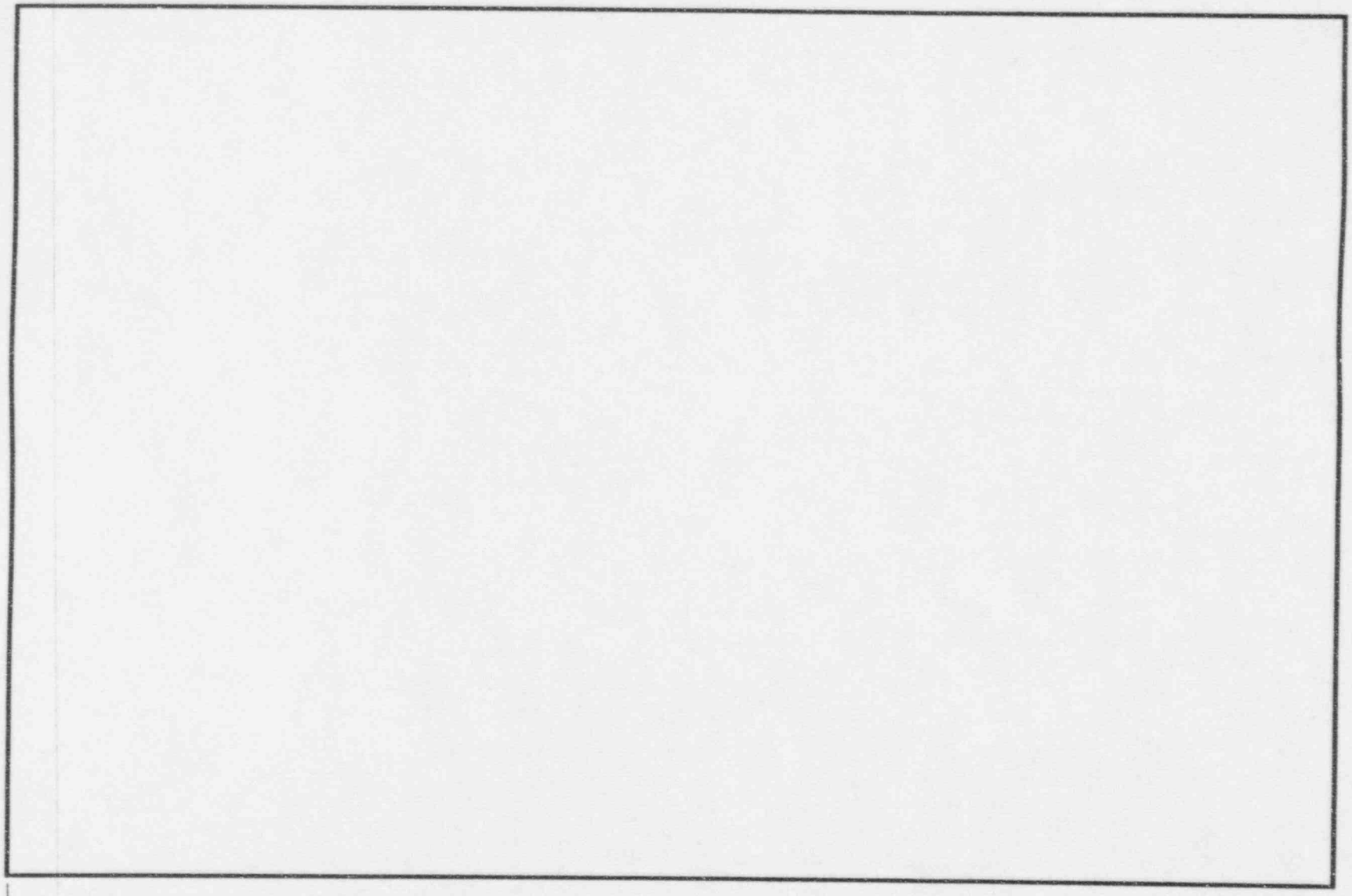
a,b,c

Figure 4.3.2: Wolf Creek EOC-8 Assembly H16 Thimble Tube Drag Data - Full Length .381"OD Rodlet Probe Drawing P6664E34, Rev. 1



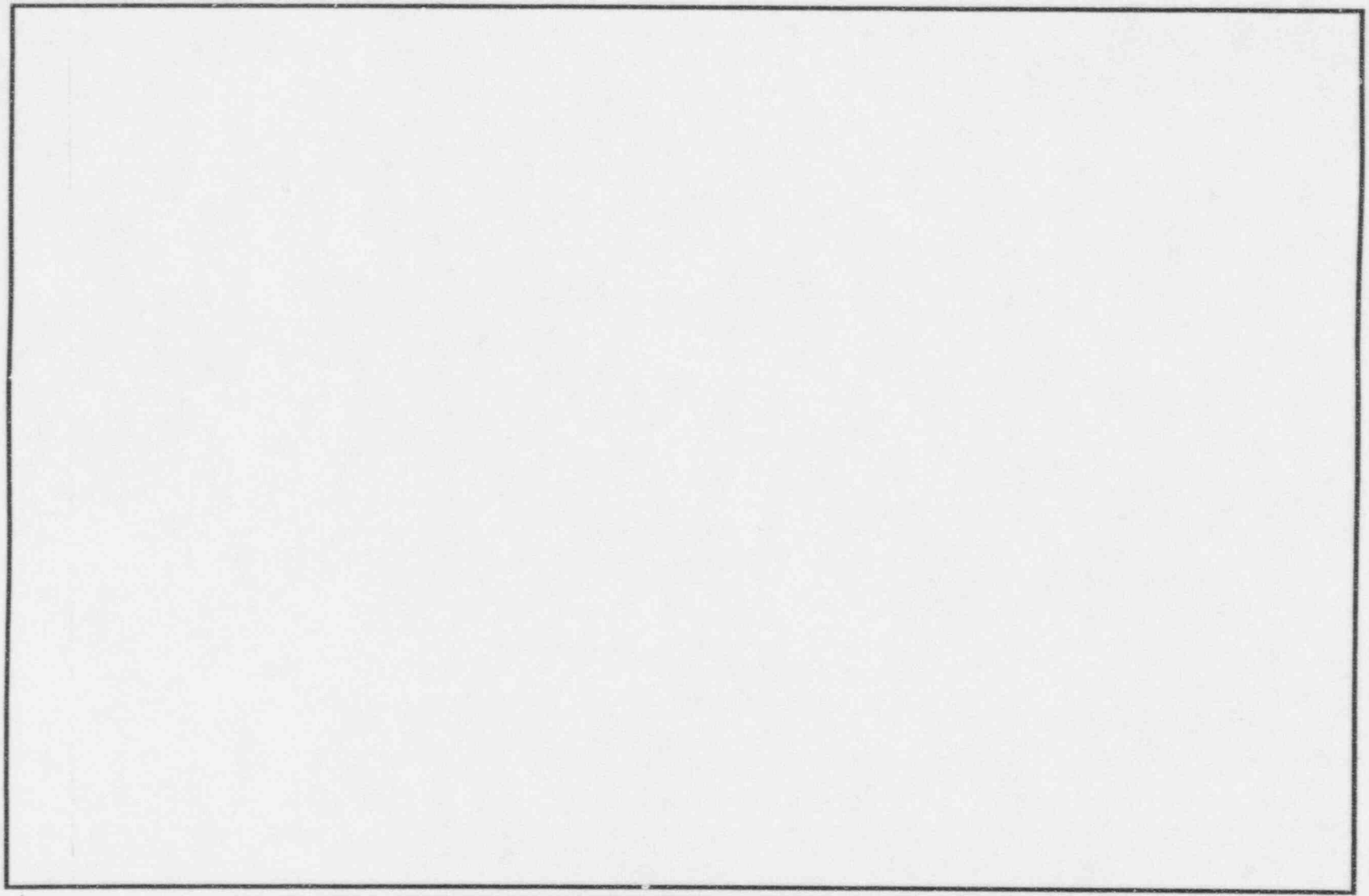
a,b,c

Figure 4.3.3: Wolf Creek EOC-8 Assembly H16 Thimble Tube Drag Data - Probe H05 (.430"OD, 3"L)
Probe Drawing 8534C14, Rev. 2



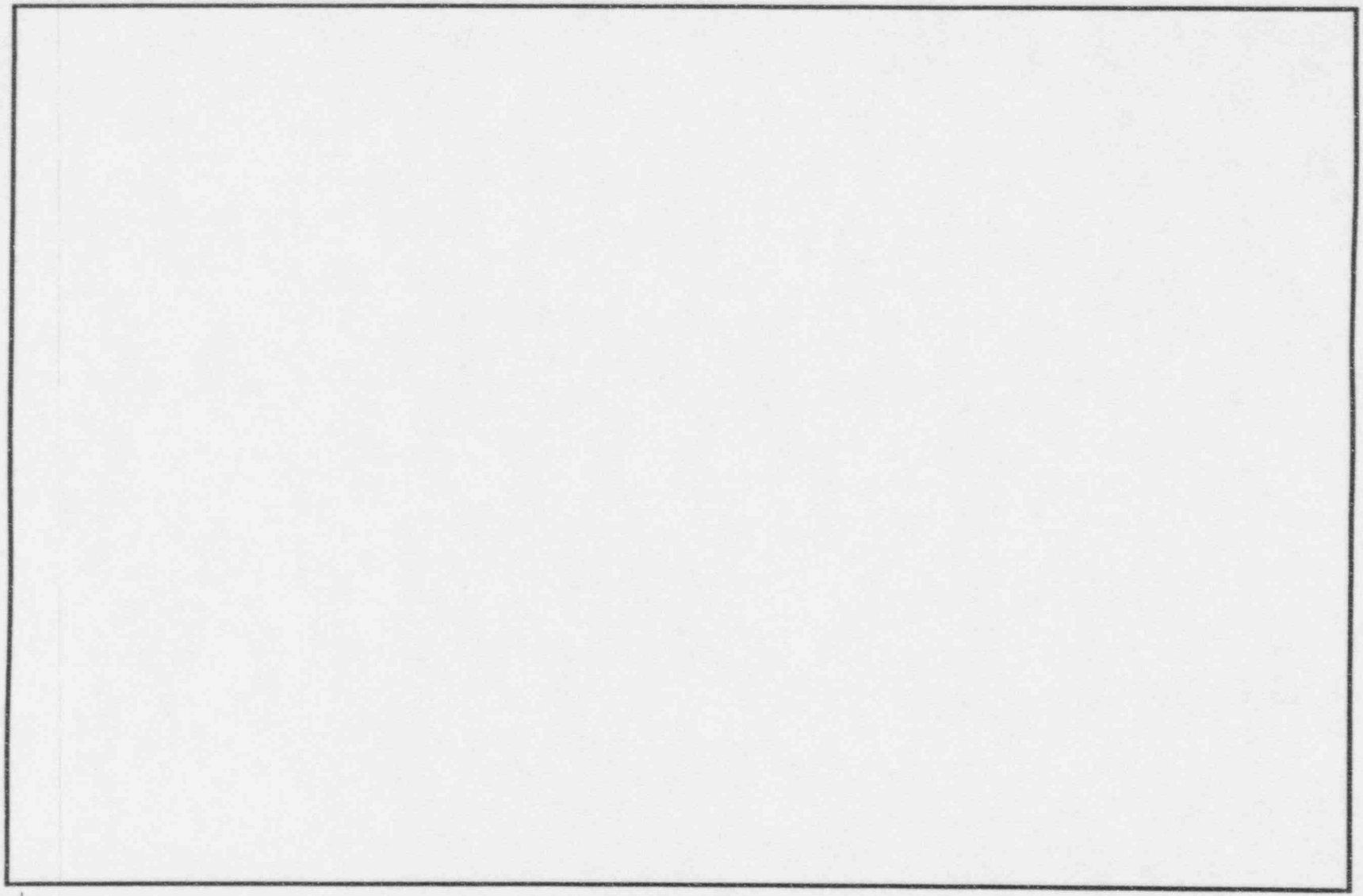
a,b,c

Figure 4.4.1: Wolf Creek EOC-8 Assembly H38 Thimble Tube Go/ No-Go Probe Data



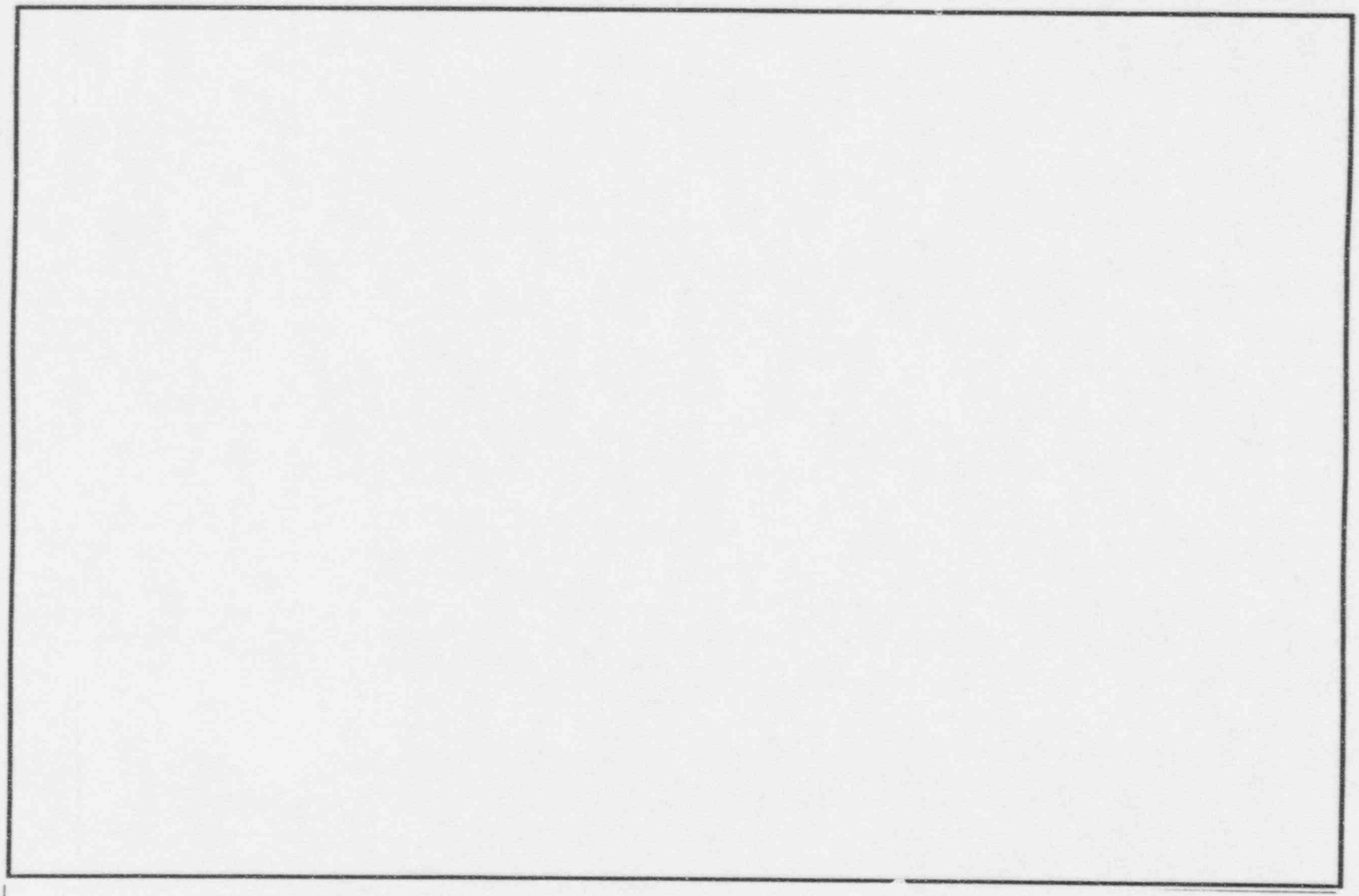
a,b,c

Figure 4.4.2: Wolf Creek EOC-8 Assembly H38 Thimble Tube Drag Data - Full Length .381"OD Rodlet Probe Drawing P6664E34, Rev. 1



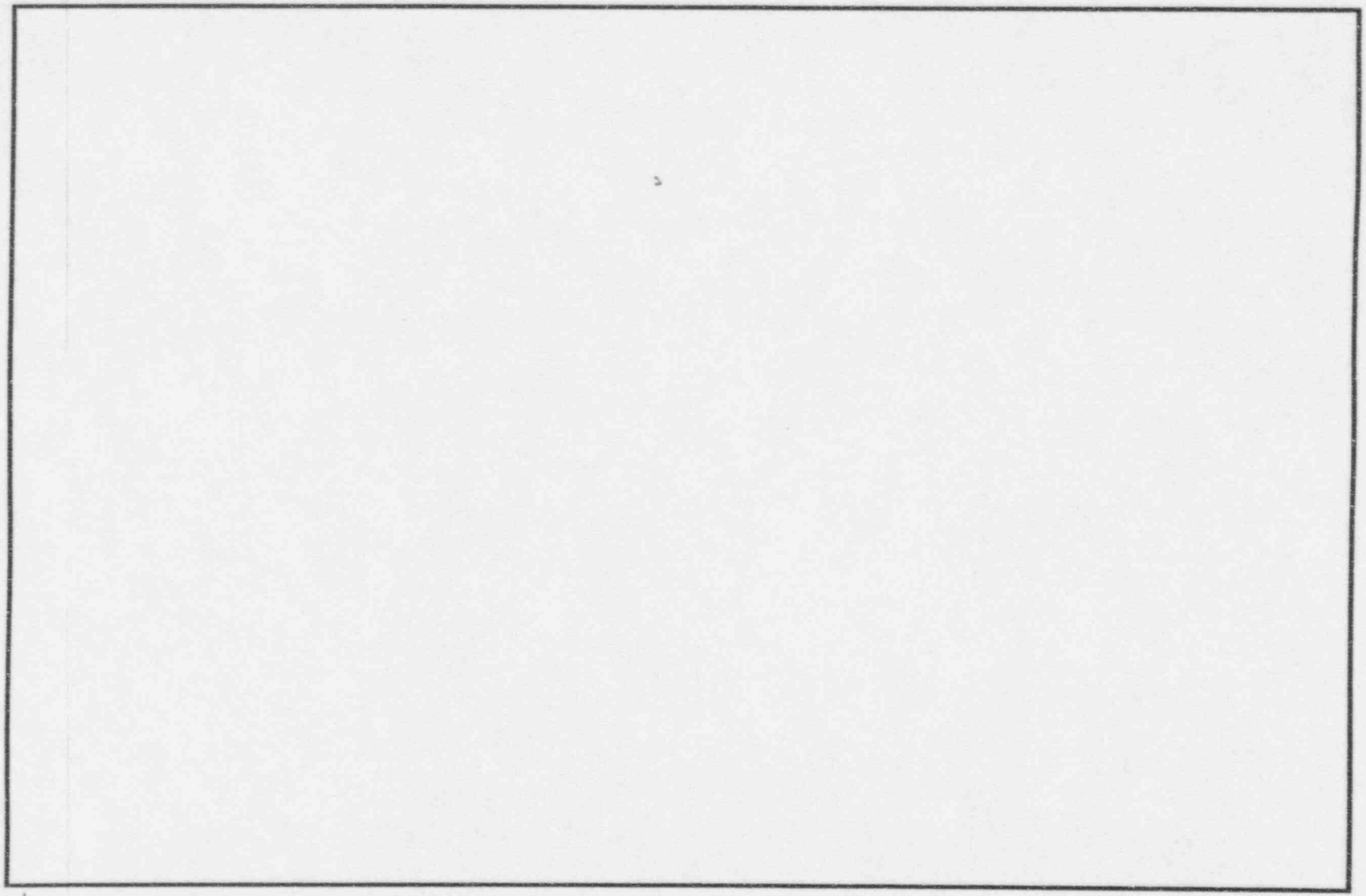
a,b,c

Figure 4.4.3: Wolf Creek EOC-8 Assembly H38 Thimble Tube Drag Data - Probe H05 (.430"OD, 3"L)
Probe Drawing P8534C14, Rev. 2



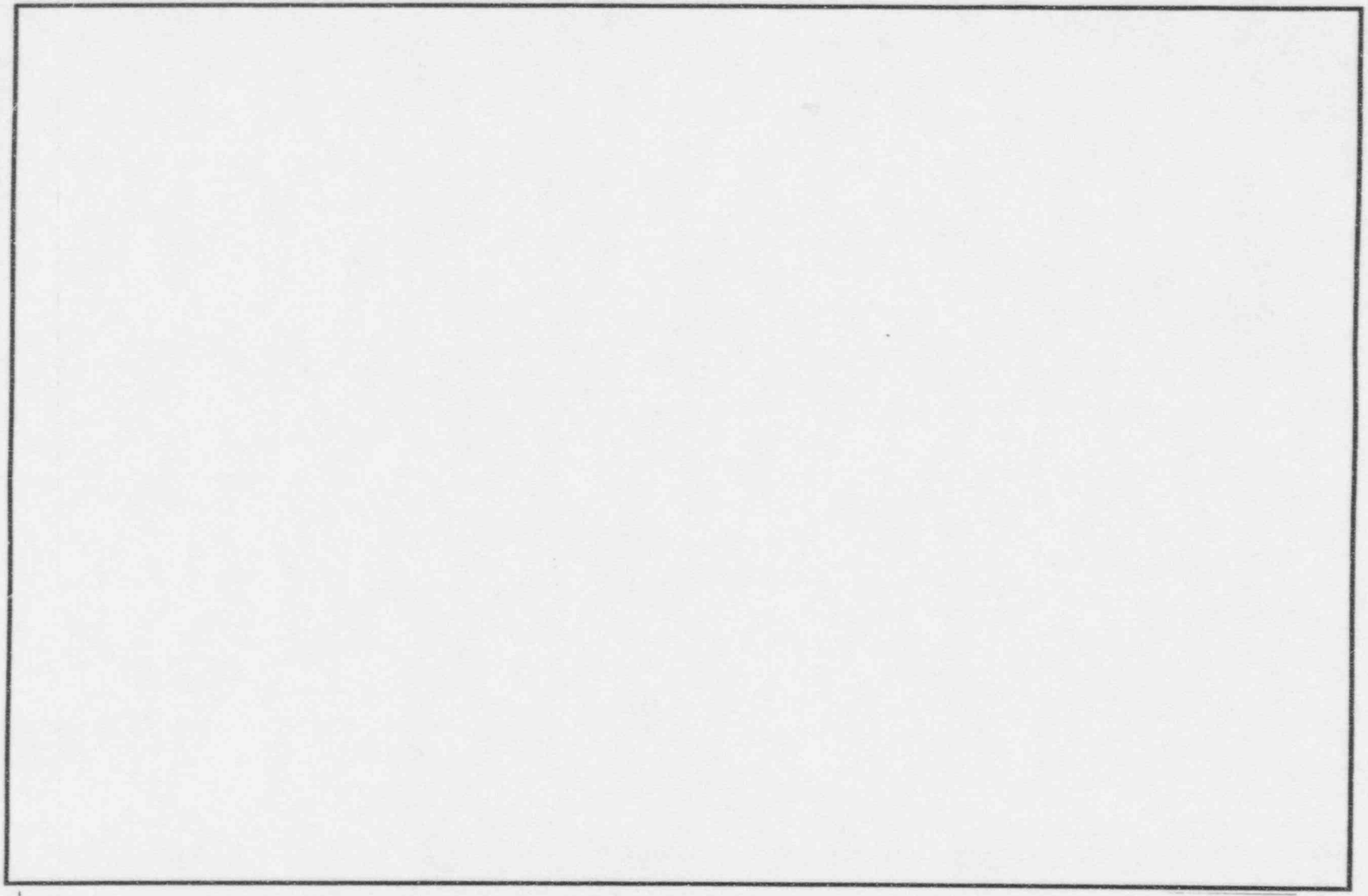
a,b,c

Figure 4.5.1: Wolf Creek EOC-8 Assembly H50 Thimble Tube Go/ No-Go Probe Data



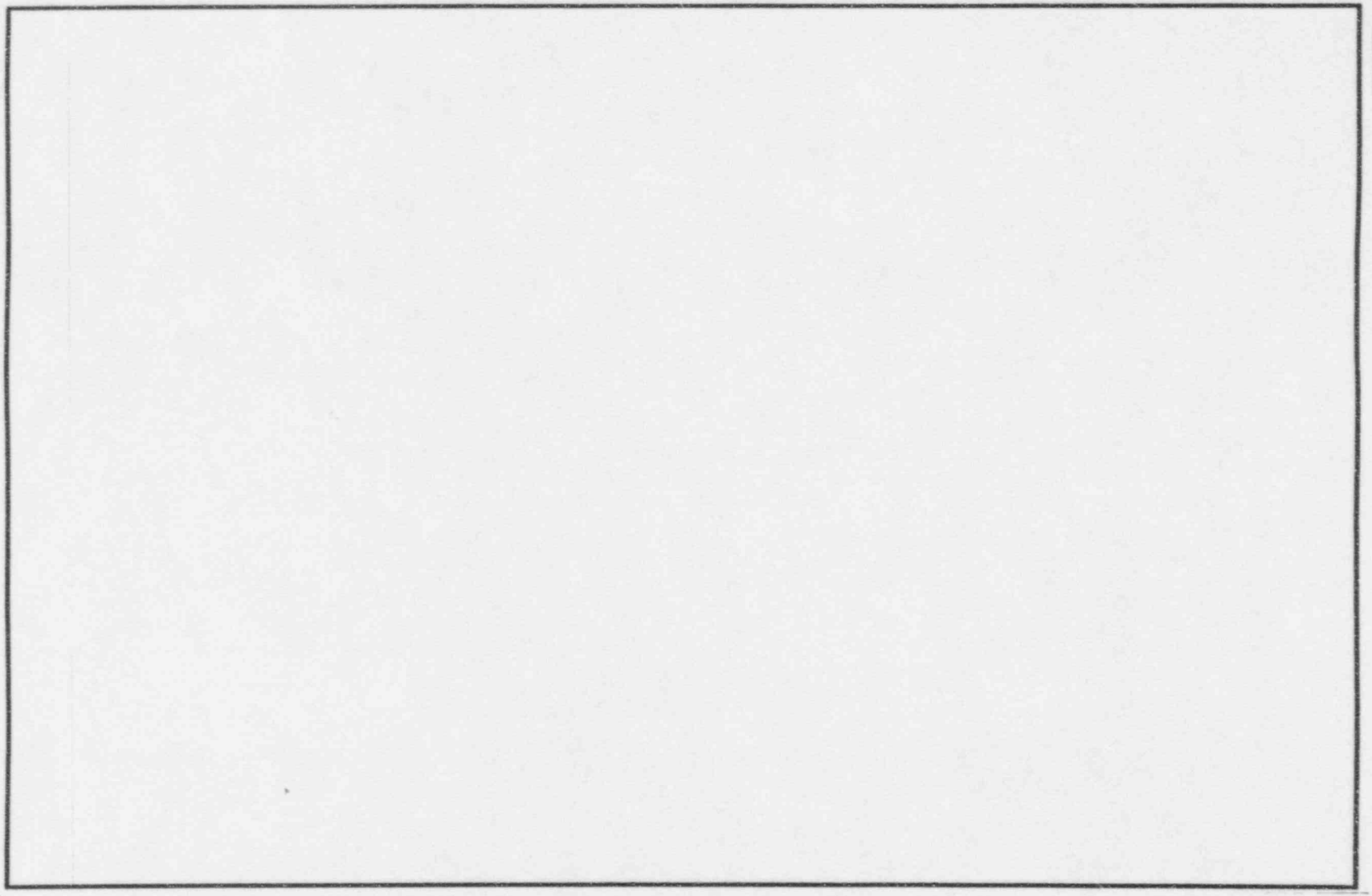
a,b,c

Figure 4.5.2: Wolf Creek EOC-8 Assembly H50 Thimble Tube Drag Data - Full Length .381"OD Rodlet Probe Drawing P6664E34, Rev. 1



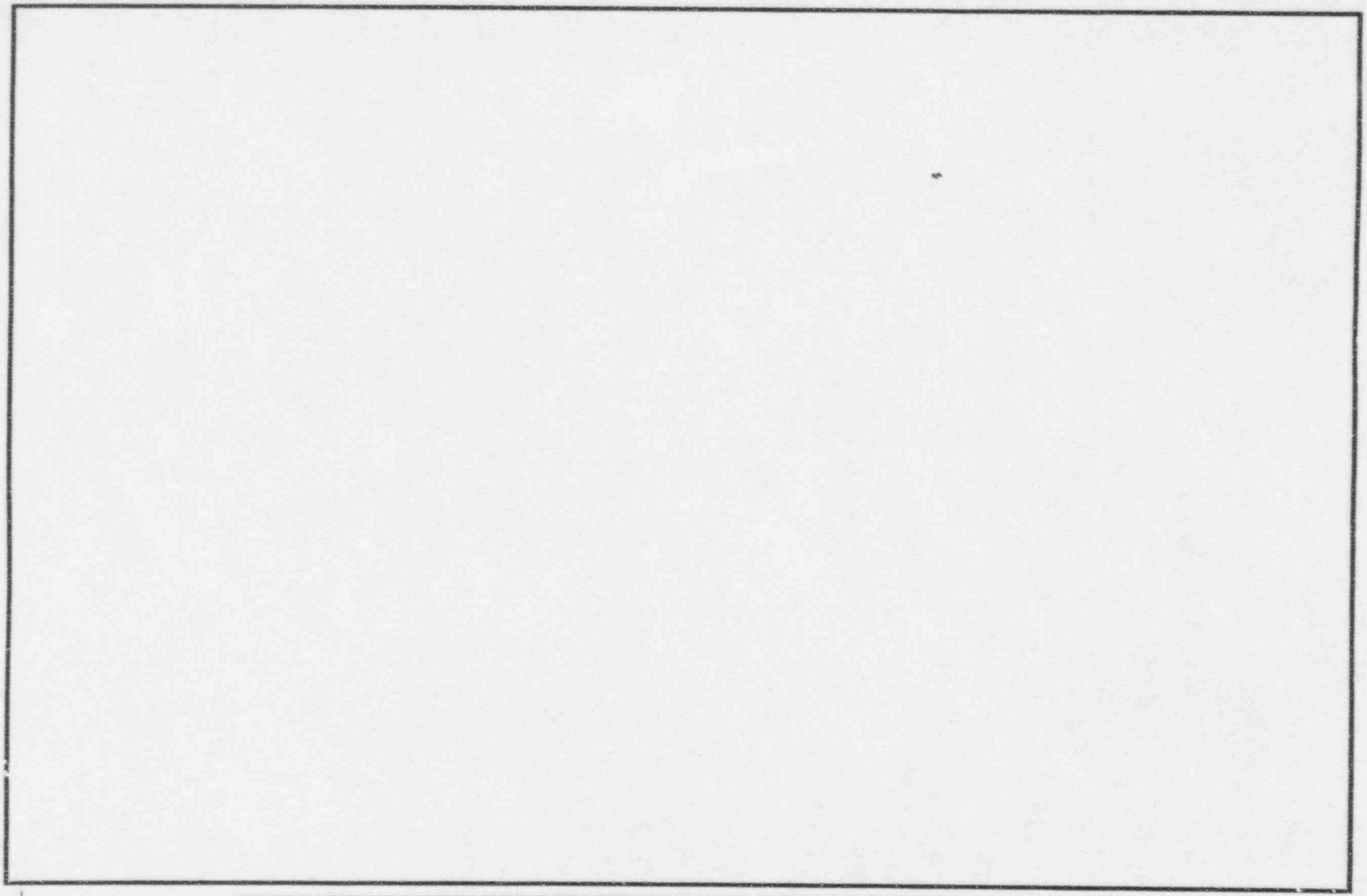
a,b,c

Figure 4.5.3: Wolf Creek EOC-8 Assembly H50 Thimble Tube Drag Data - Probe H05 (.430"OD, 3"L)
Probe Drawing P8534C14, Rev. 2



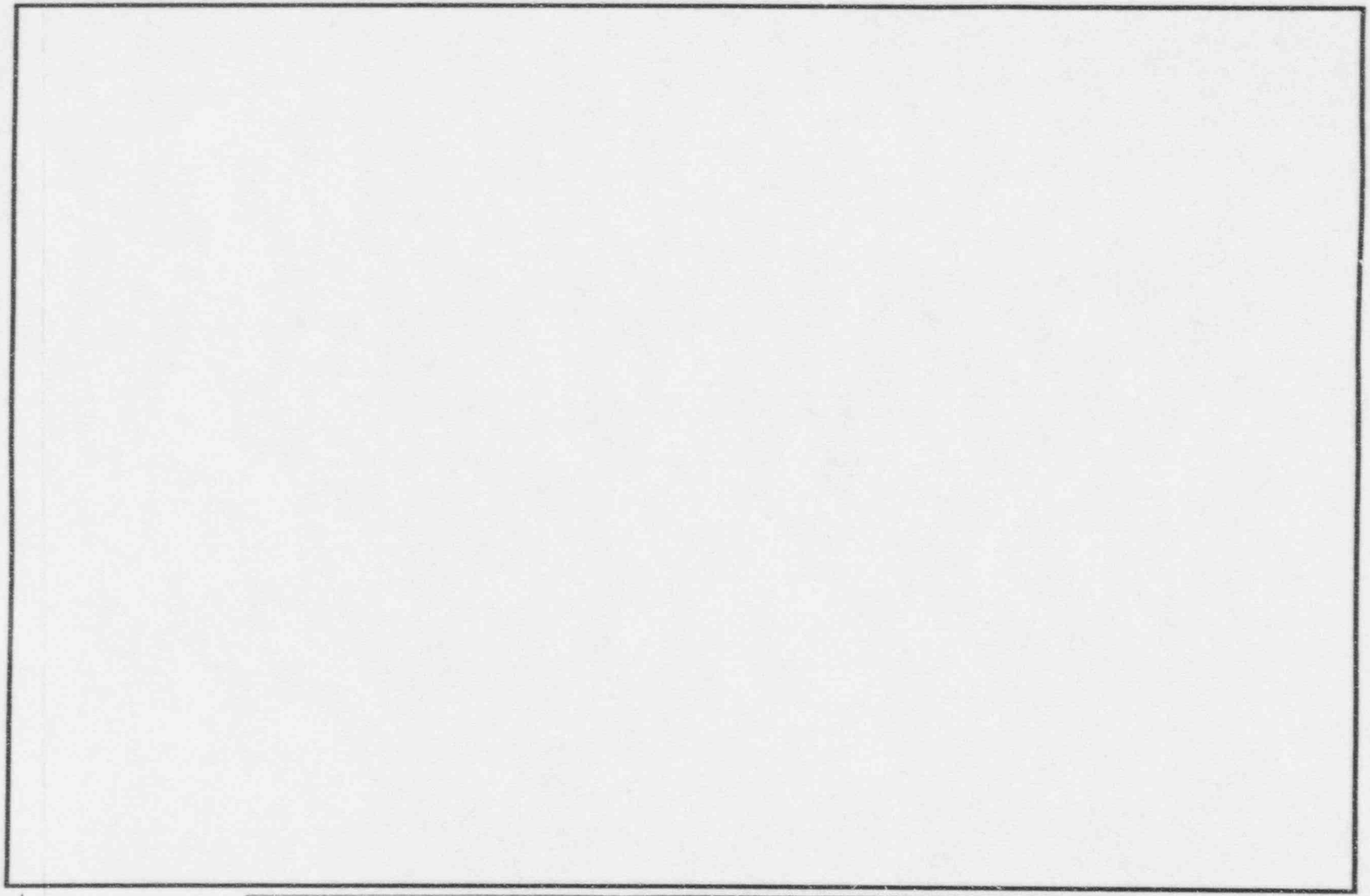
a,b,c

Figure 4.6.1: Wolf Creek EOC-8 Assembly H81 Thimble Tube Go/ No-Go Probe Data



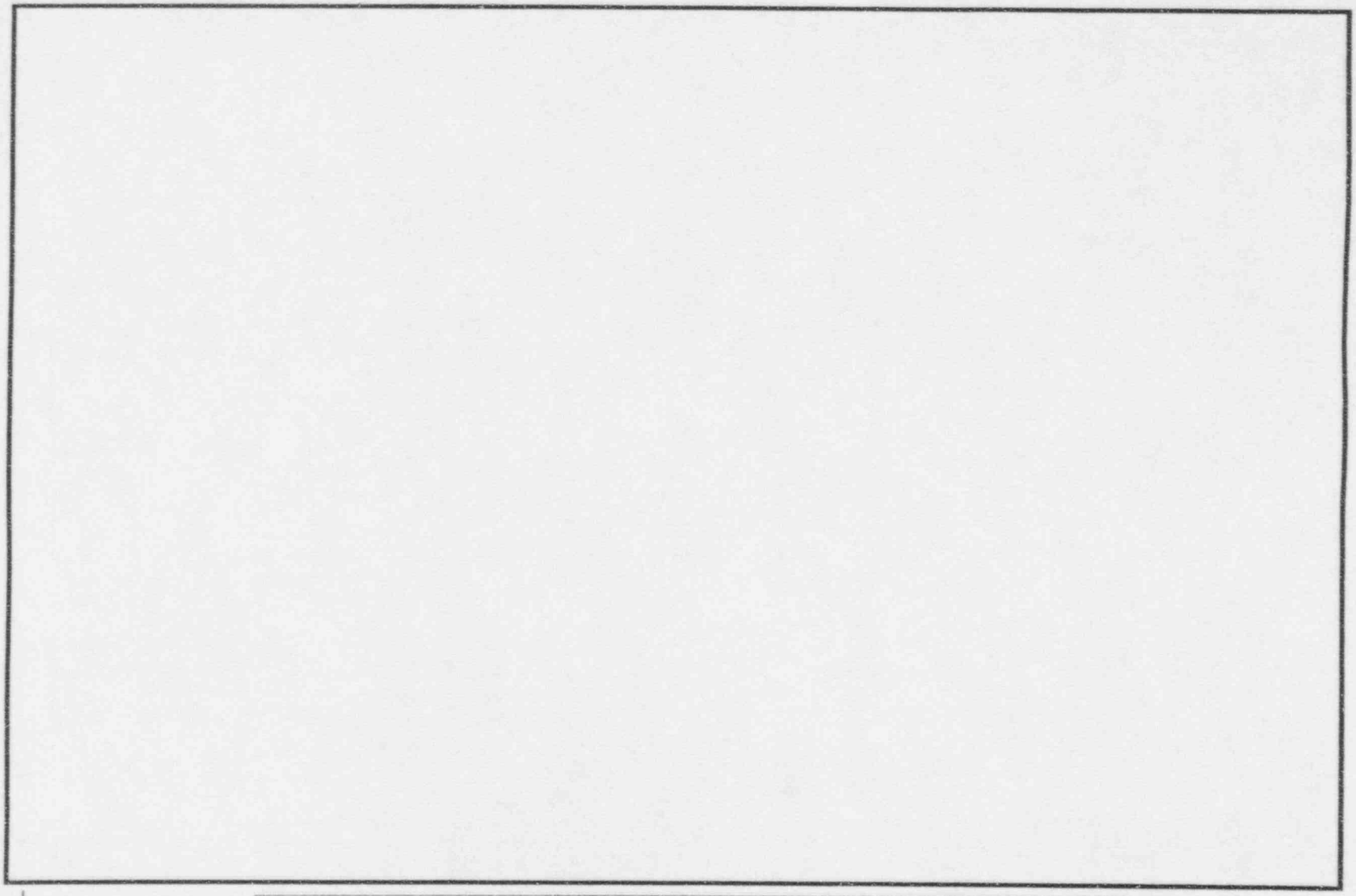
a,b,c

Figure 4.6.2: Wolf Creek EOC-8 Assembly H81 Thimble Tube Drag Data - Full Length .381" OD Rodlet Probe Drawing P6664E34, Rev. 1



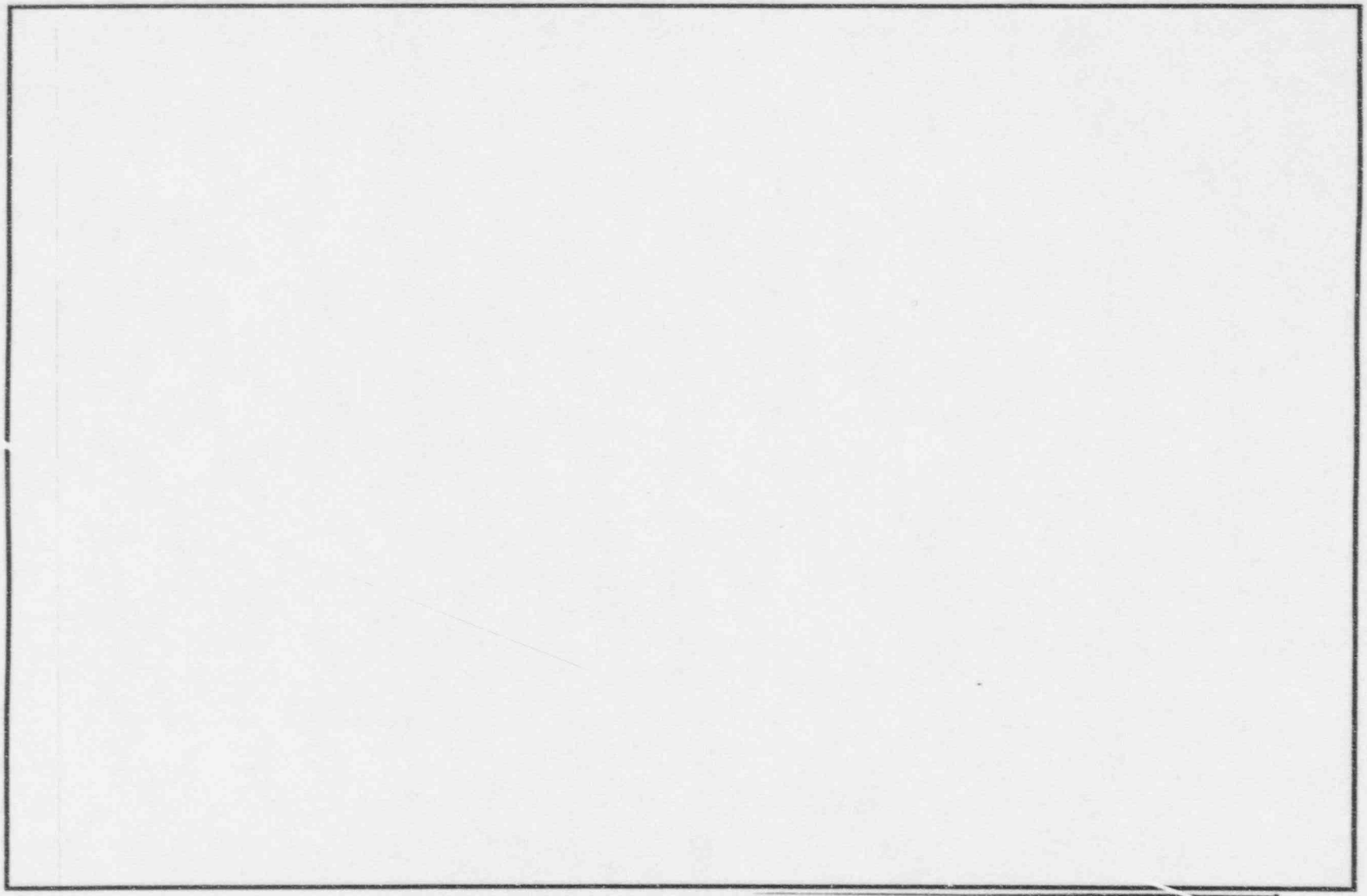
a,b,c

Figure 4.6.3: Wolf Creek EOC-8 Assembly H81 Thimble Tube Drag Data - Full Length .381" OD Rodlet Probe Drawing P6664E34, Rev. 1



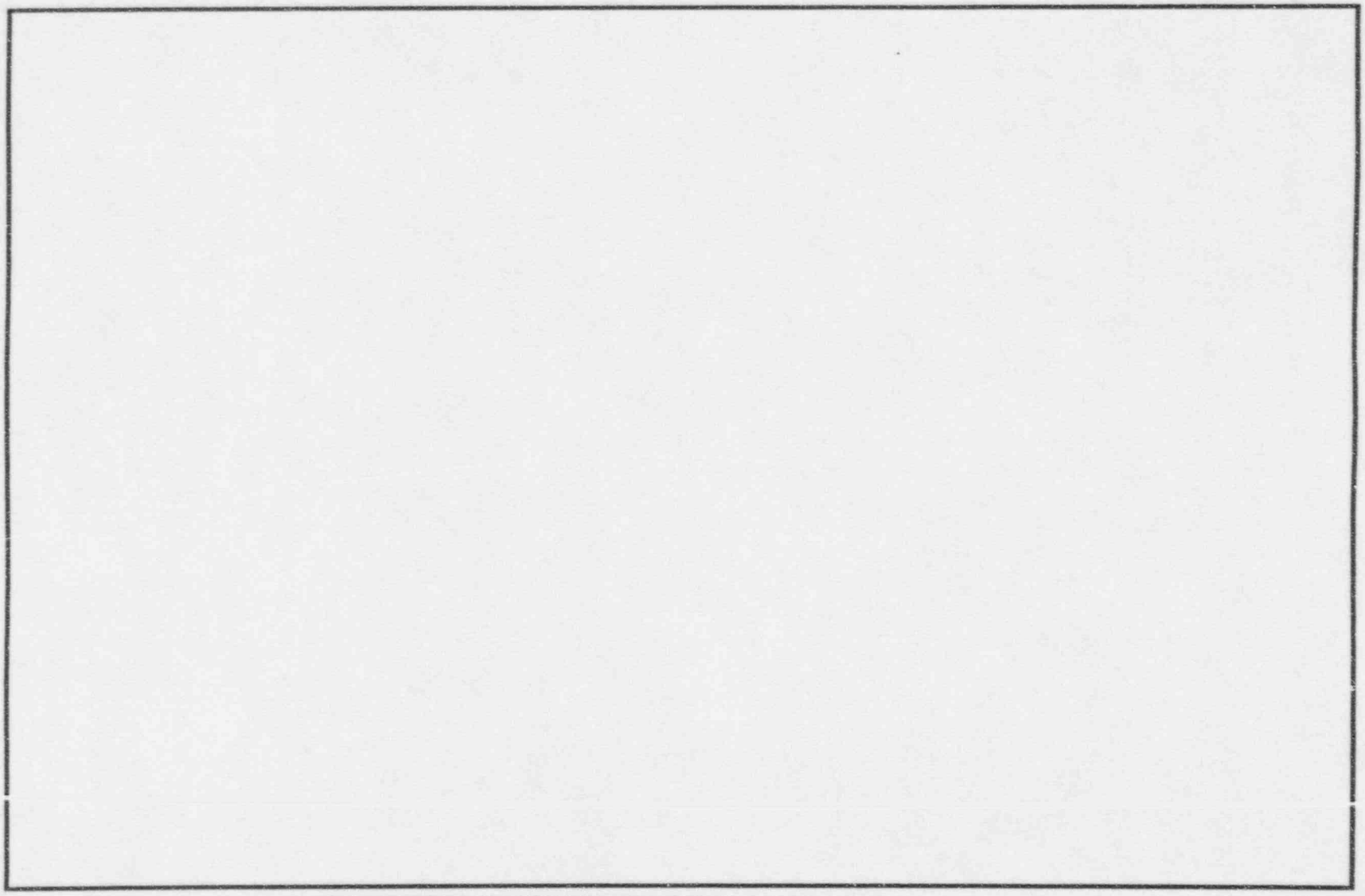
a,b,c

Figure 4.6.4: Wolf Creek EOC-8 Assembly H81 Thimble Tube Drag Data - Probe H04 (.434" OD, 3"L)
Probe Drawing P8534C14, Rev. 2



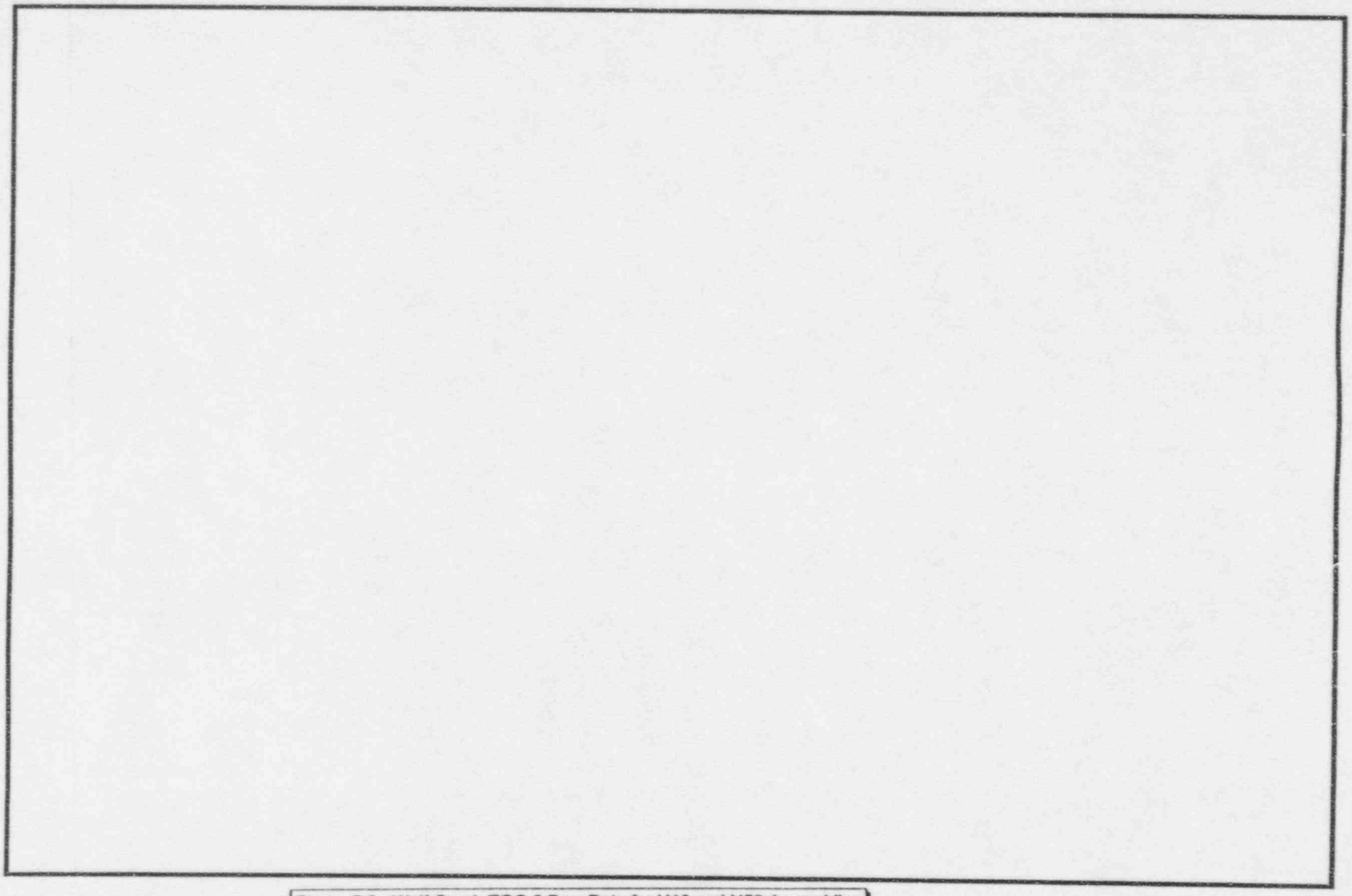
a,b,c

Figure 4.6.5: Wolf Creek EOC-8 Assembly H81 Thimble Tube Drag Data - Probe H06 (.430" OD, 36"L)
Probe Drawing P8534C14, Rev. 2



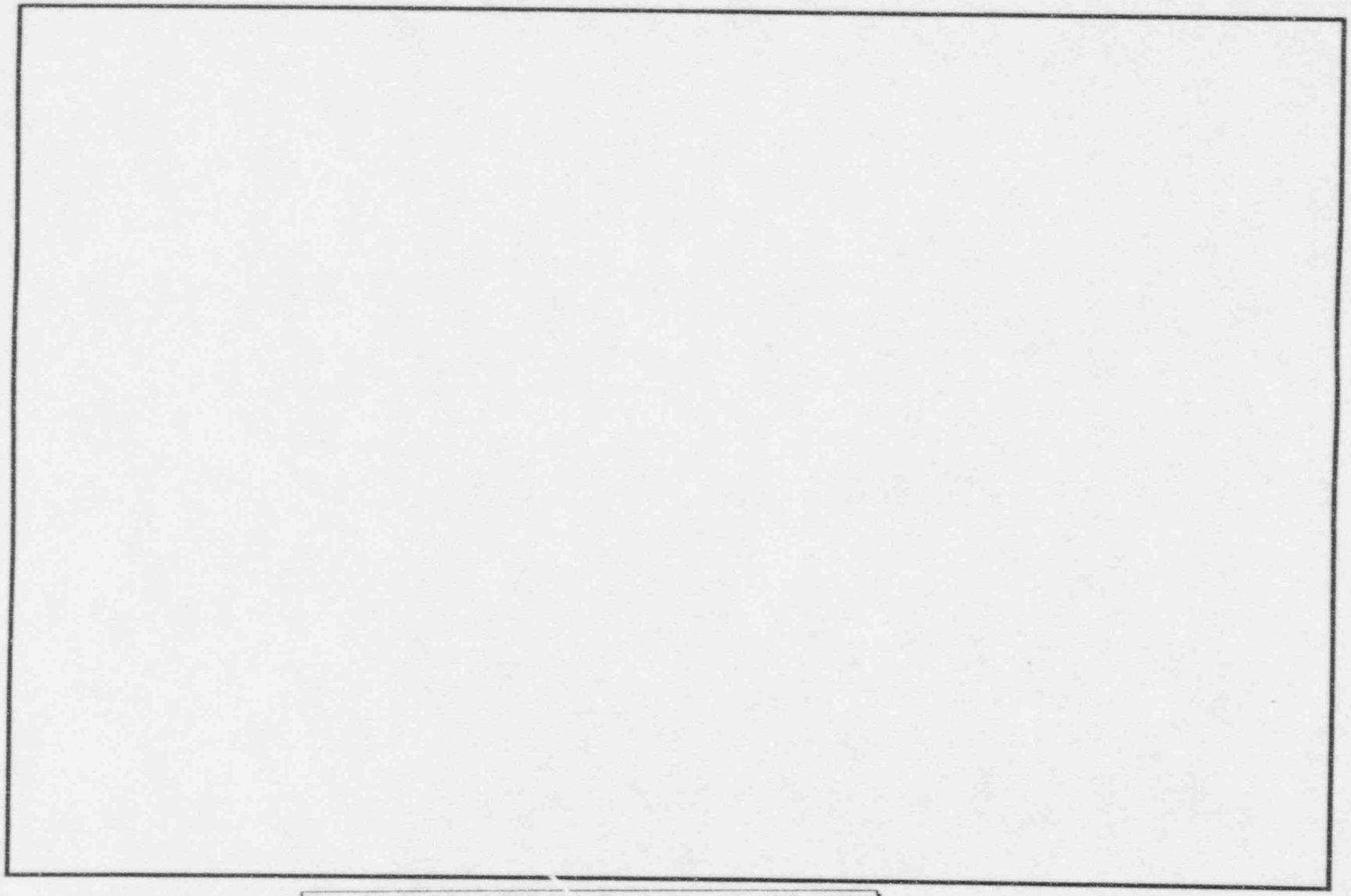
a,b,c

Figure 5.1: Wolf Creek EOC-8 Bow Data for H50, H59 and H38 Assemblies



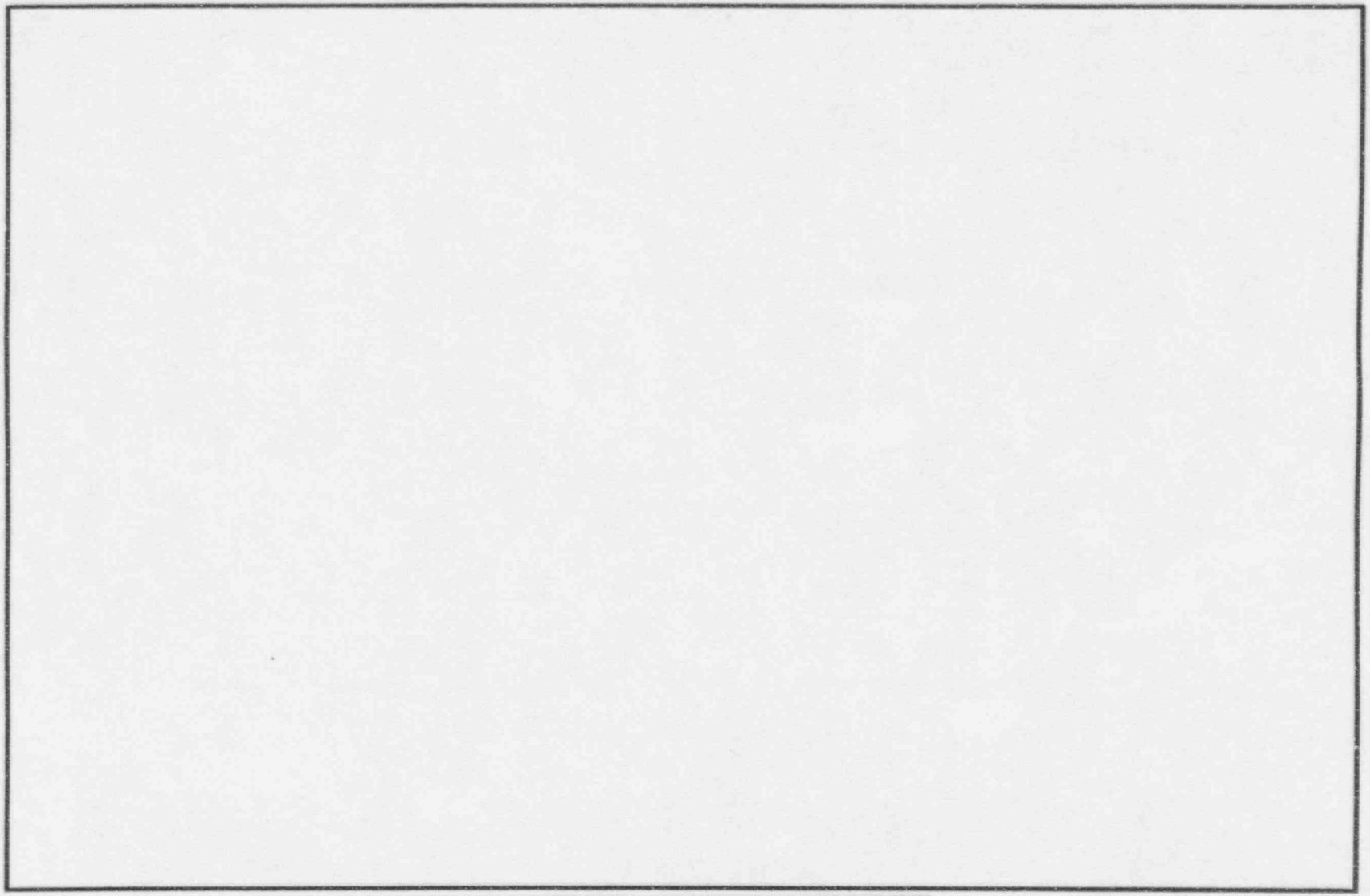
a,b,c

Figure 5.2: Wolf Creek EOC-8 Bow Data for H16 and H53 Assemblies



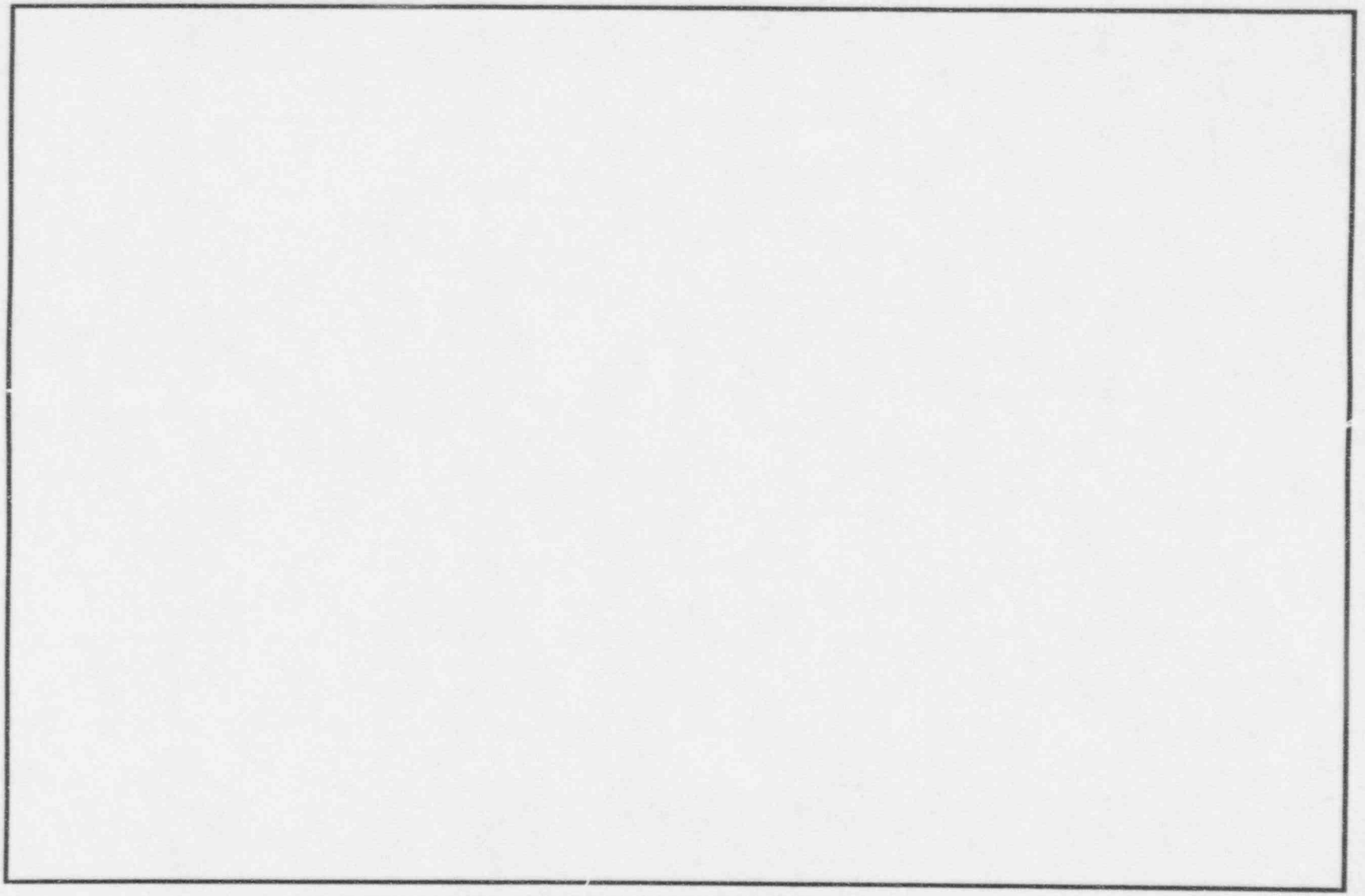
a,b,c

Figure 5.3: Wolf Creek EOC-8 Bow Data for Assemblies H45 and H54



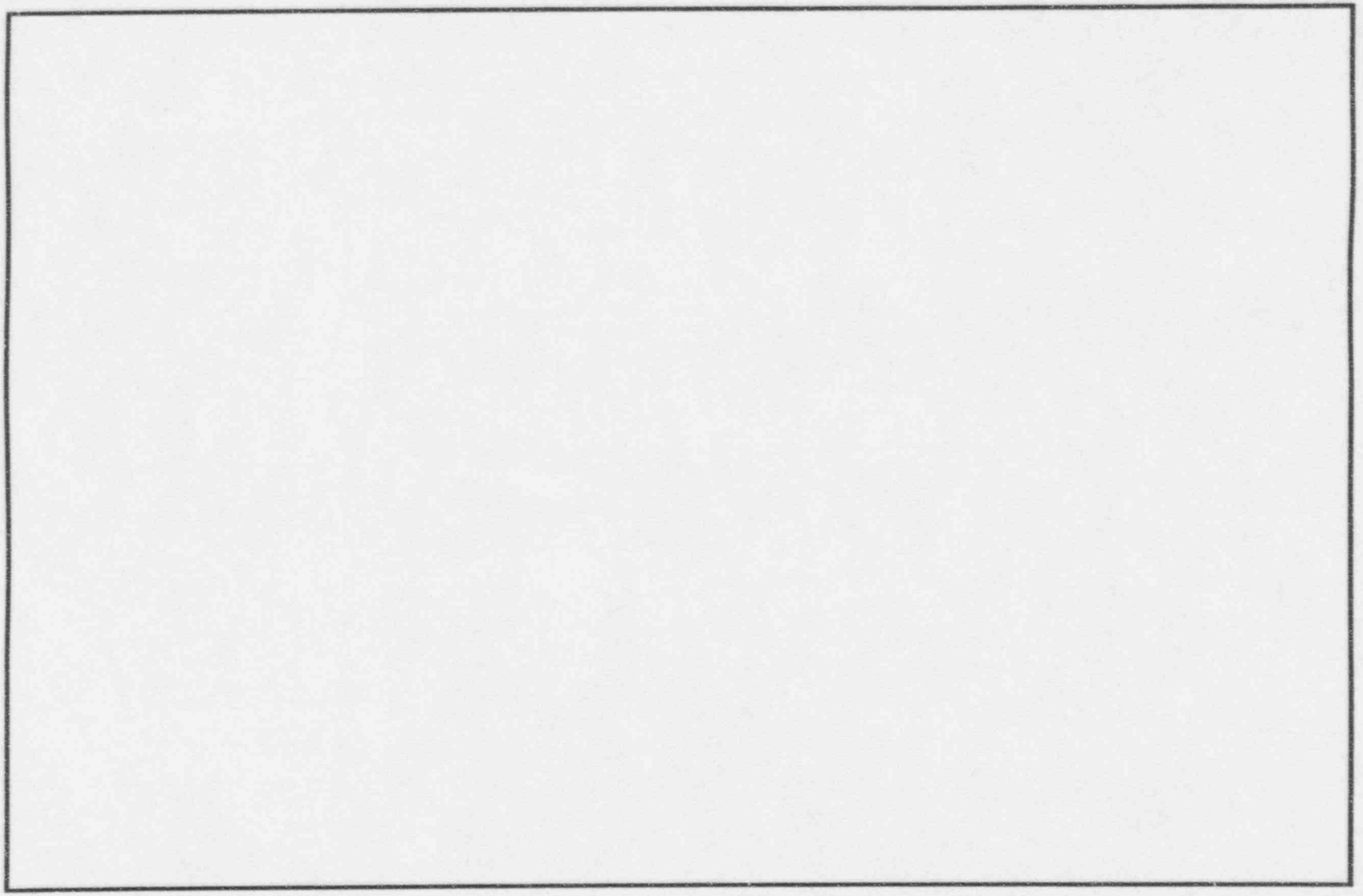
a,b,c

Figure 5.4: Wolf Creek EOC-8 Assembly Bow Data for H11 and H03 Assemblies



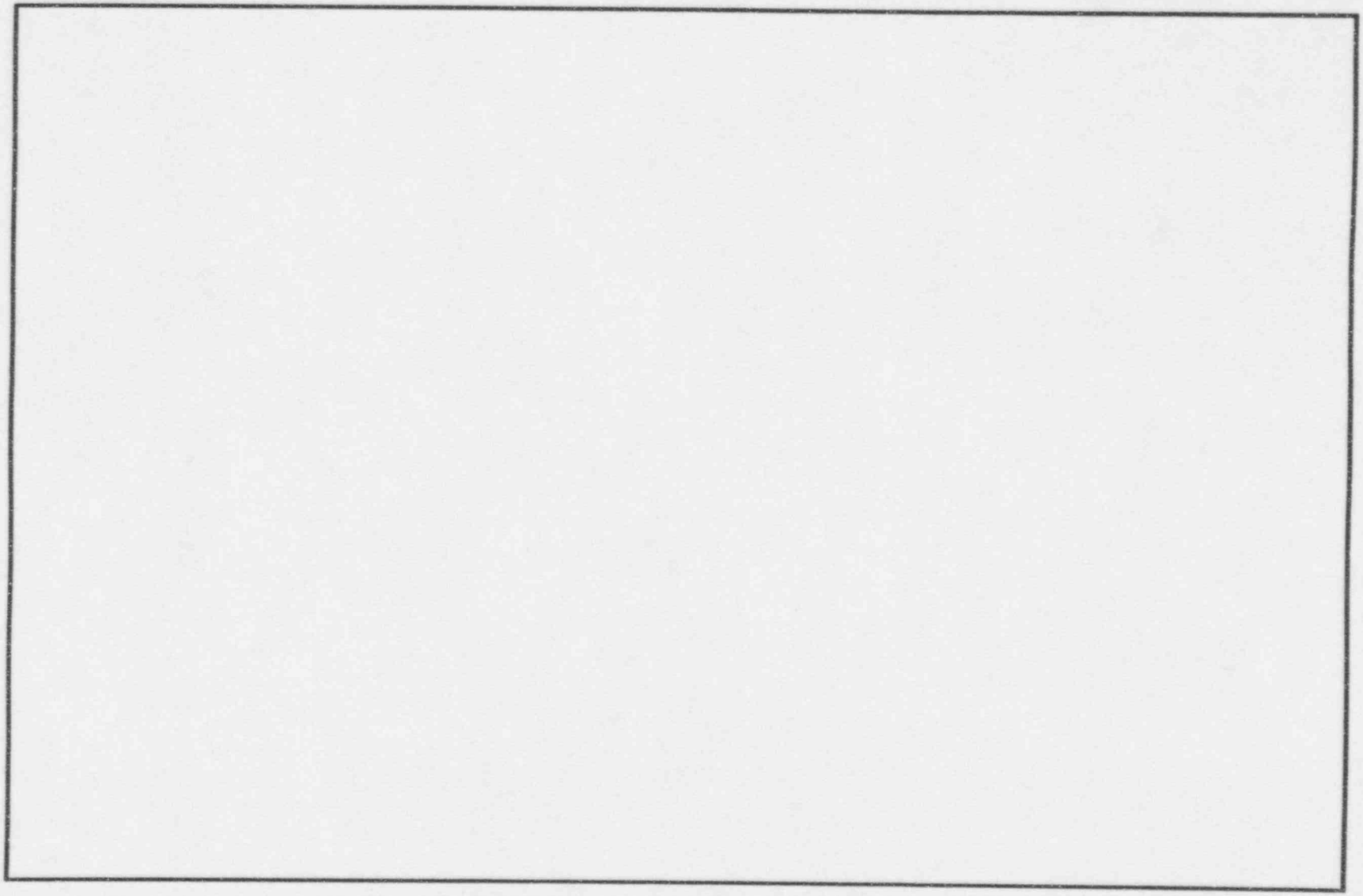
a,b,c

Figure 5.5: Wolf Creek EOC-8 Bow Data for H81 and H32 Assemblies



a,b,c

Figure 5.6: Wolf Creek EOC-8 Bow Data for K46 and K06 Assemblies



a,b,c

Figure 5.7: Wolf Creek EOC-8 Bow Data for J37 and J50 Assemblies

a,b,c

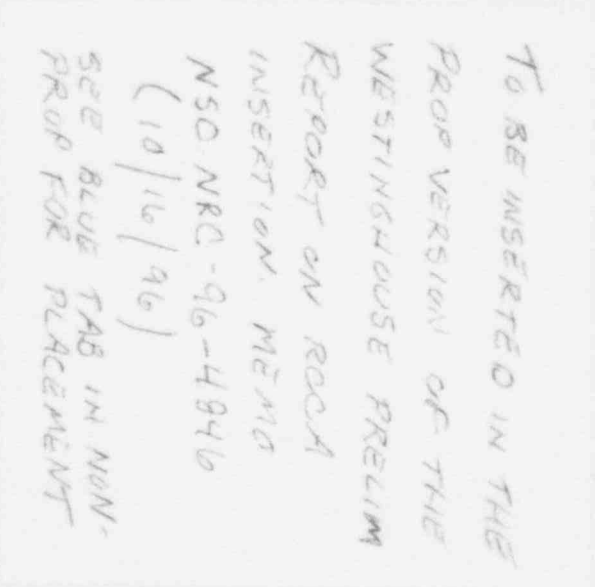
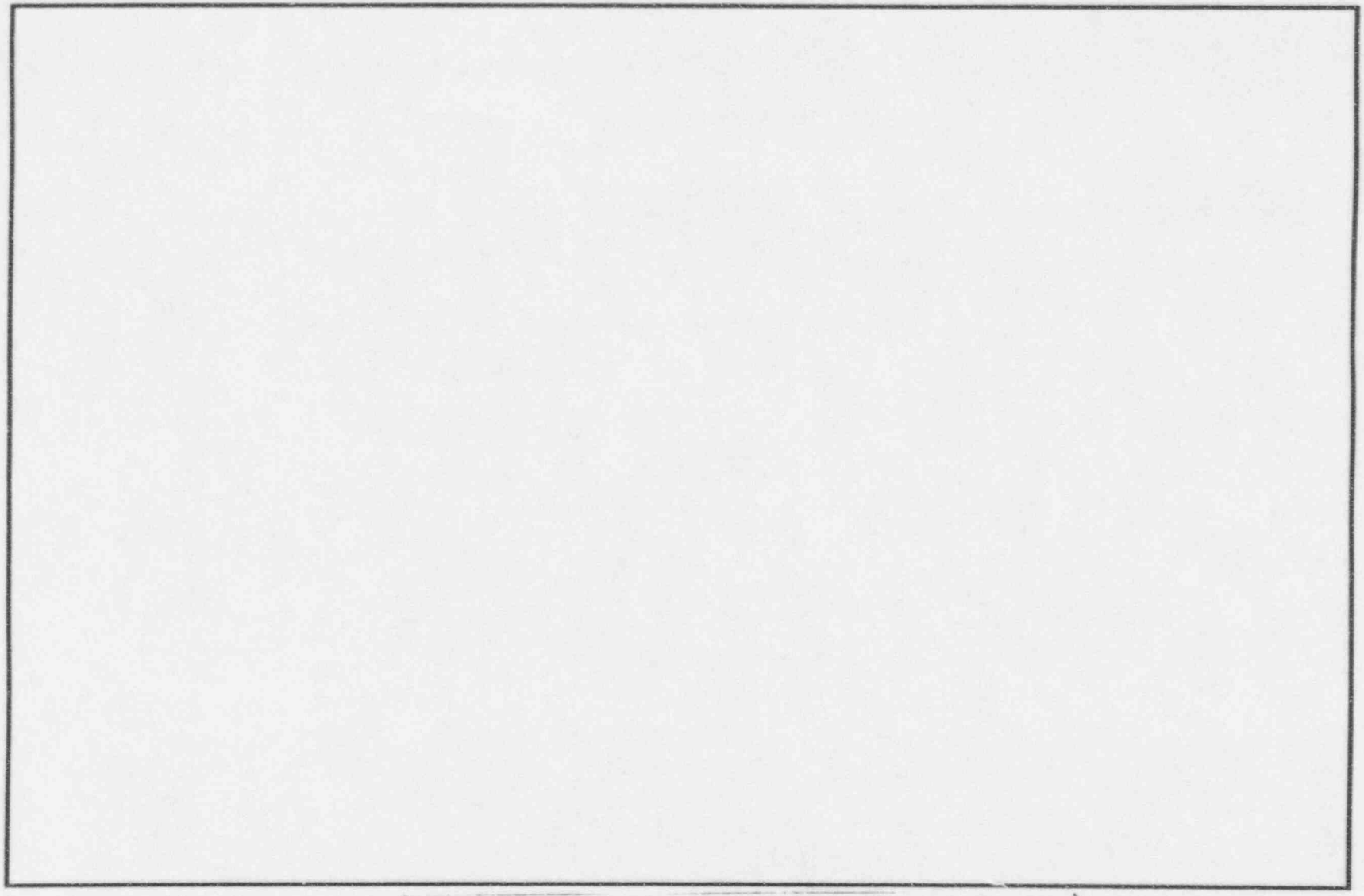



Figure 5.8: Wolf Creek EOC-8 Bow Data for J03 and J52 Assemblies



a,b,c

Figure 5.9: Wolf Creek EOC-8 Dashpot Area and Assembly Bow Data

a,b,c

Figure 6.1: Wolf Creek EOC-8 Fuel Assembly Growth Data

FIGURE 7.1 WOLF CREEK EOC-8 ROD GROWTH DATA

a,b,c

# Appendix 'B'

# Fuel Rod Growth Data Tables

ASSY GROWTH SUMMARY

a,b,c

___ ASSY GROWTH SUMMARY

a,b,c

ASSY GROWTH SUMMARY

a,b,c