

FINAL REPORT  
MAY 1995

REPORT NO. 93-22

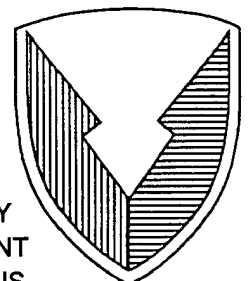
STEEL STRAPPING  
JOINT STRENGTH  
EVALUATION

19960710 038

Prepared for:  
U.S. Army Defense Ammunition  
Center and School  
ATTN: SMCAC-DET  
Savanna, IL 61074-9639

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VALIDATION ENGINEERING DIVISION  
SAVANNA, ILLINOIS 61074-9639

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)  The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Transportation Engineering Division (SMCAC-DET), to conduct a study to assess the maximum strengths of 1-1/4- and 2-inch steel strapping sealed with crimping sealers and notching sealers. The configurations tested included the following for both sizes of strapping:  a. One strapping seal per strap with one crimp per seal. b. One strapping seal per strap with two crimps per seal. c. Two strapping seals per strap with two crimps per seal. d. One strapping seal per strap with one notch per seal. (Continued)					
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22a. NAME OF RESPONSIBLE INDIVIDUAL JEROME H. KROHN			22b. TELEPHONE (Include Area Code) 815-273-8929		22c. OFFICE SYMBOL SMCAC-DEV

19. ABSTRACT (Continued)

- e. One strapping seal per strap with two notches per seal.
- f. Two strapping seals per strap with two notches per seal.

Results are as follows:

- a. 1-1/4-inch strapping sealed with a crimping sealer is stronger than when sealed with a notching sealer.
- b. 2-inch strapping sealed with a notching sealer is stronger than when sealed with a crimping sealer.
- c. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a crimping sealer.
- d. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a notching sealer.
- e. The strength of 2-inch strapping is increased with the addition of a second seal when sealed by either the crimping or notching sealer.
- f. Use of a seal other than what is specified by the manufacturer of the sealer can significantly reduce the breaking strength of the strapping.

U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL  
VALIDATION ENGINEERING DIVISION  
SAVANNA, IL 61074-9639

REPORT NO. 93-22

STEEL STRAPPING JOINT STRENGTH EVALUATION

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## PART 1

### INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Transportation Engineering Division (SMCAC-DET), to conduct a study to assess the maximum strengths of 1-1/4- and 2-inch steel strapping sealed with crimping sealers and notching sealers.

B. AUTHORITY. The test was accomplished IAW mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM). Reference is made to the following:

1. Change 4, 4 October 1974, to AR740-1, 23 April 1973, Storage and Supply Activity Operation.

2. AMCCOM-R 10-17, Mission and Major Functions of USADACS, 13 January 1986.

C. OBJECTIVE. The purpose of these tests was to determine what difference, if any, existed between the breaking strengths of steel strapping sealed with a notching sealer versus steel strapping sealed with a crimping sealer.

D. CONCLUSIONS. Results are as follows:

- a. 1-1/4-inch strapping sealed with a crimping sealer is stronger than when sealed with a notching sealer.

- b. 2-inch strapping sealed with a notching sealer is stronger than when sealed with a crimping sealer.

c. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a crimping sealer.

d. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a notching sealer.

e. The strength of 2-inch strapping is increased with the addition of a second seal when sealed by either the crimping or notching sealer.

f. Use of a seal other than what is specified by the manufacturer of the sealer can significantly reduce the breaking strength of the strapping.

PART 2  
AUGUST 1993 AND MAY 1995

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## PART 3

### TEST PROCEDURES

The breaking strength of the 1-1/4- and 2-inch strapping was determined by placing a loop of the steel strapping around four pins in a test fixture with the desired seal for the test conducted (see part 5). A load cell and displacement gauge were utilized to measure the breaking strength and strap elongation during each test. The six configurations tested for both the 1-1/4- and 2-inch steel strapping were as follows:

- a. One strapping seal per strap with one crimp per seal.
- b. One strapping seal per strap with two crimps per seal.
- c. Two strapping seals per strap with two crimps per seal.
- d. One strapping seal per strap with one notch per seal.
- e. One strapping seal per strap with two notches per seal.
- f. Two strapping seals per strap with two notches per seal.

The test fixtures pulled apart at an average rate of 1.17 inches per minute. The test was continued until a point at which the maximum strength of the strapping had been obtained. During testing, both load force and load displacement were recorded so that precise results could be obtained. Five straps were broken for each configuration to avoid the possibility of skewed results.

## PART 4

### TEST RESULTS

As described in part 3, steel strapping was tested in six different configurations for two different sizes of steel strapping with five straps being broken for each configuration. During each test, the mode of failure was observed for each strap and recorded in order to provide an accurate record for the test results (see part 7). Initially, six sets of straps were tested for the 1-1/4-inch strapping and six sets were tested for the 2-inch strapping. The 1-1/4-inch straps were tested with a Signode seal, part number 107DG, and the 2-inch straps were tested with a Signode seal, part number 207. While analyzing the test data, a discrepancy was noted for the breaking strengths of the 2-inch straps with crimped seals (see table 2). After further investigation, the seal that was used for the tests with the 2-inch strapping and crimping sealer was determined to be improper for the sealer that was used for these tests. After consultation with the manufacturer of the 2-inch crimping sealer, the tests with the 2-inch crimping sealer were conducted again utilizing Signode seal 208DG. The 208DG seal had a grit coating on the inner side of the seal. The results obtained from the second set of tests for the 2-inch steel strapping and crimping sealer indicated a more reasonable maximum breaking strength for the crimping sealer than had been obtained during the first series of tests. As can be seen in tables 1 and 2 and in the summary graph in part 6, the crimping sealer had a slightly higher average breaking strength than the notching sealer for the 1-1/4-inch strapping, while the notching sealer had a higher average breaking strength than the crimping sealer for the 2-inch strapping. The large difference in breaking strengths for the 2-inch strapping for the crimping sealer with the wrong seal and with the 208DG seal can also be seen in table 2 as well as the summary graph in part 6.

Table 1

Breaking Strengths of 1-1/4-Inch Steel Strapping (all values in pounds)

	Single Seal <u>Single Notch</u>	Single Seal <u>Single Crimp</u>
	5,176	5,363
	5,330	5,965
	5,884	6,120
	5,851	6,201
	5,762	5,851
Average:	5,601	5,900
	Single Seal <u>Double Notch</u>	Single Seal <u>Double Crimp</u>
	8,049	8,862
	7,935	8,927
	8,480	9,237
	8,341	8,927
	8,691	8,797
Average:	8,299	8,950
	Double Seals <u>Double Notches</u>	Double Seals <u>Double Crimps</u>
	7,625	9,172
	7,585	9,106
	8,016	8,935
	8,268	9,391
	7,625	9,497
Average:	7,824	9,220

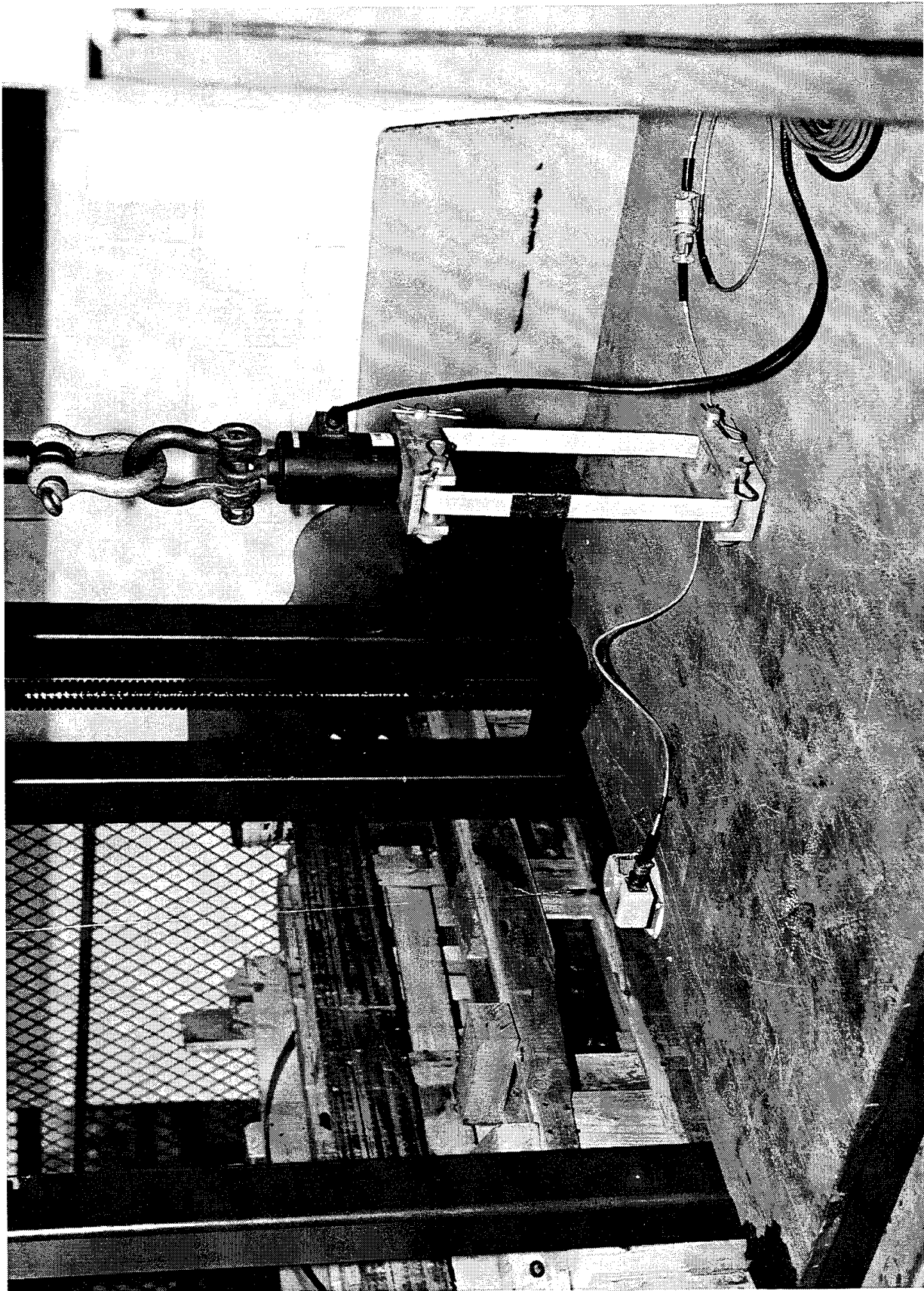
Table 2

Breaking Strengths of 2-Inch Steel Strapping (all values in pounds)

	<u>Single Seal Single Notch</u>	<u>Single Seal Single Crimp</u>	<u>Single Seal (208DG) Single Crimp</u>
	6,160	2,490	6,396
	5,737	3,507	6,877
	5,493	2,343	6,877
	5,672	2,433	7,031
	<u>6,437</u>	<u>2,710</u>	<u>6,641</u>
Average:	5,900	2,697	6,764
	<u>Single Seal Double Notch</u>	<u>Single Seal Double Crimp</u>	<u>Single Seal (208DG) Double Crimp</u>
	12,988	5,583	10,522
	12,638	5,151	10,067
	13,395	5,306	10,026
	13,118	5,070	10,498
	<u>12,614</u>	<u>5,241</u>	<u>11,003</u>
Average:	12,951	5,270	10,423
	<u>Double Seal Double Notches</u>	<u>Double Seal Double Crimps</u>	<u>Double Seal (208DG) Double Crimps</u>
	20,036	10,628	19,238
	20,377	11,312	18,978
	19,482	11,287	19,140
	20,459	10,653	18,750
	<u>19,401</u>	<u>11,182</u>	<u>18,880</u>
Average:	19,951	11,012	18,997

PART 5

PHOTOGRAPH



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL -  
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AO317-SCN93-243-4499. This photograph shows the test setup that was used to determine the breaking strength of both the 1-1/4- and 2-inch steel strapping.

PART 6

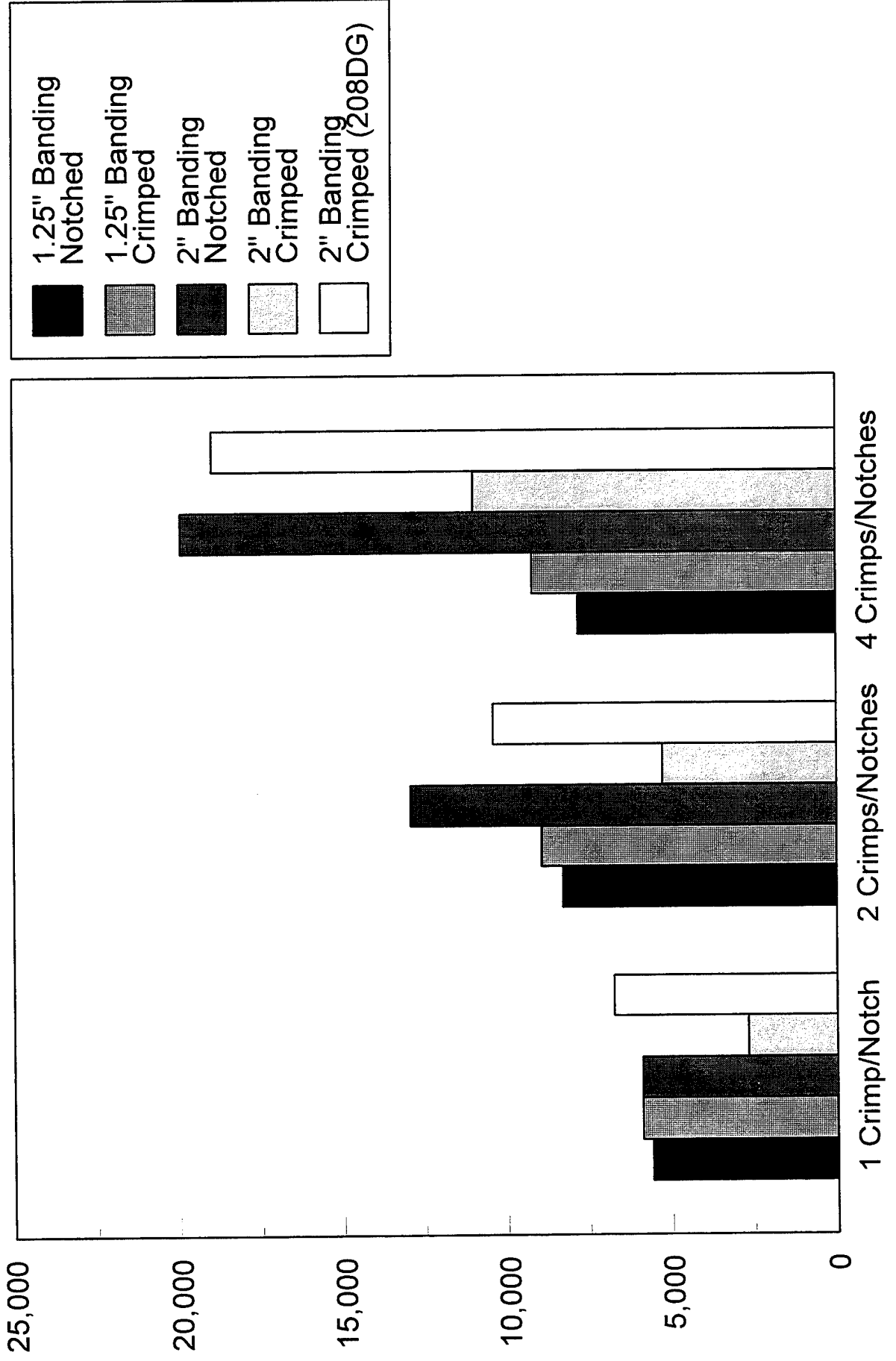
GRAPHS

Summary Results from the  
Steel Strapping Joint Evaluation



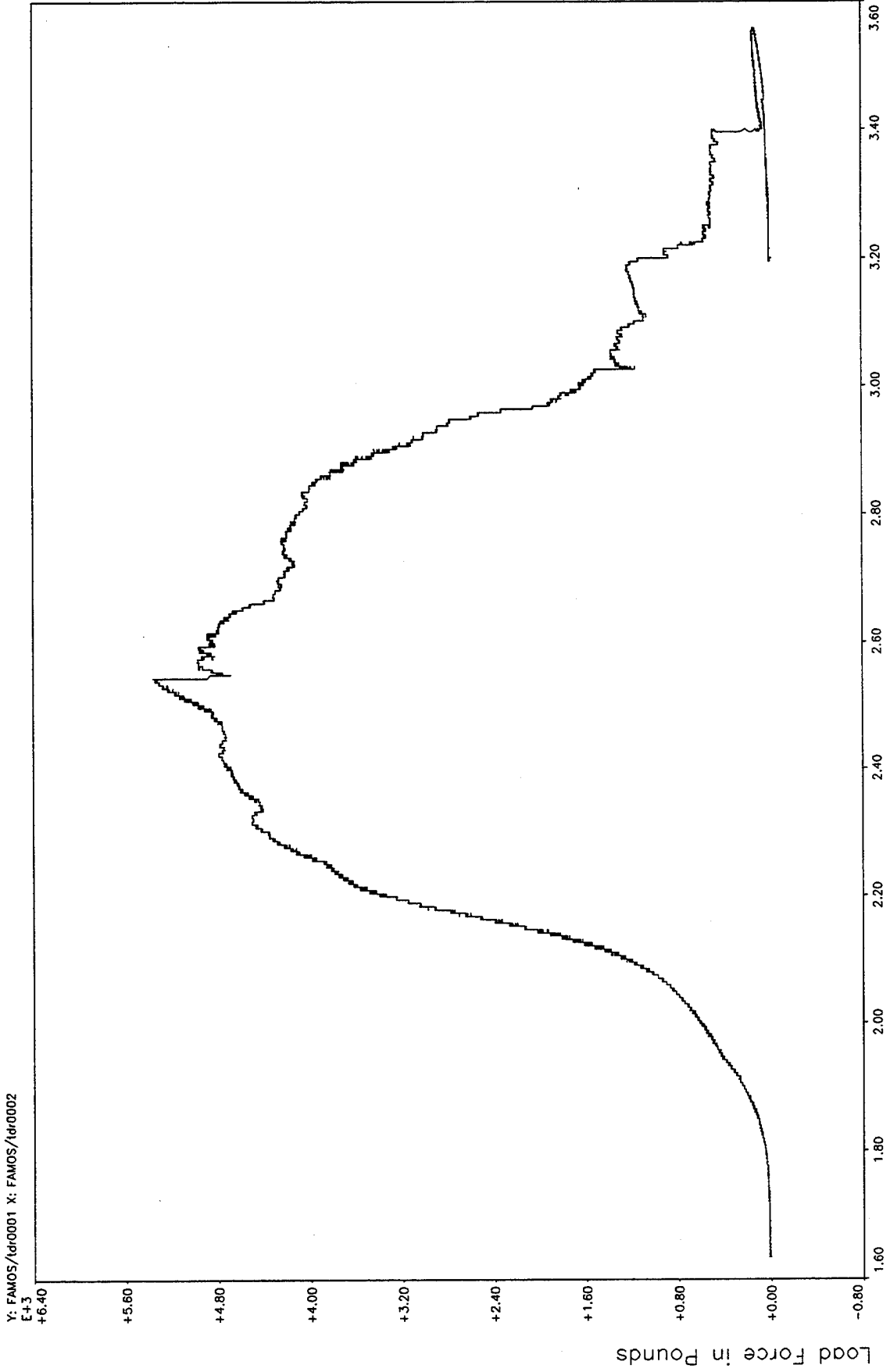
# Results from the 1-1/4 Inch and 2-inch Steel Strapping Joint Evaluation

## Average Strap Breaking Strength (Pounds)

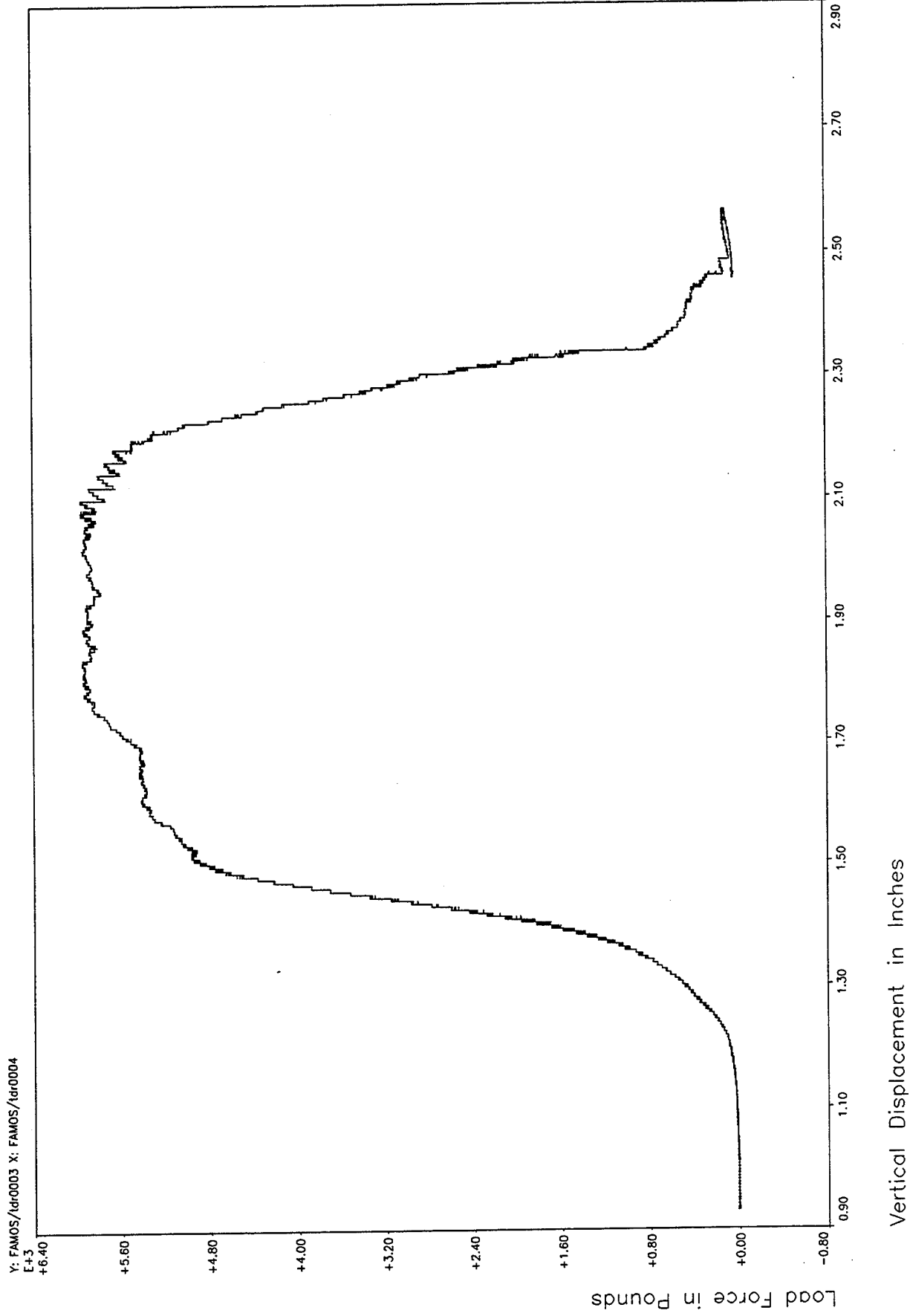


Test Data from  
1-1/4-Inch Strapping: 1 Seal, 1 Crimp

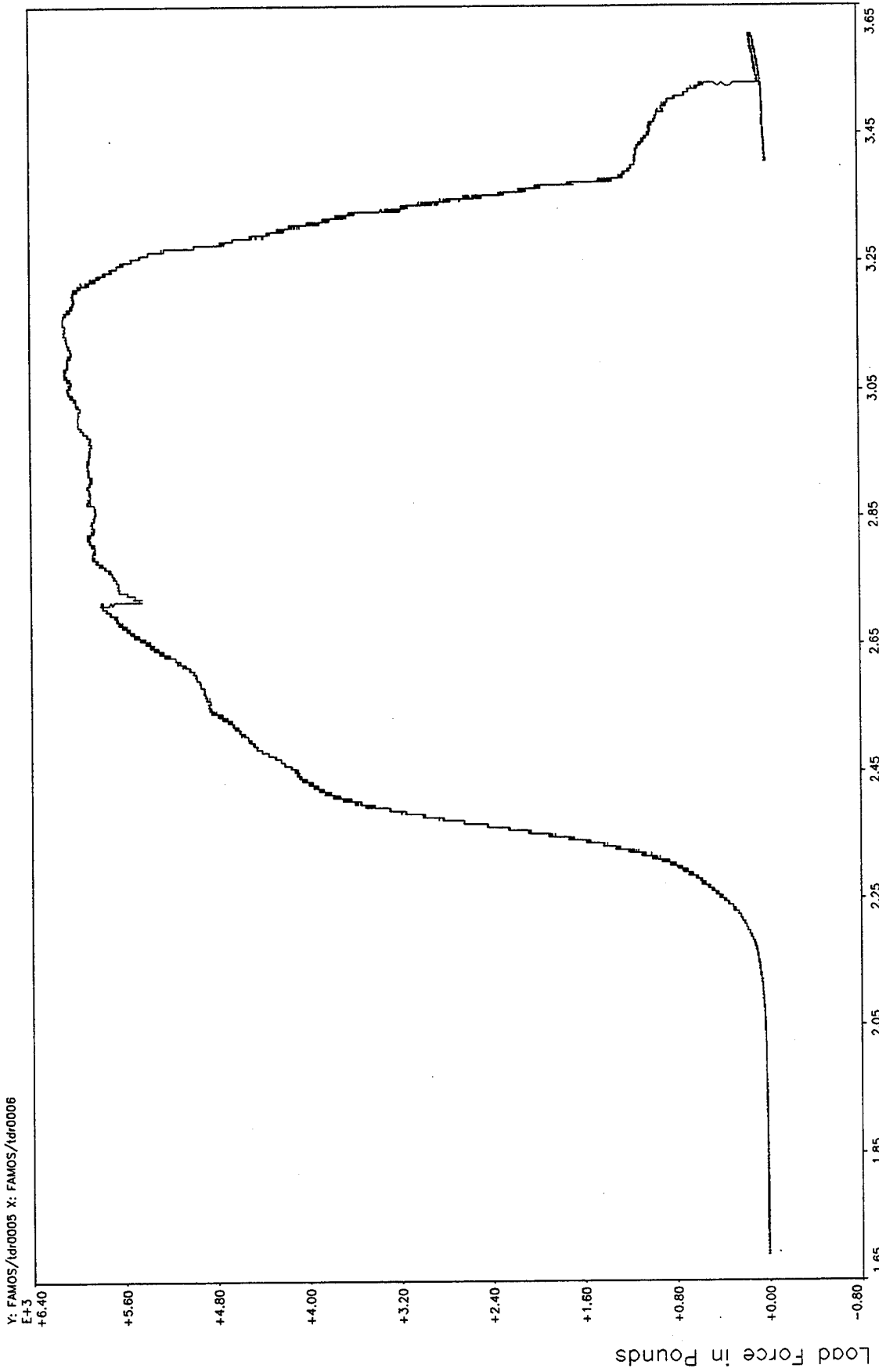
Test 1: 1.25 Inch Banding, 1 Seal, 1 Crimp



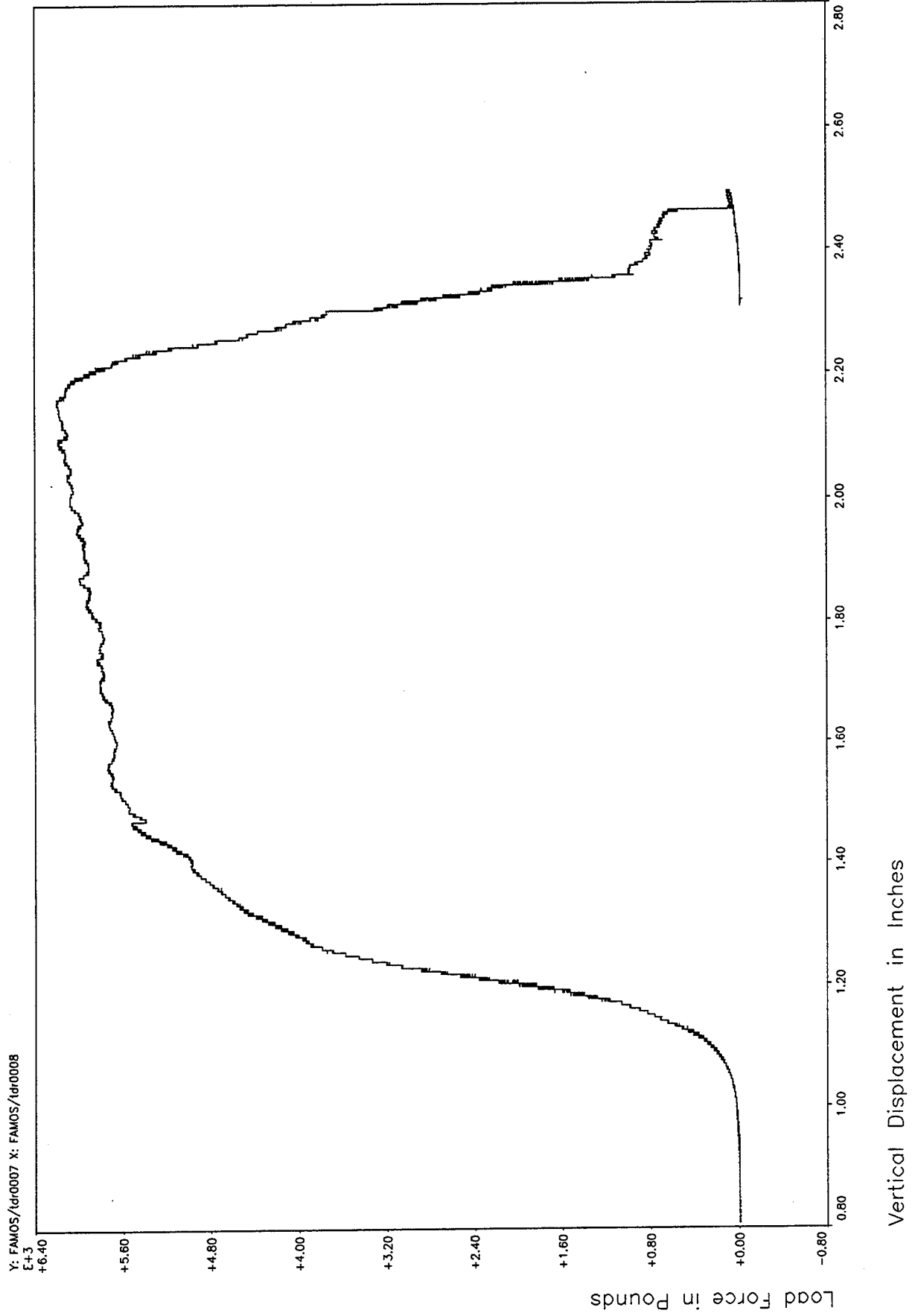
Test 2: 1.25 Inch Banding, 1 Seal, 1 Crimp



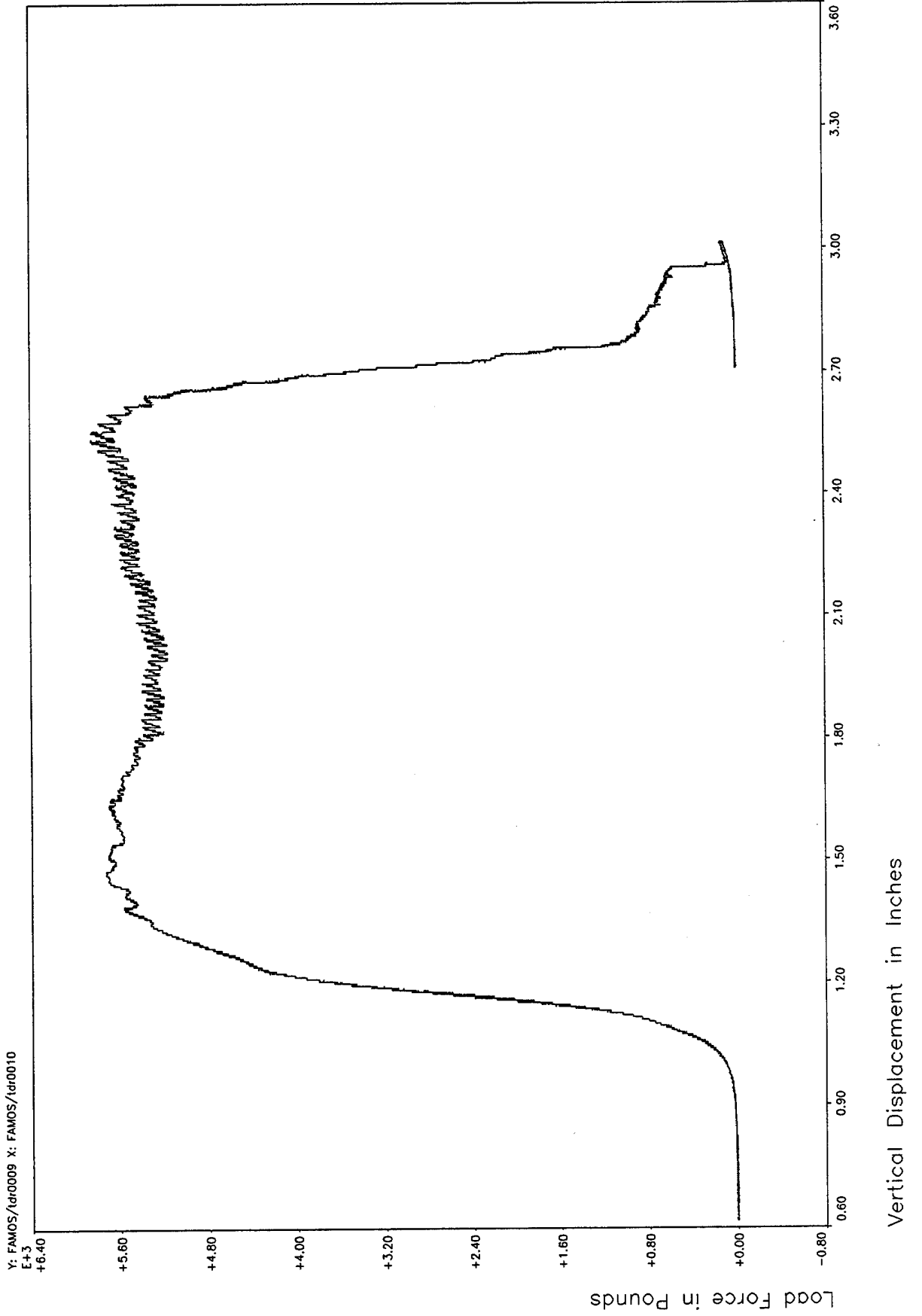
Test 3: 1.25 Inch Banding, 1 Seal, 1 Crimp



Test 4: 1.25 Inch Banding, 1 Seal, 1 Crimp



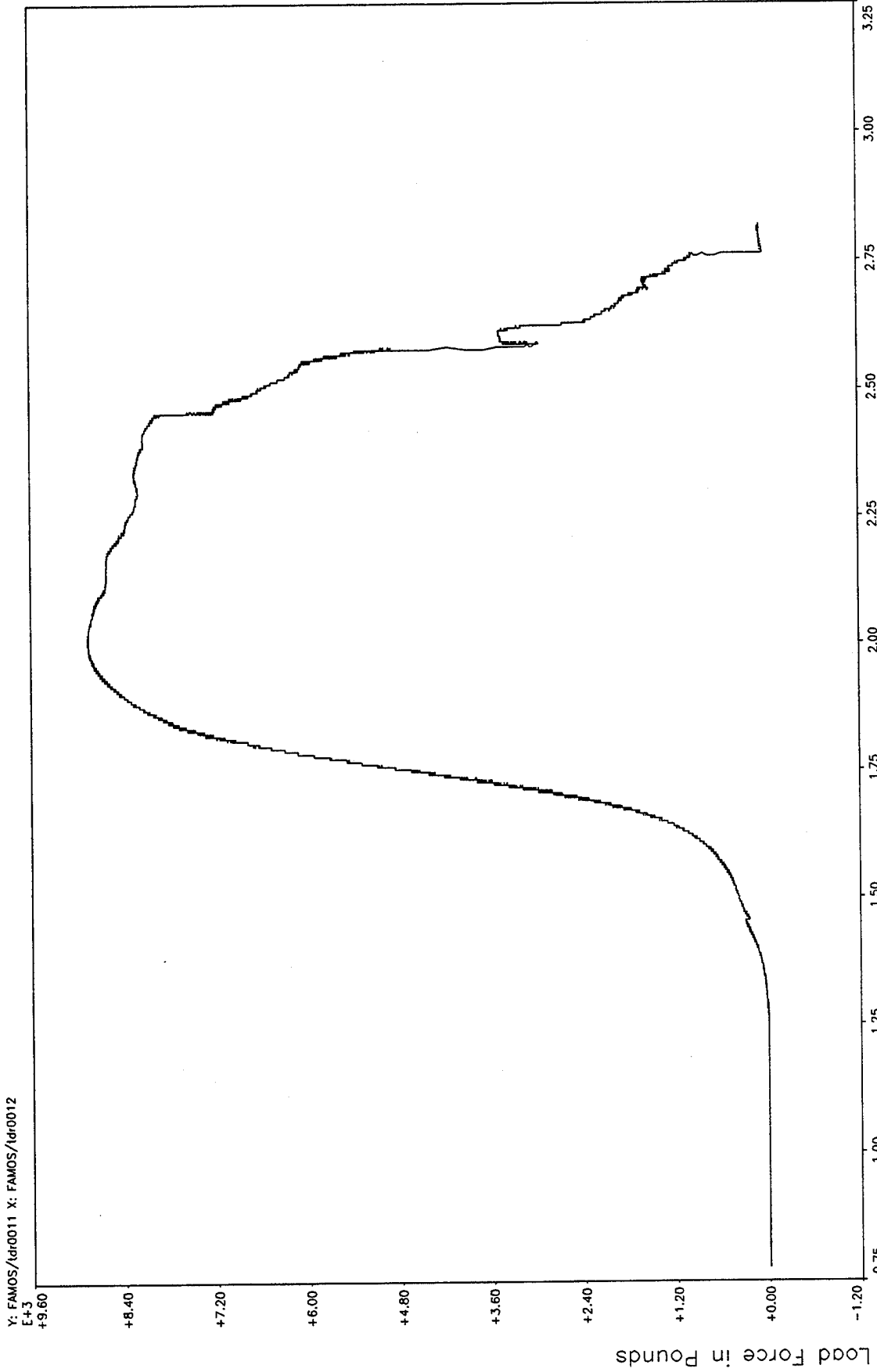
Test 5: 1.25 Inch Banding, 1 Seal, 1 Crimp



Test Data from  
1-1/4-Inch Strapping: 1 Seal, 2 Crimps

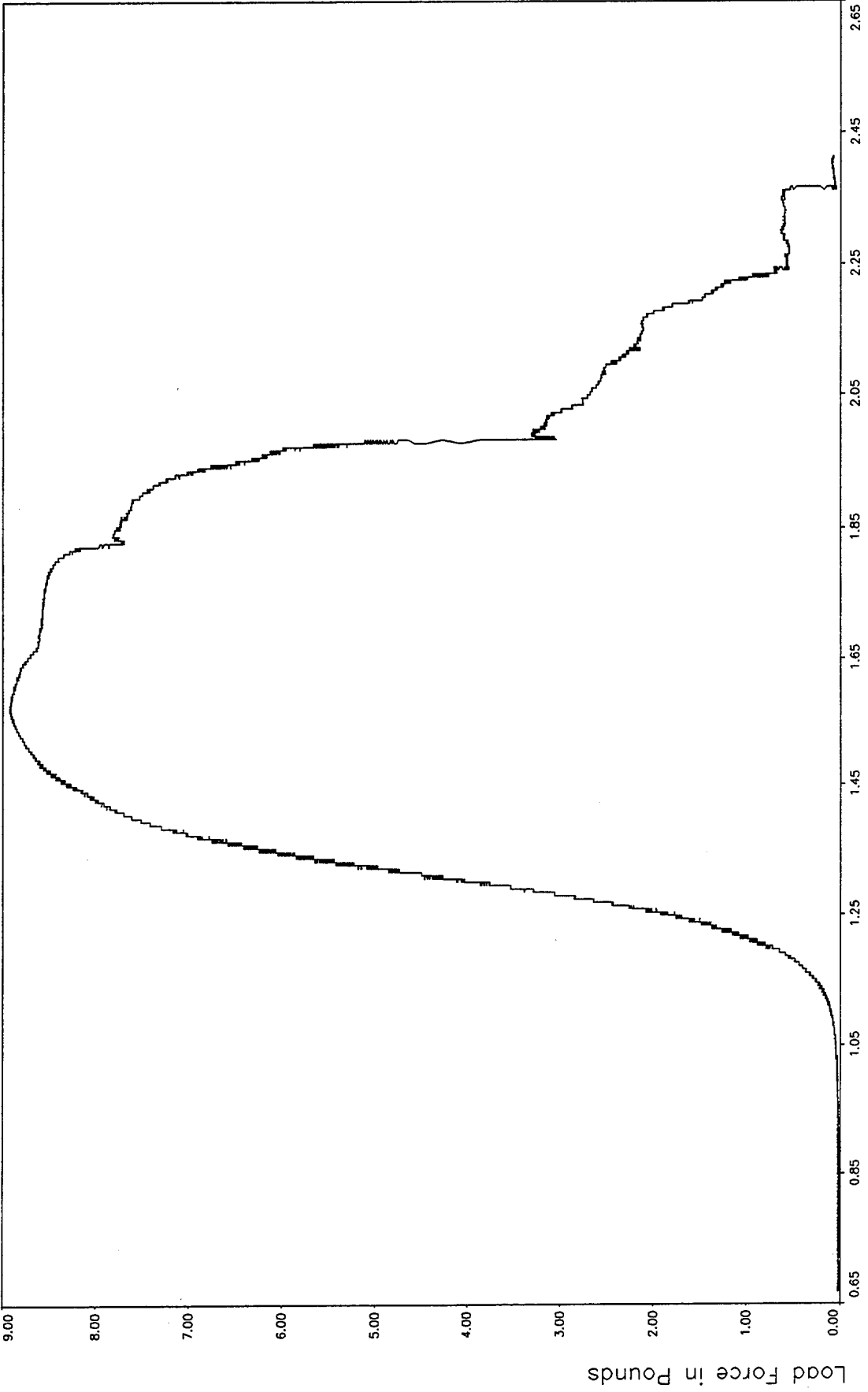


Test 1: 1.25 Inch Banding, 1 Seal, 2 Crimps



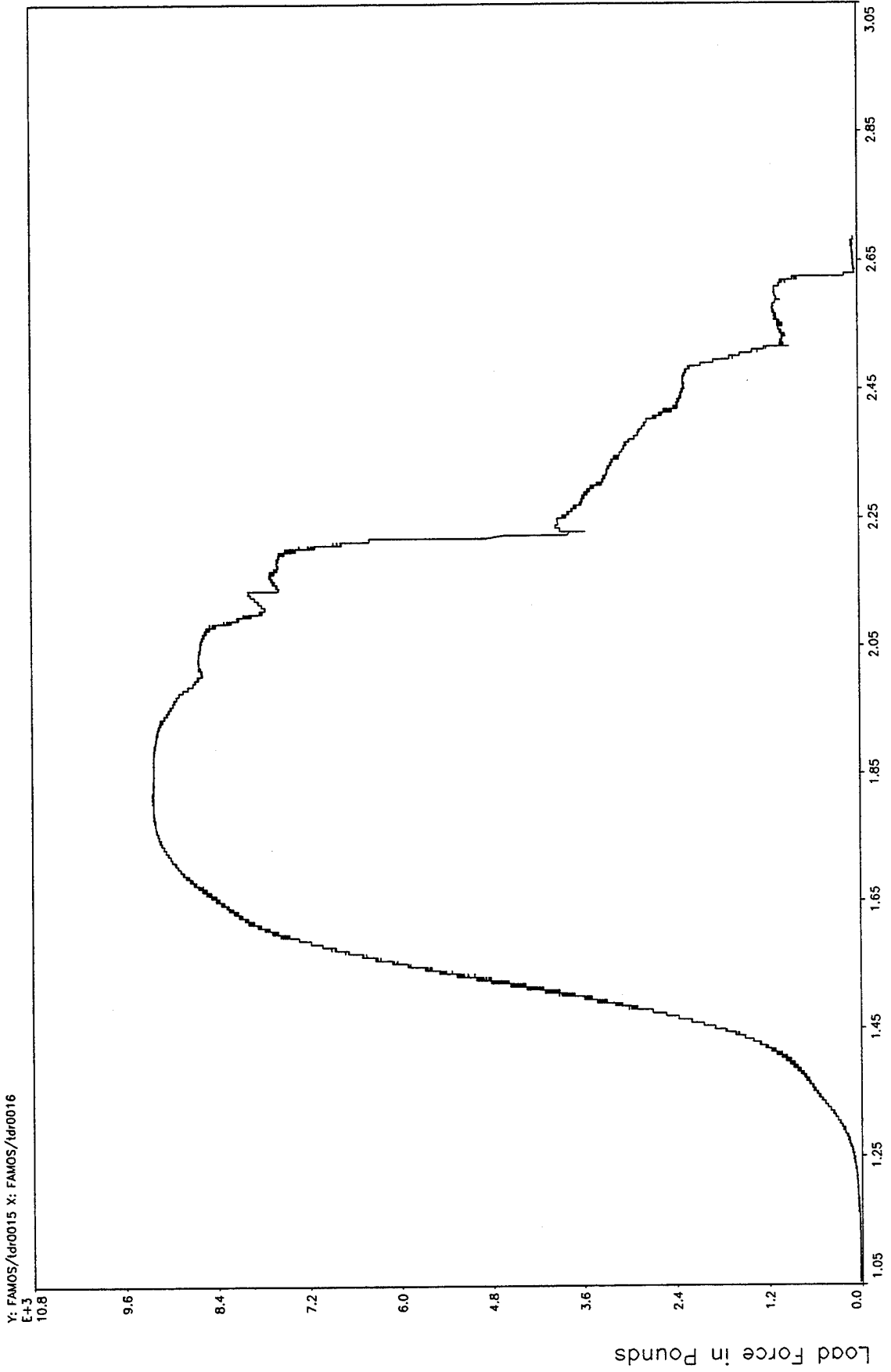
Test 2: 1.25 Inch Banding, 1 Seal, 2 Crimps

Y: FAMOS/ldr0013 X: FAMOS/ldr0014



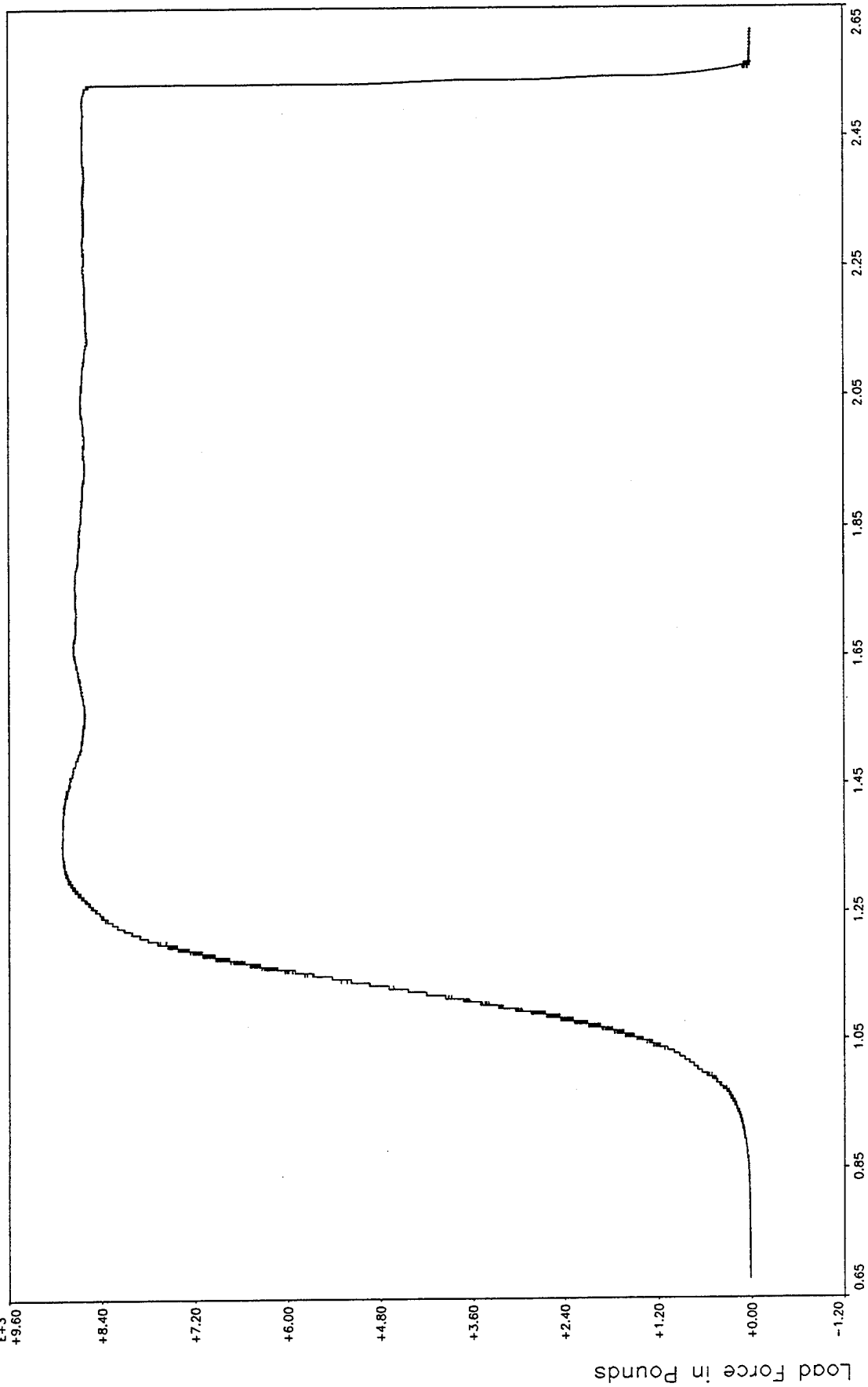
Vertical Displacement in Inches

Test 3: 1.25 Inch Banding, 1 Seal, 2 Crimps



Test 4: 1.25 Inch Banding, 1 Seal, 2 Crimps

Y: FAMOS/ldr0017 X: FAMOS/ldr0018  
E+3  
+9.60



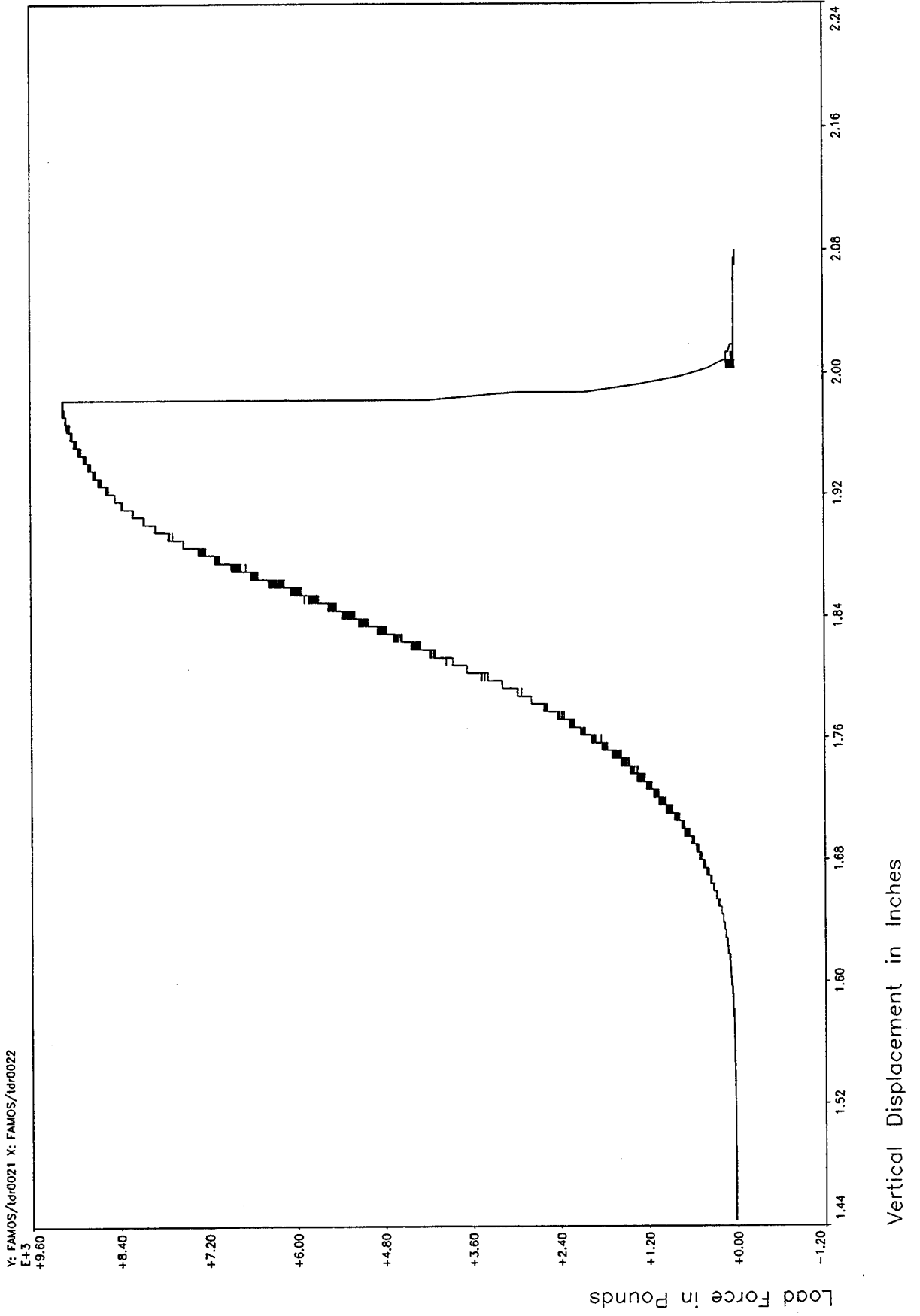
Vertical Displacement in Inches

Test 5: 1.25 Inch Banding, 1 Seal, 2 Crimps



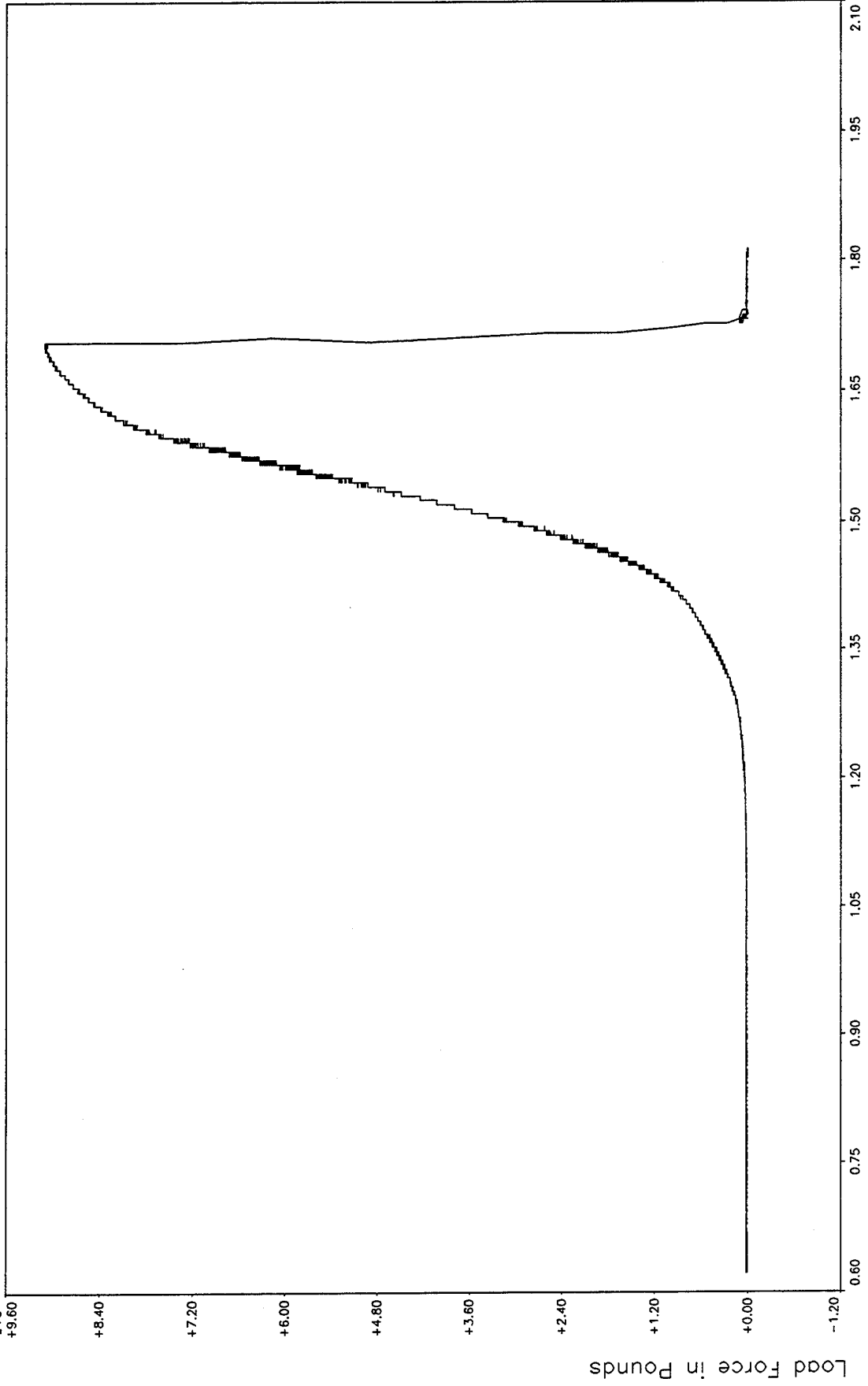
Test Data from  
1-1/4-Inch Strapping: 2 Seals, Double Crimps

Test 1: 1.25 Inch Banding, 2 Seals, 2 Crimps



# Test 2: 1.25 Inch Banding, 2 Seals, 2 Crimps

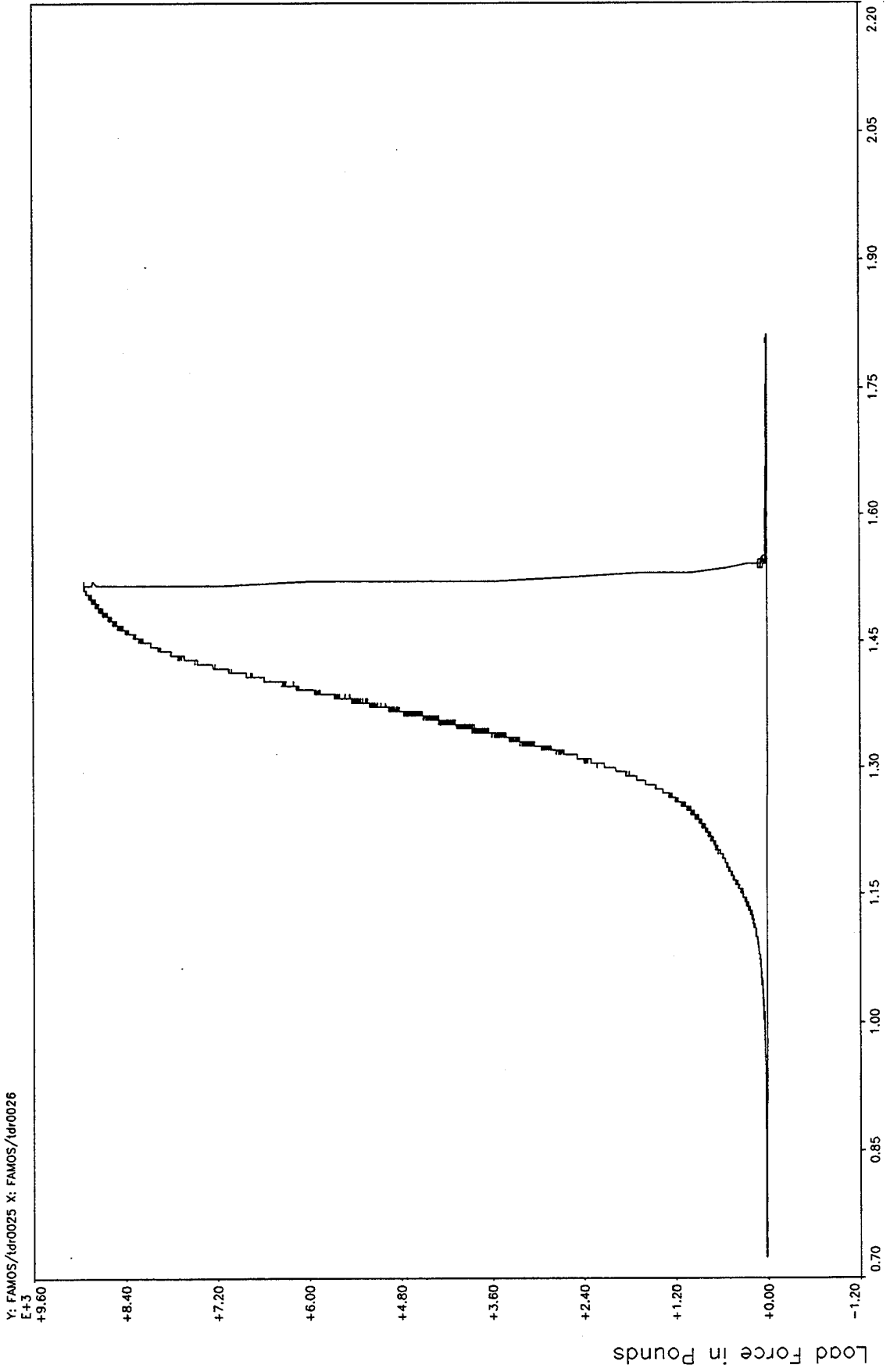
Y: FAMOS/ldr0023 X: FAMOS/ldr0024  
E+3  
+9.60



Vertical Displacement in Inches

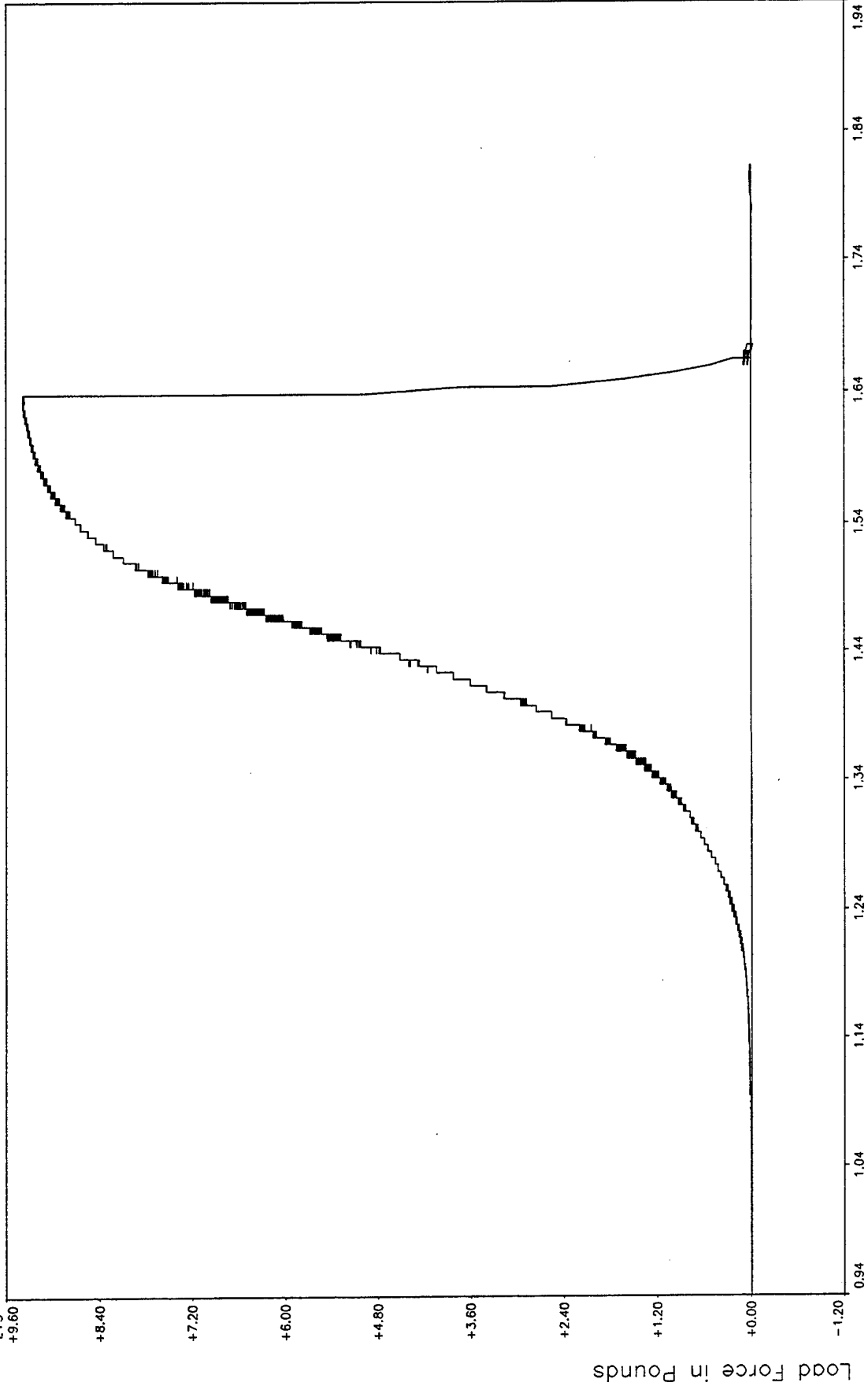


Test 3: 1.25 Inch Banding, 2 Seals, 2 Crimps



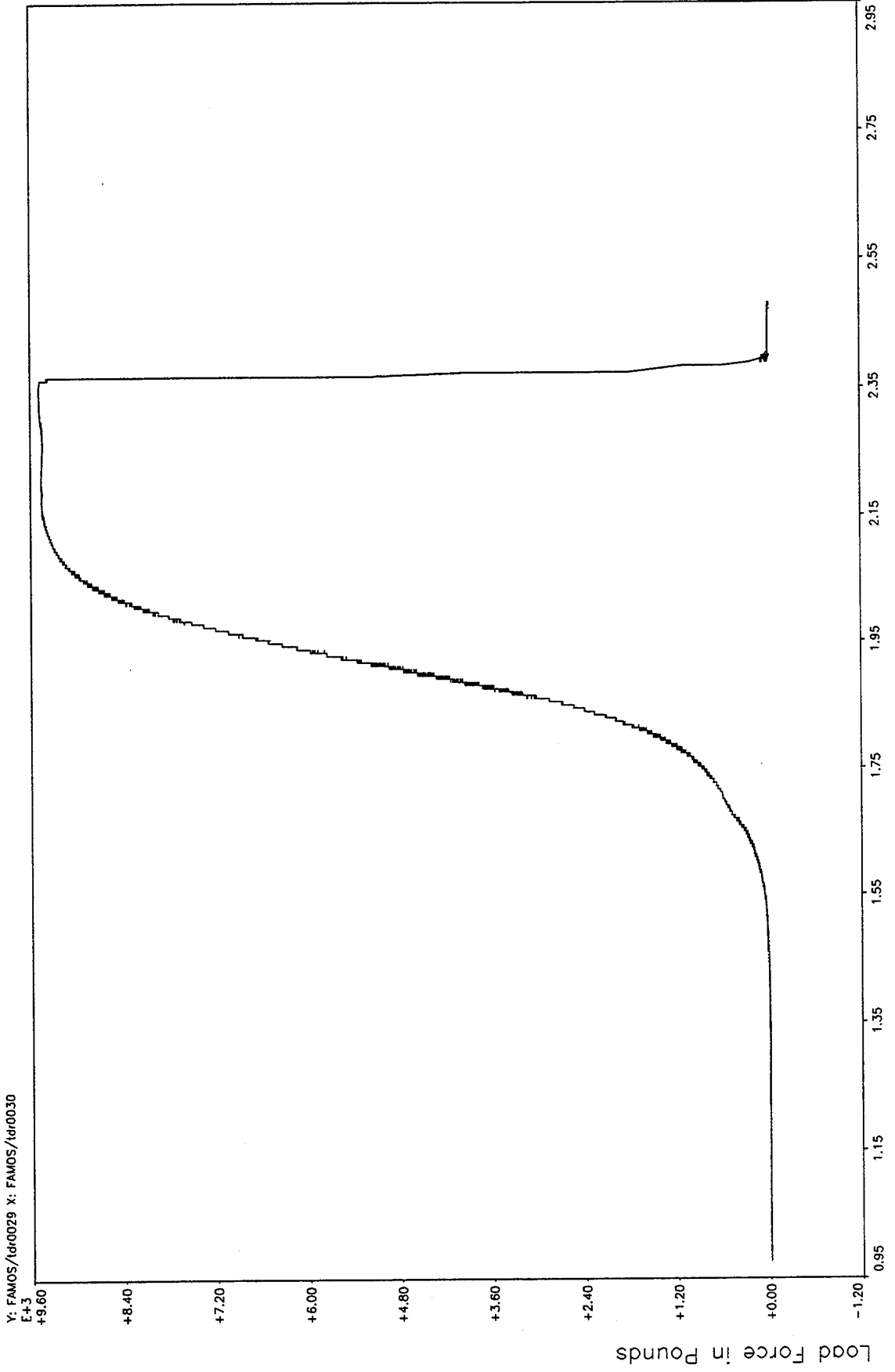
Test 4: 1.25 Inch Banding, 2 Seals, 2 Crimps

Y: FAMOS/ldr0027 X: FAMOS/ldr0028  
E+3  
+9.60



Vertical Displacement in Inches

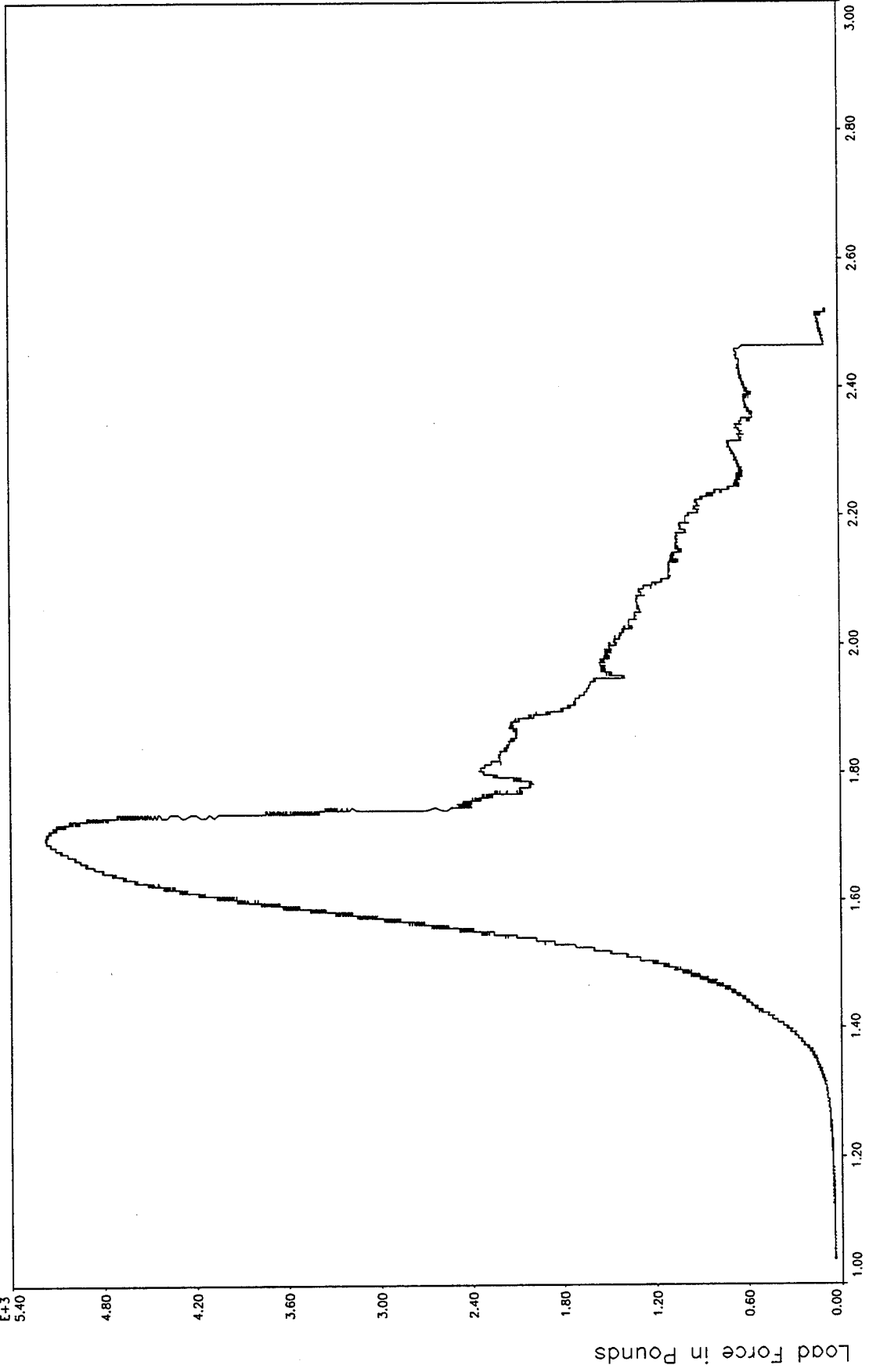
Test 5: 1.25 Inch Banding, 2 Seals, 2 Crimps



Test Data from  
1-1/4-Inch Strapping: 1 Seal, 1 Notch

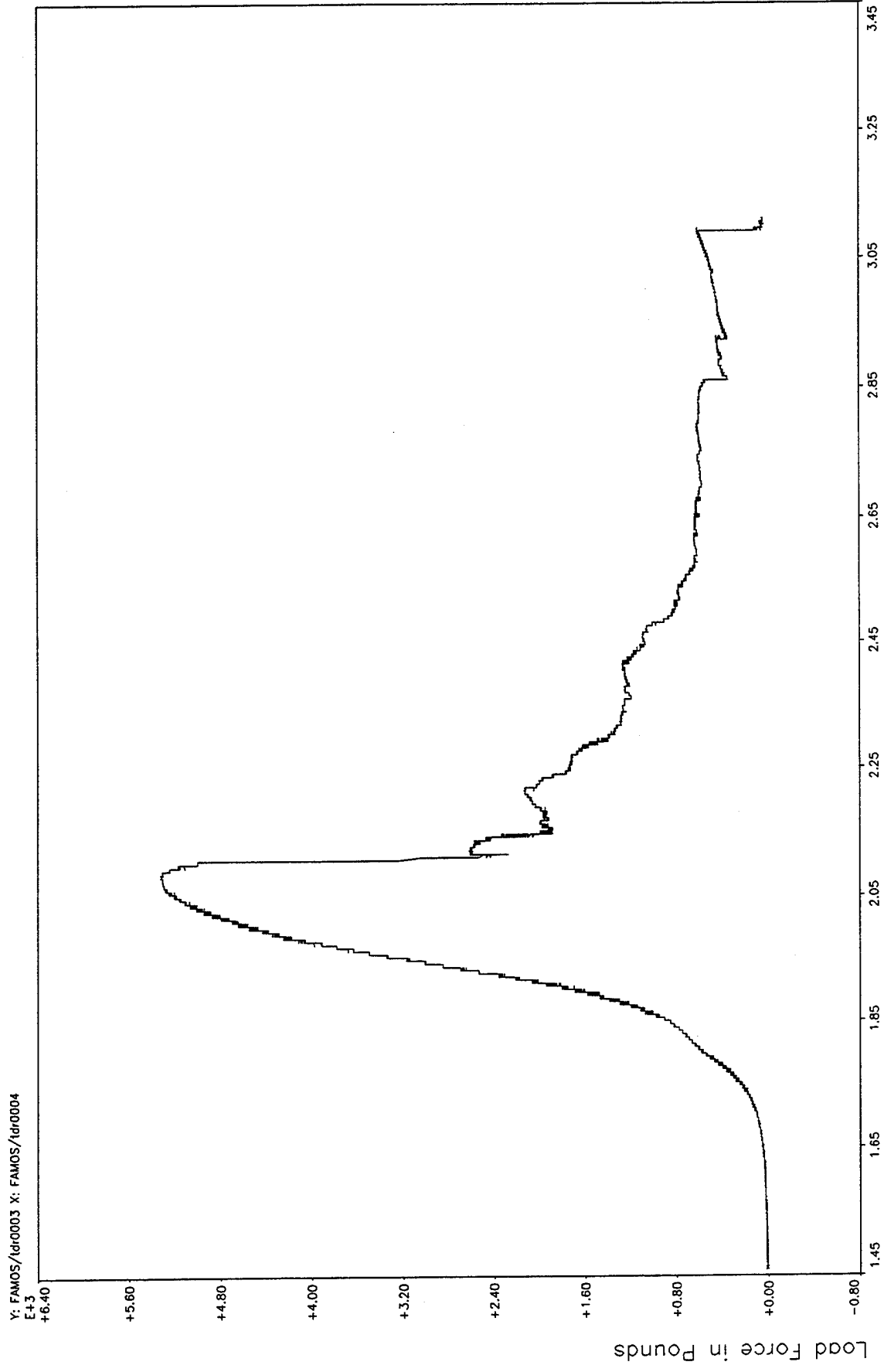
Test 1: 1.25 Inch Banding, 1 Seal, 1 Notch

Y: FAMOS/ldr0001 X: FAMOS/ldr0002  
E+3  
5.40

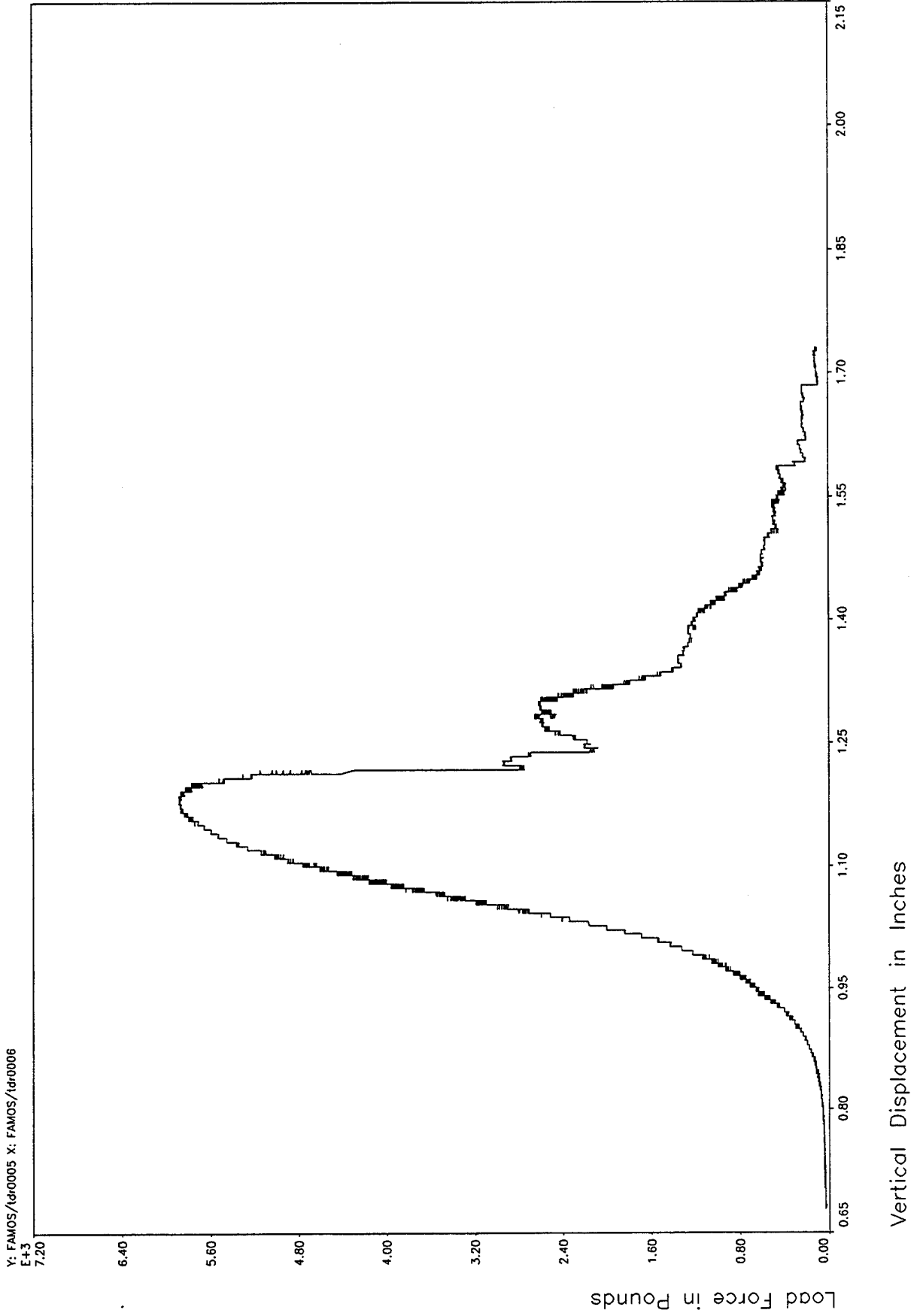


Vertical Displacement in Inches

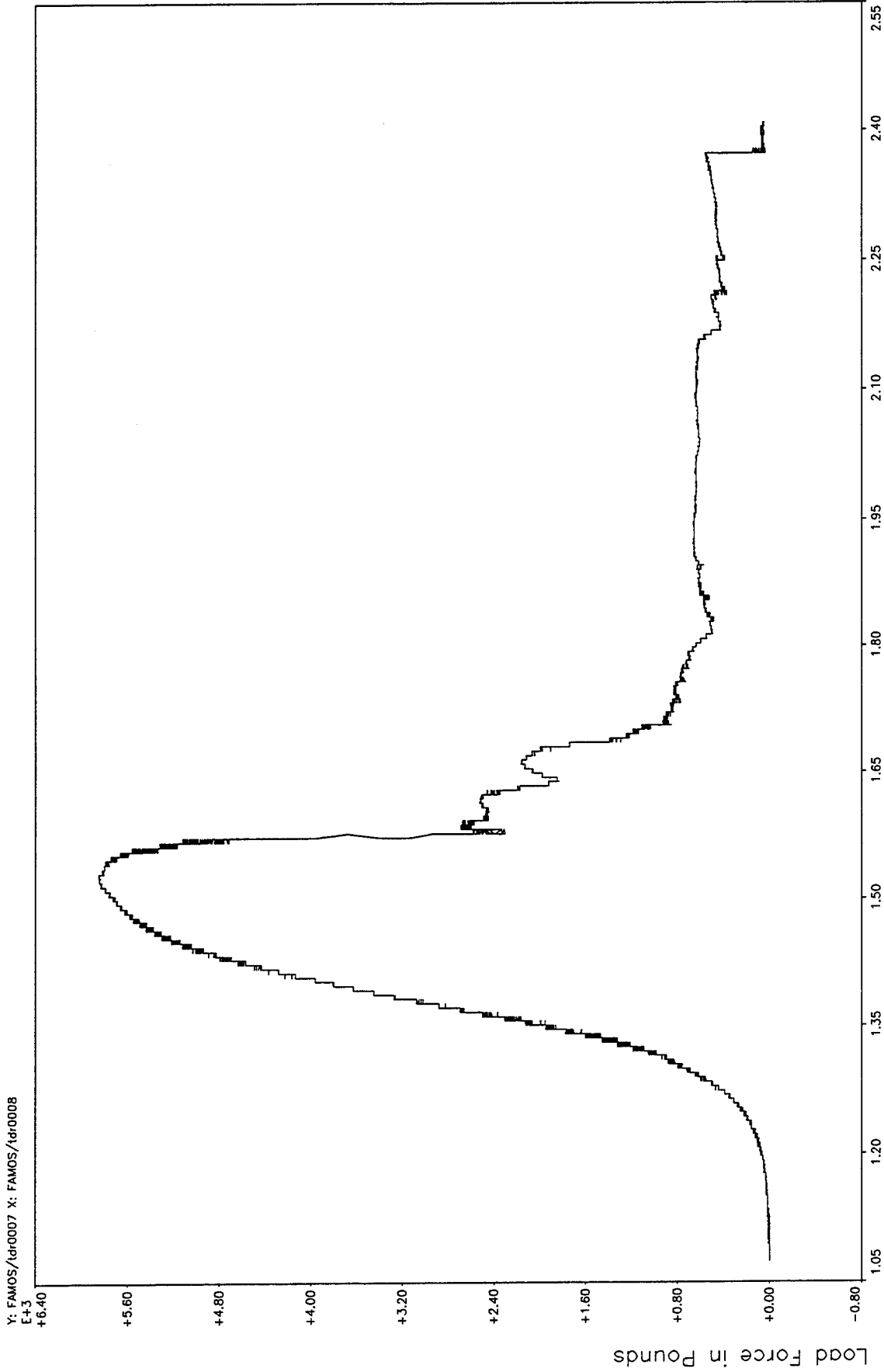
Test 2: 1.25 Inch Banding, 1 Seal, 1 Notch



Test 3: 1.25 Inch Banding, 1 Seal, 1 Notch

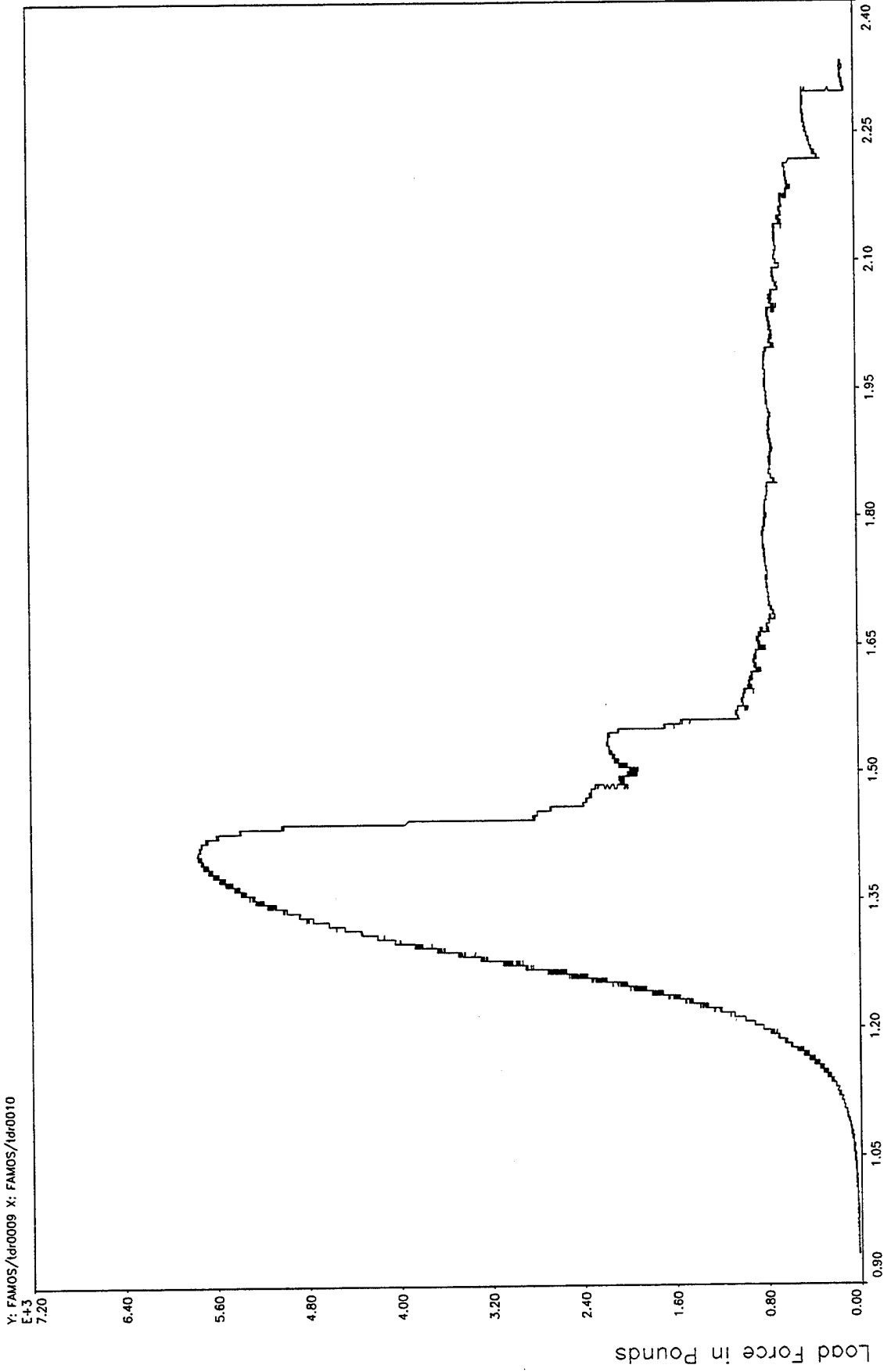


Test 4: 1.25 Inch Banding, 1 Seal, 1 Notch





Test 5: 1.25 Inch Banding, 1 Seal, 1 Notch

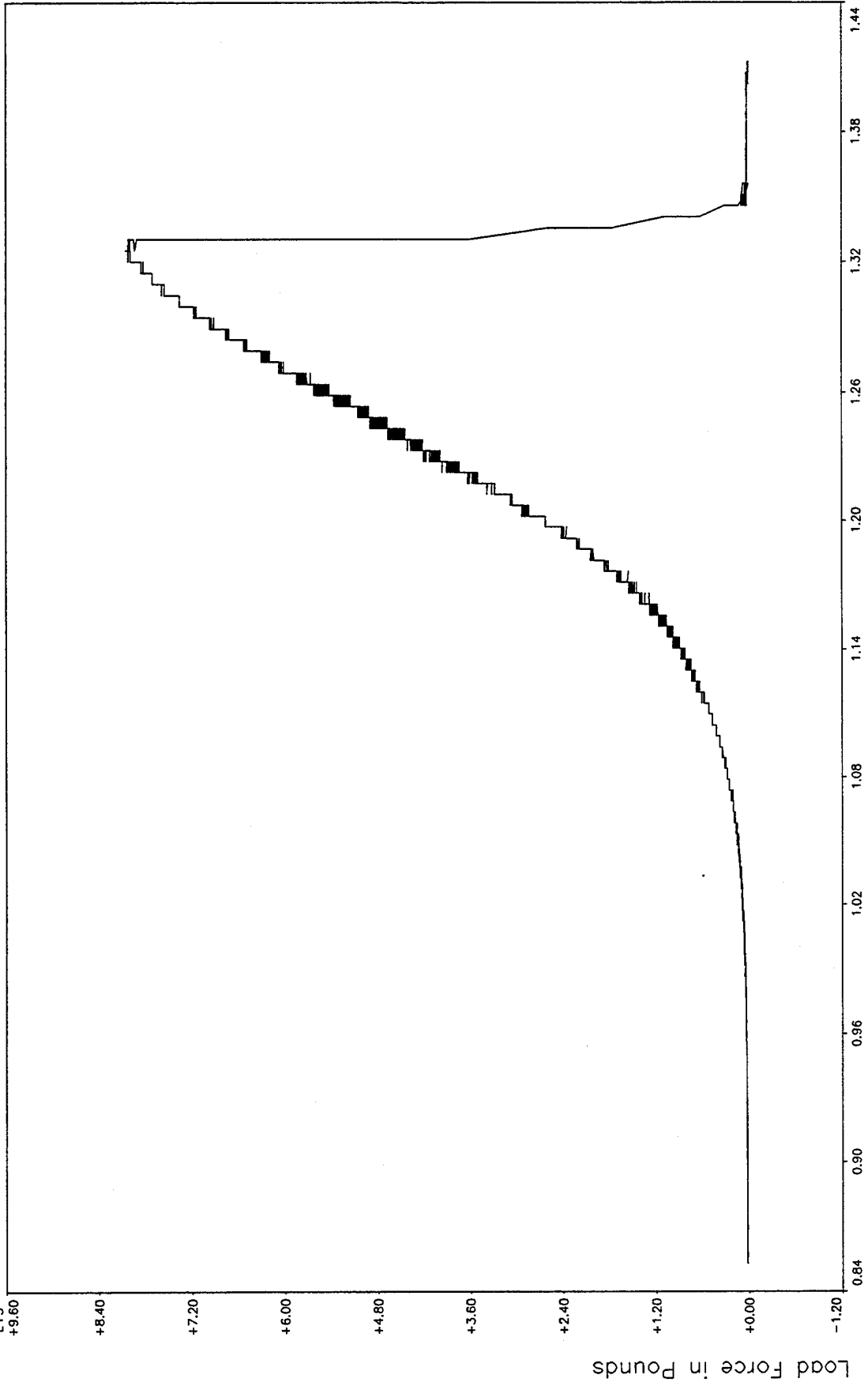


Vertical Displacement in Inches

Test Data from  
1-1/4-Inch Strapping: 1 Seal, 2 Notches

Test 1: 1.25 Inch Banding, 1 Seal, 2 Notches

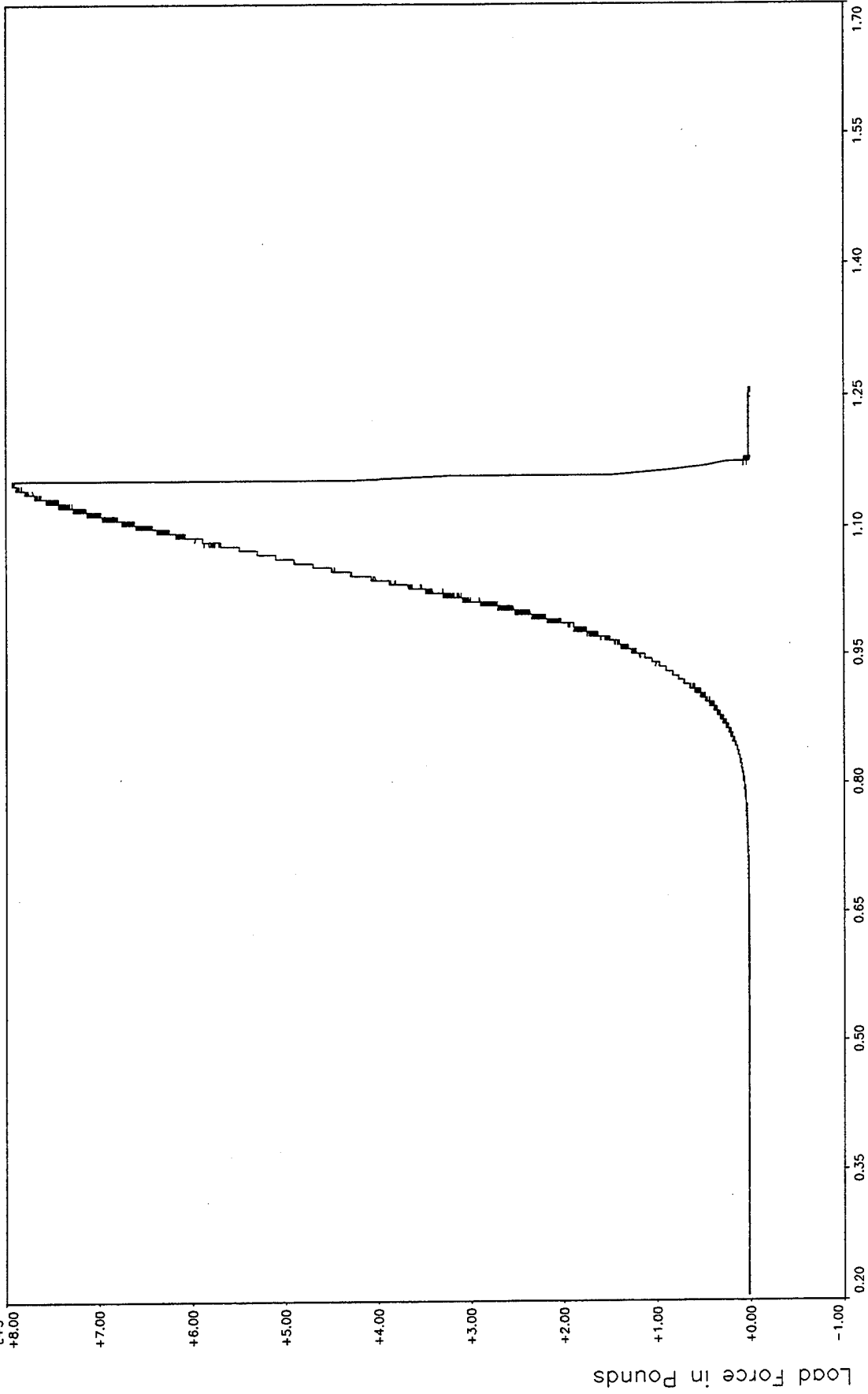
Y: FAMOS/ldr0011 X: FAMOS/ldr0012  
E+3  
+9.60



Vertical Displacement in Inches

Test 2: 1.25 Inch Banding, 1 Seal, 2 Notches

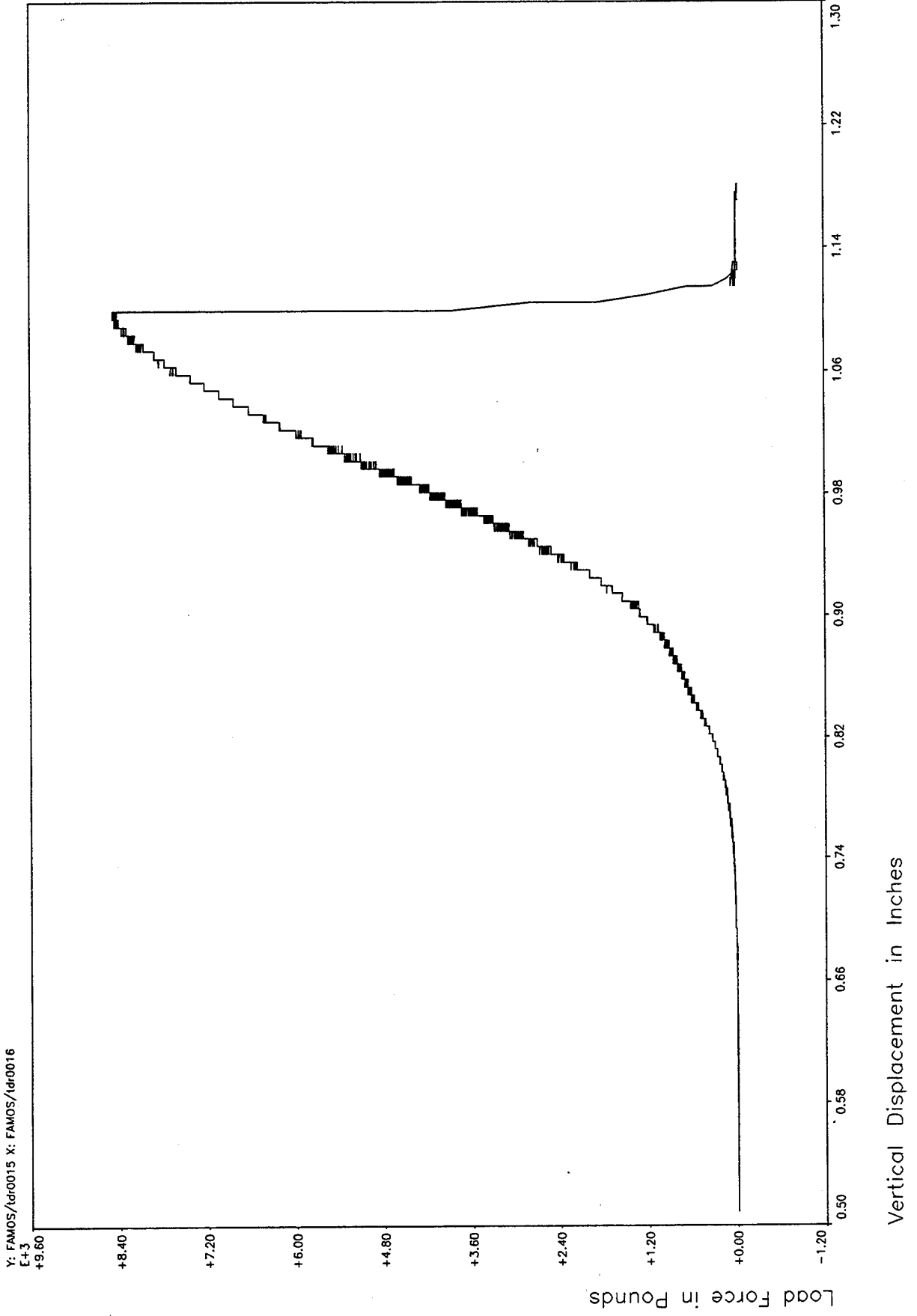
Y: FAMOS/ldr0013 X: FAMOS/ldr0014  
E+3



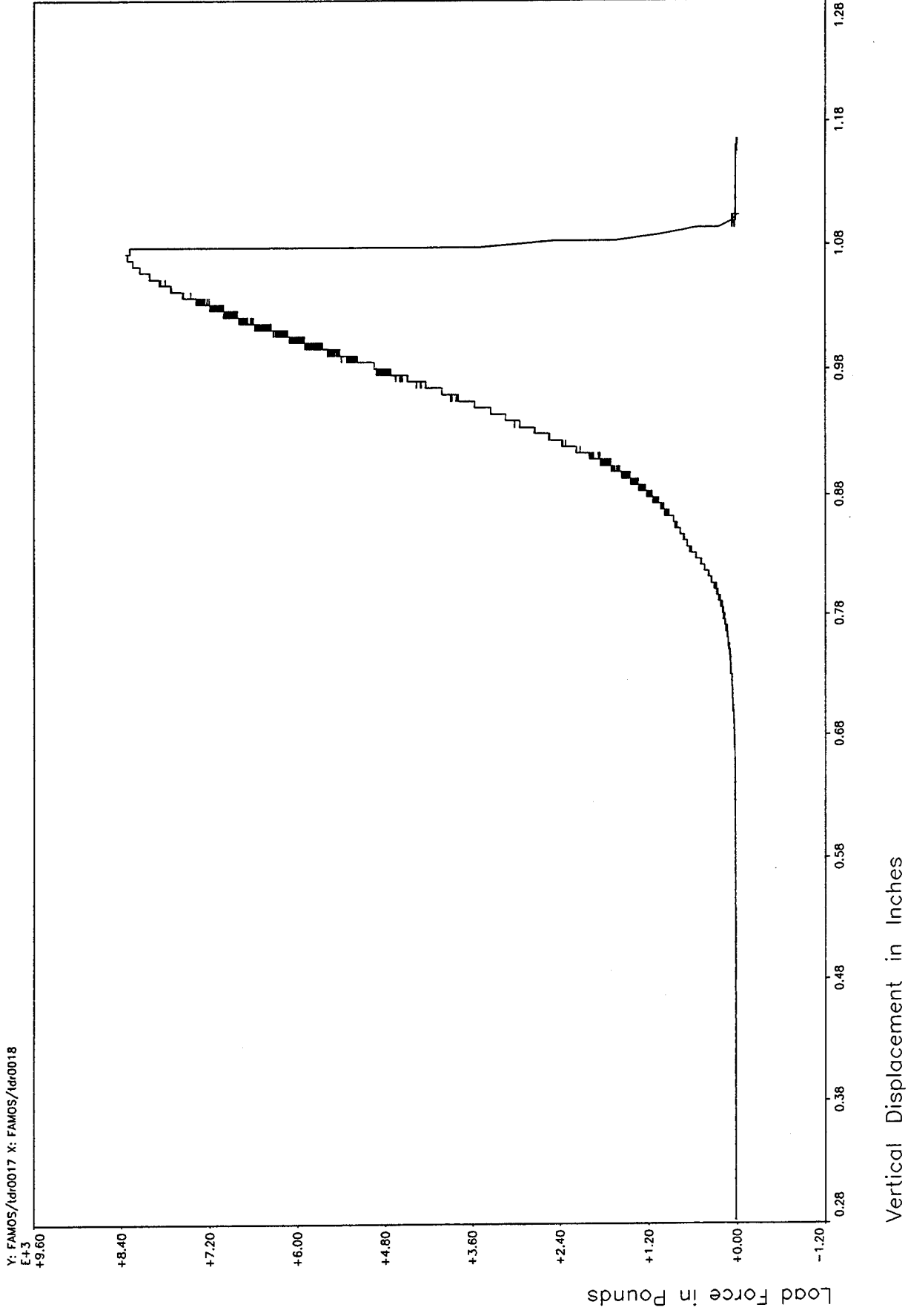
Vertical Displacement in Inches

Load Force in Pounds

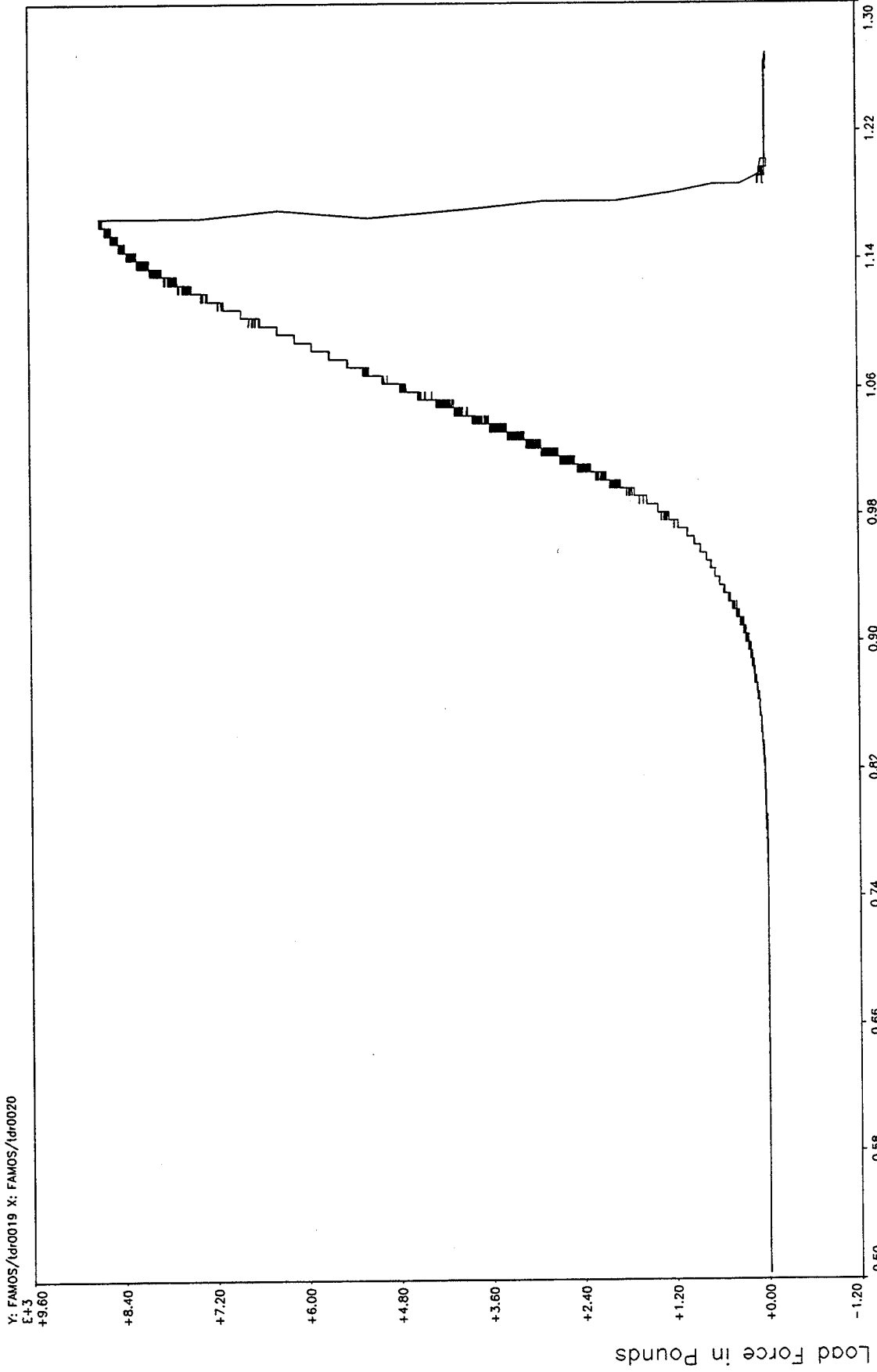
Test 3: 1.25 Inch Banding, 1 Seal, 2 Notches



Test 4: 1.25 Inch Banding, 1 Seal, 2 Notches



Test 5: 1.25 Inch Banding, 1 Seal, 2 Notches

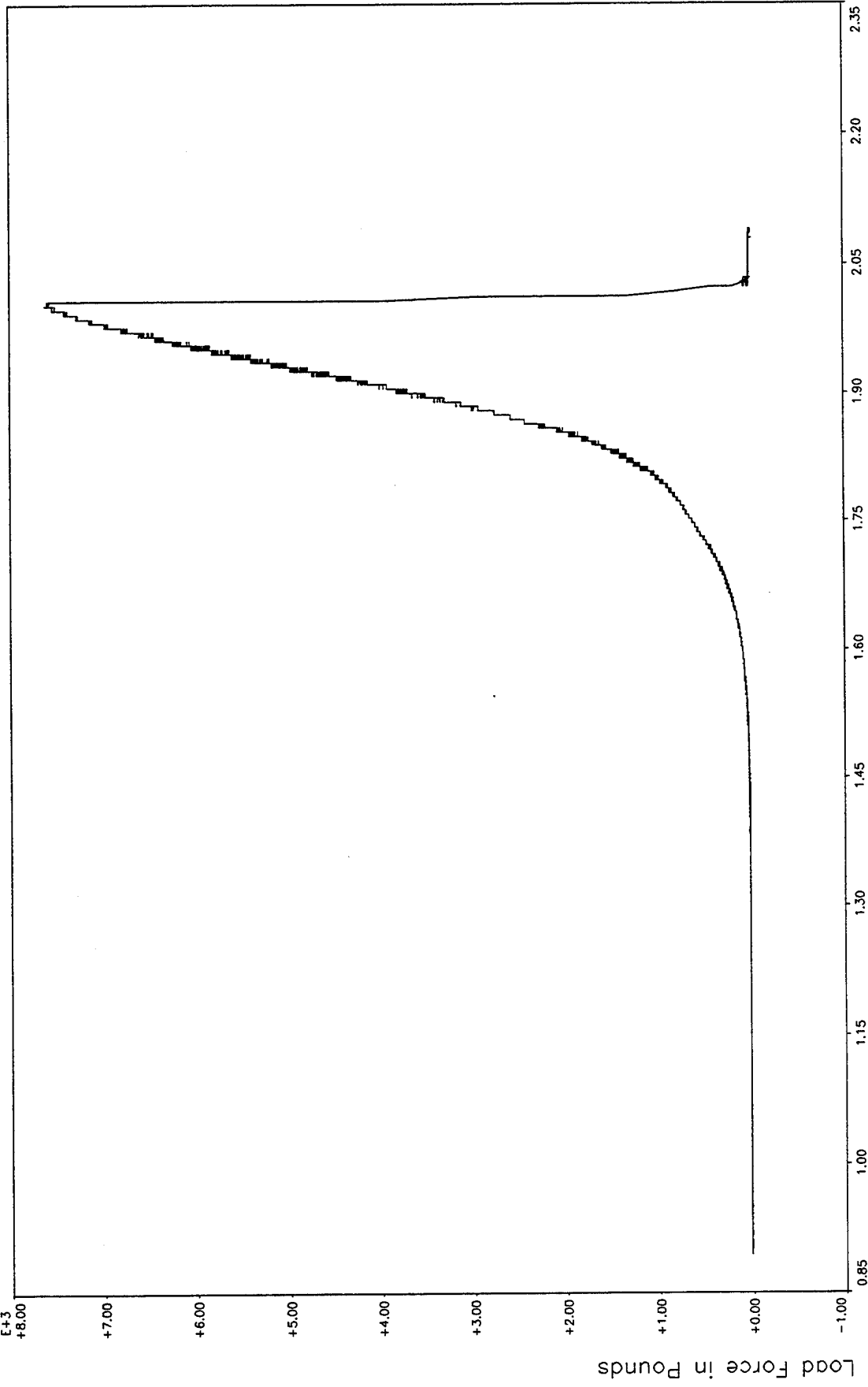


Test data from  
1-1/4-inch Strapping: 2 Seals, Double Notches



# Test 1: 1.25 Inch Banding, 2 Seals, 2 Notches

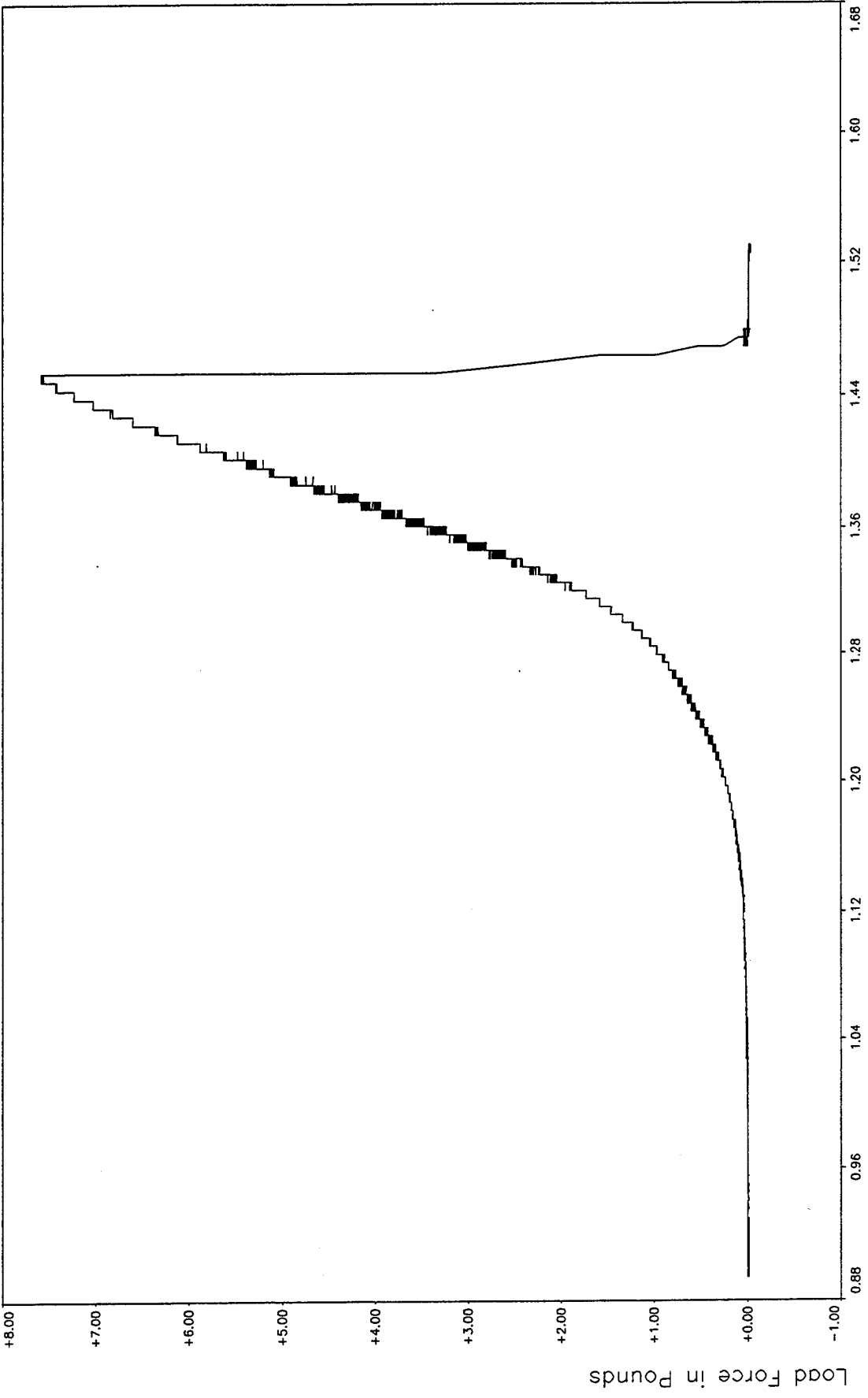
Y: FAMOS/1dr0021 X: FAMOS/1dr0022  
E+3



Vertical Displacement in Inches

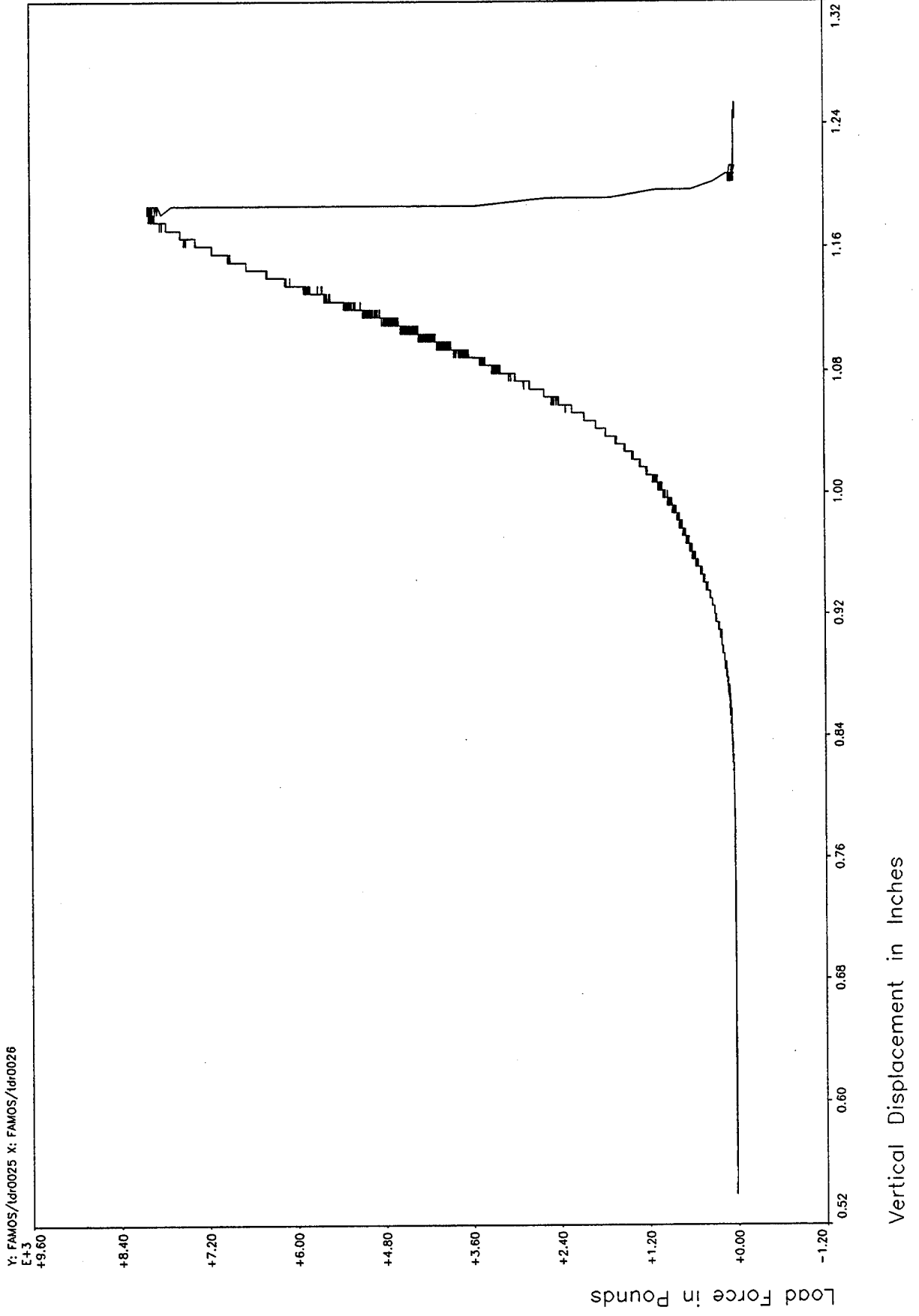
Test 2: 1.25 Inch Banding, 2 Seals, 2 Notches

Y: FAMOS/ldr0023 X: FAMOS/ldr0024  
E+3  
+8.00



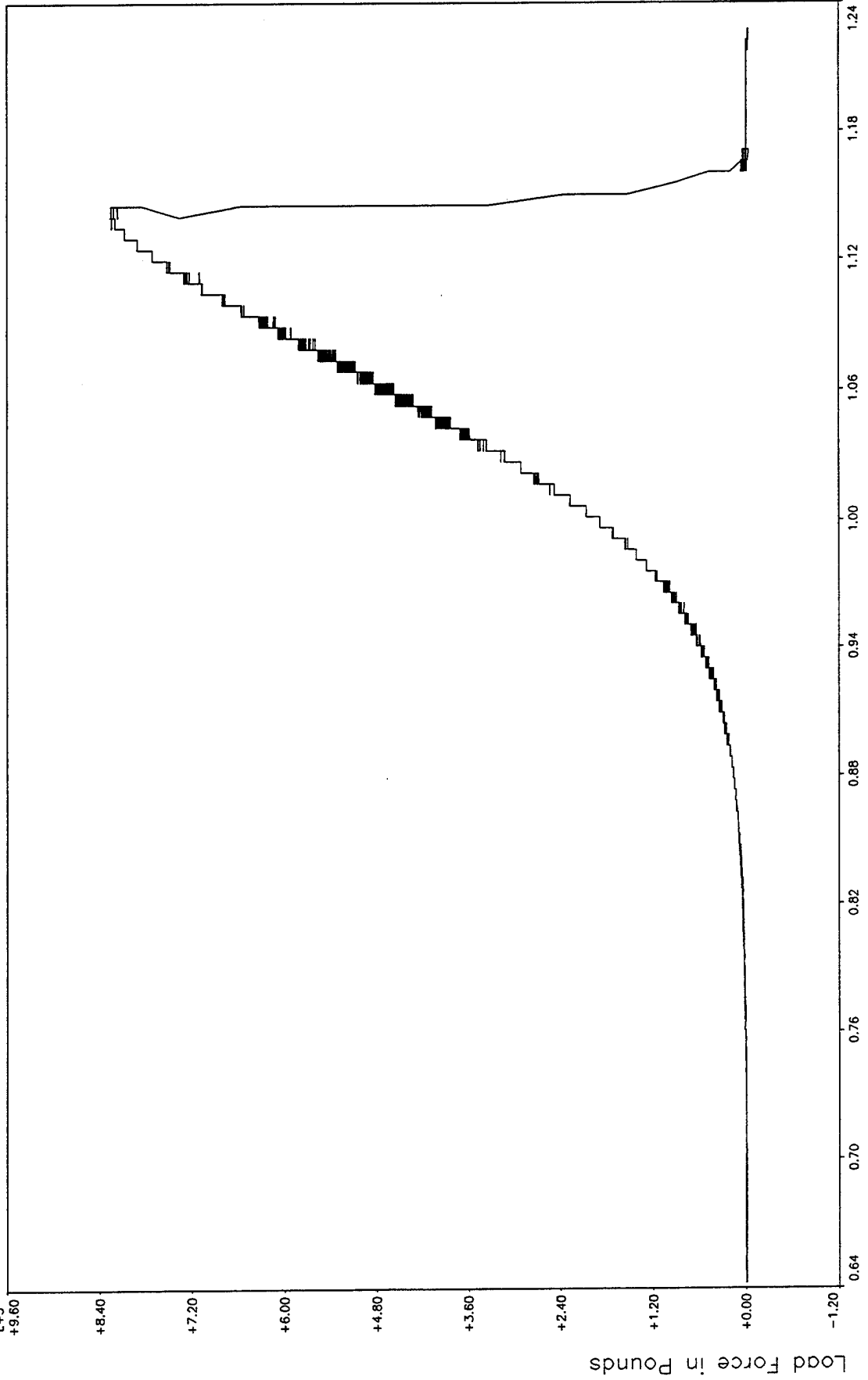
Vertical Displacement in Inches

Test 3: 1.25 Inch Banding, 2 Seals, 2 Notches



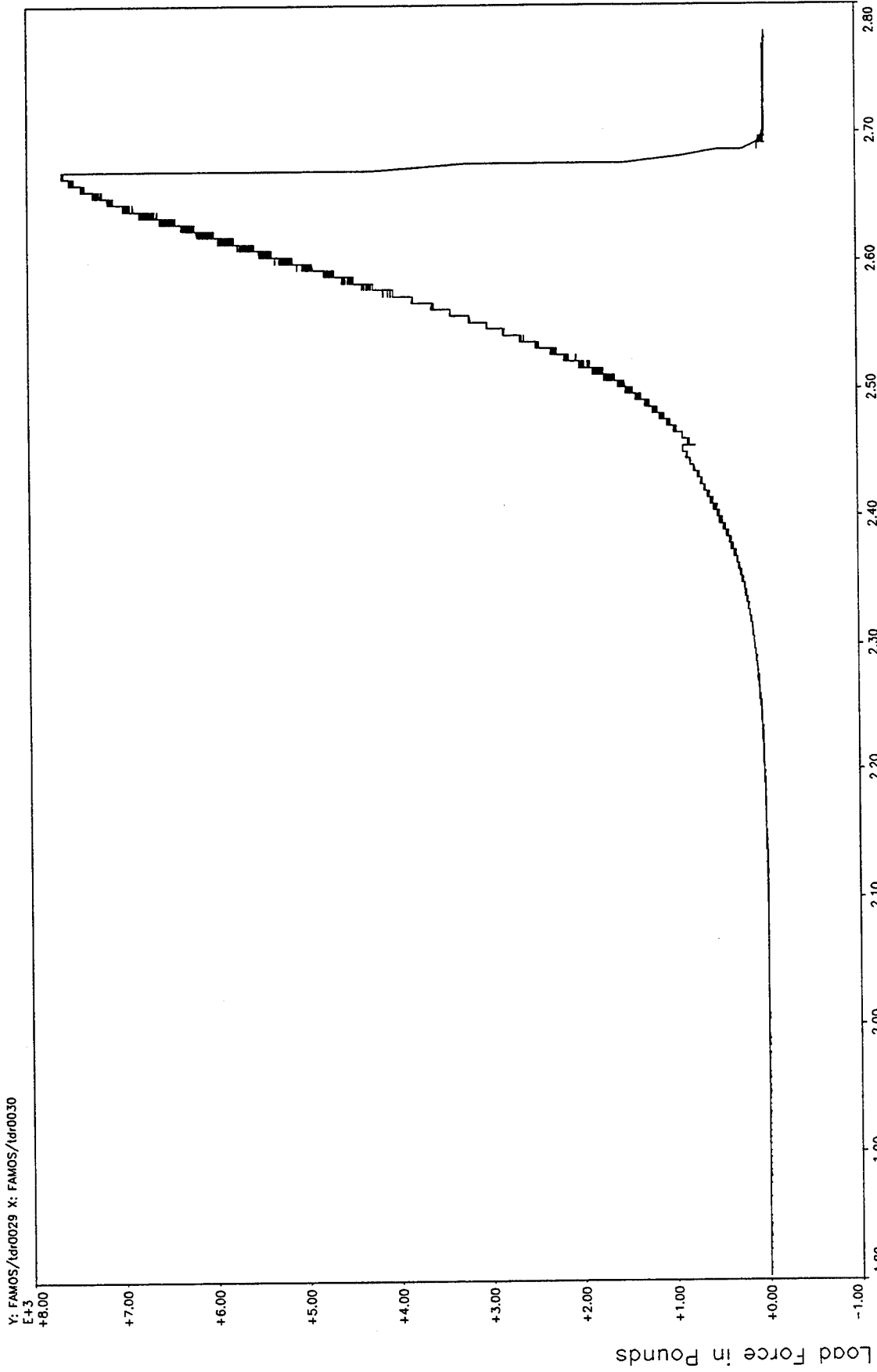
Test 4: 1.25 Inch Banding, 2 Seals, 2 Notches

Y: FAMOS/ldr0027 x: FAMOS/ldr0028  
E+3  
+9.60



Vertical Displacement in Inches

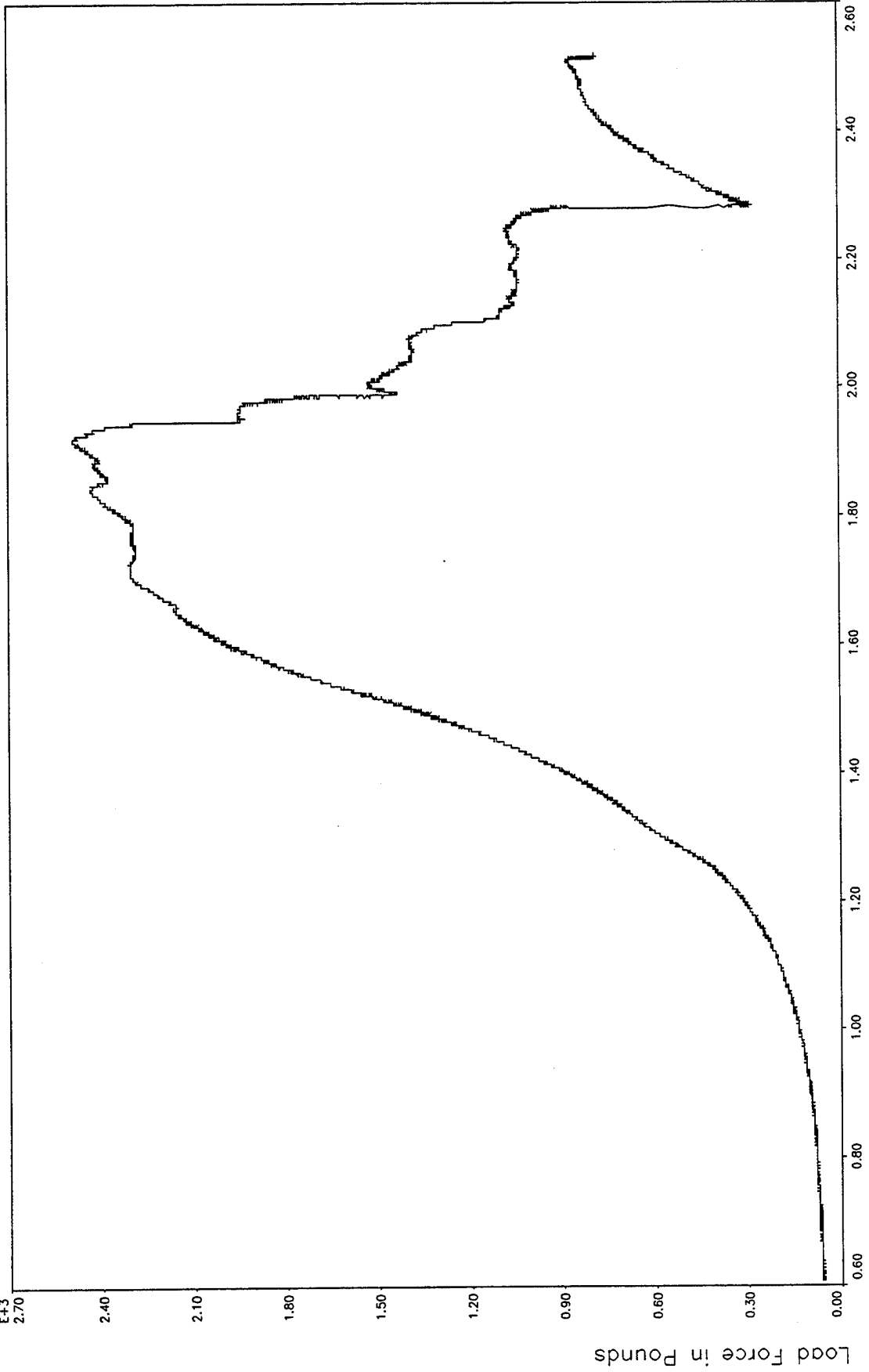
Test 5: 1.25 Inch Banding, 2 Seals, 2 Notches



Test Data from  
2-Inch Strapping: 1 Seal, 1 Crimp

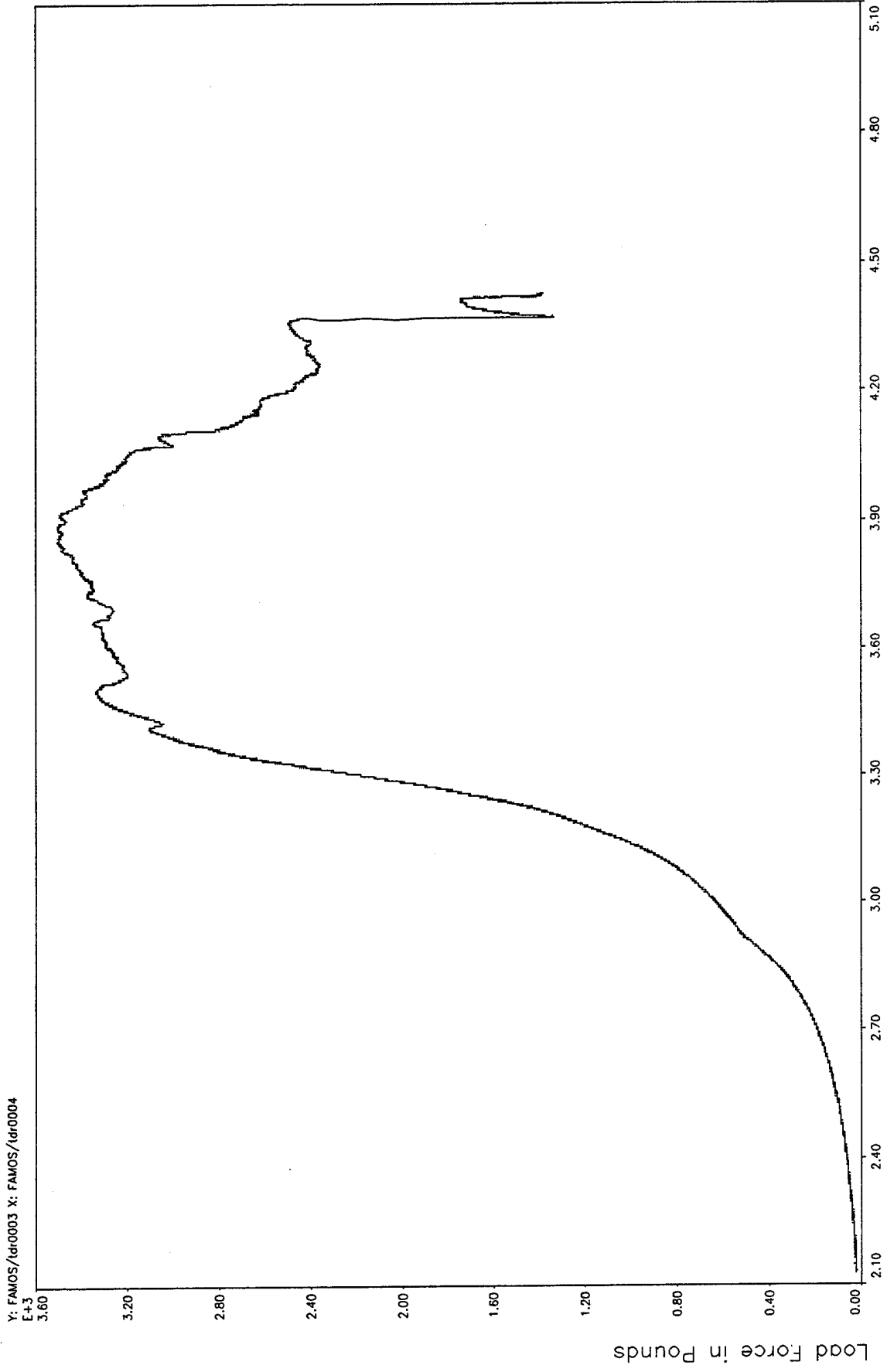
Test 1: 2 Inch Banding, 1 Seal, 1 Crimp

Y: FAMOS/ldr0001 X: FAMOS/ldr0002  
E+3  
2.70



Vertical Displacement in Inches

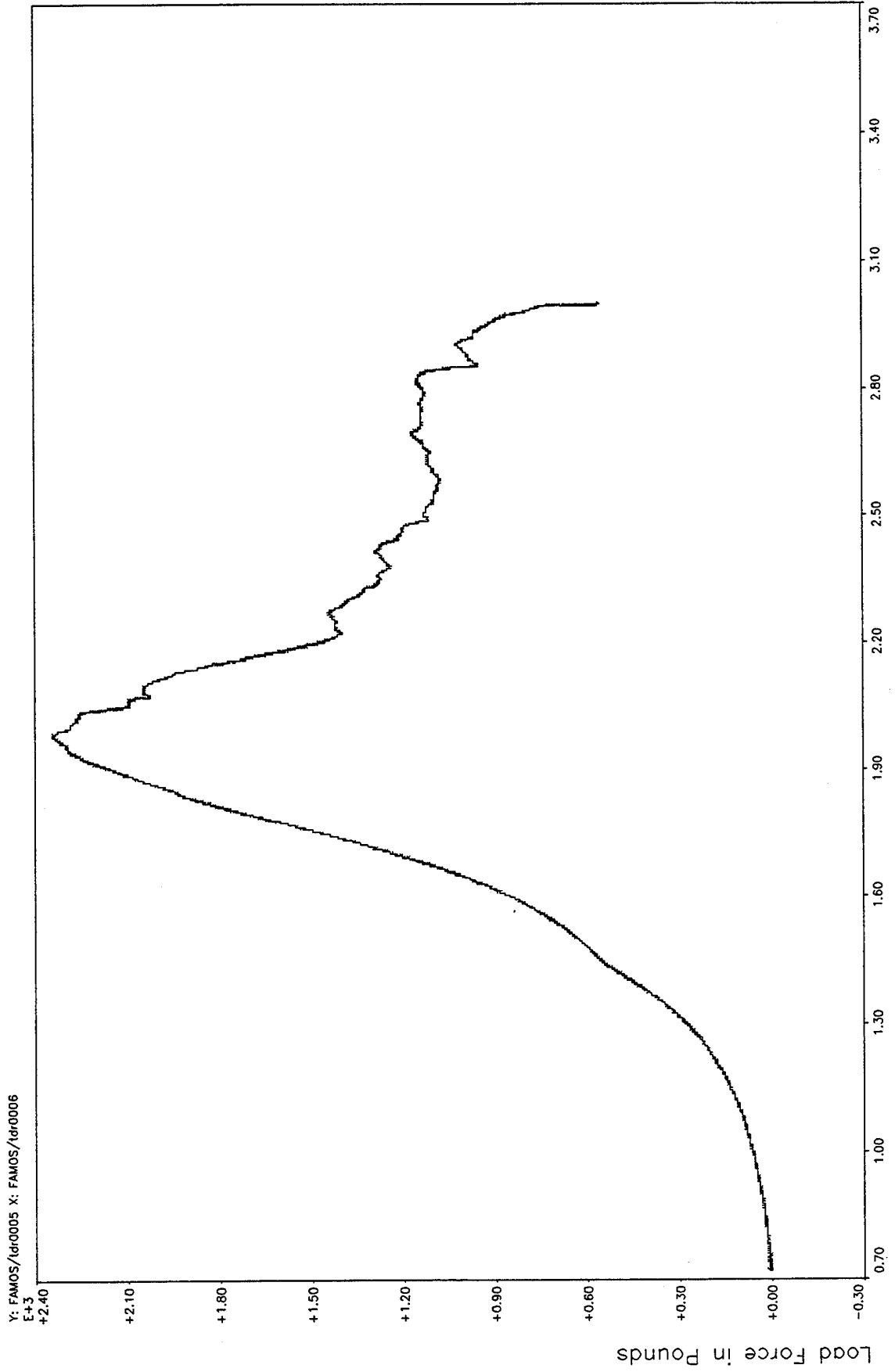
Test 2: 2 Inch Banding, 1 Seal, 1 Crimp



Vertical Displacement in Inches

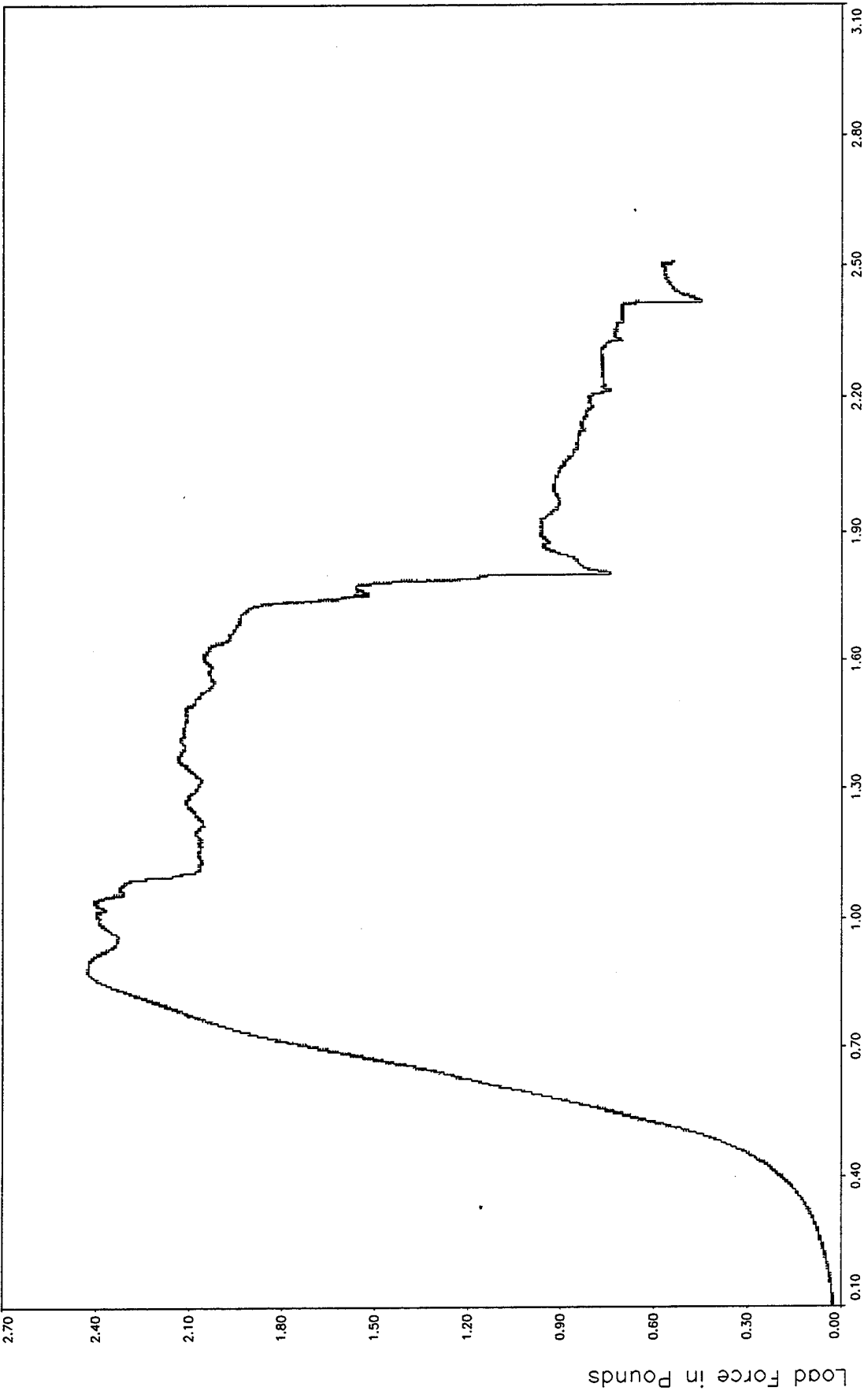


Test 3: 2 Inch Banding, 1 Seal, 1 Crimp



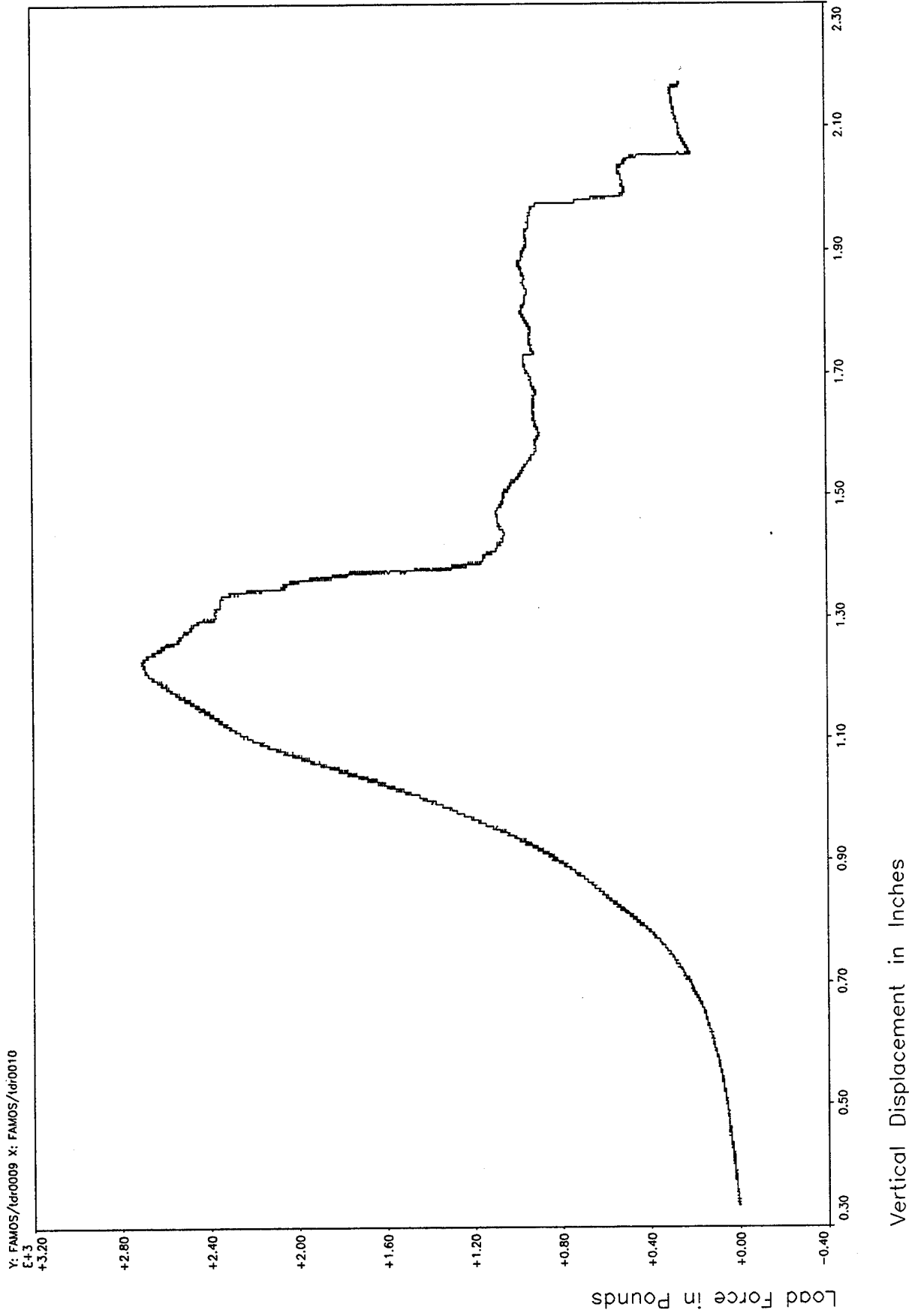
Test 4: 2 Inch Banding, 1 Seal, 1 Crimp

Y: FAMOS/dhr0007 X: FAMOS/ldr0008  
E+3  
2.70



Vertical Displacement in Inches

Test 5: 2 Inch Banding, 1 Seal, 1 Crimp



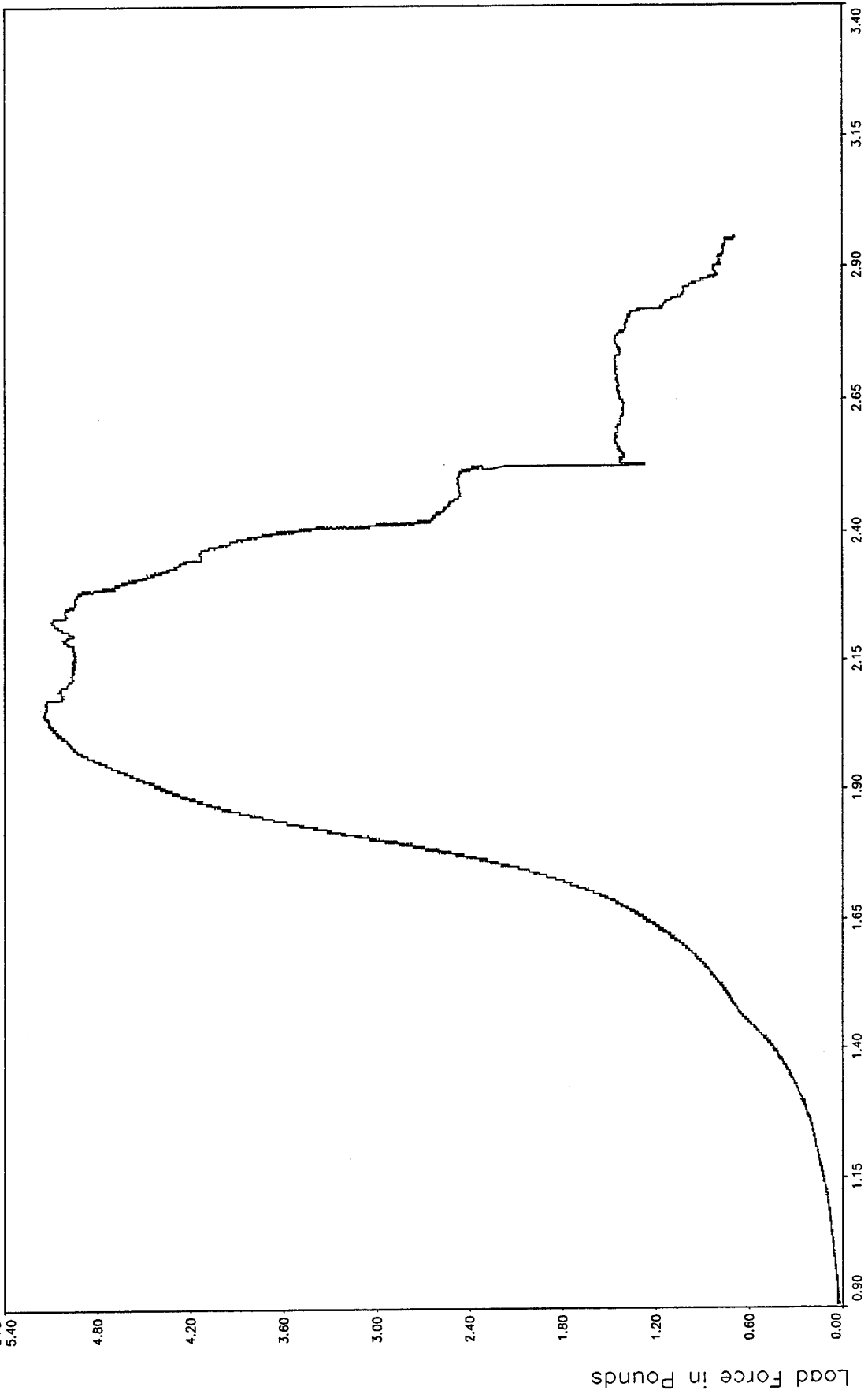
Test Data from  
2-Inch Strapping: 1 Seal, 2 Crimps

Test 1: 2 Inch Banding, 1 Seal, 2 Crimps



Test 2: 2 Inch Banding, 1 Seal, 2 Crimps

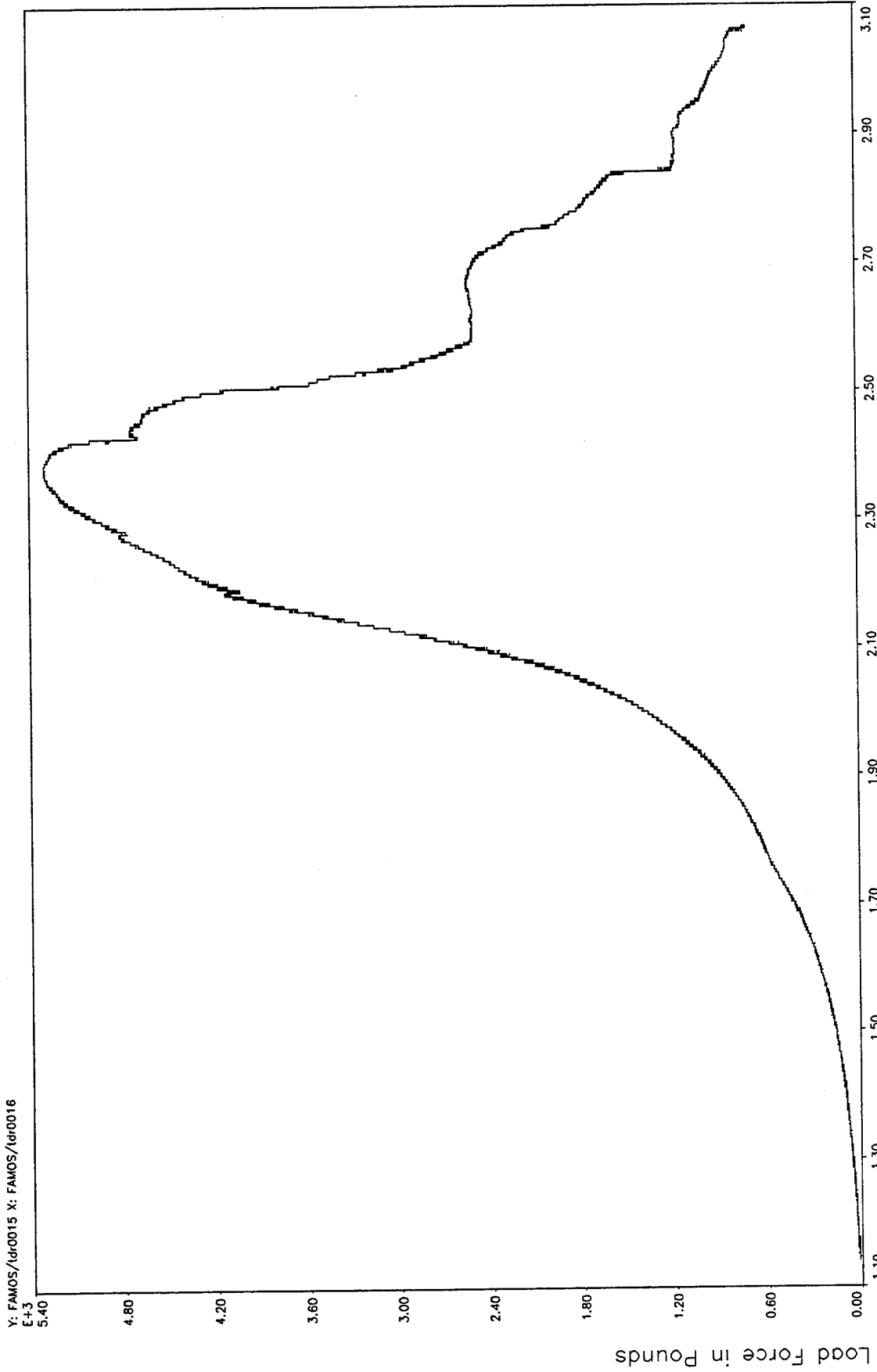
Y: FAMOS/ldr0013 X: FAMOS/ldr0014  
E+3  
5.40



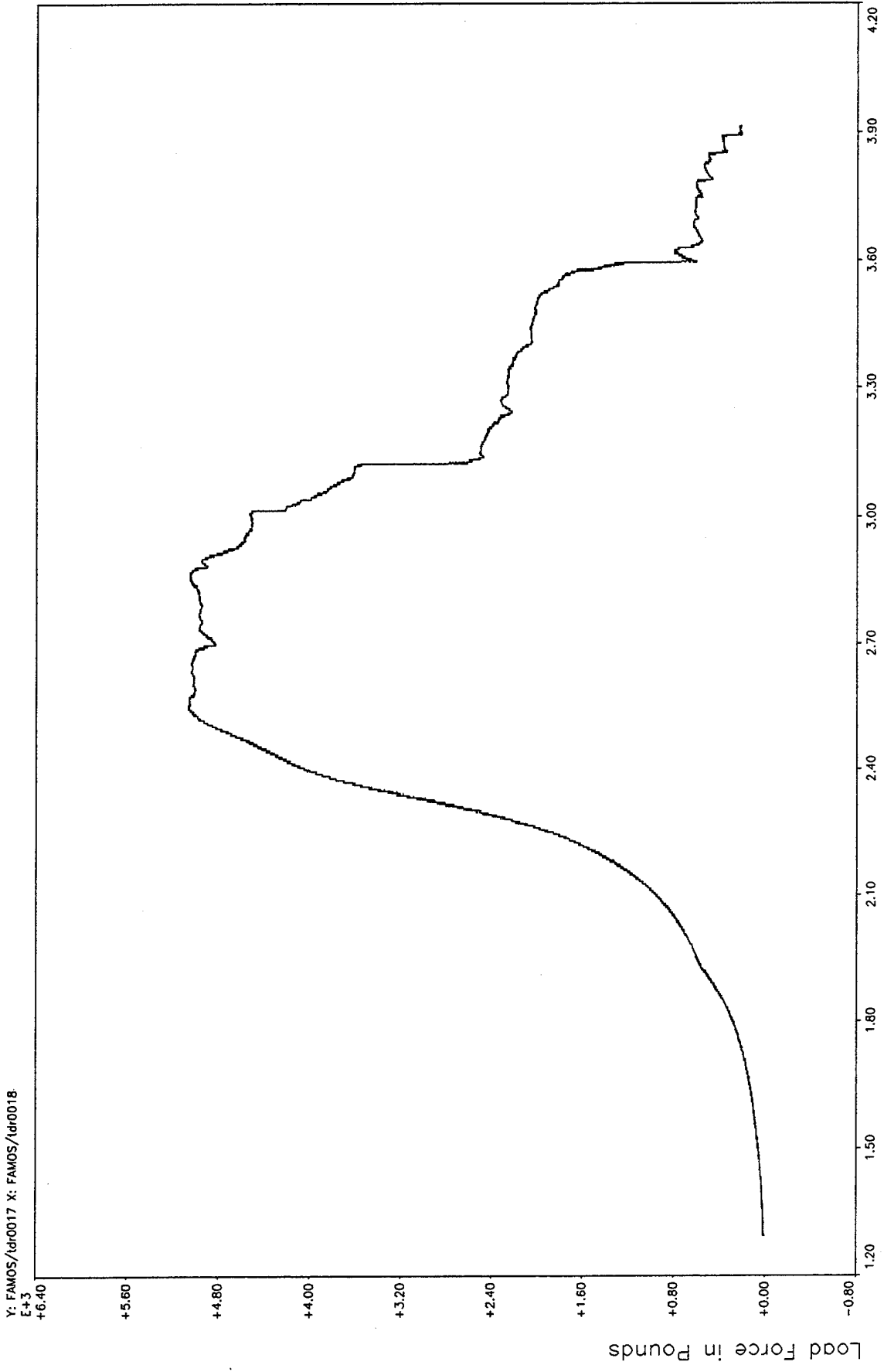
Vertical Displacement in Inches

Load Force in Pounds

Test 3: 2 Inch Banding, 1 Seal, 2 Crimps

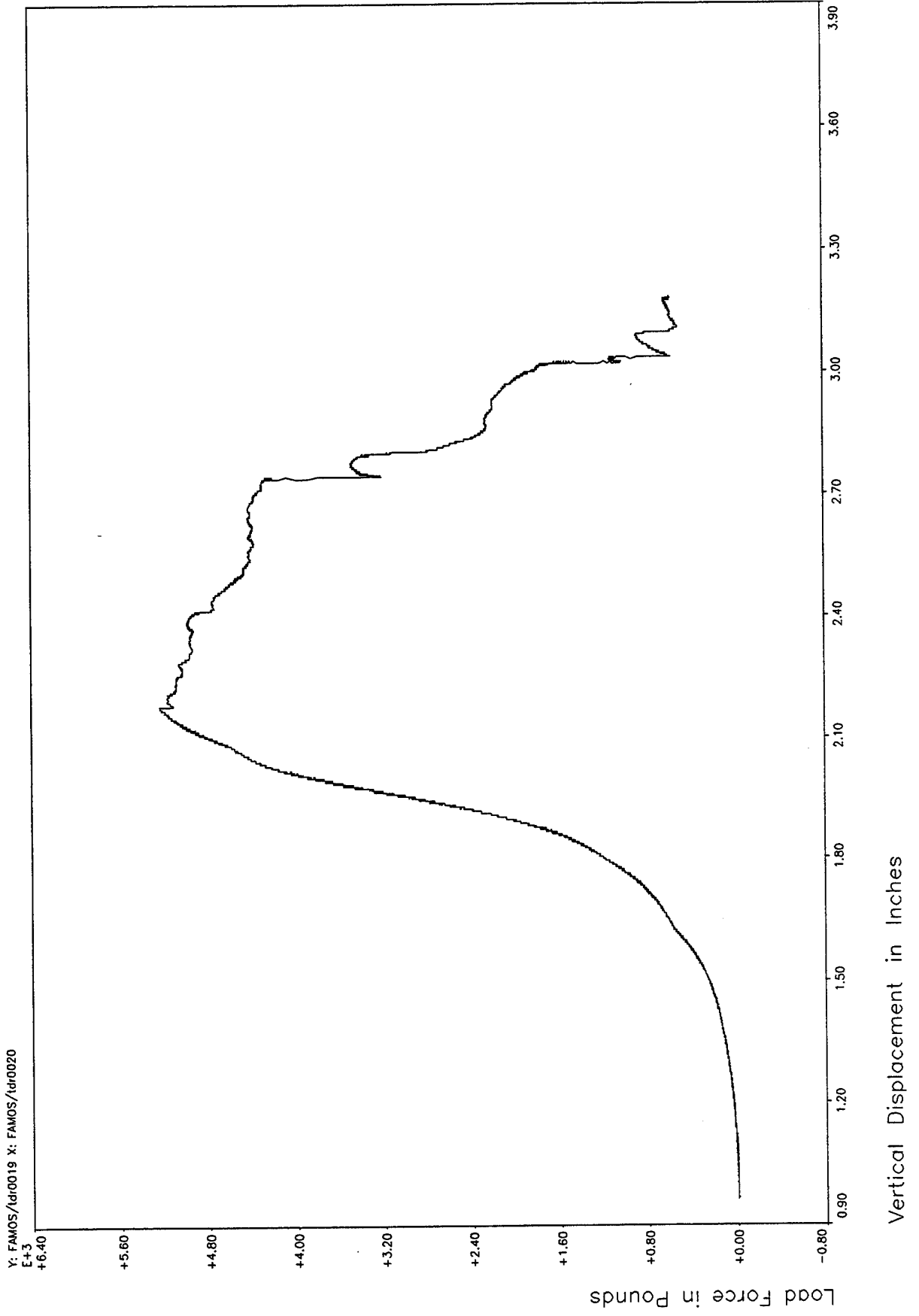


Test 4: 2 Inch Banding, 1 Seal, 2 Crimps



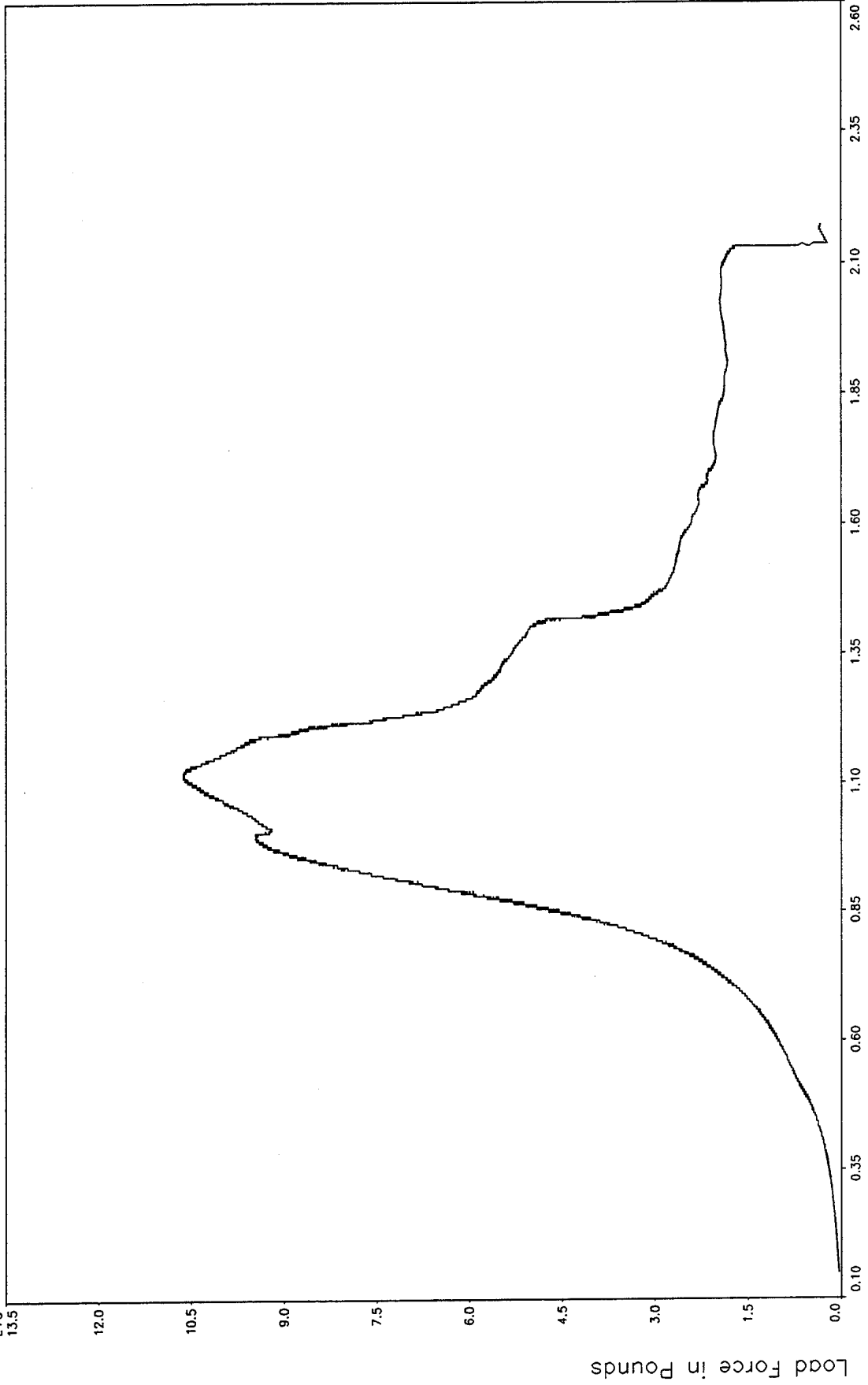


Test 5: 2 Inch Banding, 1 Seal, 2 Crimps



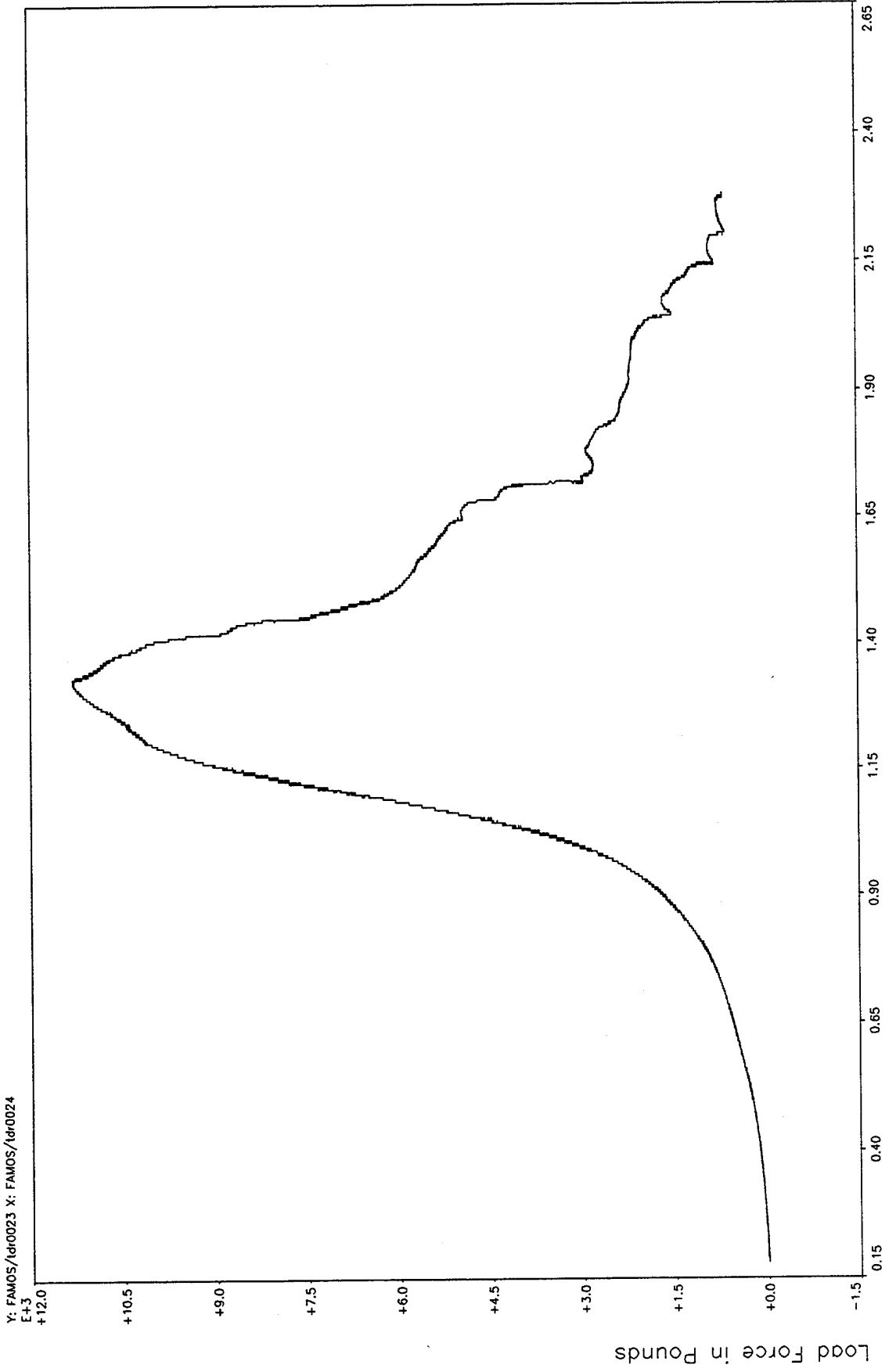
Test 1: 2 Inch Banding, 2 Seals, 2 Crimps

Y: FAMOS/ldr0021 X: FAMOS/ldr0022  
E+3  
13.5

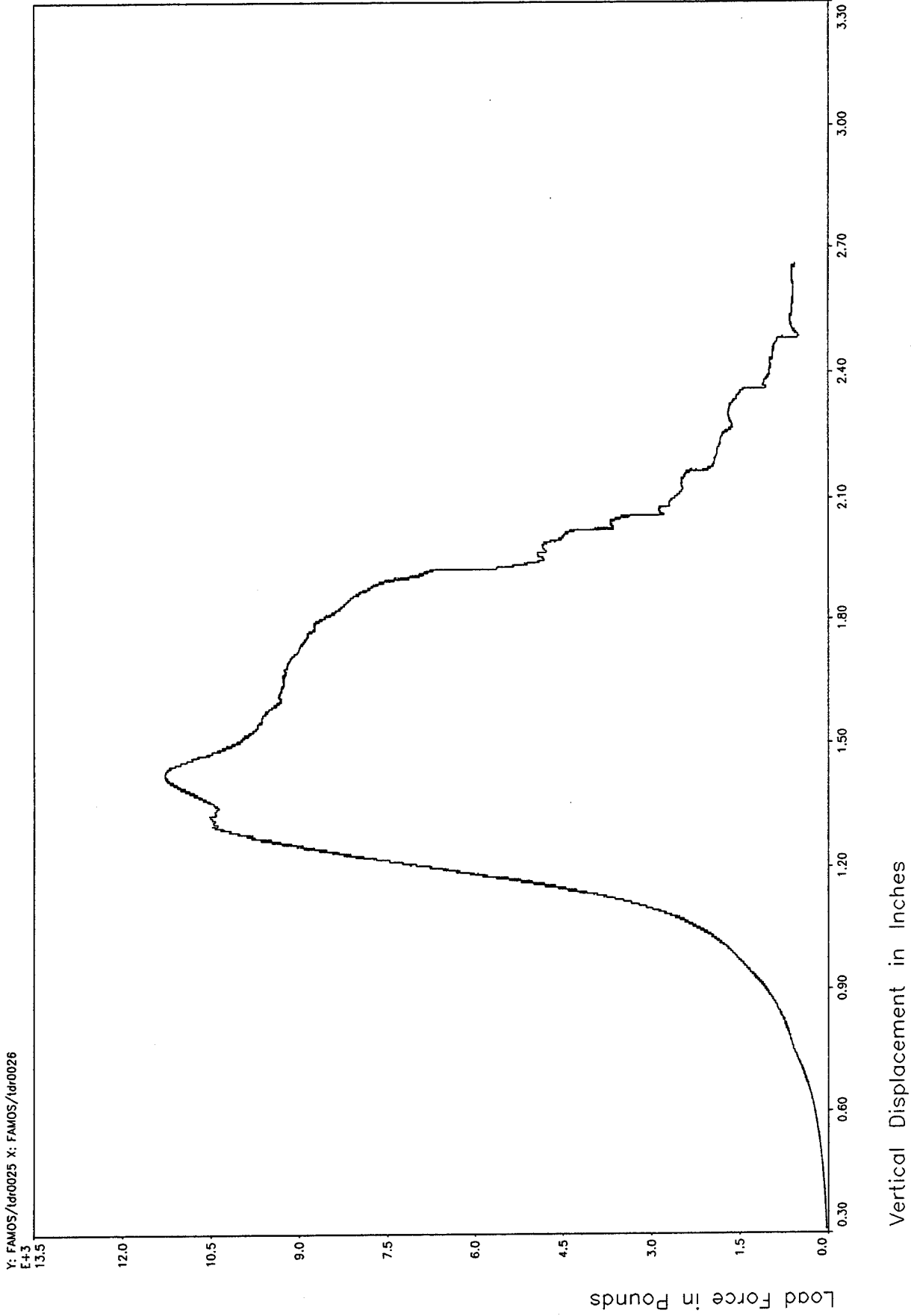


Vertical Displacement in Inches

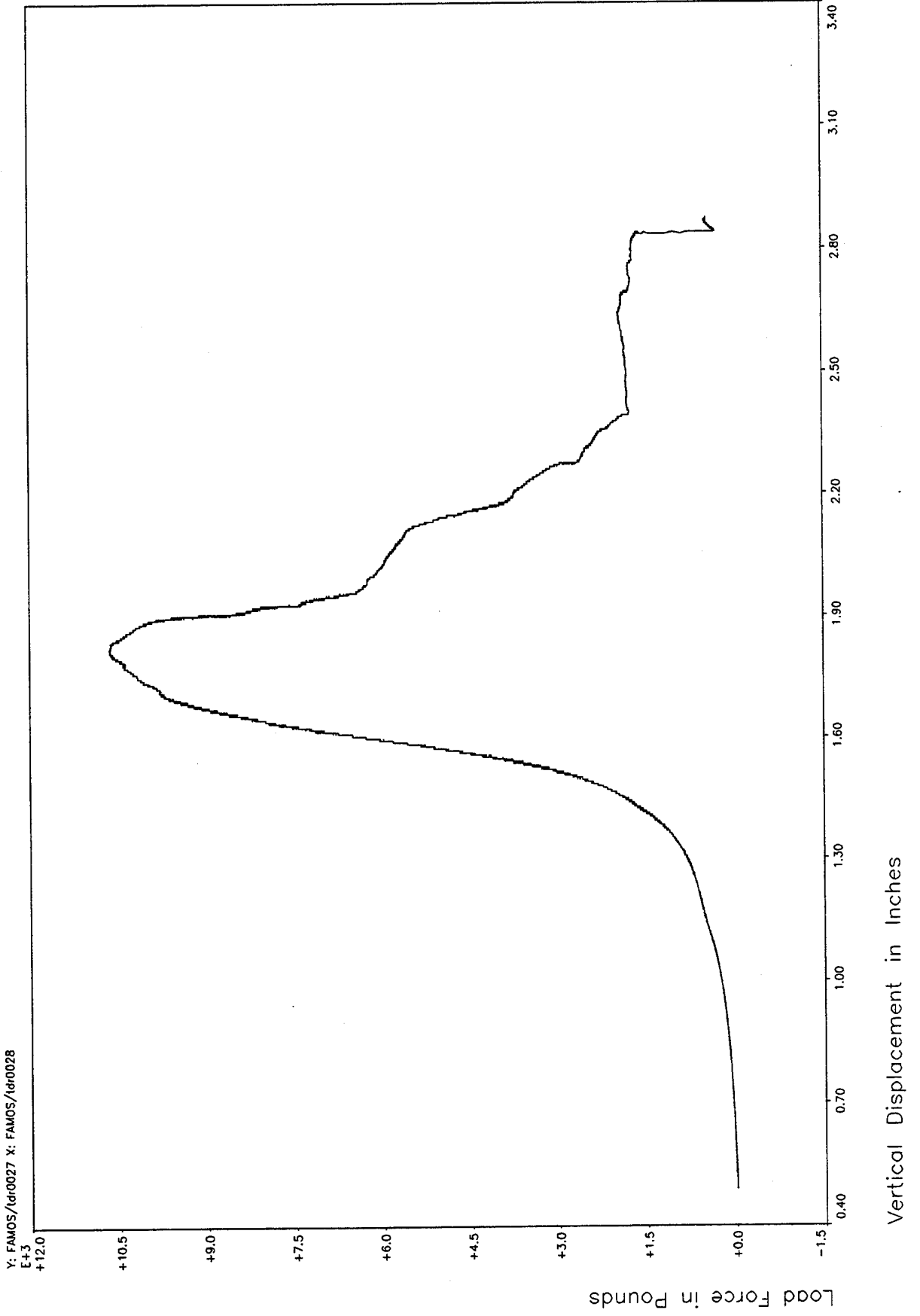
Test 2: 2 Inch Banding, 2 Seals, 2 Crimps



Test 3: 2 Inch Banding, 2 Seals, 2 Crimps

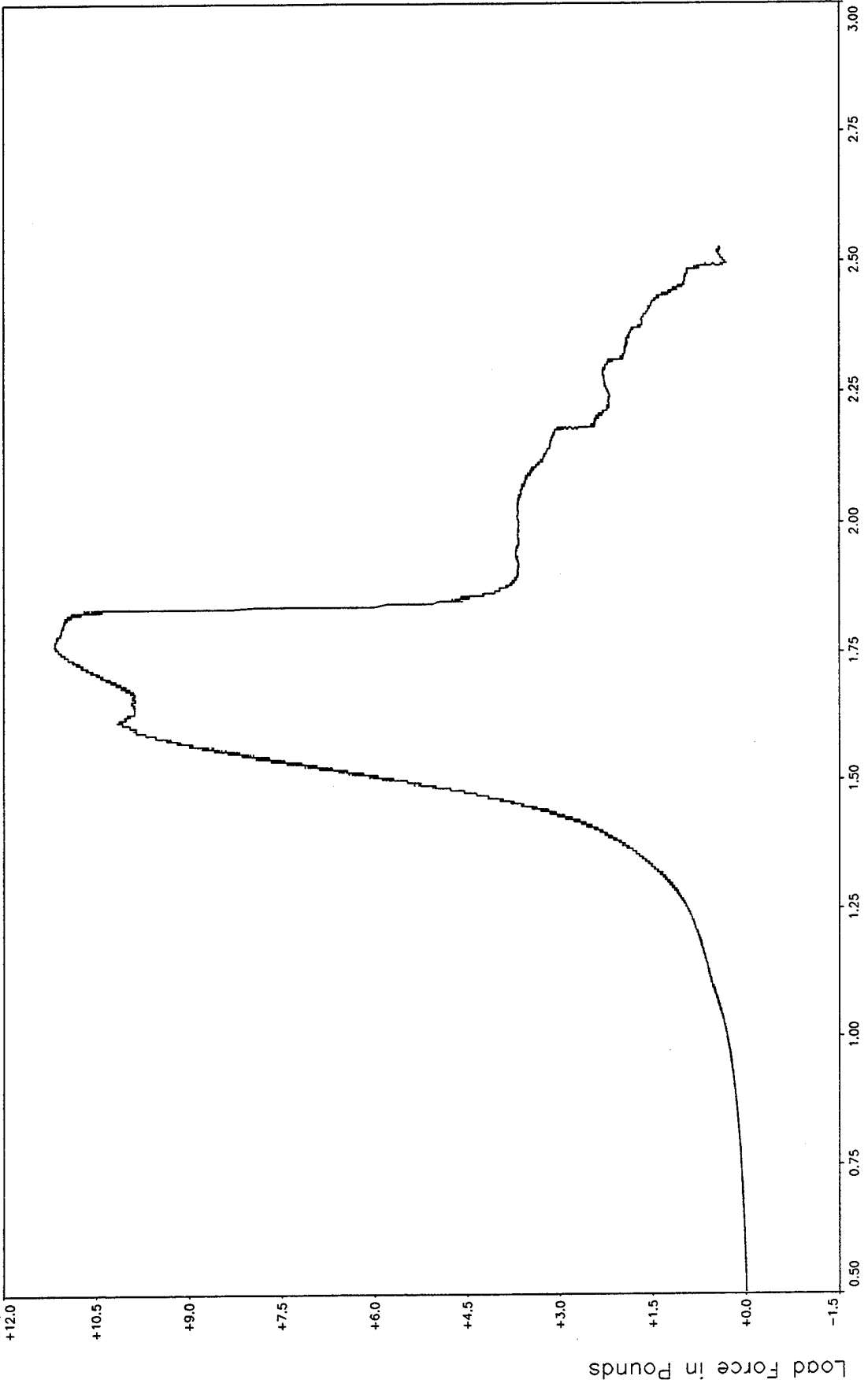


Test 4: 2 Inch Banding, 2 Seals, 2 Crimps



Test 5: 2 Inch Banding, 2 Seals, 2 Crimps

Y: FAMOS/ldr0029 X: FAMOS/ldr0030  
E+3  
+12.0

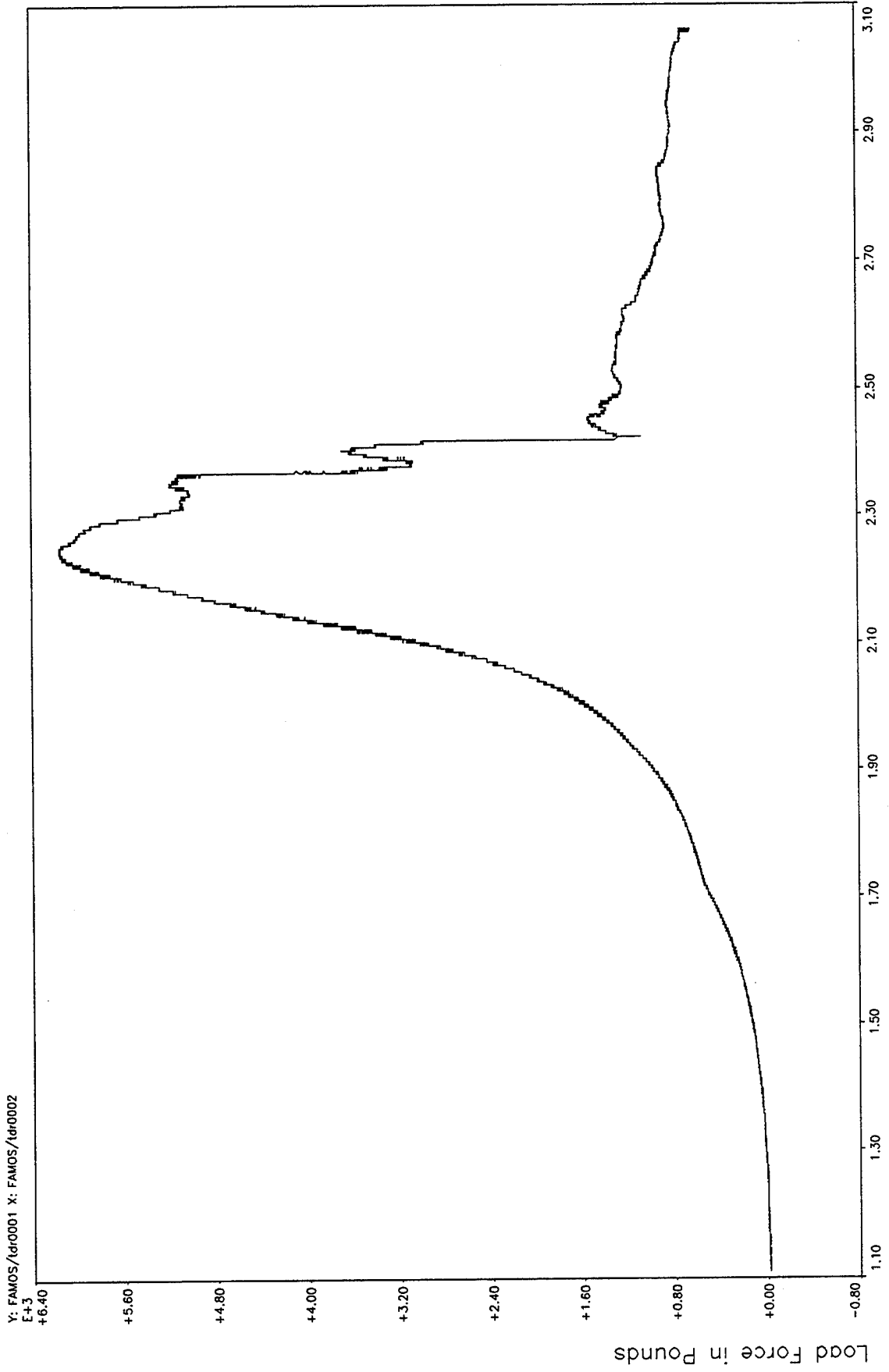


Vertical Displacement in Inches

Load Force in Pounds

Test Data from  
2-Inch Strapping: 1 Seal, 1 Notch

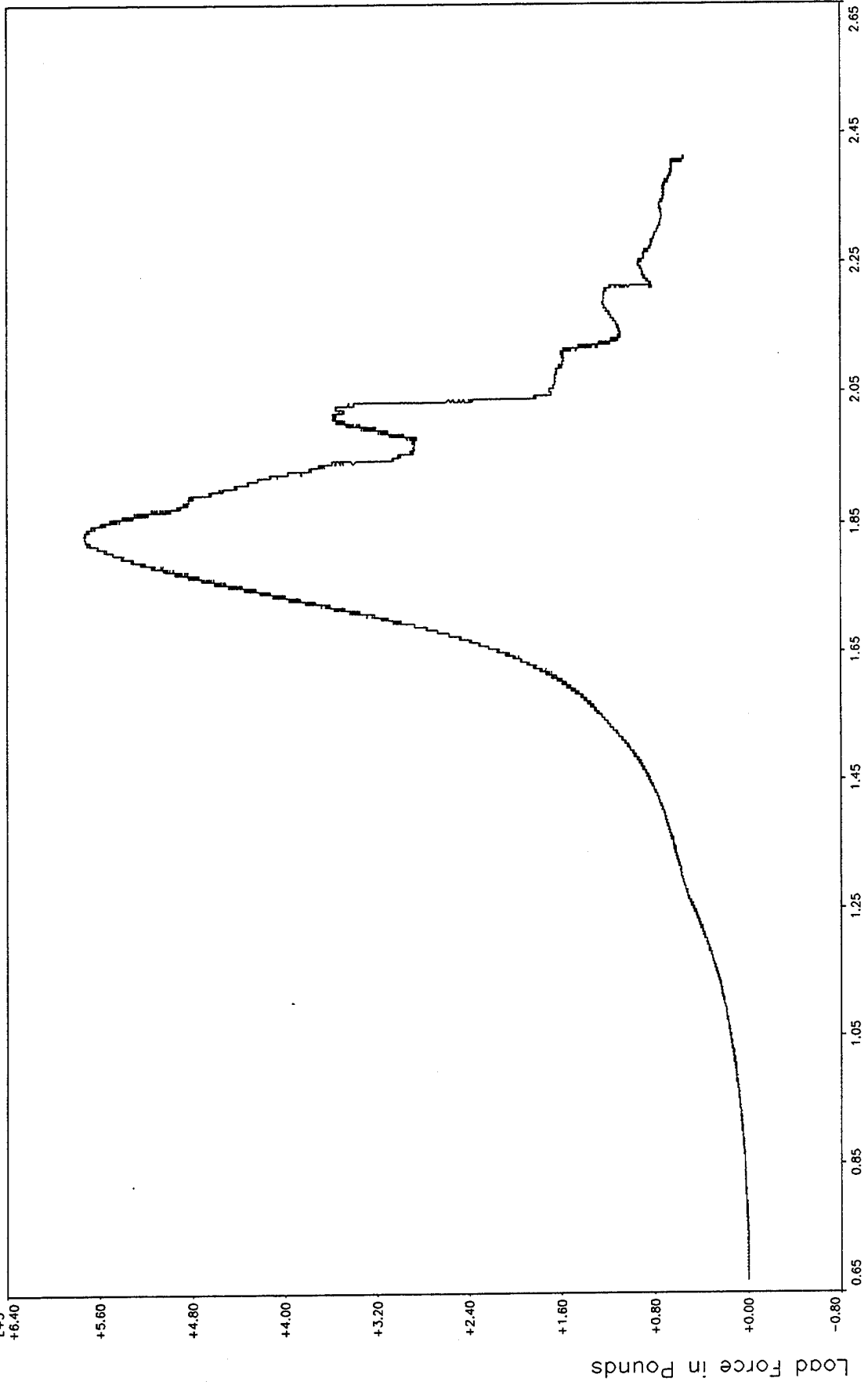
Test 1: 2 Inch Banding, 1 Seal, 1 Notch





Test 2: 2 Inch Banding, 1 Seal, 1 Notch

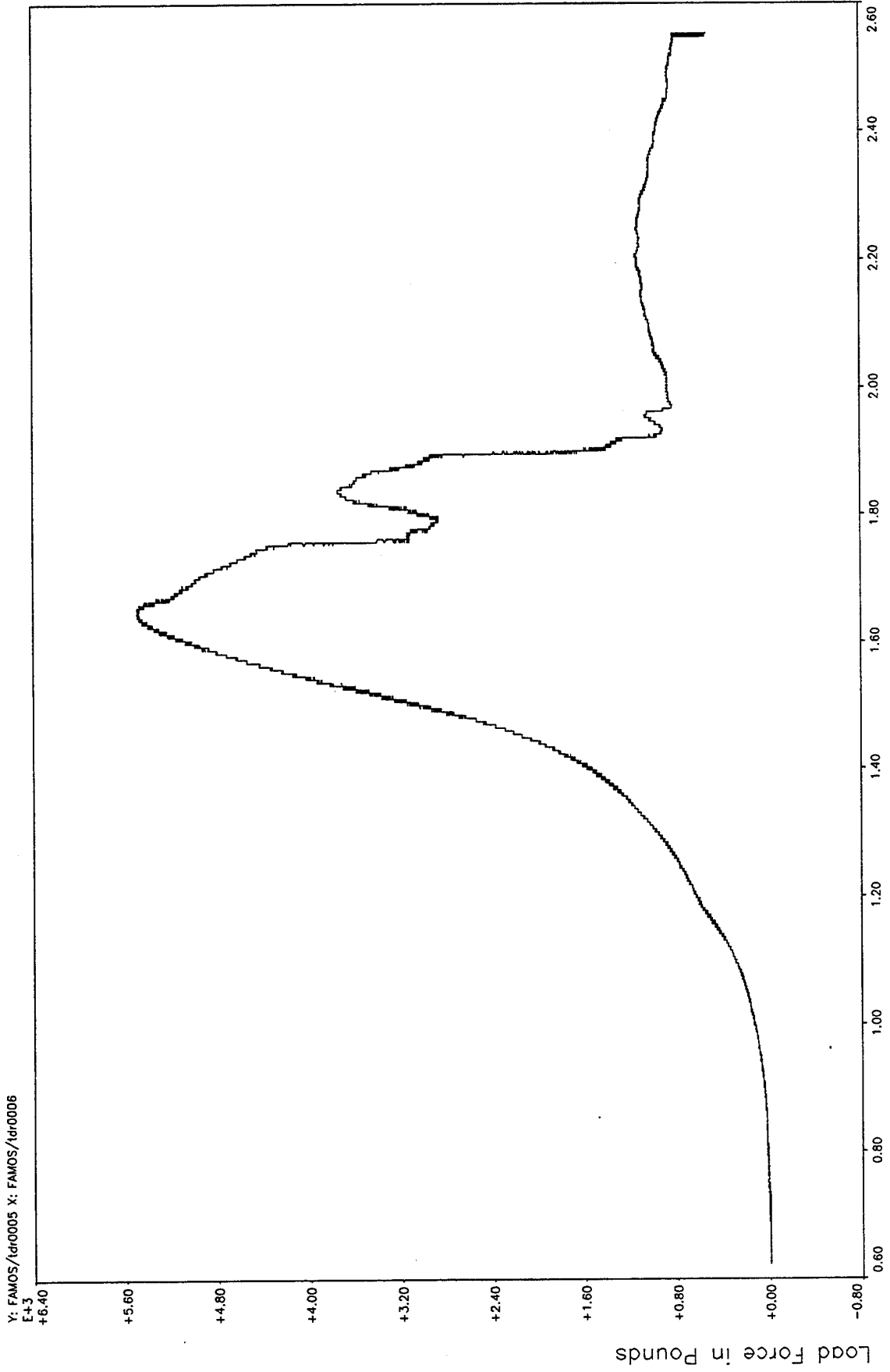
Y: FAMOS/ldr0003 X: FAMOS/ldr0004  
E+3  
+6.40



Vertical Displacement in Inches

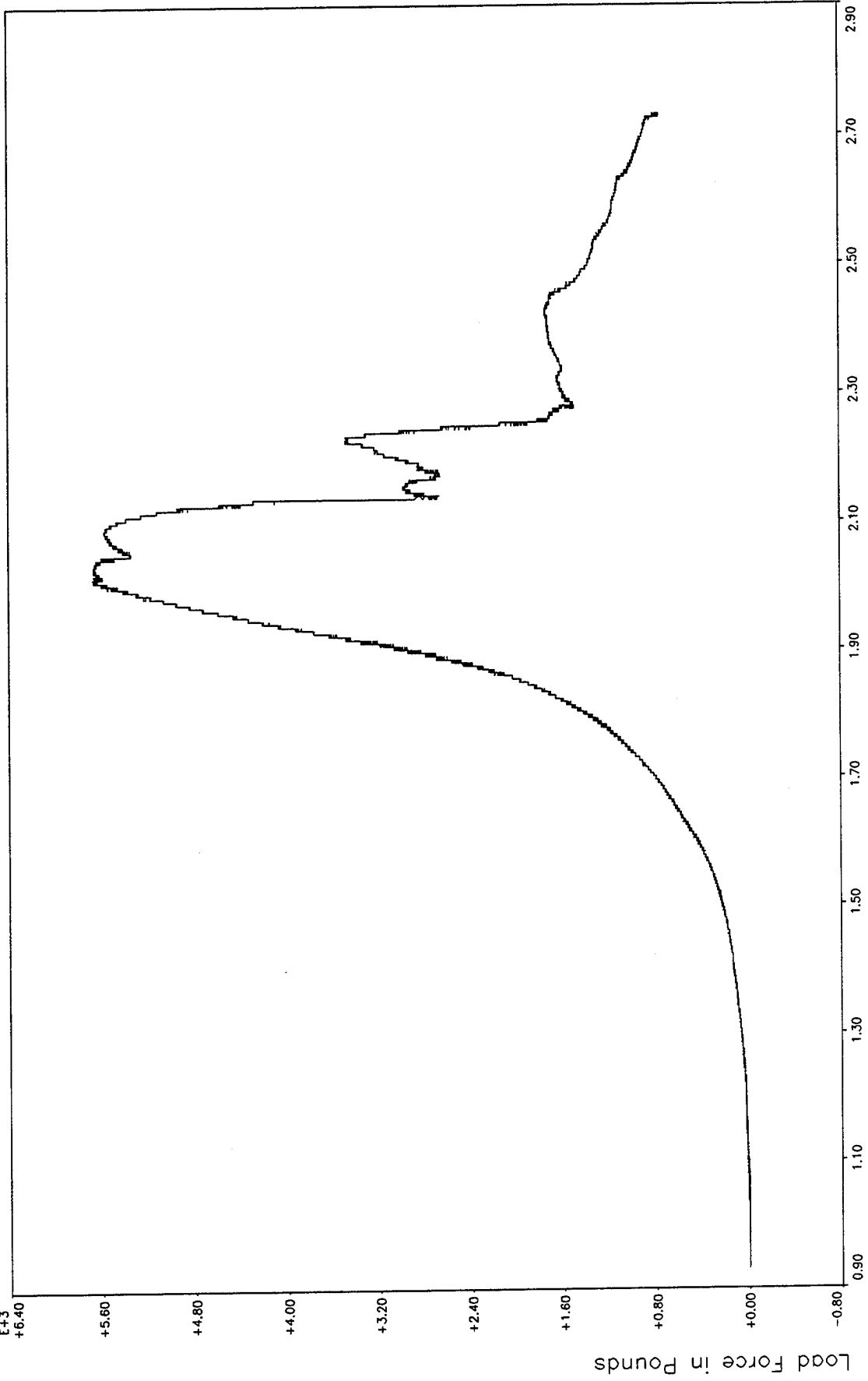
Load Force in Pounds

Test 3: 2 Inch Banding, 1 Seal, 1 Notch



Test 4: 2 Inch Banding, 1 Seal, 1 Notch

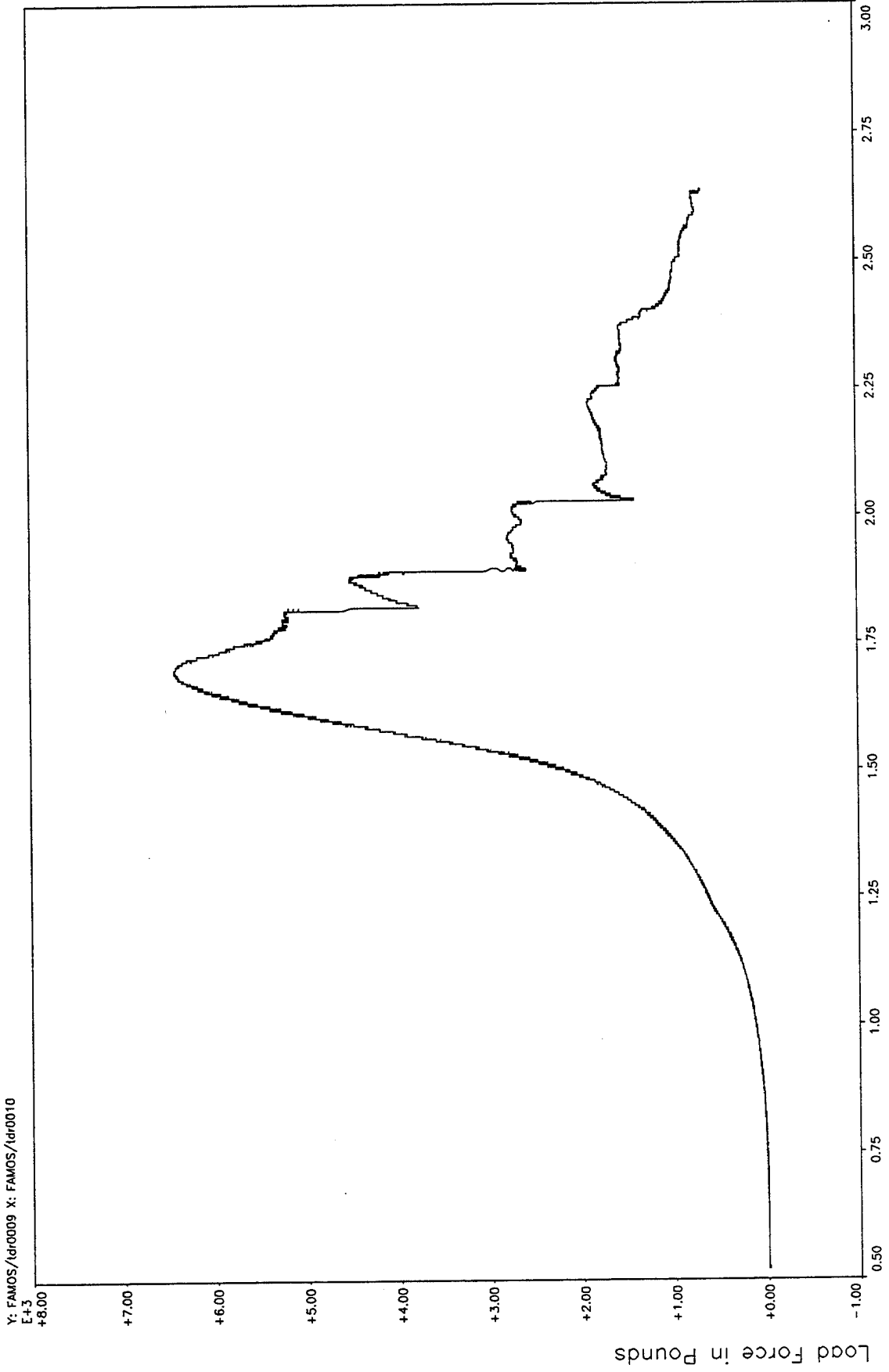
Y: FAMOS/ldr0007 X: FAMOS/ldr0008  
E+3  
+6.40



Vertical Displacement in Inches

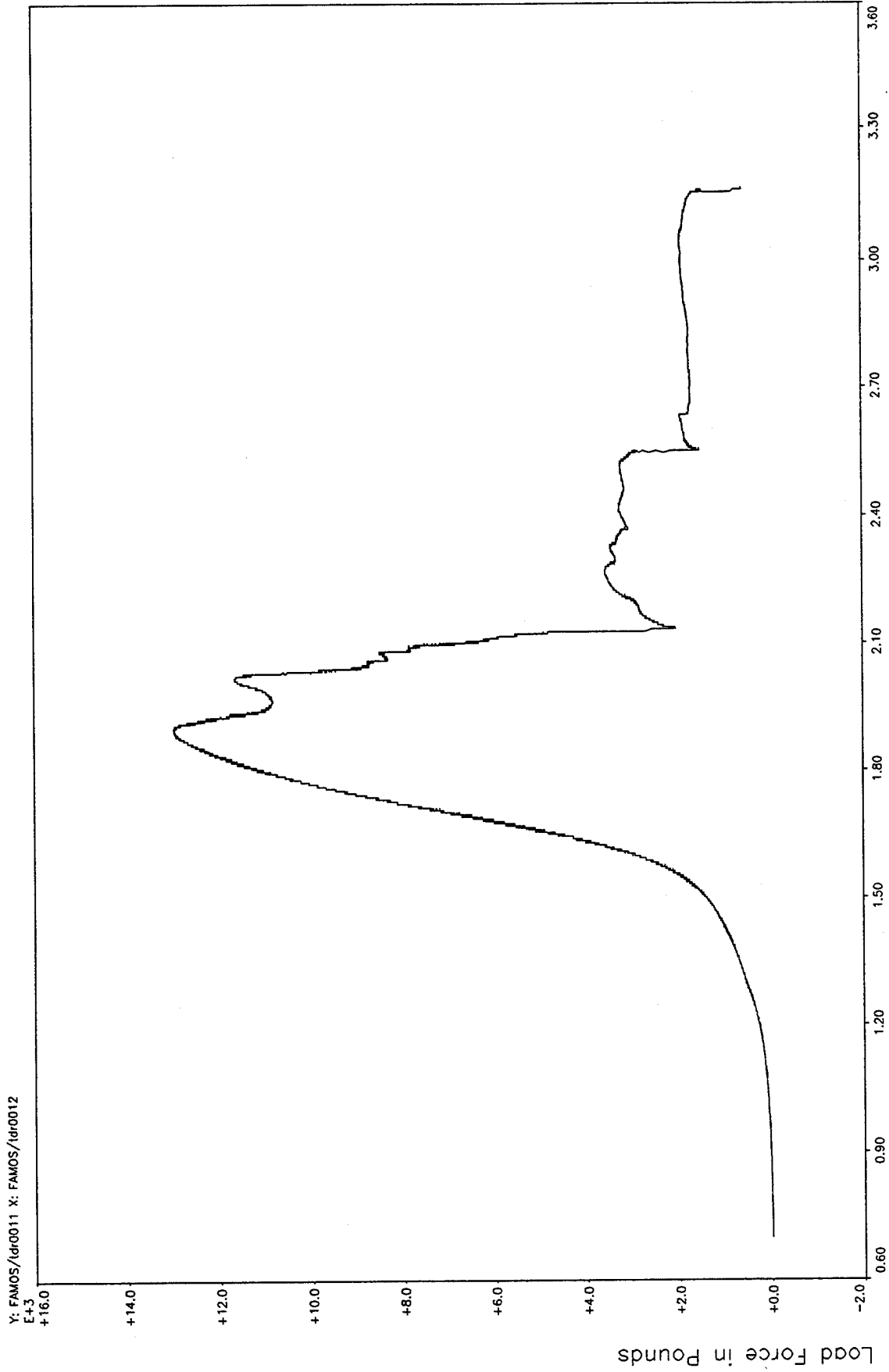
Load Force in Pounds

Test 5: 2 Inch Banding, 1 Seal, 1 Notch

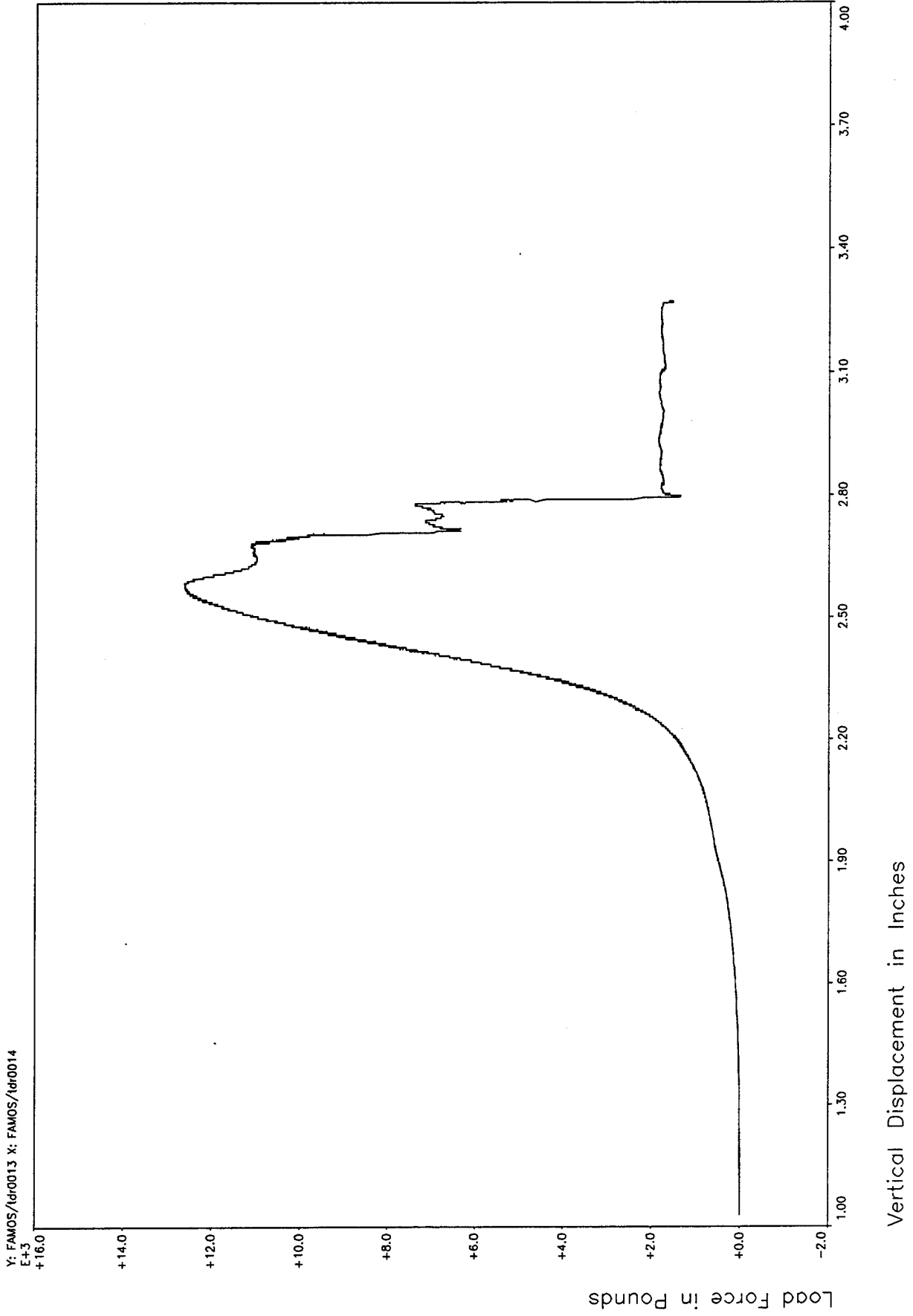


Test Data from  
2-Inch Strapping: 1 Seal, 2 Notches

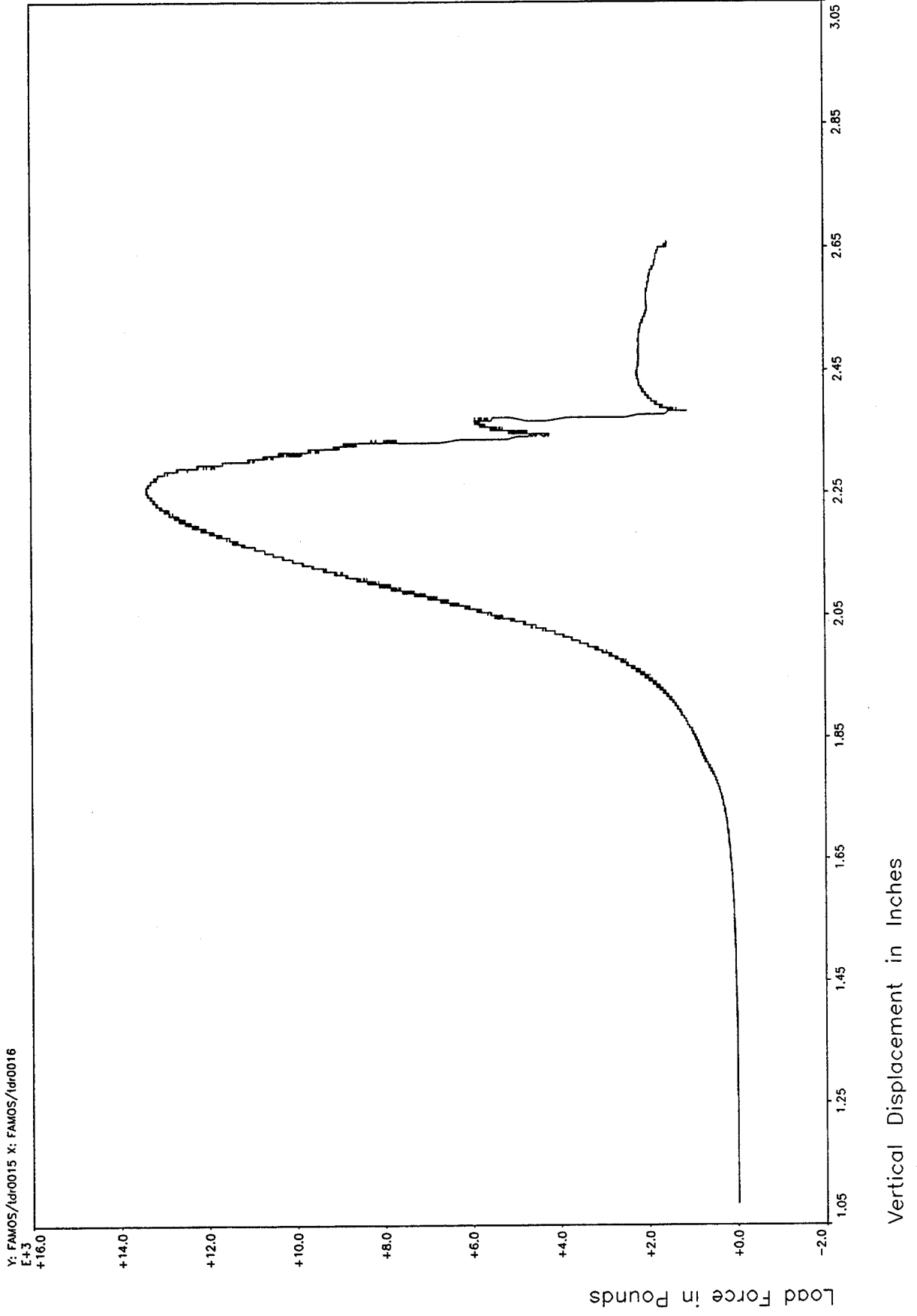
Test 1: 2 Inch Banding, 1 Seal, 2 Notches



Test 2: 2 Inch Banding, 1 Seal, 2 Notches



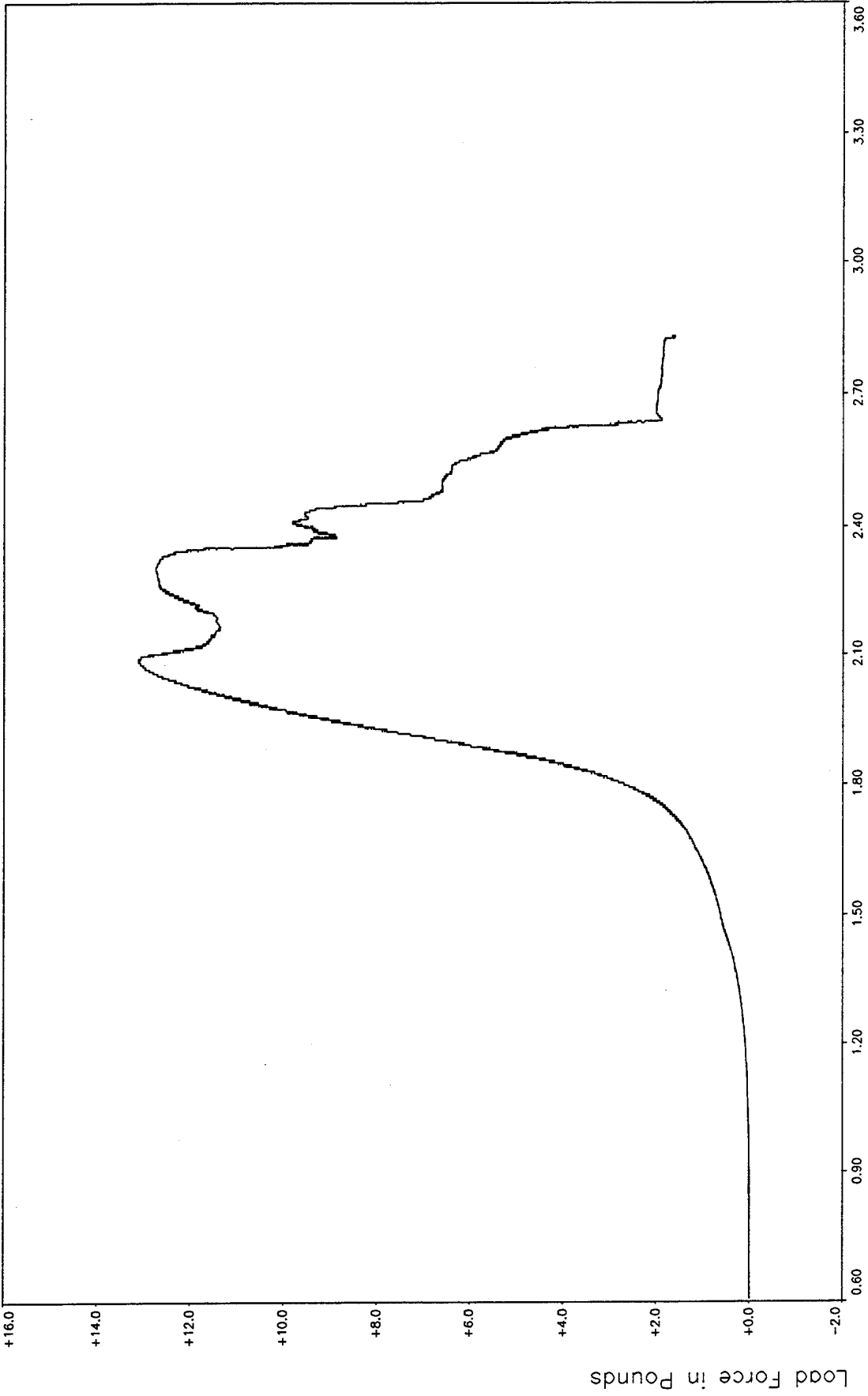
Test 3: 2 Inch Banding, 1 Seal, 2 Notches





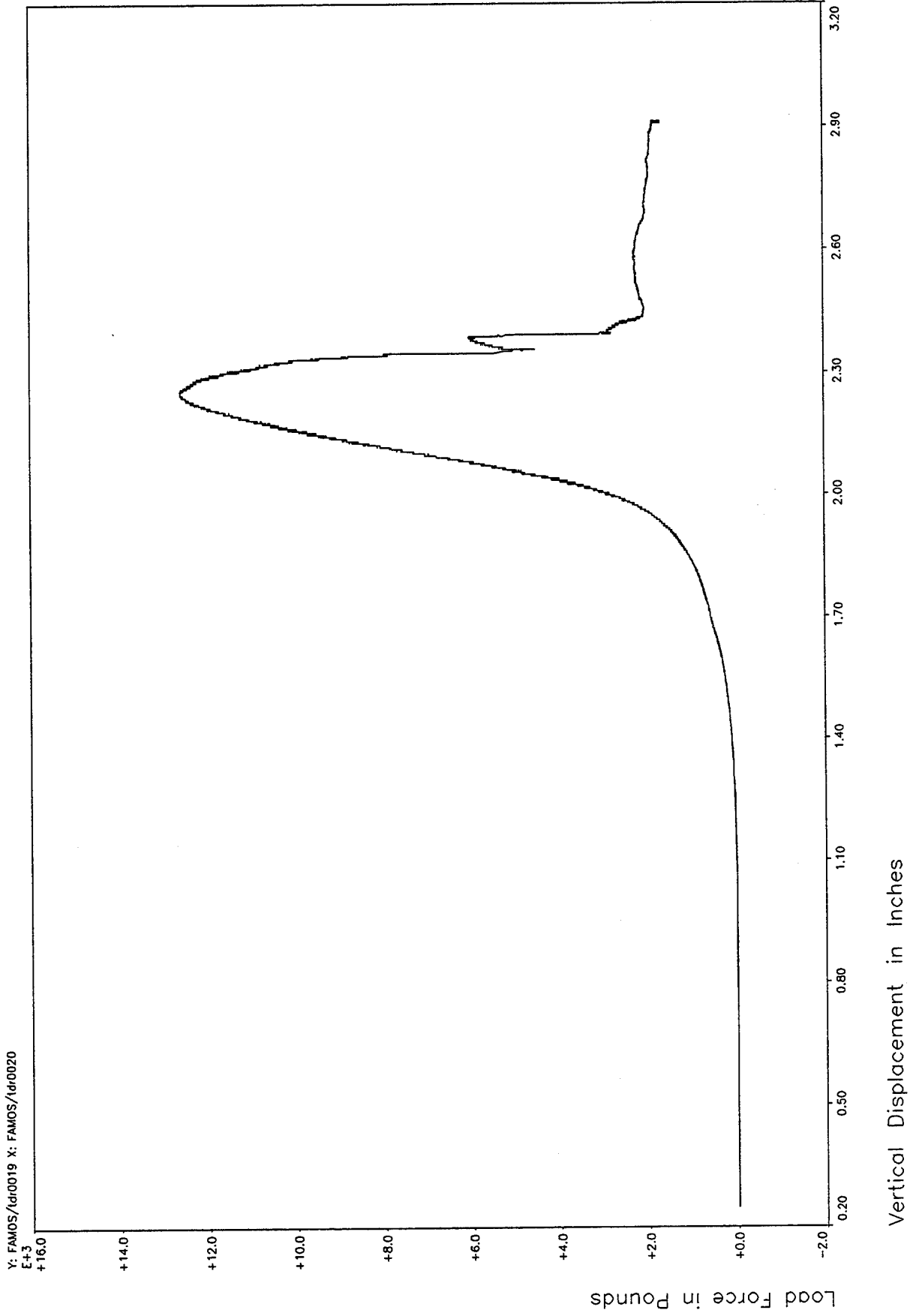
Test 4: 2 Inch Banding, 1 Seal, 2 Notches

Y: FAMOS/ldr0017 X: FAMOS/ldr0018  
E+3  
+16.0



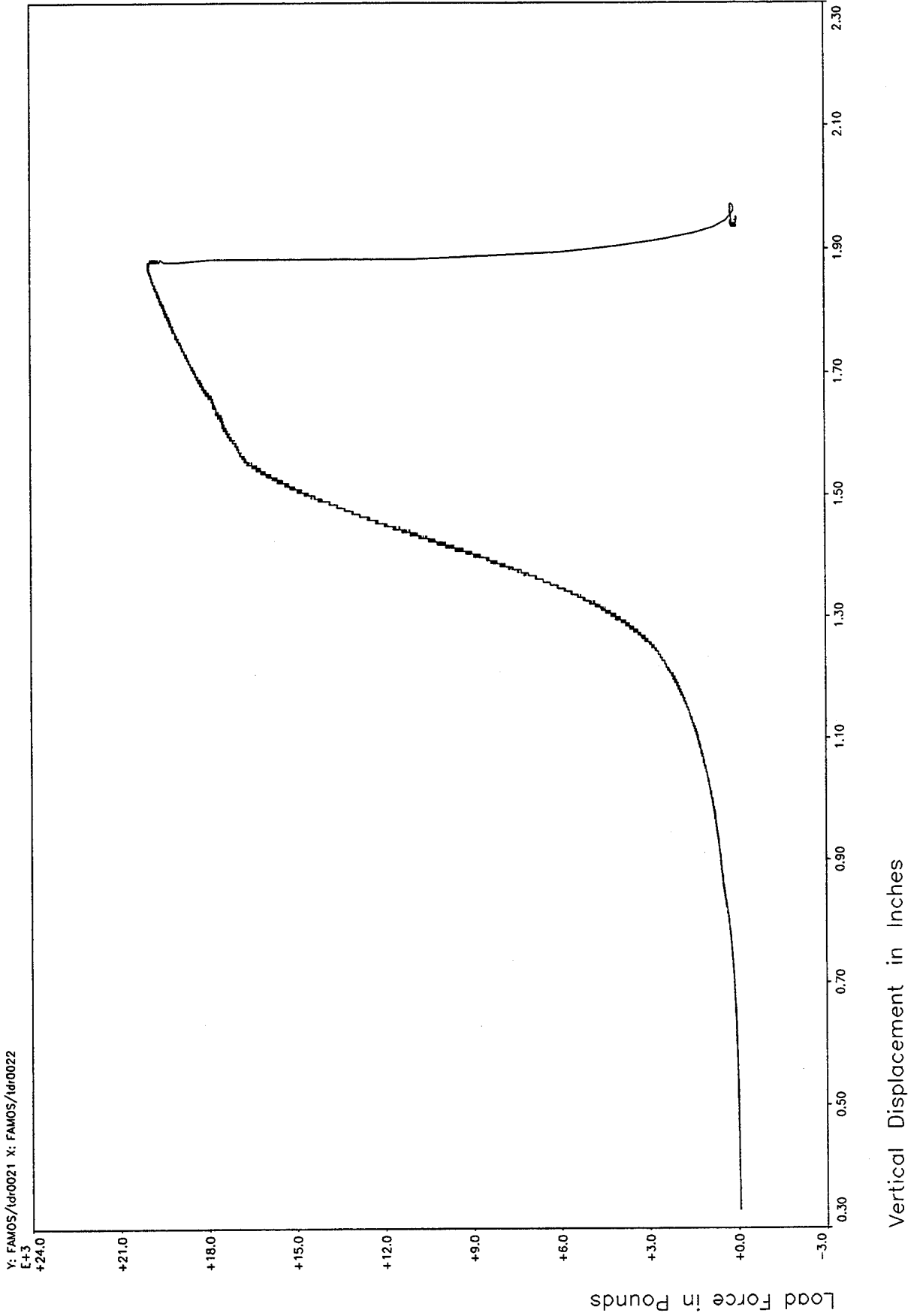
Vertical Displacement in Inches

Test 5: 2 Inch Banding, 1 Seal, 2 Notches



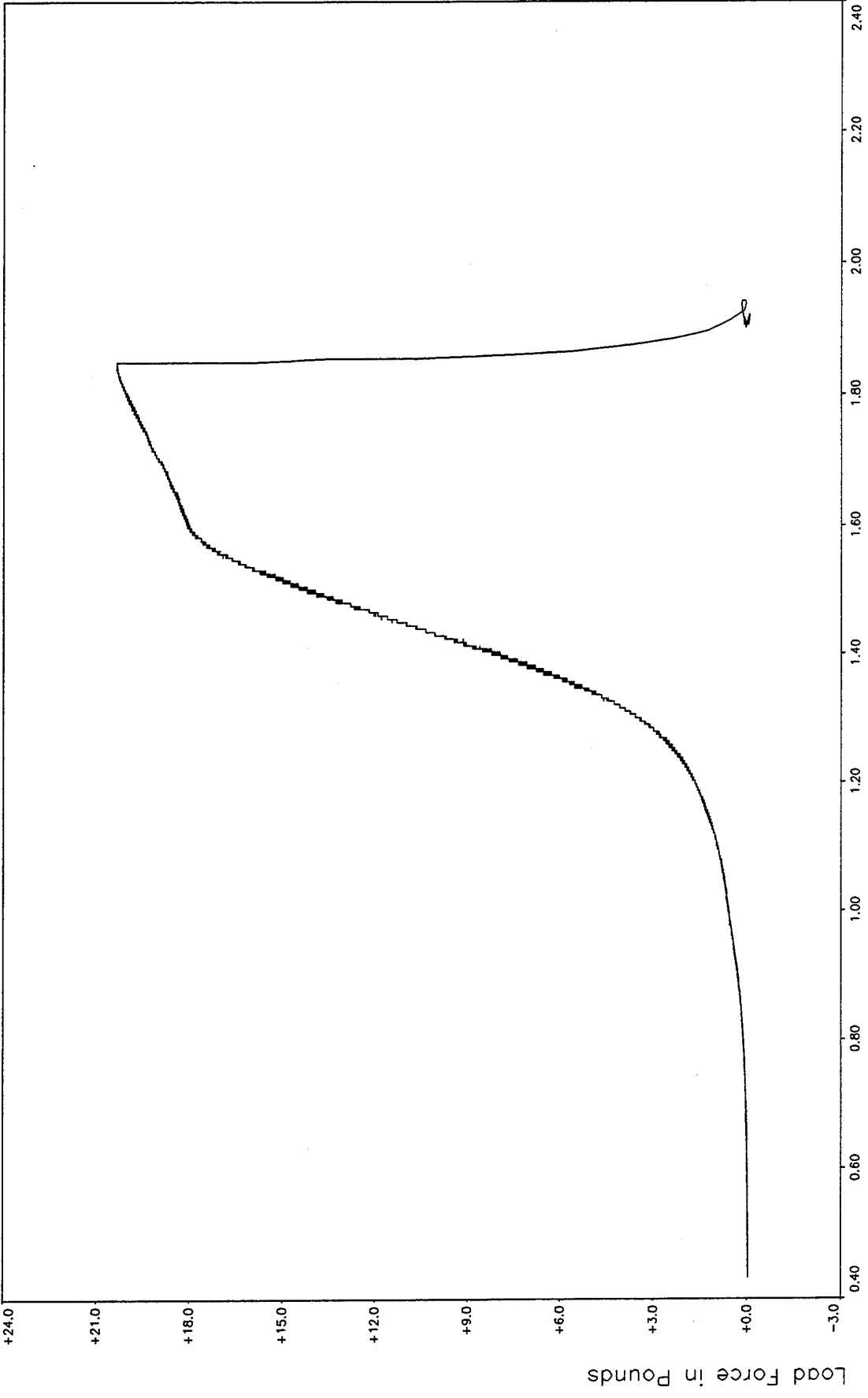
Test Data from  
2-Inch Strapping: 2 Seals, Double Notches

Test 1: 2 Inch Banding, 2 Seals, 2 Notches



# Test 2: 2 Inch Banding, 2 Seals, 2 Notches

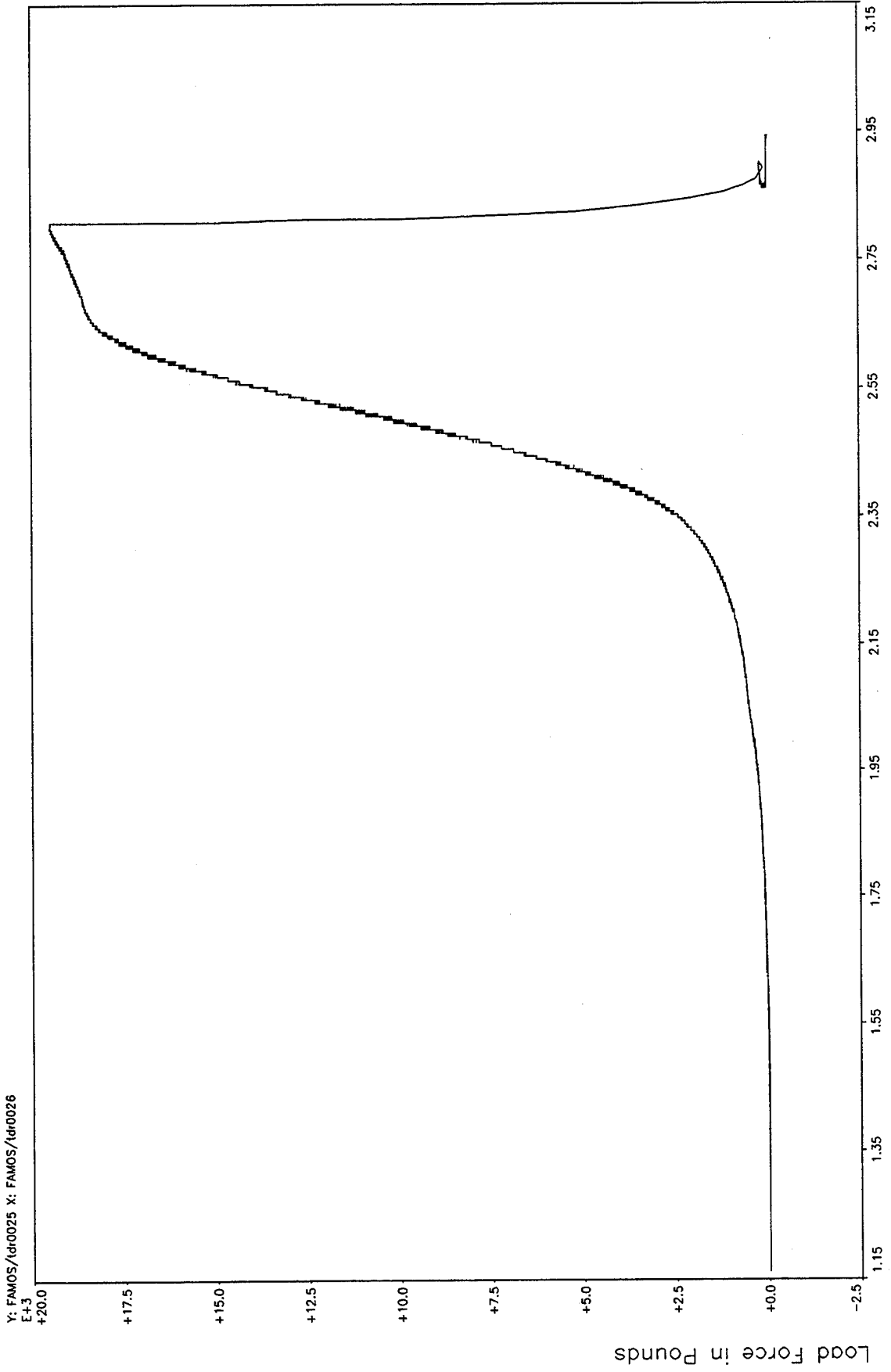
Y: FAMOS/ldr0023 X: FAMOS/ldr0024  
E+3  
+24.0



Vertical Displacement in Inches

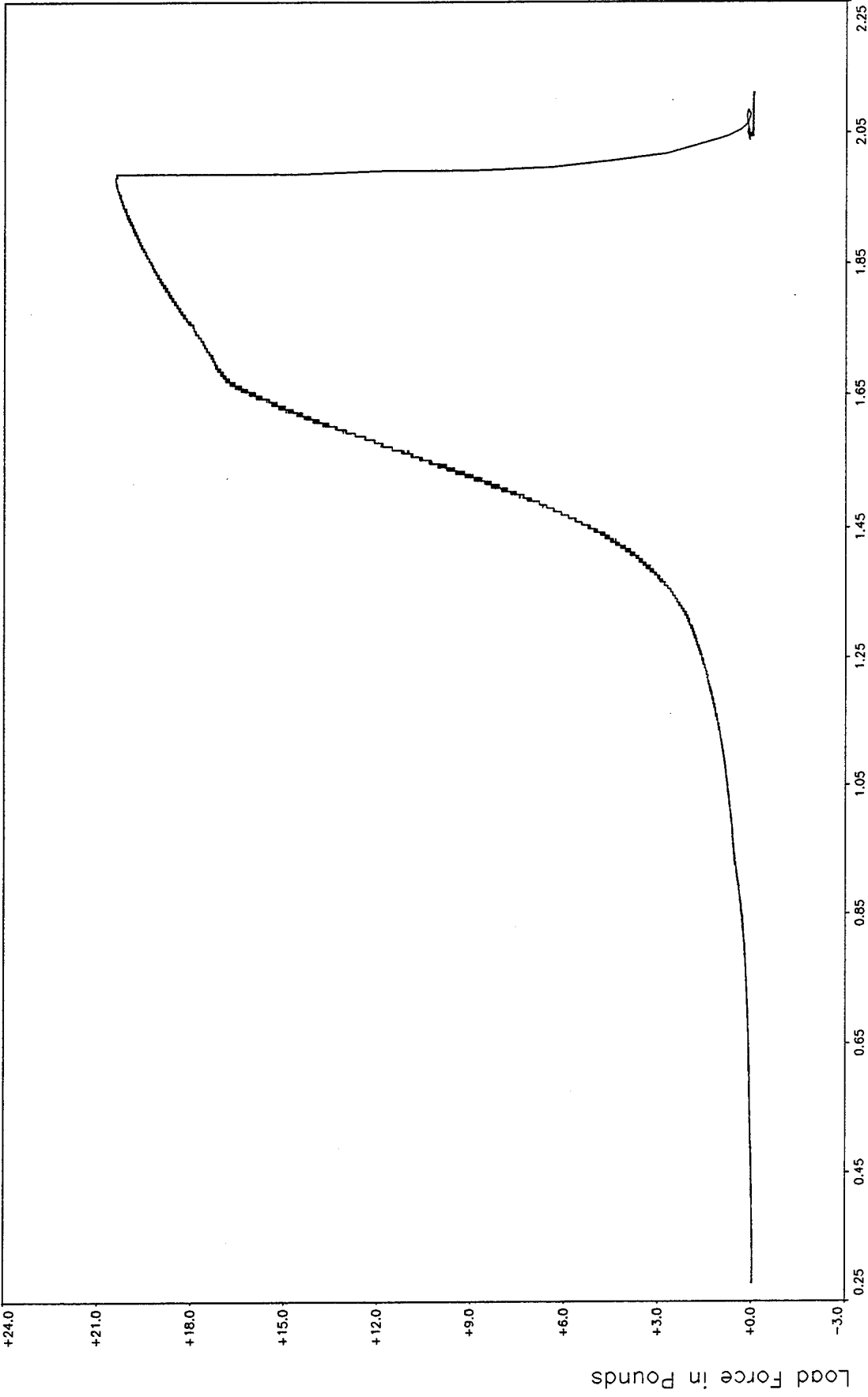
Load Force in Pounds

Test 3: 2 Inch Banding, 2 Seals, 2 Notches



Test 4: 2 Inch Banding, 2 Seals, 2 Notches

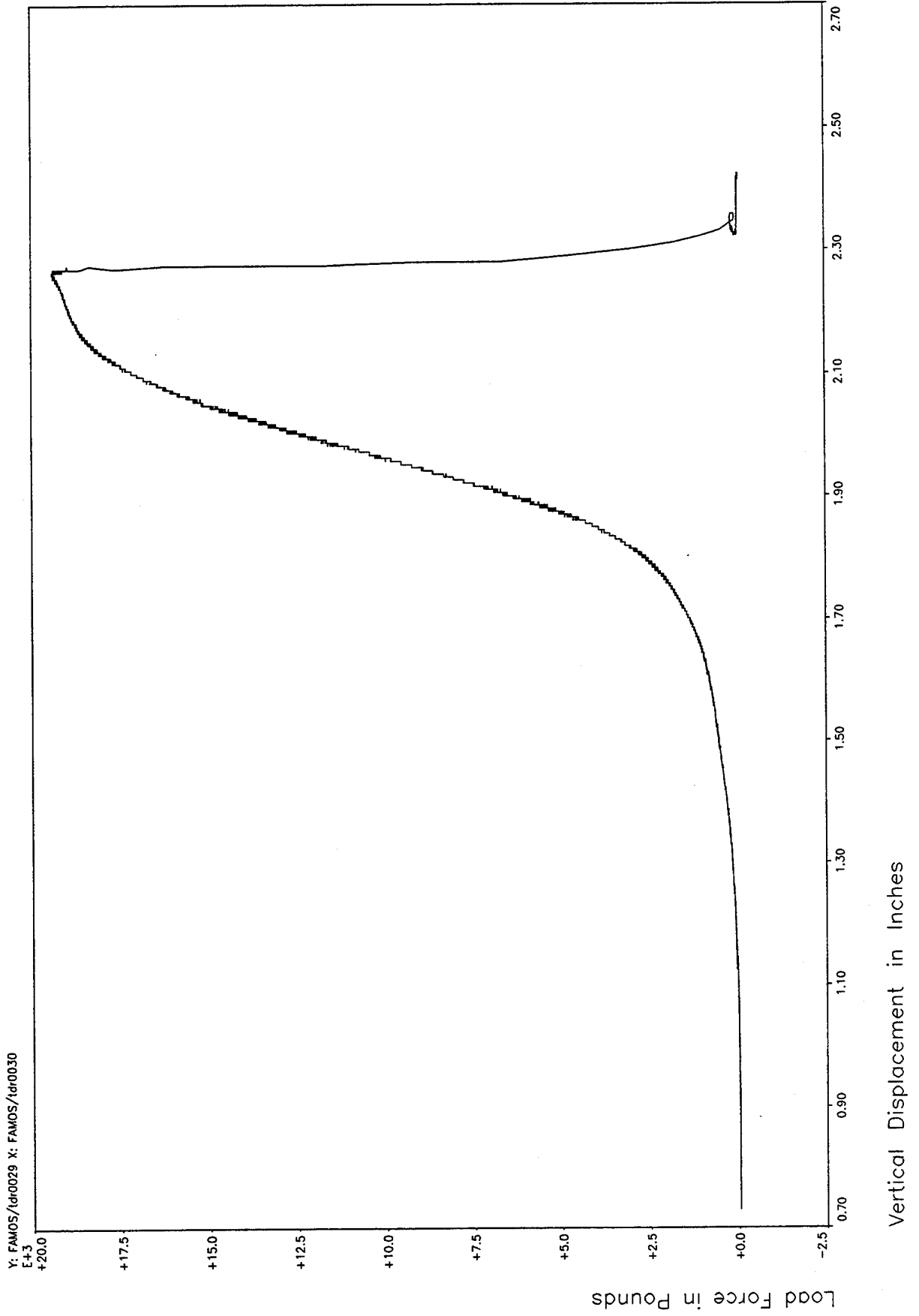
Y: FAMOS/ldr0027 X: FAMOS/ldr0028  
E+3  
+24.0



Vertical Displacement in Inches

Load Force in Pounds

Test 5: 2 Inch Banding, 2 Seals, 2 Notches

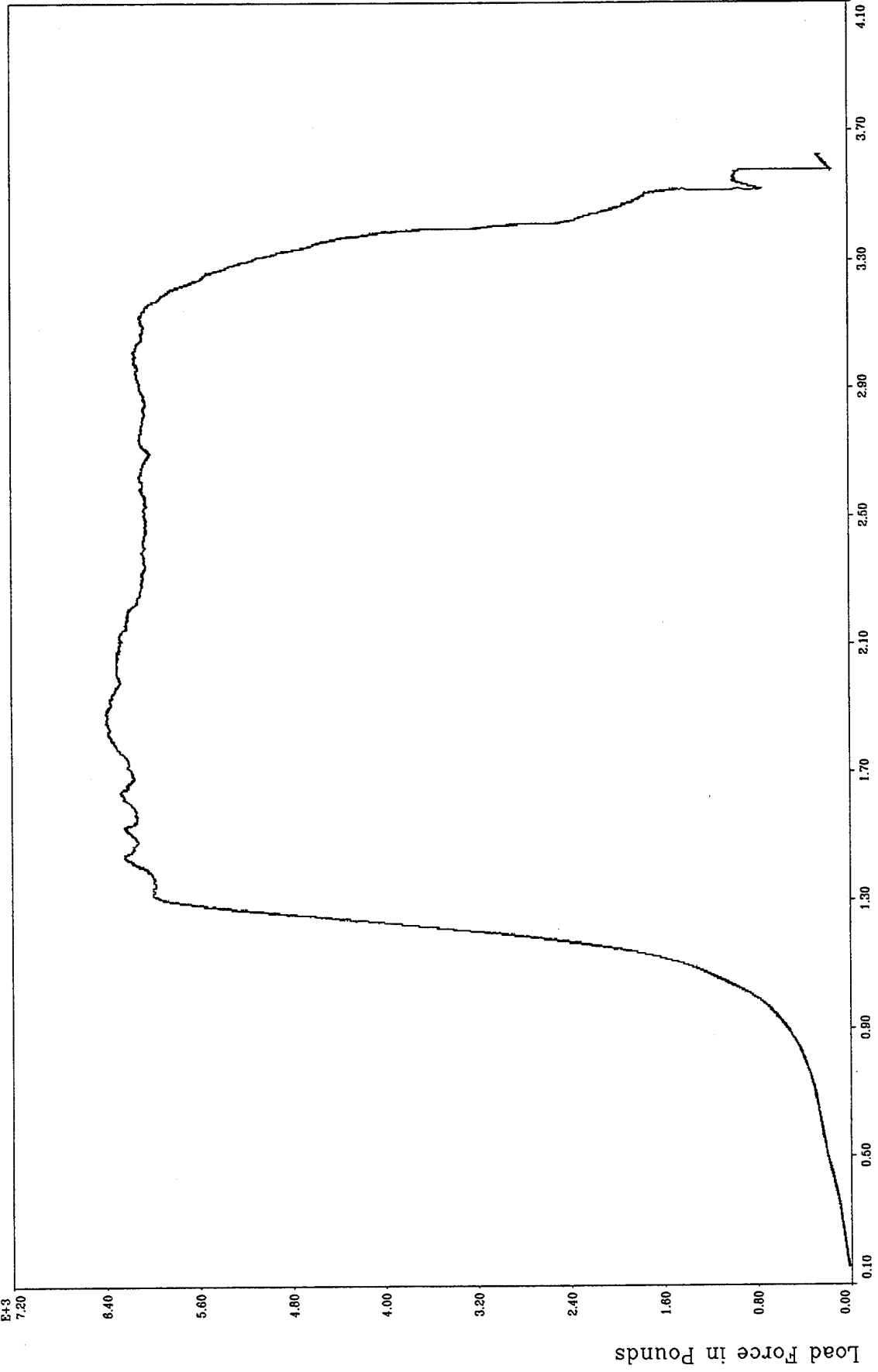




Test Data from  
2-Inch Strapping: 1 Seal (208DG), 1 Crimp

Test 1: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

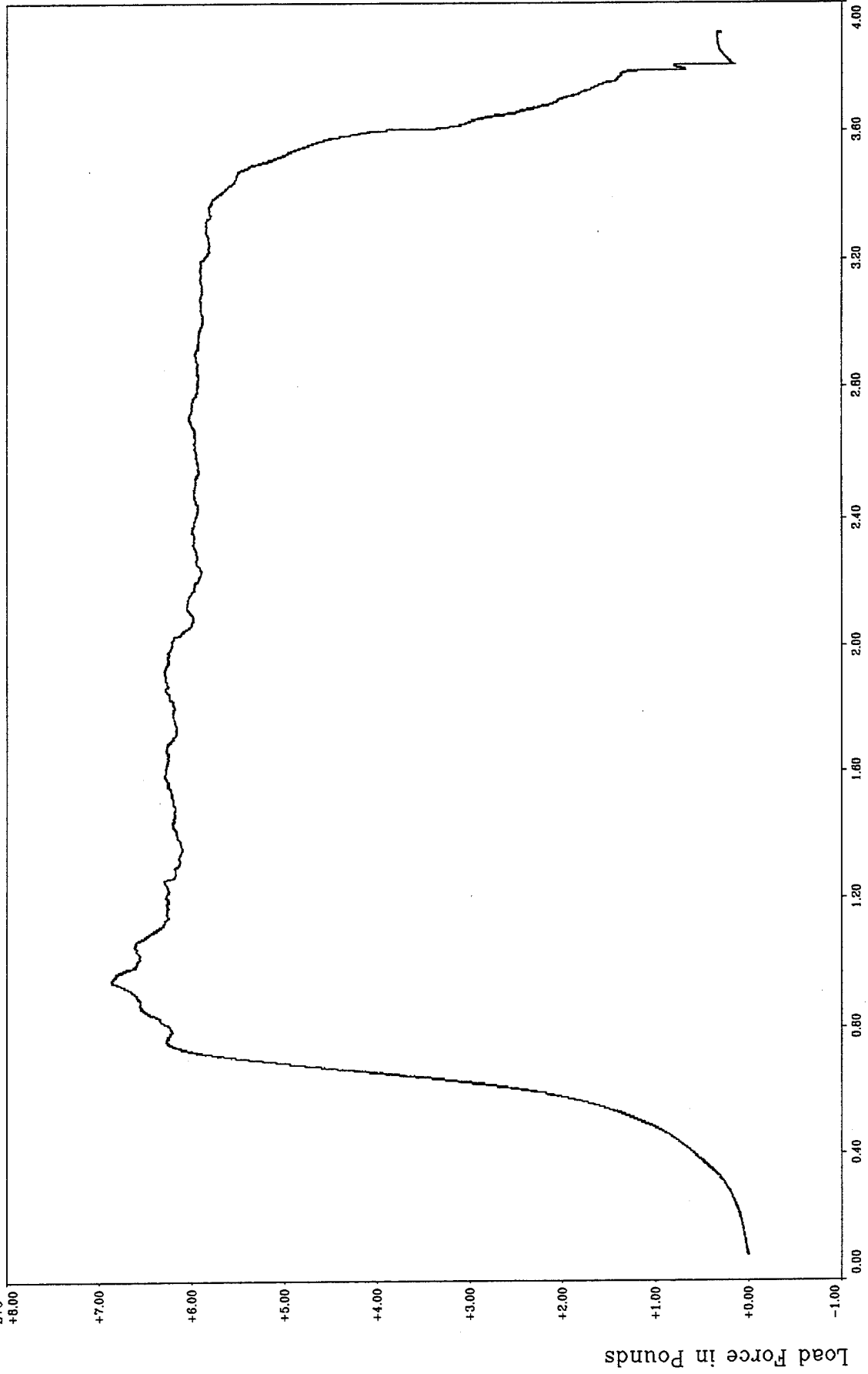
Y: FAMOS/Adr0001 X: FAMOS/Adr0002



Vertical Displacement in Inches

Test 2: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

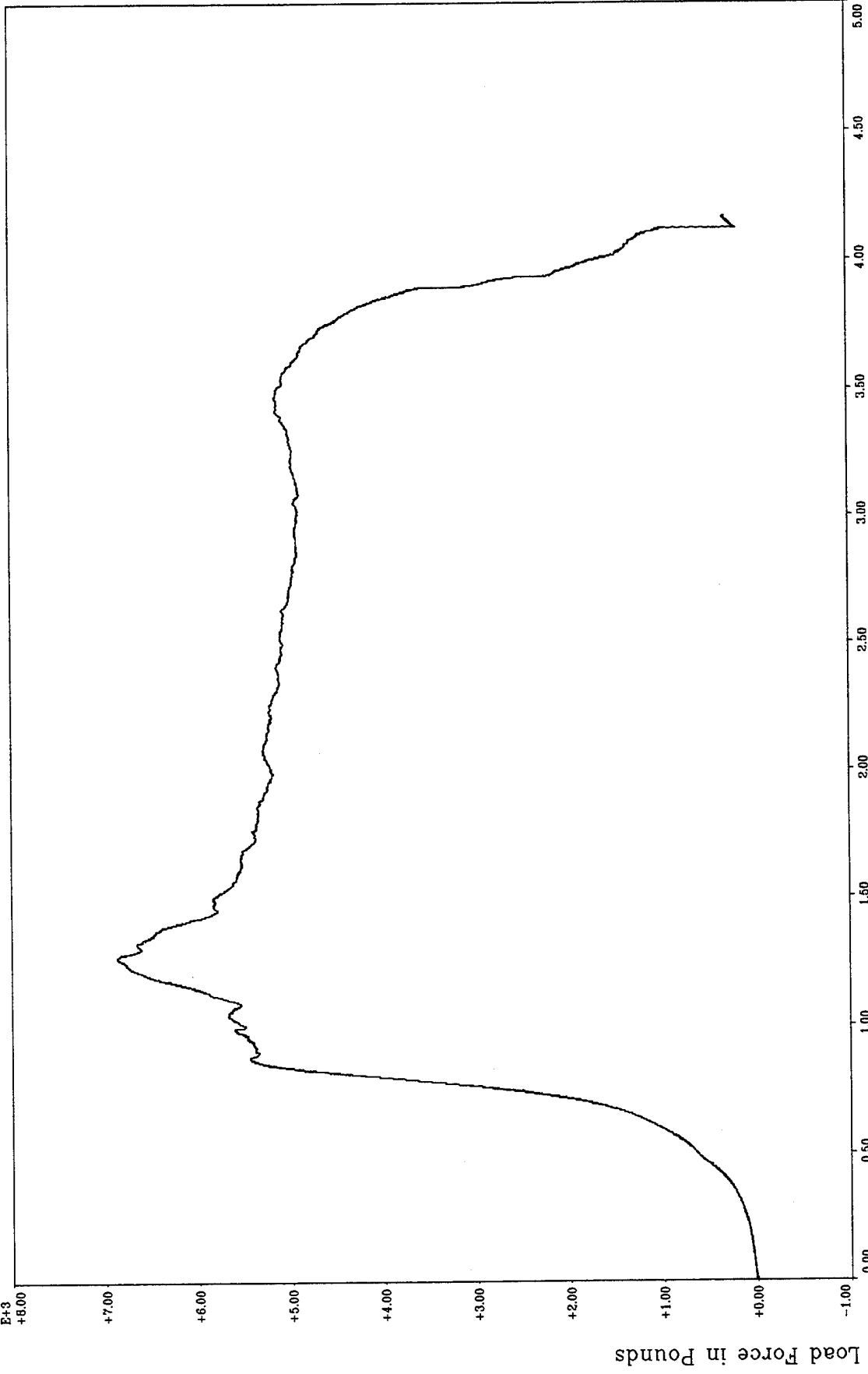
Y: FAMOS/ldr0003 X: FAMOS/ldr0004  
E+3



Vertical Displacement in Inches

Test 3: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

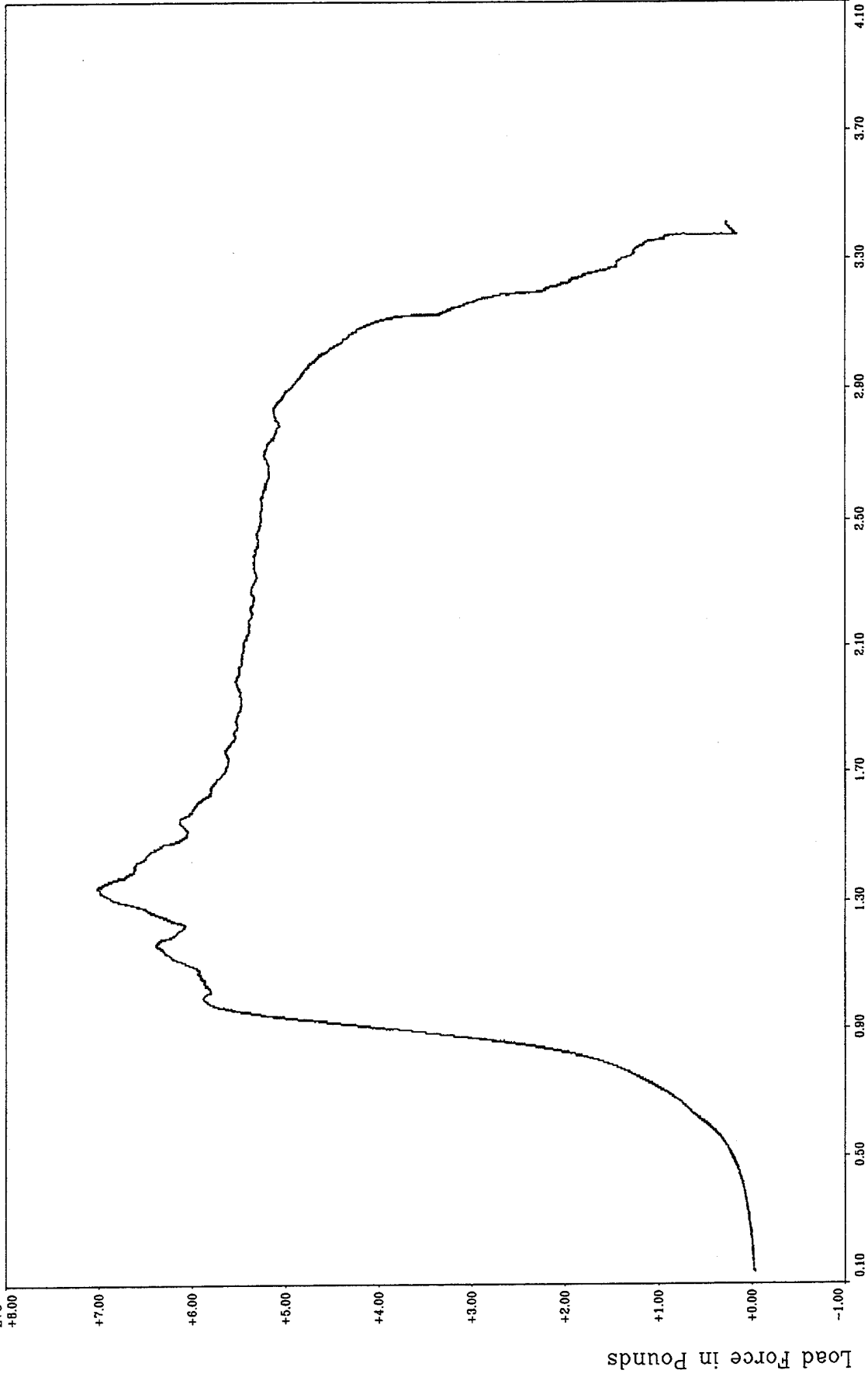
Y: FAMOS/(dr0005 X: FAMOS/(dr0006



Vertical Displacement in Inches

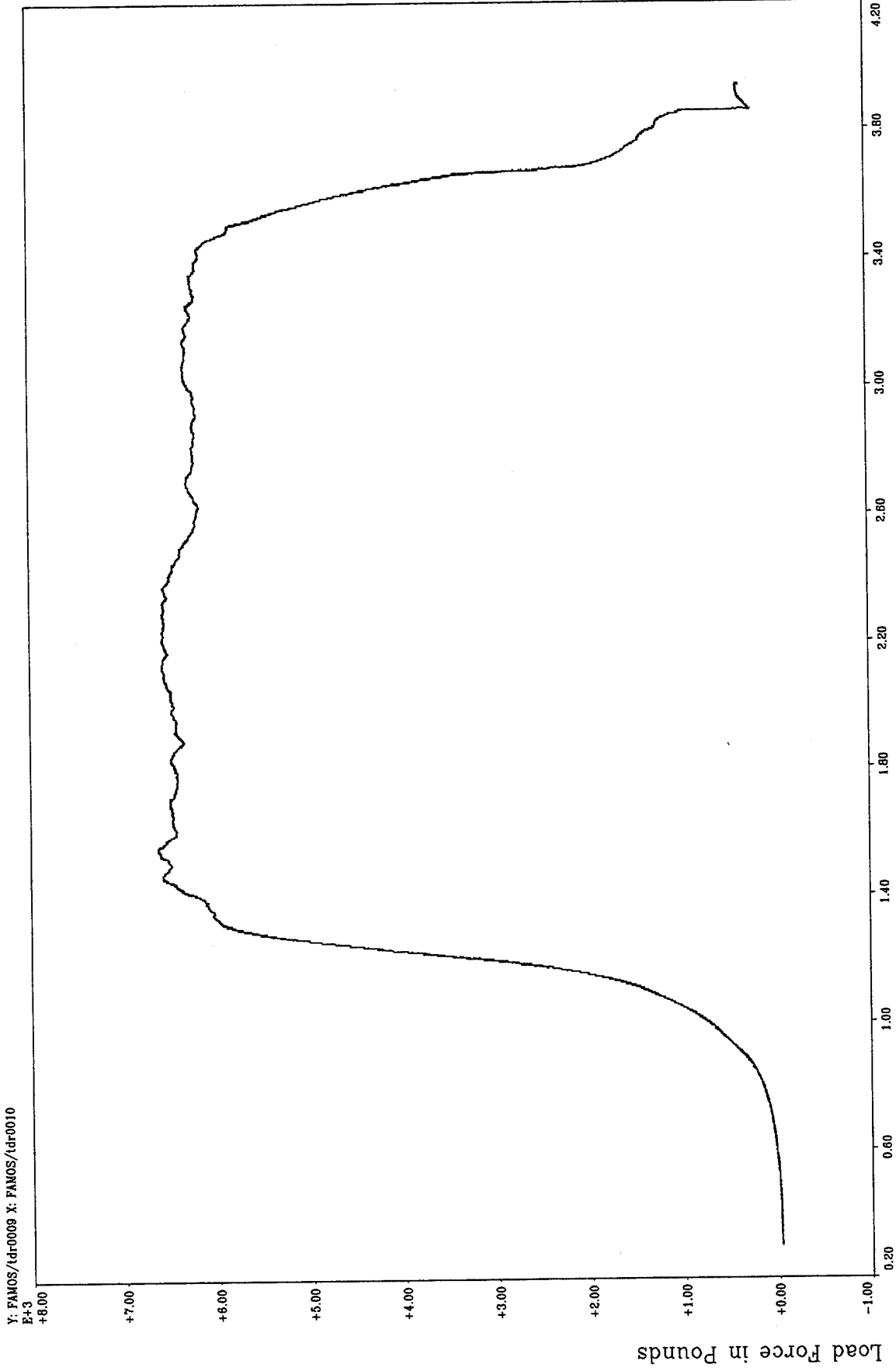
Test 4: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

Y: FAMOS/ldr0007 X: FAMOS/ldr0008  
E+3



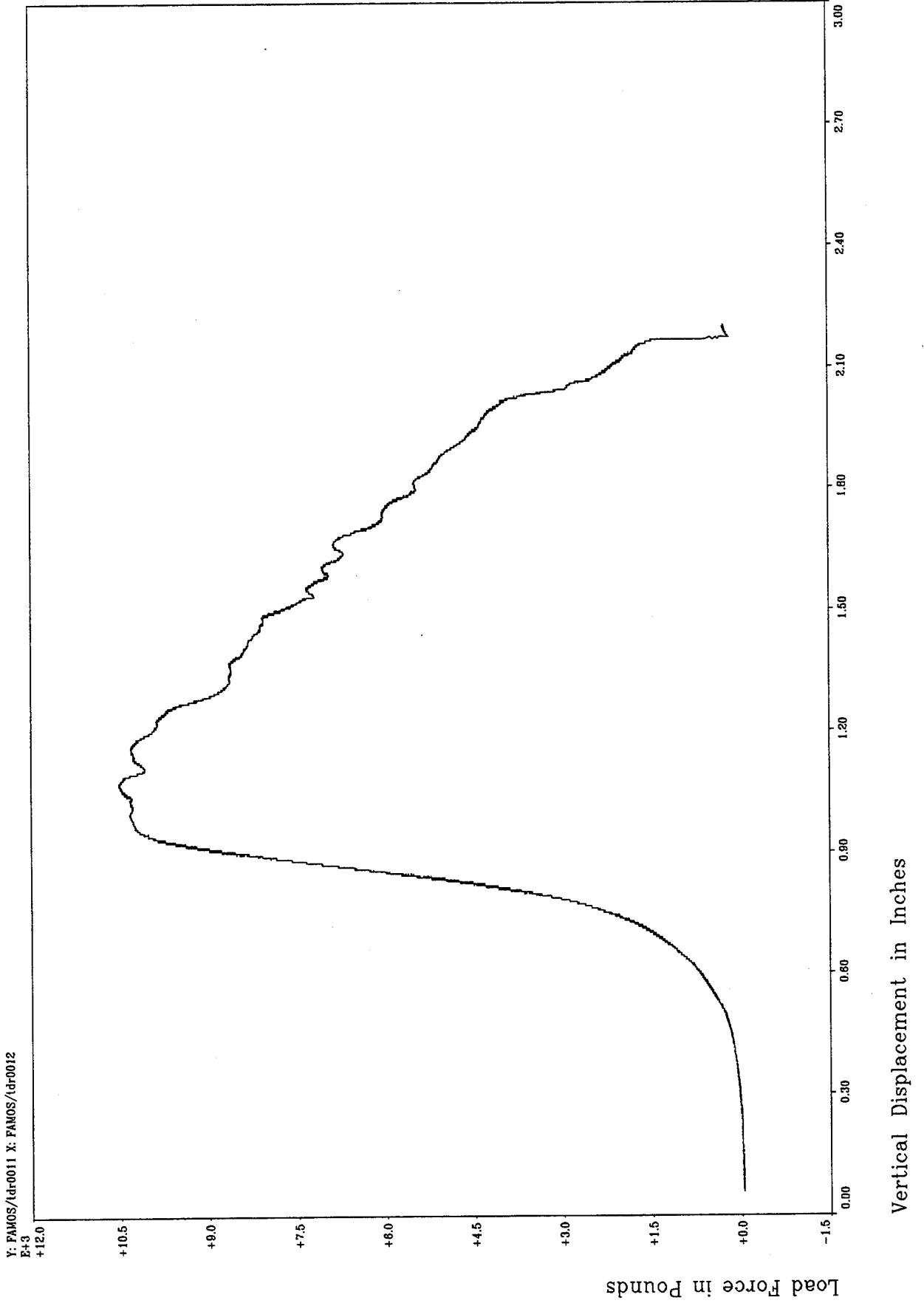
Vertical Displacement in Inches

Test 5: 2 Inch Banding, 1 Seal (208DG), 1 Crimp



Test Data from  
2-Inch Strapping: 1 Seal (208DG), 2 Crimps

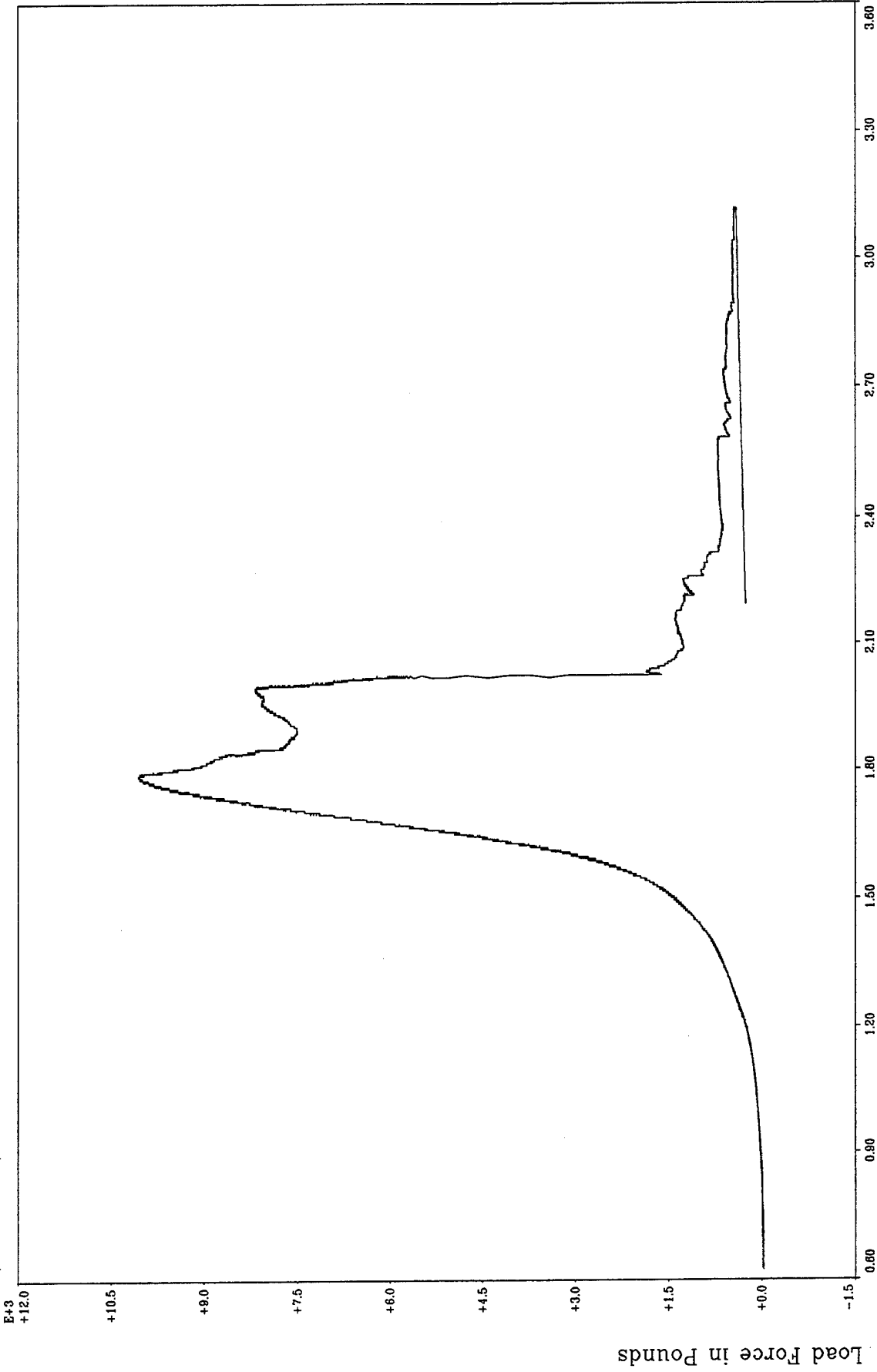
Test 1: 2 Inch Banding, 1 Seal (208DG), 2 Crimps





Test 2: 2 Inch Banding, 1 Seal (208DG), 2 Crimps

Y: FAMOS/ldr0013 X: FAMOS/ldr0014

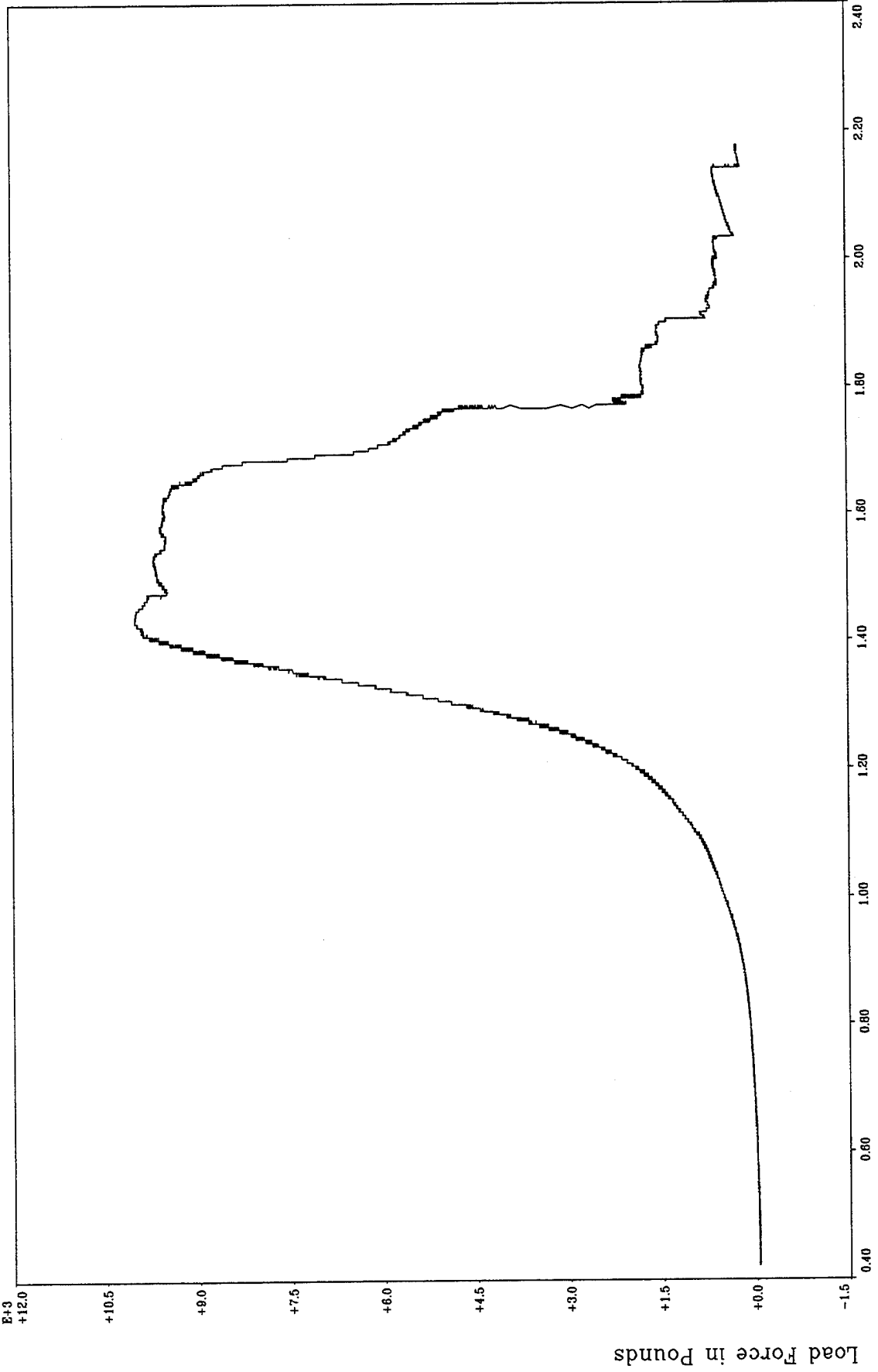


Vertical Displacement in Inches

Load Force in Pounds

Test 3: 2 Inch Banding, 1 Seal (208DG), 2 Crimps

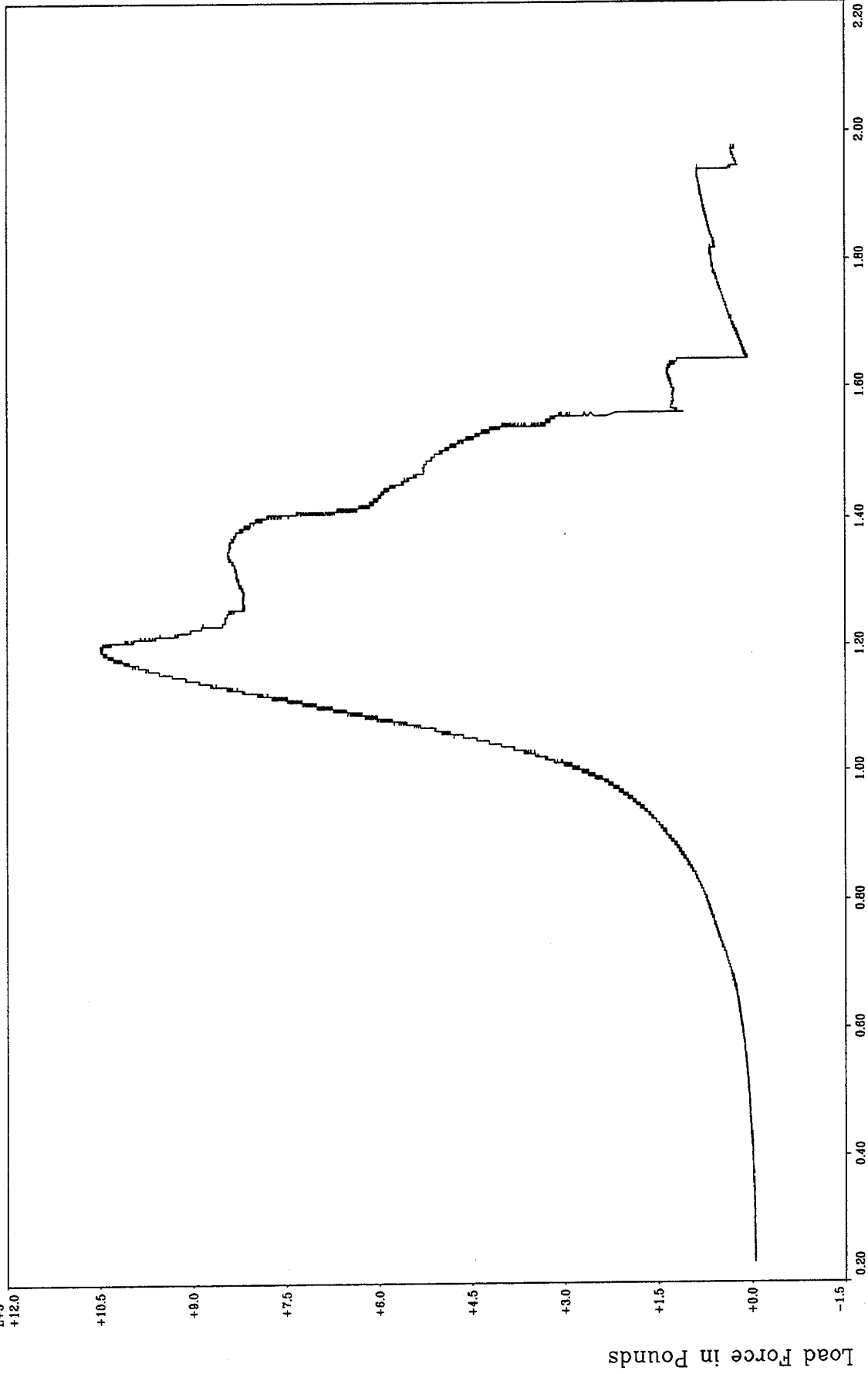
Y: FAMOS/ldr0015 X: FAMOS/ldr0016



Vertical Displacement in Inches

Test 4: 2 Inch Banding, 1 Seal (208DG), 2 Crimps

Y: FAMOS/ldr0017 X: FAMOS/ldr0018  
E+3

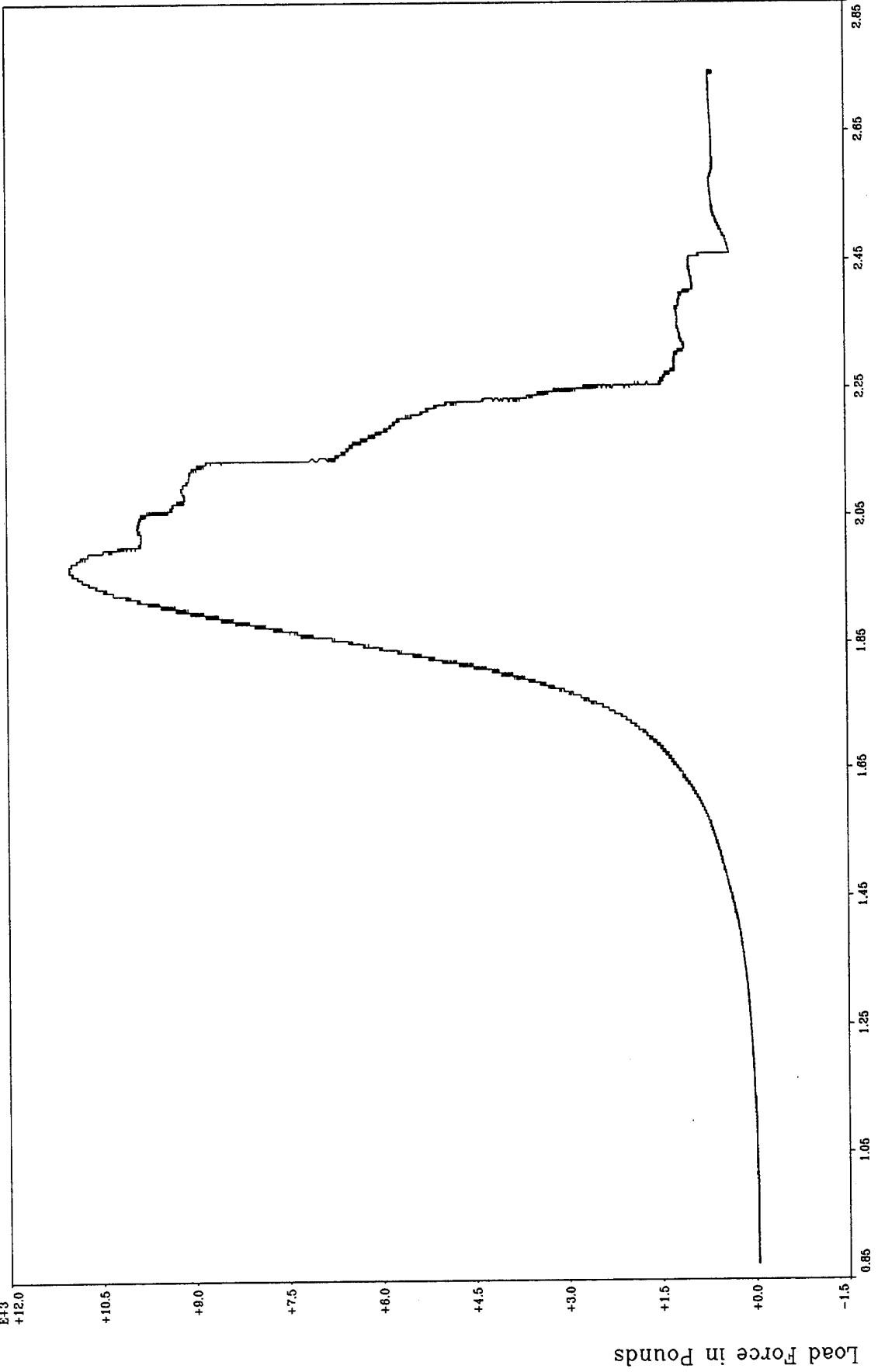


Vertical Displacement in Inches

Load Force in Pounds

Test 5: 2 Inch Banding, 1 Seal (208DG), 2 Crimps

Y: FAMOS/ldr0019 X: FAMOS/ldr0020  
E+3  
+12.0

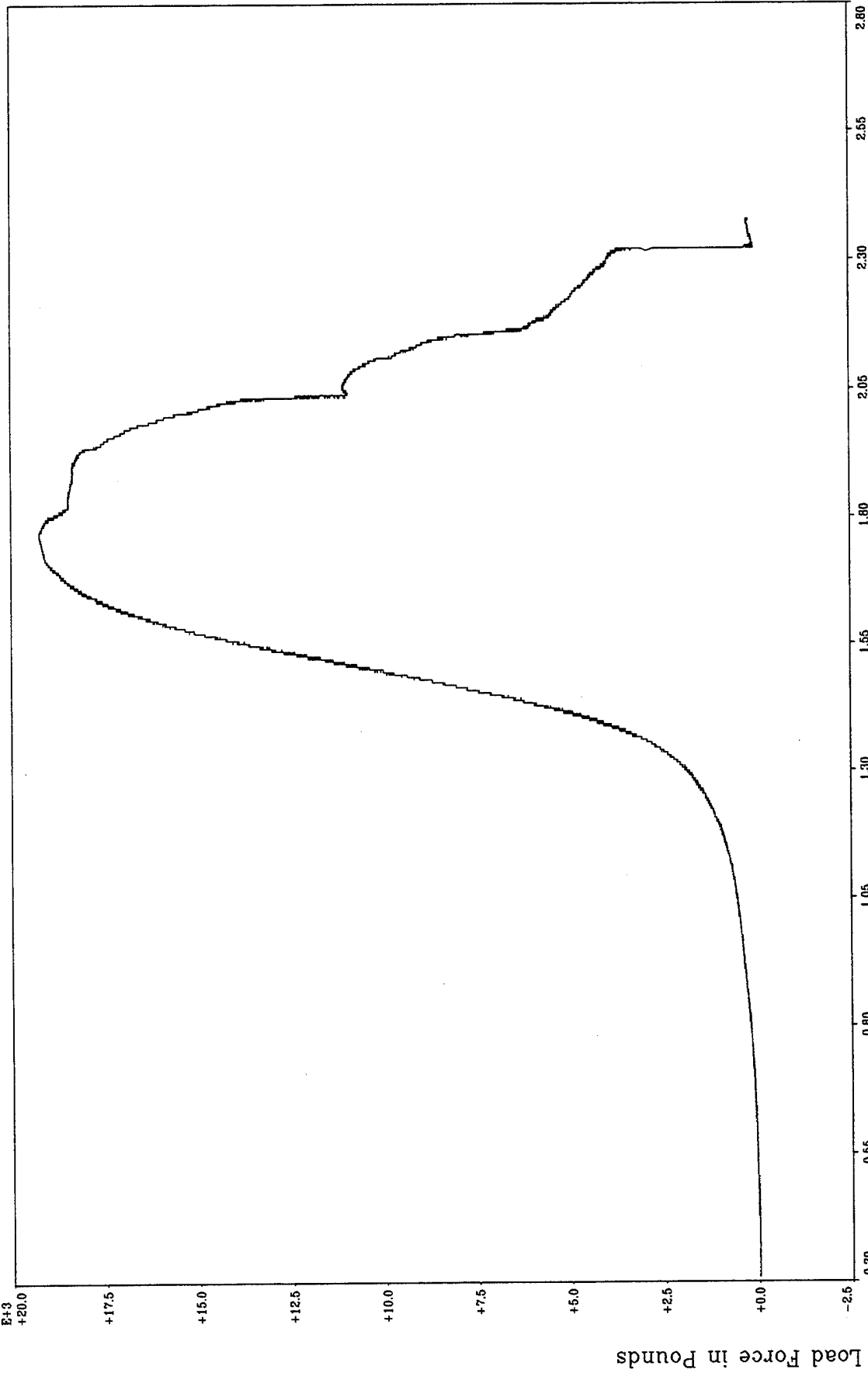


Vertical Displacement in Inches

Test Data from  
2-Inch Strapping: 2 Seals (208DG), Double Crimps

Test 1: 2 Inch Banding, 2 Seals (208DG), 2 Crimps

Y: FAMOS/ldr0021 X: FAMOS/ldr0022

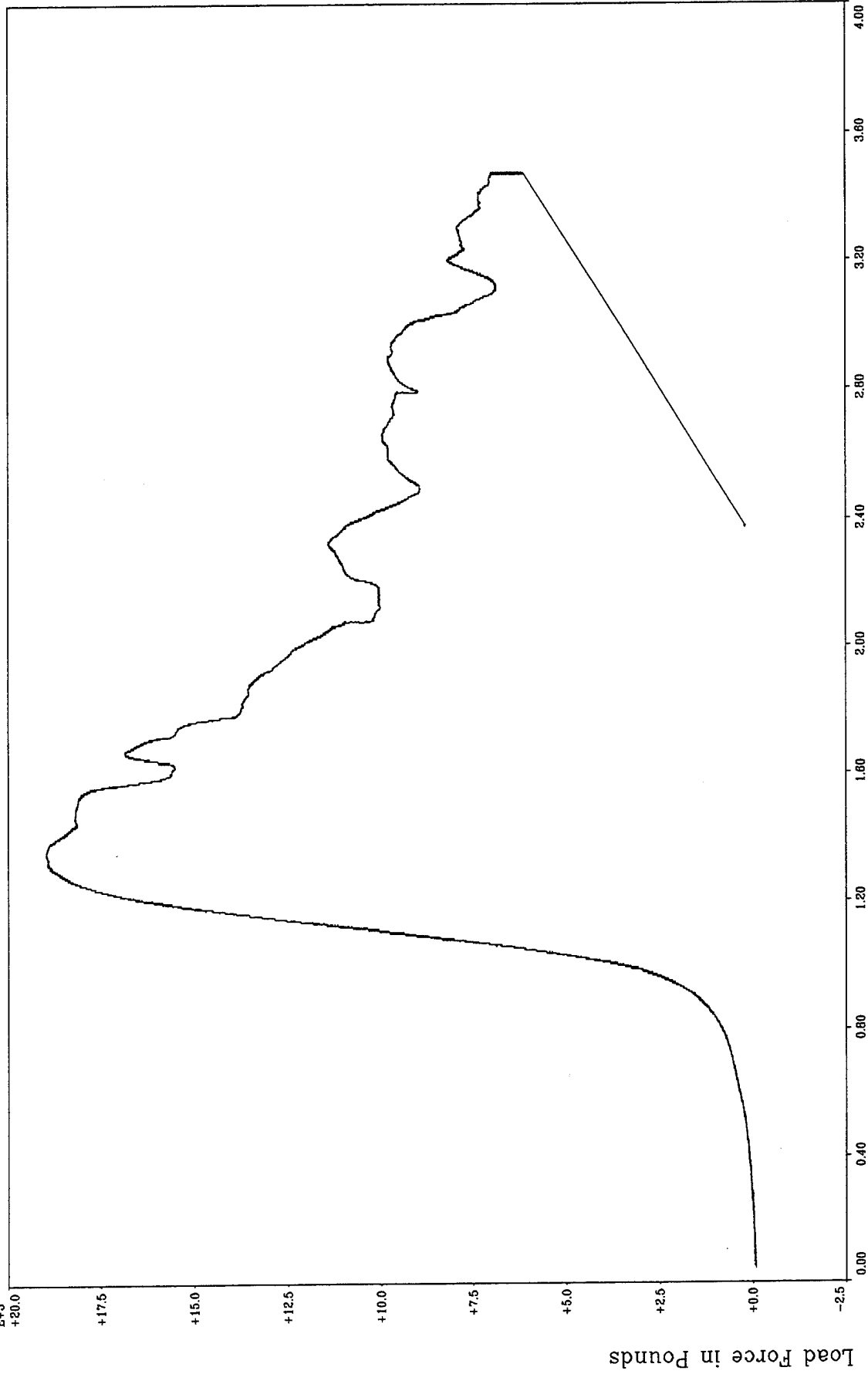


Vertical Displacement in Inches

Load Force in Pounds

Test 2: 2 Inch Banding, 2 Seals (208DG), 2 Crimps

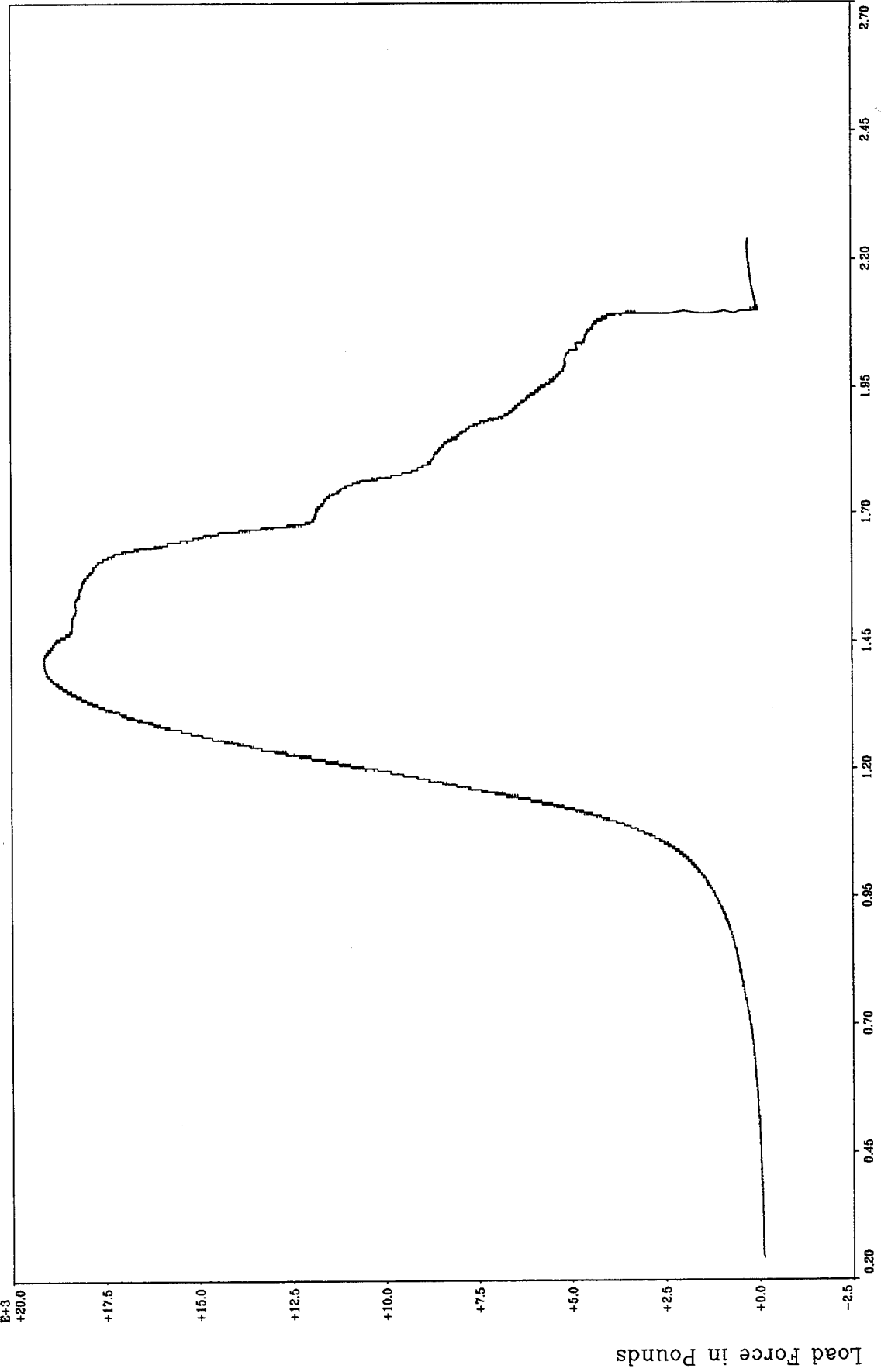
Y: FAMOS/tr0023 X: FAMOS/tr0024  
E+3



Vertical Displacement in Inches

# Test 3: 2 Inch Banding, 2 Seals (208DG), 2 Crimps

Y: FAMOS/ldr0025 X: FAMOS/ldr0026

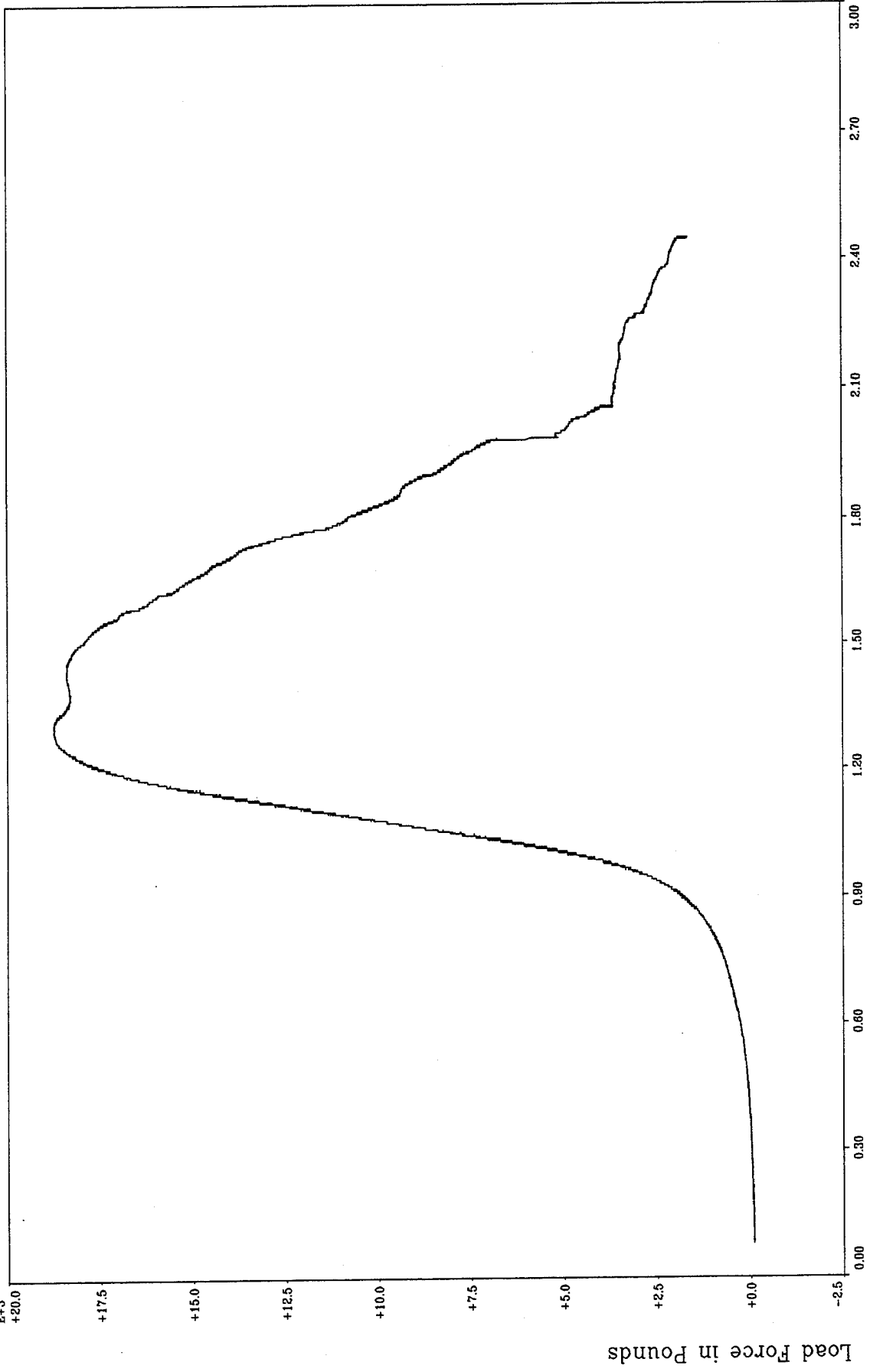


Vertical Displacement in Inches



Test 4: 2 Inch Banding, 2 Seals (208 DG), 2 Crimps

Y: FAMOS/ldr0027 X: FAMOS/ldr0028  
E+3

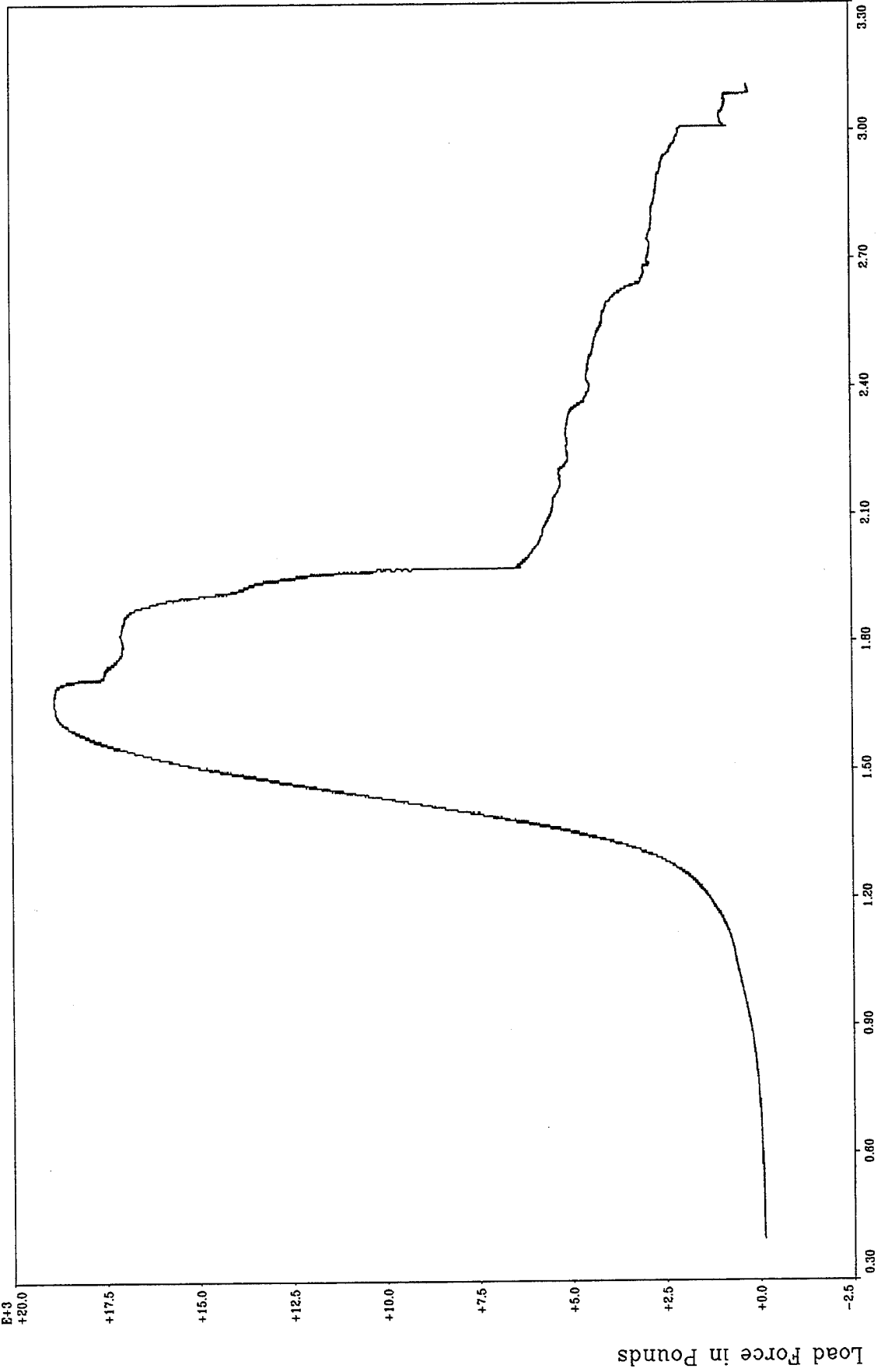


Vertical Displacement in Inches

Load Force in Pounds

Test 5: 2 Inch Banding, 2 Seals (208DG), 2 Crimps

Y: FAMOS/ldr0029 X: FAMOS/ldr0030



Vertical Displacement in Inches

PART 7

TEST NOTES

Following are test synopsis and results.

a. 1-1/4-Inch Strapping: 1 Seal, 1 Crimp

All straps pulled through the seal during the test.

b. 1-1/4-Inch Strapping: 1 Seal, 2 Crimps

- (1) Test 1: Strap pulled the seal apart.
- (2) Test 2: Strap pulled the seal apart.
- (3) Test 3: Strap broke.
- (4) Test 4: Strap pulled the seal apart.
- (5) Test 5: Strap pulled through the seal.

c. 1-1/4-Inch Strapping: 2 Seals, Double Crimps

All straps broke at an outer crimp.

d. 1-1/4-Inch Strapping: 1 Seal, 1 Notch

All straps pulled through the seal.

e. 1-1/4-Inch Strapping: 1 Seal, 2 Notches

All straps broke at an outer notch.

f. 1-1/4-Inch Strapping: 2 Seals, Double Notches

All straps broke at an outer notch.

g. 2-Inch Strapping: 1 Seal, 1 Crimp

All seals were pulled apart.

h. 2-Inch Strapping: 1 Seal, 2 Crimps

All seals pulled apart.

i. 2-Inch Strapping: 1 Seal, 1 Notch

All straps pulled through the seals, tearing the seals at the notch points.

j. 2-Inch Strapping: 1 Seal, 2 Notches

All straps pulled through the seals, tearing the seals at the notch points.

k. 2-Inch Strapping: 2 Seals, Double Notches

All straps broke at an outer notch.

l. 2-Inch Strapping: 1 Seal (208DG), 1 Crimp

All straps pulled through the seal.

m. 2-Inch Strapping: 1 Seal (208DG), 2 Crimps

(1) Test 1: Strap pulled through the seal.

(2) Tests 2 - 5: Seal pulled apart.

n. 2-Inch Strapping: 2 Seals (208DG), Double Crimps

All seals pulled apart.