

NASA CR-135037

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PROOF TEST CRITERIA FOR THIN-WALLED 2219 ALUMINUM PRESSURE VESSELS

VOLUME II - CRACK OPENING DISPLACEMENT AND STRESS-STRAIN DATA

By
R. W. Finger

THE BOEING AEROSPACE COMPANY

Prepared For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Lewis Research Center
Contract NAS3-18906
Gordon T. Smith, Project Manager

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NASA-CR-135037



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12 Sponsoring Agency Name and Address National Aeronautics and Space Administration Lewis Research Center 21000 Brookpark Road Cleveland, Ohio 44135		15 Supplementary Notes Project Manager, Gordon T. Smith Materials and Structures Division NASA Lewis Research Center Cleveland, Ohio 44135	
16 Abstract This experimental program was undertaken to investigate the crack growth behavior of deep surface flaws in 2219 aluminum. The program included tests of uniaxially loaded surface flaw and center crack panels at temperatures ranging from 20K (-423 ^o F) to ambient. The tests were conducted on both the base metal and as-welded weld metal material. The program was designed to provide data on the mechanisms of failure by ligament penetration, and the residual cyclic life, after proof-testing, of a vessel which has been subjected to incipient penetration by the proof test. The results were compared and analyzed with previously developed data to develop guidelines for the proof-testing of thin walled 2219 pressure vessels.			
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FORWORD

This report contains the crack opening displacement records developed during an investigation of the crack growth characteristics of both center crack and part through surface cracks and the extensometer and strain gage data developed during the mechanical property testing portion of the program. The work was performed by the Boeing Aerospace Company from July 1974 to September 1975 under NASA Contract NAS3-18906. The work was administered by Mr. Gordon T. Smith of the NASA-Lewis Research Center.

This program was conducted by the Research and Engineering Division of the Boeing Aerospace Company, Seattle, Washington, under the supervision of Mr. H. W. Klopfenstein, Structures Research and Development Manager. The Program Leader was Mr. J. N. Masters, Supervisor, Failure Mechanisms Group. The Technical Leader was R. W. Finger; A. A. Ottlyk and H. M. Olden provided testing engineering support, and G. Buehler produced the technical illustration and art work. This technical report is also released as Boeing Document D180-20100-2.

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INTRODUCTION

This report contains the crack opening displacement records obtained during the testing of both the center crack and surface flawed specimens and the extensometer and strain gage curves from the mechanical property characterization portion of the program. The remaining test data is summarized and discussed in CR-135036 (Reference 1).

The crack opening displacement records presented are reproductions of the actual traces. The specimen number is given on each plot so that the other detailed test information can be located in CR-135036. Peculiarities encountered during testing have been noted on the individual plots. Some general comments pertinent to all of the plots are presented below:

- o The Electrical Deflection Indicator (EDI) was reset after each load cycle;
- o The EDI gage was spring loaded against integrally machined knife edges for all of the center crack panels and all of the 6.35 mm and 9.53 mm (0.25 and 0.375 in) thick surface flaw specimen. Clip gage brackets were used for attaching the EDI to the remaining specimen;
- o All of the center-crack panels were loaded directly to failure, therefore, all of the associated crack opening displacement records are for the fracture loading;
- o The surface flawed specimens were subjected to a variety of different loadings which are denoted on the plots.

The crack opening displacement records were used to calculate the constant "c_o" in the following equation

$$\delta = c_o \frac{\sigma a}{\sqrt{Q}}$$

- where
- δ = crack opening displacement
 - σ = gross area applied stress
 - a = flaw depth
 - Q = flaw shape parameter (presented in Figure 6 of NASA CR-135036)

Only the initial linear portion of the crack opening displacement records was considered in making these calculations. This was done to avoid the region of stable crack growth and to permit the initial crack dimension to be used. The calculated c_o values were compared to those presented in Appendix B of Reference 2. Reference 2 found that the calculated c_o value was dependent upon the ratio of flaw depth to specimen thickness (a/t) and the flaw shape ($a/2c$). Under the subject study three different flaw shapes were considered within a limit range of flaw depth to specimen thickness (a/t 's). The calculated c_o values from this report were in good agreement with the Reference 2 values. Additionally, the " c_o " values have been compared to a theoretical solution of Kobayashi (3). The agreement between the experimental values obtained in both this study and Reference 2 with the theoretical solution is quite good especially for flaw depth to thickness ratios in excess of 0.40.

The slopes of the crack opening displacement record during load and unloading were compared to the initial and final flaw sizes. The linear portion of the loading curve and the initial linear portion of the unload curve were considered in these calculations. It was hoped that these linear portions of the curves being reflection of the compliance of the specimen at the flaw would be directly relatable to flaw size. The ratio of final to initial compliance was compared to the ratio of final to initial flaw depth. The data generally fell within an acceptable scatter band, however, there were a number of points which varied significantly from the general data trends. Specimen to specimen variation in flaw shape within target flaw shape range were not considered nor was the change in flaw shape as a result of the crack growing considered. The results of the brief investigation suggests that the comparison of the loading and unloading slopes will generally yield some insight into the extent of stable crack growth that has occurred. A further review of the crack opening displacement records may yield information which can be used to determine flaw sizes directly.

The load-extensometer and load-steam gage curves generated during the mechanical property characterization portion of the program are presented in Appendix III. The extensometer curves were used in the calculation of the yield strength. A 50.8 mm (2.0 inch) gage length was used for all of the extensometer tests.

The strain gage records have been identified as either axial strain gage or Poisson's strain gage. The axial strain gages were mounted on the specimen parallel to the loading direction and the Poisson's strain gages were oriented perpendicular to the loading direction. The strain gage results were used in the calculation of Poisson's Ratio.

References:

1. R. W. Finger, "Proof Test Criteria For Thin Walled 2219 Aluminum Pressure Vessels," Volume I NASA CR-135036, August 1976
2. J. N. Masters, W. D. Bixler, R. W. Finger, "Fracture Characteristics of Structural Aerospace Alloys Containing Deep Surface Flaws" NASA CR-134587, December 1973.
3. A. S. Kobayashi, "Crack Opening Displacement in A Surface Flawed Plate Subjected To Tension or Plate Bending". Boeing Document D180-19446-1, February 1976.

APPENDIX I - Center Crack Panel Crack
Opening Displacement Records

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BCR 11-1

$t = 0.1255$

$W = 11.993$

Area = 1.3051

Specimen
BCR 11-1

70- ULT 69100

0.005
INCH



(K/ps)

LOAD

70-

60-

50-

40-

30-

20-

10-

$< 0.05\% >$

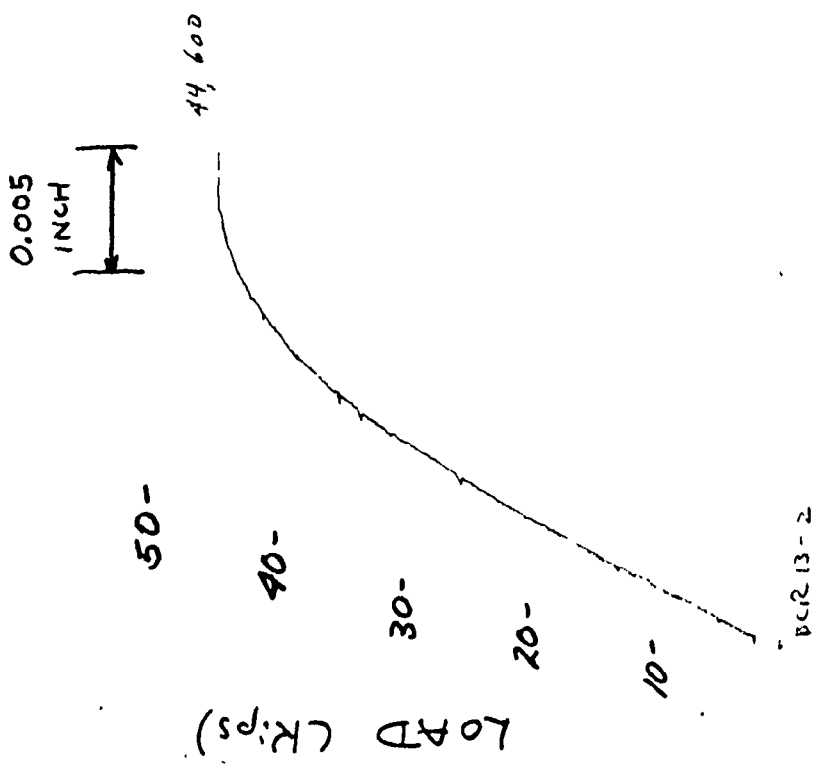
RT

4-23-5 ST

BCR 11-1

Specimen
BCR 13-2

BCR 13-2
 $f = .123$
 $w = 126$
 Area = 1.976
 $\sigma_{Gross} = 30.2$



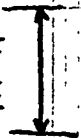
RT

100%

Specimen

BCR 14-2

0.005
INCH



50-

(Kips)

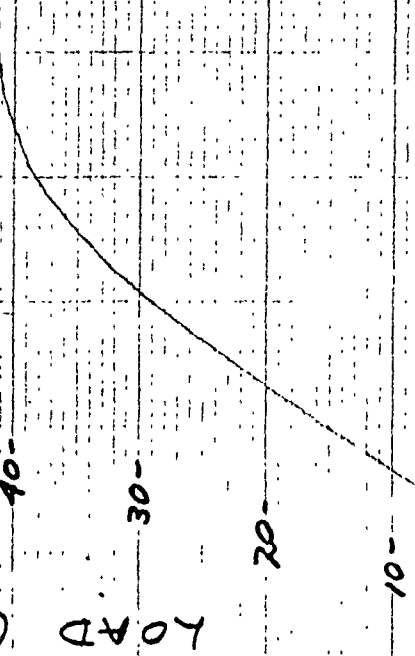
40-

30-

20-

10-

DEF. 41,500



RT.

<005%>

579-3

BCR 14-2

BCR 21-1

Specimen

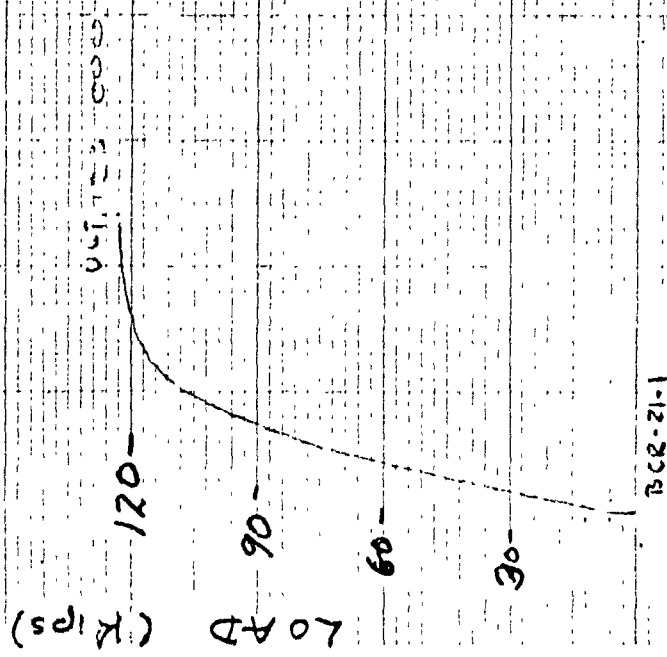
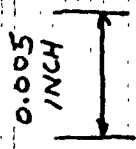
BCR 21-1

$t = 0.2474$

$W = 12.01$

$A_{area} = 2.9713$

$V = 41.4$



P.T.

4.005 (1.7)

4-23-5 sil

BCR-21-1

BCR 21-2

Specimen
BCR21-2

0.005
INCH

UT 102,000

100-

LOAD (KIPS)

01

80-

60-

40-

20-

BCR21-2

UT

1000

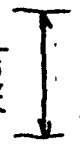
5.66



BCR23-1

Specimen
BCR23-1

0.005
INCH



126,800

110

120

100

80

60

40

20

LOAD (KIPS)

500% →

R.T.

5-6-5 S-

BCR23-1

BCR 23-2

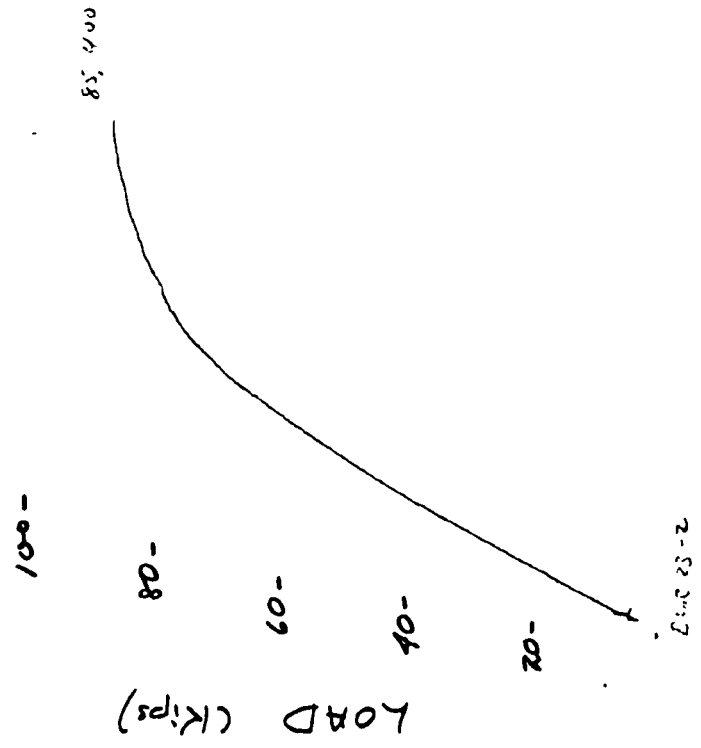
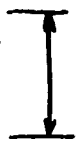
t = .2971

w = 12.008

Area = 2.9672

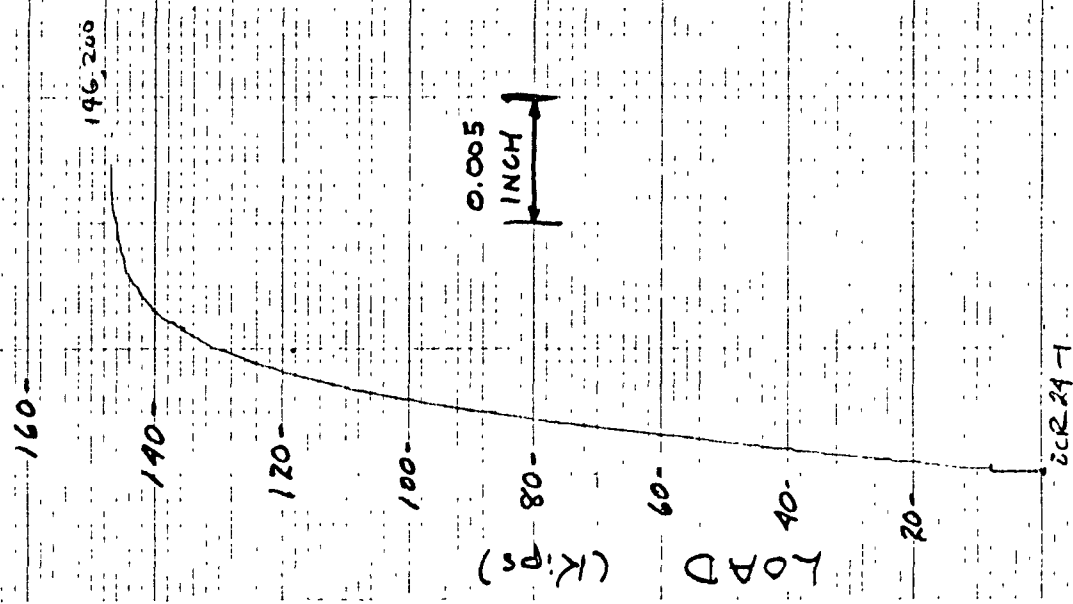
$\sigma_g = \frac{85.4}{2.9672}$

0.005
INCH



Specimen
BCR 23-2

Specimen
BCR 24-1



4005 >
RF
55-5.5m

24 8

BCR 31-1

Specimen
BCR 31-1

0.005
INCH

ULT 171,000 LBS.

140-

150-

120-

90-

60-

30-

(Kips)
LOAD

R.T.

< 0.05% >

4-22-55 SK

BCR 31-1

BCR31-2

160-

140-

120-

100-

80-

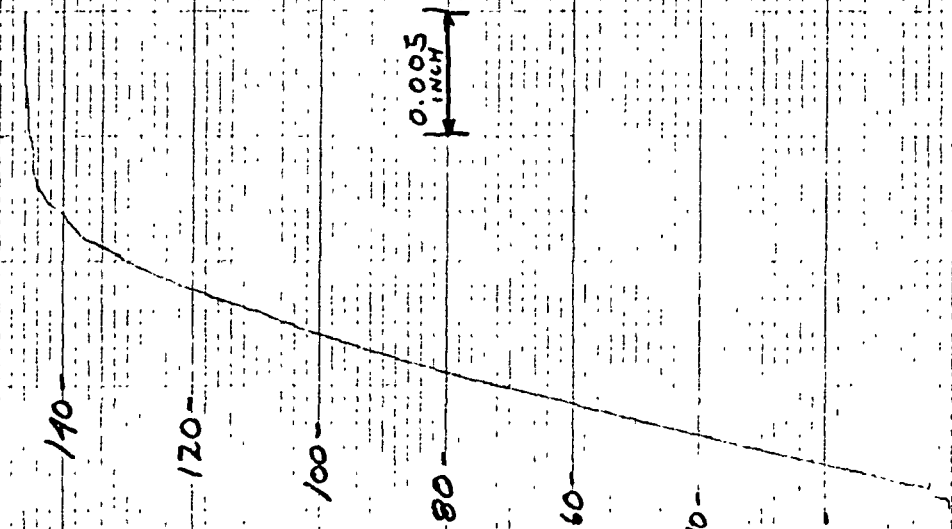
60-

40-

20-

LOAD (KIPS)

ULT 146,000



Specimen
BCR31-2

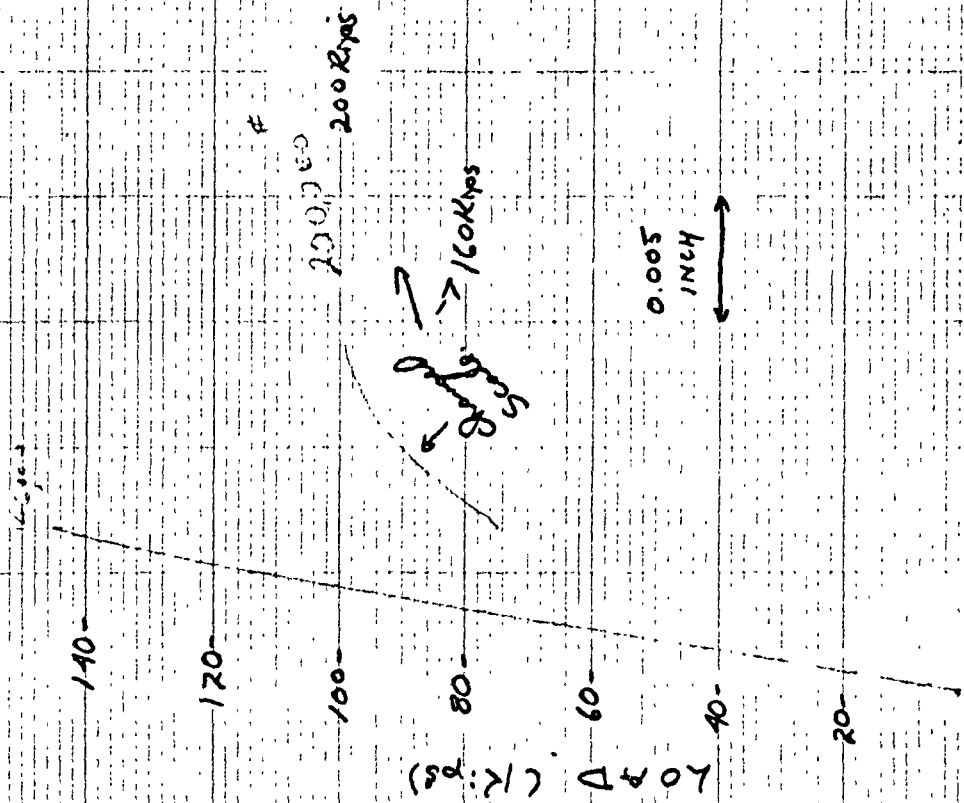
< 0.5% >
PT.
6.30.5 4C

~~BCR31-2~~
BCR31-2

BCR 33-1

Specimen
BCR 33-1

BCR 33-1



< 0.005 >

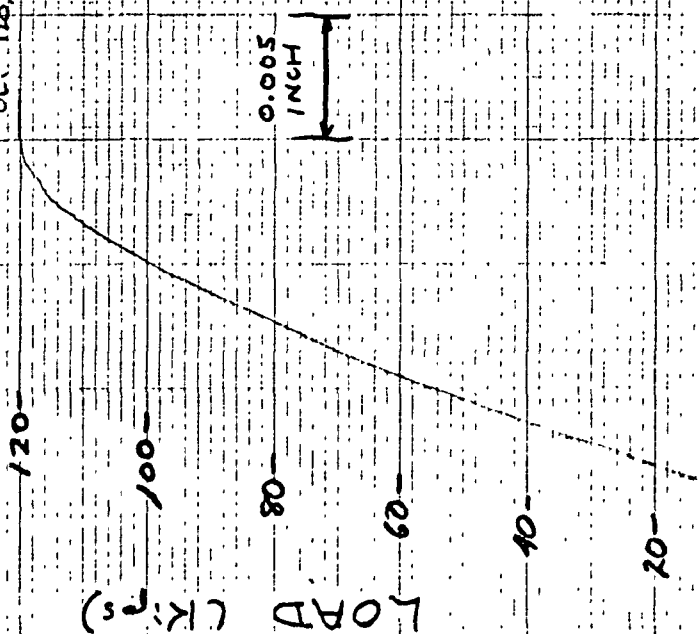
EDF
TRT
4-30-75

BCR 33-2

Specimen

BCR 33-2

0.5 125.400

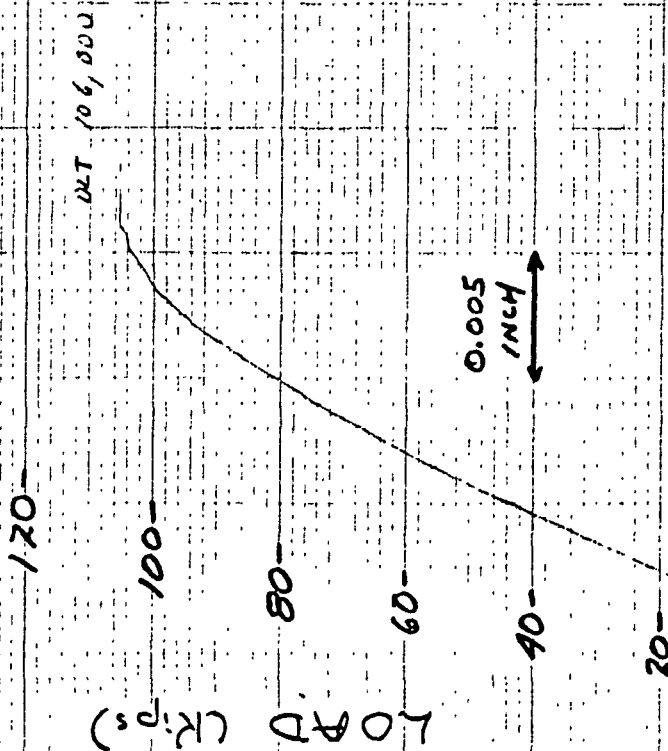


RT
2005/1.2
6-30-5

BCR 33-2

Specimen

BCR 34-2

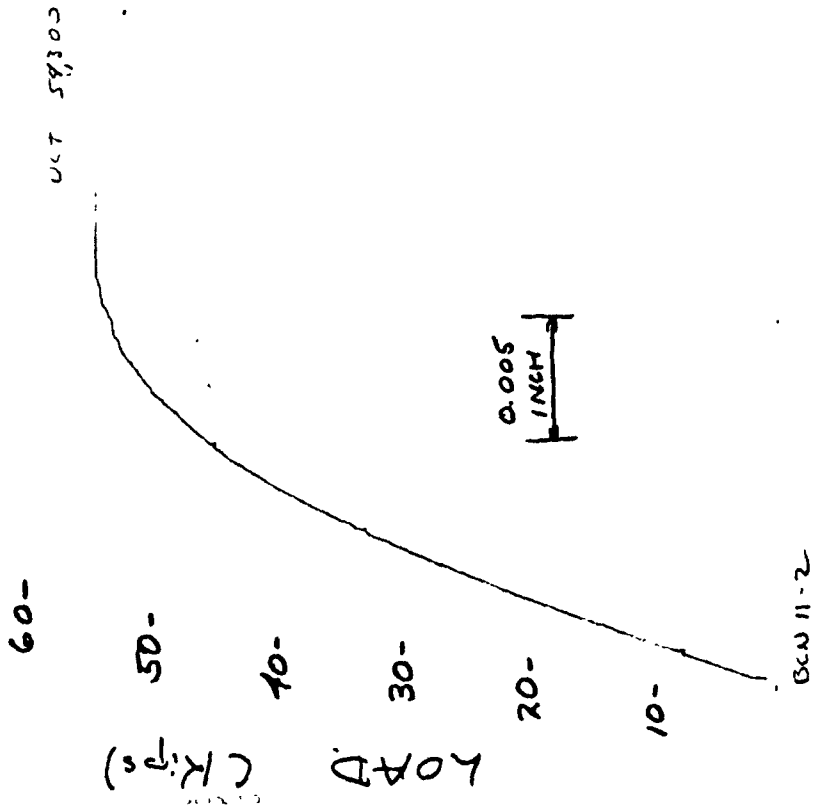


R.T.
< 0.05% >
5.29-5

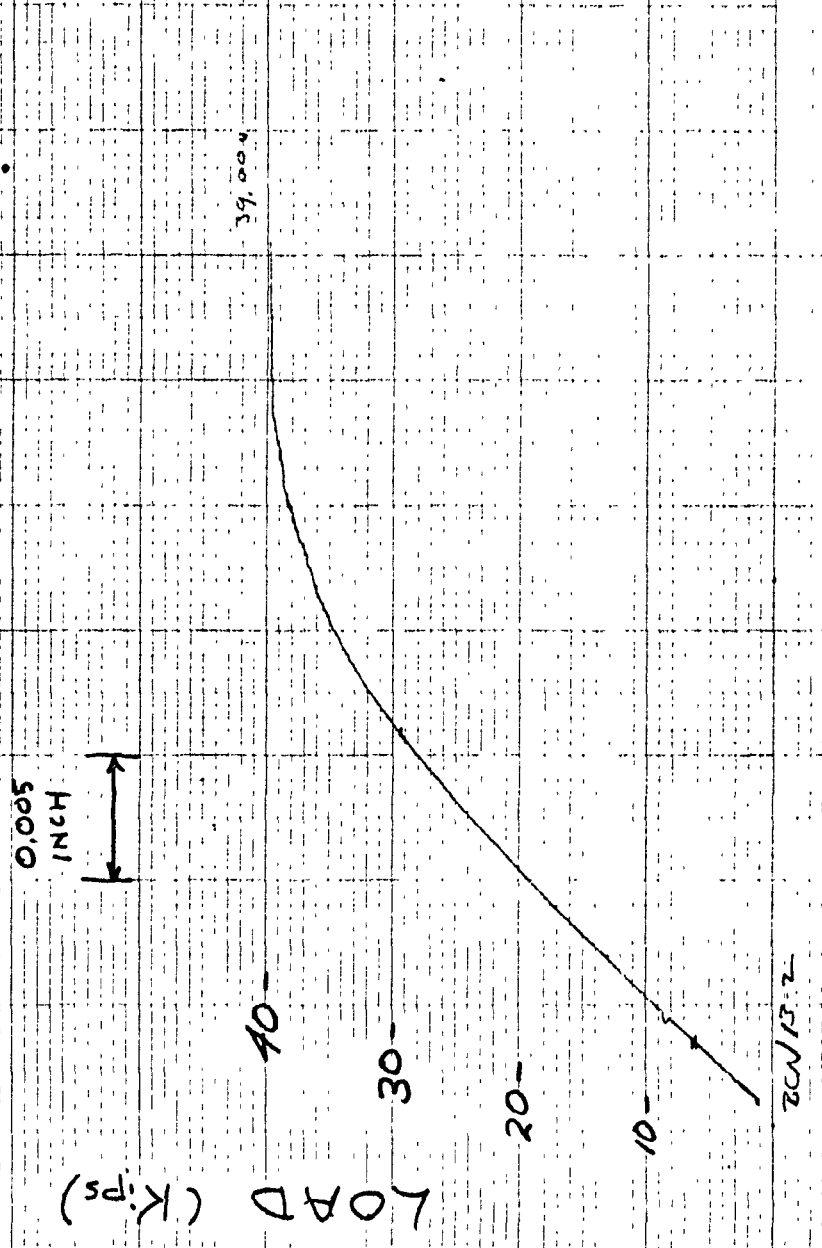
BCR 34-2

BCN 11-2

Specimen
BCN 11-2



Specimen
BCN 13-2



BCN 21-1

Specimen
BCN 21-1

140-

ULT 139,000

120

100-

(K
P)

80-

0.005
INCH

60-

40-

20-

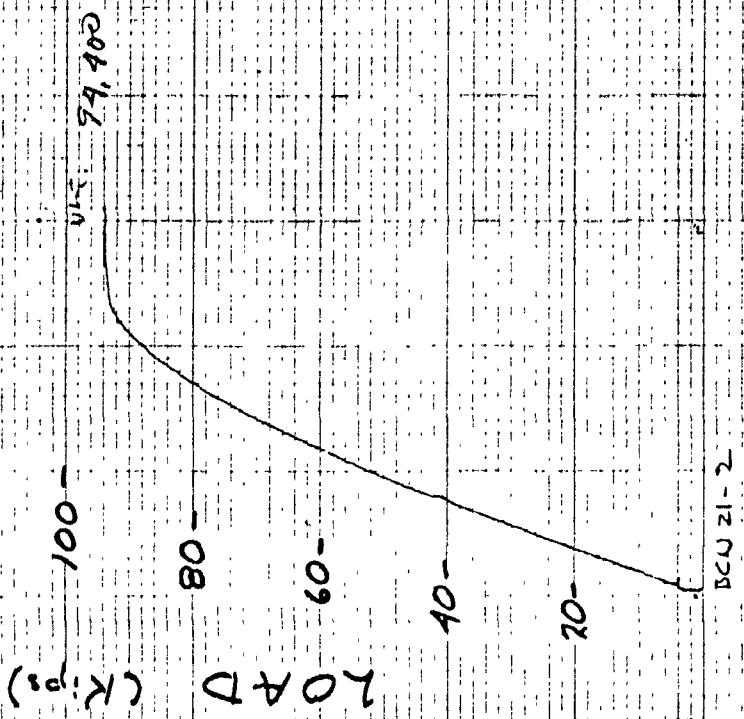
0.005%
-320°F LN₂
4-24-5 SL

BCN 21-1

BCN 24-2

Specimen
BCN 21-2

0.005
INCH



$$\frac{79.4}{2.9605} =$$

$\times 0.0573$

BCN 21-2

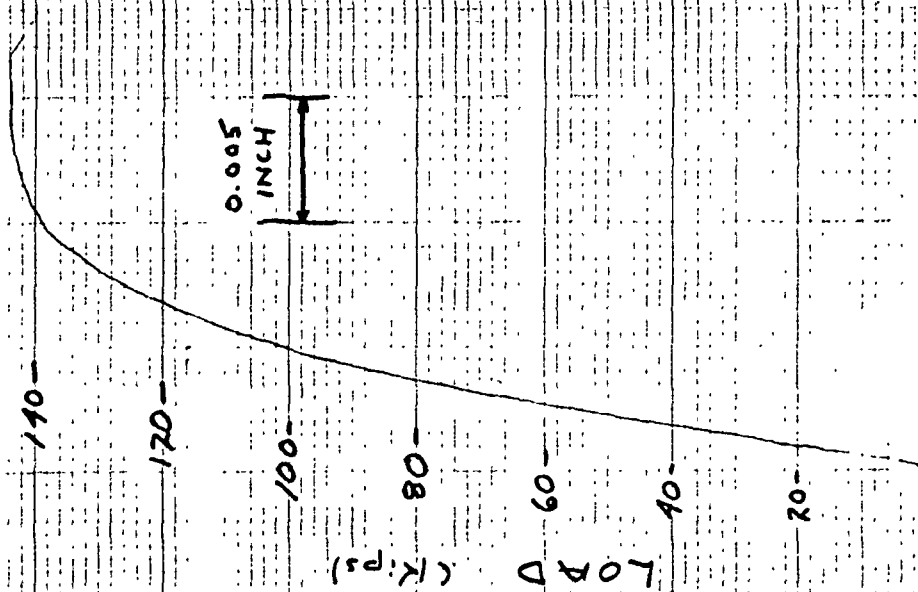
320
LN 2

BCN 23-1

Specimen

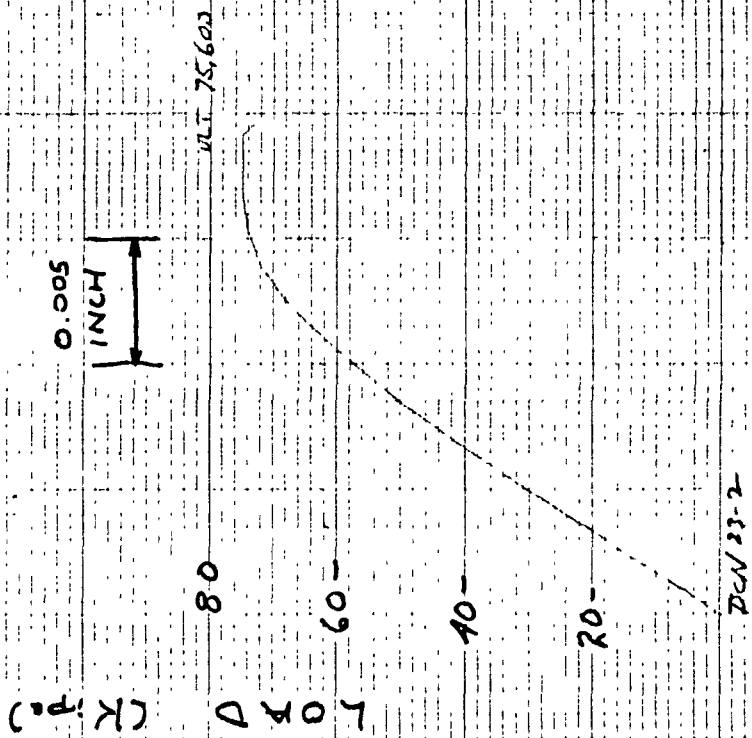
BCN 23-1

0.57 144,000



$\approx 0.005 \text{ INCH}$
 $\approx 320 \text{ PS}$
 $\approx 5.2 \times 10^{-5}$

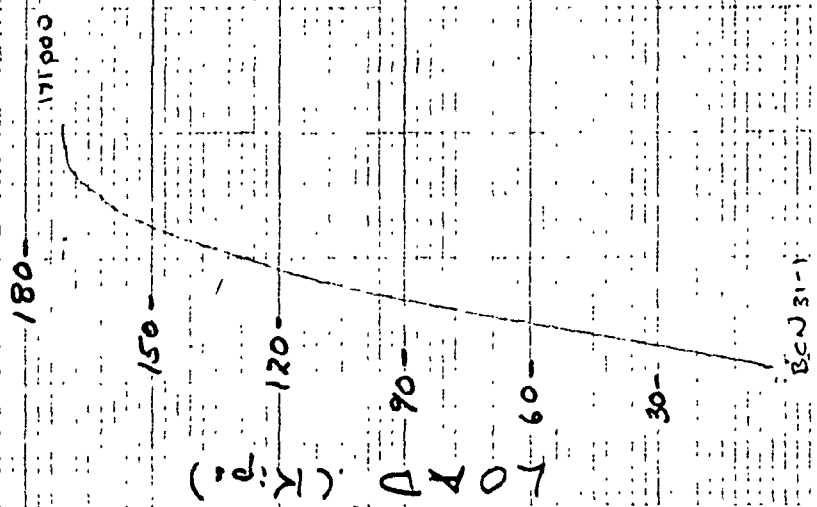
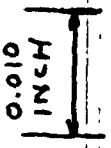
Specimen
BCN 23-2



200% >
-320% 21%
5-24-5 5A

BCN 31-1

Specimen
BCN 31-1

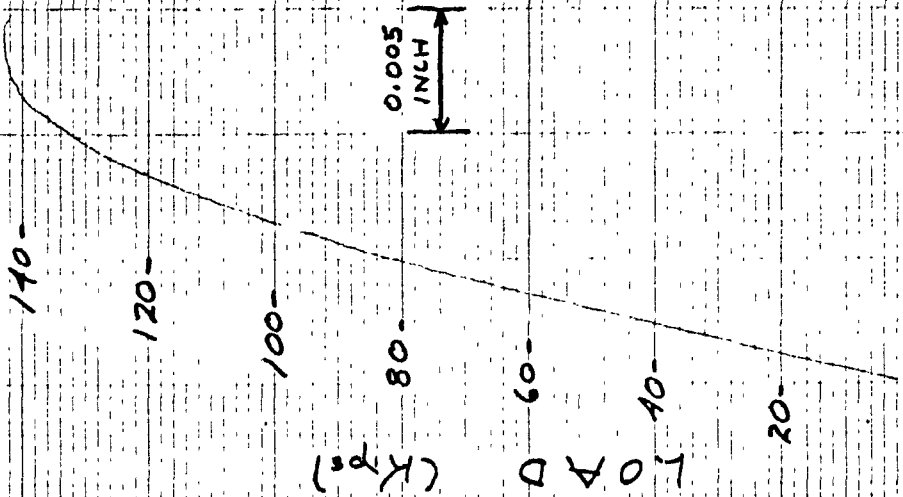


6.9%
-320°F W₂
4-29-5

BCN 31-2

Specimen
BCN 31-2

140- 120- 100- 80- 60- 40- 20-



← 0.005 m →
-320'12 LNL
6-30-5 SL

BCN 31-2

BCN 33-1

Specimen

BCN 33-1

0.005
INCH
5000

19500

200

160

120

80

10

0

LOAD (KI) 2

BCN 33-1

4005 >

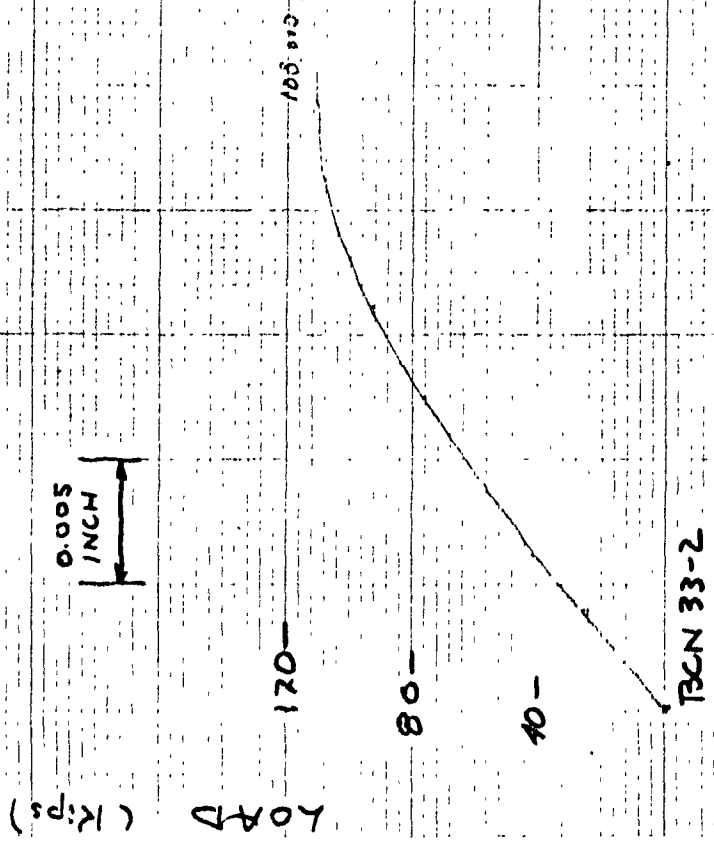
3201F 4M

5-5-5 5

Specimen



BCN 33-2



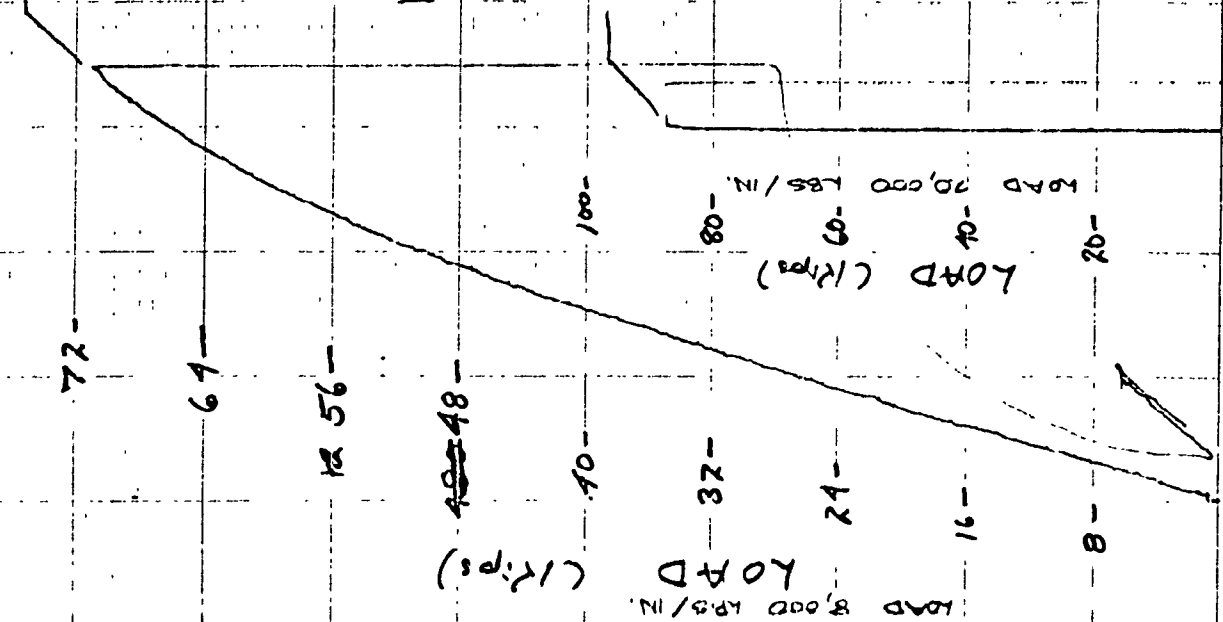
330 1.14
 505
 5-15-6 24

Specimen
BCH 11-1

79,500 LBS (1ST LOADING)

0.002
/ INCH

85,000 LBS 2ND LOADING (FAILURE)
(CSDI IN OPERATIVE)



SPECIMEN BCH 11-1 (-913° F)
TOTAL LIFE TEST SITE
4-29-75

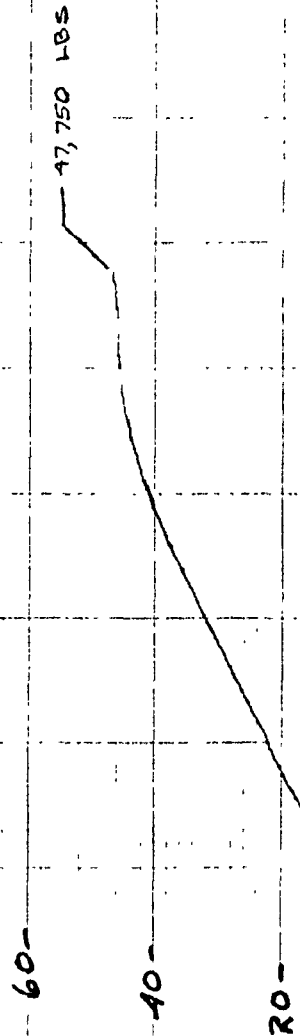
CRACK DISPL ~ 0.002 IN./IN.

Specimen
BCH 11-2

LOAD (Kips)

LOAD ~ 20,000 LBS/IN

0.001
INCH

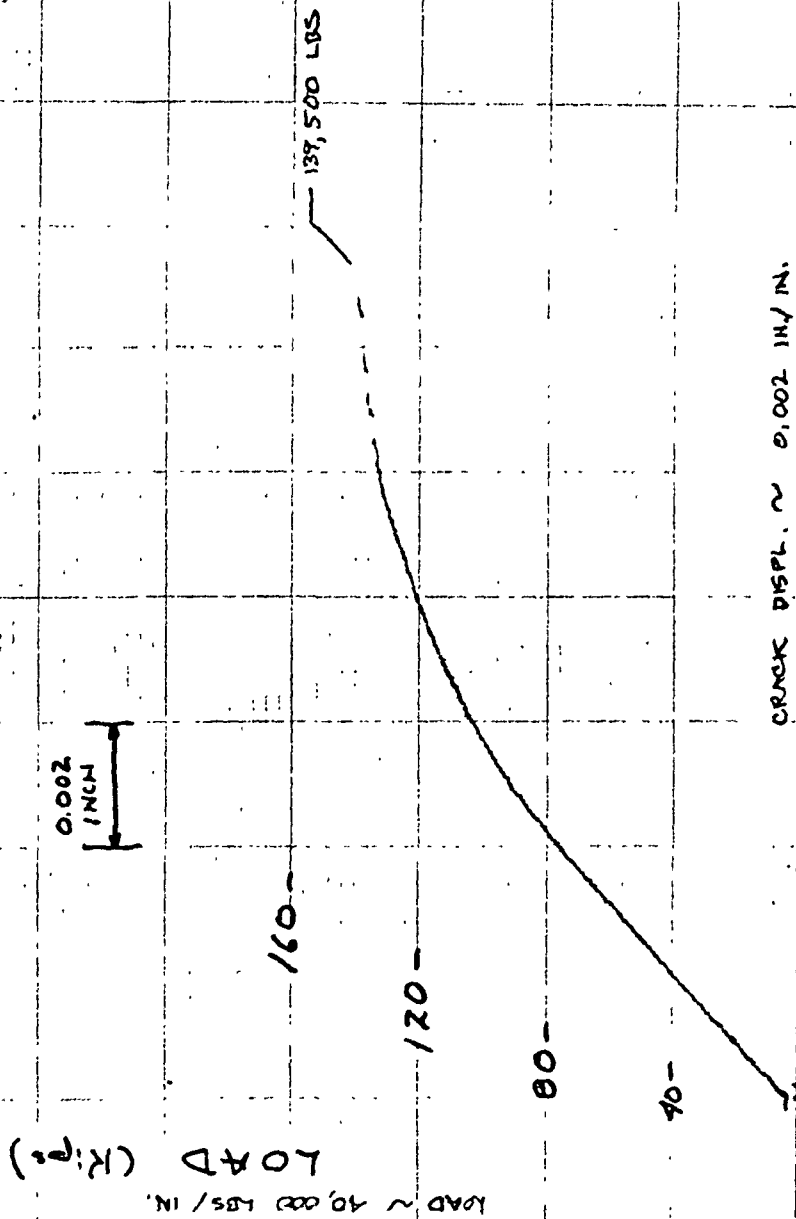


SPECIMEN BCH 11-2
LOAD TO FAILURE IN LH2
TUALIP 8-25-75

Specimen

BCH 21-1

SPECIMEN BCH 21-1 (-113°F)
TUALIP TEST SITE
5-1-75



BCH 21-1
5-1-75

Specimen

BCH 21-2

LOAD (KIP)

LOAD ~ 2000 LBS/IN

0.001
INCH



78,500 LBS

80-

60-

40-

20-

SPECIMEN BCH 21-2
LOAD TO FAILURE IN LH2
TOTALIP 8-25-75

CRACK DISPL ~ .004 IN/IN

Specimen
BCH 31-1

SPECIMEN BCH 31-1 (-473°F)
TULALIP TEST SITE
5-1-75

0.002
INCH

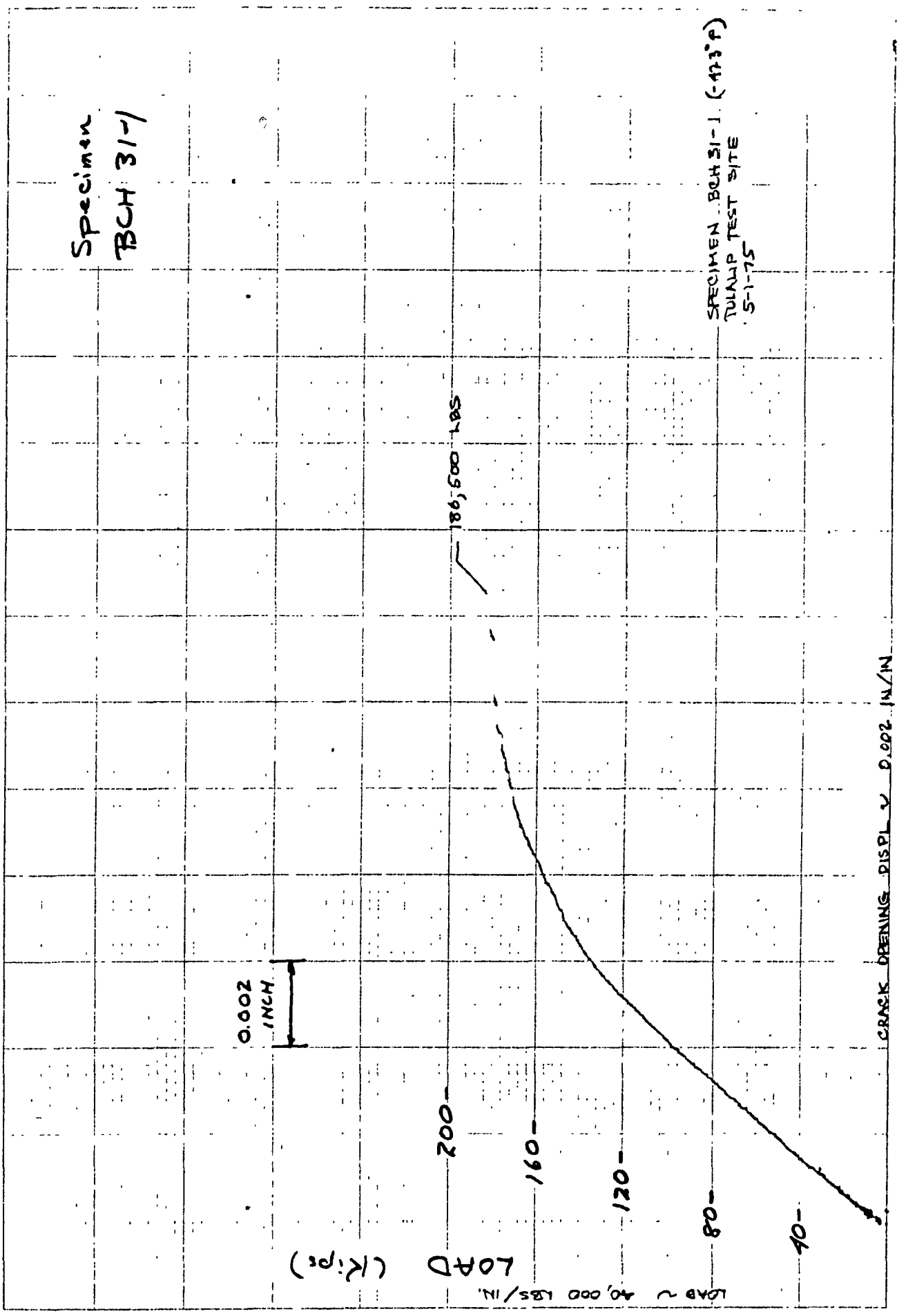
LOAD (Kips)

LOAD ~ 40,000 LBS/IN.

186,000 LBS

CRACK OPENING DISPL V 0.002 IN/IN

BCH 31-1
5-1-75



Specimen

BCH 31-2

SPECIMEN BCH 31-2
LOAD TO FAILURE IN LH2
TULALIP 8-25-75

0.004
INCH

113,750 LBS

LOAD (Kips)

LOAD ~ 20,000 LBS/IN

CRACK DISPL ~ 0.004 IN/IN

170
100
80
60
40
20

L = 0.1262

W = 17.000

Area = 1.5144

$\sigma = 31.0$

RT

Specimen
WCNH-1

0.005

INCH

ULT 47000 LBS

50

40

30

20

10

(K)

PLO

<005/>

RT

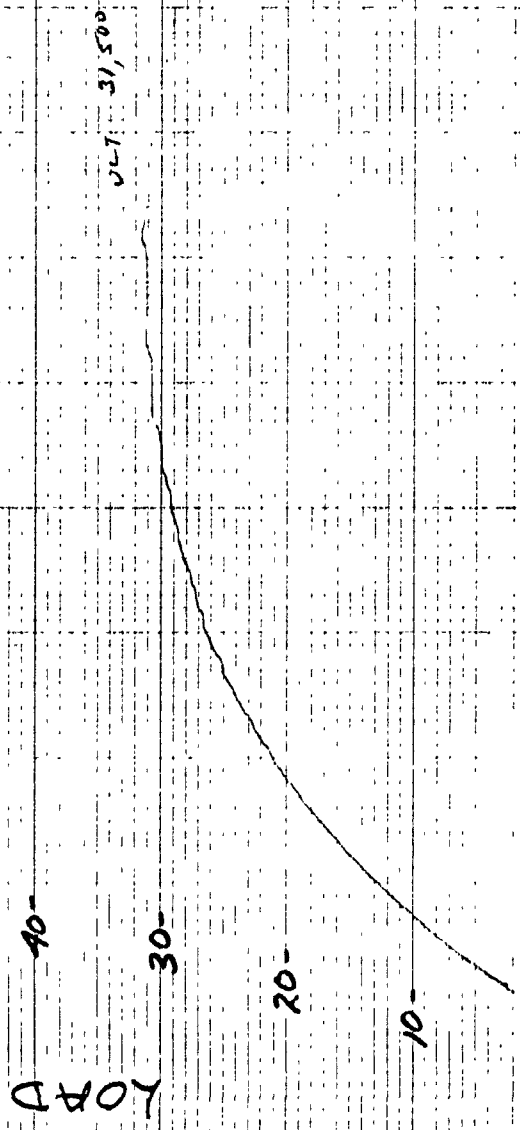
4-23-5 SK

WCNH-11-1

Specimen
WCR11-2

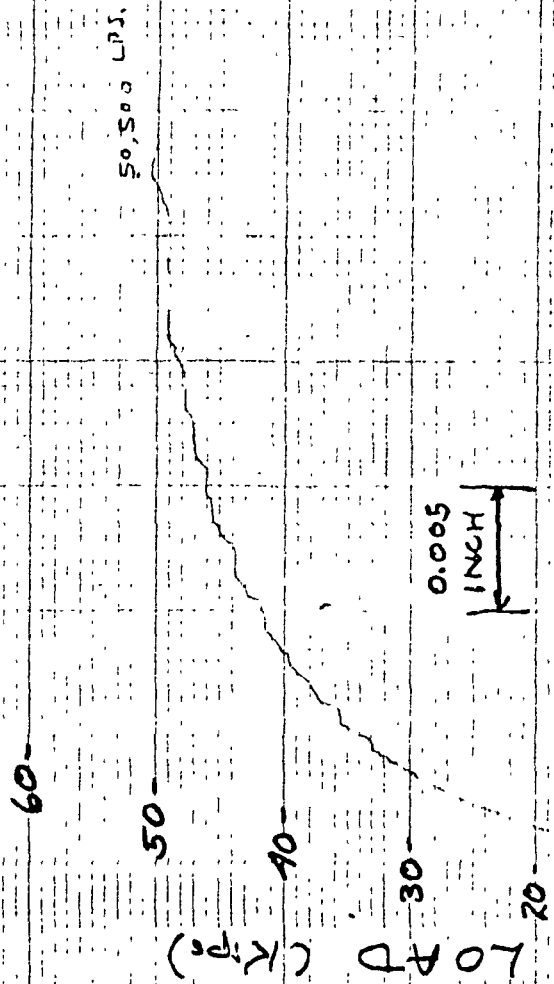
LOAD (Kips)

0.005
1/2
500.0



WCR 11-2
5-29-5

Specimen
WCR 13-1

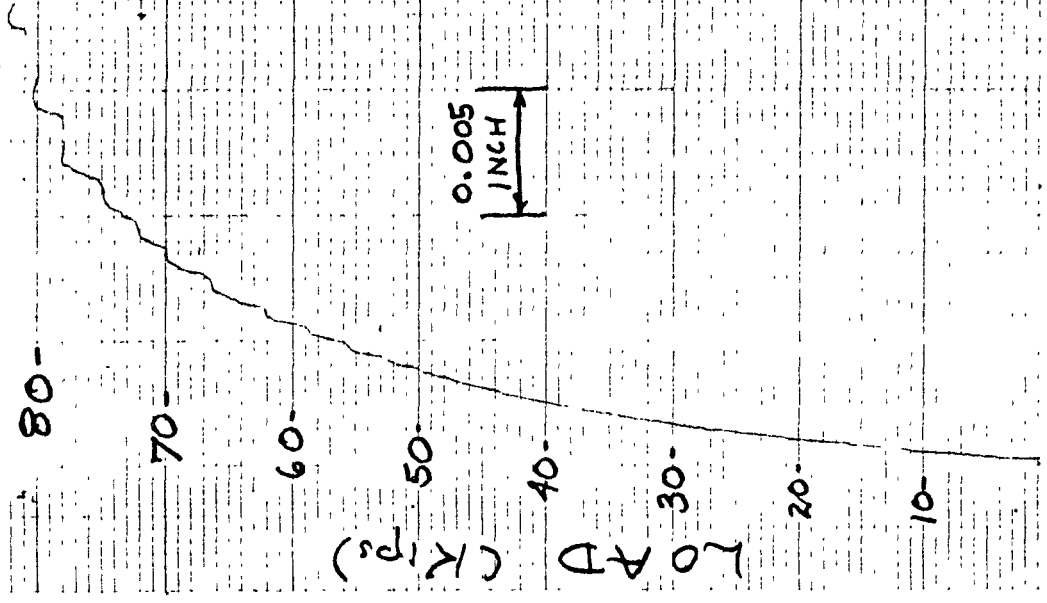


5.905/3
P.T.
WCR 13-1

WCR 13-1

Specimen
WCN 21-1

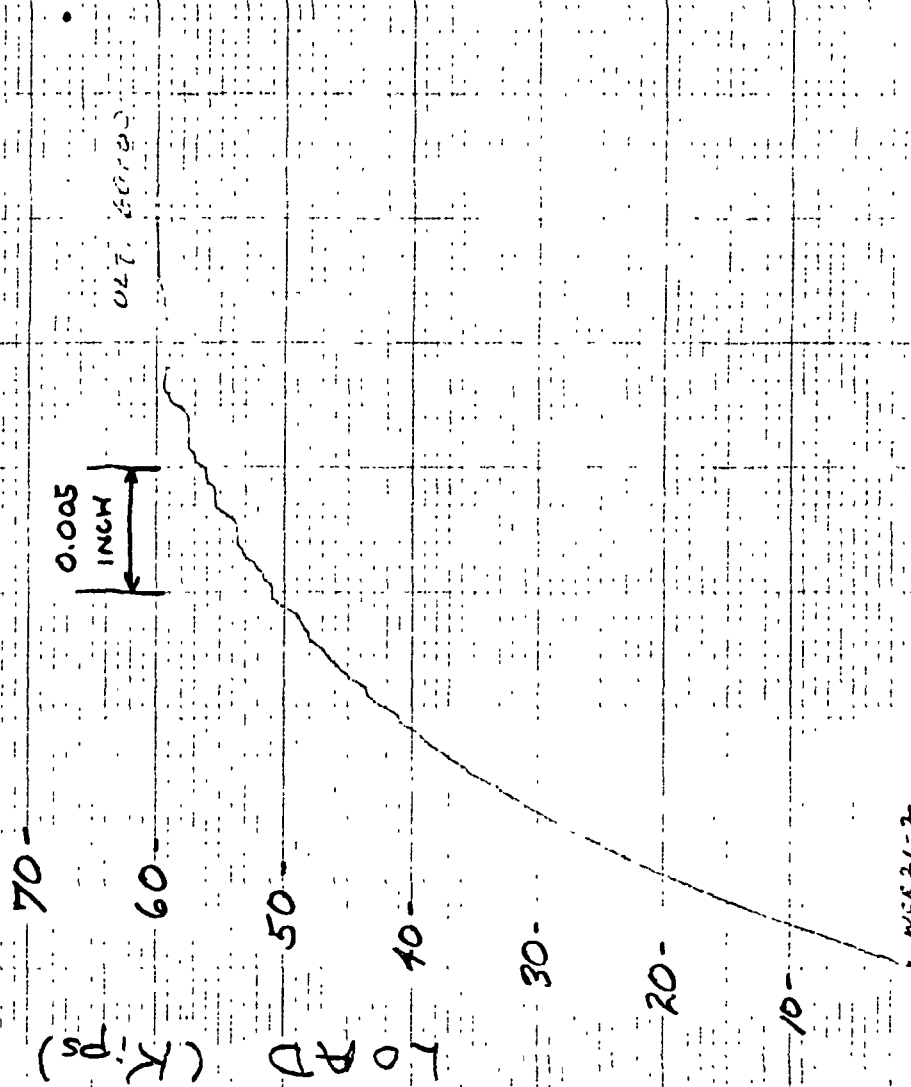
ULT 82,100 LBS



< 0.05%
RT.
4-22-53

WCN 21-1

Specimen
WCR 21-2



P.T.
0.005%
5-0-0-5-0-0

85,000

70-

80-

70-

60-

50-

40-

30-

20-

10-

LOAD (Kips)

LOAD

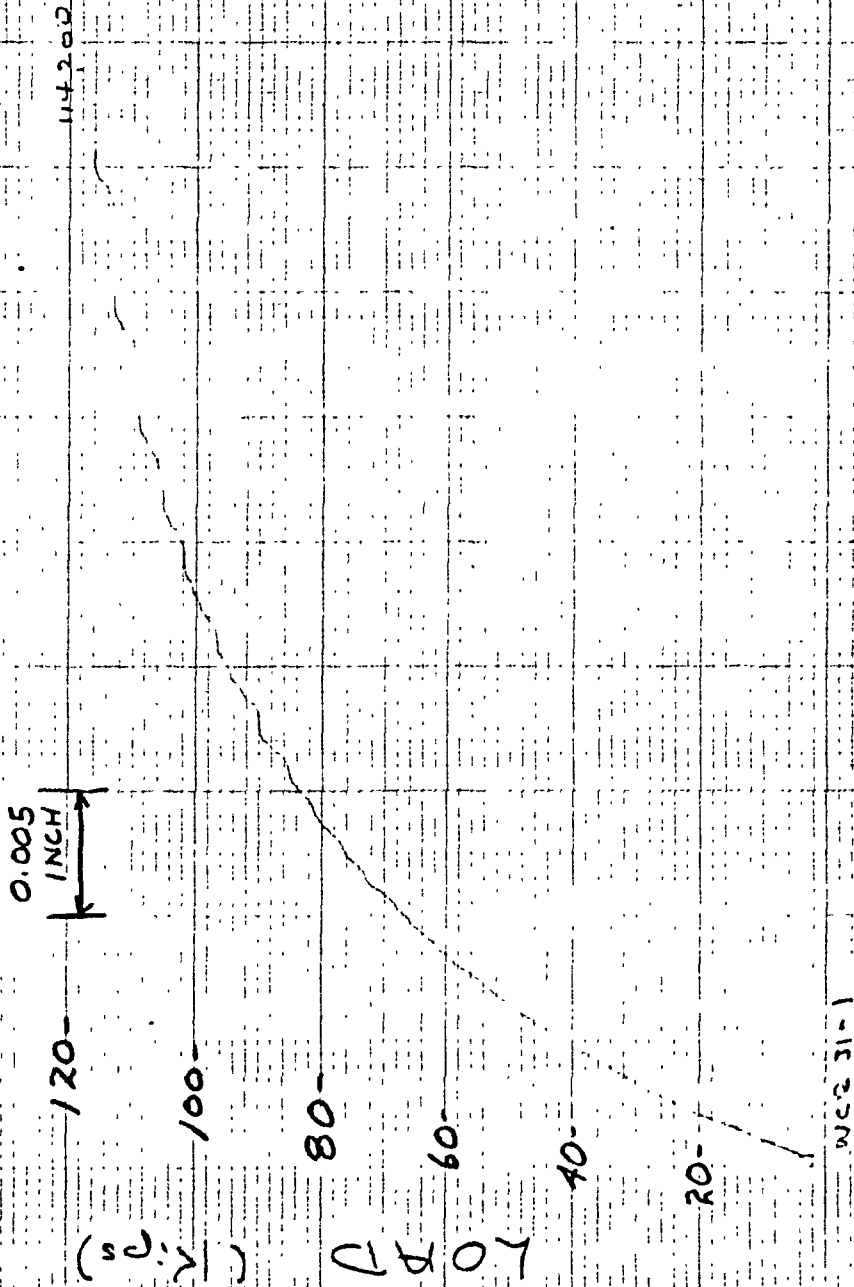
0.005
INCH

Specimen
WCR23-1

R.T.
4.005%
4.29 = S

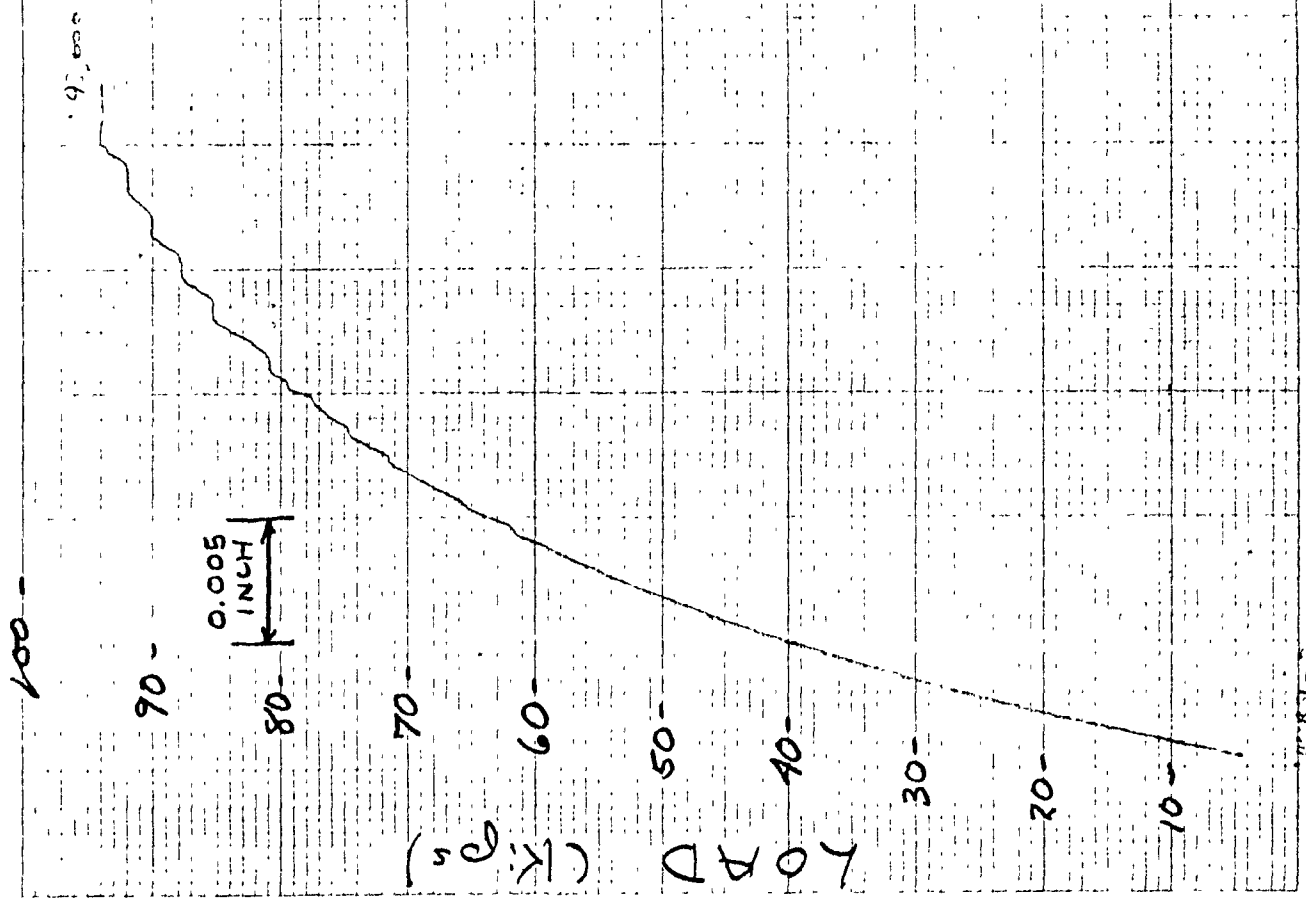
WCR 23-1

Specimen
WCR31-1



R.T.
2-25-57
4-30-58

Specimen
WCR 31-2



L.T.
< 0057 >
5728-57 52

Specimen

WCR33-1

129,500

0.005
INCH

140-

120-

100-

80-

60-

40-

20-

(K:ps)

LOAD

RT.
2015 >

5-5-5 sin

wcr33-1

Specimen

WCR11-1

0.005
INCH

ULT 59 #00

60-

50-

40-

30-

20-

10-

LOAD (K) (50)

-320°F LN₂

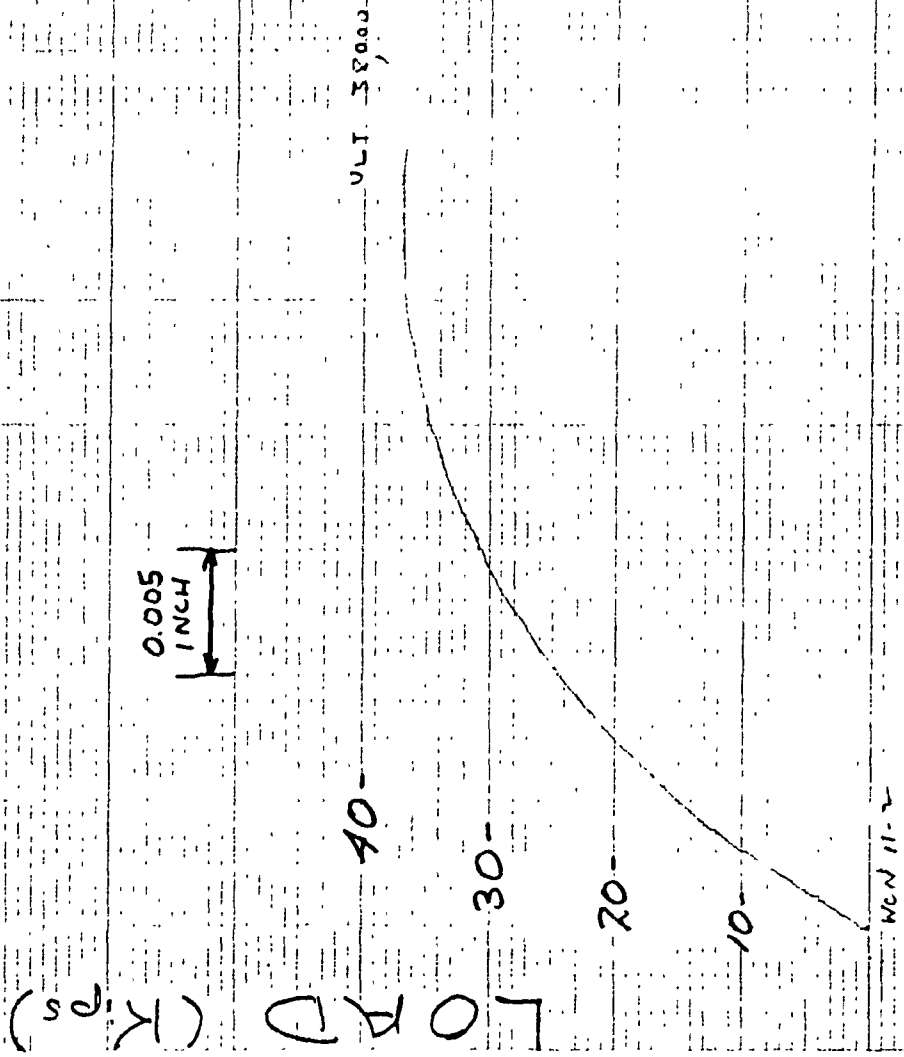
<0.05% >

4-25-5 5/16

WCR11-1

Specimen

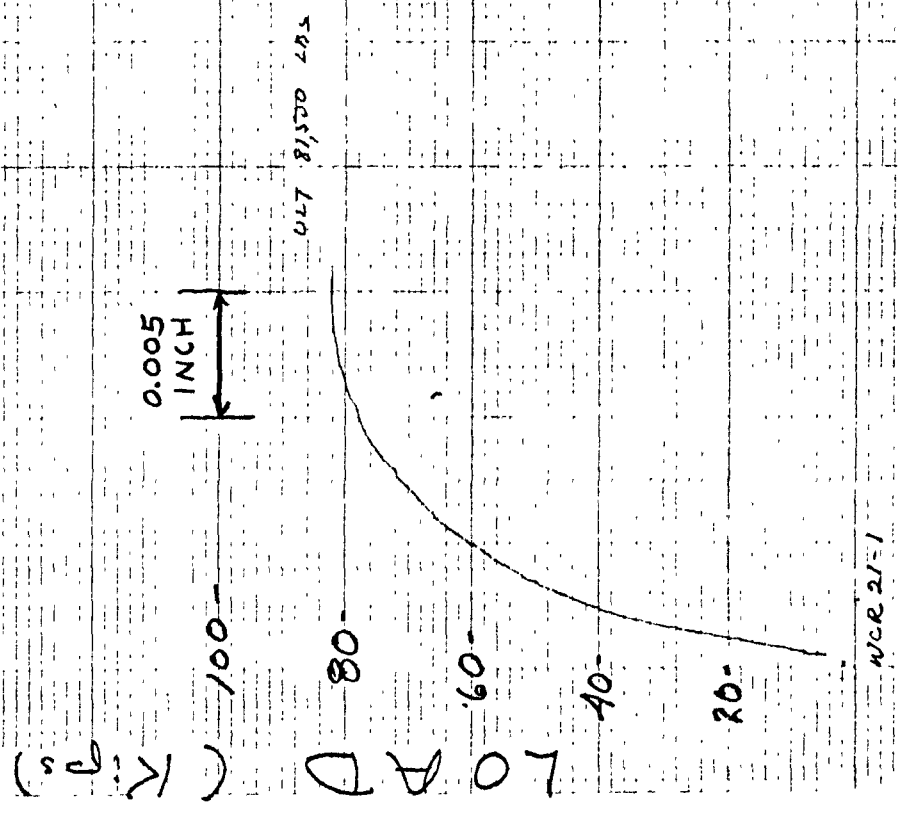
WCN 11-2



-320' = W
< 0.05% >
5.78-5.5



Specimen
WCRZ1-1



<005% >
-32-0°F LN₂
4-29-5 OK

Specimen
WCN21-2

0.005
INCH

LOAD (Kips)

80

60

40

20

61300

WCN21-2

-370°F end
6005" →
529-5 150

Specimen

WCN 31-1

73520

0.005
INCH

140

120

100

80

60

40

20

LOAD (Kips)

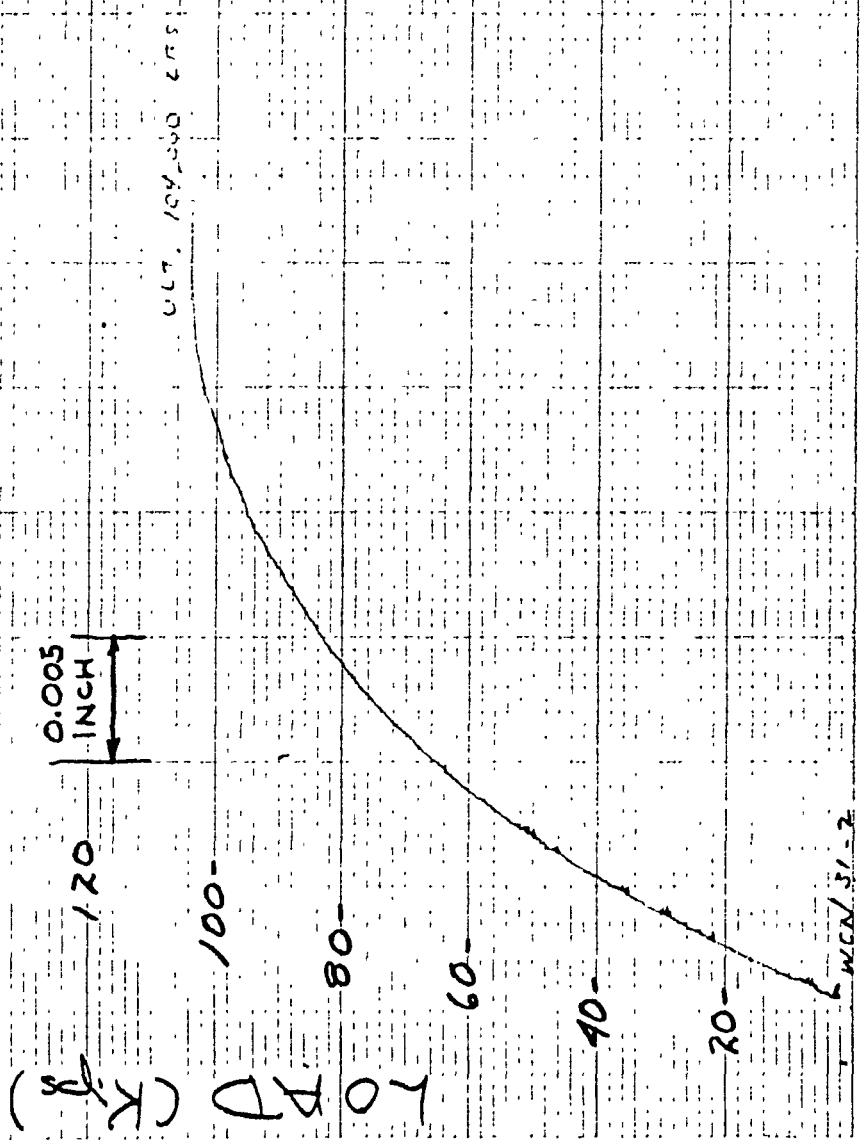
WCN 31-1

- 22012 2 1/2

- 605 1/2

5 5 5 5 5

Specimen
WCN31-2



-3207 LBS
 0.05%
 5-58-5 SL

Specimen

WCH 11-1

0.002
INCH

57,600 LBS

SPECIMEN WCH 11-1 (-423°F)
TULALIP TEST SITE
4-30-75

(Kips)

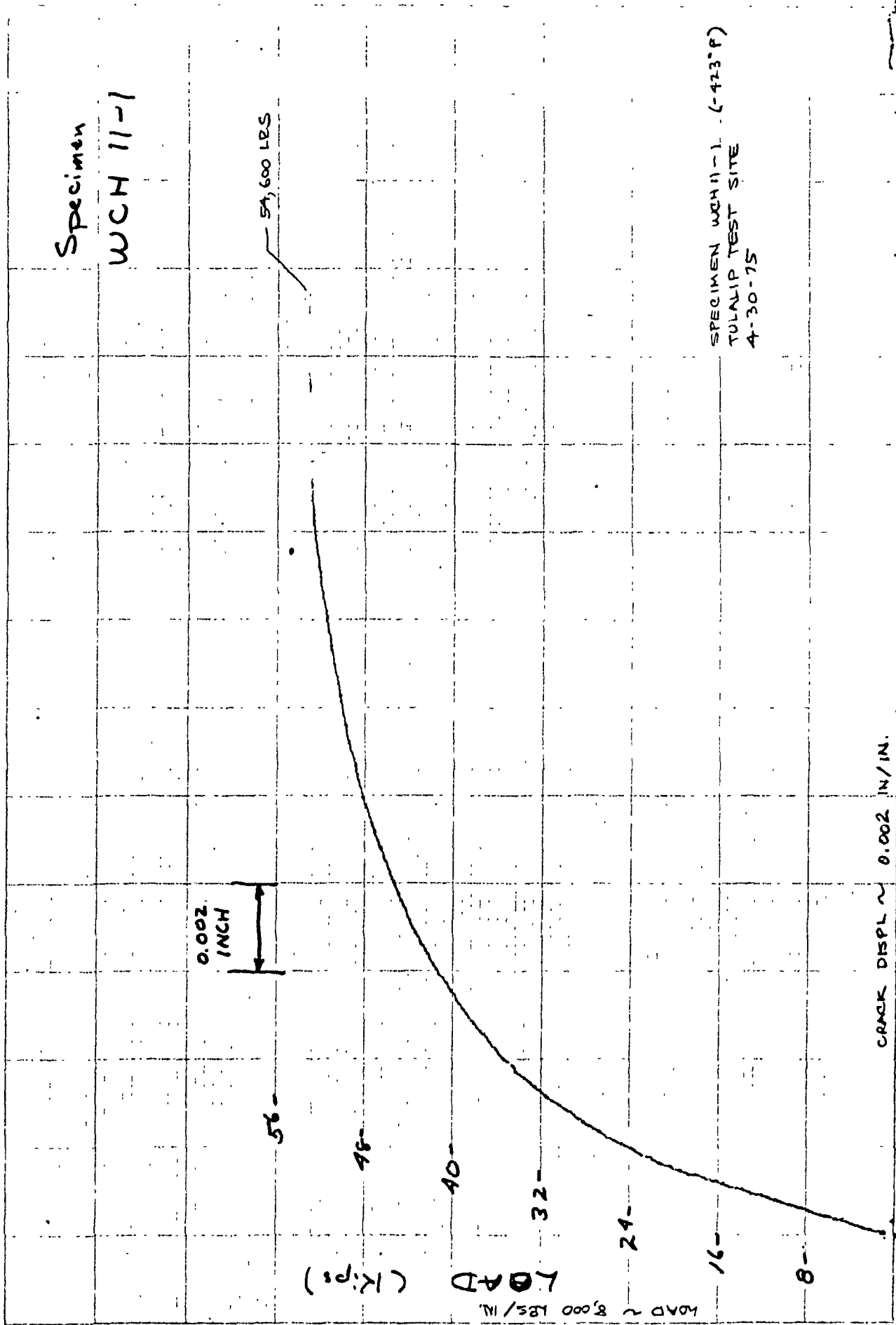
LOAD

LOAD ~ 8,000 LBS/IN.

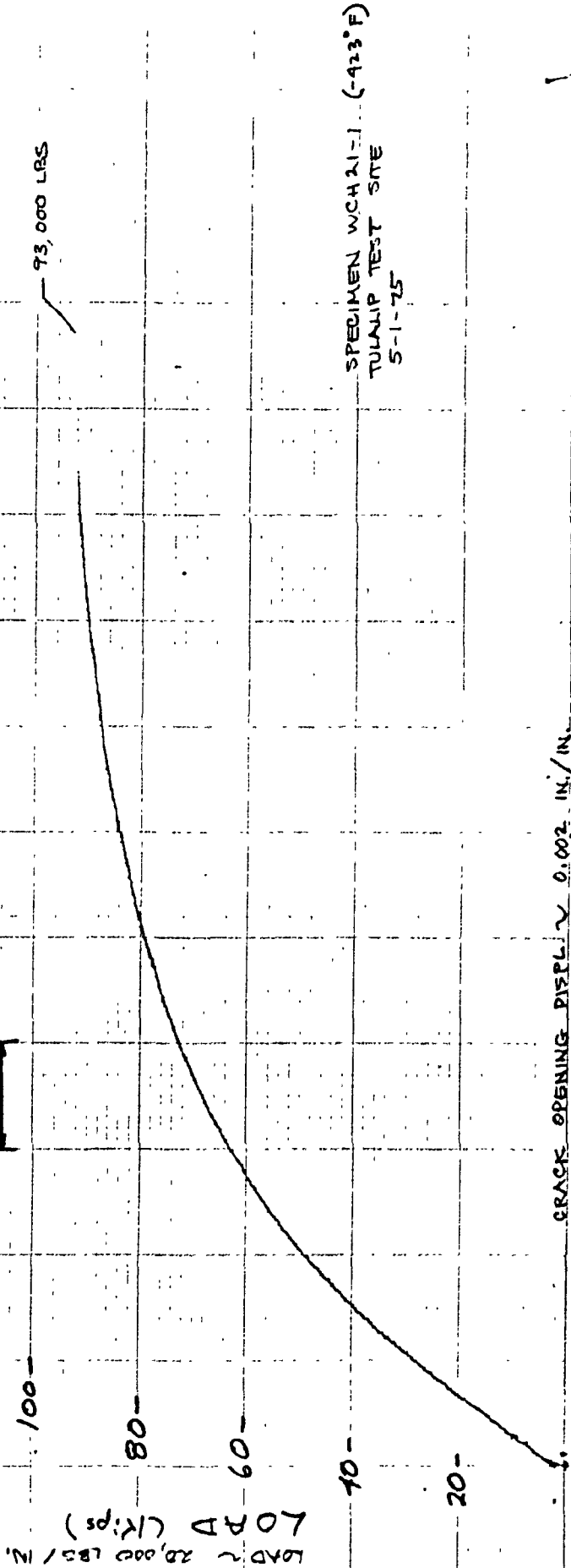
CRACK DISPL ~ 0.002 IN/IN.

11-11-75

8



Specimen
WCH 21-1



SPECIMEN WCH 21-1 (-423°F)
TULALIP TEST SITE
5-1-75

Specimen
WCH 31-1

128,500 LBS

SPECIMEN WCH 31-1 (-423°F)
TULALIP TEST SITE
5-2-75

0.002
INCH

LOAD (Kips)

LOAD ~ 20,000 LBS / K

CRACK OPENING DISPL ~ 0.002 IN / IN.

WCH 31-1
5-2-75

APPENDIX II - Surface Flawed Specimen Crack
Opening Displacement Records

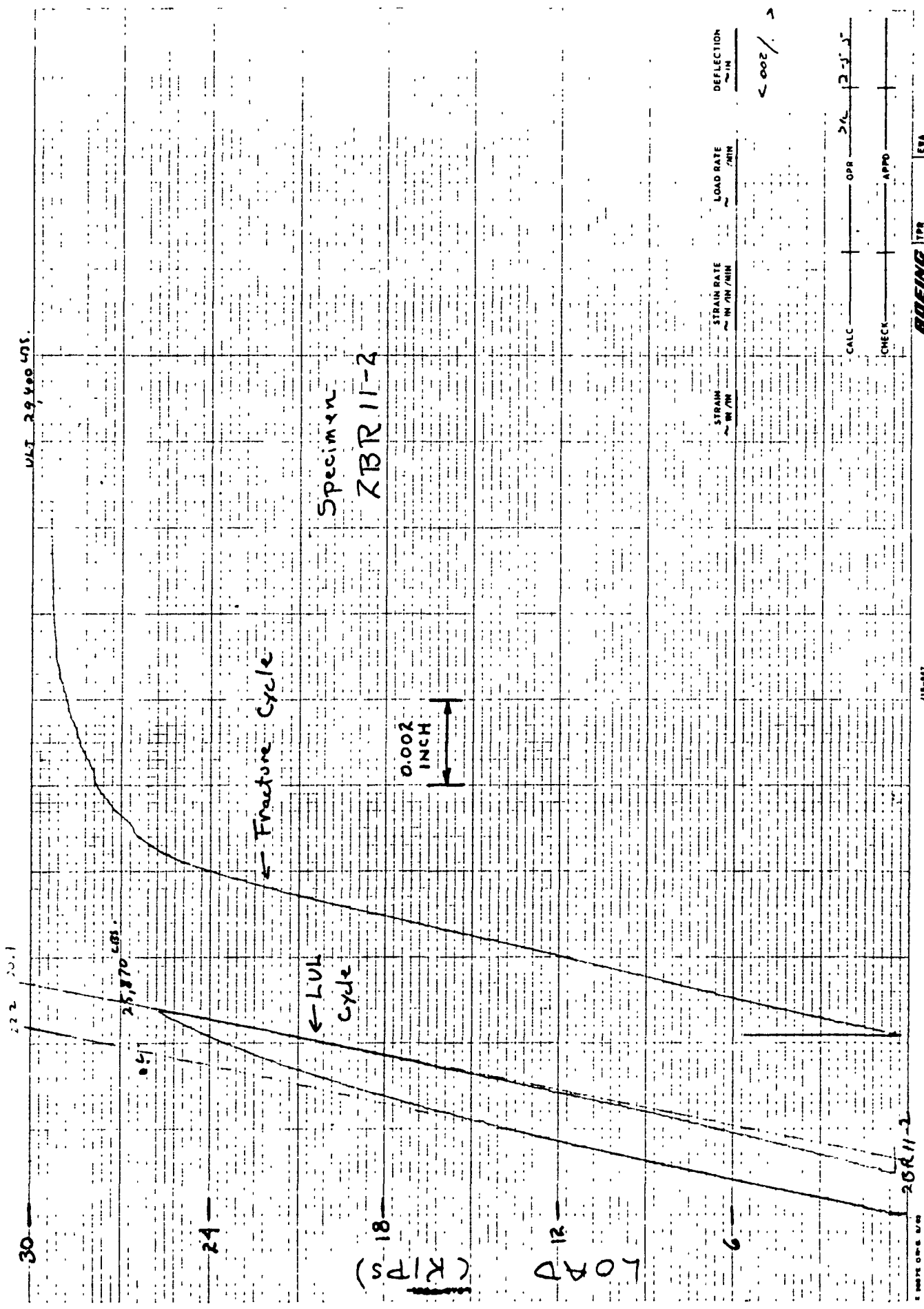
	<u>Page</u>
Crack Opening Displacement Records for the Specimen Presented in Table 14 of Vol. I. CR-135036	59 - 65
Crack Opening Displacement Records for the Specimen Presented in Table 15 of Vol. I. CR-135036	66 - 71
Crack Opening Displacement Records for the Specimen Presented in Table 16 of Vol. I. CR-135036	72 - 79
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Crack Opening Displacement Records for the Specimen Presented in Table 18 of Vol. I. CR-135036	88 - 94
Crack Opening Displacement Records for the Specimen Presented in Table 19 of Vol. I. CR-135036	95 - 102
Crack Opening Displacement Records for the Specimen Presented in Table 20 of Vol. I. CR-135036	103 - 110
Crack Opening Displacement Records for the Specimen Presented in Table 21 of Vol. I. CR-135036	111 - 117
Crack Opening Displacement Records for the Specimen Presented in Table 22 of Vol. I. CR-135036	118 - 125
Crack Opening Displacement Records for the Specimen Presented in Table 23 of Vol. I. CR-135036	126 - 132
Crack Opening Displacement Records for the Specimen Presented in Table 24 of Vol. I. CR-135036	133 - 138
Crack Opening Displacement Records for the Specimen Presented in Table 25 of Vol. I. CR-135036	139 - 146

APPENDIX II - Surface Flawed Specimen Crack
Opening Displacement Records

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Crack Opening Displacement Records for the Specimen Presented in Table 27 of Vol. I. CR-135036	152 - 159
Crack Opening Displacement Records for the Specimen Presented in Table 28 of Vol. I. CR-135036	160 - 165
Crack Opening Displacement Records for the Specimen Presented in Table 29 of Vol. I. CR-135036	166 - 172
Crack Opening Displacement Records for the Specimen Presented in Table 30 of Vol. I. CR-135036	173 - 178
Crack Opening Displacement Records for the Specimen Presented in Table 31 of Vol. I. CR-135036	179 - 181
Crack Opening Displacement Records for the Specimen Presented in Table 32 of Vol. I. CR-135036	182 - 189
Crack Opening Displacement Records for the Specimen Presented in Table 33 of Vol. I. CR-135036	190 - 194
Crack Opening Displacement Records for the Specimen Presented in Table 34 of Vol. I. CR-135036	195 - 200
Crack Opening Displacement Records for the Specimen Presented in Table 35 of Vol. I. CR-135036	201 - 203
Crack Opening Displacement Records for the Specimen Presented in Table 36 of Vol. I. CR-135036	204 - 209
Crack Opening Displacement Records for the Specimen Presented in Table 37 of Vol. I. CR-135036	210 - 216

APPENDIX II - Surface Flawed Specimen Crack
Opening Displacement Records

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Crack Opening Displacement Records for the Specimen Presented in Table 38 of Vol. I. CR-135036	217 - 224
Crack Opening Displacement Records for the Specimen Presented in Table 39 of Vol. I. CR-135036	225 - 229
Crack Opening Displacement Records for the Specimen Presented in Table 40 of Vol. I.	230 - 239
Crack Opening Displacement Records for the Specimen Presented in Table 41 of Vol. I. CR-135036	240 - 243
Crack Opening Displacement Records for the Specimen Presented in Table 42 of Vol. I. CR-135036	244 - 247
Crack Opening Displacement Records for the Specimen Presented in Table 43 of Vol. I. CR-135036	248 - 251



ULT 29.400 KIPS

Specimen
ZBR11-2

← Fracture Cycle

← LUL Cycle

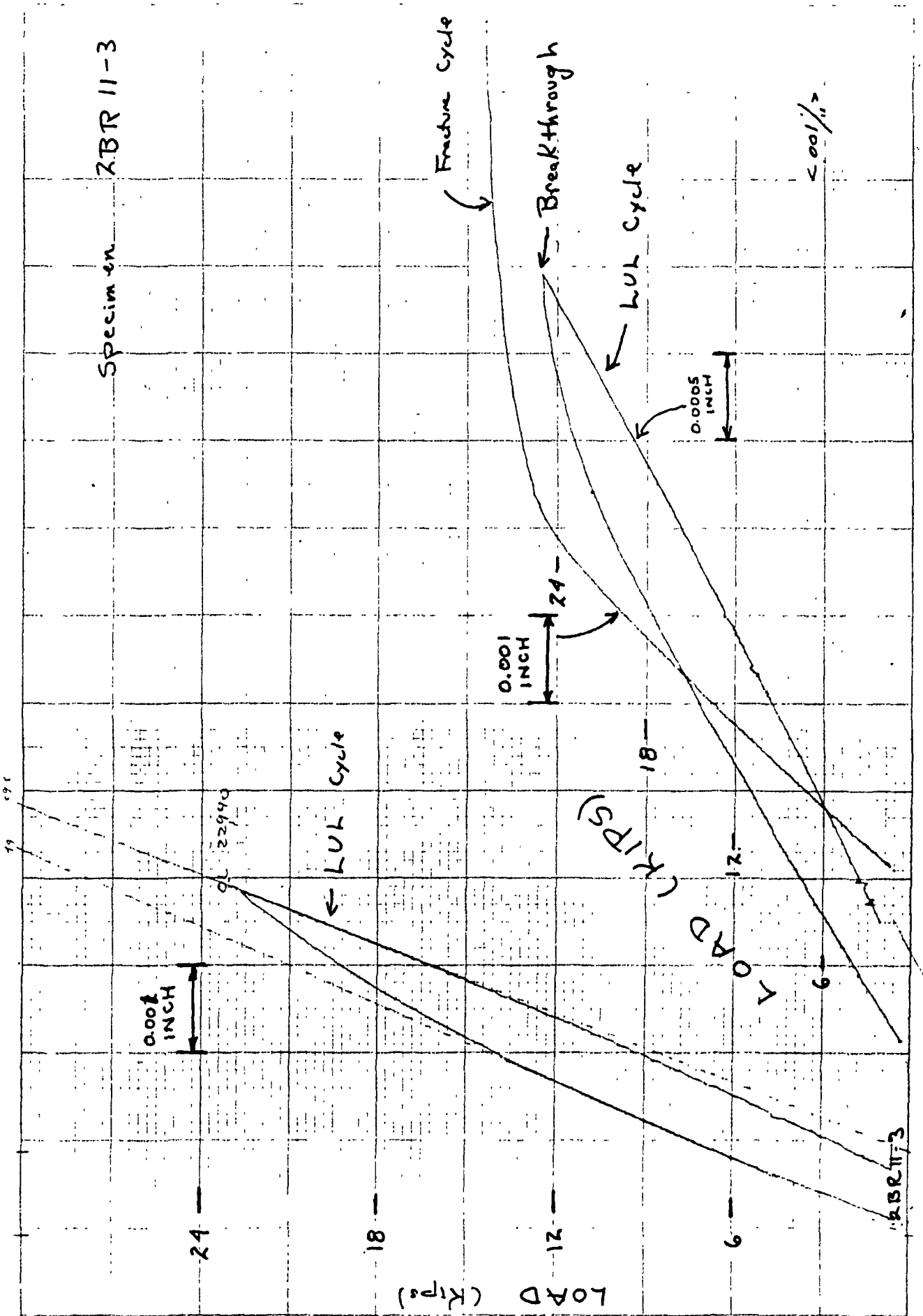
0.002
INCH

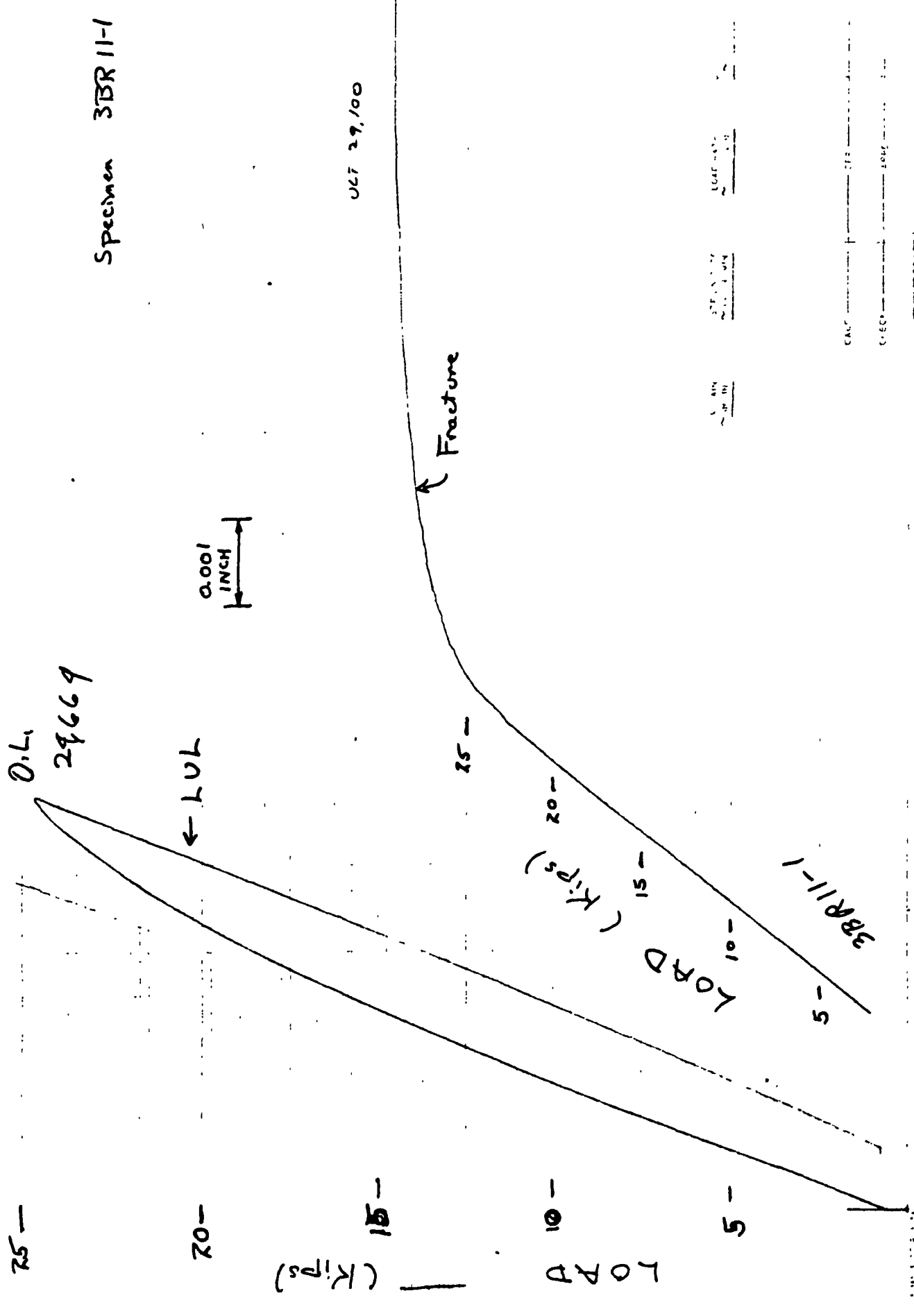
ZBR11-2

STRAIN	STRAIN RATE	LOAD RATE	DEFECTION
IN/IN	IN/IN/MIN	IN/IN	IN
			0.002

CALC	OPR	3/4	3-3-5
CHECK	APPO		

Specimen ZBR 11-3





Specimen 3BR11-1

001 29,100

0.4
24.669

← 1.001

0.001
INCH

↑ Fracture

LOAD (Kips)

3BR11-1

(Kips)

LOAD

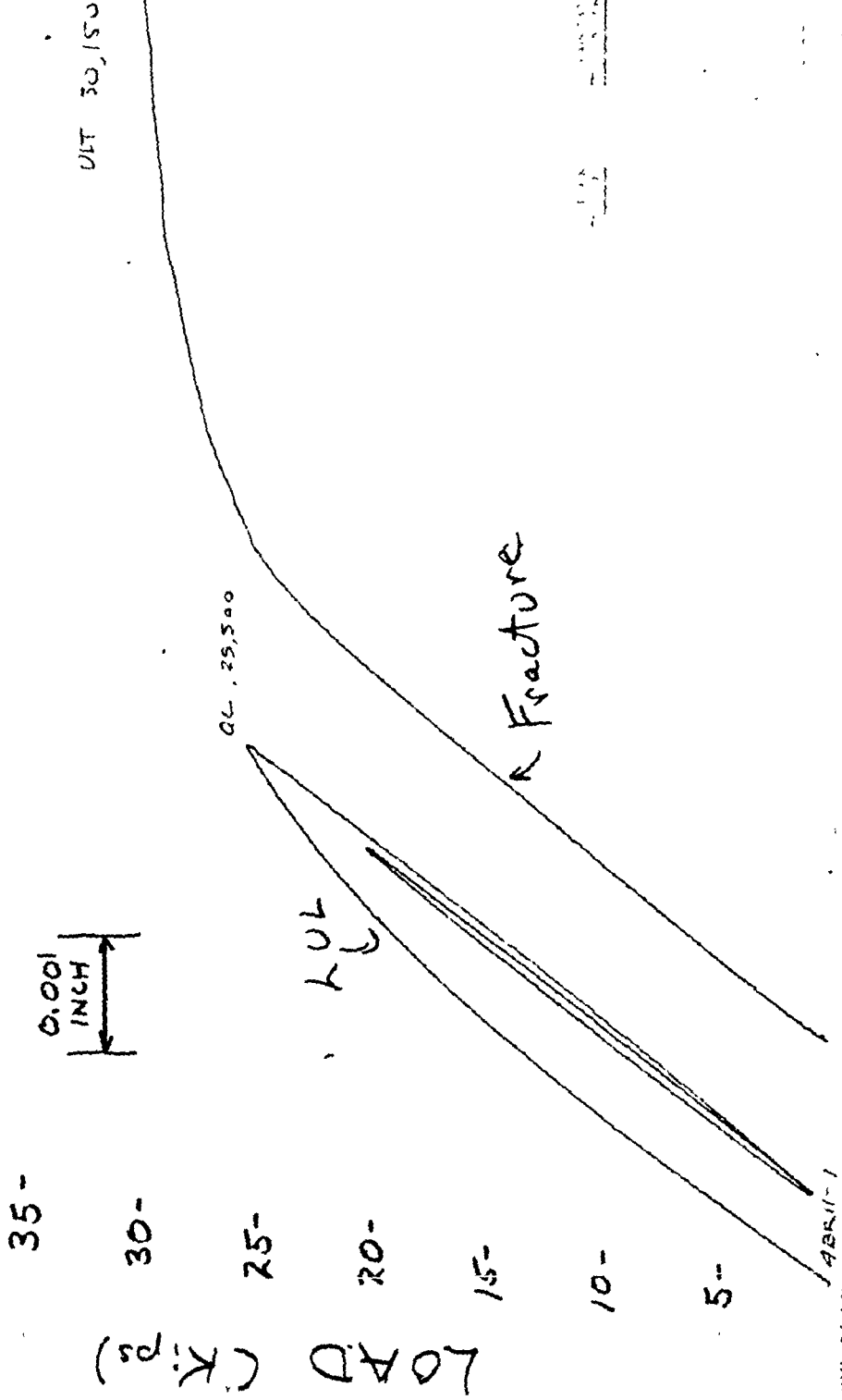
DATE: 11/11/54
 TIME: 10:00 AM
 BY: J. H. ...

TEST NO: 3BR11-1
 DATE: 11/11/54

BOEING TIPS

Specimen

ATR 11-1



RT

.007

8-5

Specimen
4BR11-2

U.S. 29,850

0.001
INCH

LOAD (KIP)

30-

75-

20

~~15-~~

10-

5-

BT 25050

e Fracture

4BR11-2

BOEING

PAGE

Specimen
3BN11-1A

0.001
INCH

LOAD (Kips)

30-

25-

20-

15-

10-

5-

0.1 25,700

LOAD

← Fracture

3BN11-1A

FT

0.001

SL 7 1/2

BUCKLING

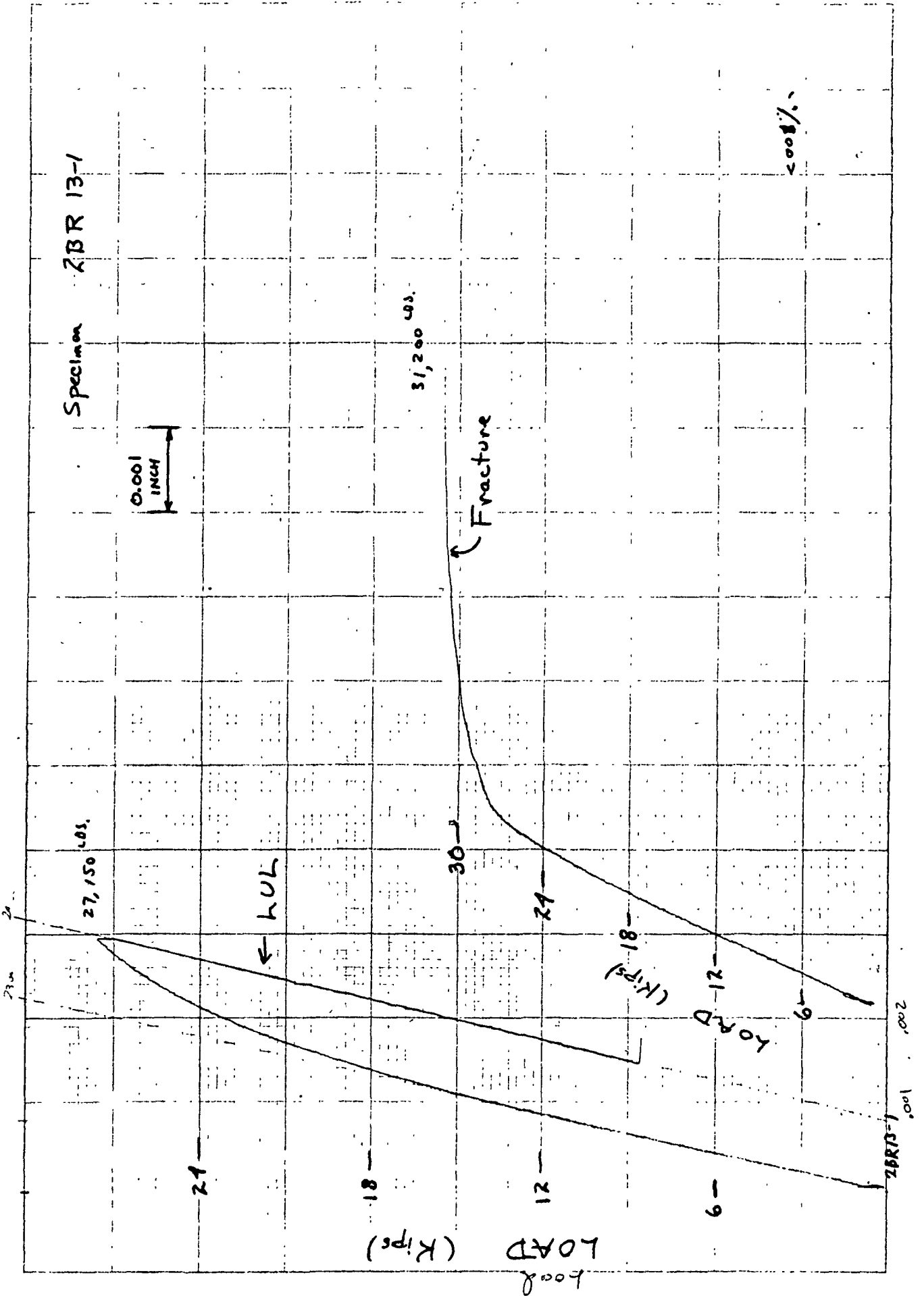
Specimen ZBR 13-1

0.001
INCH

31,200 lbs.

Fracture

<0.001%



27,150 lbs.

HUL

30

21

18

21

9

LOAD (Kips)

21

LOAD (Kips)

LOAD

9

2BR13-1

200'

100'

Specimen RBR 13-2

2550 29.2

26870 LBS.

0.001 INCH

32,280 LBS.

Fracture

<.001%>

24

18

12

6

RBR 13-2

LOAD (KIPS)

LOAD (KIPS)

LOAD (KIPS)

6

30

LUL

Specimen
RBR 13-3

0.001
INCH

32,400 lb

Fracture

LUL

LOAD (KIPS)

30-

24-

18-

12-

6-

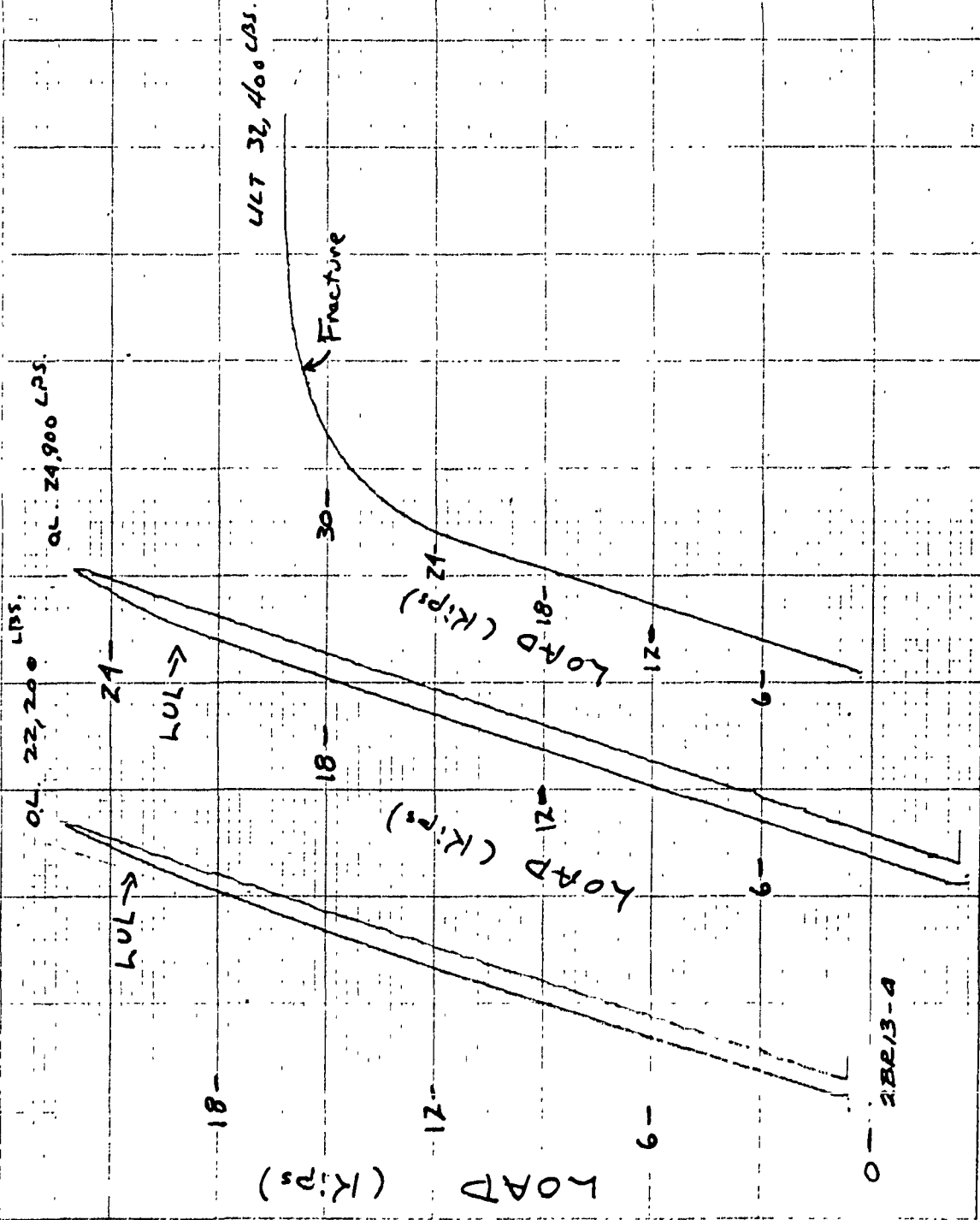
2,000 1/3-1

< 0.01% >

Specimen
RBR 13-4

0.001
INCH

< 0.01%
R.T.
3-24-5
JK.



Specimen
3BR13-1

R.T
0.001/in.
3-20-5
SL

0.001
INCH

Fracture

R.T.

217. 274

OL. 24660

← LUL

(KIPS)

LOAD

LOAD (KIPS)

24

18

12

6

0 3BR13-1

30

24

18

12

6

0

20

Specimen
3BR13-2

0.007
INCH

33.050

27.250 BT

LOAD (KIP)

Fracture

35-

30-

25-

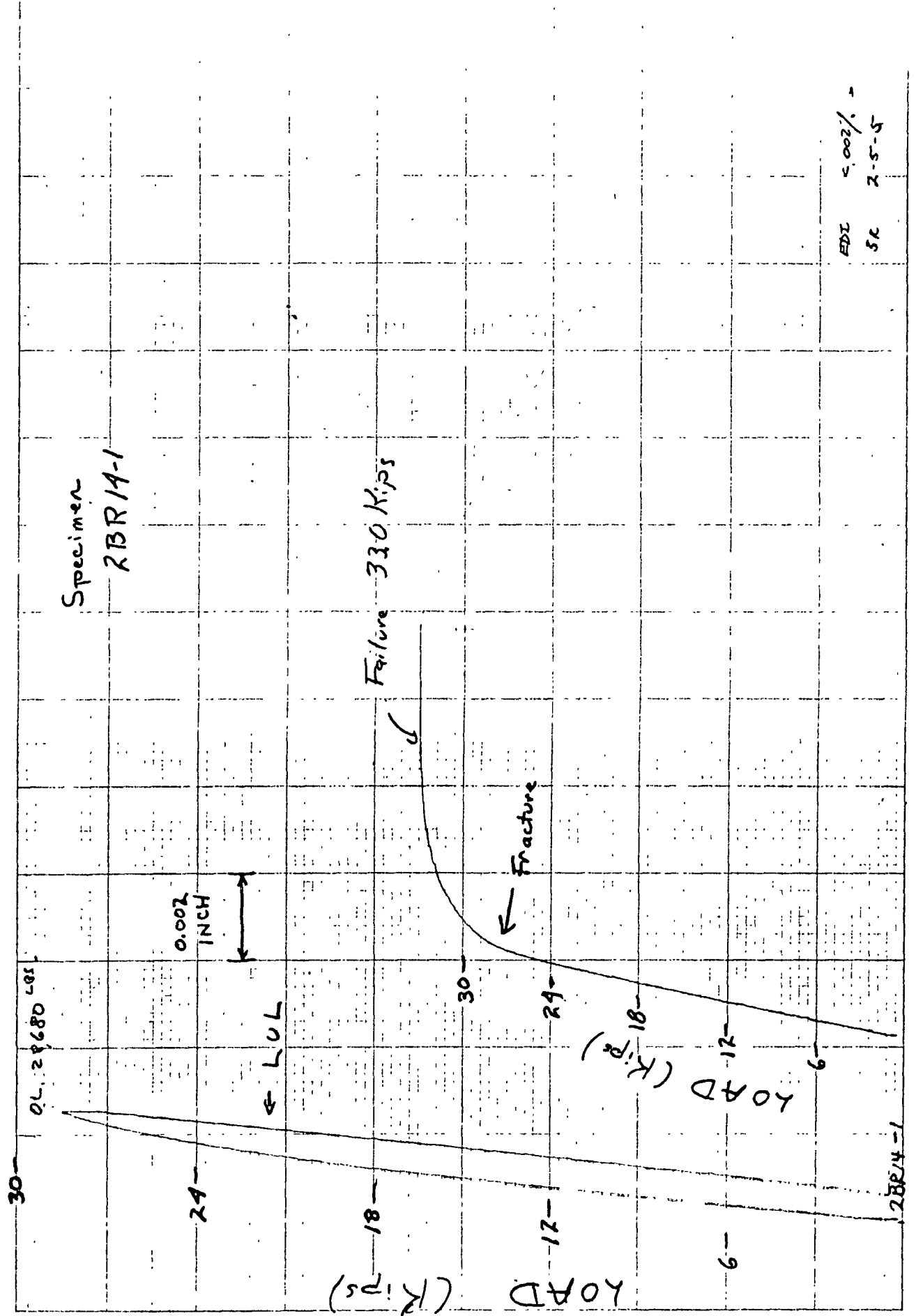
20-

15-

10-

5-

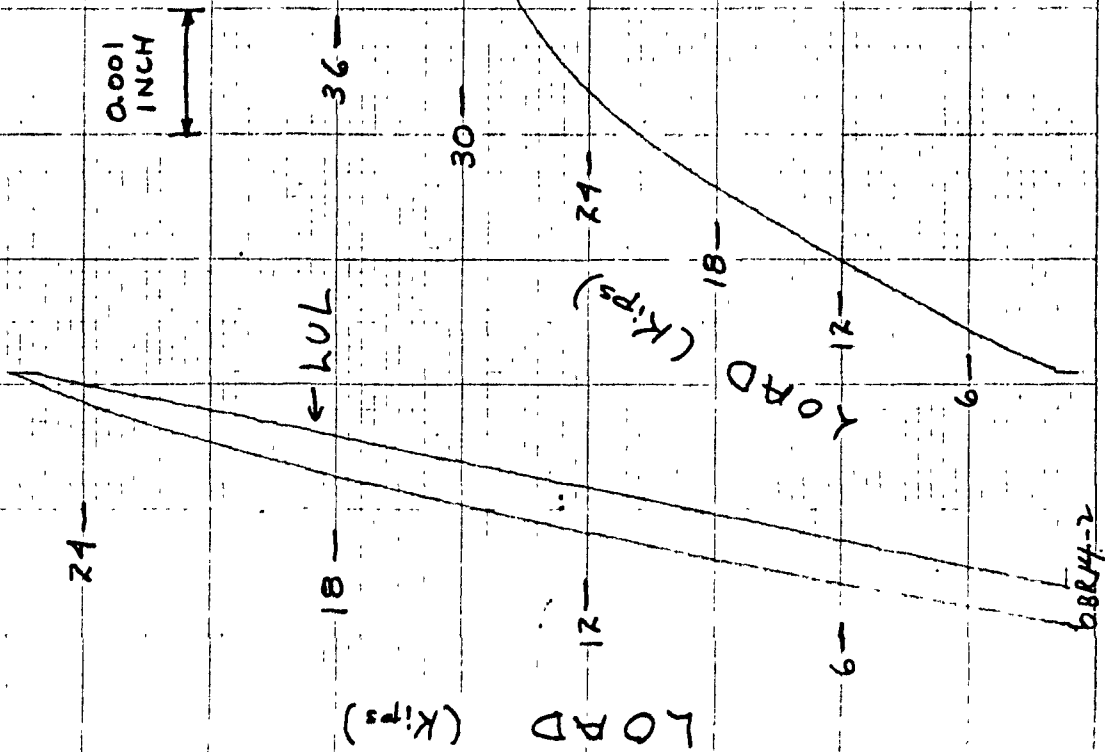
3BR13-2



Specimen
ZBR1A-2

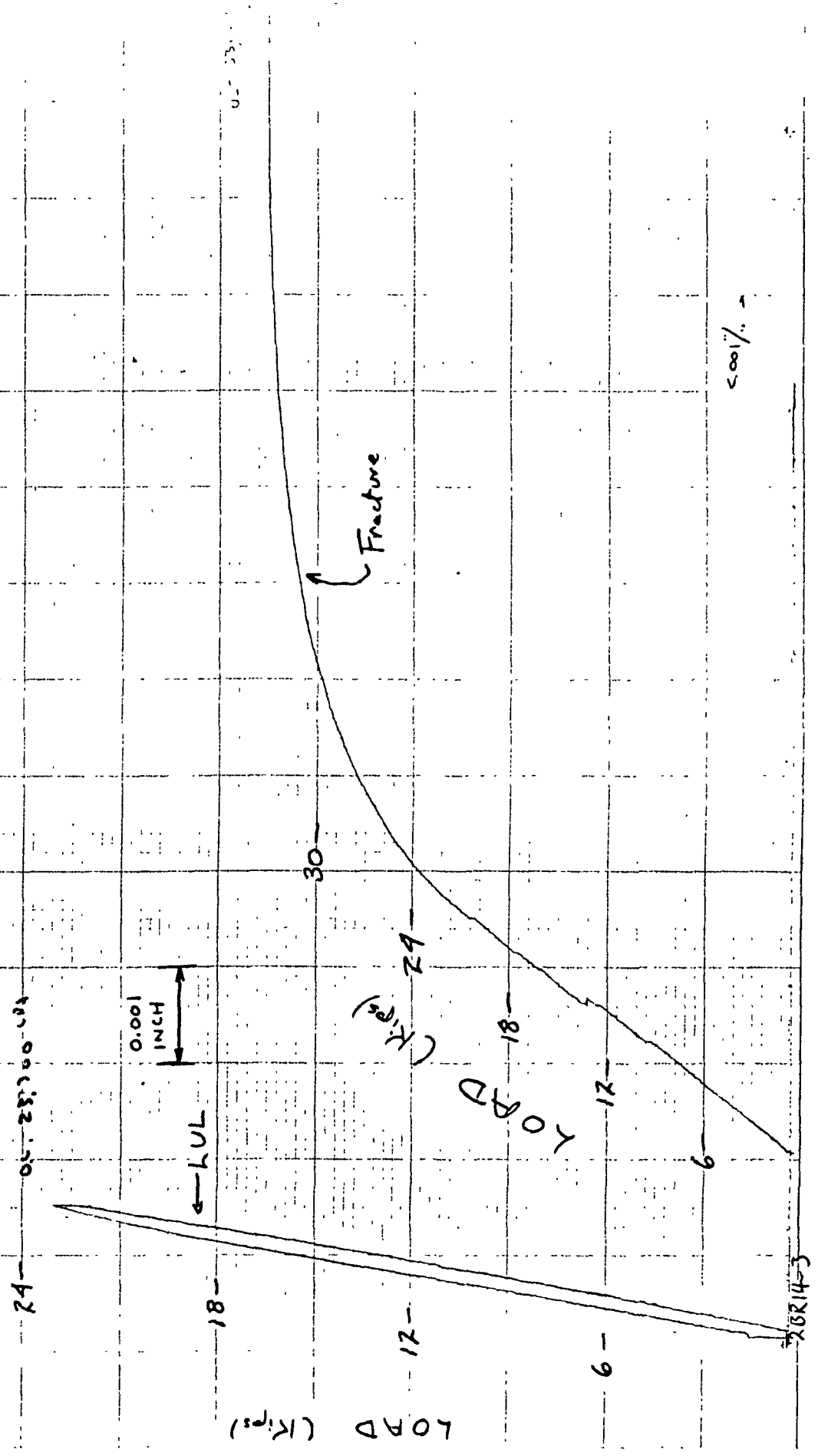
O.L. 25,880

0.001
INCH



EDT < 0.01%
SK 2-5-4

Specimen
ZBR 14-2



Specimen
ZBR 14-4

ULT 53,700

35-

30-

25-

20-

15-

10-

5-

LOAD (Kips)

Fracture.

0.001
INCH

50 f/ms

STRAIN

DISPLACEMENT

LOAD

001

ZBR 14-4

CONTRACT

PIECE

Specimen 3BR 14-1

0.001
INCH

U.T. 33,300

LOAD (KIP)

BT 27,800

Fracture

← LUL

< 0.01% >

R.T.

3-24-5

ML

3BR 14-1

Specimen
3BR14-2

0.001
INCH

35-

30-

25-

20-

15-

10-

5-

LOAD (Kips)

FL

32,850

Fracture

500/15,

STRAI

1001

96.685

3BR14-2

BRIDGE

14.1

Specimen
ABTR 14-1

0.001
INCH

ULT 35900 psi

40-

35-

30-

25-

20-

15-

10-

5-

LOAD (Kips)

OL

ULT

Fracture

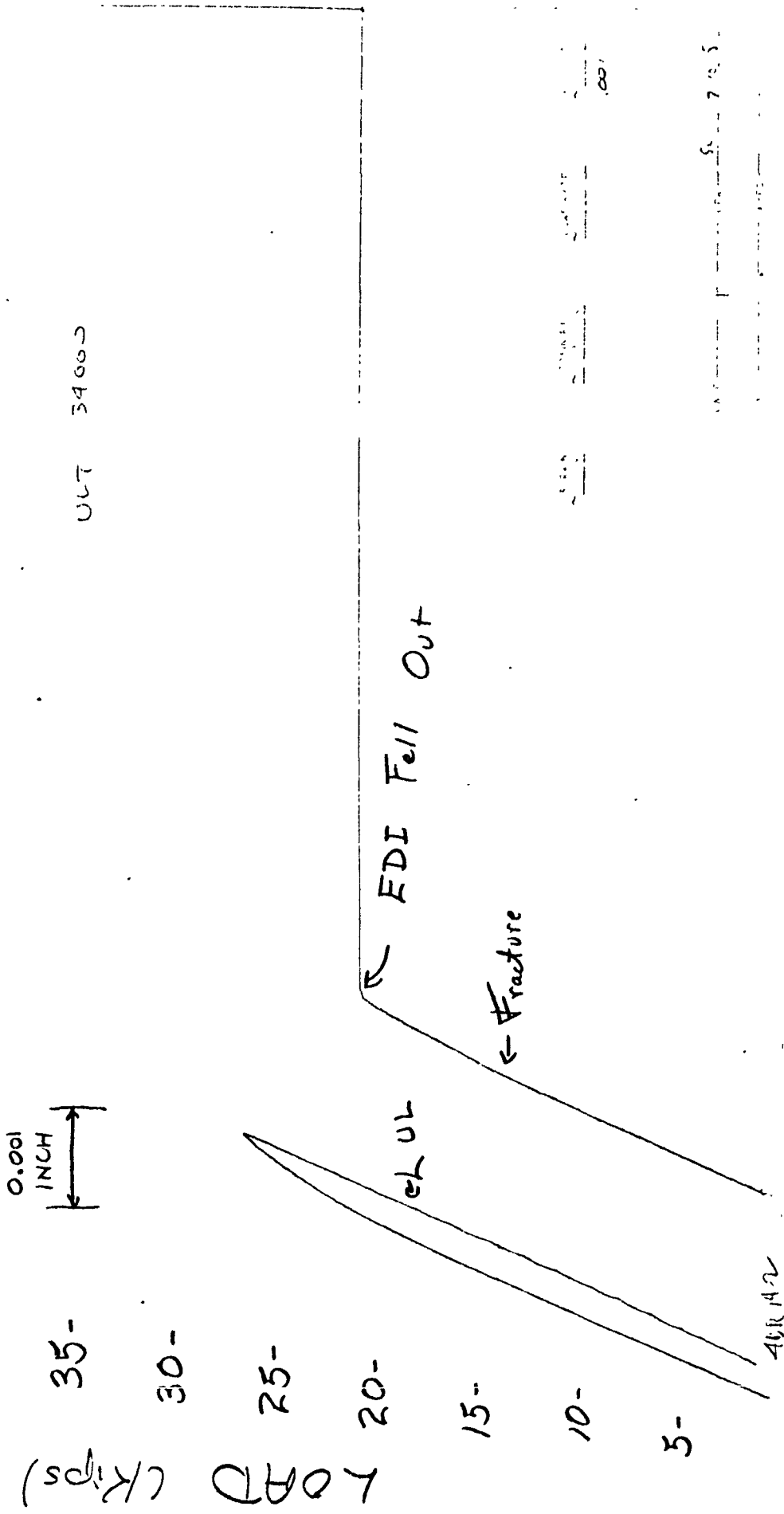
ABTR 14-1

001

9-8-5

Specimen

4BR/A-2



ULT 34000

Specimen
2BR21-1

0.002
INCH

170

100

LOAD (KIPS)

80

60

40

20

2BR21-1

D.L. 100,500 LBS

93.9 lbs

Fracture

eLUL

<0.002 % >

Specimen
2BR21-2

0.002
INCH

102 500 ⁴PS

Fracture

90 800

100 -

80 -

60 -

40 -

20 -

LOAD (KIPS)

~~200~~
2BR21-2

5/2002

Specimen
ZBR21-3

0.002
INCH

LOAD (Kips)
100
80
60
40
20

ULT 104,100

#2 @ 40840

UL 81870

← Fracture

e-LUL

e-LUL

← 0.002" → R.T. 2-19-5 SK.

ZBR21-3

Specimen
2BR21-4

0.002
INCH



SPECIMEN
3BRZ1-Z

0.002
INCH

ULT 95800 LBS

22.18 IN

100-

80-

60-

40-

20-

3BRZ1-Z

(KIPS)

LOAD

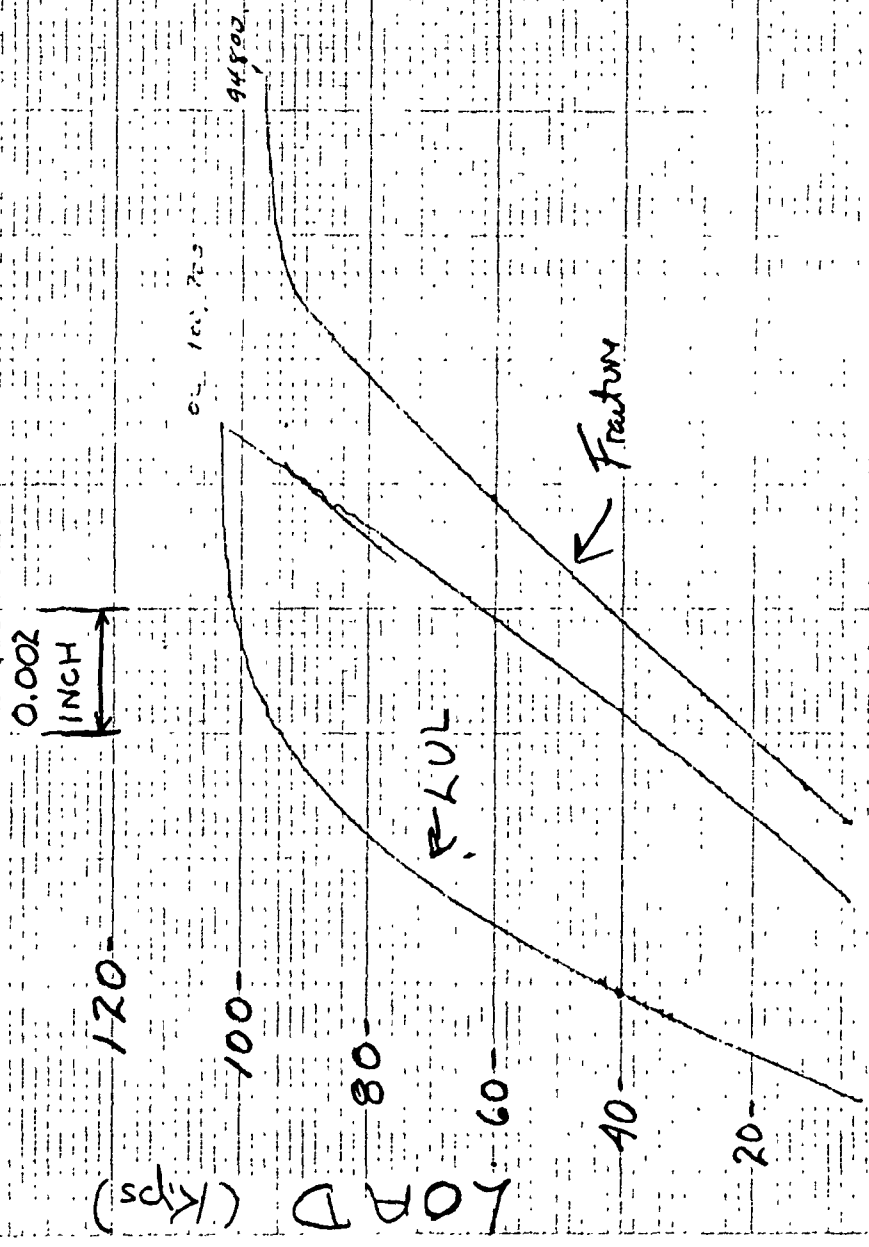
c-Fracture

ULT

6355.72

Specimen

ABRRI-1



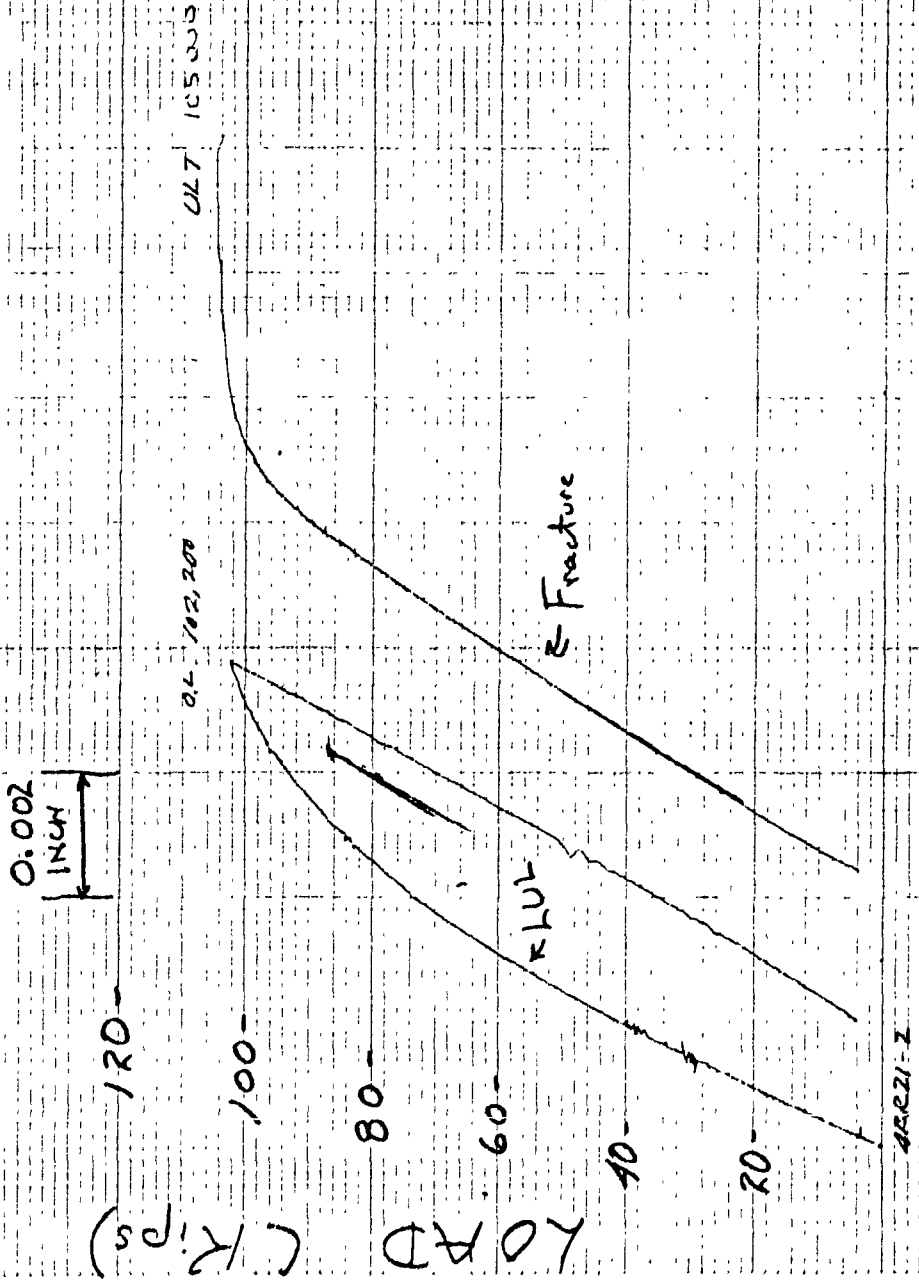
2002/2

R.T.

5-14-5 56

ABRRI-1

Specimen
4BTR21-2



4002/07
R.T
5-21-5 J.

Specimen
2BR23-2

0.002/in

0.002
INCH

118,000
S.T. 106,300

90,400

0.1

Fracture

LUL

LOAD (KIP)

100
80
60
40
20
0

2BR23-2

Specimen
ZBR 23-3

<002%
R.T.
2-19-5

0.002
INCH

ULT 197,800

91,200

82,200

100

(KIPS)

8

KE 101 42 0103

Fracture

LOAD

LUL

LUL

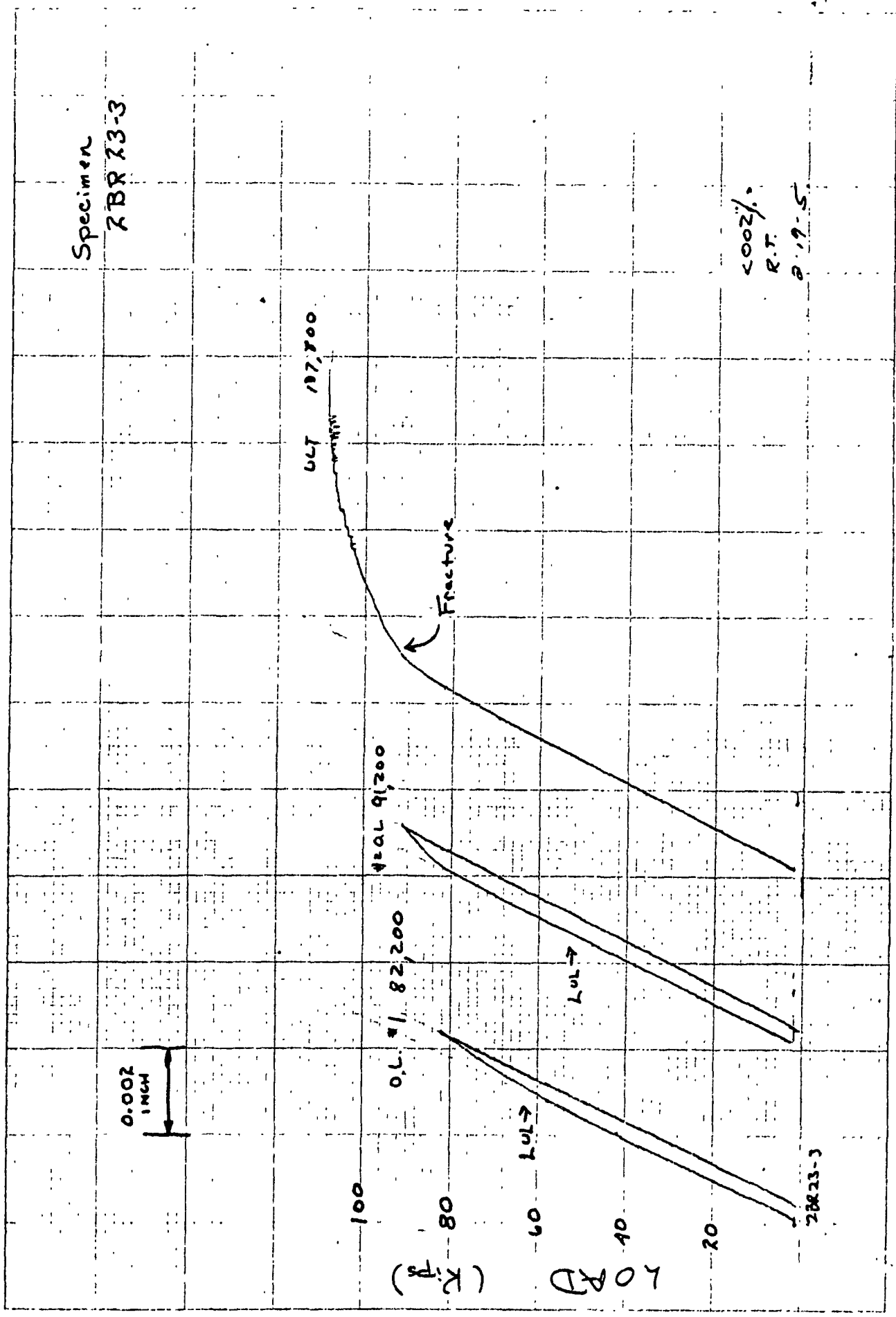
20

40

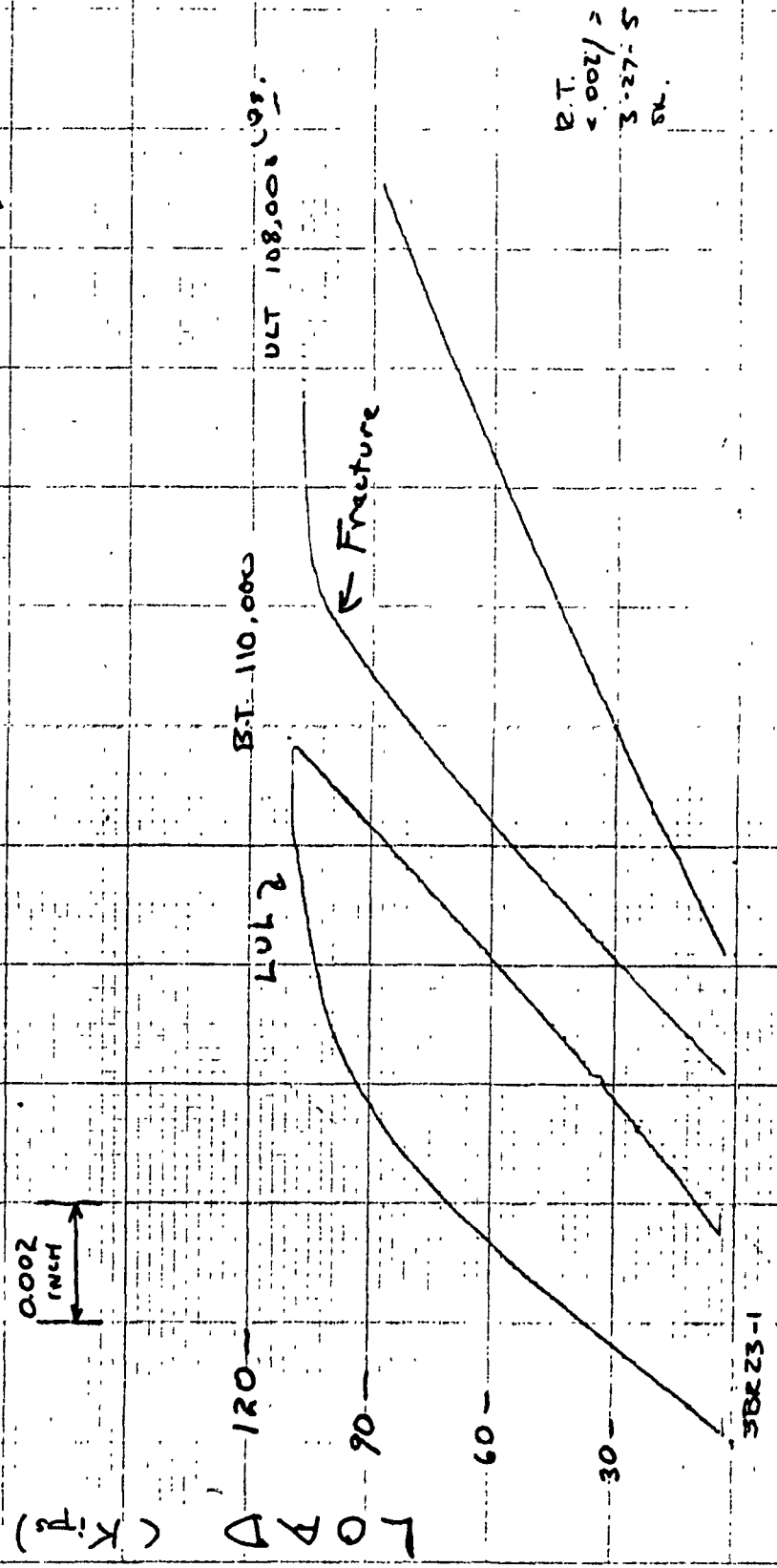
60

80

ZBR 23-3



Specimen
3BR 23-1

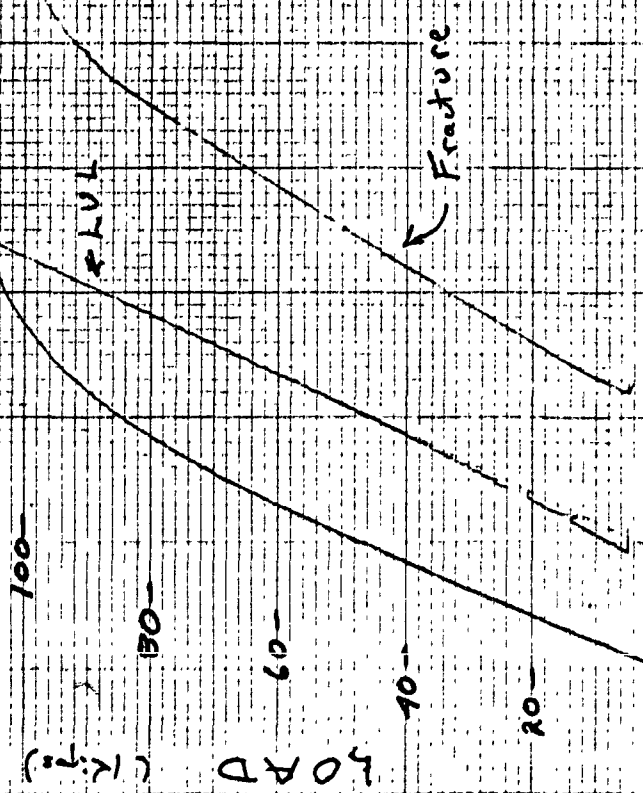


Specimen
3BR 23-2

0.002
INCH

0.106, 880

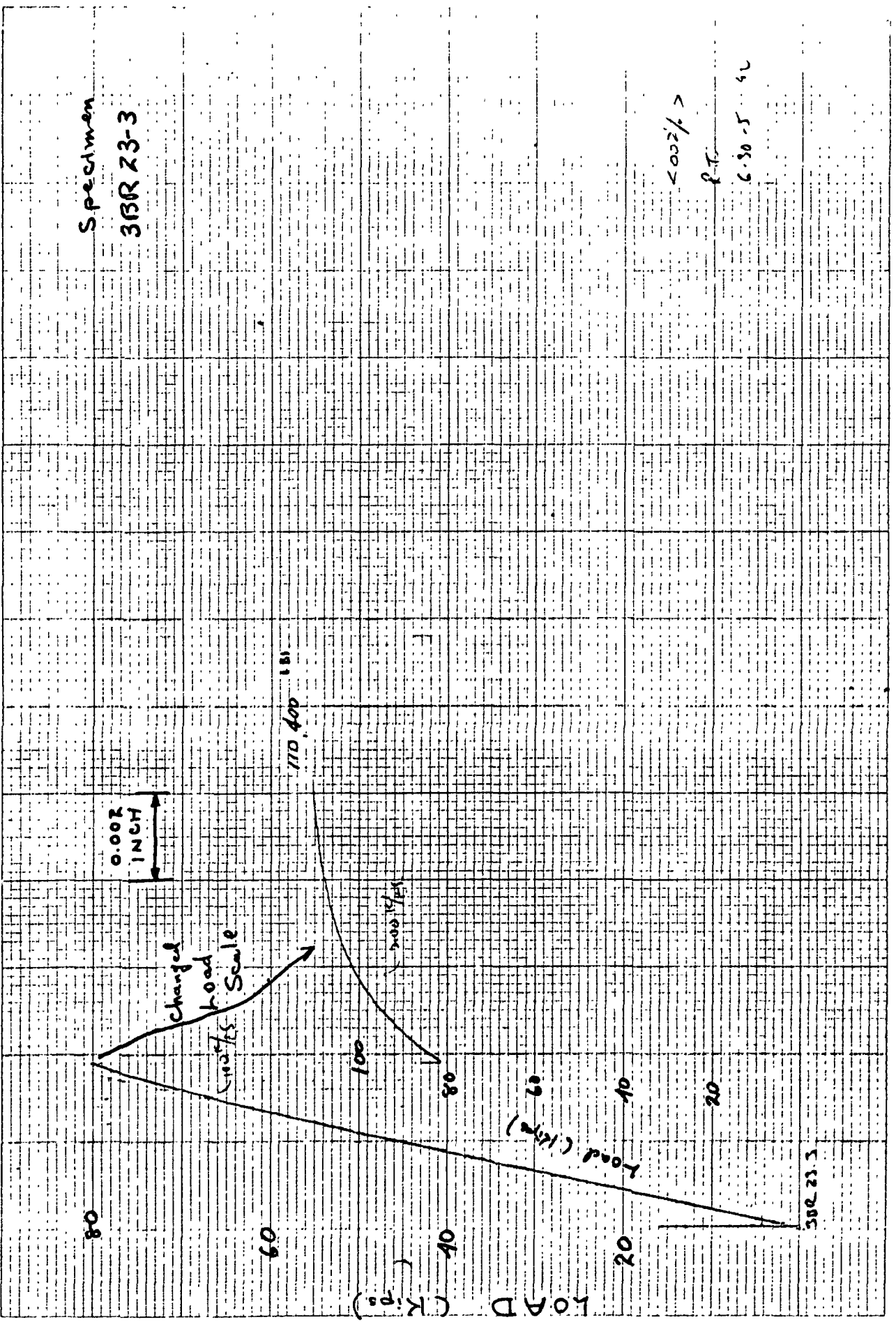
0.107, 85, 200



5.0027 >
RT.
6.9-5-1K

Specimen
3BR 23-3

< 0.02% >
P.T.
6.30-5 42



Specimen
2BR24-1

0.002
INCH

0.47 106,500

0.000001
0.000001

LOAD (KILO)

100

80

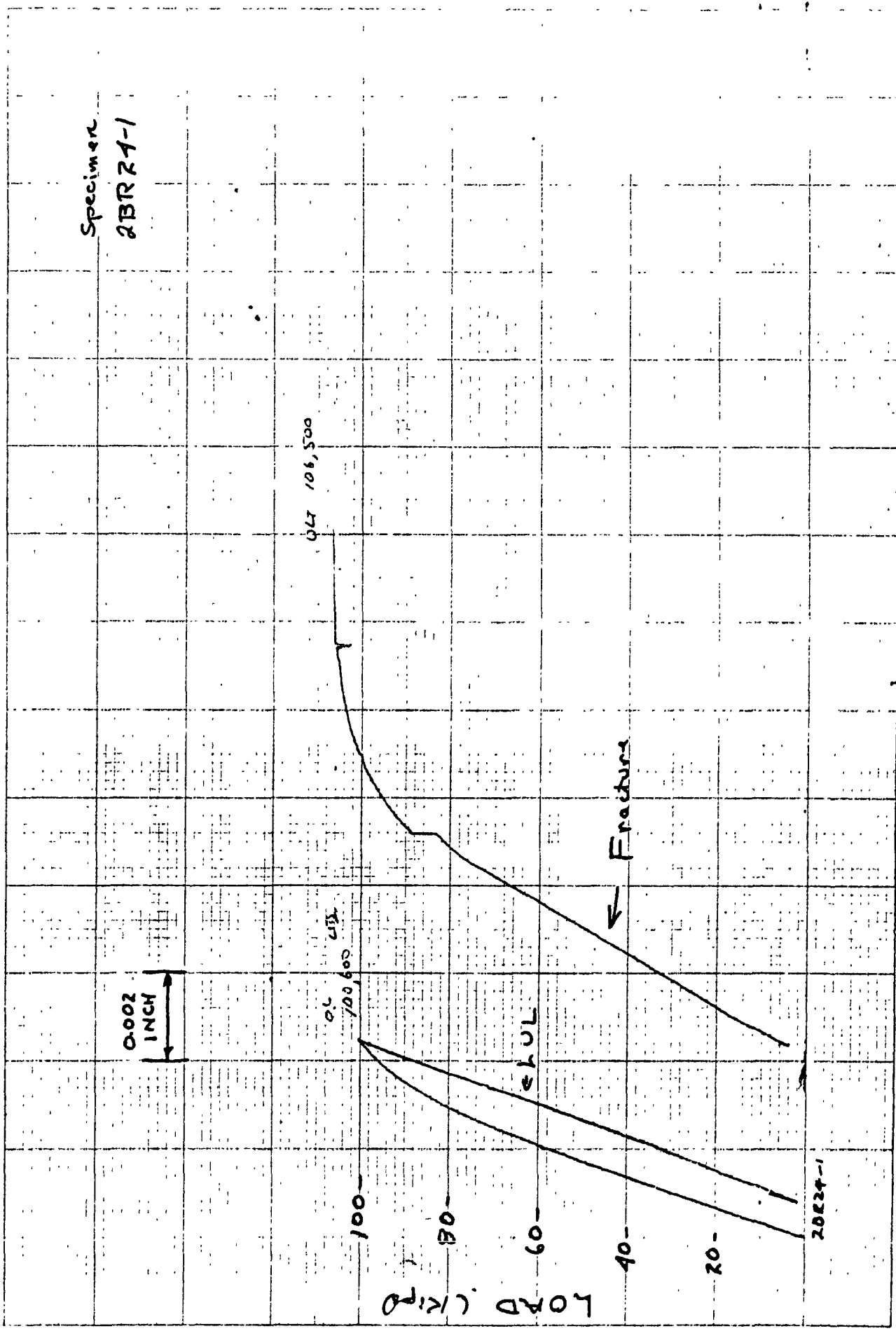
60

40

20

2BR24-1

← Fracture



Specimen
RBR24-2

114200

0.002
INCH

0.1
99800

← Fracture

← LUL

LOAD (Kips)

120

100

80

60

40

20

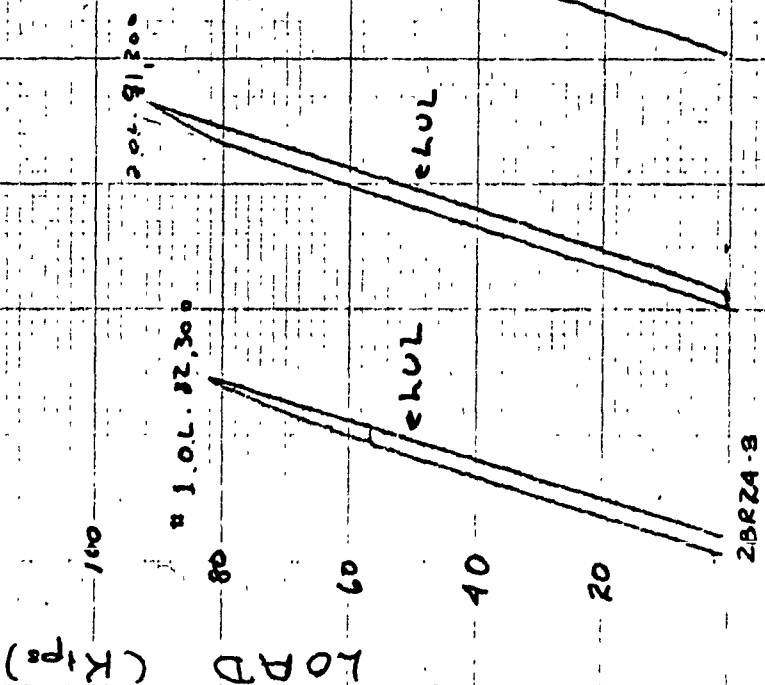
RBR24-2

0.002" >
2-M-S JK.
R.T.

Specimen.
2BR 24-3

0.002
INCH

ULT 114,000



EDL < .002% >
R.T. 2-20-5

Specimen
3BR24-1

0.002
INCH

119,000

Mo. R.T.

120

105

90

75

60

45

30

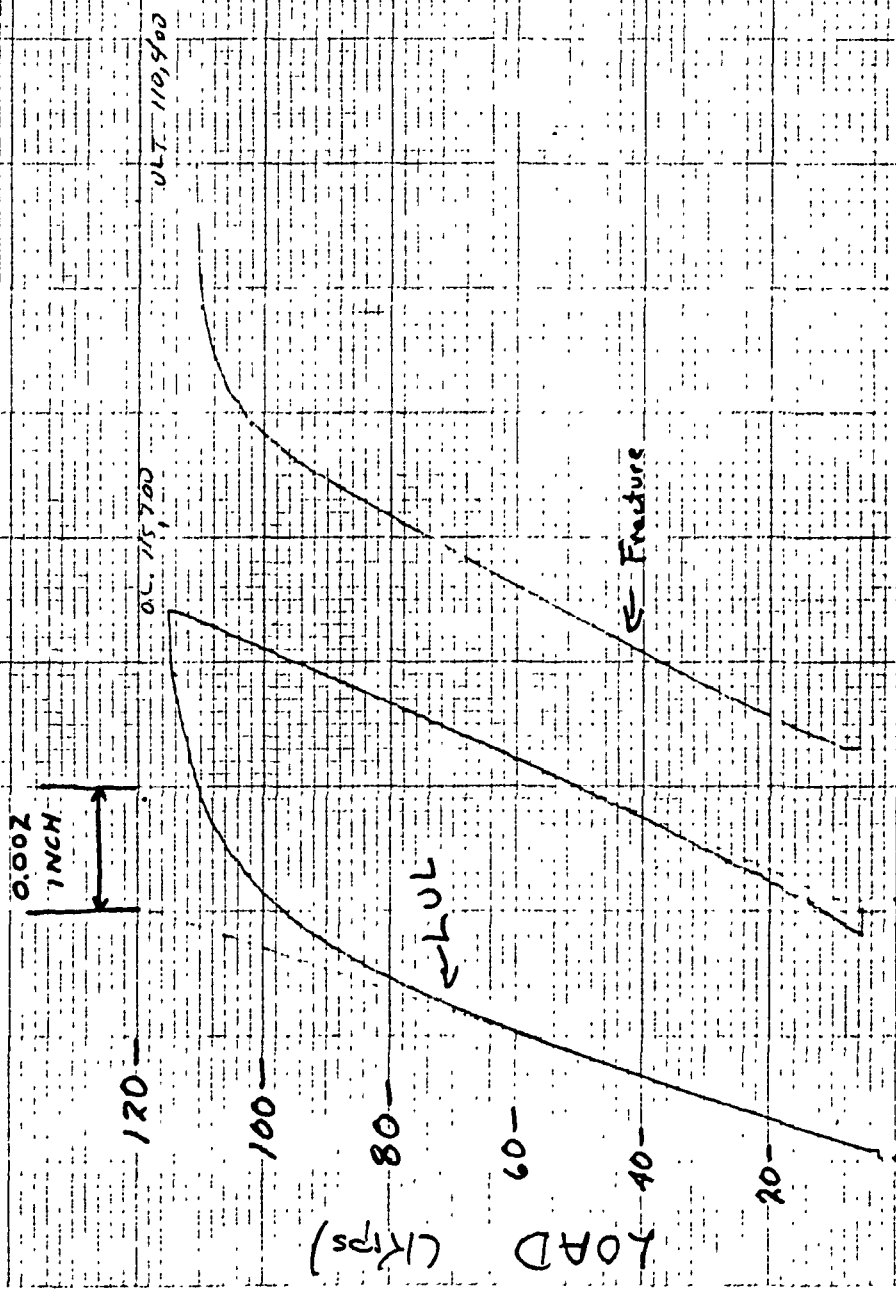
15

0°

LOAD (Kips)

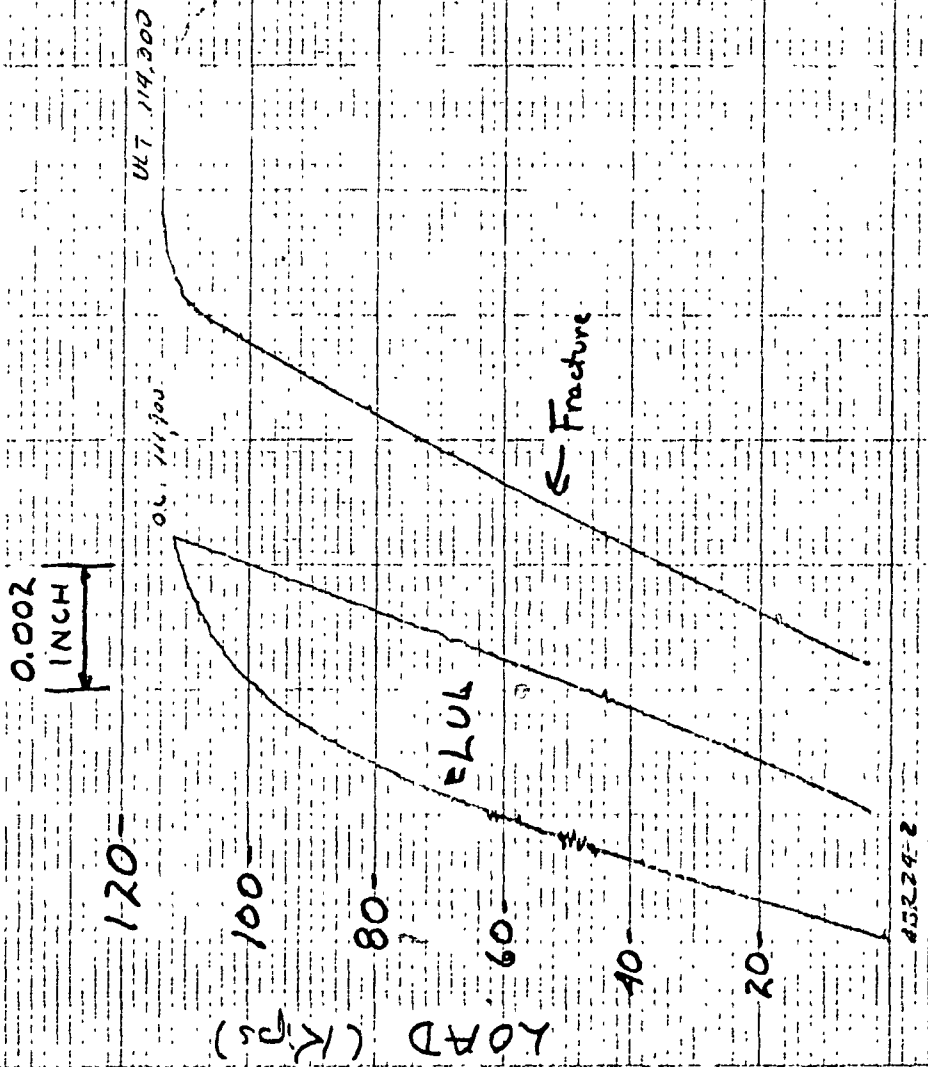
R.T.
0.002% >
3-27-5
576

Specimen
3BR24-2



6-9-5
PT.
6-9-5

Specimen
4BR24-2



R.T
5-2-55

Specimen
ZBR31-1

AL 2387.700

210

210

180

150

120

90

60

30

ZBR 31-1

LOAD (KIP)

LOAD (KIP)

e_{hul}

Failure

0.002
INCH

400 200 500 1000

DEFLECTION
IN

LOAD RATE
/MIN

STRAIN RATE
IN./IN./MIN

STRAIN
IN./IN.

1/2000

EVAL OPR 5/4 4-9-5

CHECK APPD

BOEING

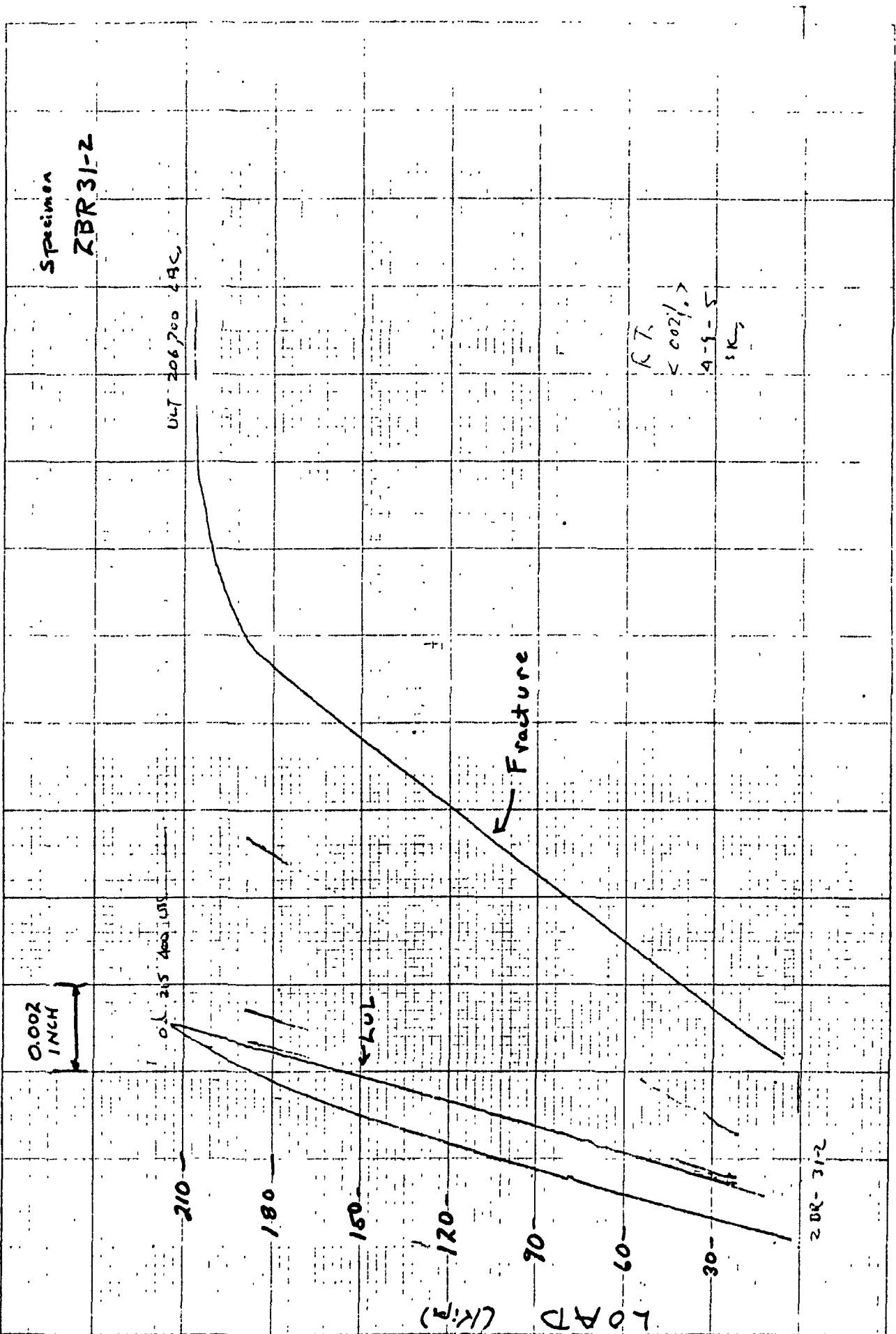
EVA

PAGE

OF

J18-043

3 WHITE OPR. 5/43



Specimen
ZBR 31-3

UCL 211,800 LBS

RT
<0.02% S
4-15-5 SL

0.002
1 INCH

UL 191,300 LBS

LUL

210

180

150

120

90

60

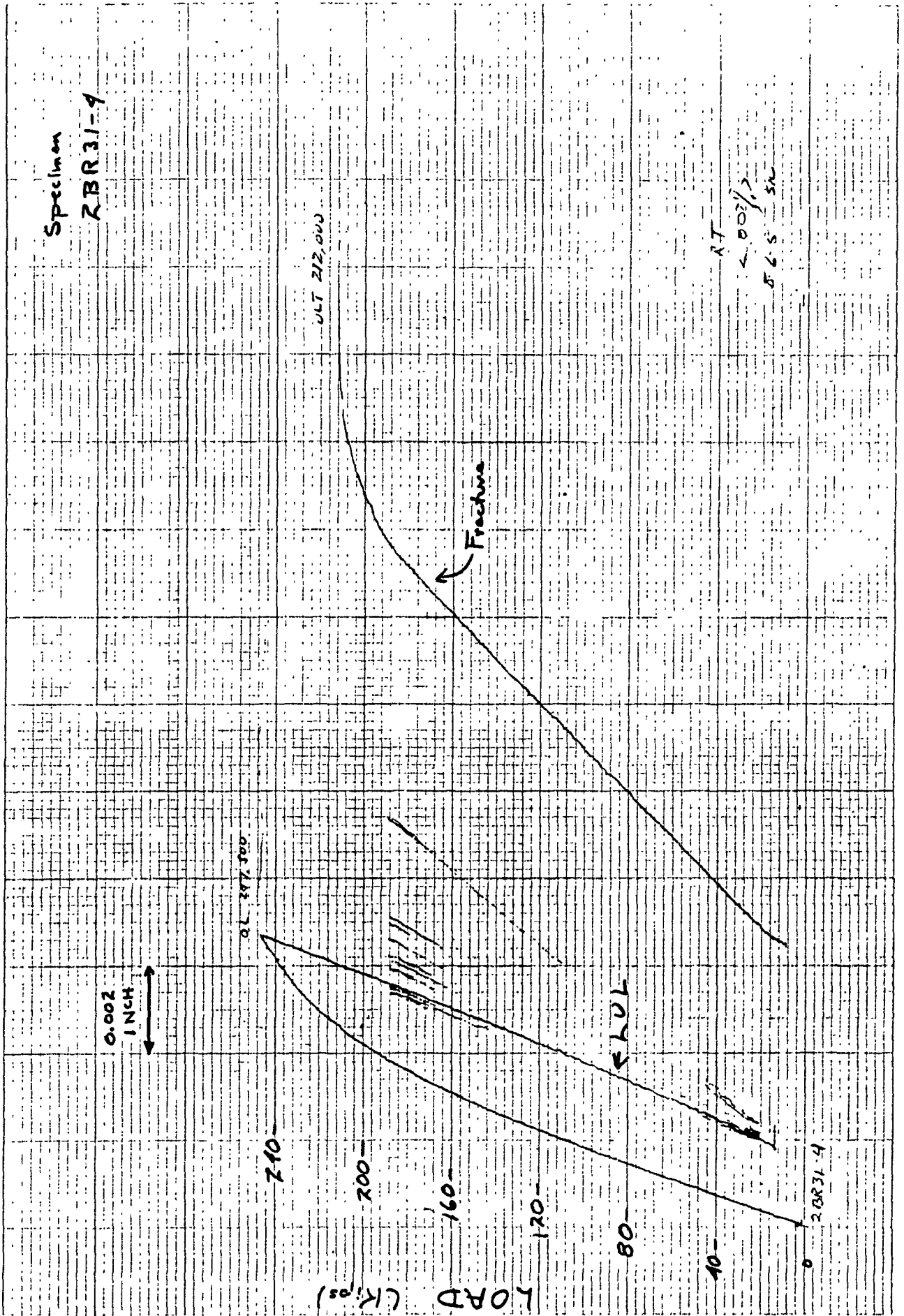
30

0

ZBR 31-3

Fracture

Specimen
RBR31-4



Specimen
3BR31-1

0.002
INCH

ULT 256,000

280

240

200

160

120

80

40

LOAD (Kips)

3BR31-1

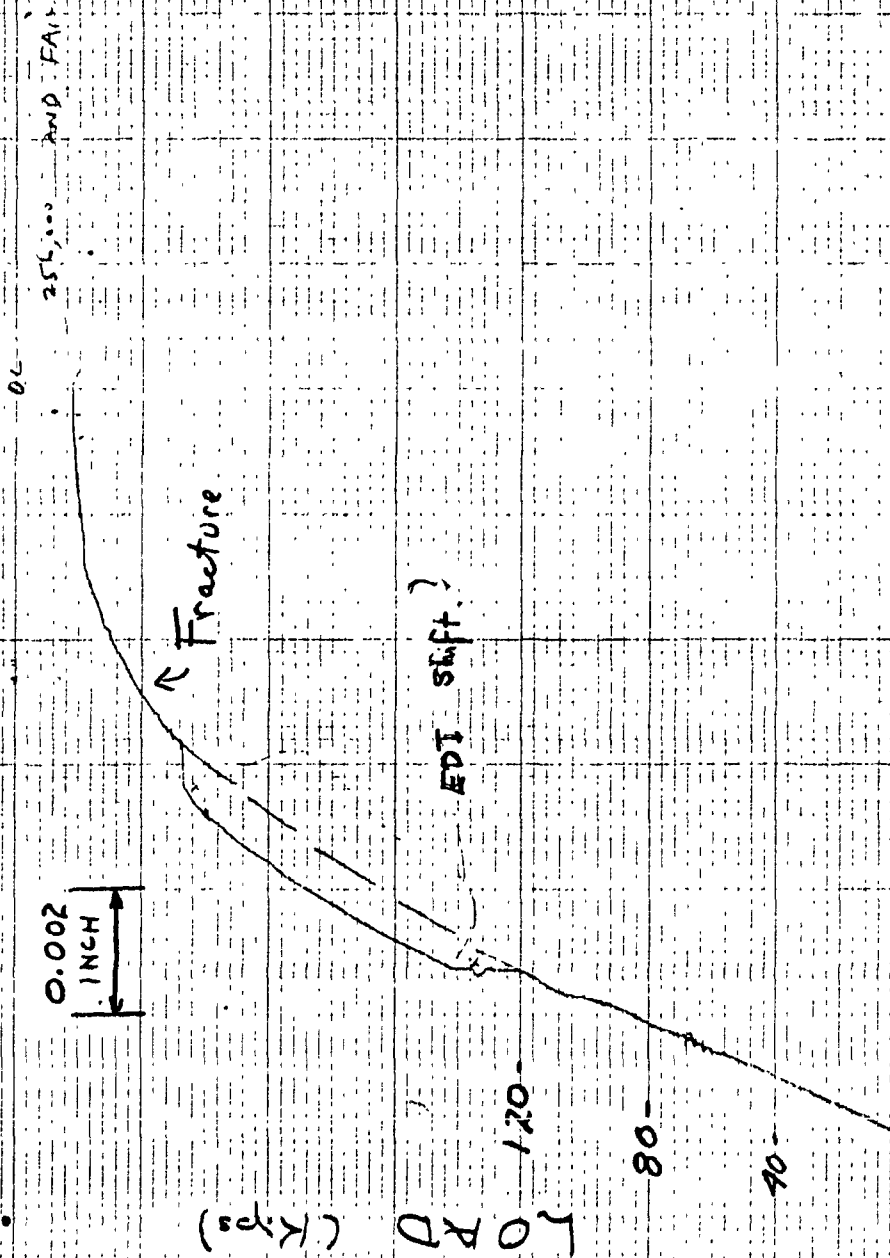
RT

2002/1/3

5-1-5 SIC

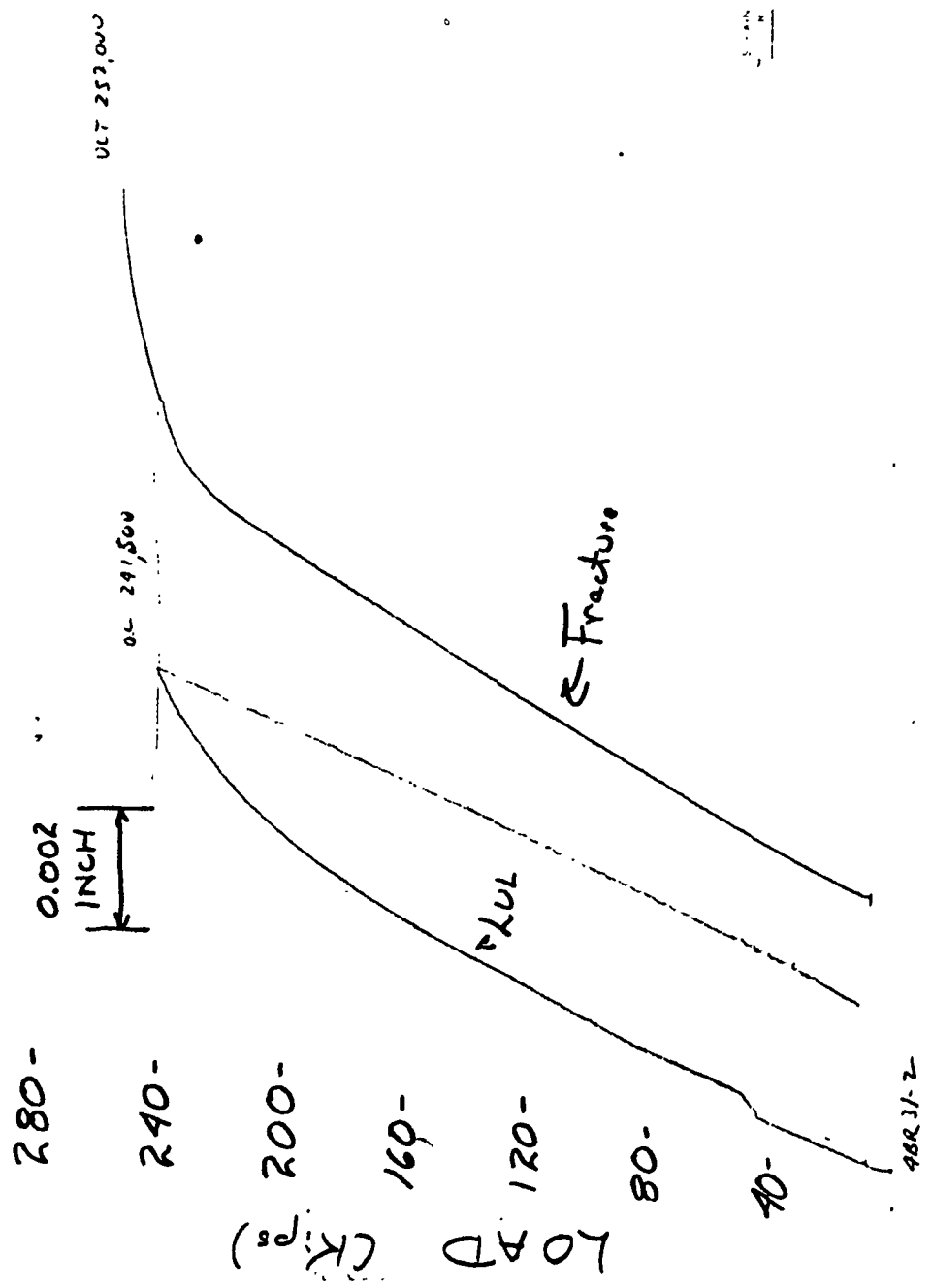
Specimen

4BR31-1



K.T.
< .007% >
5-14-5

Specimen
4BR31-2



1002

PT

9/11 2-1-5

Specimen
RBR33-1

ULT 212,100 LBS.

O.L. 238,200

0.002
INCH

240

210

180

150

120

90

60

30

20231-1

LOAD (Kips)

7072

← Fracture

0.002/ →
R.T.
4-9-5
SM.

Specimen
RBR 33-3

VLT 216000

0.002
INCH

CS 288,000

210

180

150

120

90

60

30

LOAD (Kips)

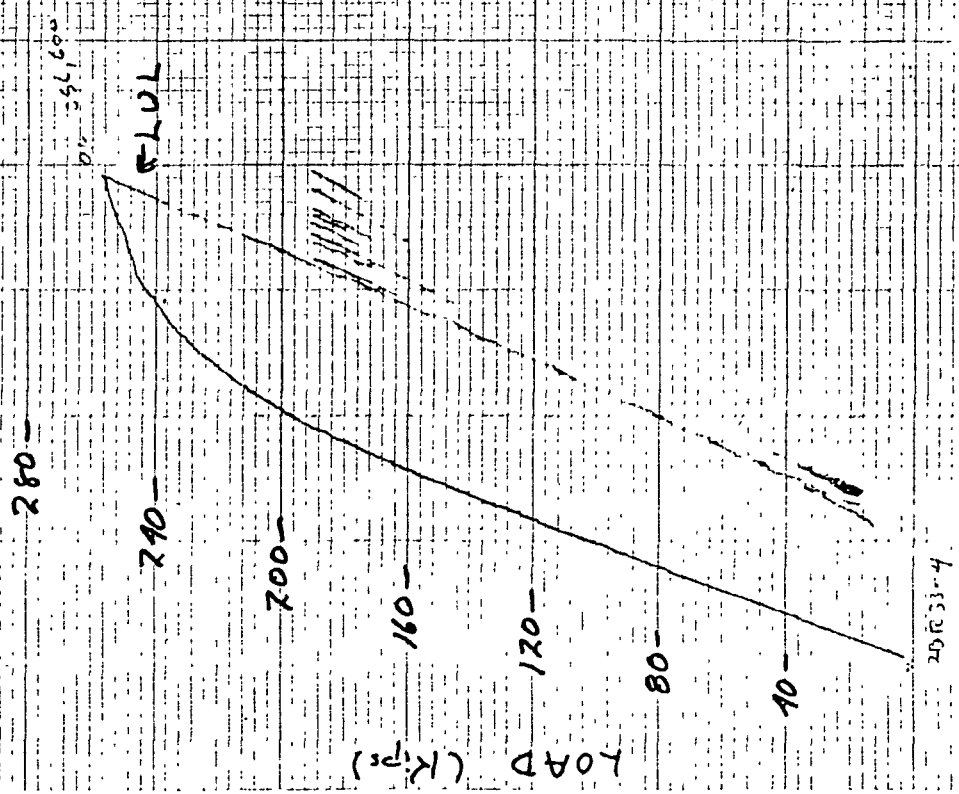
Fracture

2002-33-3

0.002
P.T. 4-15-5
JL

Specimen
ZBR33-4

0.002
1 INCH



5:07 >
R.I.
5:17 - 5:30

Specimen
3BR33-1

0.002
INCH

280

270

200

190

170

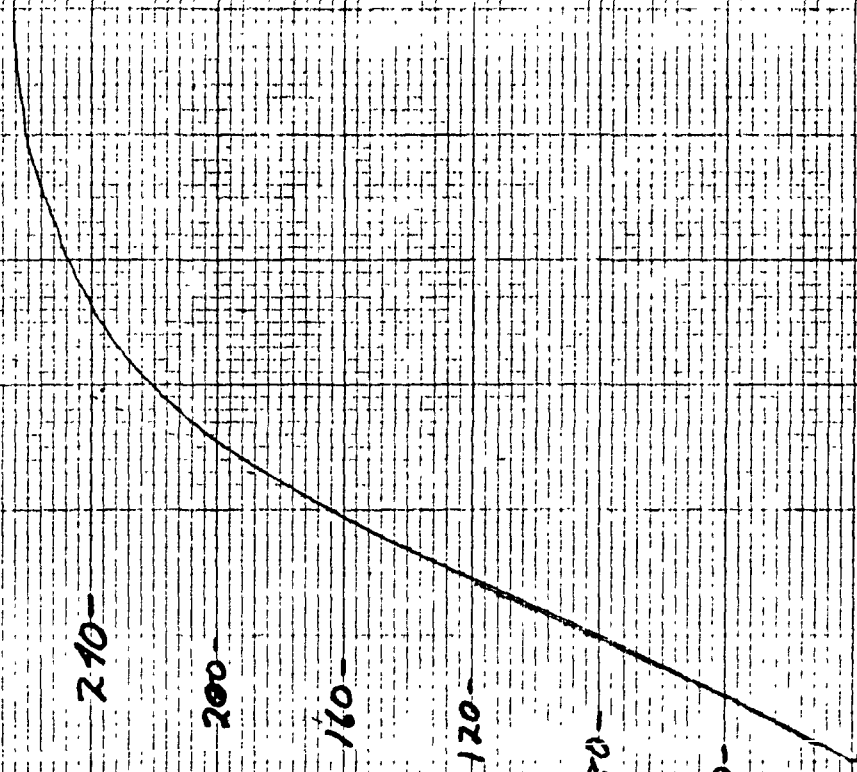
80

40

3BR33-1

LOAD (KIPS)

RT
0.0027
5.25



Specimen
3BR 33-2

0.002
INCH

262.400

280-

240-

200-

160-

120-

80-

40-

LOAD (Kips)

3BR 33-2

PT

< 0.02%

6-A-5-R

Specimen
RBR 34-1

ULT 223,500 LBS.

0.002 INCH

0.002 INCH

Fracture

LUL

< 602 1/2

R.T.

4-10-5

SK

240

210

180

150

120

90

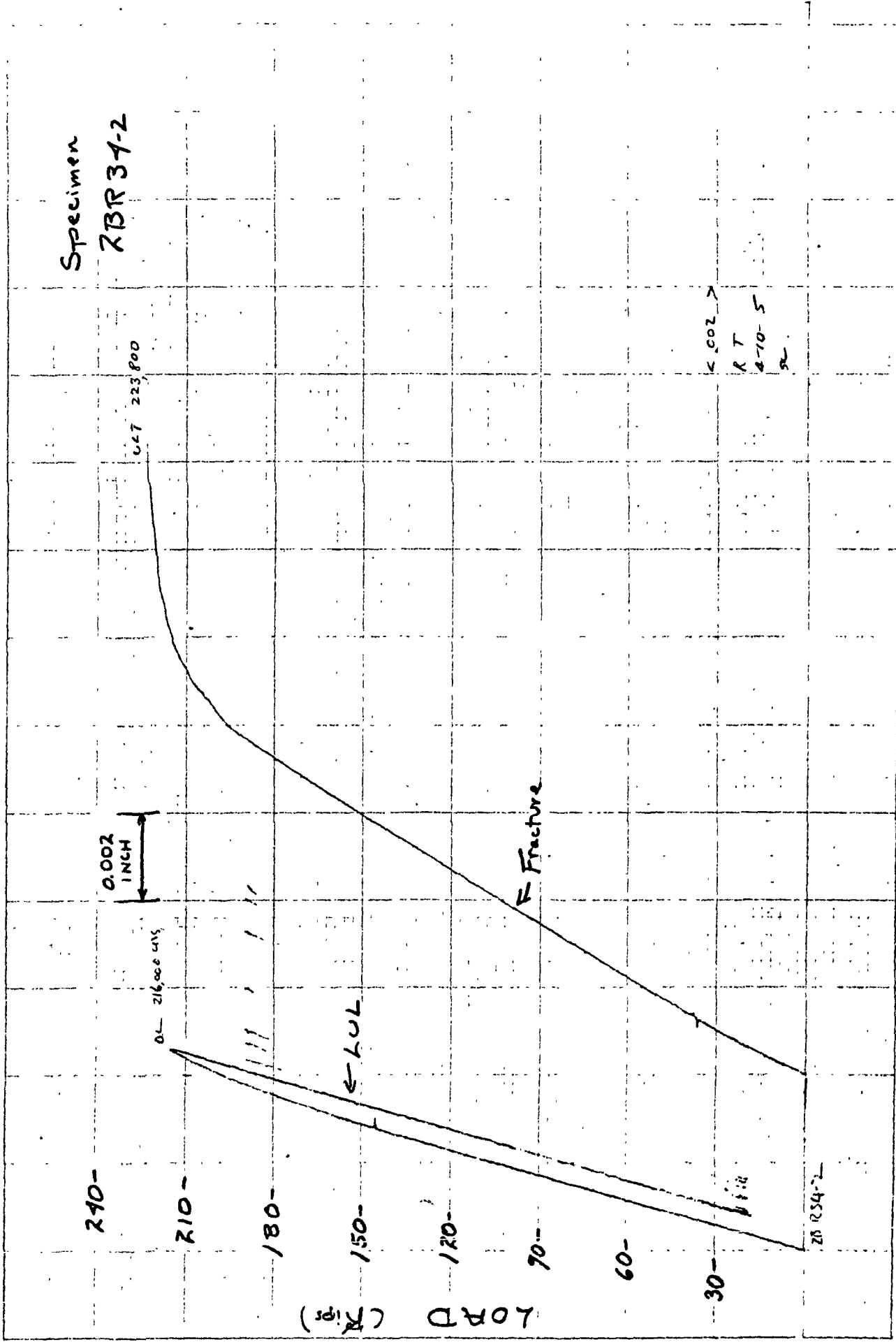
60

30

26R 34-1

LOAD (KIPS)

Specimen
ZBR 34-2



Specimen
ZBR 34-3

ULT = 223,500

0.002
INCH

0.187,700

Fracture

R.T.
4.002%
4-16-5 J.R.

210-

180-

150-

120-

90-

60-

30-

ZBR 34-3

Y O P D (Kips)

Specimen
RB R 34-4

0.002
INCH

280-

210-

200-

160-

120-

80-

40-

RB R 34-4

0.265, 200

LIT 7.5 WOL

LOAD (Kips)

R Fracture

R LUL

0.002/ >

R.T.
5-7-5 Sil

Specimen
3BR34-1

278,900

280-

240-

200-

160-

120-

80-

40-

0.002
INCH

(KIPs)

LOAD

PT

2.008
5-7-5

BB234-1

Specimen
3BR 34-2

272,000

Fracture

0.002
INCH

280

210

200

160

170

80

10

(KIP)

LOAD

5BR34-2

RS
5007
6.0-5' 50

Specimen
4BR34-1

0.002
INCH

280-

240-

200-

160-

120-

80-

40-

(Kips)

LOAD

at 265,700

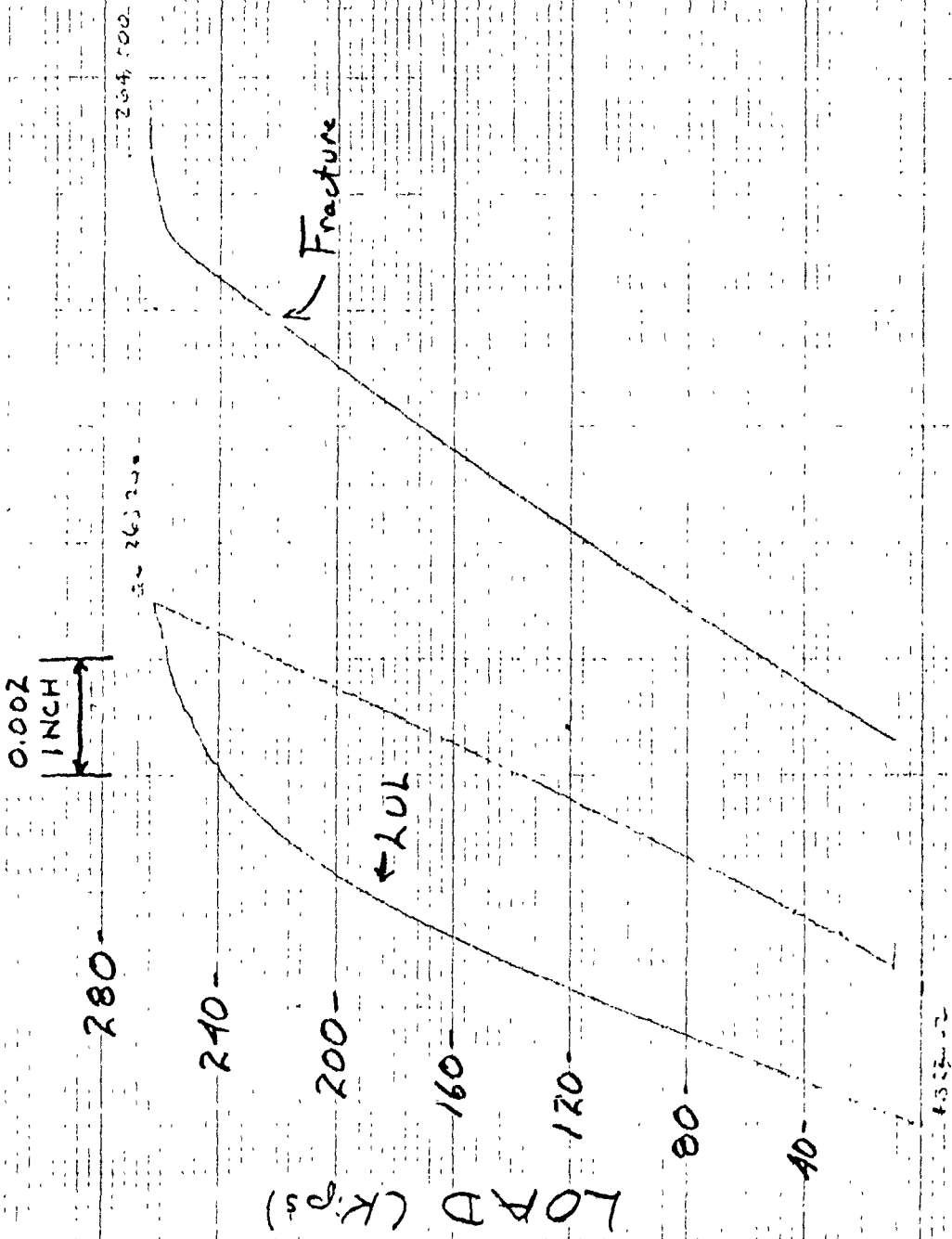
at 267,400

Fracture

0.002
3.125

4BR34-1

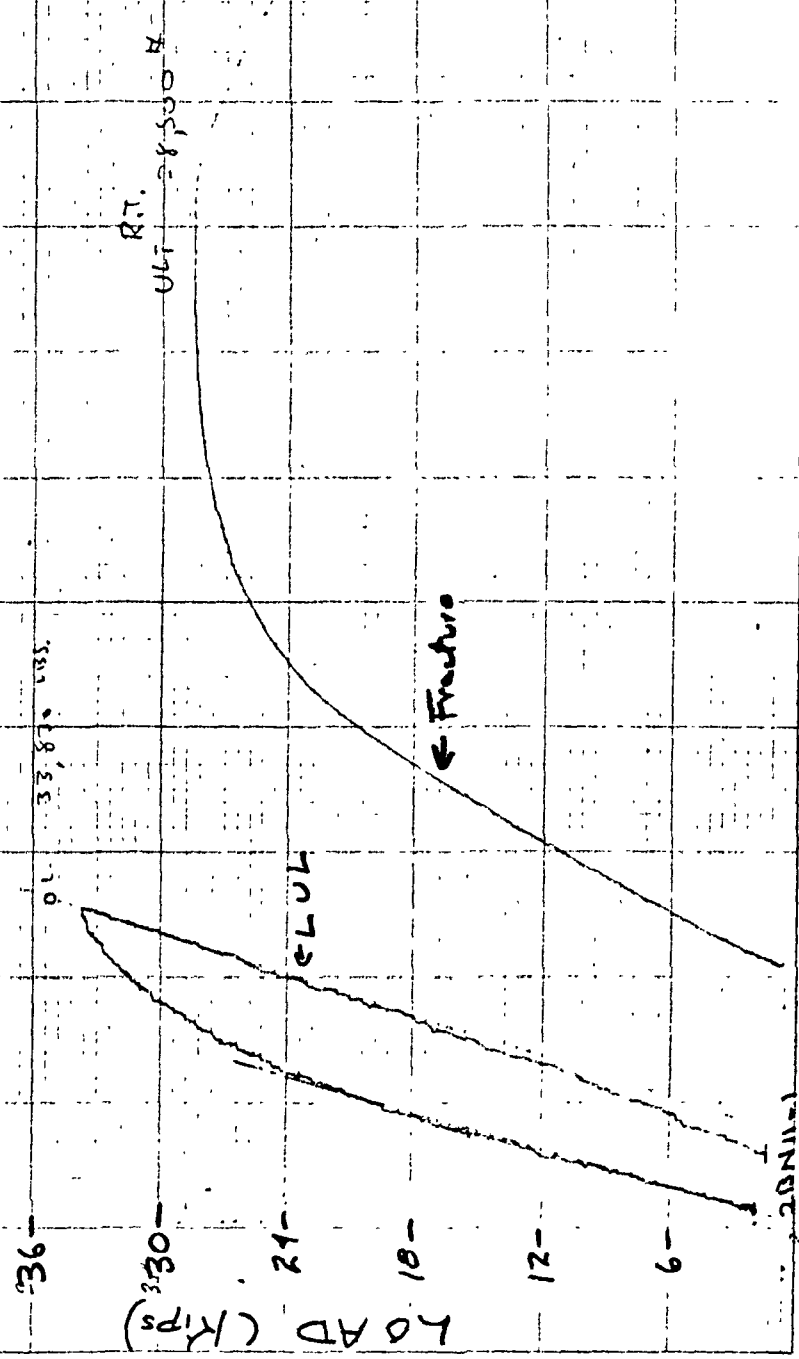
Specimen
ABR34-2



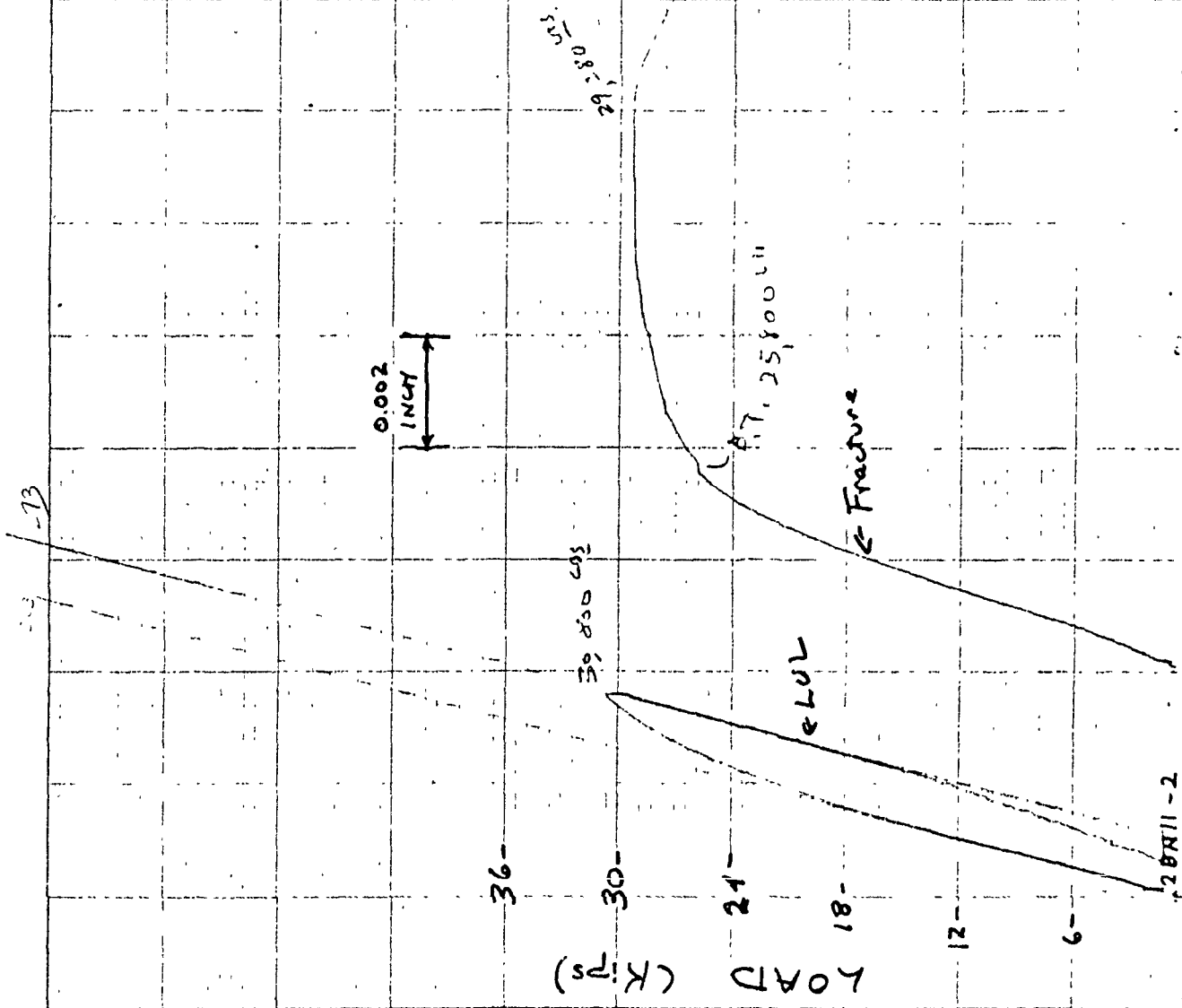
Specimen
RBN 11-1

0.002"
320°F LNE
2-10-55

0.002
INCH



Specimen
RBN 11-2



Specimen
RBN11-3

0.002
INCH

LOAD (Kips)

30-

27-

18-

12-

6-

32 K2

270 K2

ULT 28,440

ε Fracture

ε LUL

ε LUL

$\epsilon < 0.021$

$P = 11.5$

$\sigma = 32.7$

RBN11-3

RBN 11-3

Specimen
3BN 11-1

ULT 35,200 LBS.

B.T. 34,300 LBS.

0.001
INCH

-320°F 1N₂

<0.01%

3-25-5

SK

← Fracture

→ LUL

LOAD (K₂)

36-

30-

24-

18-

12-

6-

3BN 11-1

Specimen
3BN 11-2

0.001
INCH

BT. 33,100

ULT 34,500

35-

30-

25-

20-

15-

10-

5-

(Kips)

LOAD

← Fracture

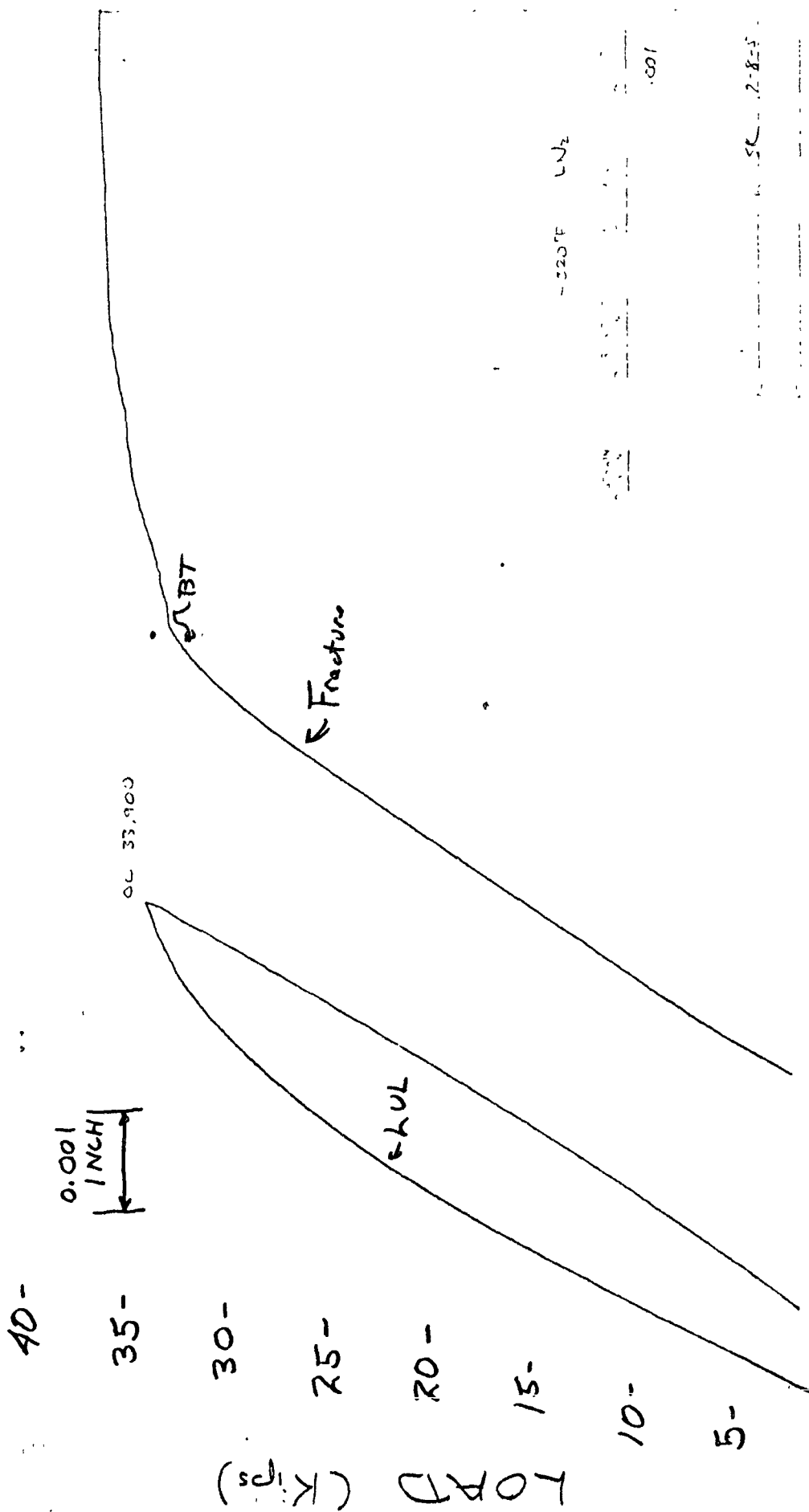
0.002 L/2

0.001

0.001

6/11-5

Specimen
4BN11-1



-320°F LN₂

0.001

5K 2.8-5

4BN 11-1

Specimen
ABN11-2

ULT 35,150

OL 34,200

0.001
INCH

40-

35-

30-

25-

20-

15-

10-

5-

LOAD (KI)

e- Fracture

e-LUL

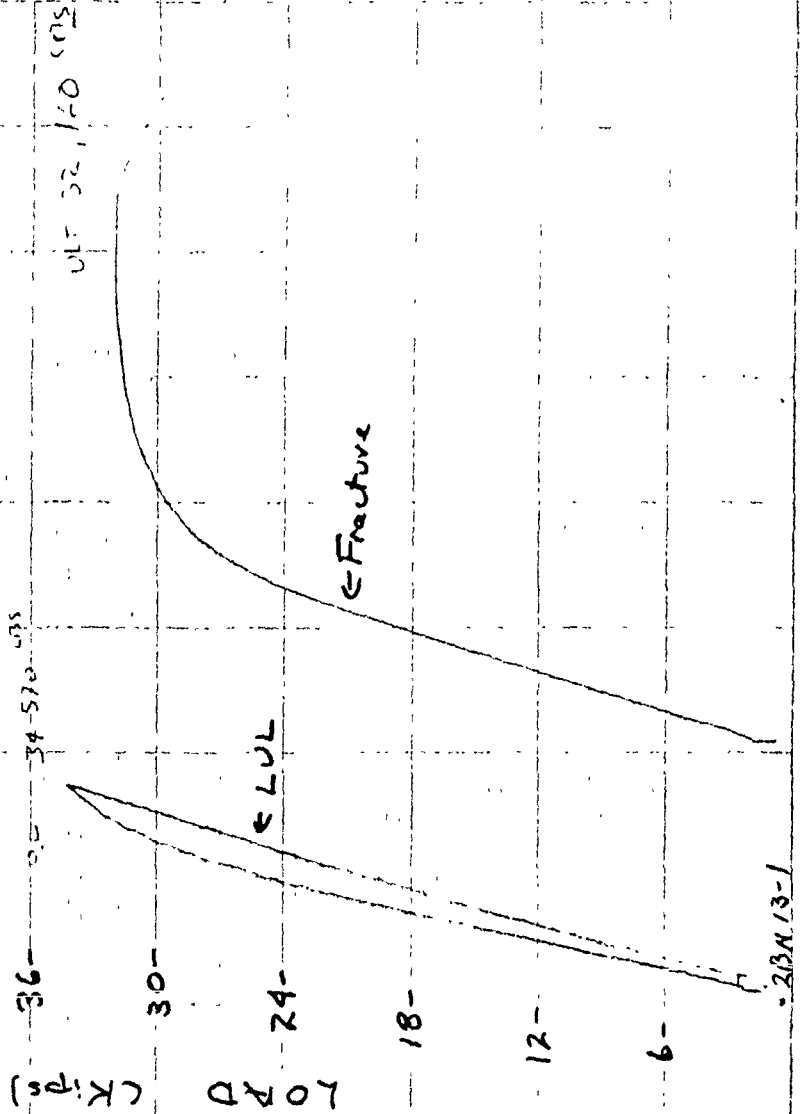
.001

7.9.5

ABN11-2

Specimen
RBN 13-1

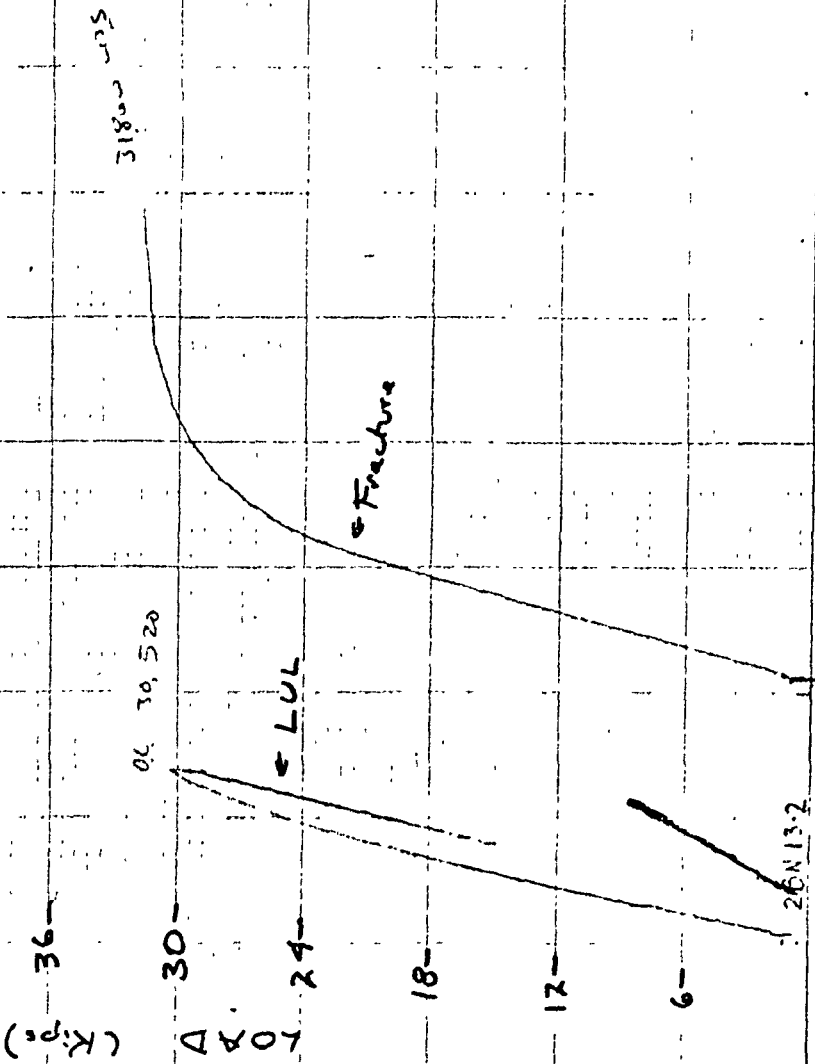
0.002
INCH



5.002 / 113
- 3200 F L N₂
R 11 - 55 50

Specimen
2BN13-2

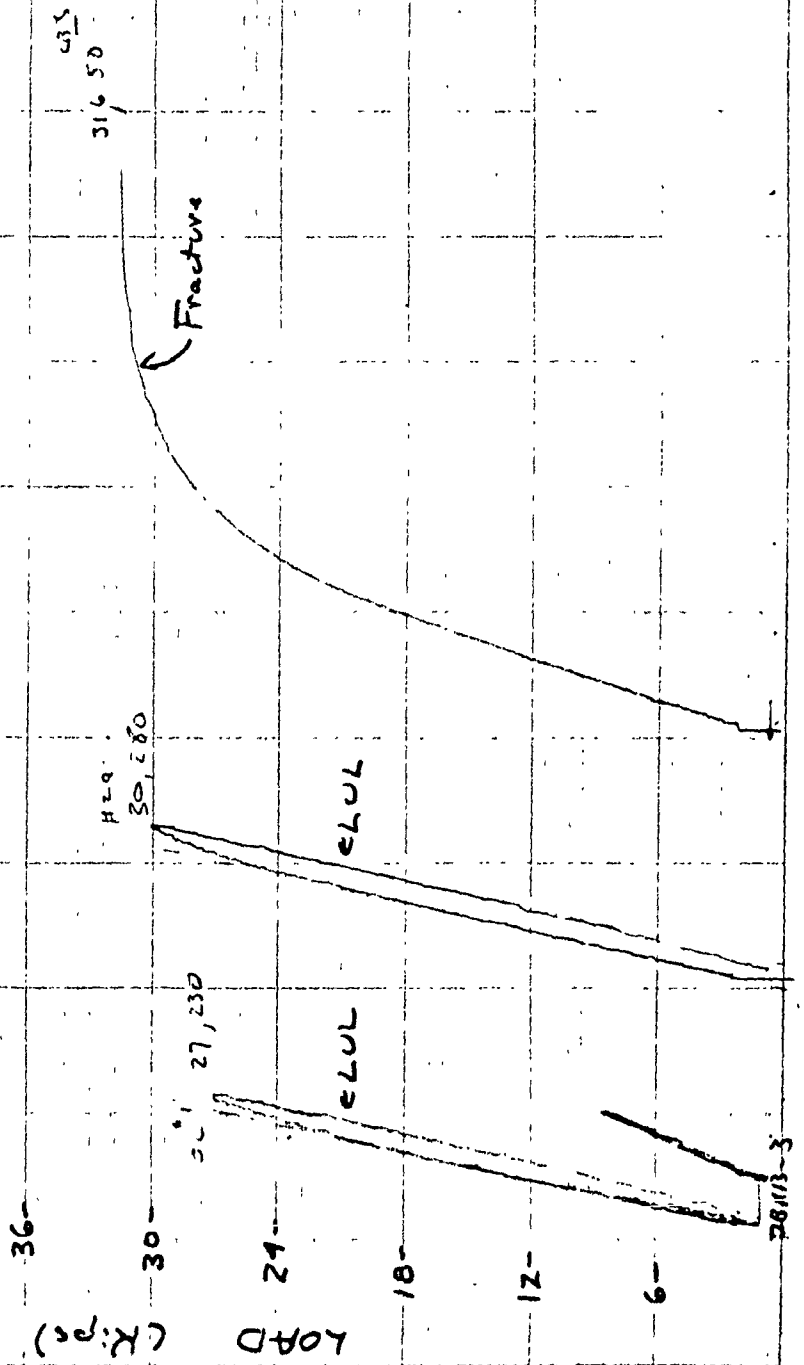
0.002
INCH



0.002%
- STAIN-LESS
2-11-5

Specimen
RBN 13-3

0.002
INCH



2.12.5
- 320 LCL
0.002

Specimen
RTN 13-9

ULT 38,400 lbs.

< 0.01%
-320°F LN₂
3-17-5
JNL

0.001
INCH

42-

0.1 34,000 lbs.

36-

30-

24-

18-

12-

6-

RTN 13-9

LOAD (KIPS)

ε LUL

ε Fracture

Specimen
3BN13-1

627 39050

0.0005
INCH



40-

35-

30-

25-

20-

15-

10-

5-

LOAD (Kips)

OL 31850 LBS

Fracture

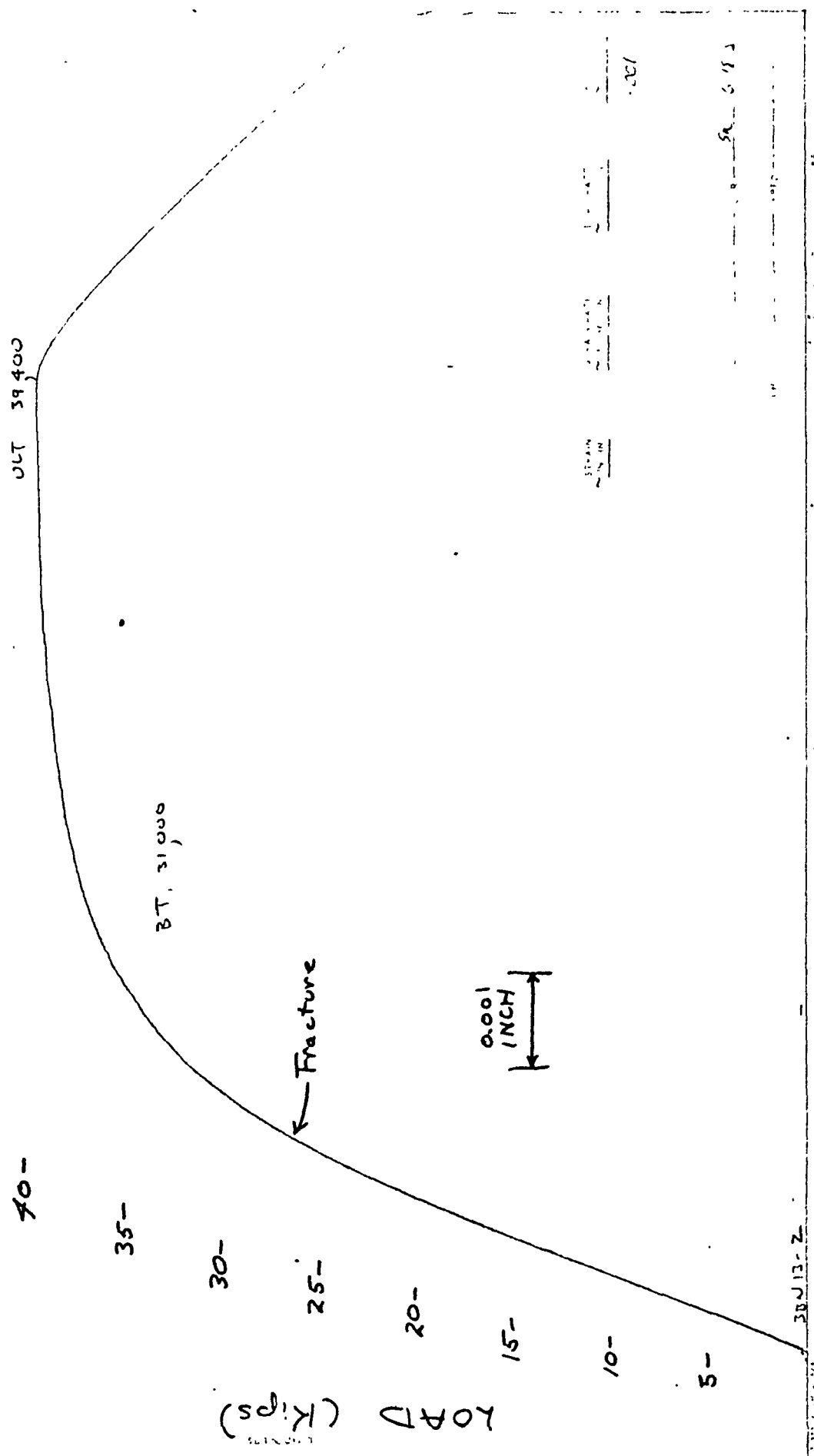
-320°F LUL

OL
LUL

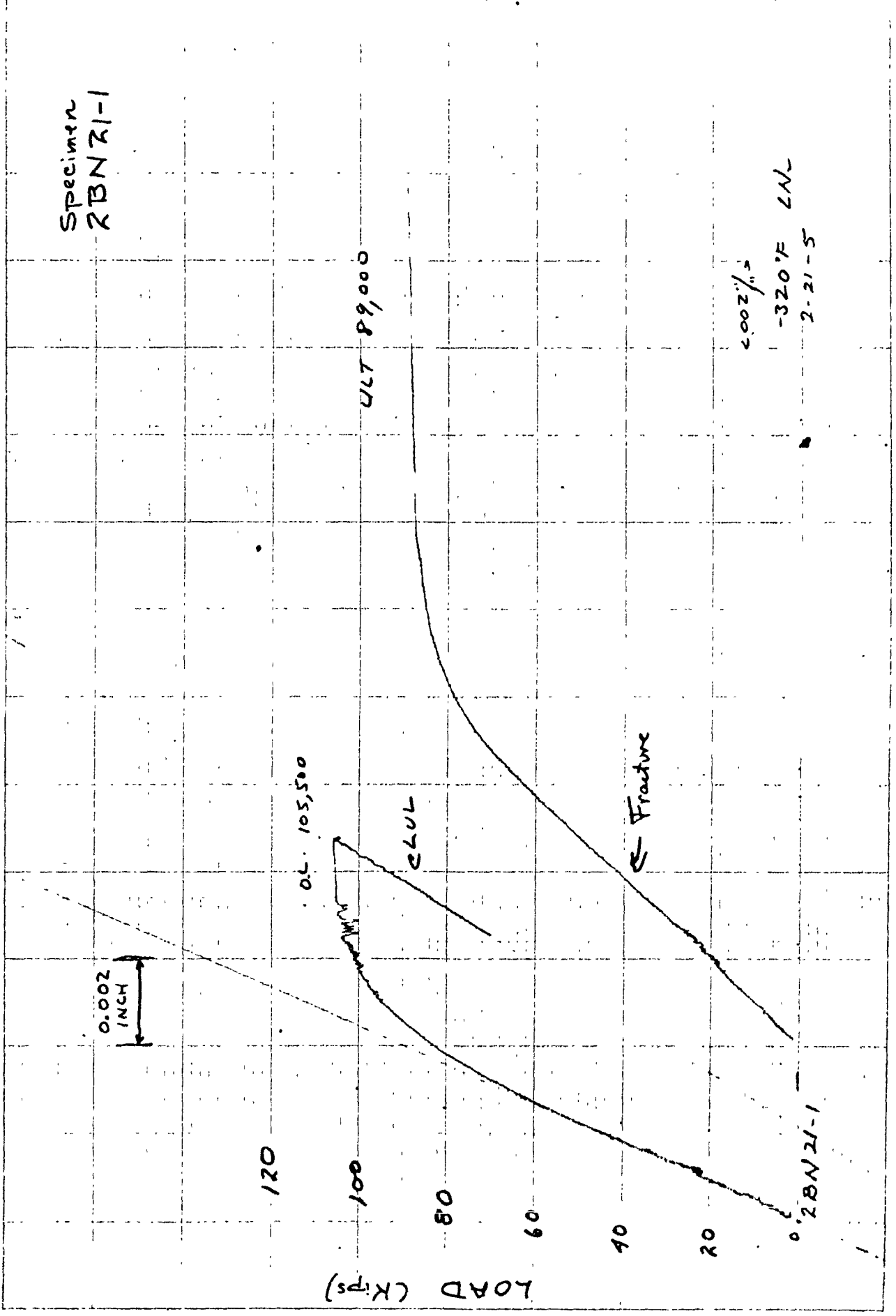
61.5

3BN13-1

Specimen
3BN 13-2



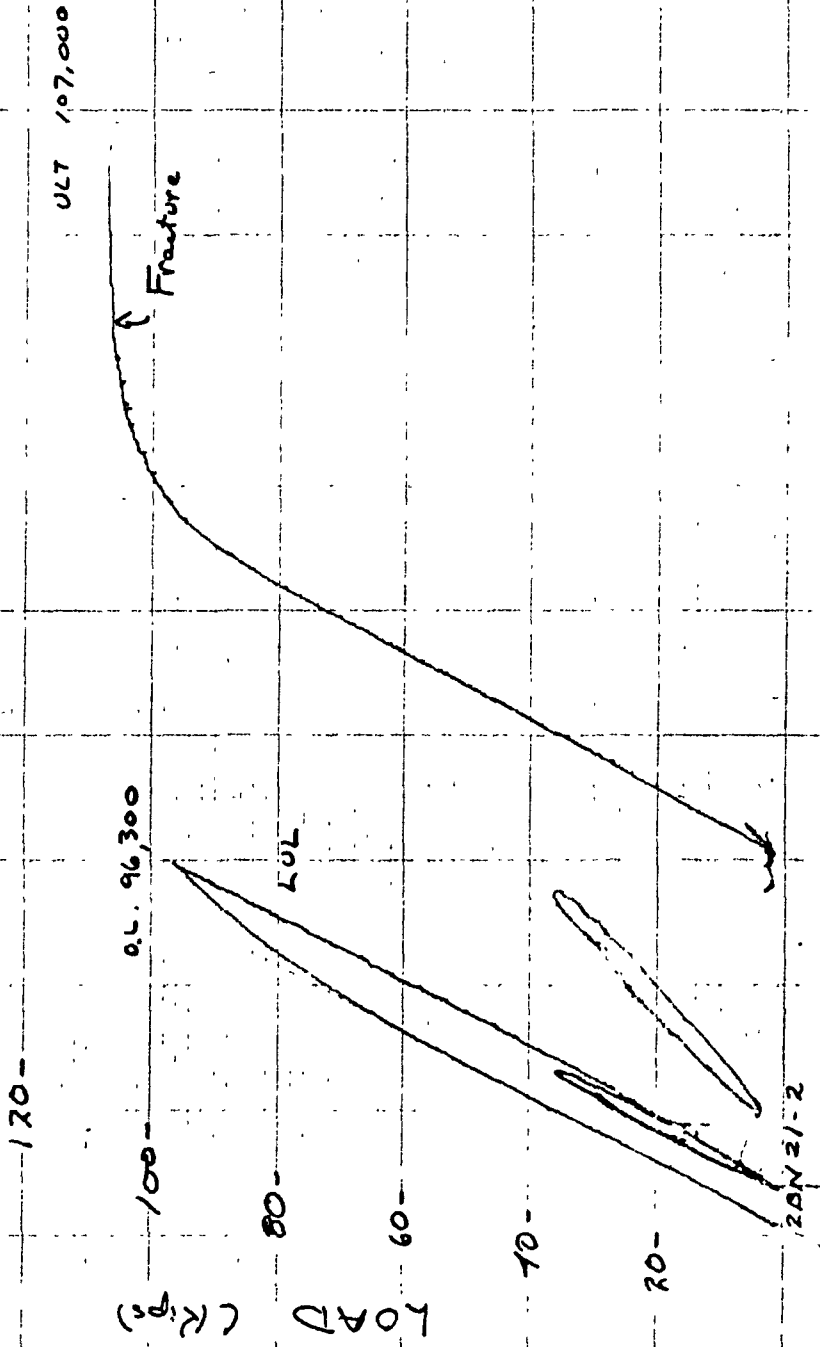
Specimen
RBN21-1



0.002"
-320°F LNL
2-21-5

Specimen
2BN R1-2

0.002
INCH



0.002 in./min
-320°F LN₂
2-21-5

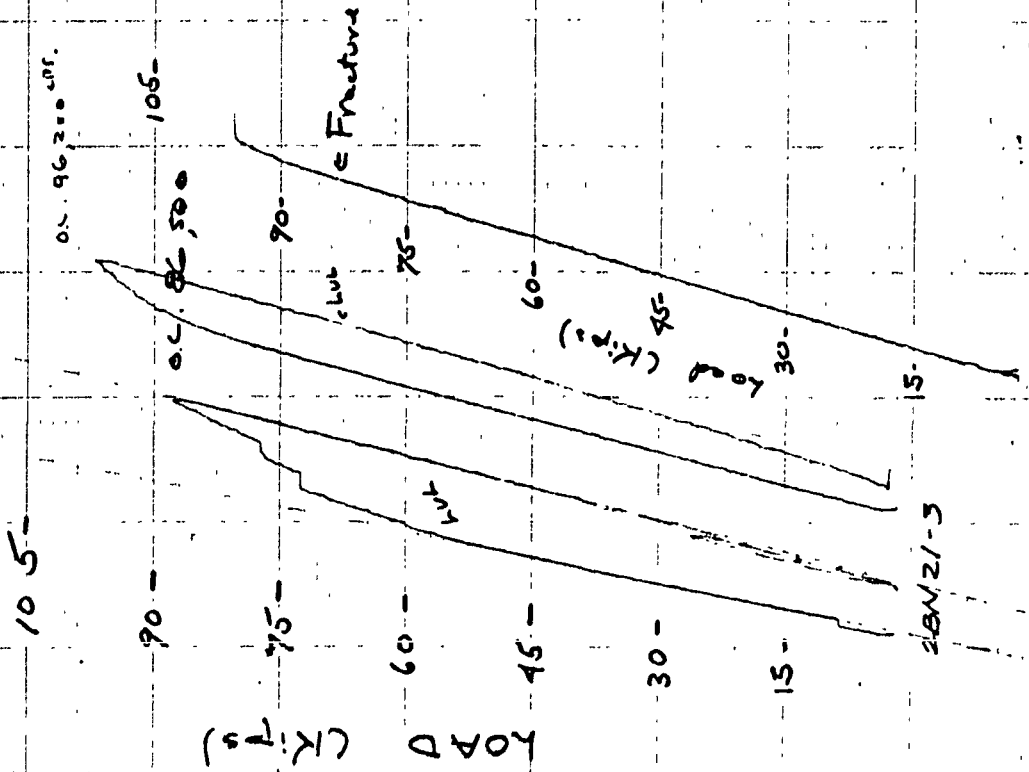
Specimen
RBN 21-3

0.002
INCH

NO. B.T.
6 LT / 105,300

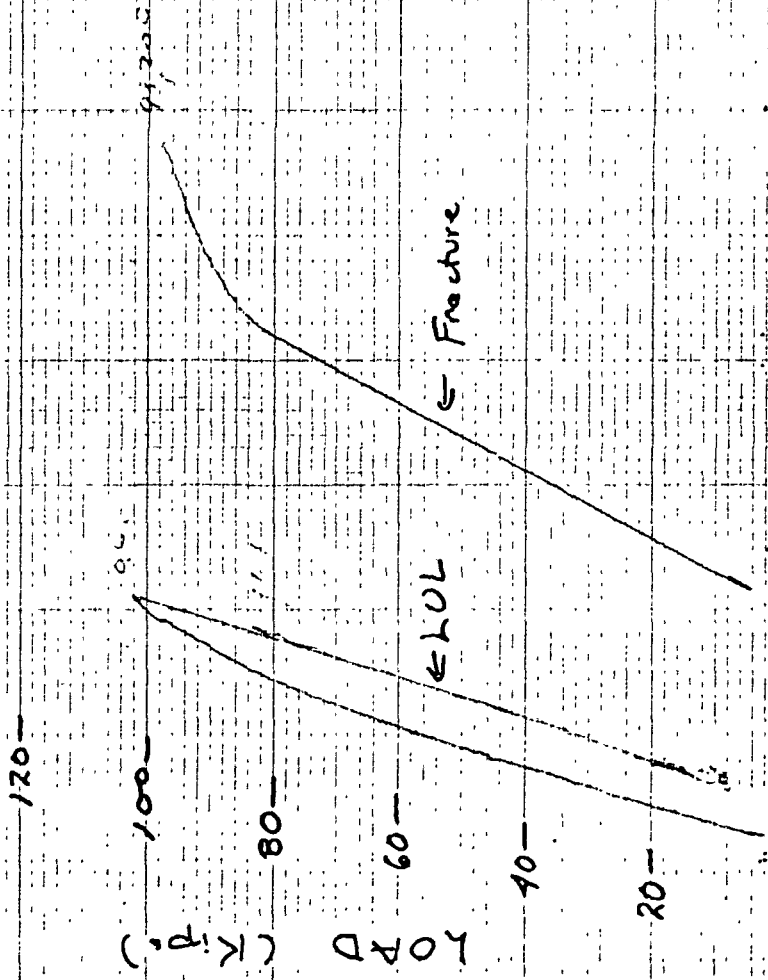
↑ EDI Slipped

< 0.02%
-320°F L.M.
4-1-5
S.K.



Specimen
ZBN 21-4

0.002
INCH



ZBN 21-4

Specimen:
3BN21-1

No. B.T.

ULT 109,500 lbs.

< 0.01%
320
3-31-5
3%

120-

105-

90-

75-

60-

45-

30-

15-

3BN21-1

0.001
INCH

LOAD (KIPS)

Specimen

3BN 21-2

0.002
INCH

UT 777600

120-

100-

80-

60-

40-

20-

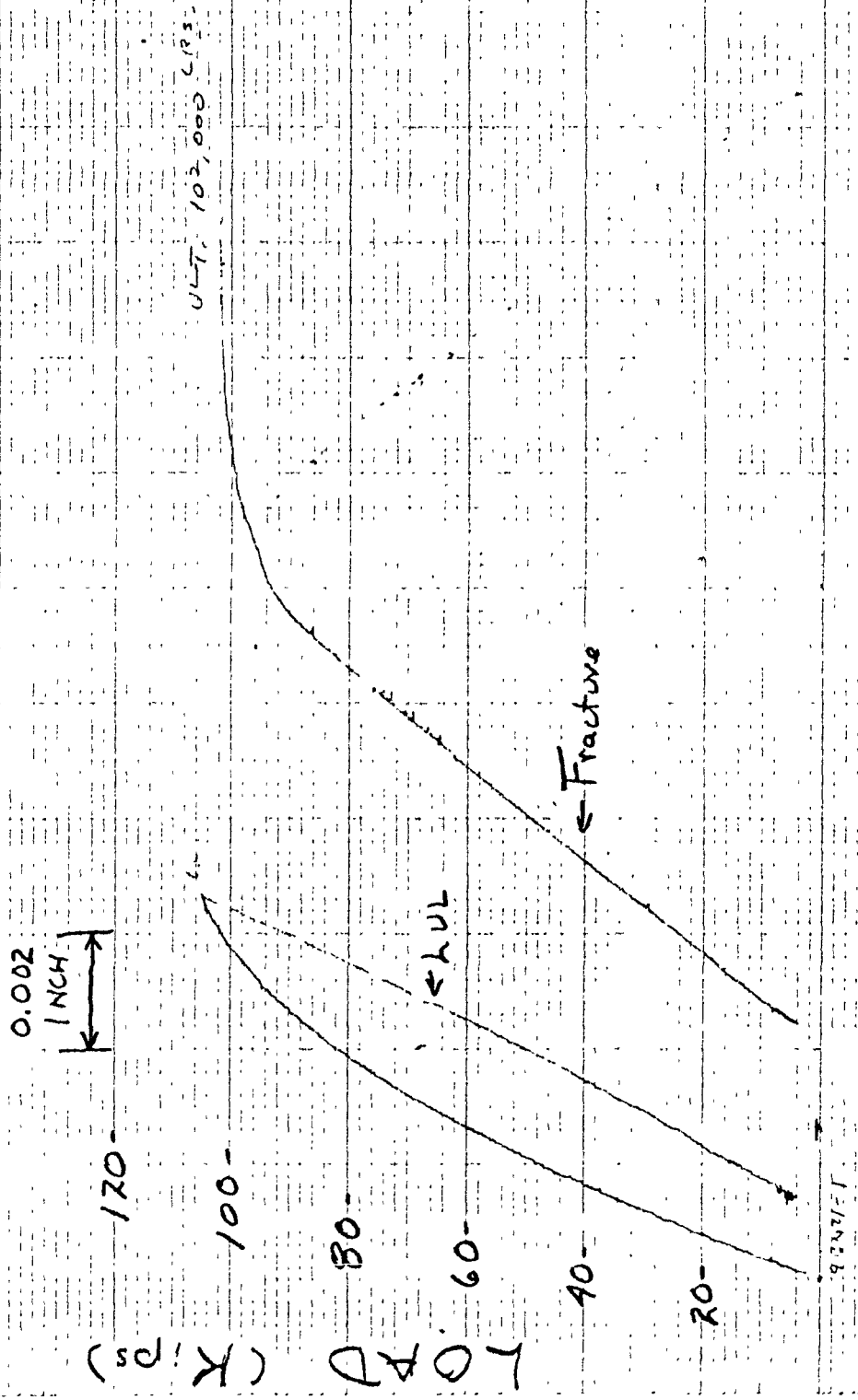
LOAD (KIP)

Fracture

0.002/INCH
5320 LUN
6-10 51 SL

3BN 21-2

Specimen
4BN21-1



20037
320.17
5-18-5

Specimen
ZBN 23-1

0.002
INCH

0.6 118,750 LBS.

100,750
105,000 LBS.

120-

100-

80-

60-

40-

20-

ZBN 23-1

FLUL

Fracture

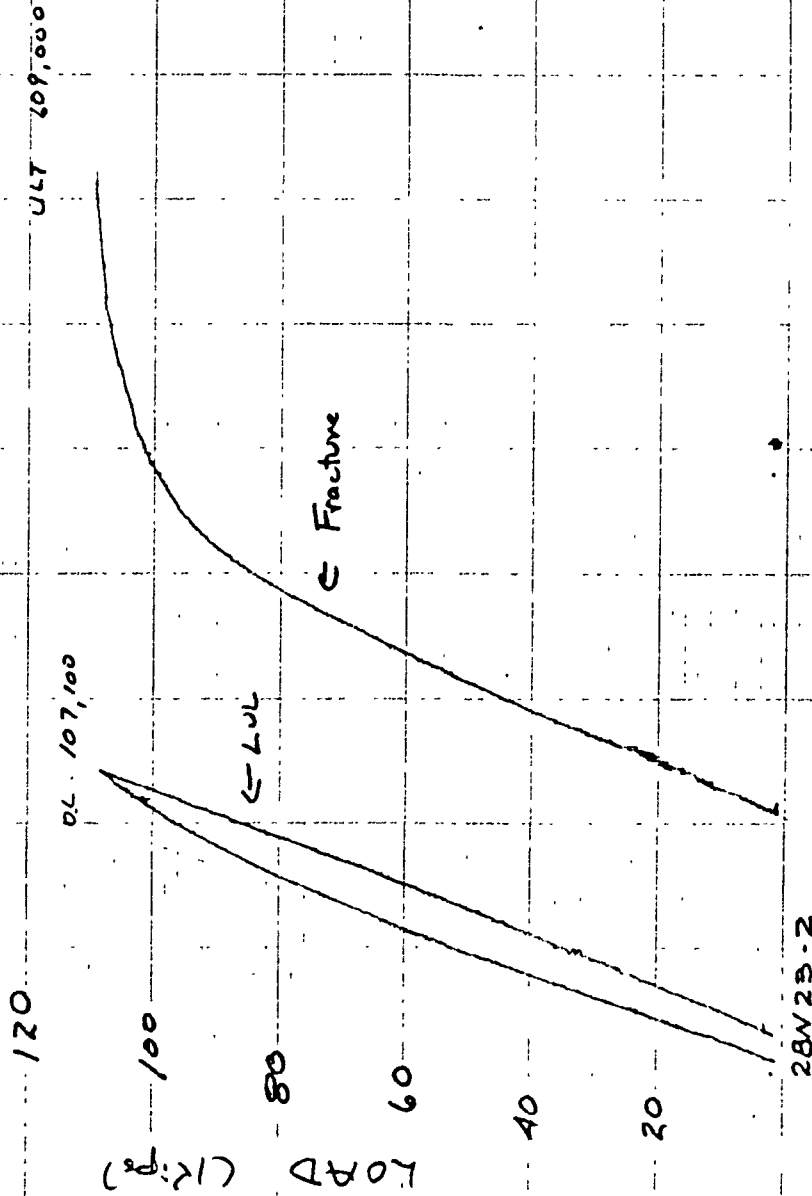
LOAD (KIPS)

<0.02%
-320°F LN₂
2-24-S

Specimen

2BN23-2

0.002
INCH

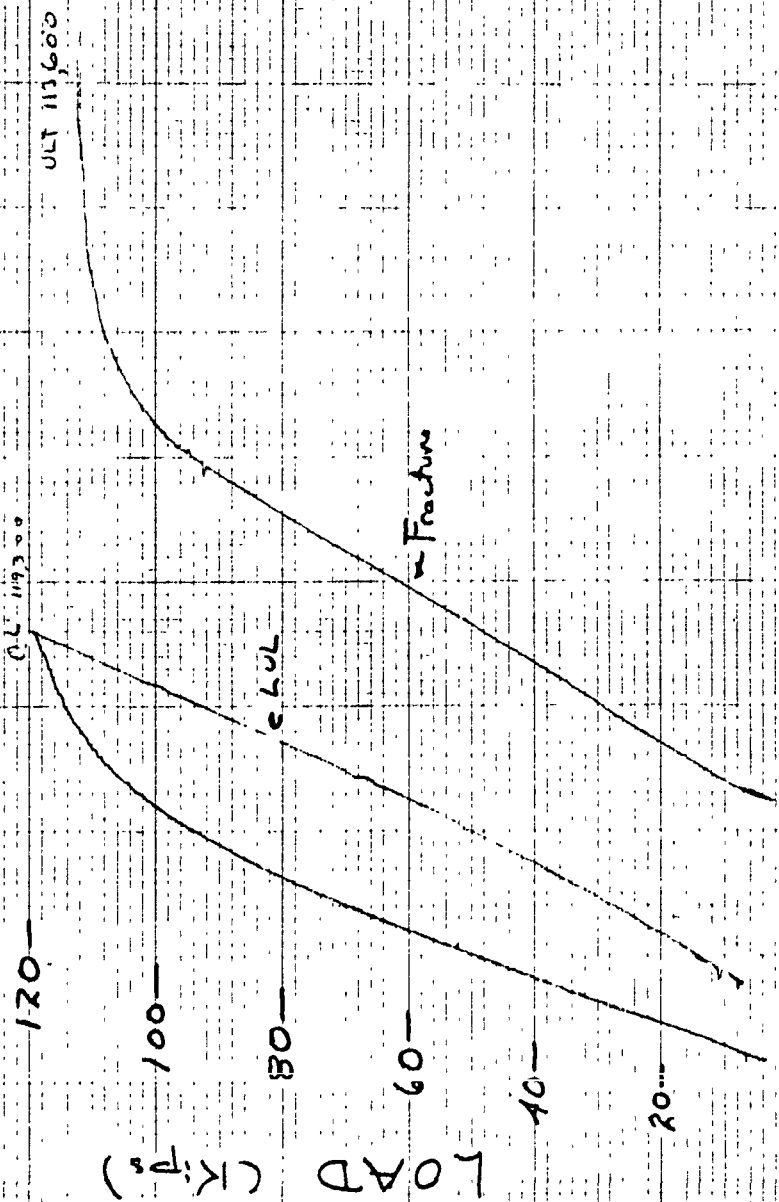


Specimen

RBN 23-9

0.002

INCH



113.6
1000
4000
5-5-5

RBN 23-9

Specimen
3BN23-1

no. B.T.
067 123,300 CPS

< .001 / . >
- 320°F LN₂
3-81-S
SK

LOAD (K:ps)

0.001
INCH

120-

90-

60-

30-

3BN23-1

Specimen
3BN R3-Z

0.002
INCH

BI

119,600

120

LOAD

(Kips)

100

80

60

40

20

Fracture

3BN R3-Z

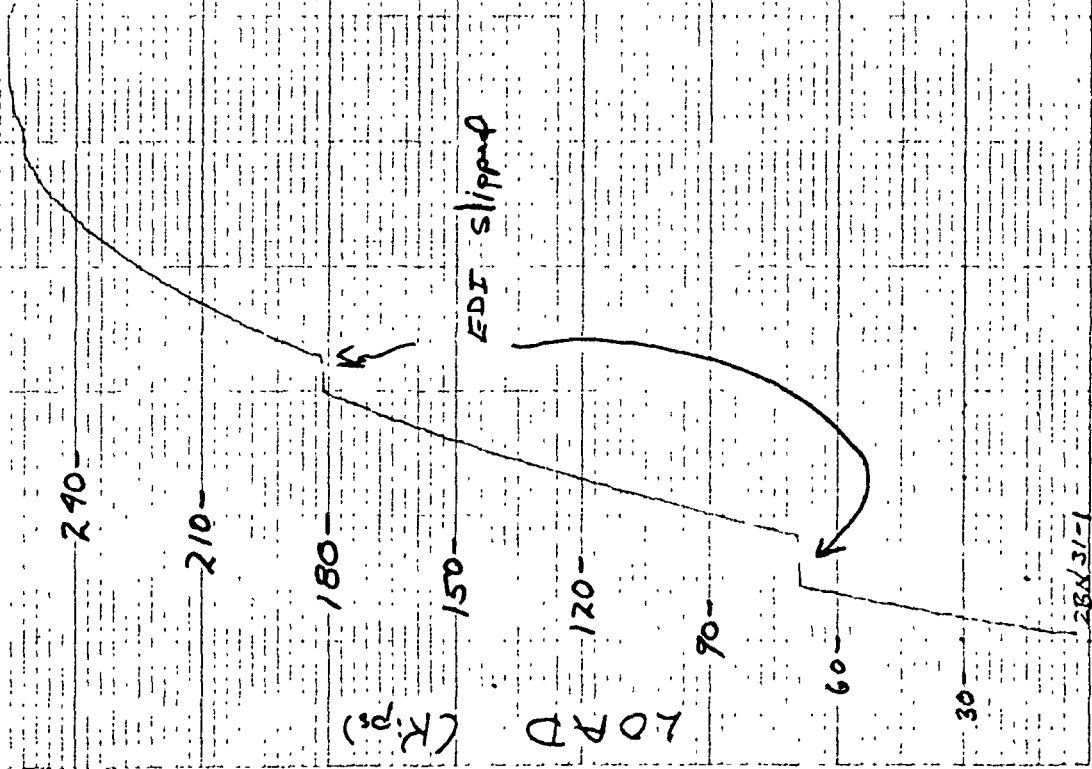
-320°F Uth

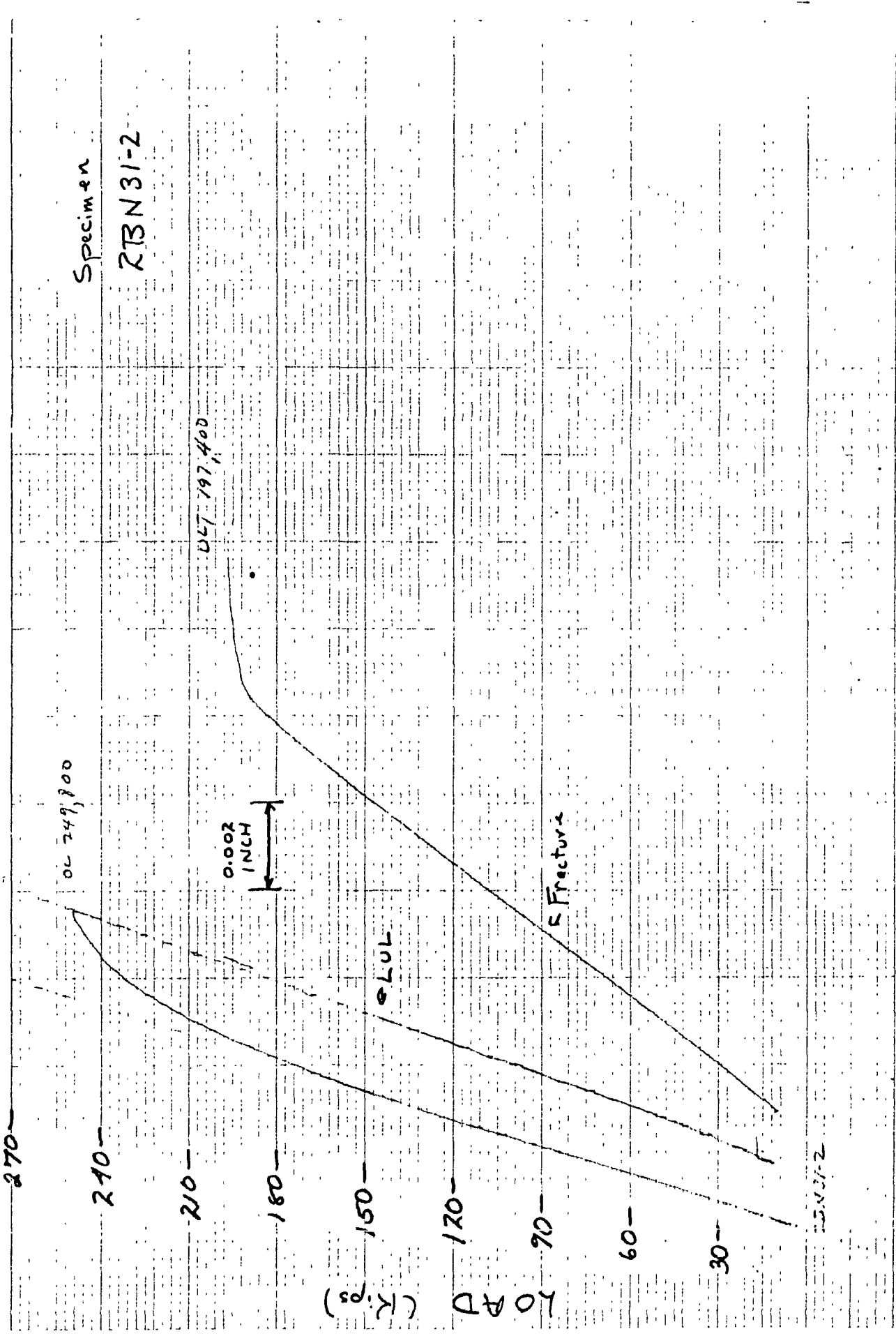
6002/2.7

6-9-55

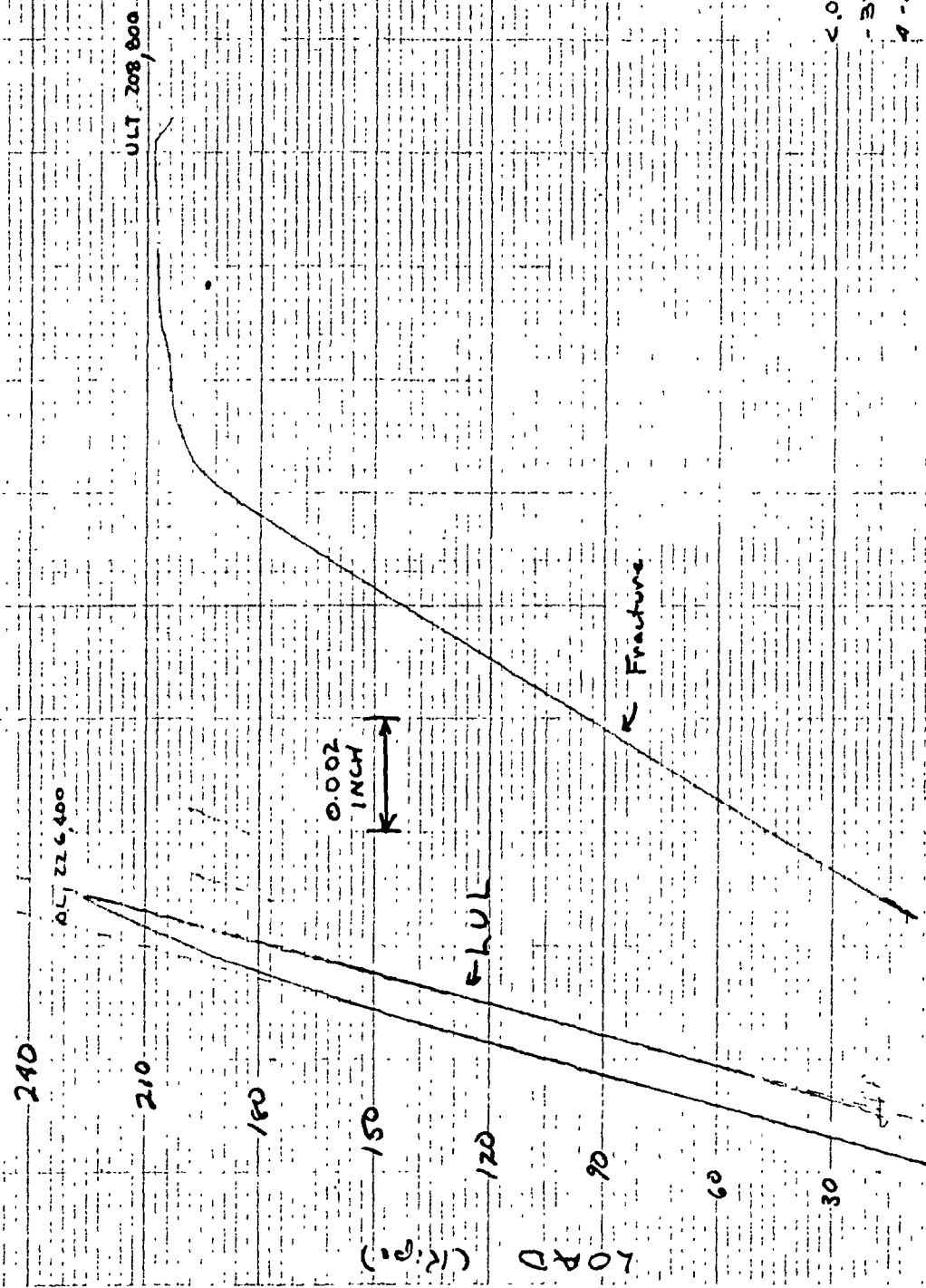
Specimen
RBN 31-1

270
4LT 256,800 70, BT





Specimen
RTBN 31-3



RTBN 31-3

Specimen 2BN31-9

0.002
INCH

0.259, 200

UCT 207,200

240

200

160

120

80

40

(K) A
LOAD

ELUL

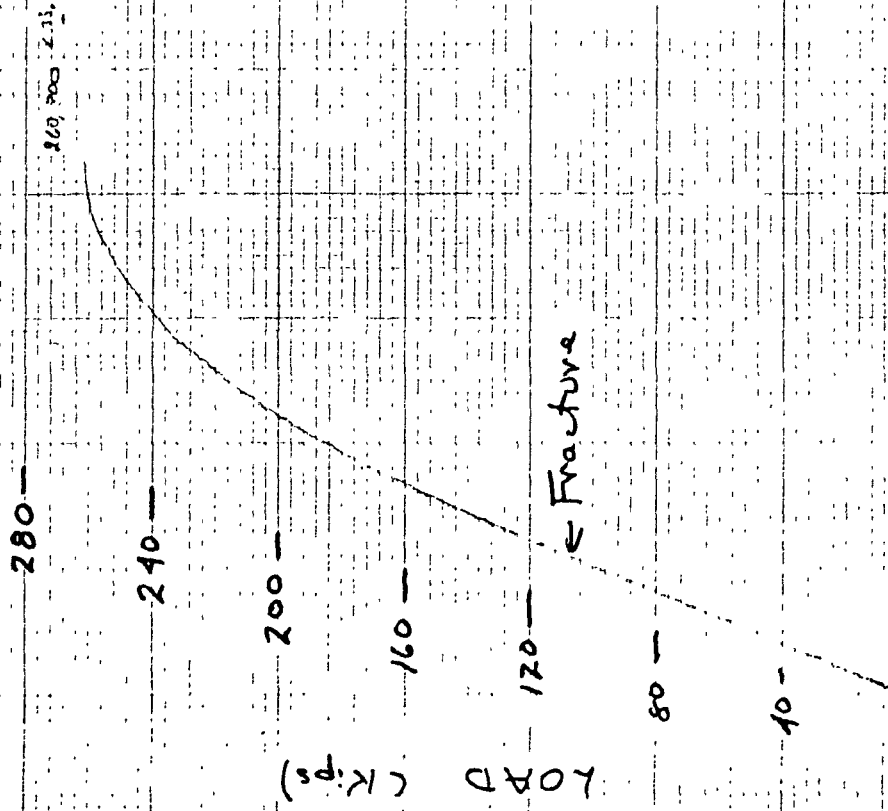
← Fracture

0.002 / >
-320 F INH
57.5 SL

0.15 INCH

Specimen
3BN 314

0.002
INCH



0.001
0.002
0.003
0.004
0.005

0.001

0.002
INCH

Specimen

3BN31-2

OL 251 200

ULT 201,600

c LUT

Fracture

LOAD (KIPS)

280-

240-

200-

160-

120-

80-

40-

< 0.02% >

-32072 2N

-8-1-5 N

3BN31-2

Specimen
4BN31-2

0.002
INCH

251,200

62,345 sec

Fracture

FLUL

240

200

160

120

80

40

LOAD (Kips)

4BN31-2

Specimen
ATBN 31-3

0.002
INCH

280

OL 209,900

23,600 0.017

240

RULY

200

160

120

80

40

LOAD (KIPS)

Fracture

600 2/3

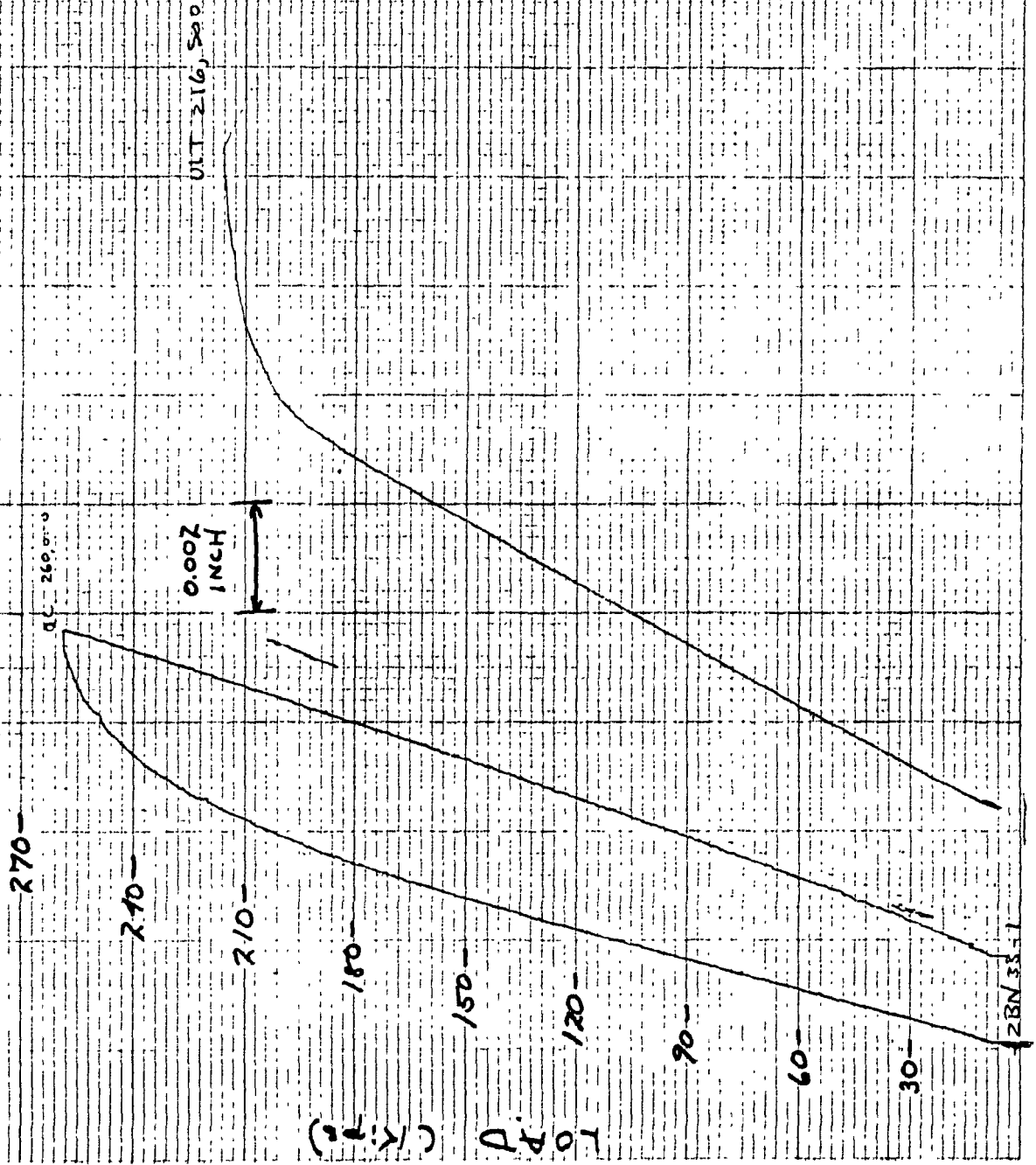
376.9

5.15 - 5

ATBN 31-3

Specimen
RBN 33-1

< 0.02% S
-320 P L₂
4-1A-5 516



Specimen
ZBN 33-2

ULT 226,500

DL 232,700

210-

210-

180-

150-

120-

90-

60-

30-

ZBN 33-2

0.002
INCH

→ LUL

→ Fracture

f_i

0.007

LN₂ - 320°K

4-14-55

LOAD (KIPS)

Specimen
ZBN 33-3

ULT 225,000

0.002
INCH

DL 208,100

210

180

150

120

90

60

30

0 ZBN 33-3

LOAD (KIP)

Fracture

0.002%
4N2 - 320
0.15 - 5.5%

Specimen
RBN33-4

0.002
INCH

280

0.4 154,500

240

0.47 220,810

LOAD (KIPS)

200

SHUL

160

120

Fracture

80

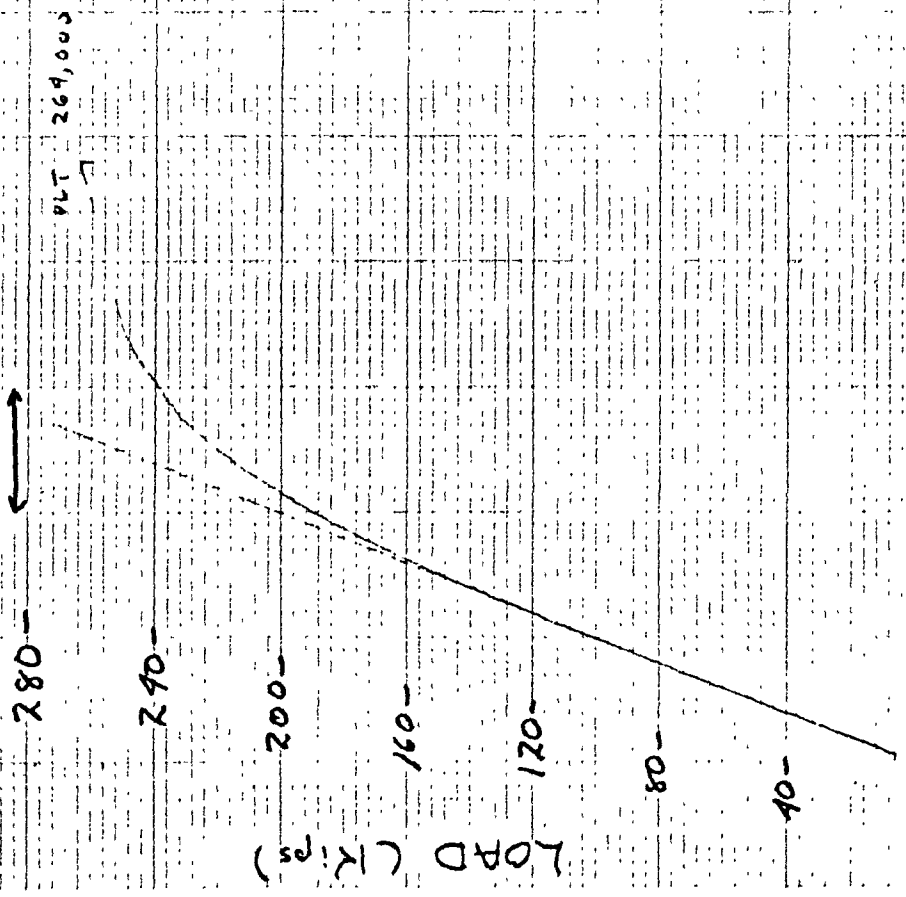
40

RBN33-4

2002
- 320
1-6-5

Specimen
3BN 33-1

0.002
INCH



0.002/in >
-3200- LNH
5-1-5

3BN33-1

Specimen
3BN 33-2

0.002
INCH

ULT 265,000

280-

240-

200-

160-

120-

80-

40-

LOAD (Kips)

LN₂ - 720°F

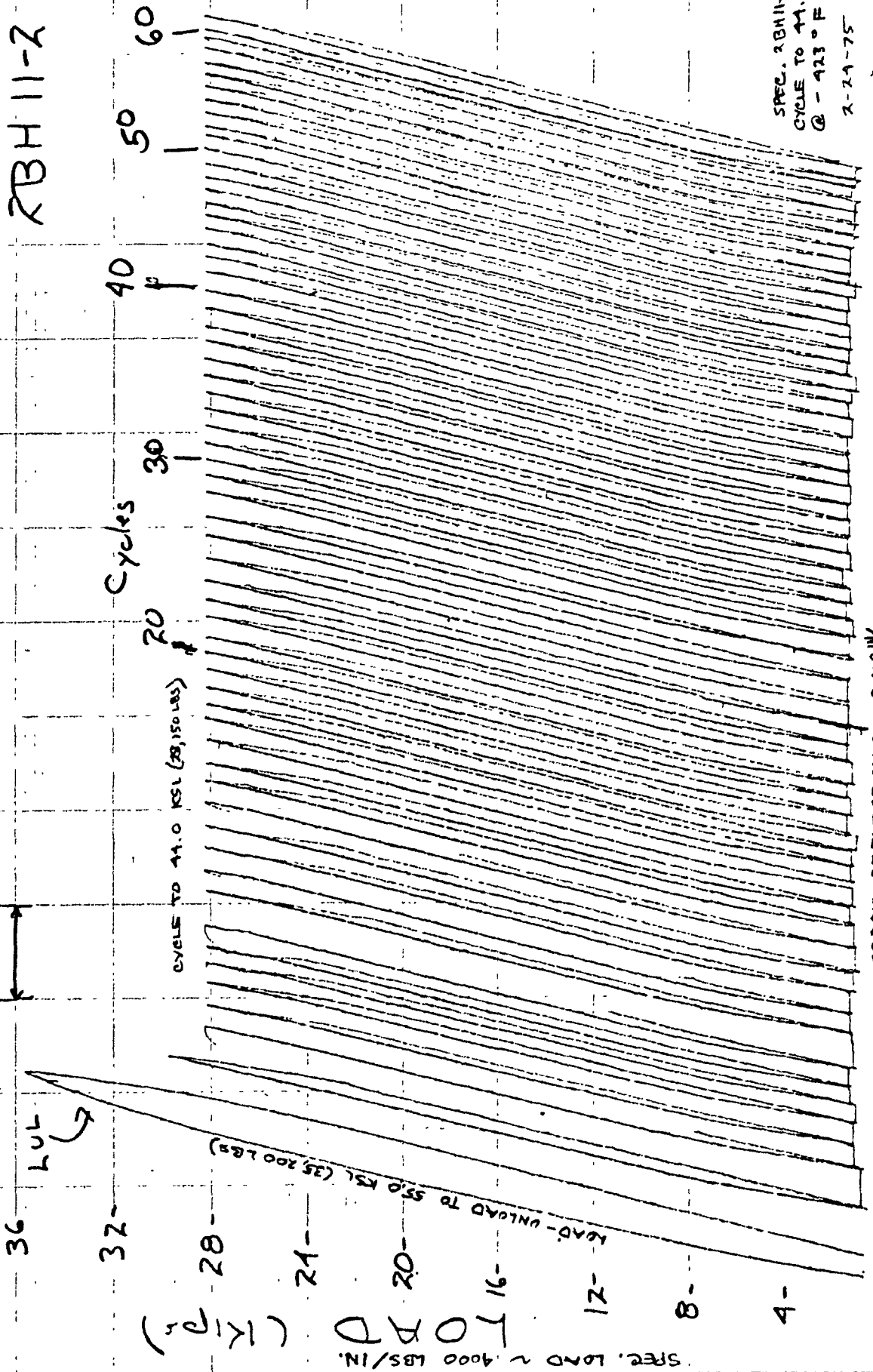
<0.02% >

6.5-5 5K

3BN33-2

Specimen
ZBH11-2

0.002
INCH



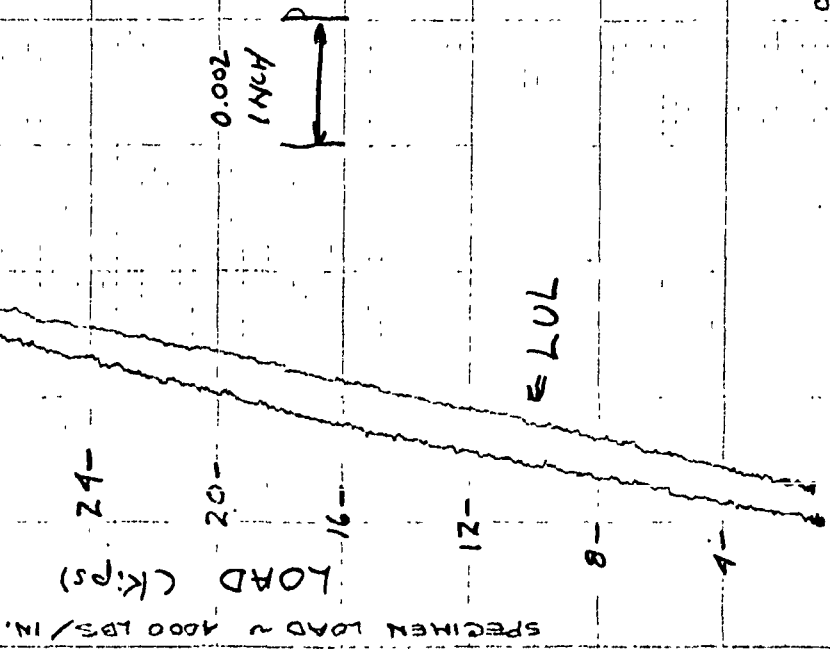
SPEC. ZBH11-2
CYCLE TO 41.0 KSI
@ - 423 ° F
2-21-75

RBH 11-3

Specimen
RBH 11-3

SPEC RBH 11-3
LOAD-UNLOAD TO 49.5 KSI (32,350 LBS)
2-26-75 TULAH TEST SITE - AREA A1

CRACK OPENING DEFLECTION \approx 1 IN \approx 0.002 IN.



Specimen
ZBH 11-3

ULT 31,600
US

< 0.01% >

0.001
INCH

Fracture

36-

30-

24-

18-

12-

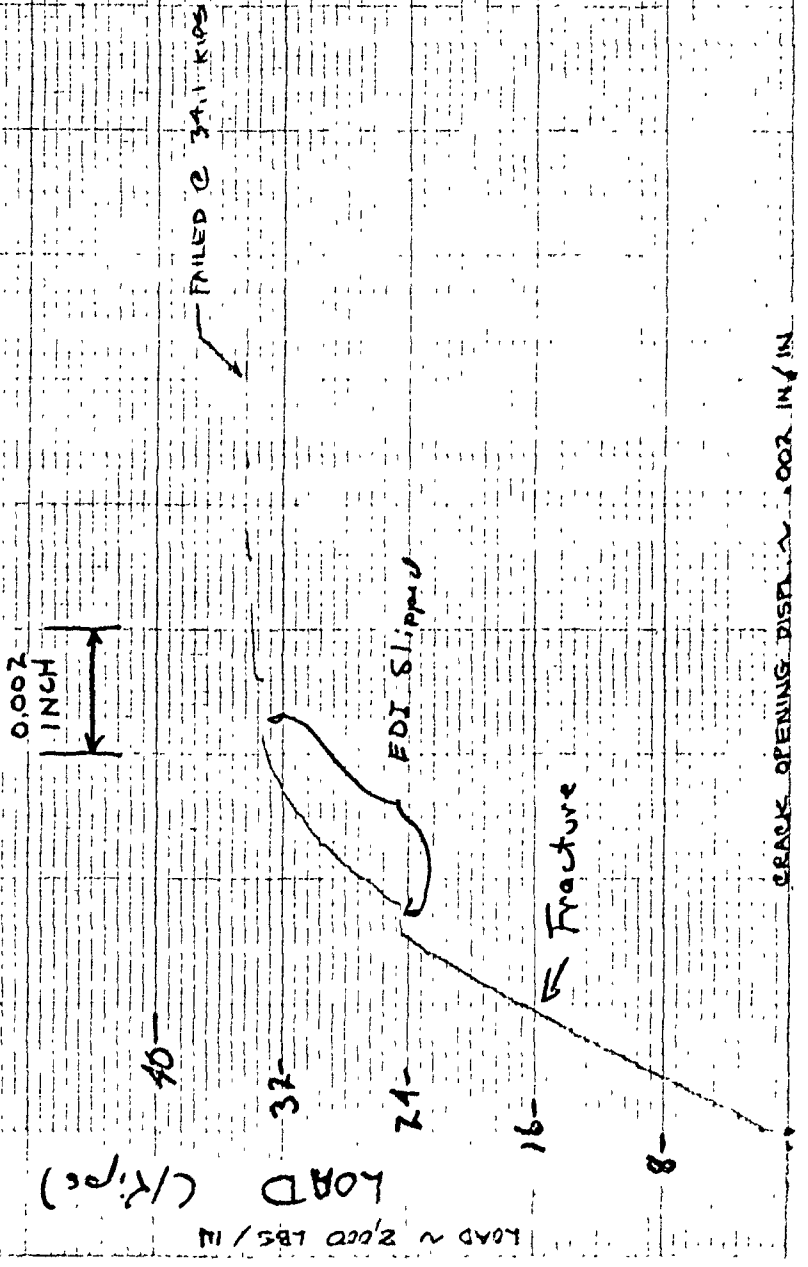
6-

ZBH 11-3

LOAD (KIPS)

21-1-7

Specimen
ZBH11-4



SPECIMEN ZBH11-4
LOAD TO FAILURE @ -423°F
TUMALIP 8-21-75

Specimen
3BH11-1

SPECIMEN 3BH11-1 (-123°F)
TULALIP TEST SITE
3-12-75

18,150 LBS

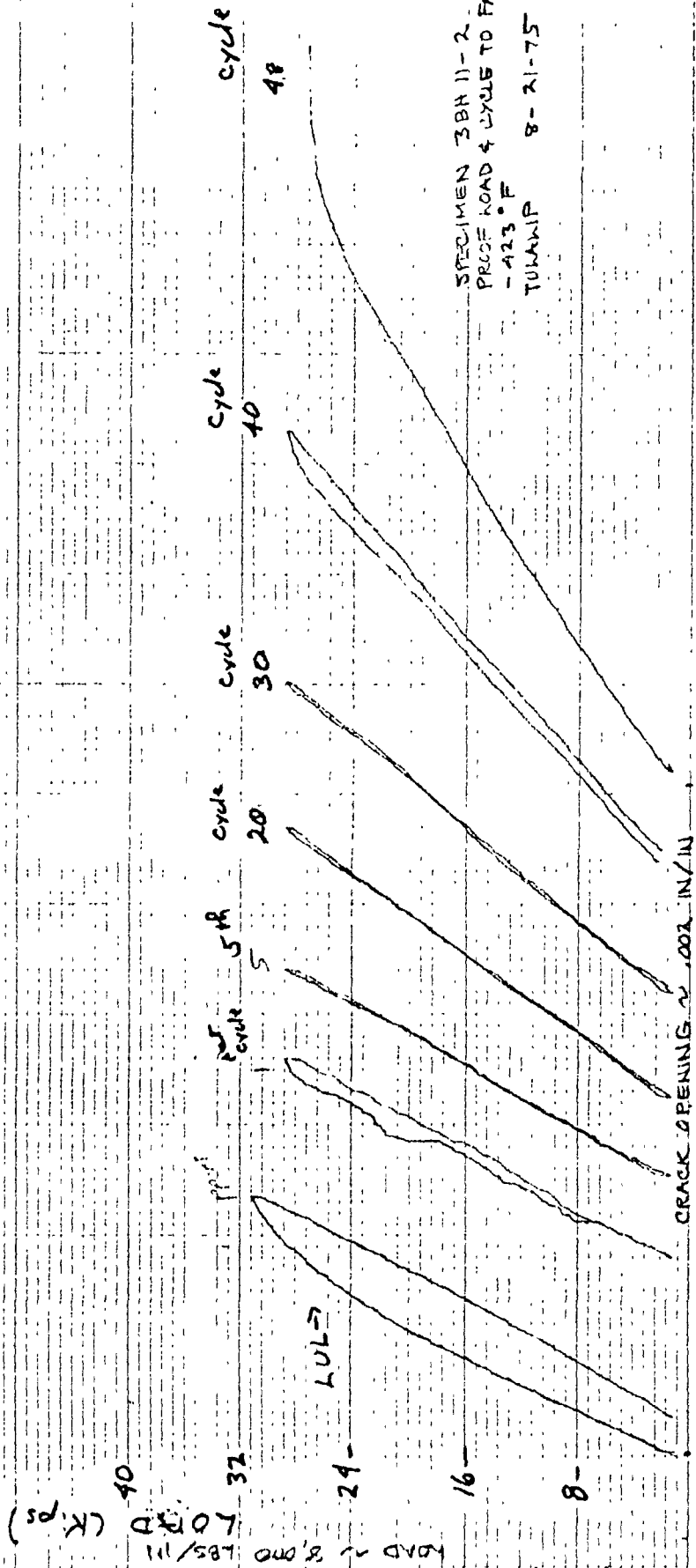
LOAD ~ 4,000 LBS/IN.

CRACK OPENING DISPL. ~ 0.002 IN./IN.

3-12-75 3BH11-1

Specimen
3BH 11-2

0.002
INCH



SPECIMEN 3BH 11-2
PROF LOAD & CYCLES TO FAILURE
-423 °F
TUMMINP 8-21-75

4BH11-1 8-11-75

Specimen
4BH11-1

(Kips)

LOAD

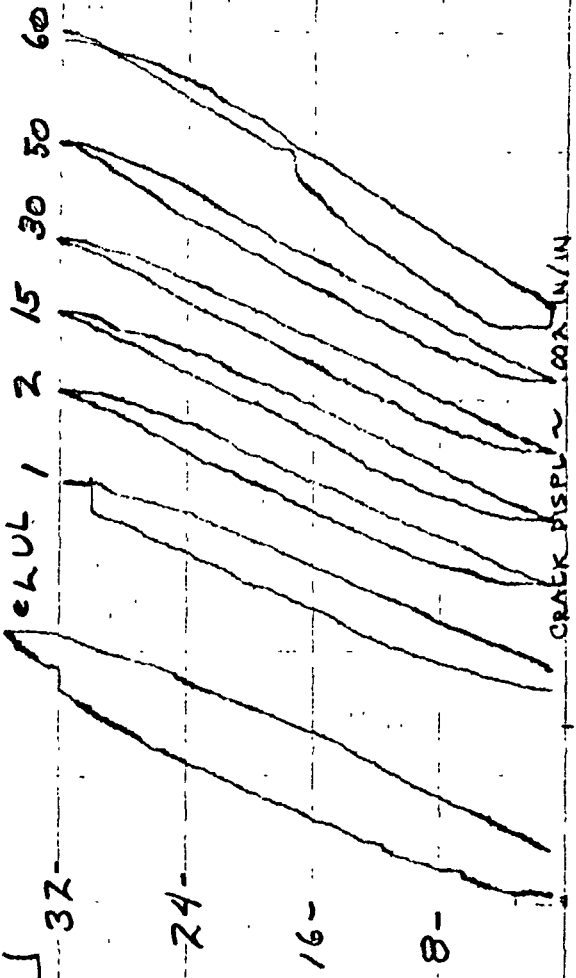
LOAD ~ 8,000 LBS / IN

0.002
INCH

Cycle

PROOF

CRACK BREAK-THRU
ON 73 RD CYCLE



SPECIMEN 4BH11-1
PROOF LOAD, CYCLE TO BREAK-THRU IN LA2
TULAHIP 8-11-75

CRACK DISPL ~ 0.002 IN/IN

Specimen

ZBH21-1

SPECIMEN ZBH21-1
LOAD-UNLOAD TO 57.0 KSI (152,100 LBS)
@ -423°F
CYCLE TO 17.2 KSI @ -423°F
3-10-75 TULALIP TEST SITE - AREA 41

180-

160-

140-

120-

100-

80-

60-

40-

20-

LOAD (Kips)

LOAD ~ 10,000 LBS/IN.

FAILED 131,500 LBS

0.002
INCH

F Fracture

CRACK OPENING DISPLACEMENT ~ .002 IN./IN.

Specimen
ZBH21-2

0.002
INCH



PROOF LOAD 125,500 LBS

LOAD ~ 10,000 LBS / IN.
(K/IN)

110-

120- LUL →

100-

80-

60-

40-

20-

Cycle

10 20 30 40 50 60 70 80 90 100 110 120 130

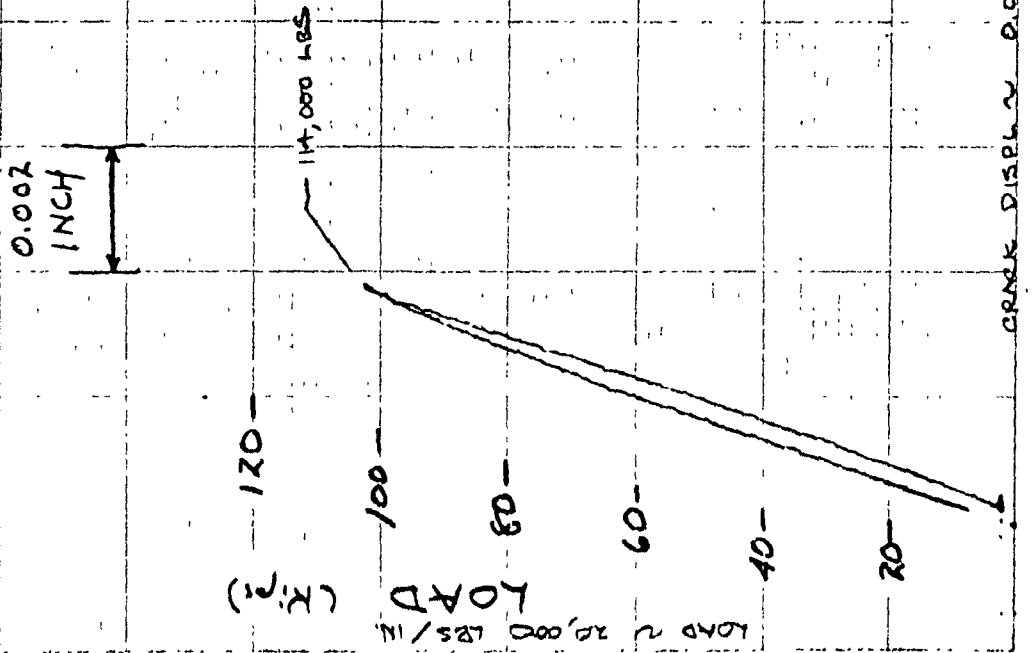
CYCLIC LOAD 100,500 LBS

SPECIMEN ZBH21-2
LOAD-UNLOAD TO 56.0 KSI @ -423 °F
CYCLE TO 44.8 KSI @ -423 °F
3-11-75 TUKAHP TEST SITE - AREA 41

CRACK OPENING DISPLACEMENT ~ .002 IN./IN.

Specimen
2BH 21-3

SPECIMEN 2BH 21-3 (-123°F)
TULALIP TEST DATE
3-12-75

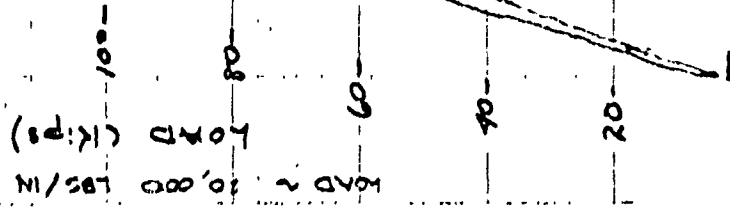


175
21 21 3 3-12-75

Specimen RBH21-4

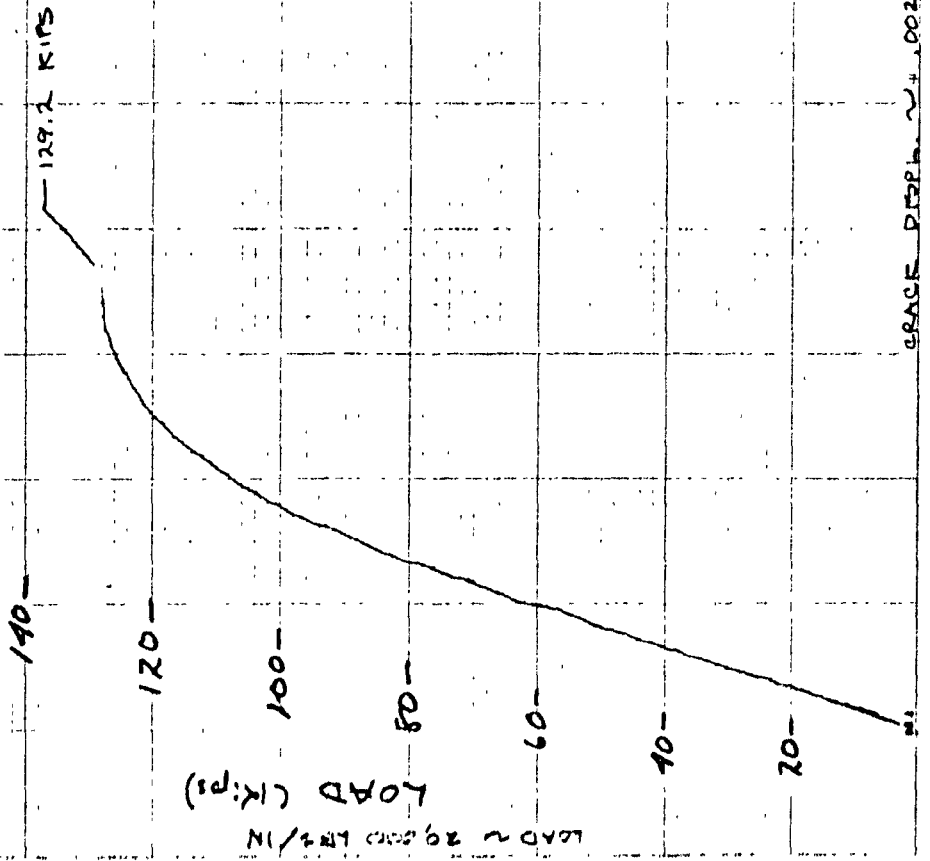
SPECIMEN RBH21-4
PROOF LOAD TO 15.9 KSI IN LH₂
TULALIP 8-22-75

0.002
1 INCH



Specimen
3BH21-1

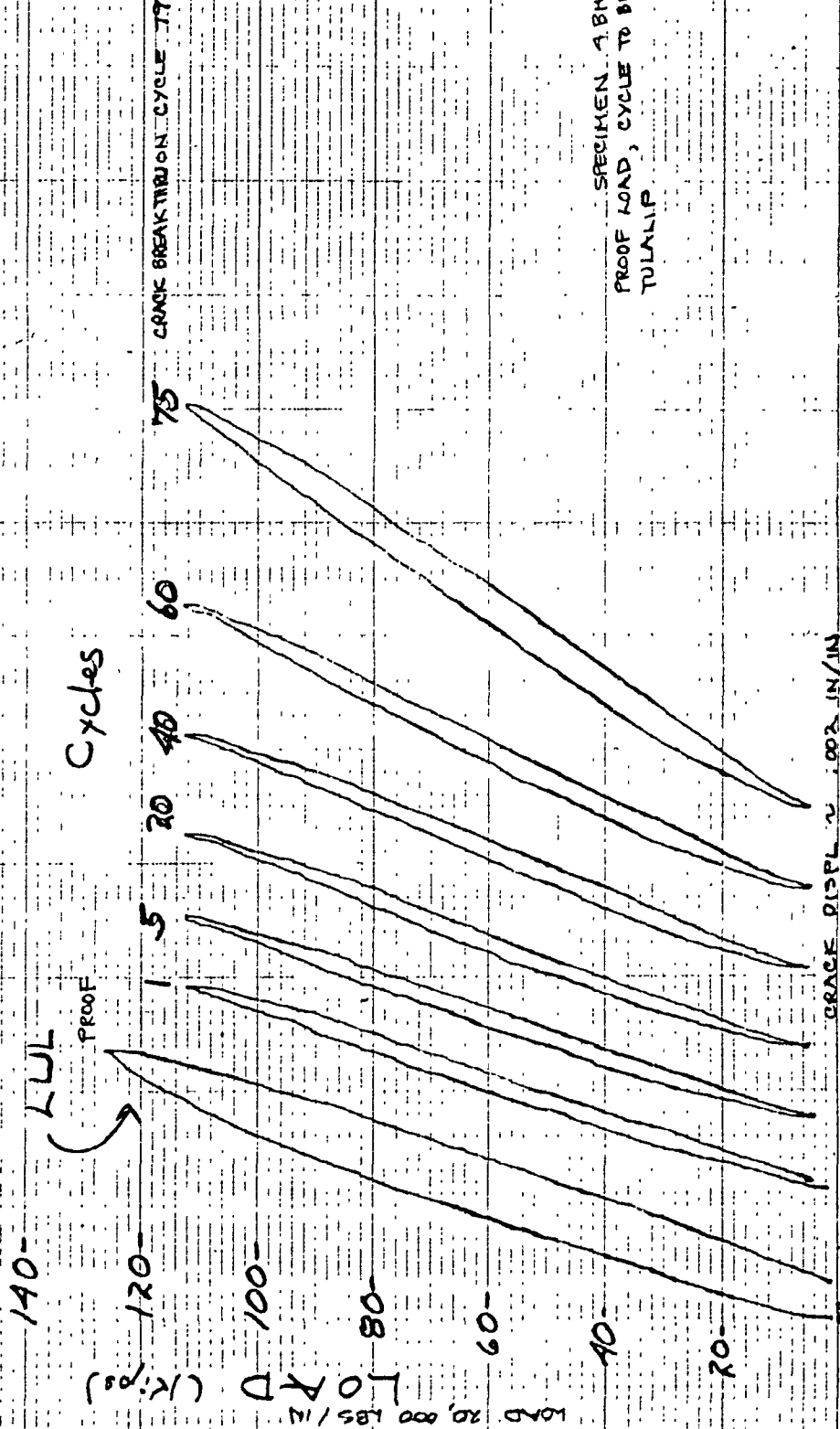
0.002
INCH



SPECIMEN 3BH21-1
LOAD TO FAILURE IN L₂
TULLALIP 8-22-75

Specimen
ATBH 21-1

0.002
INCH



SPECIMEN ATBH 21-1
PROOF LOAD, CYCLE TO BREAK-THRU IN LH-2
TULLALIP 8-13-75

Specimen
RBH 31-1

0.002
INCH

314,000 LBS

370-

280-

240-

200-

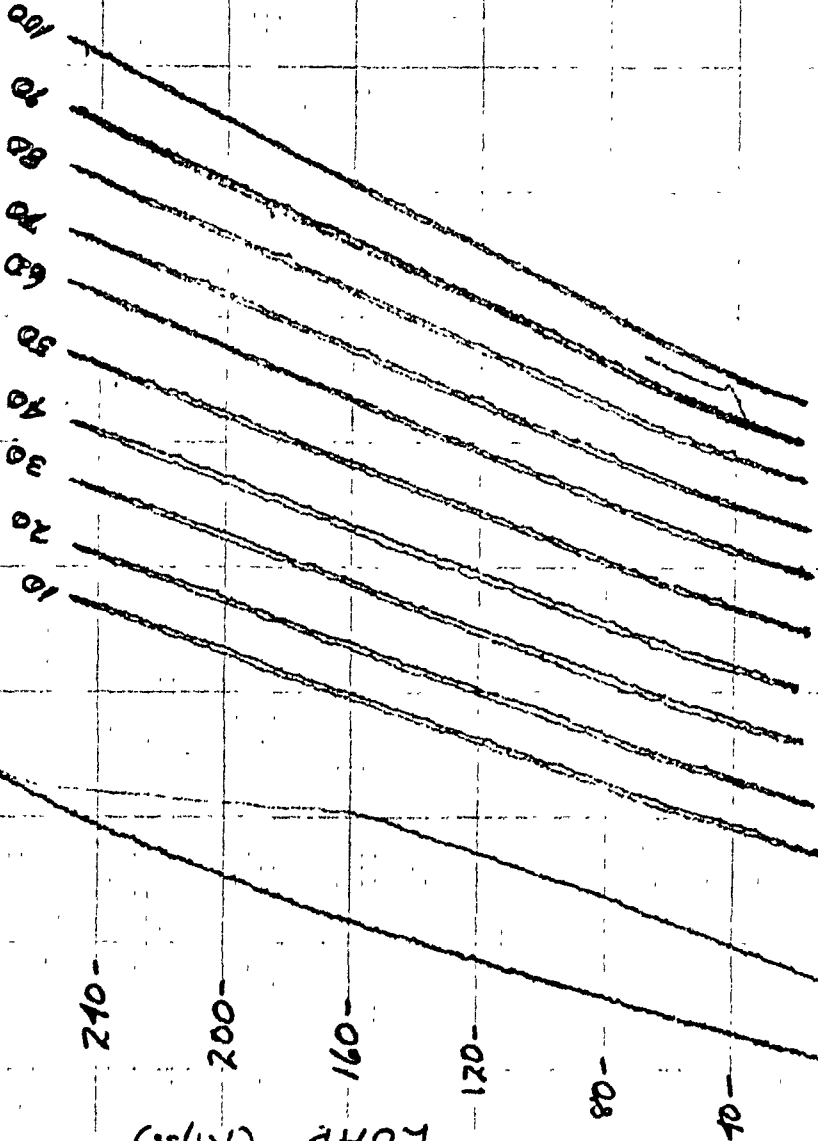
160-

120-

80-

40-

Cycle



LOAD ~ 40,000 LBS/IN.
LOAD (kips)

CRACK OPENING DISPL. ~ 0.002 IN/IN

SPECIMEN RBH 31-1 (-423°F)
TULANIP TEST SITE
3-13-75


3-13-75

RBH 31-1

Specimen
RTBH 31-2

SPECIMEN ADH 31-2 (-123P)
TULALIP TEST SITE
4-21-75

0.002
INCH



178,500 LBS

280-

210-

200-

160-

120-

80-

40-

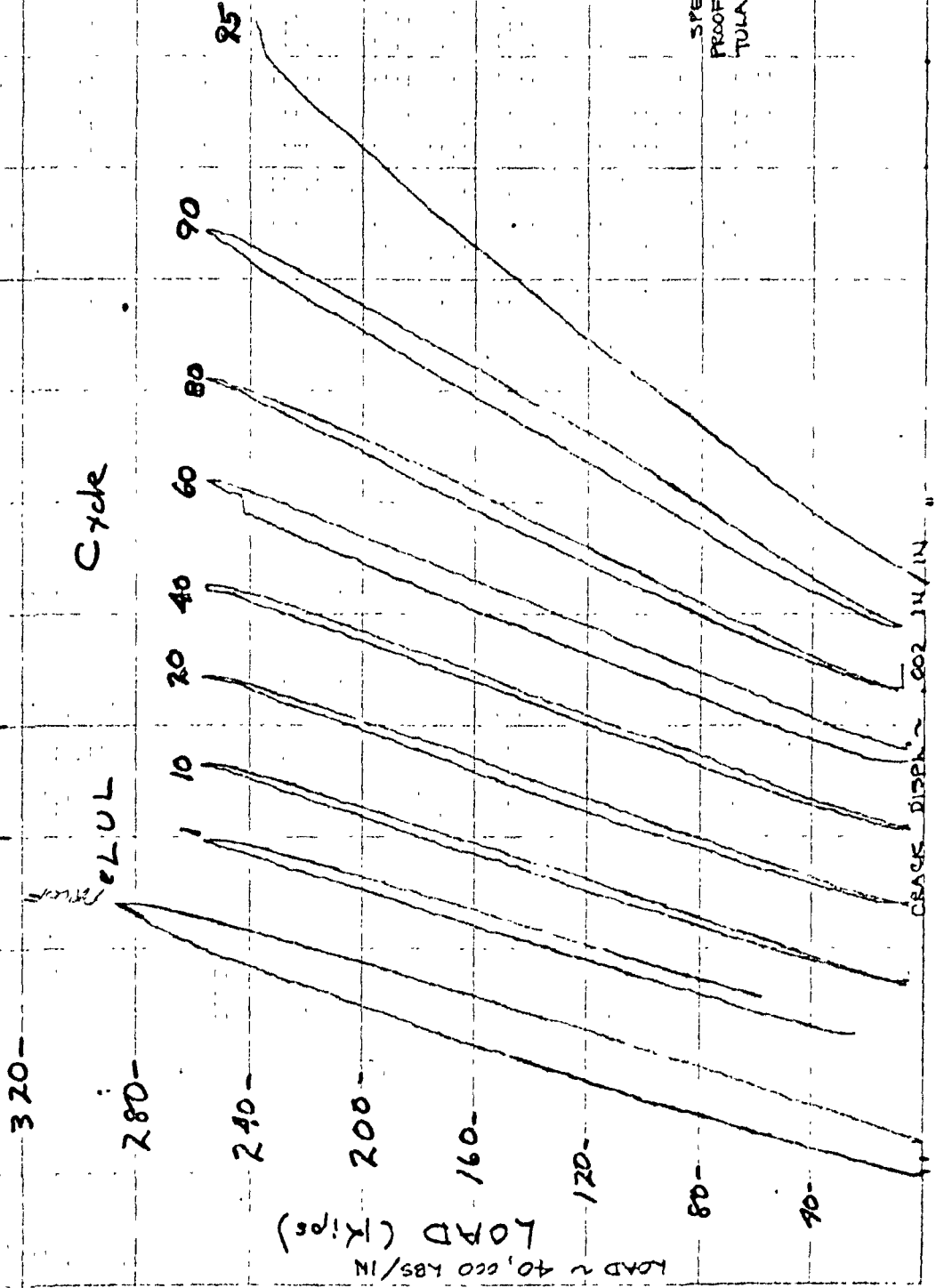
LOAD (KIPS)

LOAD ~ 40,000 LBS / IN.

CRACK DISPL ~ 0.002 IN / IN.

Specimen
3BH31-1

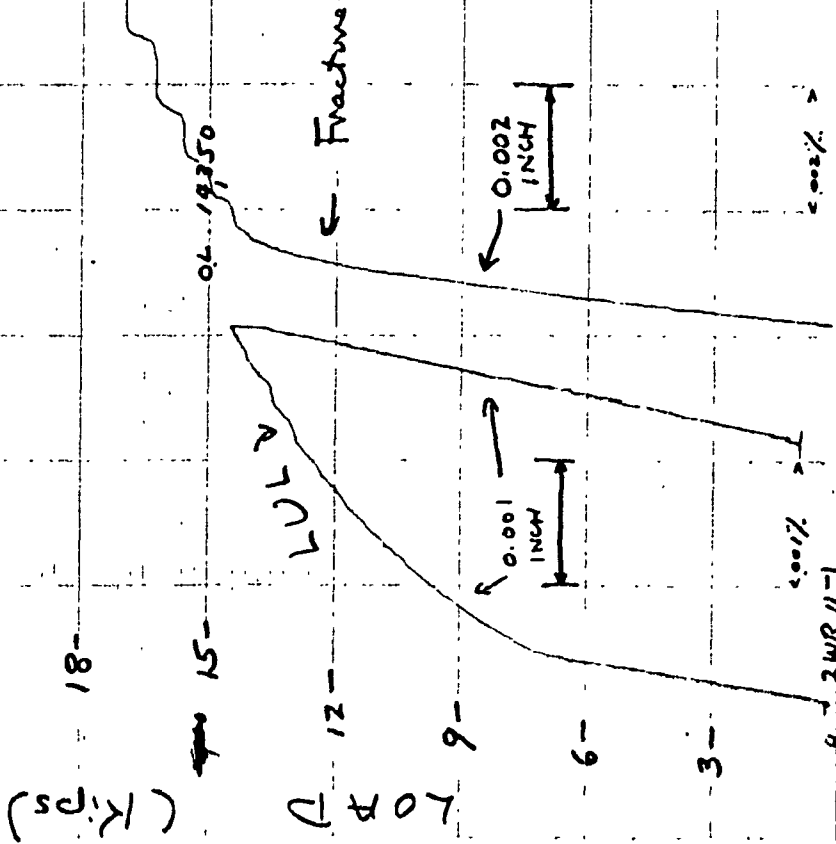
0.002
INCH



SPECIMEN 3BH 31-1
PROOF LOAD & CYCLE IN LH2
TULAH, MS 8-18-75

Specimen
ZWR 11-1

ULT 18,300 LBS.



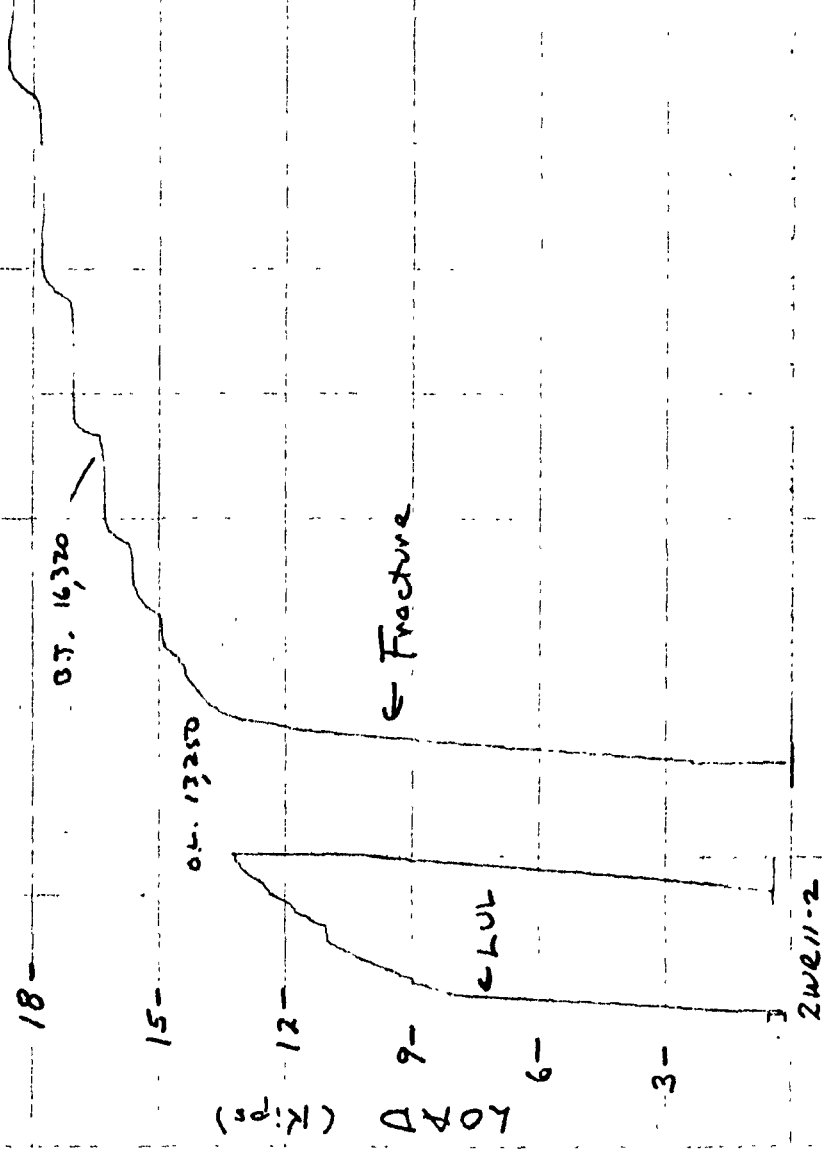
3-10-5 SK
d.T.

0.007% >

Specimen
ZWR11-2

ULT 18,600 LBS.

0.001
INCH

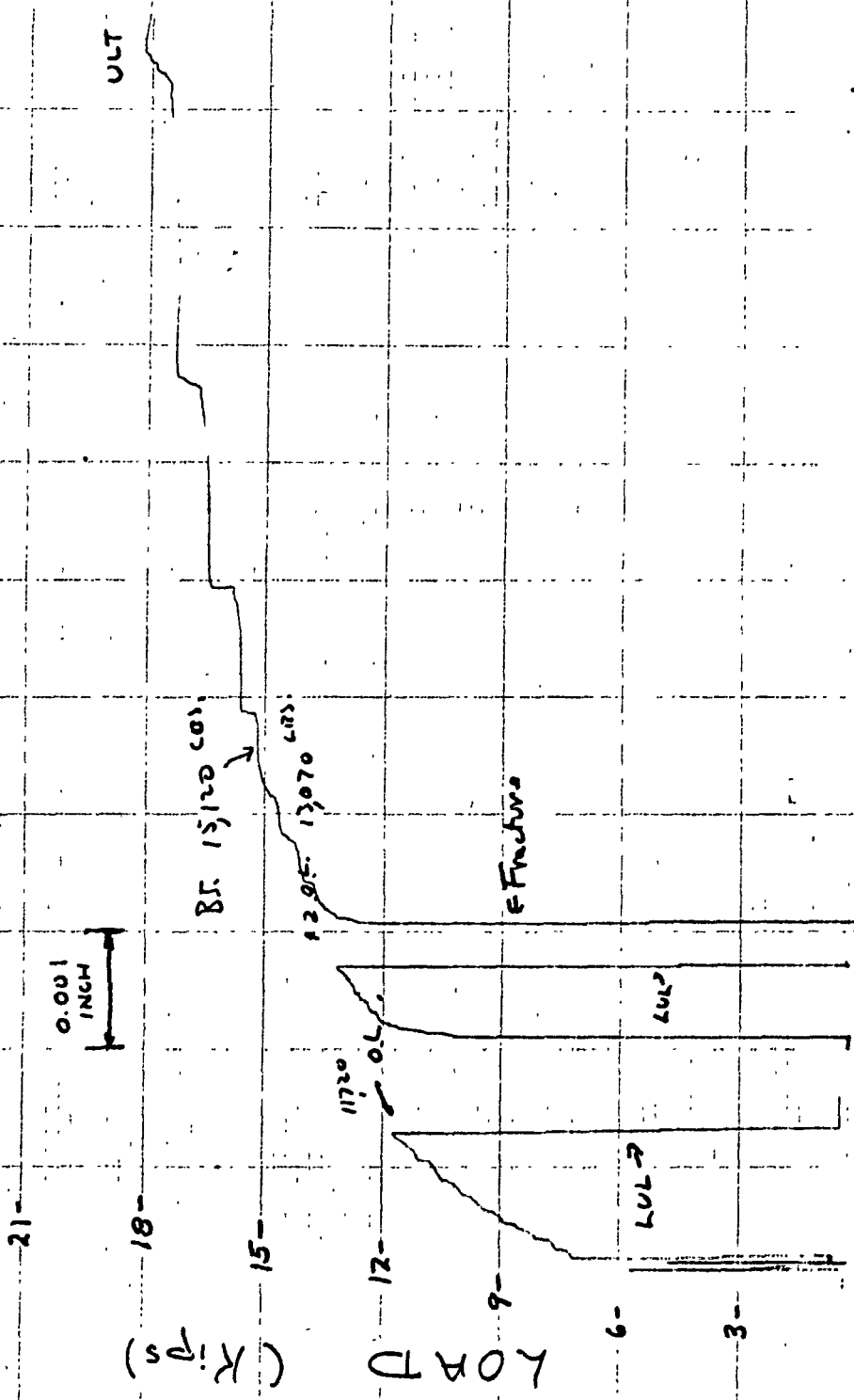


< 0.01% >
3-10-5
R.T.

Specimen
2WR11-3

ULT 18,150 LBS.

<0.01%
R.T. 3-10-5
SK.



Specimen
3WR 11-1

0.001
INCH

B.T. 18,700

LOAD (Pounds)
18000
15000
12000
9000
6000
3000
0

← LUL

< 0.01%
RT.
3-21-5
SK

JWR 11-1

Specimen
3WR11-2

20.0 -

17.5 -

15.0 -

12.5 -

10.0 -

7.5 -

5.0 -

2.5 -

LOAD (Kips)

OUT 18,600

B-T

BT 14,100

0.001
INCH

Fracture

3WR11-2

Specimen
AWR11-1

0.0005
INCH

17.5

15.0-

12.5-

10.0-

7.5-

5.0-

2.5-

(KIP IN)

LOAD

KLUL

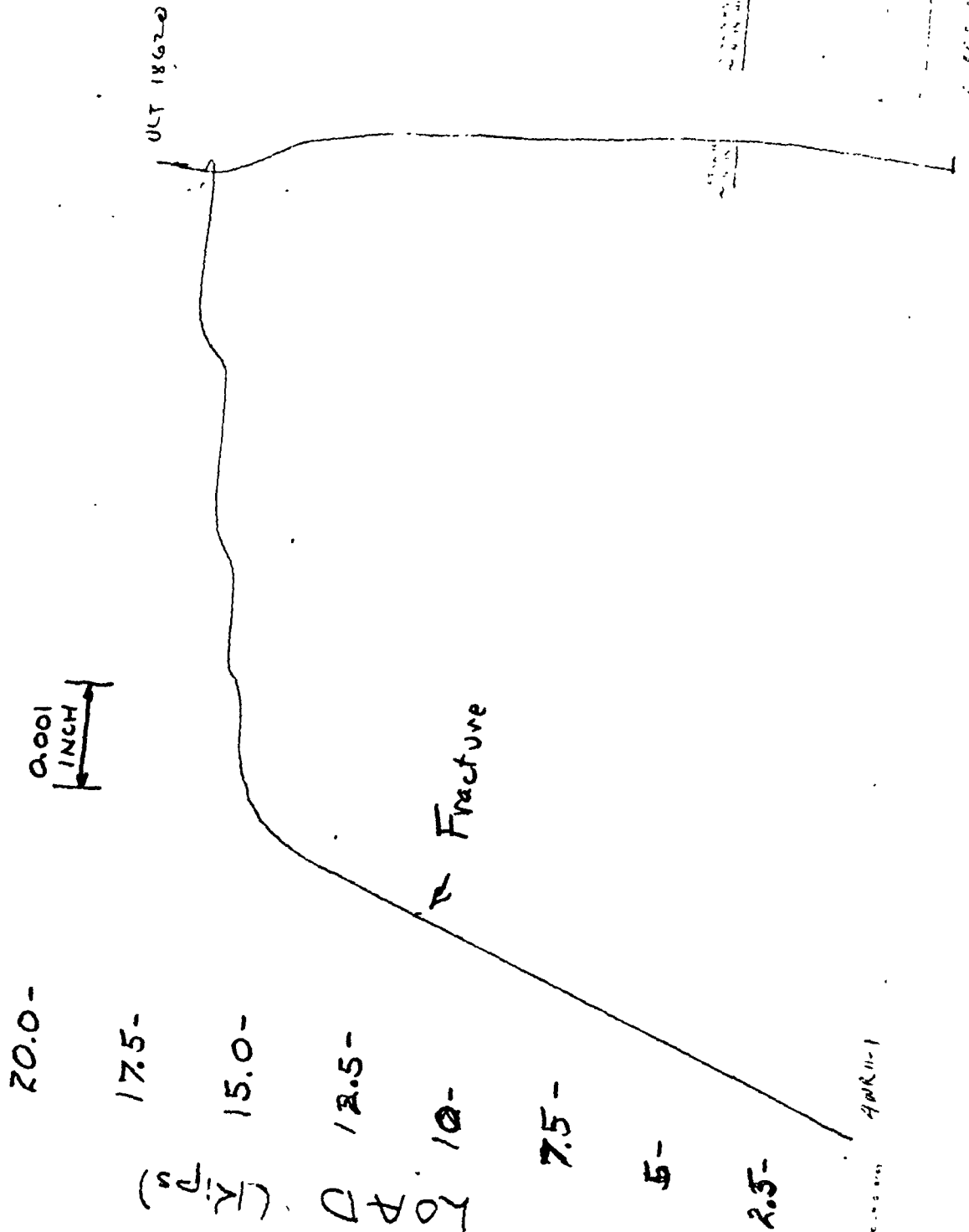
0-15,000

STRAIN
IN IN

0.0005

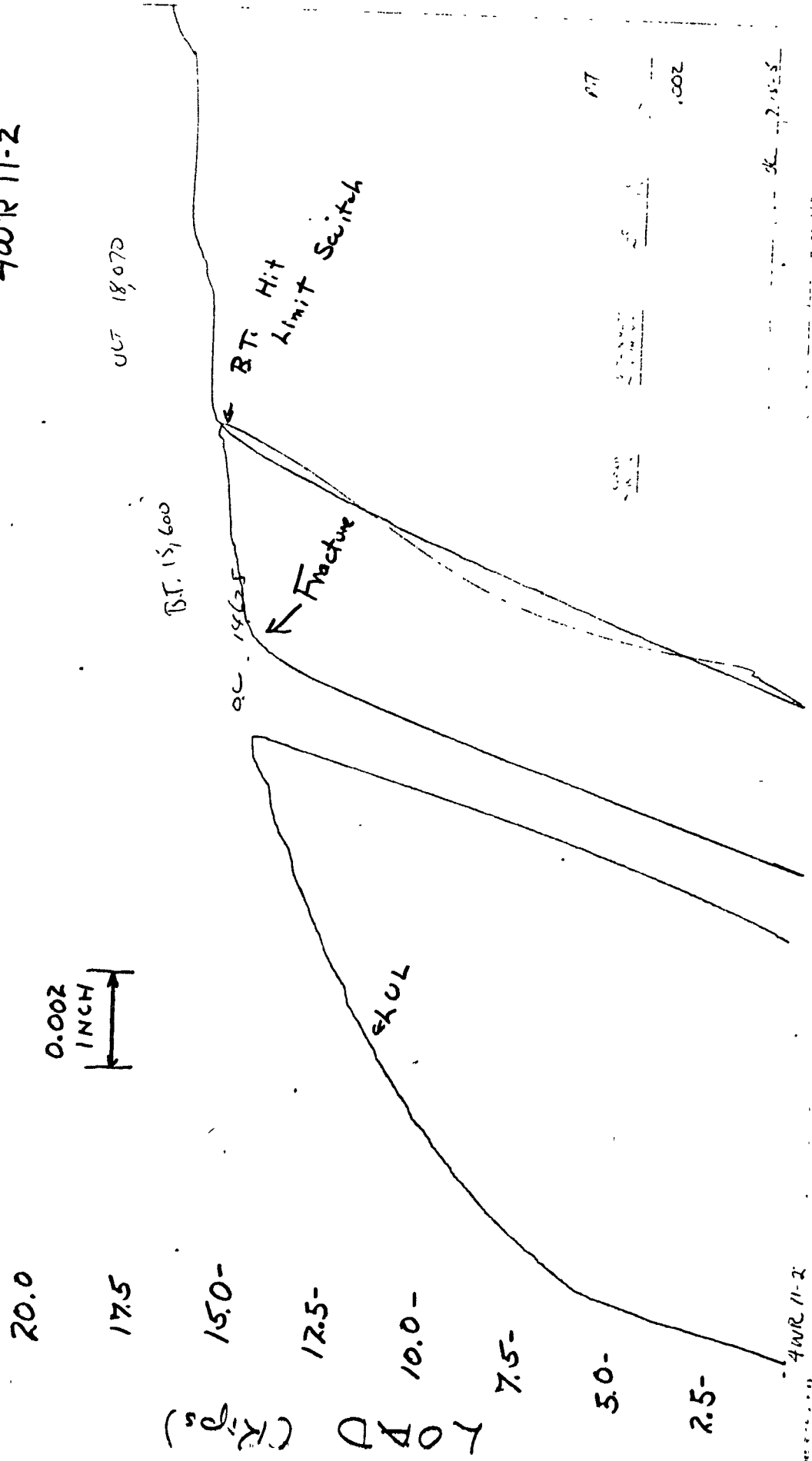
AWR11-1

Specimen
AWR 11-1



APR 11-1

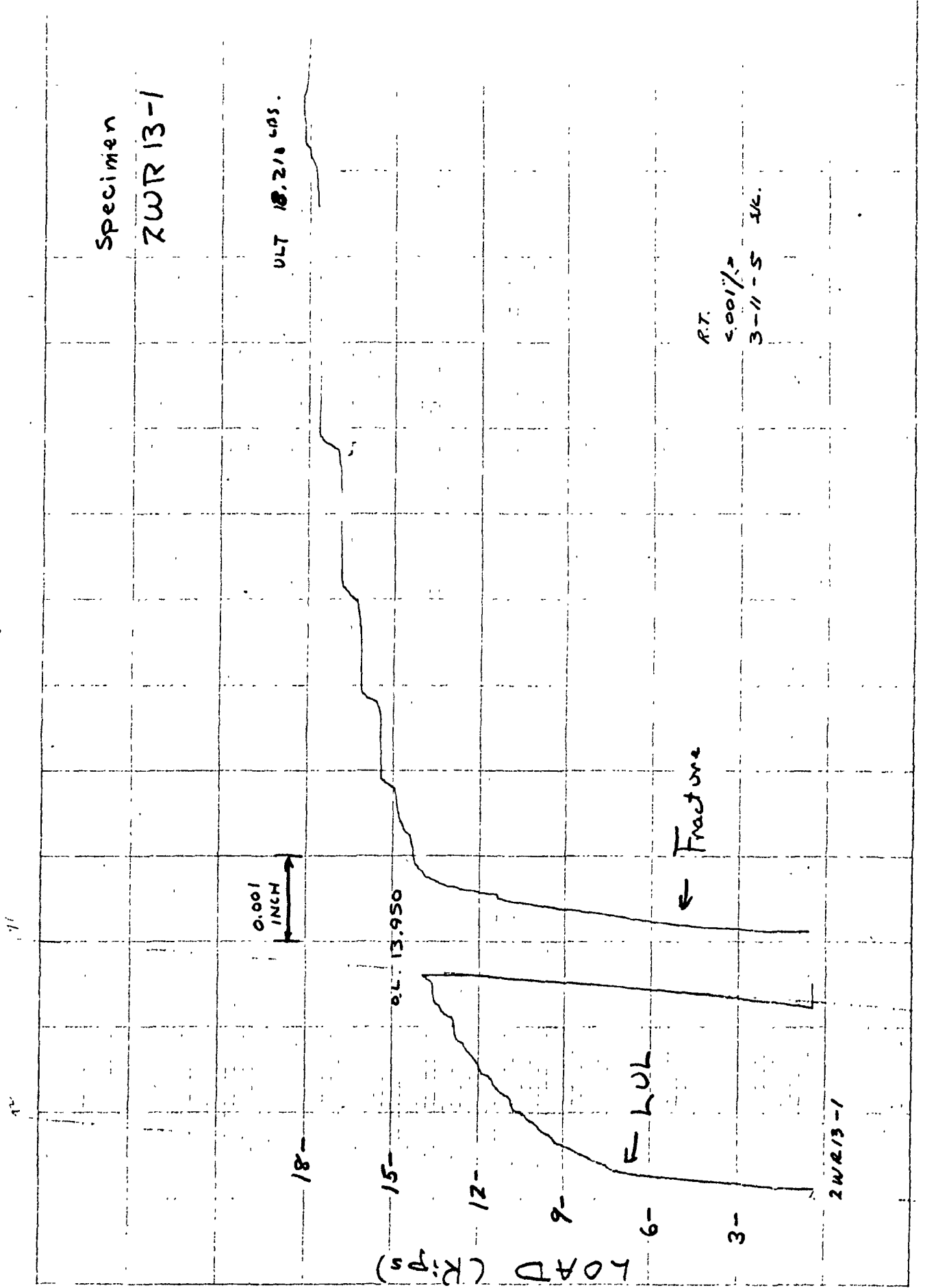
Specimen
4WR 11-2



Specimen
ZWR13-1

ULT 18,210 LBS.

R.T.
5001 1/2
3-11-53 K.



← Fracture

F - LUL

ZWR13-1

Specimen
2WR13-2

ULT 18,750 lbs

• B.T. 16,350 lbs

O.L. 12,970 lbs

Fracture

0.001
INCH

LOAD (X 10³ LBS)

18-

15-

12-

9-

6-

3-

F LUL

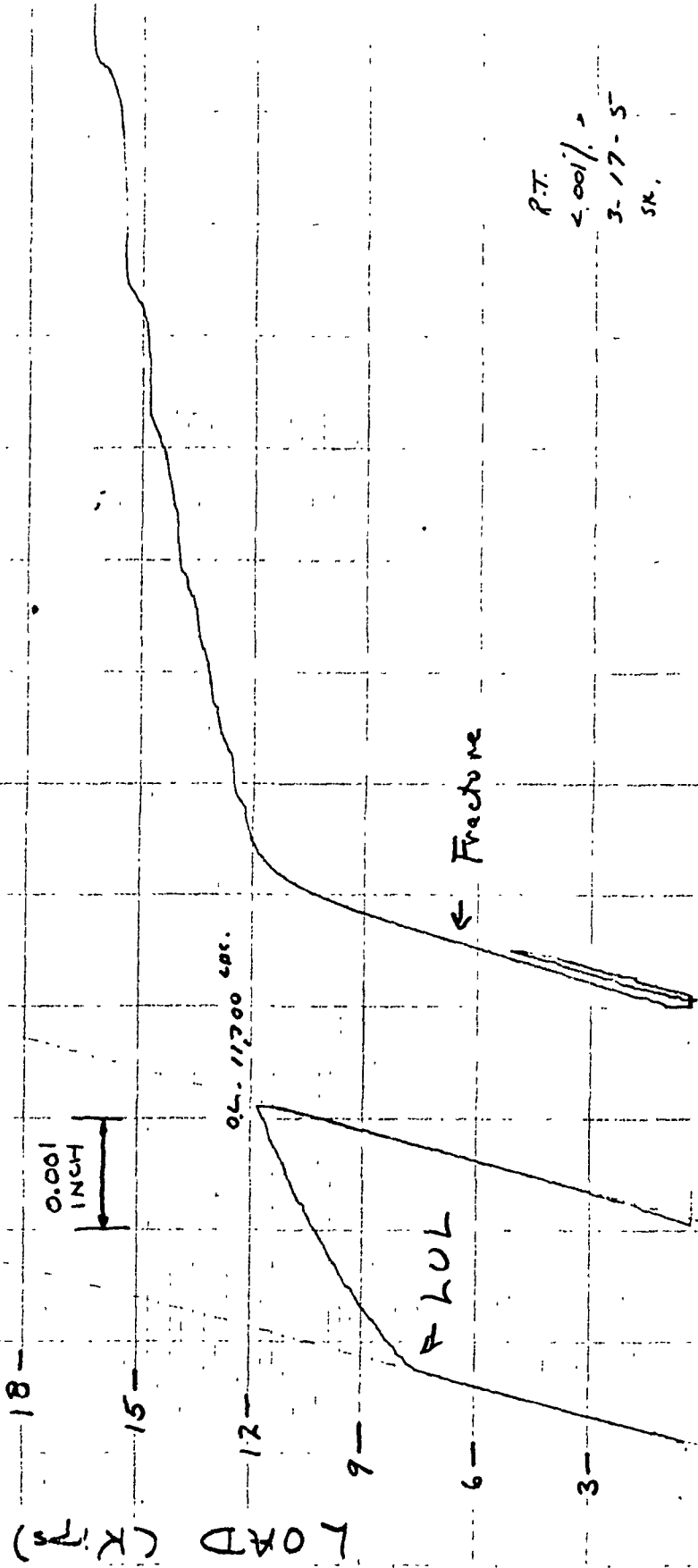
2WR13-2

R.T.

< 0.01%

3-12-5 JR

Specimen
RWR 13-3



R.T.
2.001%
3-17-5
SK.

RWR 13-3

Specimen
3WR13-1

ULT 19,200 LBS.

B.T. 15,700 LBS.

R.T.
ε .001 / >
3-24-5
57X

0.001
INCH

LOAD (KIPS)

18-

15-

12-

9-

6-

3-

← LUL

← Fracture

3WR13-1

Specimen

3WR13-2

ULT 19,400

OL 14,270

0.001
INCH

Fracture

15-

12-

9-

6-

3-

0-

LOAD (Kips)

20-

15-

10-

5-

LOAD (Kips)

707

130

6.19.5

3WR13-2

116

54,280 LB LOAD

Specimen
2WR21-1

2WR21-1
RT
2-28-75

54-

48-

42-

36-

30-

24-

18-

12-

6-

BT
44400

0.1

0.002
INCH

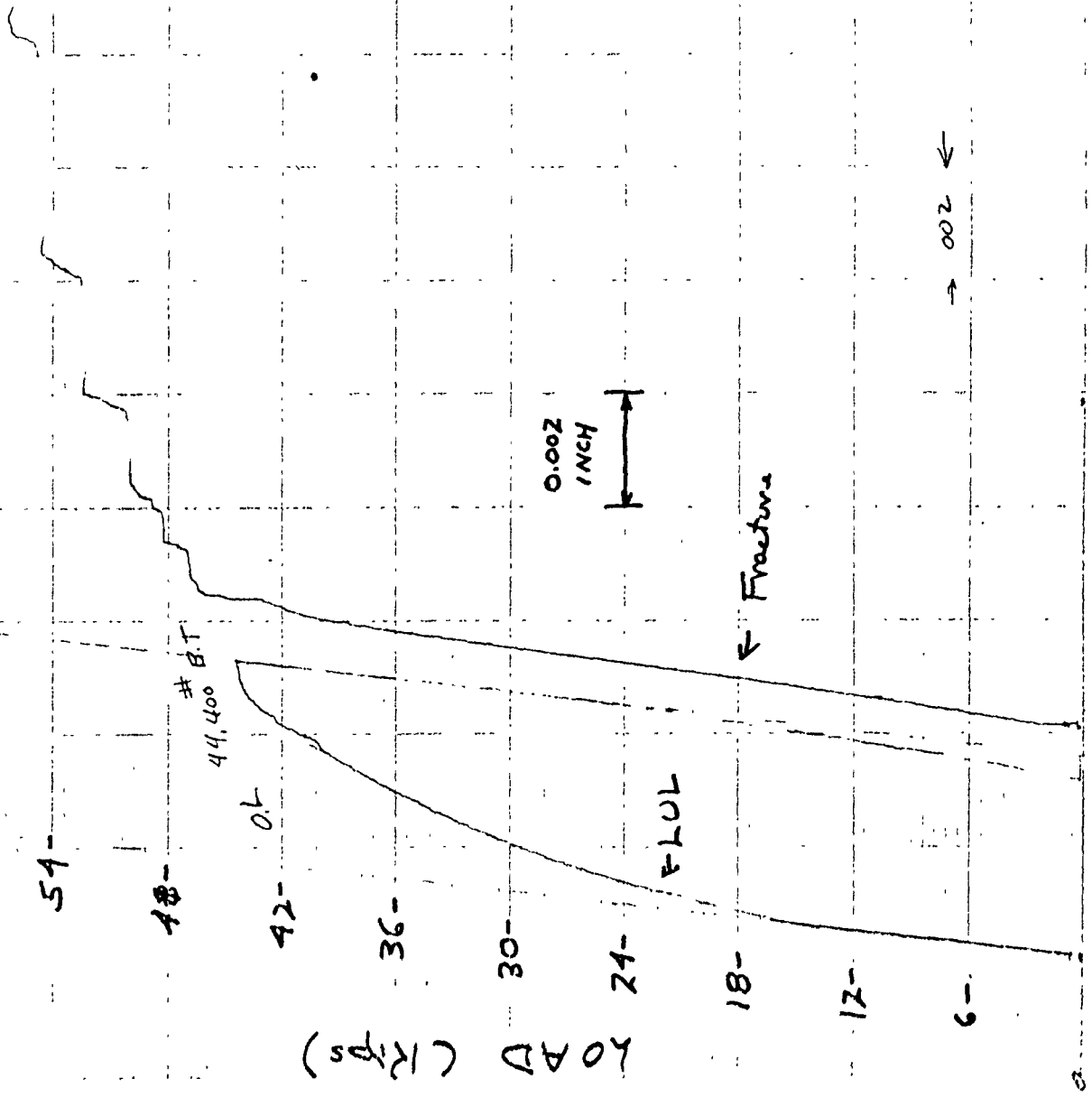
FLUL

← Fracture

→ 002 ←

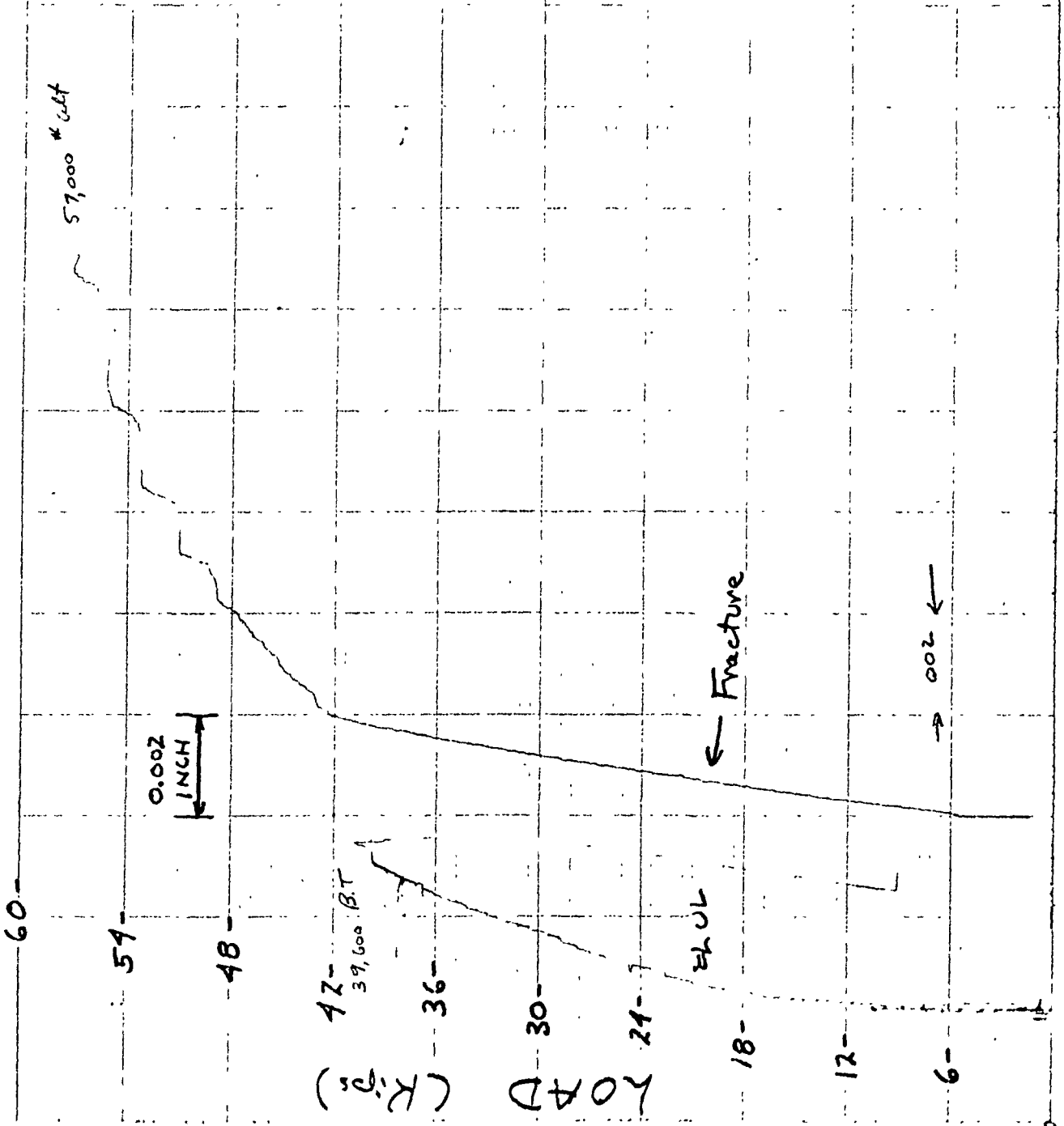
LOAD (KIPS)

564



Specimen
RWR 21-2

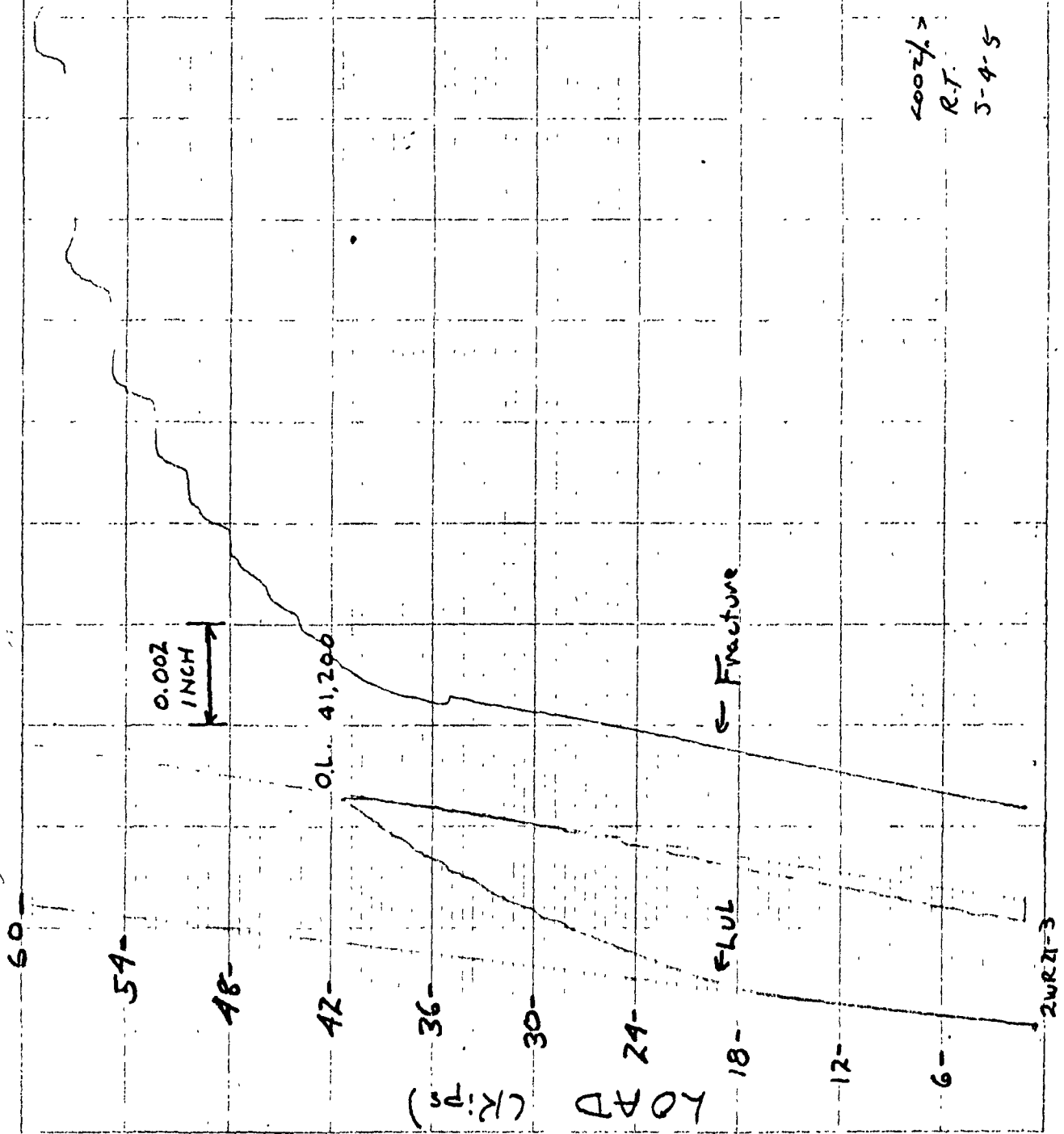
57,000 # Calt



2WR 21-2
R.T.
2-28-75

ULT 59,400

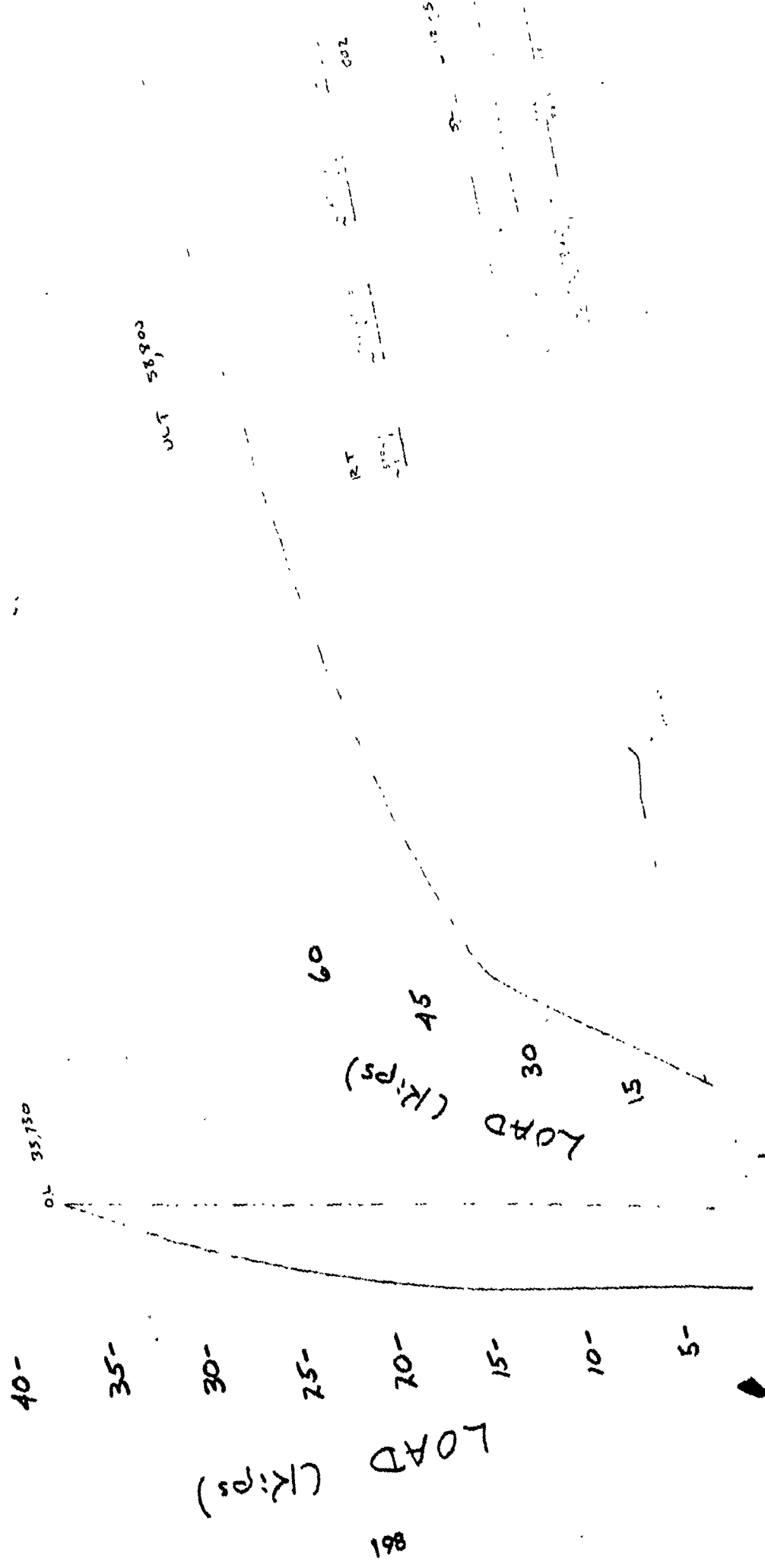
Specimen
RWR 21-3



00024.
R.T.
5-4-5 SK

Specimen
3WR21-1

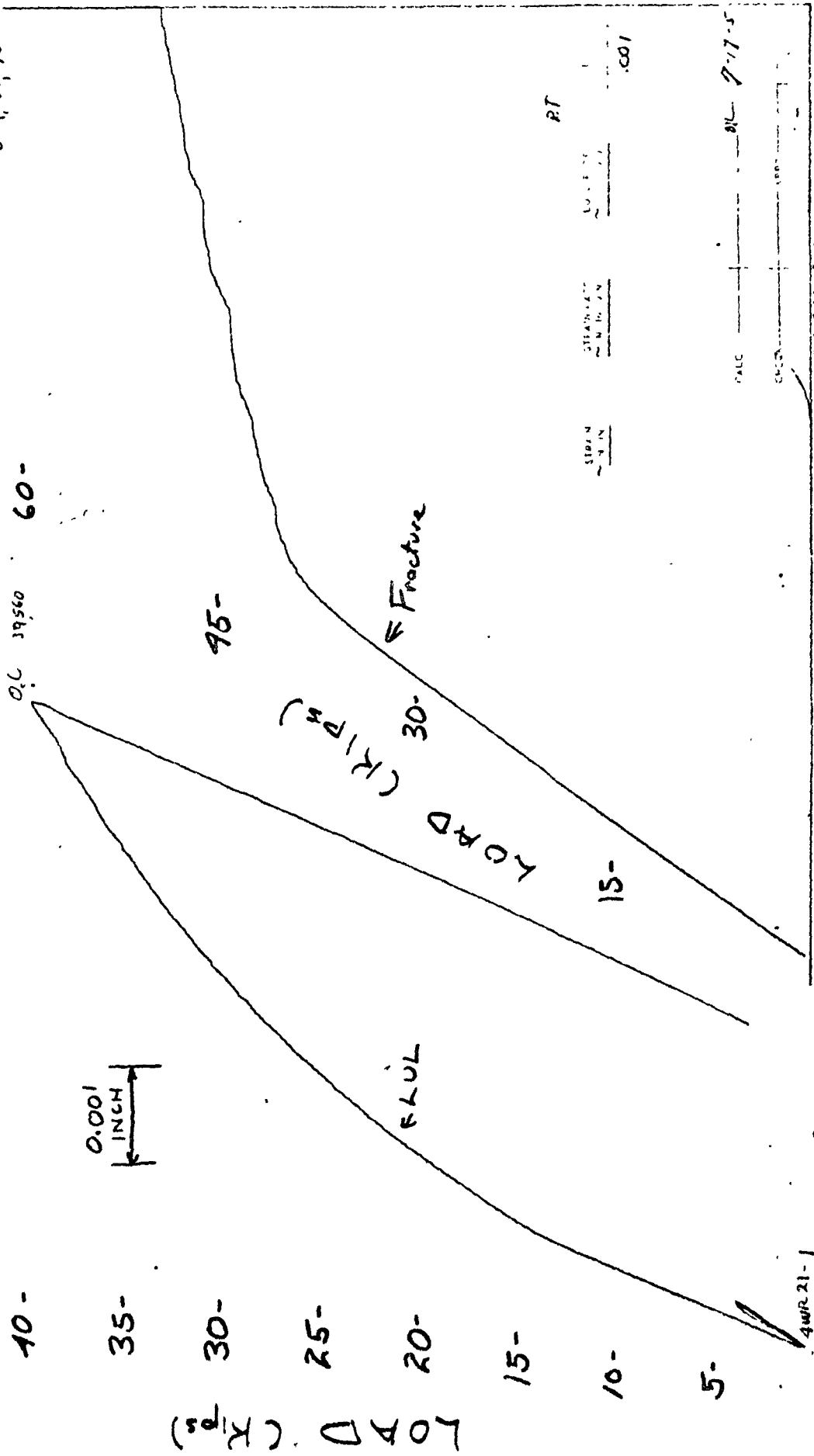
0.002
INCH



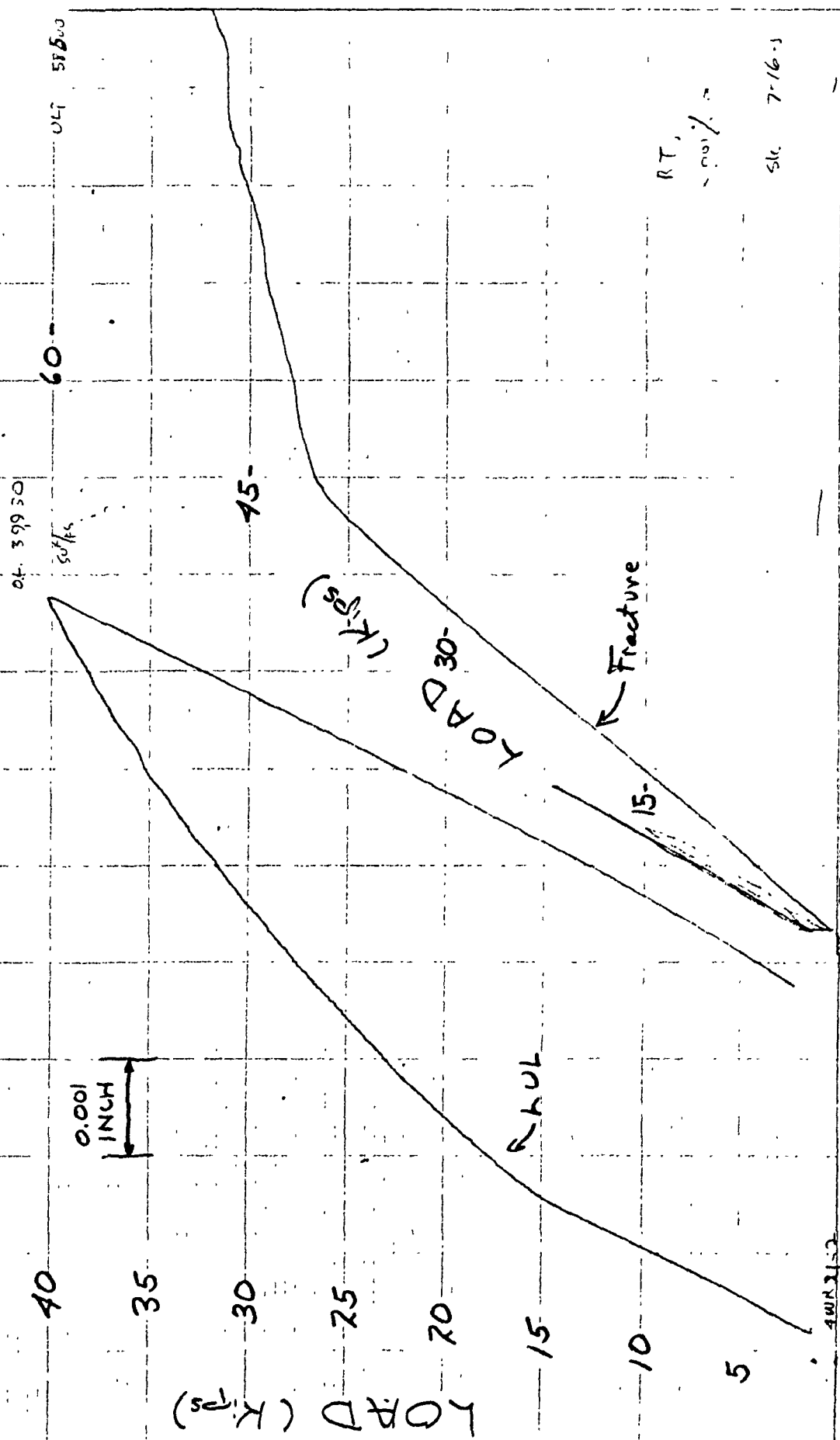
75-

Specimen
4WR21-1

ULT, 61275



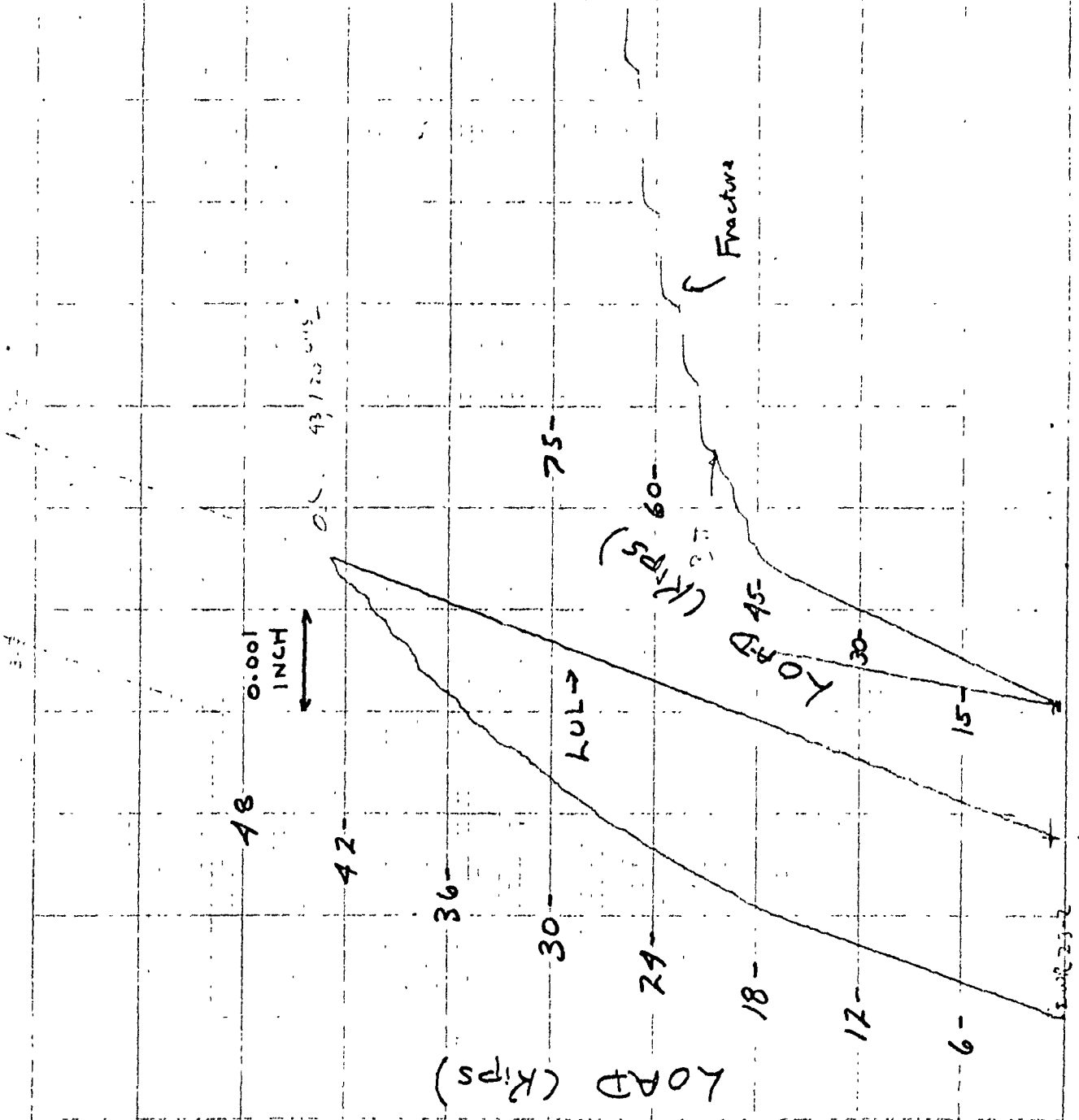
Specimen
4WR21-2



RT, 100%

SLC 7-16-5

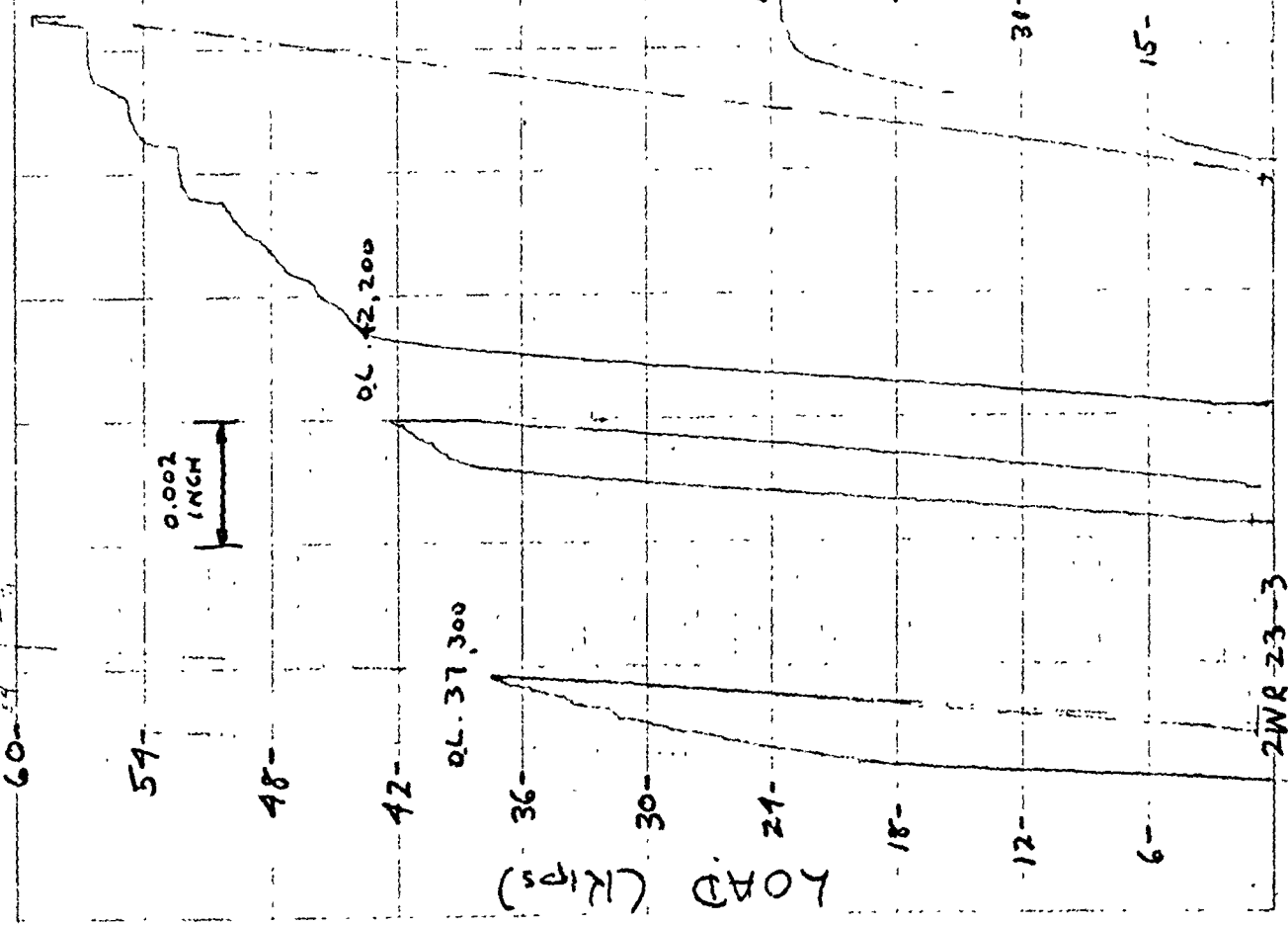
Specimen
RWR 23-2



← 150' / s

Specimen
RWR 23-3

← Break through



R.T.
5-3-5
5K.
0.002%

Specimen
3WR23-1

0.002
INCH

LOAD (KIP)

75-

60-

45-

30-

15-

Fracture

BT 42,650

0.025 IN

200

5-21-9

64

3WR23-1

135-

120-

105-

90-

75-

60-

45-

30-

15-

2WR31-1

Specimen
2WR31-1

120,700 LBS. B.T.

487,144,600 LBS

Fracture

LOAD (LBS)

0.002 INCH

changed scales

(KIPS)

LOAD

0.001 INCH

0.001 INCH

R.T.
4-1-5
SK.

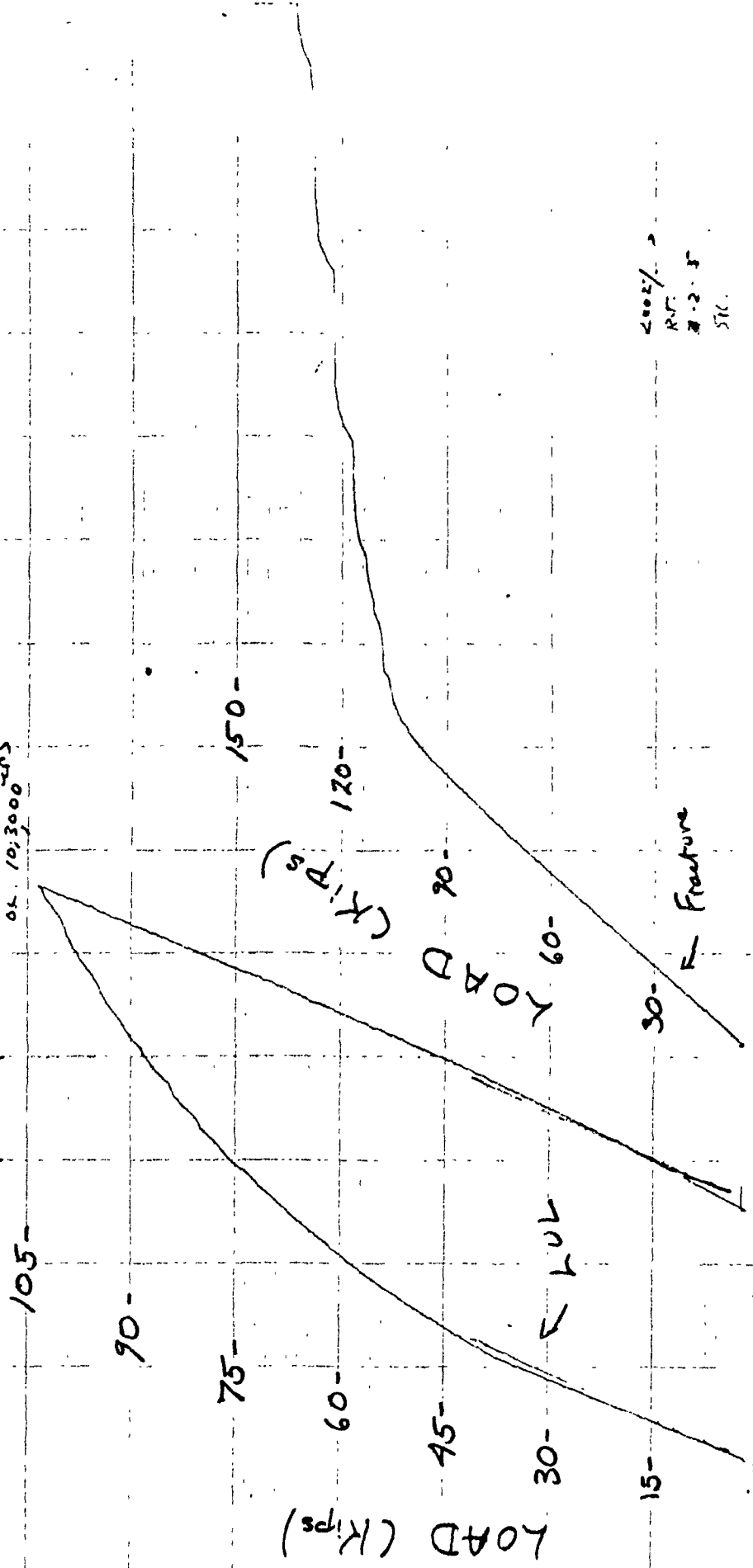
0.004%

0.004%

Specimen
RWR 31-3

0.002
INCH

or 10,300 psi



4002/
R.F.
2-2-5
STC

RWR 31-3

Specimen

3WR31-1

OUT 148,400

Fracture

ST. 113,800

0.002 INCH

RT.
6007
5.12
SN

160-

140-

120-

100-

80-

60-

40-

20-

LOAD (kips)

FLUL

3WR31-1

Specimen
3WTR 31-2

ULT 148,200

160-

0.002
INCH

140-

120-

100-

80-

60-

40-

20-

LOAD (KIPS)

σ = 106,468

Fracture

ε_{LUL}

3WTR 31-2

STRAIN

0.001

0.002

0.003

1.002

50-7-1.5

Specimen

AWR3H

119,000

0.002

INCH

LOAD (Kips)

160

140

120

100

80

60

40

20

→ LUL

→ Fracture

R.T.

6002/2

520-5

94.22.17

Specimen

4WR31-Z

199, 2000

160-

140-

120-

100-

80-

60-

40-

20-

LOAD (Lbs)

0.002
INCH

at 109,200

Fracture

K_{HUL}

27

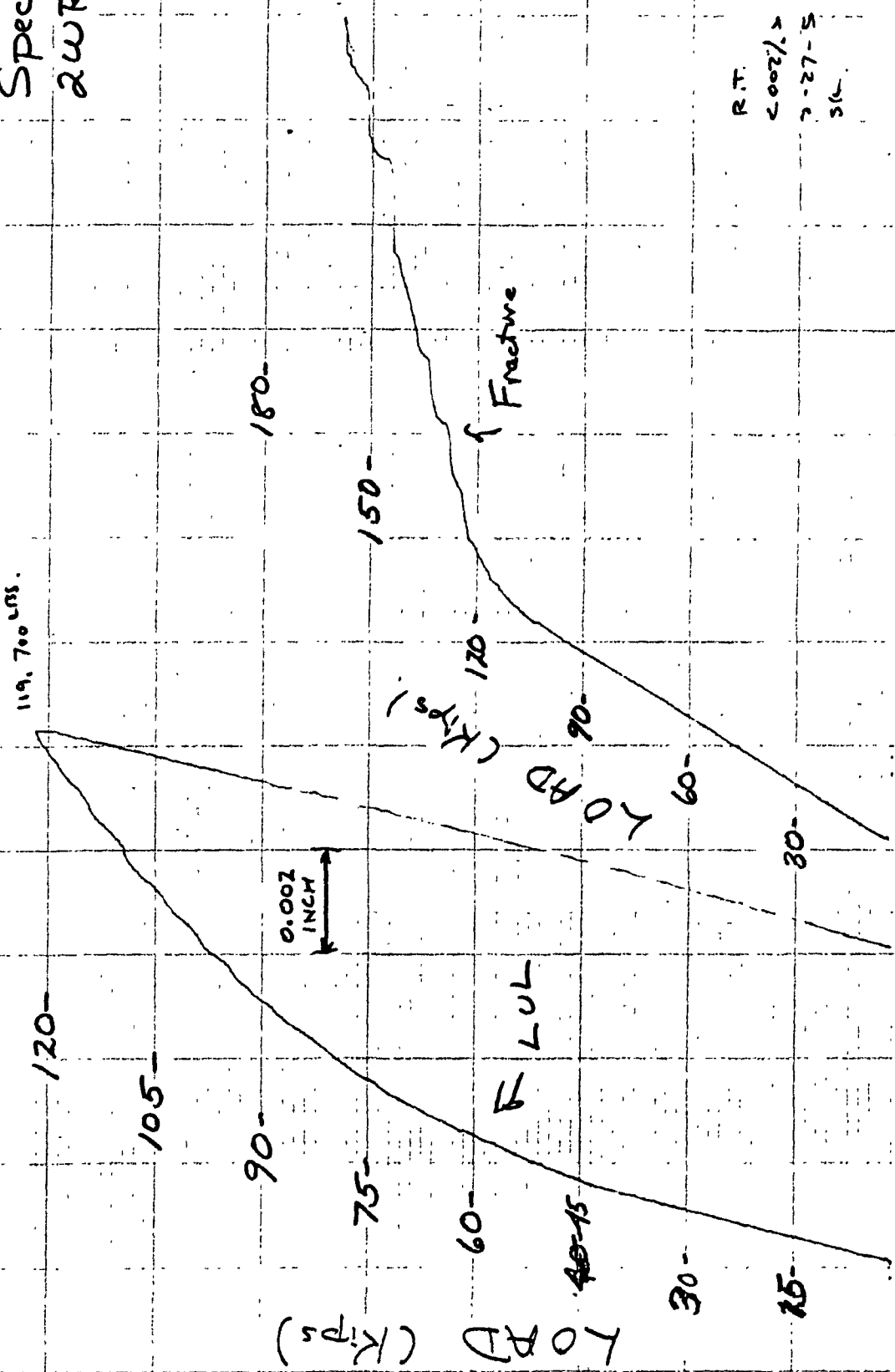
2007/1/2

6-5-5 50

4WR31-Z

Specimen
2WR33-1

R.T.
0.002%
7-27-5
SL



2WR33-1

Specimen
ZWR 33-Z

0.002
INCH

O.C. 108,800 LBS.

ULT 179,000

R.T. 136,000 (B)

R.T.
-002% >
3-27-5
SR

120-

90-

60-

30-

ZWR 33-Z

LOAD (KIPS)

(KIPS)

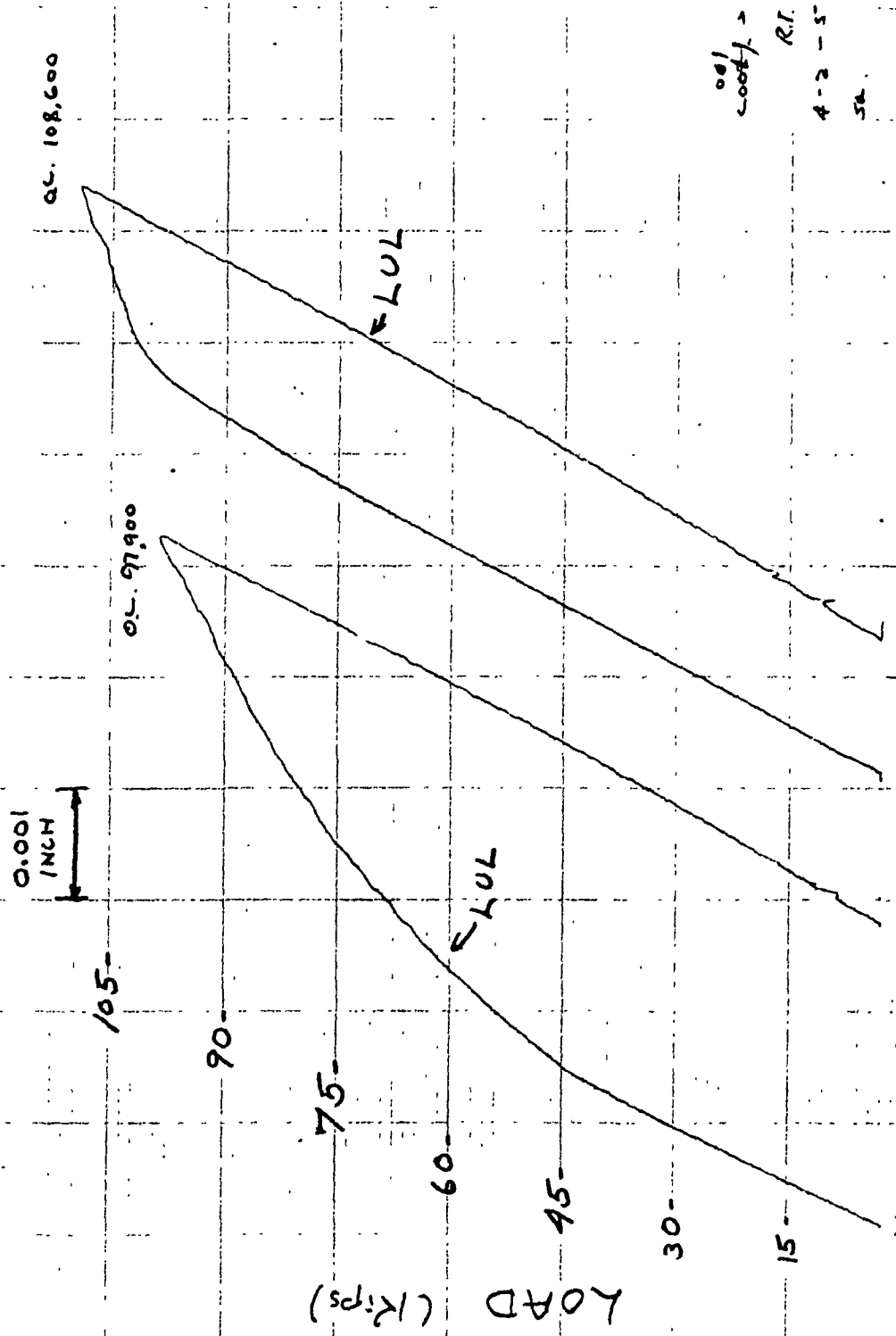
OAD 90-

60-

30-

Fracture

Specimen
ZWR 33-3



ZWR 33-3

Specimen
RW R 33-3

0.002
INCH

180-

150-

120-

90-

60-

30-

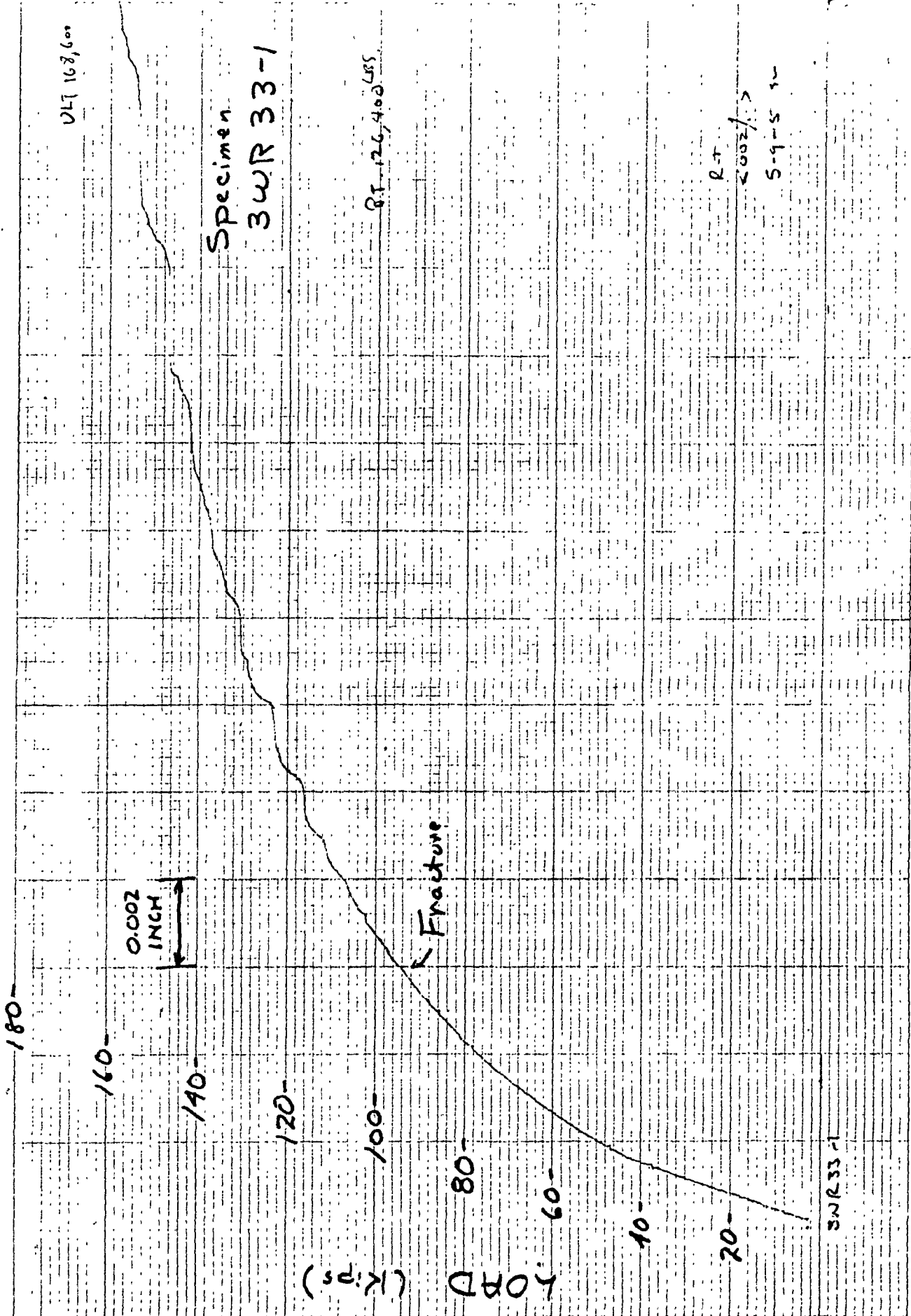
LOAD (Kips)

B.T. 131,400

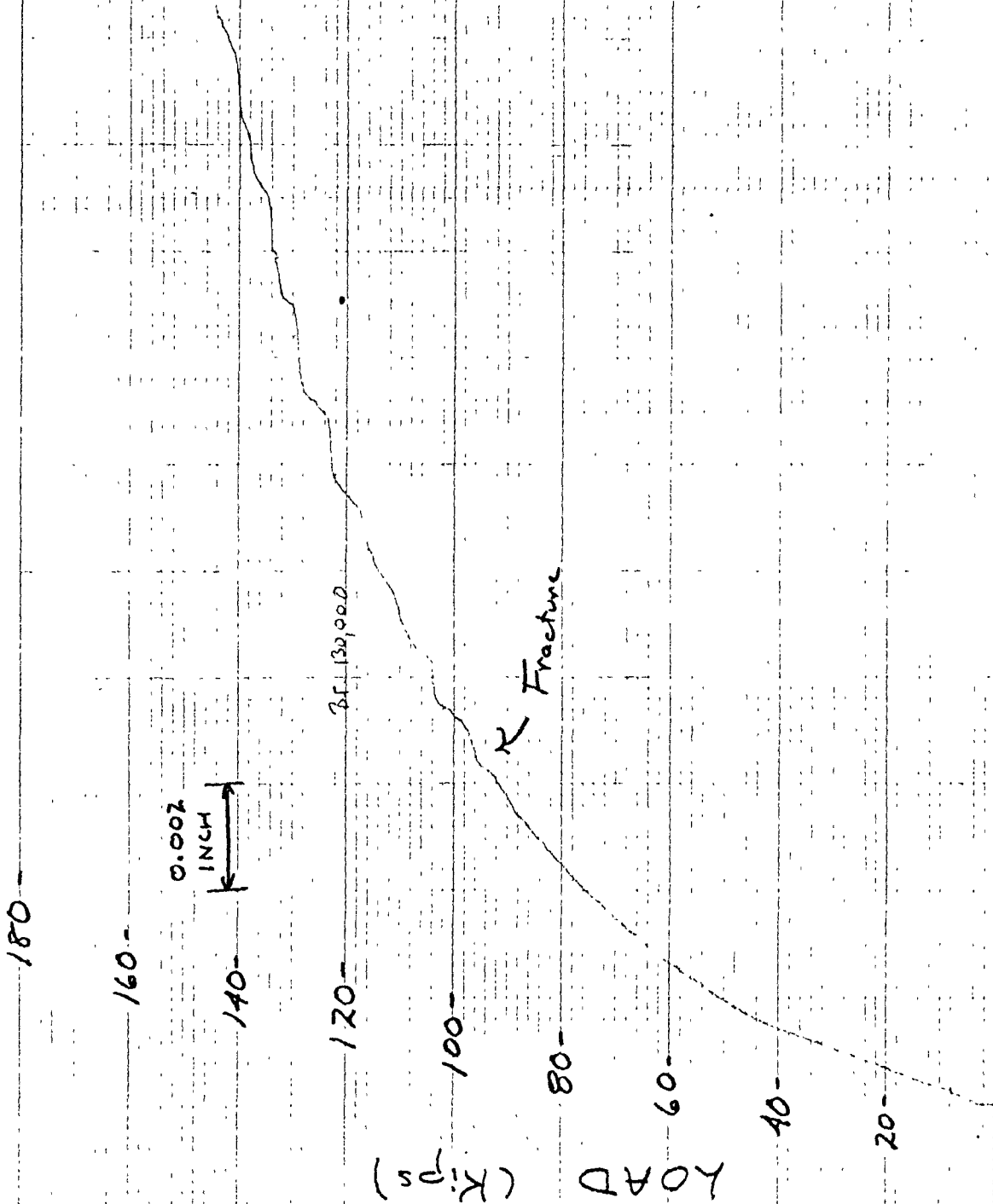
ULT 160,000
Fracture

R_m
2002/13
4-2-5
SK

RW R 33-3



Specimen
3WR33-2
0.14, 14, 46 133



<0021 >
FT
6-30-5-61

JUL 33 7

Specimen
3WR33-2A
ULT 160,300

180 -

160 -

140 -

120 -

100 -

80 -

60 -

40 -

20 -

LOAD (Kips)

0.002
INCH

0.115,200

← Fracture

← LUL

3WR33-2A

L.T.

0.02

9-1-5

Specimen

ZWN11-1

0.001
INCH

O.L. 16,990 LBS.

LOAD (KIP)

18-

15-

12-

9-

6-

3-

ZWN11-1

627 16,100 LBS

Fracture

0.001% ϵ

-320°F $\epsilon_{N/2}$

5-13-5 S.R.

Specimen
ZWN 11-2

21-

18-

15-

12-

9-

6-

3-

ZWN 11-2

0.001
INCH

ULT 15,450

Fracture

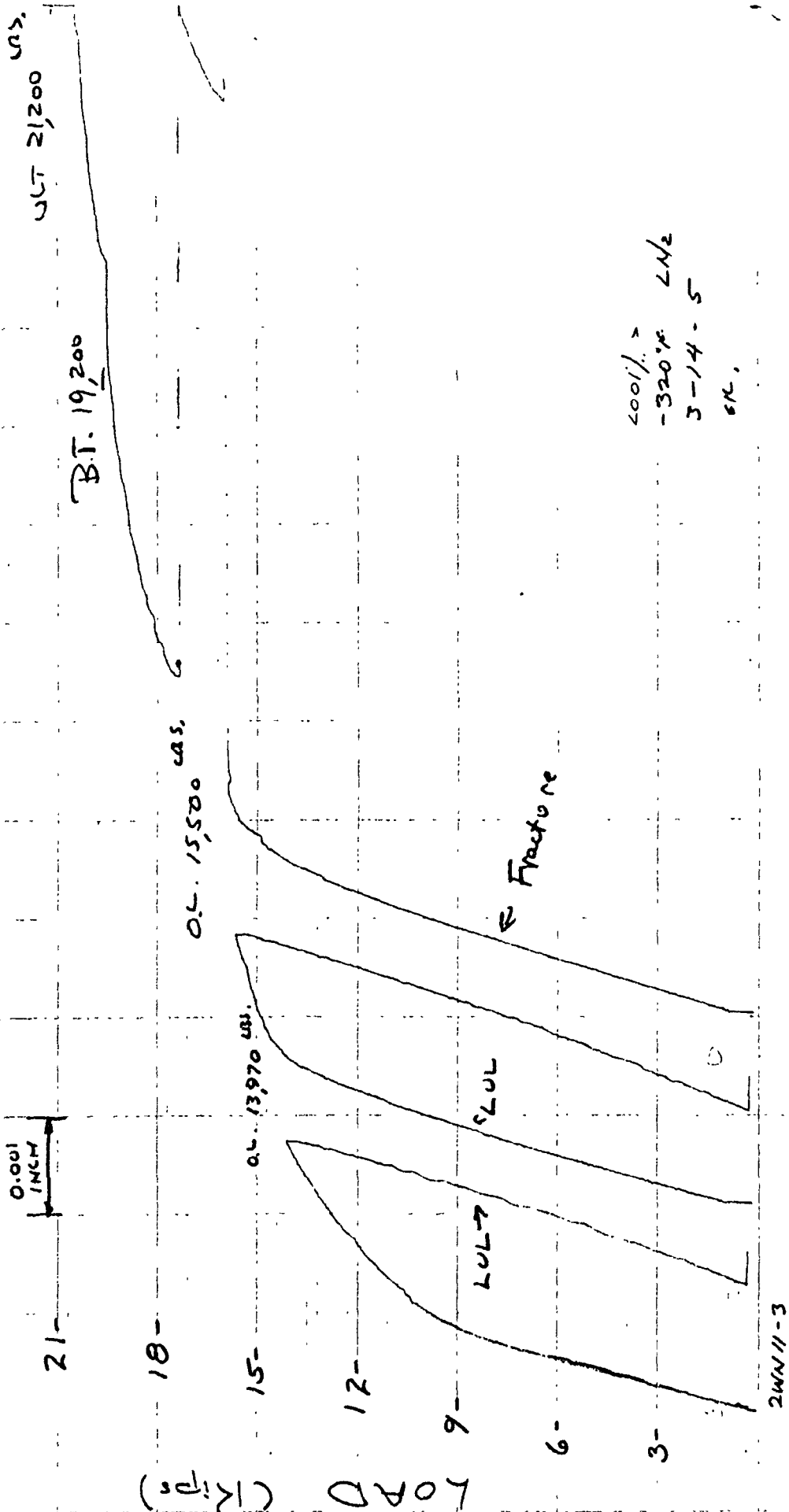
0.2 14,570

B.T. 14,400

400%
-320 Lb
3-14-5
SK

LOAD (Kips)

Specimen
ZWN 11-3



Specimen
ZWN11-4

ULT 21,625 LBS

22.5-

20.0-

0.0005
INCH

17.5-

15.0-

12.5-

10.0-

7.5-

5.0-

2.5-

LOAD (KIPS)

22

OL. 16,850

F Fracture

F LUL

-320°F LUL

0.0005

SL 6.0-5

ZWN11-4

Specimen
3WN 11-1

ULT 20350 lbf

B.T. 18000 lbf

0.001
INCH

21-

18-

15-

12-

9-

6-

3-

LOAD (KIP)

DISPLACEMENT (INCH)

F_{LU}

← Fracture

cooling

-320°F 4x6

3-25-5

3/C.

1-11 MC

Specimen

3WN11-2

ULT 19,700

20.0 -

17.5 -

15.0 -

12.5 -

10.0 -

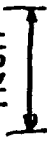
7.5 -

5.0 -

2.5 -

LOAD (Kips)

0.001
INCH



0.2 15.175

N Fracture

← LUL

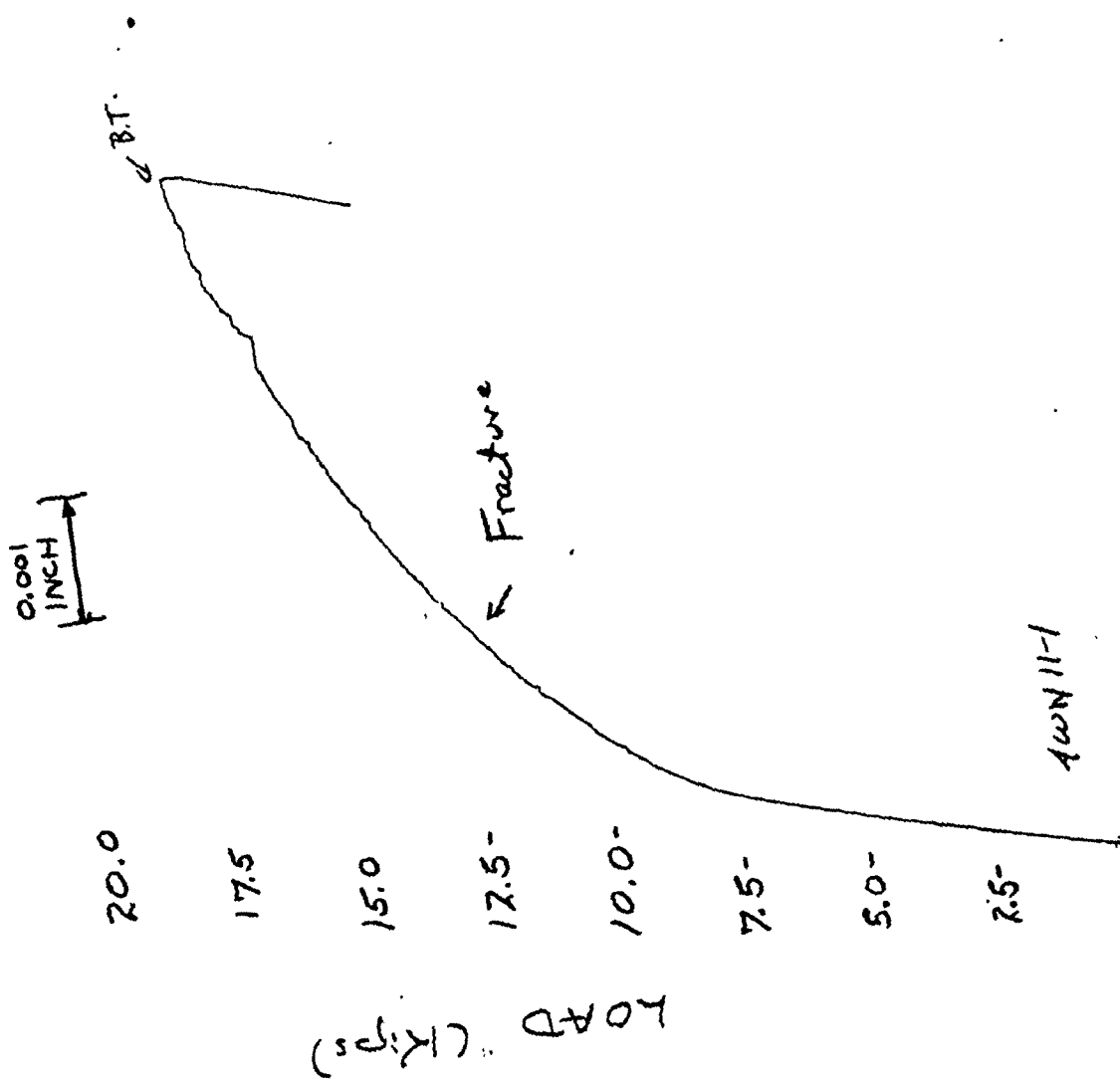
-320°F LUL

001

3WN 11-2

SIC 6225

Specimen
AWN11-1



Specimen
ACUN11-2

ULT 20925

22.5

20.0

17.5

15.0

12.5

10.0

7.5

5.0

2.5

LOAD (Kips)

0.001
INCH

0L

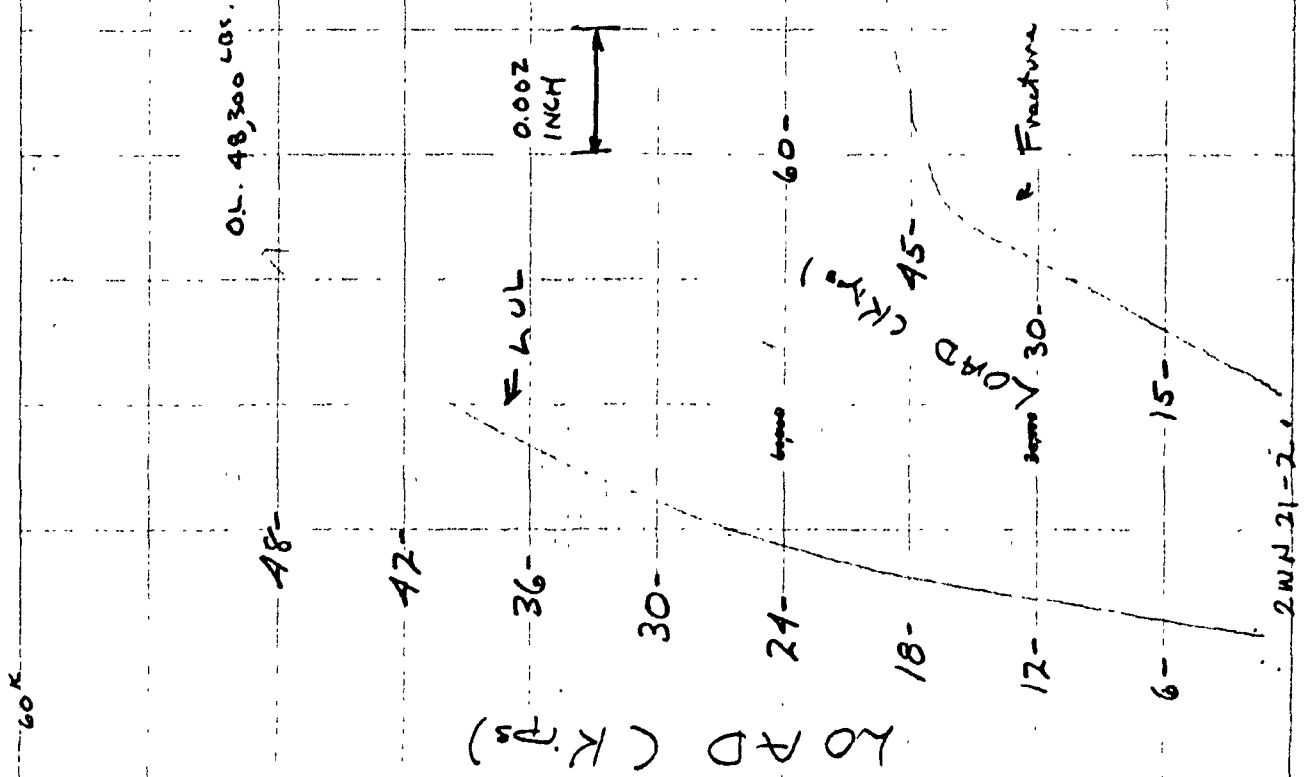
Fracture

R_L L_{0L}

- 320 4 1/2

.001

Specimen
2WN21-2



ULT: 53,250 LBS. RT.

3-7-5 SK
LN₂ - 320°F
< 0.02 / >

Specimen
ZWN 21-3

ULT 66,750 lbs.

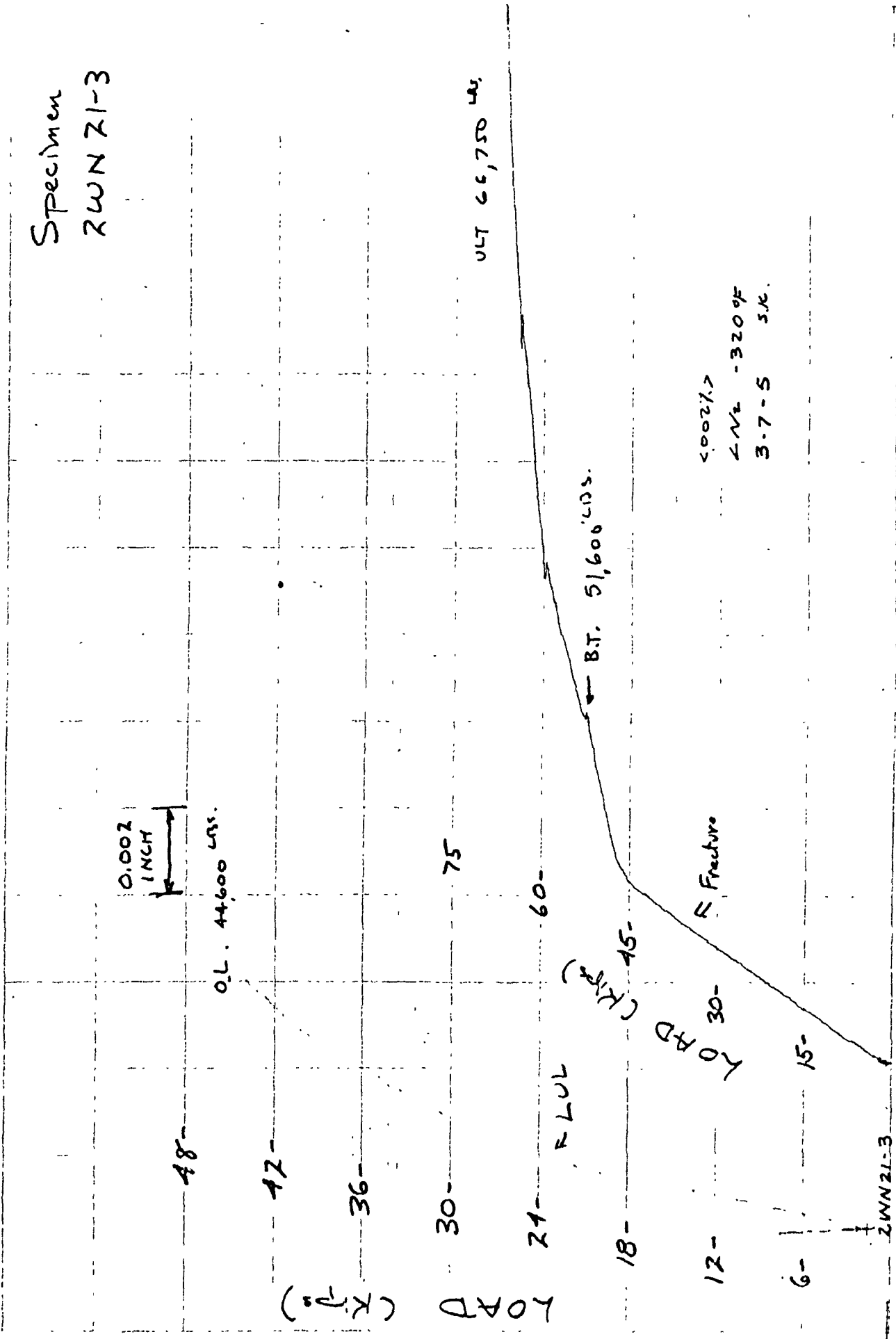
0.002
INCH

OL 44,600 lbs.

BT. 51,600 lbs.

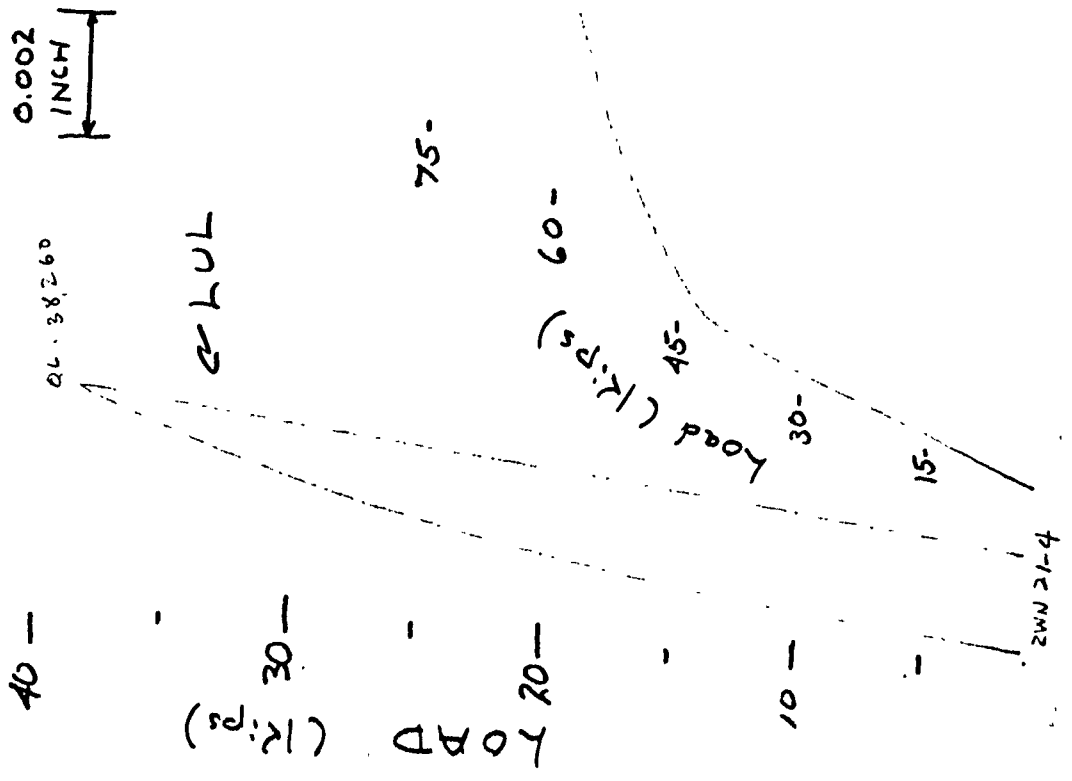
0.00217
4N2 - 3200F
3-7-5 S.K.

Fracture



Specimen
RWN 21-4

OUT 69,360



75.0

67.5-

60.0-

52.5-

45.0-

37.5-

30.0-

22.5-

15.0-

7.5-

AWN21-1

LOAD (Kips)

Specimen
AWN21-1

ULT 6780

Fracture

OL. 52,750

0.001
INCH

WULF

First Cycle

0.001

0.001

92.8.17.5

75.0

67.5-

60.0-

57.5-

45.0-

37.5-

30.0-

22.5-

15.0-

7.5-

LOAD (Kips)

Specimen
4WN 21-2

UCI 64,075

0.001
INCH

26.53,400

Fracture

FLUL

-3231F

.001

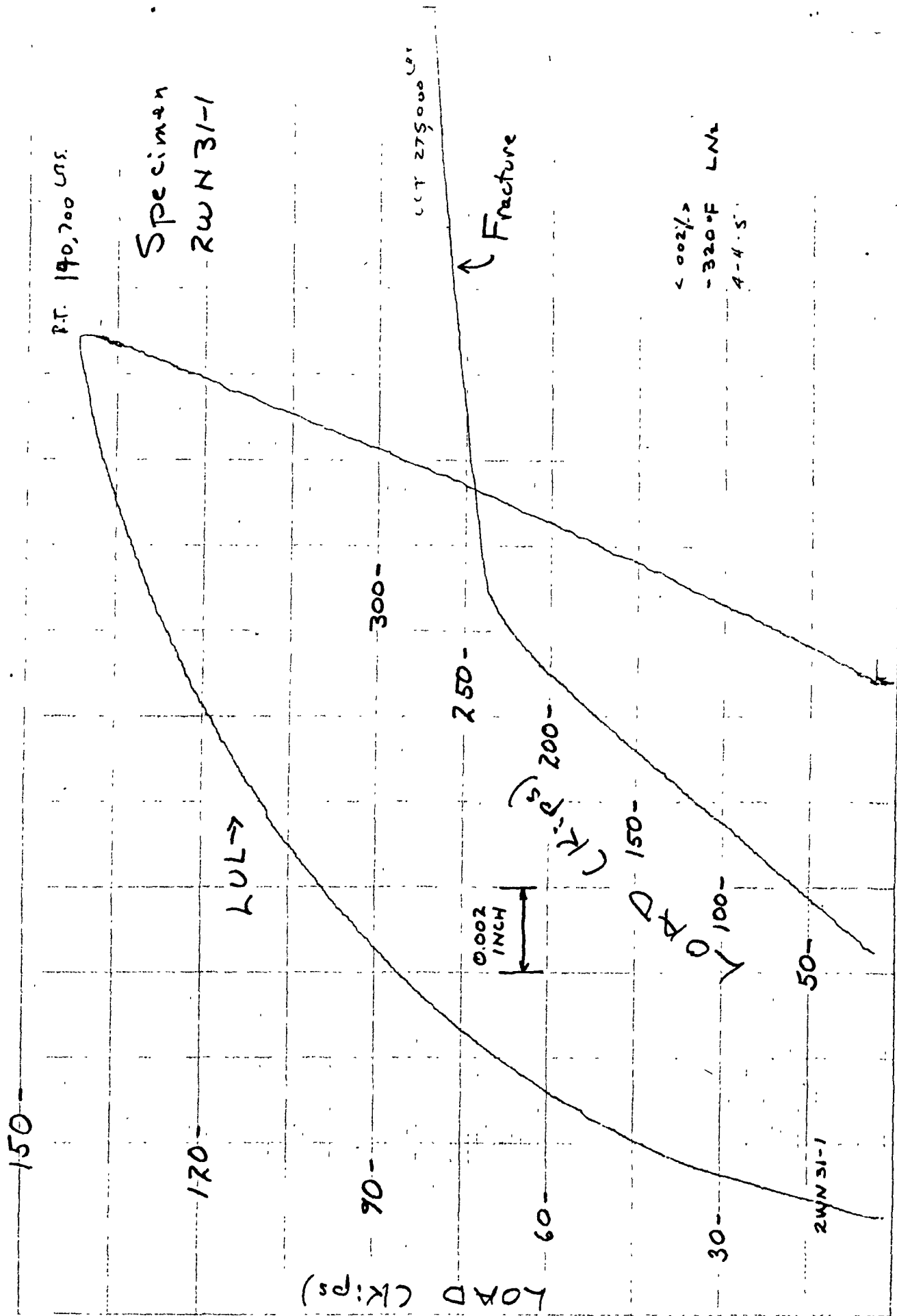
SK 710-5

DATE

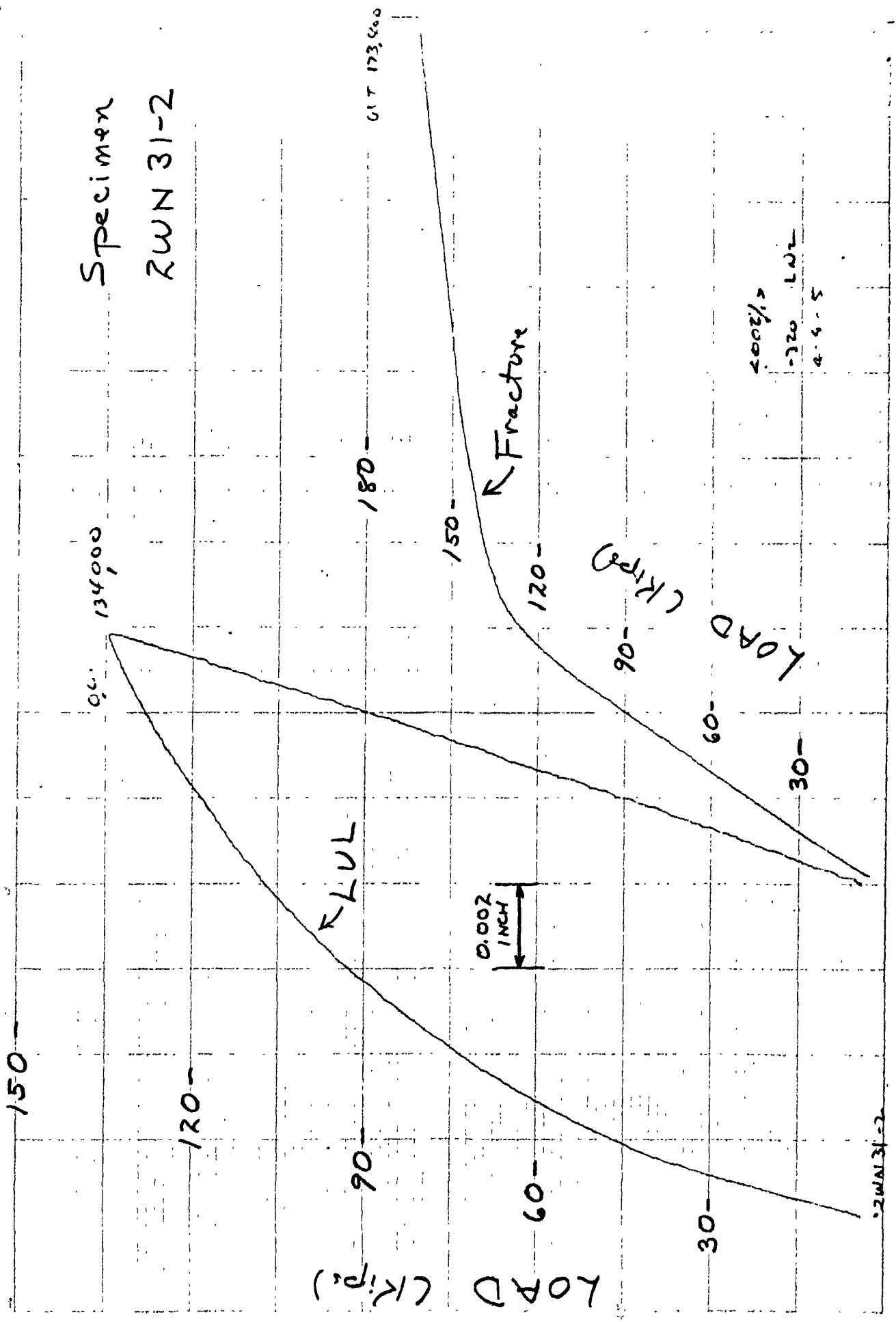
TIME

TESTER

4WN 21-2



Specimen
ZWN 31-2



Specimen
ZWN31-3

0.002
INCH

129,54 #

OVERLOAD
ZWN31-3
-320°F
4-7-75

LUL

→ 002 ←

150-

120-

90-

60-

30-

34,000

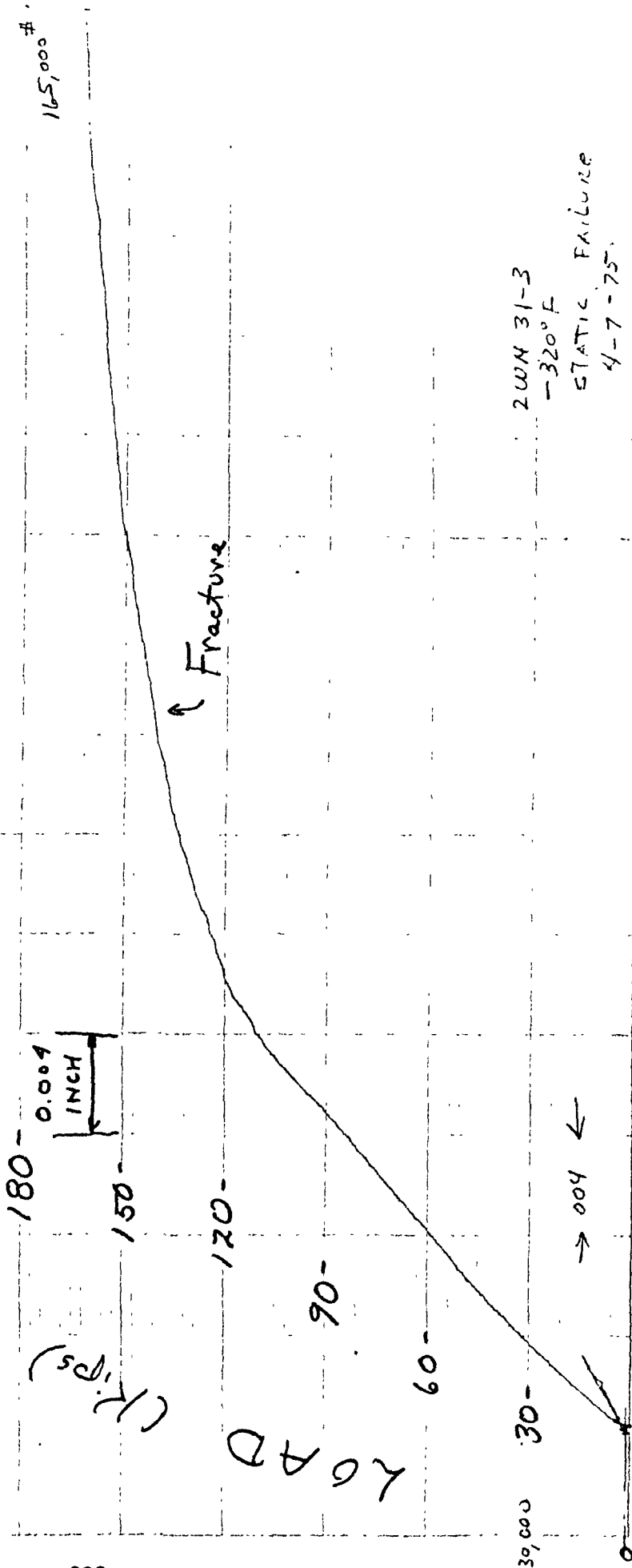
0

(Kips)

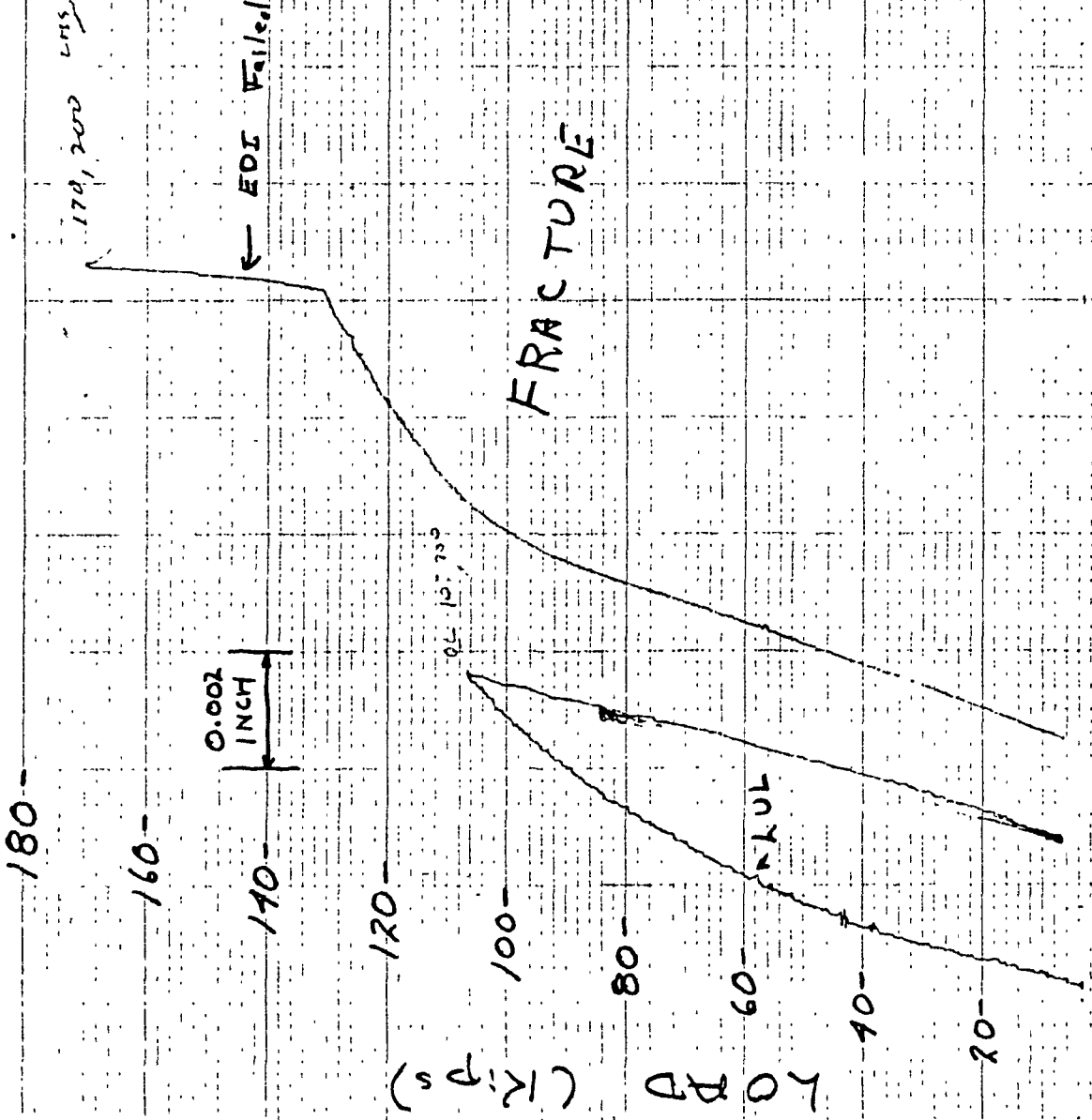
LOAD

Specimen

2WN 31-3



Specimen
RW N 31-4



FRACTURE

4 001/2
5 7 5 1/2

180-

160-

140-

120-

100-

80-

60-

40-

20-

LOAD (KIPS)

3WN31-1

UCT 168400

Specimen
3WN31-1

← GDT Failure

OC 135400

← Fracture

0.002
INCH

← LUL

-3200 LUL

← 0.02%

5-12-55 S.A.

180-

160-

140-

120-

100-

80-

60-

40-

20-

LOAD (Kips)

Specimen
3WN 31-2

ULT 166,500

OL 122,700

0.002
INCH

Fracture

YUL

3WN 31-2

-32071- LUL

SEPARATION

TRAINING

EXPERIMENT

002

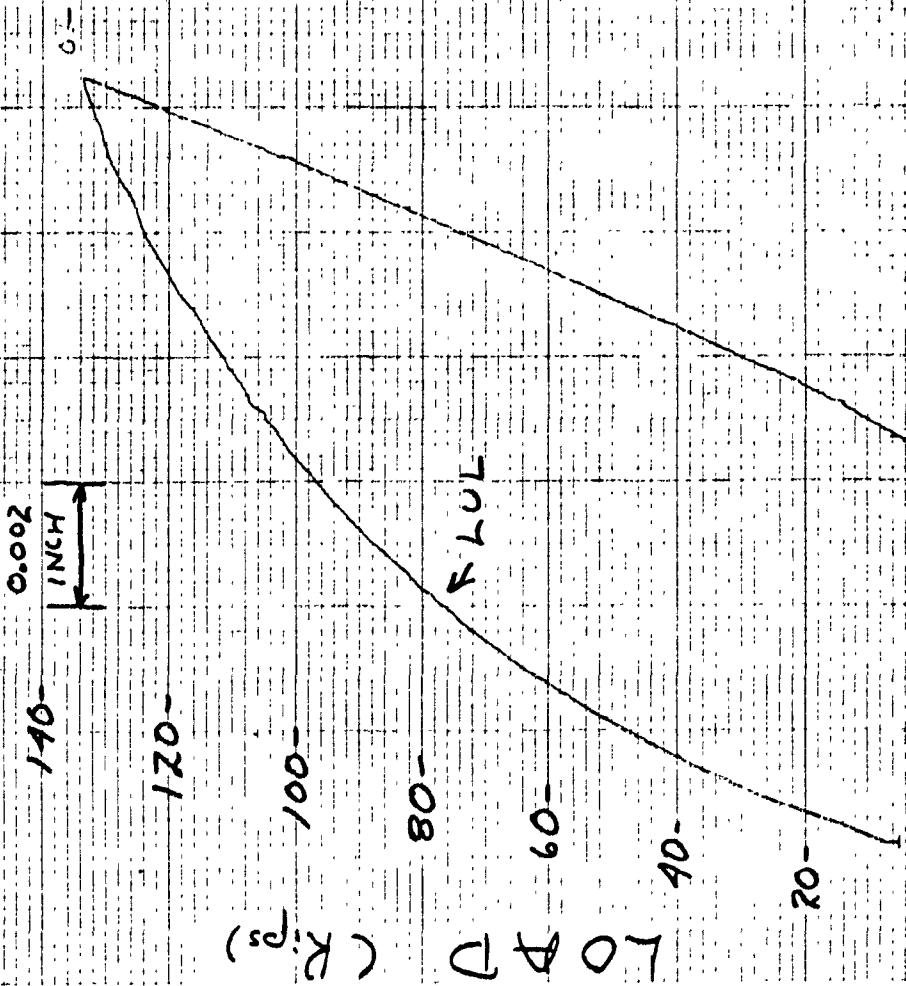
DATE: 7-2-5

TESTER: [Signature]

APPROVED: [Signature]

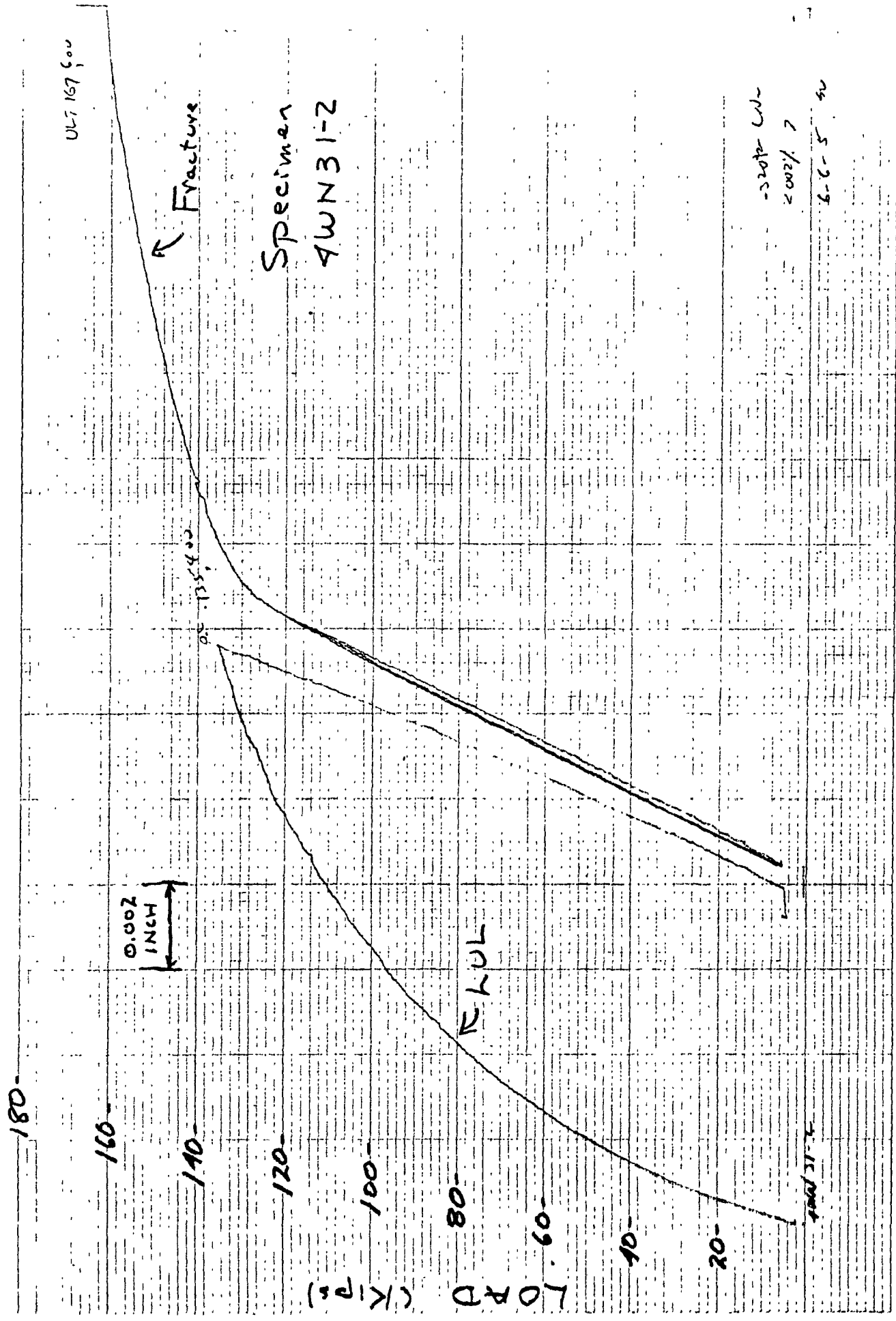
LAB: [Signature]

Specimen
4WN 31-1

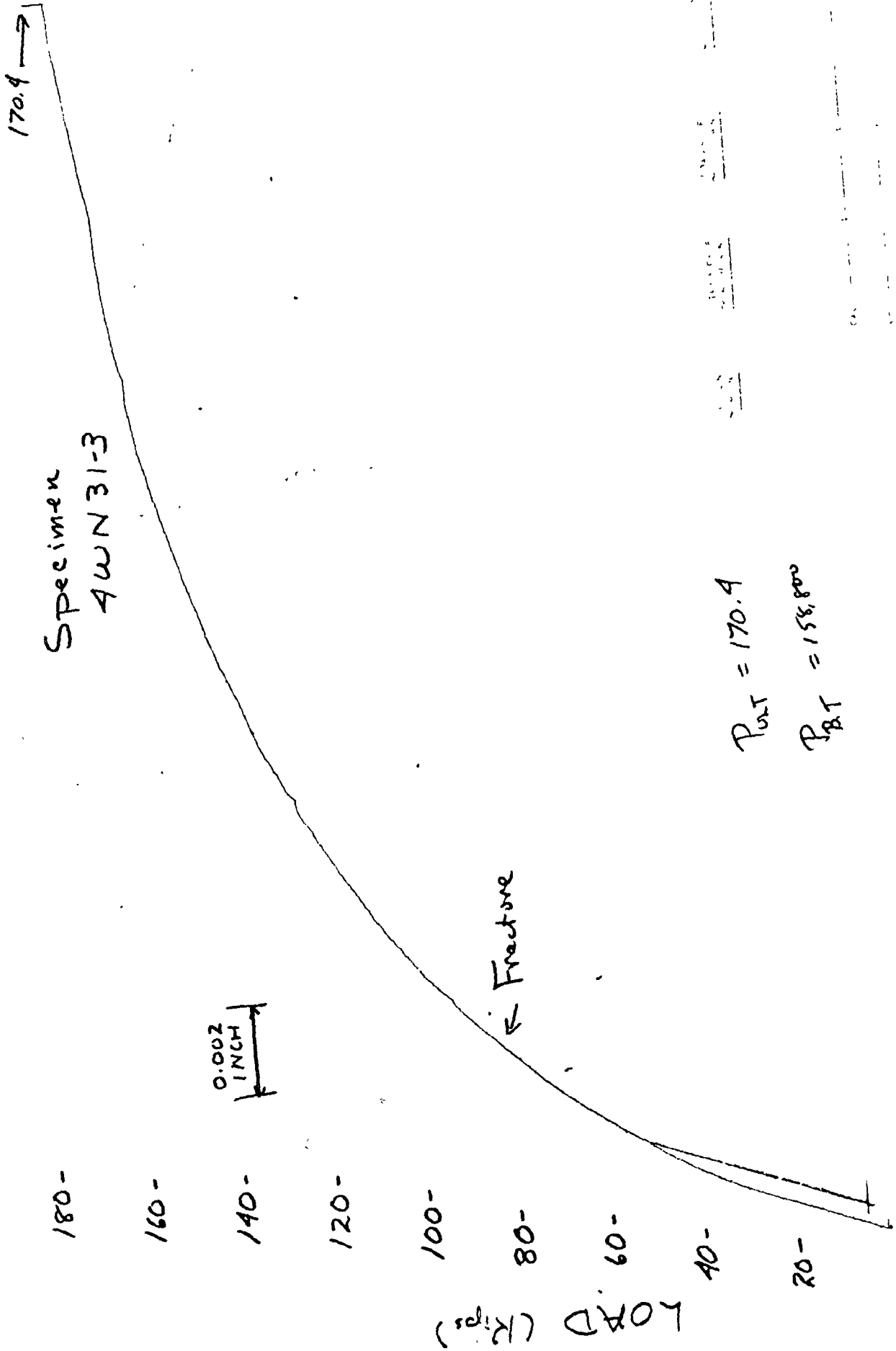


F L U L

4WN 31-1



-stop UL-
 2007/7
 6-6-5 92

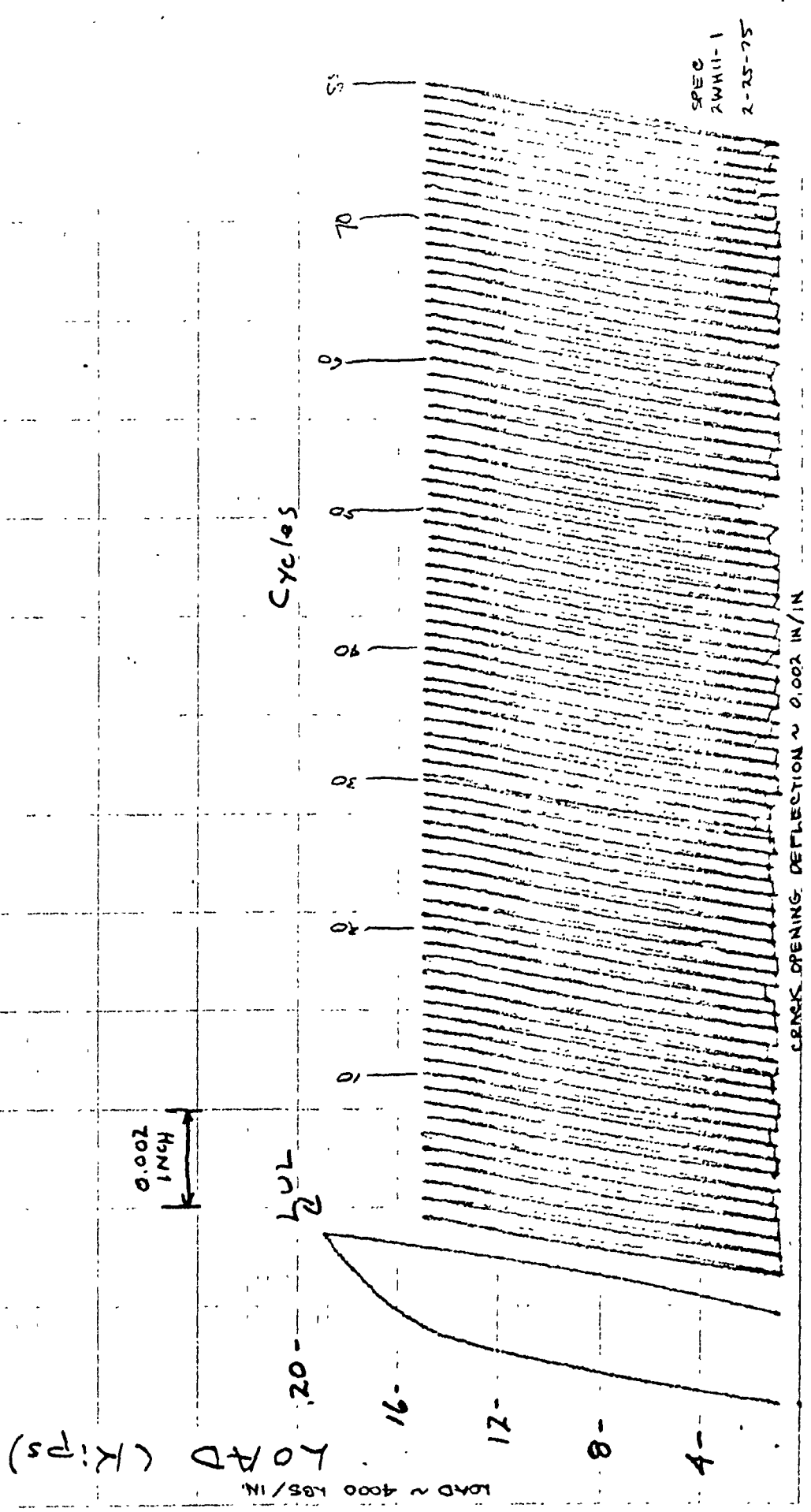


$P_{ULT} = 170.9$

$P_{BT} = 158.8$

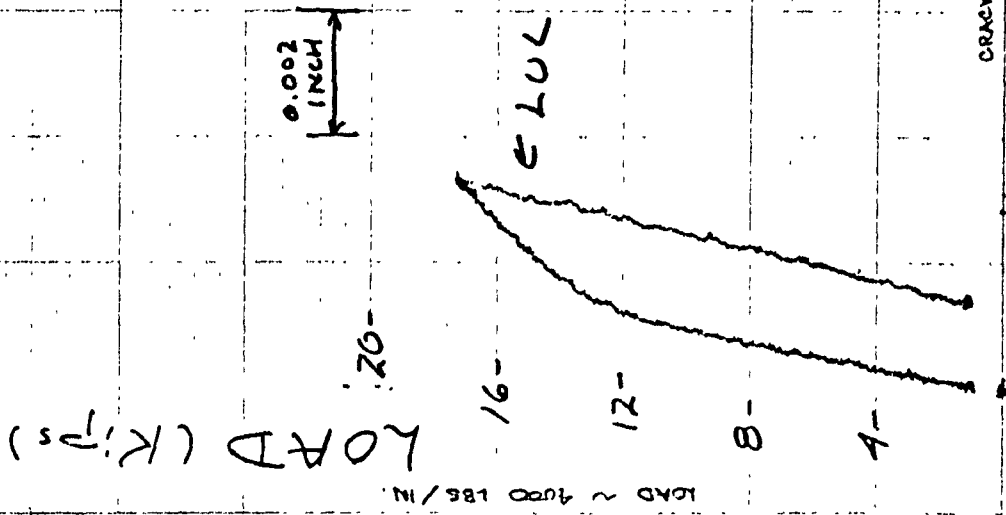
Awn 31-3 -320°F

Specimen
ZWH11-1



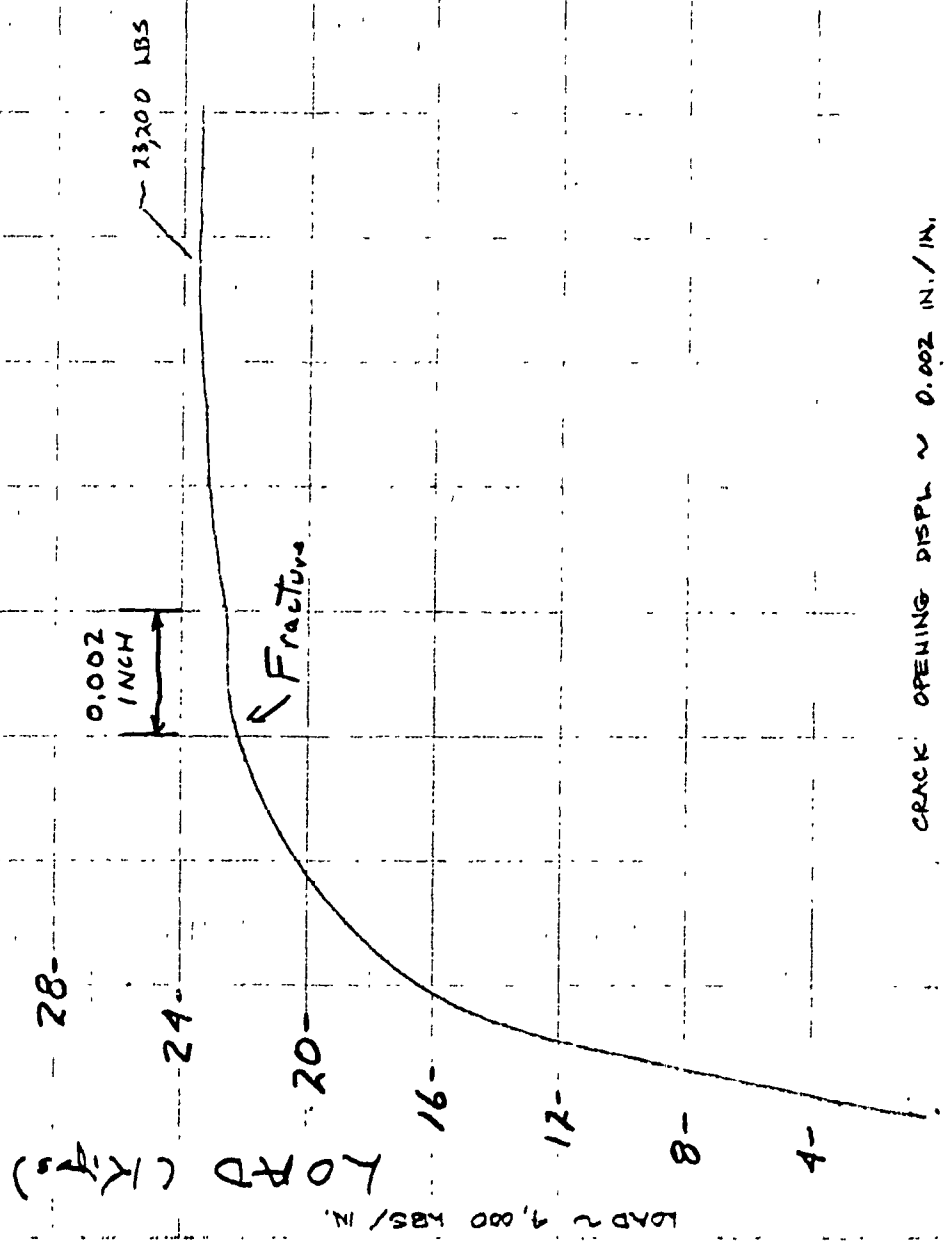
Specimen
RWH11-2

SPEC. RWH11-2
LOAD - UNLOAD TO 26.6 KSI (17,200 LBS)
AT -92.3 °F
3-A-75 TULALIP TEST SITE - AREA 41



Specimen
3WH11-1

SPECIMEN 3WH11-1 (-123°F)
TULALIP TEST SITE
4-25-75



CRACK OPENING DISPL ~ 0.002 IN./IN.

8-12-75

Specimen

AWH11-1

0.002
INCH

78

24

20

16

12

8

4

FAILURE - 23,400 LBS

Fracture

PROOF

TUL

5 20 40 60 80 100

Cycles

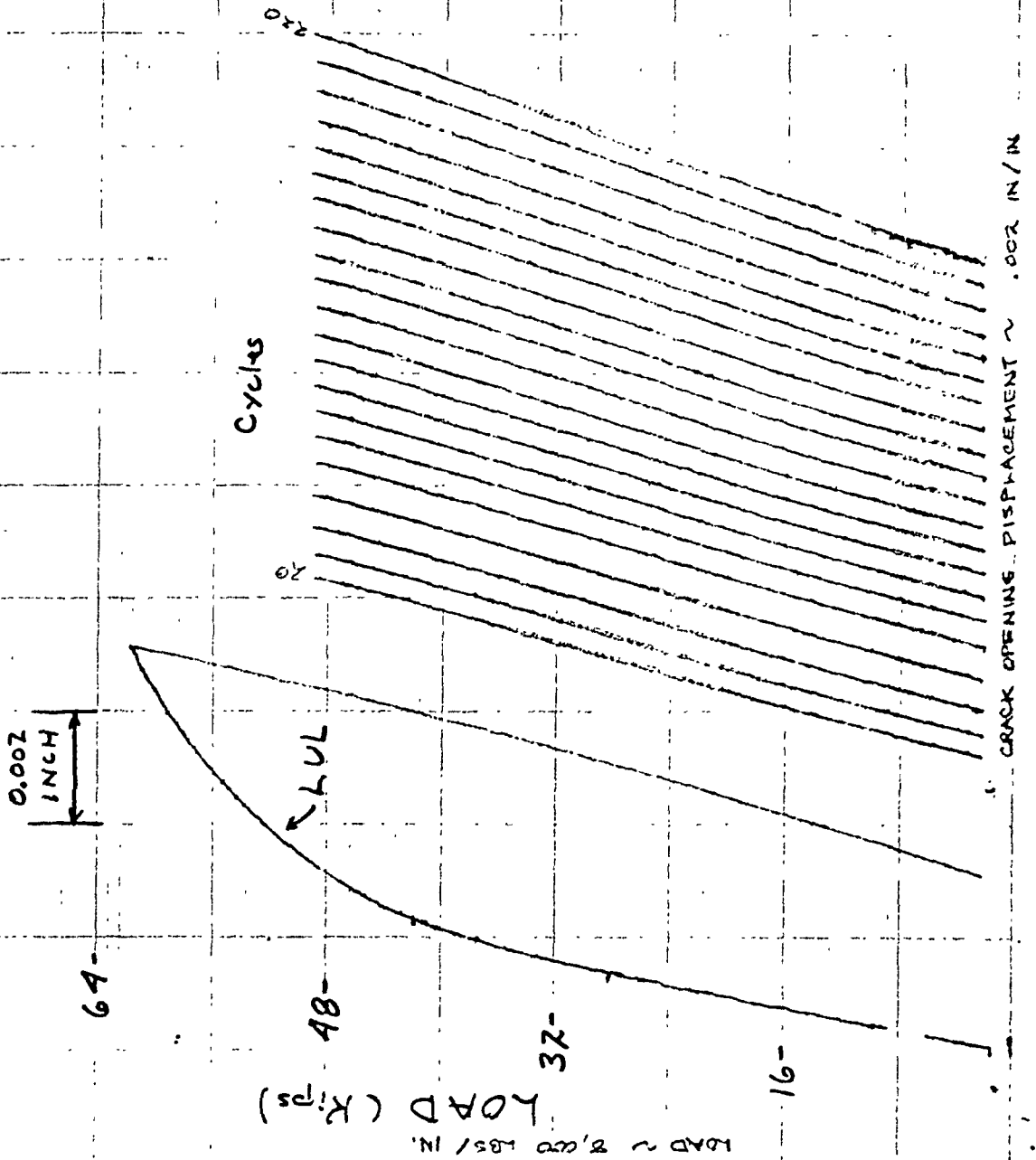
LOAD ~ 4,000 LBS/IN

CRACK PITCH ~ 0.002 IN/IN

SPECIMEN AWH11-1
PROOF LOAD, 100 CYCLES, FOLLOW TO FAILURE IN LH₂
TULALIP 8-12-75

Specimen
RWH21-1

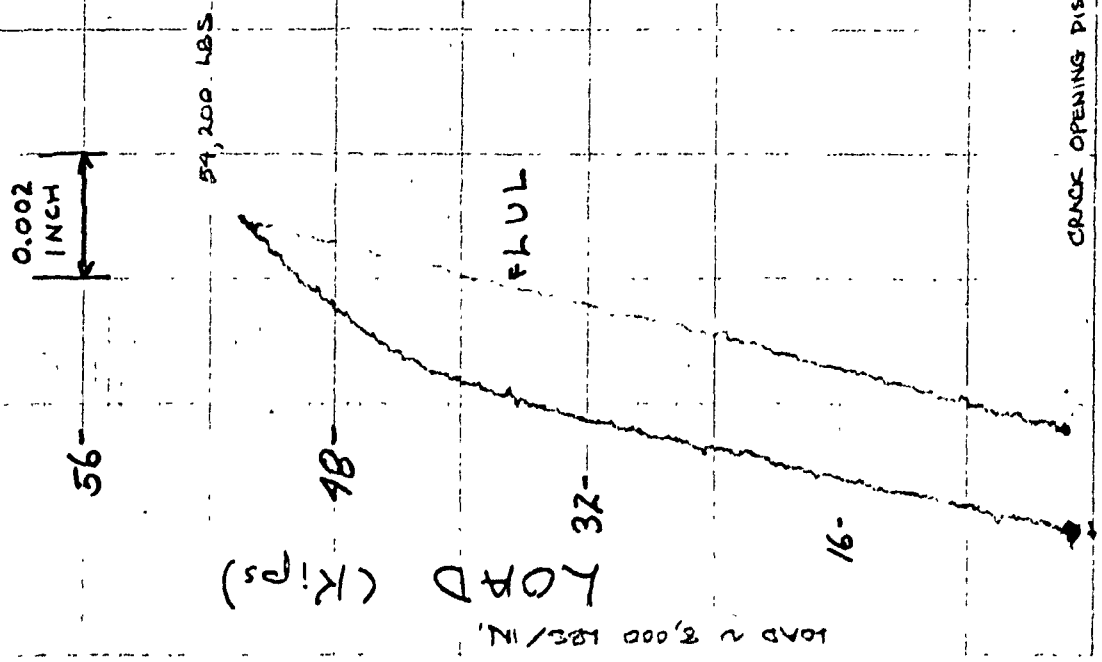
SPECIMEN RWH21-1
LOAD-UNLOAD TO 29.5 KSI @ -127°F
CYCLE TO BREAKTHRU @ 17,300 LBS
3-6-75 TULALUP TEST SITE - AREA 41



RWH21-1

Specimen
RWH 21-2

SPECIMEN RWH 21-2
LOAD UNLOAD TO 26.5 KSI @ -423°F
3-7-75 TULALIP TEST SITE - AREA 41



Specimen
ZWH 21-3

0.002
INCH

LOAD (KIPS)

LOAD \times 20,000 LBS/IN.

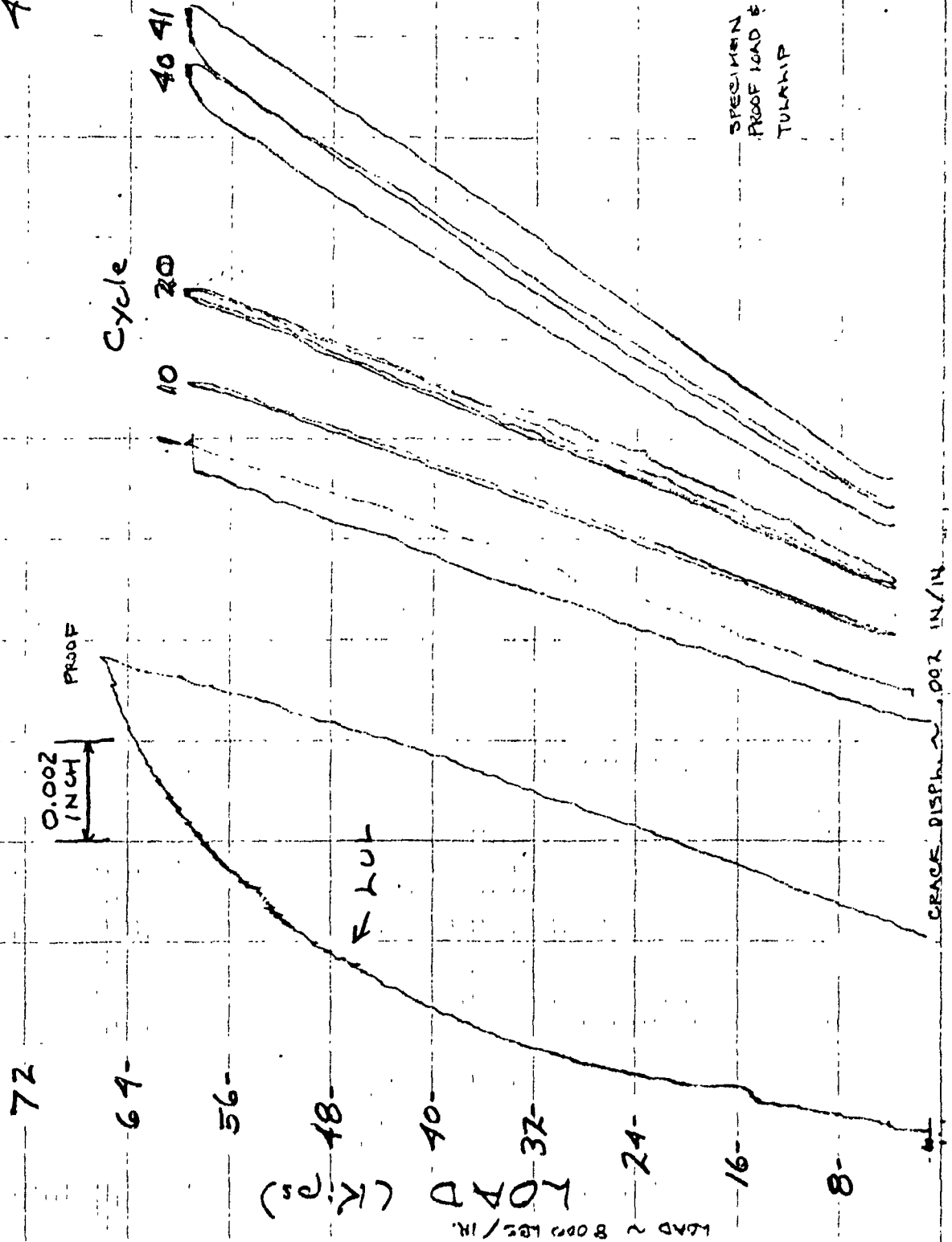
Fracture

SPECIMEN ZWH 21-3
LOAD TO FAILURE @ -423 °F
3-7-75 TULALUP TEST SITE - AREA 41

CRACK OPENING DISPLACEMENT \sim .002 IN./IN.

Specimen
AWH21-1

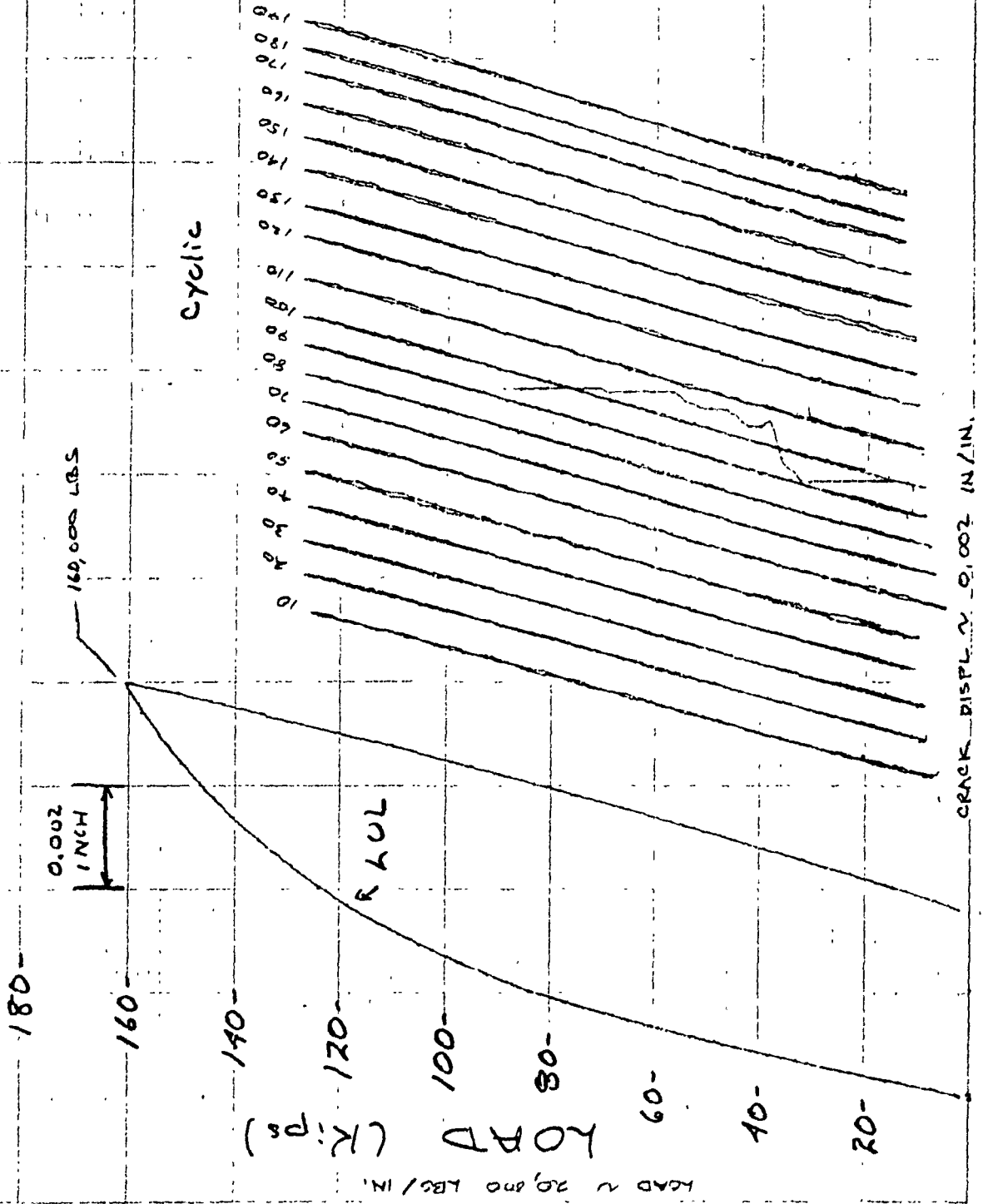
SPECIMEN AWH21-1
PROOF LOAD & CYCLE IN LH2
TULAHIP 8-19-75



Specimen

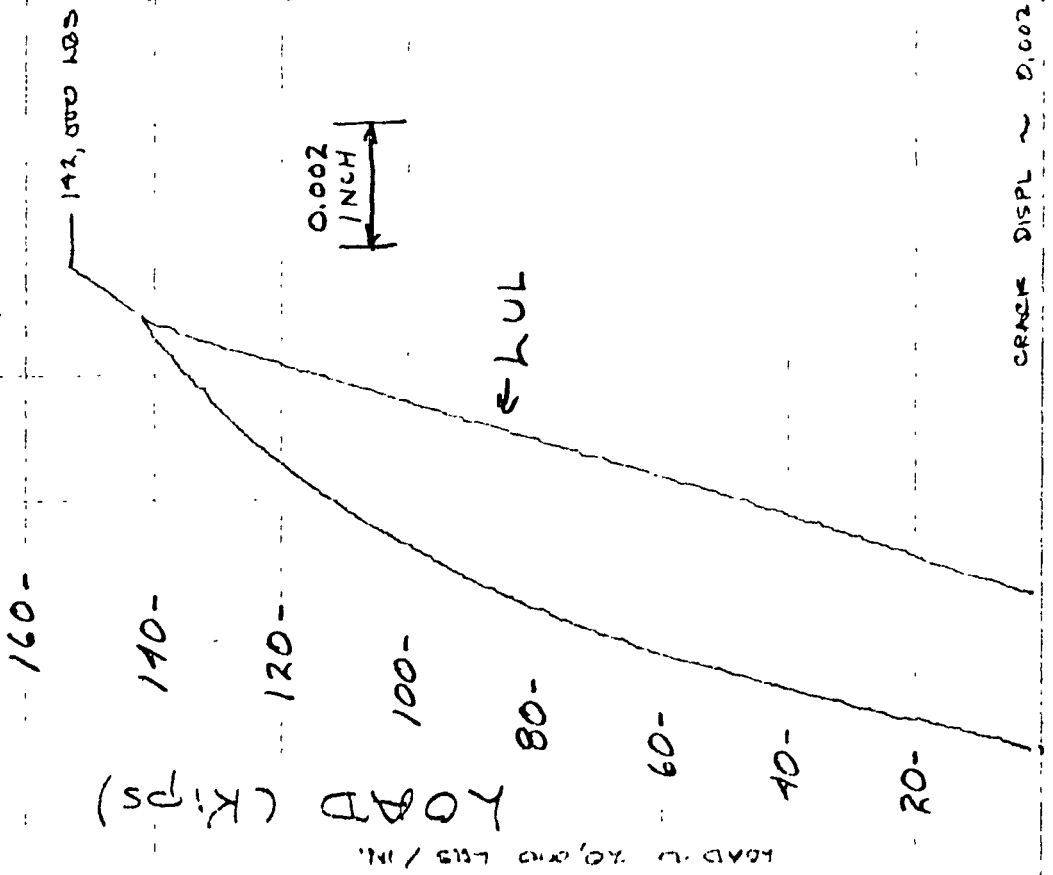
RWH31-1

SPECIMEN RWH31-1 (A117)
TULALIP TEST SITE
A-23-75



Specimen
 RWH31-2

SPECIMEN RWH31-2 (-113°F)
 TOLAHIP TEST SITE
 4-29-75



200-

180-

160-

140-

120-

100-

80

60-

40-

20

(KIPs)

LOAD

173.6 KIP

Specimen
3WH31-1

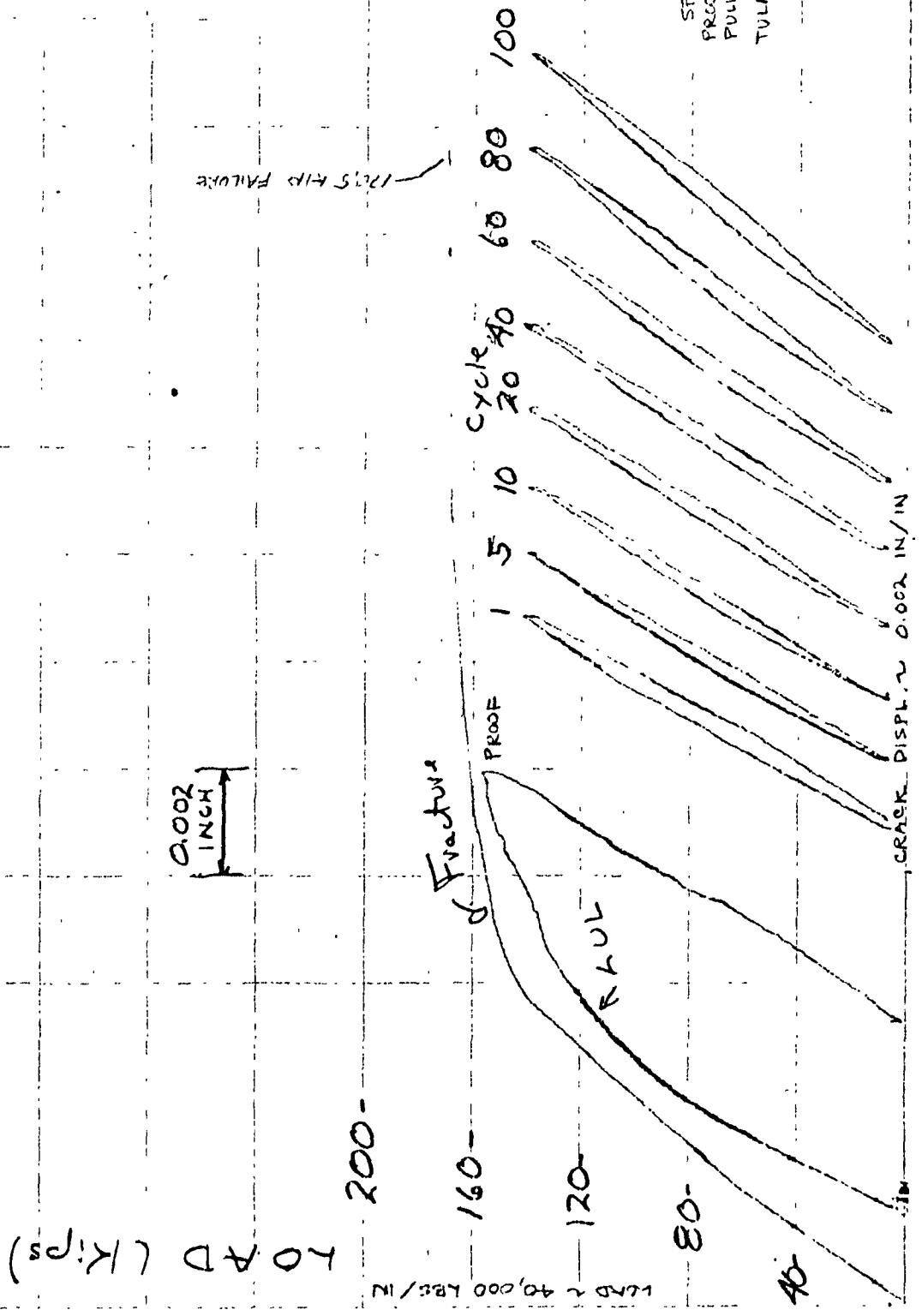
Fracture

0.002
INCH

SPECIMEN 3WH 31-1
LOAD TO FAILURE IN LH2
TULALIP 8-22-75

CRACK DISPL. 0.002 IN/IN

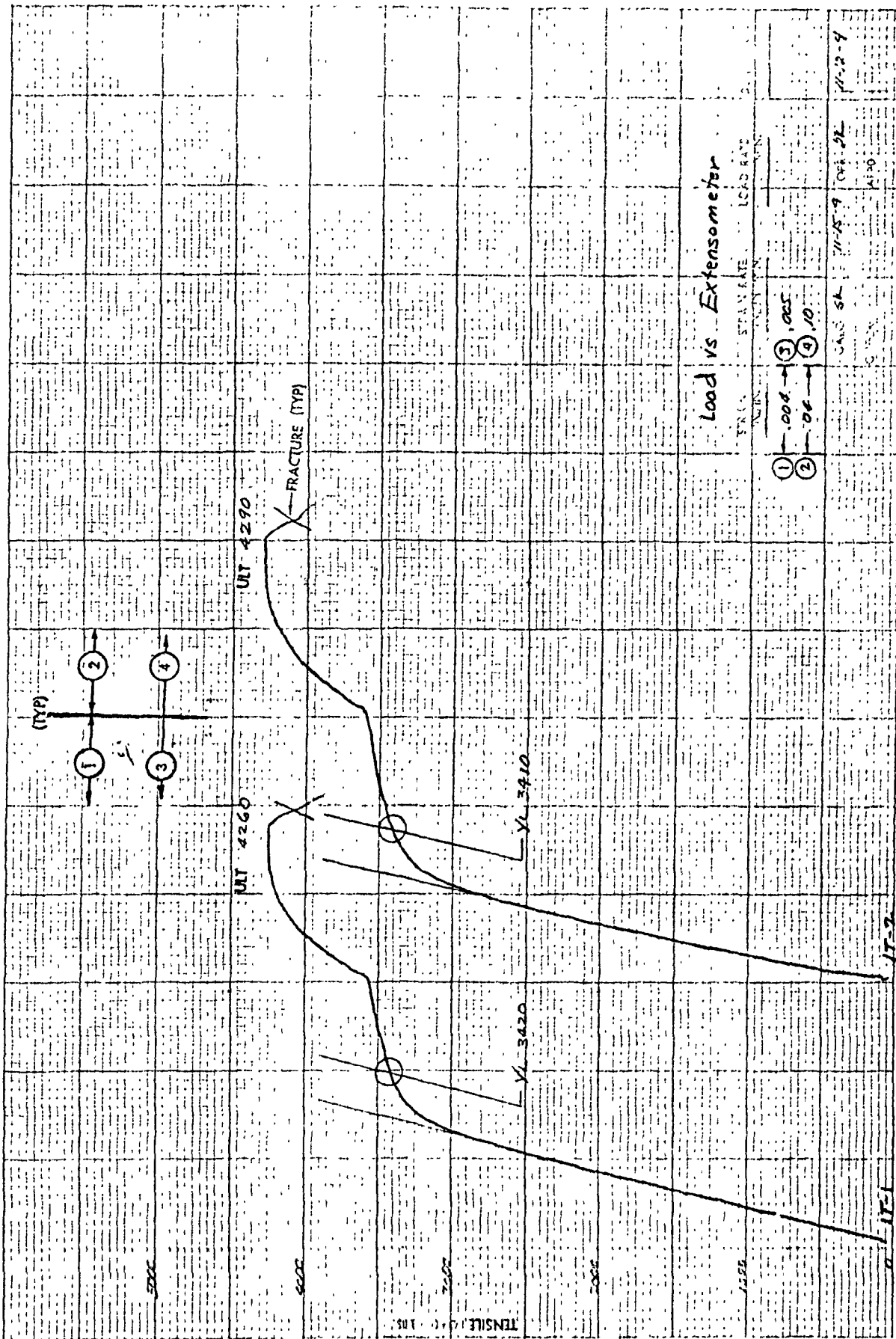
Specimen
AWH 31-1

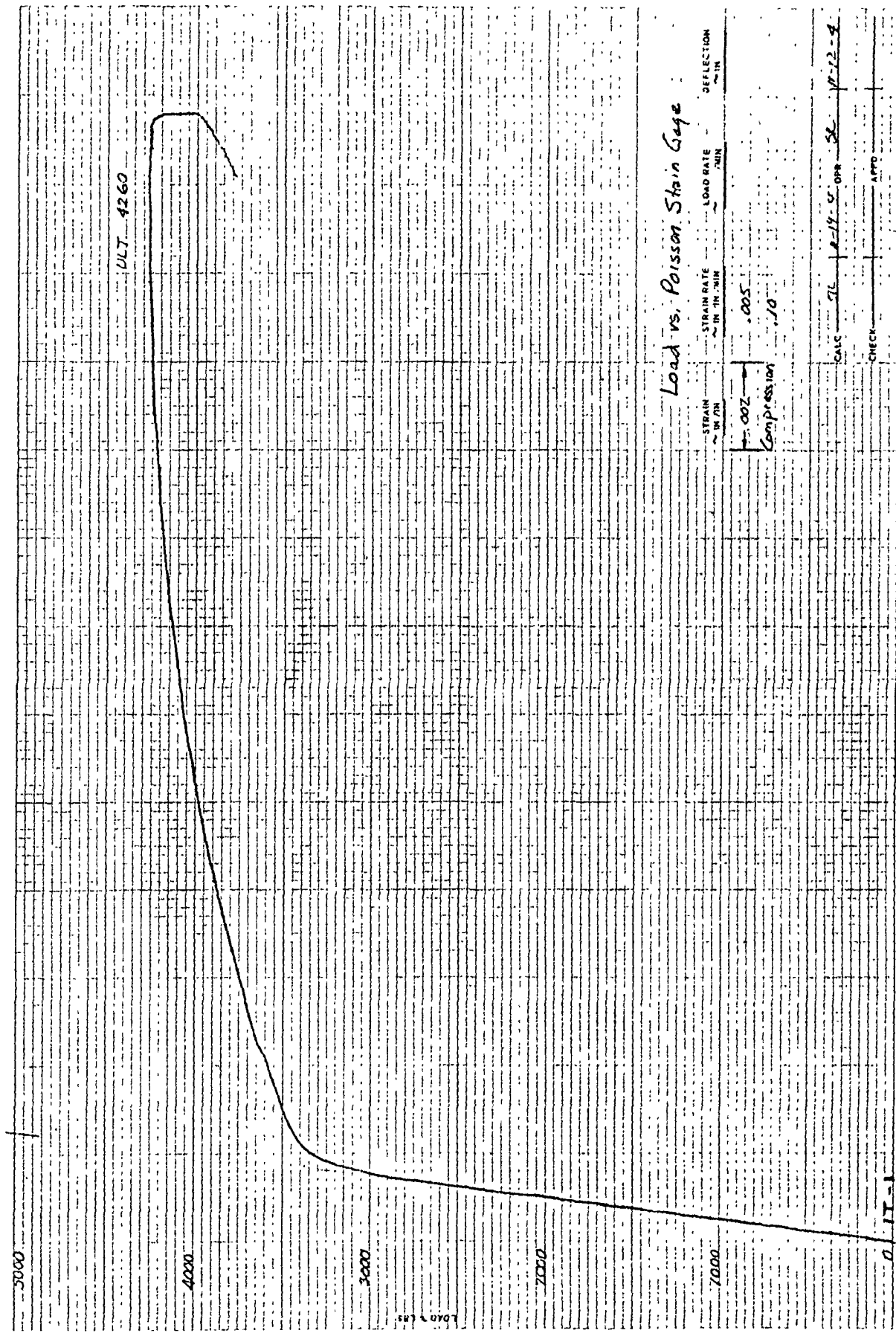


SPECIMEN AWH 31-1
PROOF LOAD CYCLE 100 TIMES,
PULL TO FAILURE IN L&L
TULALIP 8-15-75

APPENDIX III - Extensometer and Strain Gage Records

	<u>Page</u>
Extensometer and Strain Gage Records From Table 2 of Volume I. CR-135036.	254-291
Extensometer and Strain Gage Records From Table 3 of Volume I CR-135036.	292-323
Extensometer and Strain Gage Records From Table 4 of Volume I. CR-135036.	324-377





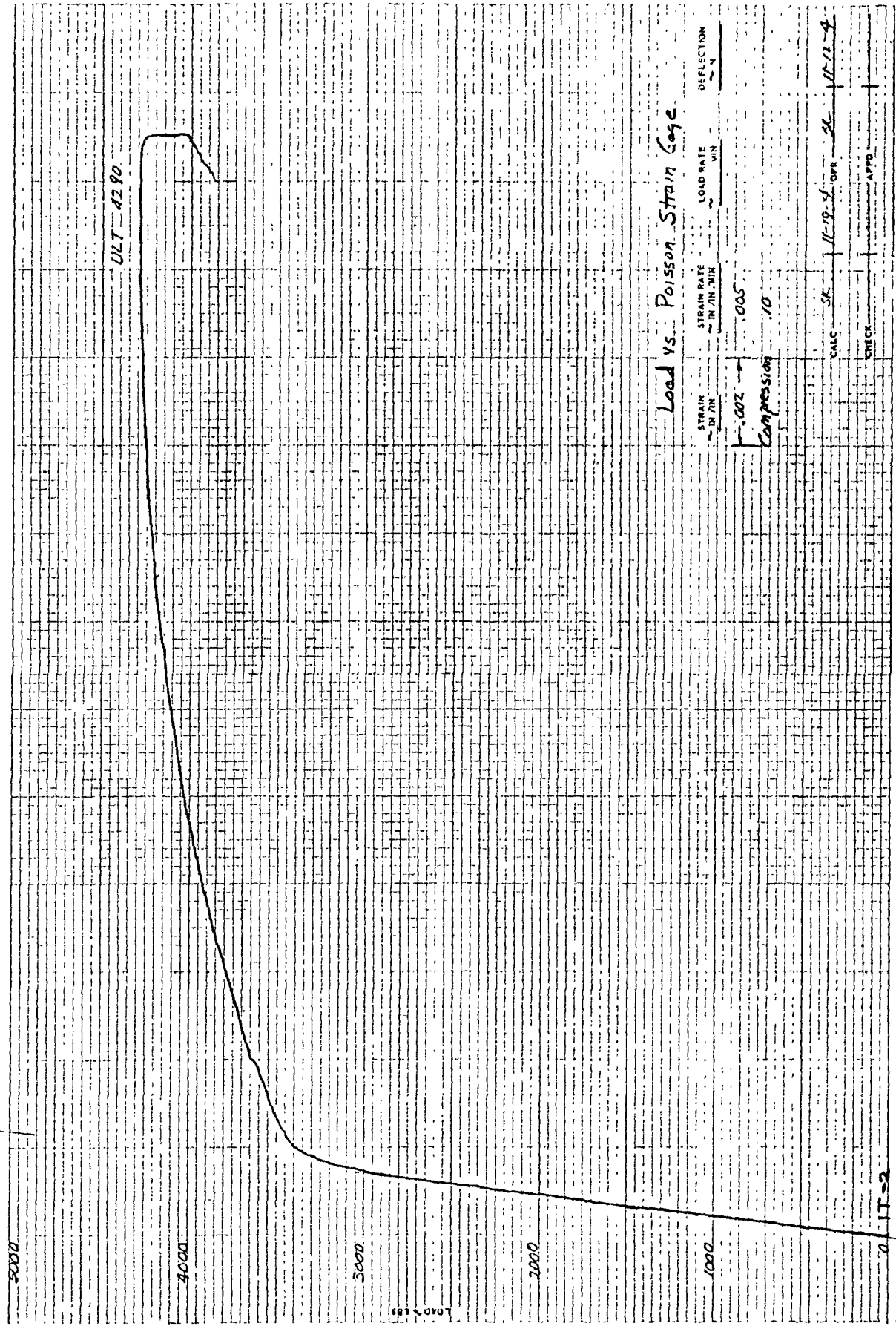
Load vs. Poisson Strain Gage

STRAIN IN / IN	STRAIN RATE IN / IN / MIN	LOAD RATE LBS / MIN	DEFLECTION IN
0.002	0.005		
Compression			
CALC JL 2-14-50 DRN SL 10-12-4			
CHECK APPD			

ULT 4290

Load vs. Axial Strain Gage

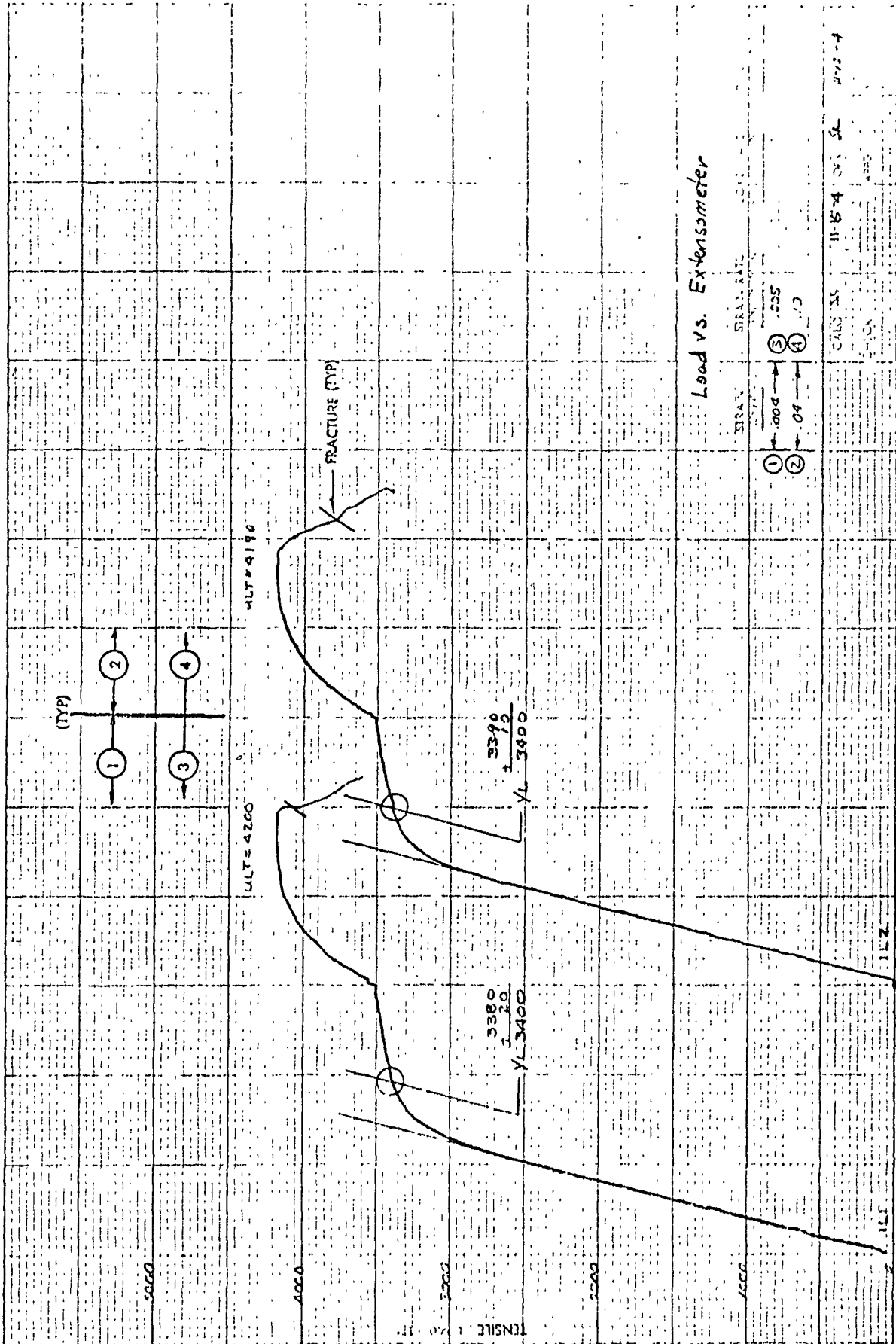
STRAIN BY IN.	STRAIN RATE IN./IN. MIN.	LOAD RATE MIN.	DEFLECTION IN.
0.002	0.05		
	.10		
CALC 25		1:10-U	OPR 25
CHECK		APPD	11-12-74



BOEING TPR

EVA PAGE OF

J17-947





318-887

5

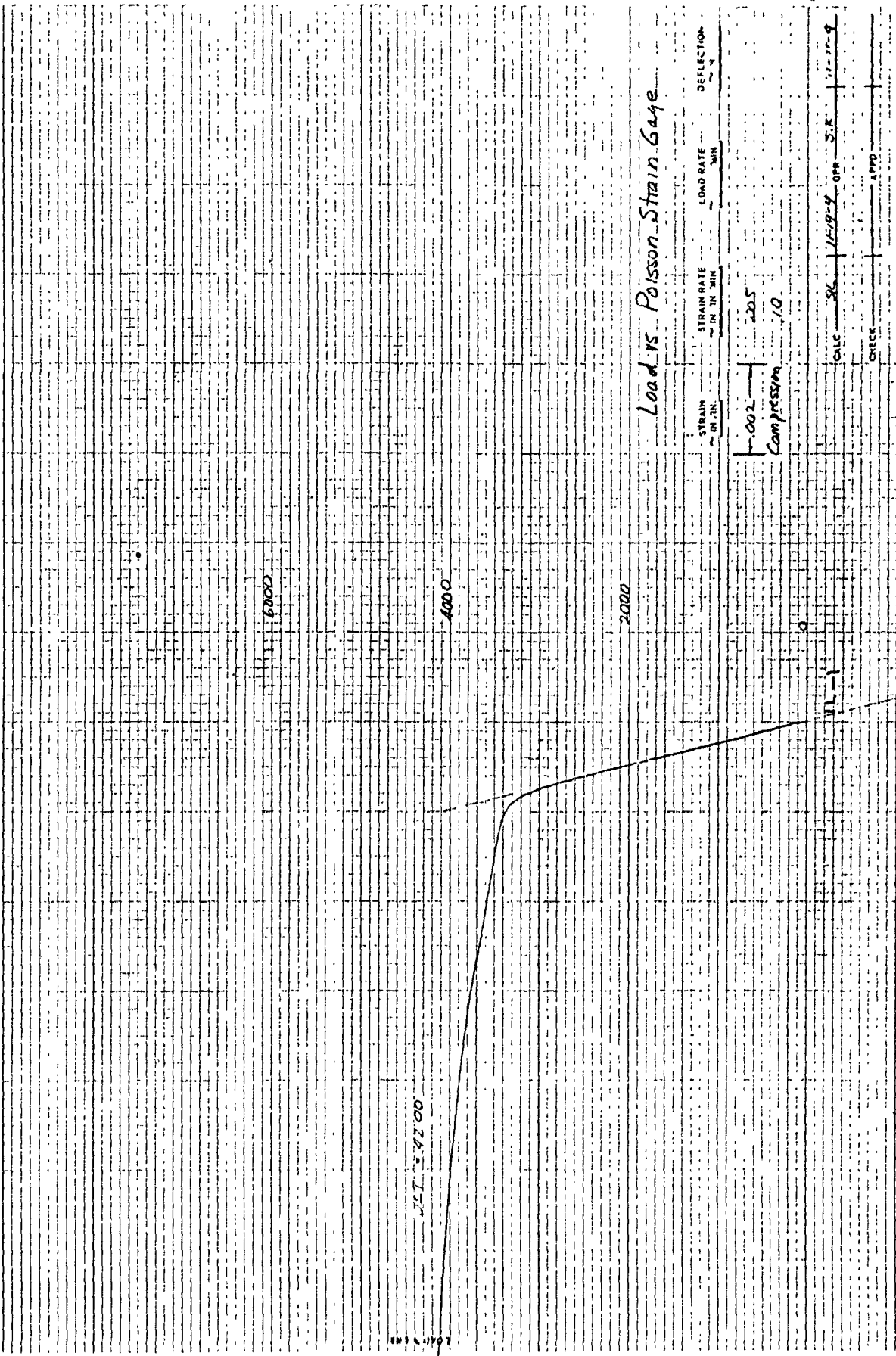
318-887

A: 061914

BOEING TPR

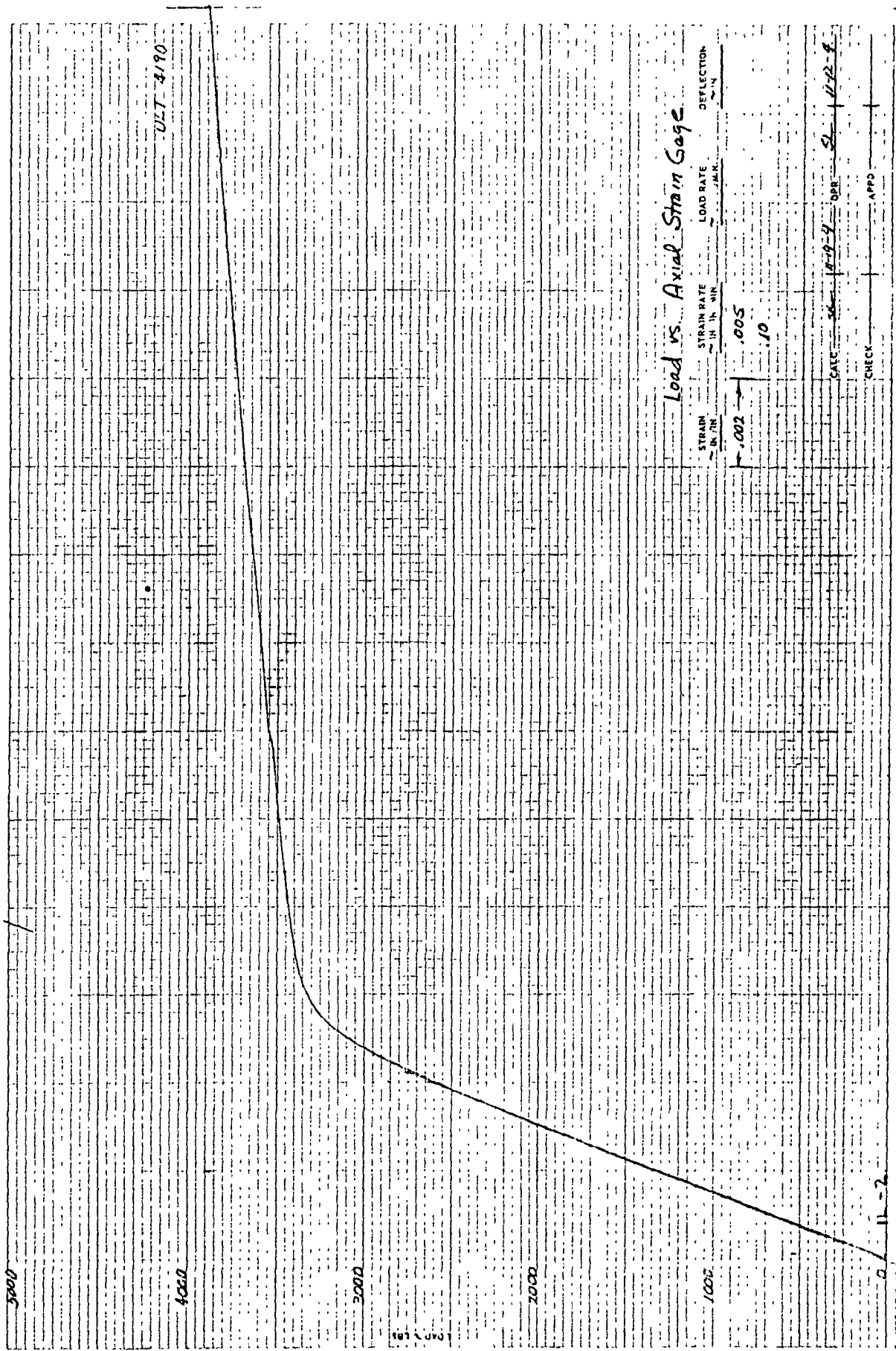
EWB PAGE OF

318-887



Load vs Poisson Strain Gauge

STRAIN IN IN	STRAIN RATE IN IN MIN	LOAD RATE LBS	DEFLECTION IN
0.002	20.5		
Compressive			
0.004	20.5		
0.006	20.5		



Load vs. Axial Strain Gage

STRAIN IN IN. STRAIN RATE IN IN. MIN. LOAD RATE LBS. DEFLECTION IN.

.002 .005 .10

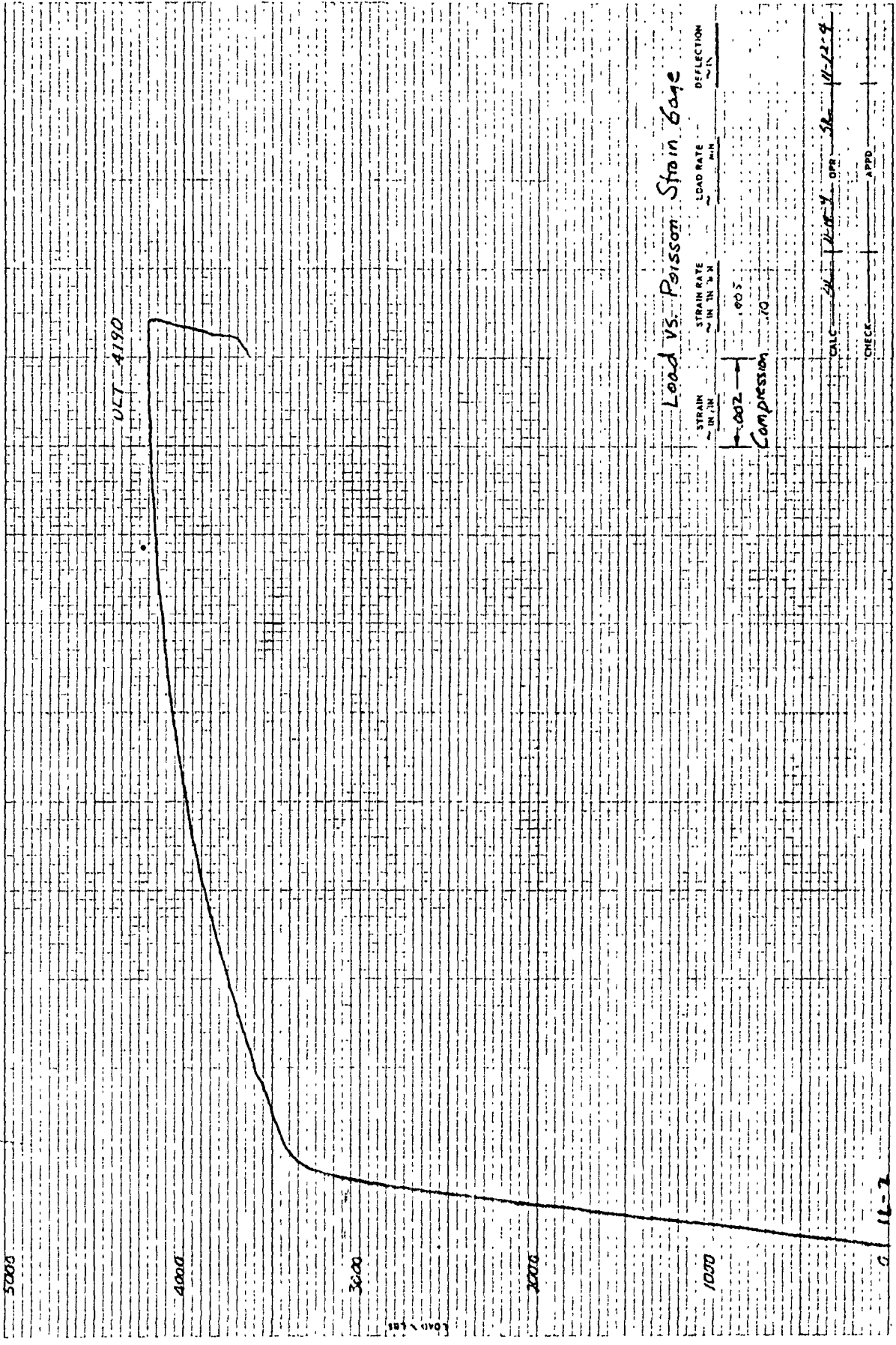
CAGE 56 1-19-4 DBB SL 11-2-4

CHECK APPD

J18-007

BOEING ITR

EWA PAGE OF



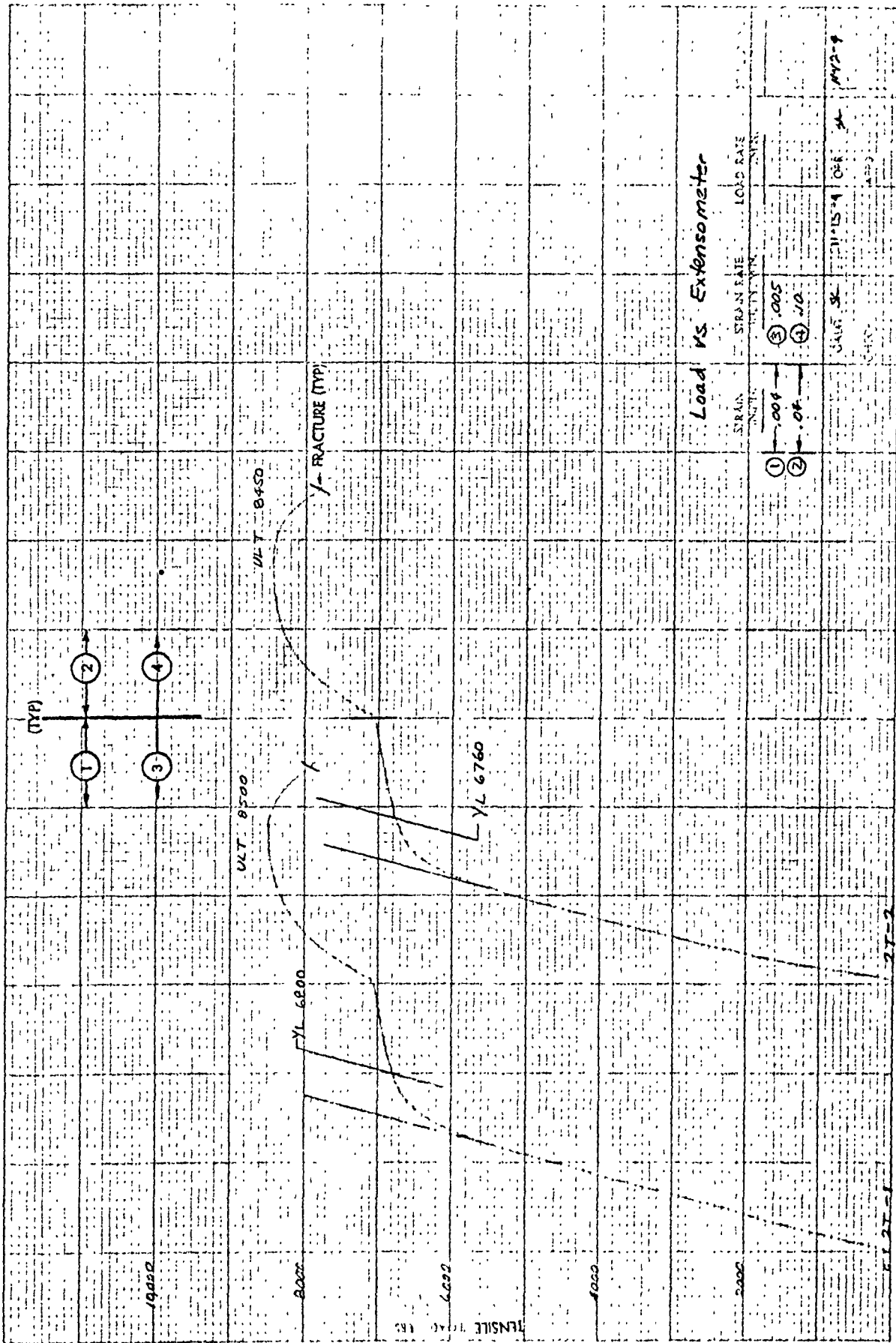
UET 4190

LOAD x 10³

POISSON'S RATIO

STRAIN IN IN IN STAIN RATE IN IN MIN LOAD RATE MIN DEFLECTION IN

0.002 1005
Compression .70
CALC SK 12-11-9 DFR SK 11-12-9
CHECK APPD
BOEING TPR
EVA PAGE OF

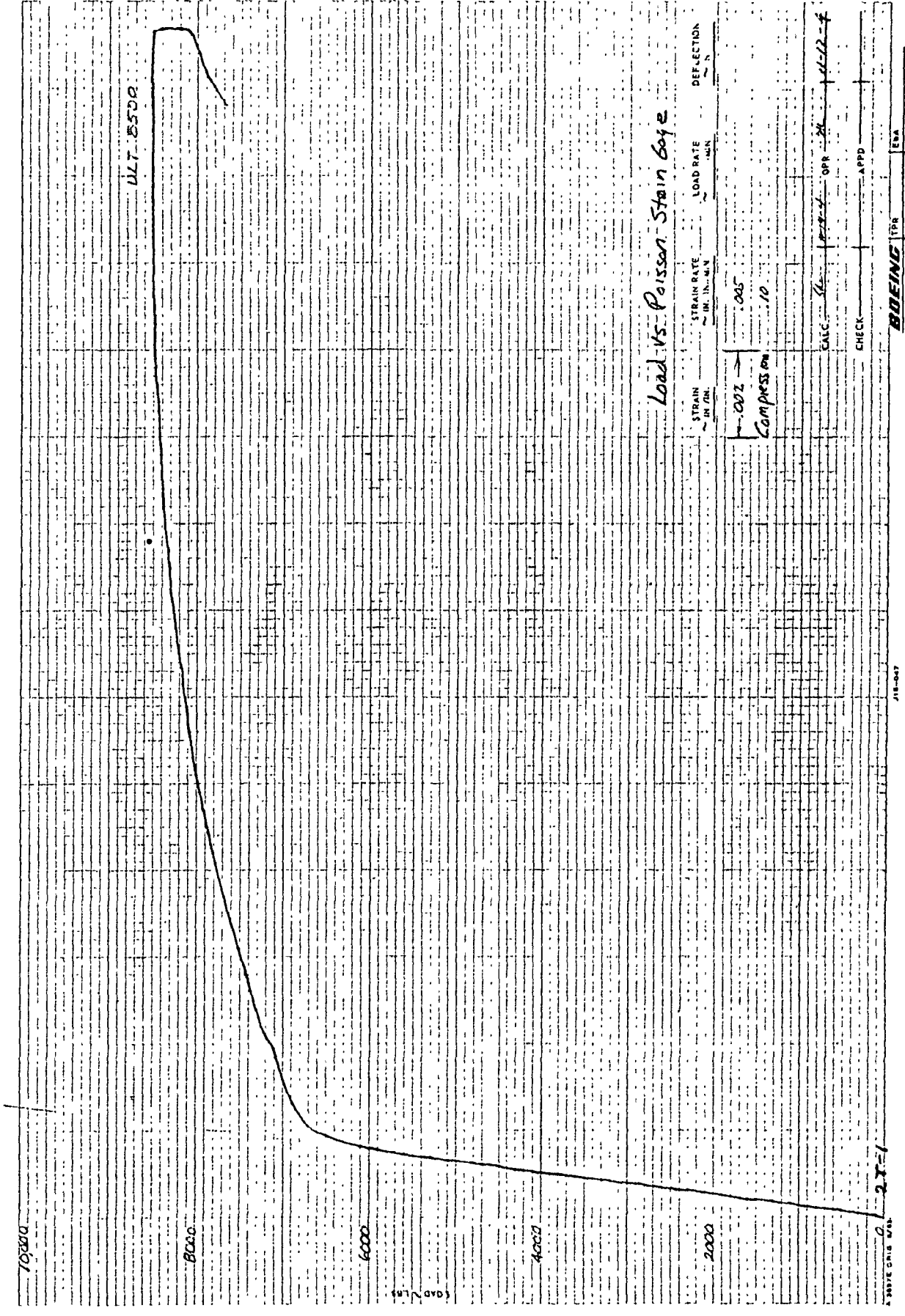




Load vs. Axial Strain Gage

STRAIN IN/IN	STRAIN RATE IN/IN MIN	LOAD RATE LBS/MIN	DEFLECTION IN
0.002	.005		
	.10		

CALC	SI	11-18-54	OPR	SR	11-18-54
CHECK			APPD		



Load vs. Poisson's Ratio

STRAIN IN IN.	LOAD RATE	DEFLECTION
0.002		
0.005		
0.010		
0.020		
0.050		
0.100		
0.200		
0.500		
1.000		

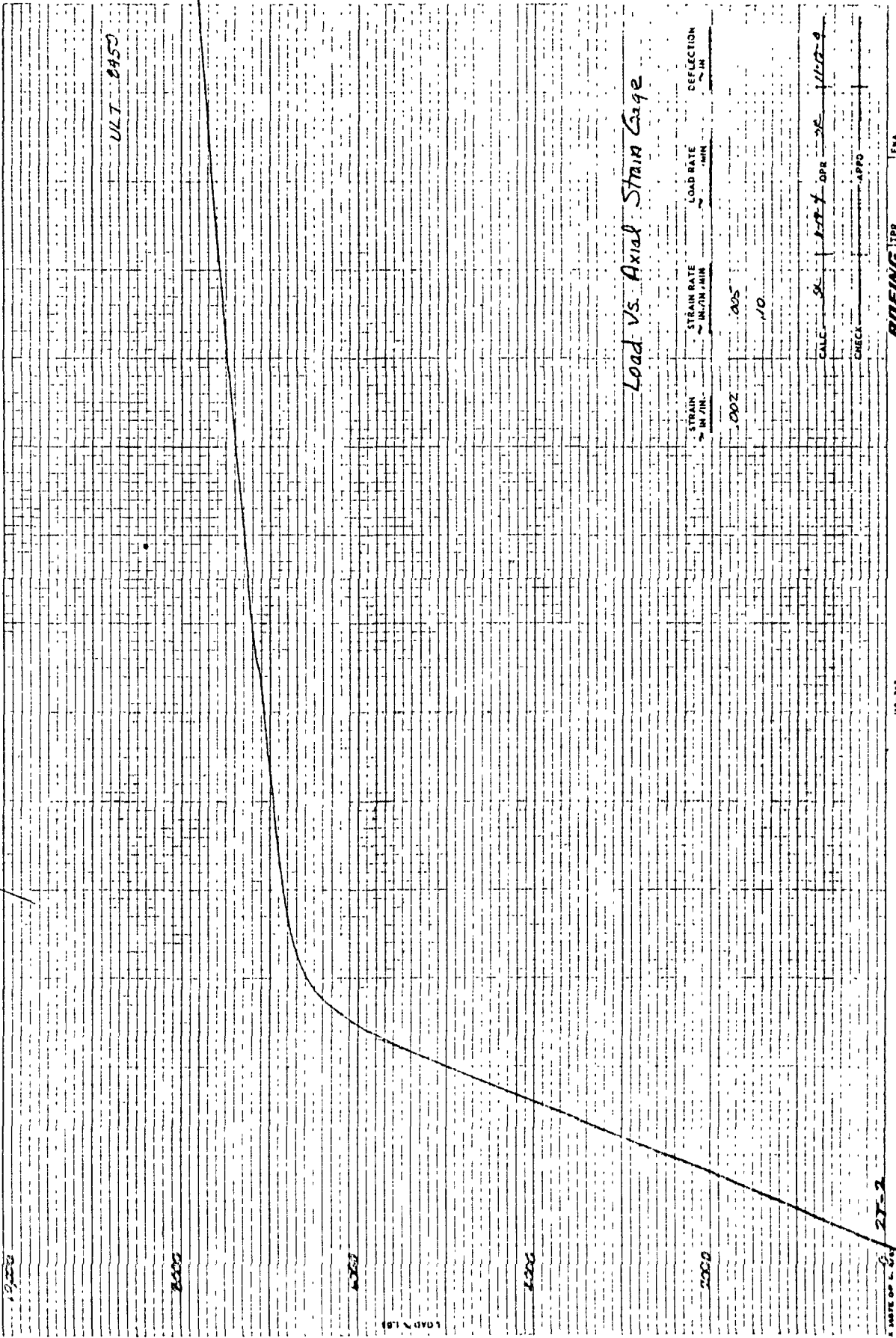
CALC. BY: [Signature] APPD. BY: [Signature]

CHECK: [Signature]

DATE: 11-12-54

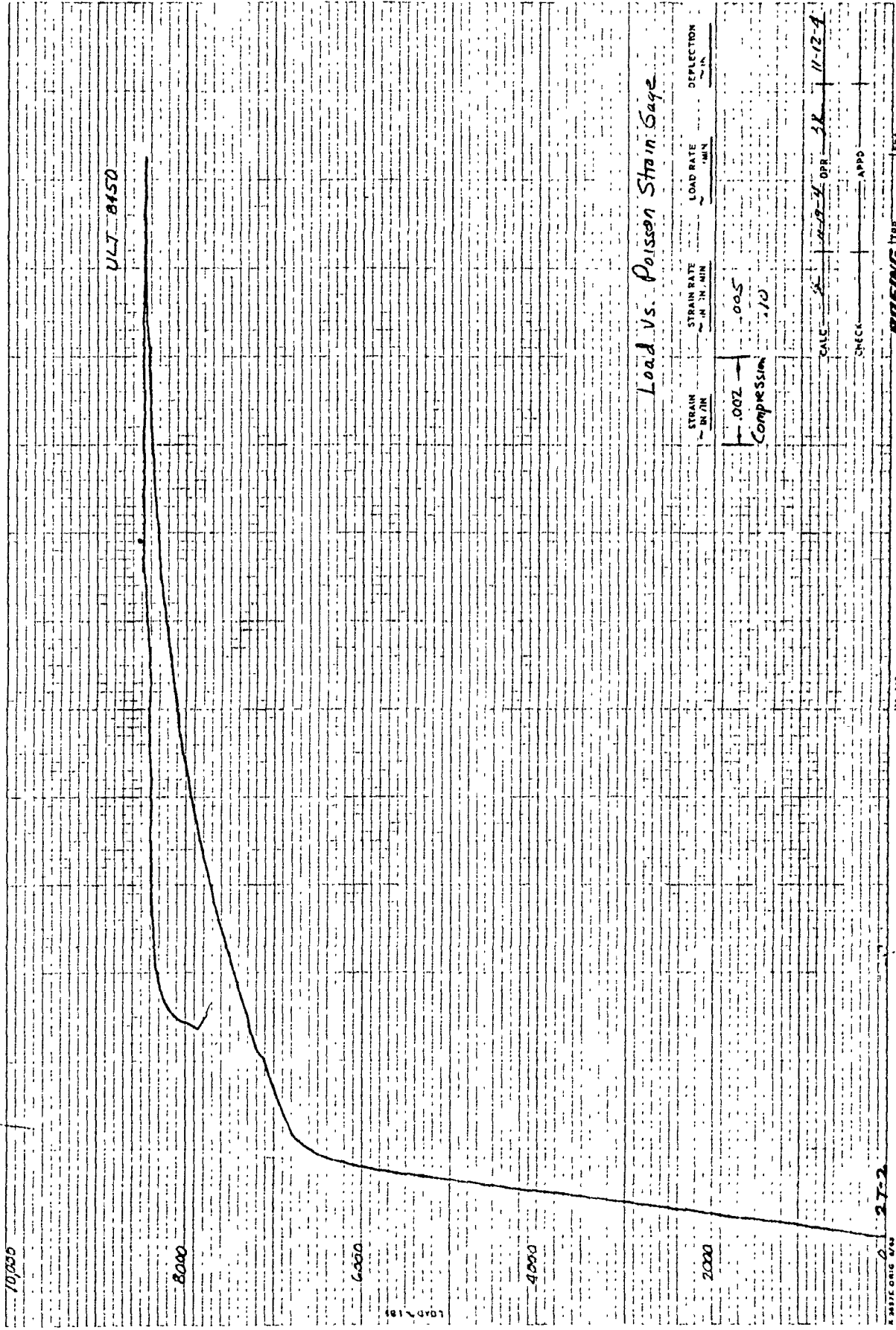
BOEING TPR

27-1



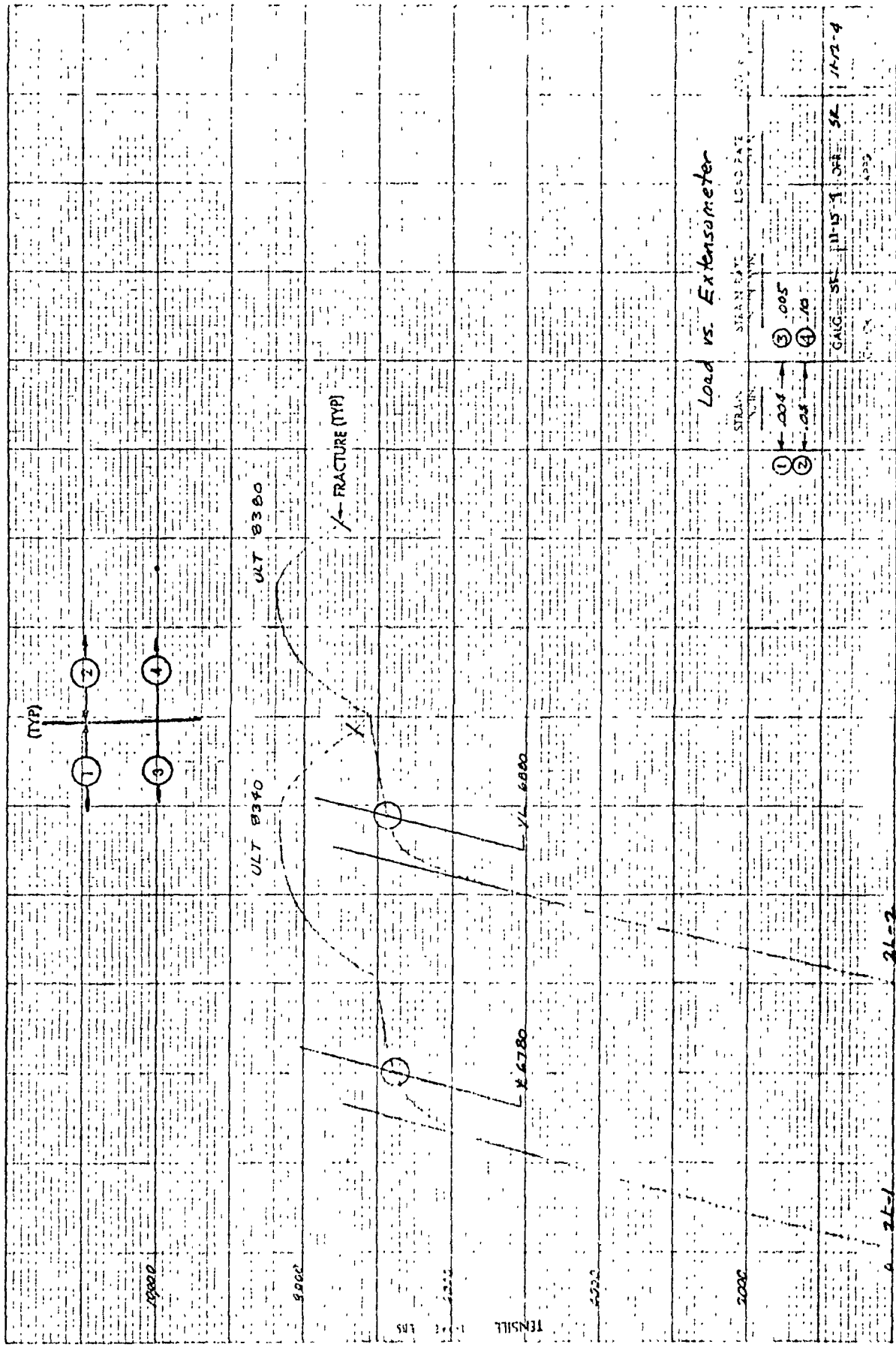
Load vs. Axial Strain Gage

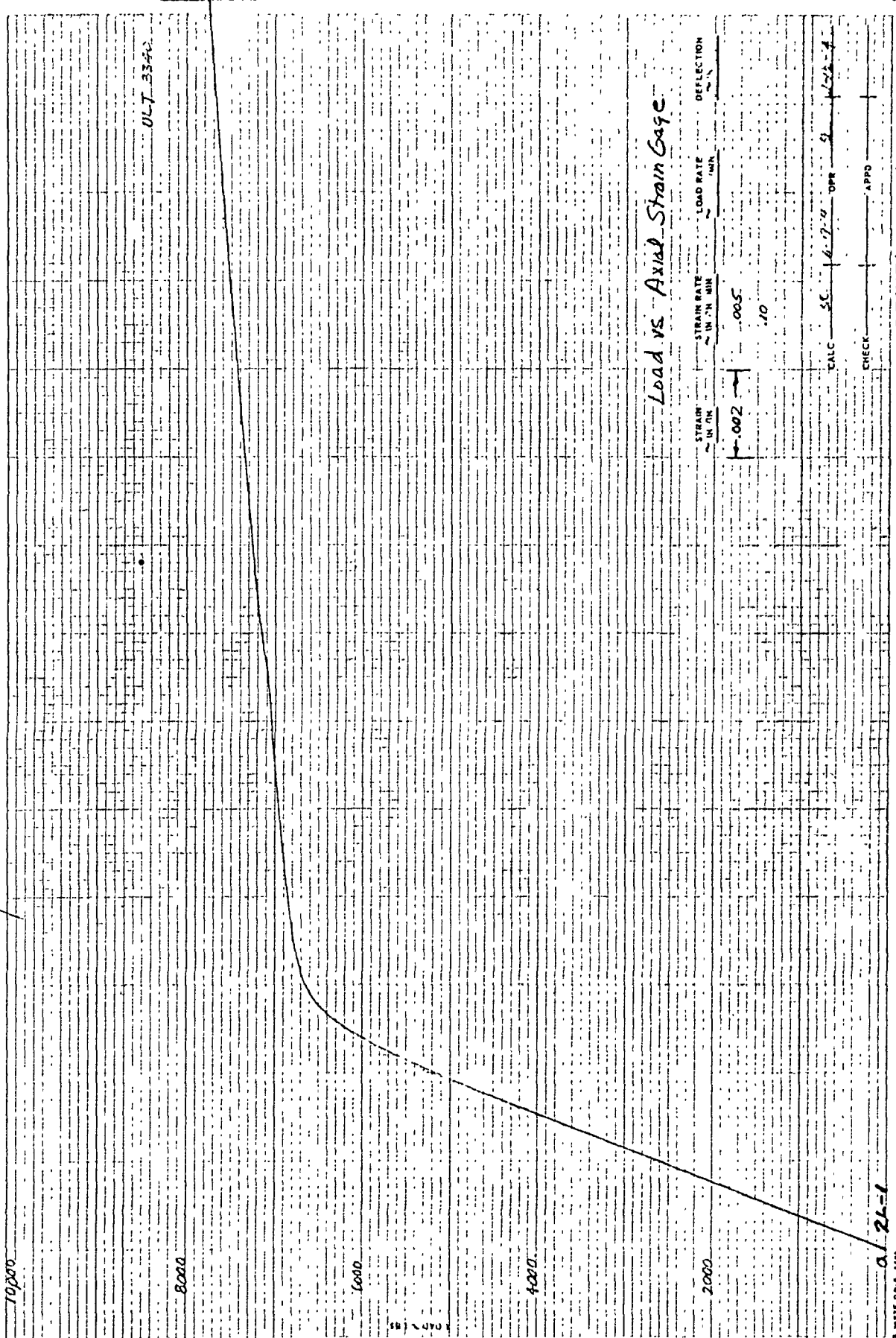
STRAIN RATE IN/IN	STRAIN RATE IN/IN MIN	LOAD RATE MIN	DEFLECTION IN
0.002	0.005		
	NO		
CHECK		APPRO	
DATE 8-1-68		DR 2E	1117-9



Load vs. Poisson Strain Gage

STRAIN IN/IN	STRAIN RATE IN/IN MIN	LOAD RATE MIN	DEFLECTION IN
.002 Compression	.005		
CHECK			APPD
SCALE			DATE 11-29-54
OPER			3K
			11-12-54





10000

8000

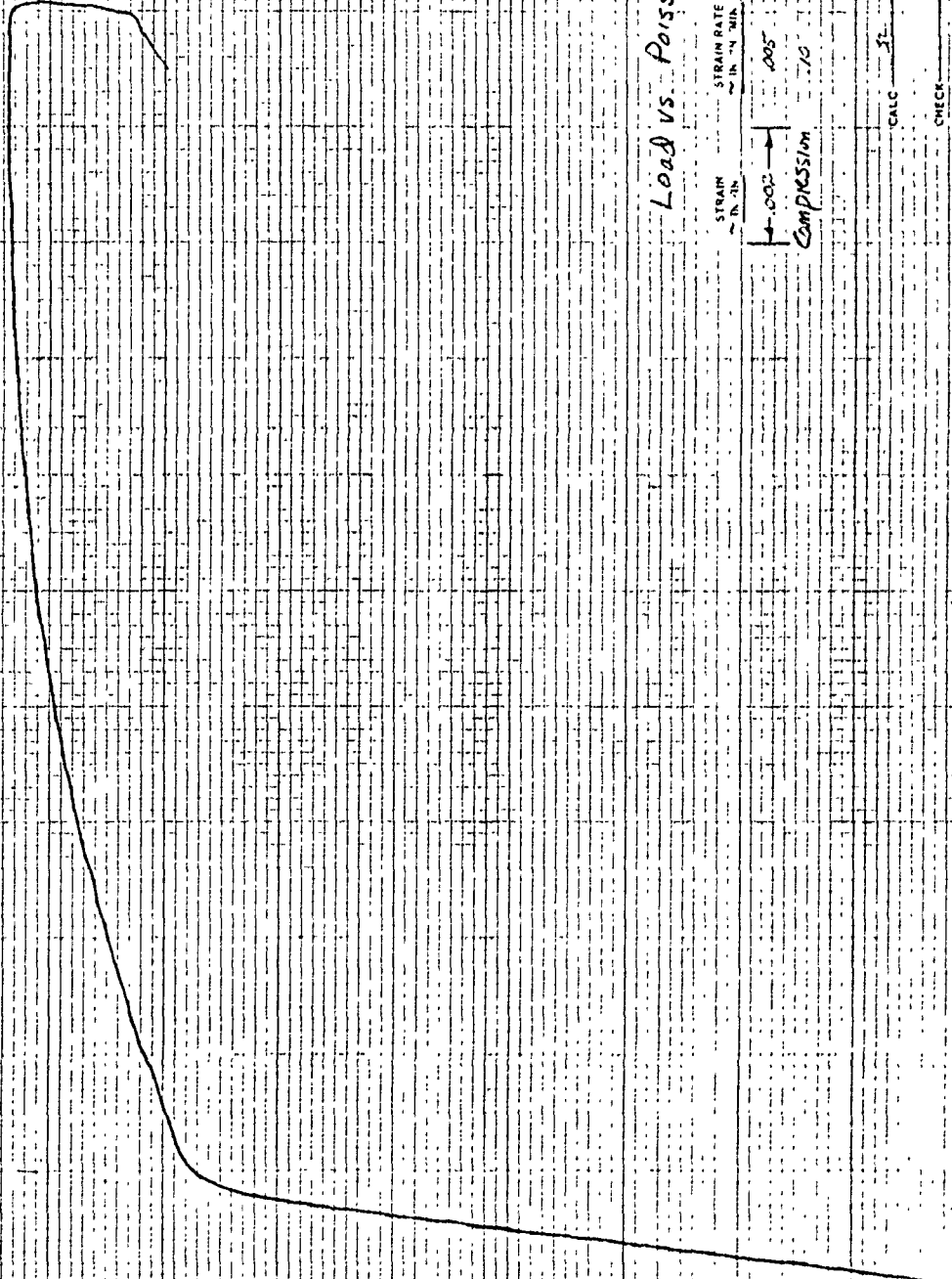
6000

4000

2000

0 21-1

ULT B300



Load vs. Poisson Strain Gage

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
IN IN	IN IN MIN	MIN	IN
0.005	0.005		
0.005	0.005		

COMPRESSION

CALC ST 11-9-54 OPS X 11-12-54

CHECK APPC

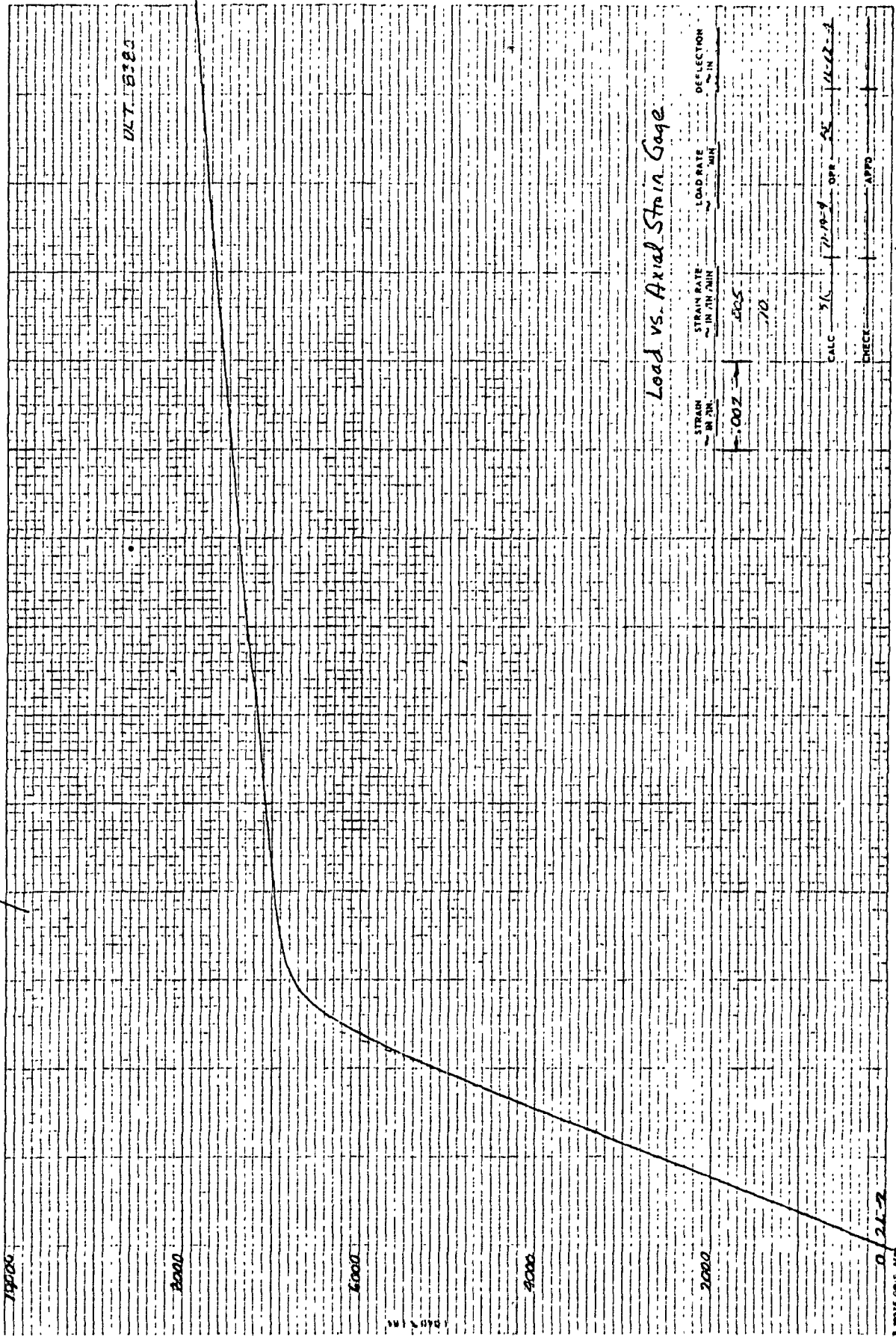
715-047

BOEING TPR

ENA

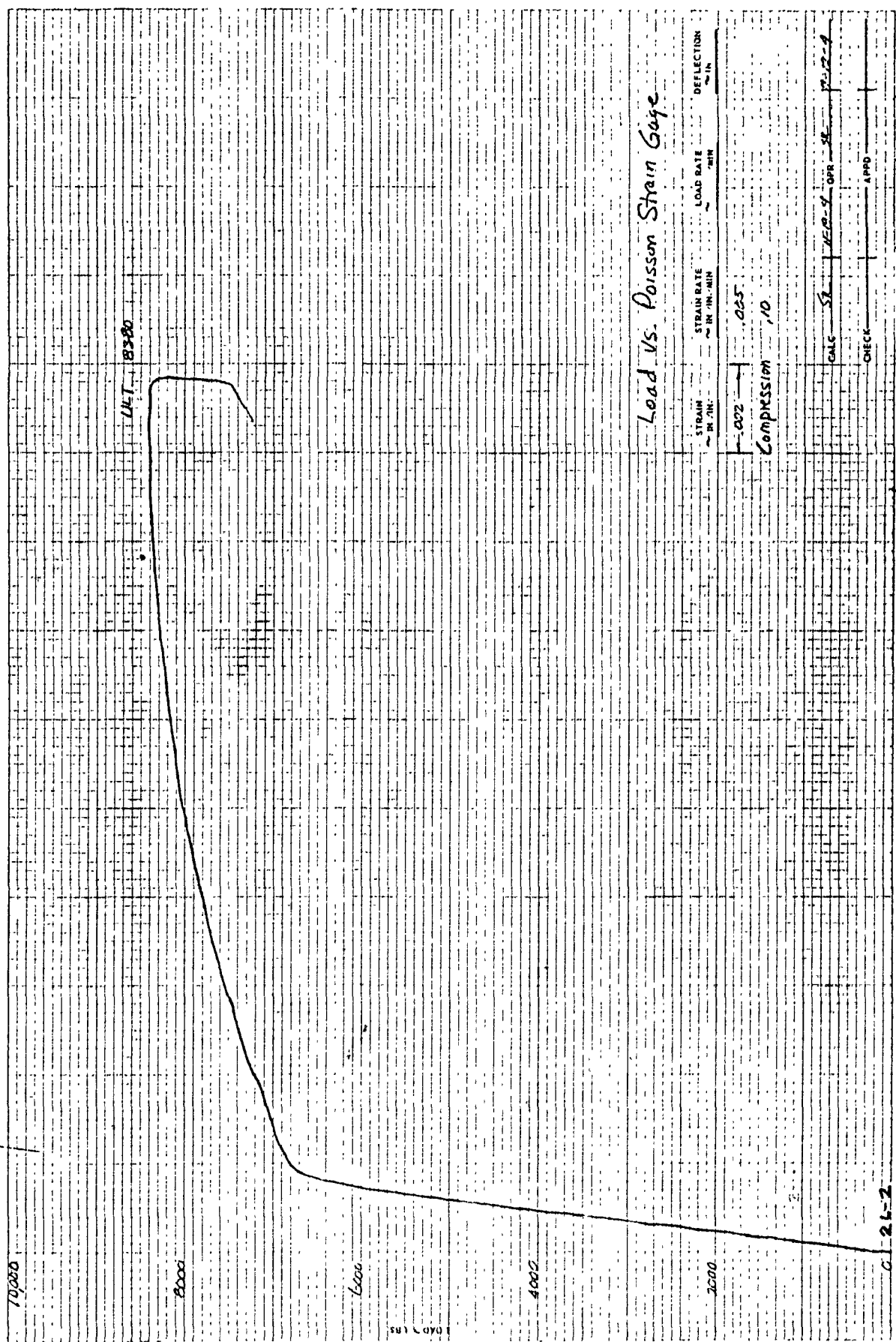
PAGE

OF



Load vs. Axial Strain Gage

STRAIN RATE IN IN/MIN	LOAD RATE LBS/MIN	DEFLECTION IN
0.002	200	10
0.002	200	10
CALC 36	710-9	OFF 25
CHECK		APPRO 11/22/54



Load vs. Poisson Strain Gage

STRAIN IN./IN.	LOAD LBS	STRAIN RATE IN./IN./MIN	LOAD RATE LBS/MIN	DEFLECTION IN.
0.002	6000			
0.025				
COMPRESSION 10				
		CALC SR	14-7-83	14-7-83
		CHECK		

C 26-2

3 SHEETS ON C. 264

JTB-007

BIDING TPR

ENA

PAGE OF

10000

8000

6000

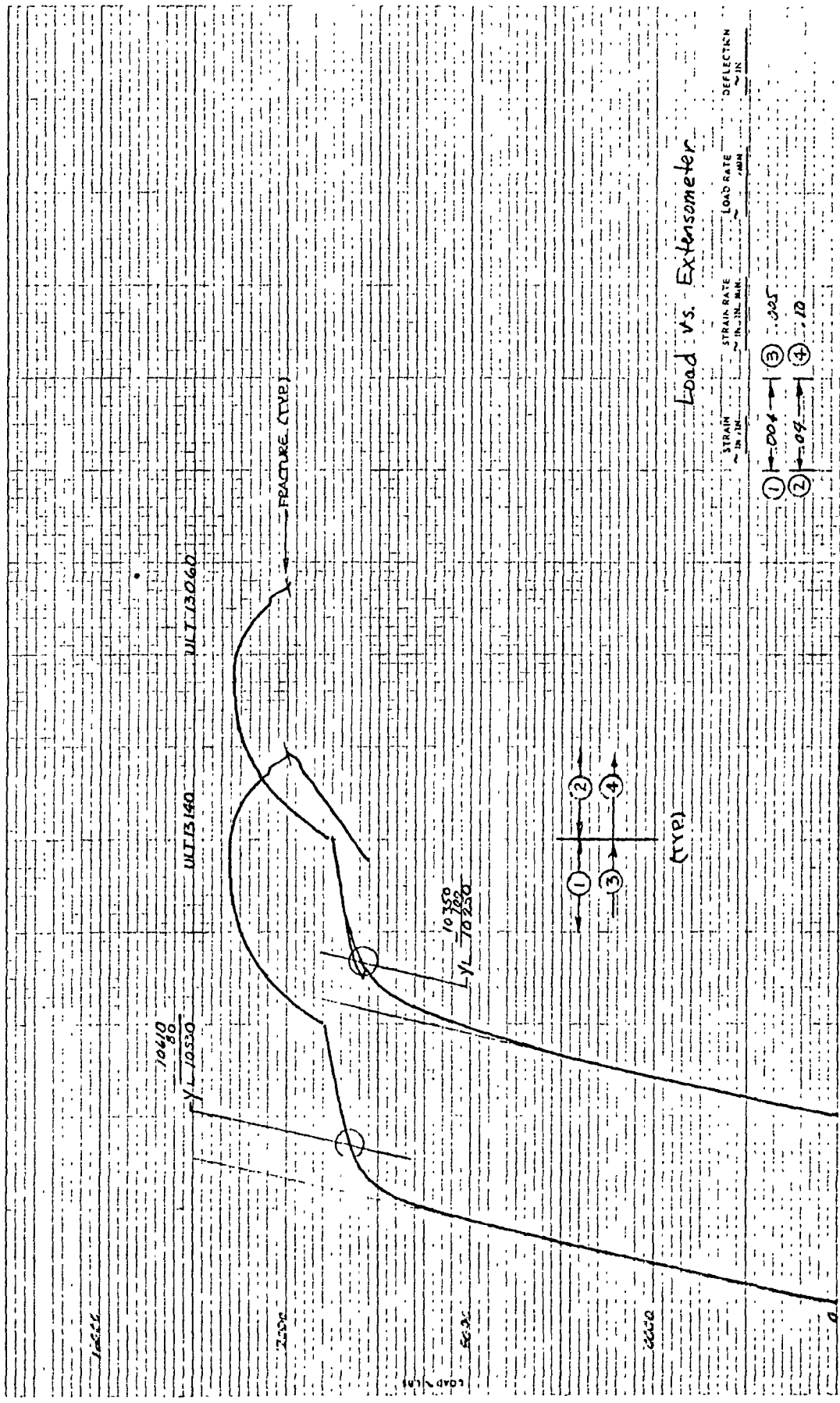
4000

2000

LOAD LBS

13160

13160



Load vs. Extensometer

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTIN
IN./IN.	IN./IN./MIN.	LB./MIN.	IN.
① 0.004	③ 0.05		
② 0.07	④ 10		

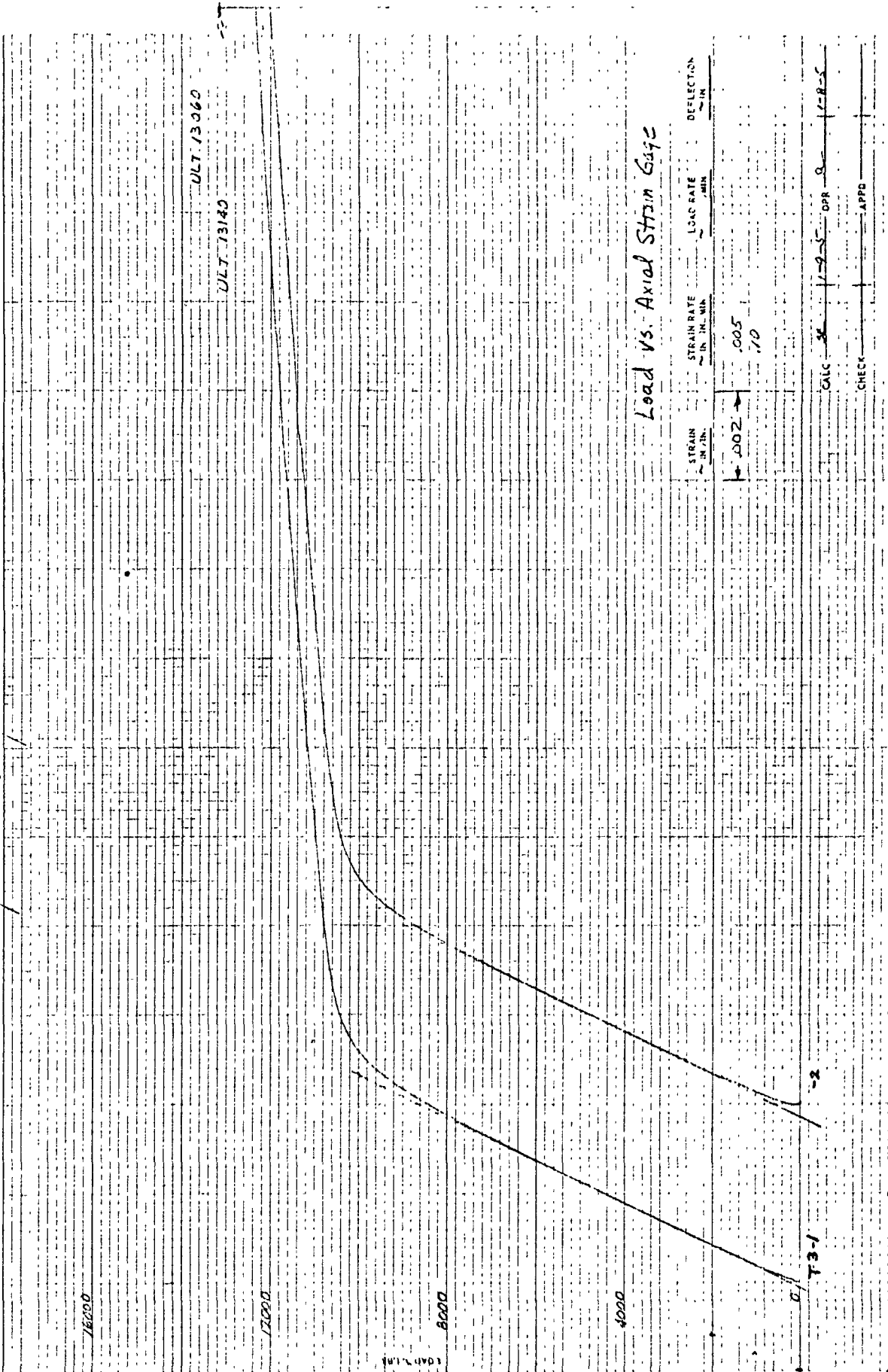
- ① 0.004
- ② 0.07
- ③ 0.05
- ④ 10

7-3:1 T-3:2
 CALC: SK 1-9-5 OPR: SK 1-7-5

CHECK: APPD:

BOEING TPR
 ERA PAGE 0P

TENS



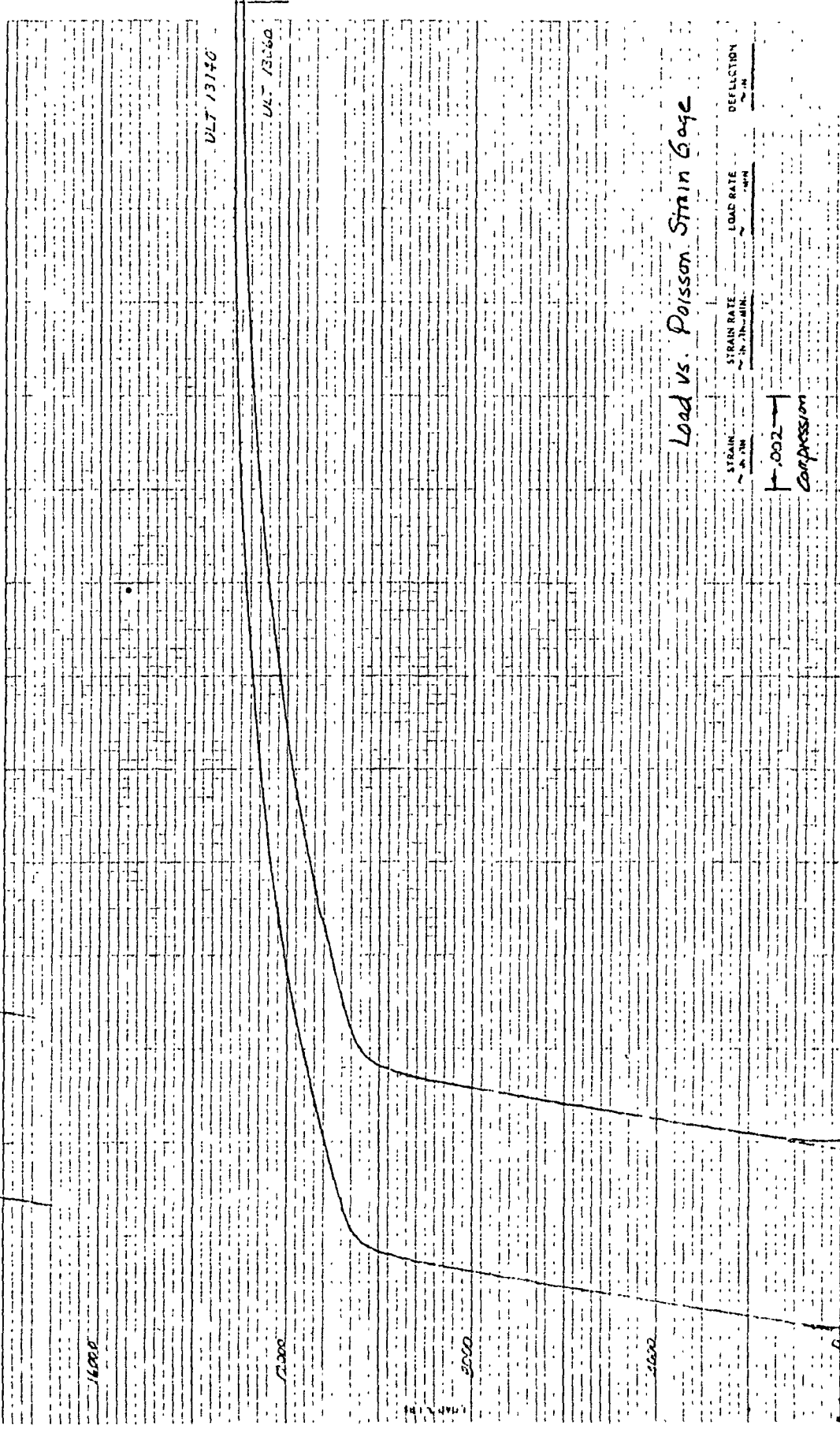
313-041

DATE DR 5 8/43

BOEING TPR

PAGE OF

Comp.



ULT 73140

ULT 73060

Load vs. Poisson Strain Gage

0.002
Compression

73-1

73-2

CALC SK 1-9-5 DOR 64 10-8-5

CHECK APPD

BOEING TPR

EWA

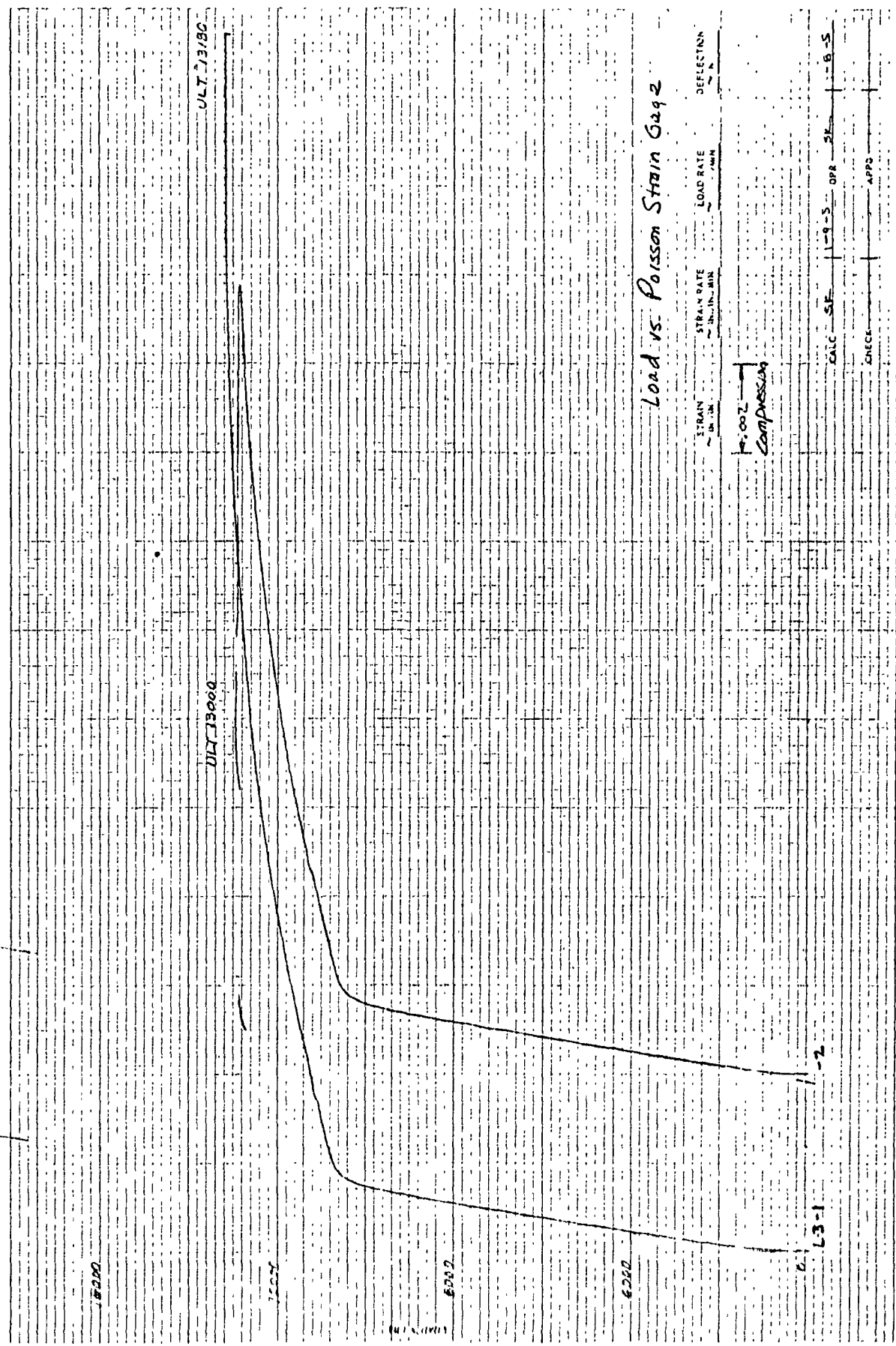
PAGE

OF

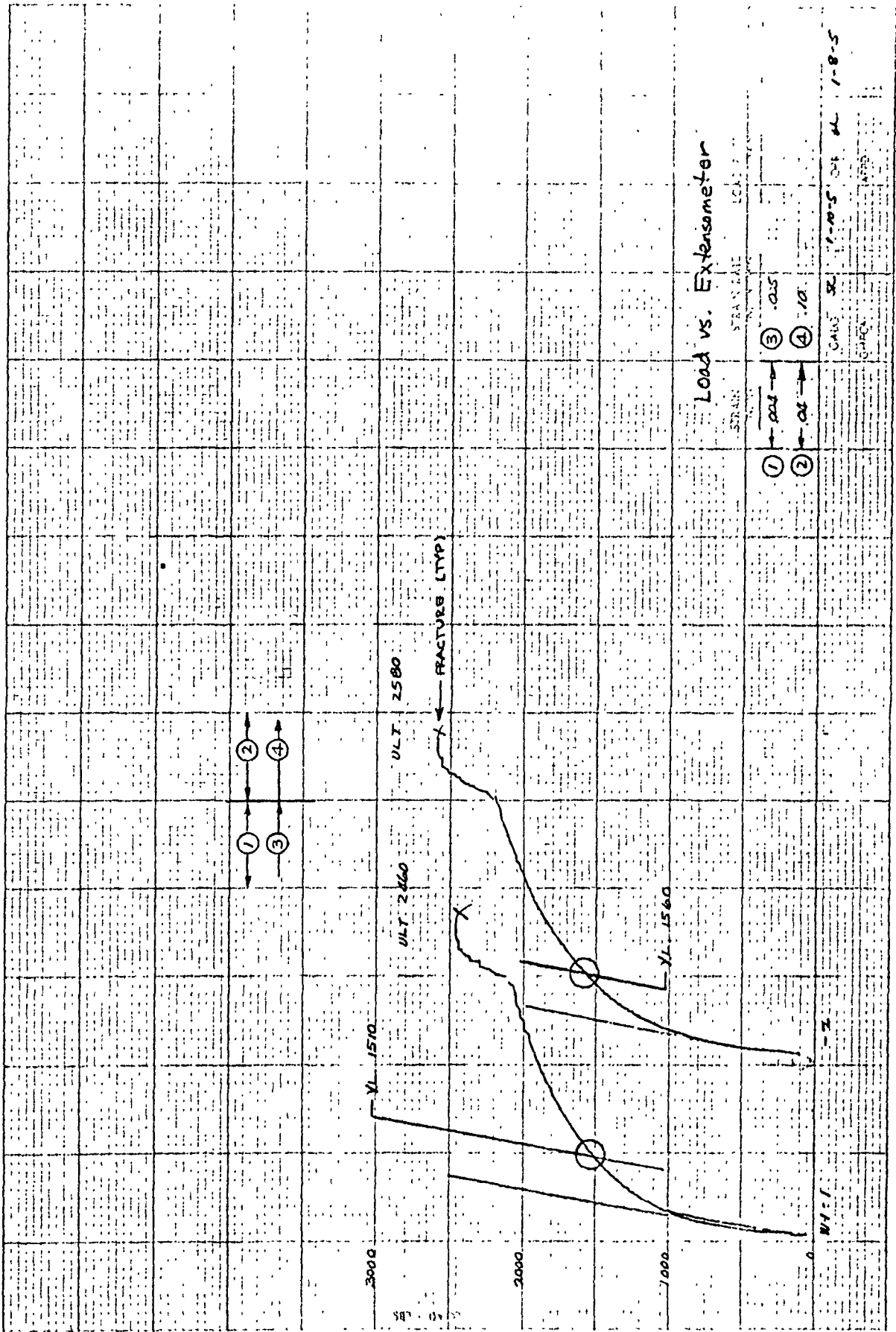
718-667

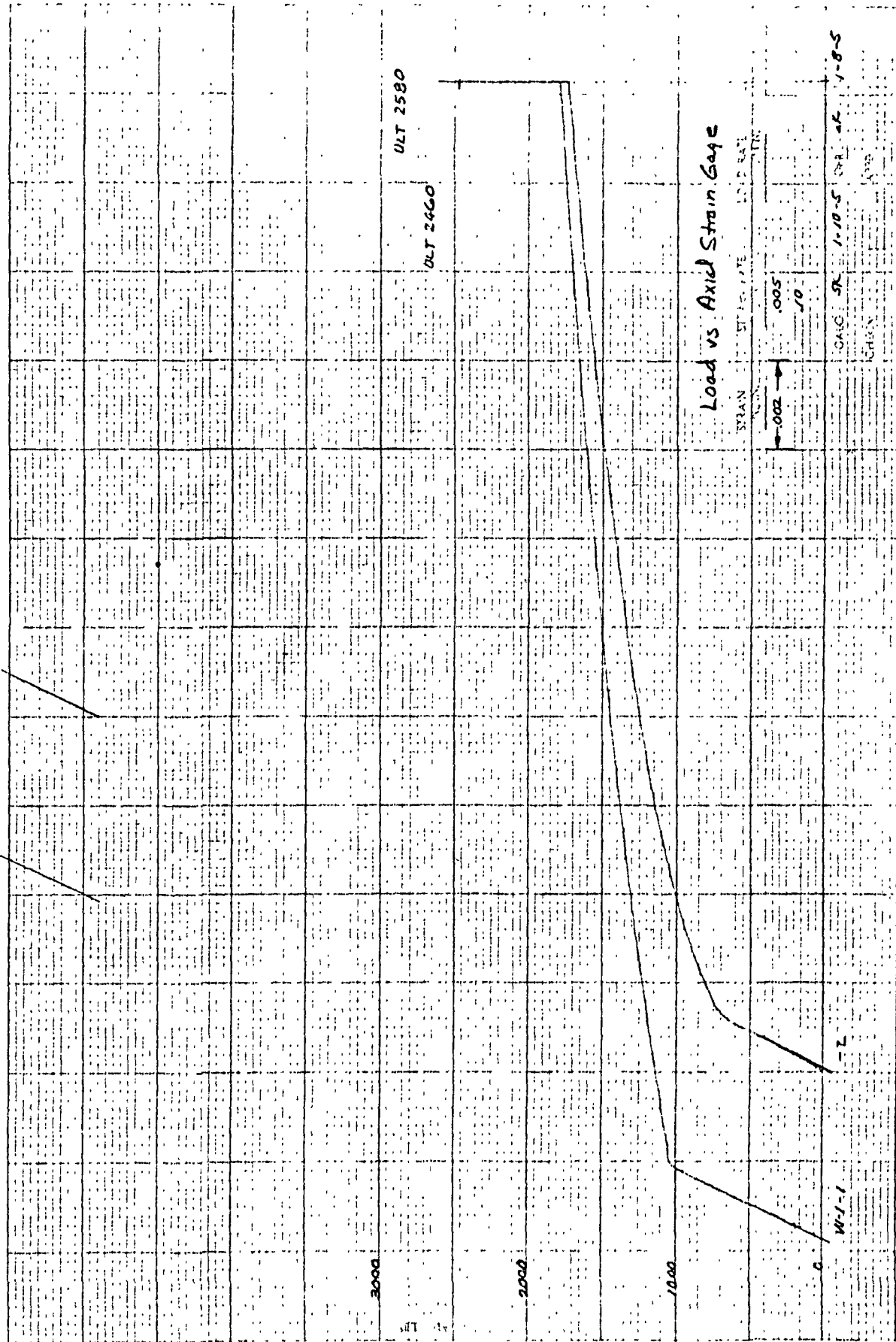
10-1-57

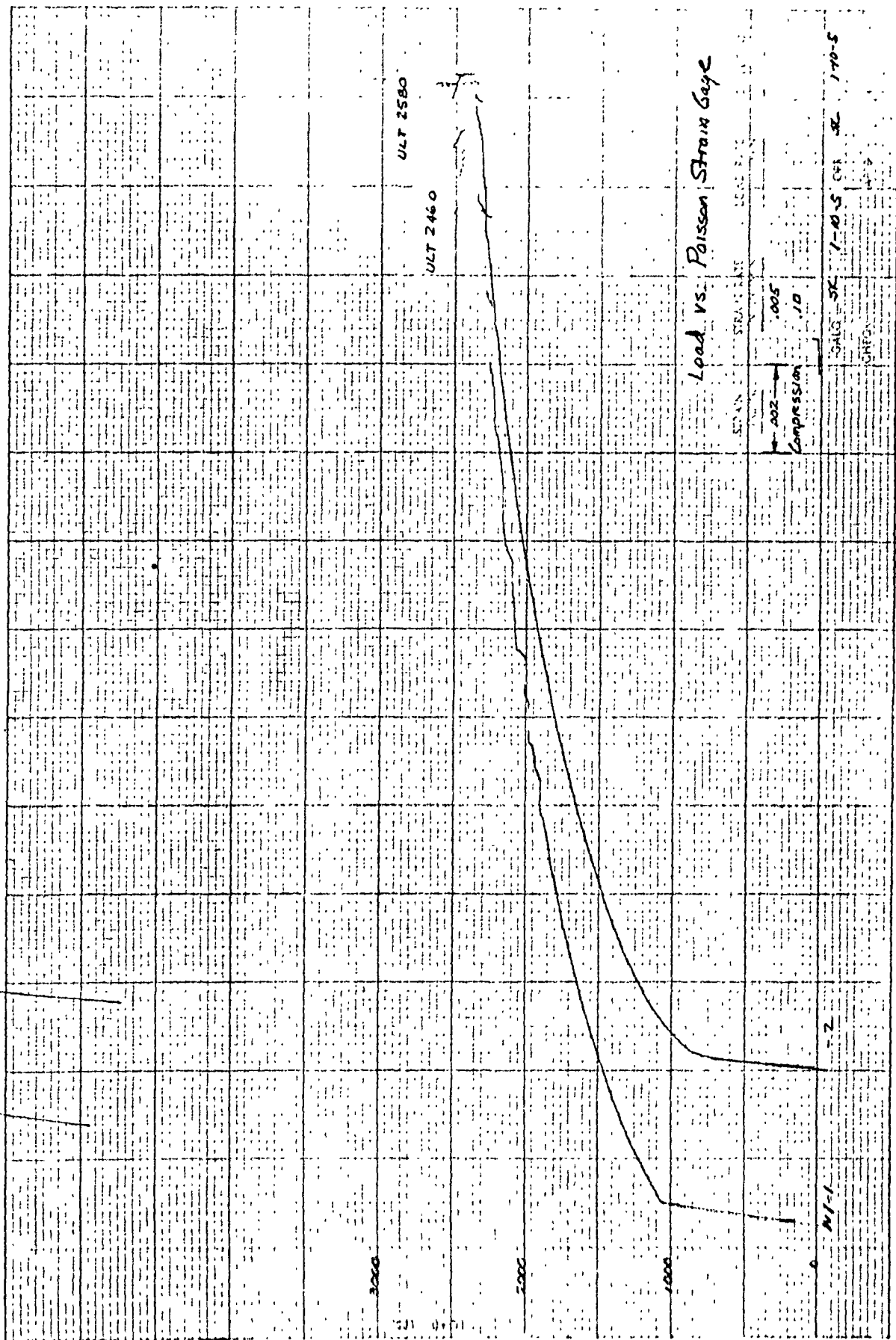
Load vs. Poisson Strain Gage



STRAIN IN/IN	STRAIN RATE IN/IN-MIN	LOAD RATE LBS/MIN	DEFLECTON IN
0.002	0.002	0.002	0.002
CALC	APPD	CHKD	APPD
13-1	13-5	098	06-5







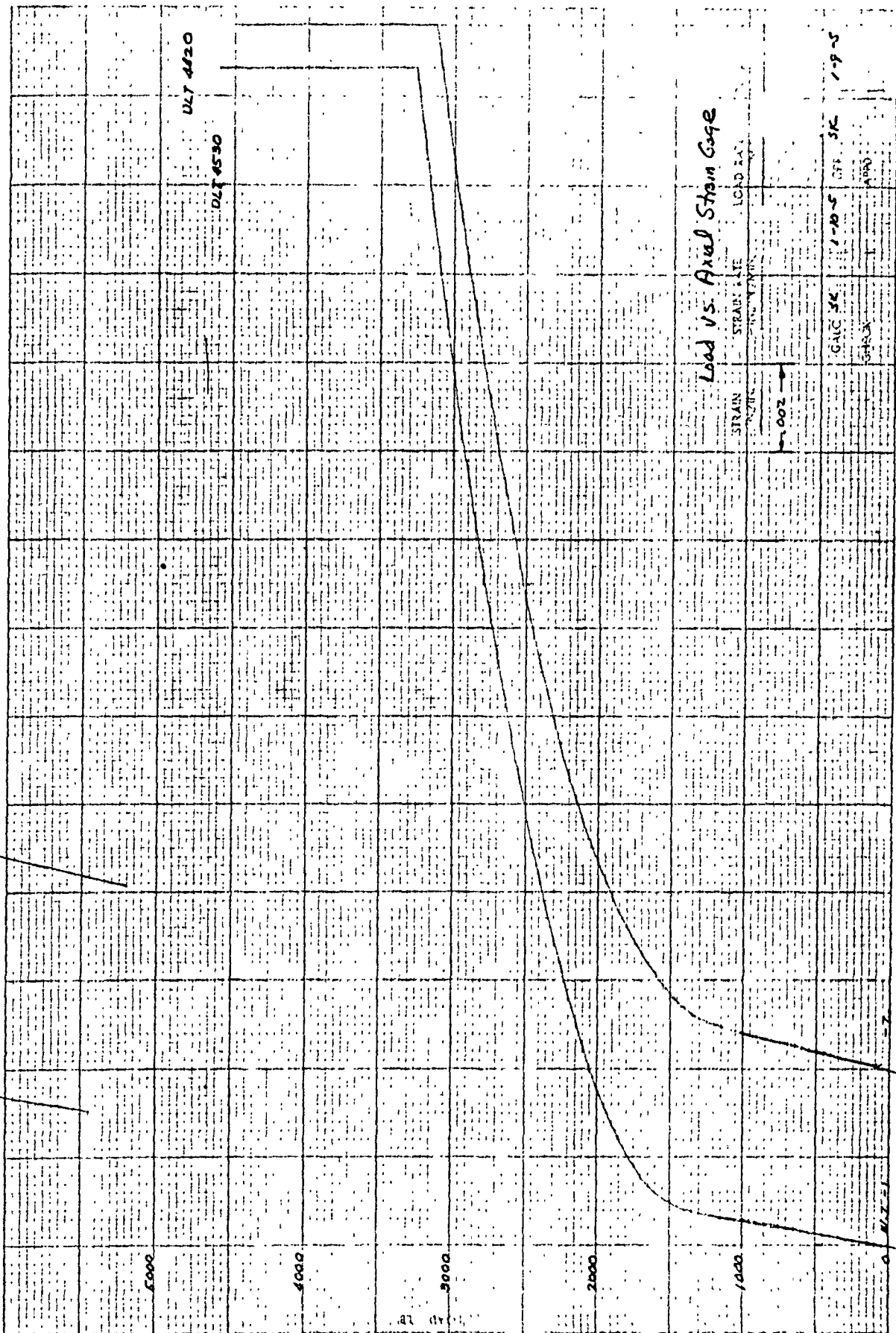
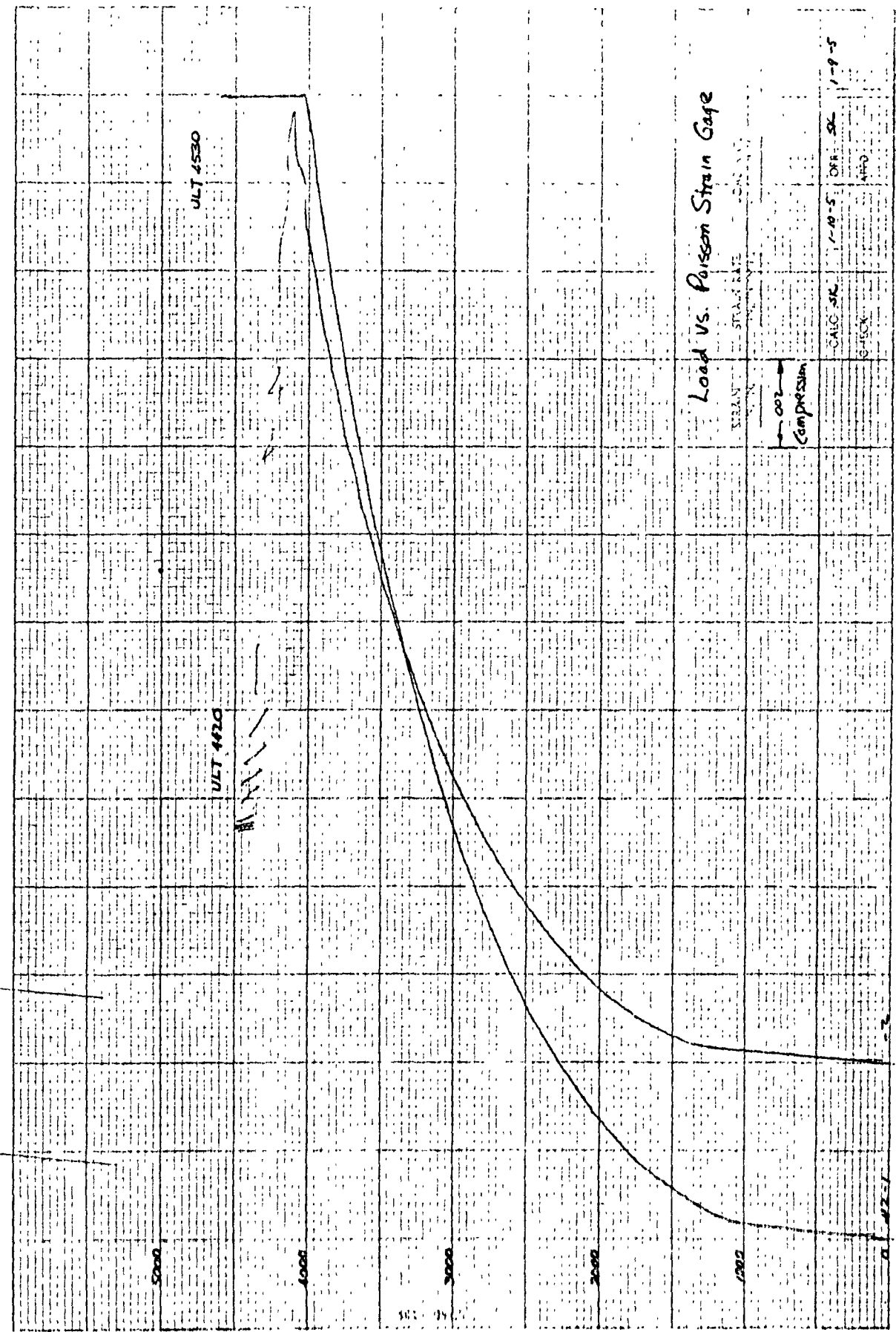


PHOTO COPY



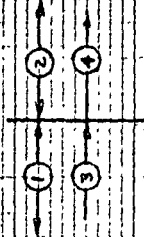
Load vs. Poisson Strain Gage

0.002
Compression

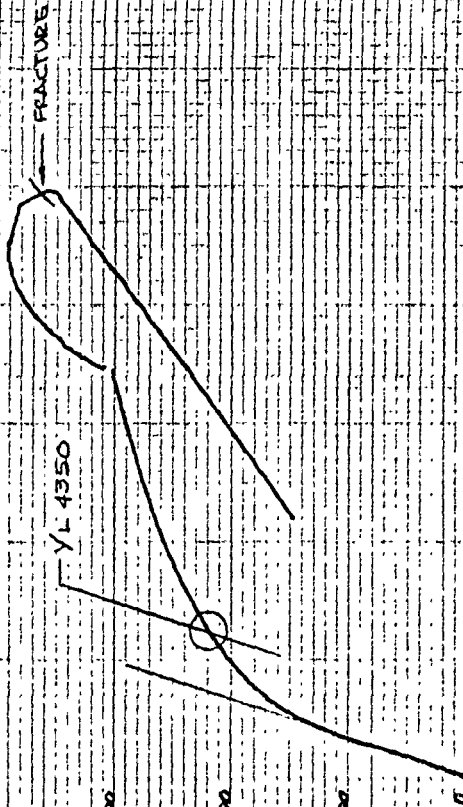
STRAIN
LOAD RATE
CONTRACT
CALC. SK. 1-10-5
CHK. SK. 1-9-5
CHECK
INFO

6-22-52

PAGE OF



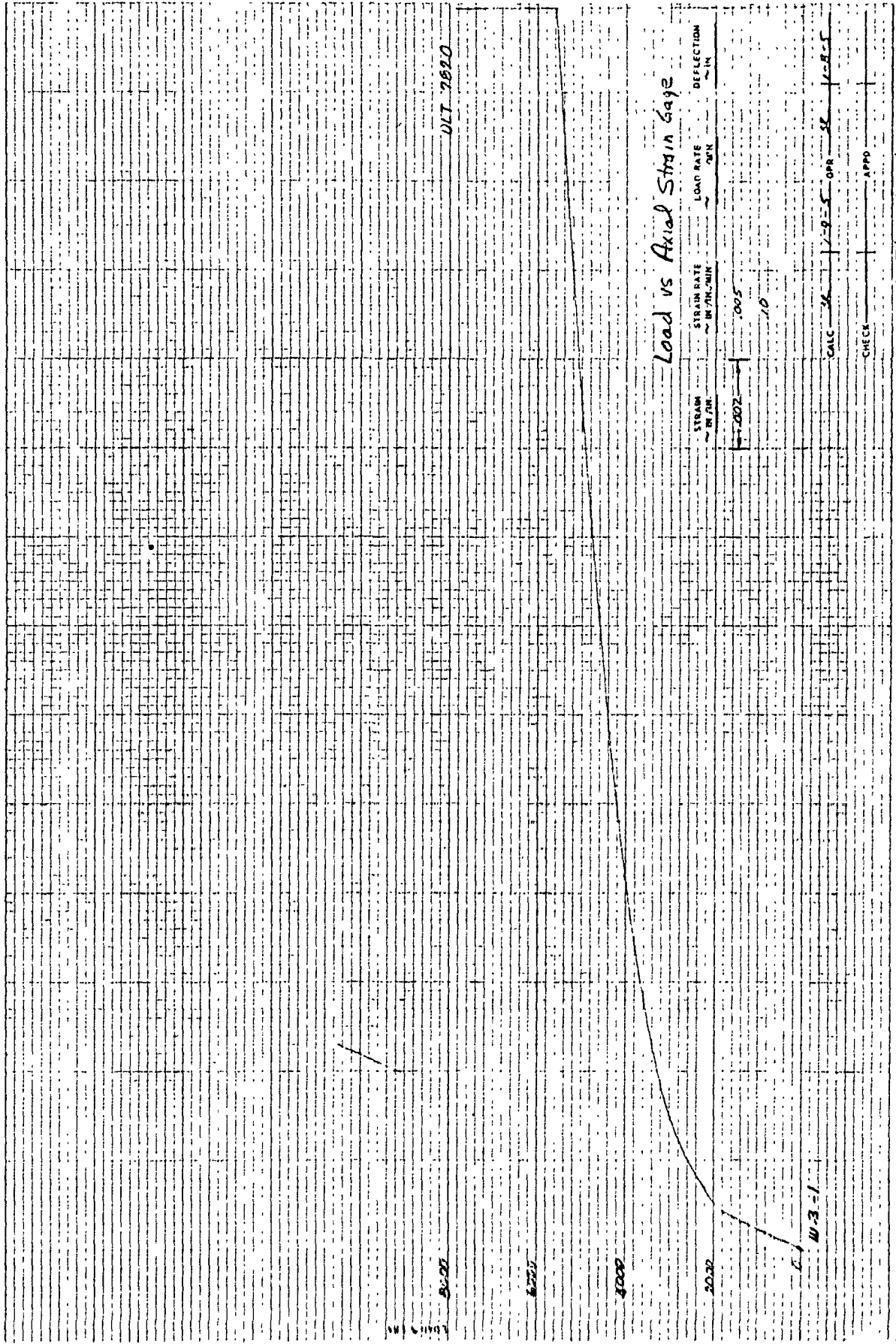
ULT 7820



Load vs. Extensometer

STRAIN RATE IN / MIN	LOAD RATE LBS / MIN	DEFLECTION IN
① .008	③ .005	
② .01	④ .01	

CALC. BY: 1-9-5 OPB
 CHECK: APPD
 DATE: 1-8-4



DLT 7690

Load vs Axial Strain Gage

STRAIN ~ IN/IN STRAIN RATE ~ IN/IN-MIN LOAD RATE ~ IN/IN DEFLECTION ~ IN

0.002 .005 .10

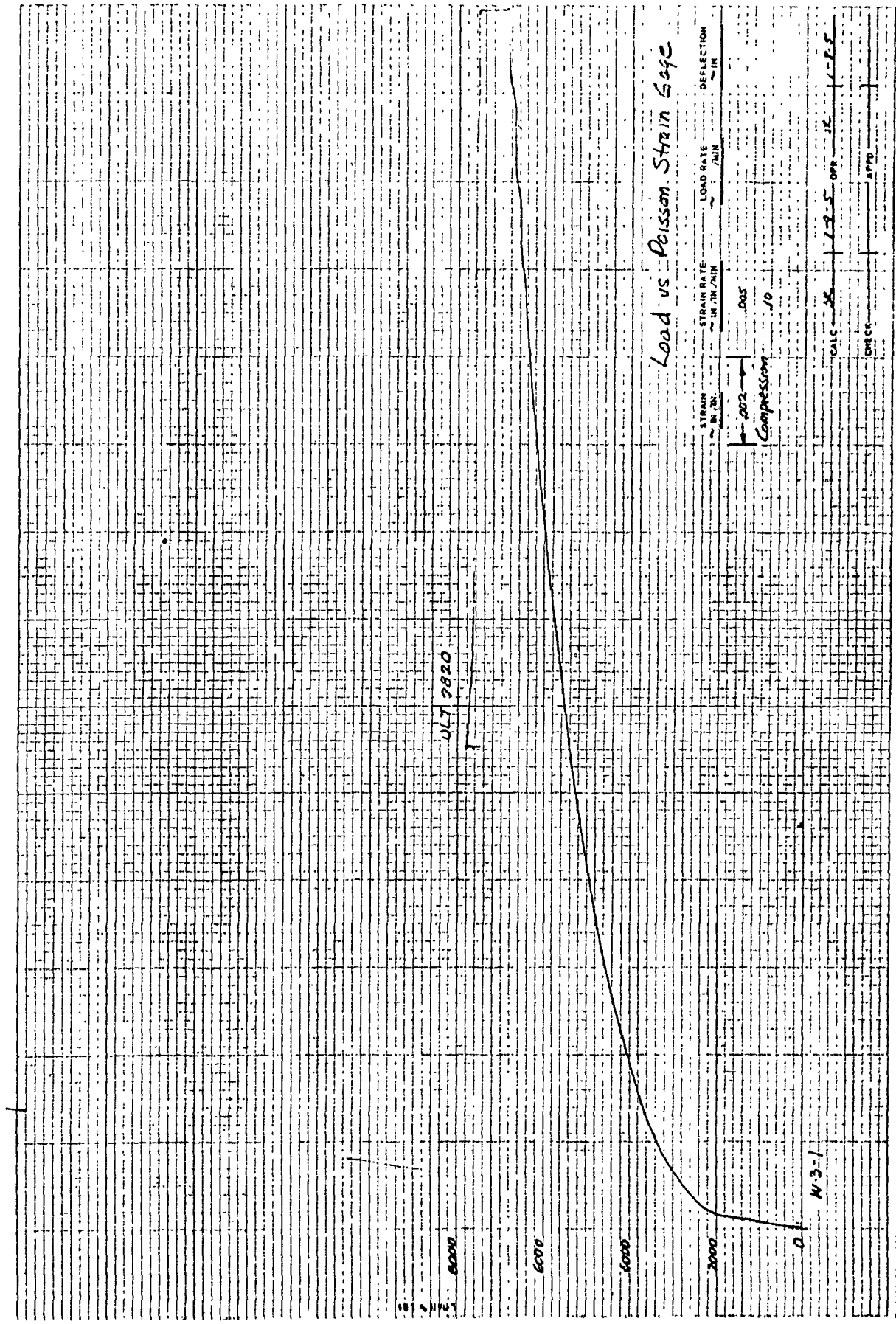
CALC 36 1-9-5 OPR 58 1-8-5

CHECK APPD

BOEING INC ENA PAGE 07

J18-247

3 WHITE CONT. 378

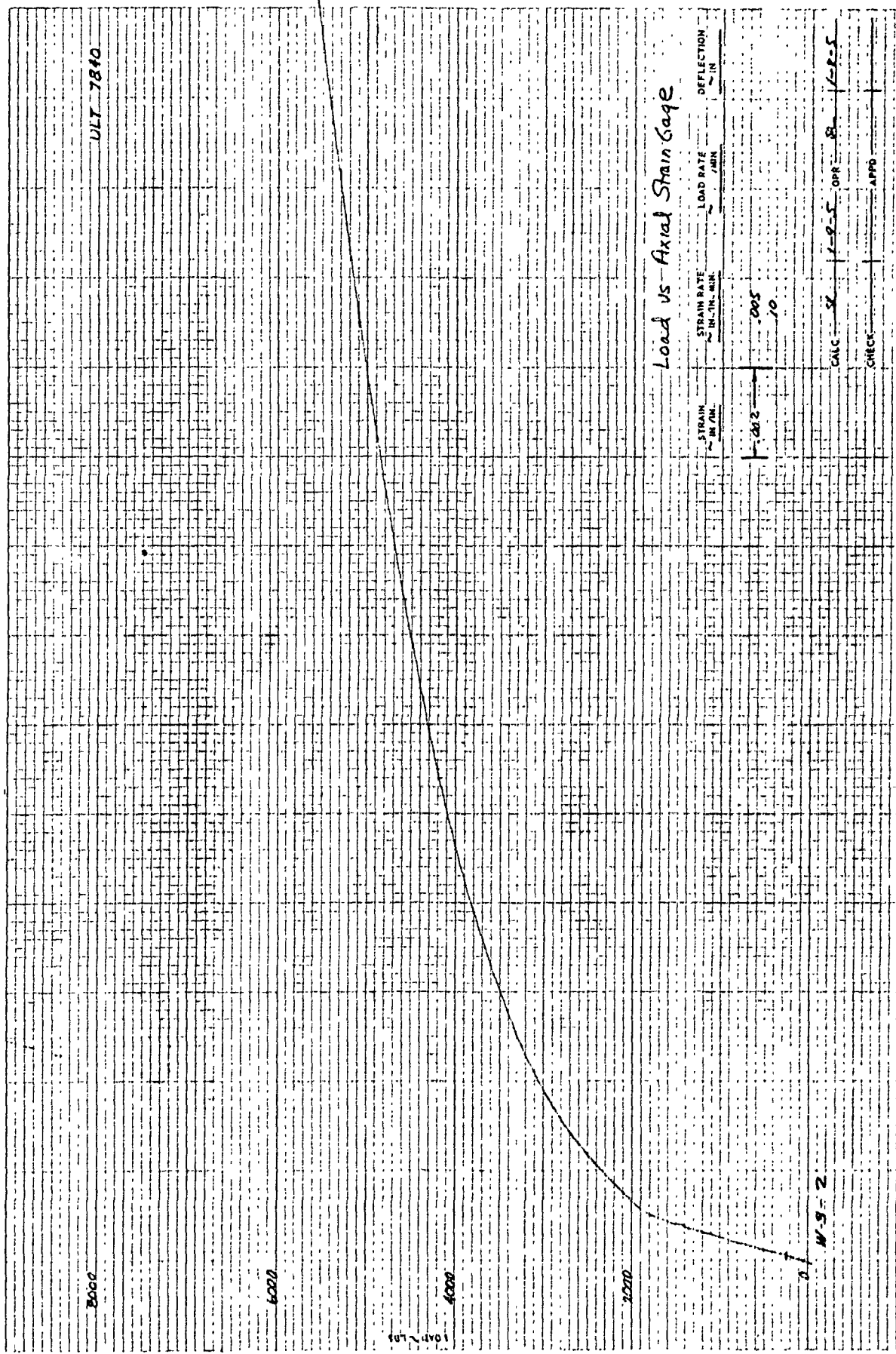


Load vs Poisson Strain Gage

STRAIN RATE IN./IN./MIN.	LOAD RATE /MIN.	DEFLECTION IN.
0.05		
202 Compression	10	
CALC. 28	DPR. 10	10
CHECK	APPRO	



DLT 7810



Load vs Axial Strain Gage

STRAIN RATE IN./IN. MIN.	LOAD RATE LBS/IN.	DEFLECTION IN.
0.005	10	
0.01		

CALC. BY	1-9-5	OPR	8	1-2-5
CHECKS		APPRO		

BOEING

318-261

W-3-2

ULT 1840

8000

6000

4000

2000

Load vs. Poisson Strain Gage

STRAIN IN./IN.	STRAIN RATE IN./IN./MIN.	LOAD RATE MIN.	DEFLECTION IN.
2000	200		
Compression			
CALC 55			
OPR 55			
APPO			
CHECK			

W-3-2

PRINTED ON 3. MVA

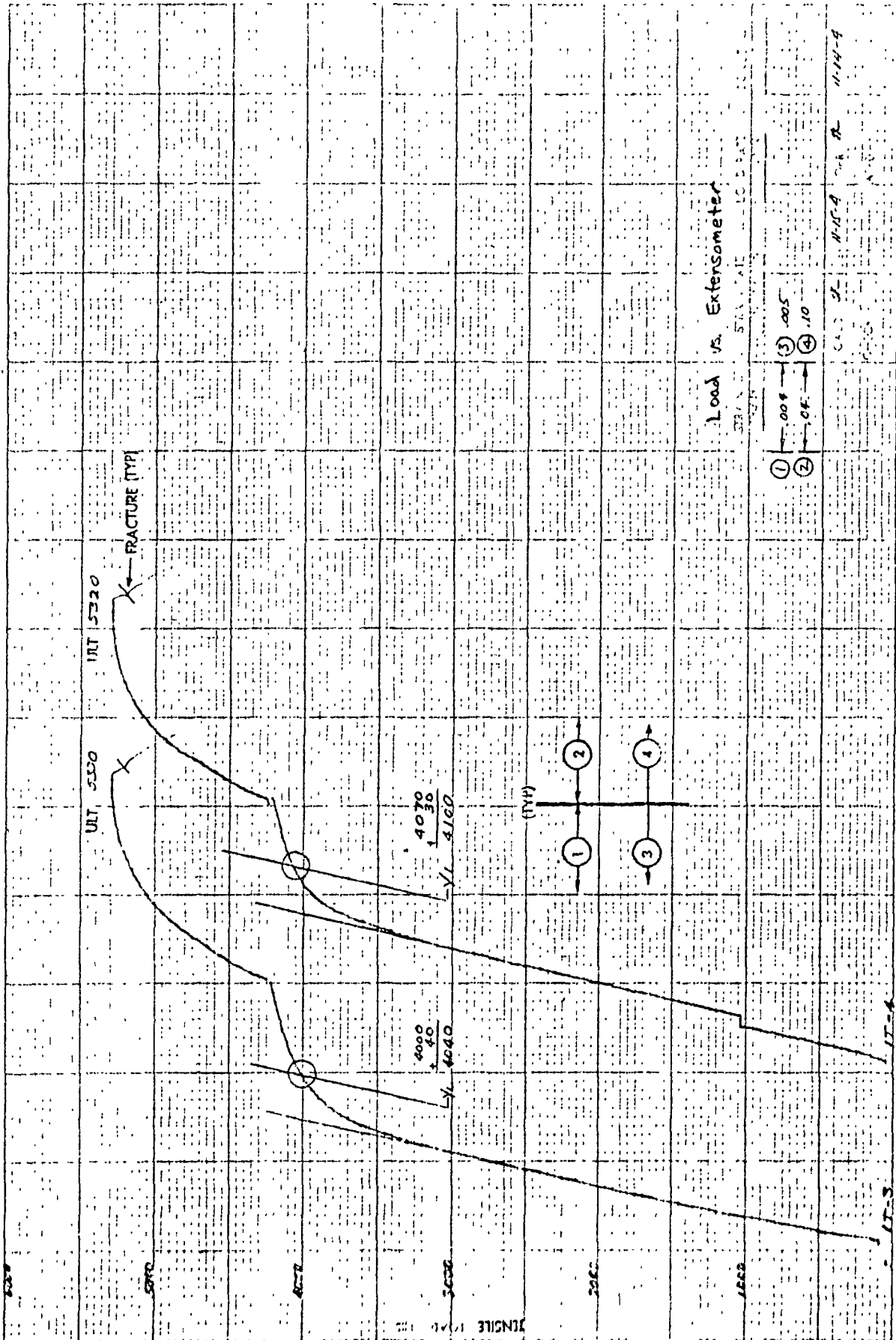
JIT-304

BOEING IPR

55A

PAGE

OF



Load vs. Extensometer

STAINLESS STEEL UC 5 BAR

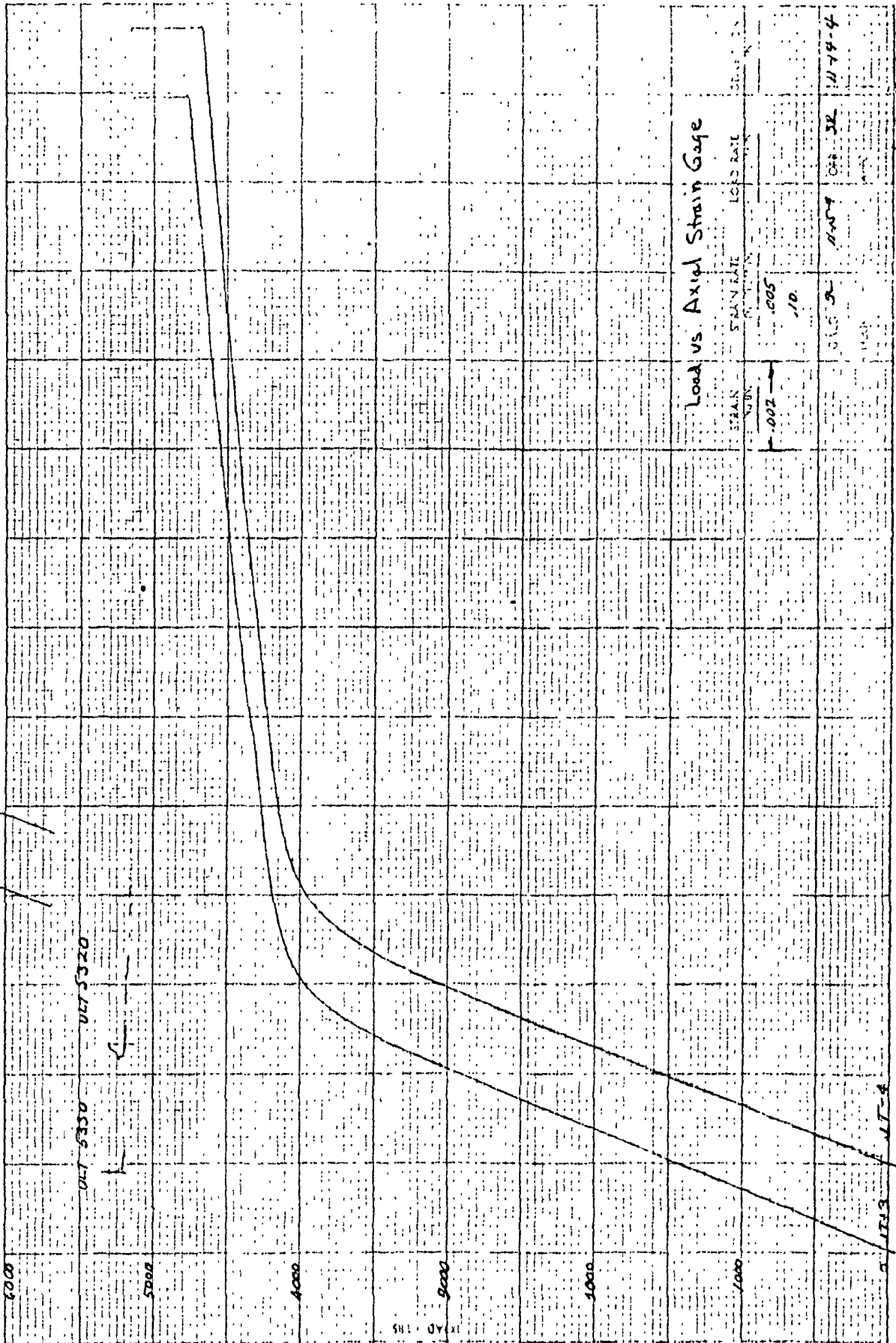
- ① .008
- ② .04
- ③ .005
- ④ .10

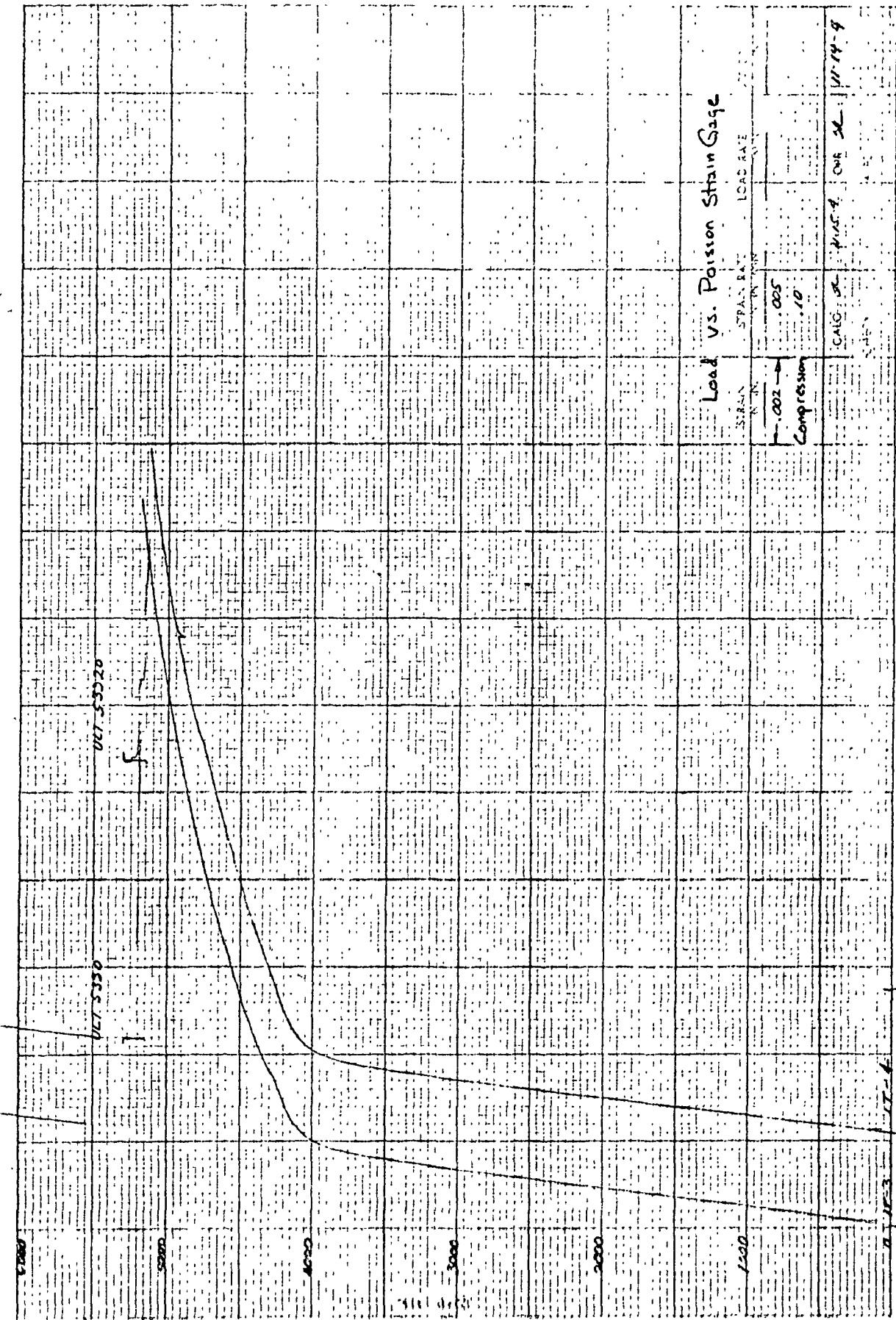
CA 3 11-15-9

11-14-9

BOEING 178

For machines only



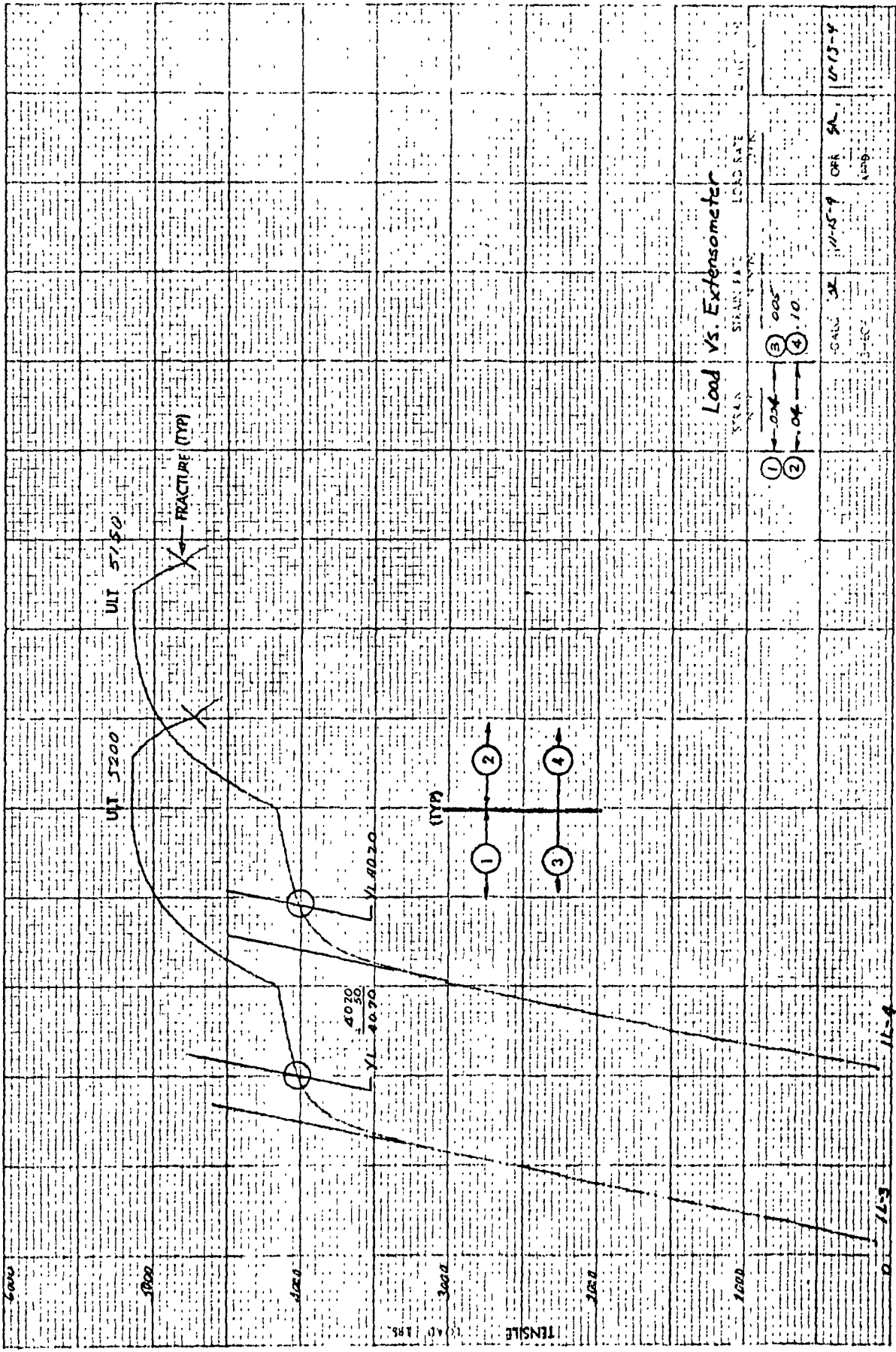


Load vs. Poisson Strain Gage

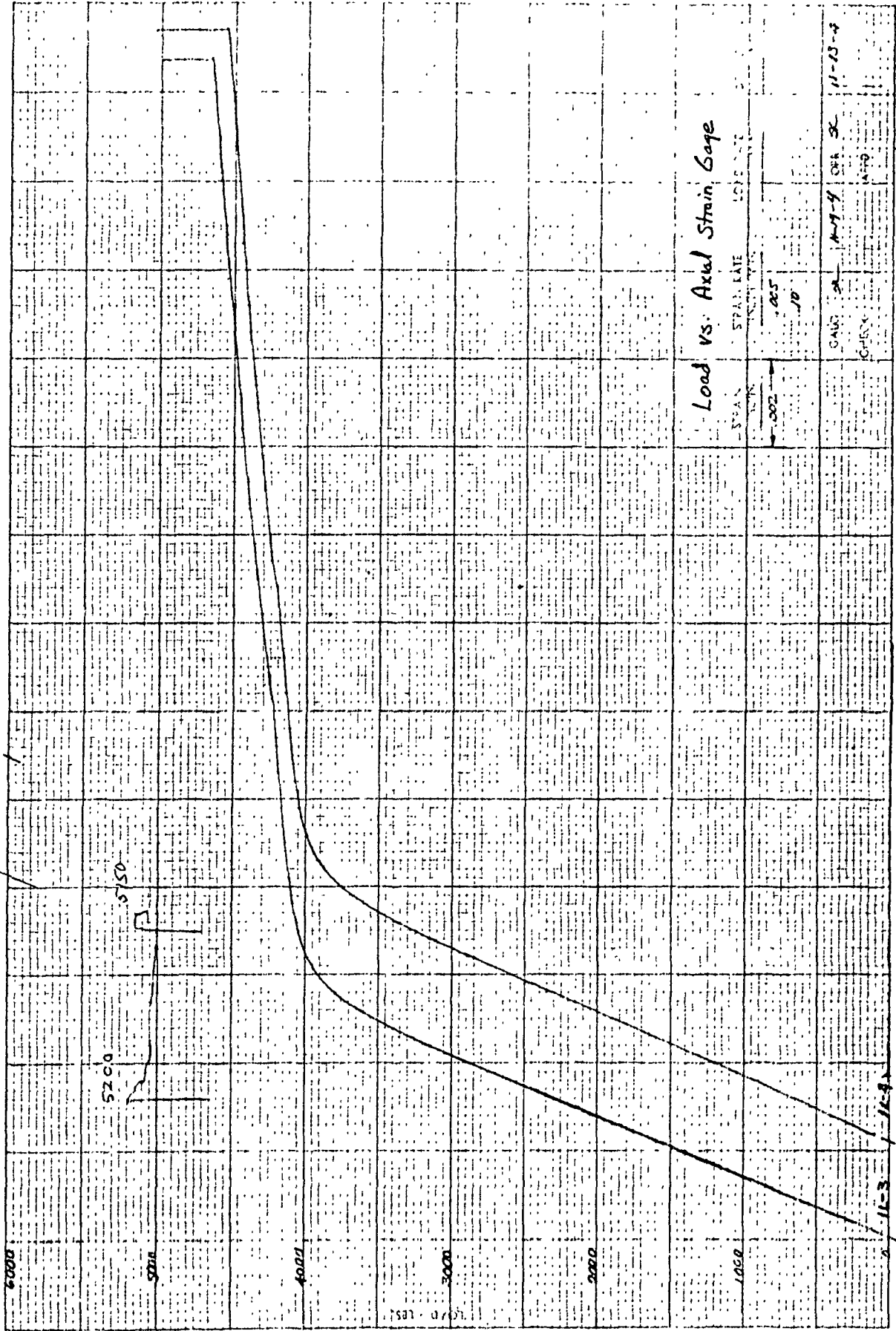
STRAIN
LOAD RATE

0.002 -> .005
Compression

GAUGE NO. 1114-9



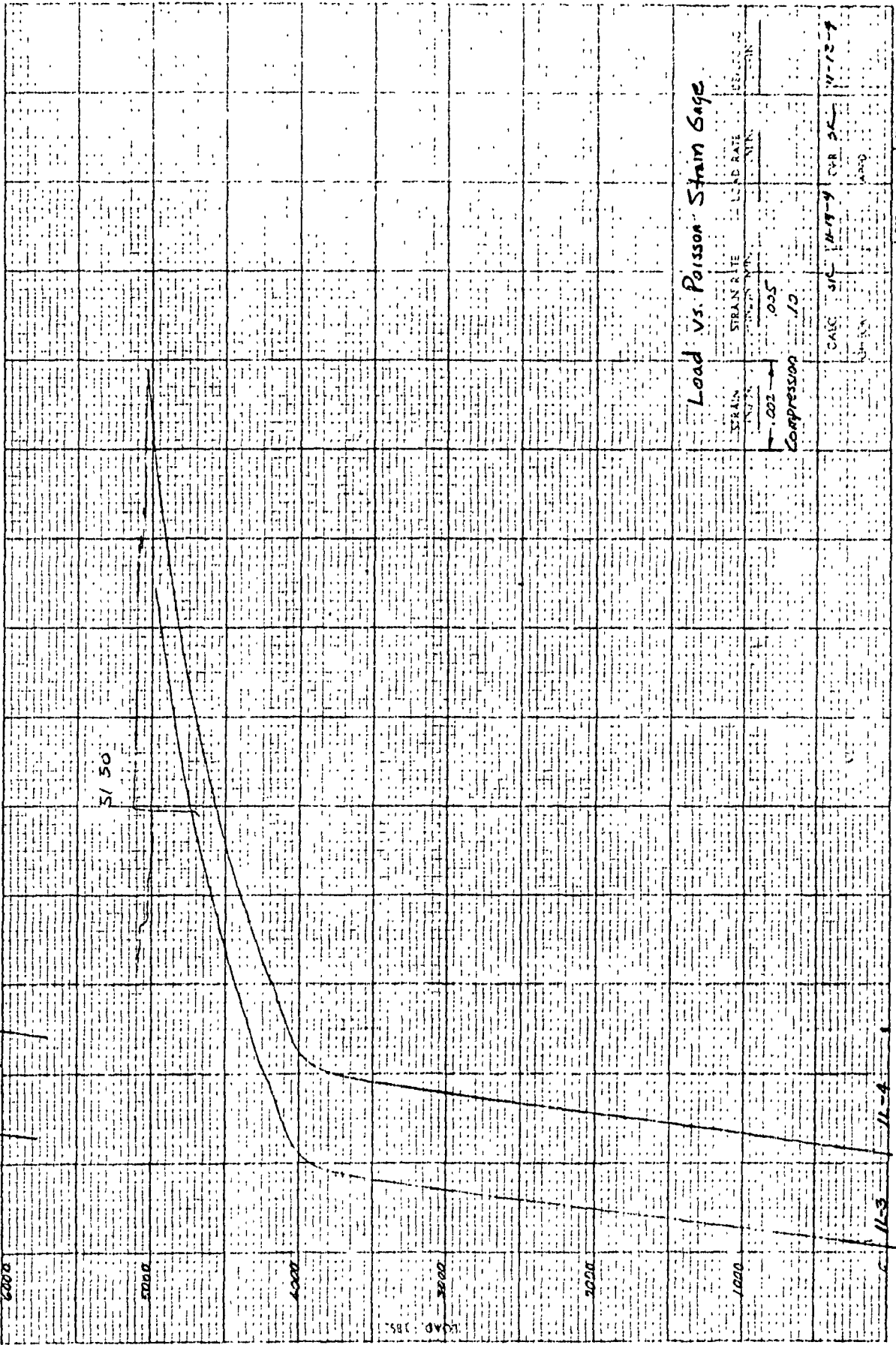
For machine only



Load vs. Axial Strain Gage

SPAC. RATE	LOAD RATE
0.002	10
0.005	10
GAGE	OFF. SC.
11-13-4	11-13-4
11-13-4	11-13-4

BRIDGEMAN TR. EWA

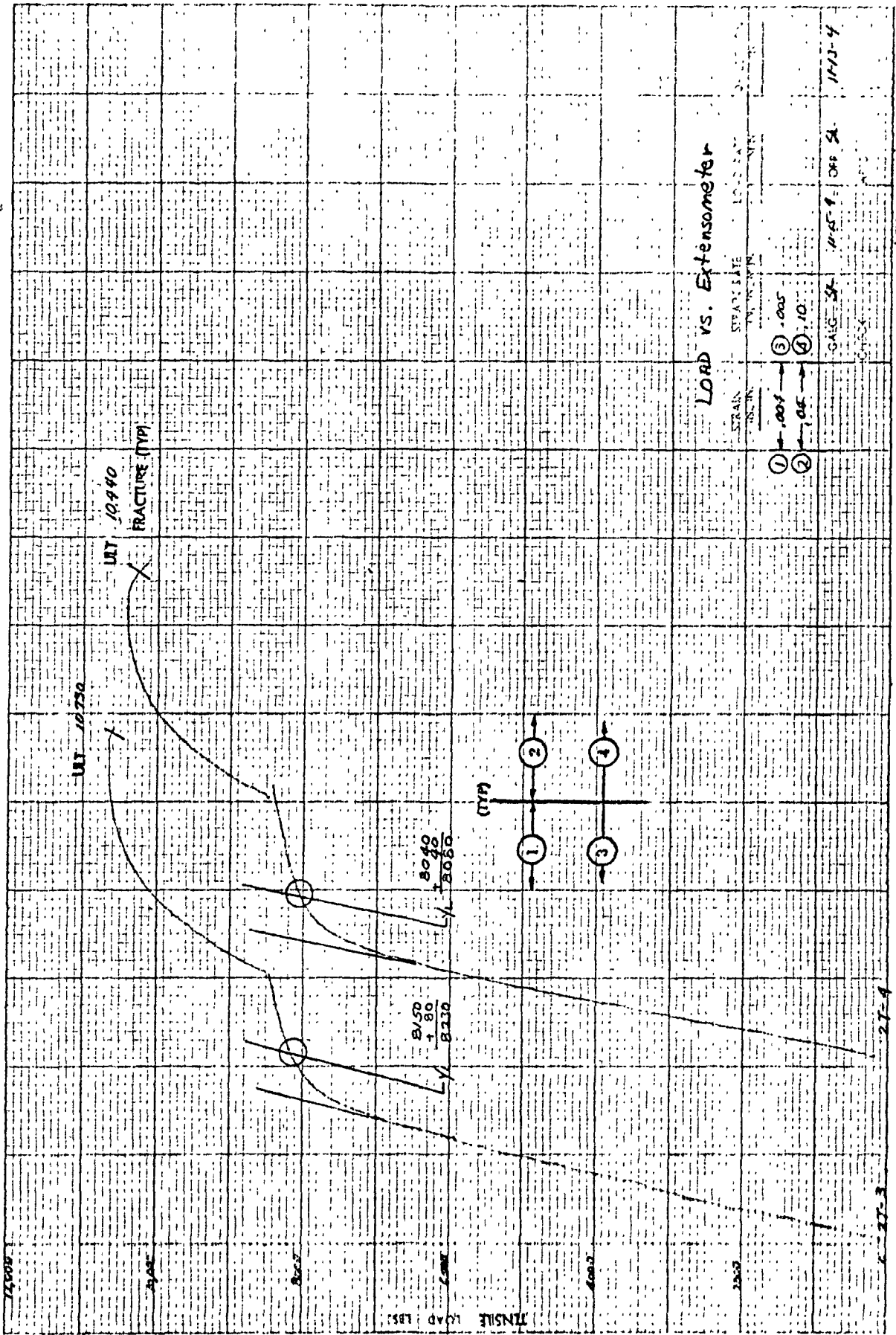


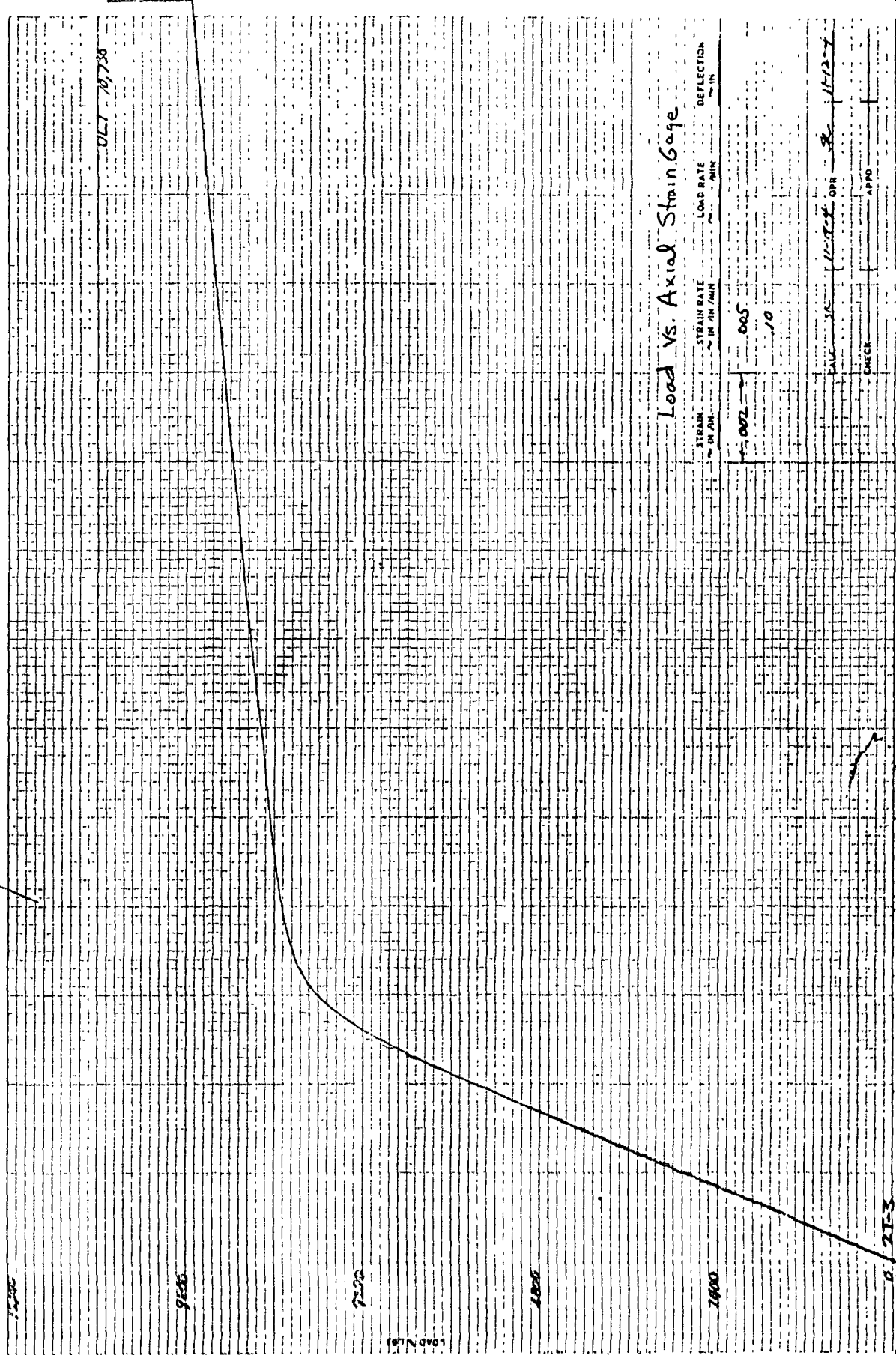
BENDING TOR

EVA

PAGE OF







ULT 24730

Load vs. Axial Strain Gage

STRAIN IN/IN	LOAD RATE IN/IN/MIN	LOAD RATE PSI/MIN	DEFLECTION IN
.002	005		
	.10		

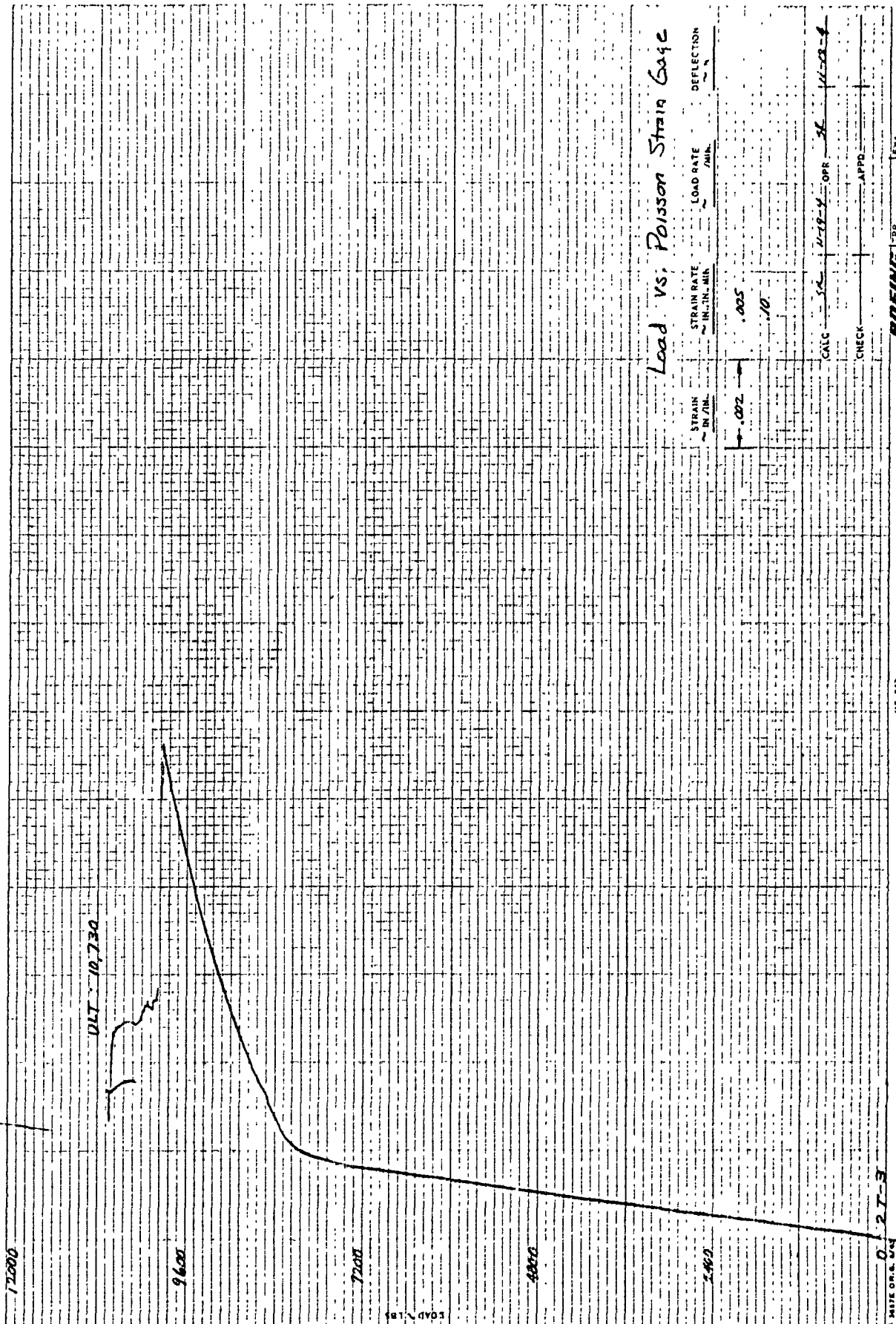
SAUC 36 11-20-58 OPR R 1-12-7
CHECK APPD

BOEING TPR
EVA PAGE OF

J11-047

21-3

DATE CHG. BY

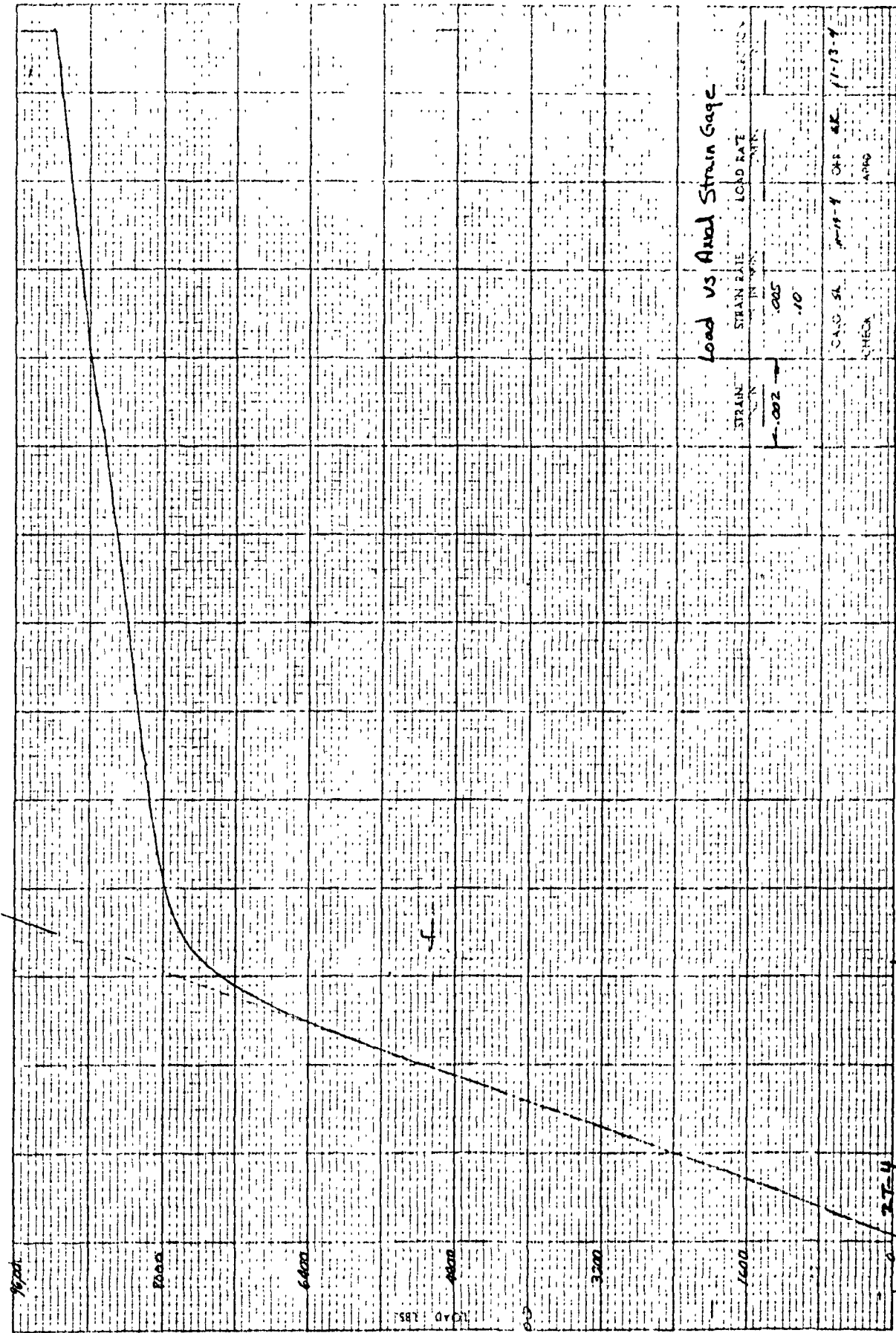


Load vs. Poisson Strain Gage

STRAIN RATE IN/IN-MIN.	LOAD RATE LBS./MIN.	DEFLECTION
.002	.005	
.10	.10	

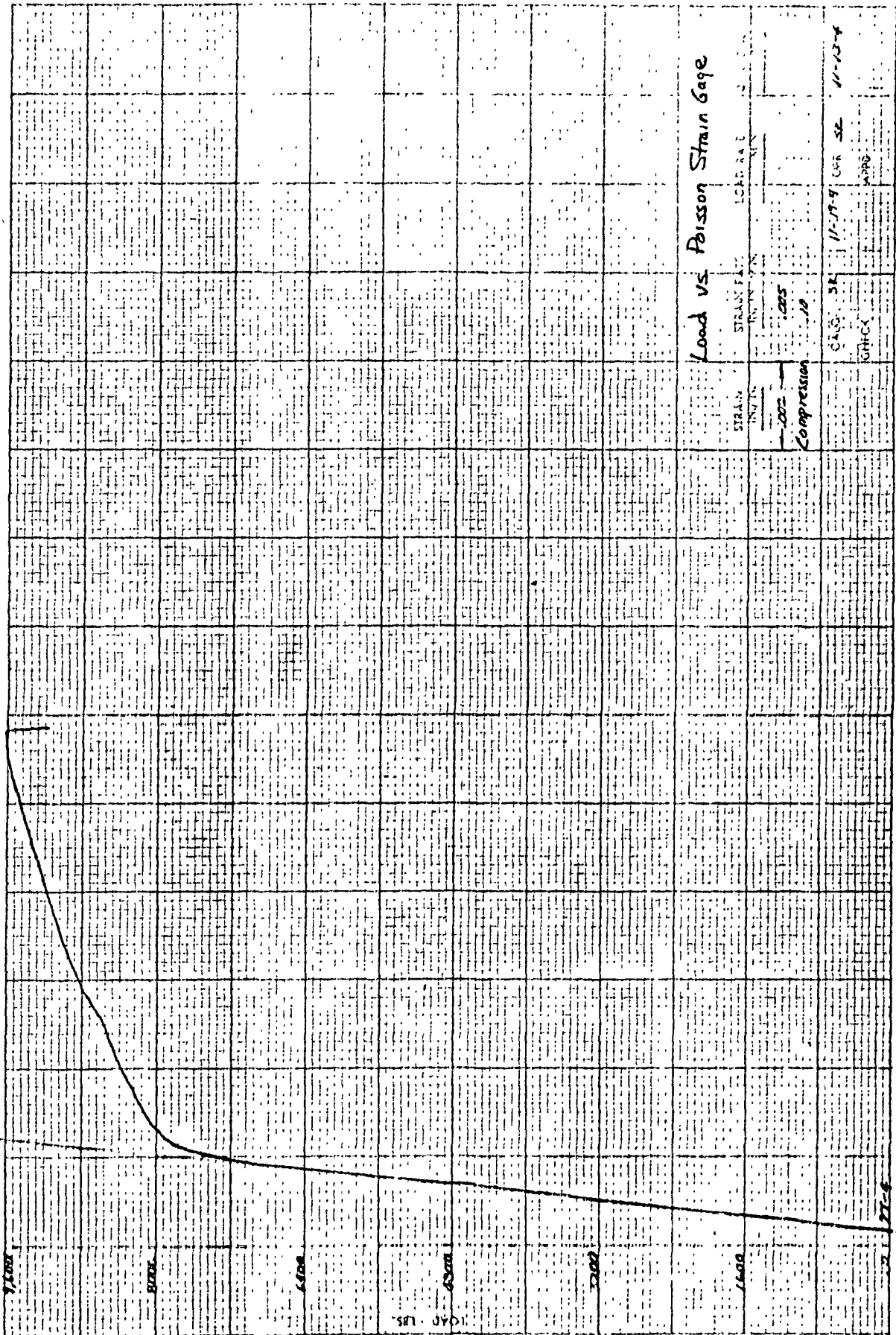
CALC. BY: J-18-4 APPR. SL 11-20-4
 CHECK: APPD.

For machine only



Load vs Axial Strain Gauge

STRAIN	STRAIN RATE	LOAD RATE	COLLECTION
0.002	0.005	10	
CALC. BY		CHK. BY	DATE
CHECK		APPRO	11/13/7

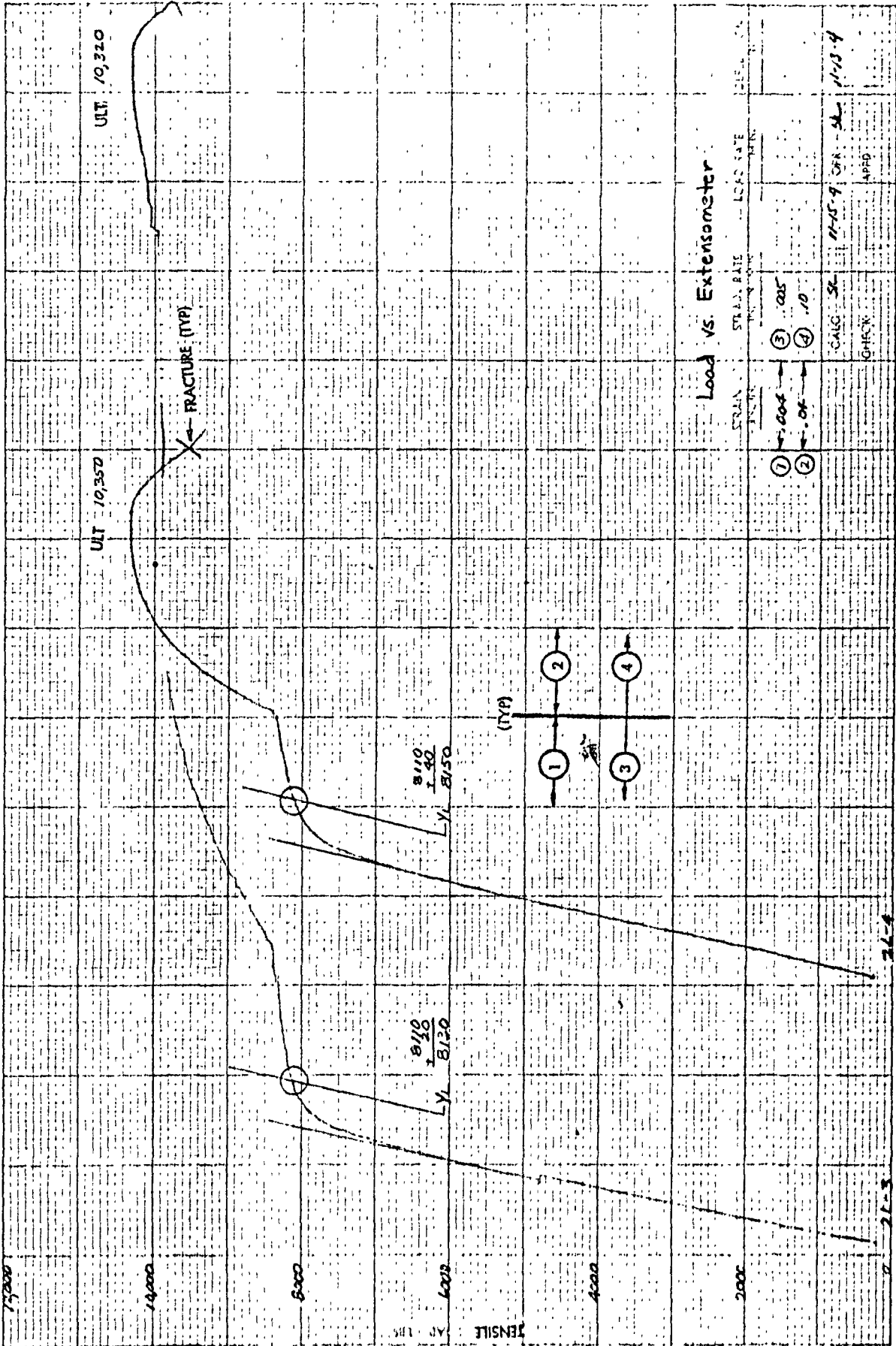


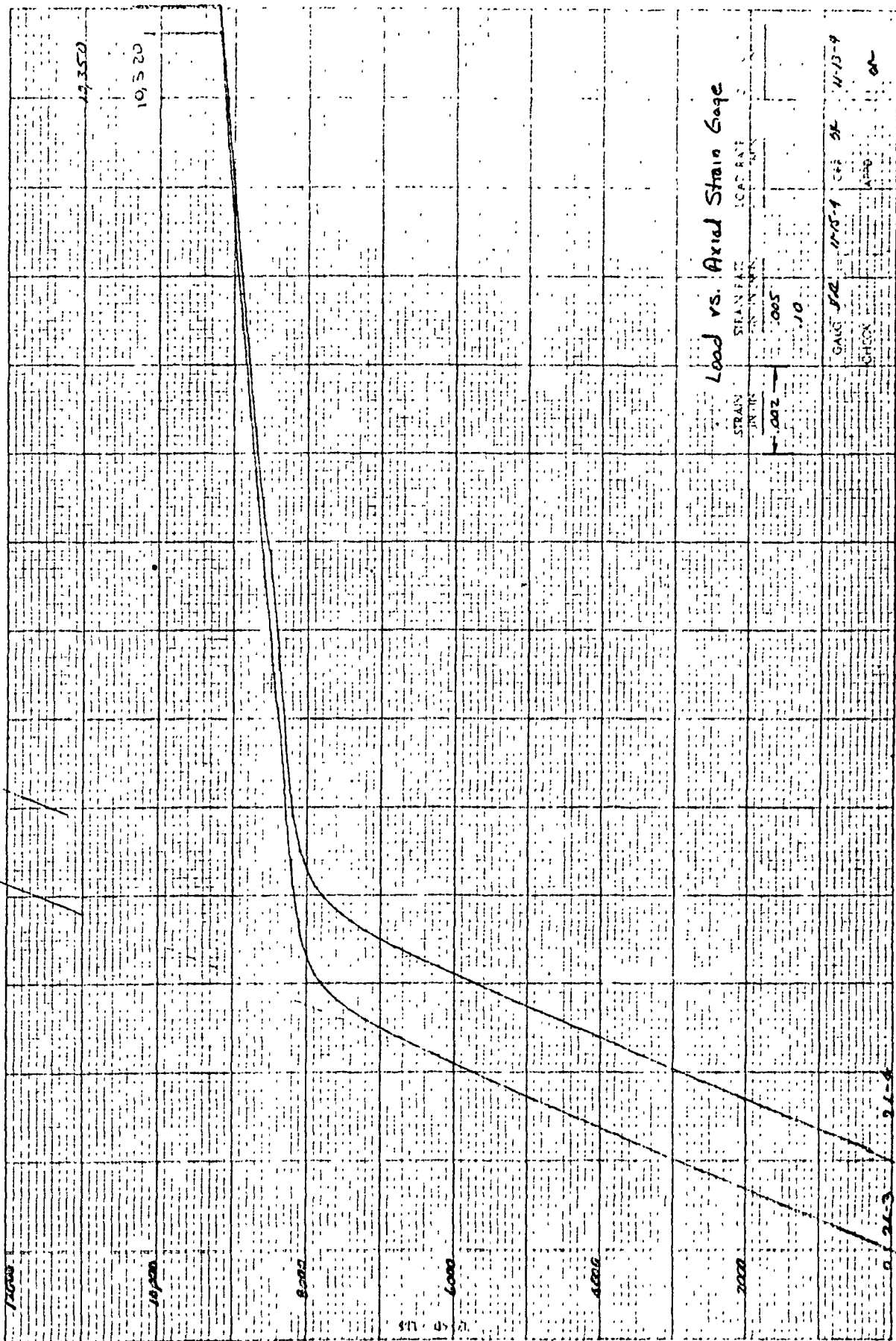
Load vs. Poisson Strain Gage

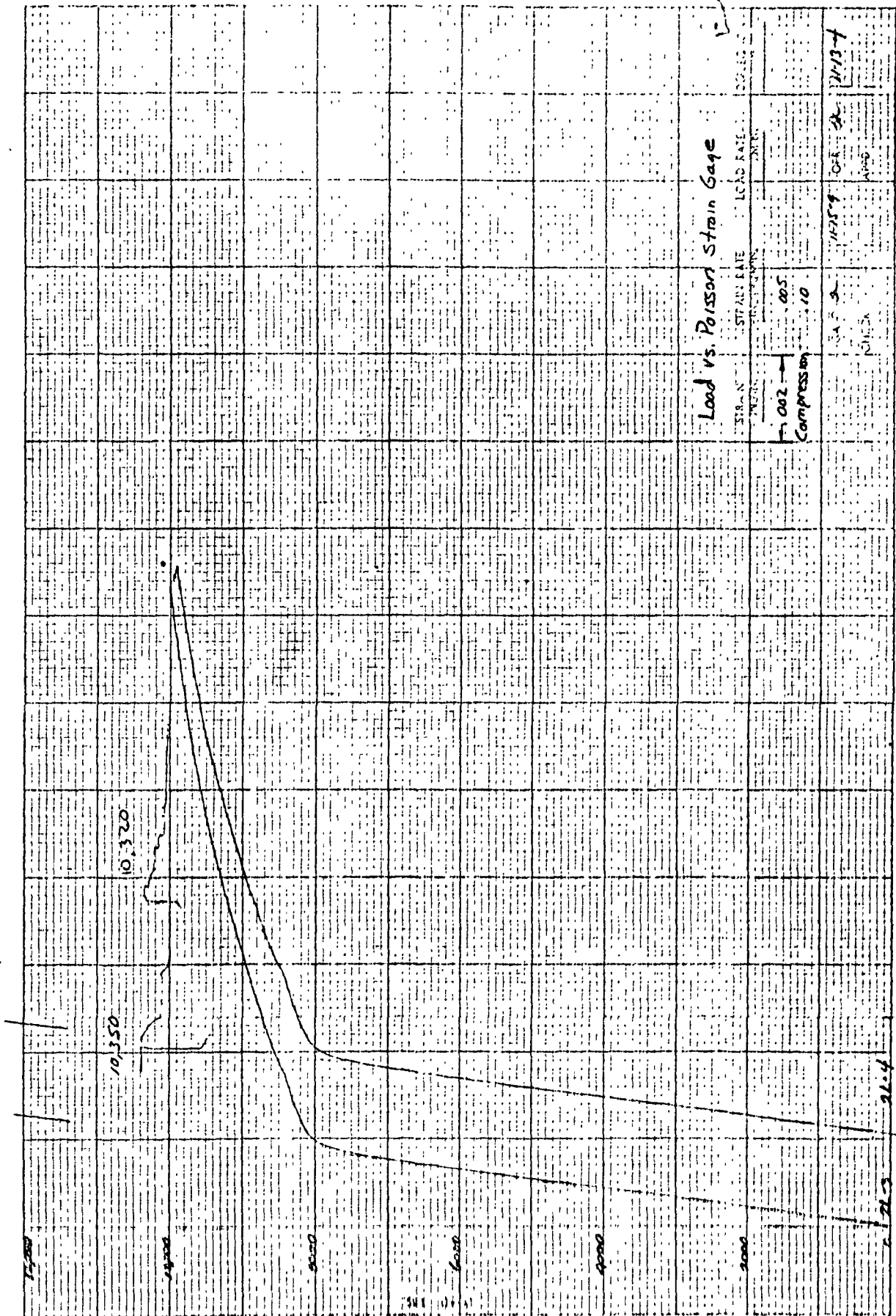
STRAIN IN INCHES
 STRAIN RATE
 LOAD RATE
 DATE
 TIME
 OPERATOR
 APPR.

BOEING ITR
 EWA
 PAGE OF

27-6

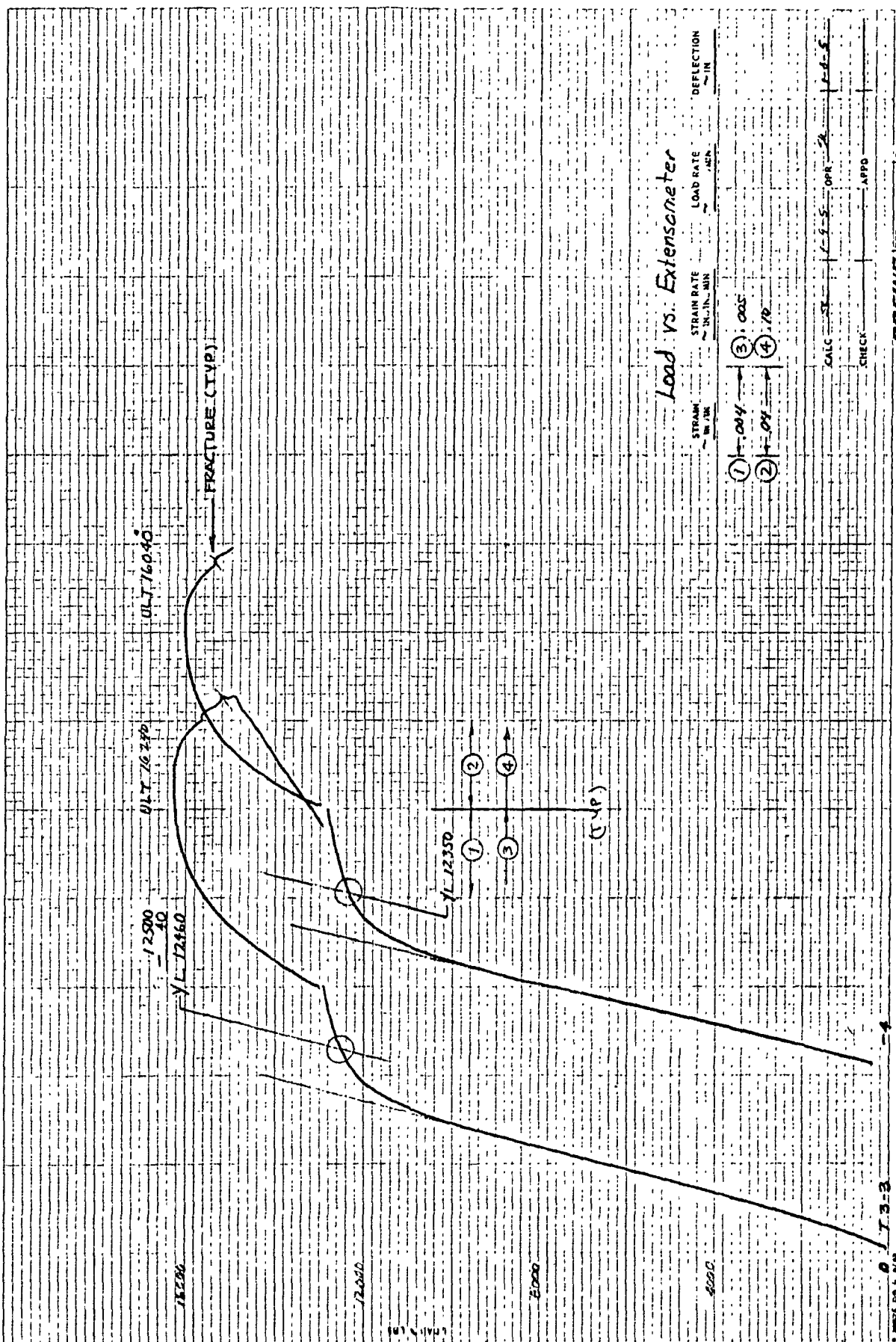






Load vs. Poisson Strain Gage

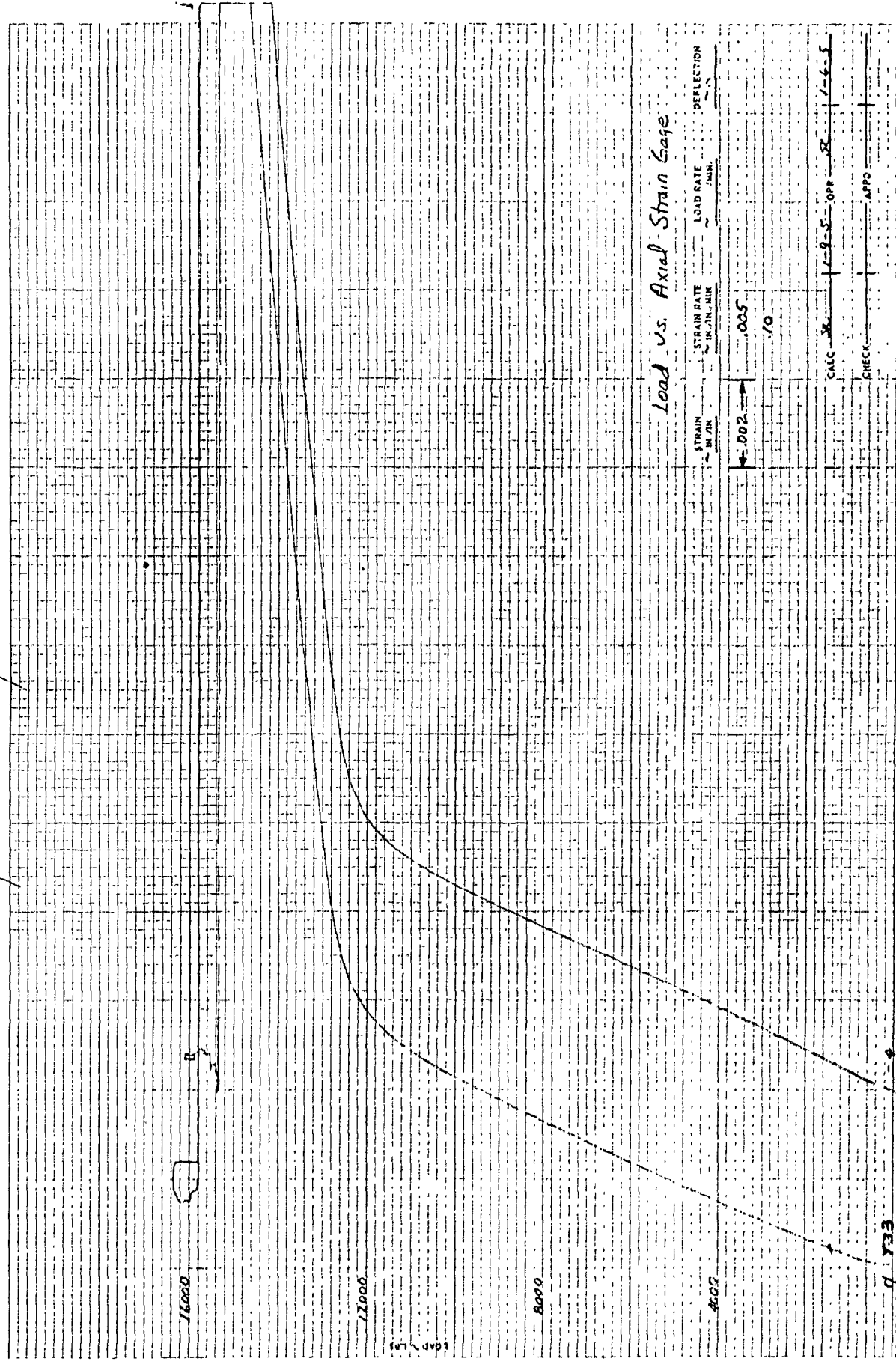
STRAIN	STRAIN RATE	LOAD RATE	LOGS
0.002	0.05		
Compression	10		
10-25-59	0.5	24-13-7	
GA. 3			
11/24			



Load vs. Extensometer

STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
(IN. IN.)	(IN. IN. MIN)	(LBS. MIN)	(IN)
① 0.04	③ 0.005		
② 0.04	④ 0.10		

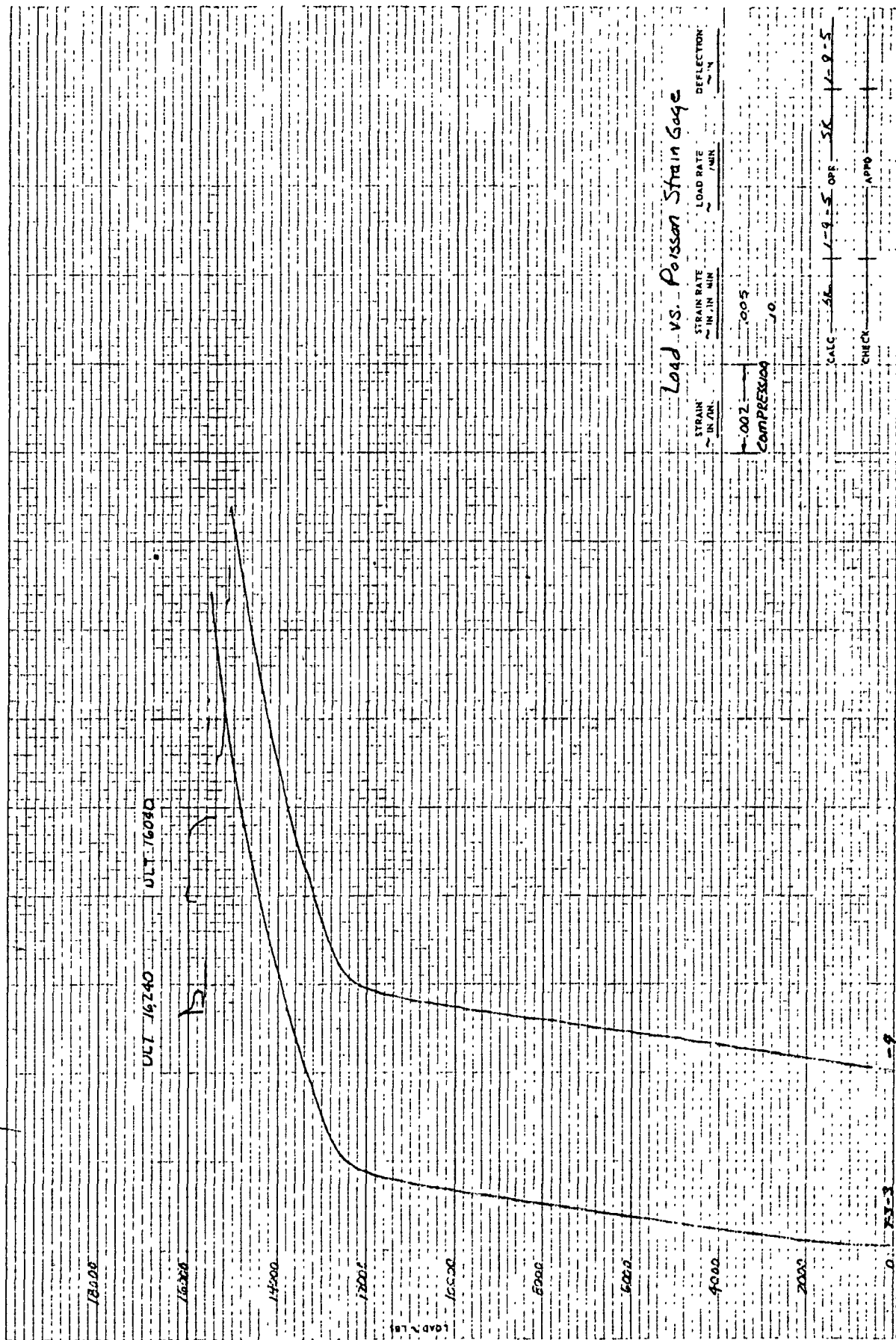
CALC. BY: J.S.S. OPR. J.S.S.
 CHECK: APPD. J.S.S.



Load vs. Axial Strain Gage

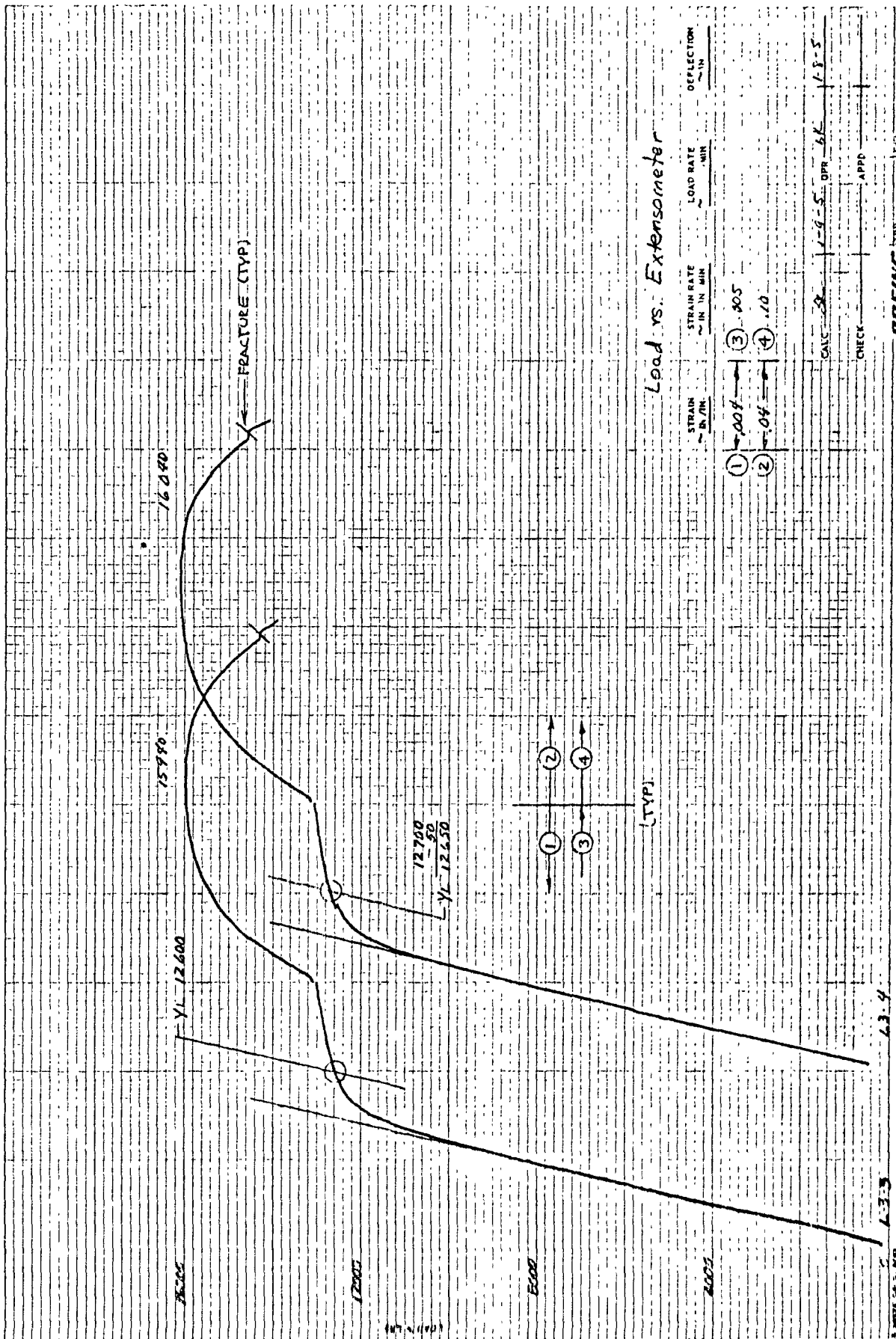
STRAIN IN/IN	LOAD RATE LBS/IN	DEFLECTION IN/IN
.002	.005	
.005	.010	

CALC 1-9-5 OFF 1-6-5
 CHECK APPD



Load vs. Poisson Strain Gage

STRAIN IN/IN	STRAIN RATE IN/IN MIN	LOAD RATE /MIN	DEFLECTION IN
0.007	0.005		
COMPRESSIVE			
CALC 56		1-9-5	OPR SK
CHECK			APPO
0			1-9-5



Load vs. Extensometer

STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN.	LOAD RATE ~ MIN.	DEFLECTION ~ IN.
① .004	③ .905		
② .04	④ .10		

CALC. 8

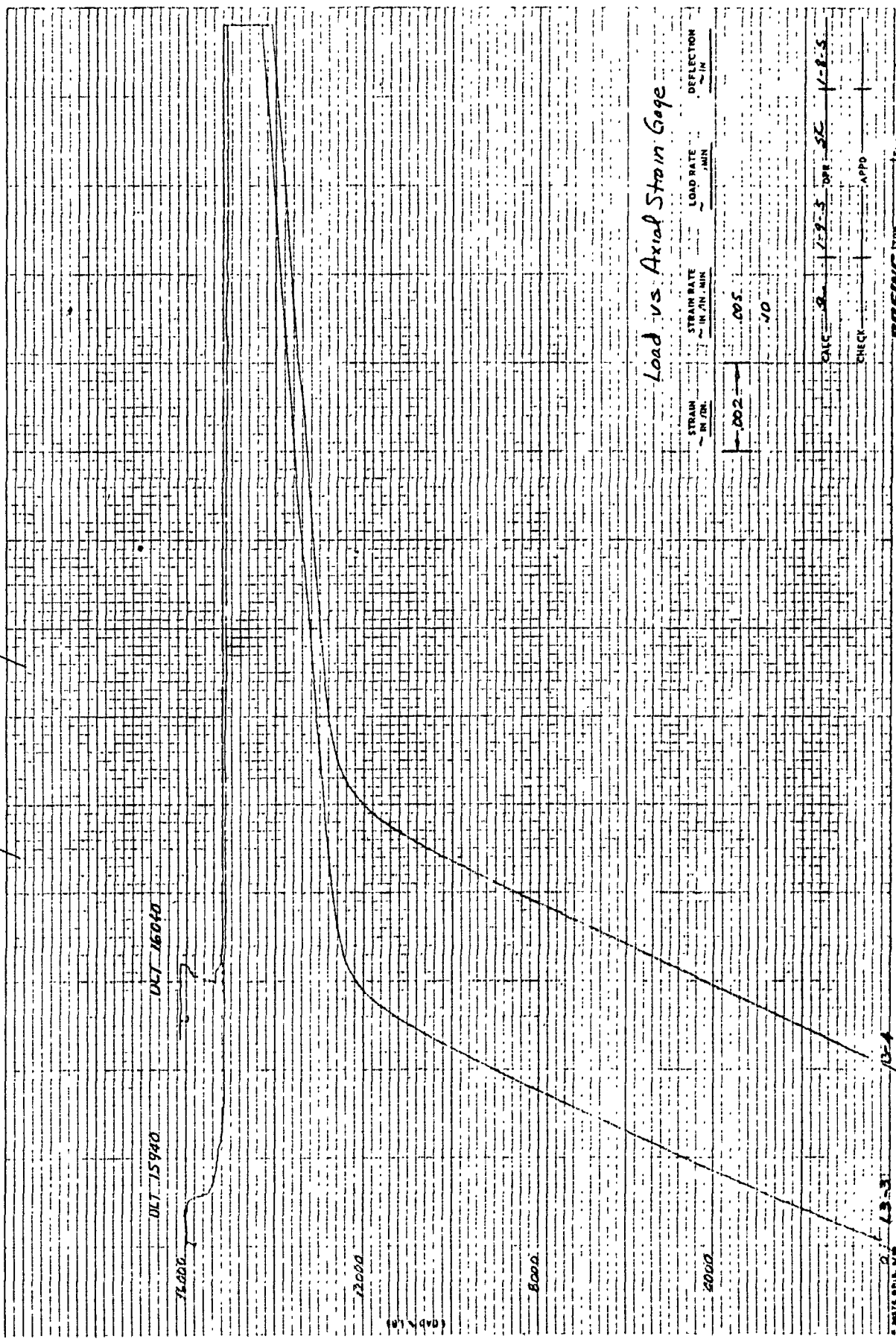
1-9-5

DPR 6K

1-8-5

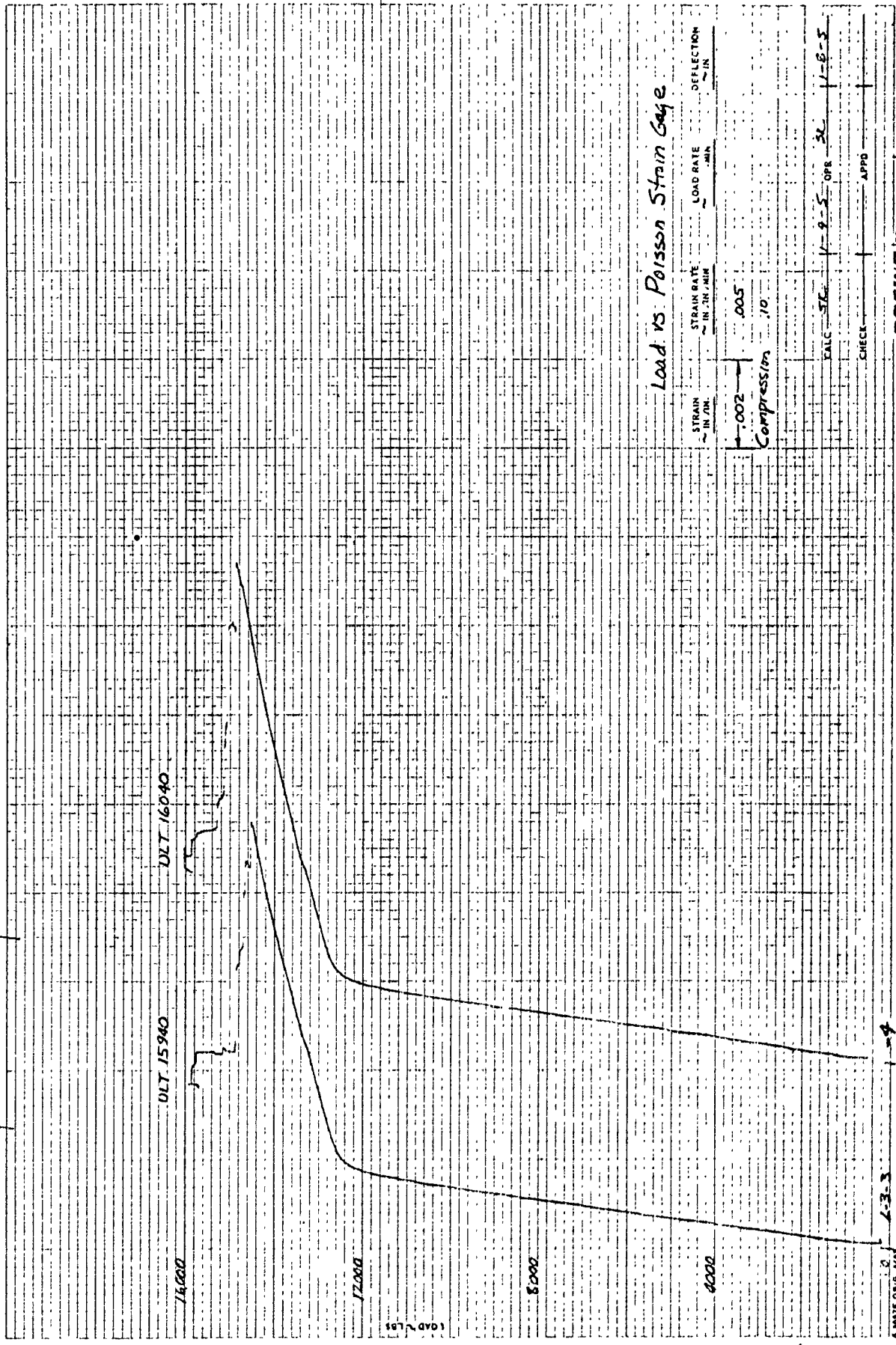
CHECK

APPD



Load vs. Axial Strain Gage

STRAIN RATE IN/IN-MIN	LOAD RATE LBS-MIN	DEFLECTION IN
.002	.005	
	NO	
CHECK	APPRO	
DATE	BY	APP
8-1-58	SK	1-8-5



J18-847

1-E-5

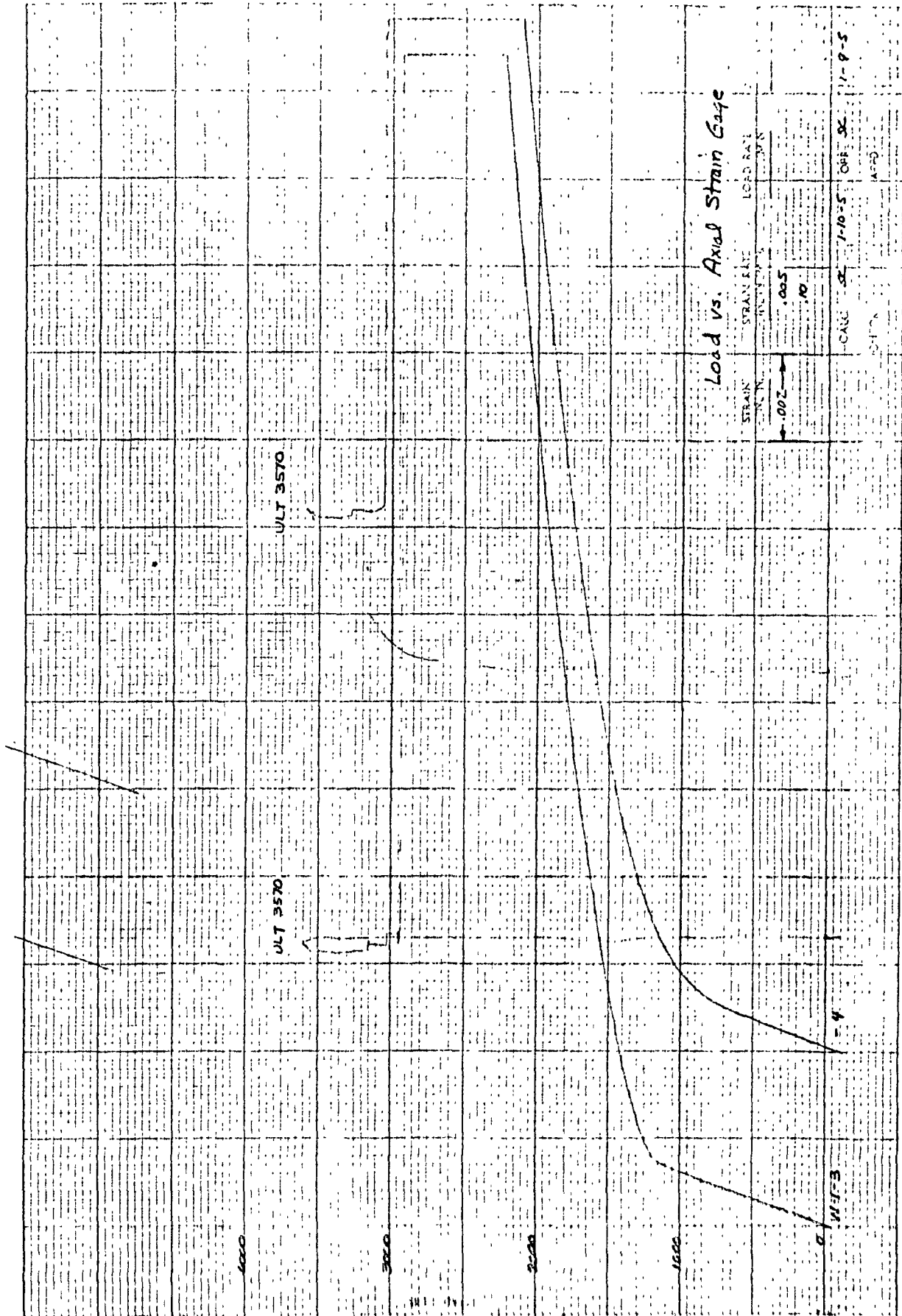
4 1487E OR 10, M, J

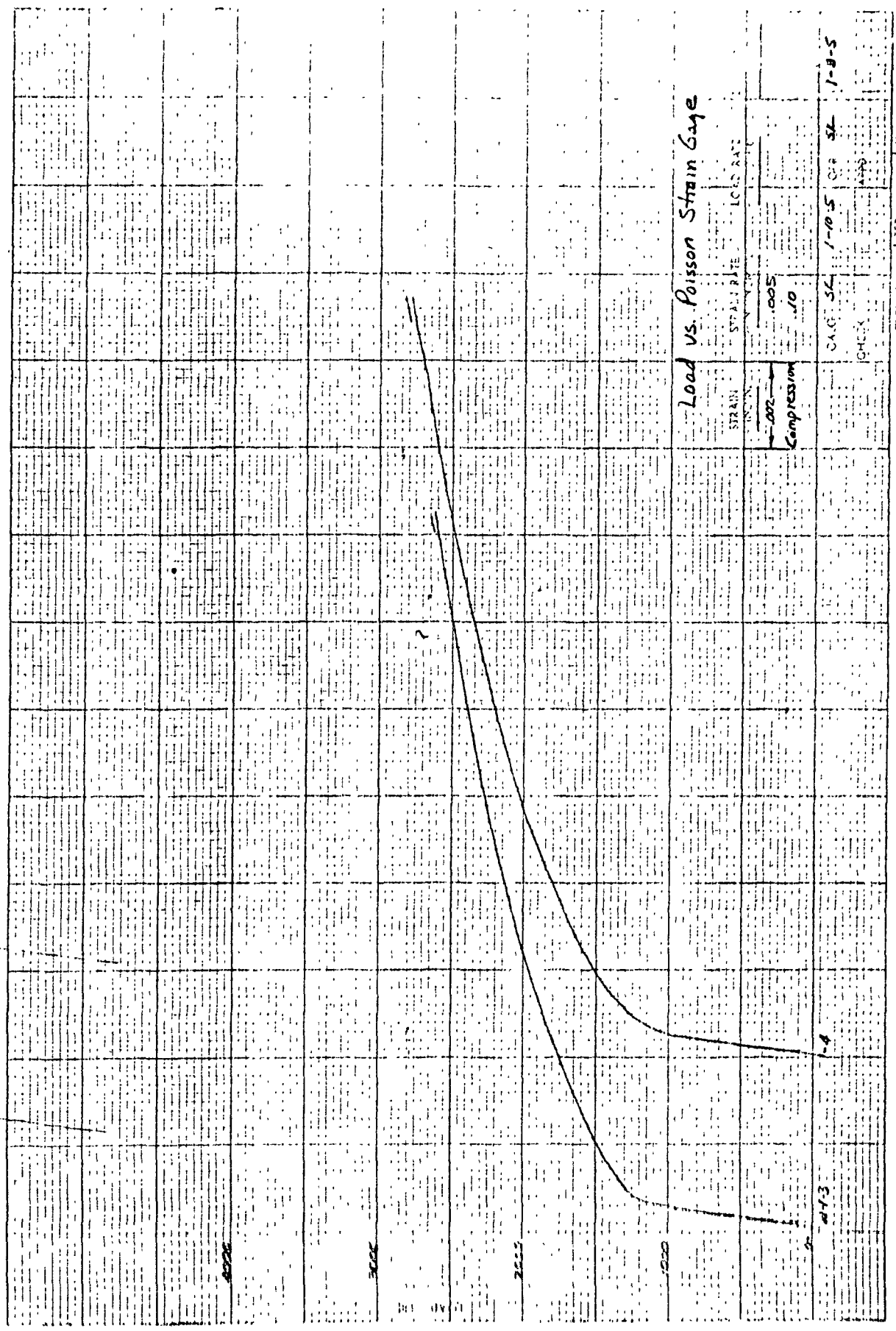
BOEING TPR

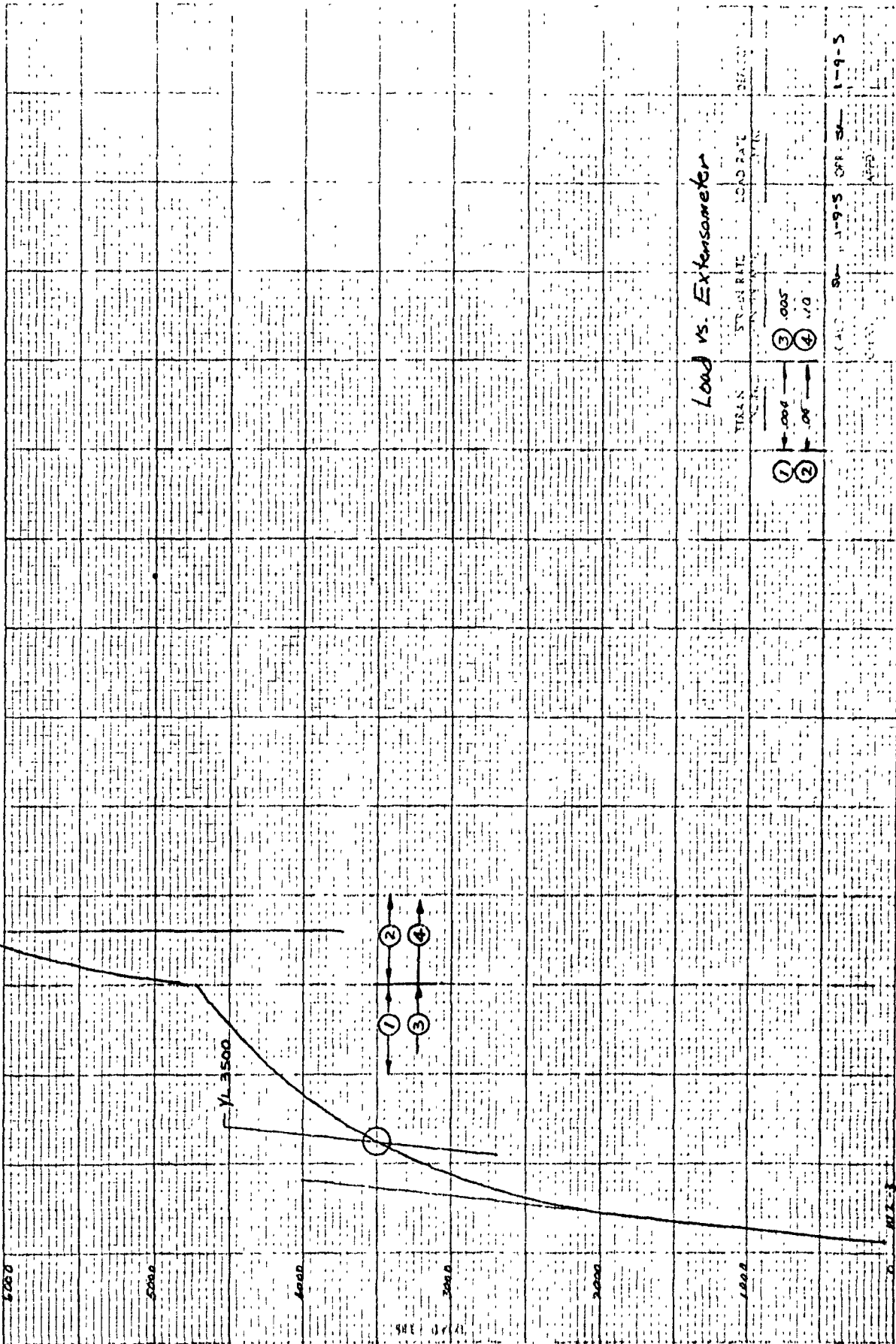
TEST

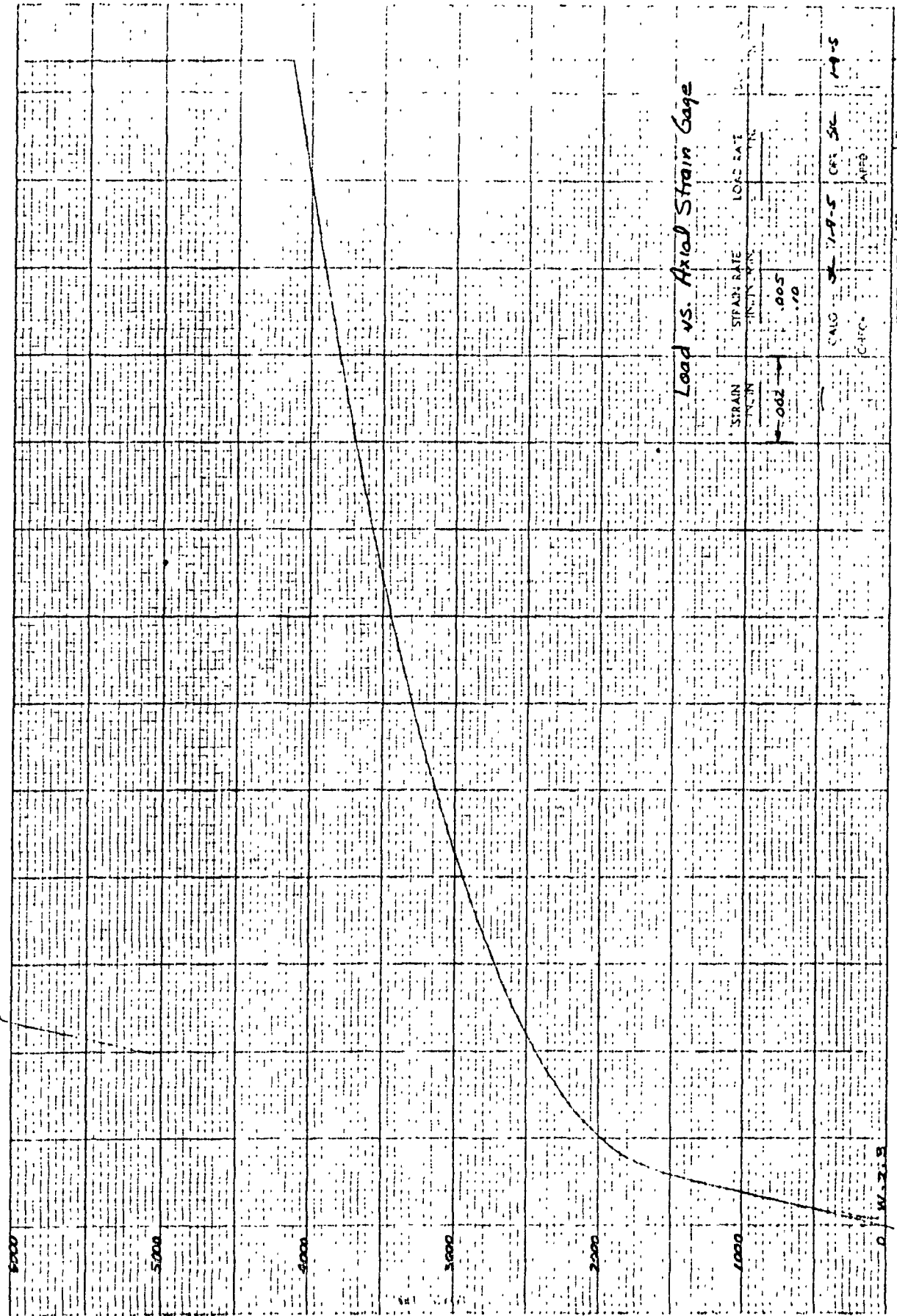
PAGE

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Lead vs. Axial Strain Gage

STRAIN
IN IN.

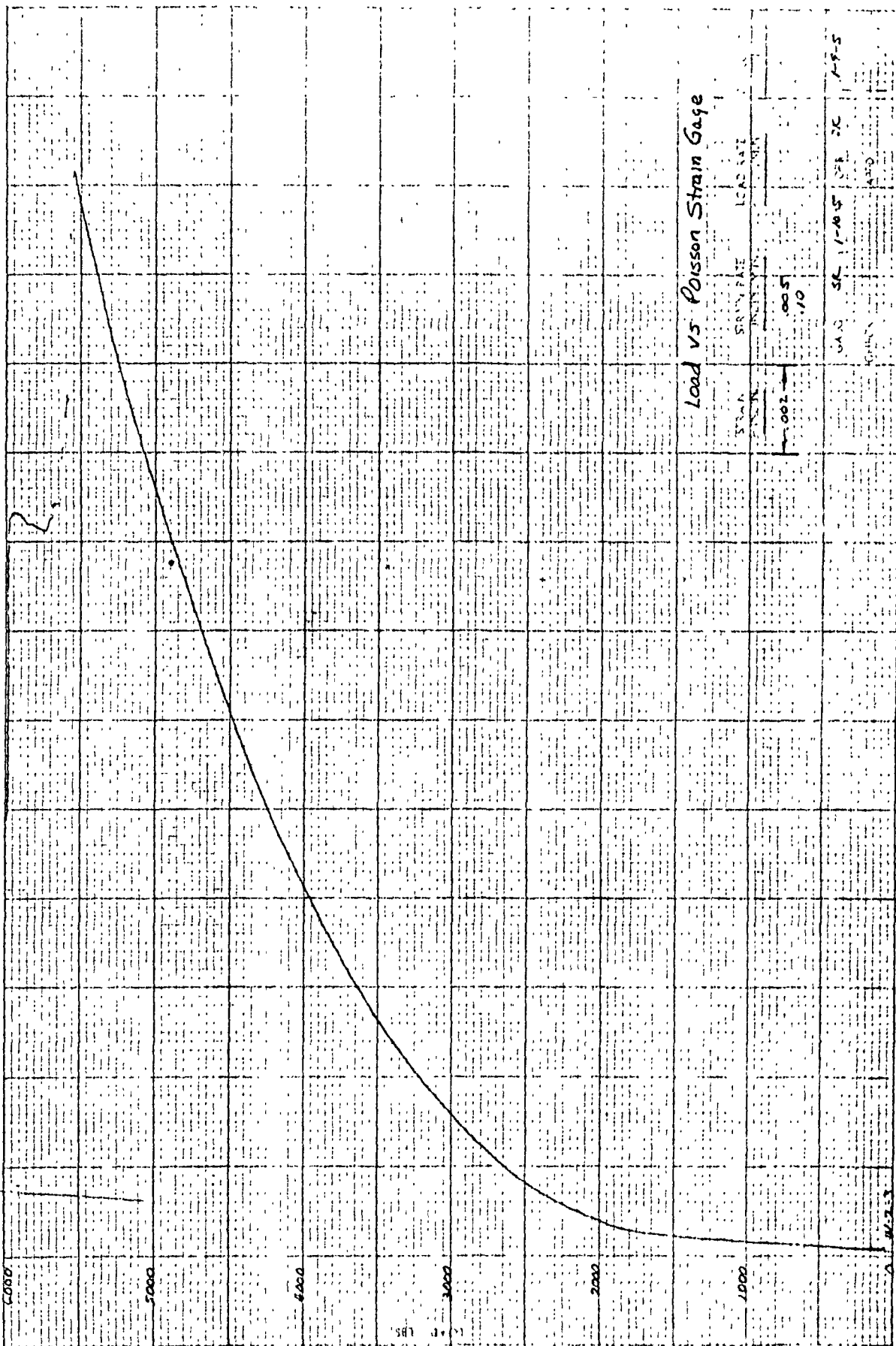
DISPLACEMENT RATE
IN IN. MIN.

LOAD RATE
IN IN. MIN.

0.002
0.005
0.010

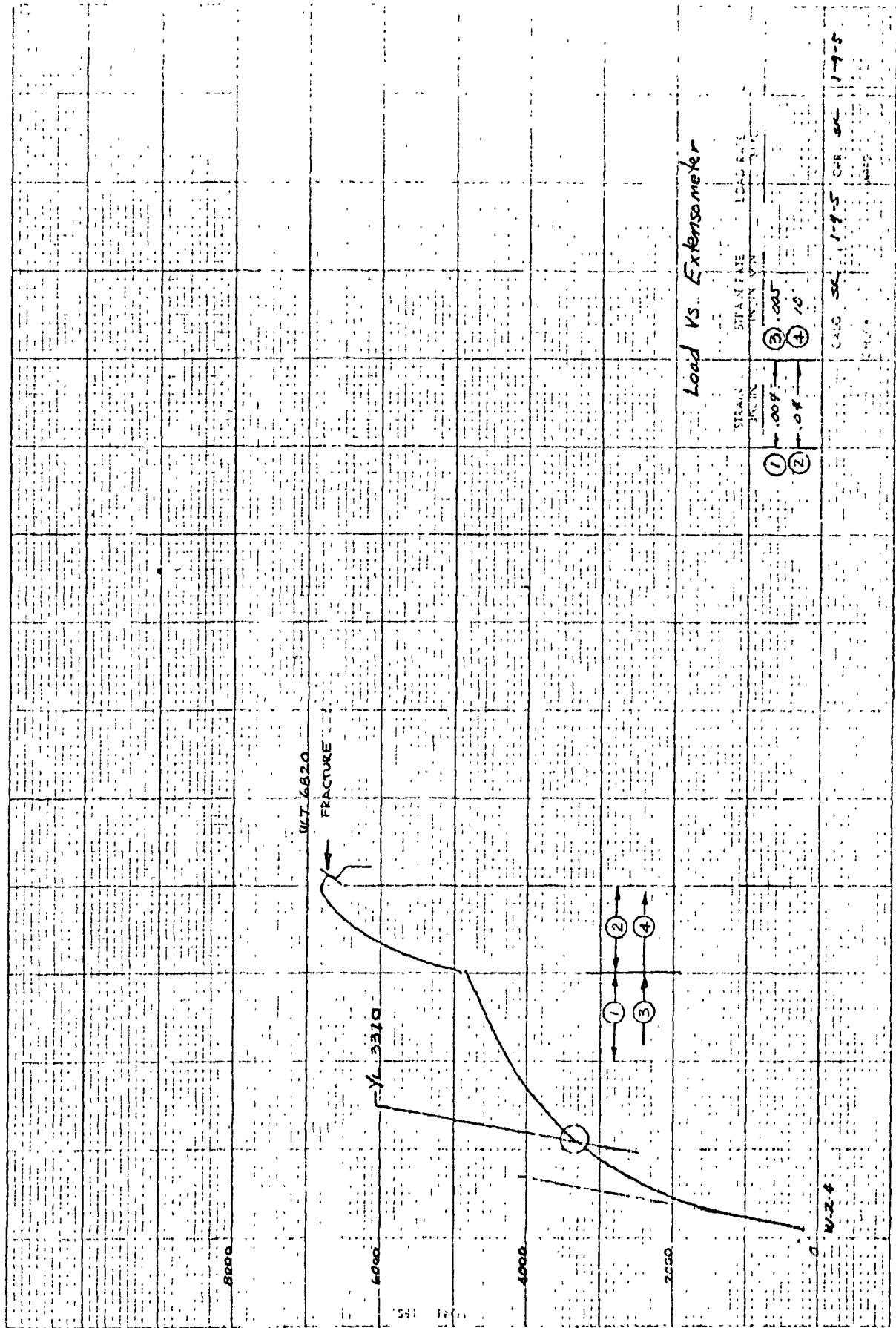
SCALE 1-9-5 OF 5K 1-9-5

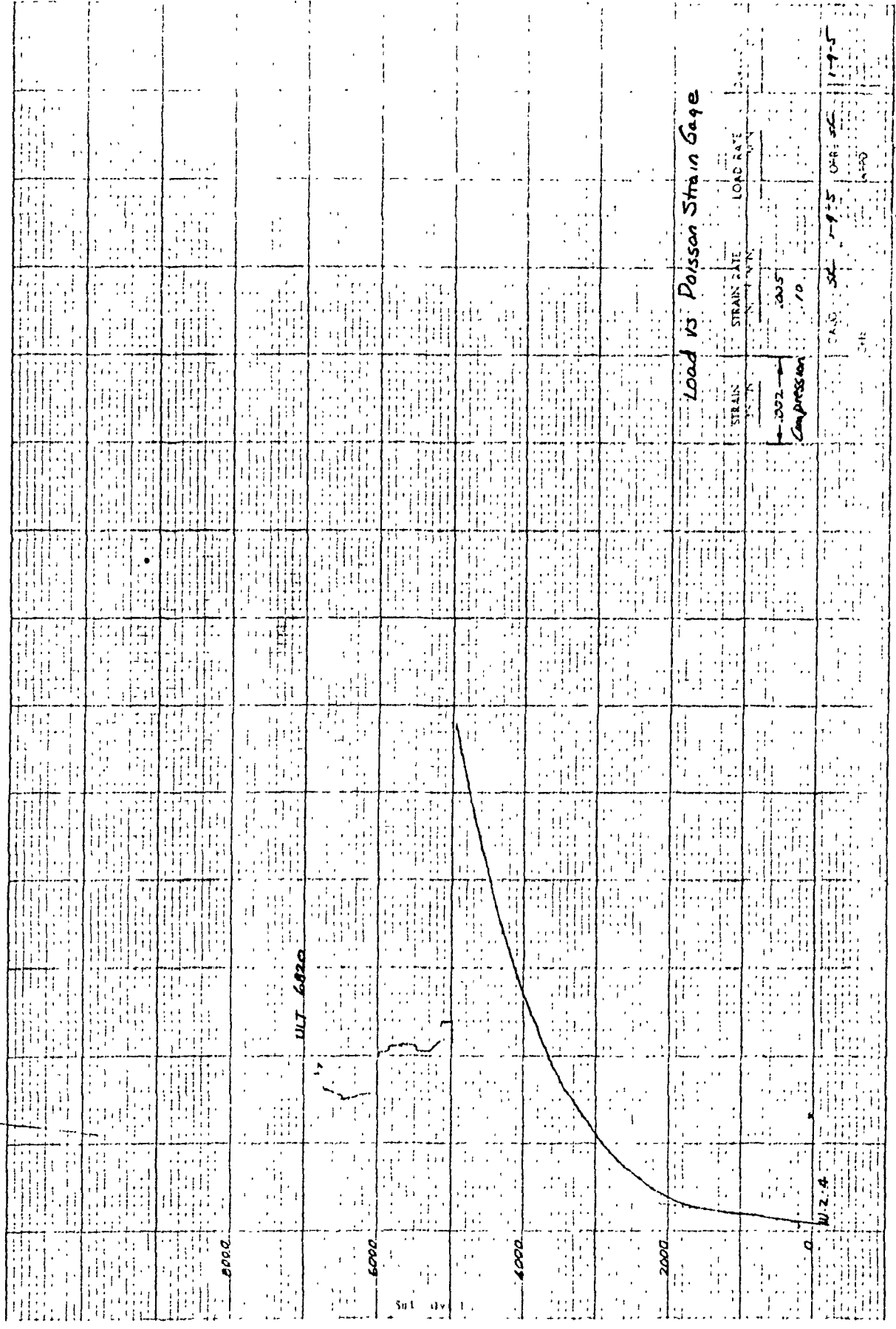
CALC. APP.



Load vs Poisson Strain Gage

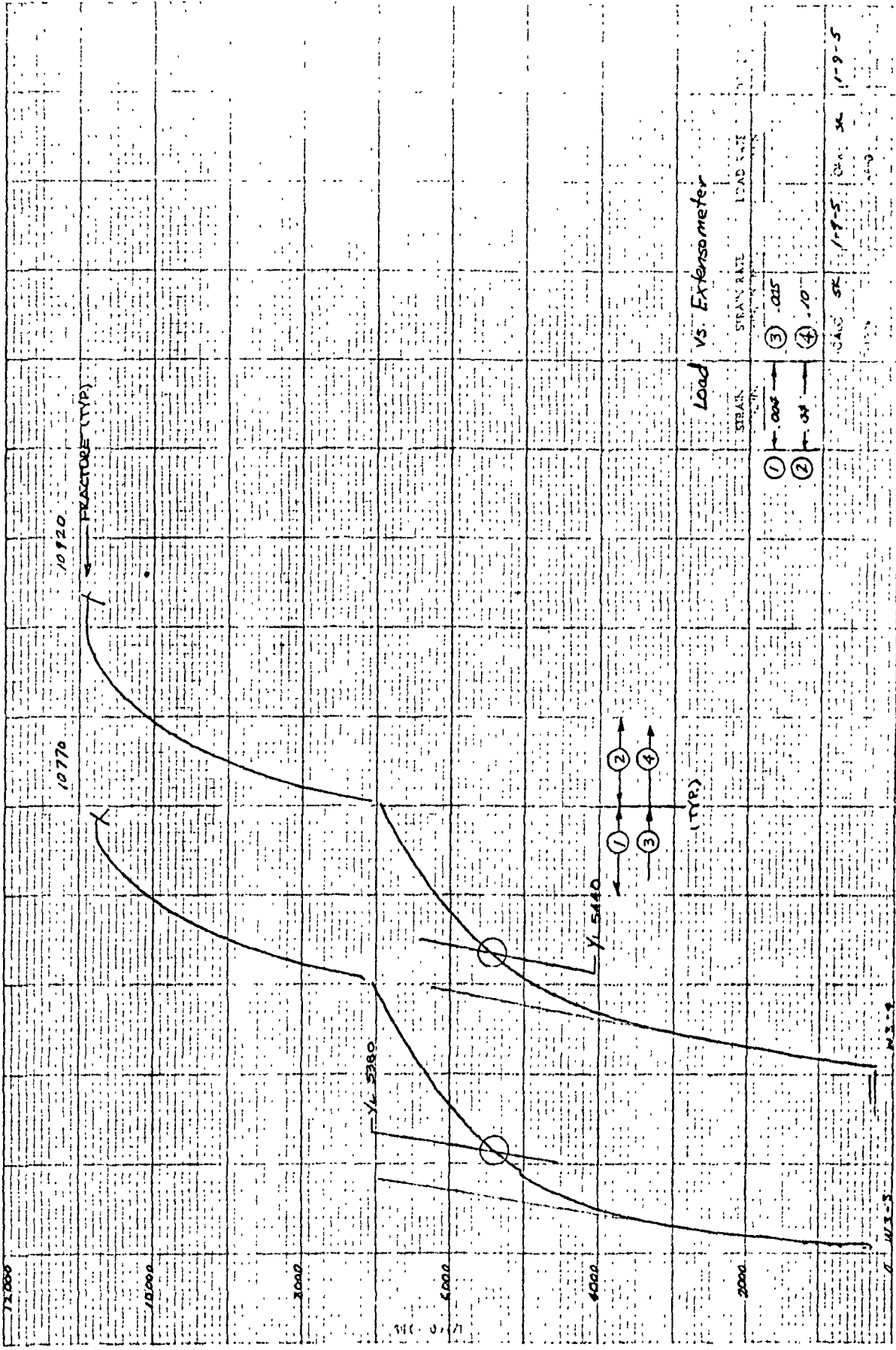
STRAIN	LOAD (LBS)
0.001	5800
0.002	5000
0.003	4500
0.004	4000
0.005	3500
0.006	3000
0.007	2500
0.008	2000
0.009	1500
0.010	1000
0.011	500
0.012	0





Load vs Poisson Strain Gage

STRAIN	STRAIN RATE	LOAD RATE
0.002	0.005	0.005
Compression	10	10
0.002	0.005	0.005
0.004	0.010	0.010
0.006	0.015	0.015
0.008	0.020	0.020
0.010	0.025	0.025
0.012	0.030	0.030
0.014	0.035	0.035
0.016	0.040	0.040
0.018	0.045	0.045
0.020	0.050	0.050



Load vs. Extensometer

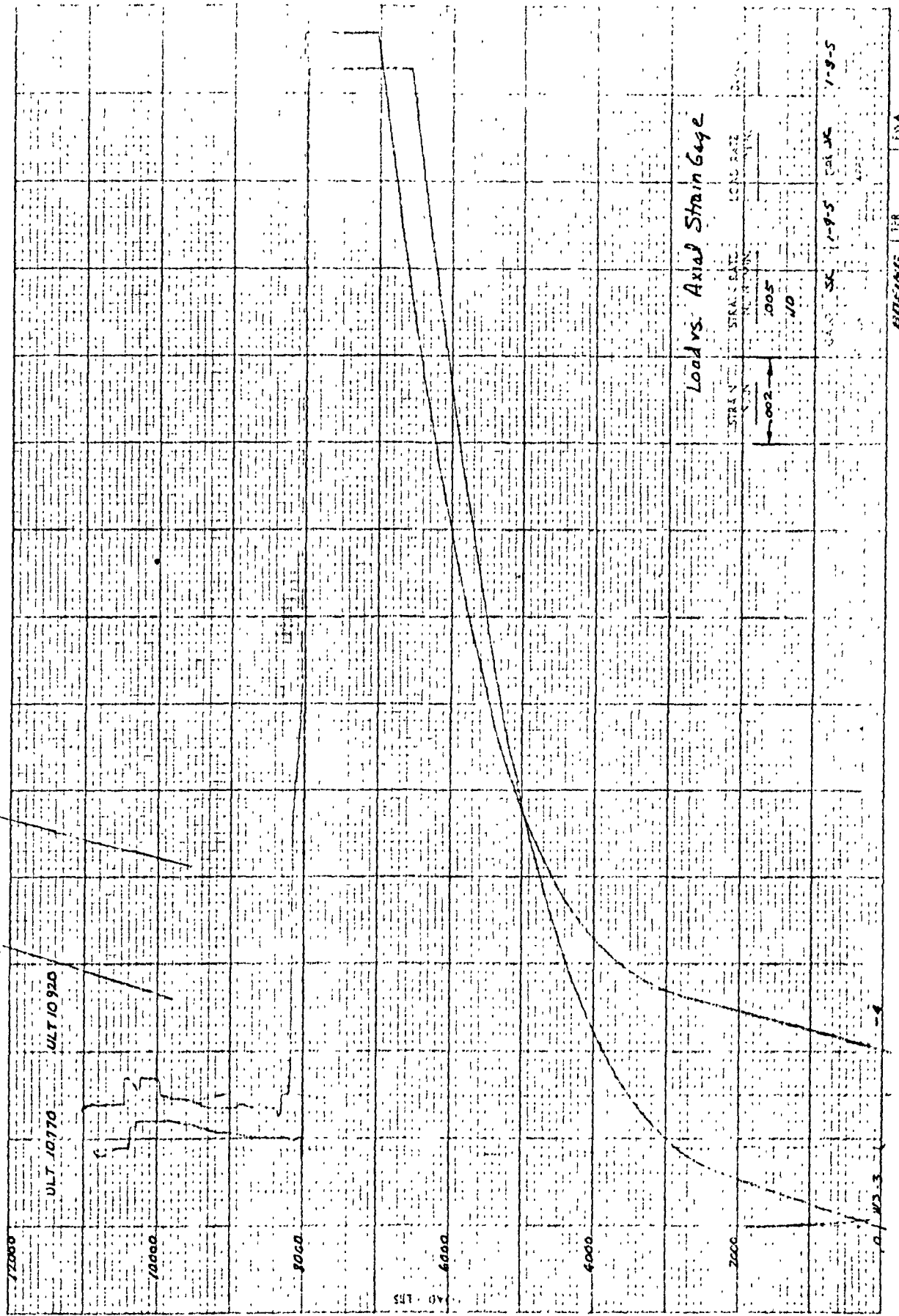
STRAIN RATE
LEAD TIME

STRAIN
① .002
② .01
③ .025
④ .10

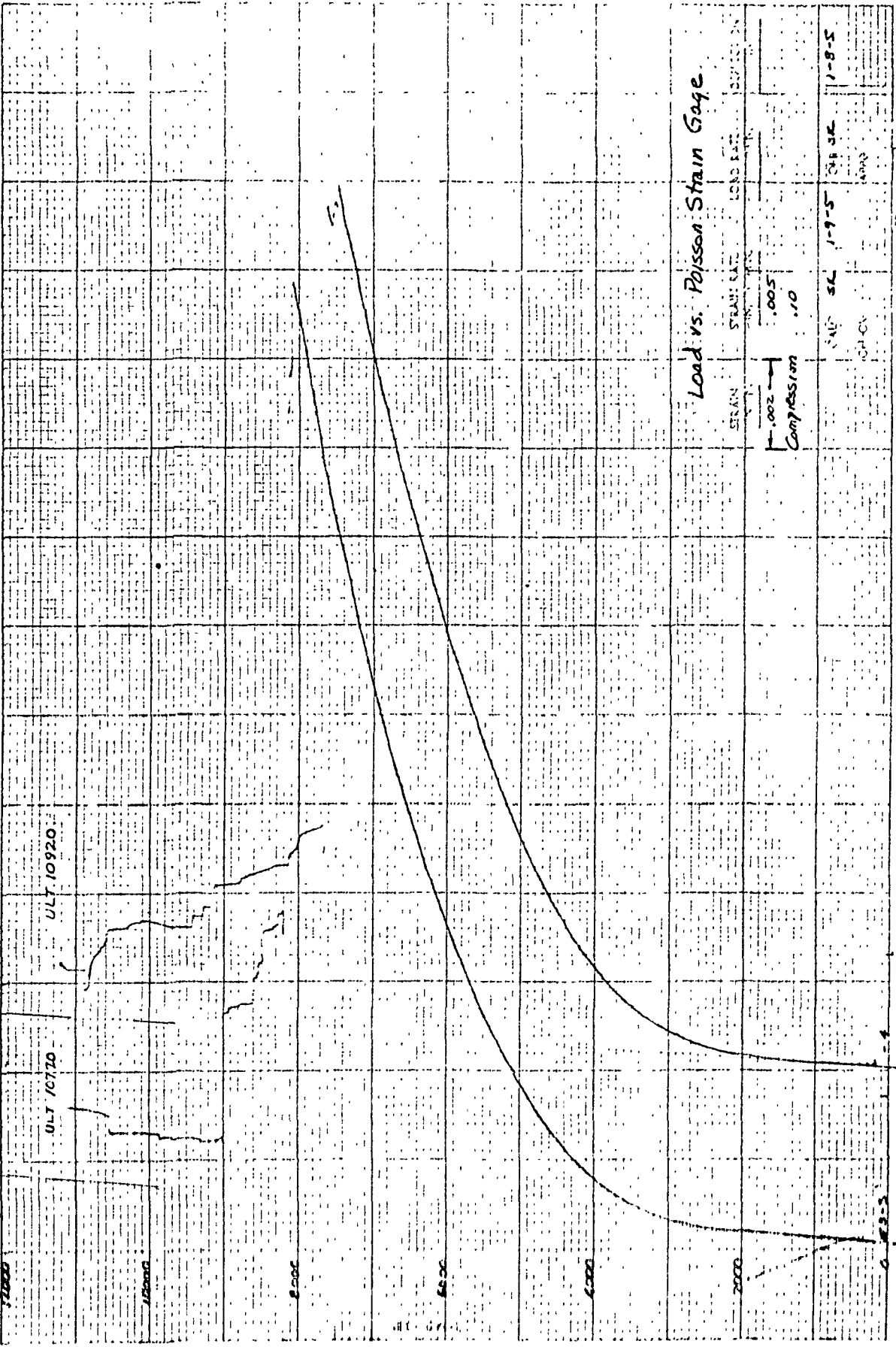
W3-5
W3-9

1953

machine only



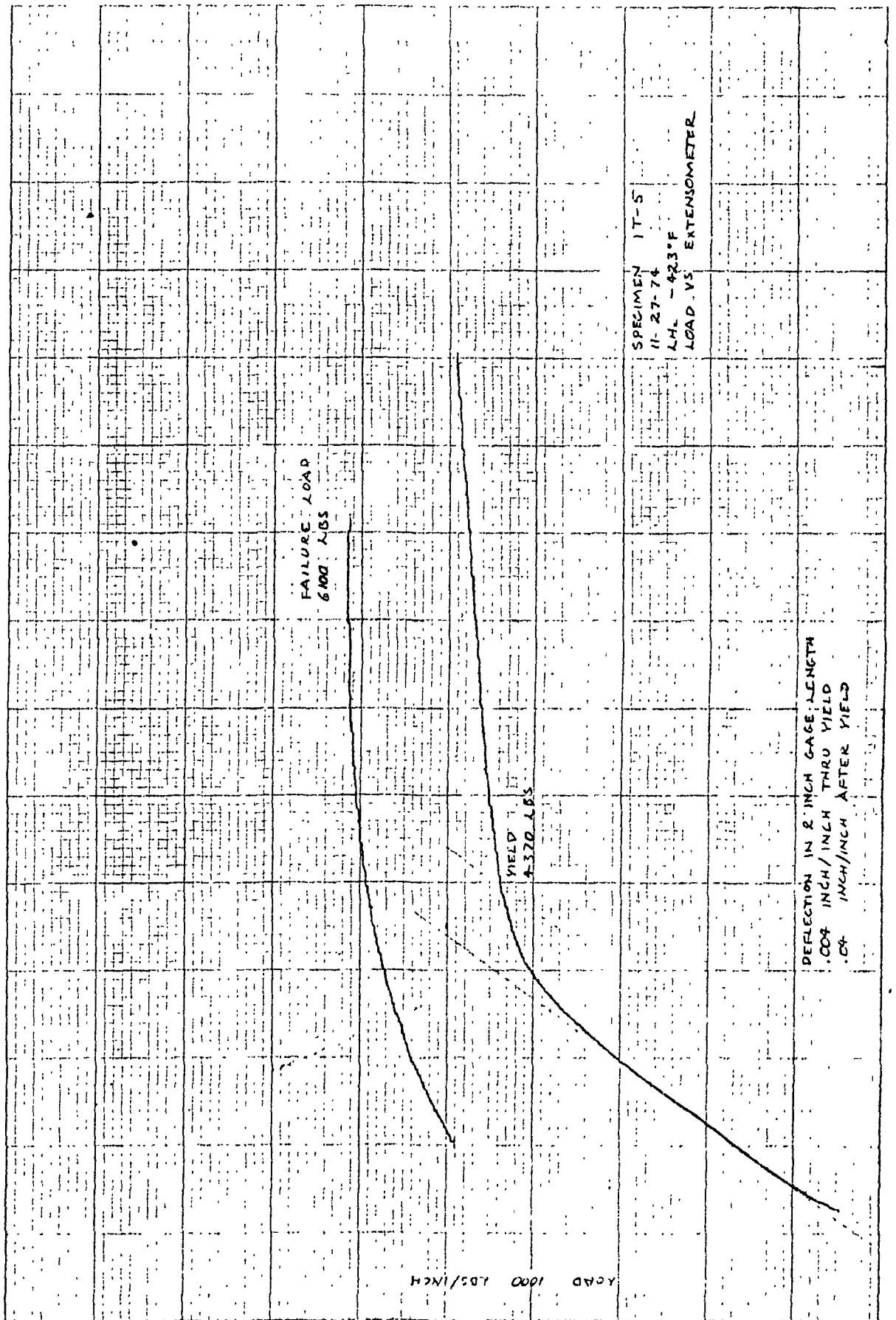
For machine only

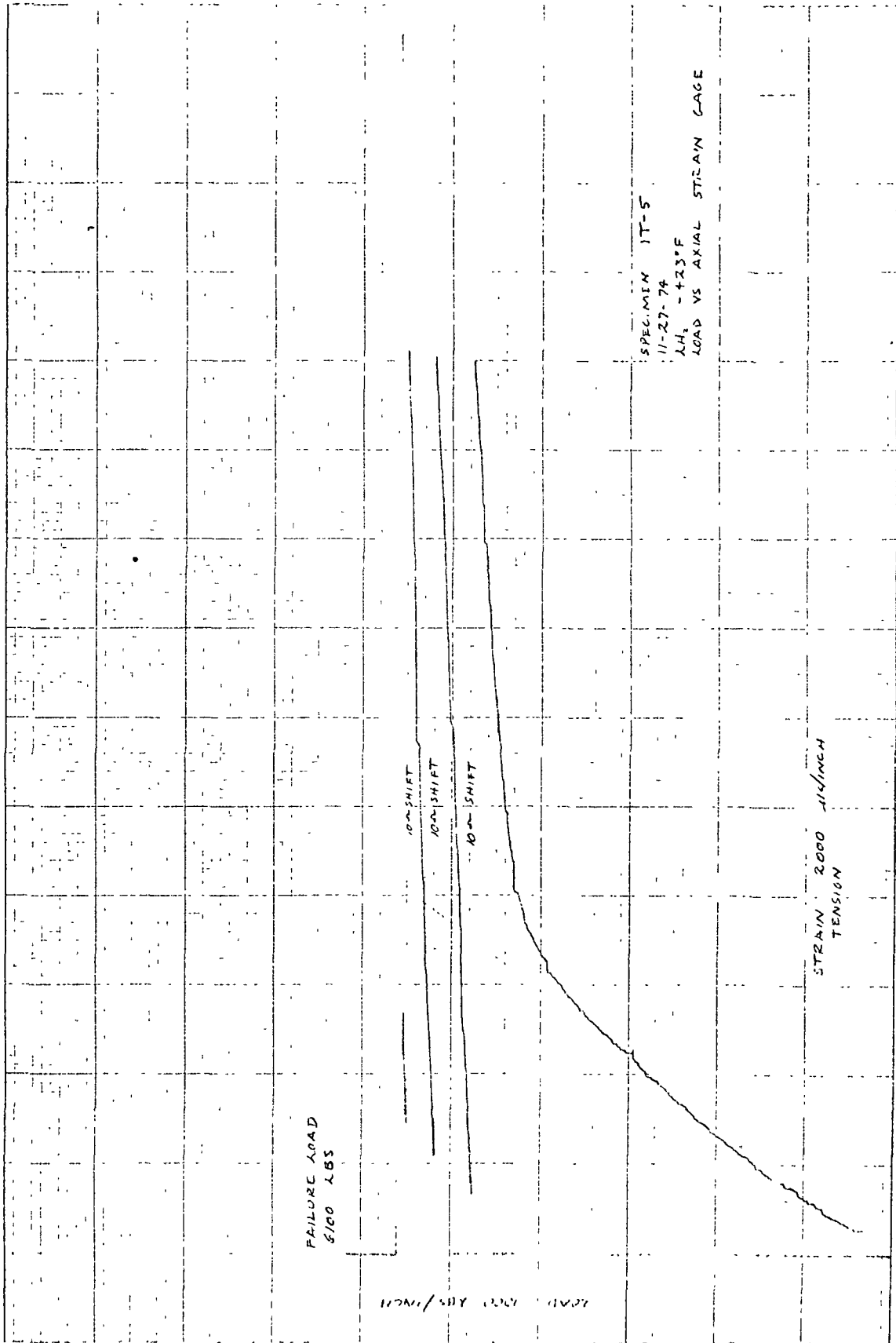


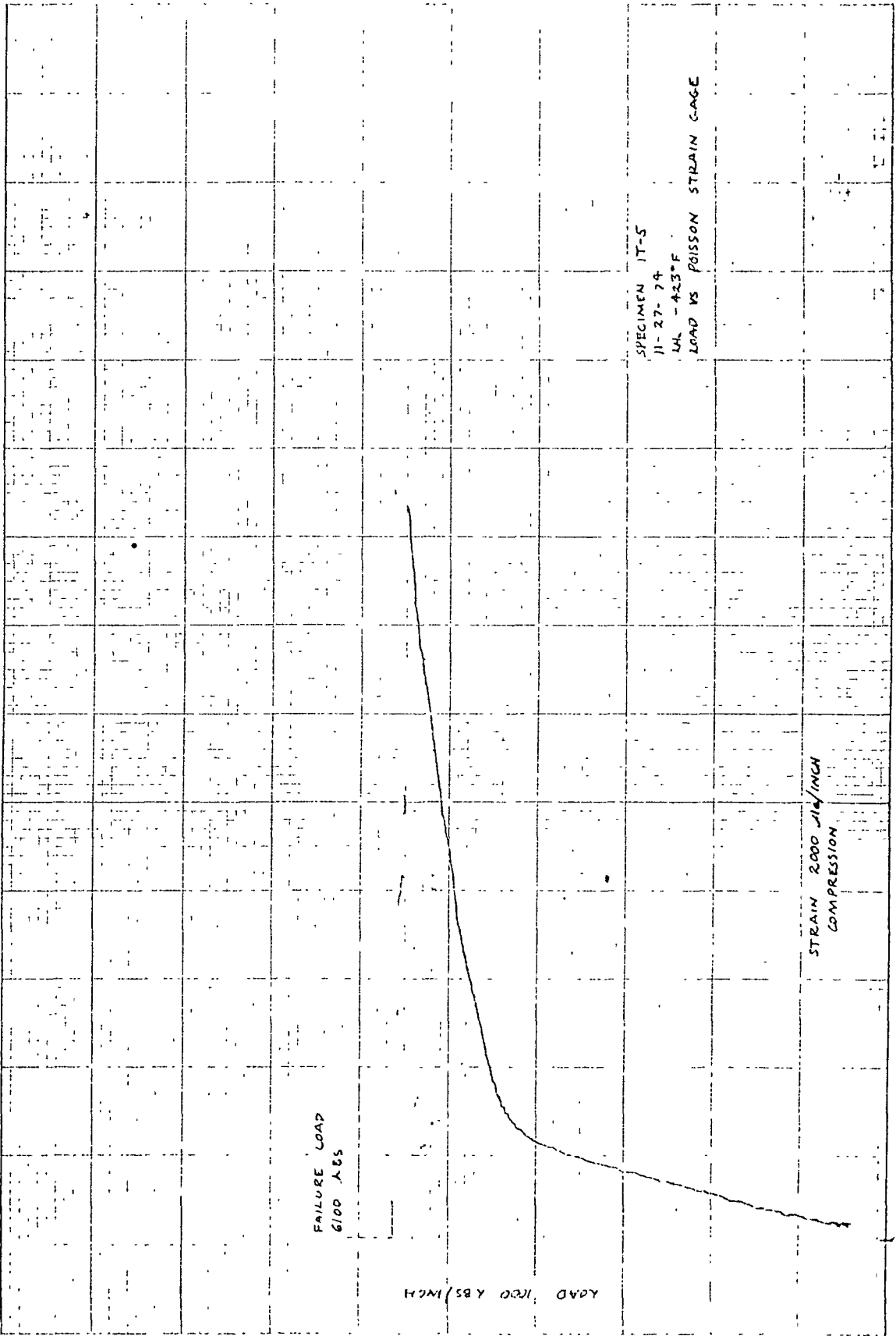
Load vs. Poisson Strain Gage.

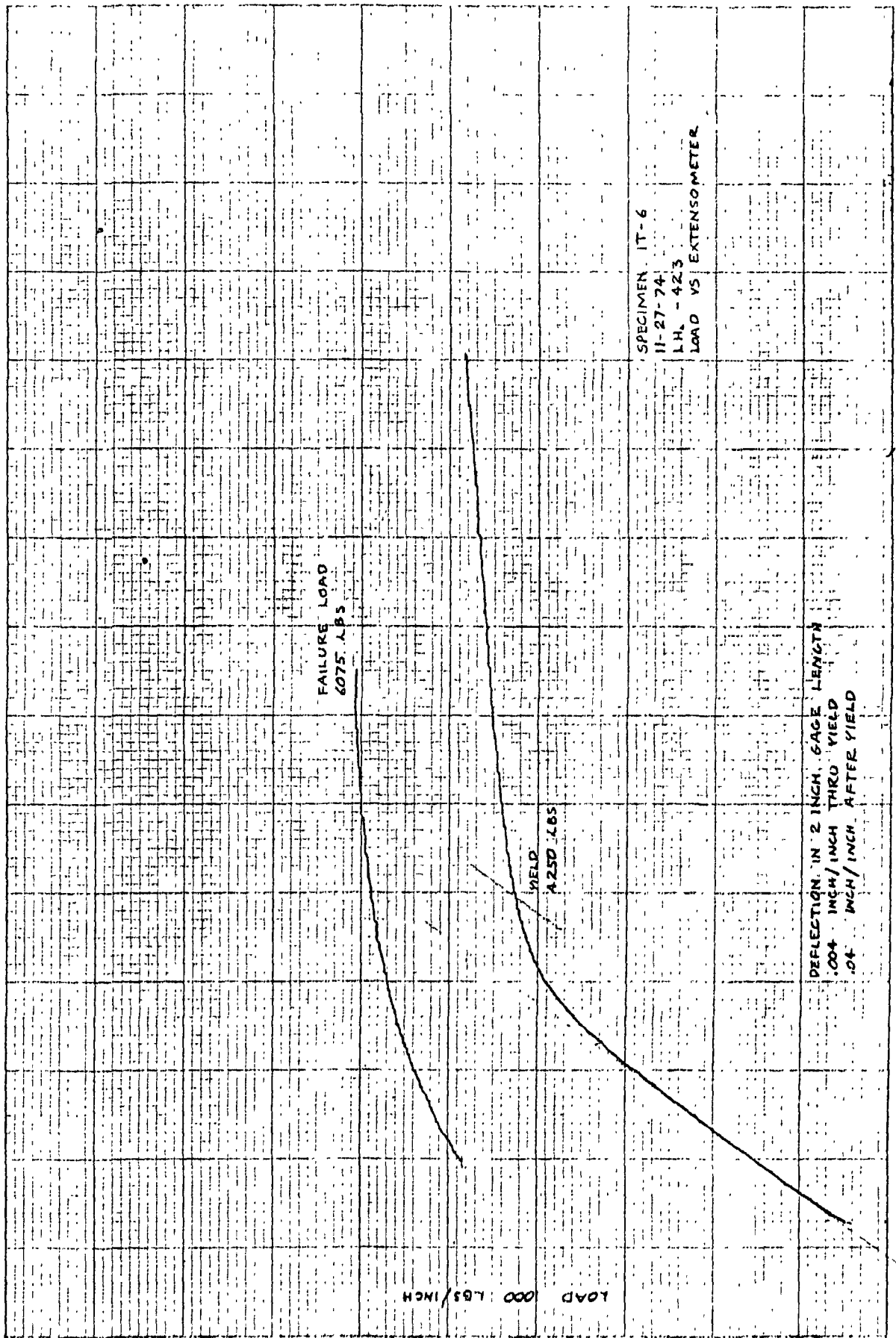
STRAIN	STRAIN RATE	LOAD RATE	DISPLACEMENT
0.002	0.005		
Compression .10			
SAP 5L 1-9-5			
CH-CV			
1-8-5			

BOEING TP 11-A
PAGE OF 1

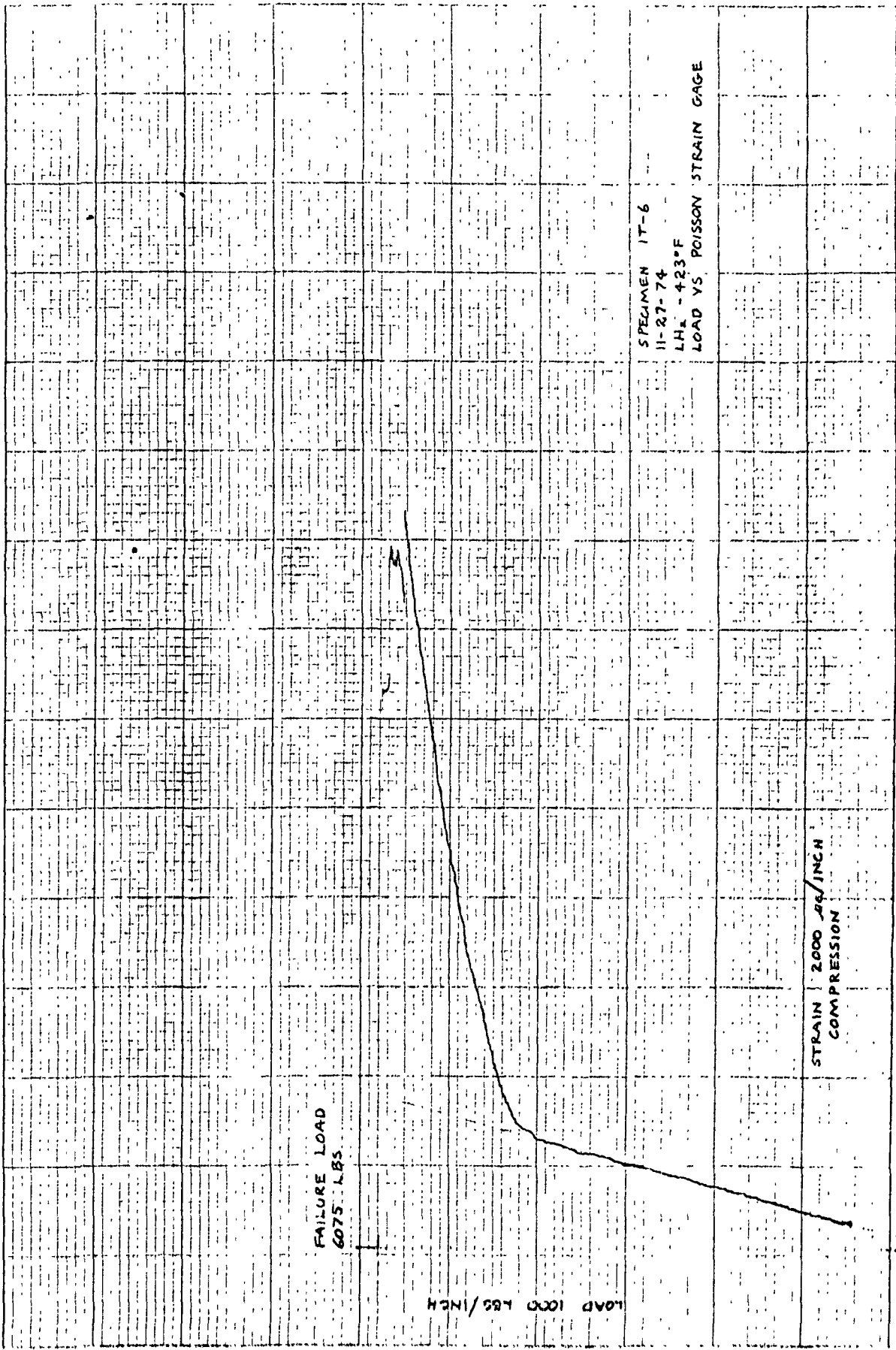


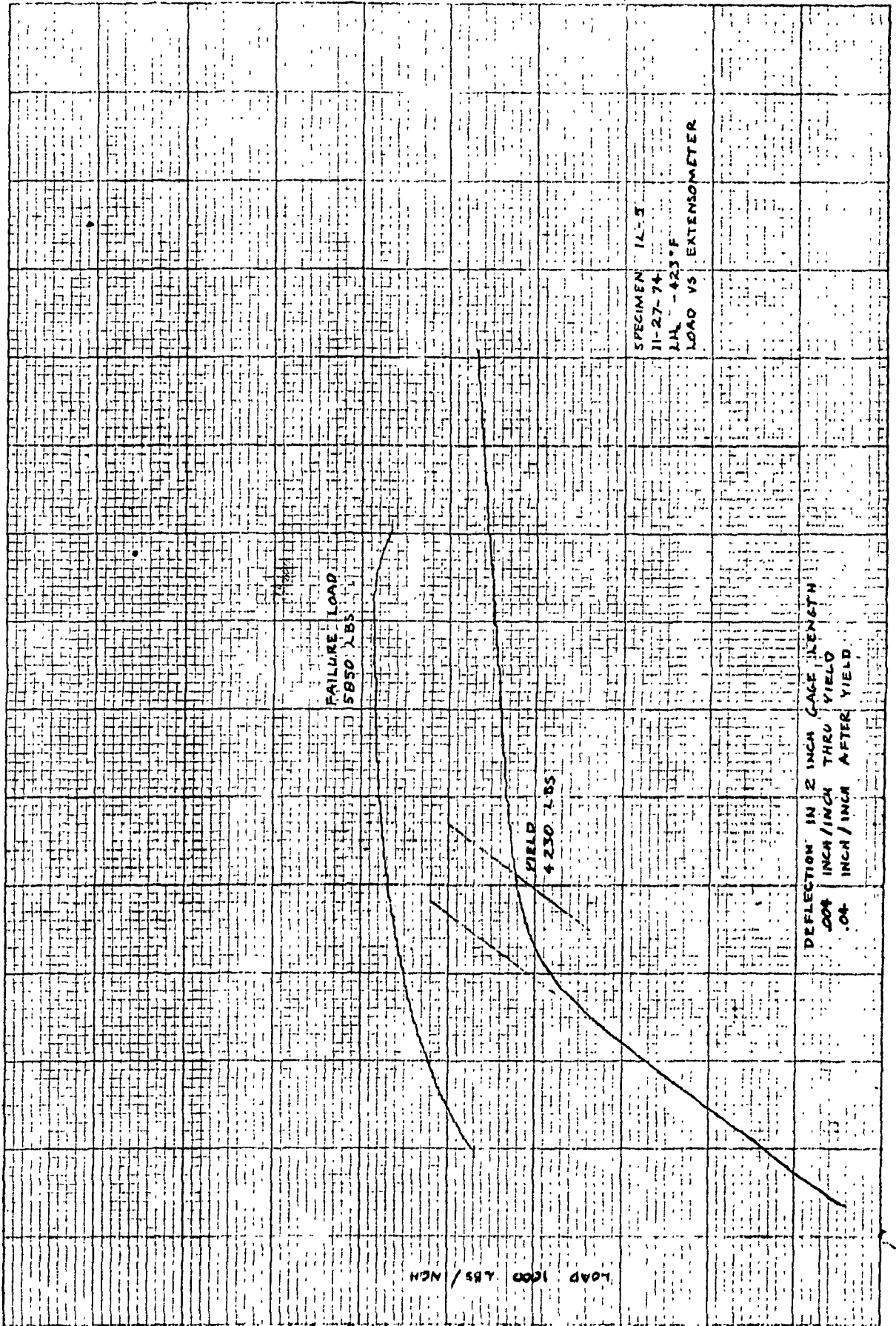






1-6
35





SPECIMEN 11-27-74
 11L - 423°F
 LOAD VS EXTENSOMETER

FAILURE LOAD
 5850 LBS

YIELD
 4230 LBS

LOAD 1000 LBS / CM

DEFLECTION IN 2 INCH GAGE LENGTH
 1000 INCH / INCH THRU YIELD
 .04 INCH / INCH AFTER YIELD

11-27-74

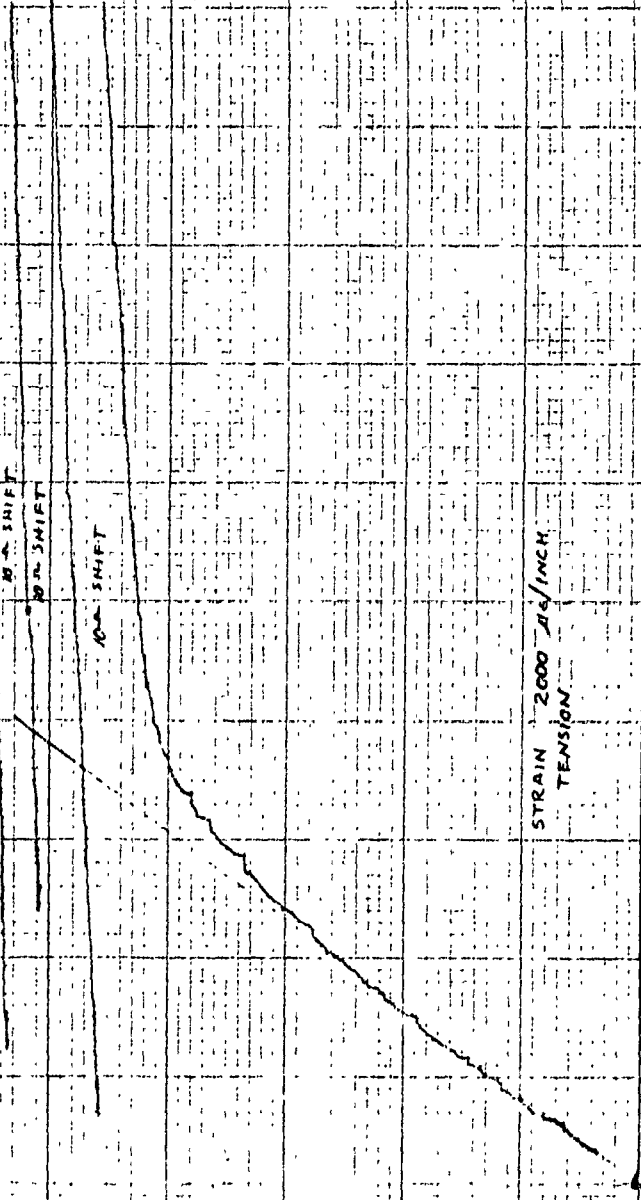
SPECIMEN 1L-5
11-27-74
LH - 423°F
LOAD VS AXIAL STRAIN GAGE

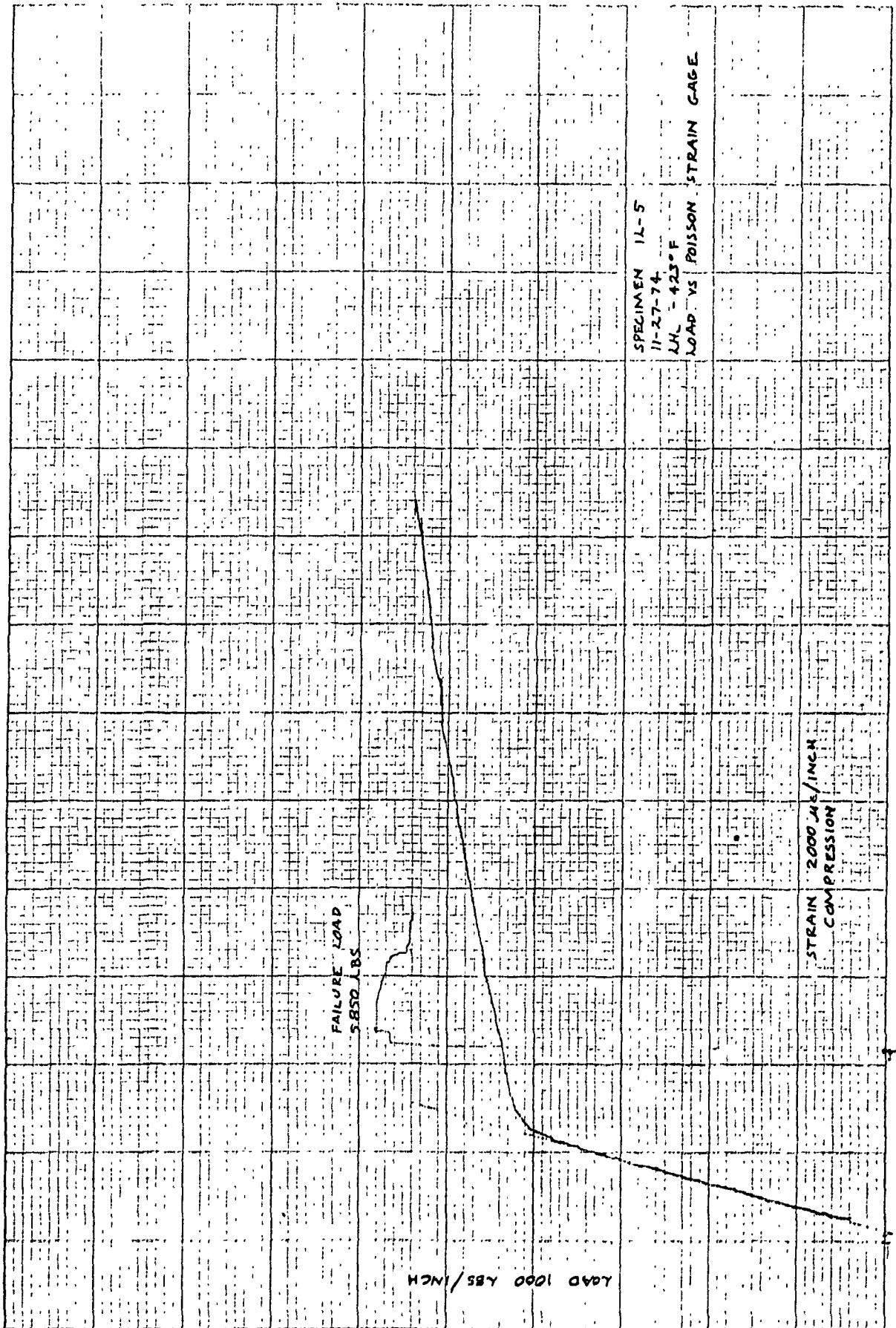
FAILURE LOAD
5850 LBS

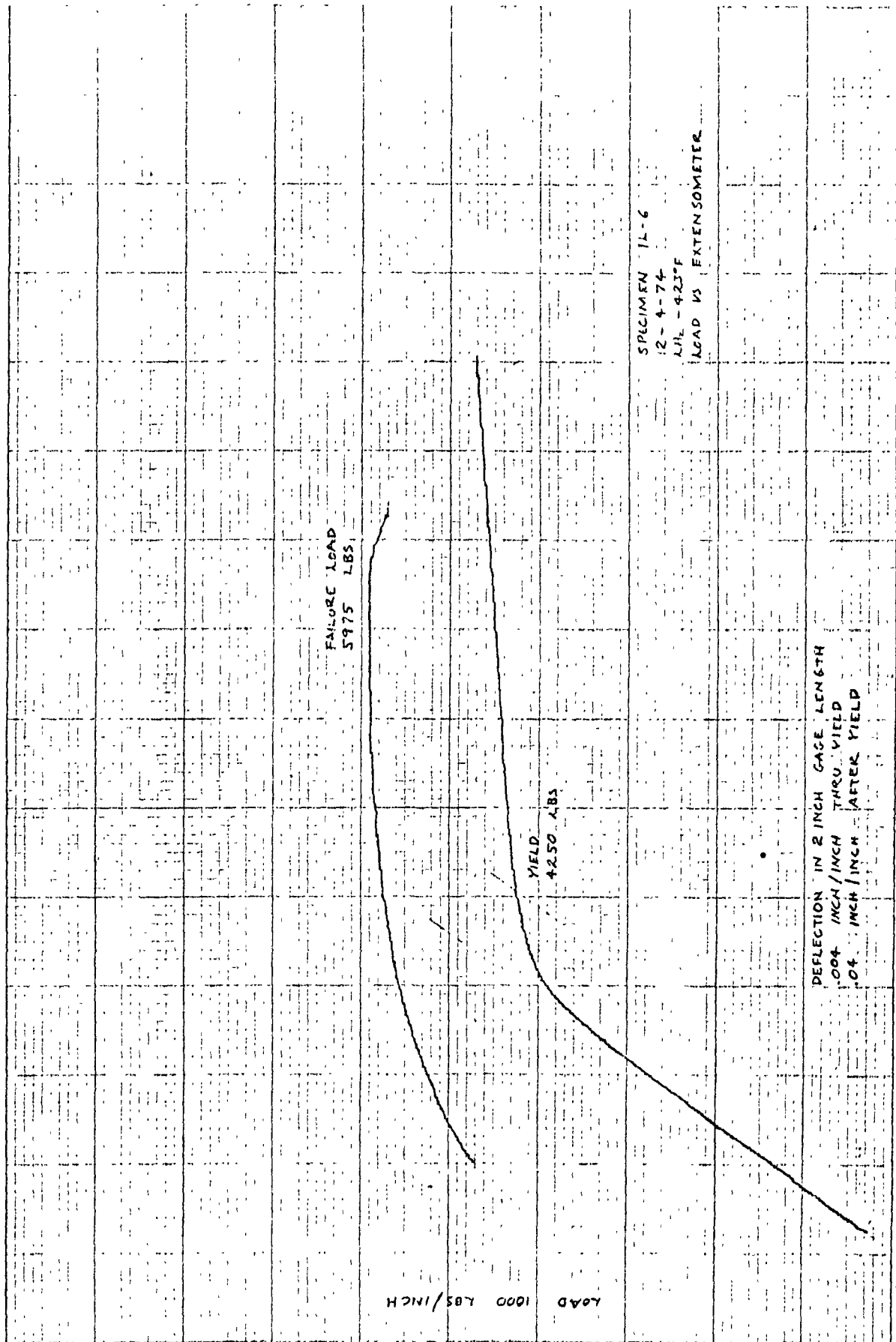
LOAD 1000 LBS/INCH

STRAIN 2000 μ /INCH
TENSION

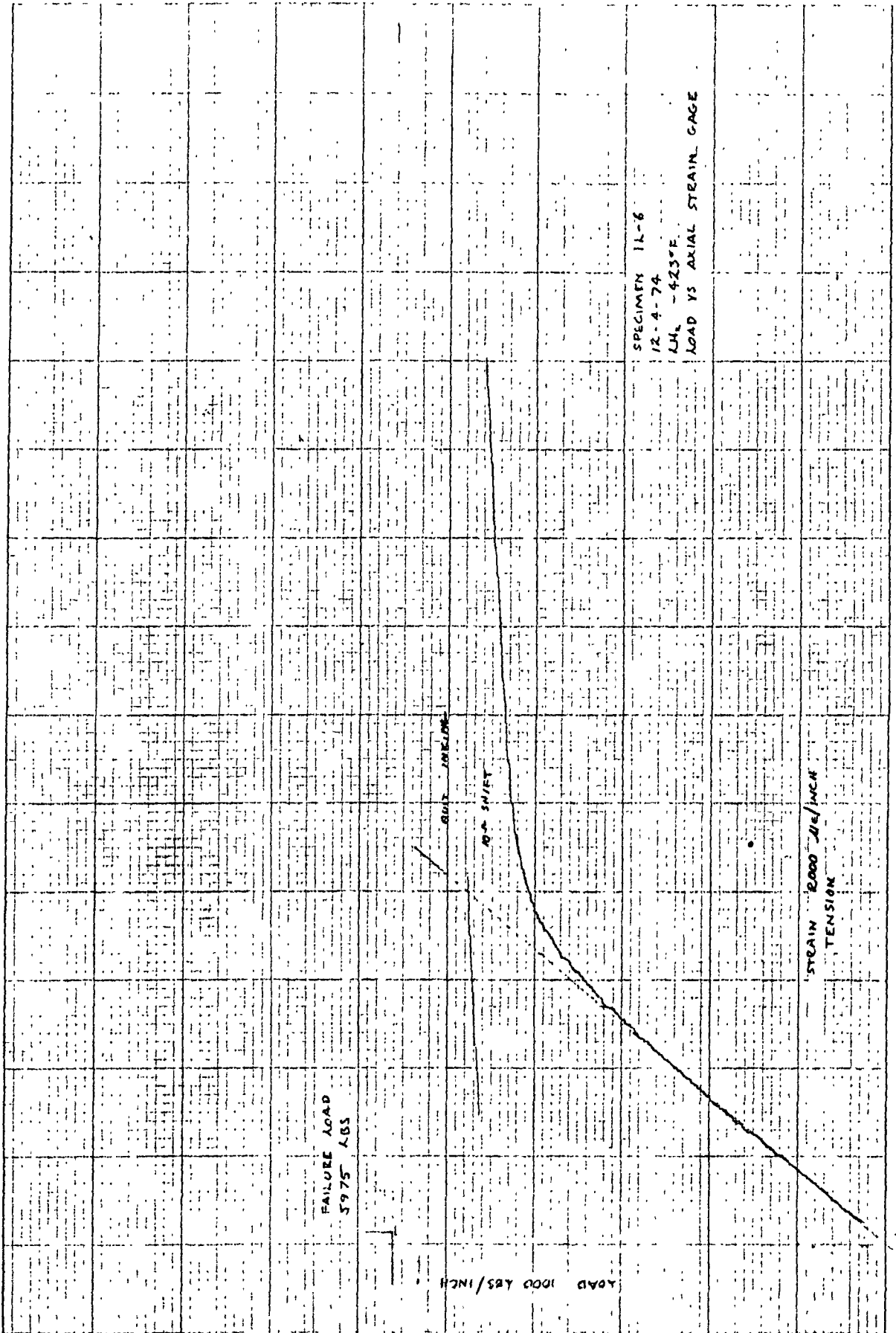
10% SHIFT
20% SHIFT
30% SHIFT

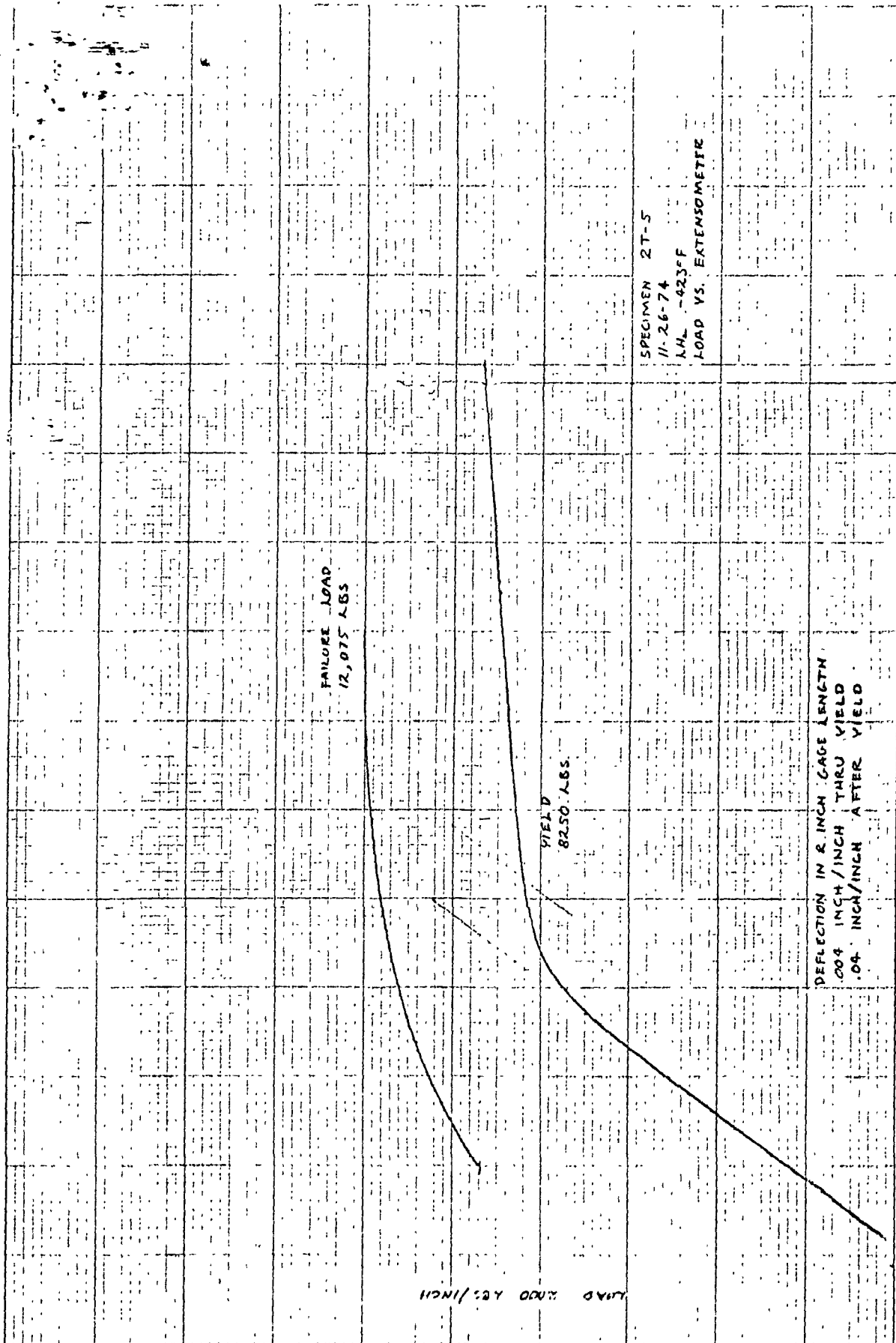


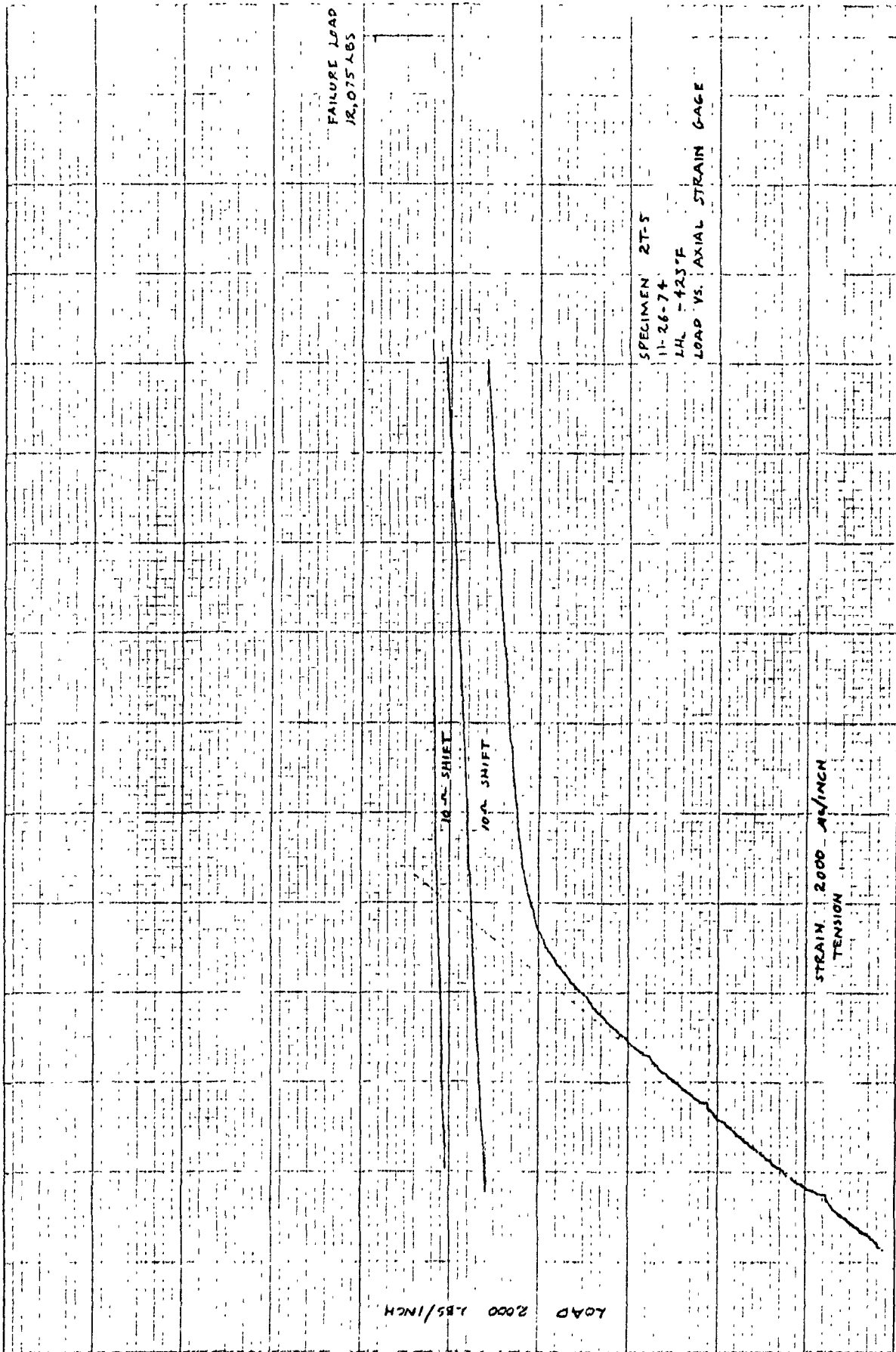


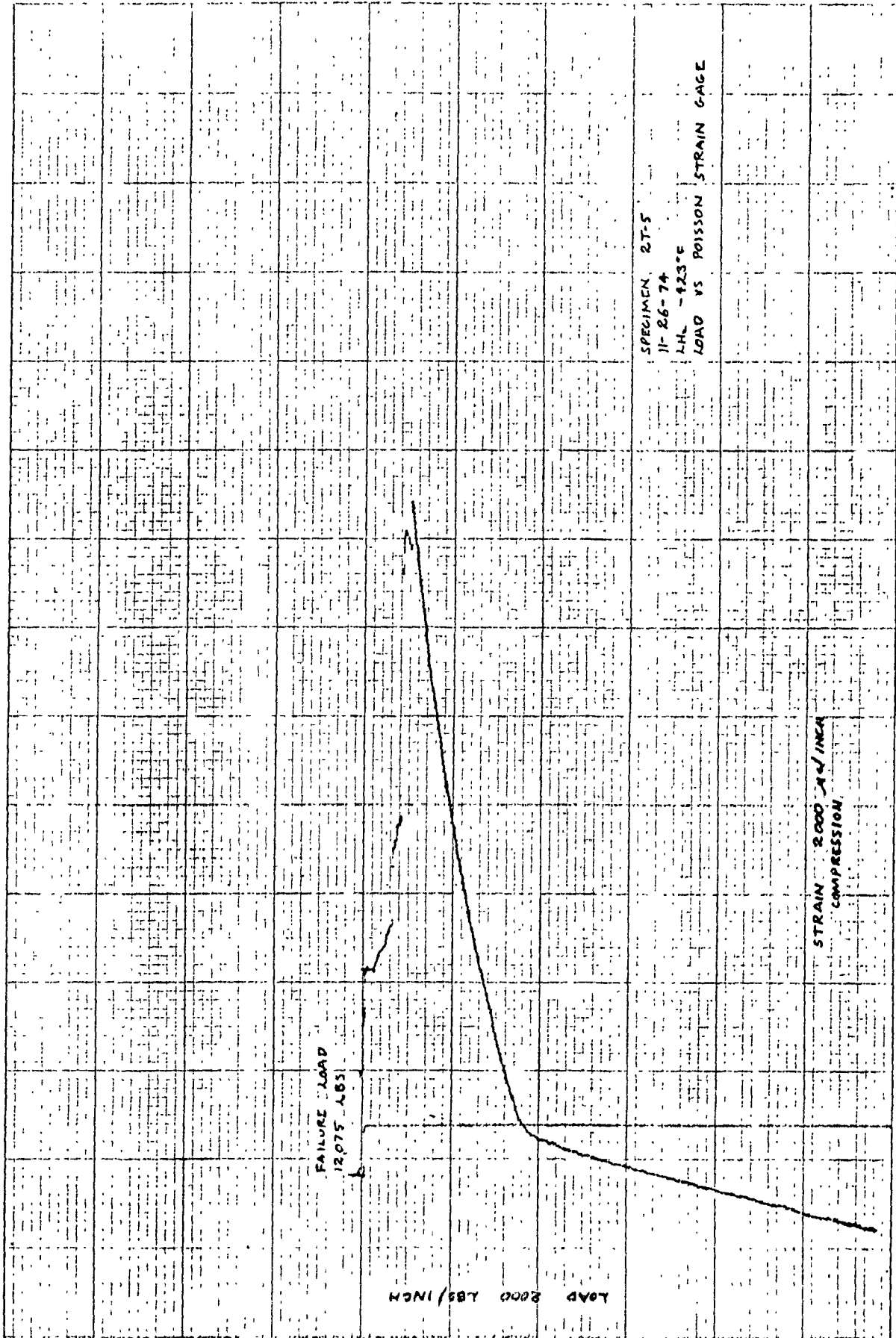


12-10-1974 11:00 AM

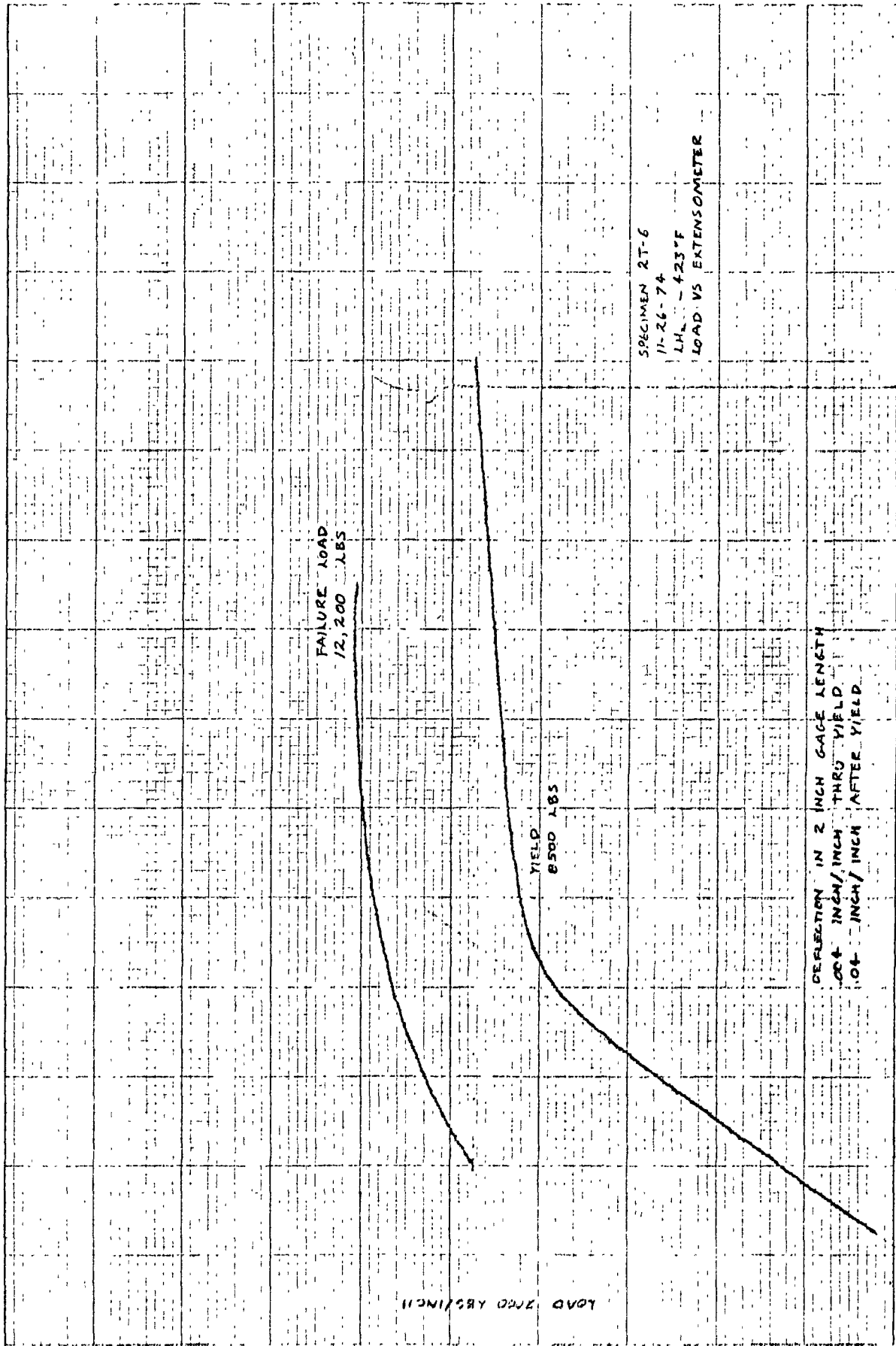


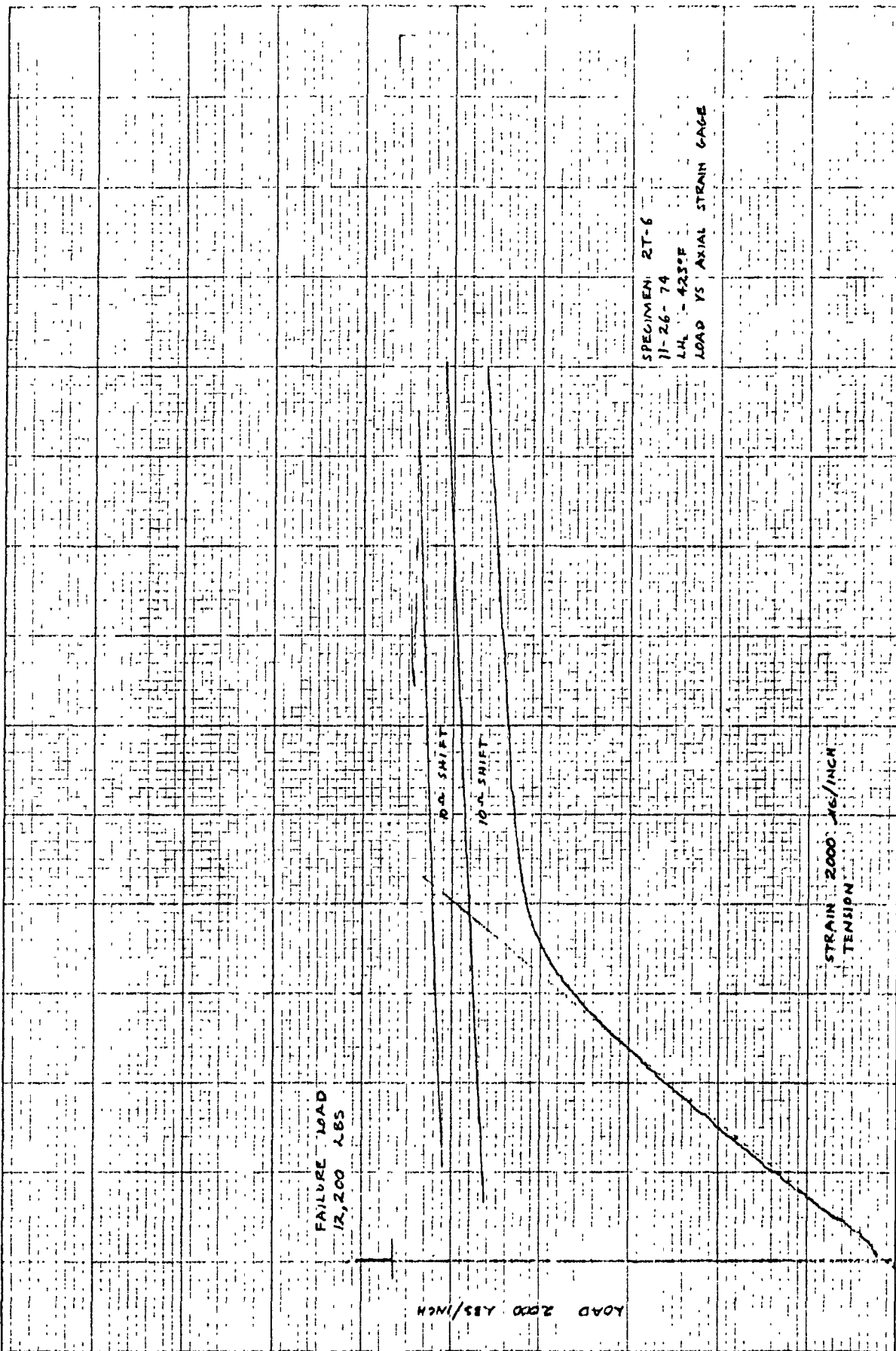


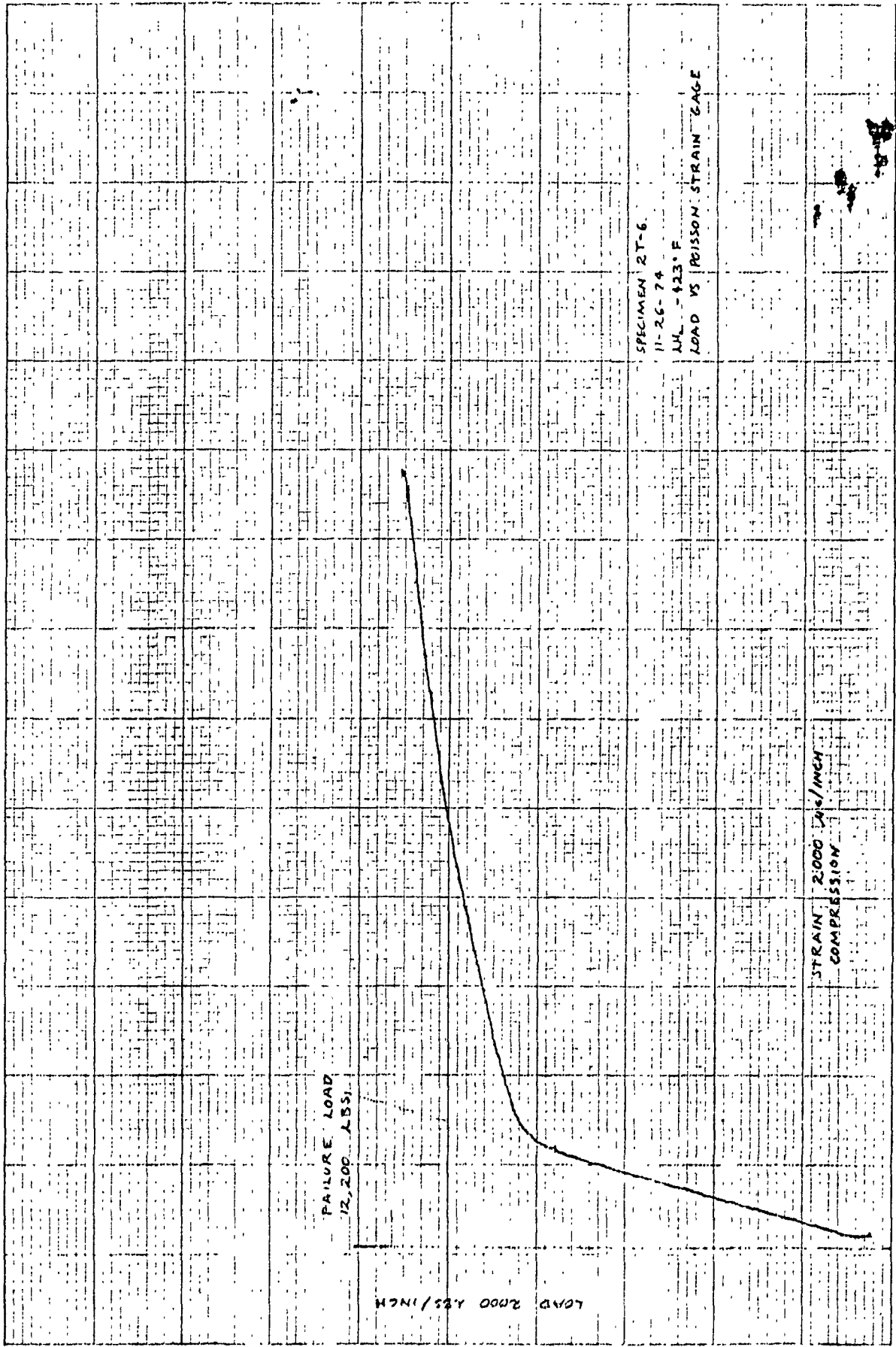


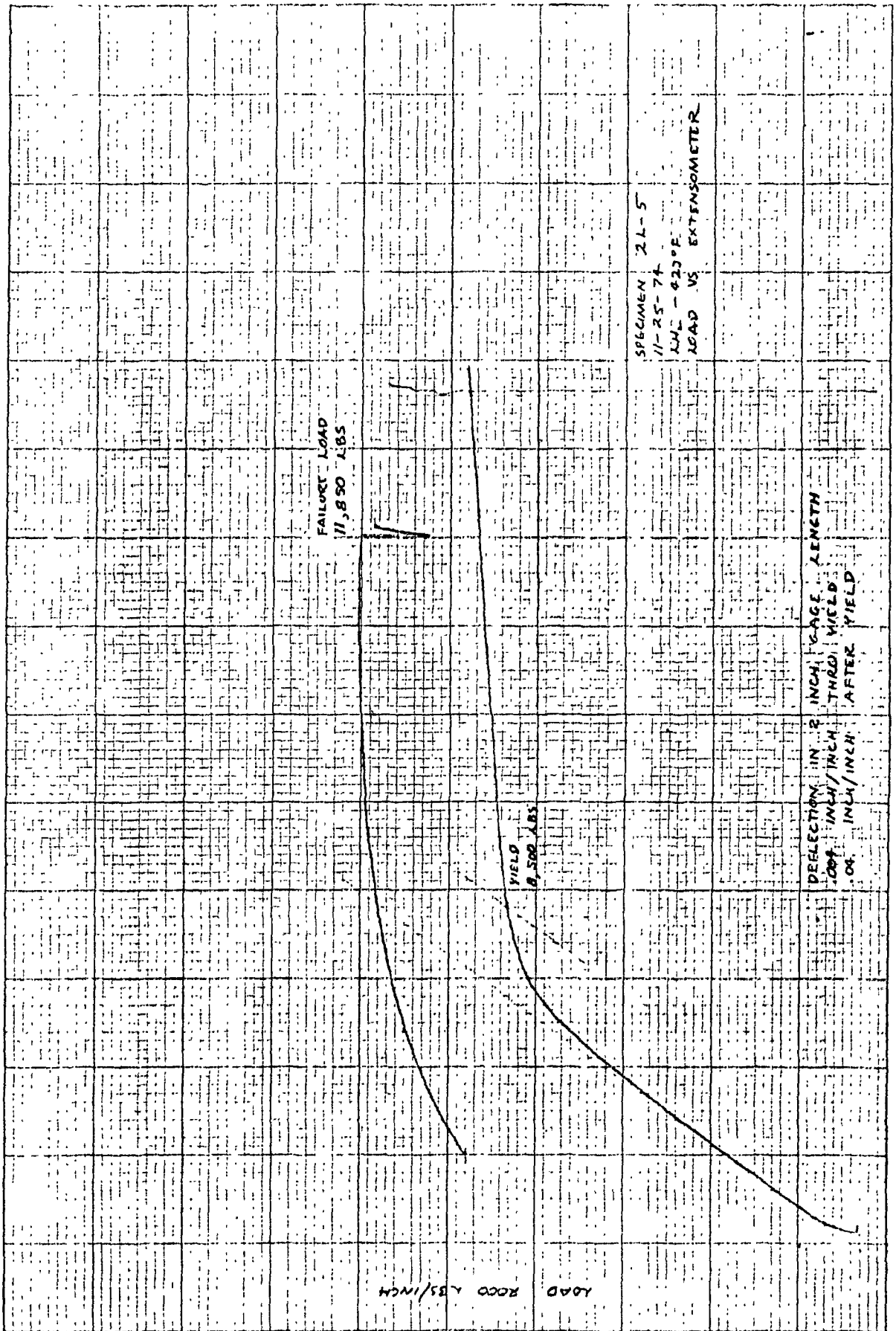


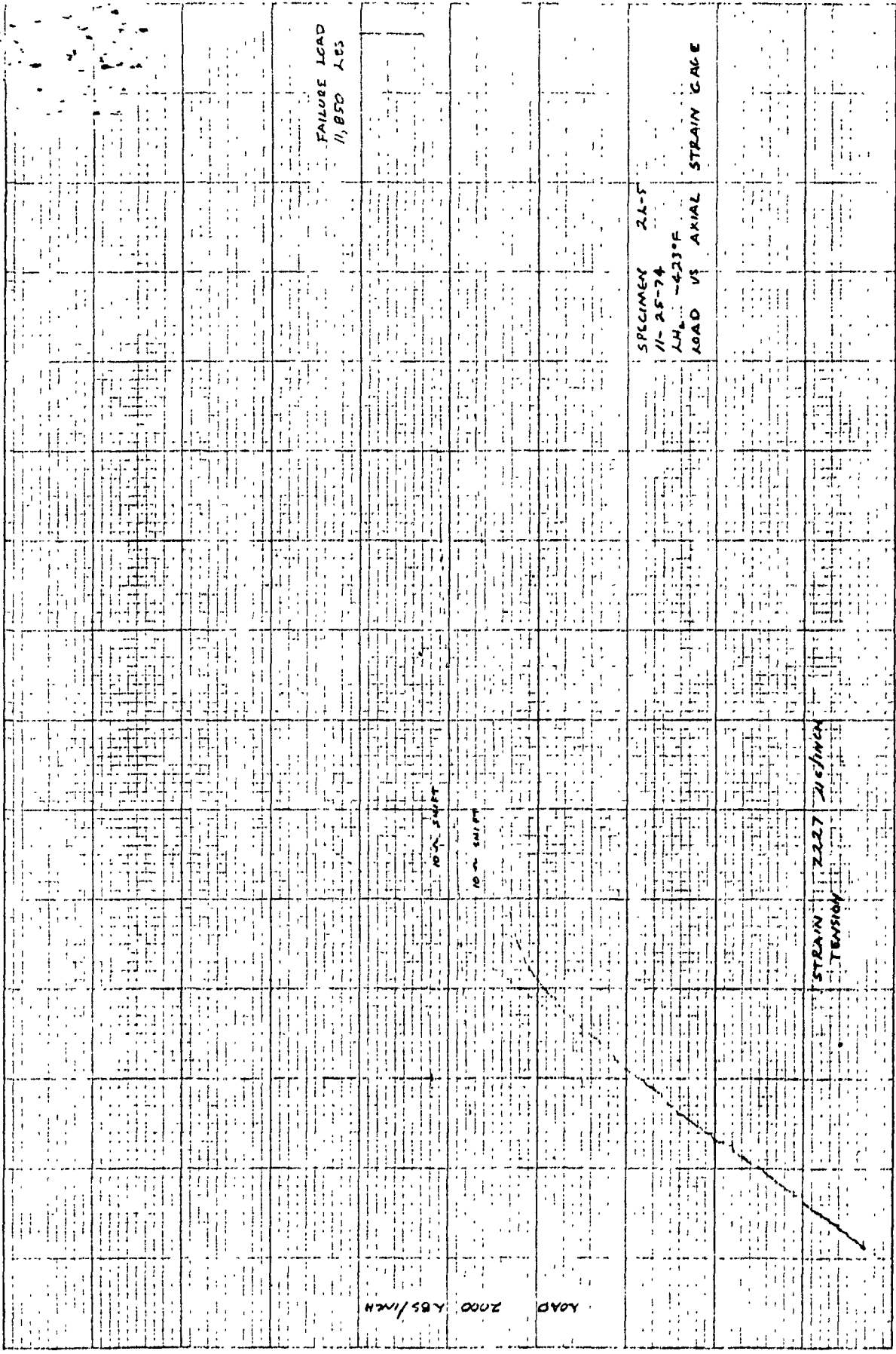
K-E 11-26-74 11-26-74

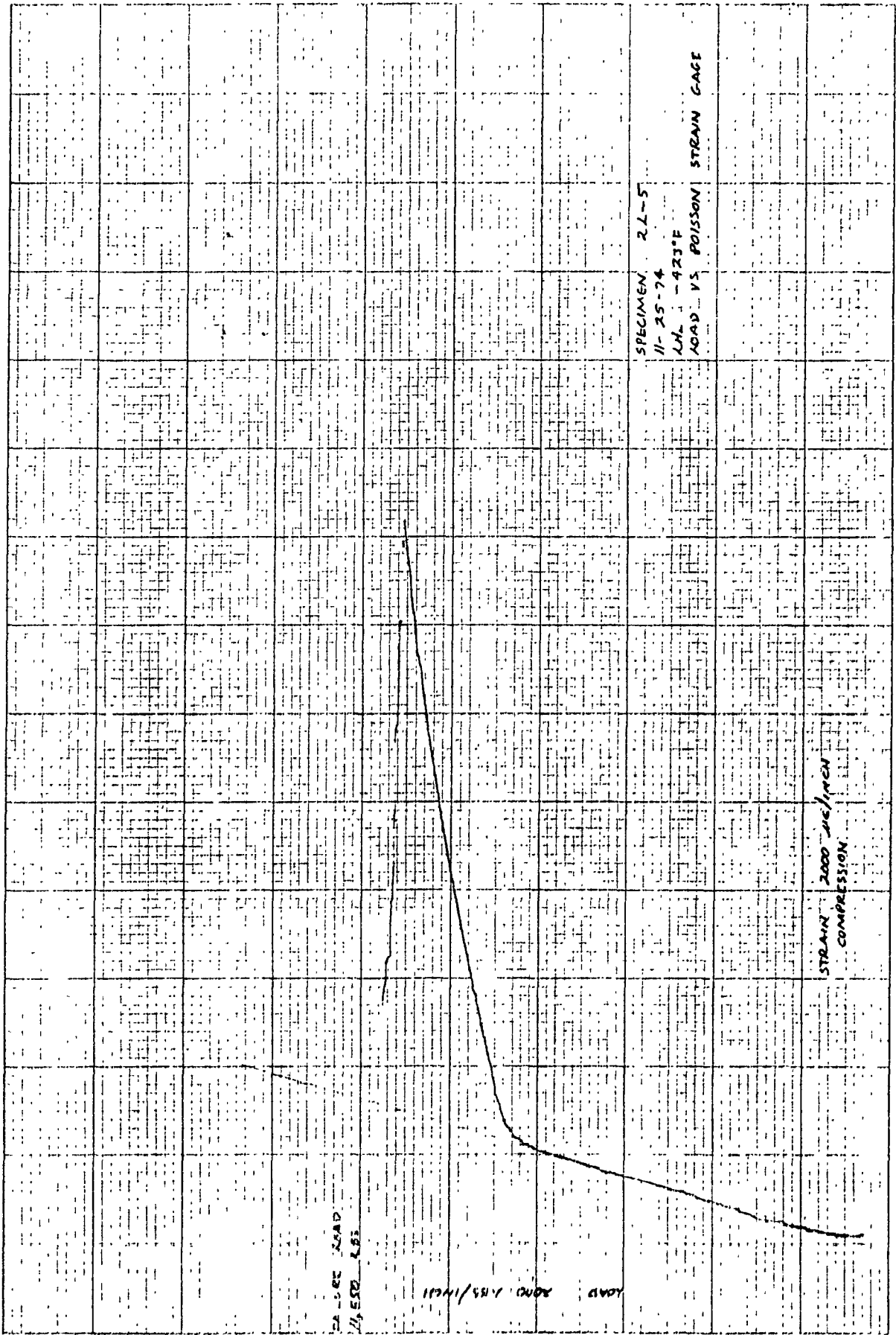


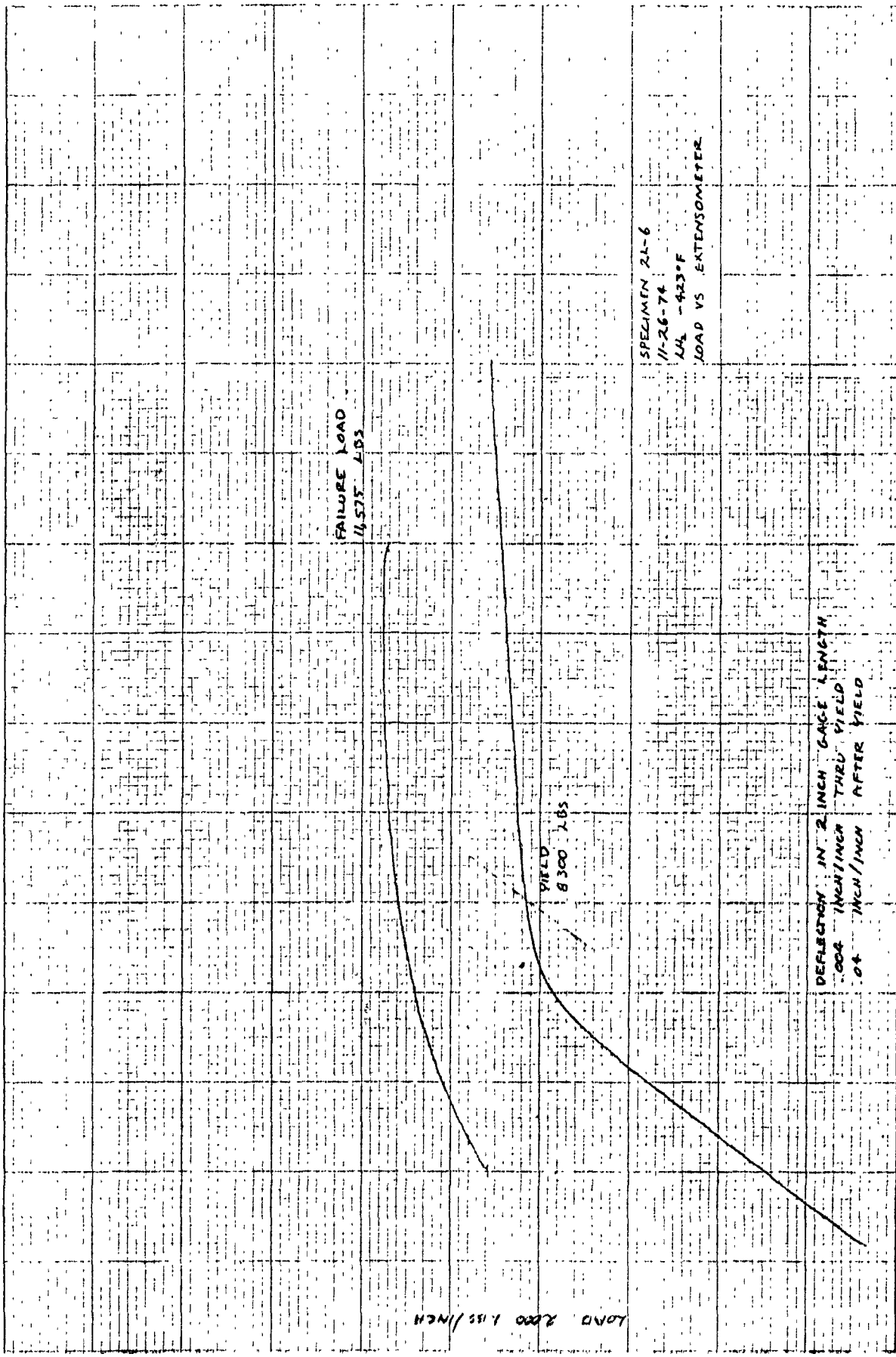












SPECIMEN 21-6
 11-26-74
 LH - 423°F
 LOAD VS. EXTENSOMETER

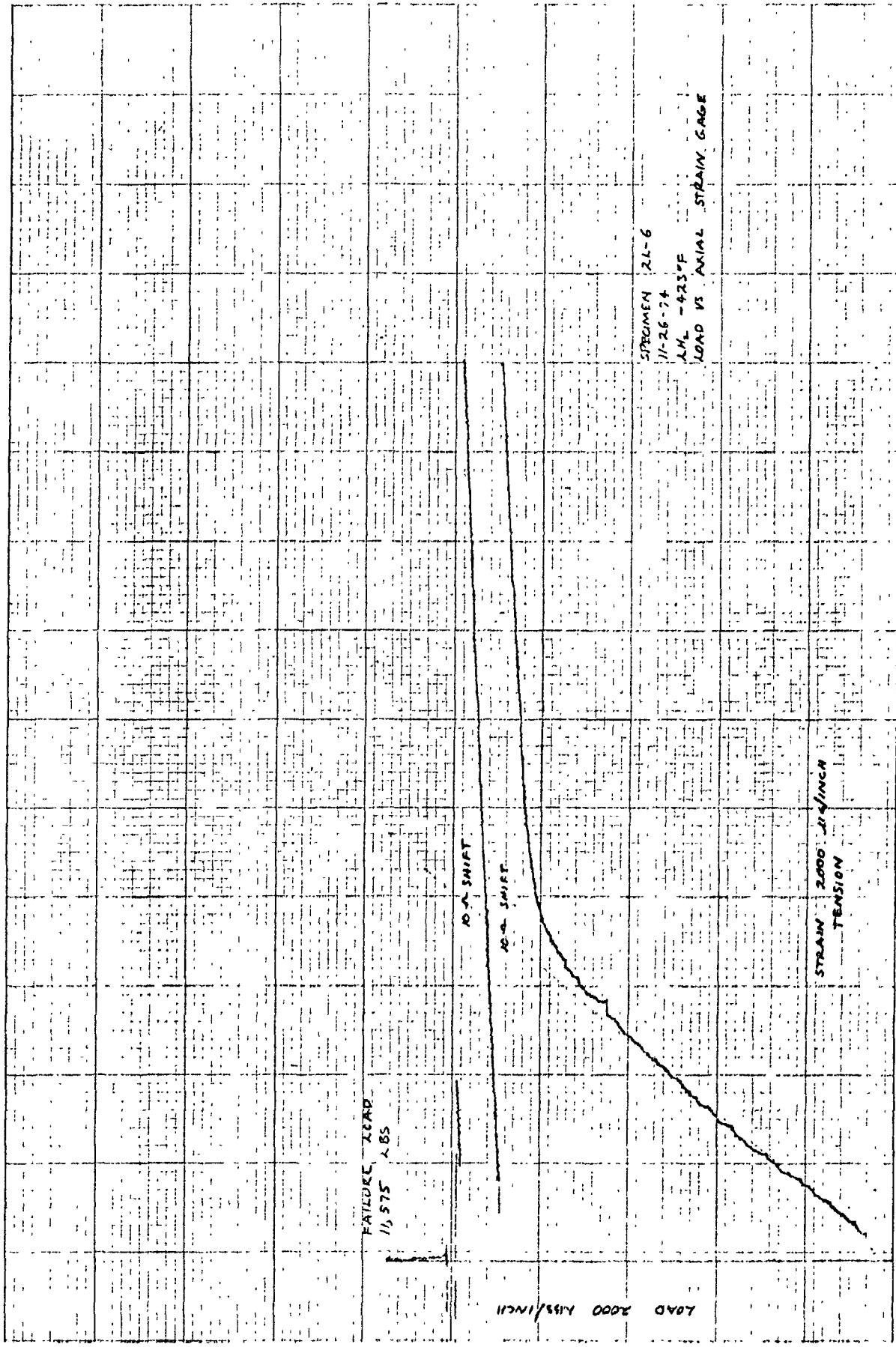
FAILURE LOAD
 11575 LBS

YIELD
 8300 LBS

DEFLECTION IN 2 INCH GAGE LENGTH
 0.04 INCH/INCH
 AFTER YIELD

LOAD 2000 LBS/INCH

(10) IN 2 IN GAGE LENGTH
 AFTER YIELD



SPECIMEN 2L-6
 11-26-74
 AL₂O₃ - 423°F
 LOAD VS AXIAL STRAIN GAGE

LOAD 2000 LBS/INCH

STRAIN 2000 IN/INCH TENSION

FAILURE LOAD
70,575 LBS

10% SHIFT

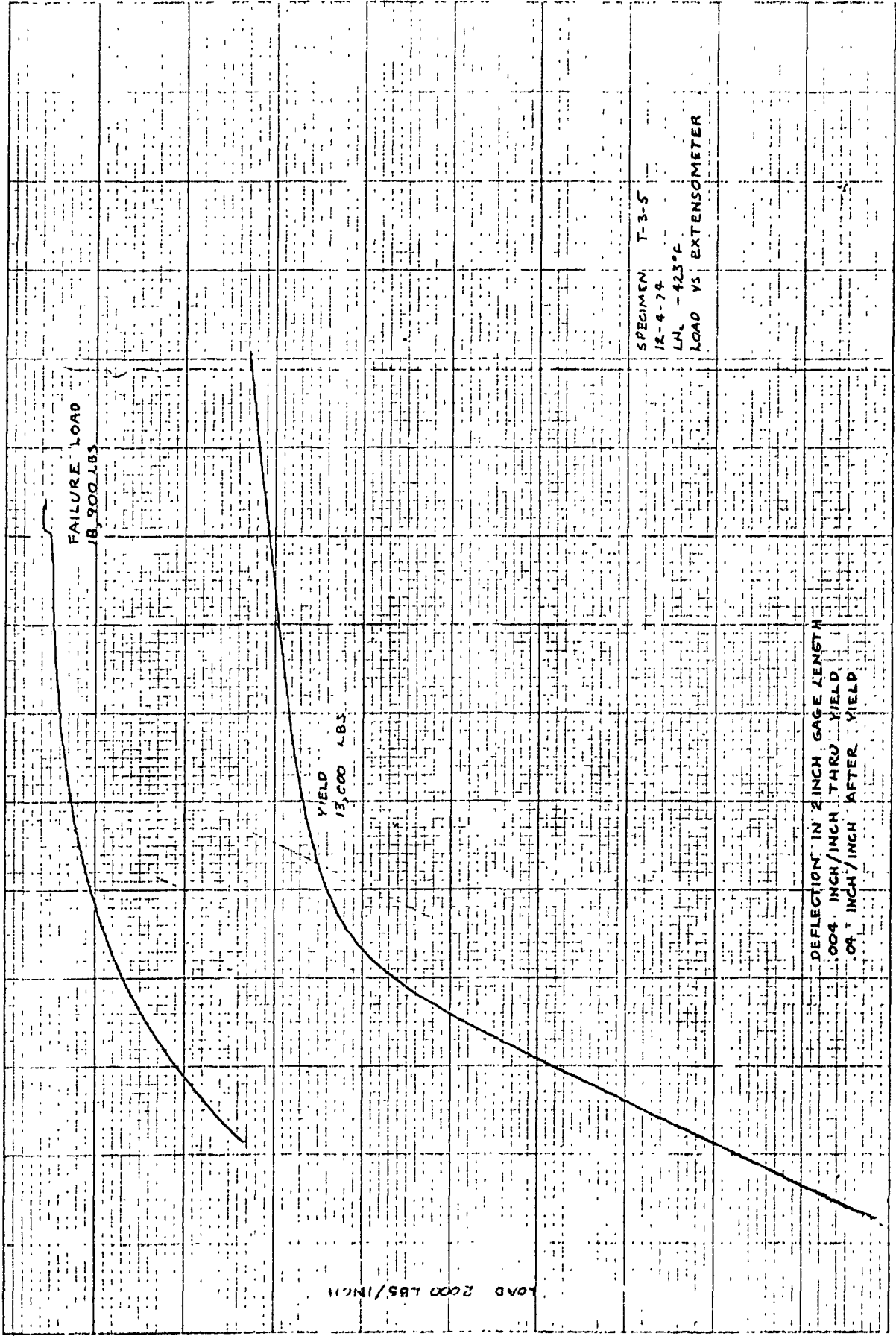
10% SHIFT

SPECIMEN: 2L-6
11-26-74
LM - 423°F
LOAD VS. POISSON STRAIN GAGE

FAILURE LOAD
11,575 LBS

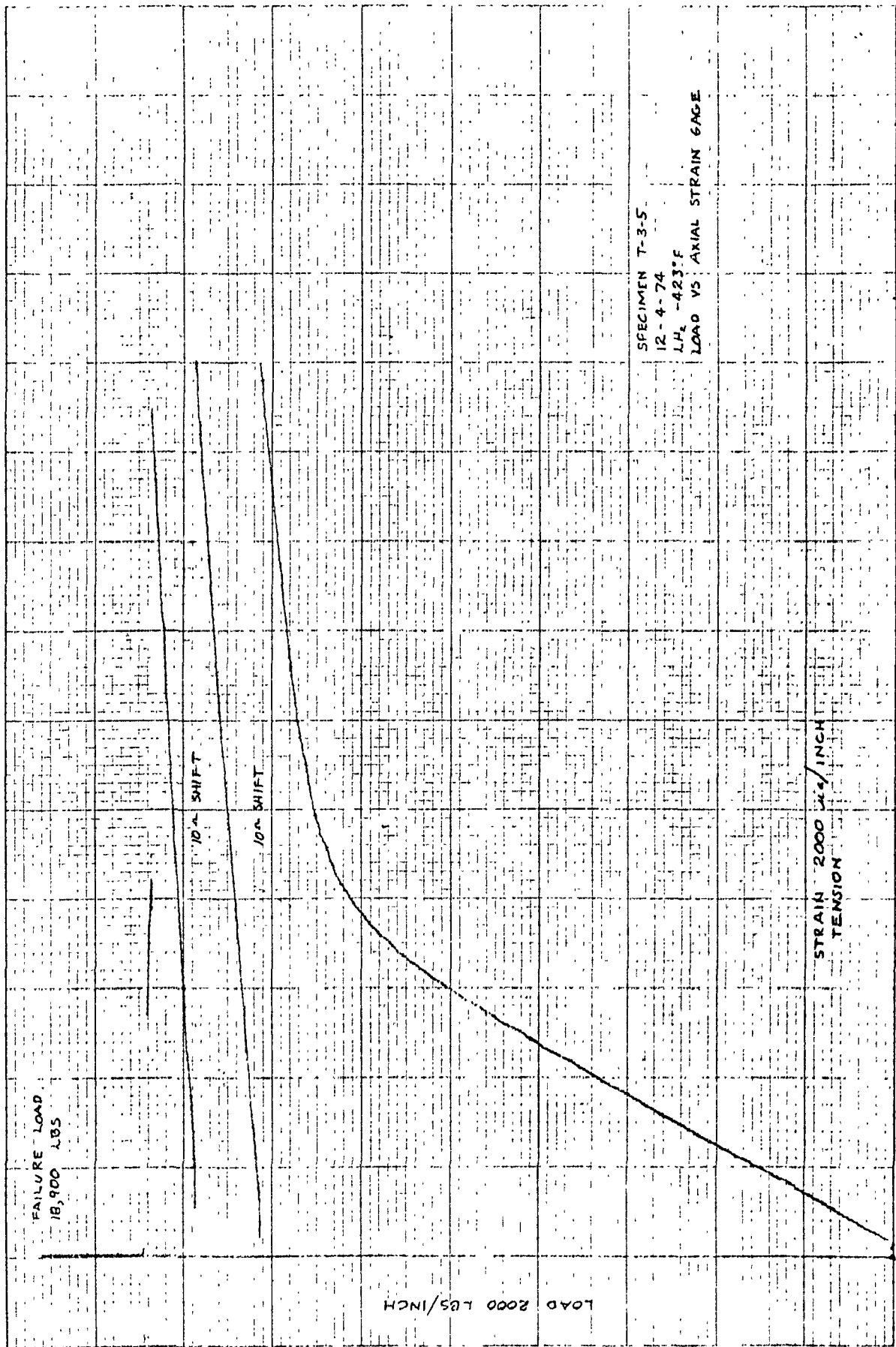
STRAIN 2000 μ /INCH
COMPRESSION

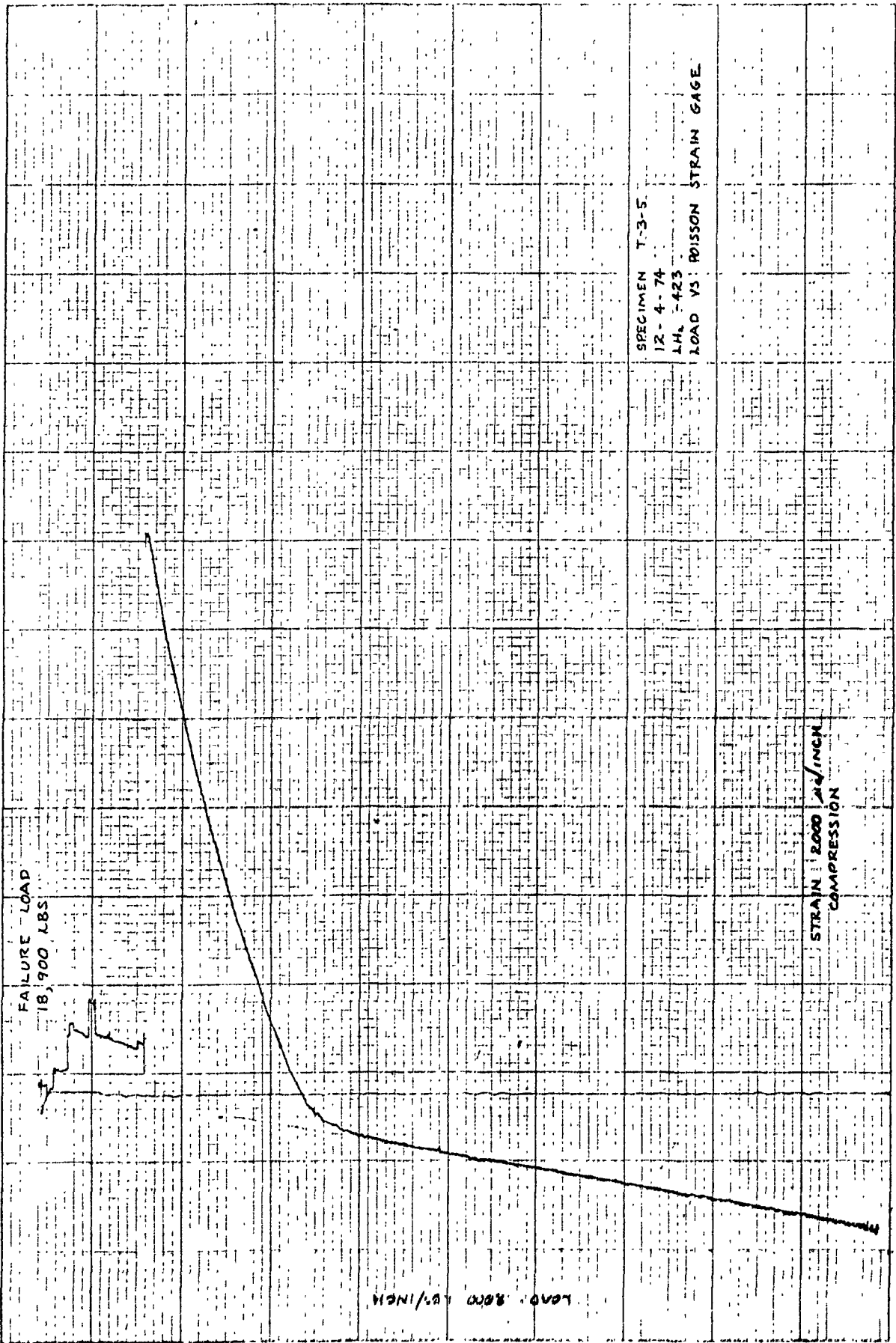
LOAD 1000 LBS/INCH

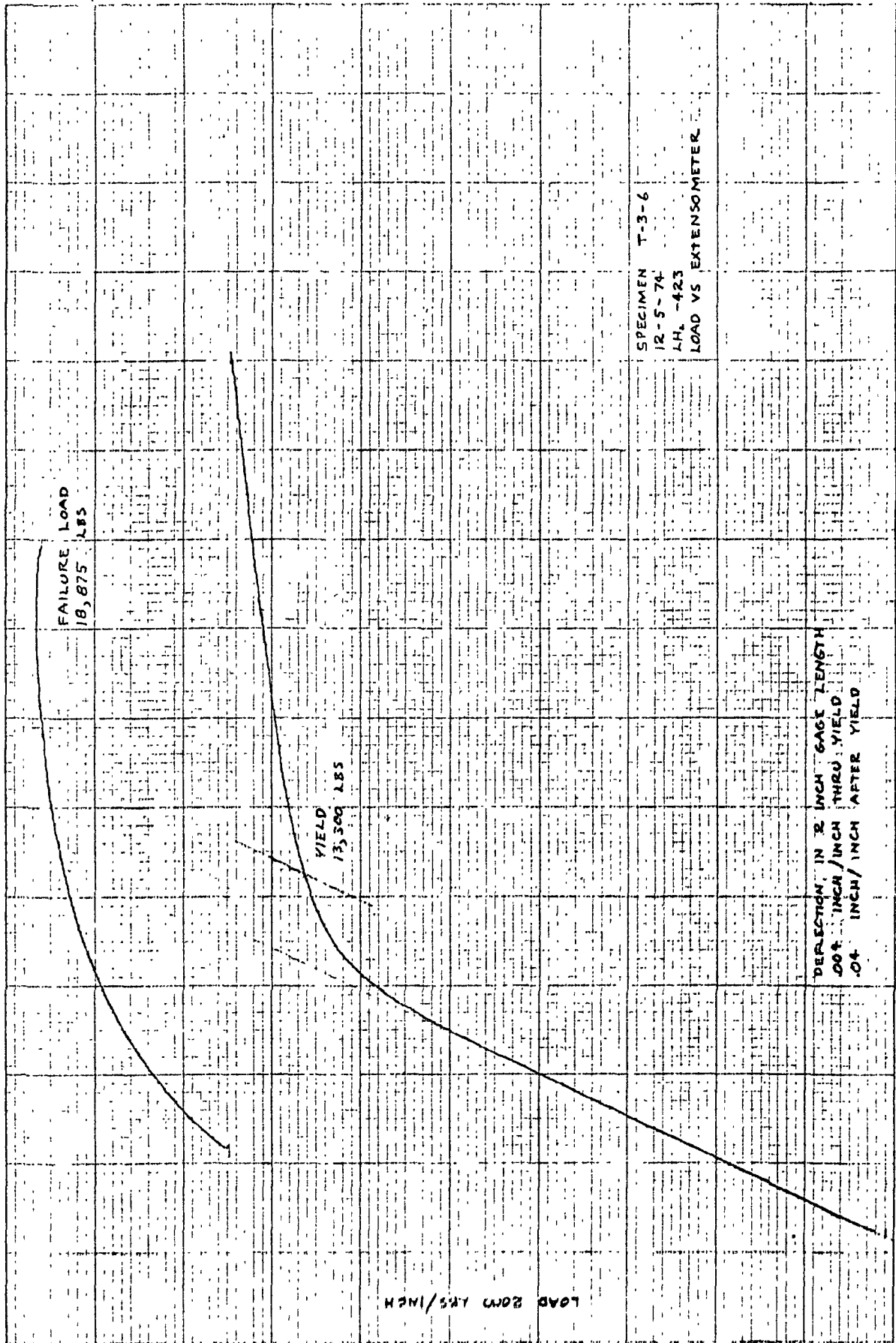


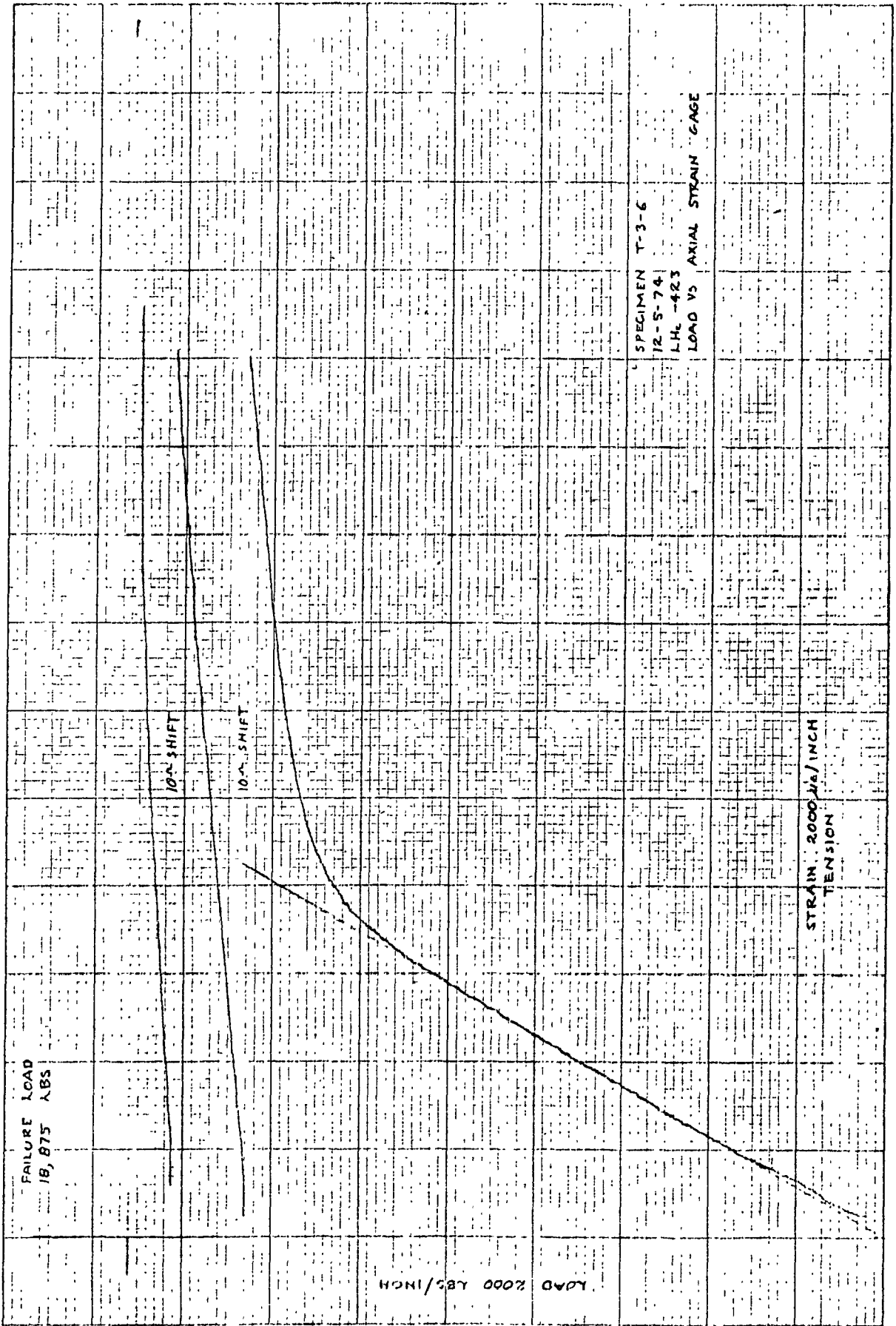
K-2
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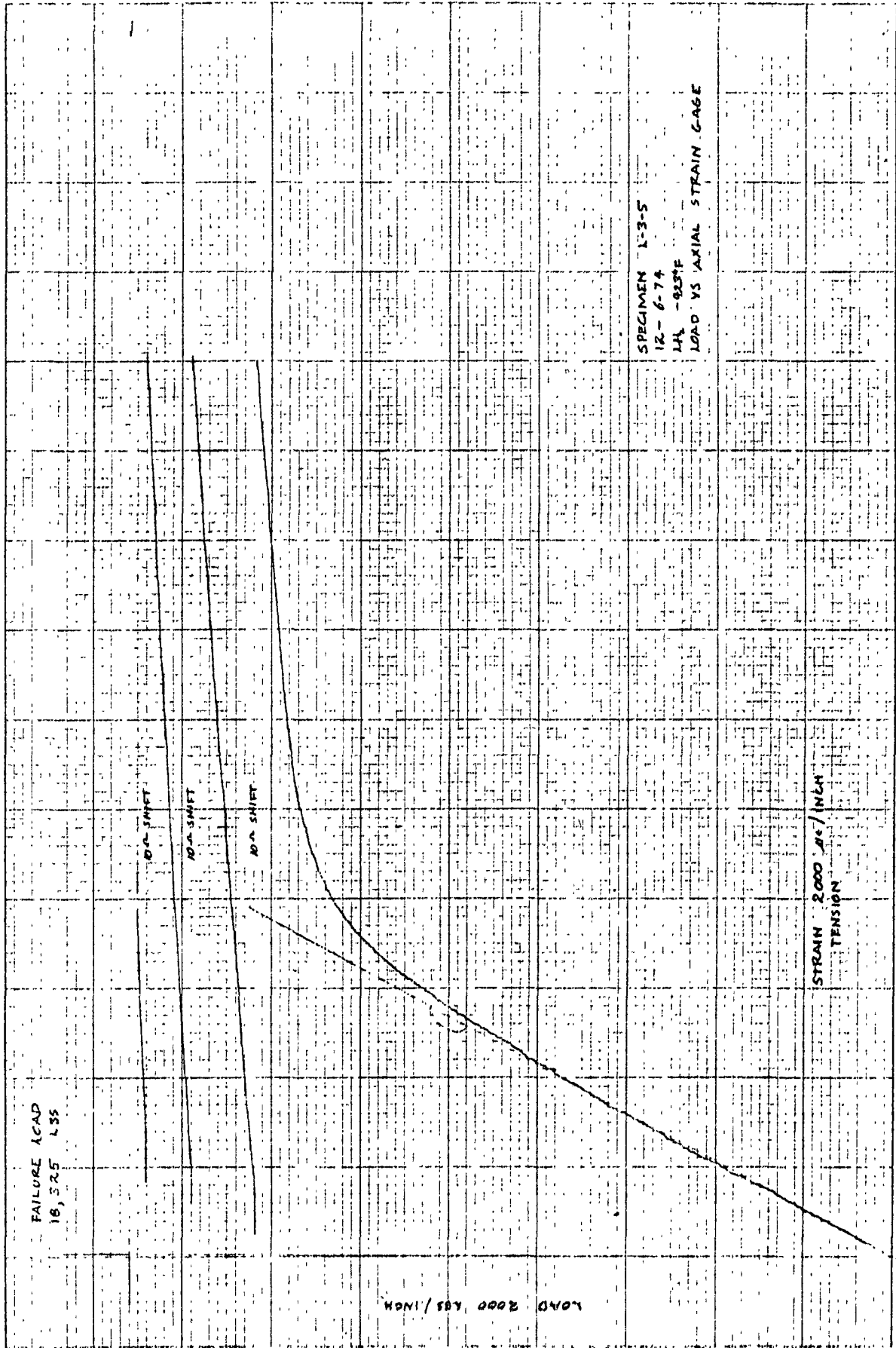
SPECIMEN T-3-5
12-4-74
LH₂ -423°F
LOAD VS AXIAL STRAIN GAGE

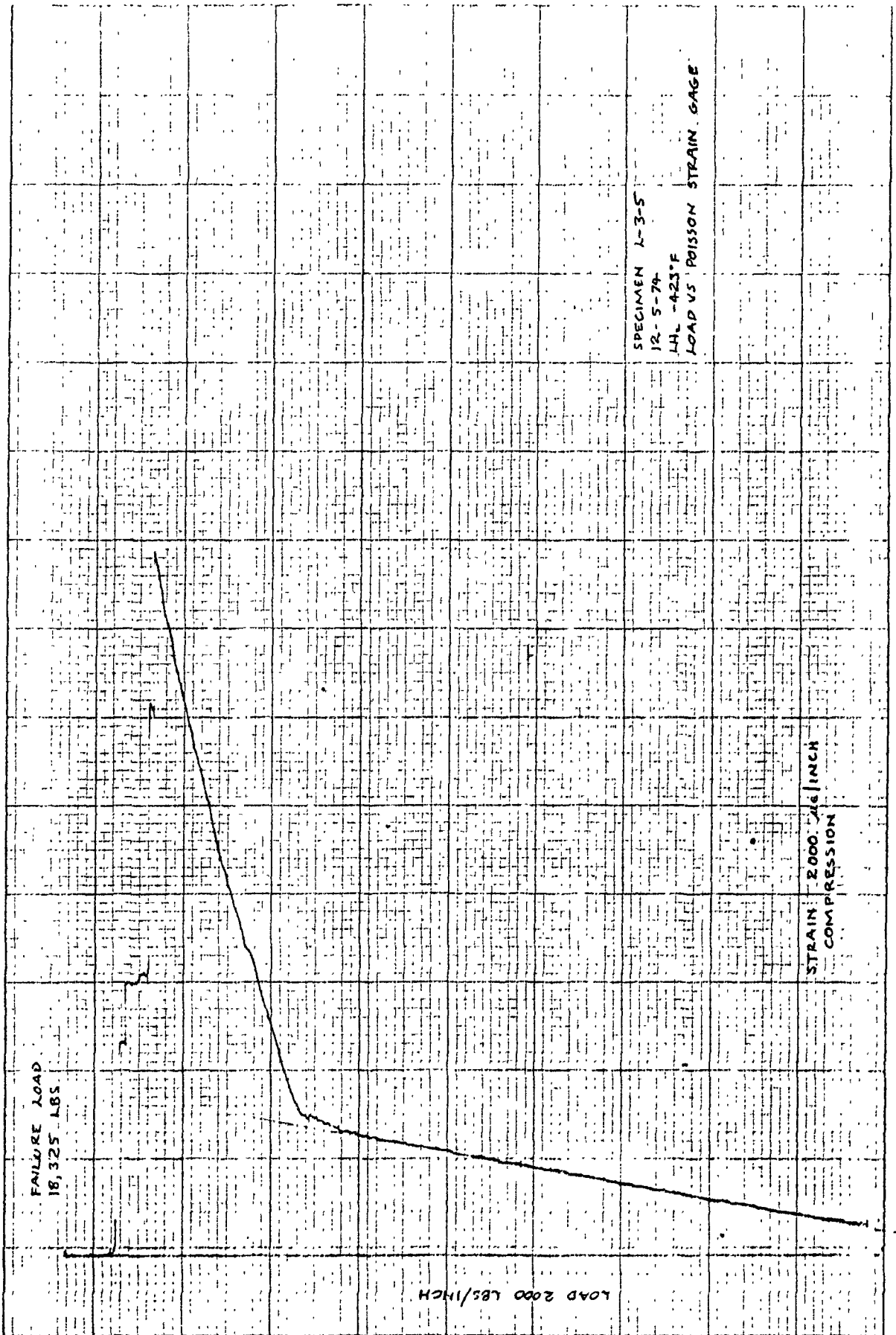


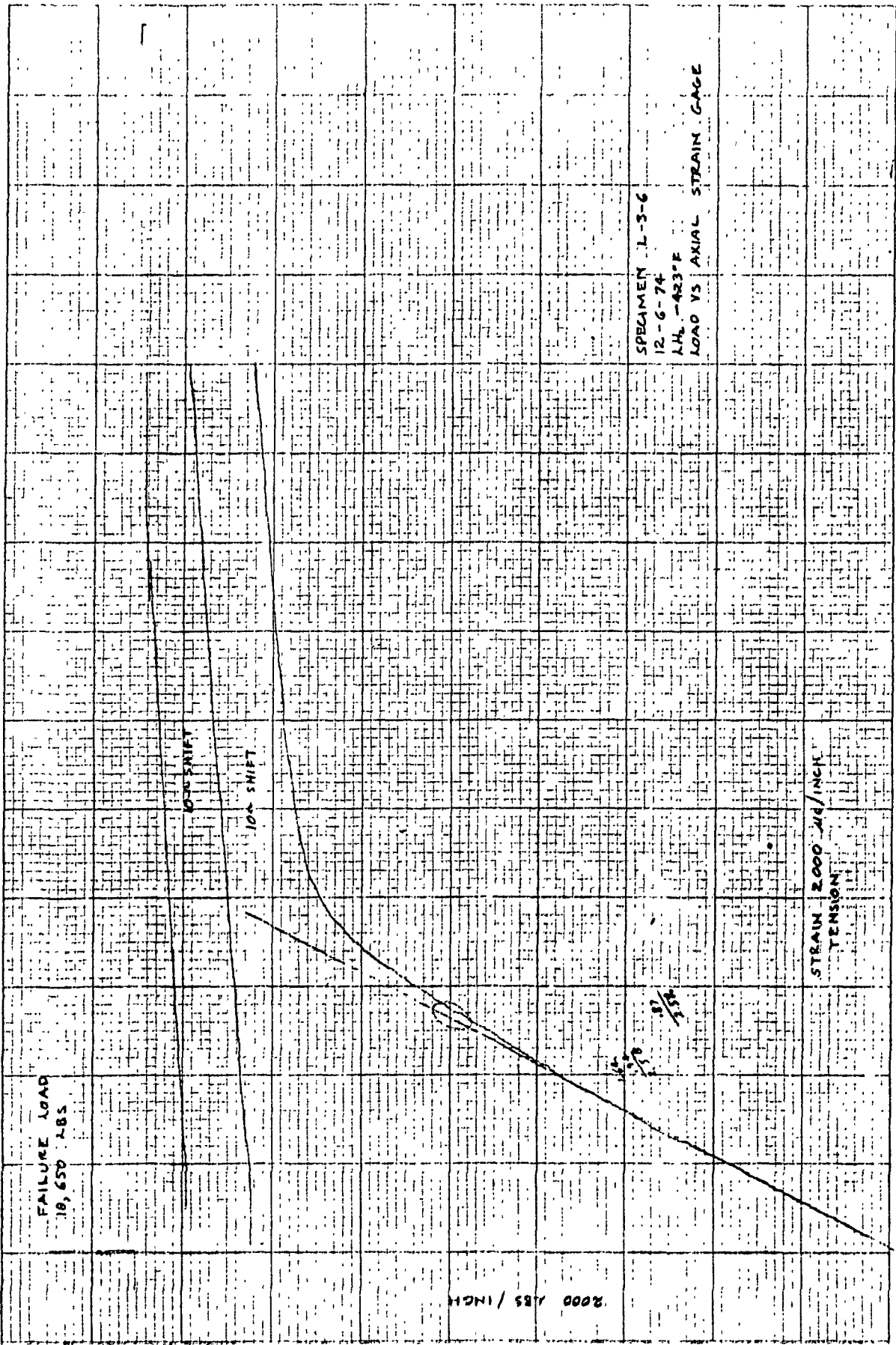












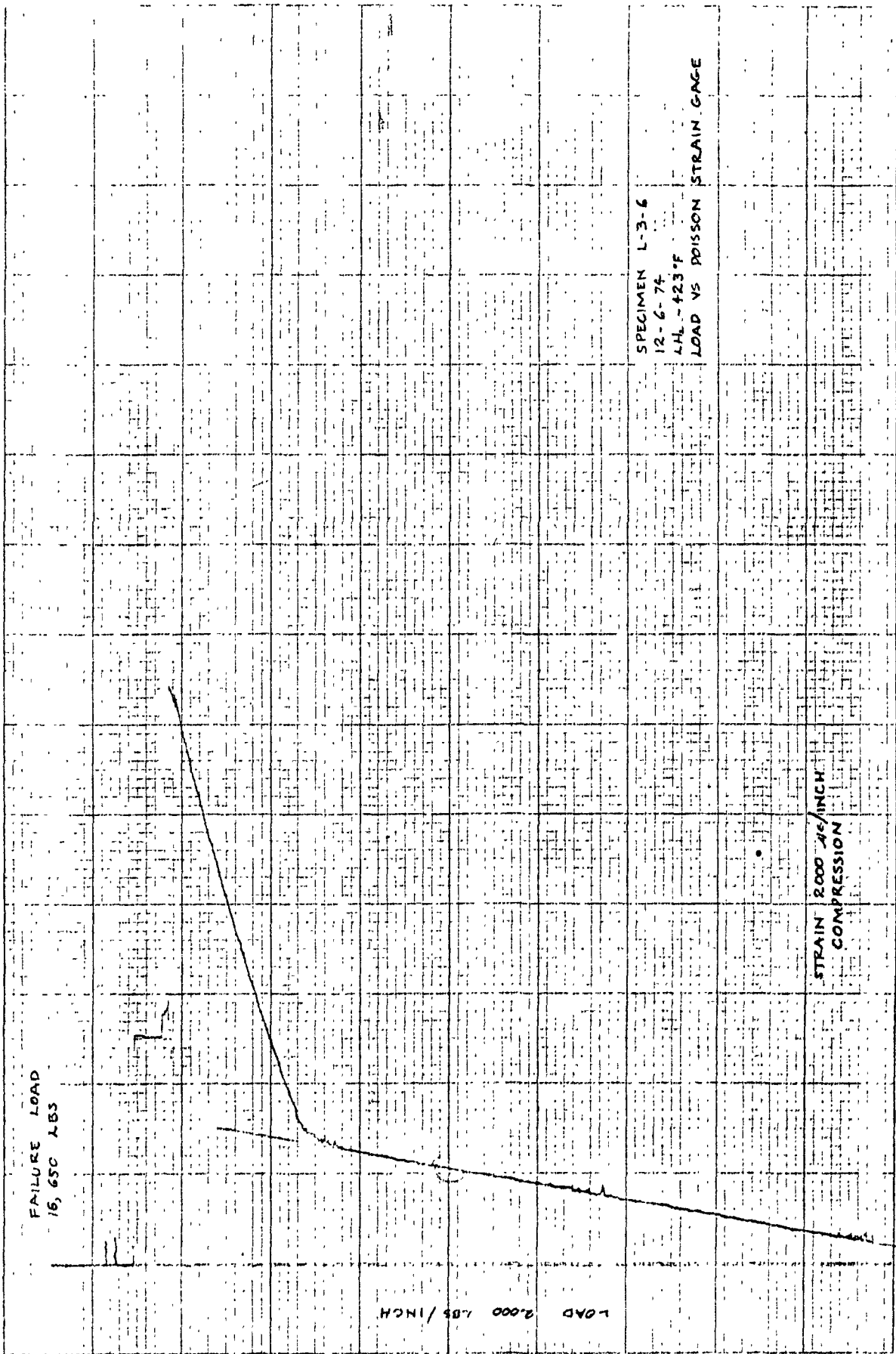
SPECIMEN L-3-6
 12-6-74
 LH -423°F
 LOAD VS AXIAL STRAIN GAGE

FAILURE LOAD
 10,650 LBS

0.005 INCH
 10% SHIFT

2000 LBS / INCH

STRAIN 2000 IN/INCH
 TENSION

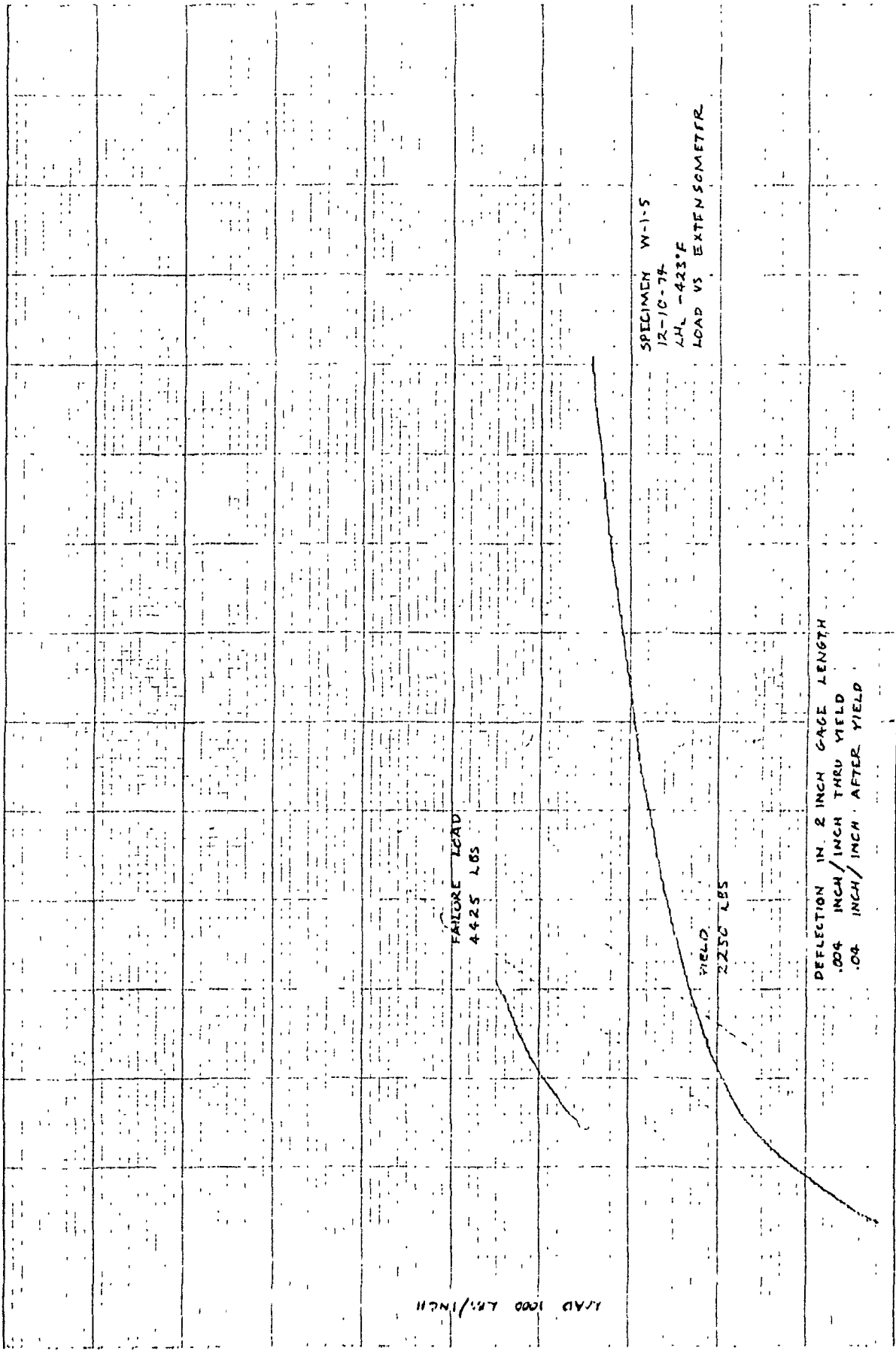


SPECIMEN L-3-6
 12-6-74
 44, -423°F
 LOAD VS POISSON STRAIN GAGE

STRAIN 2000 X 10⁻⁶ INCH
 COMPRESSION

FAILURE LOAD
 16,650 LBS

LOAD 2,000 LBS/INCH



SPECIMEN W-1-5
12-10-74
A.M. - 423°F
LOAD VS. AXIAL STRAIN GAGE.

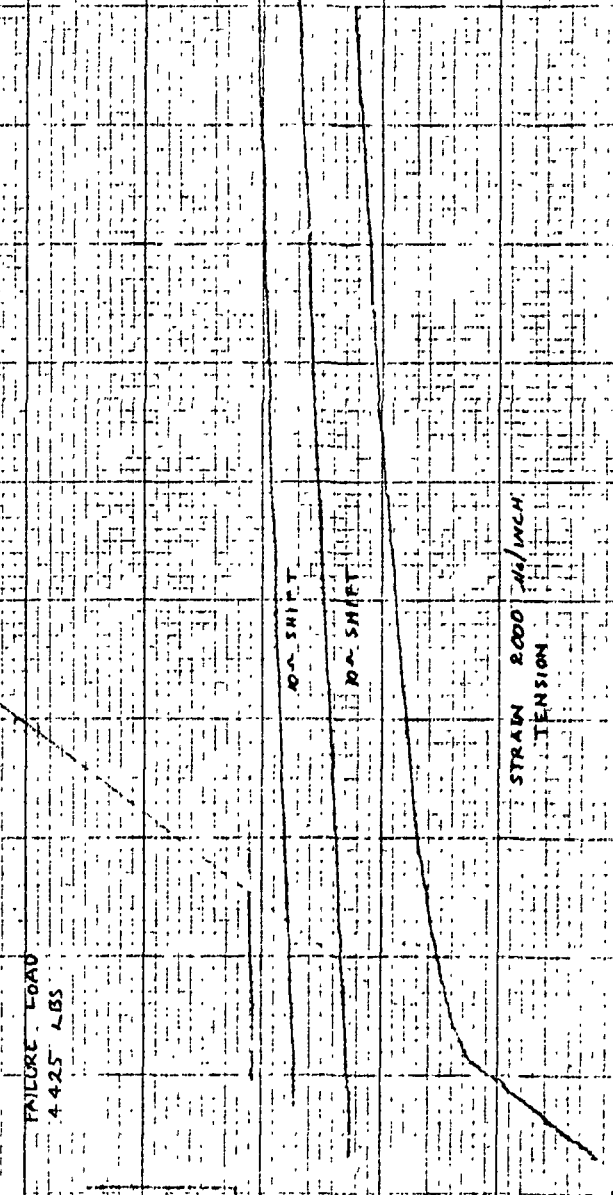
LOAD 1000 LBS/INCH

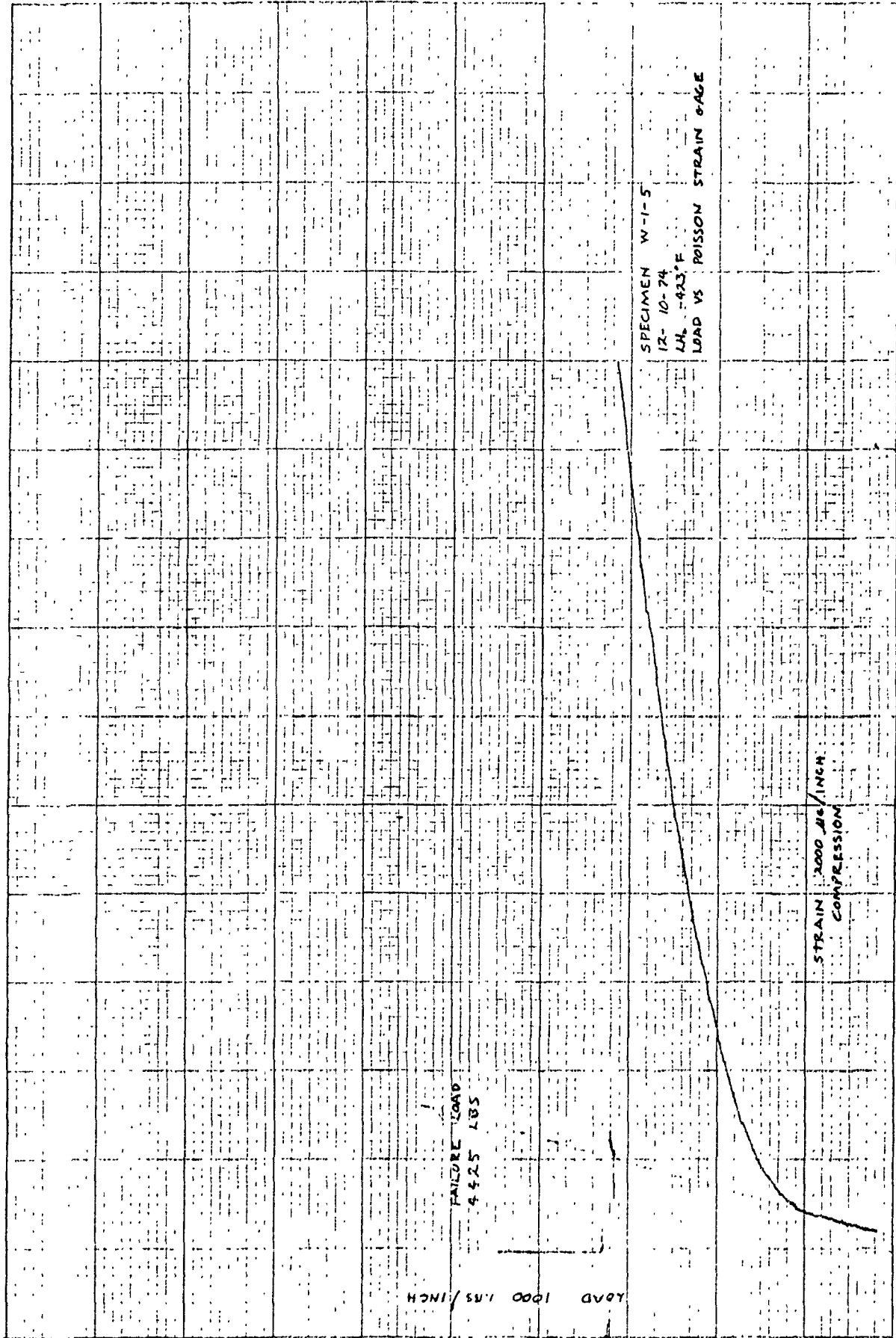
FAILURE LOAD
4425 LBS

10-A. SHIFT

10-A. SHIFT

STRAIN 2000 MG/INCH
TENSION





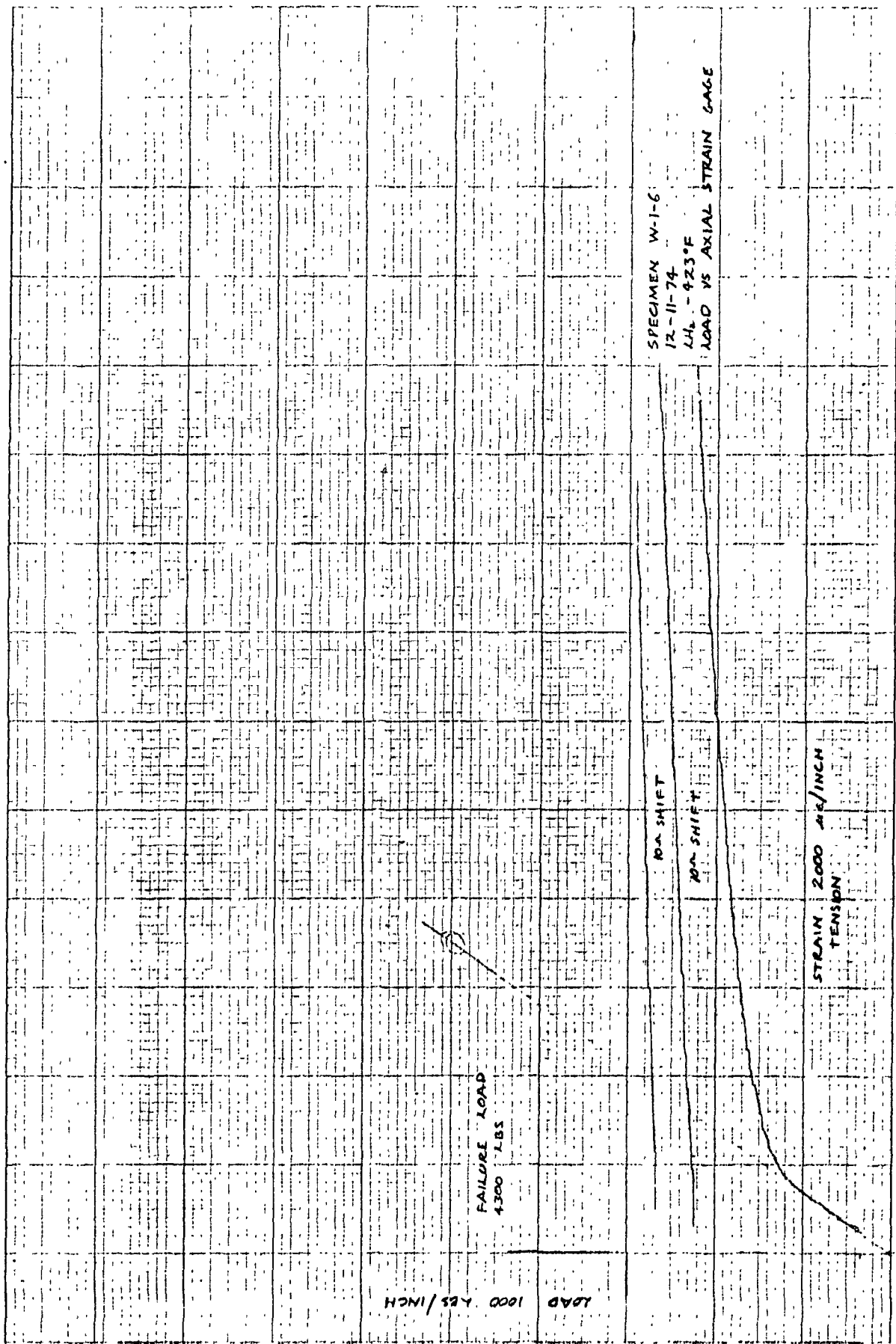
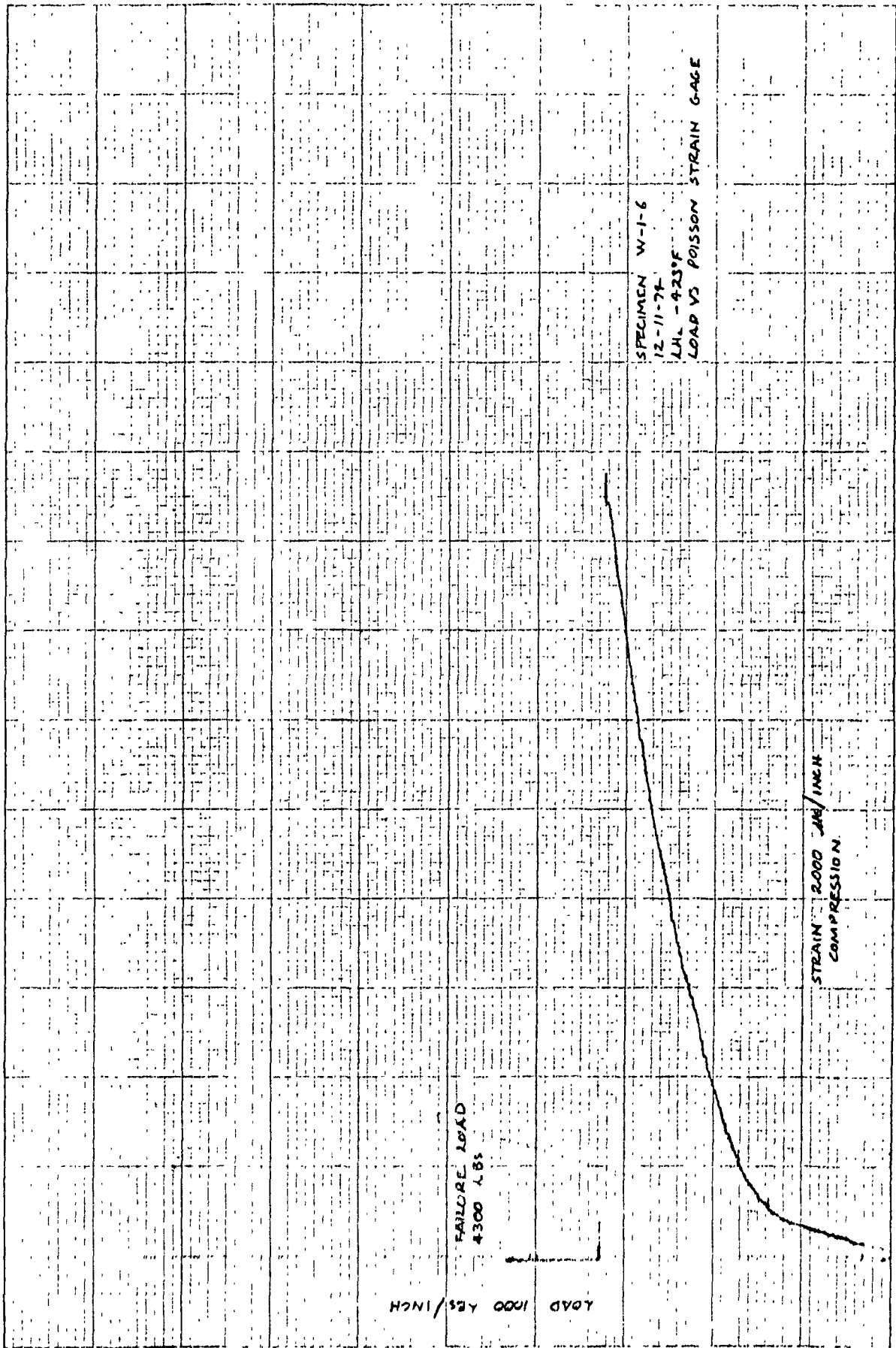
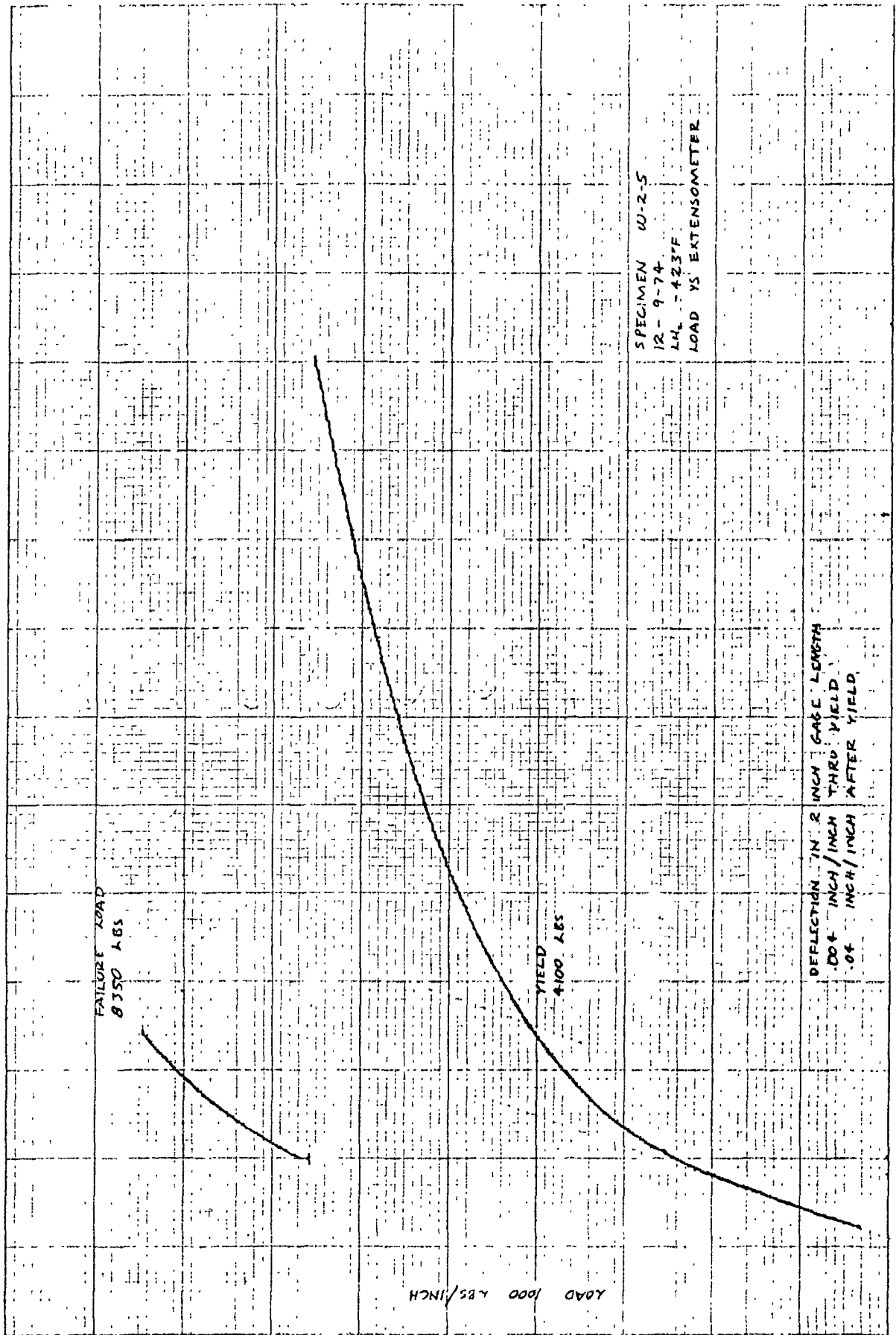
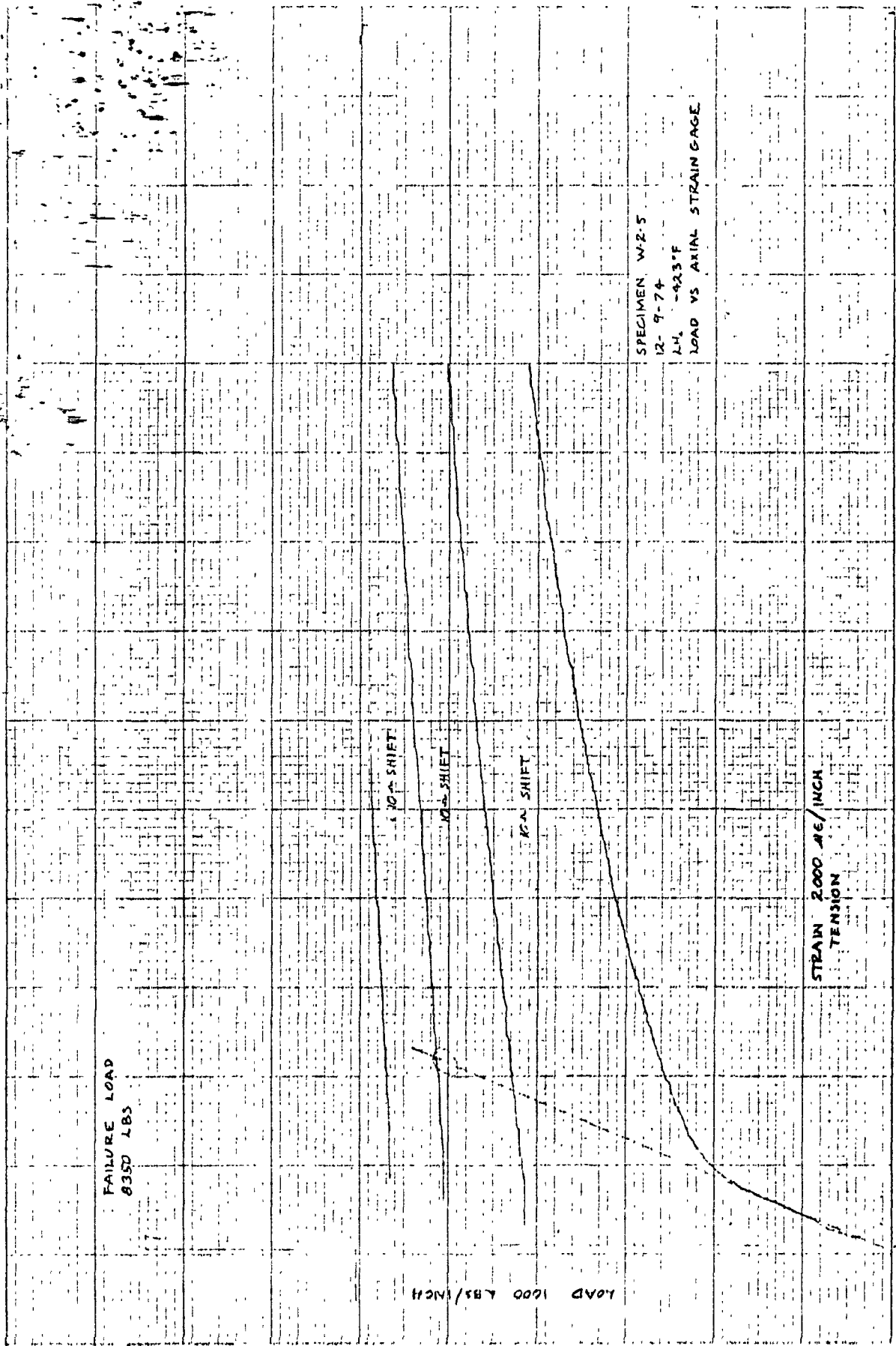


FIG. 10-2-74 (REV. 10-2-74) 43 (10-2-74)





K-E 112101-0100 47 0703

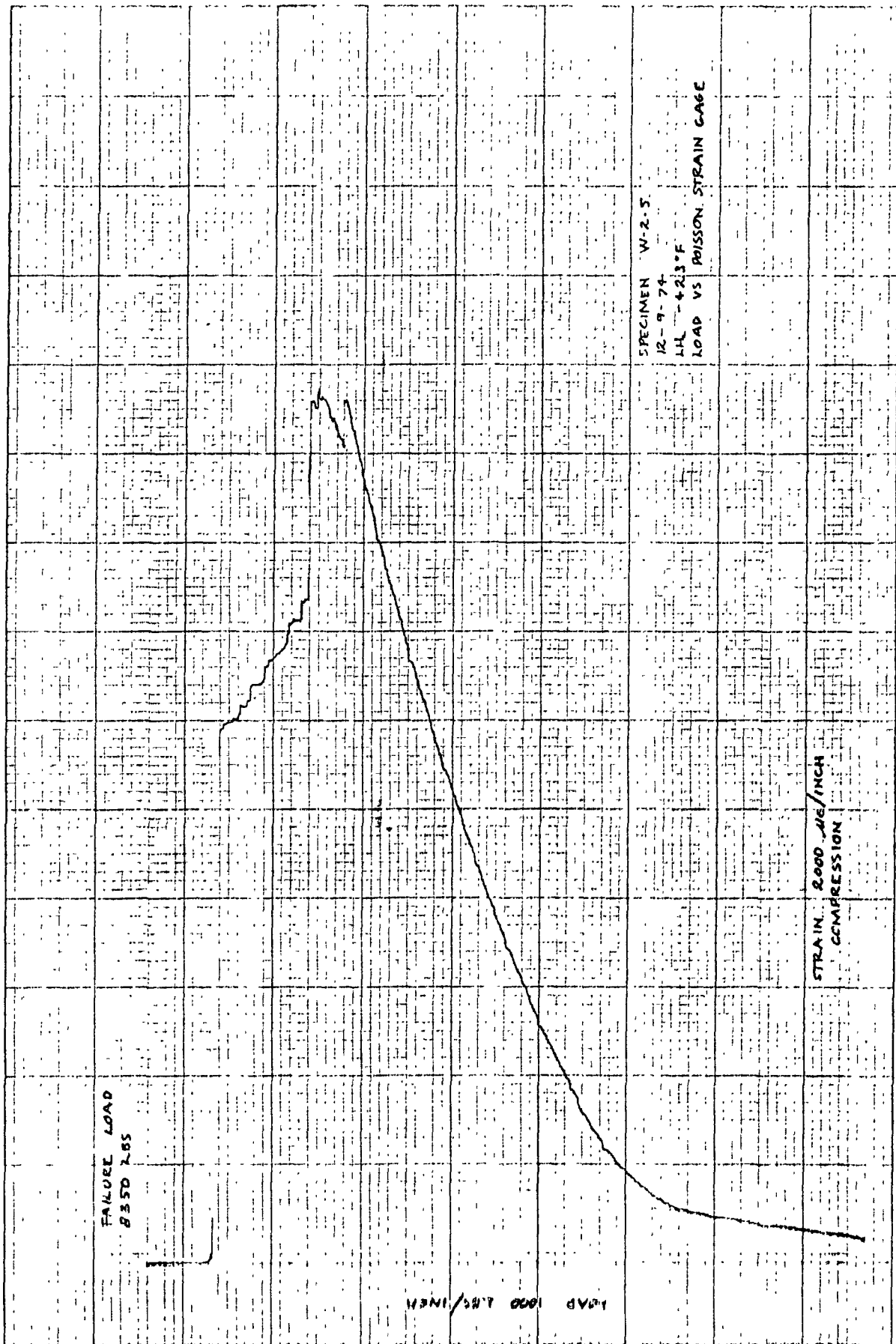


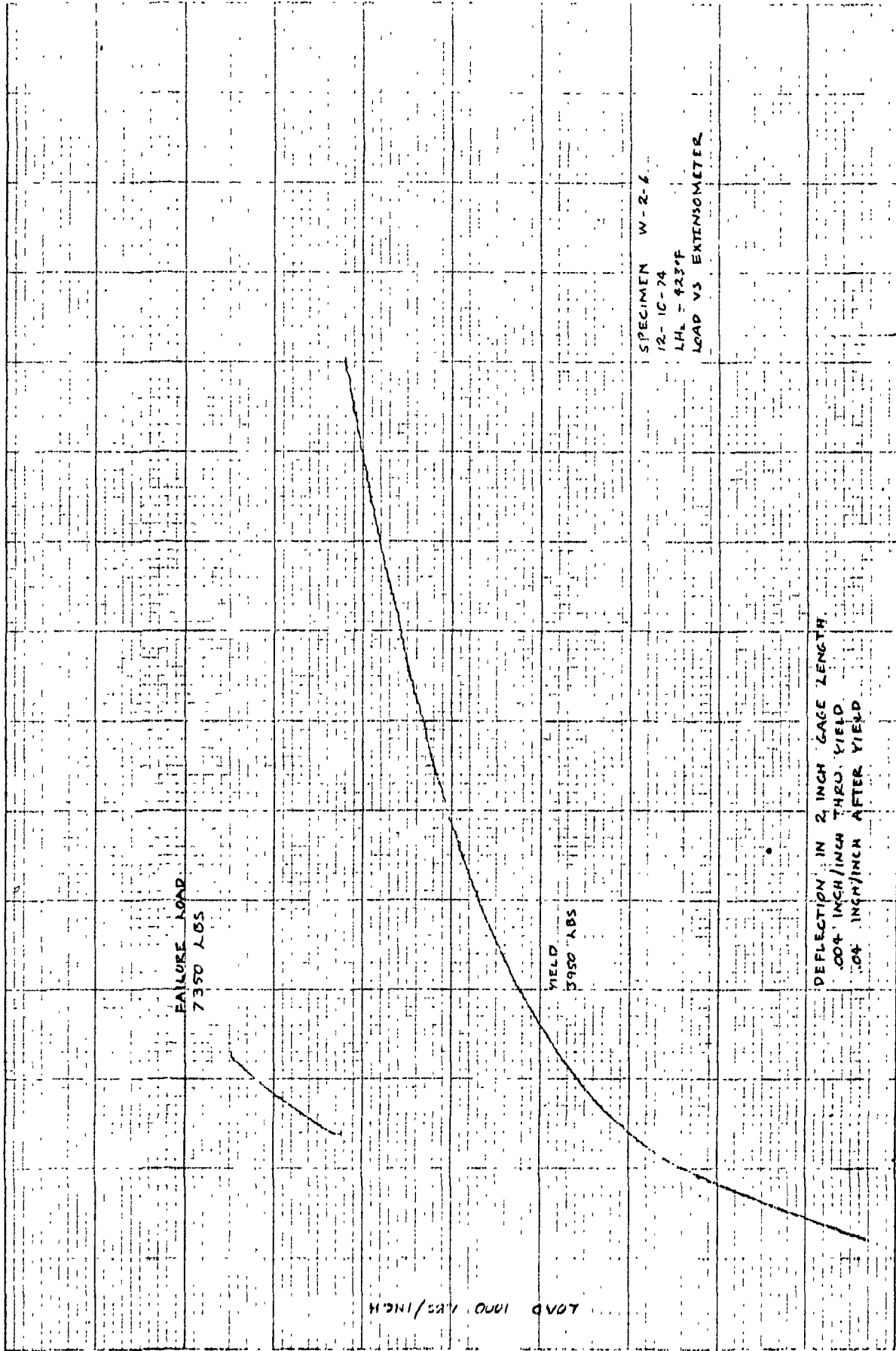
SPECIMEN W.R.5
 12-9-74
 L.H. -923°F
 LOAD VS AXIAL STRAIN GAGE

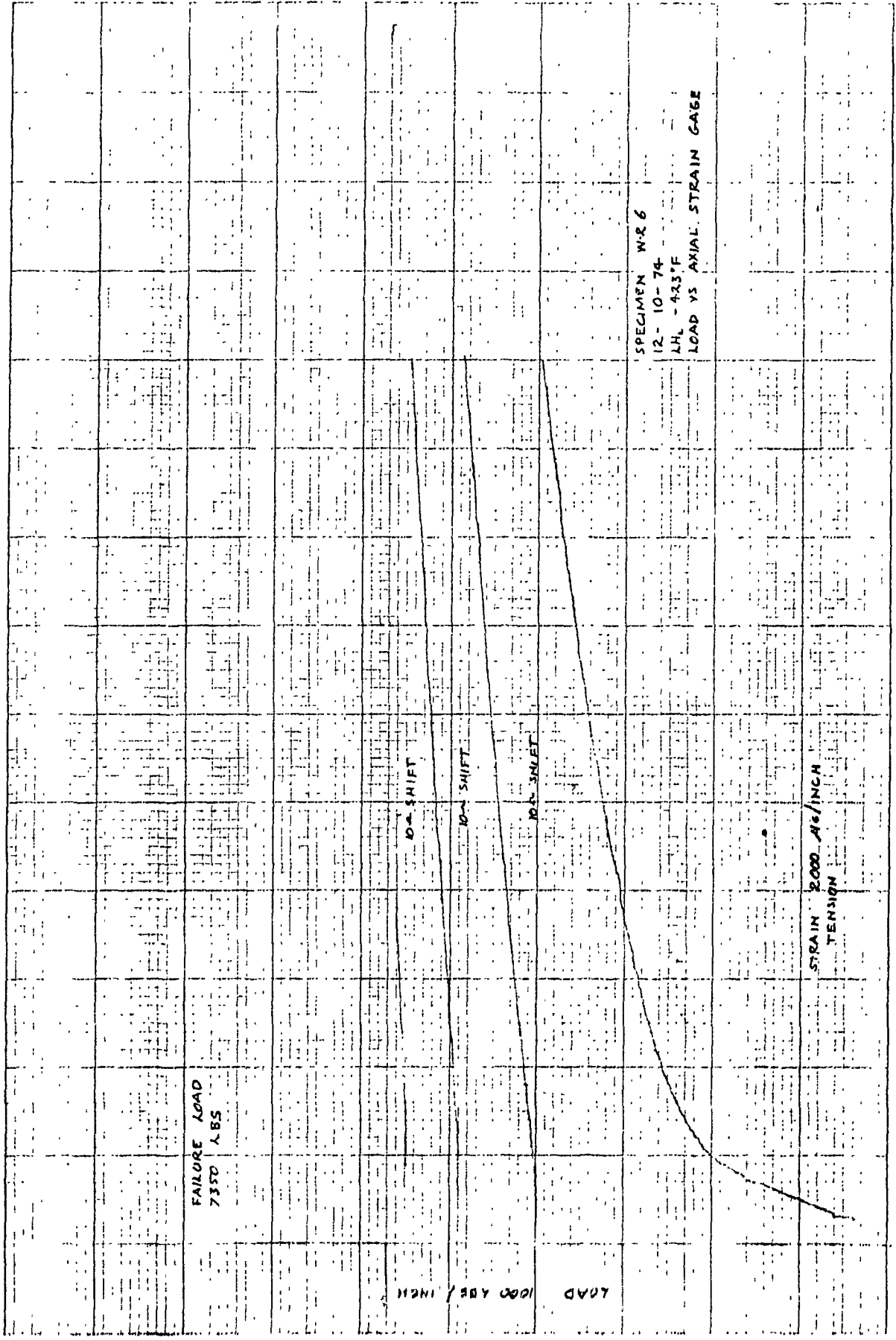
FAILURE LOAD
 8350 LBS

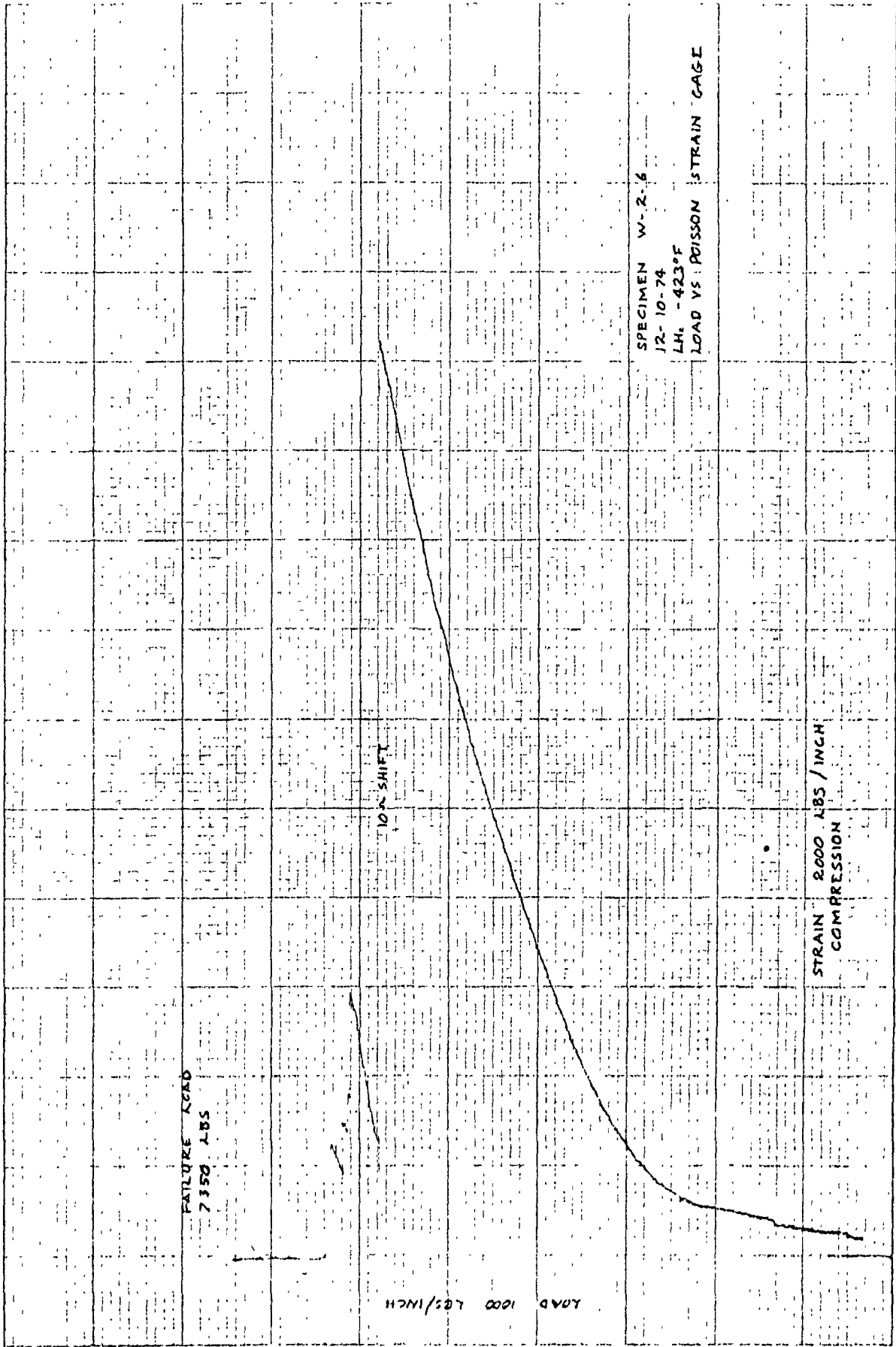
LOAD 1000 LBS/INCH

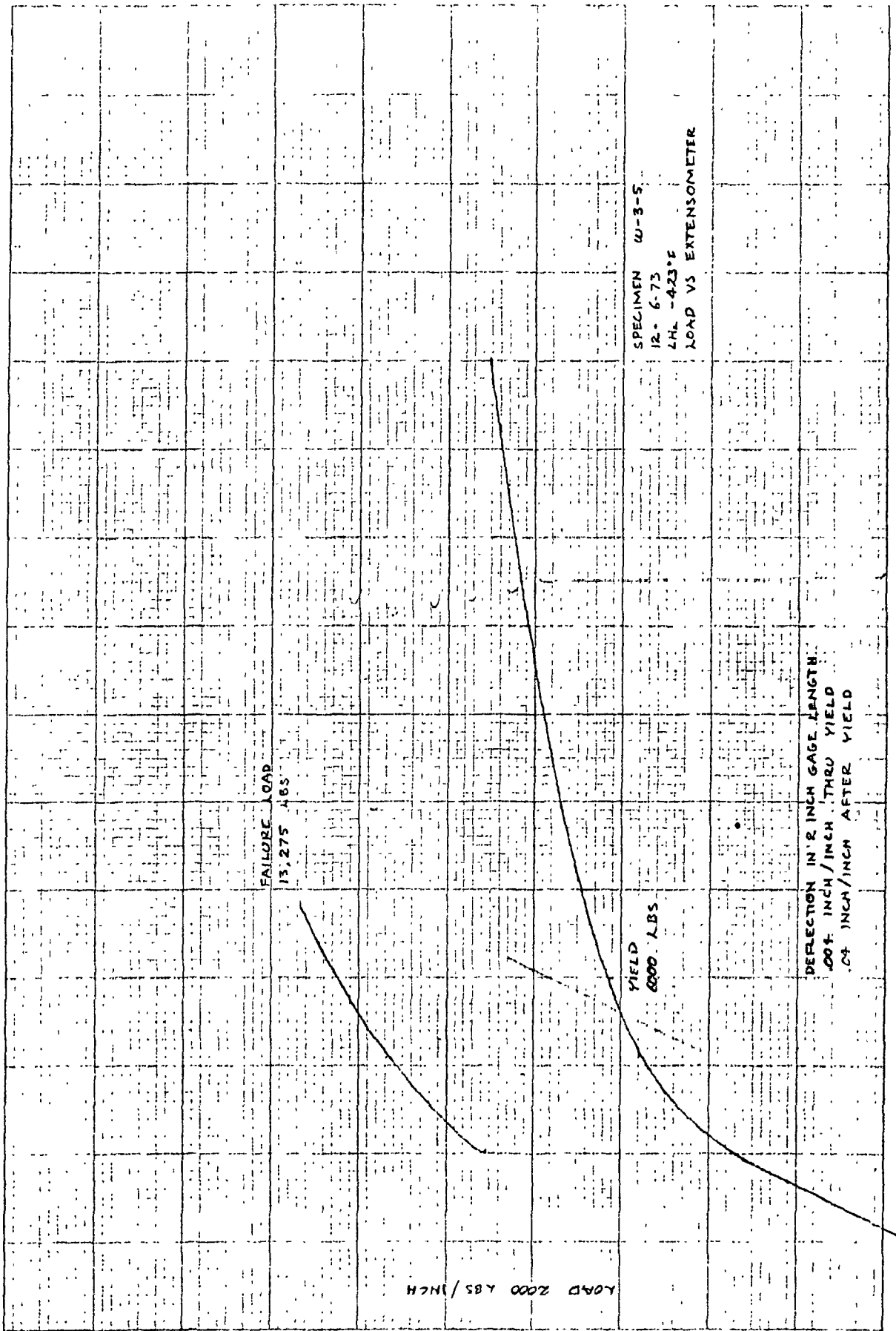
STRAIN 2000 με/INCH
 TENSION

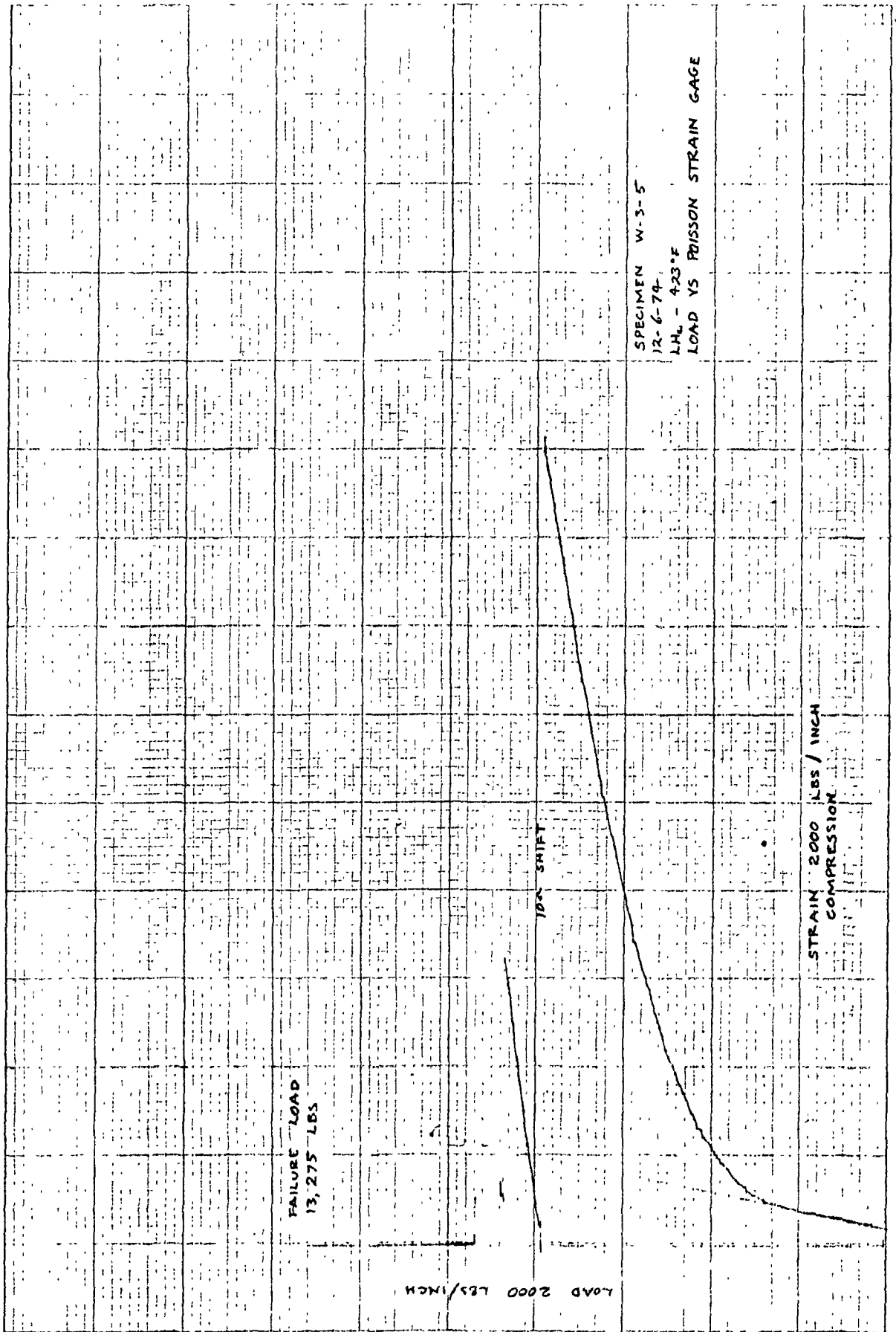


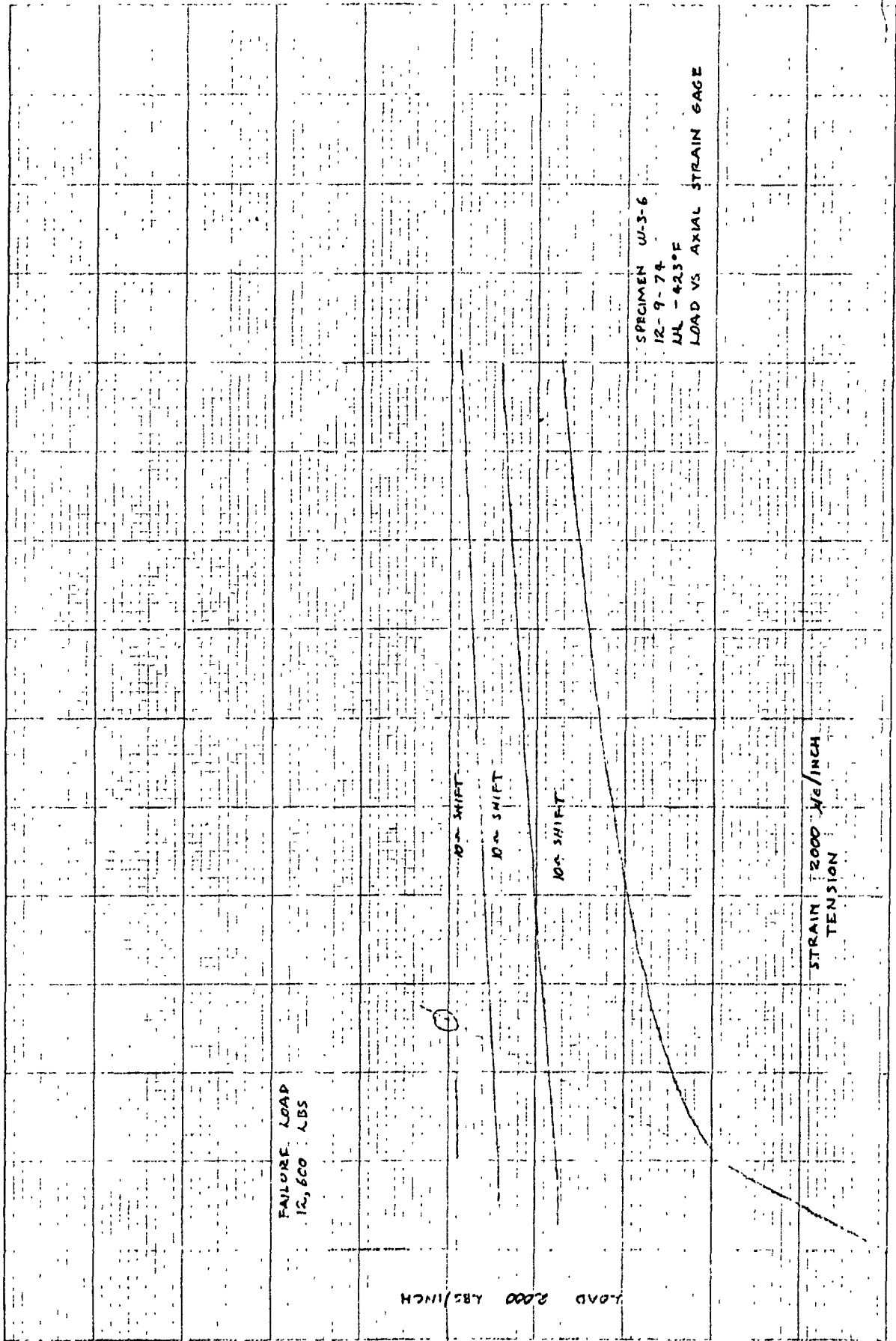




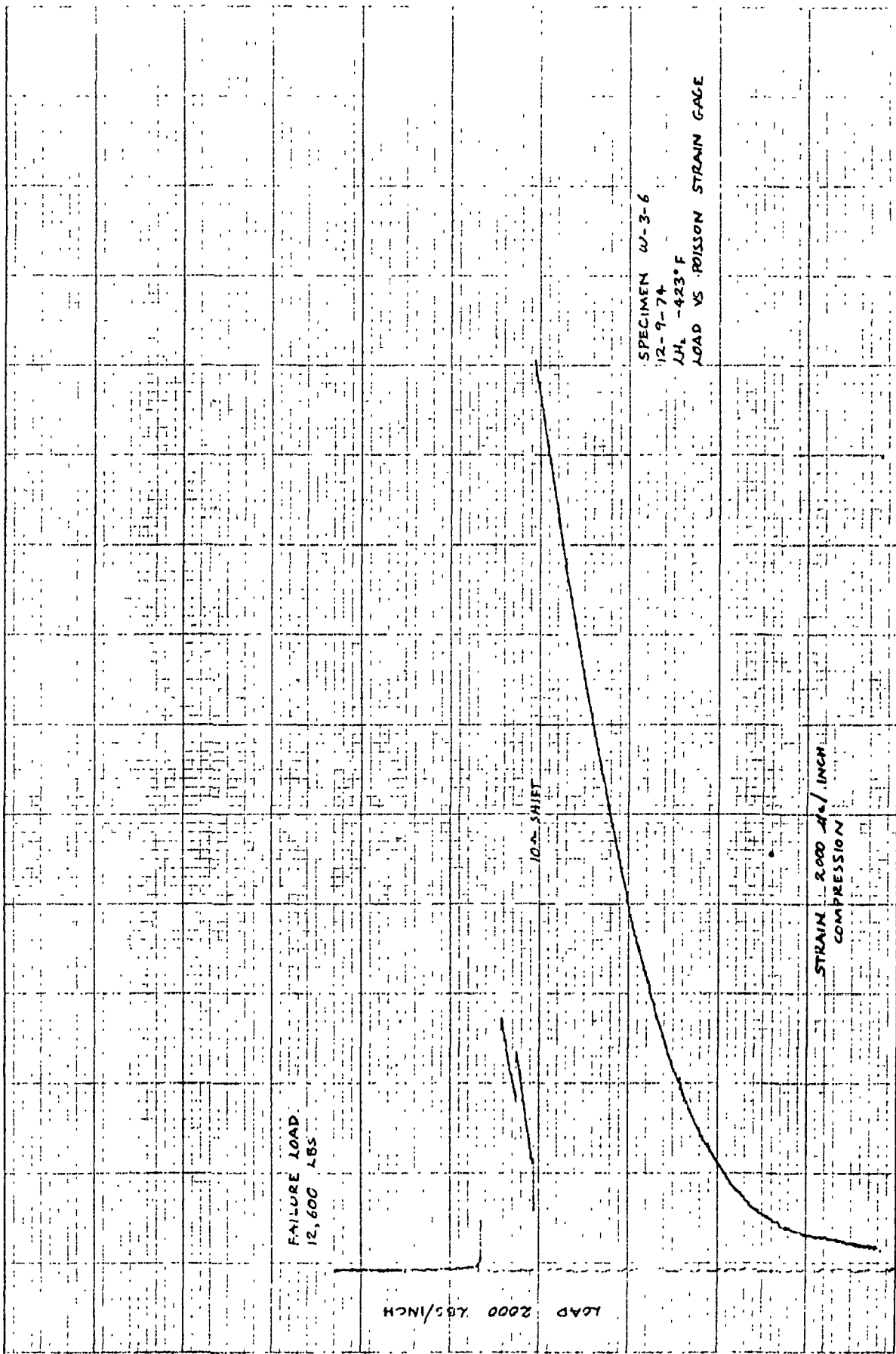








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SPECIMEN W-3-6
 12-9-74
 44% -423°F
 LOAD VS POISSON STRAIN GAGE

FAILURE LOAD
 12,600 LBS

10.2 INCH SHIFT

LOAD 2000 LBS/INCH

STRAIN 2000 IN./INCH
 COMPRESSION

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