NASA CR-135370

ANALYSIS AND TEST OF DEEP FLAWS IN THIN SHEETS OF ALUMINUM AND TITANIUM

VOLUME 2–CRACK OPENING DISPLACEMENT AND STRESS-STRAIN DATA

By
R. W. Finger

THE BOEING AEROSPACE COMPANY

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Project Manager, Gordon T. Smith
Materials and Structures Division
NASA Lewis Research Center
Cleveland, OH 44135

16. Abstract

This experiment program was undertaken to further investigate the crack growth behavior of deep flaws in thin sheets. The program was designed to supplement the work performed under contract NAS3-18906 "Proof Test Criteria for Thin Walled 2219 Aluminum Pressure Vessels." Static fracture tests were performed on surface flawed specimens of both the aluminum and titanium alloys. A simulated proof overload cycle was applied prior to all of the cyclic tests. Variables included in each test series were flaw shapes and thickness. Additionally, test temperature was a variable for the aluminum test series. The crack opening displacement and stress-strain data obtained is included in this report. The data analysis and exact specimen and flaw size dimensions are presented in Volume I - NASA CR-135369.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Crack Opening Displacement Stress-Strain Cryogen 2219-T87 Aluminum 6Al-4V STA Titanium	Unclassified Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassifed	Unclassified	209	

* For sale by the National Technical Information Service, Springfield, Virginia 22161

FOREWORD

This report summarizes the crack opening displacement and stress strain data obtained from tests of both 2219-T87 aluminum and 6Al-4V STA titanium performed by the Boeing Aerospace Company from July, 1975 through December, 1977. The work was administered by Mr. Gordon T. Smith of the NASA-Lew. Research Center. The program was conducted originally by the Research and Engineering and finally by the Boeing Military Airplane Development Division of the Boeing Aerospace Company, Seattle, Washington, under the supervision of Mr. H. W. Klopfenstein (Research and Engineering Division) and Mr. D. E. Strand (Boeing Military Airplane Division). The Program Leader was originally Mr. J. N. Masters and finally Mr. T. E. Dunning. The Technical Leader was R. W. Finger. Mr. H. Lenhart and H. M. Olden provided testing engineering support, and G. Jensen produced the technical illustration and art work. This technical report is also released as Boeing Document D180-24613-2.

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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-135369 (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-135369. Peculiarities encountered during testing have been noted on the individual plots. Some general comments pertinent to a-l of the pltos are presented below:

The Crack Opening Displacement Gage (COD) was reset after each load cycle;

The COD gage was spring loaded against integrally machined knife edges for all of the center crack panels and against gage brackets for all the surface flaw tests.

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;

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 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 the extensometer tests.

The strain gage records have been identified as either axial strain gage of 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.

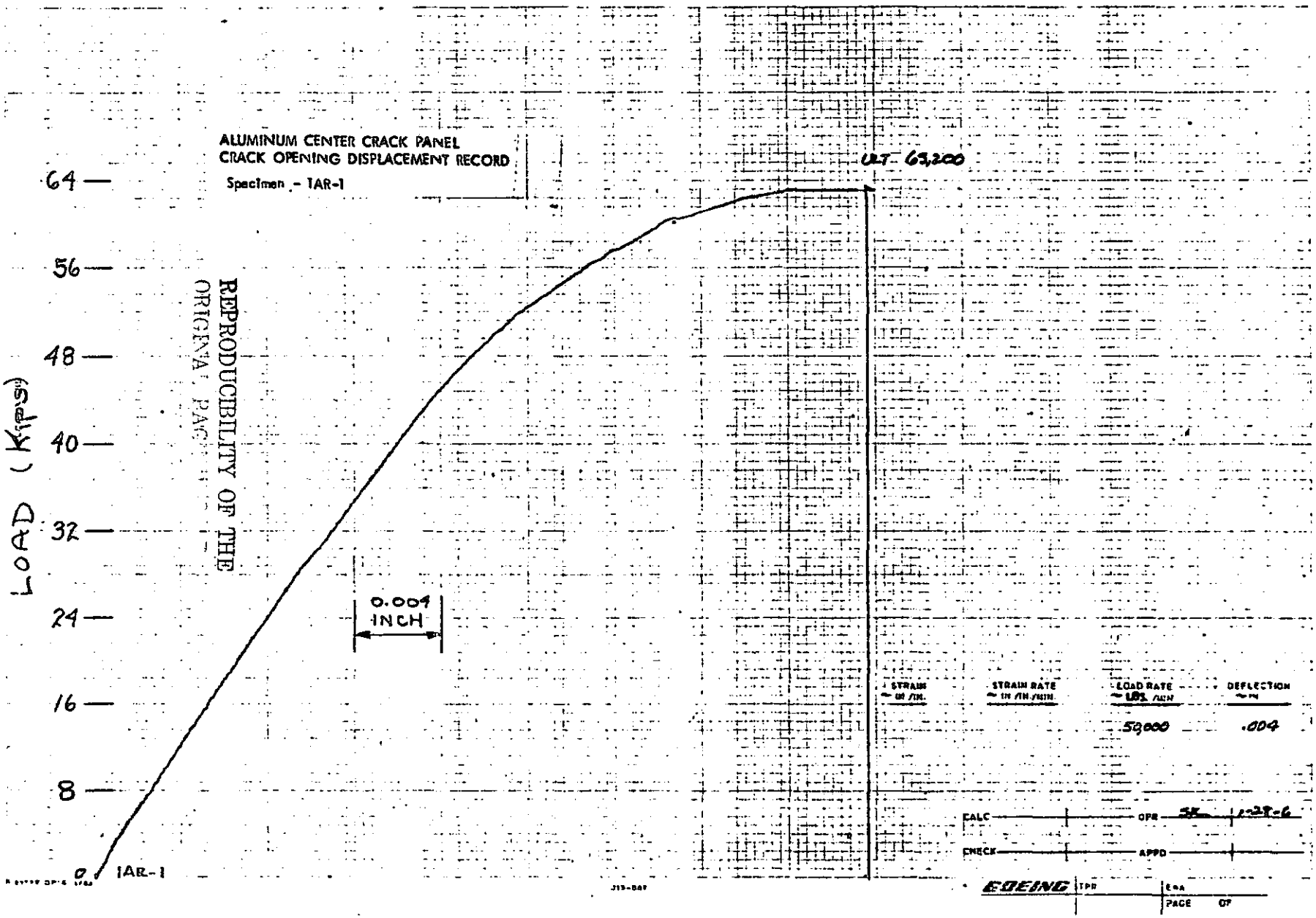
References:

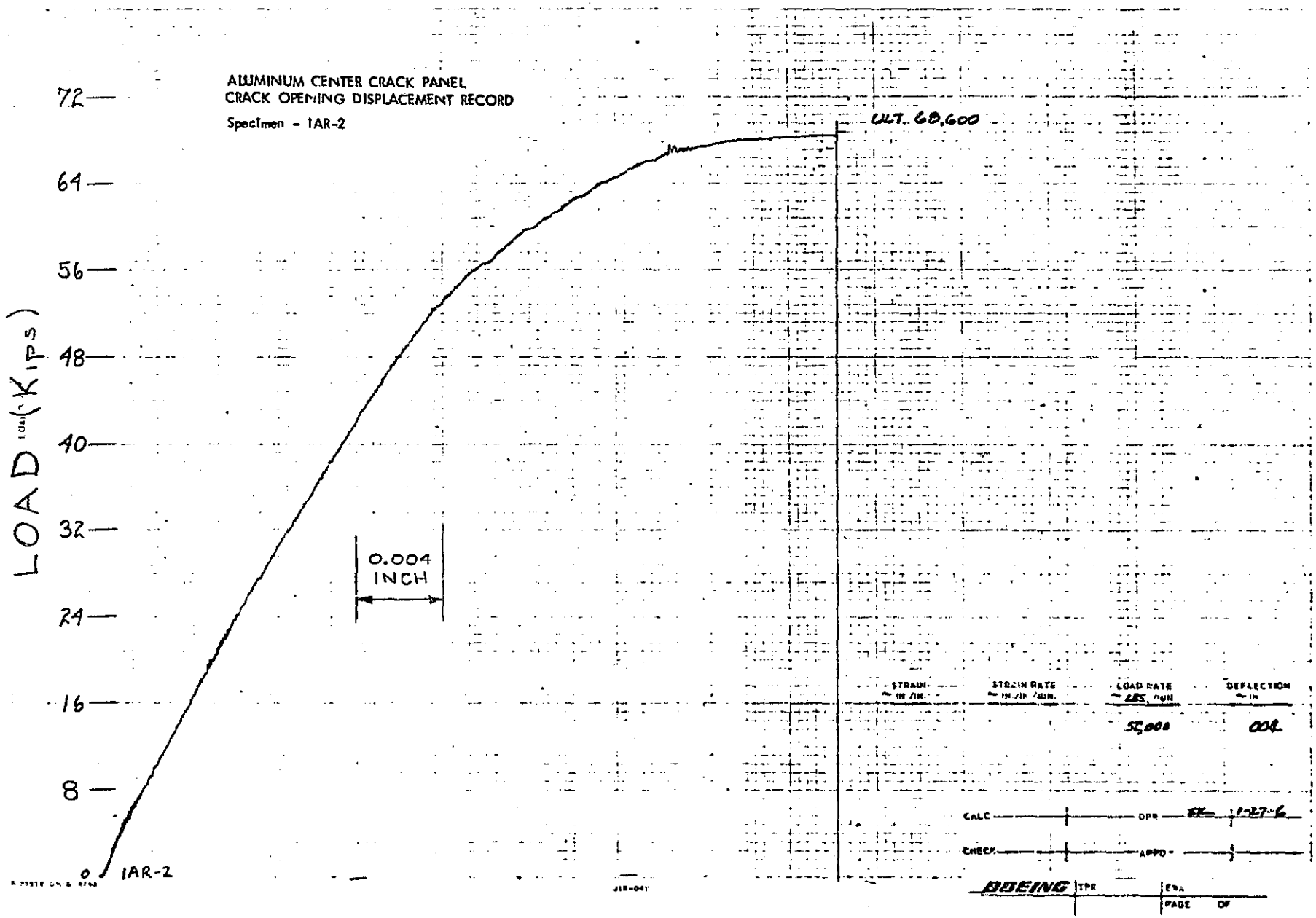
1. R. W. Finger, "Analysis and Test of Deep Flaws in Thin Sheets of Aluminum and Titanium." Volume I NASA CR-135369, April 1978.

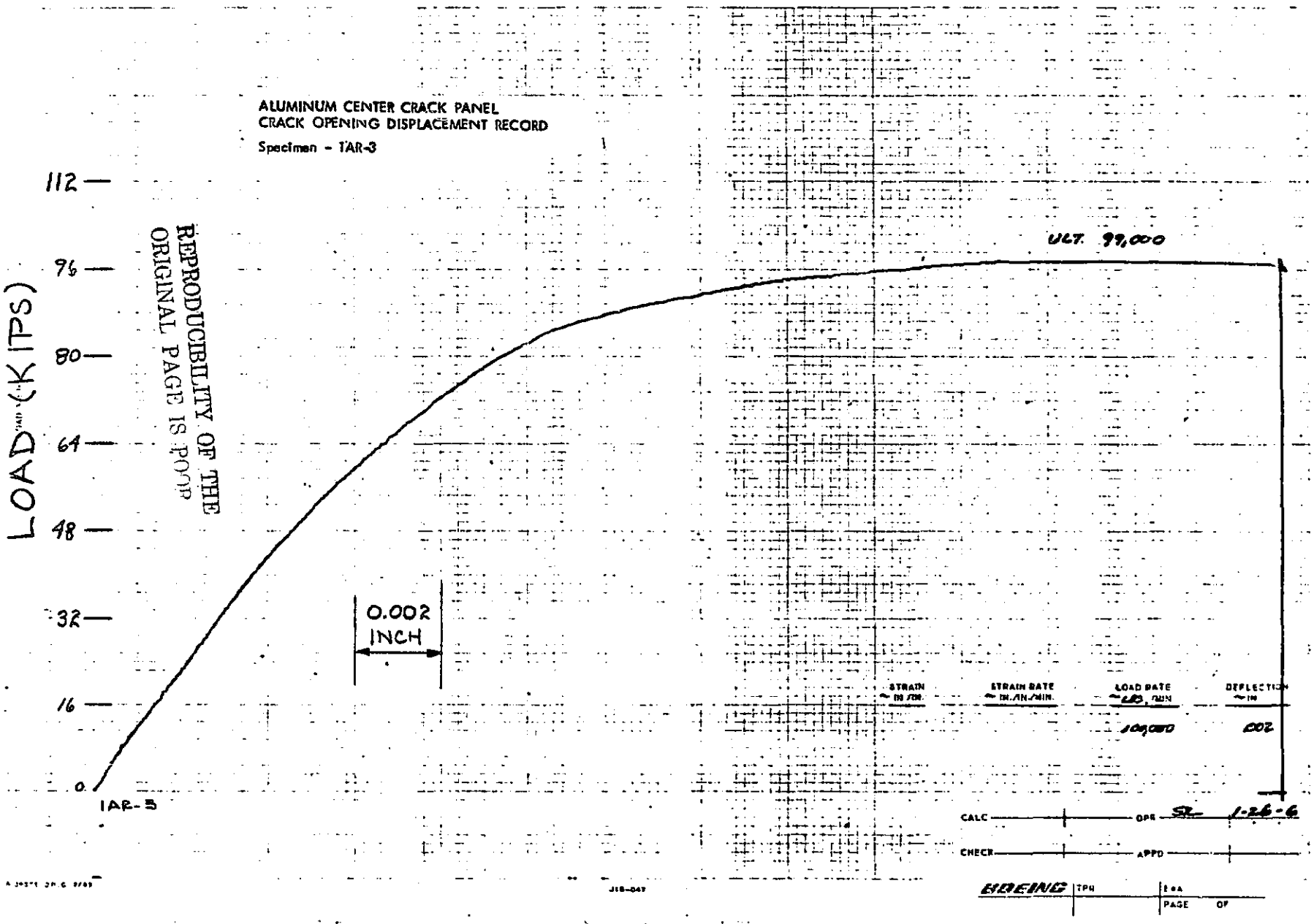
2. J. N. Masters, W. D. Bixler, R. W. Finger, "Fracture Characteristics of Structural Aerospace Alloys Containing Deep Surface Flaws." NASA CR-134587, December 1973.

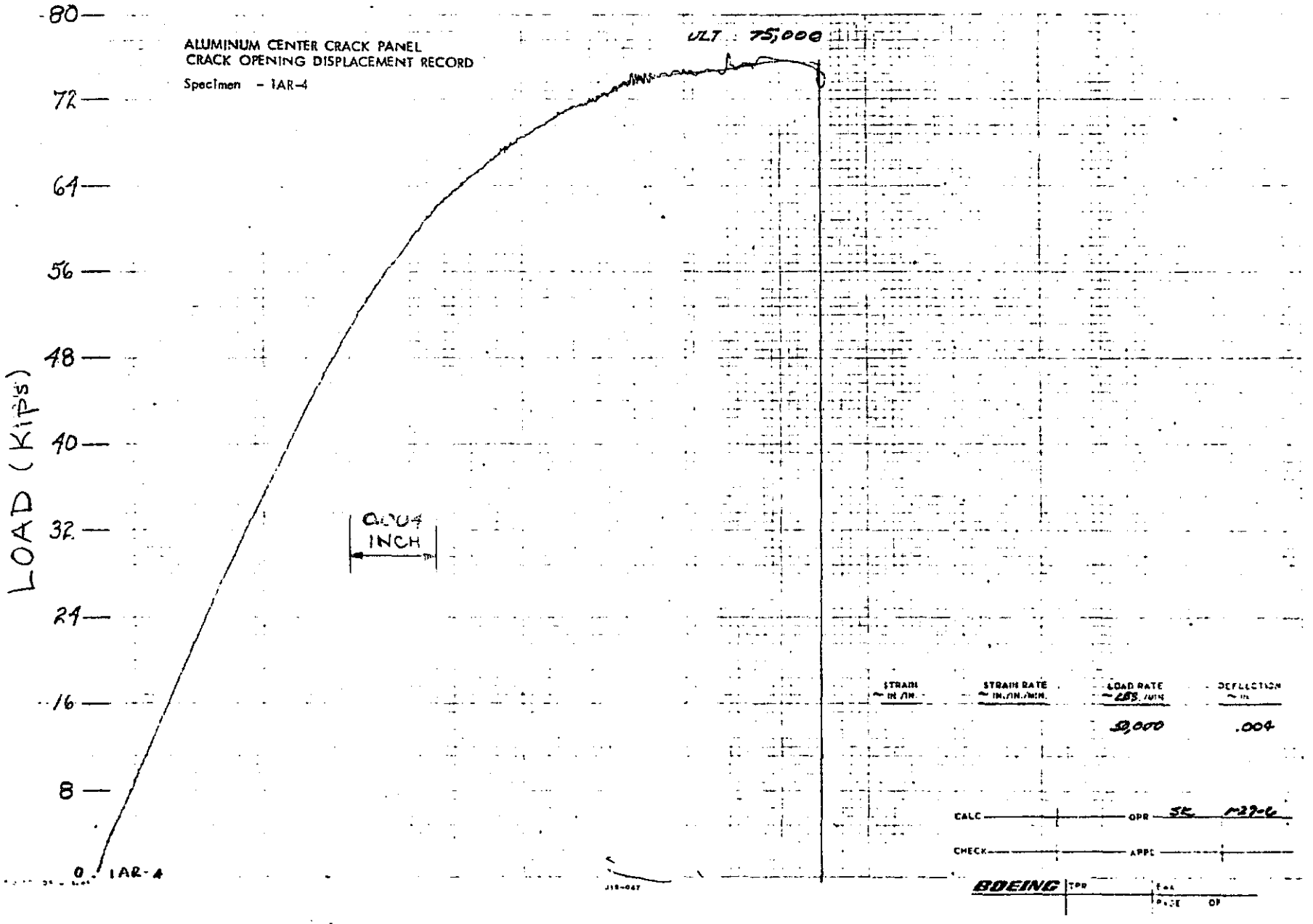
3. A. S. Kobayashi, "Crack Opening Displacement in A Surface Flawed Plate Subjected to Tension or Plate Bending." Boeing Document D180-19446-1, February 1976.

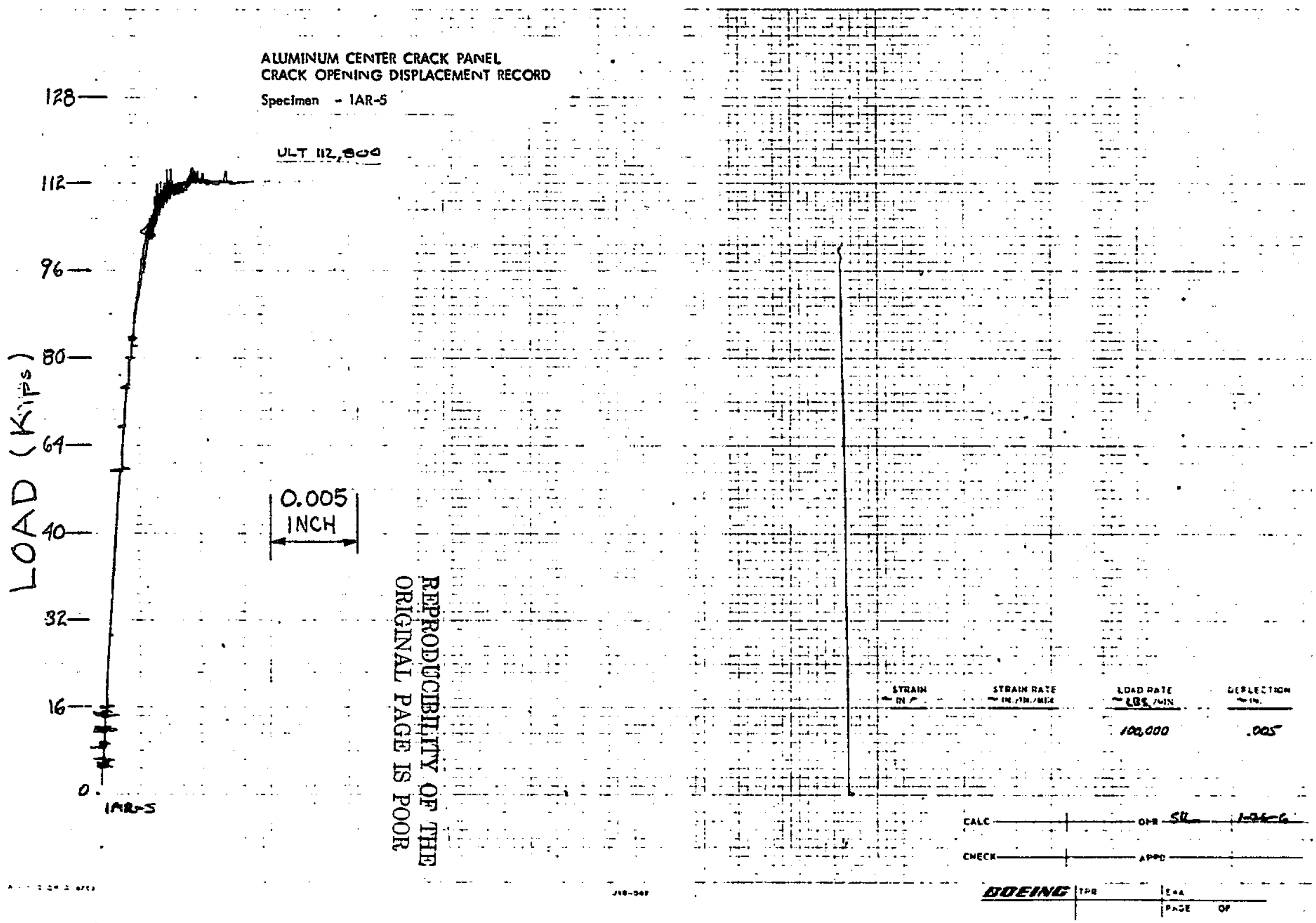
APPENDIX I - Center Center Crack Panel Crack Opening Displacement Records




ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1AR-2
ULT. 60,600
LOAD (KIPS)
72
64
56
48
40
32
24
16
8
0
0.004 INCH
1AR-2
STRAIN IN/IN
STRAIN RATE IN/IN/MIN.
LOAD RATE LBS/MIN
55,000
DEFLECTION IN
.002
CALC
DPR
CHECK
APPD
BOEING
TPR
ENG
PAGE
OF

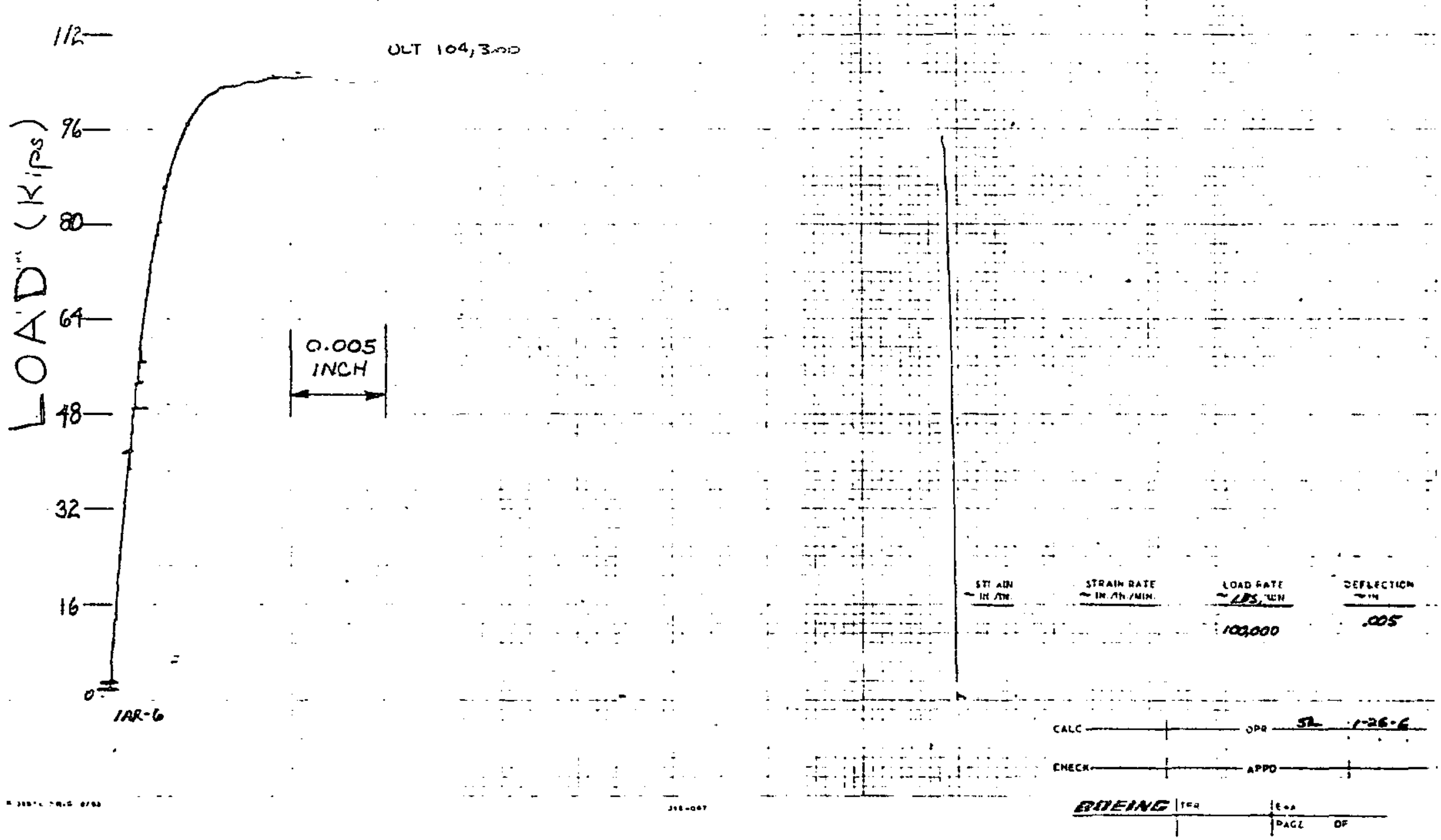


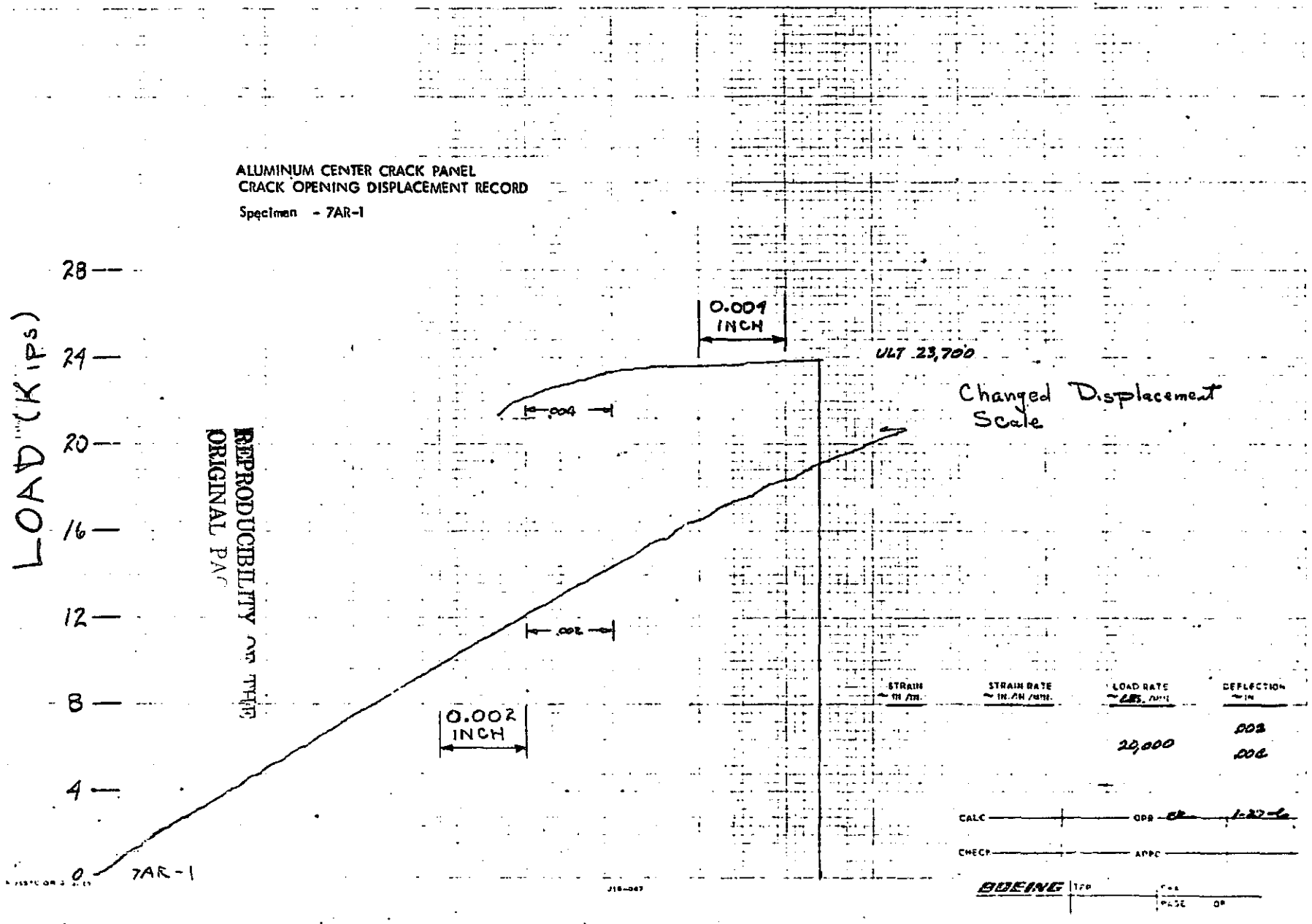

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1AR-4
ULT. 75,000
LOAD (KIPS)
80
72
64
56
48
40
32
24
16
8
0
.004 INCH
1AR-4
STRAIN IN/IN.
STRAIN RATE IN./IN./MIN.
LOAD RATE 285. /MIN
DEFLECTION IN.
50,000
.004
CALC
OPR
CHECK
APPR
BOEING
TPR
PAGE
OF



ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

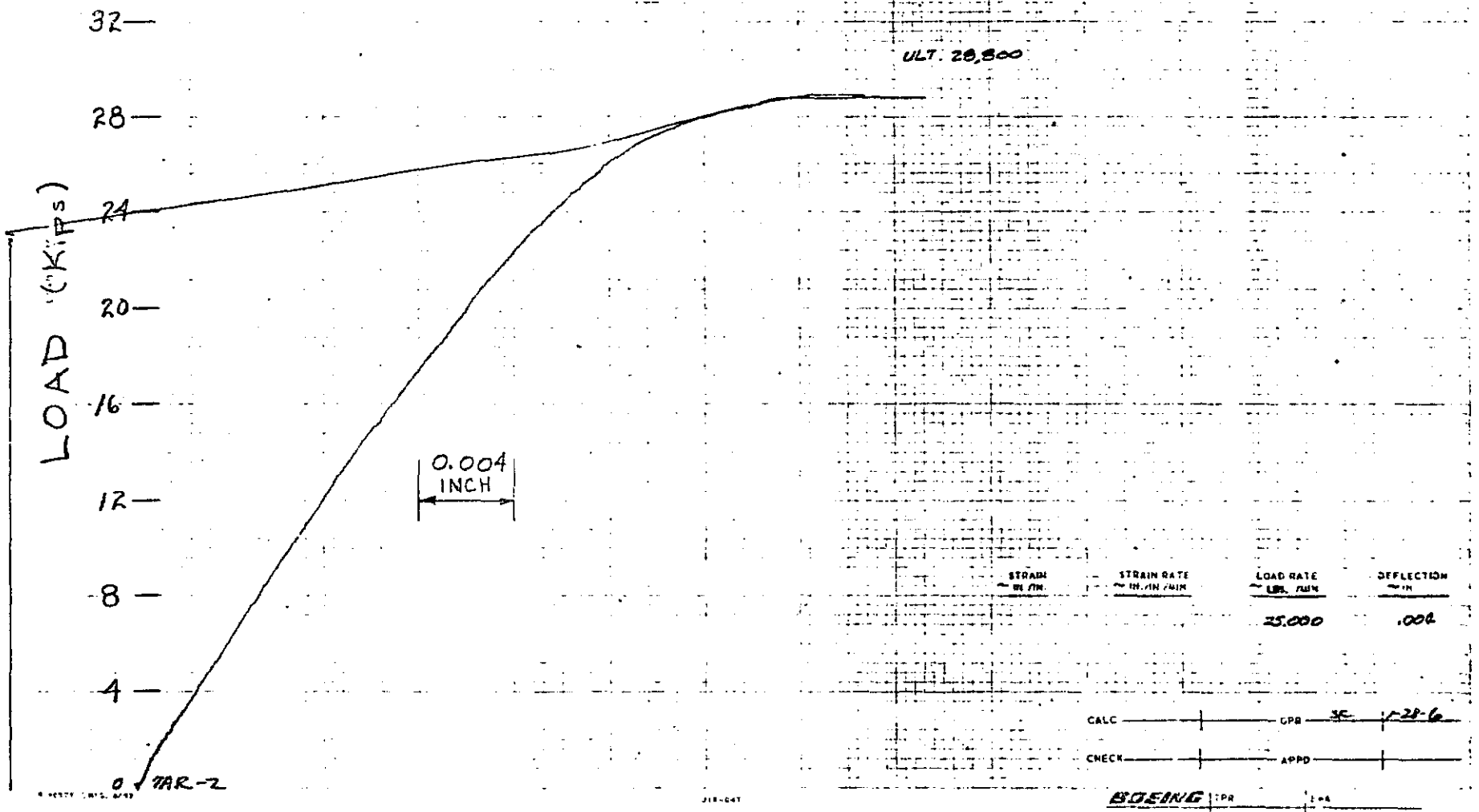
Specimen - 1AR-6




ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AR-1
LOAD (KIPS)
28
24
20
16
12
8
4
0
0.001 INCH
ULT 23,700
Changed Displacement Scale
.004
.002
0.002 INCH
7AR-1
REPRODUCIBILITY OF THE ORIGINAL PAGE
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
20,000
.002
.002
CALC
CHECK
APPD
BOEING

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 7AR-2



CALC — CPR — 3C — 28-6

CHECK — APPD

BOEING — CPR — PAGE OF

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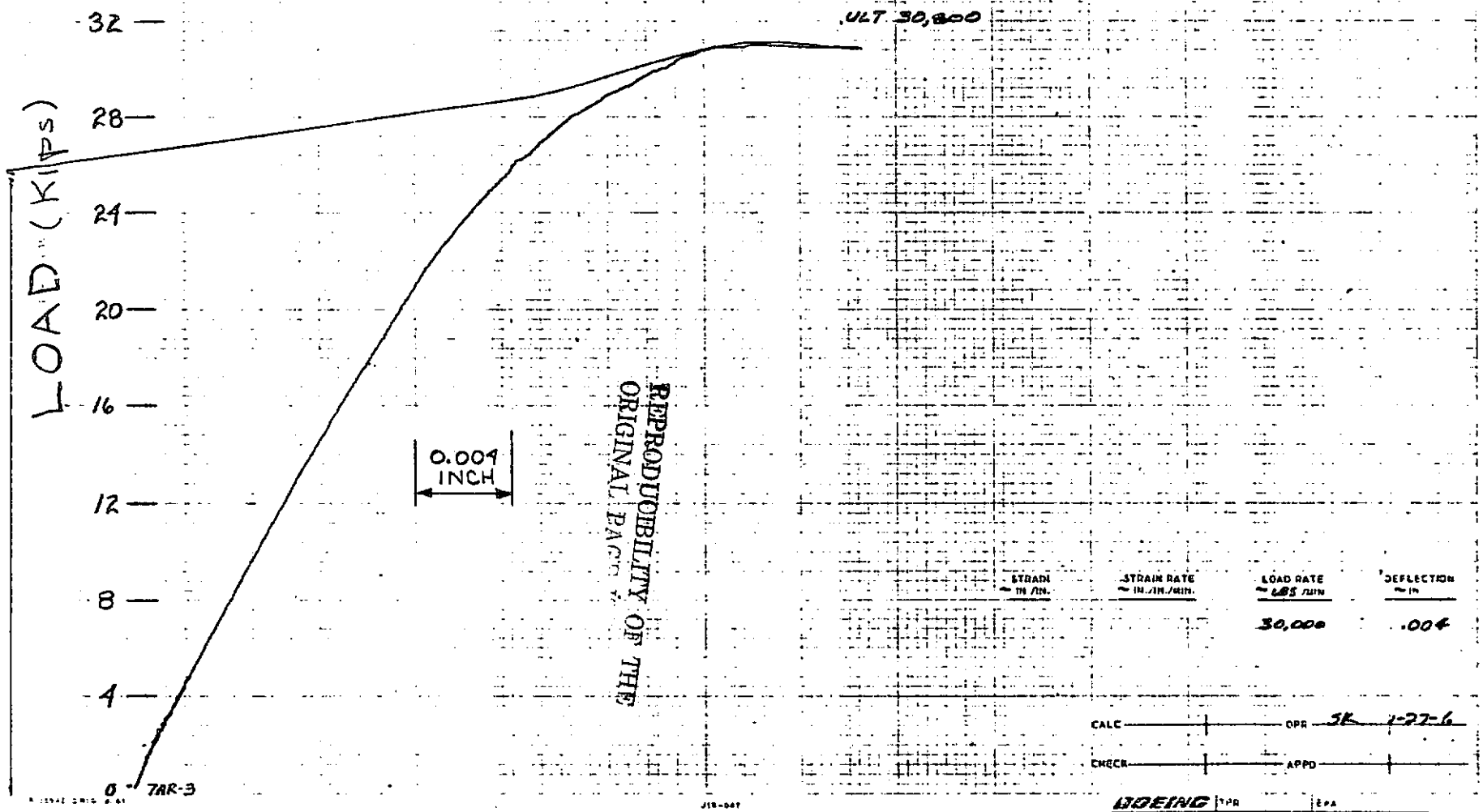
CRACK OPENING DISPLACEMENT RECORD

Specimen - 7AR-3



STRAIN ~ IN /IN.	STRAIN RATE ~ IN./IN./MIN.	LOAD RATE ~ LBS /MIN	DEFLECTION ~ IN
		30,000	.004

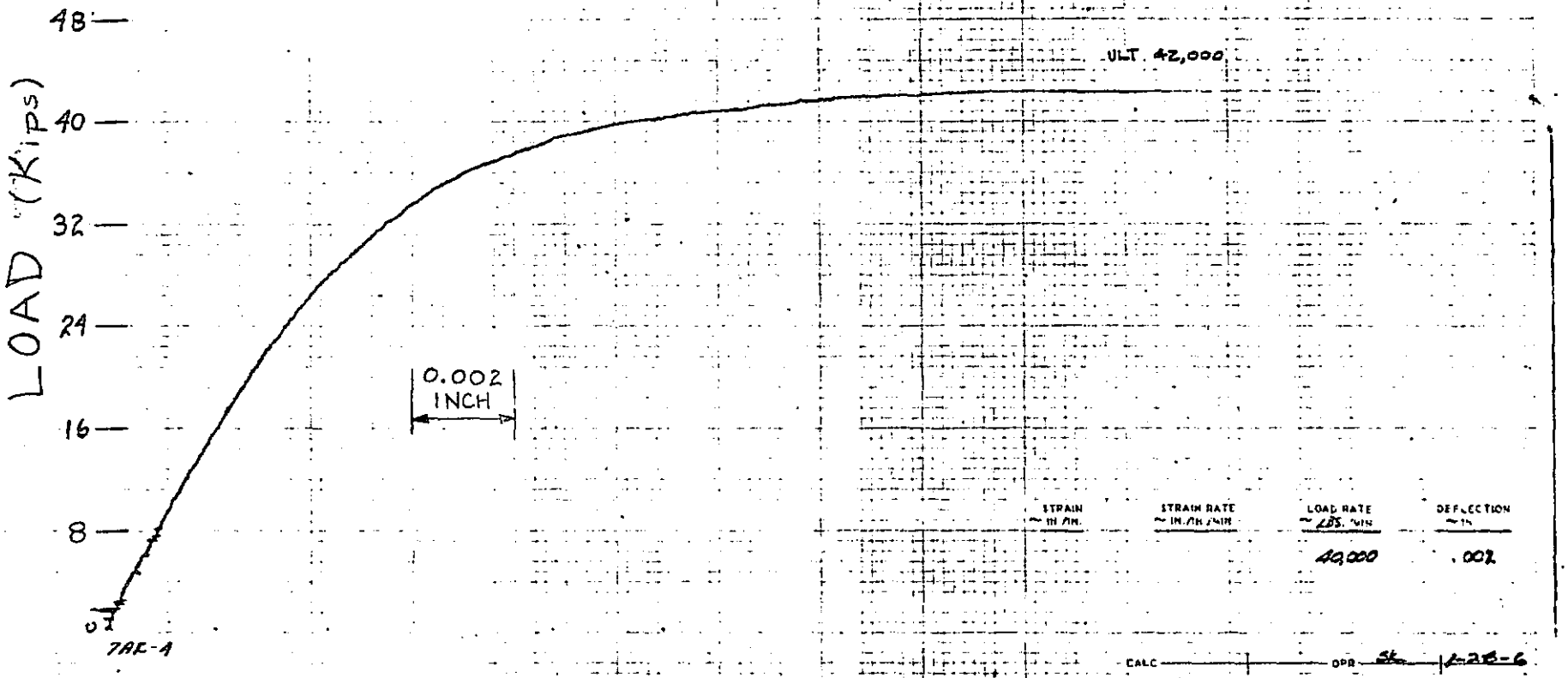
CALC ——— DPR SK 1-22-6

CHECK ——— APPD

BOEING TPR EPA PAGE OF

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 7AR-4



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		40,000	.002

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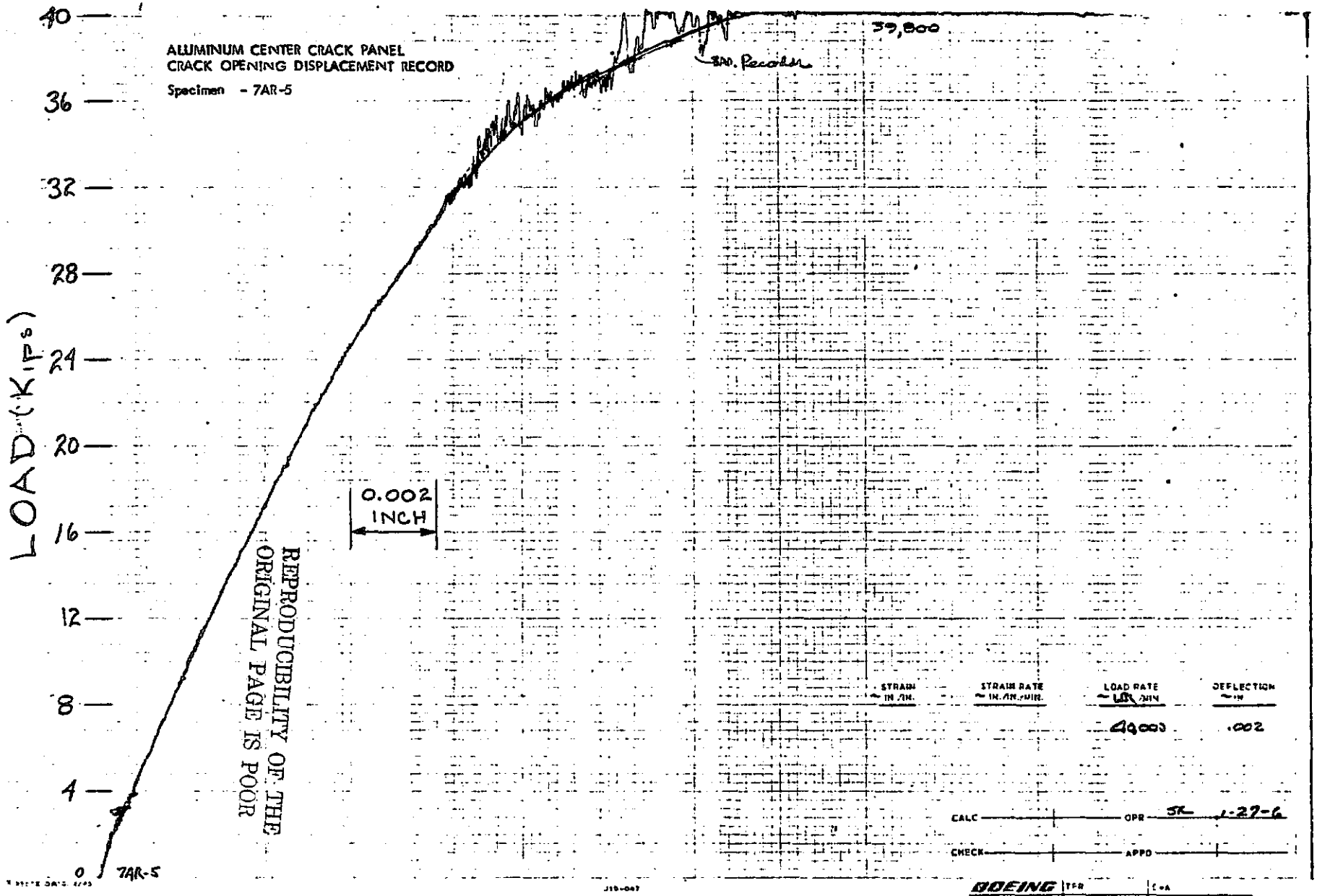
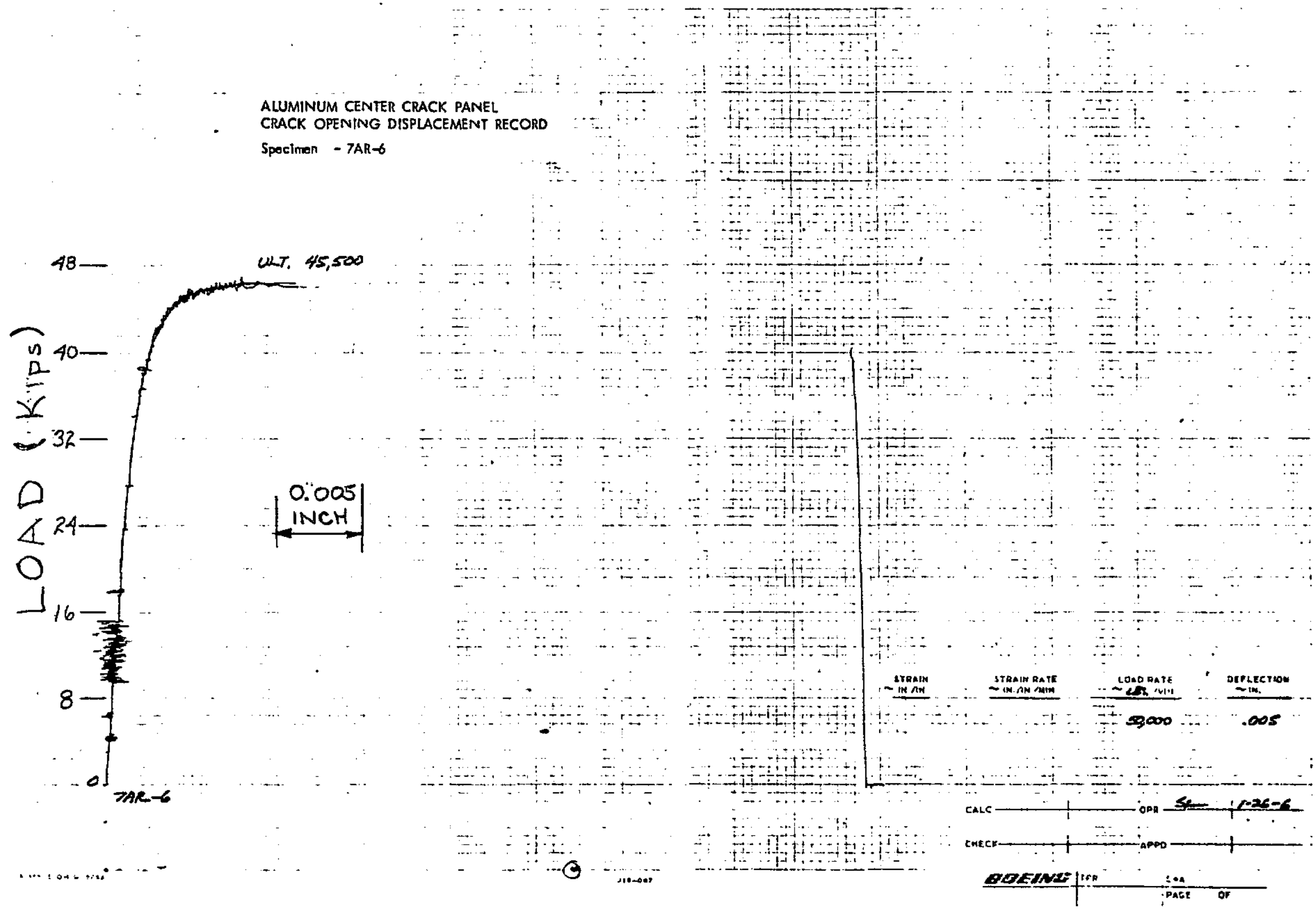
CHECK ——— APPD ———

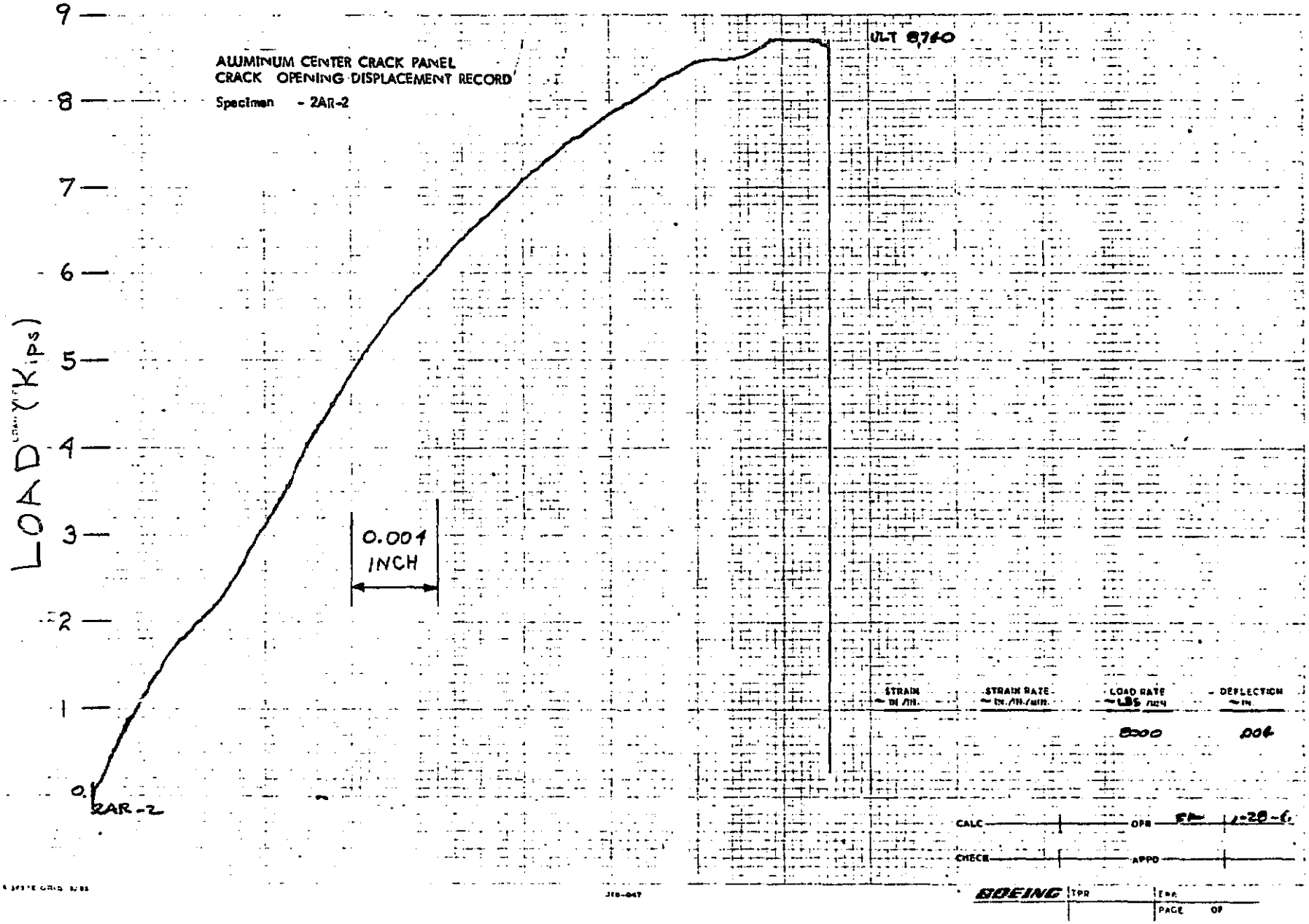
BOEING | TPR | ENA | PAGE | OF



REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

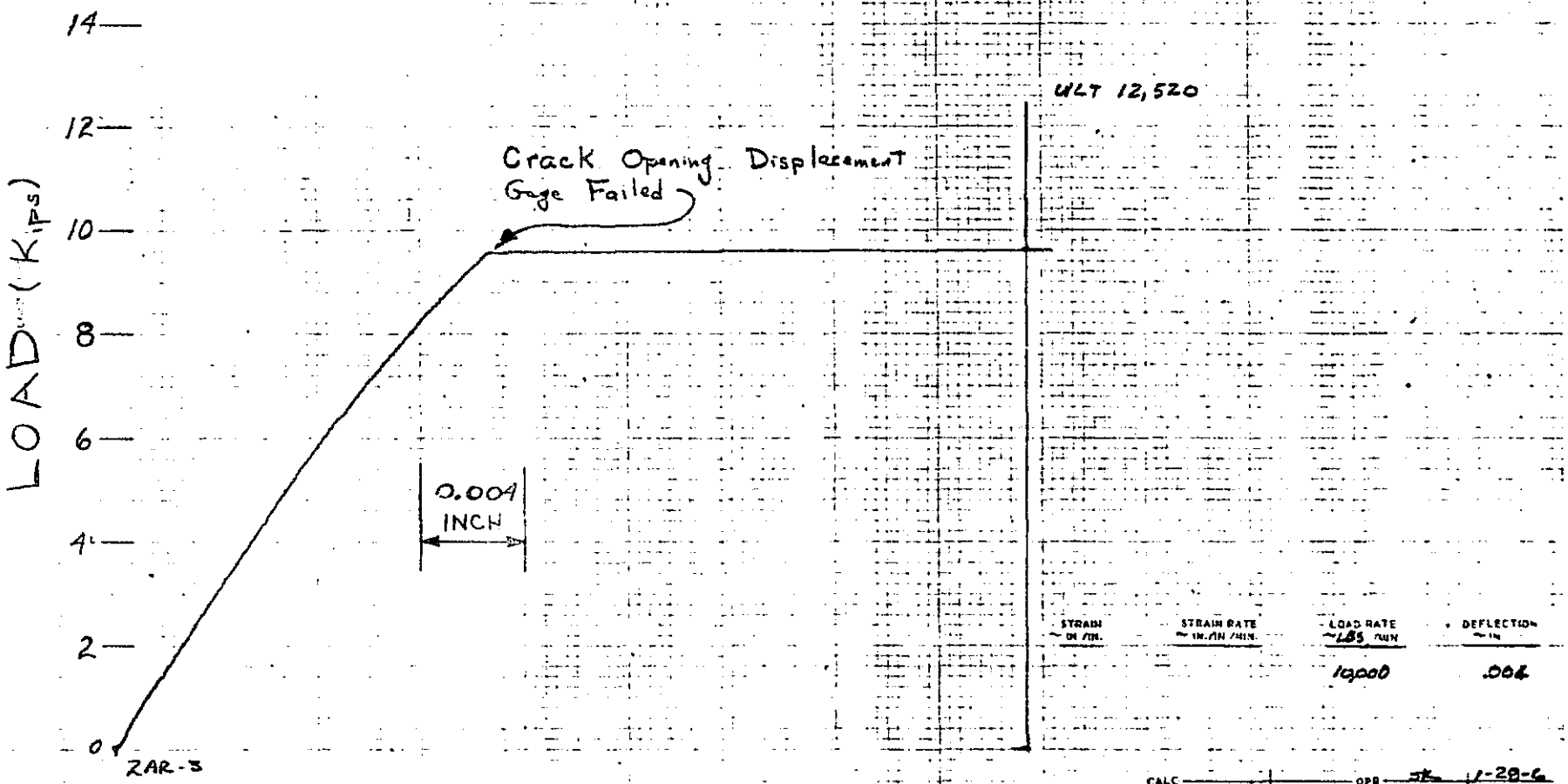
ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AR-6




ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR-2
ULT 8,760
LOAD (K ips)
9
8
7
6
5
4
3
2
1
0
0.004 INCH
2AR-2
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
8000
.004
CALC
OPR
CHECK
APPD
BOEING
TPR
PAGE

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR-3



STRAIN IN/IN.	STRAIN RATE IN./IN./MIN.	LOAD RATE ~LBS /MIN	DEFLECTION ~IN
		10000	.004

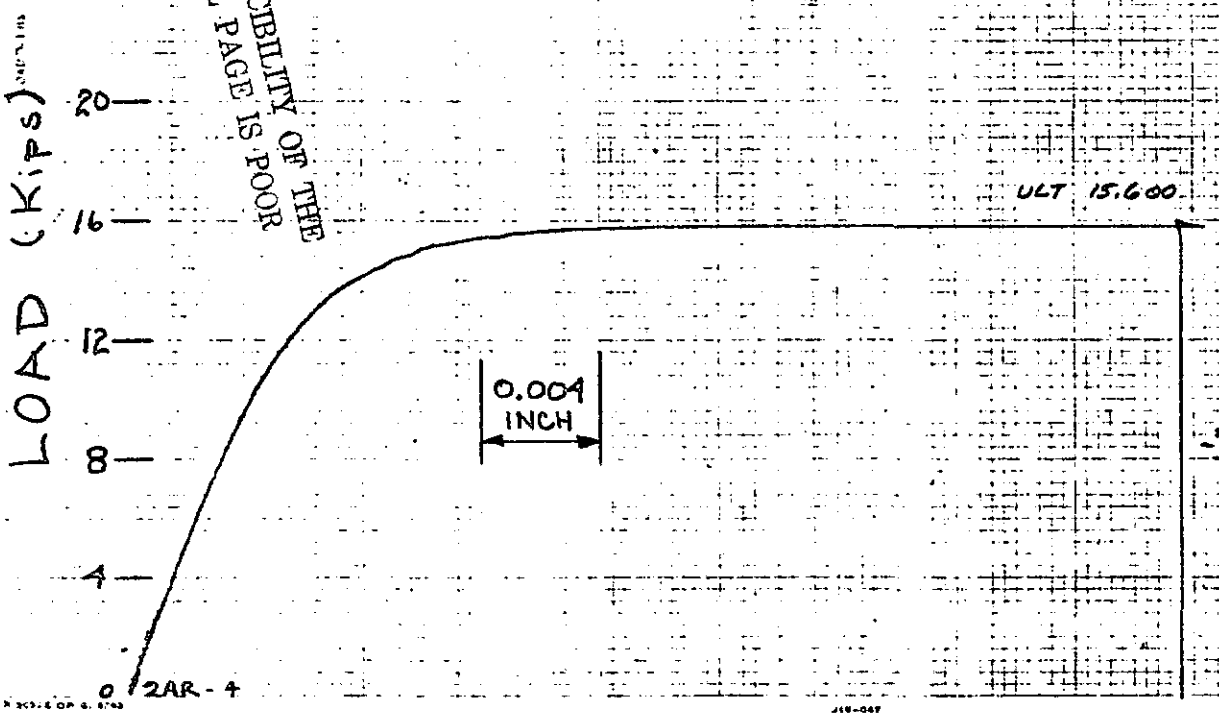
CALC ——— OPR ——— 1-28-6

CHECK ——— APPD ———

BOEING | TPR | PAGE OF

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR-4



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		15,000	.004

CALC _____ DP2 SK 1-28-6

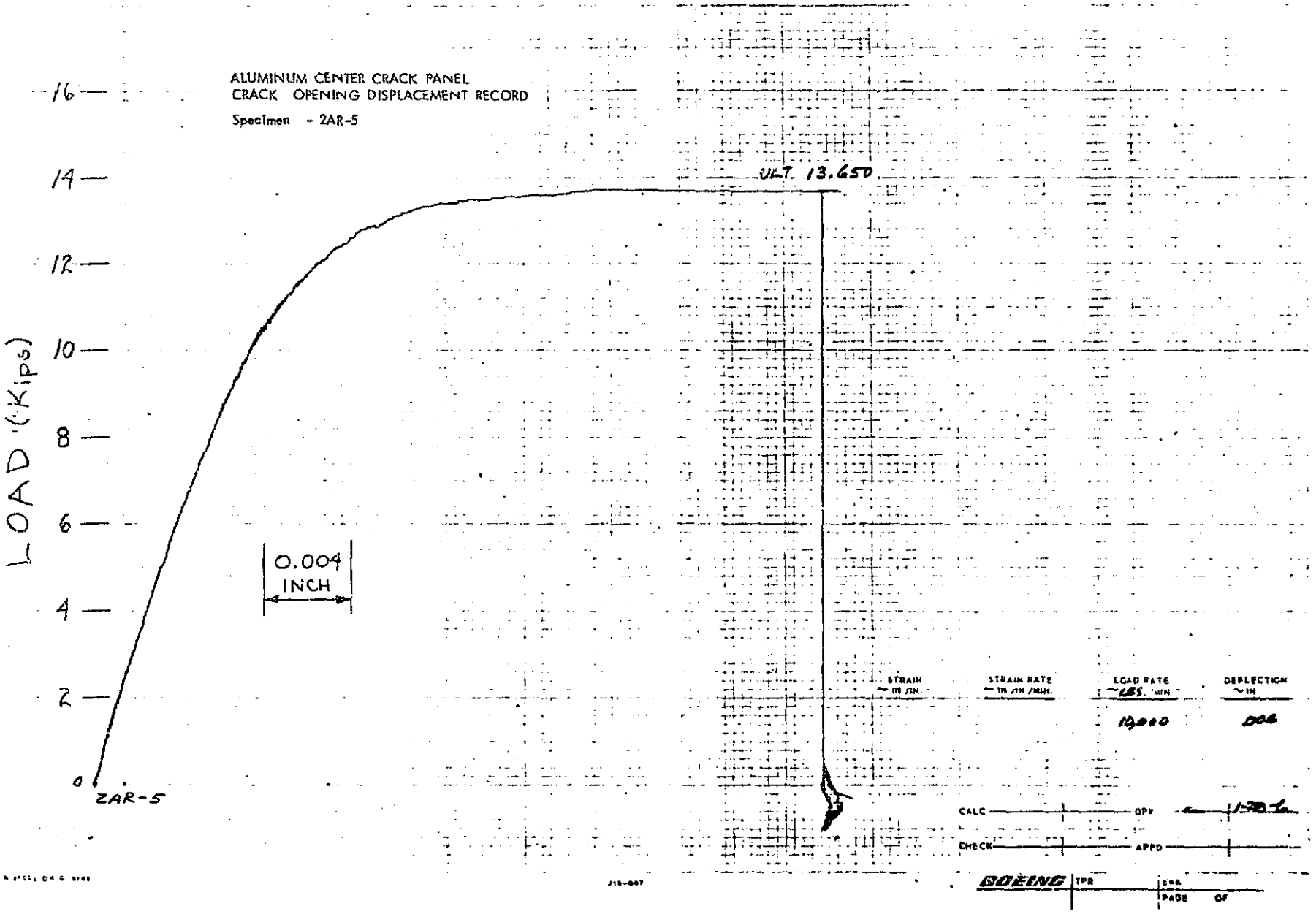
CHECK _____ APPD _____

BOEING TPR _____

PAGE _____ OF _____

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR-5



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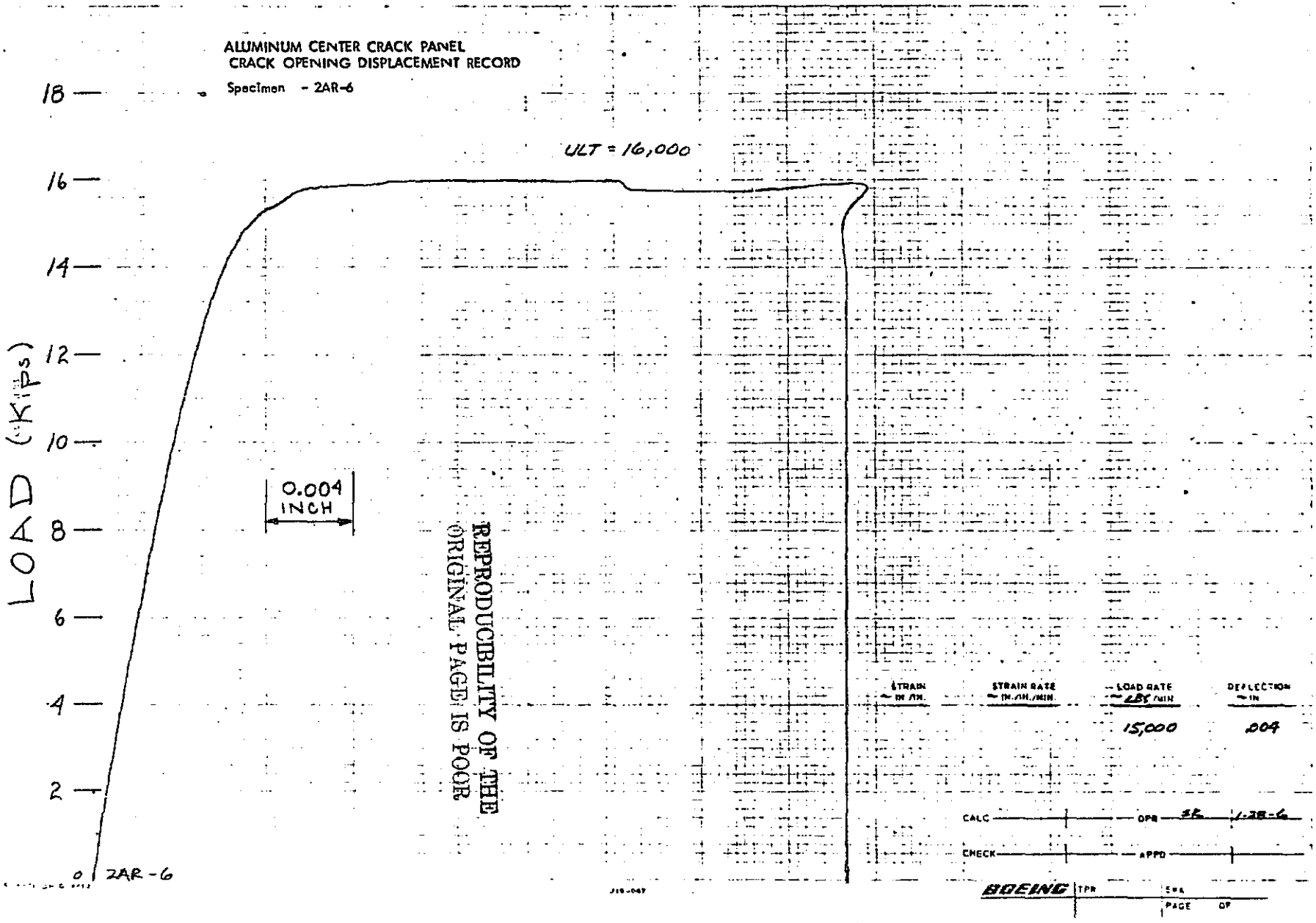
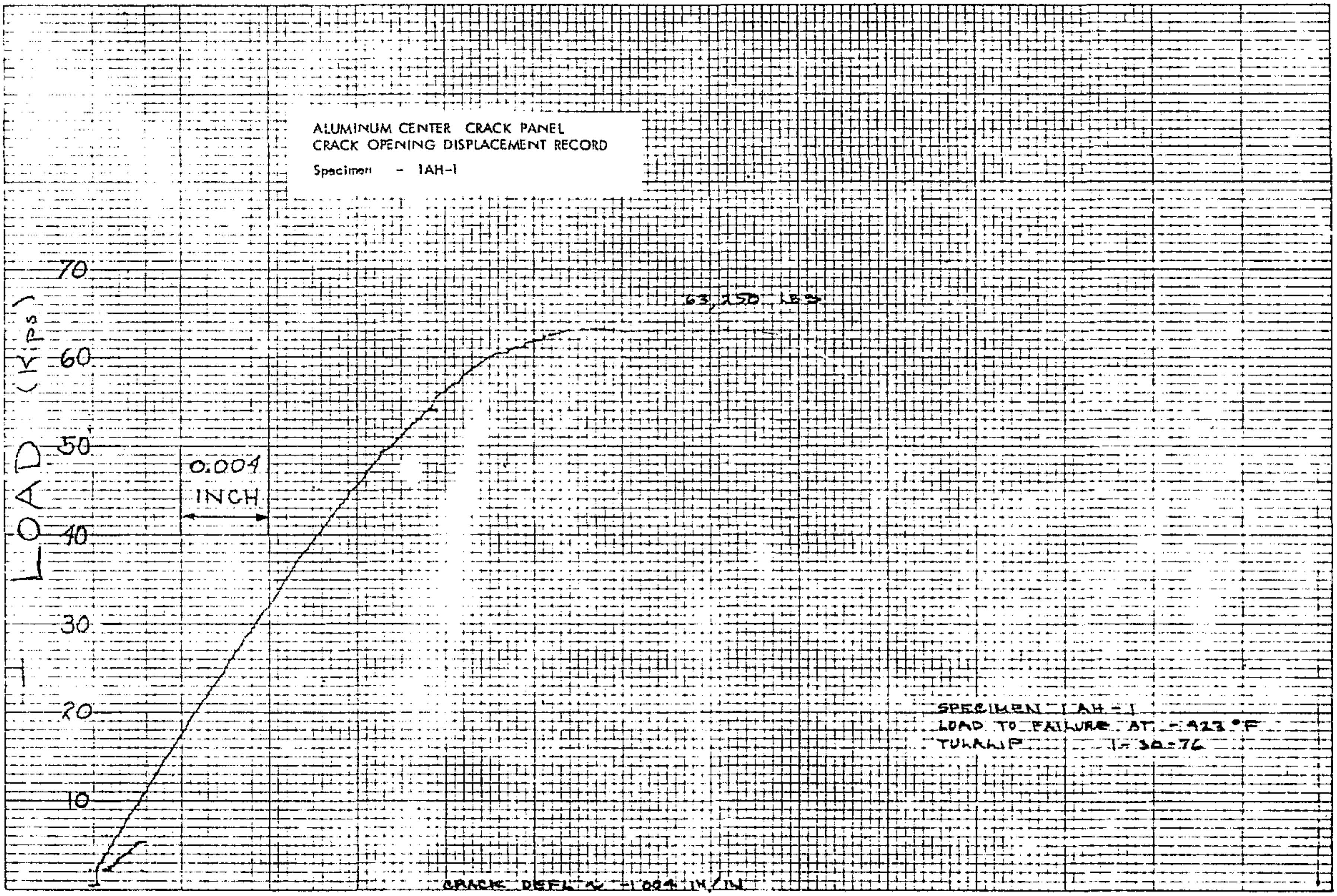
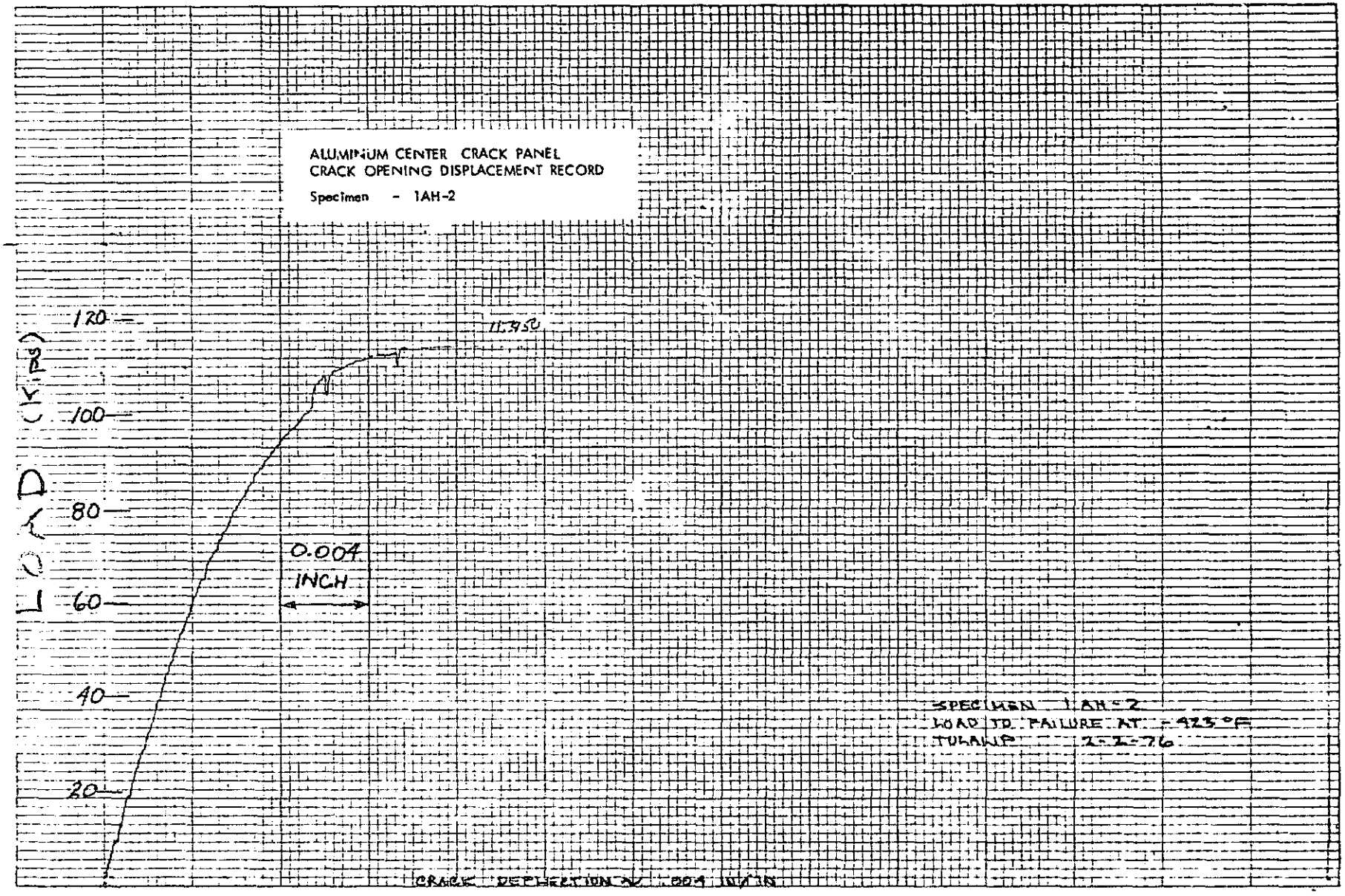
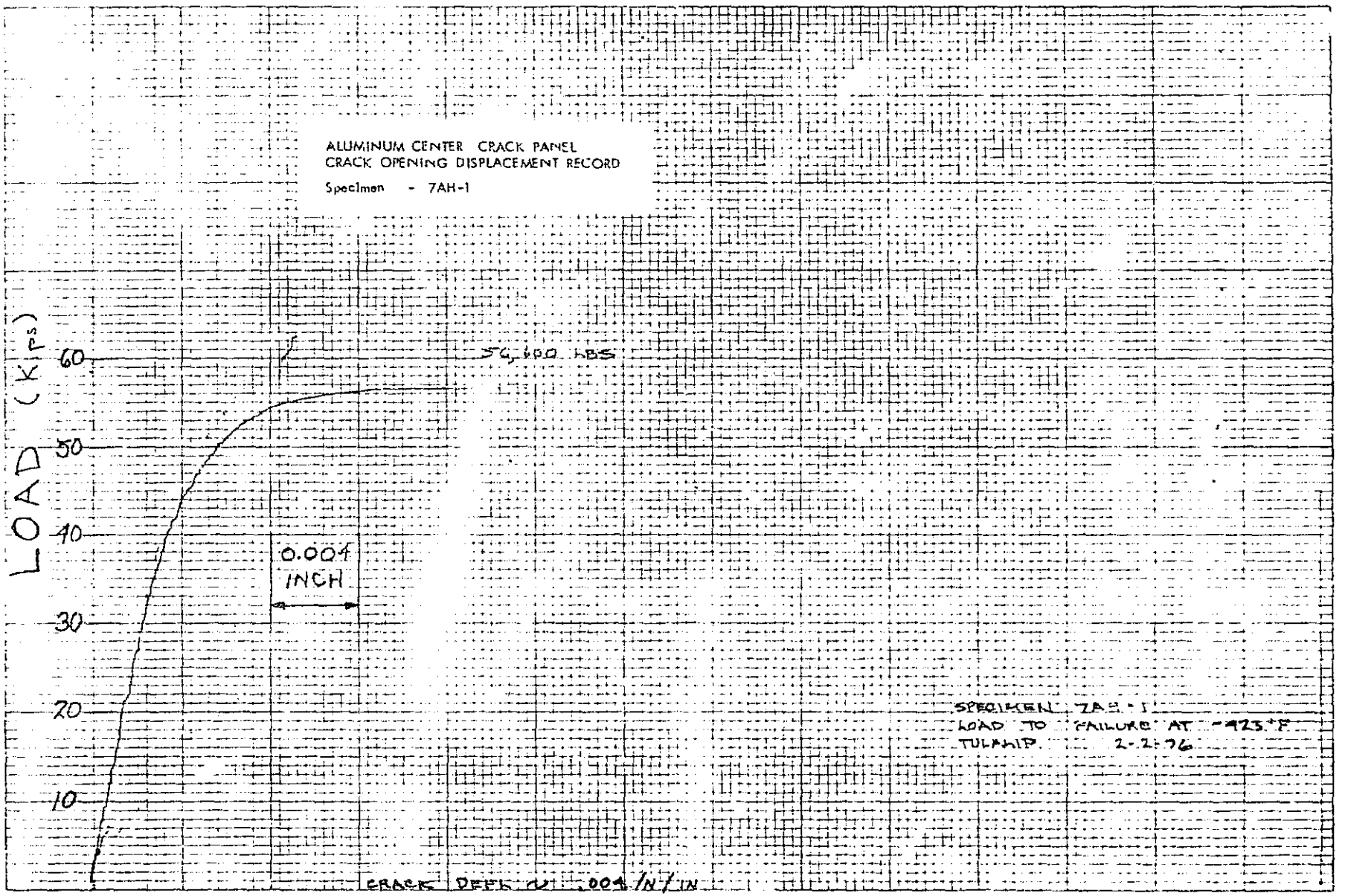

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR-6
ULT = 16,000
LOAD (KIPS)
18
16
14
12
10
8
6
4
2
0
0.004 INCH
2AR-6
REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
STRAIN IN /IN
STRAIN RATE IN./IN./MIN
LOAD RATE LBS/MIN
DEFLECTION IN
15,000
.004
CALC
DPR
CHECK
APPD
BOEING
TPR
PAGE
OF

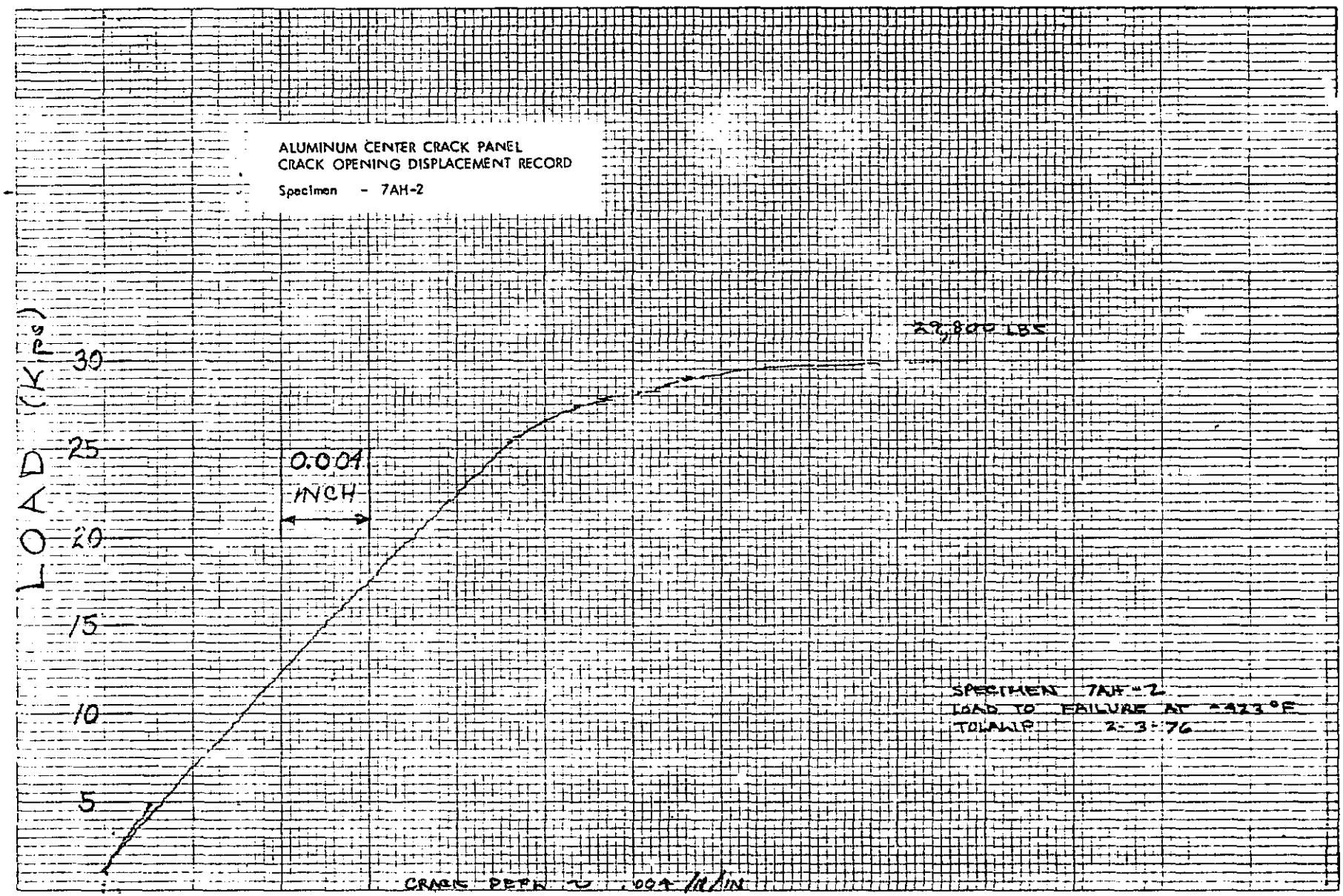

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1AH-1
LOAD (KIPS)
70
60
50
40
30
20
10
0.004 INCH
63,150 LBS
SPECIMEN 1AH-1
LOAD TO FAILURE AT -423 °F
TULALIP 1-30-76
CRACK DEFL ~ .004 IN/IN

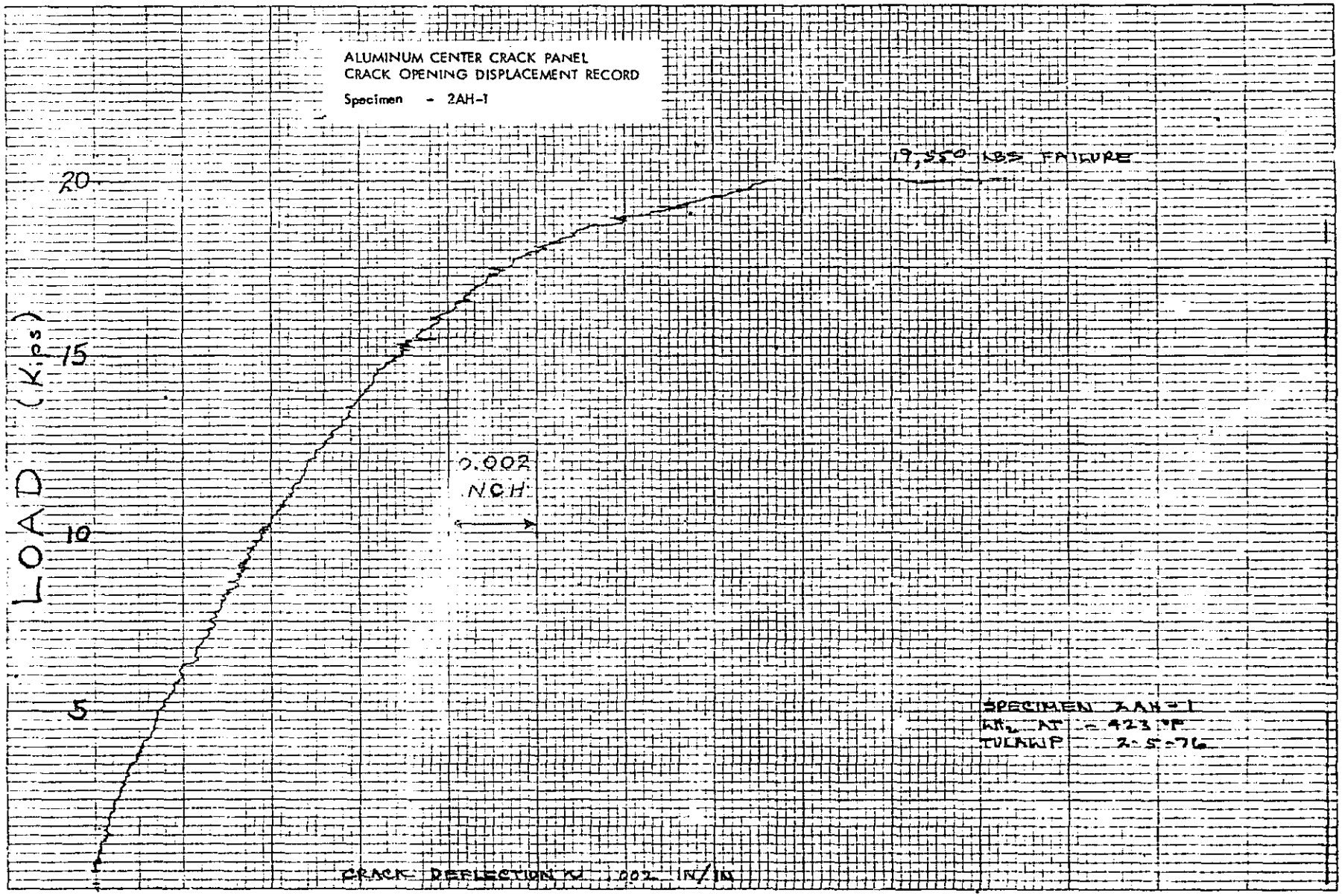
AH-2

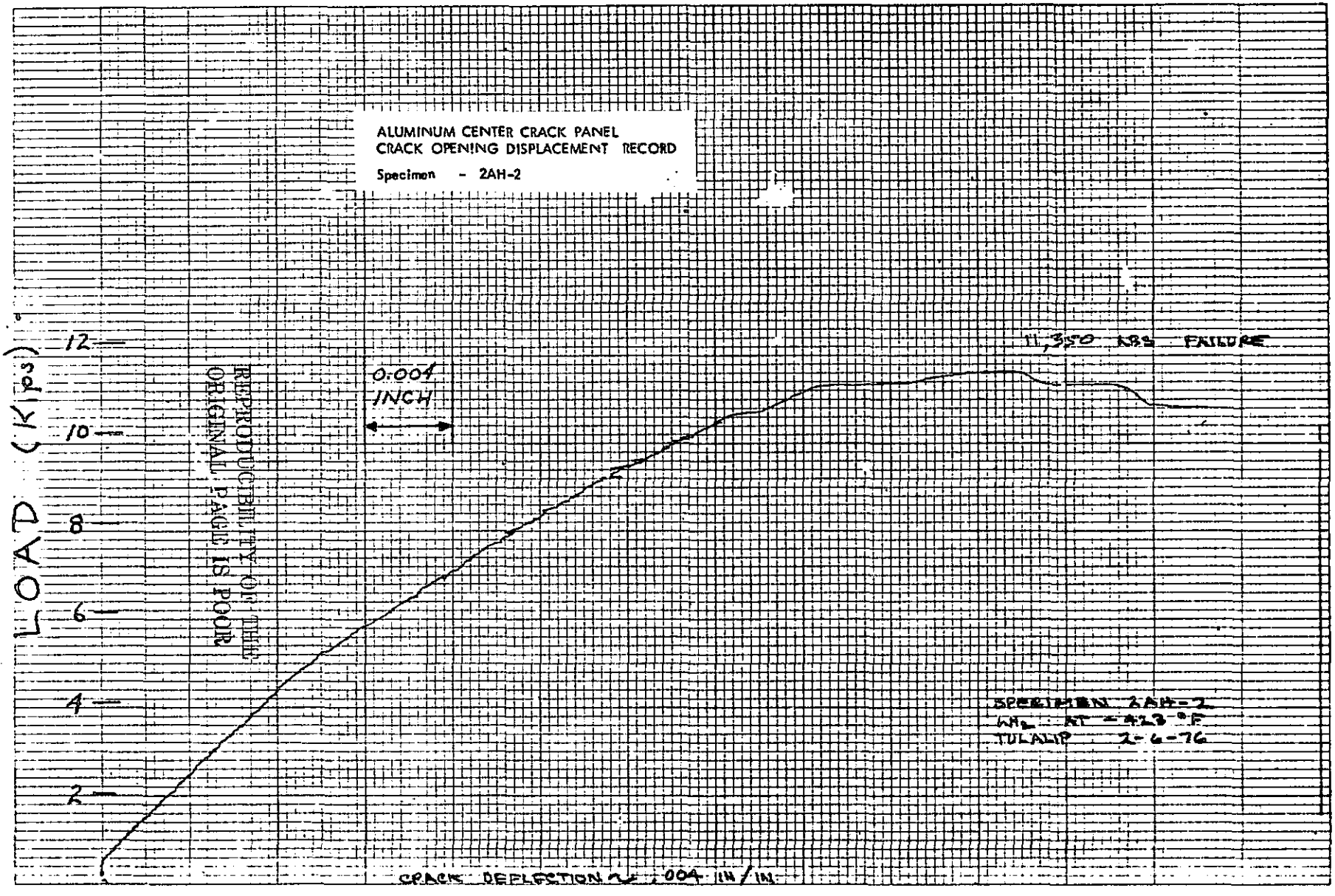

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1AH-2
LOAD (KIPS)
120
100
80
60
40
20
11,350
0.004
INCH
SPECIMEN 1AH-2
LOAD TO FAILURE AT -423°F
TUNNEL 2-2-76
CRACK DEFLECTION = .004 IN/IN

1004


ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AH-1
LOAD (KIPS)
60
50
40
30
20
10
54,100 LBS
0.004 INCH
SPECIMEN 7AH-1
LOAD TO FAILURE AT -423°F
TULAMP. 2-2-76
CRACK OPEN @ .004 IN/IN

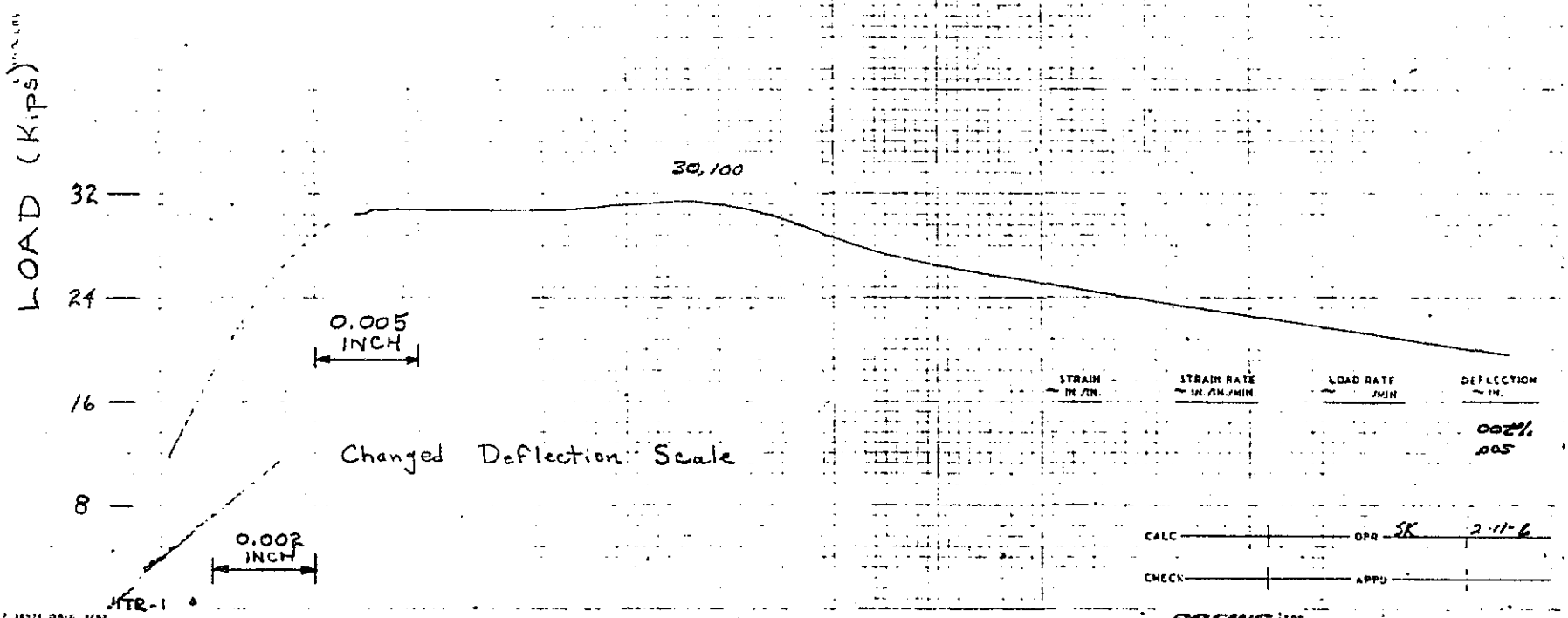

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 7AH-2
LOAD (KIPS)
30
25
20
15
10
5
0.004
INCH
29,800 LBS
SPECIMEN 7AH-2
LOAD TO FAILURE AT -423°F
TOLAN/P 2-3-76
CRACK DEPTH ~ .004 IN/IN



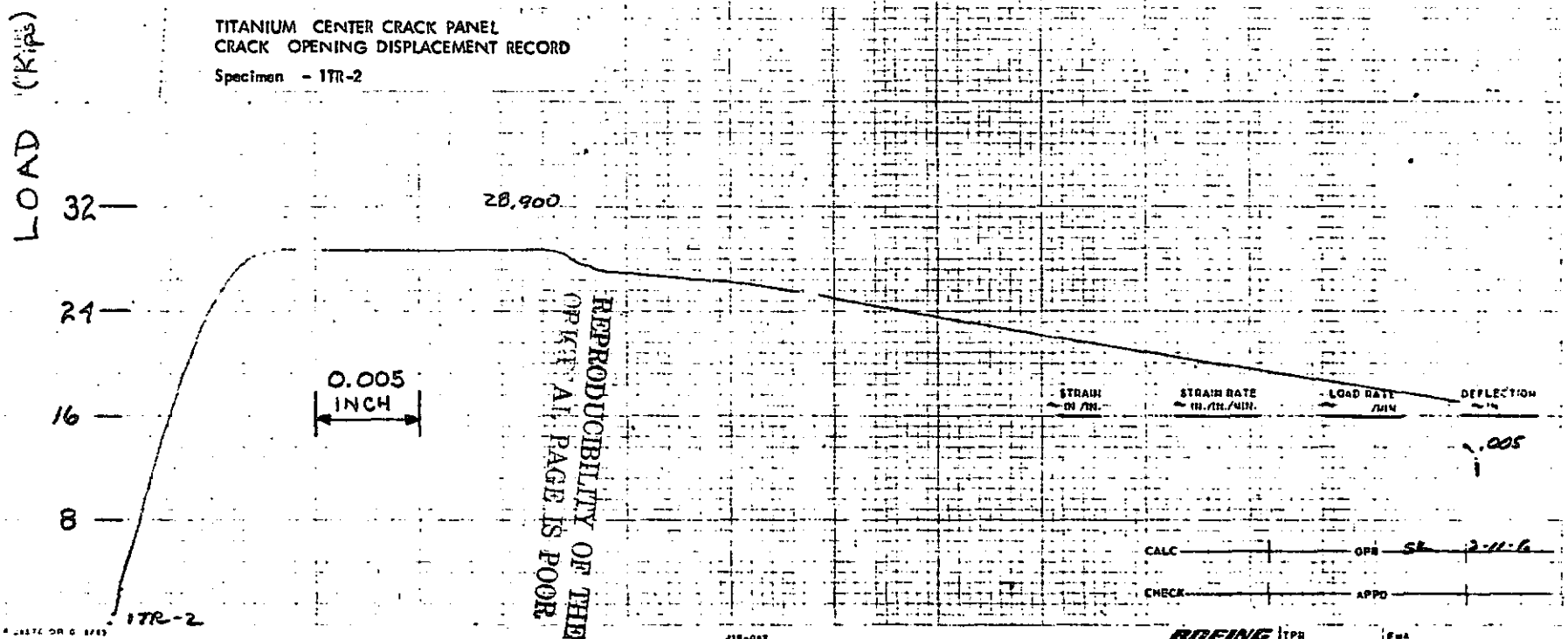

ALUMINUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH-2
LOAD (KIPS)
12
10
8
6
4
2
0.004 INCH
11,350 LBS FAILURE
REPRODUCIBILITY OF THIS ORIGINAL PAGE IS POOR
SPECIMEN 2AH-2
AR2 RT -423°F
TULALIP 2-6-76
CRACK DEFLECTION .004 IN/IN
.004

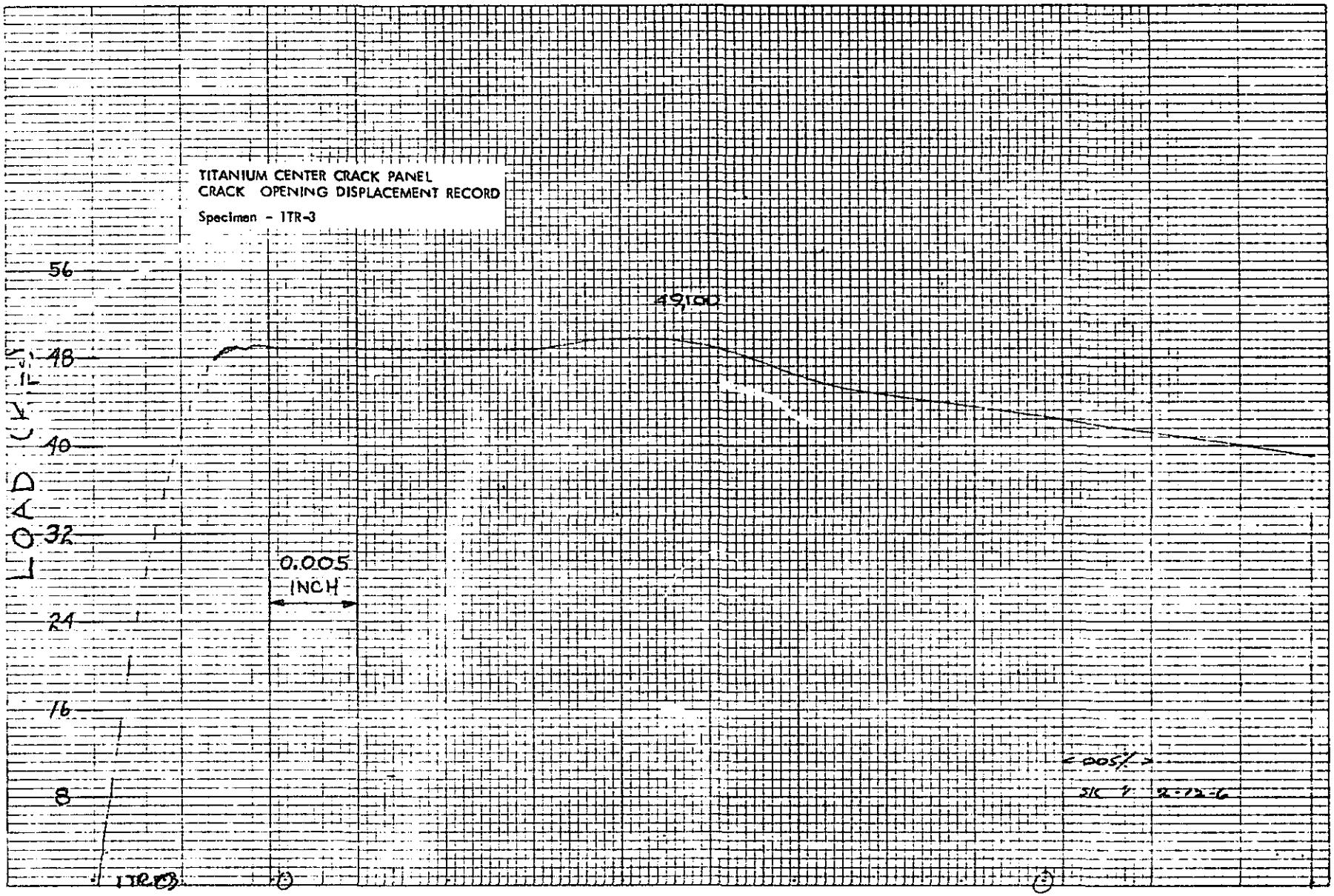
TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

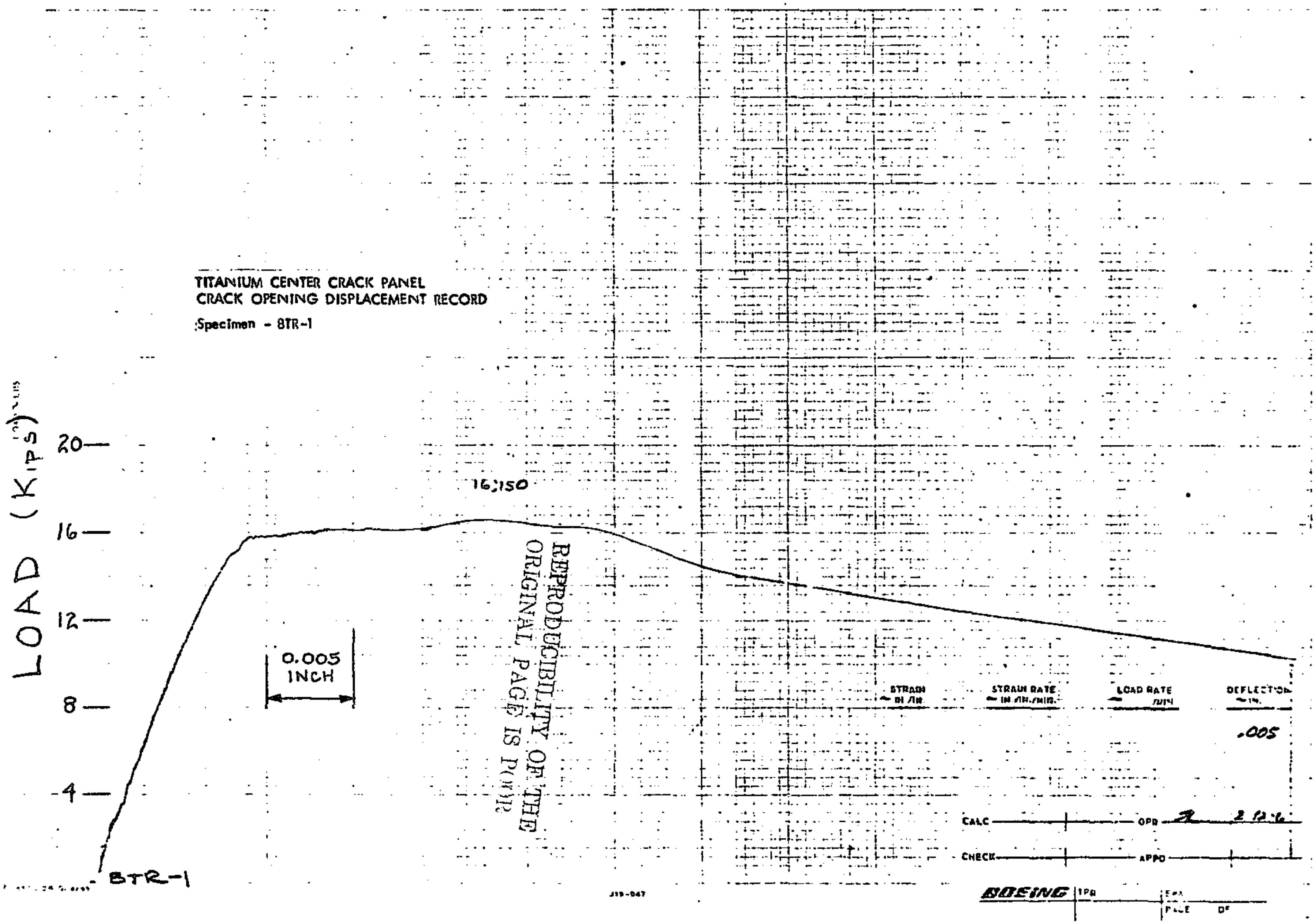
Specimen - 1TR-1



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 1TR-2

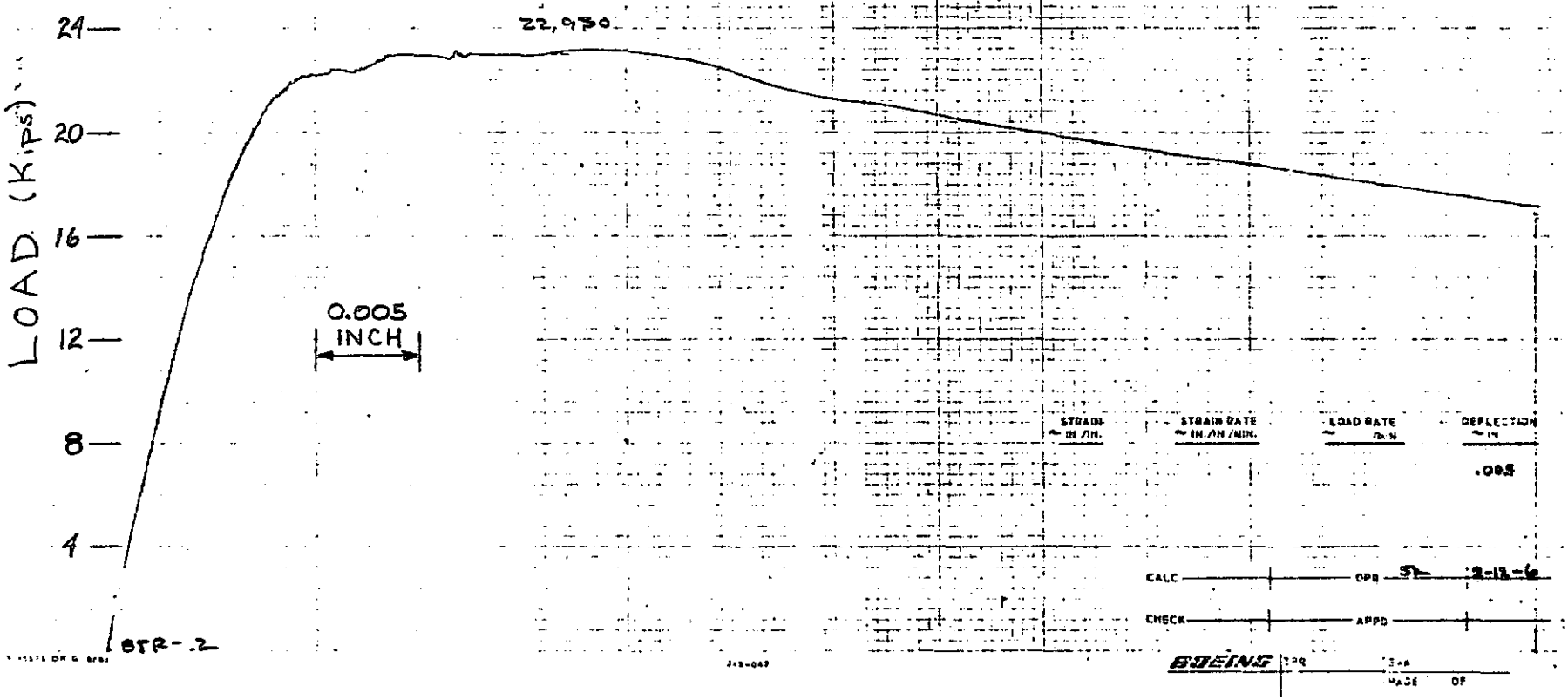



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - ITR-3
56
48
40
32
24
16
8
LOAD (KIPS)
49,100
0.005
INCH
ITR-3
.005"
SK Y 2-12-6



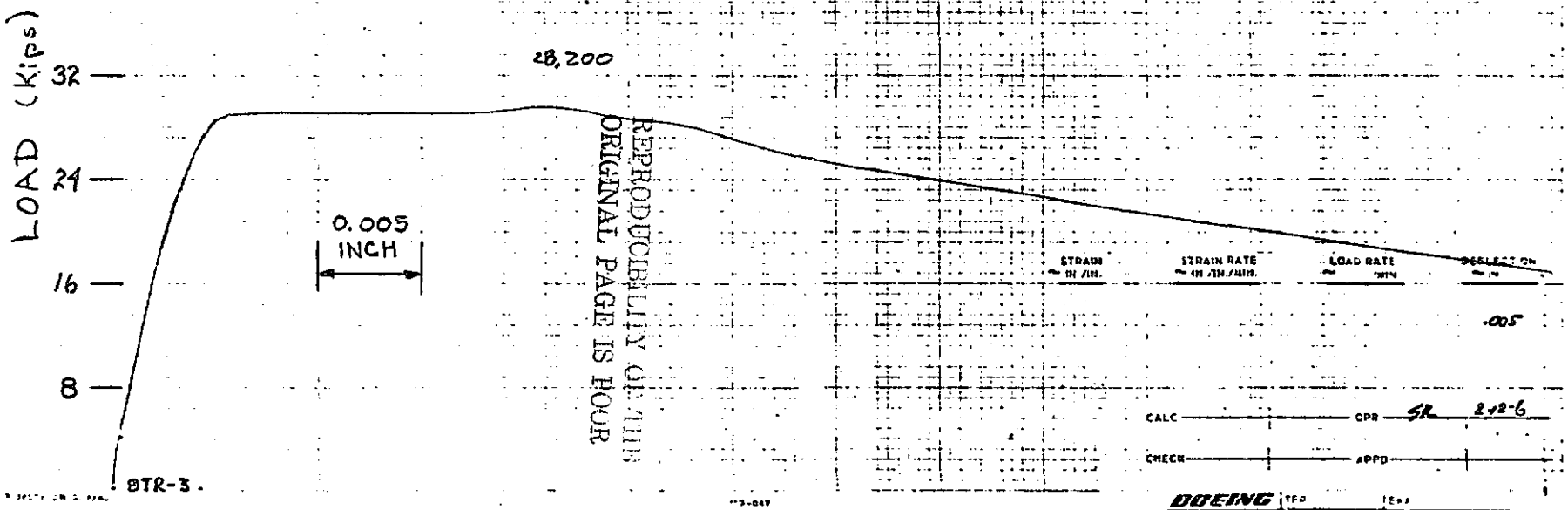
TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen – BTR-2



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 8TR-3



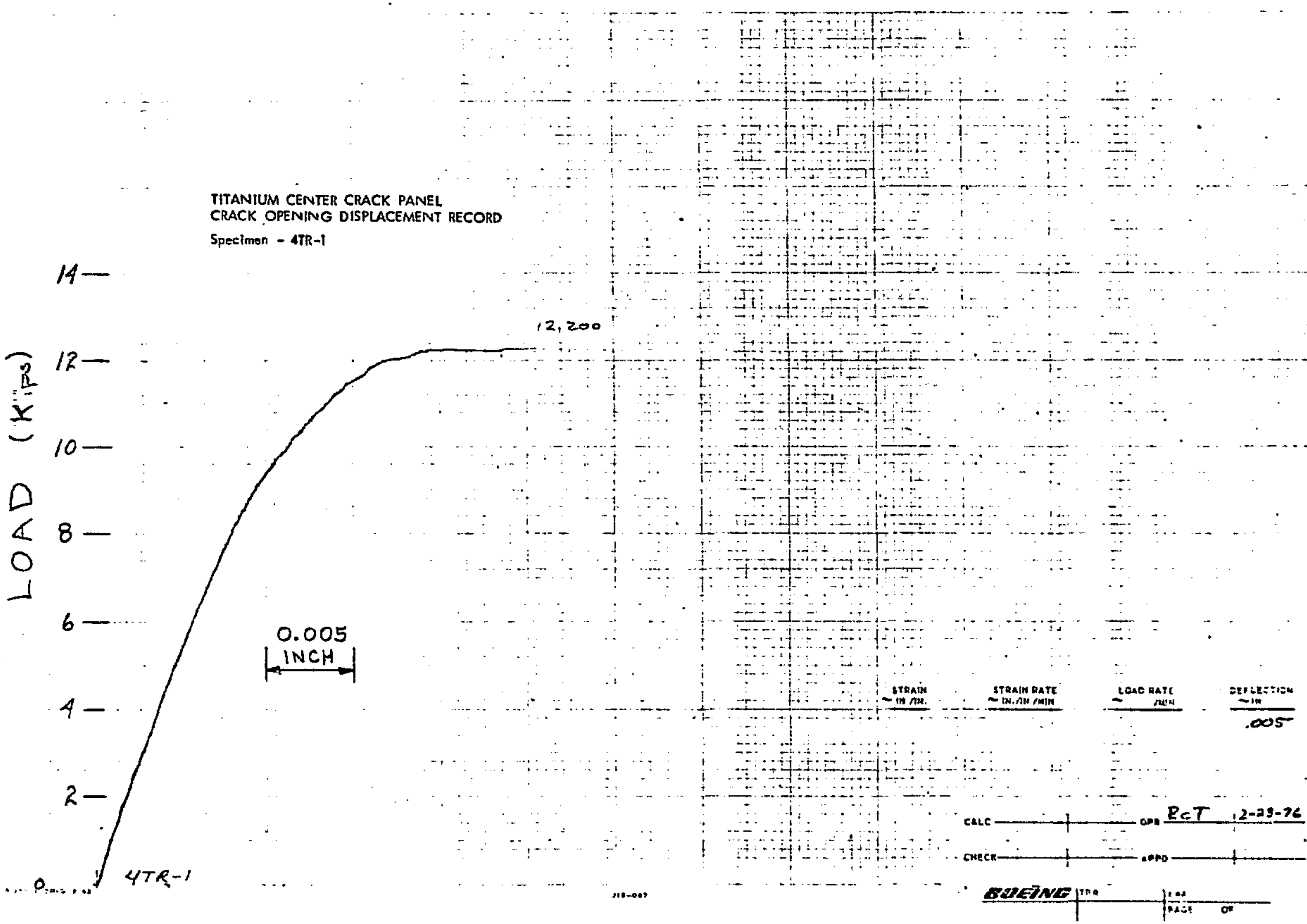
STRAIN IN /IN. | STRAIN RATE IN /IN./MIN. | LOAD RATE | DEFLECTION

.005

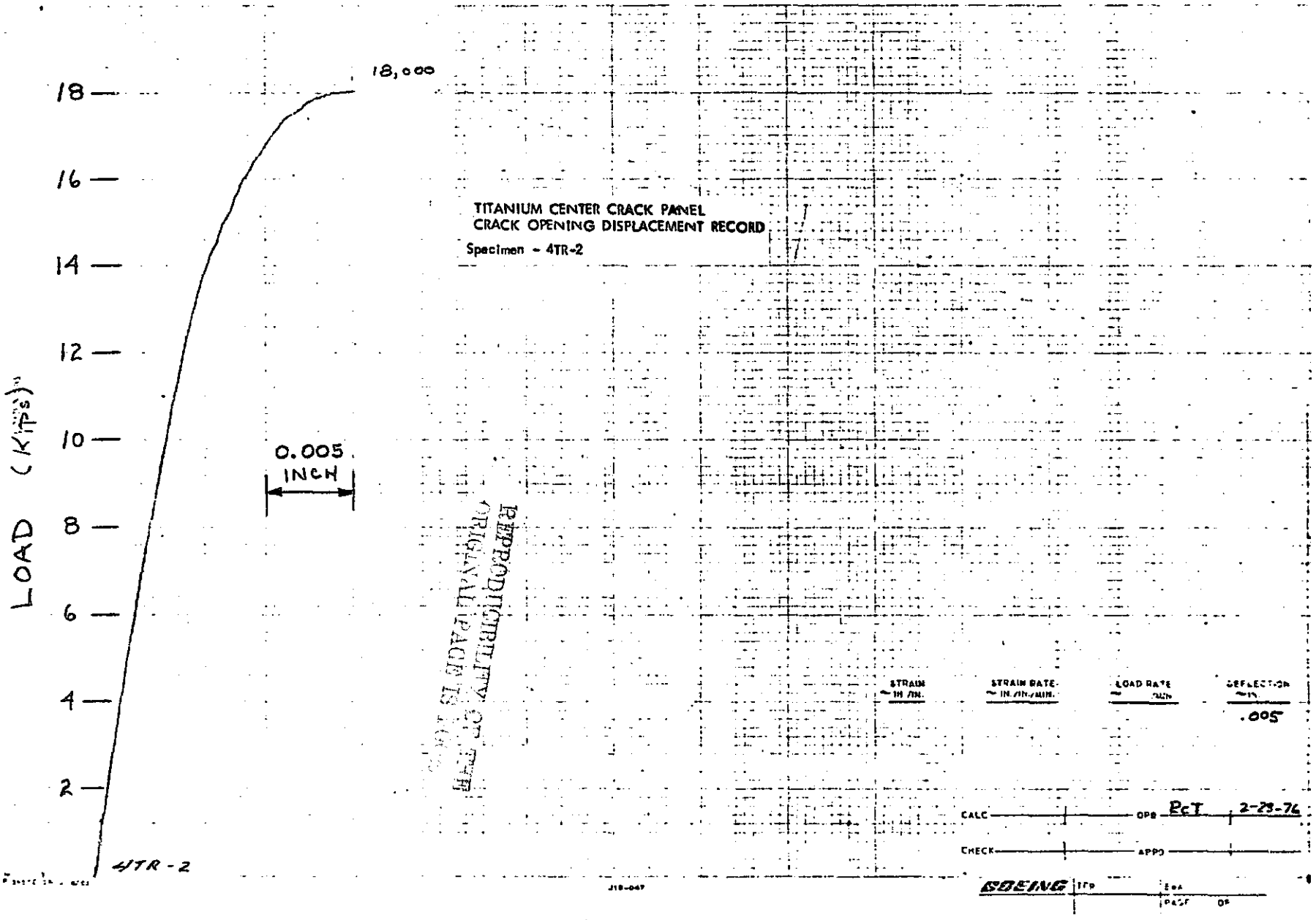
CALC ——— CPR SR 242-6

CHECK ——— APPD

BOEING TPD ——— PAGE OF

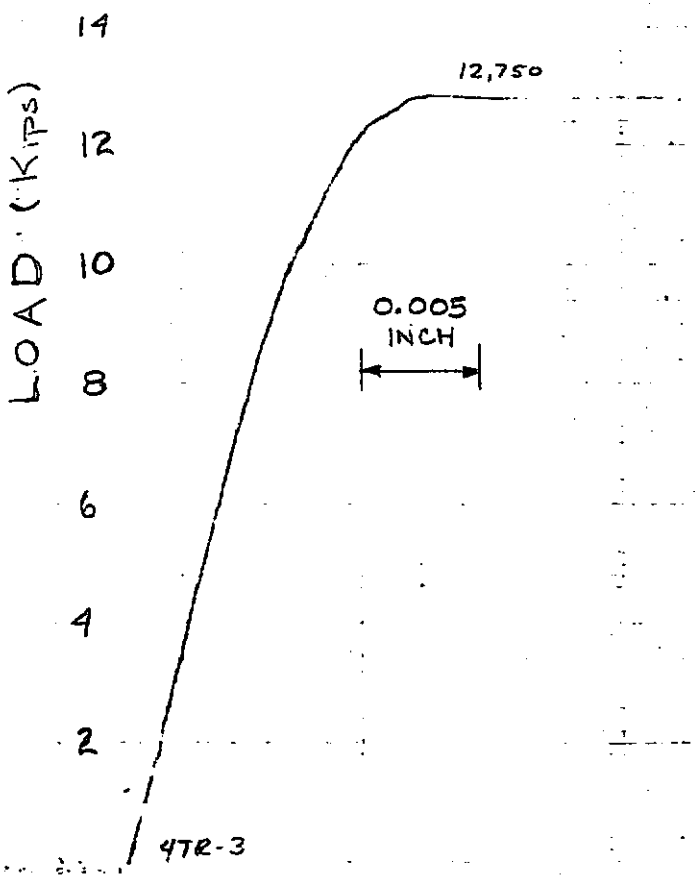


TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD
Specimen - 4TR-1



TITANIUM CENTER CRACK PANEL
CRACK OPENING DISPLACEMENT RECORD

Specimen - 4TR-3



STRAIN IN /IN.	STRAIN RATE IN /IN./MIN	LOAD RATE /MIN	DEFLECTION IN.

CALC _____ DES R.C.T 2-23-73

CHECK _____ APPD _____

BOEING _____ DWG _____

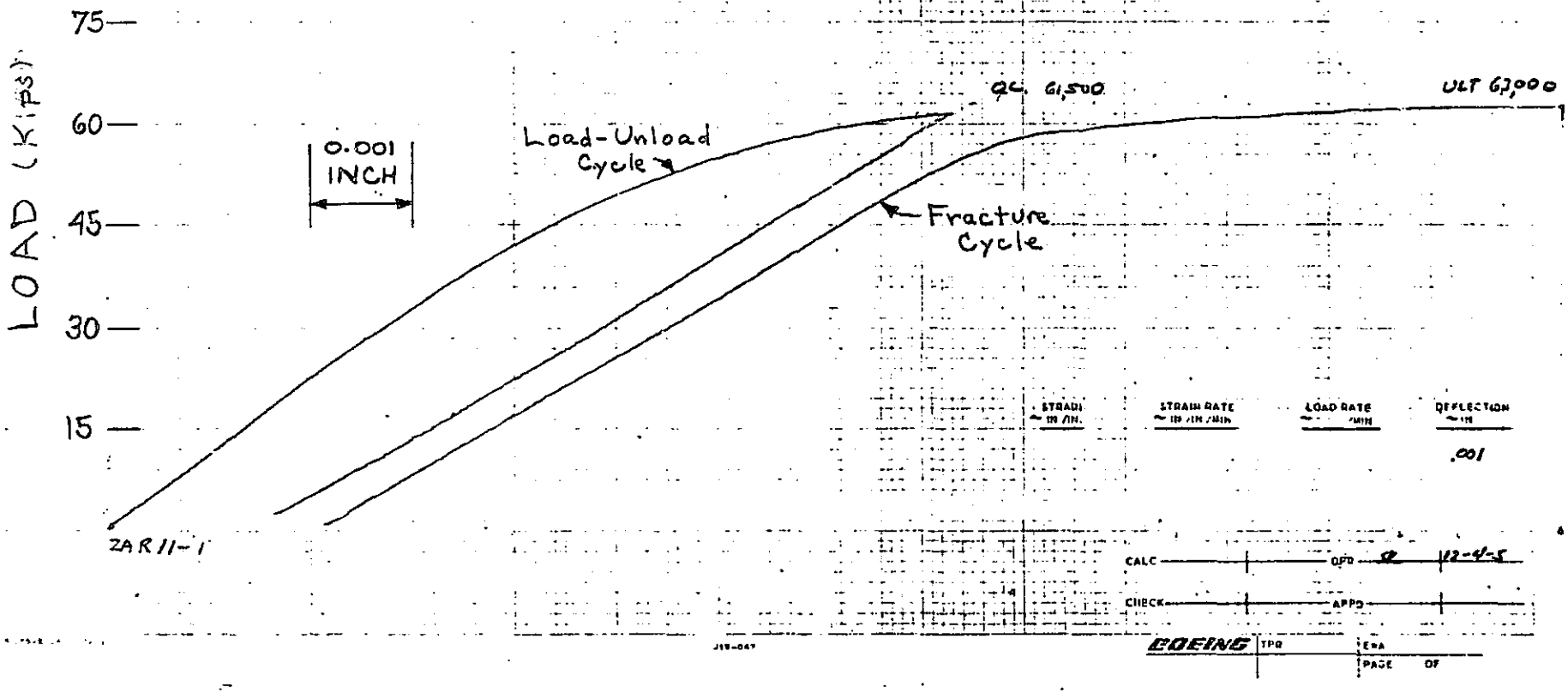
PAGE _____ OF _____

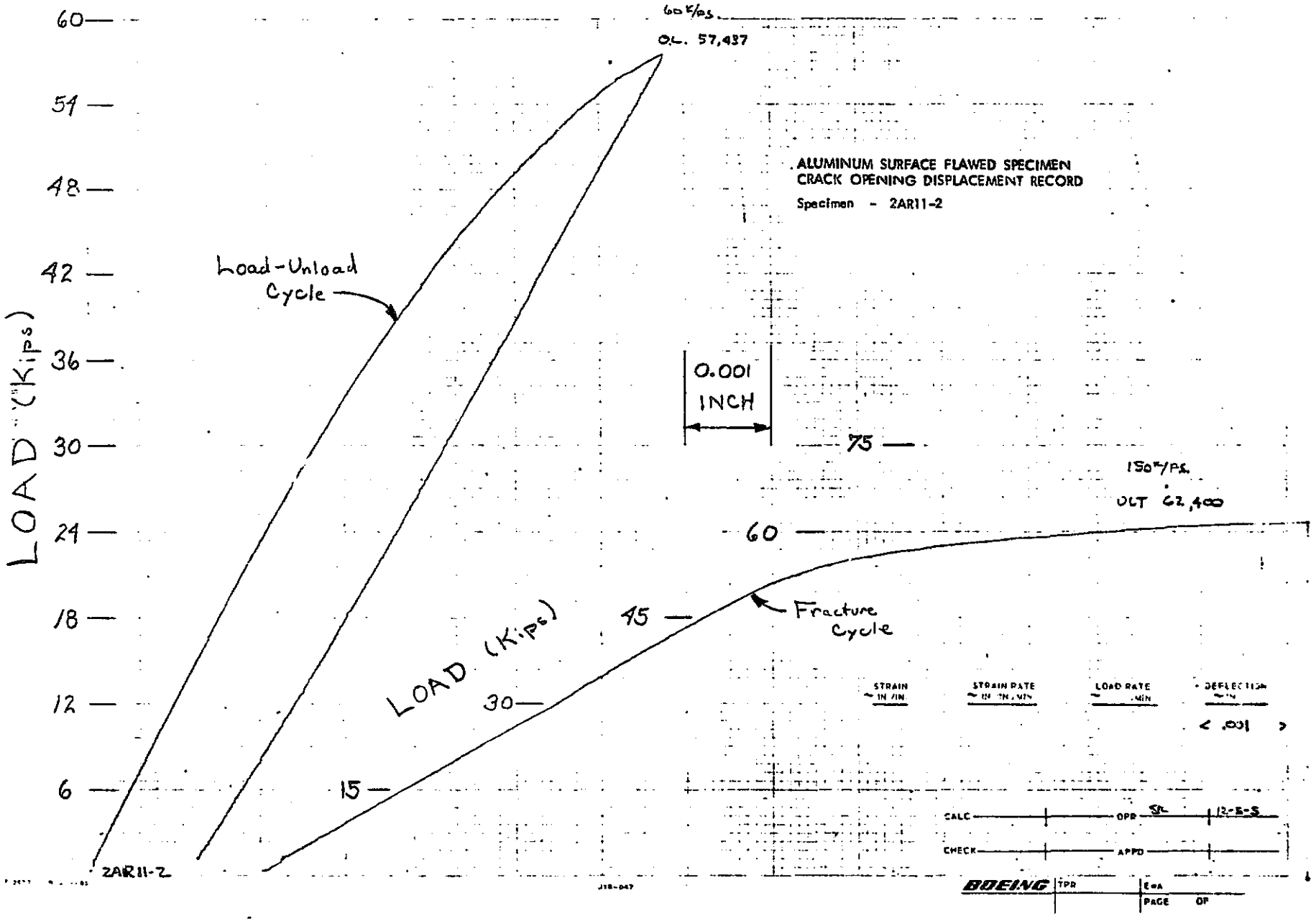
APPENDIX II - Surface Flawed Specimen Crack Opening Displacement Records

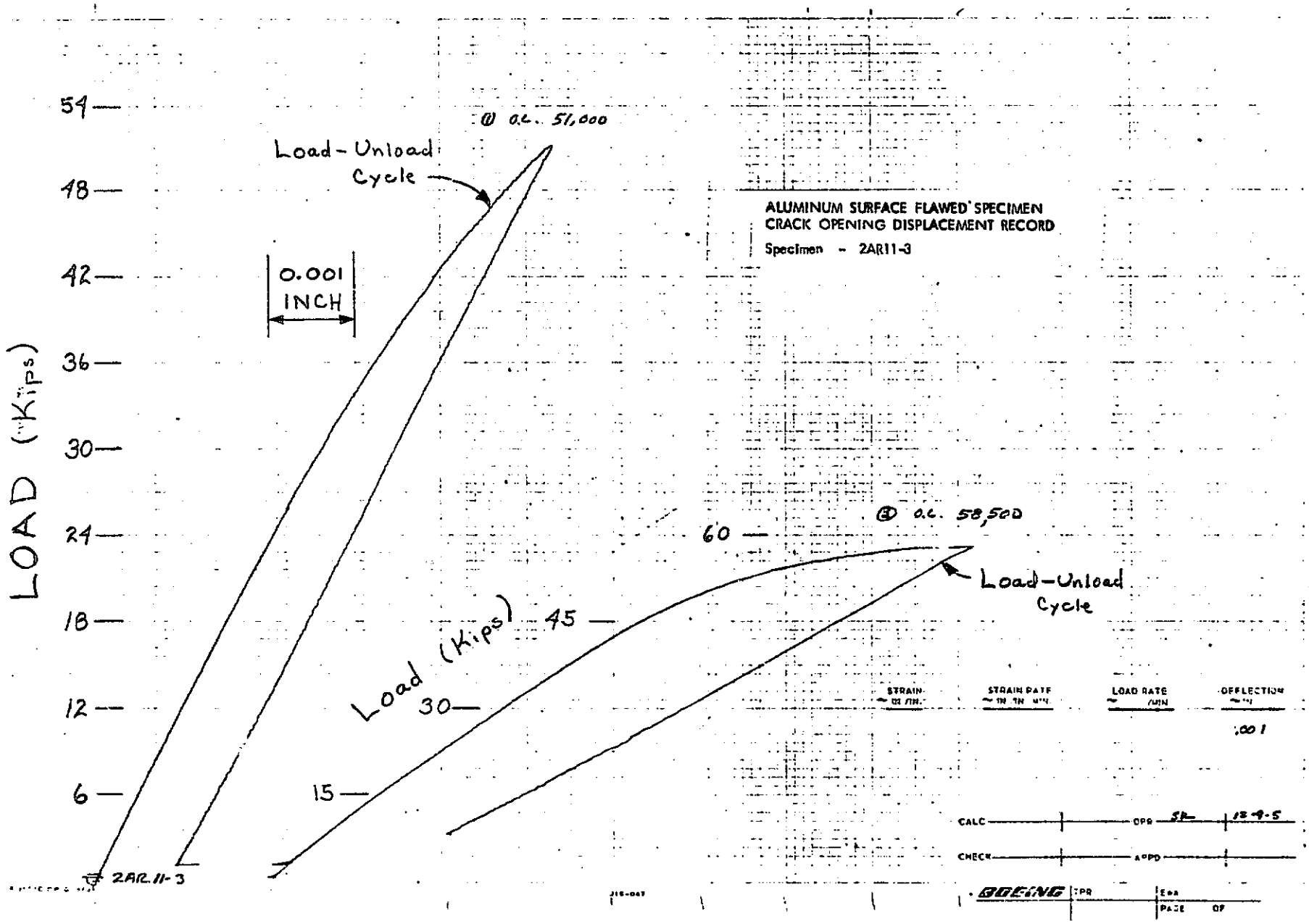
APPENDIX II - Surface Flawed Specimen Crack Opening Displacement Records

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR11-1

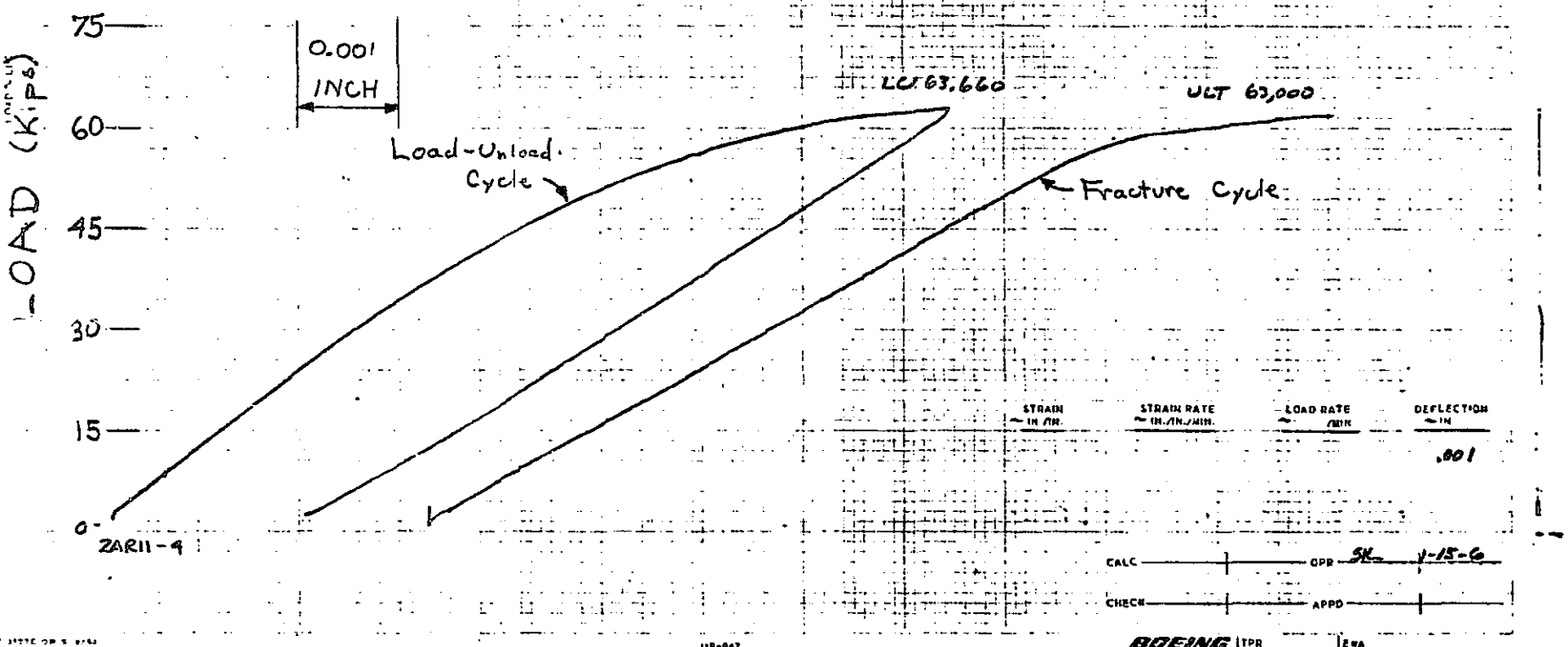



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR11-2
60 K/ps
O.L. 57,437
Load-Unload Cycle
0.001 INCH
LOAD (Kips)
60
51
48
42
36
30
24
18
12
6
75
60
45
30
15
150 K/ps
ULT 62,400
Fracture Cycle
LOAD (Kips)
2AR11-2
STRAIN IN/IN
STRAIN RATE IN/IN/MIN
LOAD RATE /MIN
DEFLECTION
< .001 >
CALC
CHECK
APPD
BOEING
TPR
PAGE
OF


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR11-3
@ o.c. 51,000
Load-Unload Cycle
0.001 INCH
LOAD (Kips)
54
48
42
36
30
24
18
12
6
@ o.c. 58,500
60
45
30
15
Load (Kips)
Load-Unload Cycle
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
CHKD
APPD
BOEING
2AR.11-3

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR11-4



STRAIN IN/IN	STRAIN RATE IN./IN./MIN.	LOAD RATE /MIN	DEFLECTION IN
			.001

CALC ——— DPR SK 1-15-6

CHECK ——— APPD

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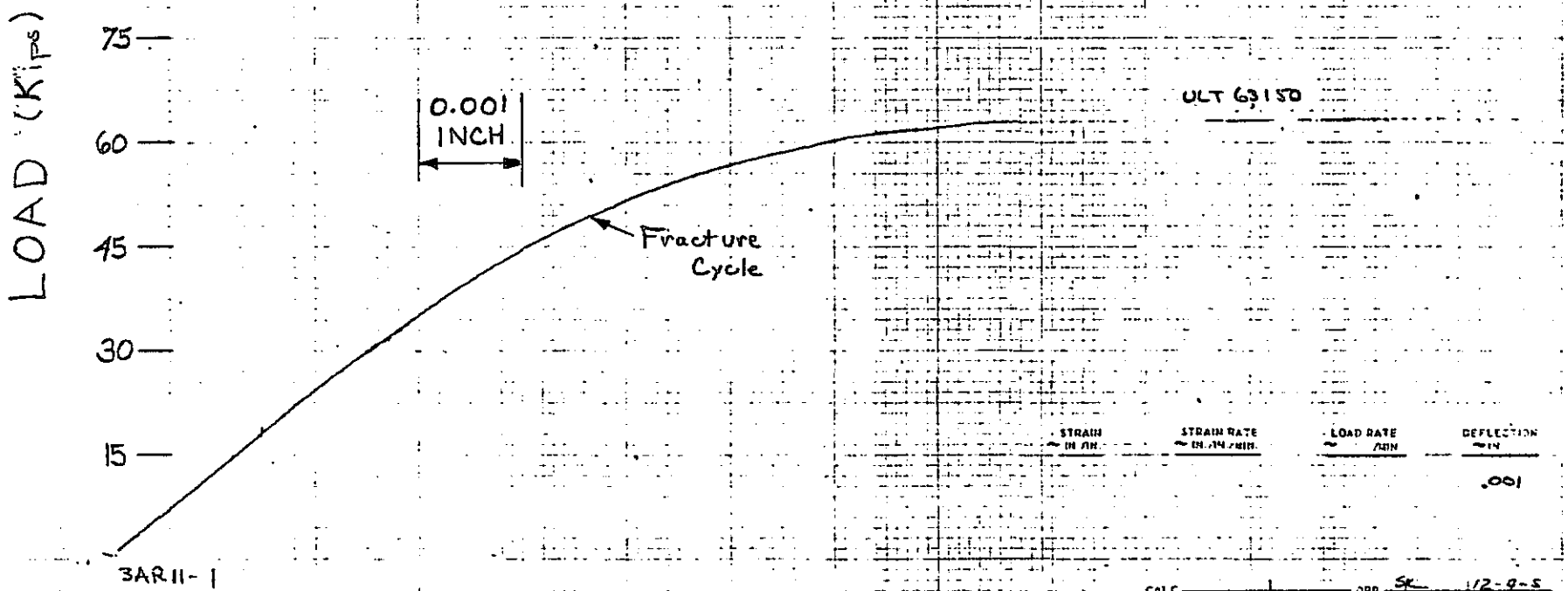
PAGE OF

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3AR11-1



STRAIN ~ IN /IN	STRAIN RATE ~ IN/IN/MIN.	LOAD RATE ~ /MIN	DEFLECTION ~ IN
			.001

CALC ____ OPR SK 12-9-5

CHECK ____ APPD ____

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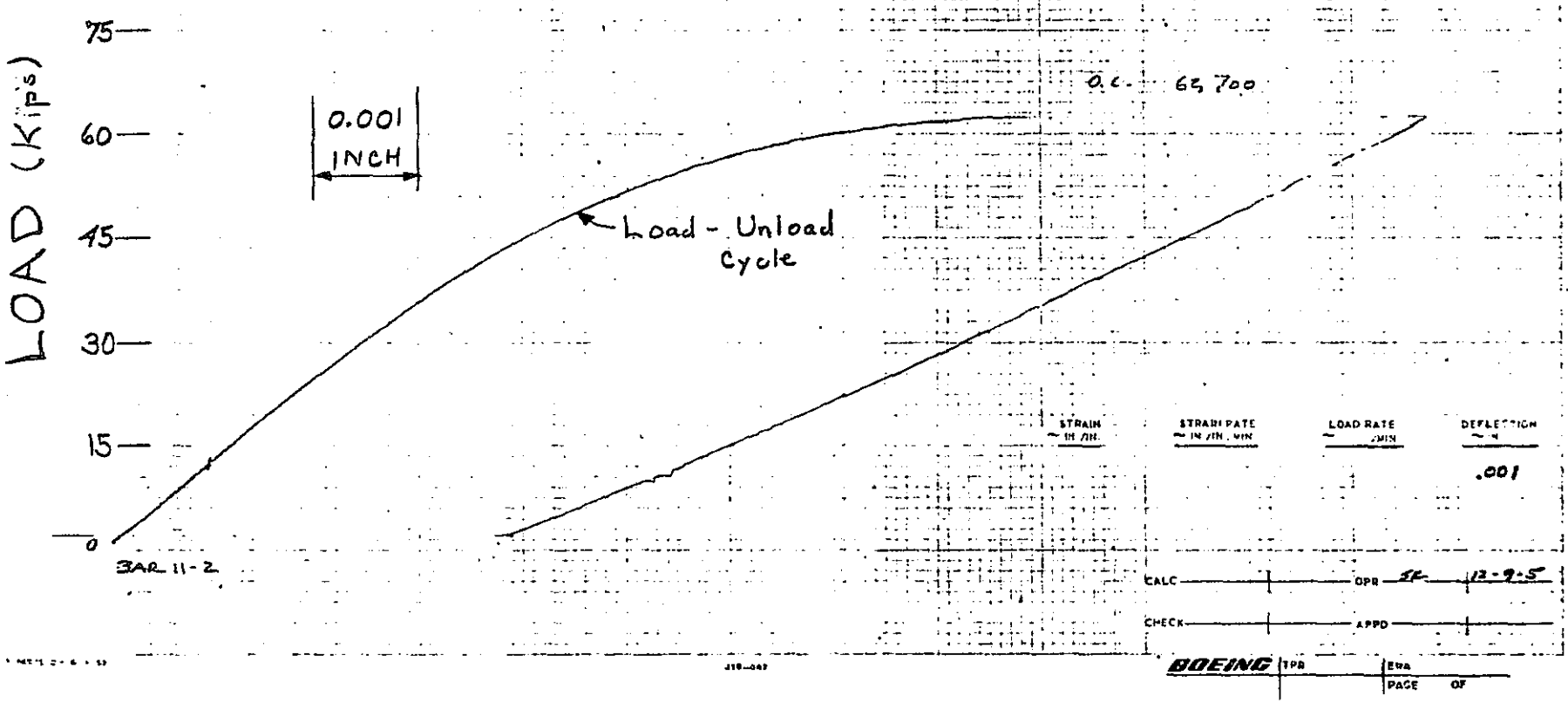
PAGE ____ OF ____

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3AR11-2



STRAIN ~ IN /IN.	STRAIN RATE ~ IN /IN . MIN	LOAD RATE ~ /MIN	DEFLECTION ~ "
			.001

CALC ——— OPR SP 12-9-5

CHECK ——— APPD

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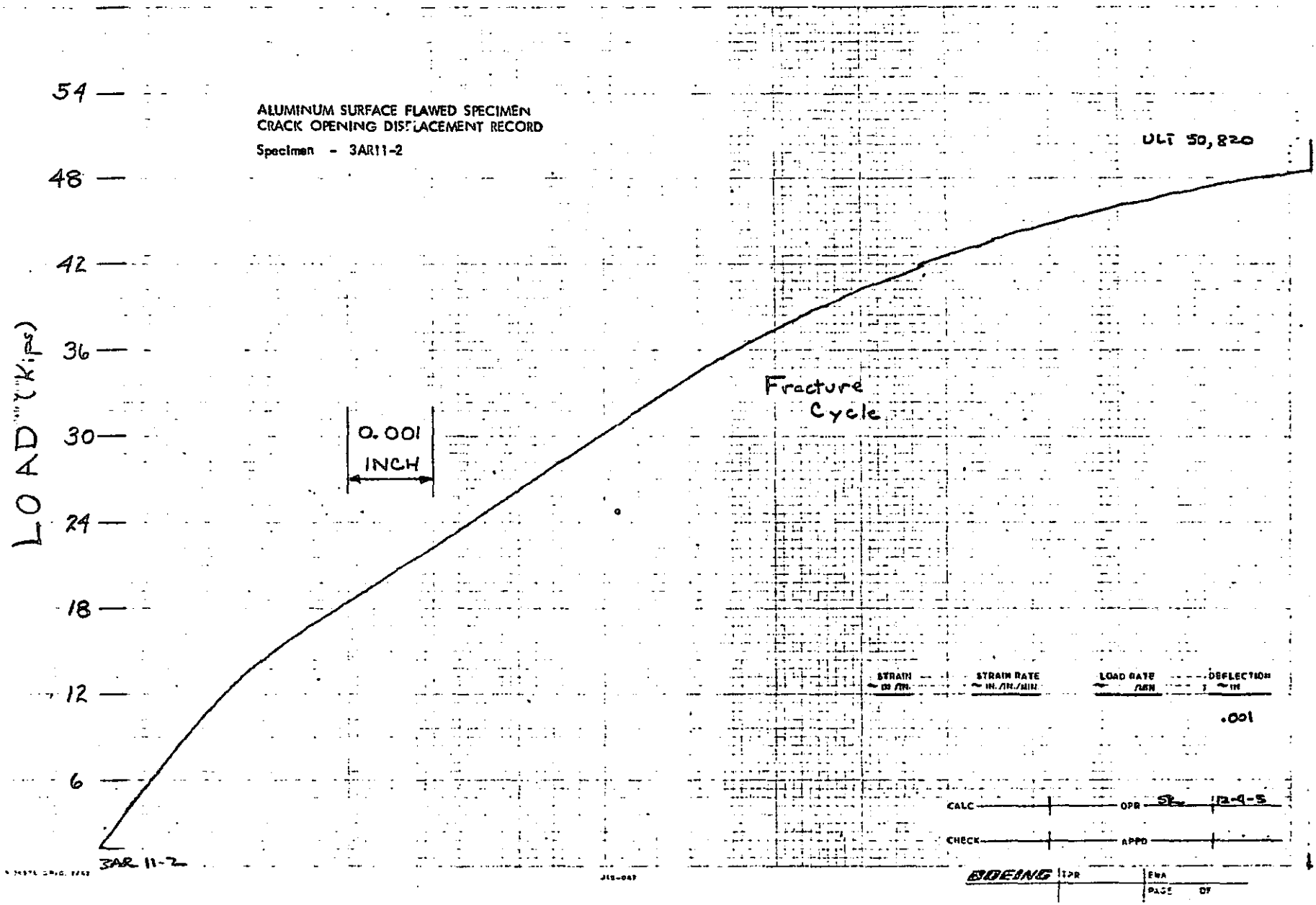
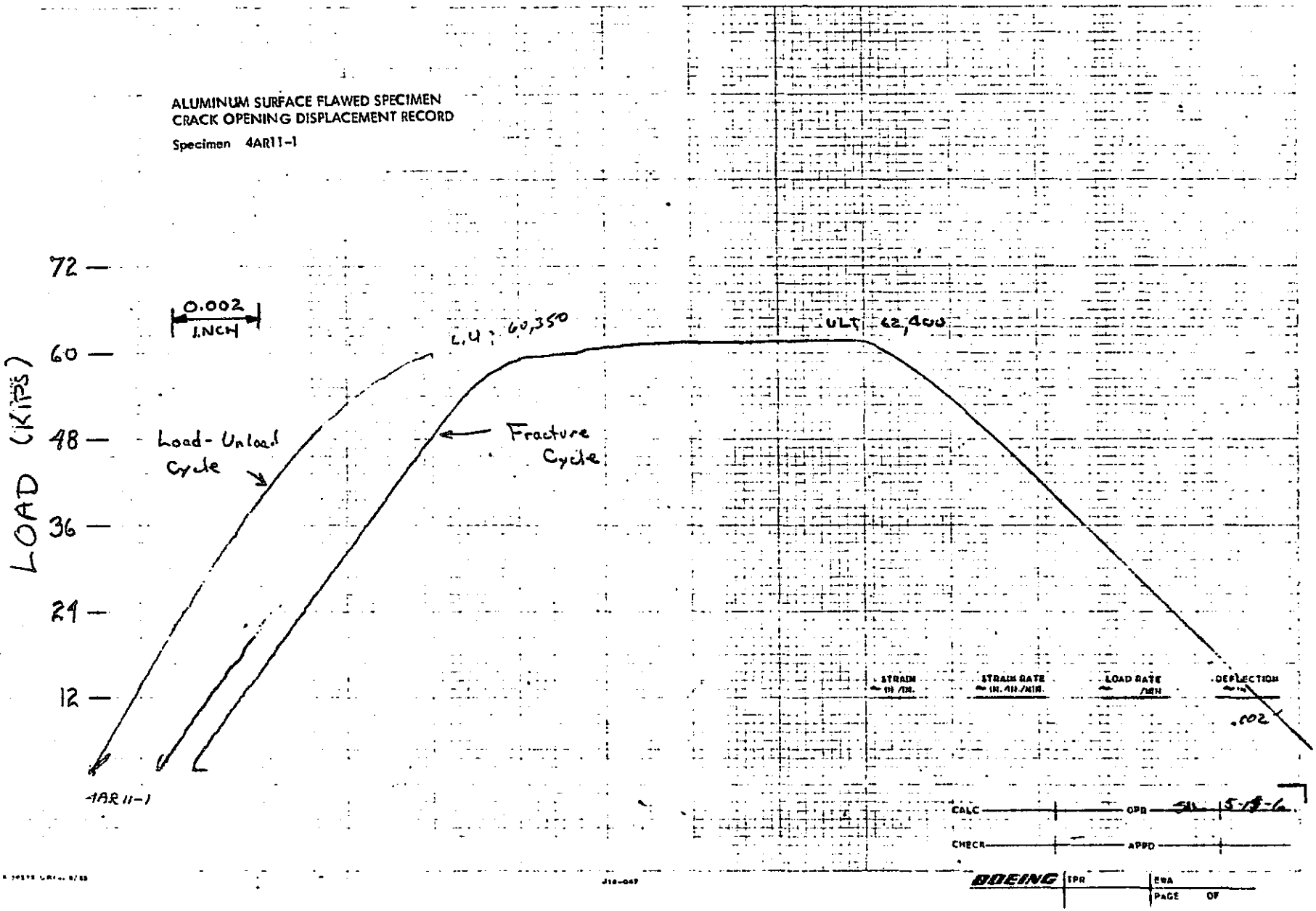
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3AR11-2



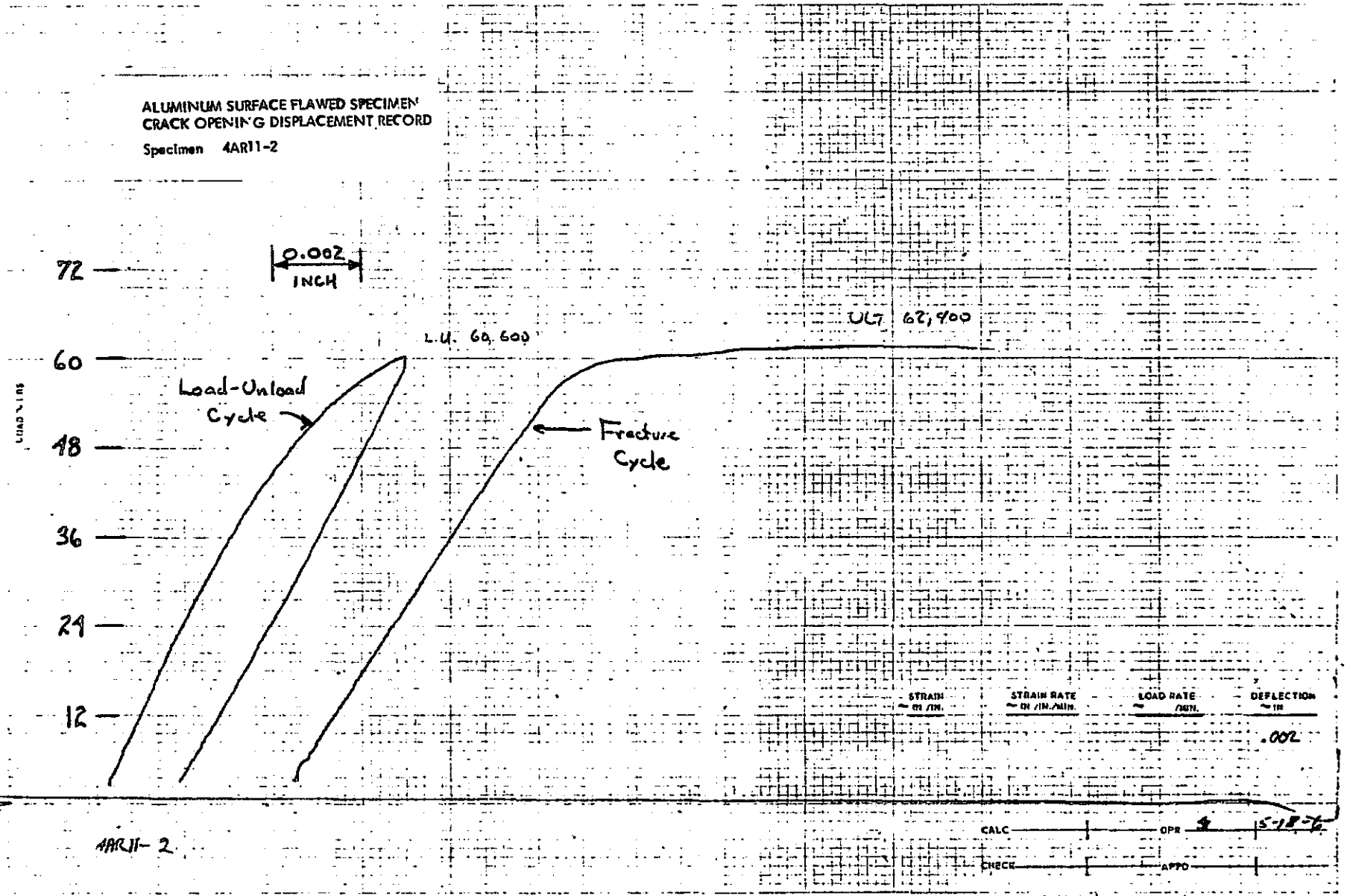
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 4AR11-1



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 4AR11-2



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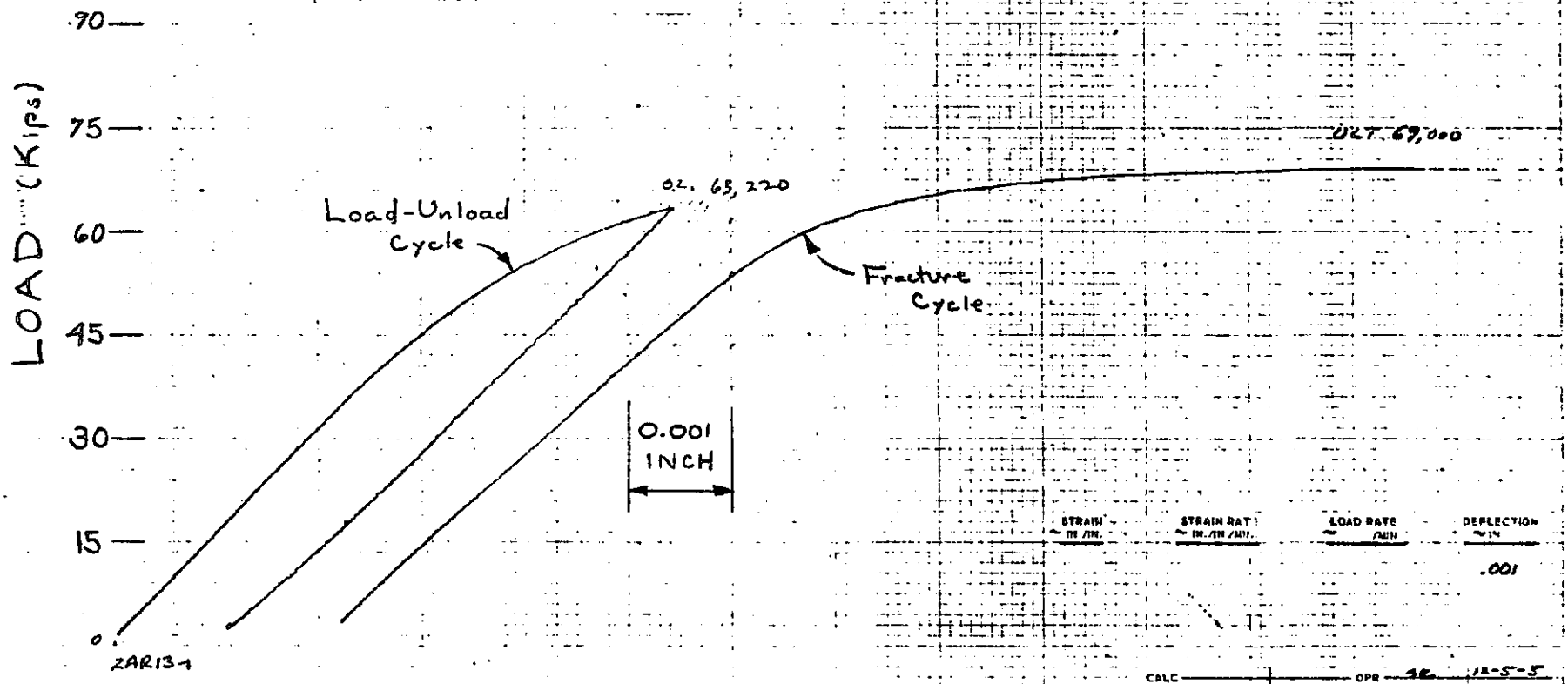
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR13-1



STRAIN IN /IN.	STRAIN RATE IN./IN /MIN.	LOAD RATE /MIN	DEFLECTION IN
			.001

CALC — OPR — 12-5-5

CHECK — APPD

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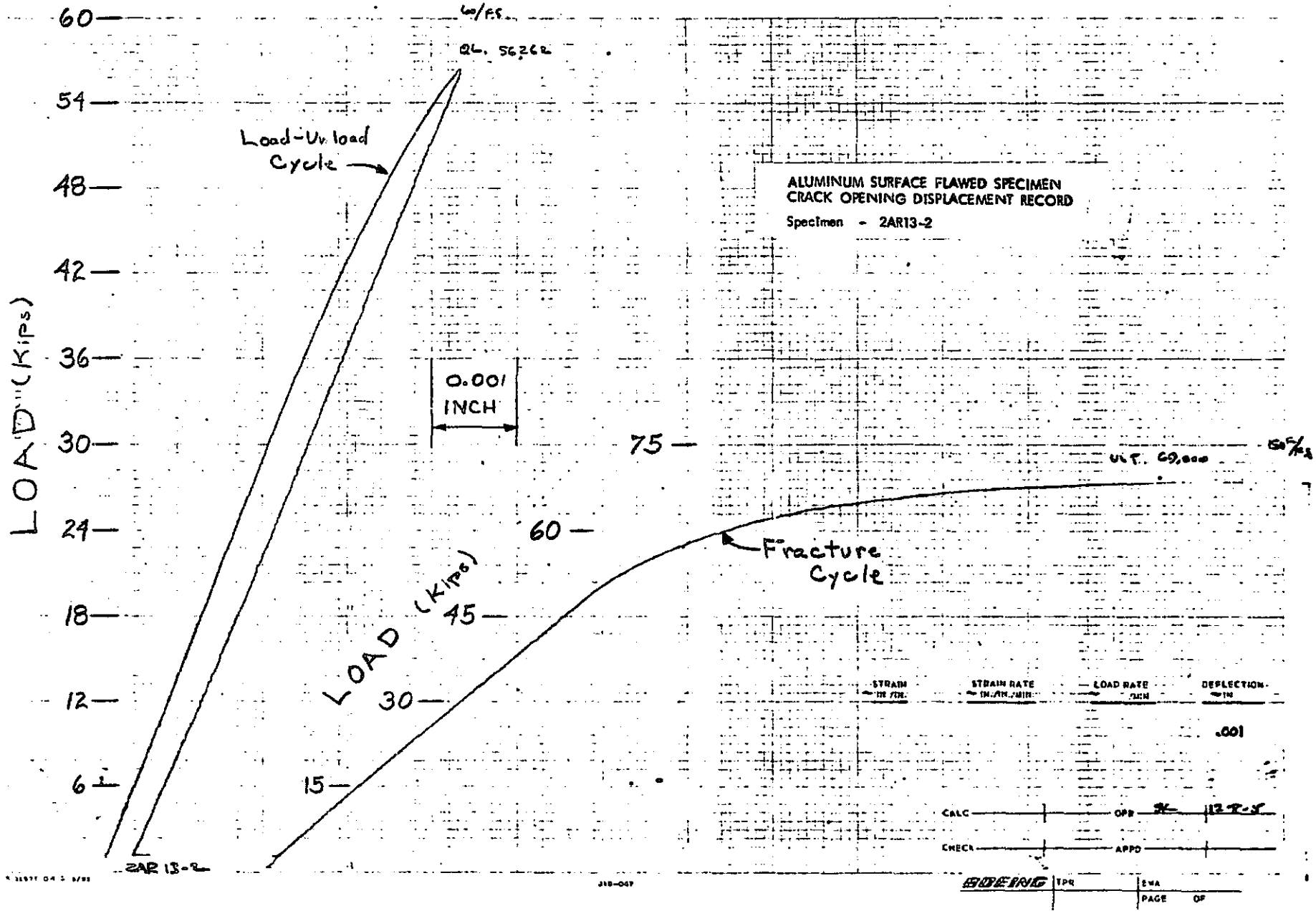
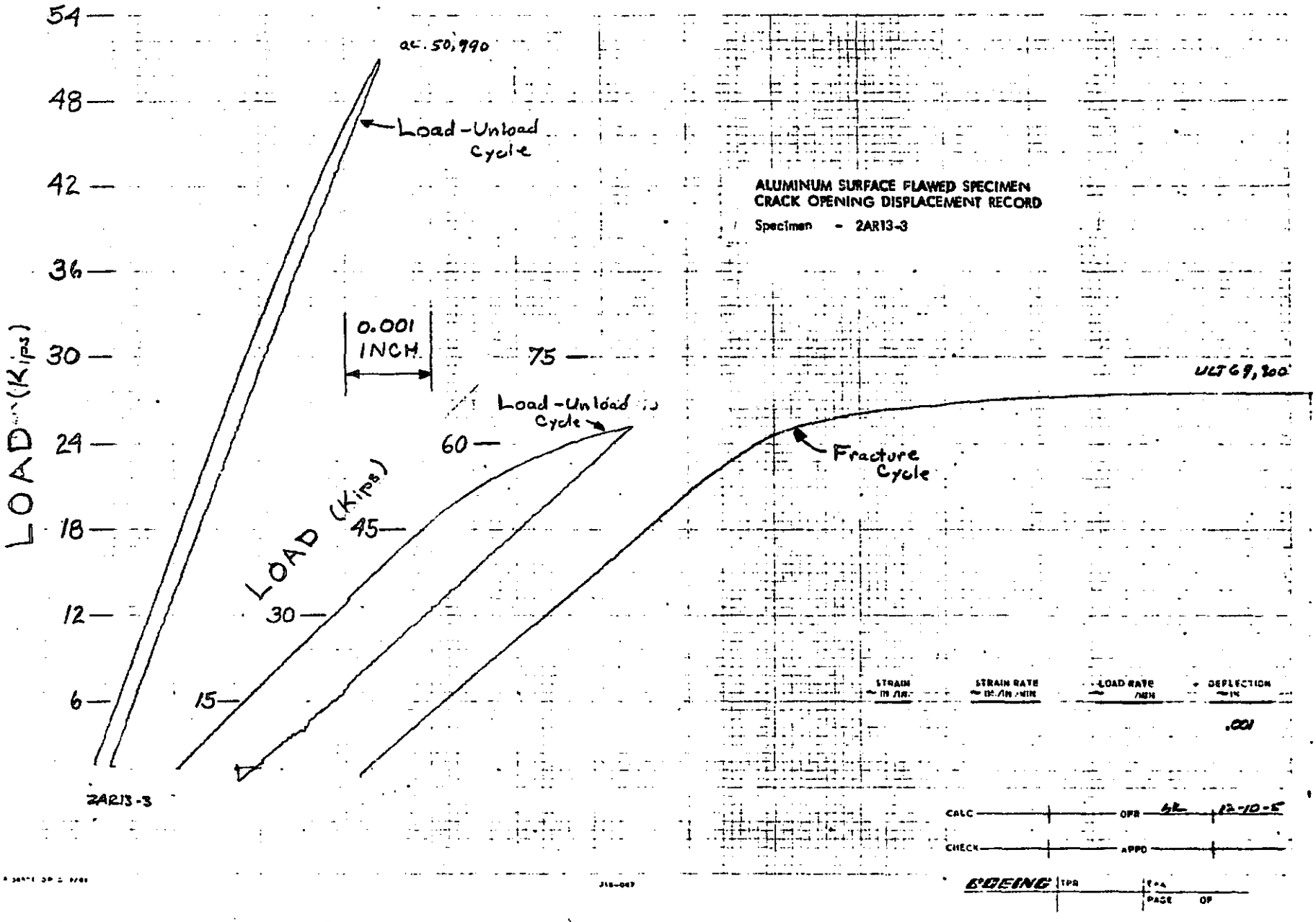
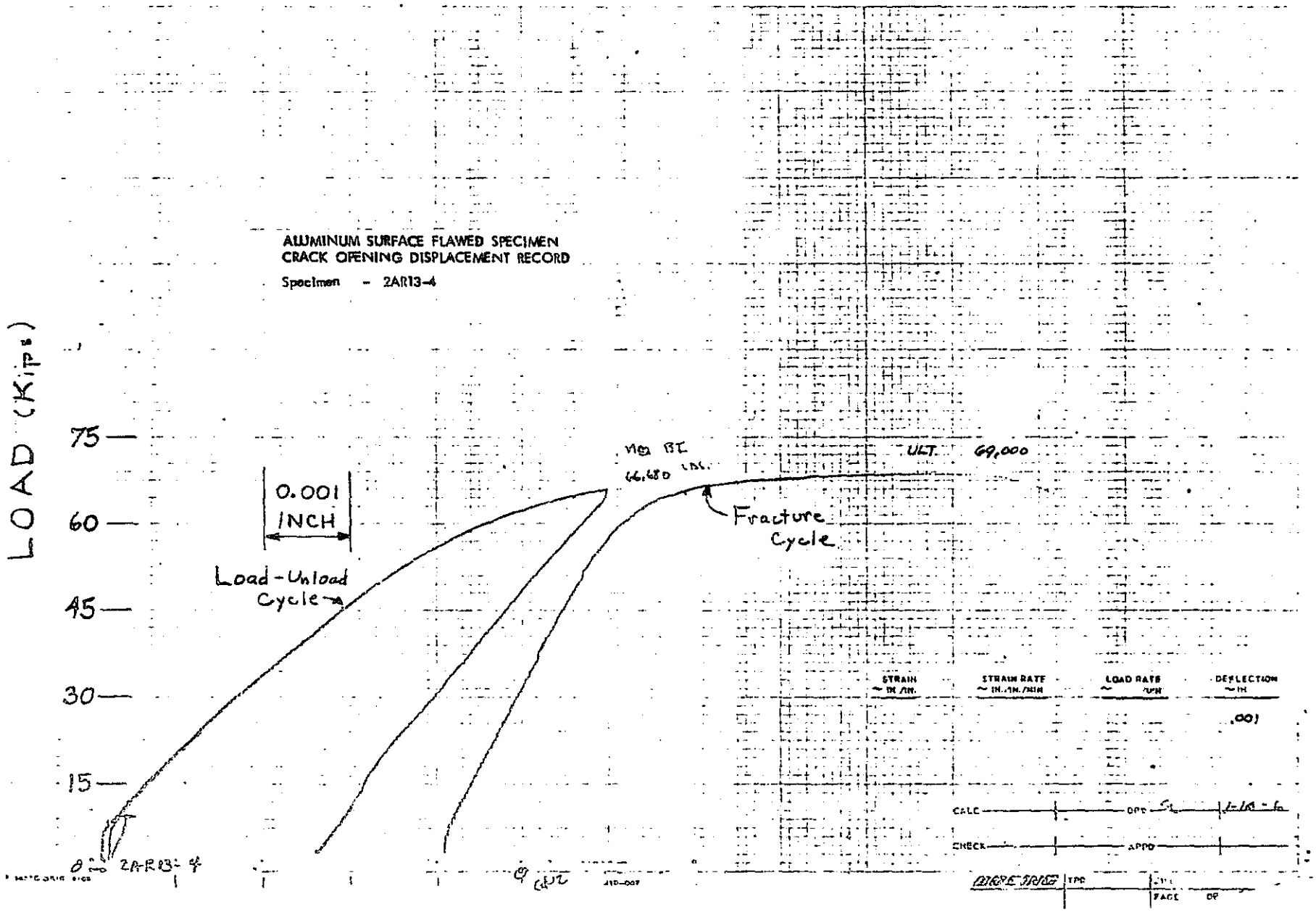

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR13-2
w/FS
QL. 56262
Load-Unload Cycle
0.001 INCH
LOAD (KIPS)
60
54
48
42
36
30
24
18
12
6
75
60
45
30
15
ULT. 69,000
Fracture Cycle
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
OPR
CHECK
APPD
2AR 13-2
TPR
EWA
PAGE
OF


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR13-3
LOAD (Kips)
54
48
42
36
30
24
18
12
6
at. 50,990
Load-Unload Cycle
0.001 INCH
75
60
45
30
15
LOAD (Kips)
Load-Unload Cycle
Fracture Cycle
ULT 69,200
2AR13-3
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
CHECK
OPR
APPD
12-10-5
BOEING
TPR
PAGE
OF

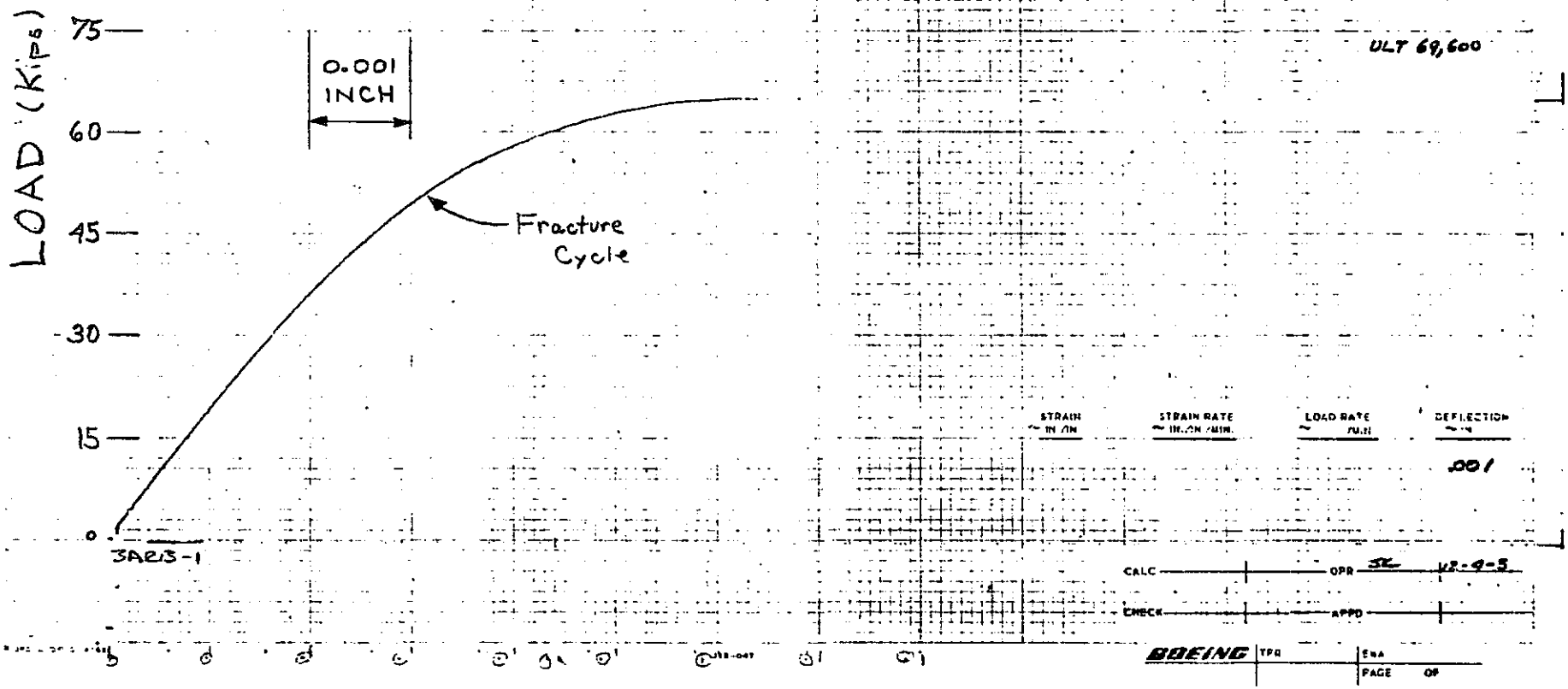
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

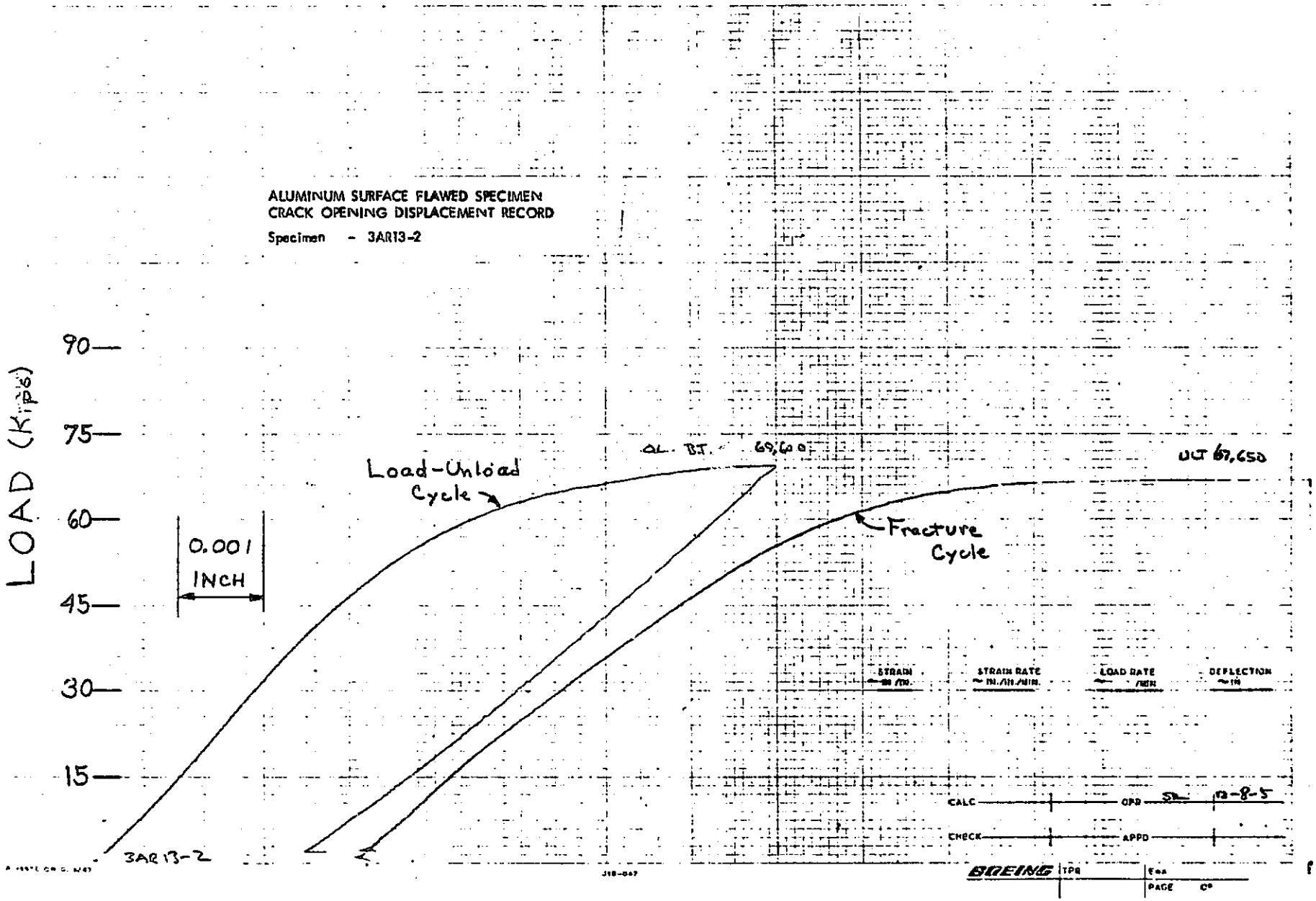
Specimen - 2AR13-4



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

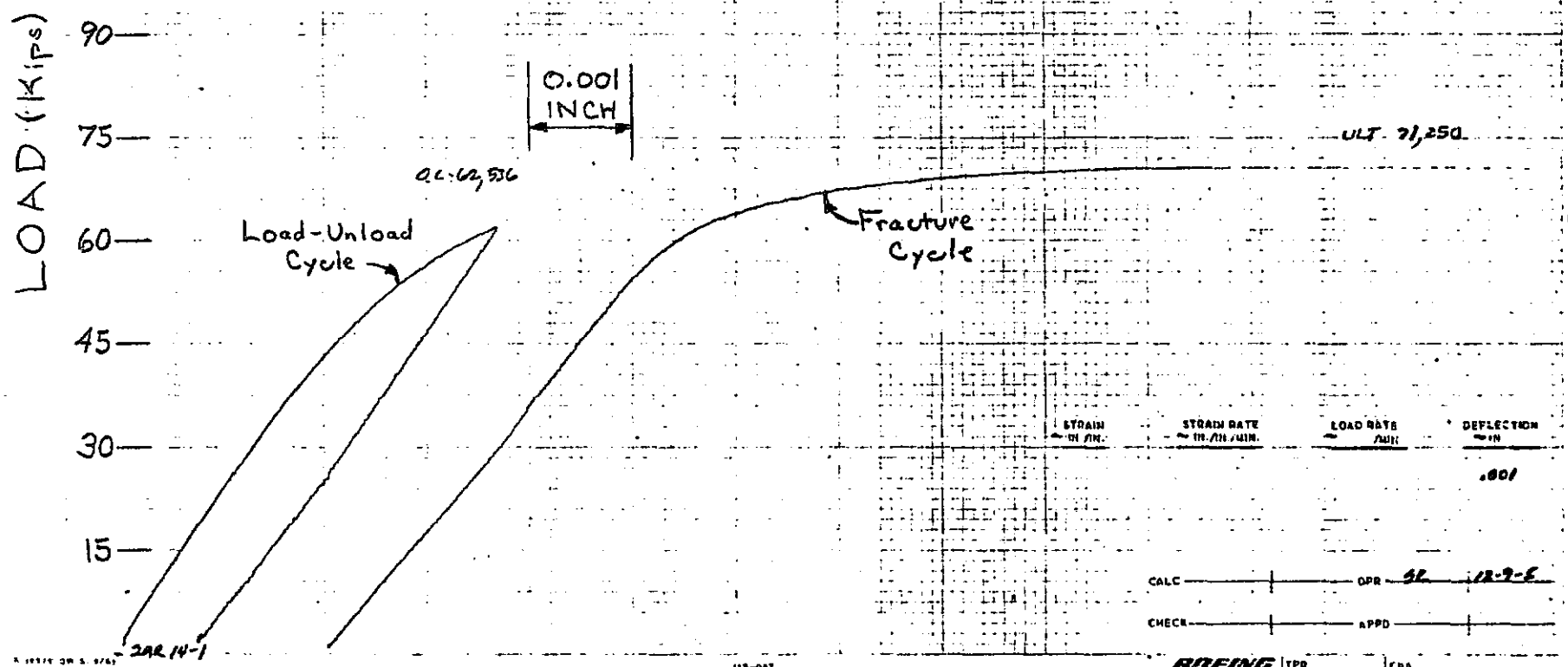
Specimen - 3AR13-1




ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR13-2
LOAD (Kips)
90
75
60
45
30
15
0.001 INCH
Load-Unload Cycle
Fracture Cycle
3AR13-2
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
CALC
CHECK
APPD
BOEING
PAGE

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR14-1



STRAIN IN/IN.	STRAIN RATE IN./IN./MIN.	LOAD RATE #/MIN.	DEFLECTION IN
			.001

CALC ——— OPR SL 12-2-E

CHECK ——— APPD

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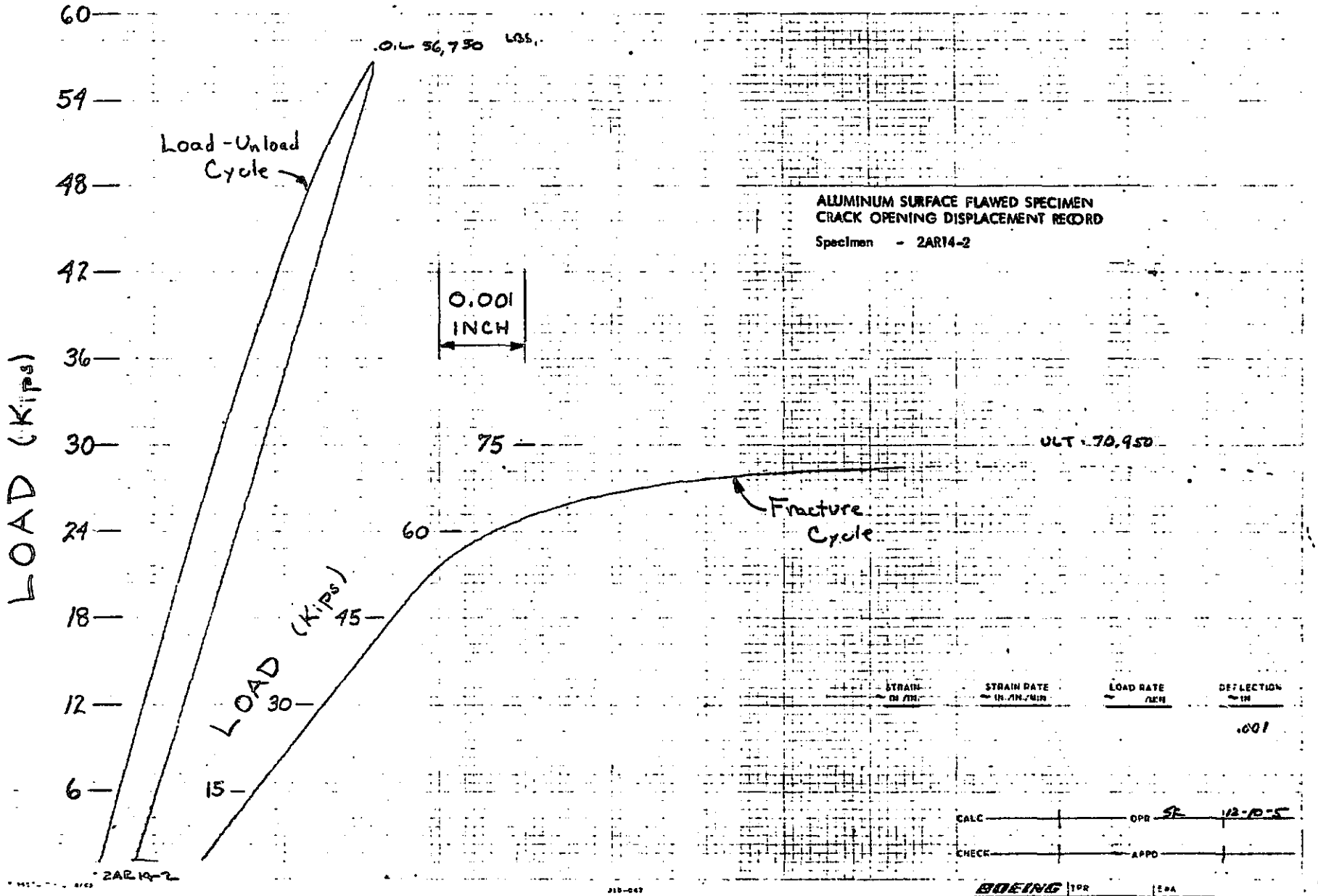
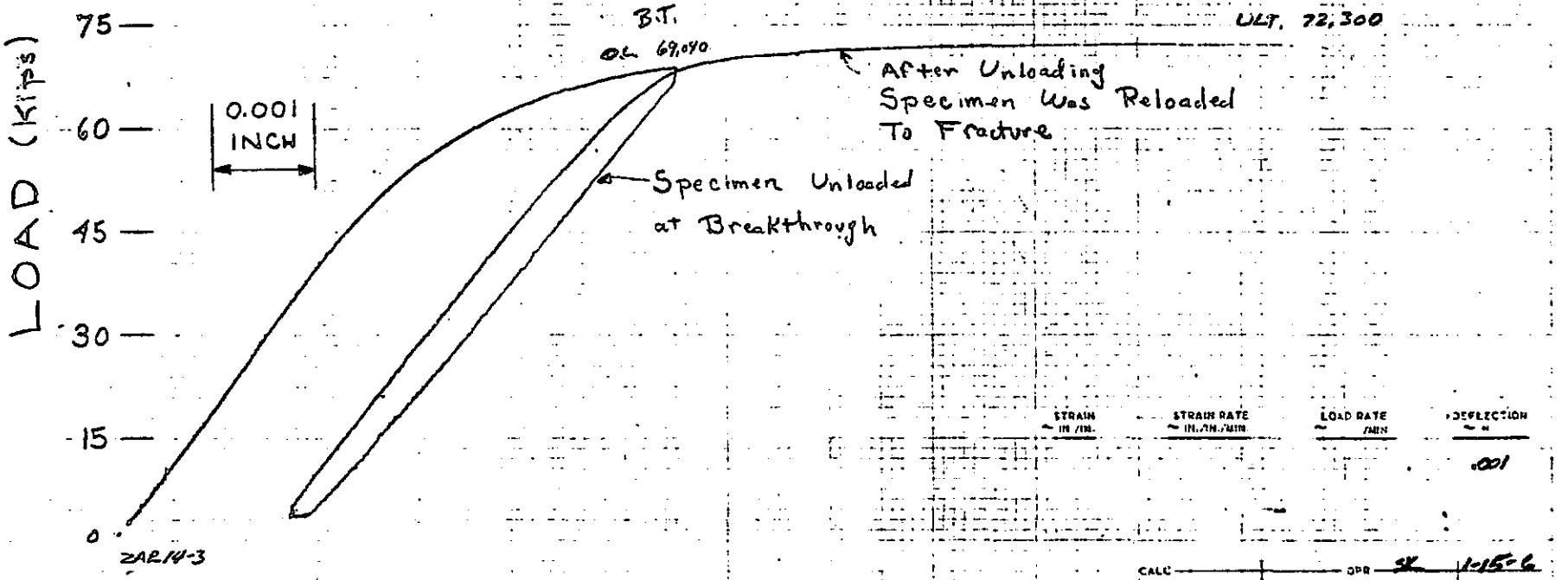

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR14-2
LOAD (KIPS)
60
54
48
42
36
30
24
18
12
6
Load - Unload Cycle
.01 - 56,750 LBS.
0.001 INCH
75
ULT - 70,950
Fracture Cycle
60
45
30
15
LOAD (KIPS)
2AR14-2
STRAIN IN/IN.
STRAIN RATE IN./IN./MIN
LOAD RATE /MIN
DEFLECTION IN
.001
CALC
OPR
CHECK
APPD
BOEING
PAGE
OF

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR14-3



STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN	LOAD RATE ~ /MIN	DEFLECTION ~ IN.
			.001

CALC ——— DPR SK 1-15-6

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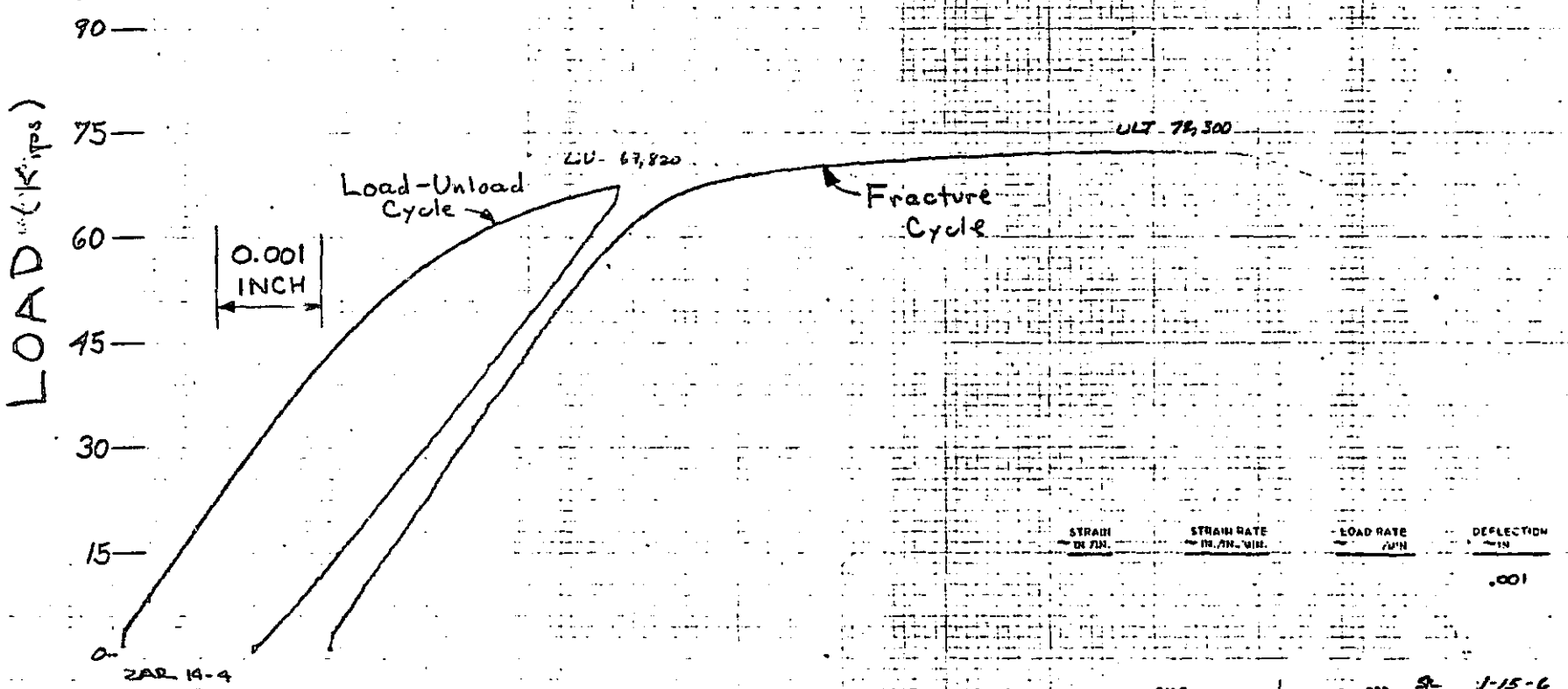
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR14-4



STRAIN IN/IN.	STRAIN RATE IN./IN./MIN.	LOAD RATE #/MIN	DEFLECTION IN.
			.001

CALC — OPR — 1-15-6

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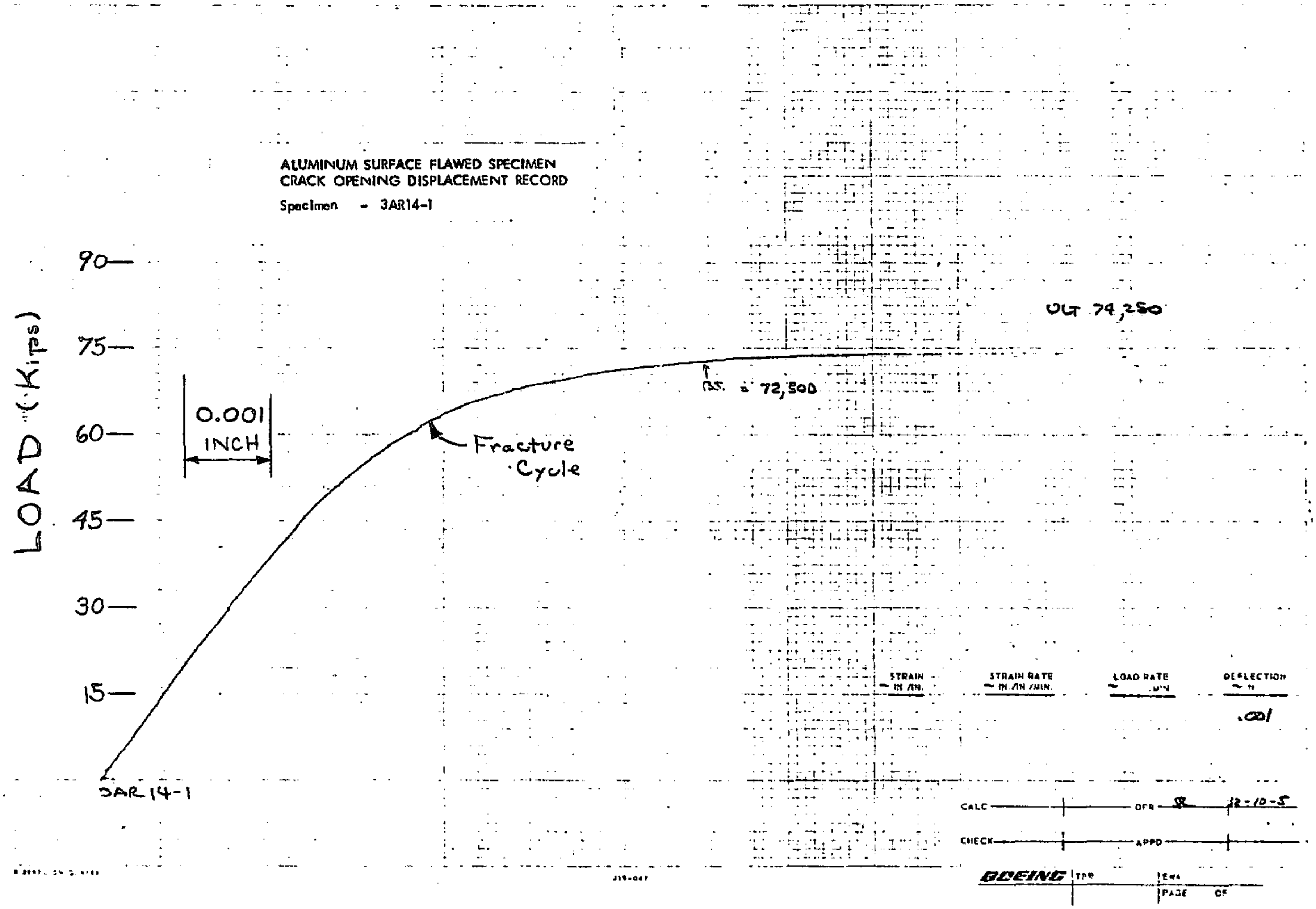
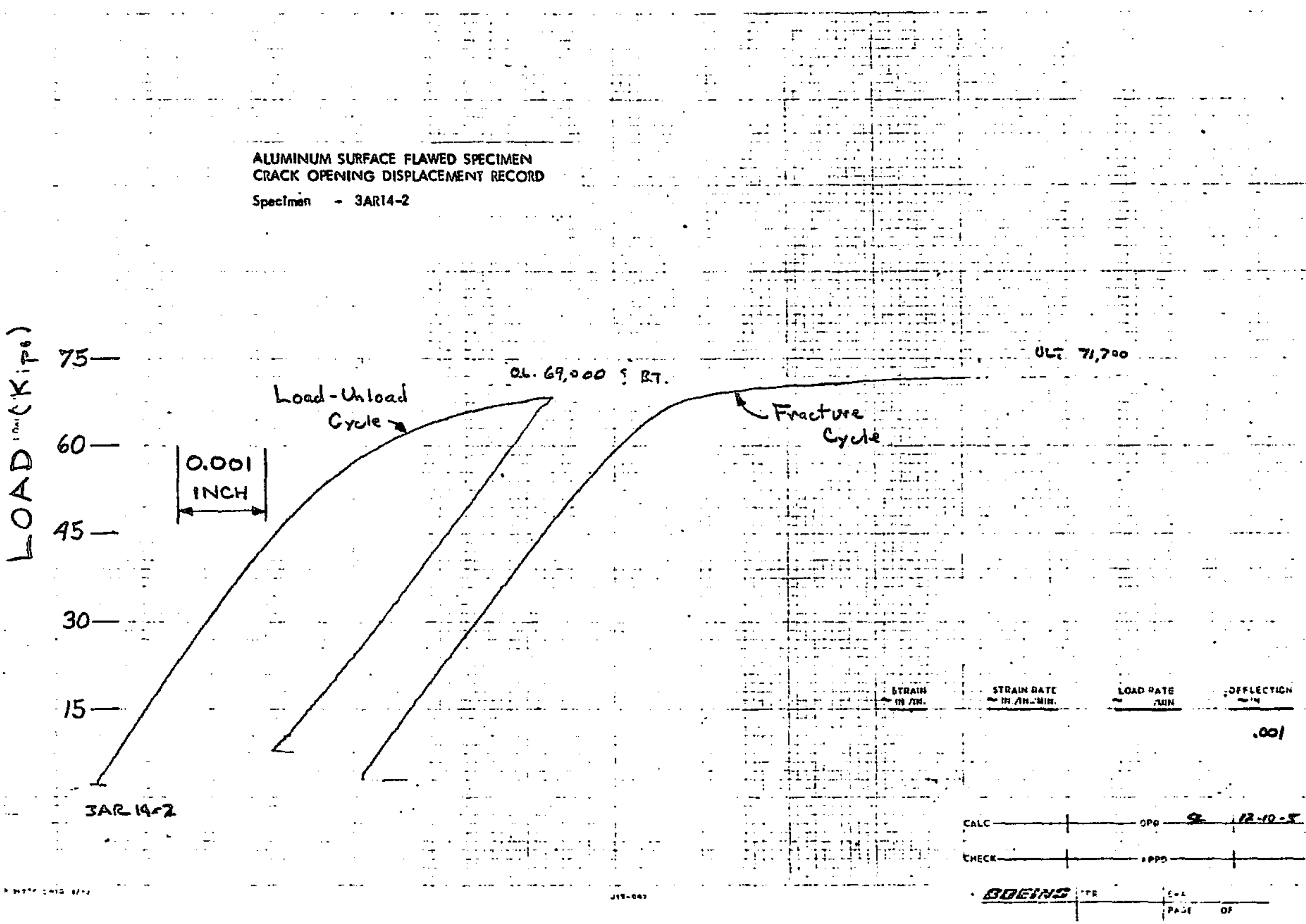
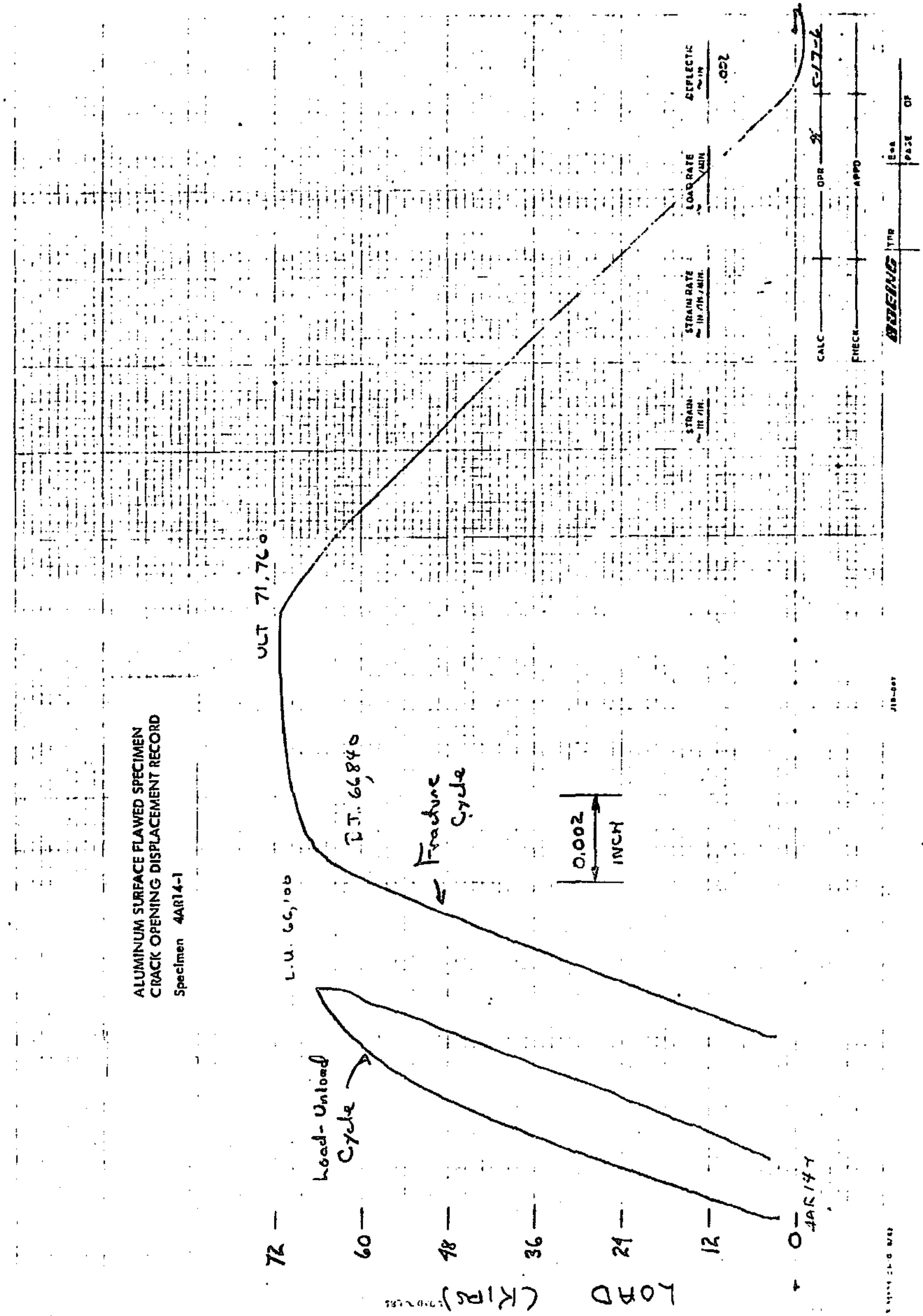


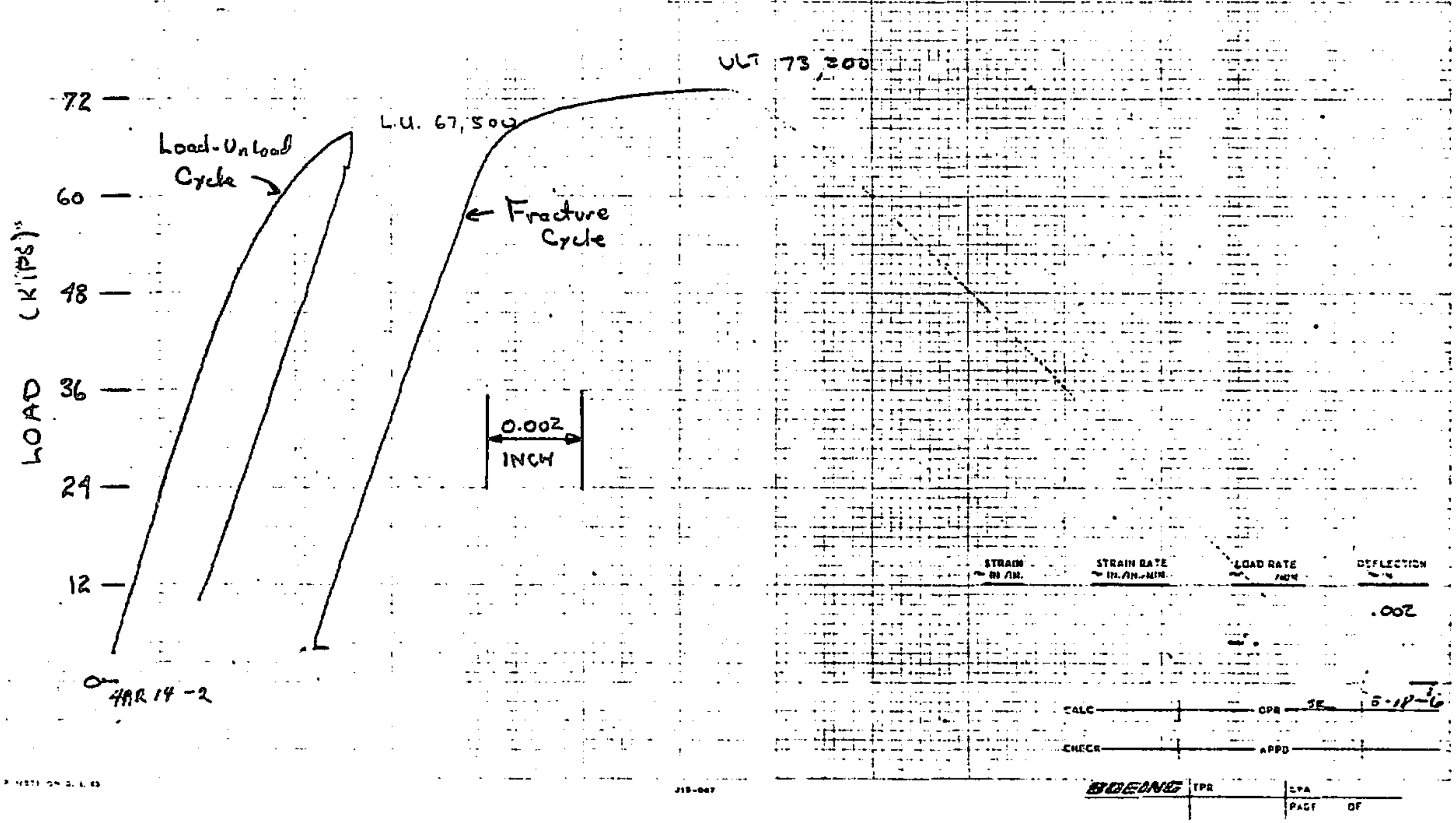
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR14-1
LOAD (Kips)
90
75
60
45
30
15
0.001 INCH
Fracture Cycle
72,500
ULT 74,250
3AR14-1
STRAIN ~ IN./IN.
STRAIN RATE ~ IN./IN./MIN.
LOAD RATE ~ /MIN
DEFLECTION ~ IN
.001
CALC
CHECK
OPR
APPD
12-10-5
BOEING
PAGE
OF

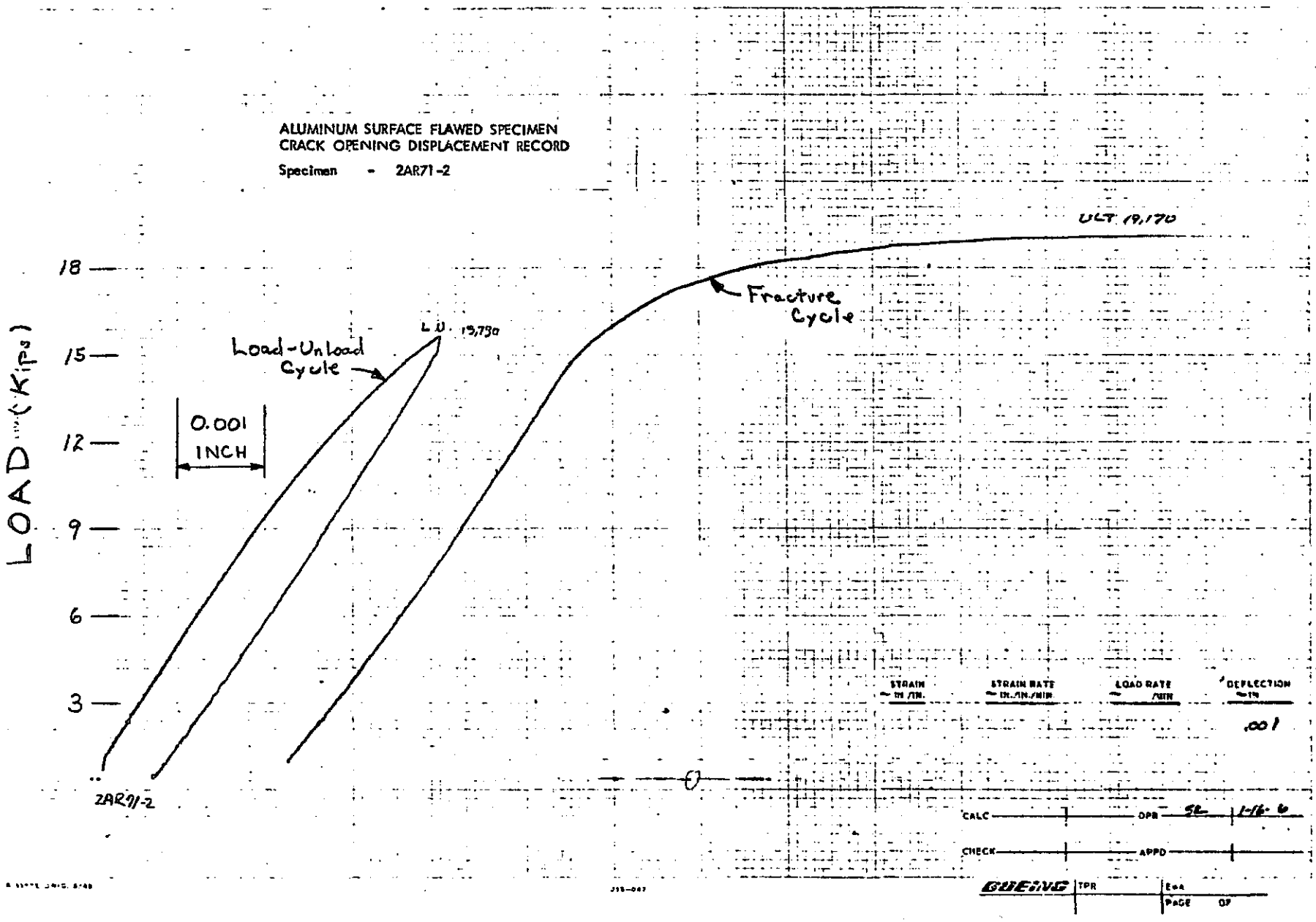

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR14-2
LOAD (Kips)
75
60
45
30
15
0.001 INCH
Load-Unload Cycle
OL. 69,000 ; RT.
ULT. 71,700
Fracture Cycle
3AR 14-2
STRAIN ~ IN./IN.
STRAIN RATE ~ IN./IN./MIN.
LOAD RATE ~ /MIN
DEFLECTION ~ IN
.001
CALC
CHECK
OPR
APPD
12-10-5
BOEING
PAGE
OF

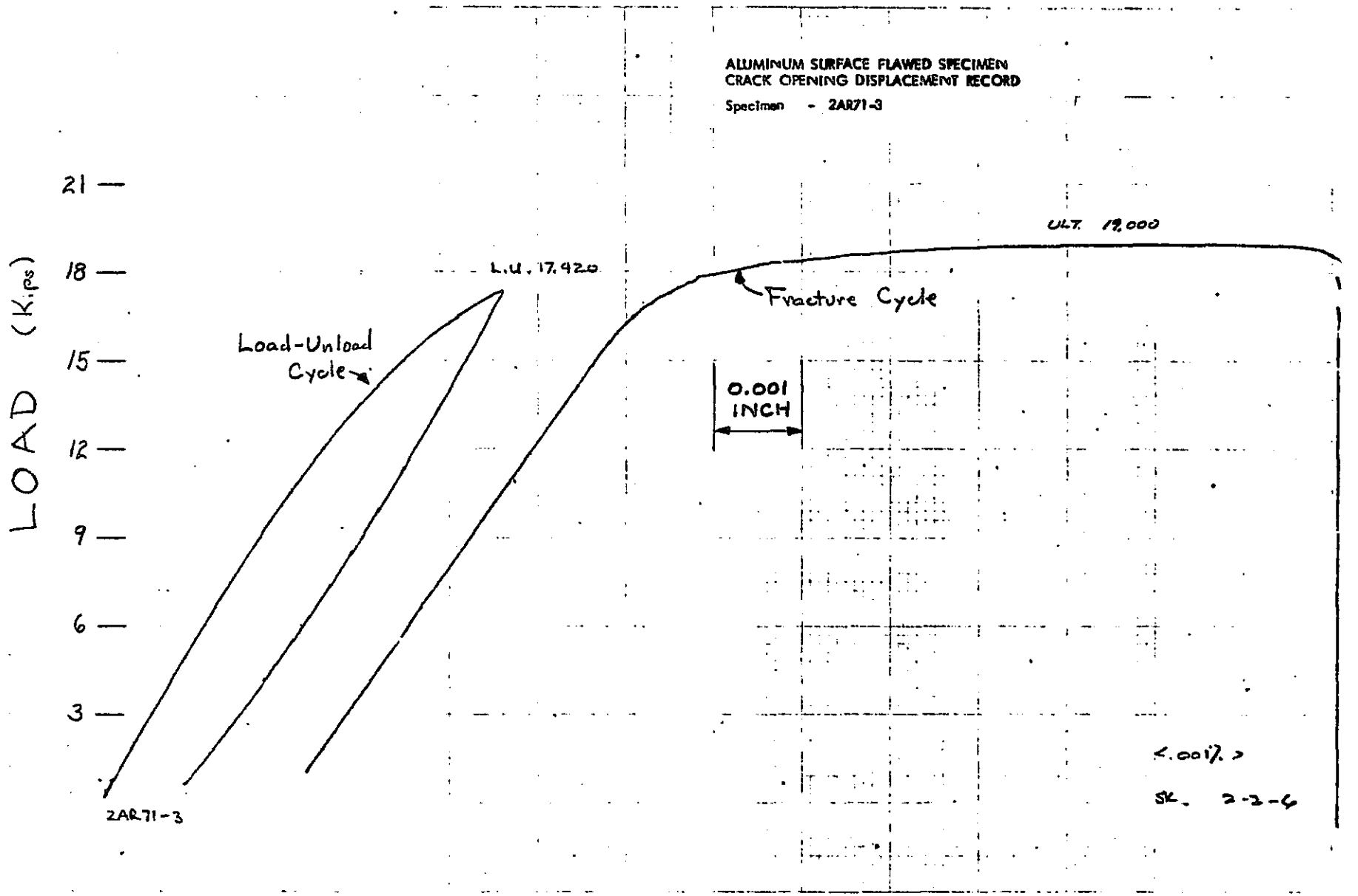

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR14-1
ULT 71,760
P.I. 66,840
L.U. 66,100
Fracture Cycle
Load-Unload Cycle
0.002 INCH
LOAD (KIPS)
72
60
48
36
24
12
0
4AR14-1
STRAIN ~IN/IN.
STRAIN RATE ~IN/IN/MIN.
LOAD RATE ~IN/MIN
DEFLECTION ~IN
.002
CALC
CHECK
APPD
OPR
BOEING
PAGE

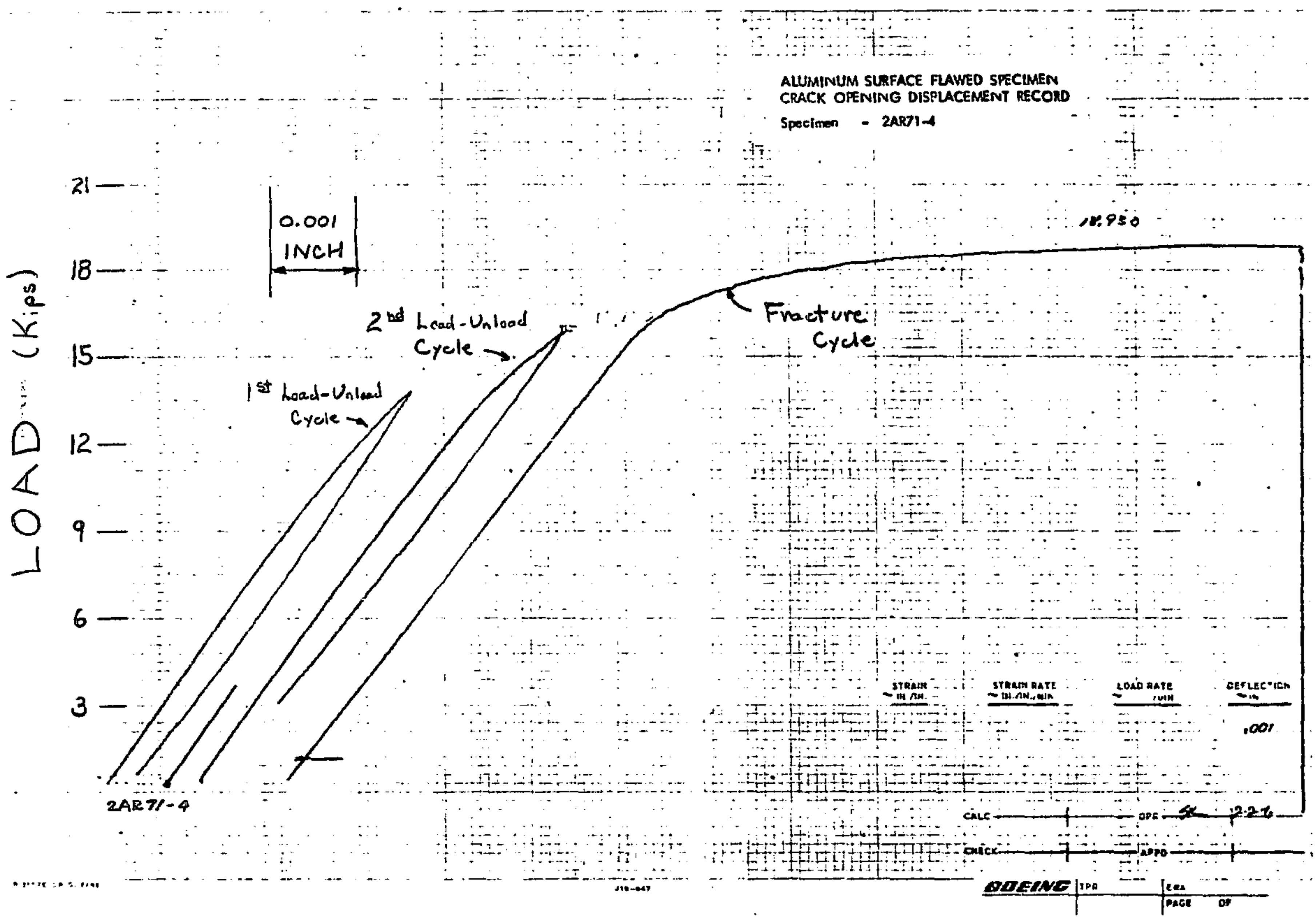
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

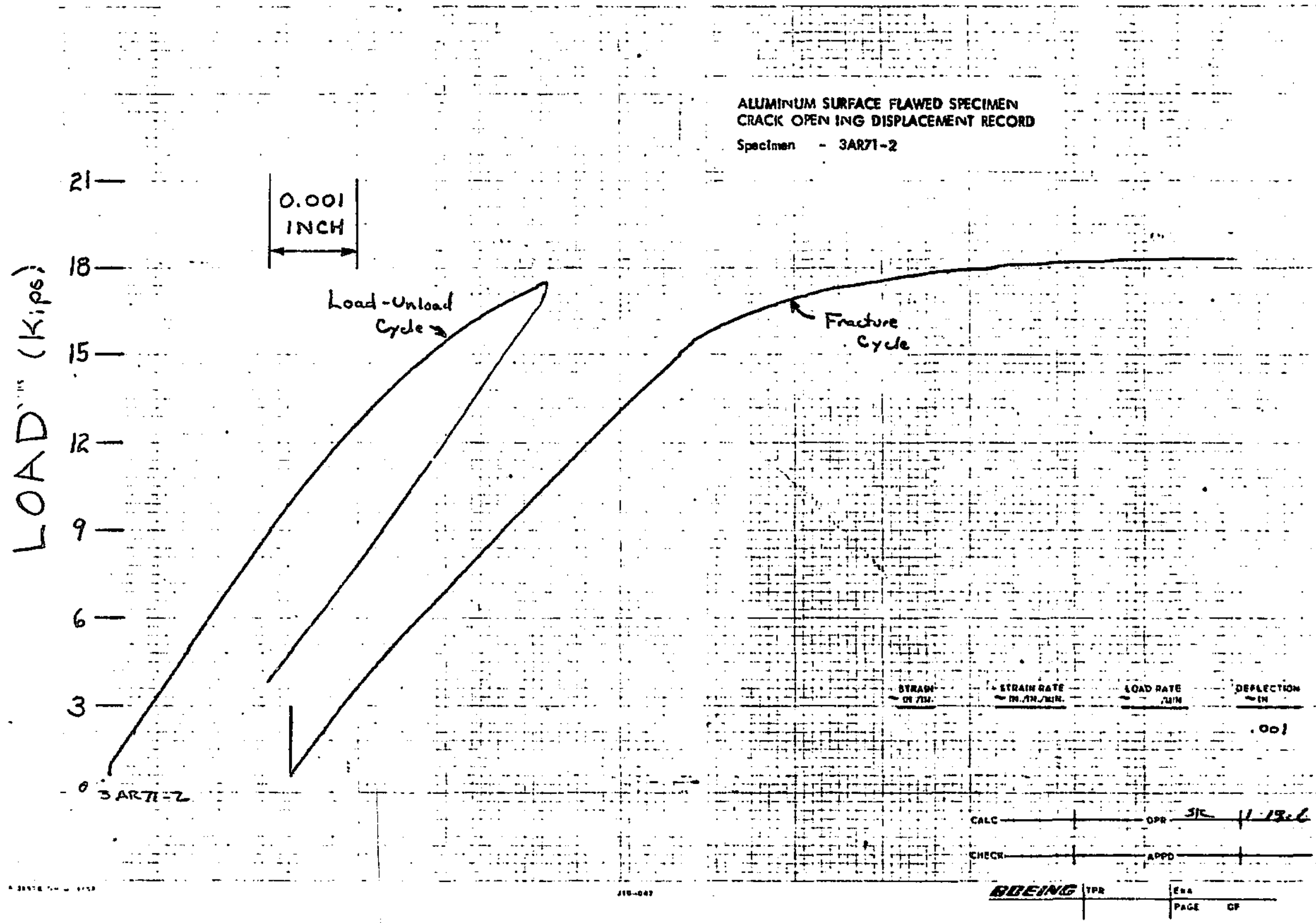
Specimen 4AR14-2

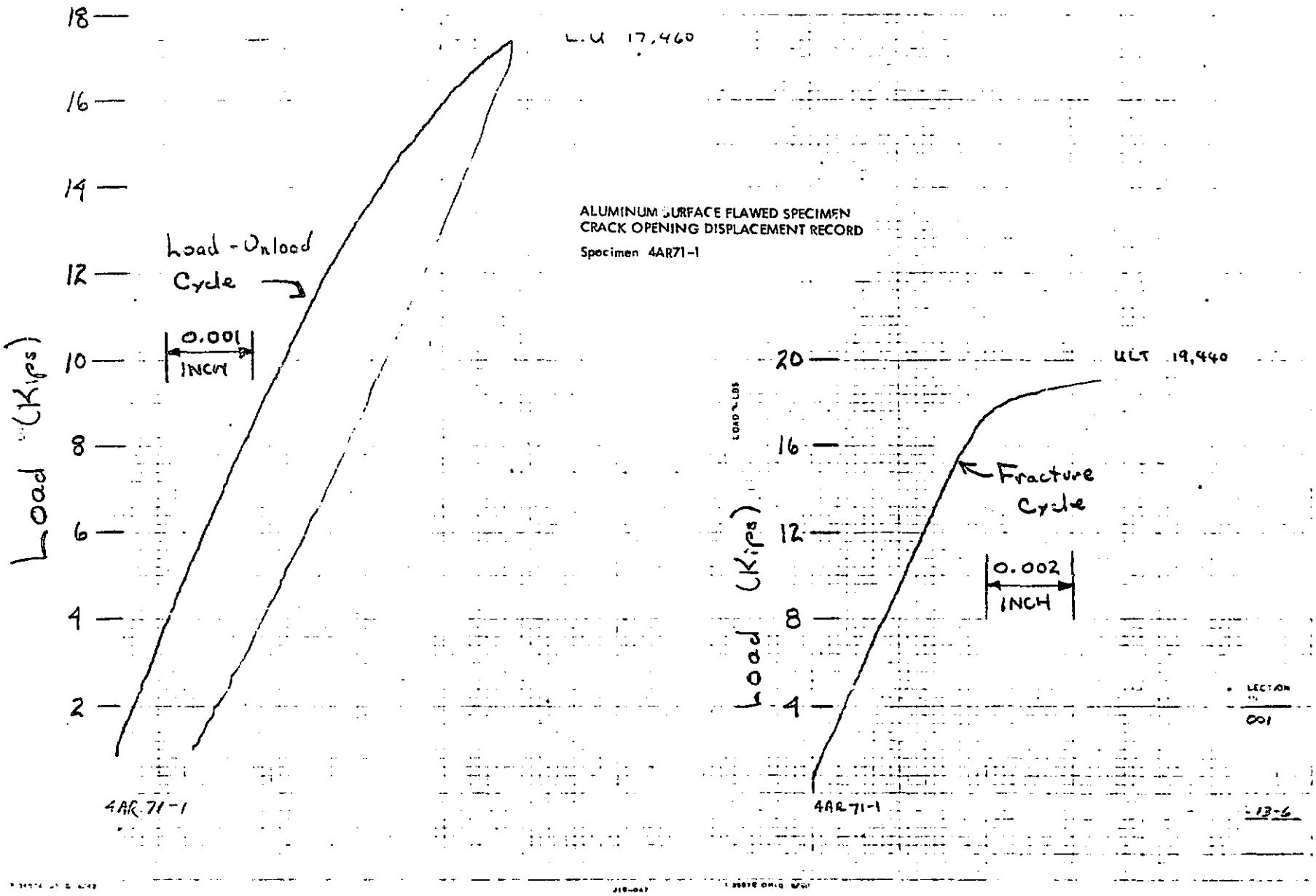


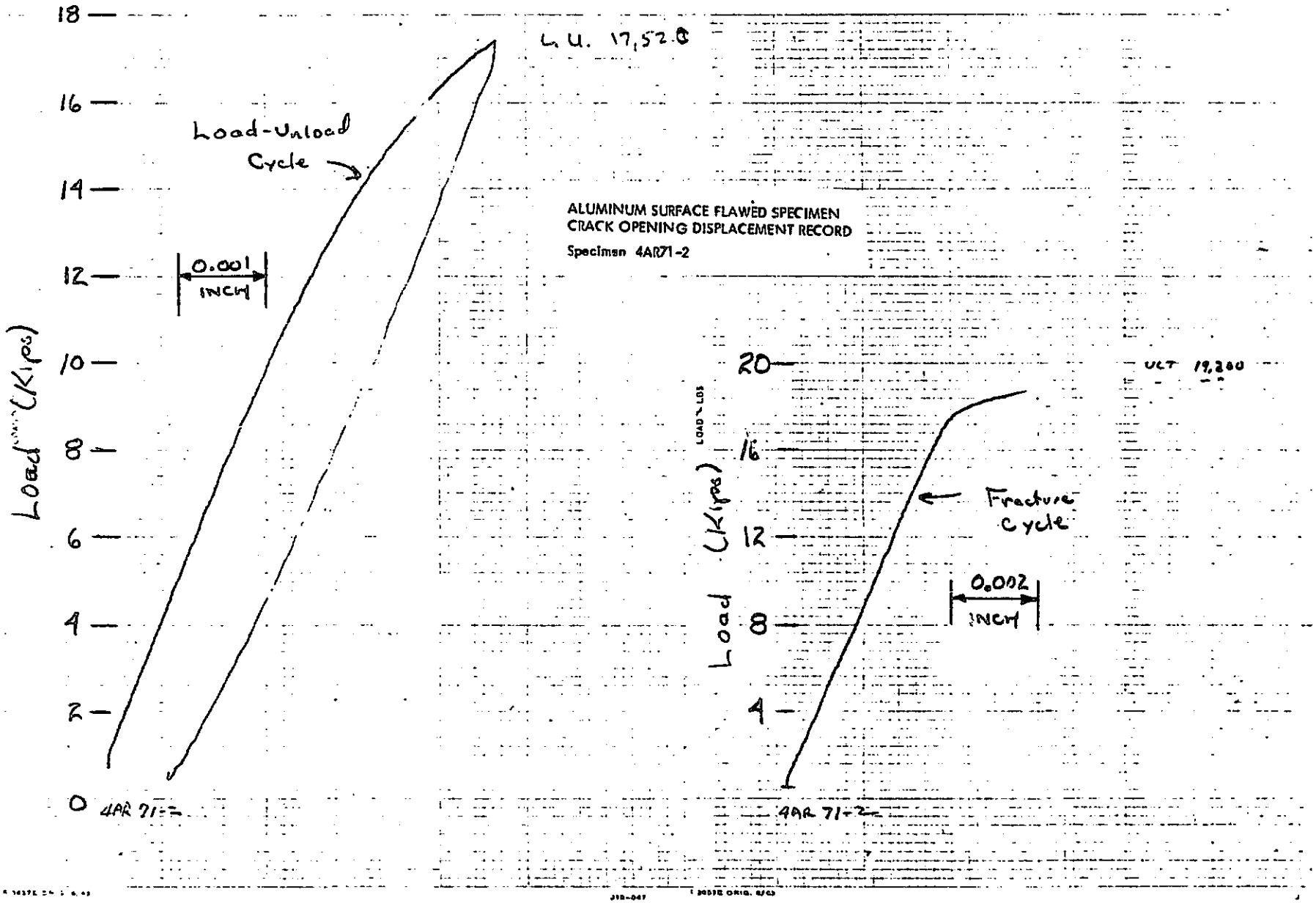

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR71-2
ULT 19,170
Fracture Cycle
LD 19,730
Load-Unload Cycle
0.001 INCH
LOAD (Kips)
18
15
12
9
6
3
0
2AR71-2
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
CHECK
APPD
BOEING
TPR
PAGE

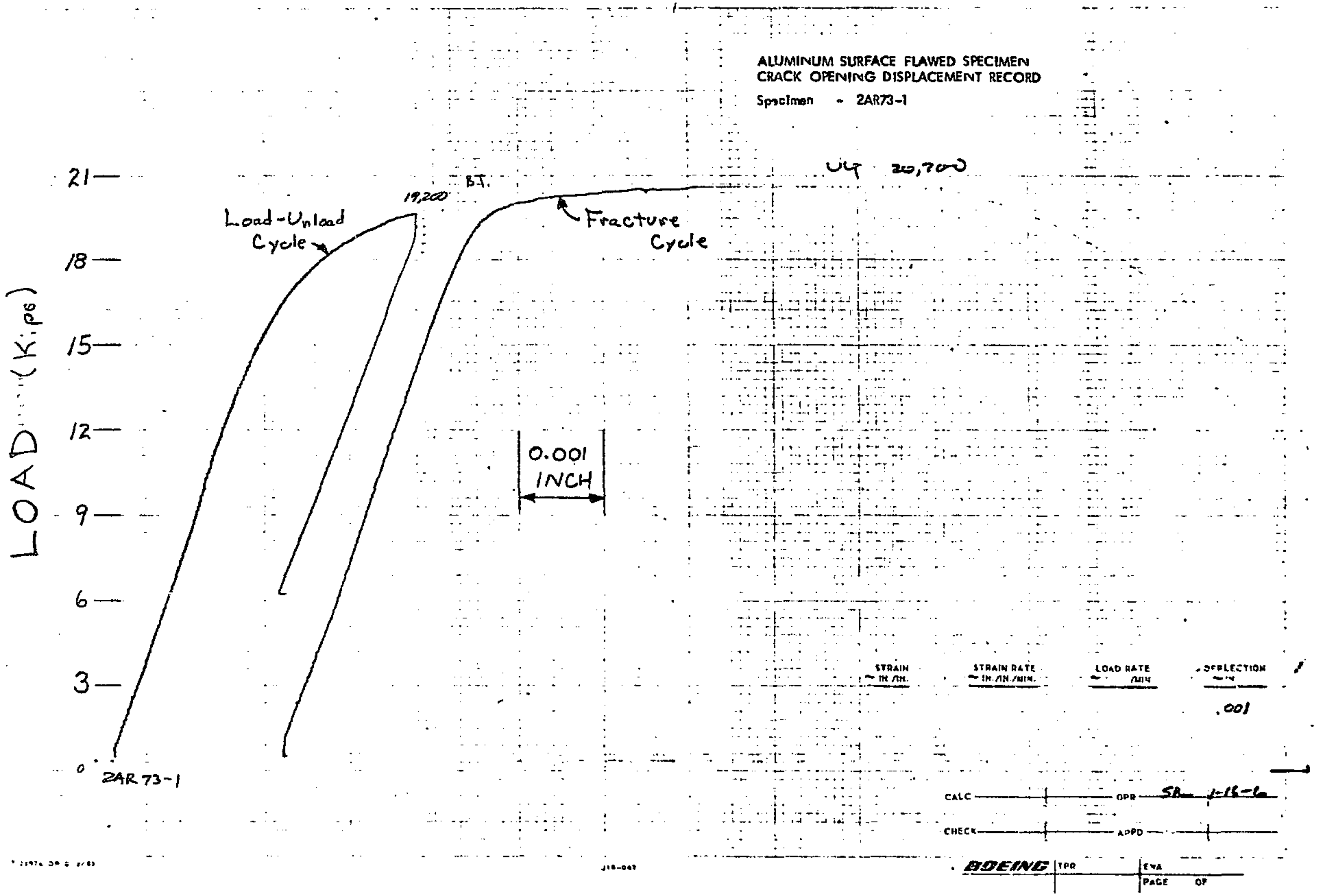

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR71-3
LOAD (Kips)
21
18
15
12
9
6
3
L.U. 17,920
ULT. 18,000
Load-Unload Cycle
Fracture Cycle
0.001 INCH
2AR71-3
<.001">
SK. 2-2-6


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR71-4
LOAD (Kips)
21
18
15
12
9
6
3
0.001 INCH
2nd Load-Unload Cycle
1st Load-Unload Cycle
Fracture Cycle
18.950
2AR71-4
STRAIN ~ IN/IN.
STRAIN RATE ~ IN/IN./MIN
LOAD RATE ~ /MIN
DEFLECTION ~ IN
.001
CALC
CHECK
OPE
APPD
BOEING
TPR
EGA
PAGE
OF


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR71-2
LOAD (Kips)
21
18
15
12
9
6
3
0
0.001 INCH
Load-Unload Cycle
Fracture Cycle
3AR71-2
STRAIN ~ IN./IN.
STRAIN RATE ~ IN./IN./MIN.
LOAD RATE ~ /MIN
DEFLECTION ~ IN
.001
CALC
CHECK
OPR
APPD
BOEING

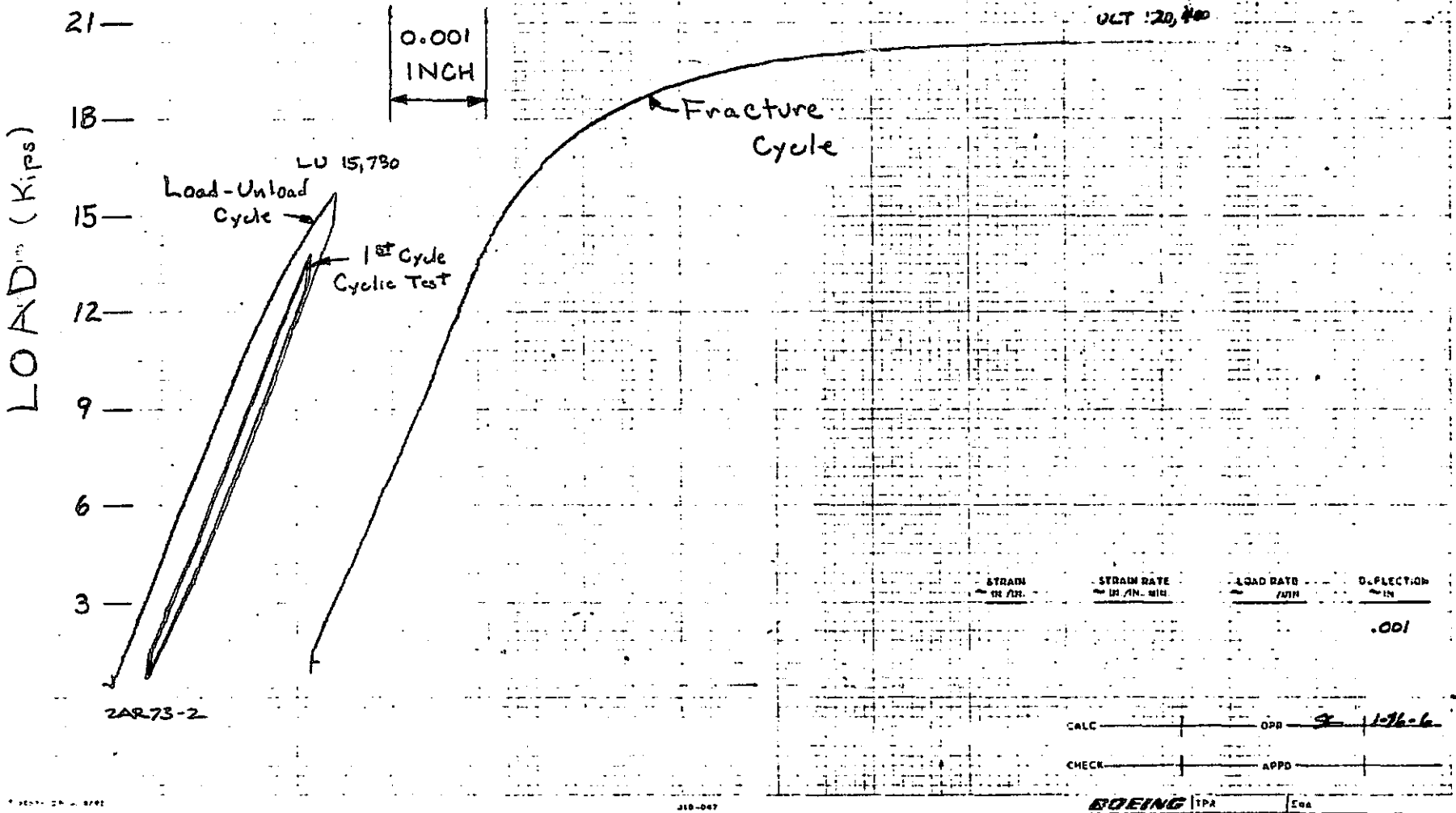

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR71-1
Load - Unload Cycle
0.001 INCH
Load (Kips)
4AR 71-1
ULT 17,460
ULT 19,440
Fracture Cycle
0.002 INCH
4AR71-1
001
13-6


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR71-2
L.U. 17,520
Load-Unload Cycle
0.001 INCH
Load (Kips)
4AR 71-2
ULT 19,200
Fracture Cycle
0.002 INCH
LOAD (Kips)
4AR 71-2


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR73-1
LOAD (Kips)
21
18
15
12
9
6
3
0
2AR 73-1
Load-Unload Cycle
19,200
B.T.
Fracture Cycle
ULT 20,700
0.001 INCH
STRAIN ~ IN./IN.
STRAIN RATE ~ IN./IN./MIN.
LOAD RATE ~ /MIN
DEFLECTION ~ IN
.001
CALC
OPR
CHECK
APPD
BOEING
TPR
EWA
PAGE
OF

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR73-2



STRAIN IN /IN.	STRAIN RATE IN /IN- MIN	LOAD RATE /MIN	DEFLECTION IN
			.001

CALC ____ OPR ____ 10-16-6

CHECK ____ APPD ____

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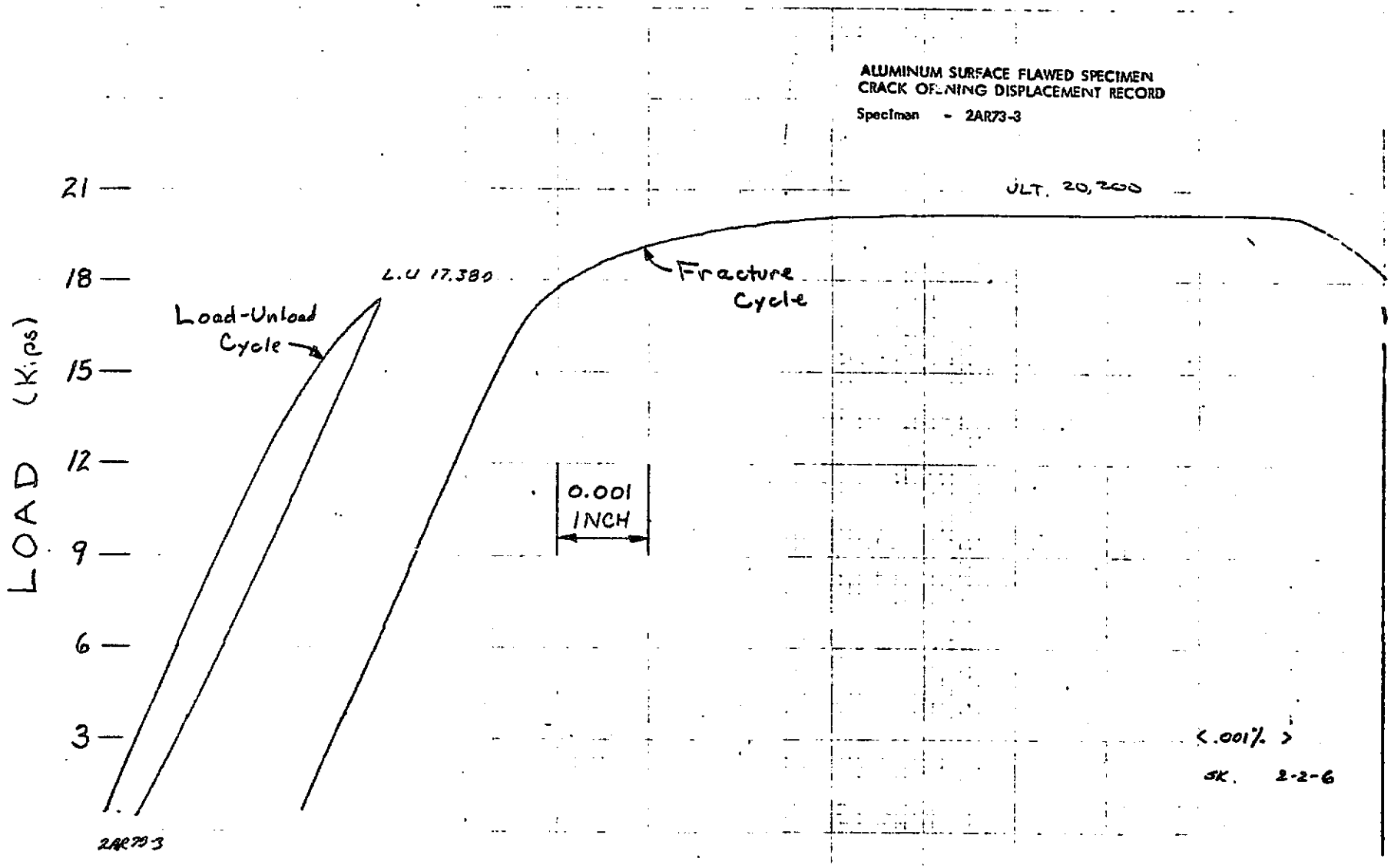
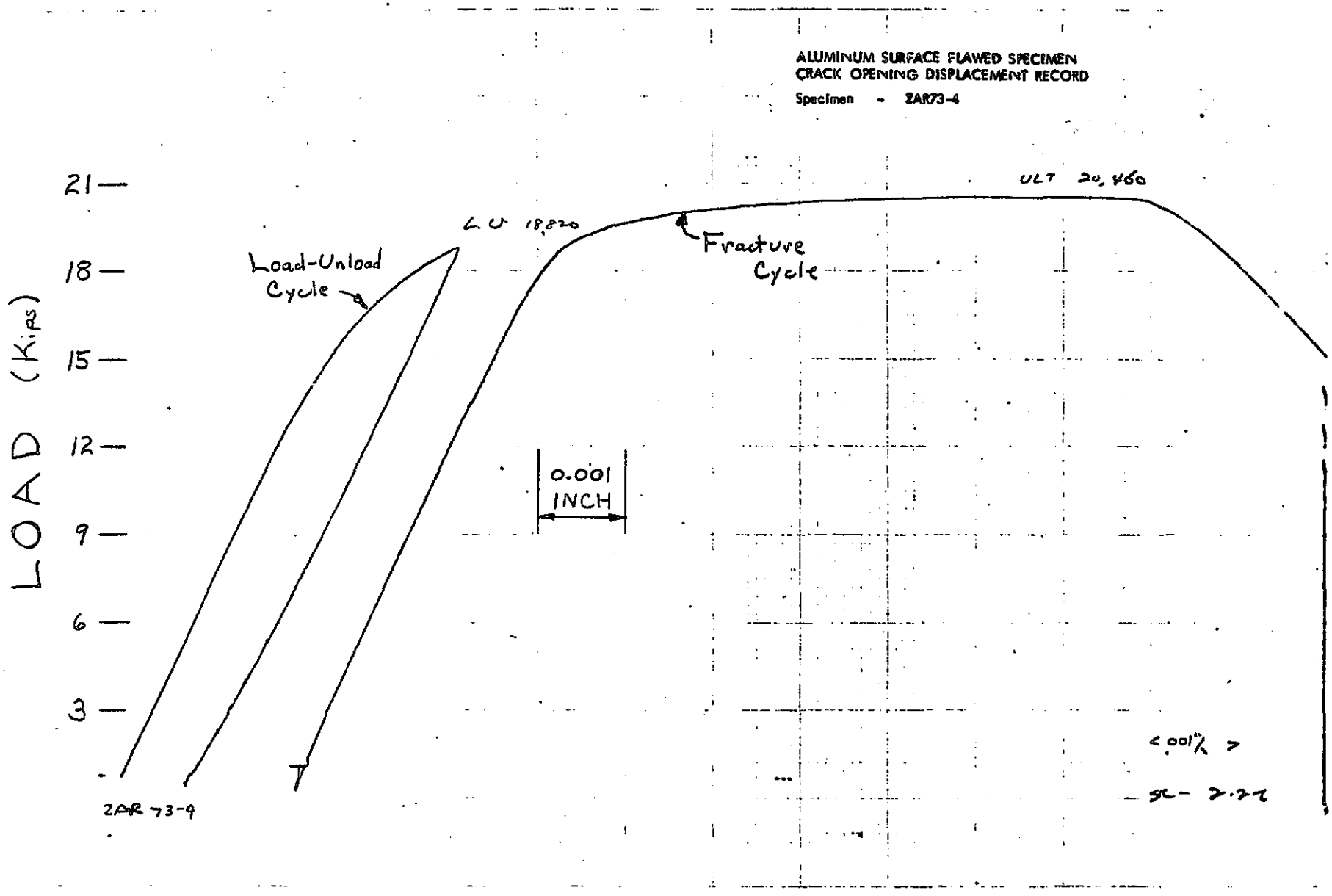
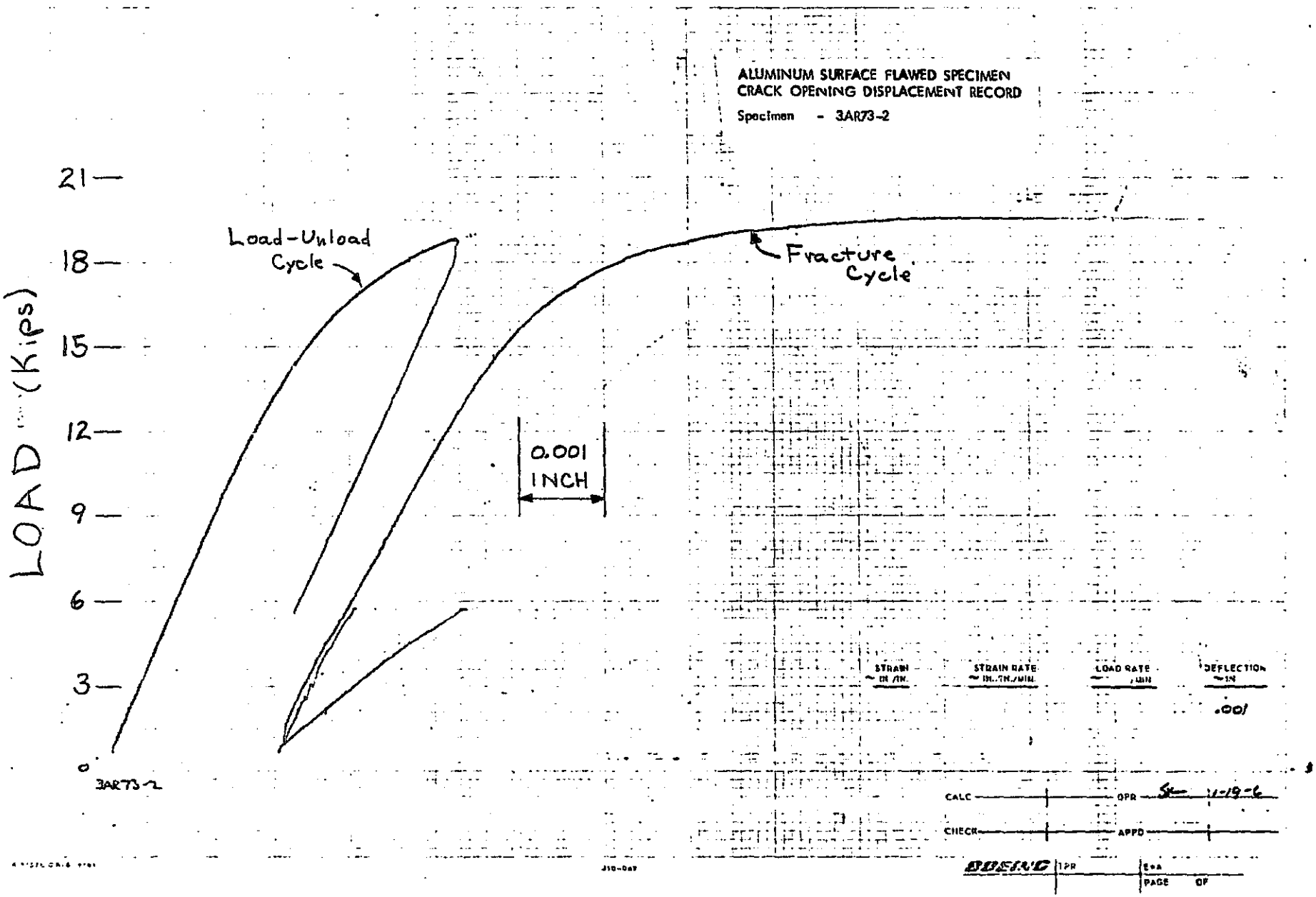

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR73-3
ULT. 20,200
L.U 17.380
Load-Unload Cycle
Fracture Cycle
0.001 INCH
LOAD (Kips)
21
18
15
12
9
6
3
<.001% >
SK. 2-2-6
2AR73-3

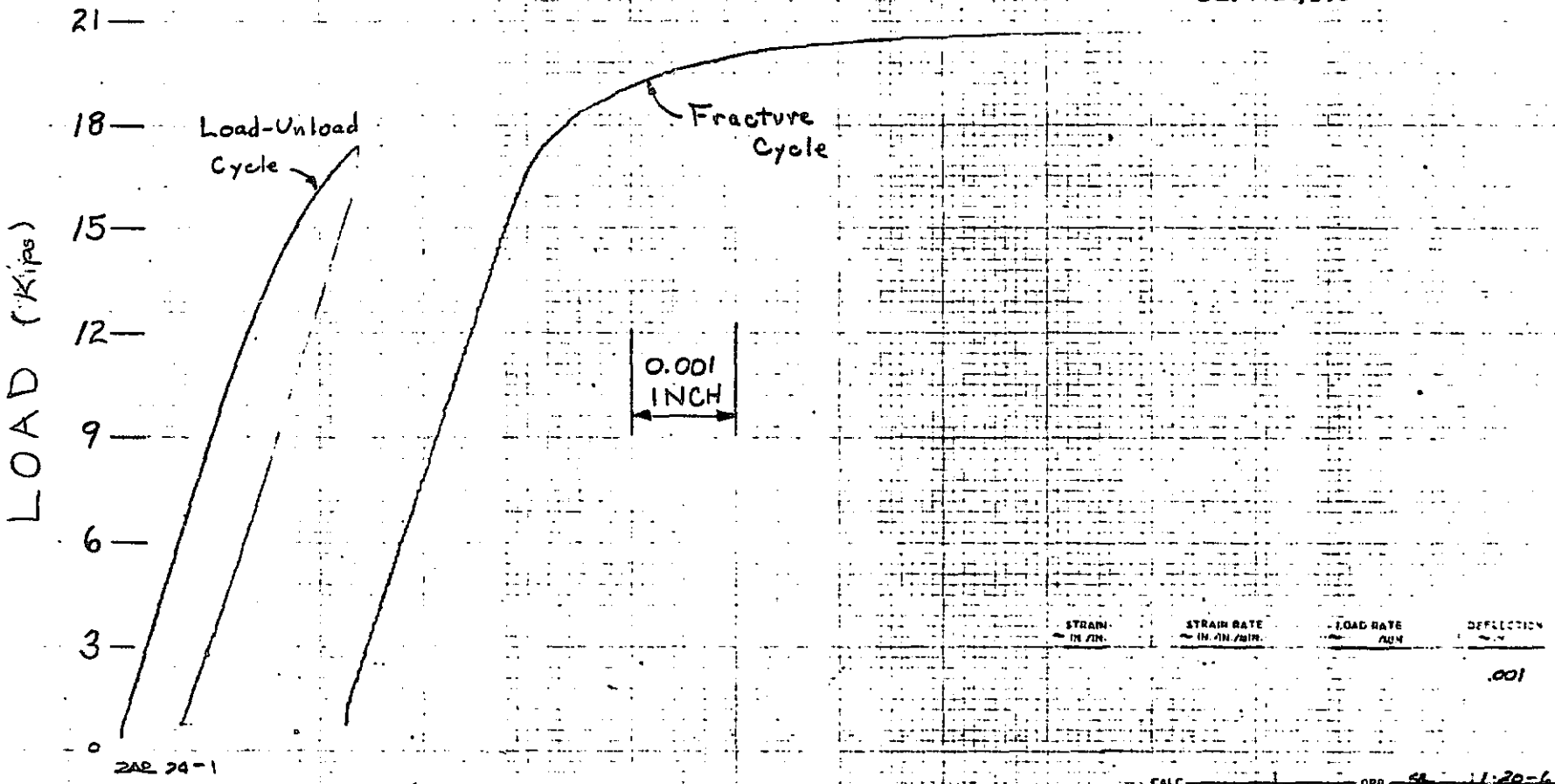

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR73-4
LOAD (Kips)
21
18
15
12
9
6
3
L.U. 18,820
ULT 20,460
Load-Unload Cycle
Fracture Cycle
0.001 INCH
2AR-73-9
<.001"/
SC- 2.2


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR73-2
LOAD (Kips)
21
18
15
12
9
6
3
0
Load-Unload Cycle
Fracture Cycle
0.001 INCH
3AR73-2
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
CHECK
OPR
APPD
BOEING

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR74-1

ULT: 20,670



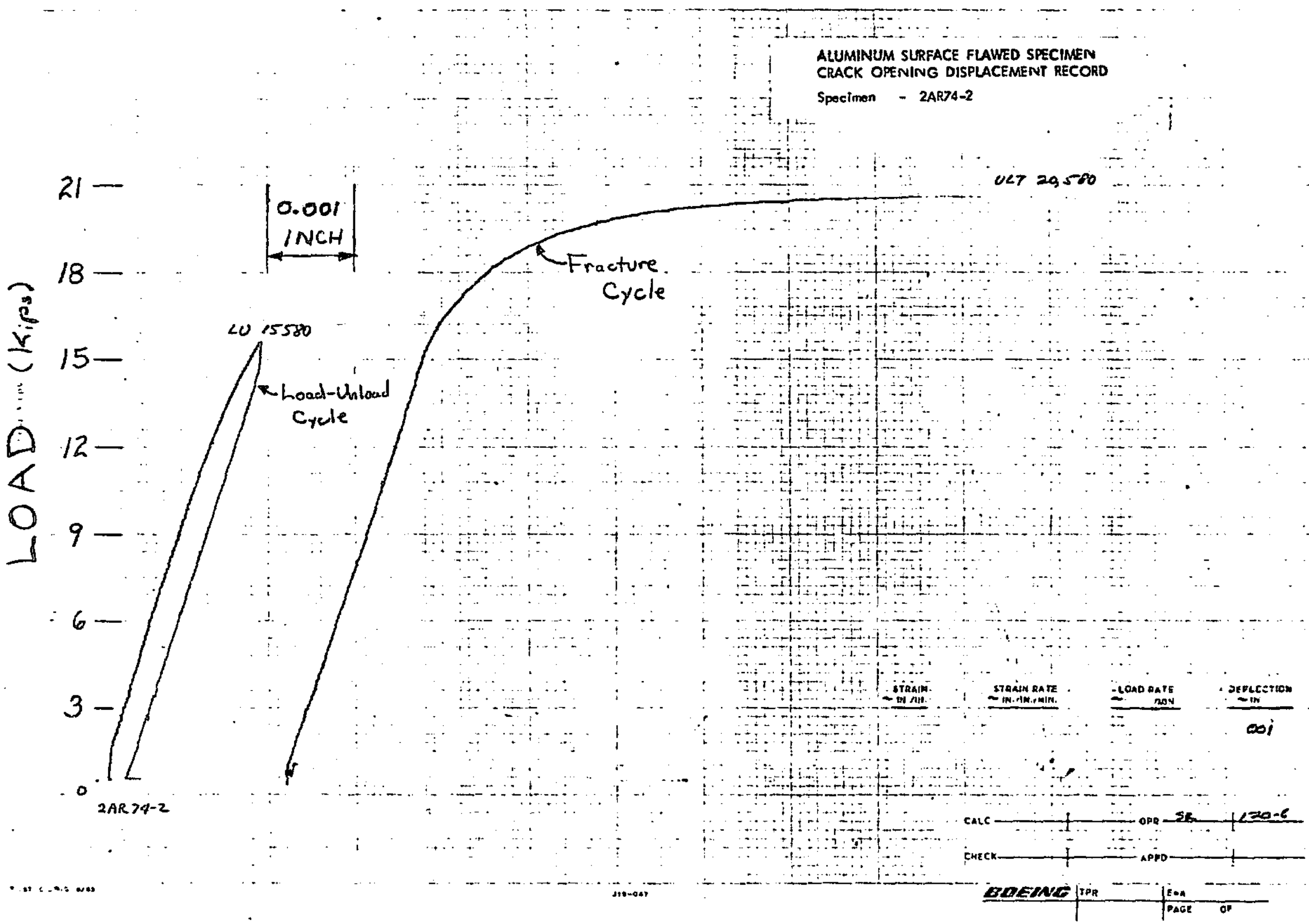
STRAIN IN/IN	STRAIN RATE IN./IN./MIN.	LOAD RATE KIPS/MIN	DEFLECTION IN.
			.001

CALC — OPR — SB — 1-20-6

CHECK — APPD

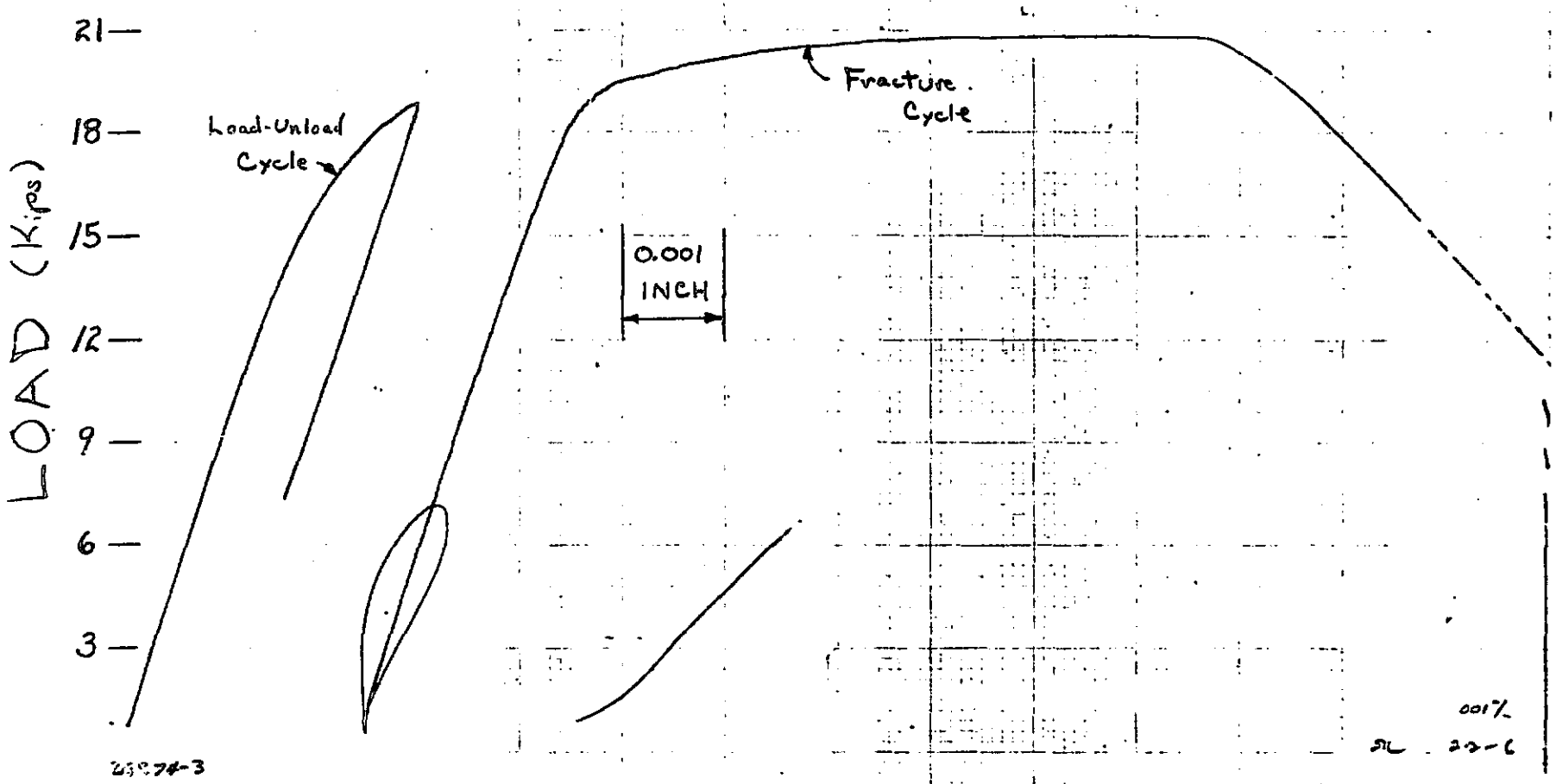
BOEING | TPR | ENG

PAGE OF


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AR74-2
LOAD (Kips)
21
18
15
12
9
6
3
0
0.001 INCH
LU 15580
Load-Unload Cycle
Fracture Cycle
ULT 20,580
2AR74-2
STRAIN ~IN/IN
STRAIN RATE ~IN/IN/MIN
LOAD RATE
DEFLECTION ~IN
.001
CALC
OPR
APPD
CHECK
BOEING
TPR
PAGE
OF

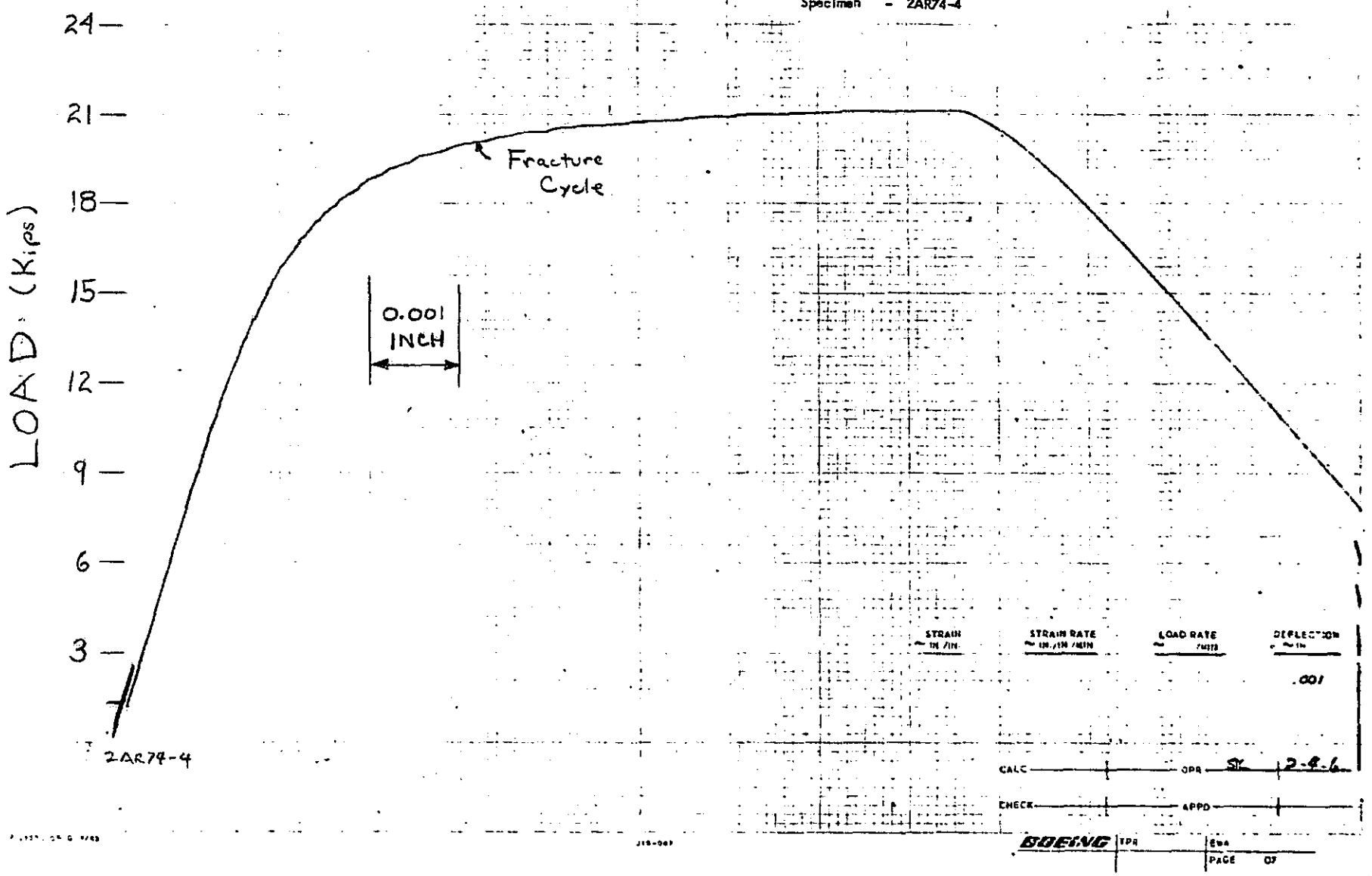
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

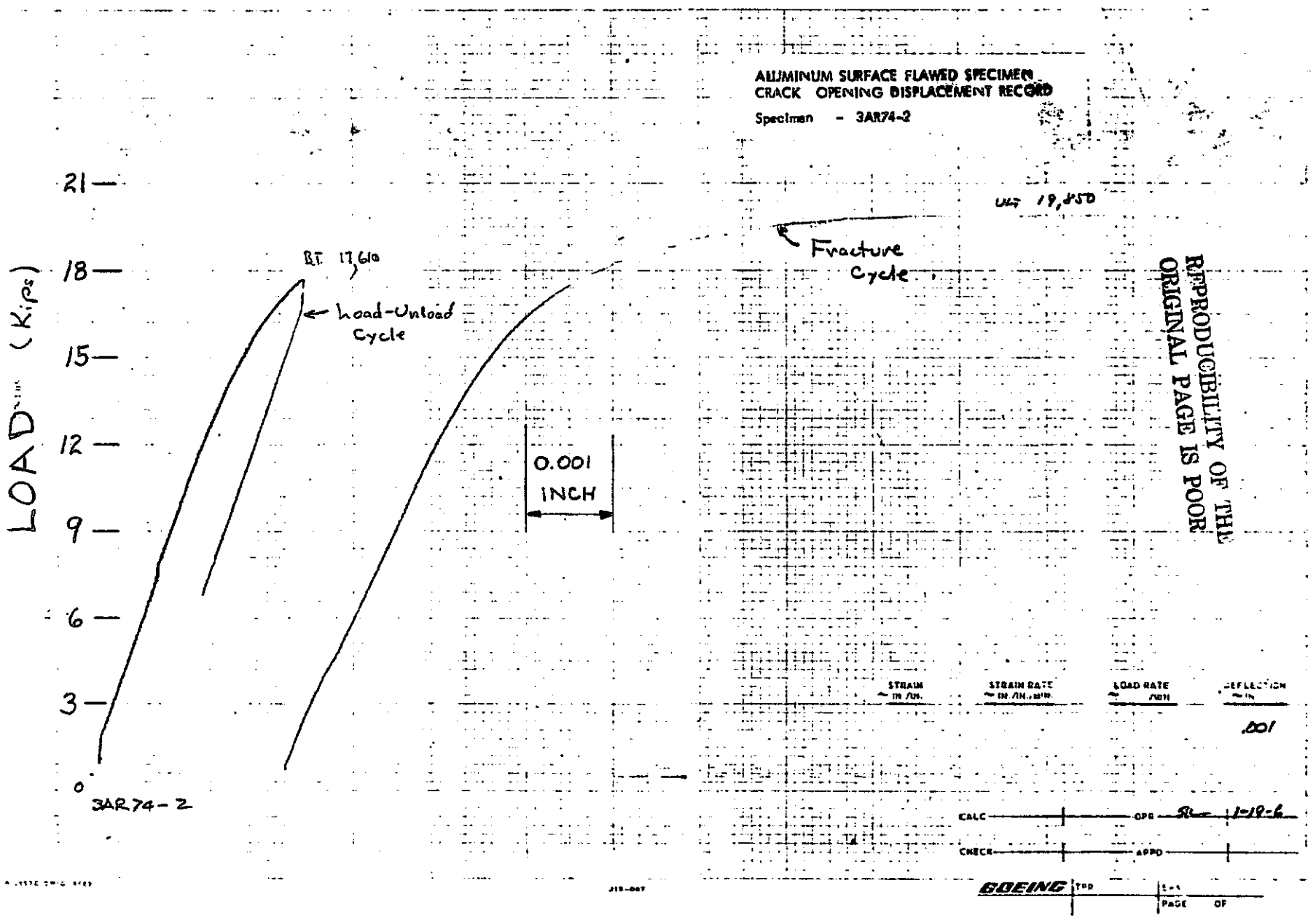
Specimen - 2AR74-3

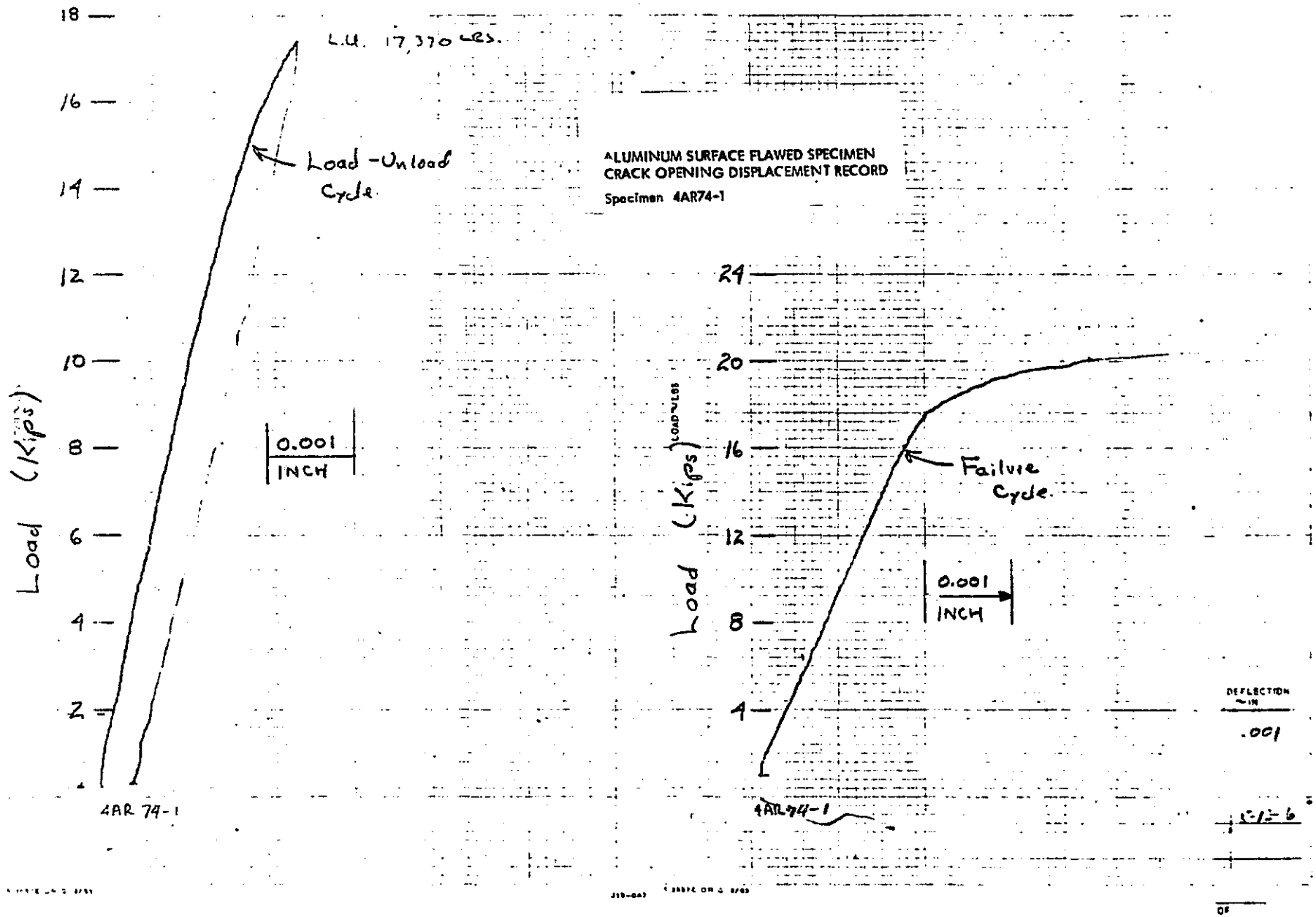


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2AR74-4

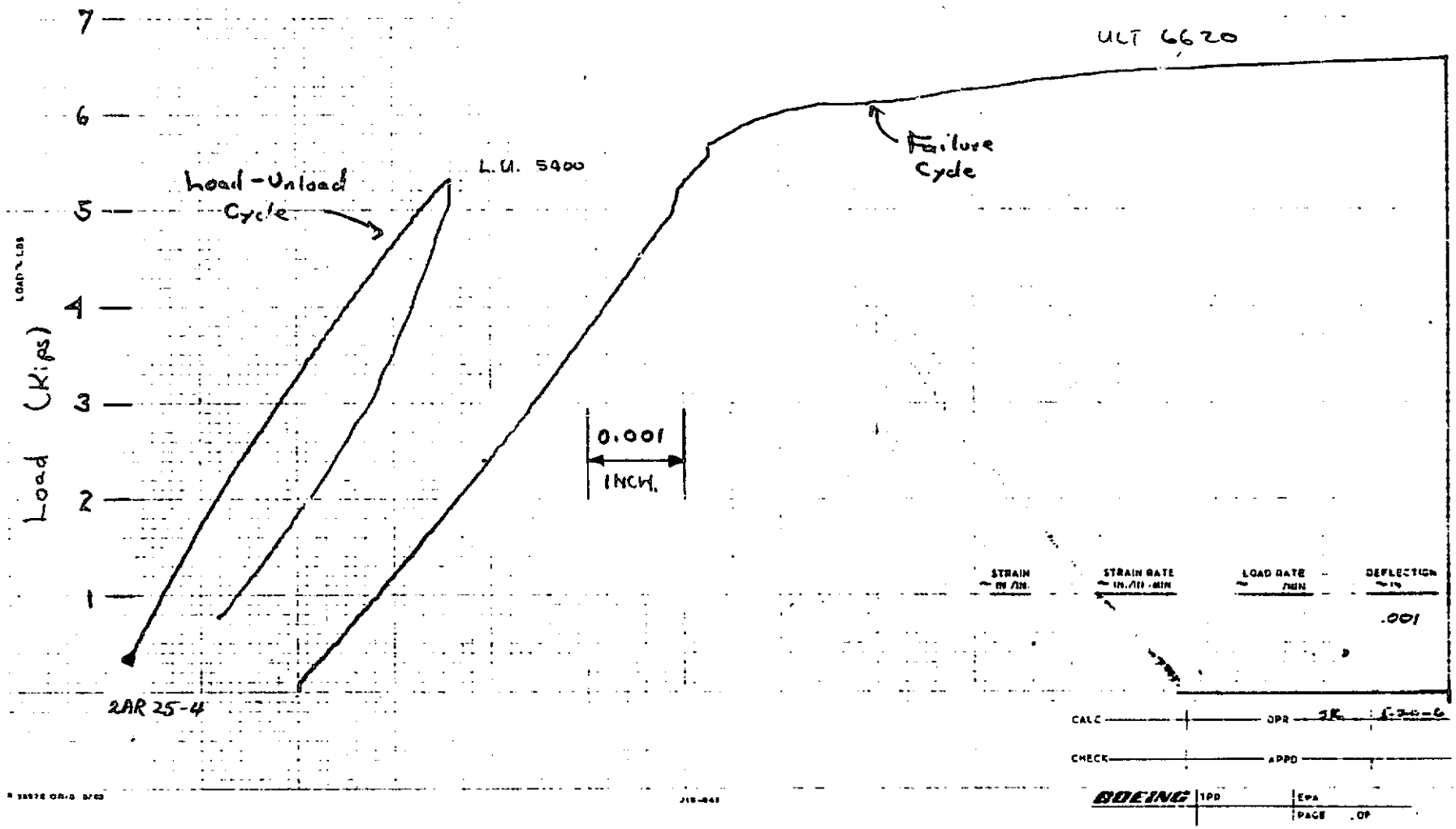



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AR74-2
LOAD (Kips)
21
18
15
12
9
6
3
0
BT 17,610
Load-Unload Cycle
Fracture Cycle
ULT 19,450
0.001 INCH
3AR74-2
REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
OPR
CHECK
APPD
BOEING
PAGE
OF


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR74-1
L.U. 17,370 lbs.
Load - Unload Cycle
Failure Cycle
0.001 INCH
0.001 INCH
Load (Kips)
LOAD VS
DEFLECTION IN
.001
4AR 74-1
4AR74-1

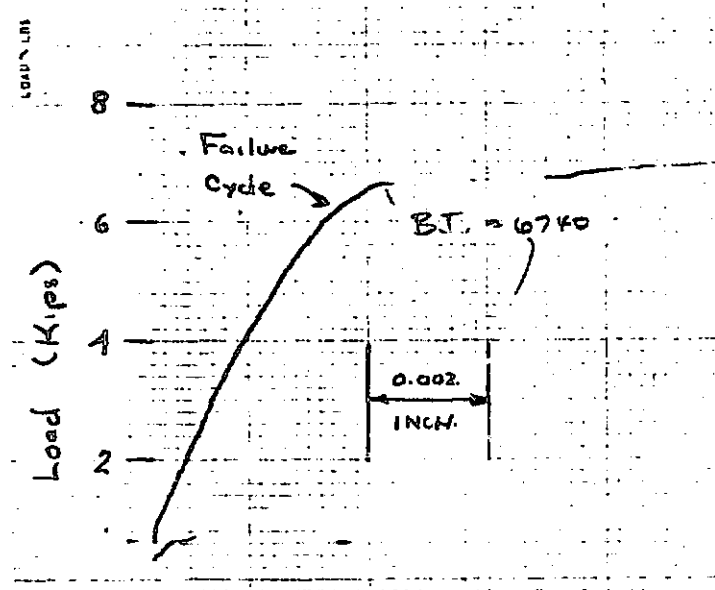
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2AR25-4



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 3AR25-1



ULT 7020

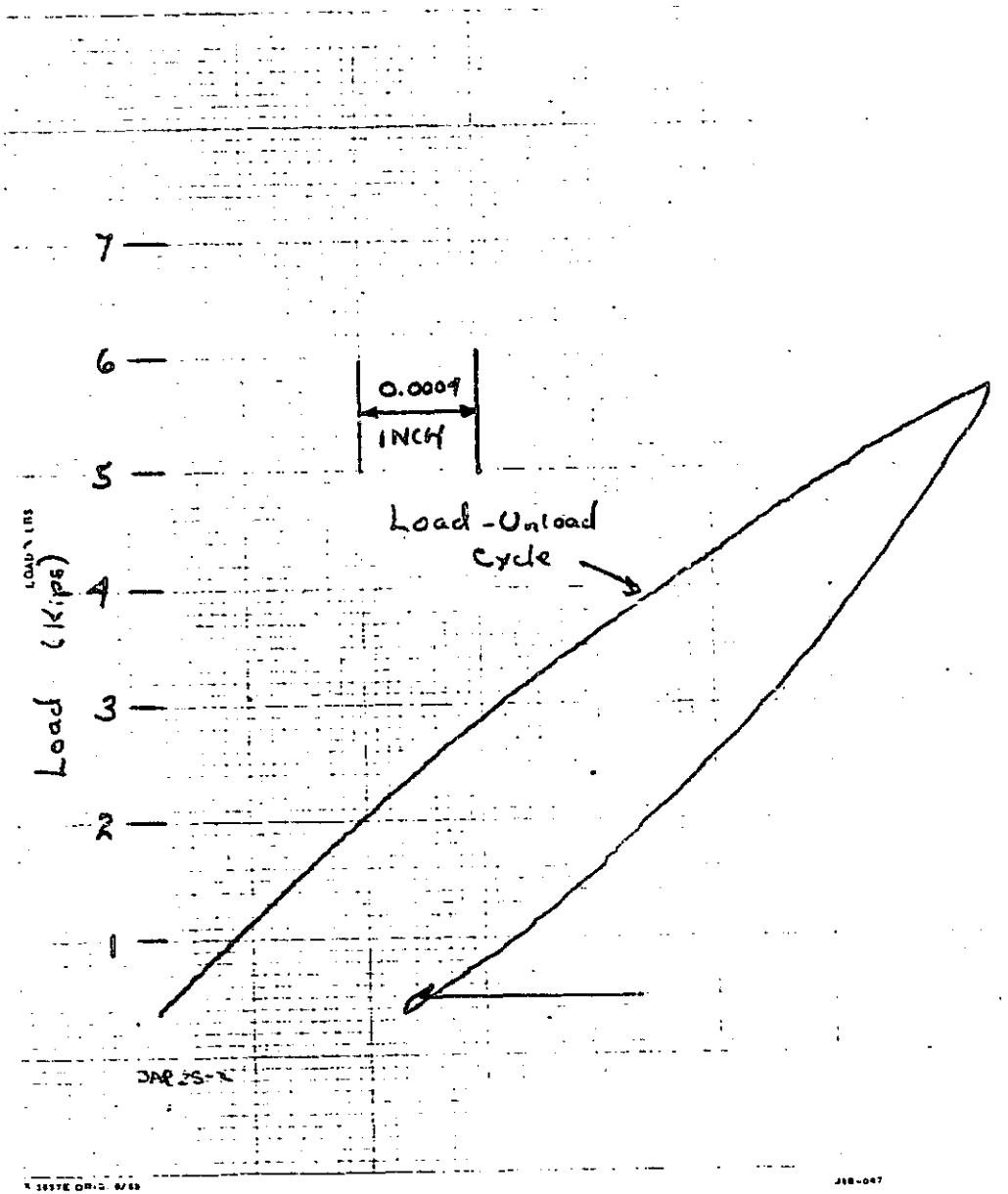
STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
~ IN./IN.	~ IN./IN./SEC	~ /SEC	~ IN.
			.002

CALC ____ DES SK 5-12-6

CHECK ____ APPD ____

BOEING TPD ____ SHEET ____ OF ____

81



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 3AR25-2

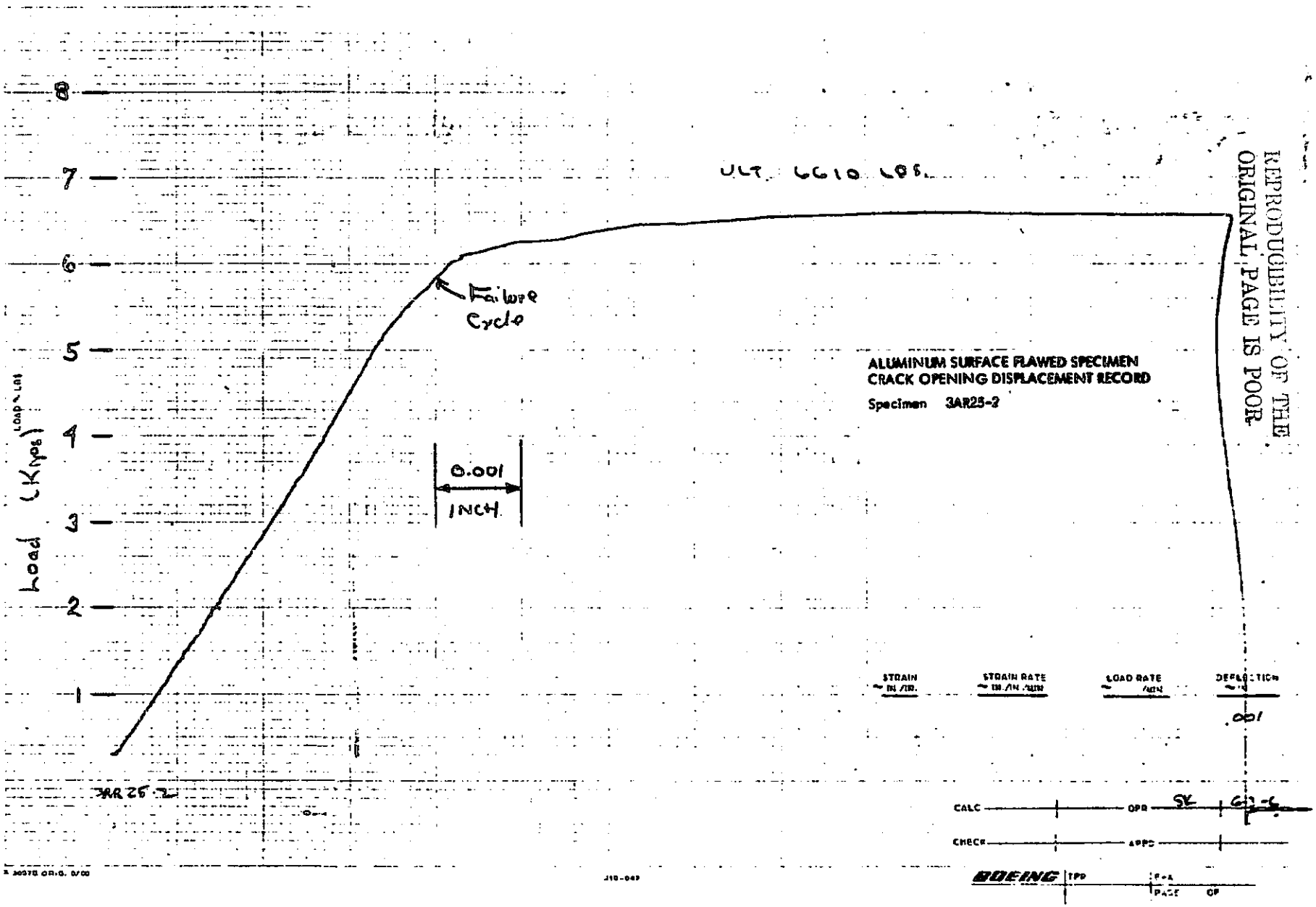
STRAIN IN/IN	STRAIN RATE IN/IN/MIN	LOAD RATE /MIN	DEFLECTION IN.
			.0009

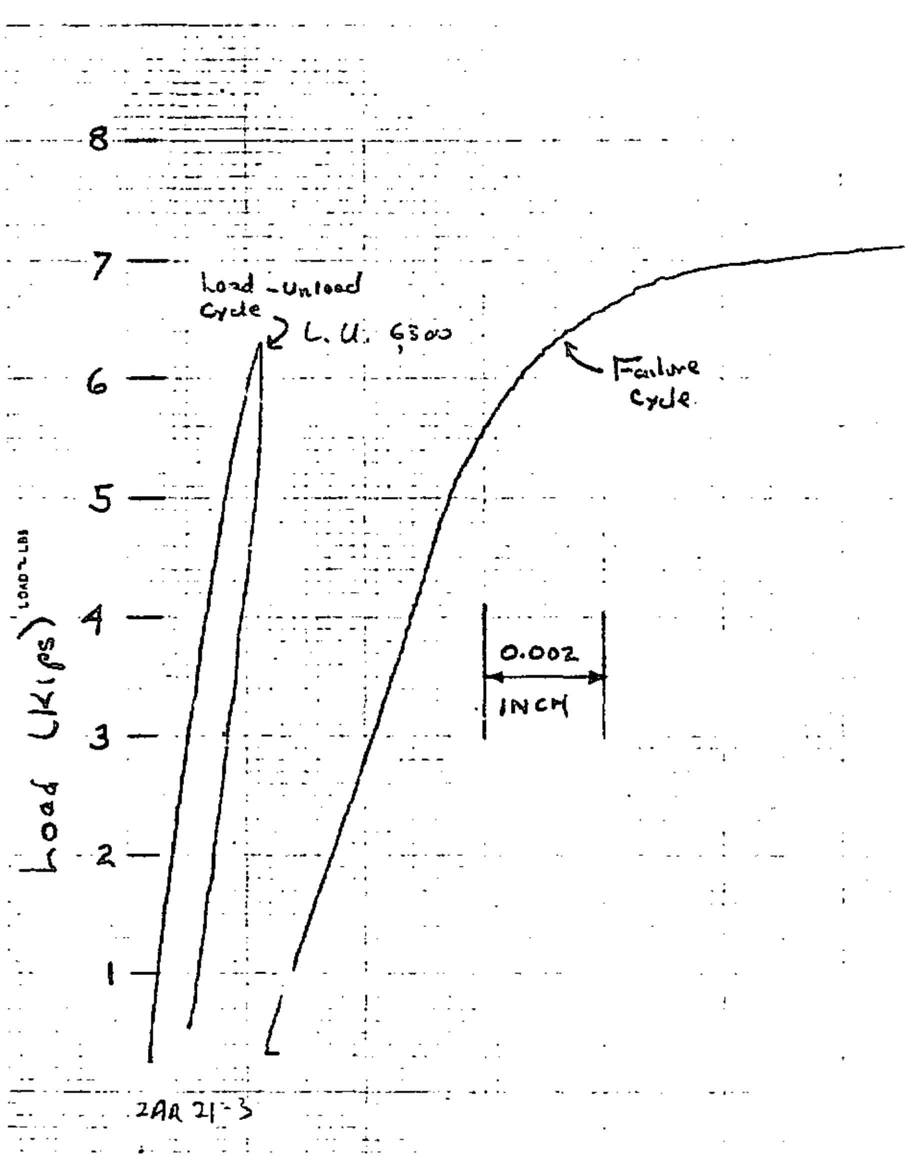
CALC — DRB 5/16 6-3-6

CHECK — APPD

BOEING TPR EWA

PAGE OF





ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

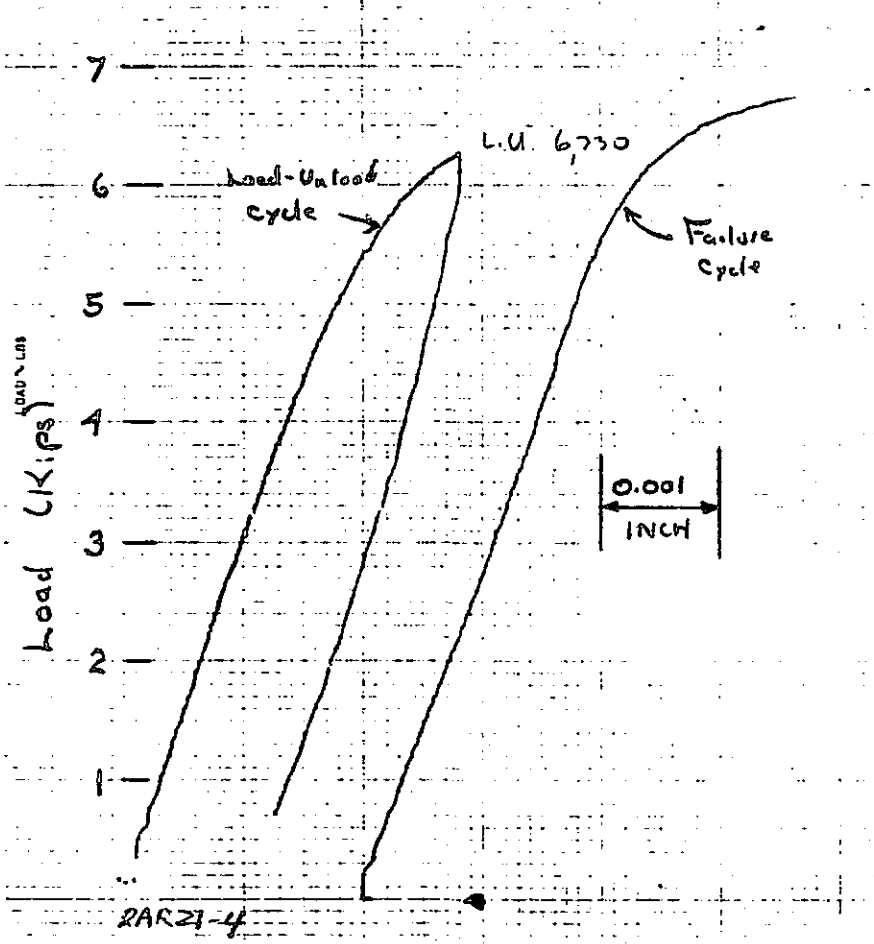
Specimen 2AR21-3

STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN., MIN	LOAD RATE ~	DEFLECTION ~ IN
			.002

CALC ——— OPR 5-1-72
CHECK ——— APPD

BOEING

ULT 7000 ~



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

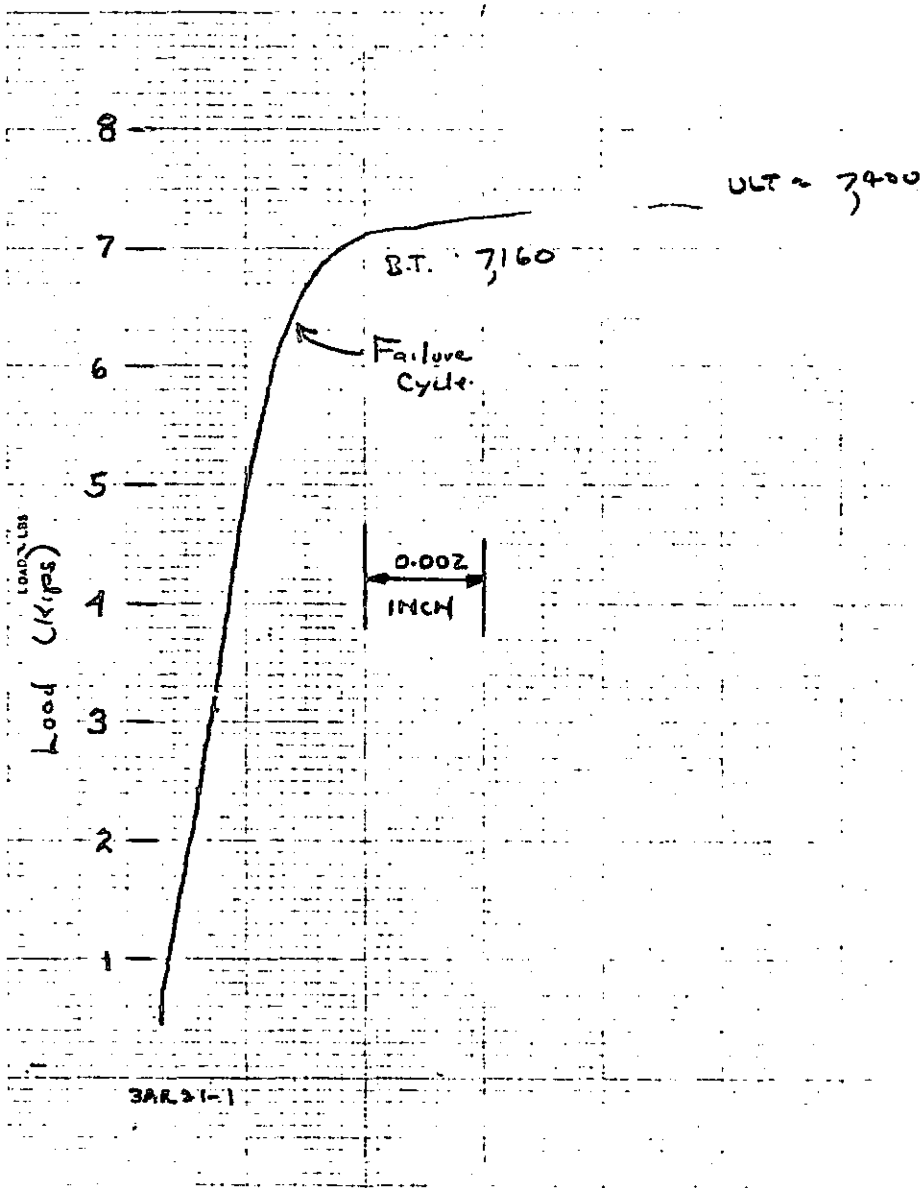
Specimen 2AR21-4

STRAIN ~ IN/IN.	STRAIN RATE ~ IN/IN./MIN	LOAD RATE ~ /MIN	DEFLECTION ~ "
			.001

CALC ____ OPR SK 5-19-6_

CHECK ____ APPD ____

BOEING



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

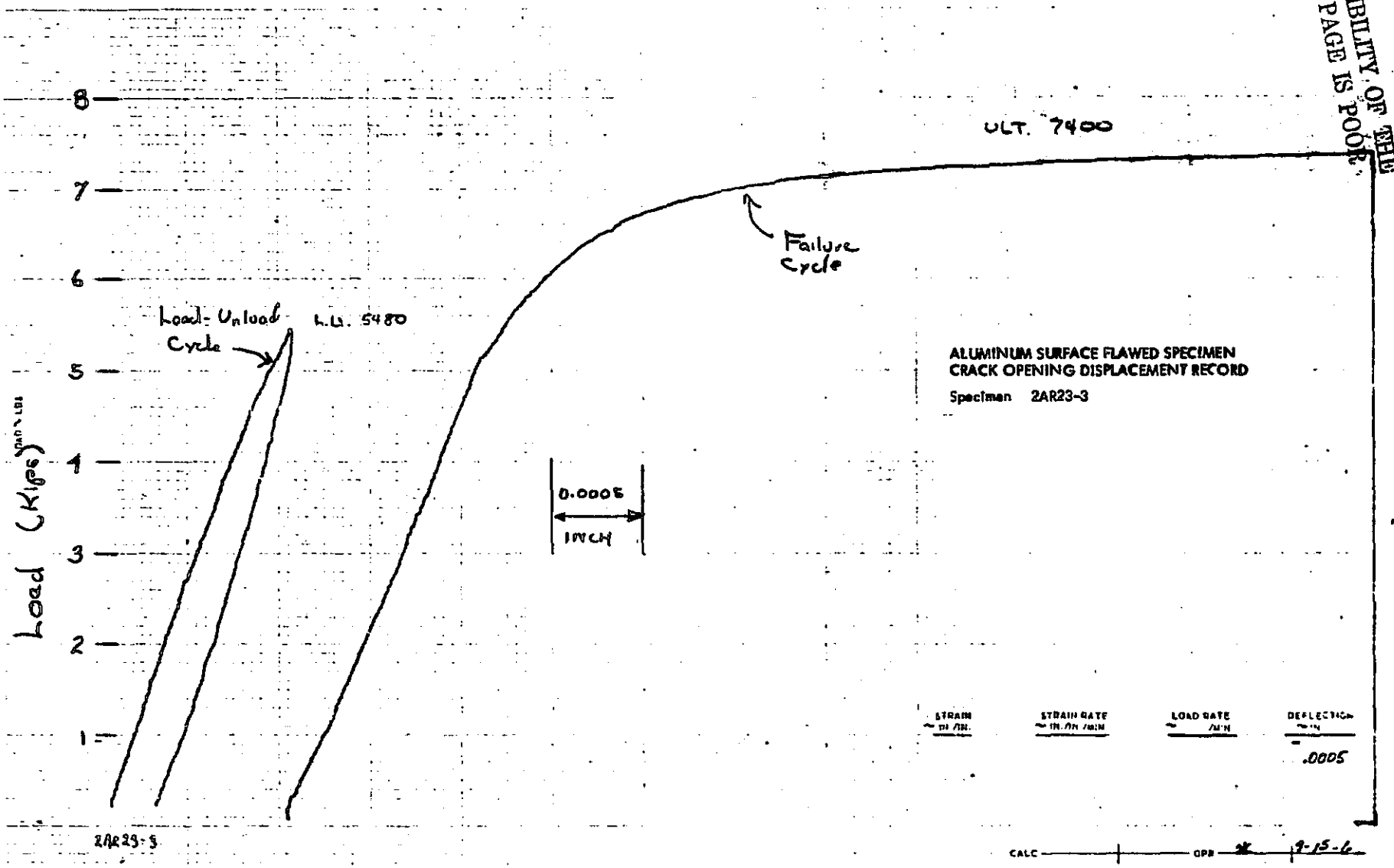
Specimen 3AR21-1

STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN.	LOAD RATE ~ /MIN	DEFLECTION ~ IN
			.002

CALC — OPR SL 3-18-6

CHECK — APPD

BOEING TPR | PAGE OF



ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2AR23-3

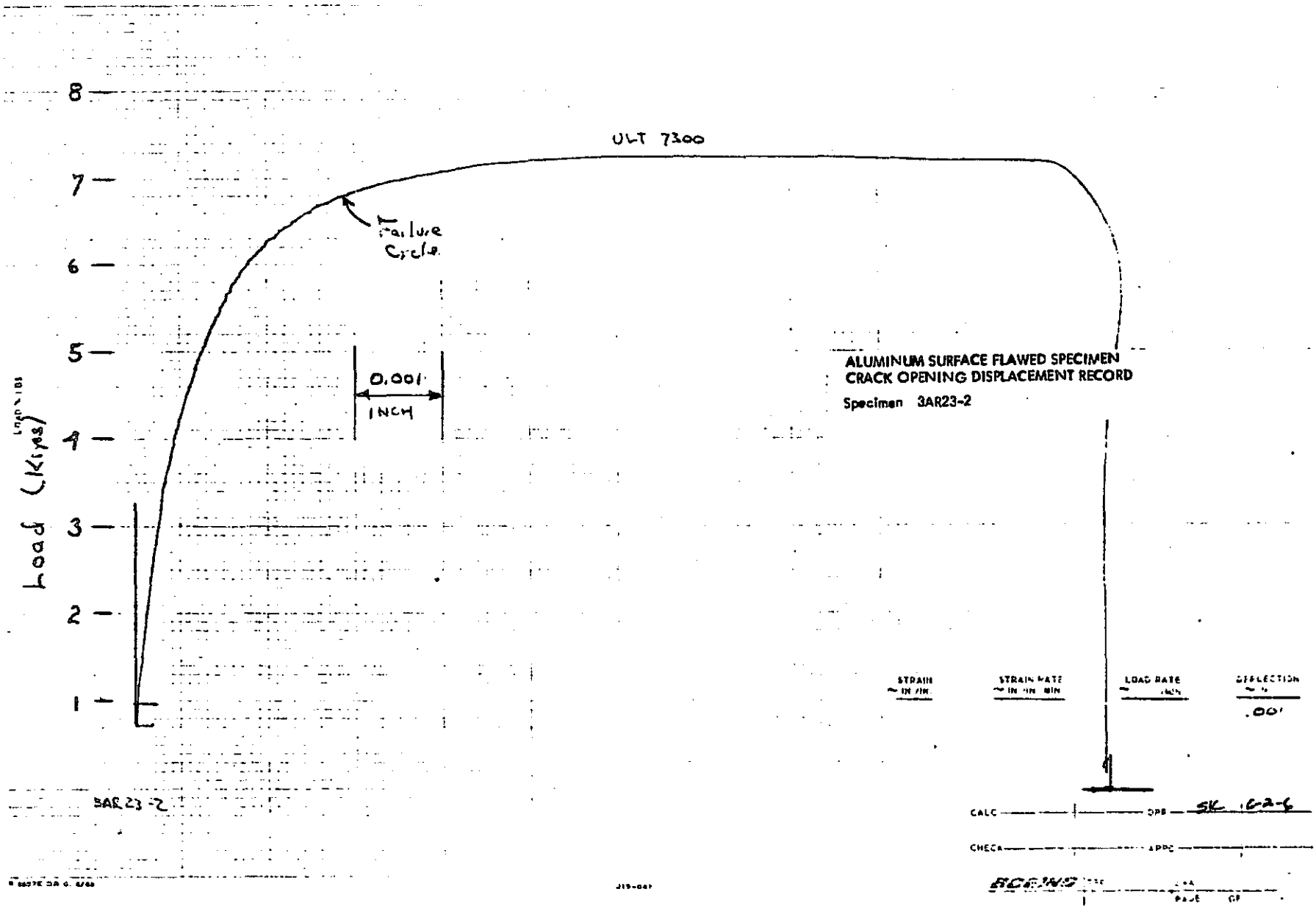
STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
~ IN./IN.	~ IN./IN./MIN	~ /MIN	~ IN.
			.0005

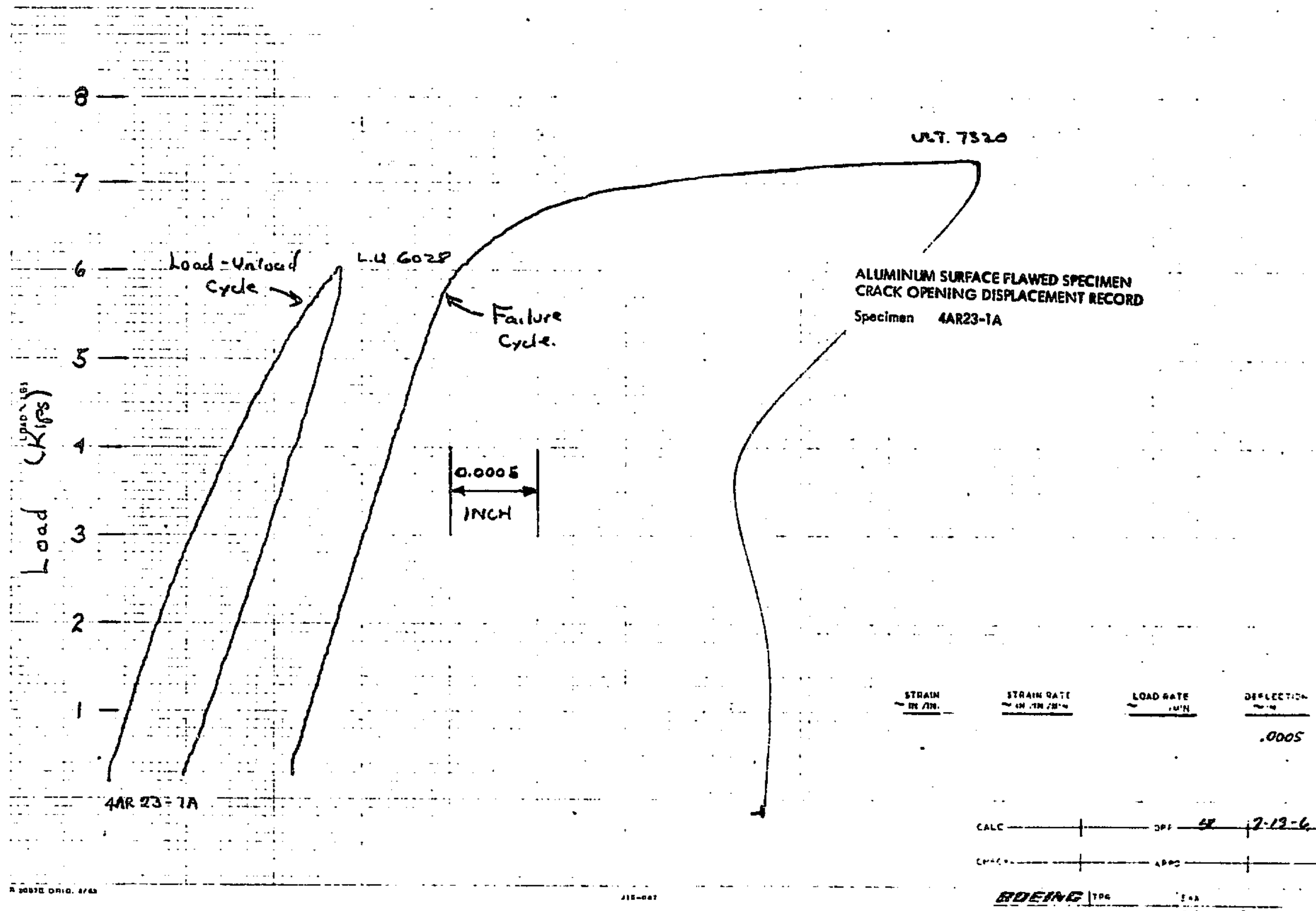
CALC — OPR — 9-15-6

CHECK — APPD —

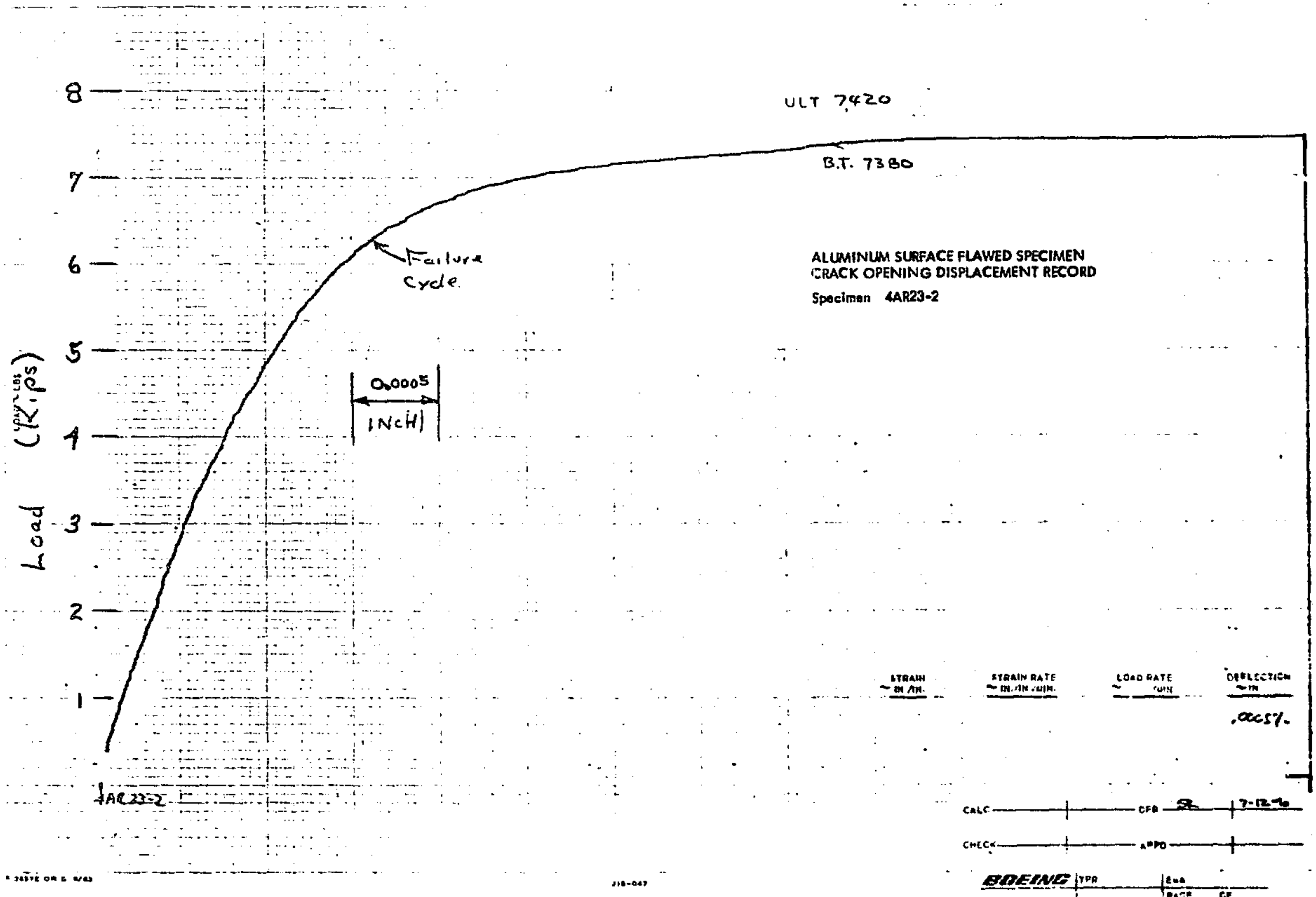
BOEING TPR

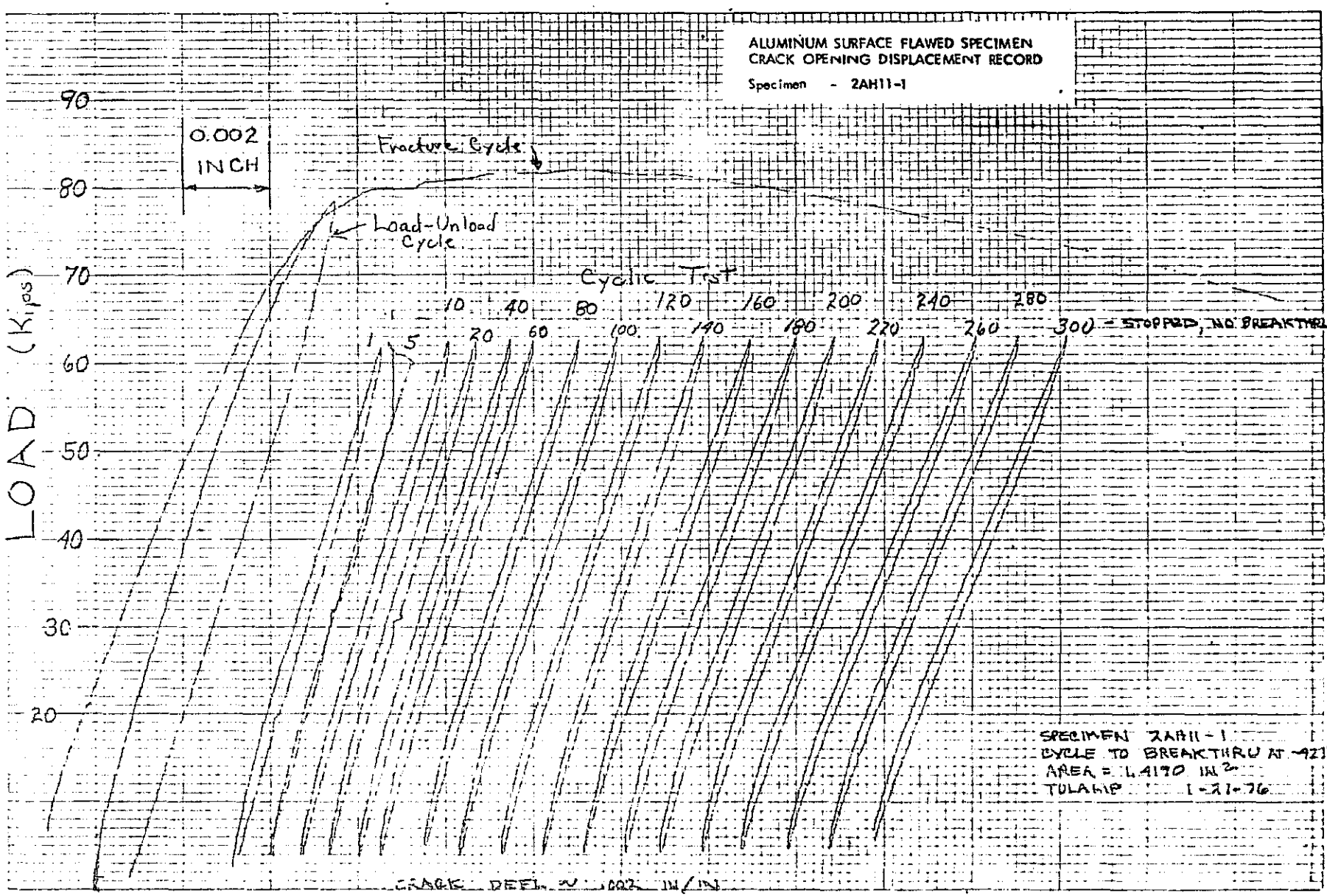
PAGE

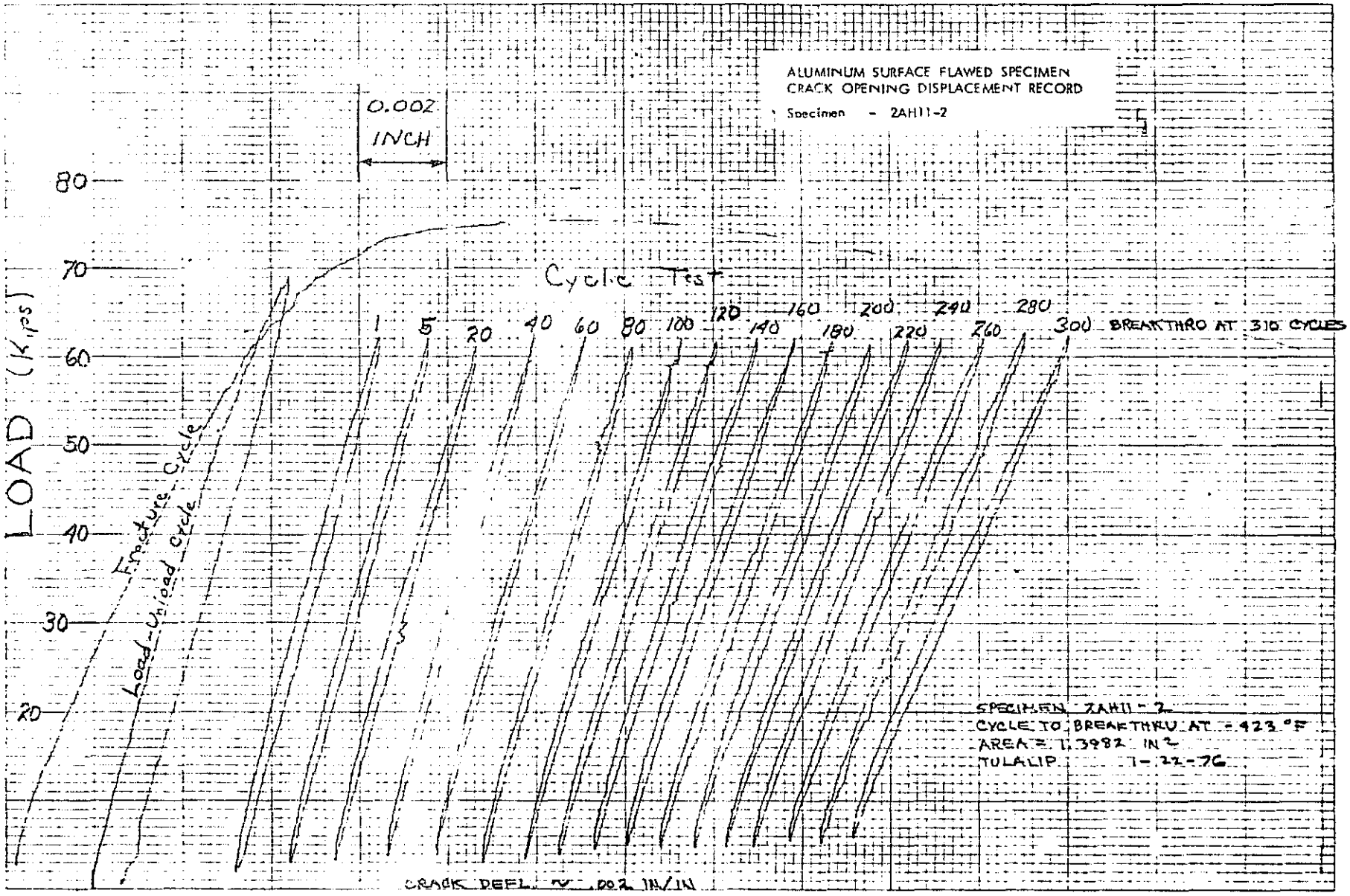

ULT 7300
Failure Cycle
0.001 INCH
Load (Kips)
8
7
6
5
4
3
2
1
SAR23-2
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3AR23-2
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
DES
SK 162-6
CHECK
APPD
BOEING

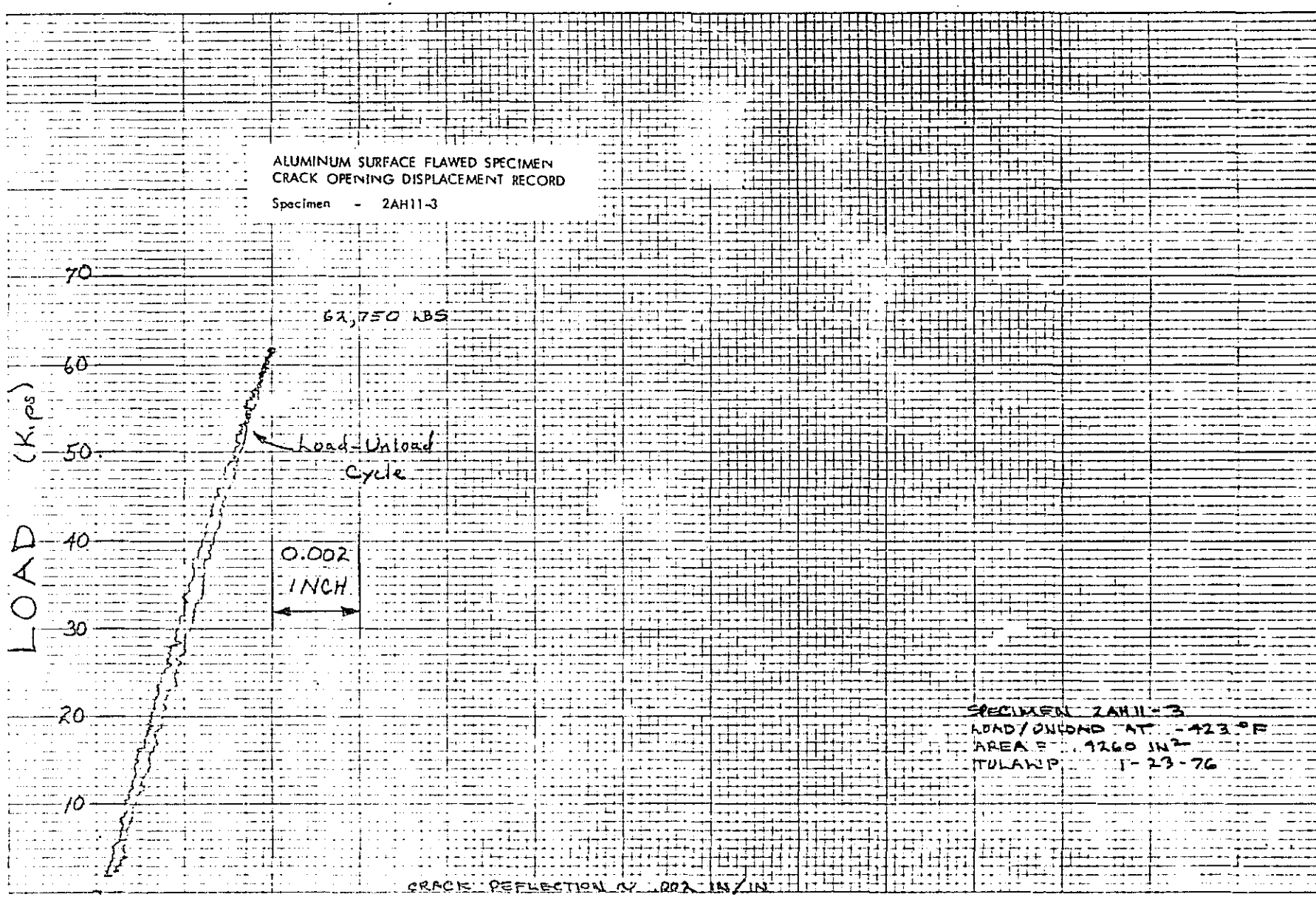


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR23-1A
ULT. 7320
L.U 6028
Load-Unload Cycle
Failure Cycle.
0.0005 INCH
Load (Kips)
8
7
6
5
4
3
2
1
4AR 23-1A
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.0005
CALC
2-13-6
BOEING


ULT 7,420
B.T. 7380
ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4AR23-2
Failure Cycle
0.0005
INCH
Load (Kips)
8
7
6
5
4
3
2
1
4AR23-2
STRAIN ~IN./IN.
STRAIN RATE ~IN./IN./MIN.
LOAD RATE ~ /MIN
DEFLECTION ~IN
.00057
CALC
CHECK
APPD
7-12-76
BOEING

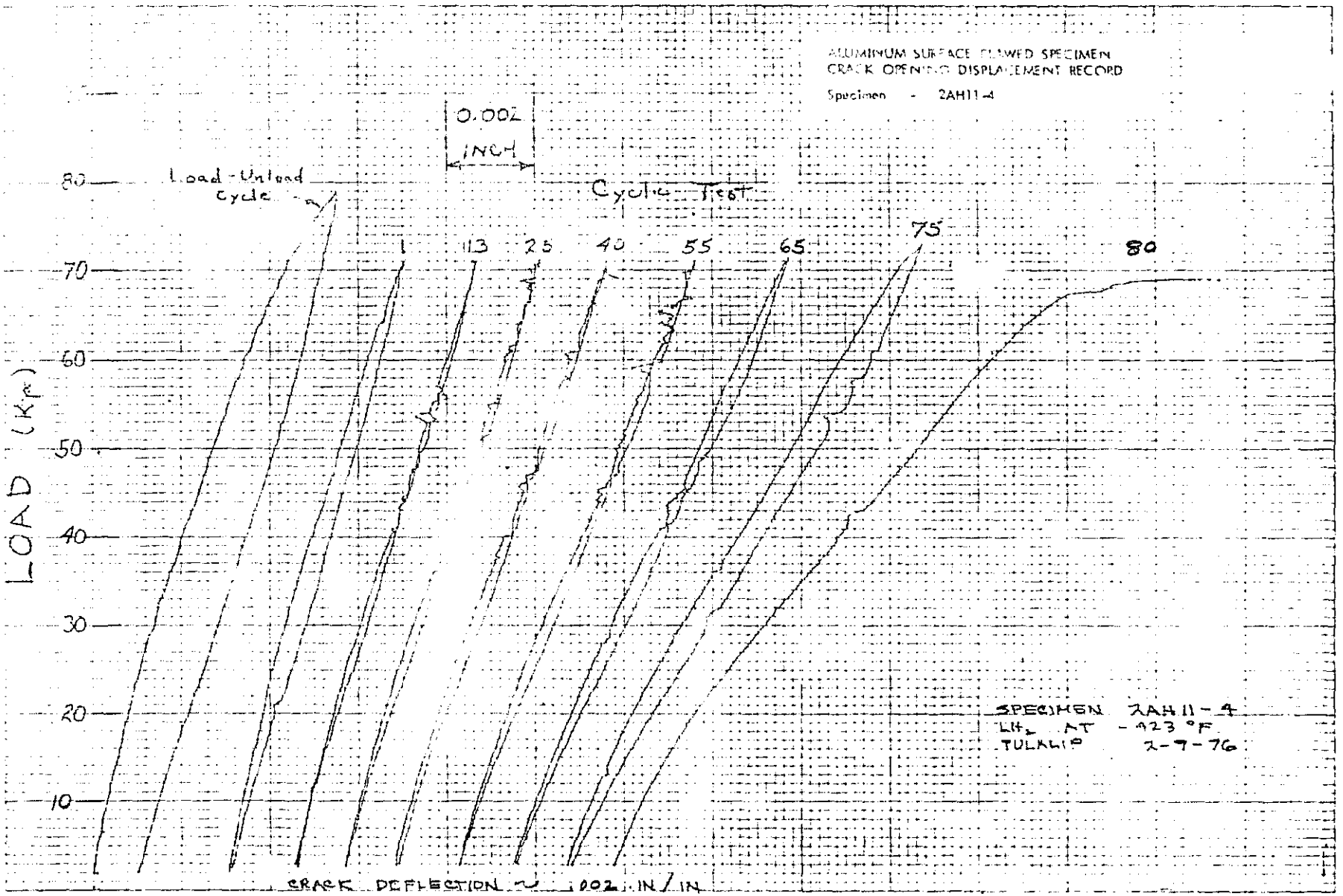

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH11-1
0.002 INCH
Fracture Cycle
Load-Unload Cycle
Cyclic Test
LOAD (K_{ips})
90
80
70
60
50
40
30
20
1
5
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300 = STOPPED, NO BREAKTHRU
SPECIMEN 2AH11-1
CYCLE TO BREAKTHRU AT ~427°F
AREA = 1.4170 IN²
TULAMP 1-21-76
CRACK DEPTH ~ .002 IN/IN

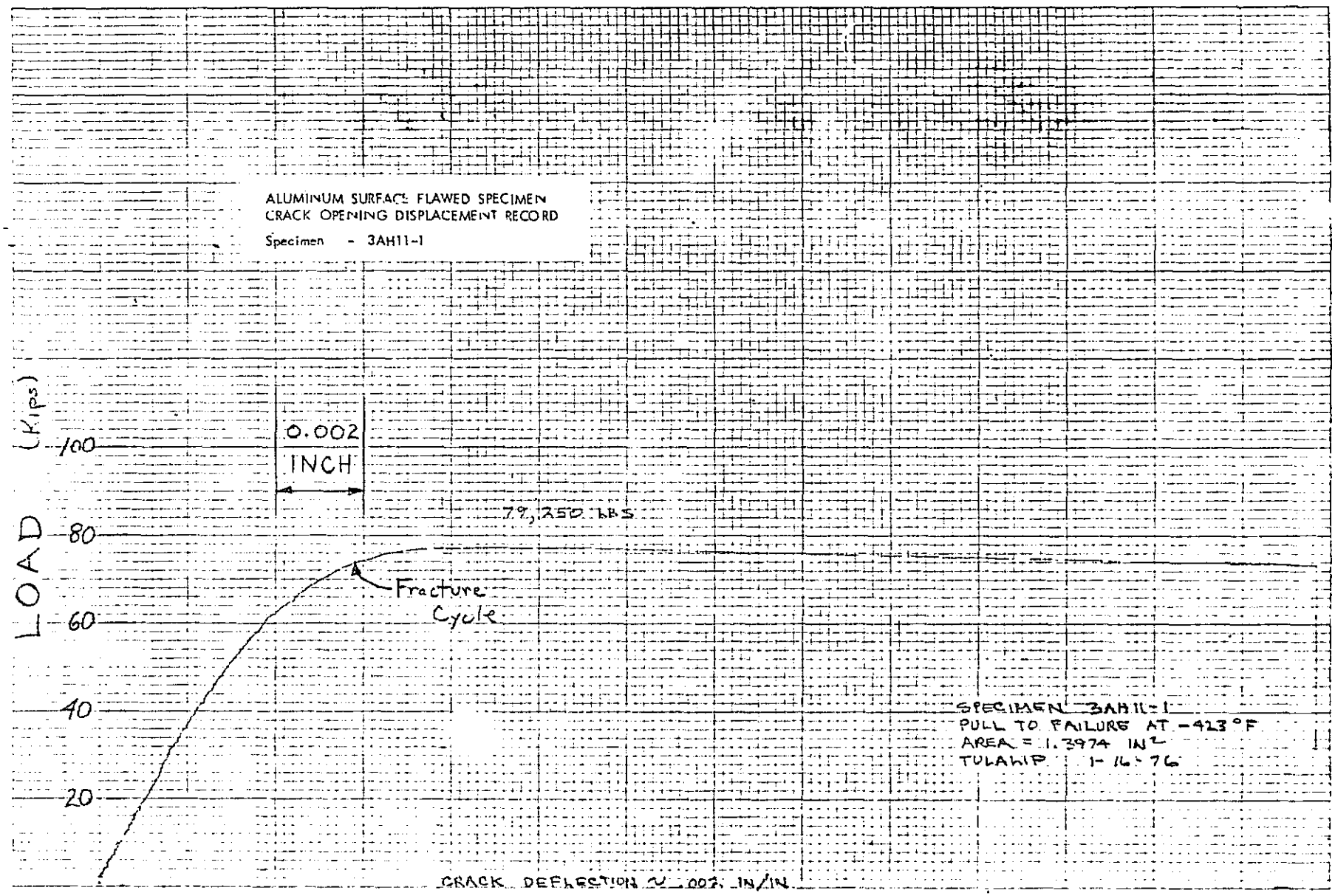

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH11-2
0.002 INCH
LOAD (Kips)
80
70
60
50
40
30
20
Cycle Test
1 5 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
BREAKTHRO AT 310 CYCLES
Fracture Cycle
Load-Unload cycle
SPECIMEN 2AH11-2
CYCLE TO BREAKTHRU AT -423 °F
AREA = 1.3982 IN²
TULALIP 1-22-76
CRACK DEFL. = .002 IN/IN

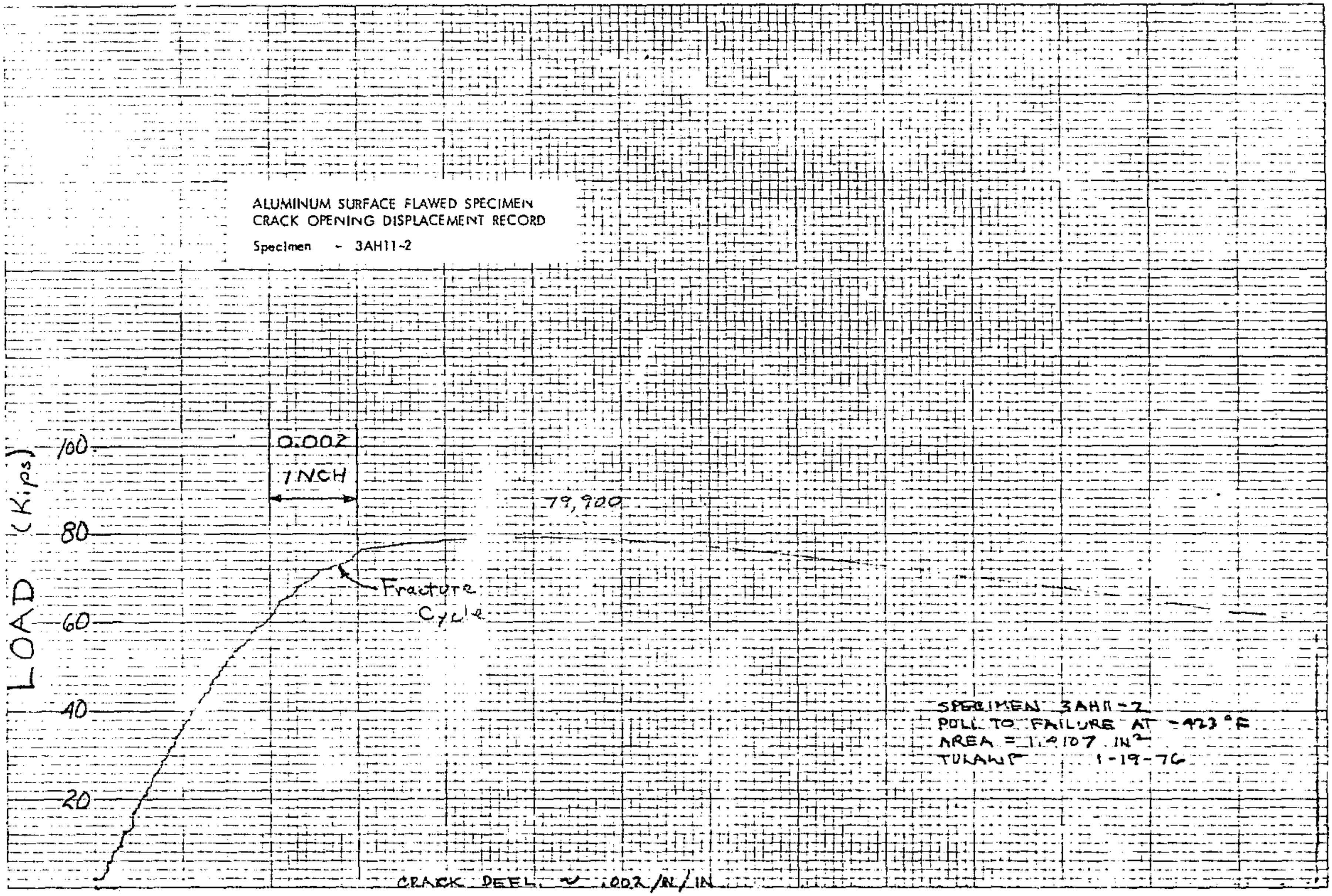

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH11-3
LOAD (Kips)
70
60
50
40
30
20
10
62,750 LBS
Load-Unload Cycle
0.002 INCH
SPECIMEN 2AH11-3
LOAD/UNLOAD AT -423°F
AREA = .1260 IN²
TULAN P 1-23-76
CRACK REFLECTION OF .002 IN/IN

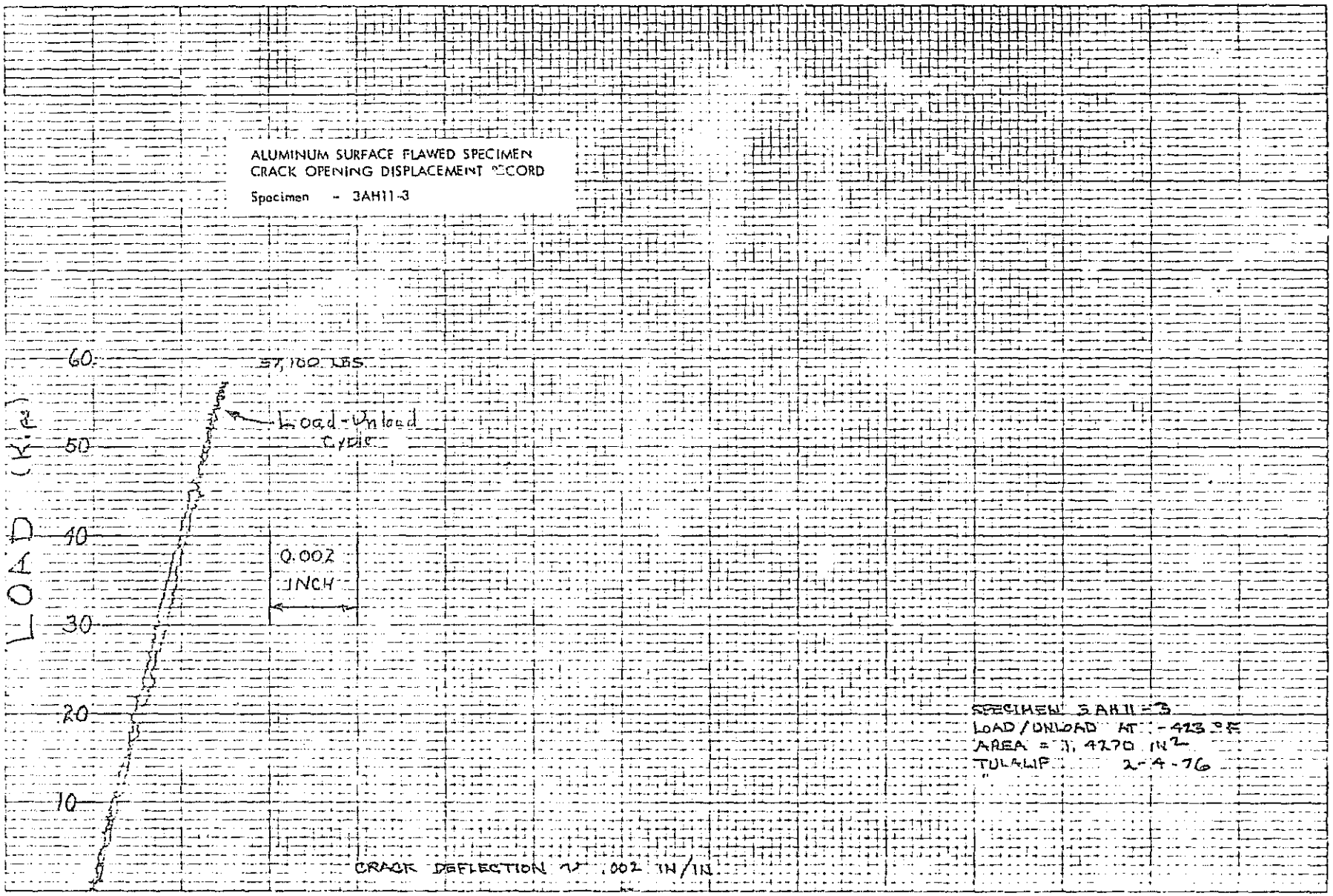
C-2

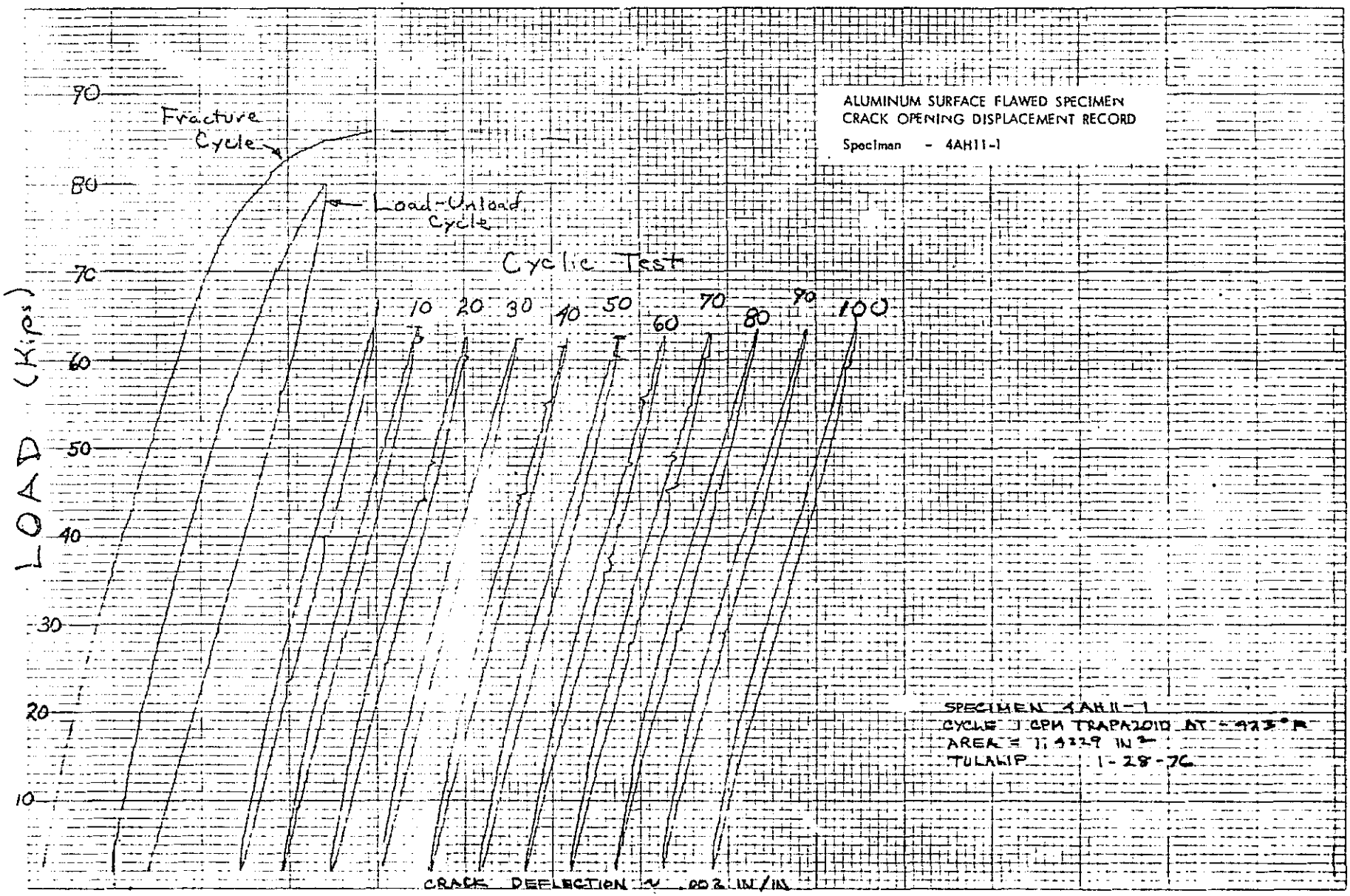
AH11-4


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH11-4
0.002 INCH
Load-Unload Cycle
Cycle-Test
1
113
25
40
55
65
75
80
LOAD (Kip)
80
70
60
50
40
30
20
10
SPECIMEN 2AH11-4
LH2 AT -423 °F
TULALIP 2-7-76
CRACK DEFLECTION ~ .002 IN/IN

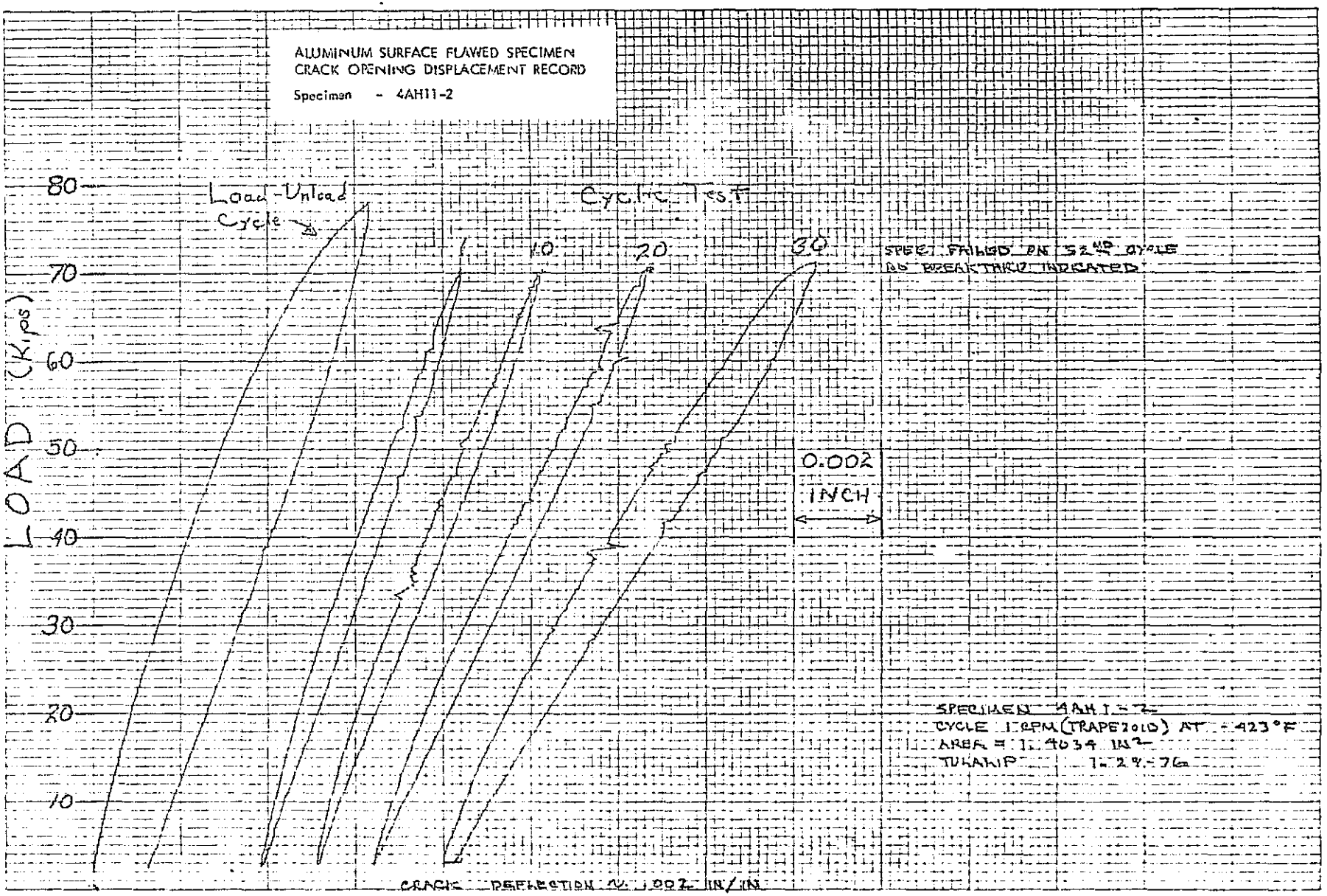

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AH11-1
LOAD (Kips)
100
80
60
40
20
0.002
INCH
79,250 lbs
Fracture
Cycle
SPECIMEN 3AH11-1
PULL TO FAILURE AT -423°F
AREA = 1.3974 IN²
TULAHIP 1-16-76
CRACK DEFLECTION ~ .002 IN/IN

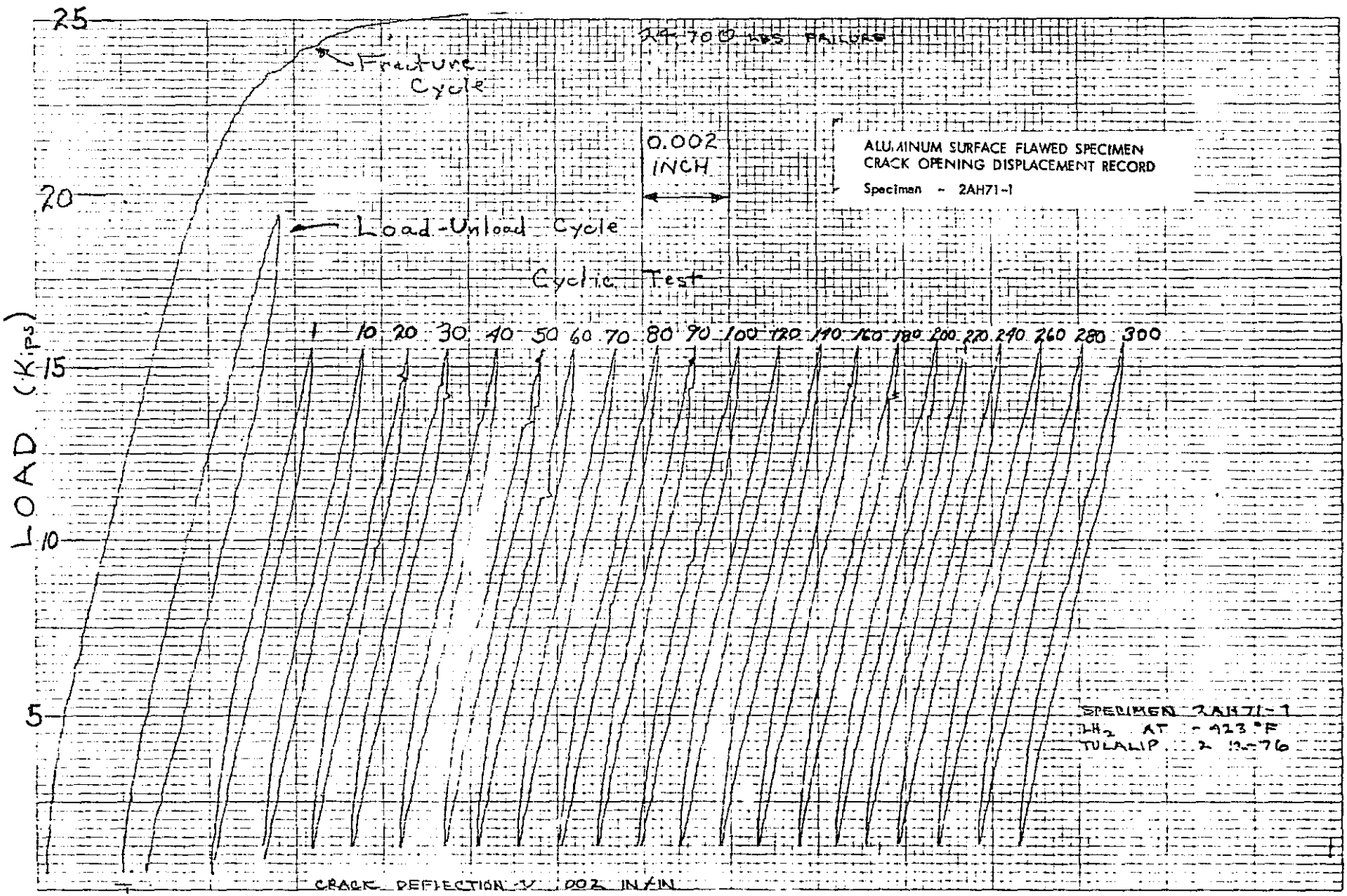

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AH11-2
0.002
INCH
79,900
Fracture Cycle
LOAD (Kips)
100
80
60
40
20
SPECIMEN 3AH11-2
PULL TO FAILURE AT -423 °F
AREA = 1.4107 IN²
1-19-76
CRACK DEFL ~ .002/IN/IN

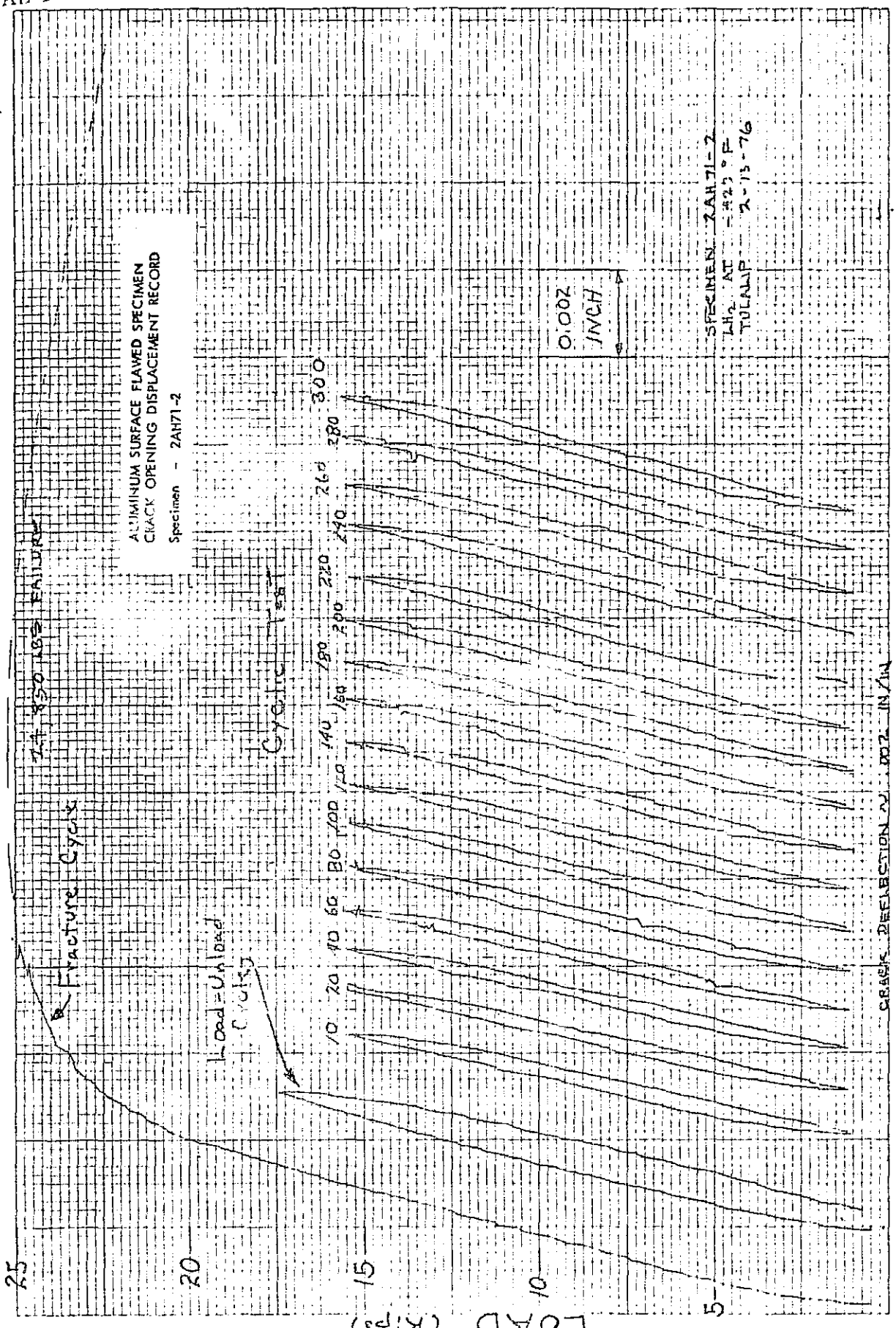

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AH11-3
LOAD (Kips)
60
50
40
30
20
10
57,100 LBS.
Load-Unload cycle
0.002 INCH
CRACK DEFLECTION .002 IN/IN.
SPECIMEN 3AH11-3
LOAD/UNLOAD AT -423°F
AREA = 1.4270 IN²
TULALIP 2-4-76

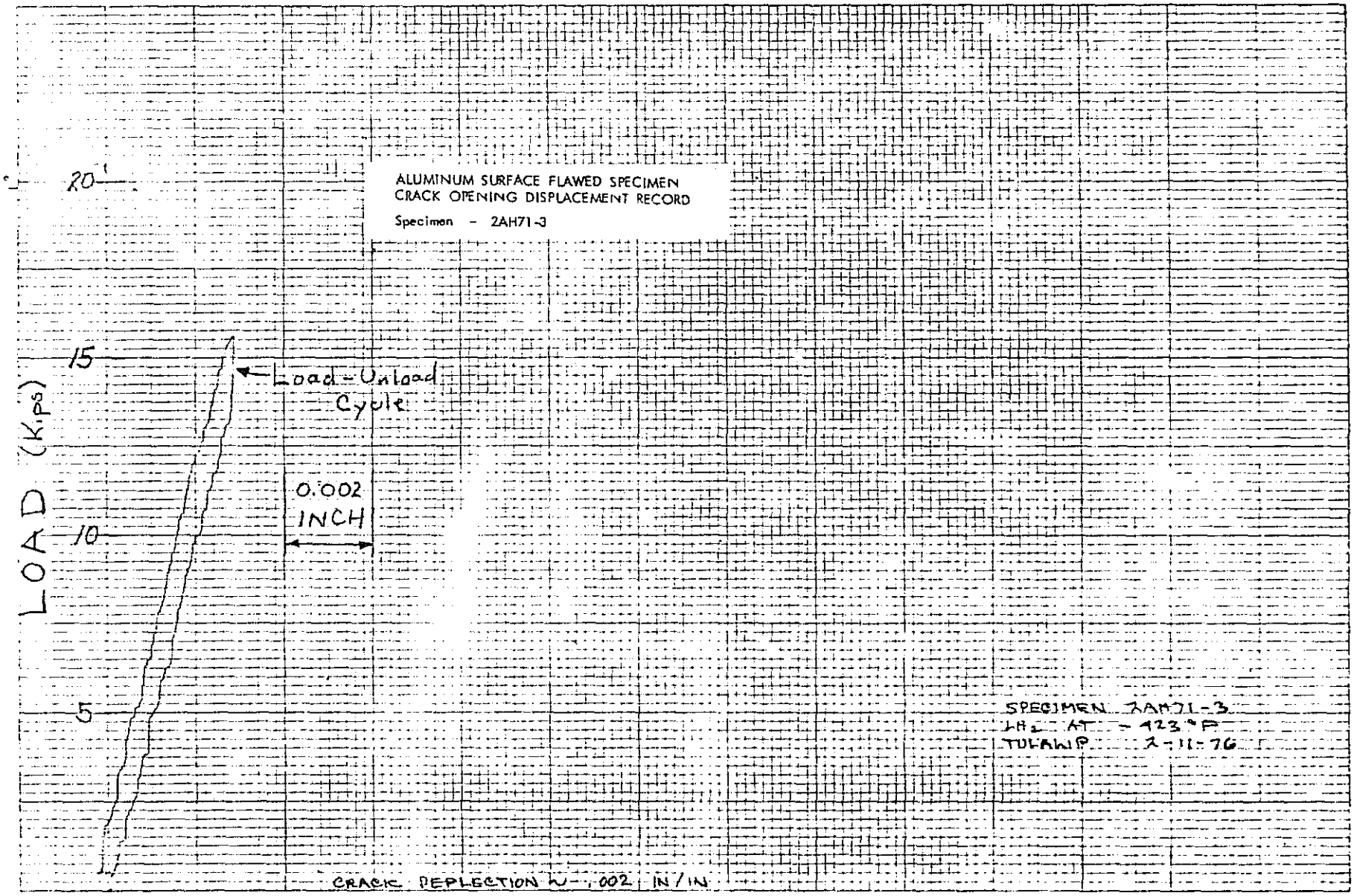

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 4AH11-1
Fracture Cycle
Load-Unload Cycle
Cyclic Test
LOAD (Kips)
90
80
70
60
50
40
30
20
10
1
10
20
30
40
50
60
70
80
90
100
SPECIMEN 4AH11-1
CYCLE 1 OPN TRAPAZOID AT -423° F
AREA = 1.4329 IN²
TULALIP 1-28-76
CRACK DEFLECTION .003 IN/IN

4AH11-2
1-29-76

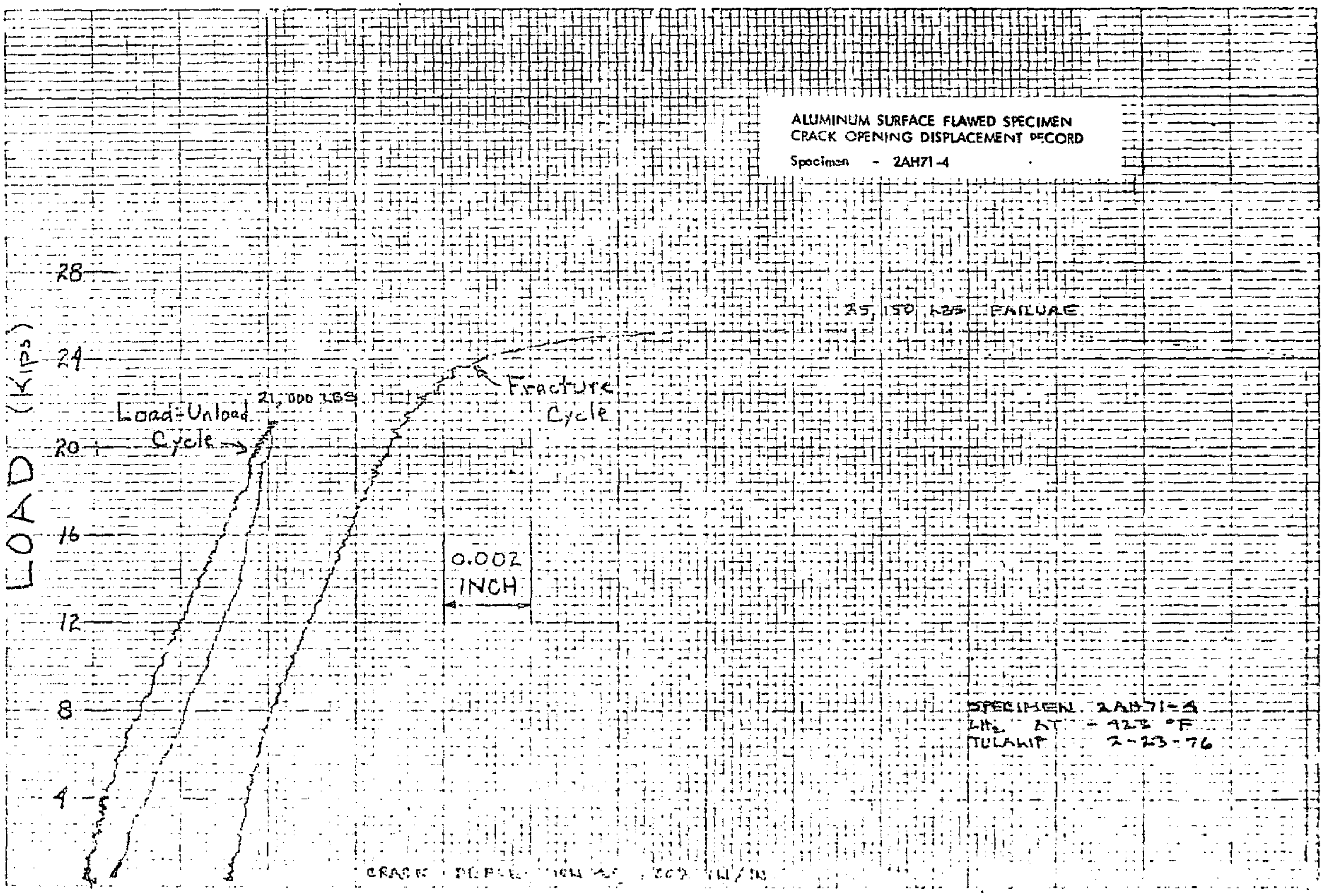


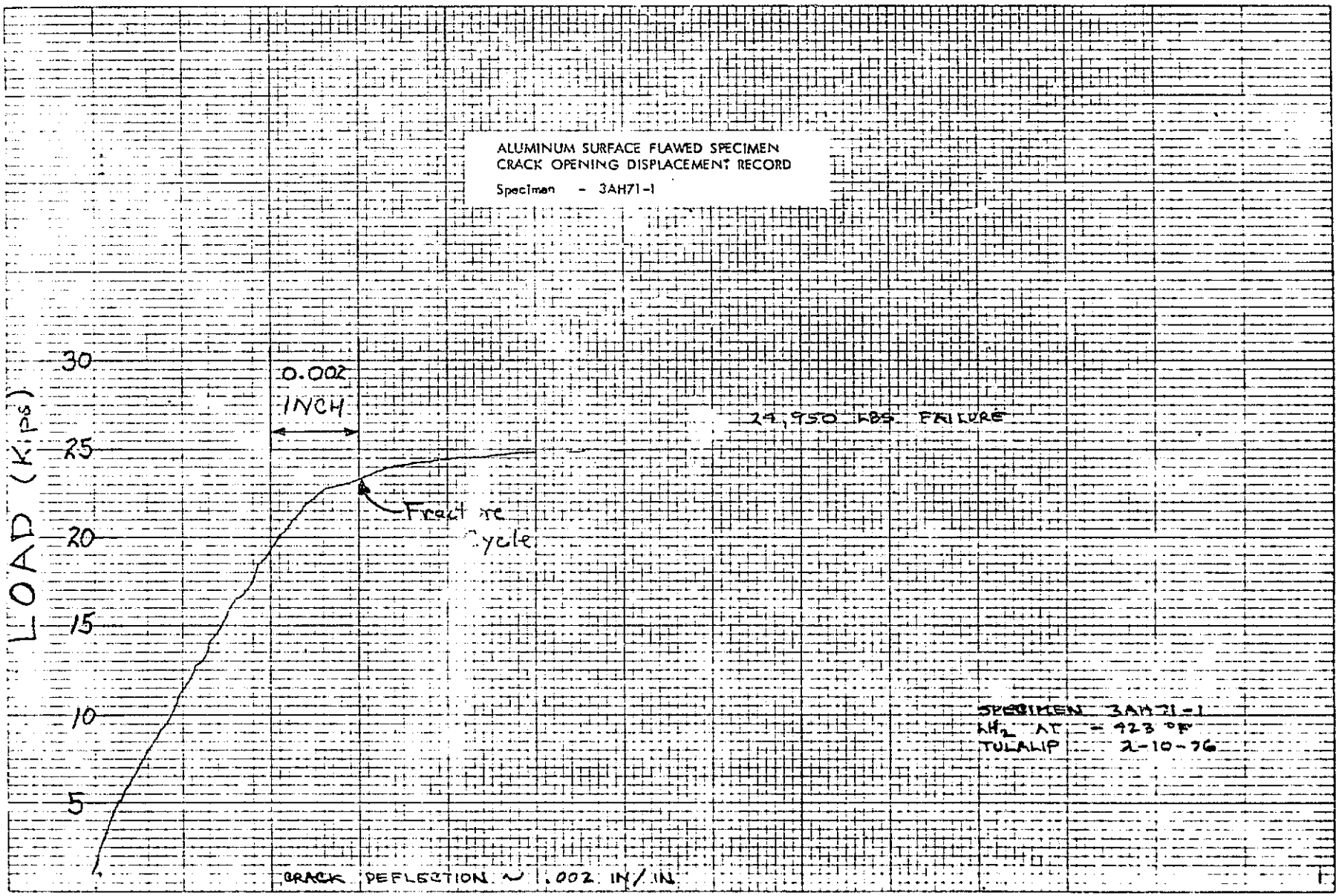


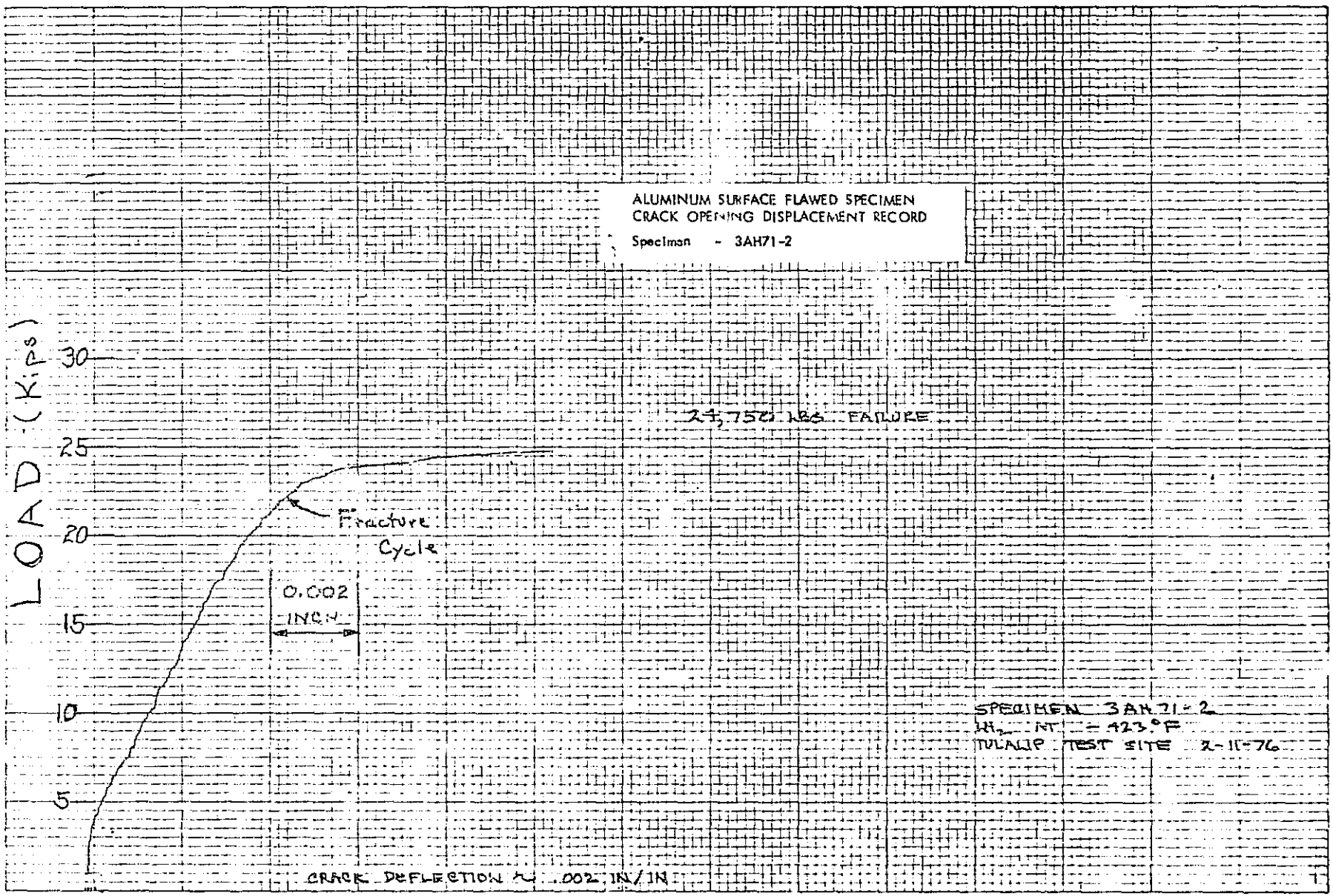


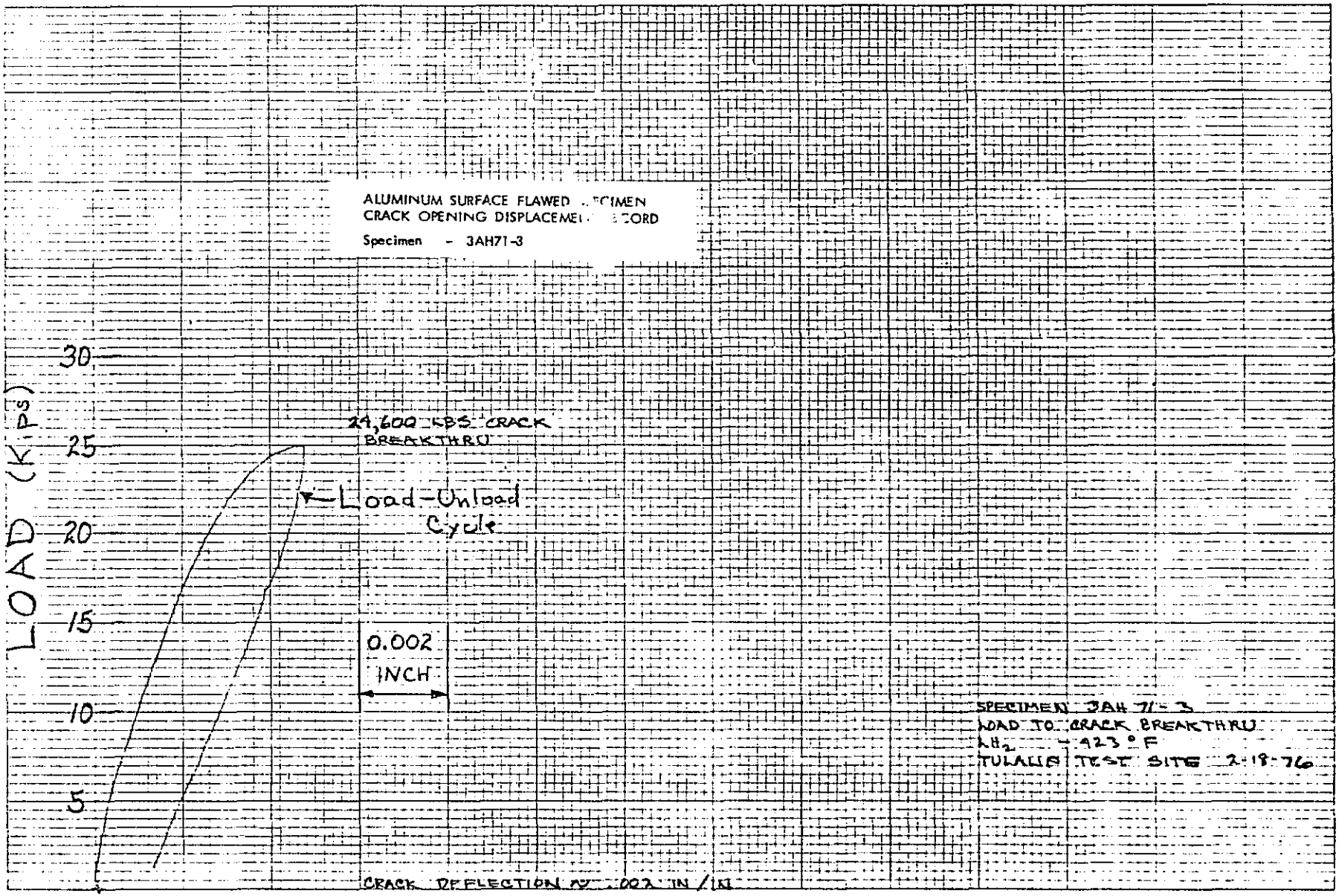

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH71-3
20
15
10
5
LOAD (KIPS)
Load-Unload Cycle
0.002 INCH
SPECIMEN 2AH71-3
LH2 AT -423°F
TULAWIP 2-11-76
CRACK DEPLECTION W-.002 IN/IN

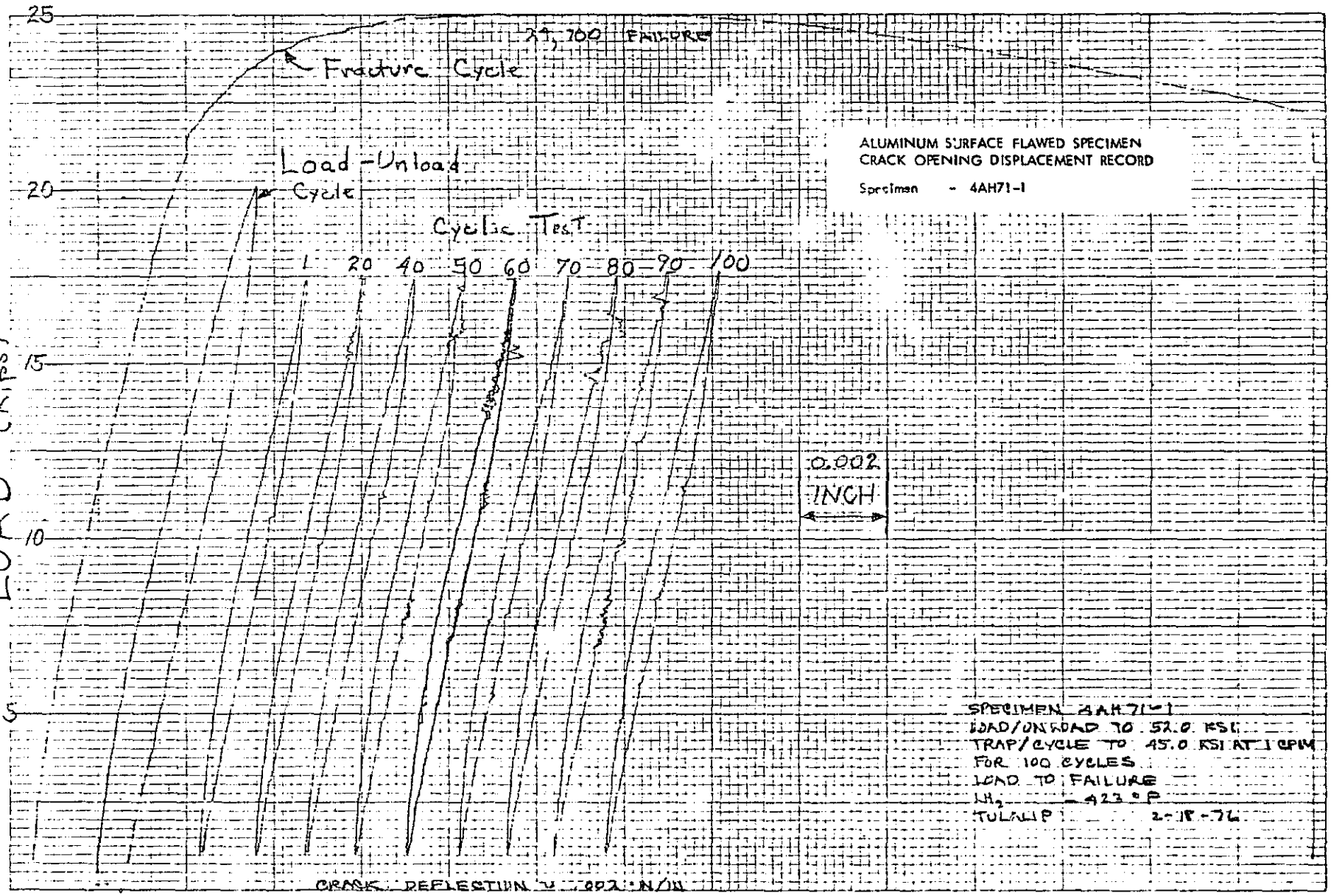
AH 71-4
-23

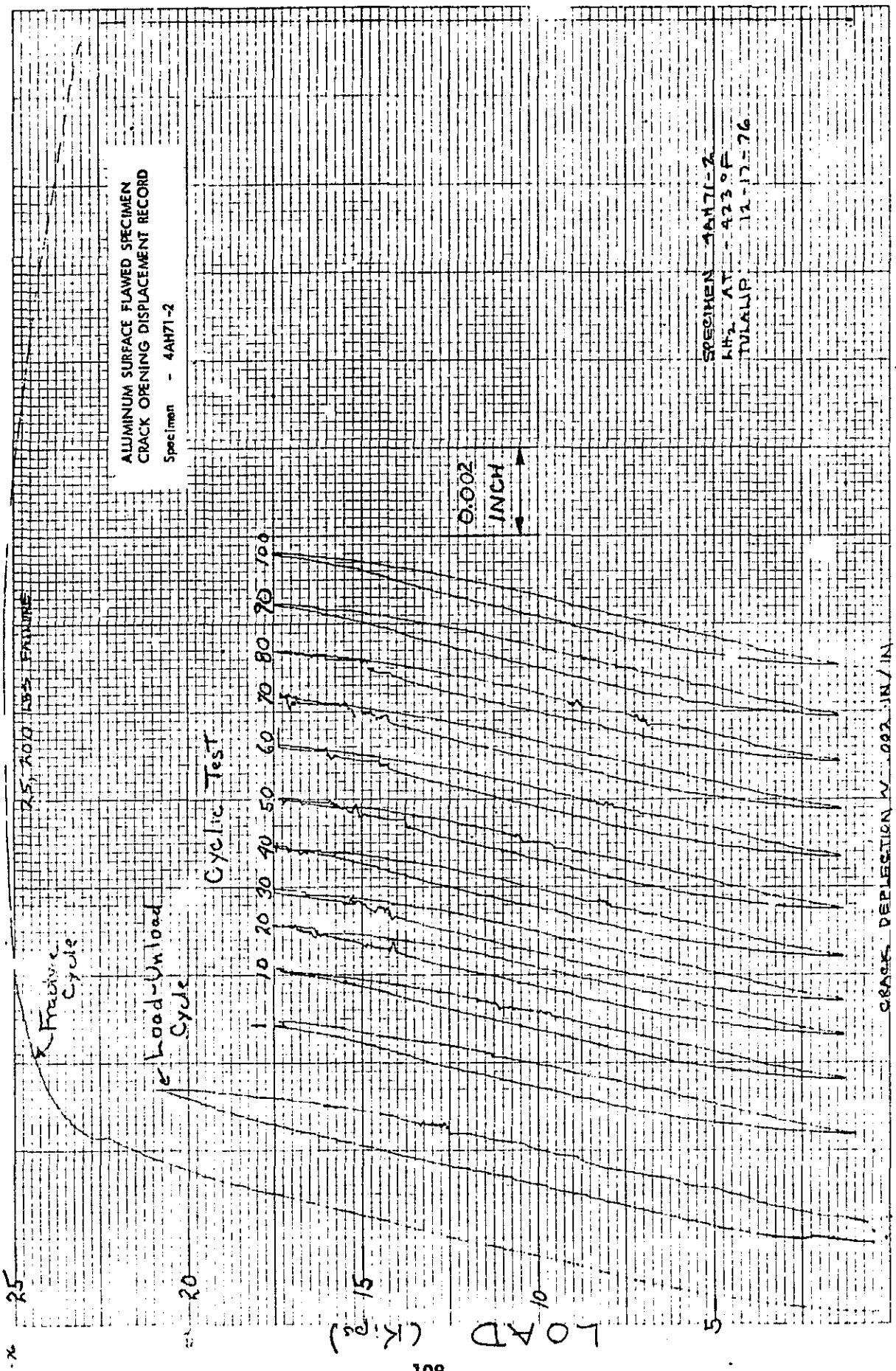

ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2AH71-4
25,150 LBS FAILURE
Fracture Cycle
21,000 LBS
Load-Unload Cycle
0.002 INCH
LOAD (KIPS)
28
24
20
16
12
8
4
SPECIMEN 2AH71-4
LH2 AT -423 °F
2-23-76


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AH71-1
LOAD (Kips)
30
25
20
15
10
5
0.002
INCH
24,950 LBS FAILURE
Fracture
Cycle
SPECIMEN 3AH71-1
NH_2 AT = 423 °F
TULALIP 2-10-76
CRACK DEFLECTION ~ .002 IN/IN


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 3AH71-2
LOAD - (K-PSI)
30
25
20
15
10
5
24,752 LBS FAILURE
Fracture Cycle
0.002 INCH
SPECIMEN 3AH71-2
NT = -423°F
TULALIP TEST SITE 2-11-76
CRACK DEFLECTION ~ .002 IN/IN

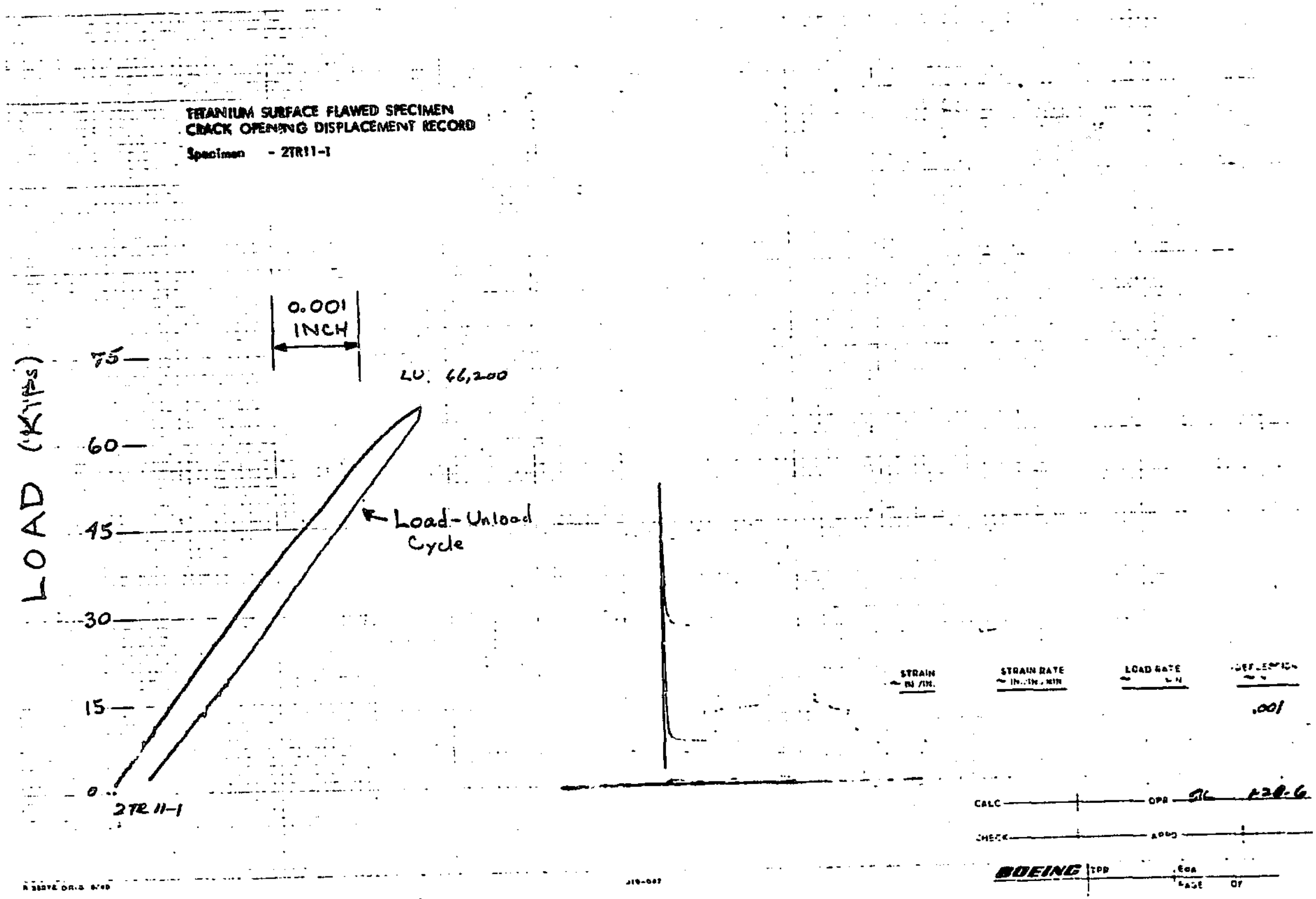

ALUMINUM SURFACE FLAWED ..ECIMEN
CRACK OPENING DISPLACEME.. ECORD
Specimen - 3AH71-3
LOAD (KIPS)
30
25
20
15
10
5
24,600 LBS CRACK BREAKTHRU
Load-Unload Cycle
0.002 INCH
SPECIMEN 3AH 71-3
LOAD TO CRACK BREAKTHRU
LH2 -423°F
TULLAHOMA TEST SITE 2-18-76
CRACK DEFLECTION AT .002 IN/IN


ALUMINUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 4AH71-1
LOAD (KIPS)
25
20
15
10
5
Fracture Cycle
Load-Unload Cycle
Cyclic Test
1 20 40 50 60 70 80 90 100
0.002 INCH
SPECIMEN 4AH71-1
LOAD/UNLOAD TO 52.0 KSI
TRAP/CYCLE TO 45.0 KSI AT 1 CPM
FOR 100 CYCLES
LOAD TO FAILURE
TULALIP 2-18-76



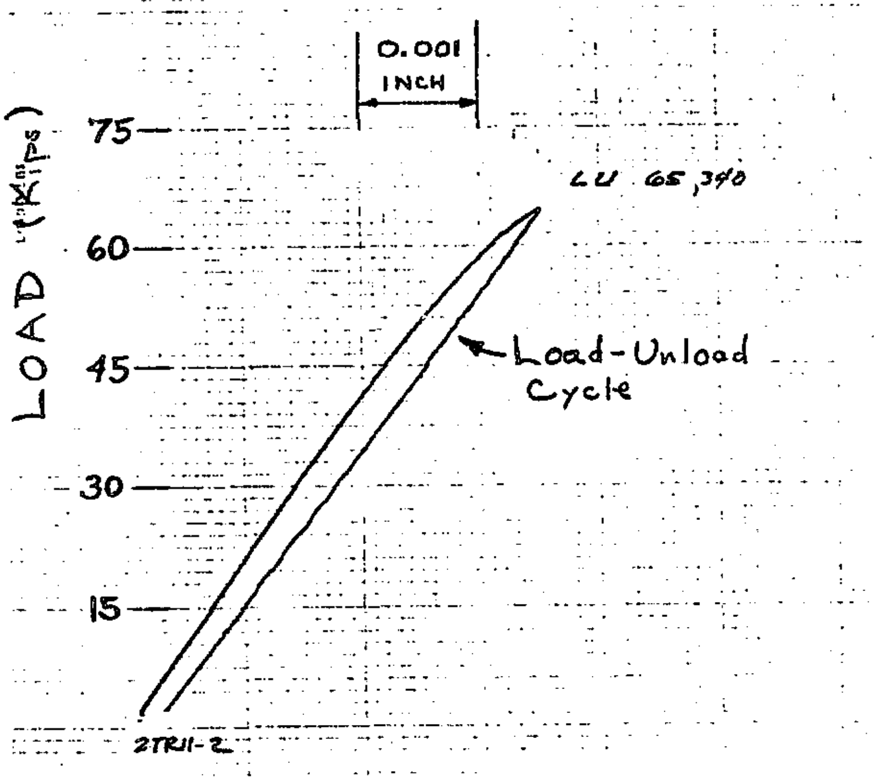
4AH71-2
2-17-76

47 0703



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR11-2

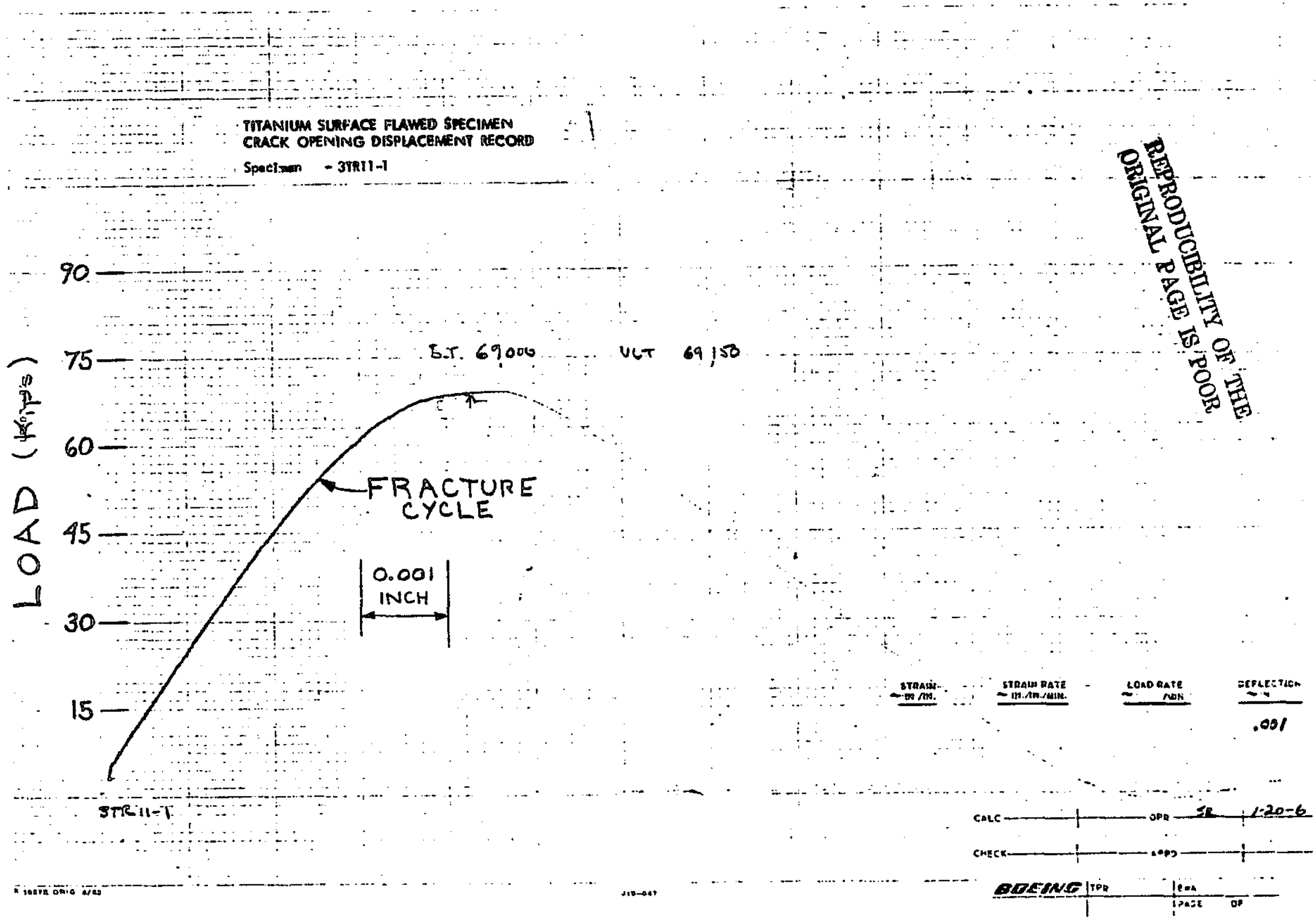


STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN	LOAD RATE ~ /MIN.	DEFLECTION ~ IN.
			.001

CALC ———— OPR ———— 1-29-6

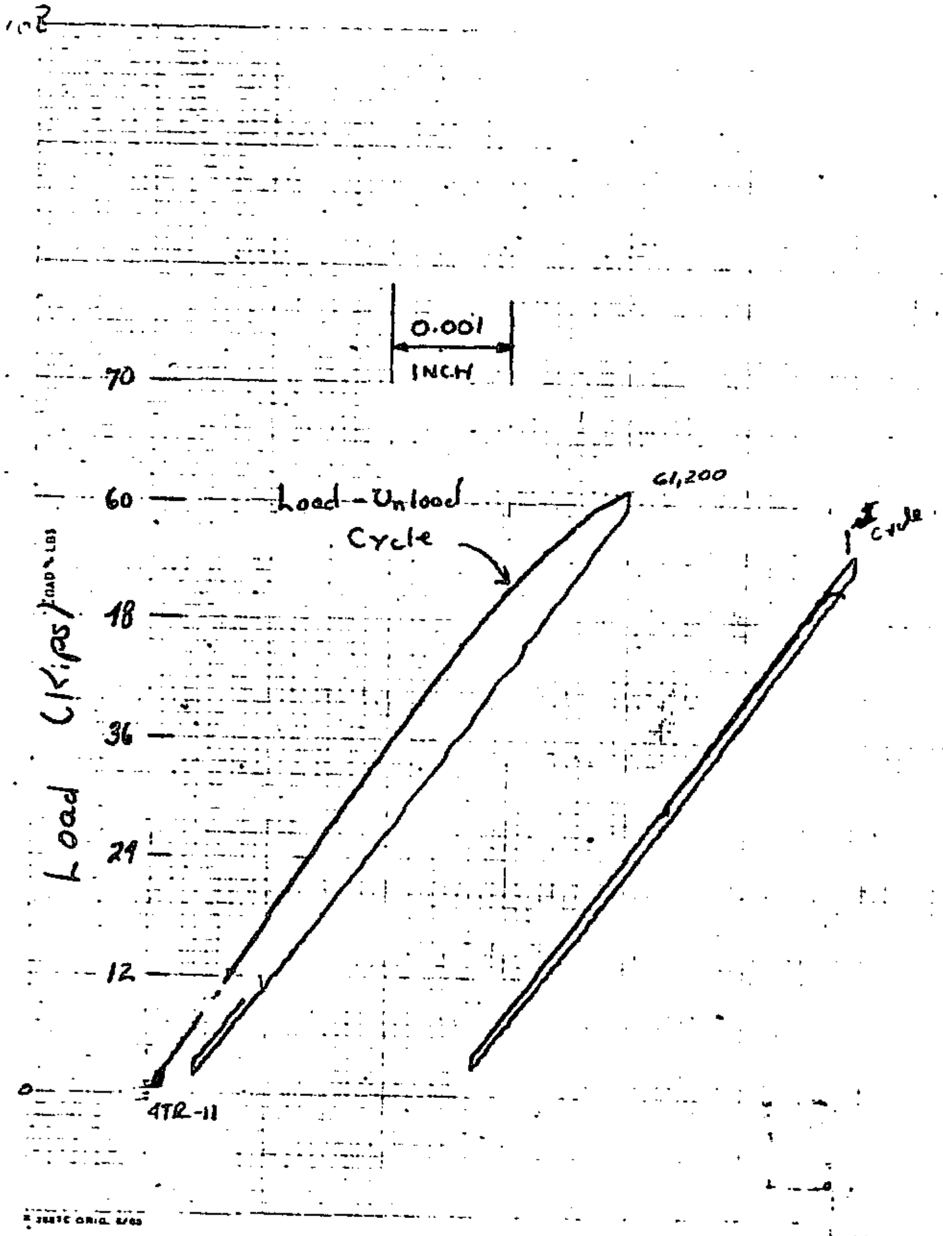
CHECK ———— APPD ————

BOEING | TPR | EWA | PAGE OF



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 4TR11-1



STRAIN IN./IN. | STRAIN RATE IN./IN./MIN | LOAD RATE /MIN | DEFLECTION .001

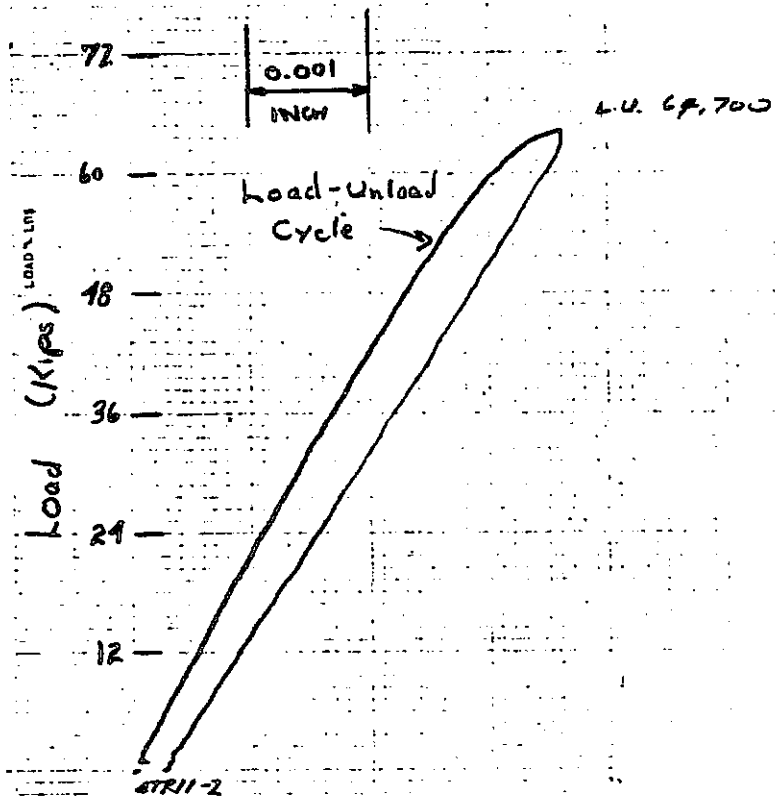
CALC | OPR SR 4-27-6_

CHECK | APPD

BOEING

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 4TR11-2

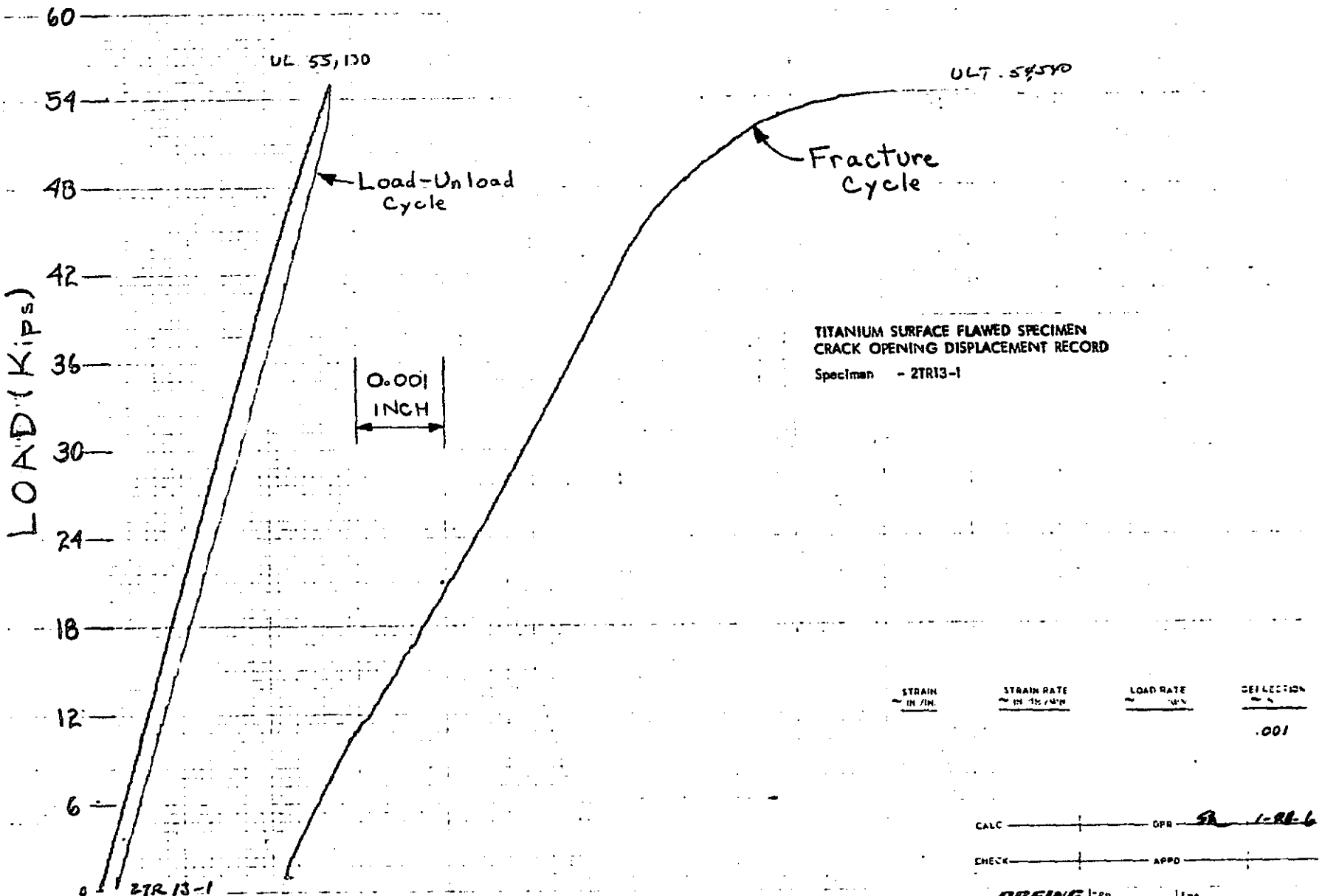


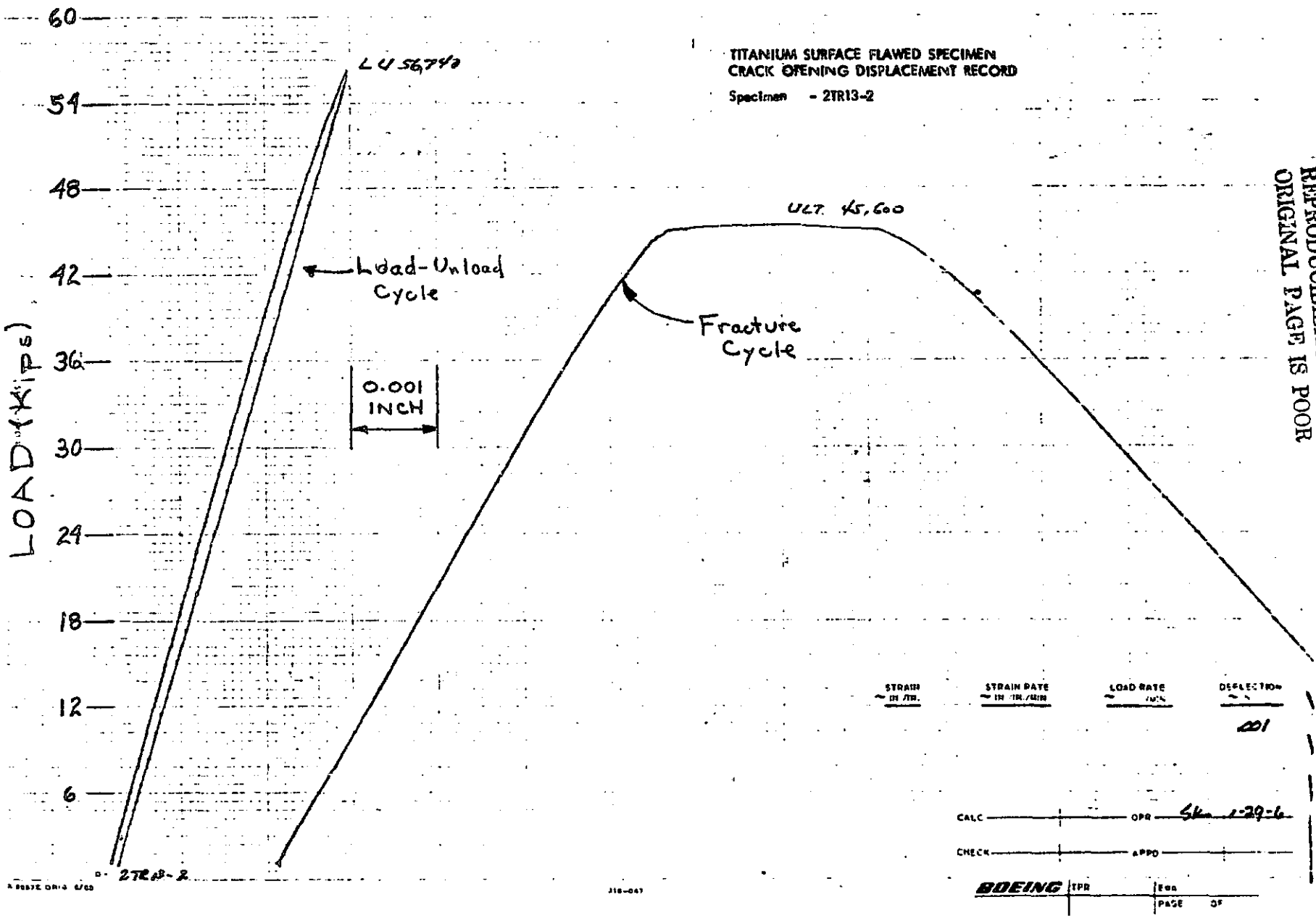
STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
			.001

CALC — OPR — 5-2-66

CHECK — APPD —

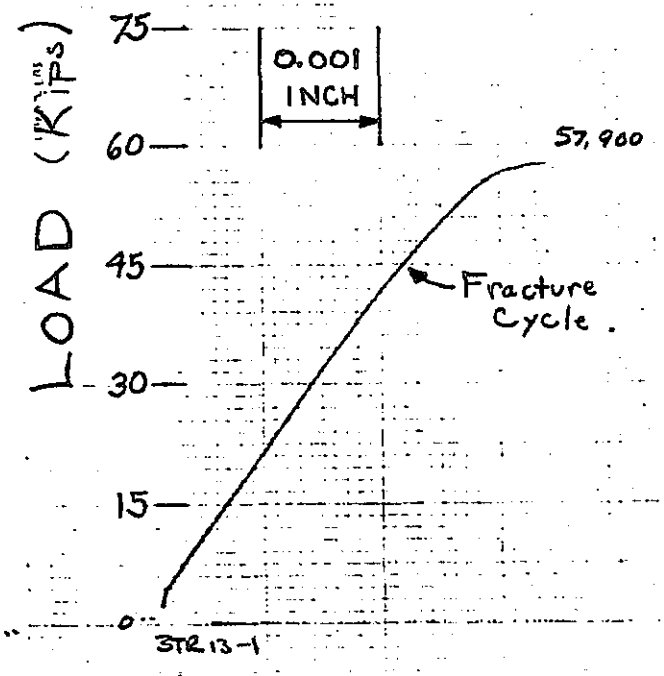
BOEING | IPR | EQA | PAGE | OF





TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3TR13-1



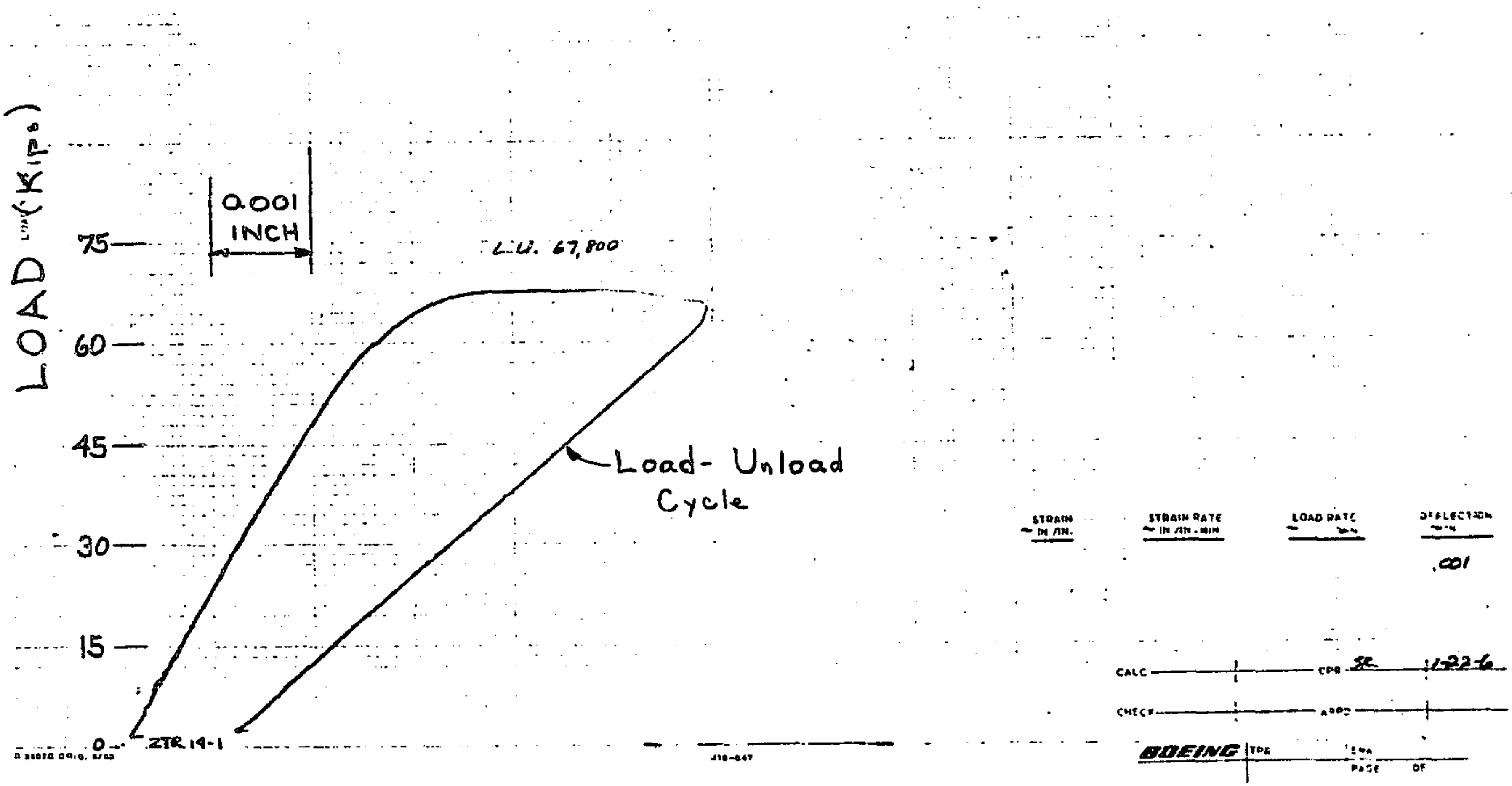
STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
			.001

CALC — OPR 1-20-6

CHECK — APPD

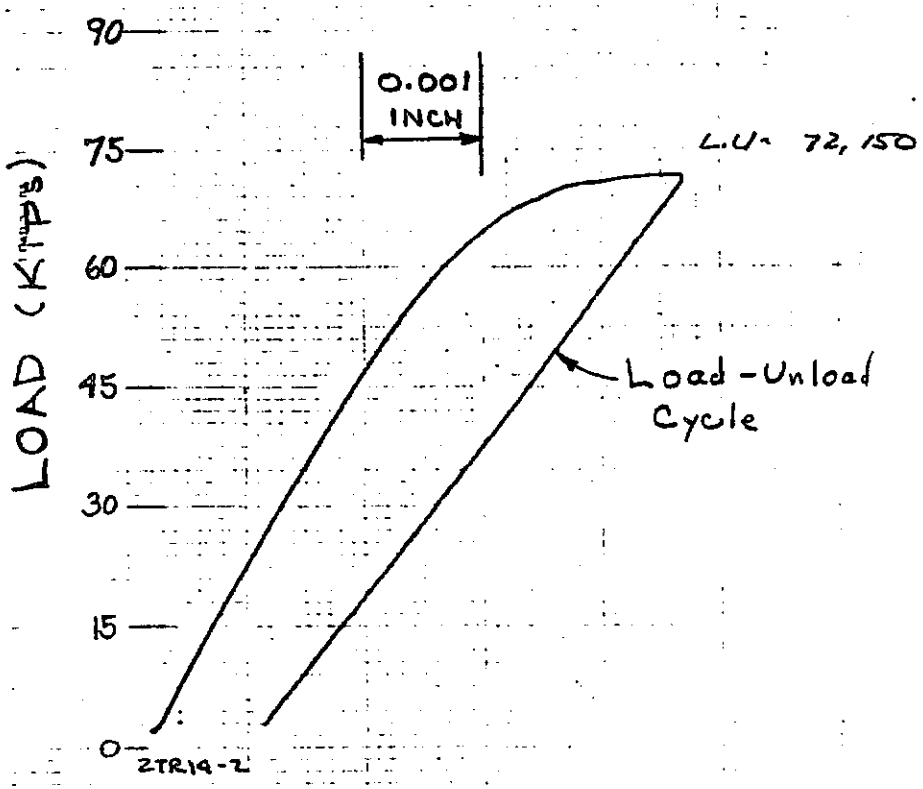
BOEING

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen -2TR14-1



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR14-2



STRAIN IN/IN.	STRAIN RATE IN/IN/MIN	LOAD RATE /MIN	DEFLECTION
			.001

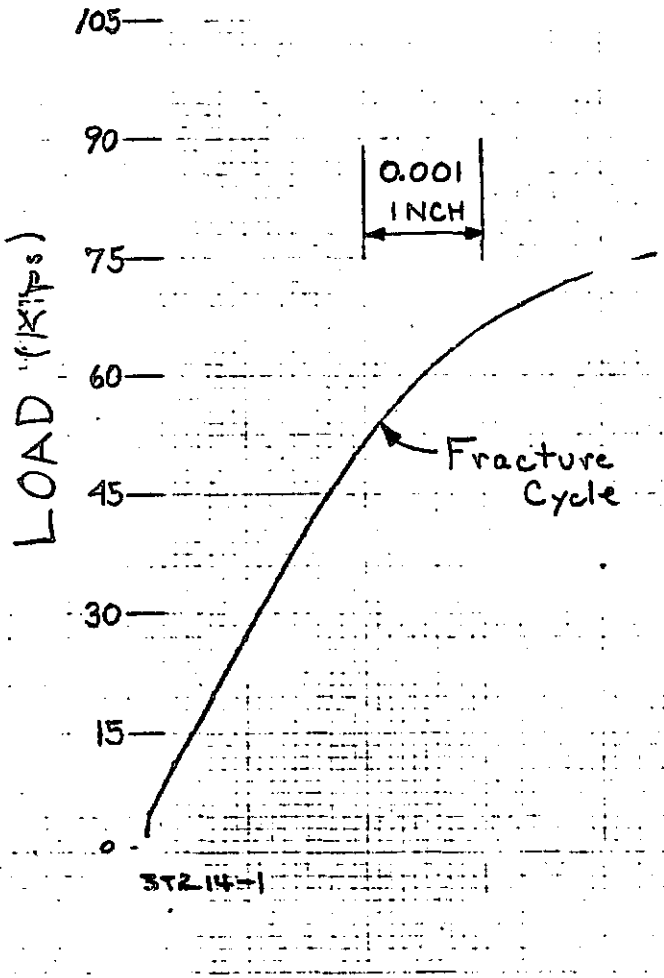
CALC _____ OPR SR 1-30-6

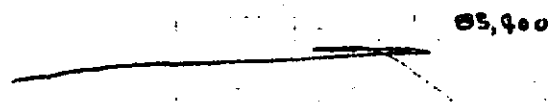
CHECK _____ APPD _____

BOEING TPD EWA BASE DP

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3TR14-1





STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
			.001

CALC ——— DPD 5k 11-30-6

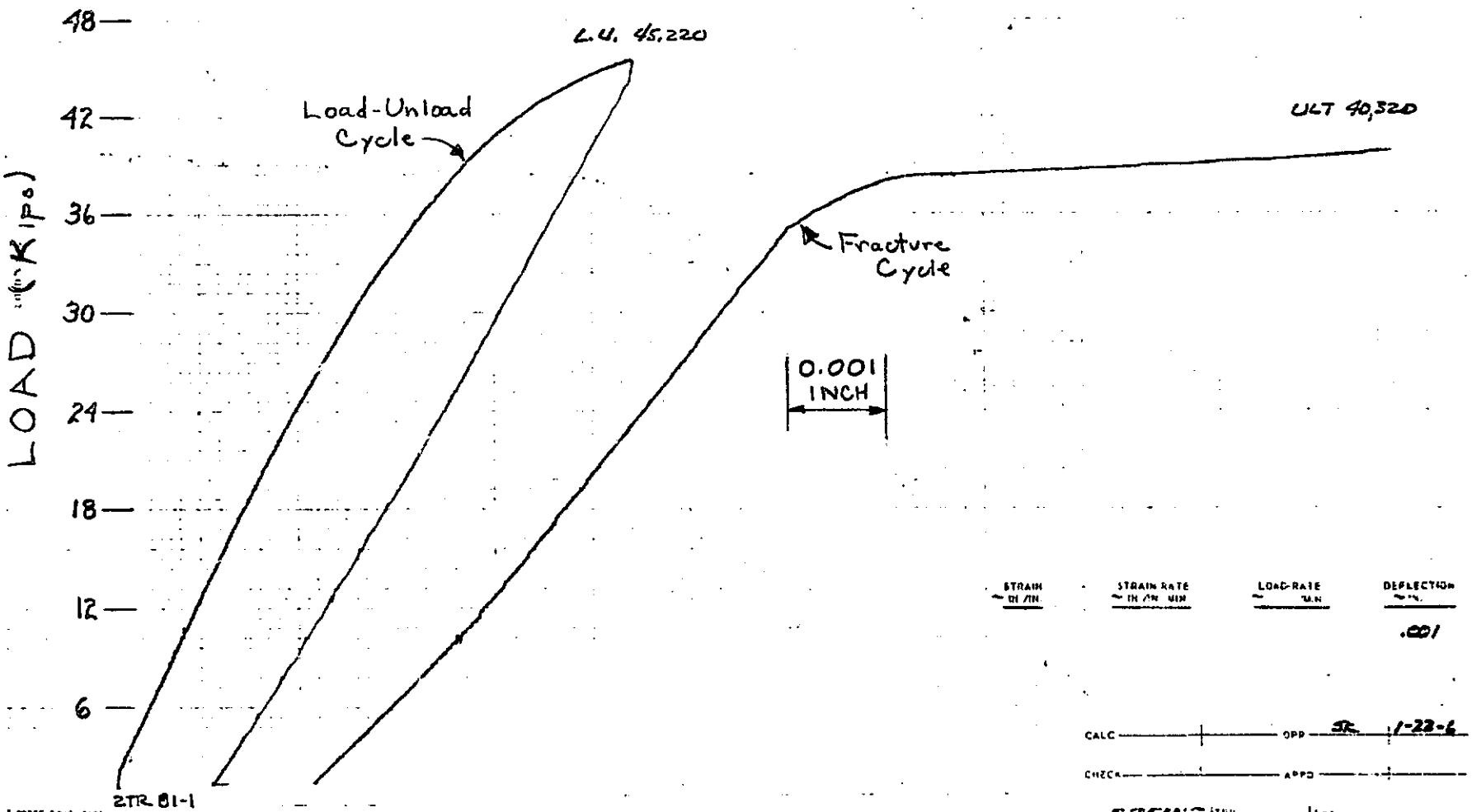
CHECK ——— APPD

BOEING TPR TDA

PAGE OF

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR81-1



STRAIN	STRAIN RATE	LOAD RATE	DEFLECTION
			.001

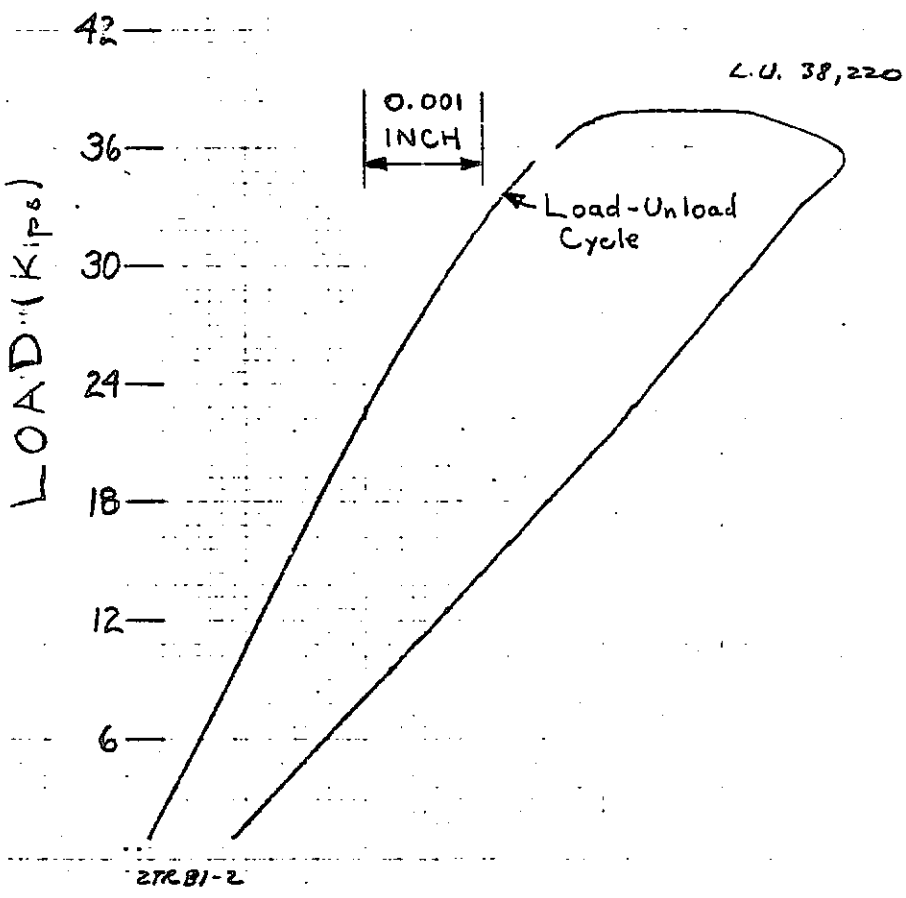
CALC ____ OPP ____ 1-22-6

CHECK ____ APPD ____

BOEING TPD ____ PAGE ____ OF ____

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen -- 2TR81-2



STRAIN ~ IN /IN	STRAIN RATE ~ IN /IN /MIN	LOAD RATE ~ /MIN	DEFLECTION ~ "
			.001

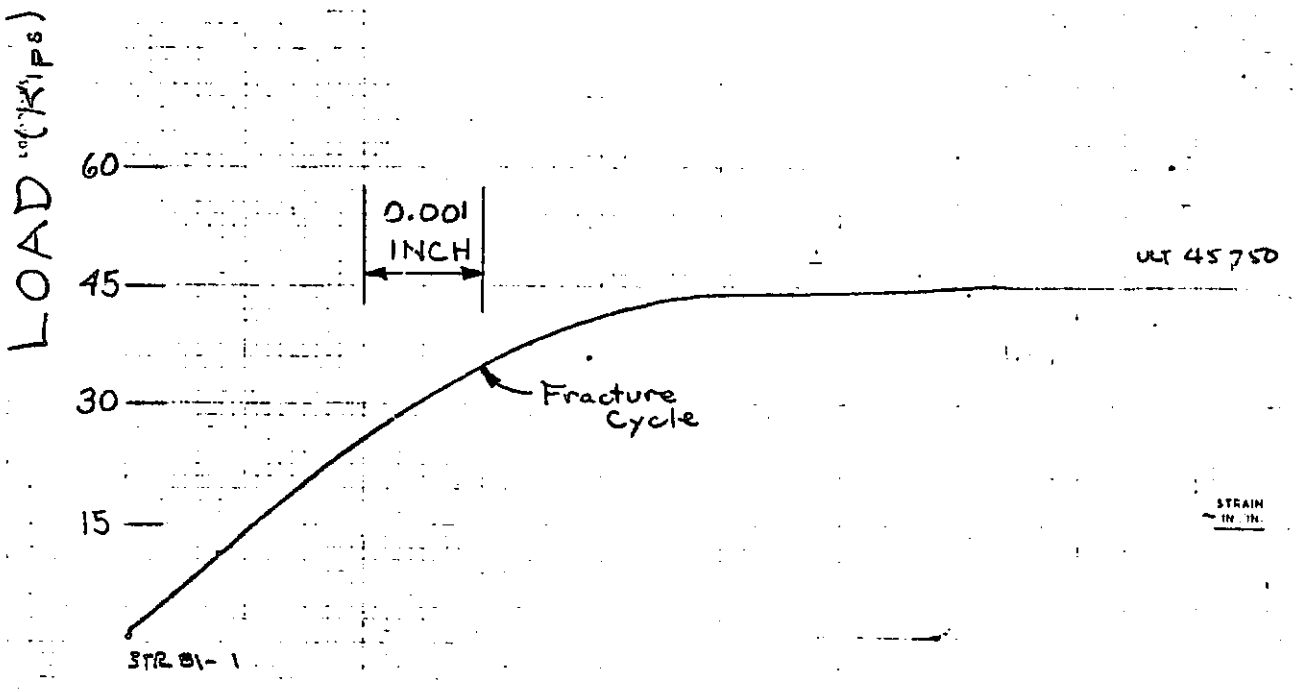
CALC _____ DSR SJL 1-30-6

MECH _____ APPD _____

BOEING ITPR _____ Exh _____ PAGE _____ OF _____

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 3TRB1-1

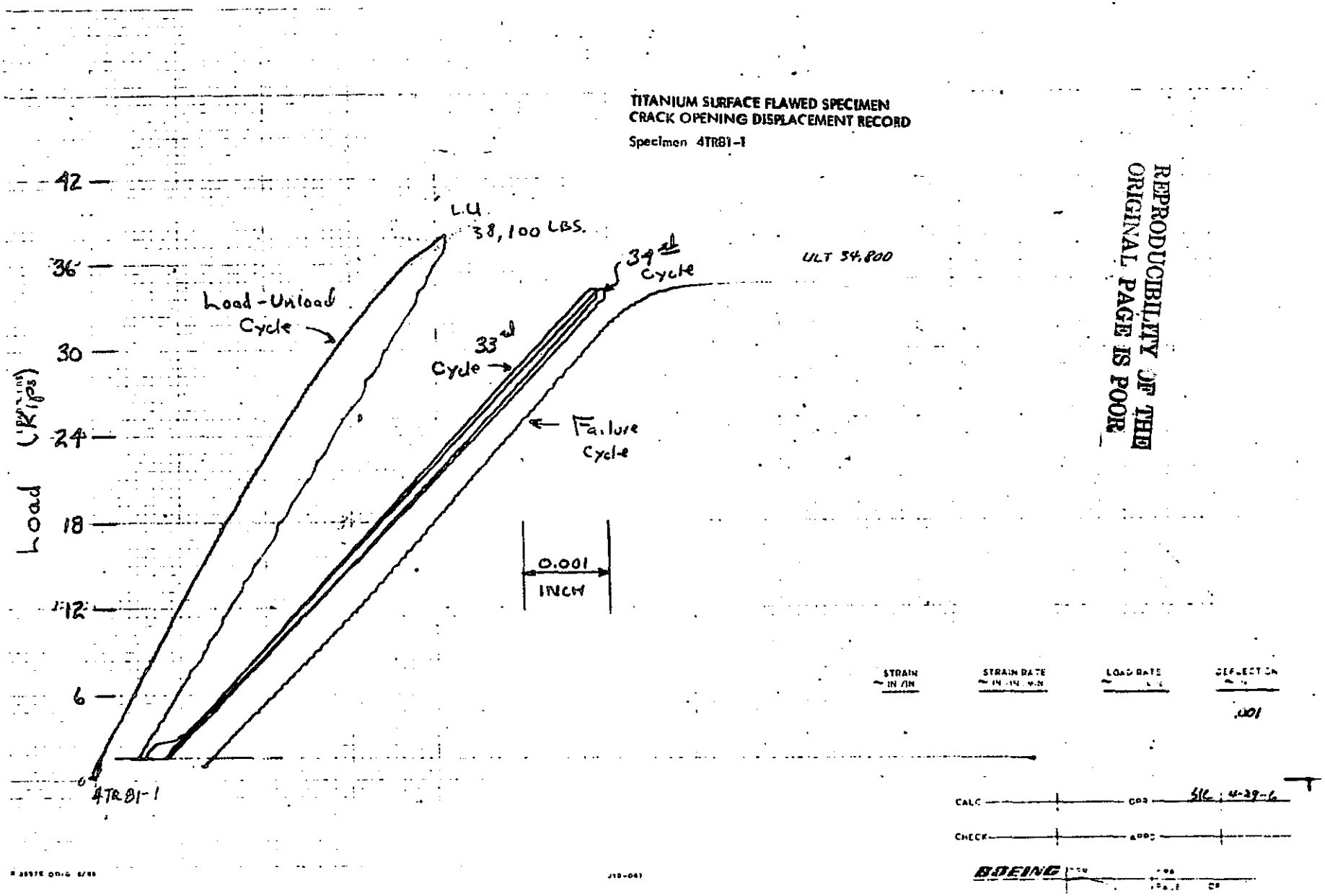


STRAIN IN/IN	STRAIN RATE IN/IN/MIN	LOAD RATE KIPS/MIN	DEFLECTION IN
			.001

CALC _____ APPR SK 1-20-6

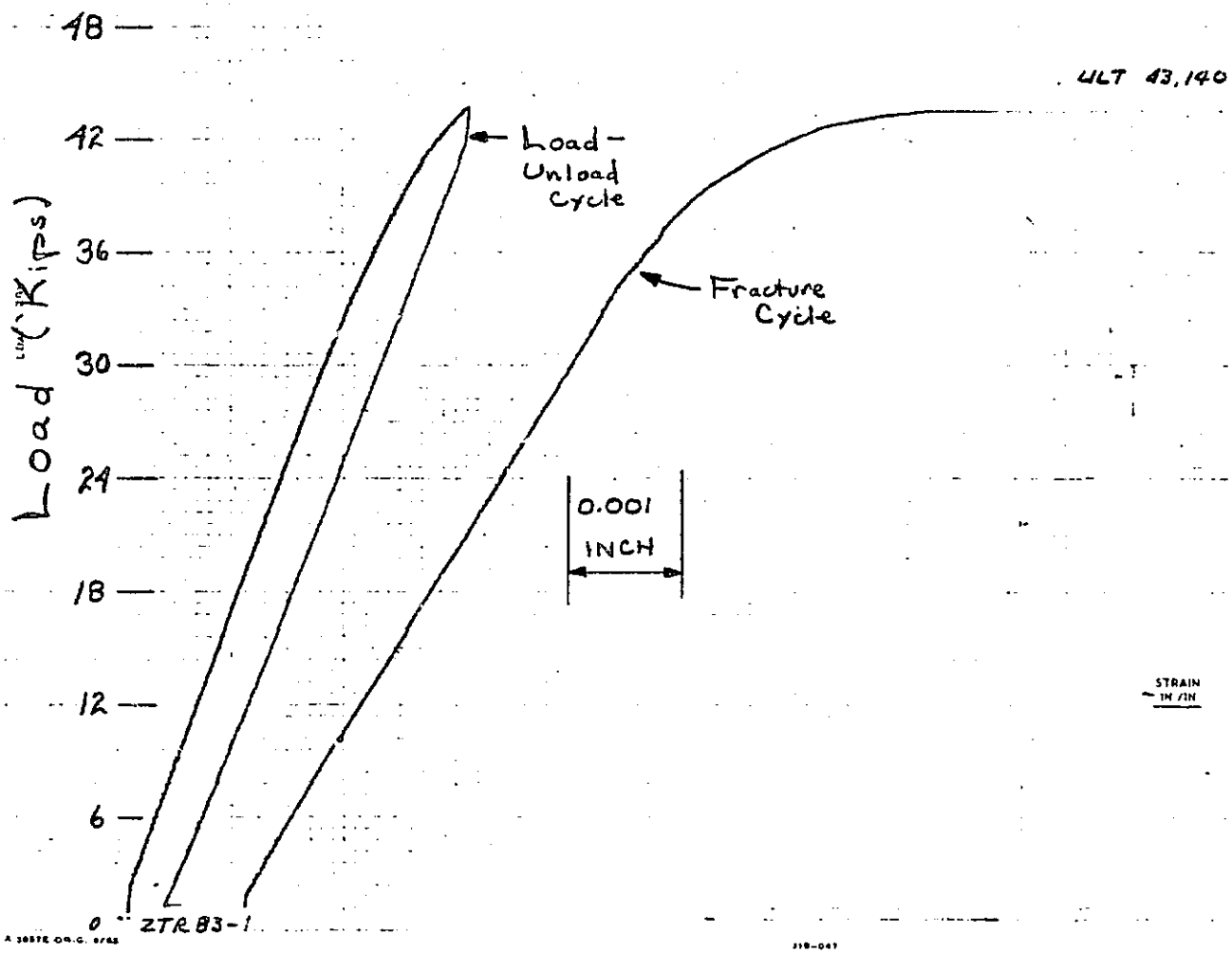
CHECK _____ APPD _____

BOEING APPR _____ DATE _____ SHEET _____ OF _____


TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 4TRB1-1
REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
Load (Kips)
42
36
30
24
18
12
6
0
L.U.
38,100 LBS.
34th Cycle
ULT 34,800
Load-Unload Cycle
33rd Cycle
Failure Cycle
0.001 INCH
4TRB1-1
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
CHECK
BOEING

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR83-1



STRAIN ~ IN/IN	STRAIN RATE ~ IN/IN/MIN	LOAD RATE ~ /MIN	DEFLECTION ~ IN
			.001

CALC ——— CPE ——— 2-22-6

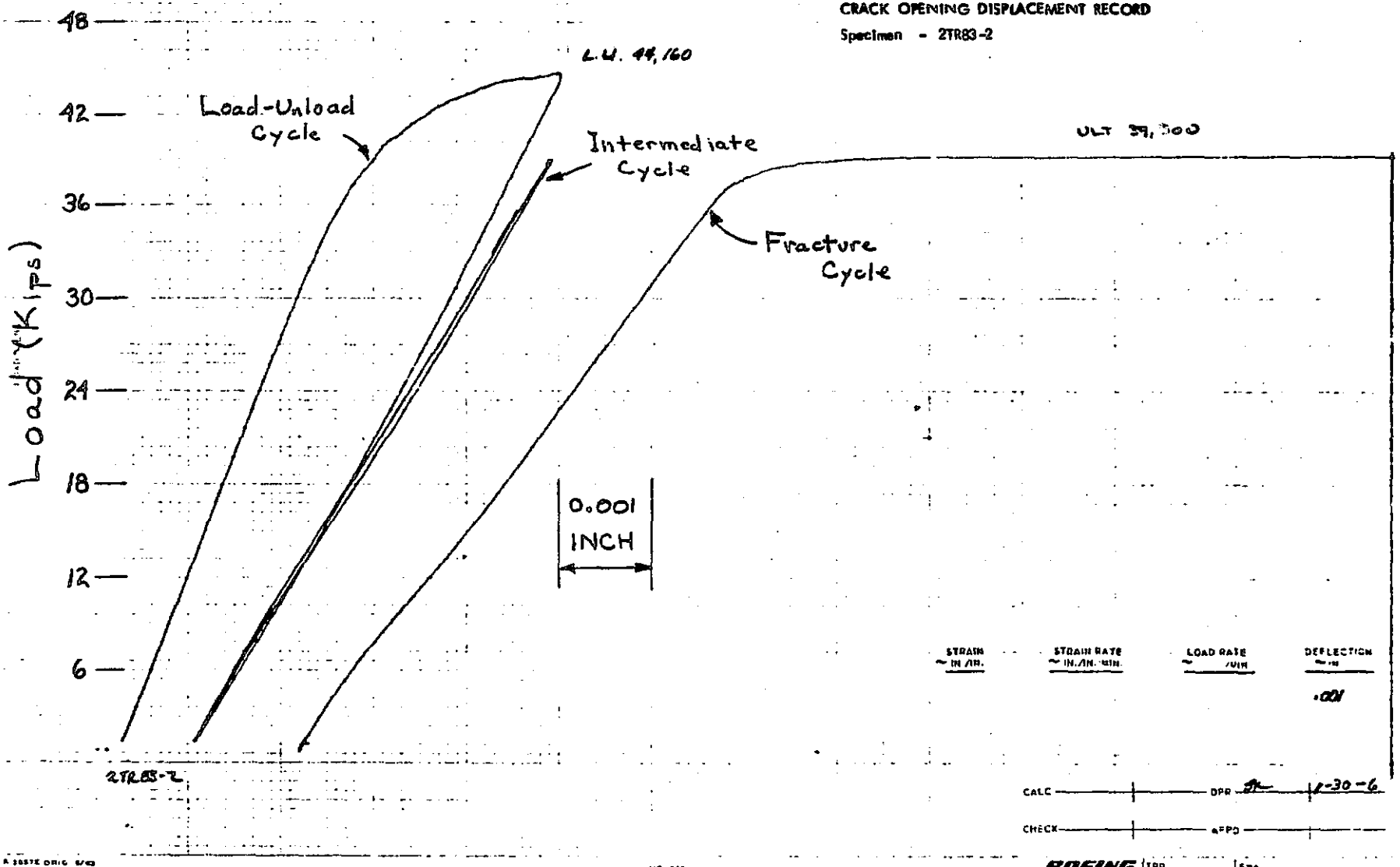
CHECK ——— APPD ———

BOEING TPR ——— E##

PAGE ——— OF

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen - 2TR83-2



STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN.	LOAD RATE ~ /MIN	DEFLECTION
			.001

CALC ——— DPR ——— 6-30-6

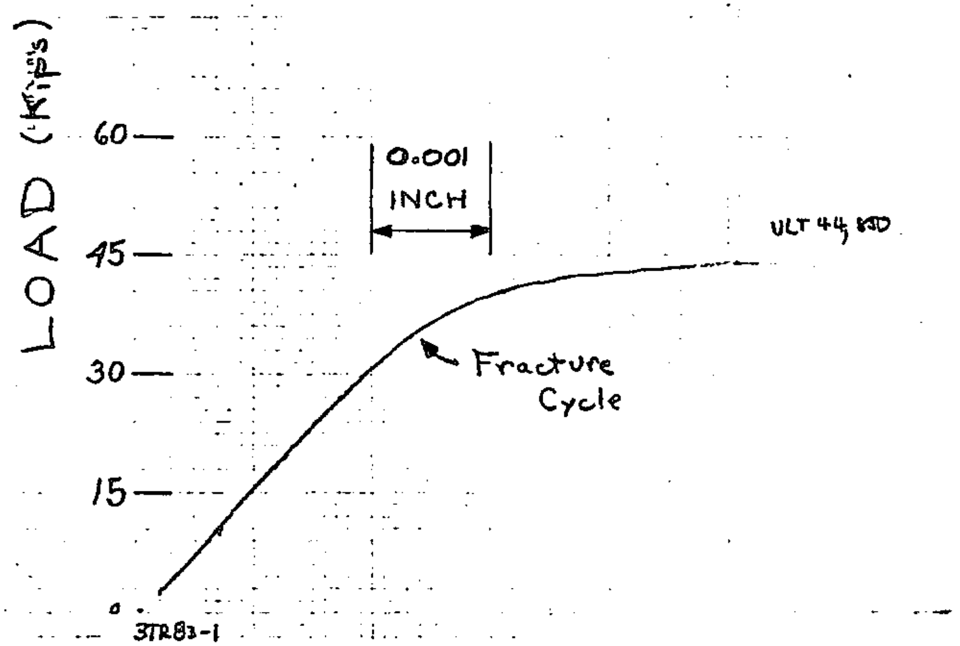
CHECK ——— APPD ———

BOEING | TPR | EDA

PAGE OF

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

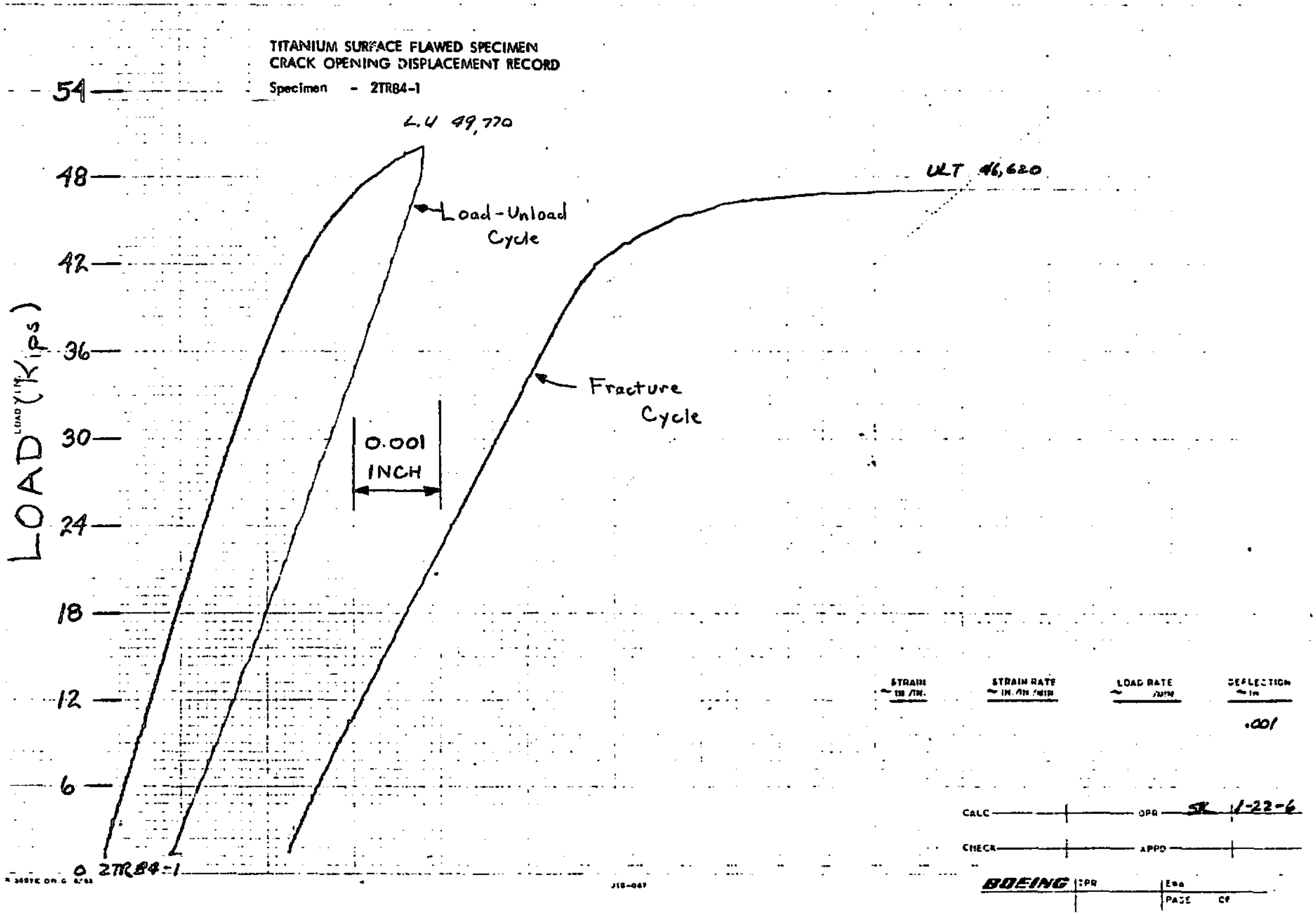
Specimen - 3TR83-1

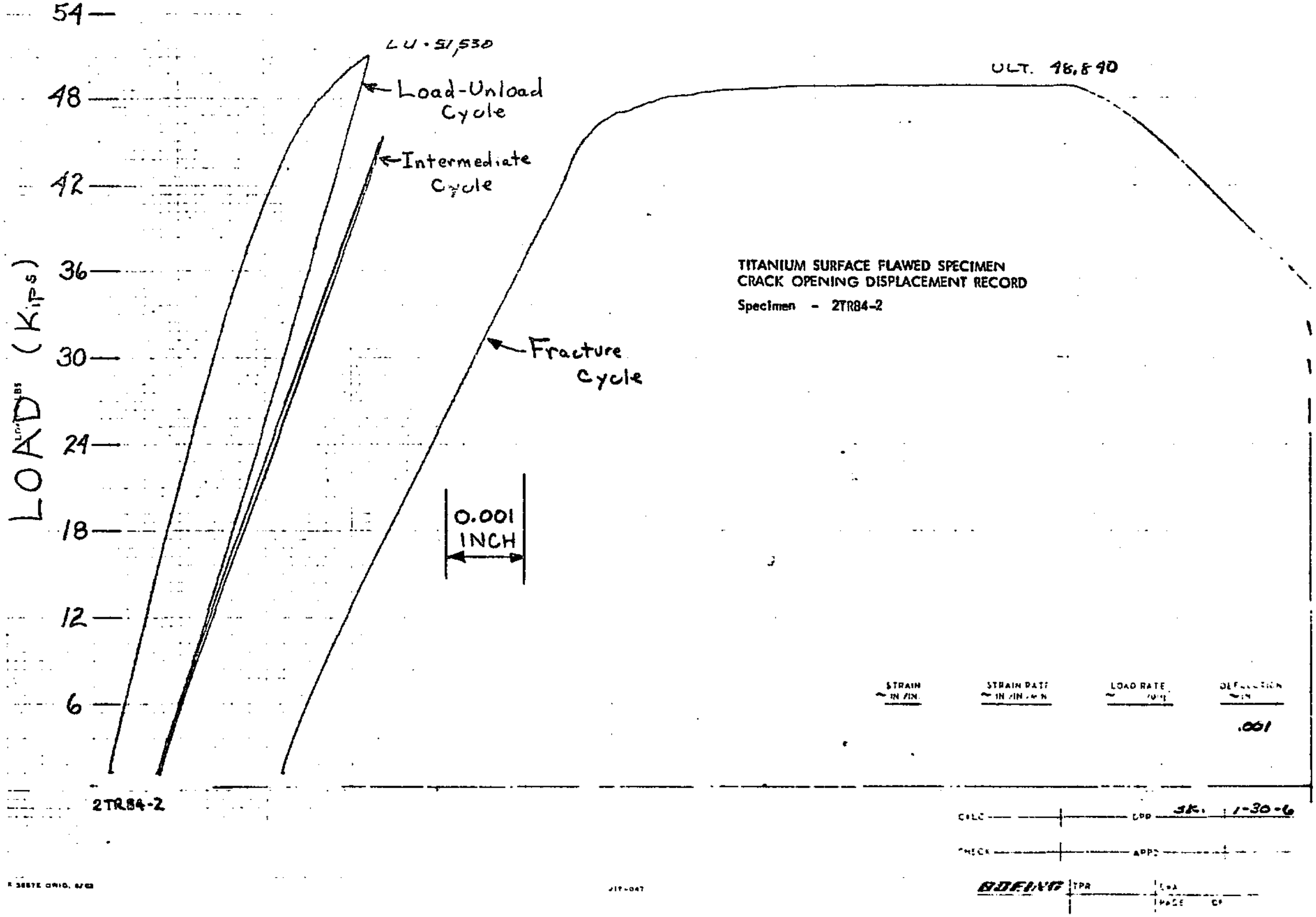


STRAIN ~ IN/IN	STRAIN RATE ~ IN/IN/MIN	LOAD RATE	DEFLECTION
			.001

CALC — OPR
CHECK — APPD

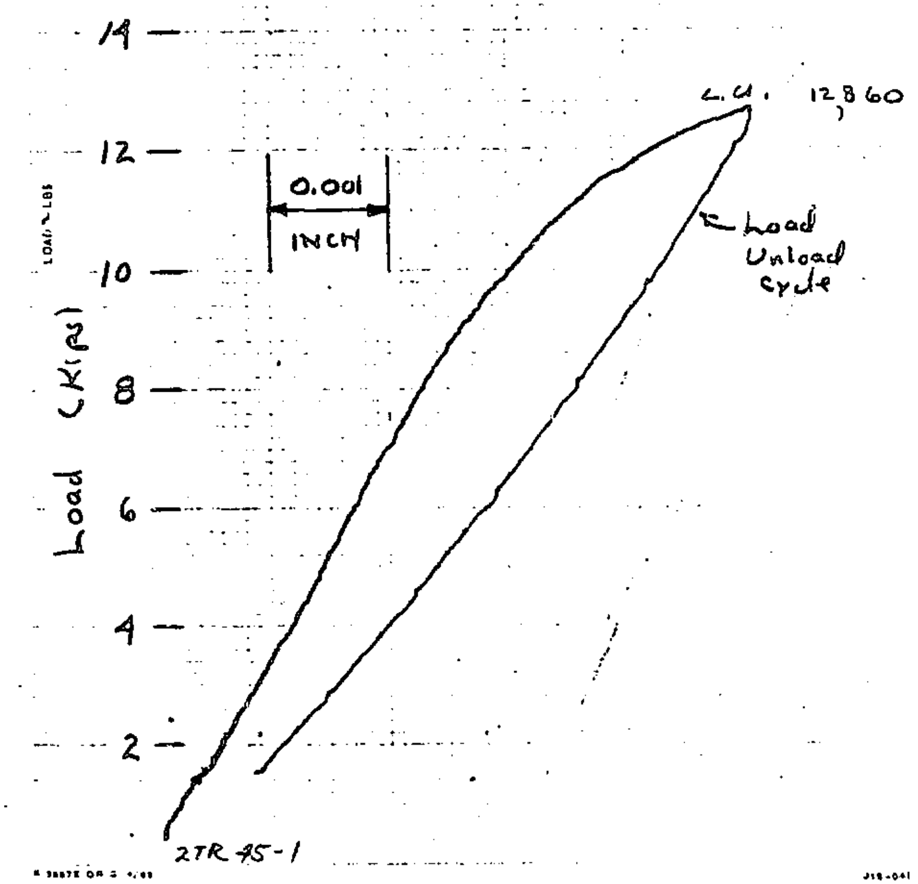
BOEING


TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2TR84-1
L.U 49,770
ULT 46,620
Load-Unload Cycle
Fracture Cycle
0.001 INCH
LOAD (Kips)
54
48
42
36
30
24
18
12
6
0
2TR84-1
STRAIN
STRAIN RATE
LOAD RATE
DEFLECTION
.001
CALC
OPR
1-22-6
CHECK
APPD
BOEING
PAGE


TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen - 2TR84-2
LOAD (Kips)
54
48
42
36
30
24
18
12
6
LU • 51,530
Load-Unload Cycle
Intermediate Cycle
Fracture Cycle
ULT. 48,840
0.001 INCH
2TR84-2
.001
BOEING

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2TR45-1



STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN	LOAD RATE ~ /MIN	DEFLECTION ~ IN
			.001

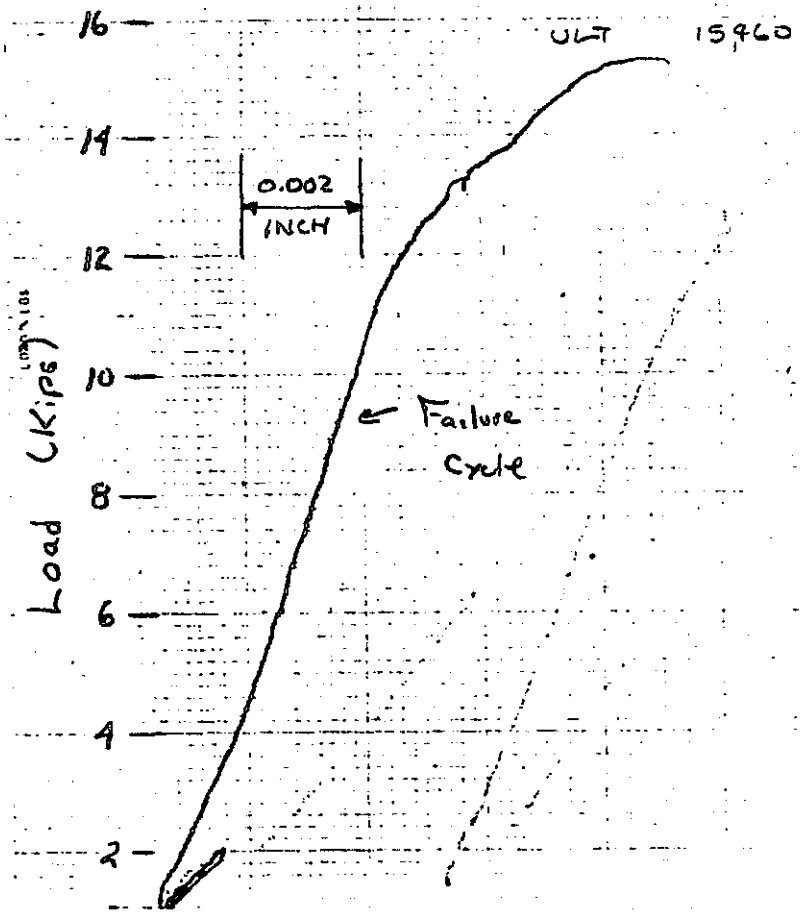
CALC ——— OPR JK 5-4-6

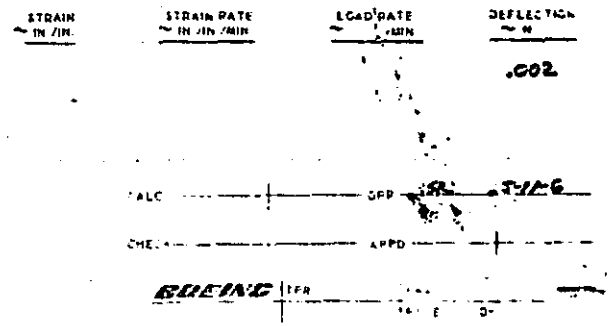
CHECK ——— APPD

BOEING TYPE Exh PART OF

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

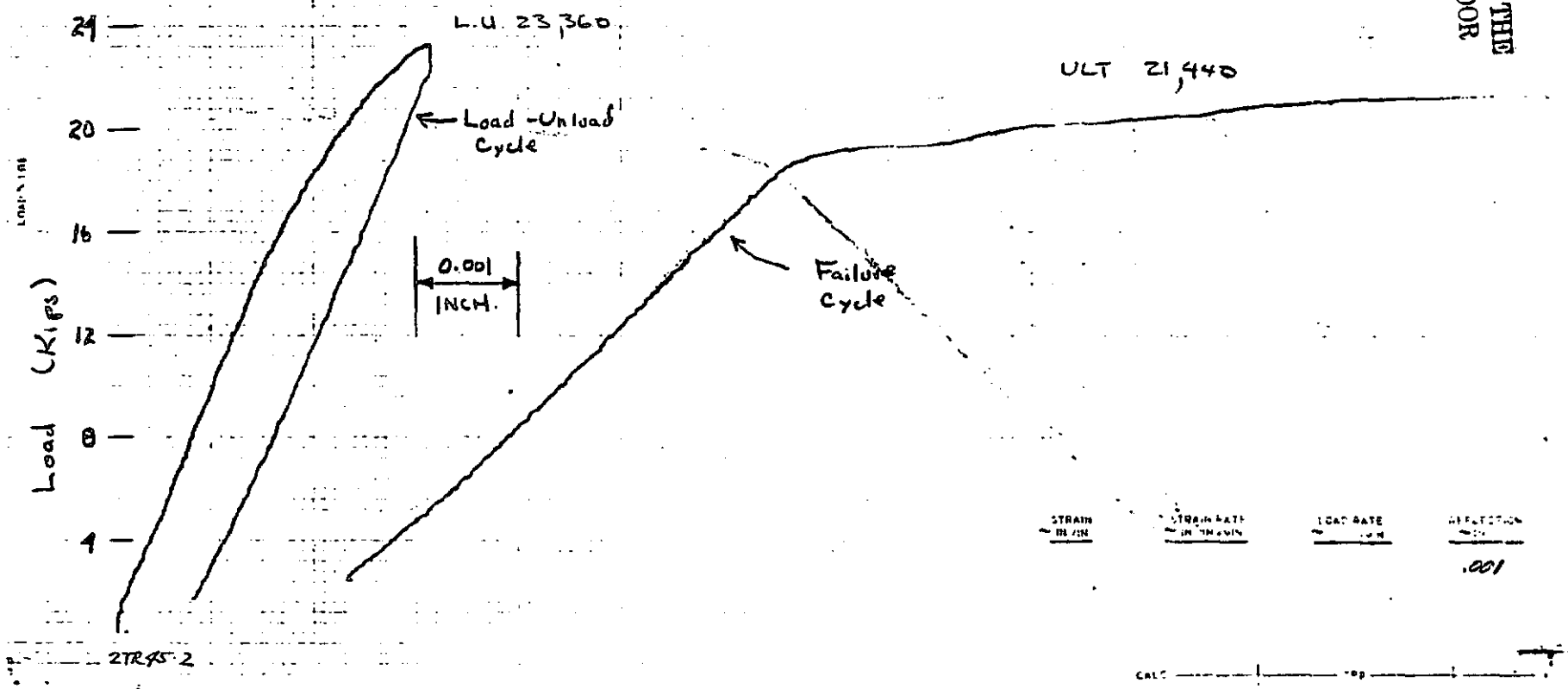
Specimen 2TR45-1

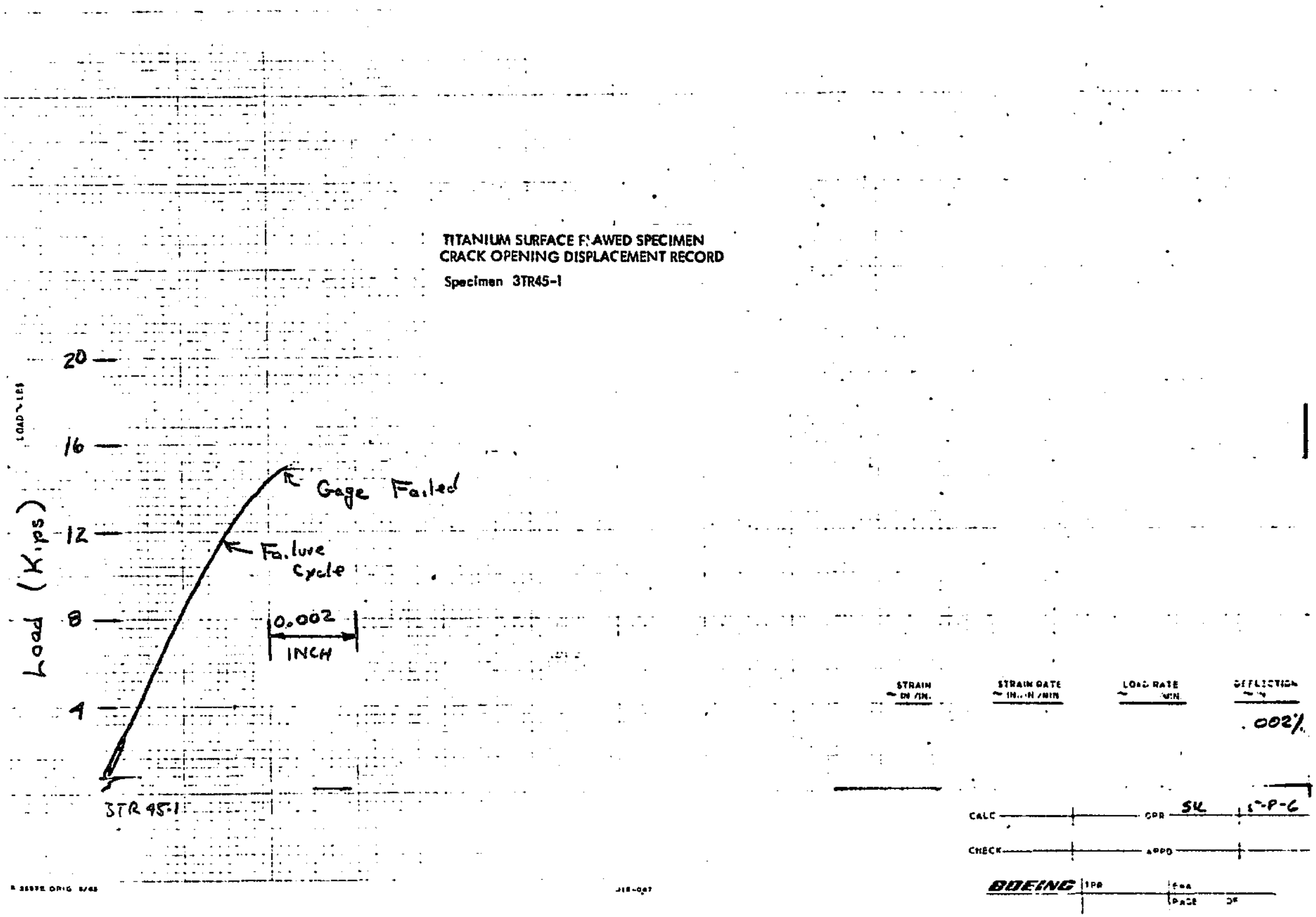


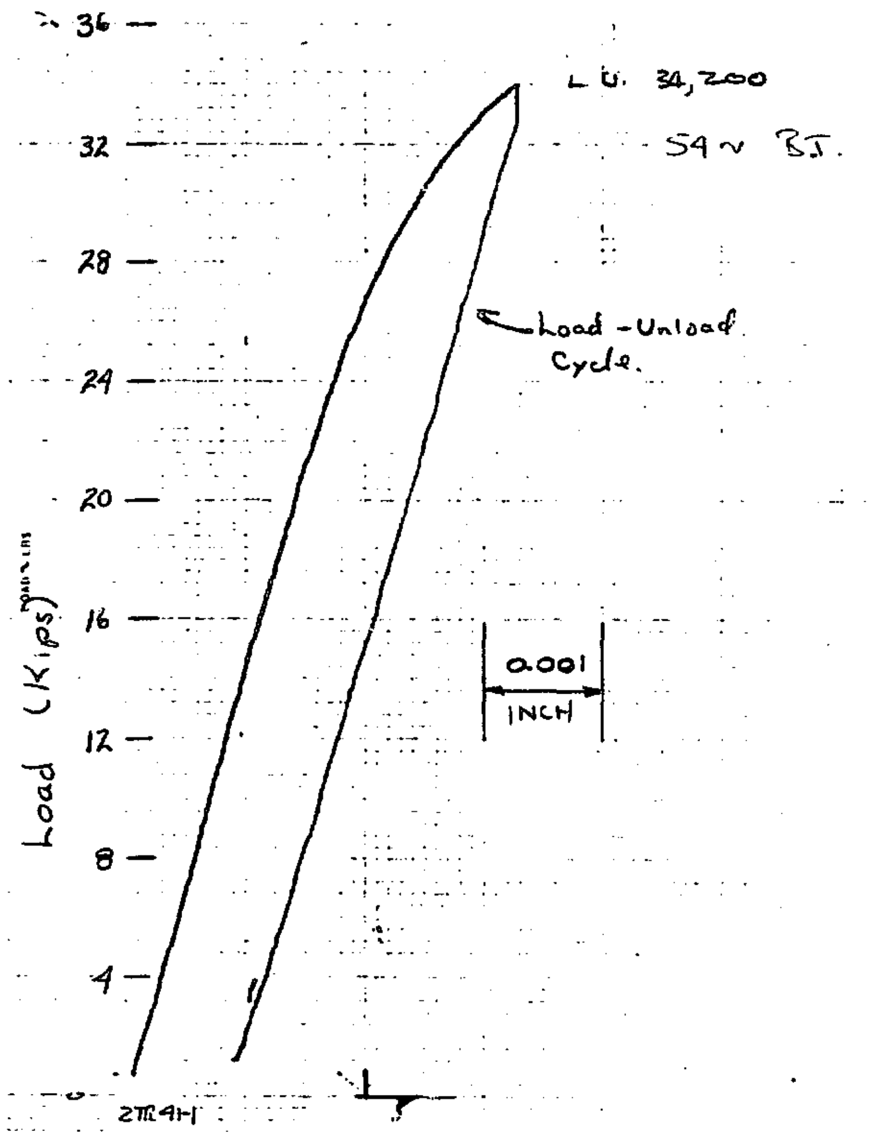


TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2TR45-2




TITANIUM SURFACE F.AWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 3TR45-1
Load (Kips)
20
16
12
8
4
Gage Failed
Failure Cycle
0.002 INCH
3TR 45-1
STRAIN ~ IN/IN.
STRAIN RATE ~ IN./IN./MIN
LOAD RATE ~ /MIN
DEFLECTION ~ IN
.002%
CALC
CHECK
OPR SK
APPD
BOEING



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

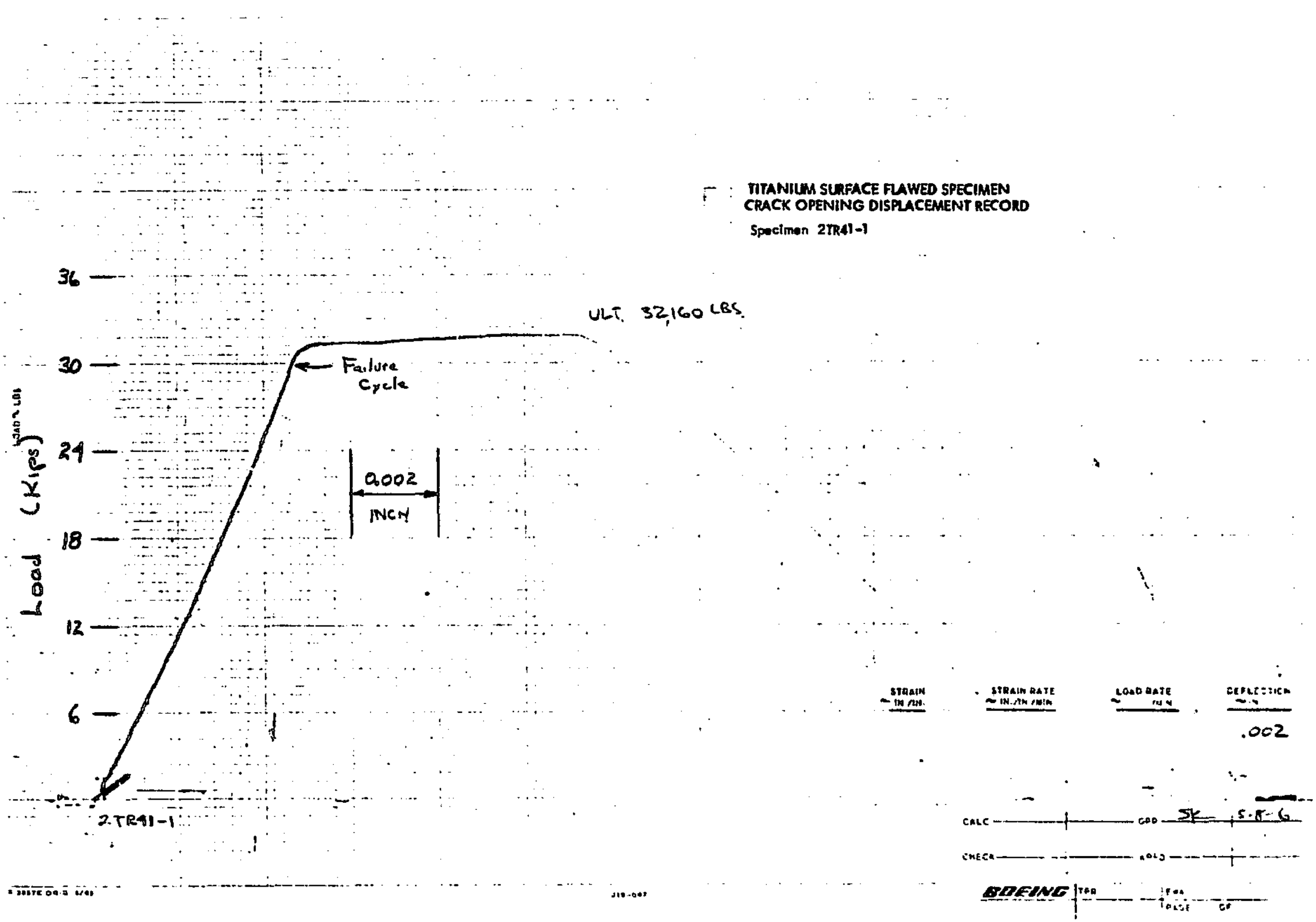
Specimen 2TR41-1

STRAIN ~ IN/IN	STRAIN RATE ~ IN/IN/MIN	LOAD RATE ~ /MIN	DEFLECTION ~
			.001

CALC — CHECK — APPD — SJC 5-8-60

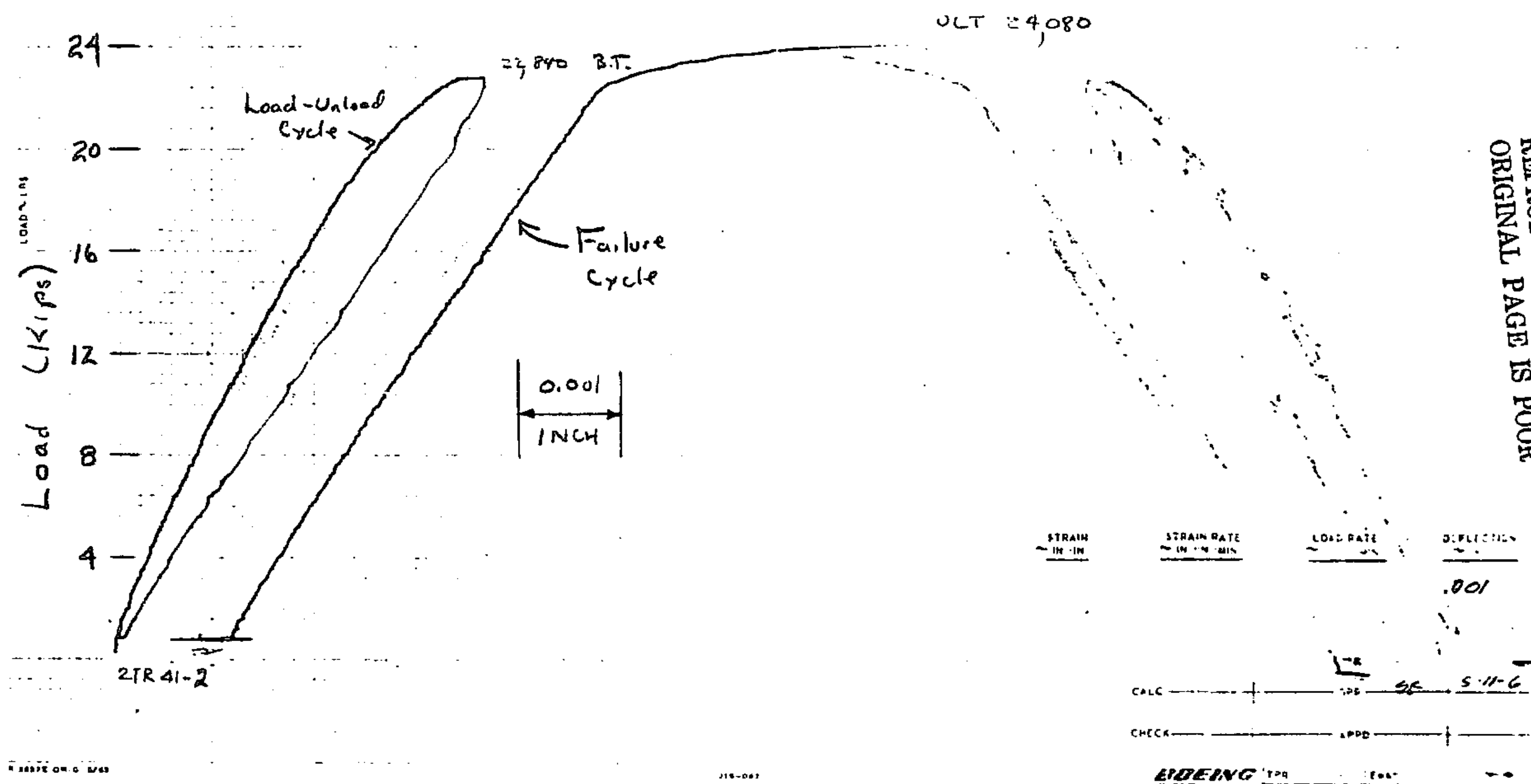
BOEING

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD
Specimen 2TR41-1



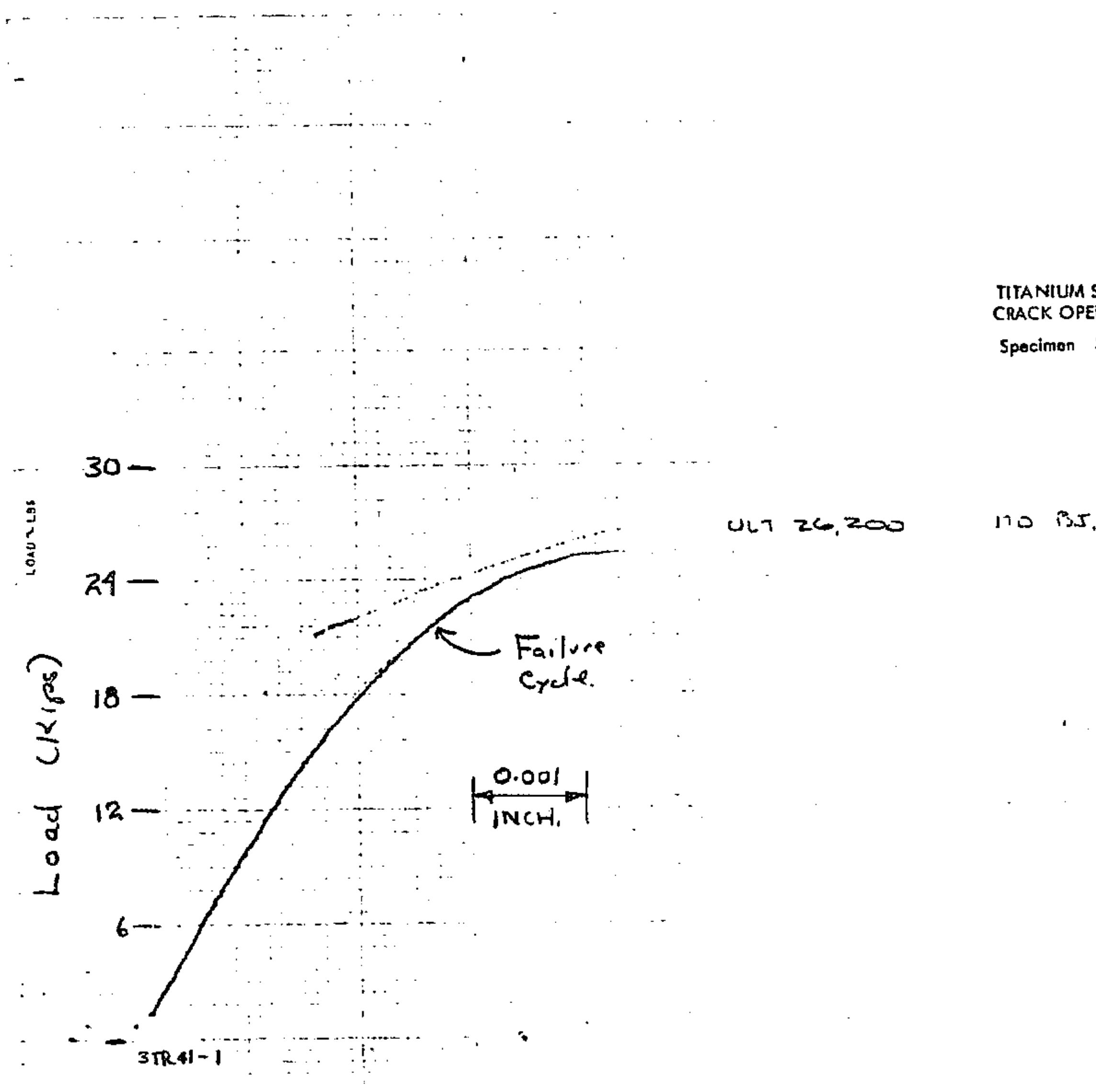
TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2TR41-2



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 3TR41-1



STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN	LOAD RATE ~	DEFLECTION ~
			.001

CALC ———— GFE SK 5-2

CHECK ———— APPD

BOEING

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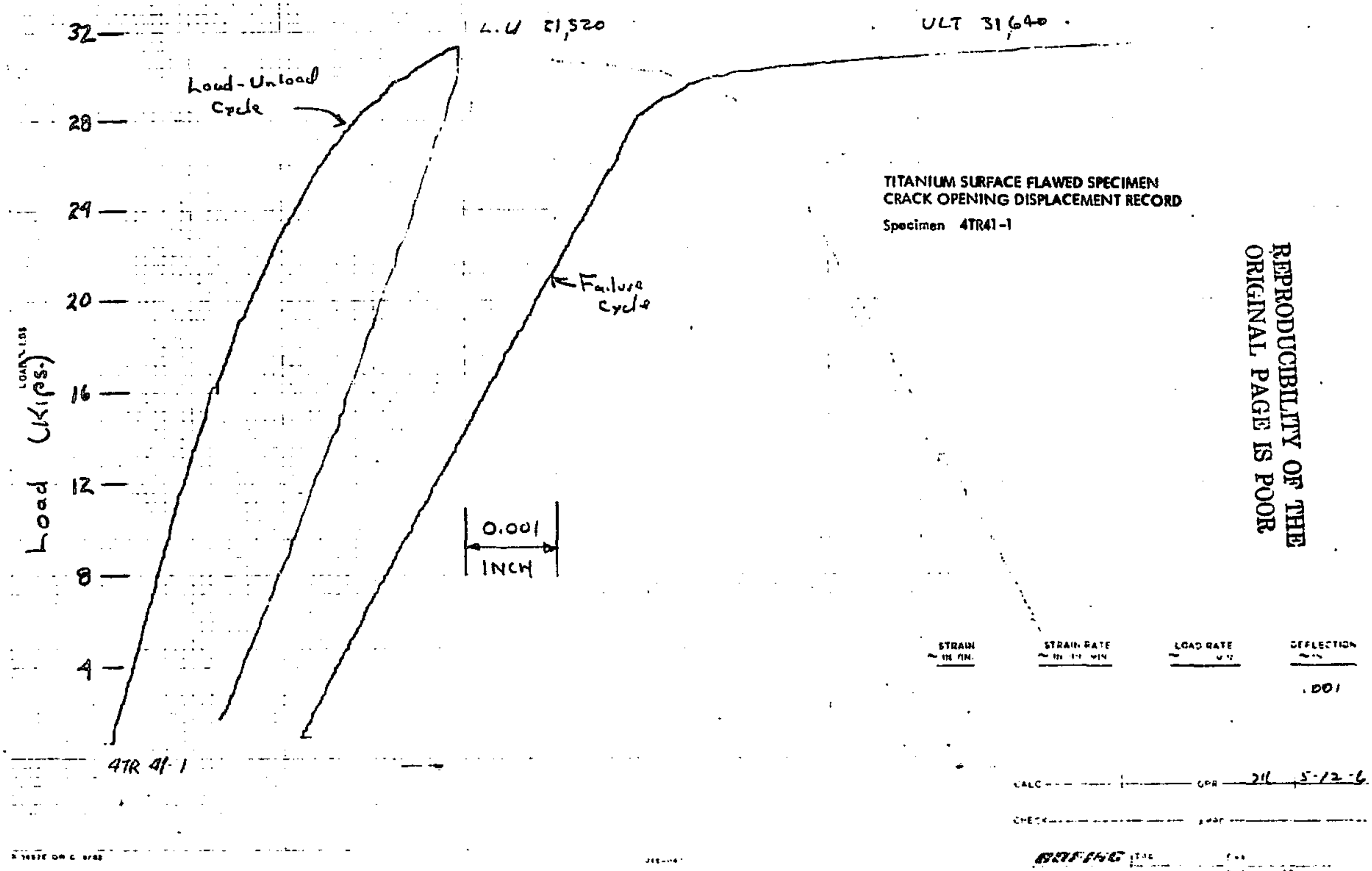
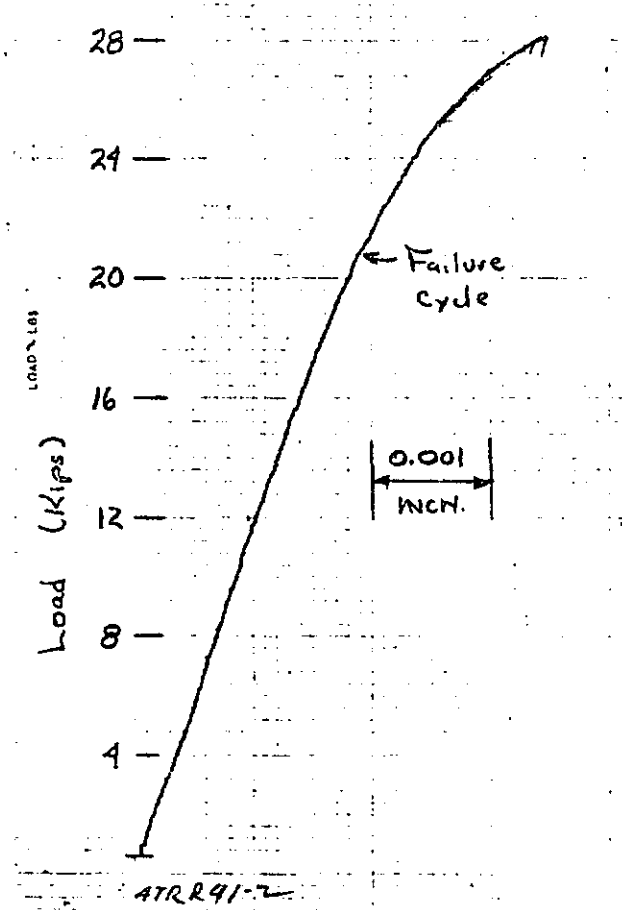


TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

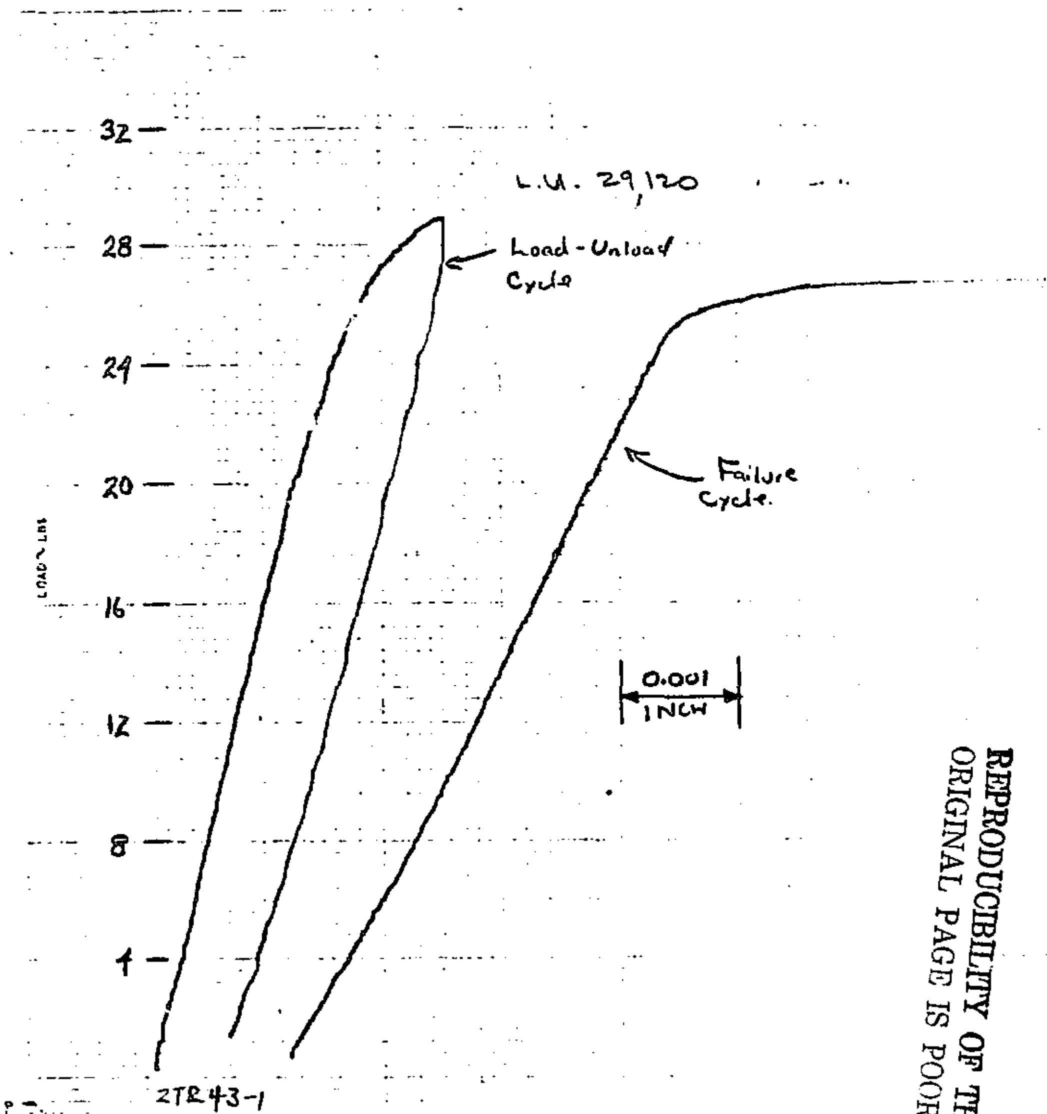
Specimen 4TR41-2



STRAIN ~ IN/IN	STRAIN RATE ~ IN/IN/MIN	LOAD RATE ~ /MIN	DEFLECTION ~
			.001

CALC | OPR
CHECK | APPD

BOEING



TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2TR43-1

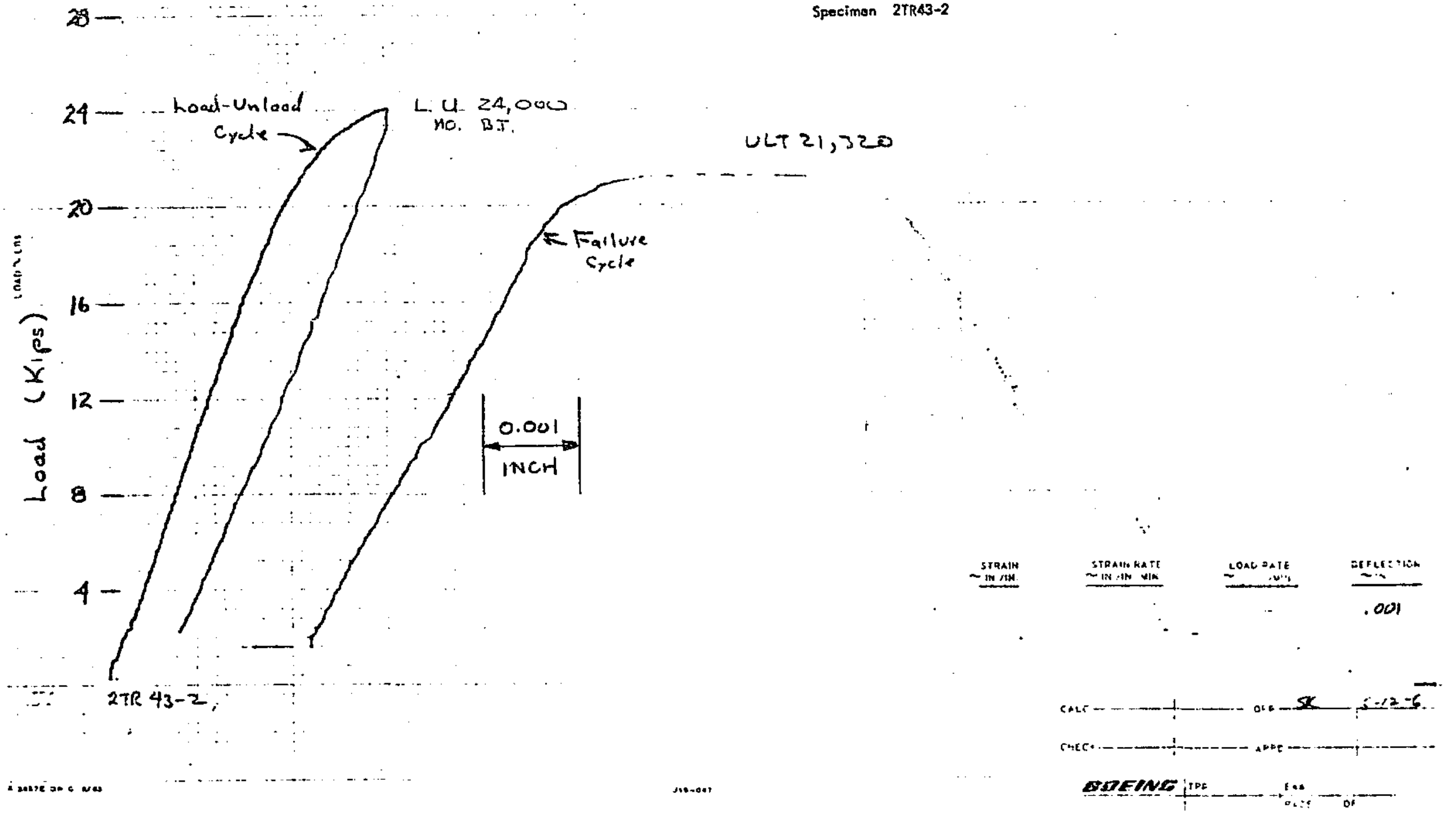
STRAIN ~ IN./IN.	STRAIN RATE ~ IN./IN./MIN	LOAD RATE ~ /MIN	DEFLECTION ~ IN.
			.001

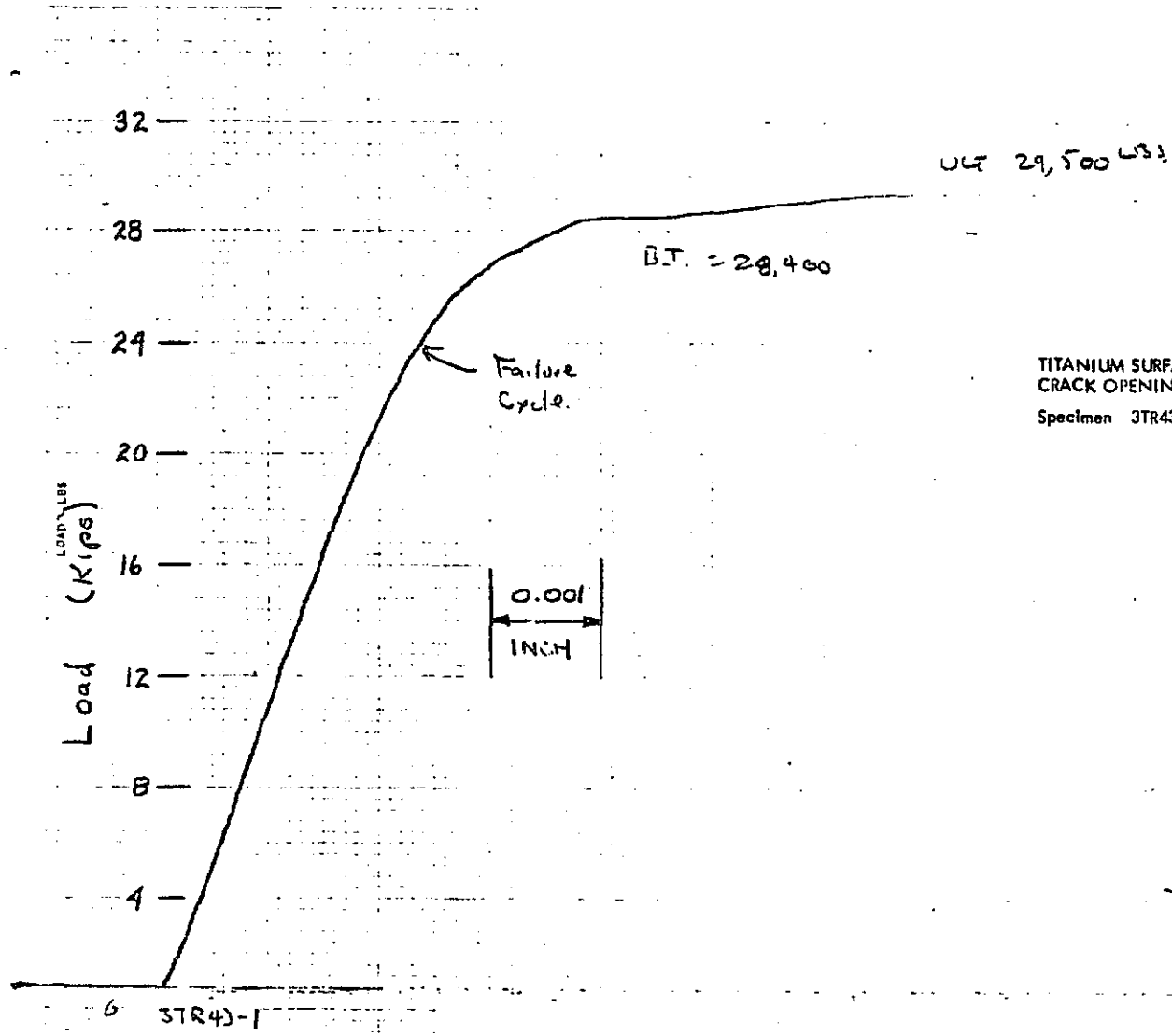
CALC — REF SK 5-11-6
CHECK — APPD

BOEING

TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 2TR43-2





TITANIUM SURFACE FLAWED SPECIMEN
CRACK OPENING DISPLACEMENT RECORD

Specimen 3TR43-1

STRAIN ~ IN/IN	STRAIN RATE ~ IN/IN/MIN	LOAD RATE ~ /MIN	DEFLECTION ~
			.001

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

CALC — OFF 3K 5-8-6

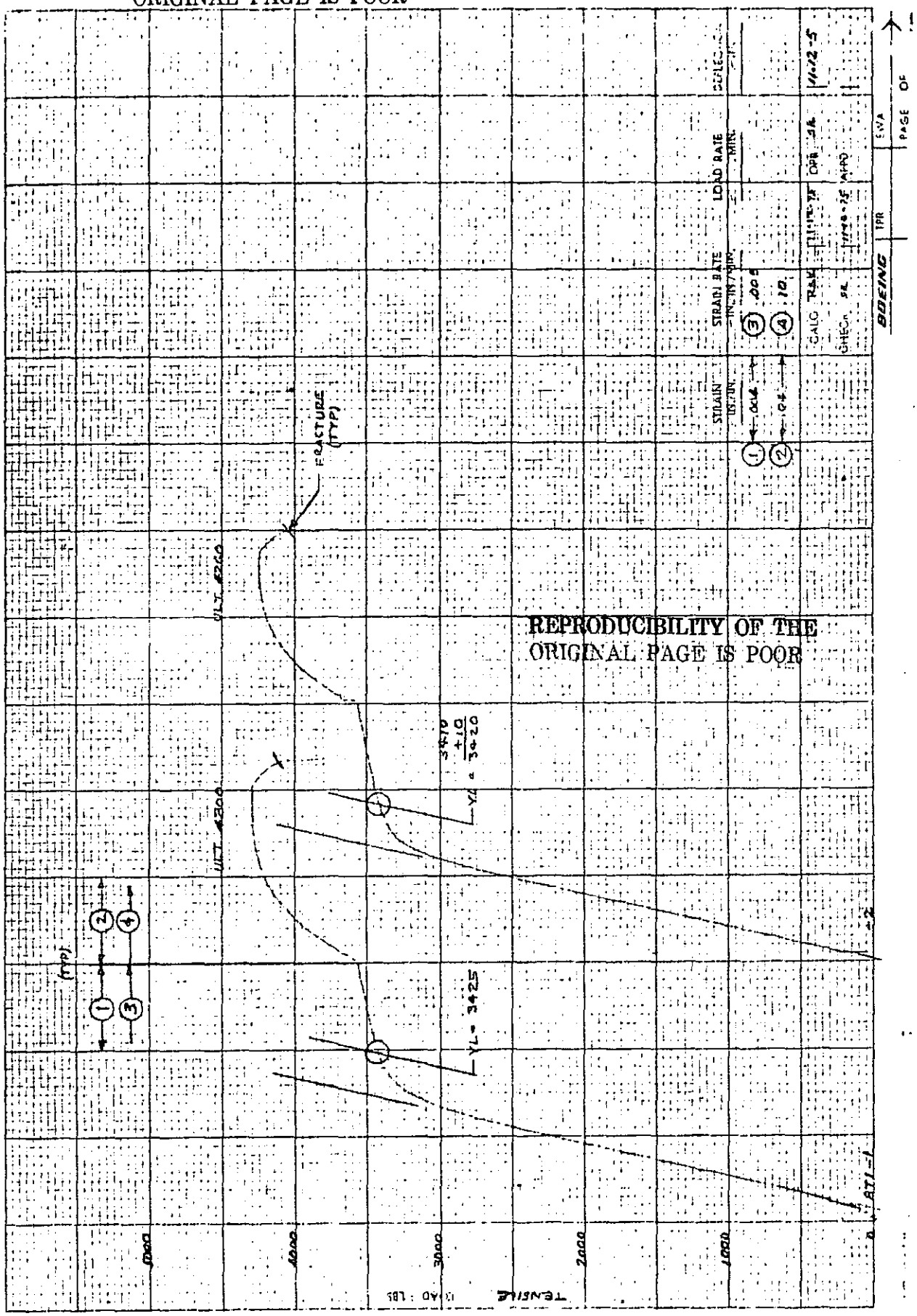
CHECK — APPD

BOEING TPR

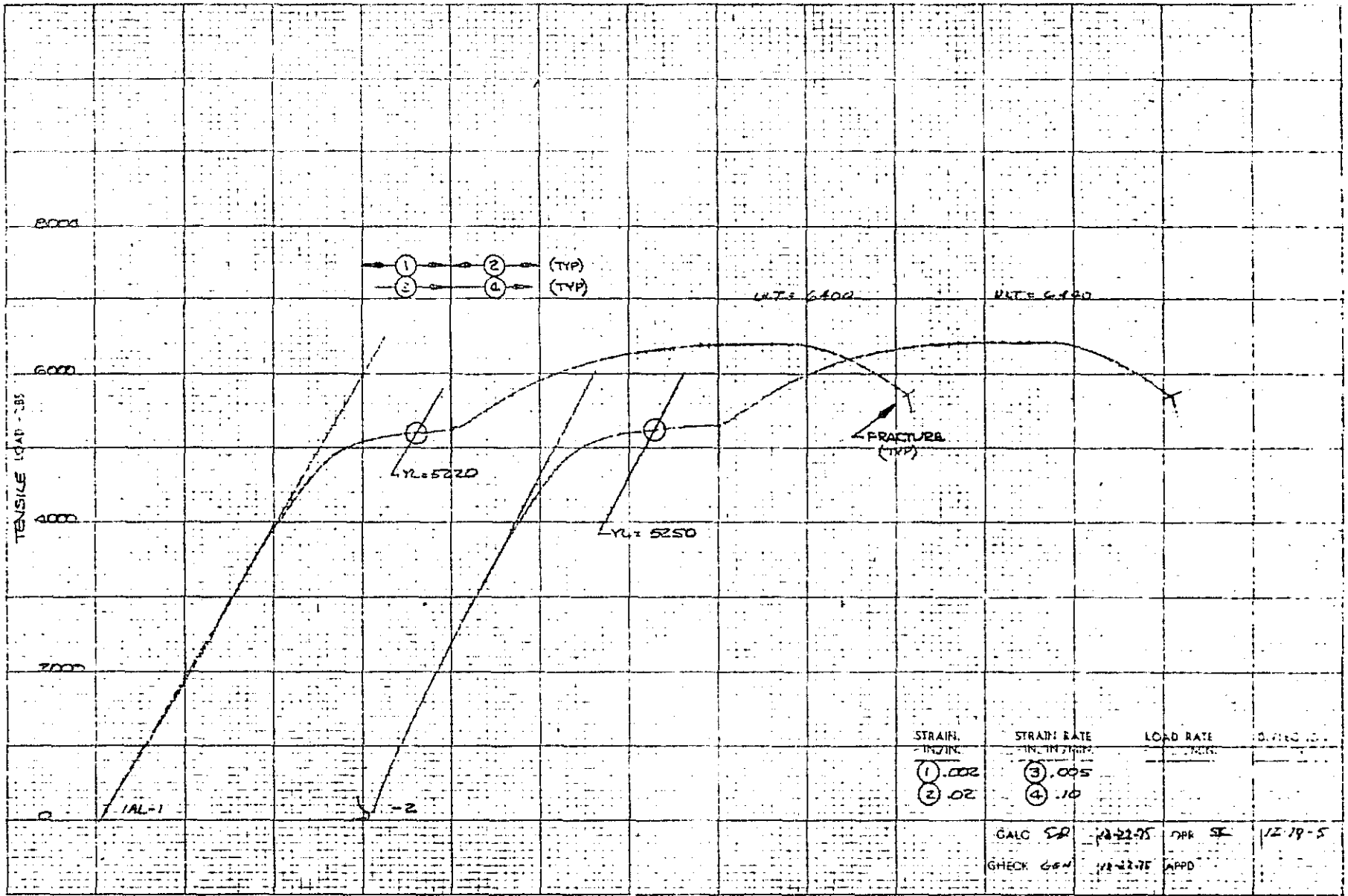
PAGE OF

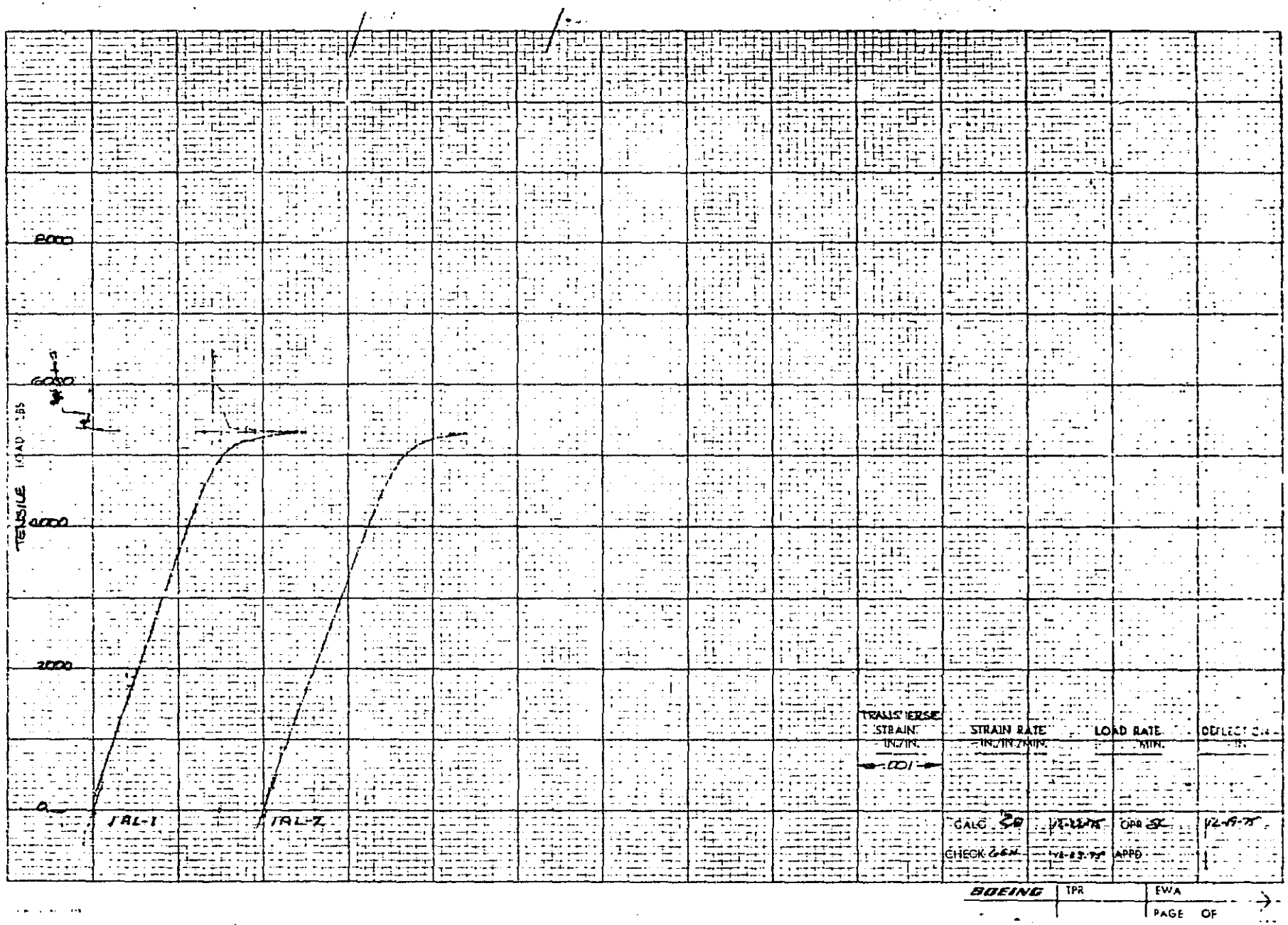
141

APPENDIX III - Extensometer and Strain Gage Records

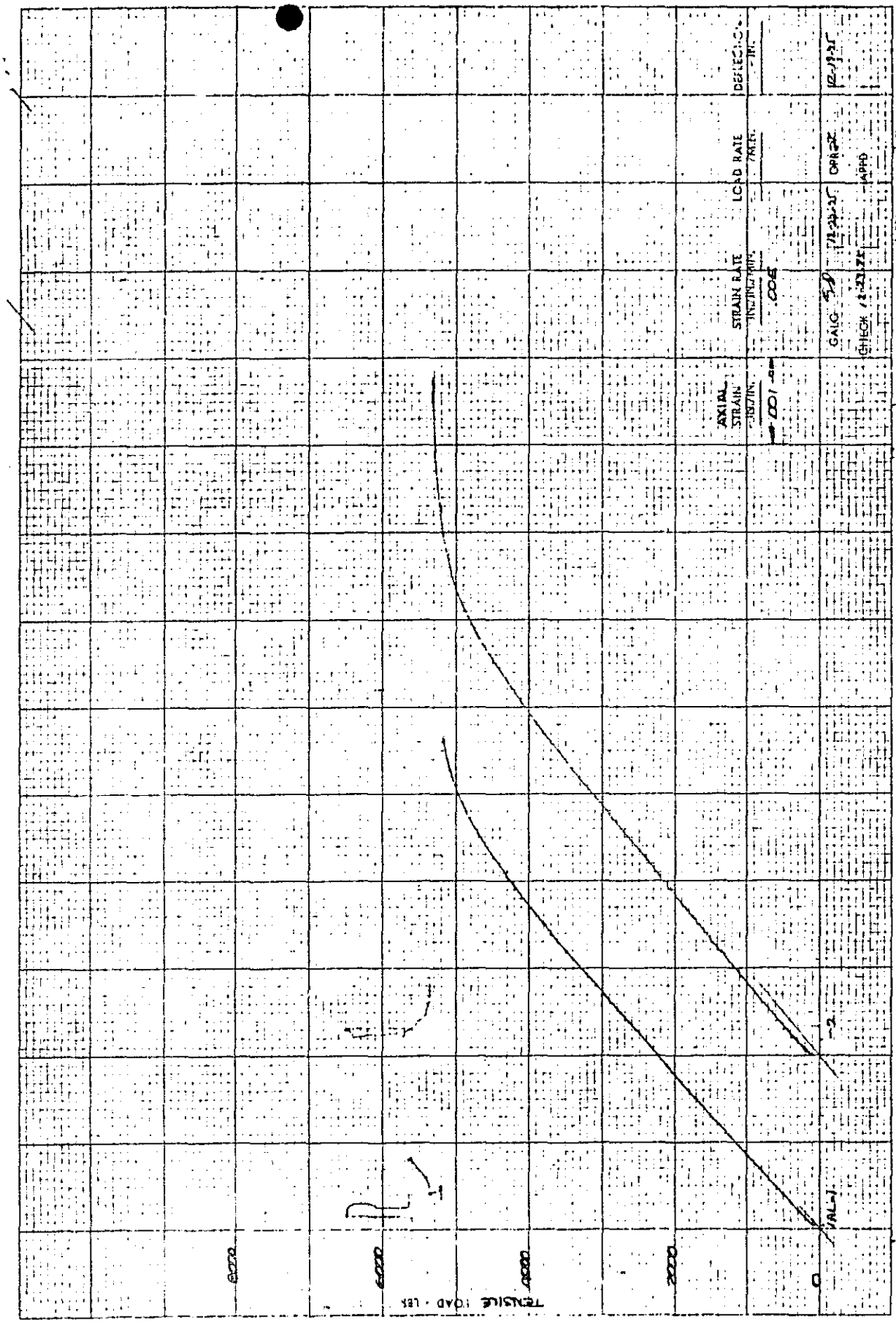


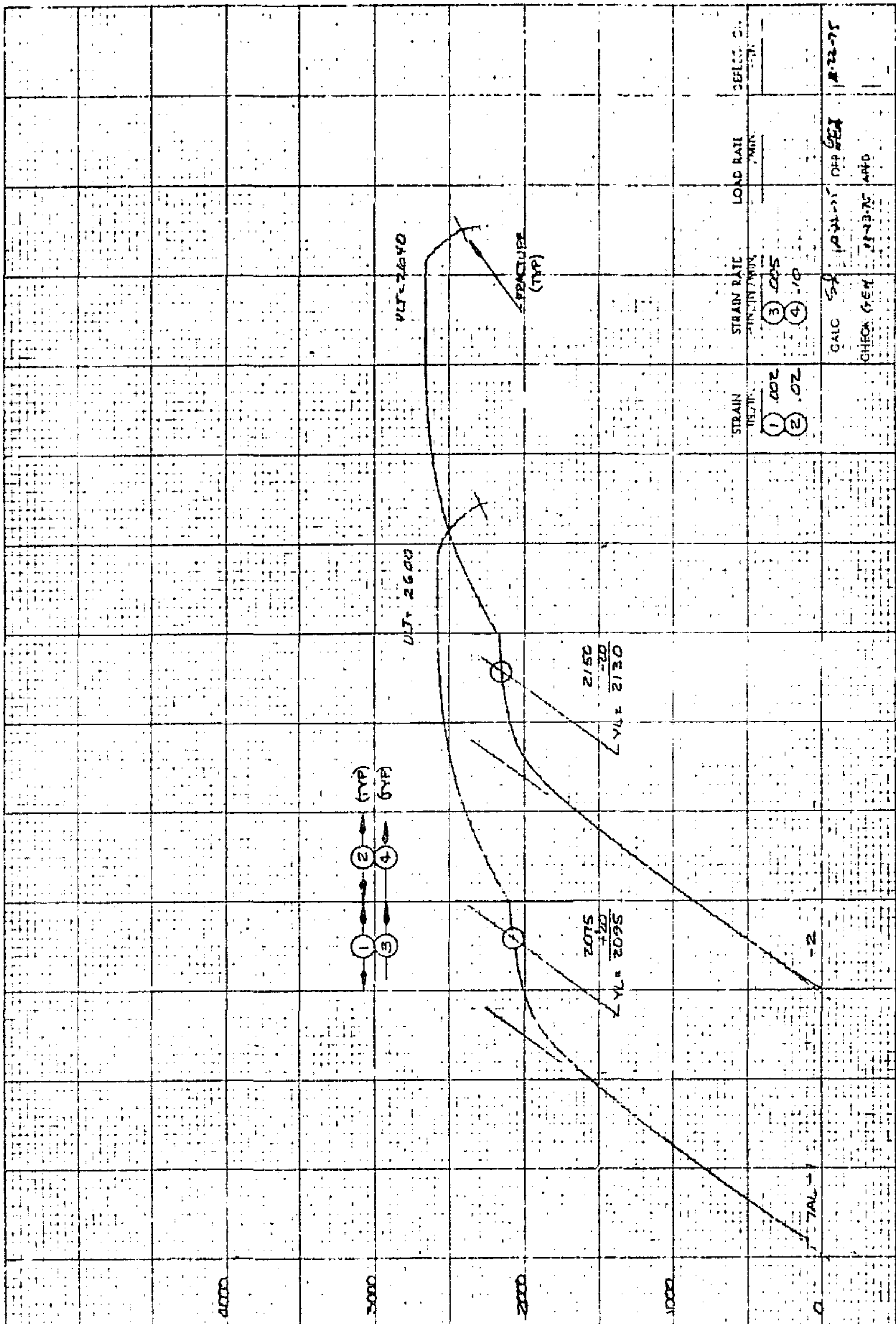
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

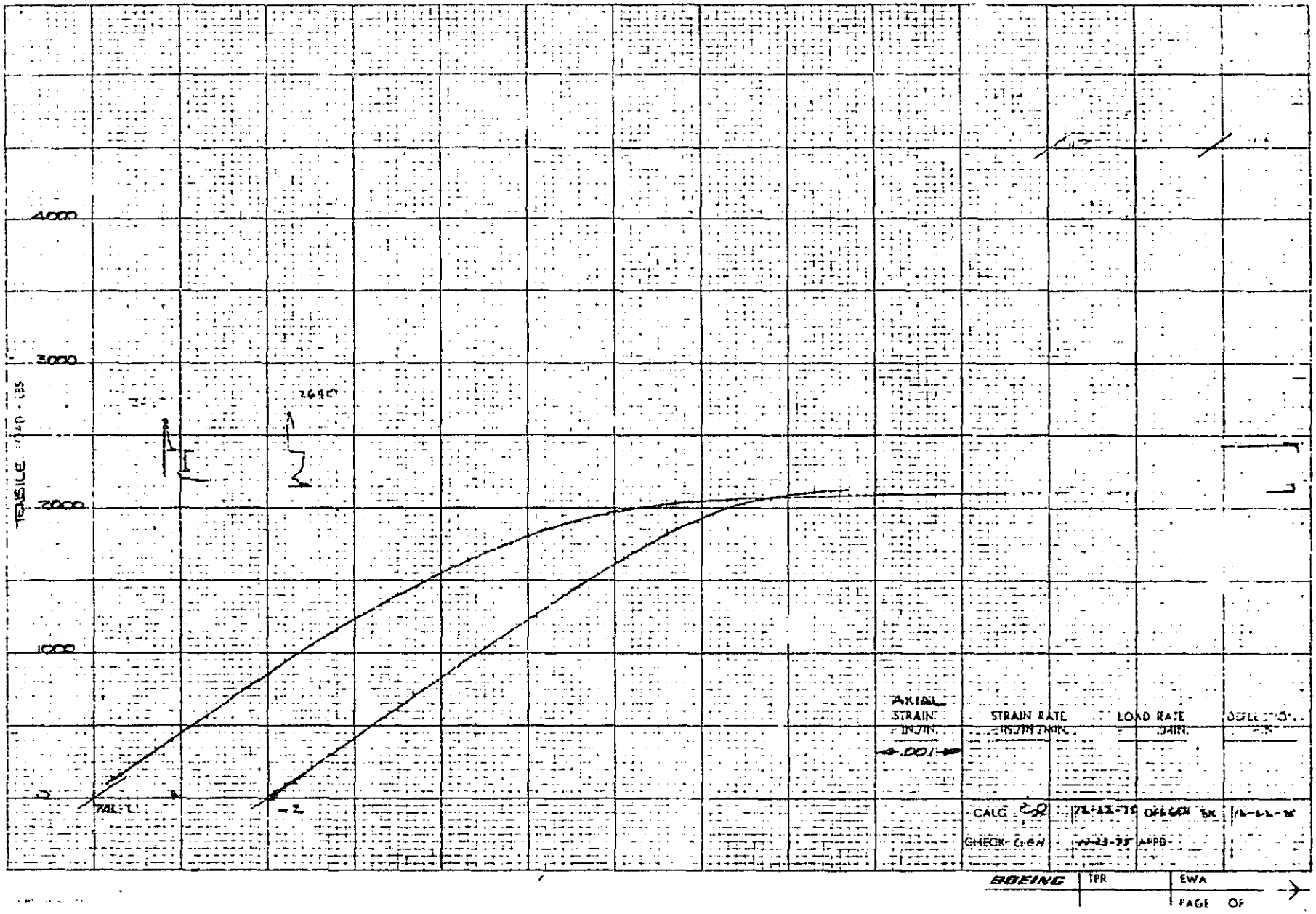


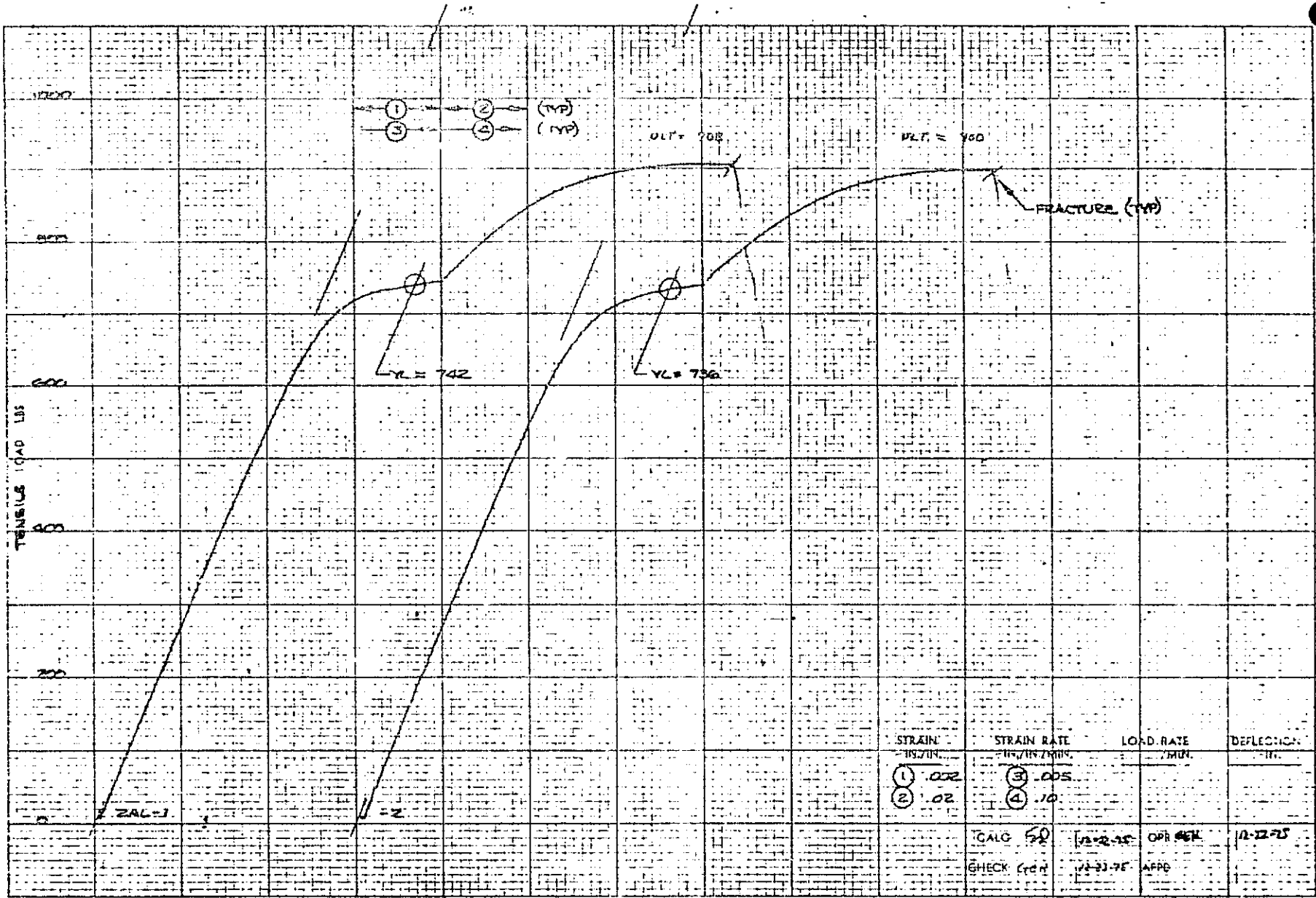


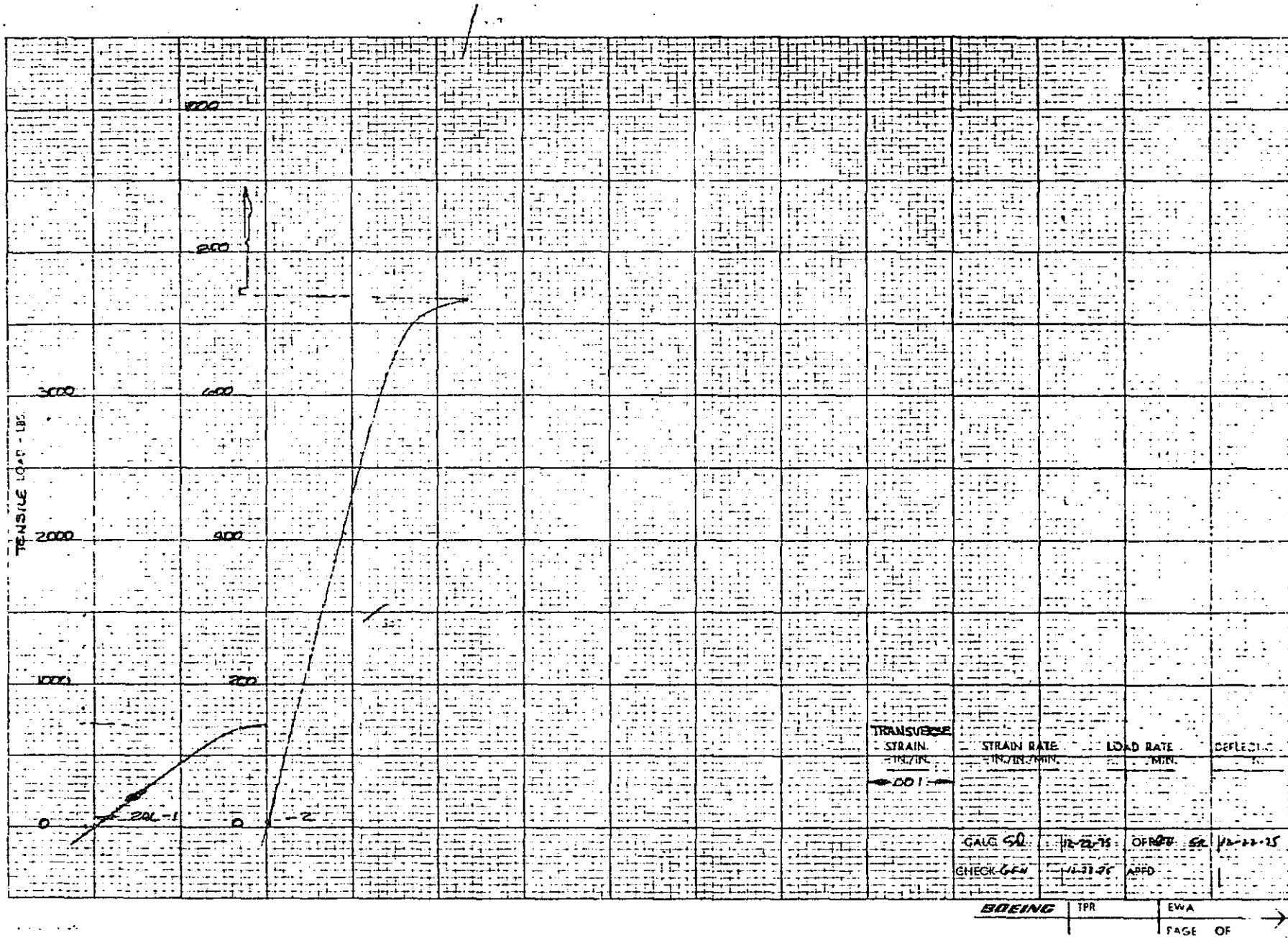
For machine only




TENSILE LOAD, LBS
0
1000
2000
3000
4000
7AL-1
-2
YL = 2095
2075
+20
2095
YL = 2130
2150
-20
2130
ULT = 2600
ULT = 2690
FRACTURE (TYP)
(TYP)
(TYP)
STRAIN
1 .002
2 .02
STRAIN RATE
3 .005
4 .10
LOAD RATE
CALC
CHECK
APPD
BOEING
PAGE
OF


4000
3000
2000
1000
TENSILE (LBS - LBS
2695
AXIAL STRAIN IN/IN.
.001
STRAIN RATE IN/IN/MIN.
LOAD RATE LBS/MIN.
CALC
CHECK
BOEING
TPR
EWA
PAGE OF





BOEING | TPR | EWA

PAGE OF

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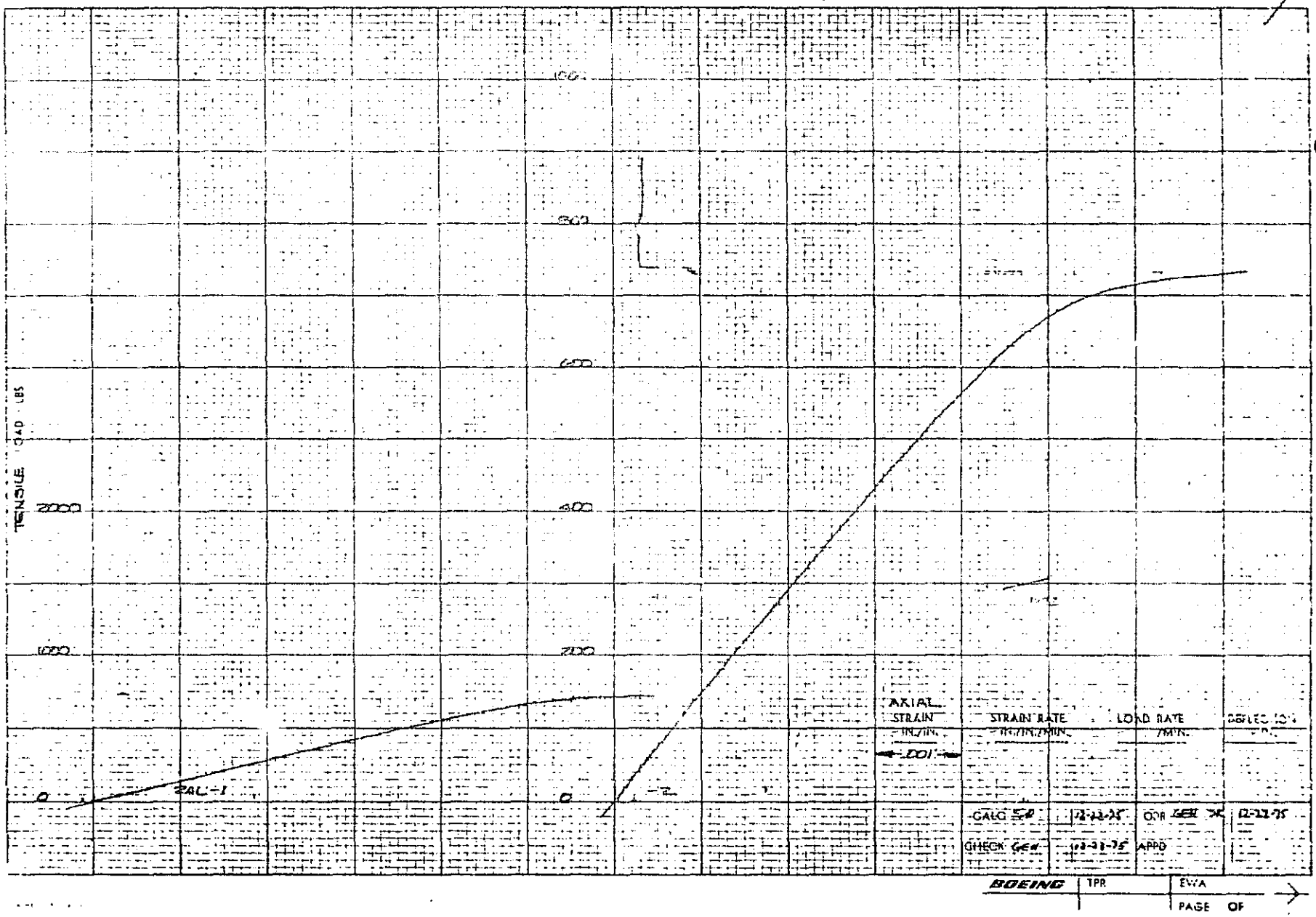
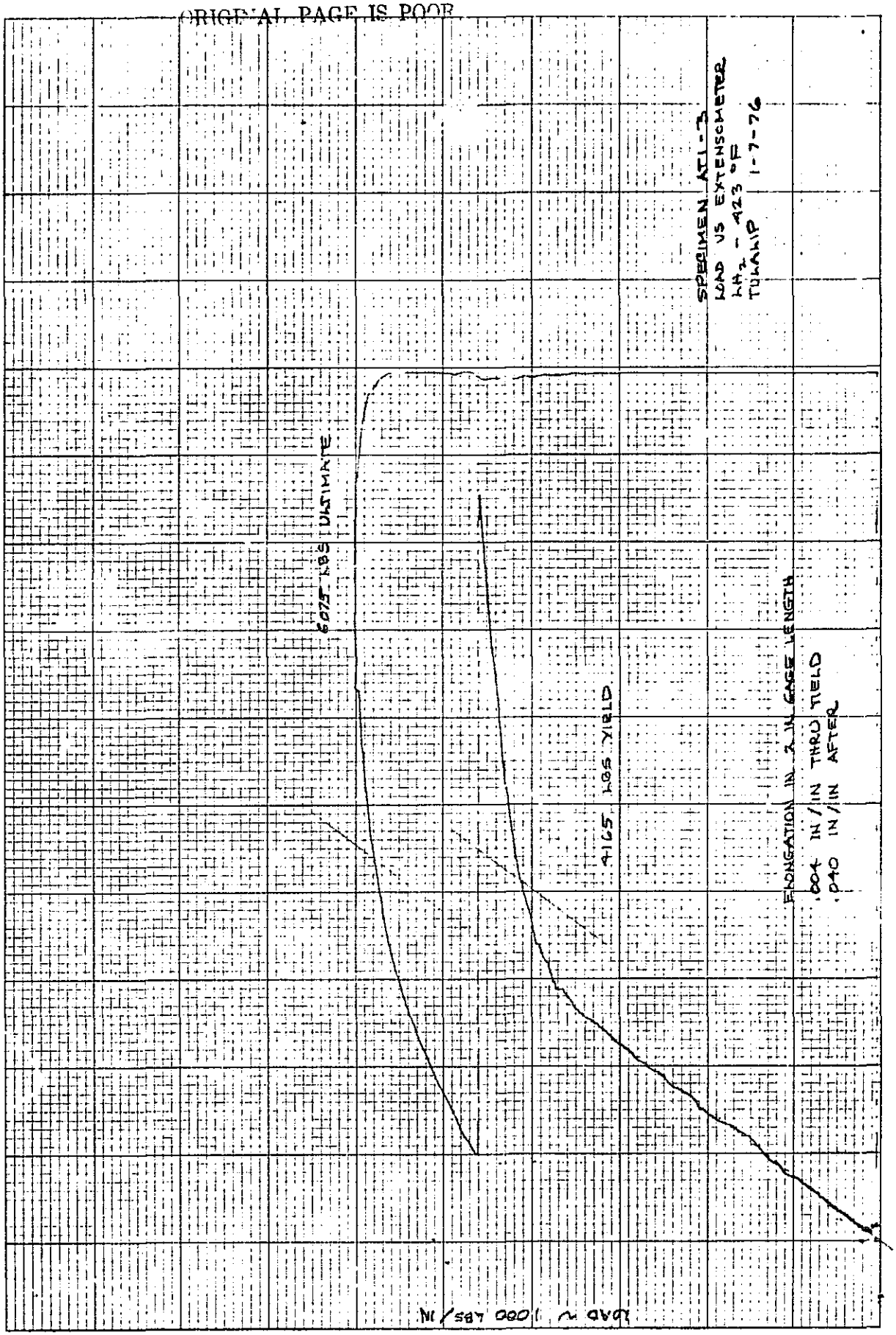
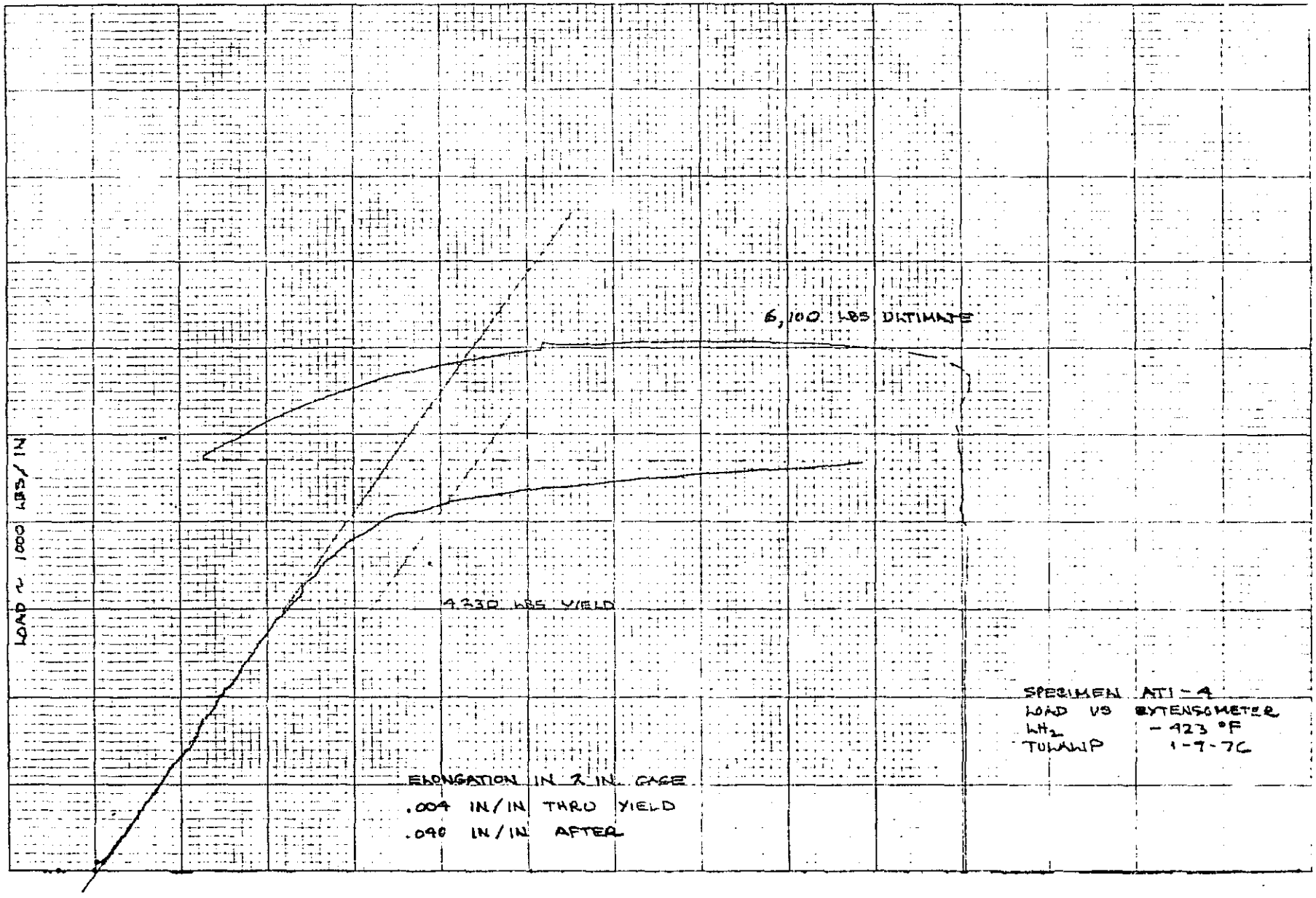
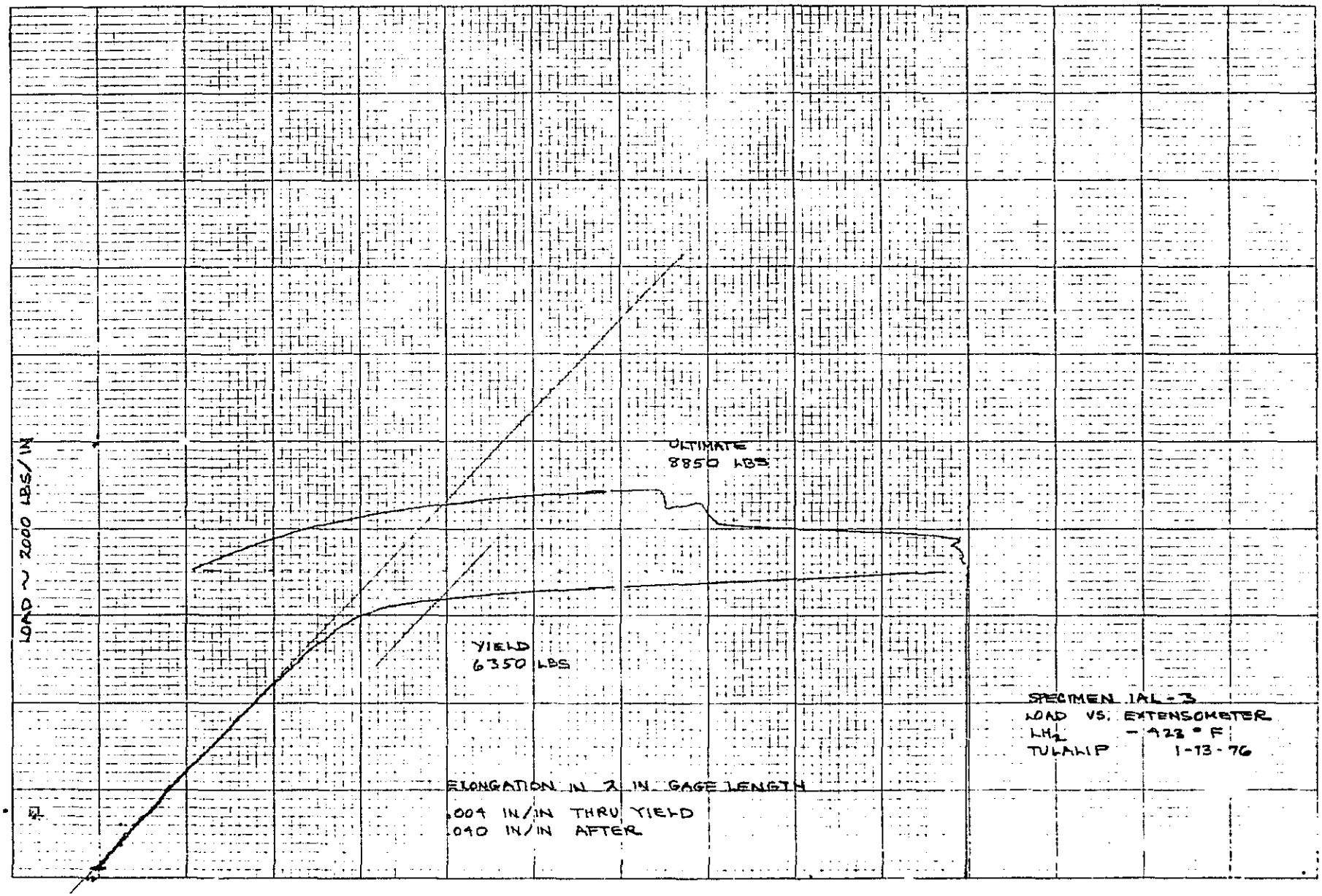
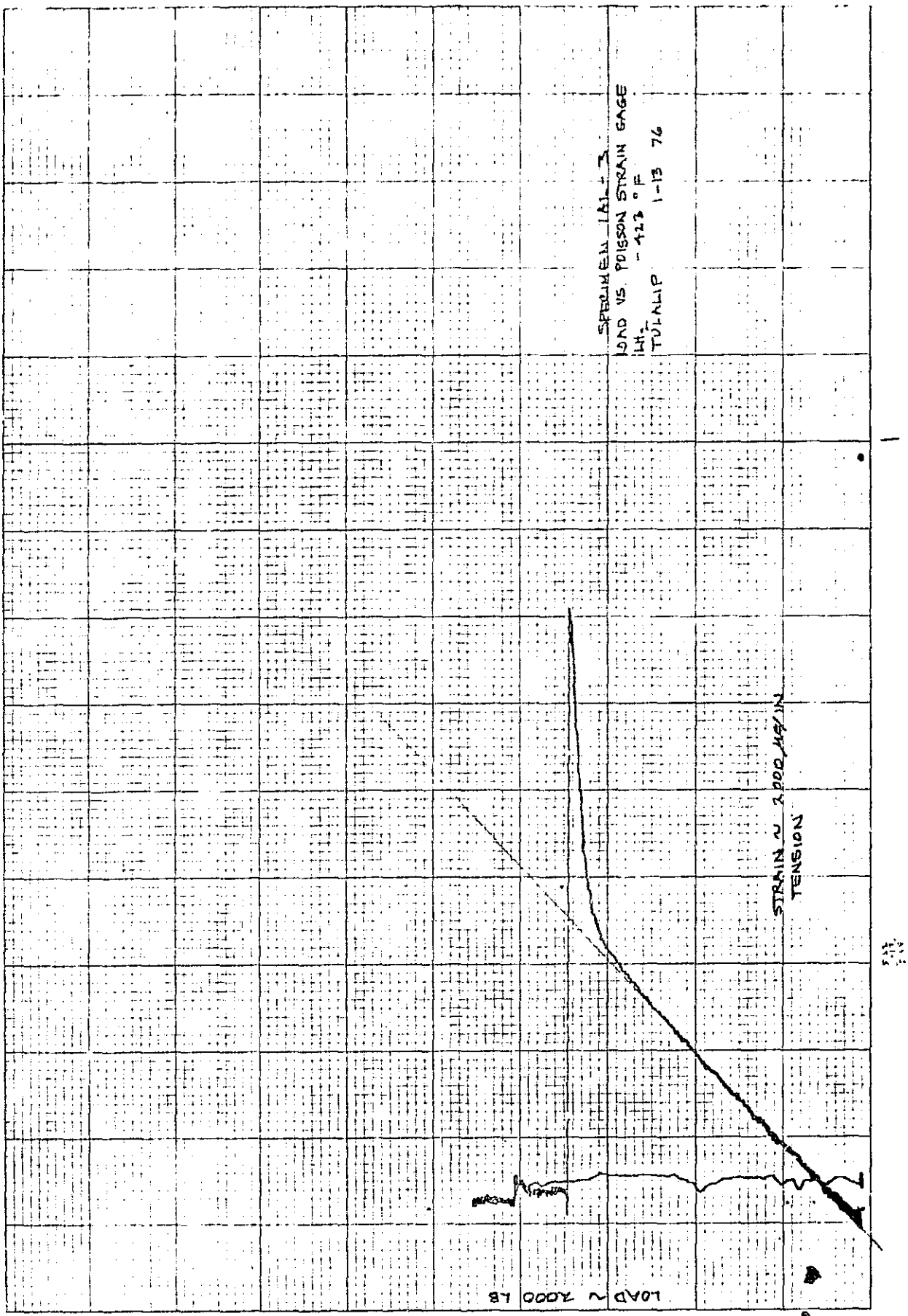
For machine only

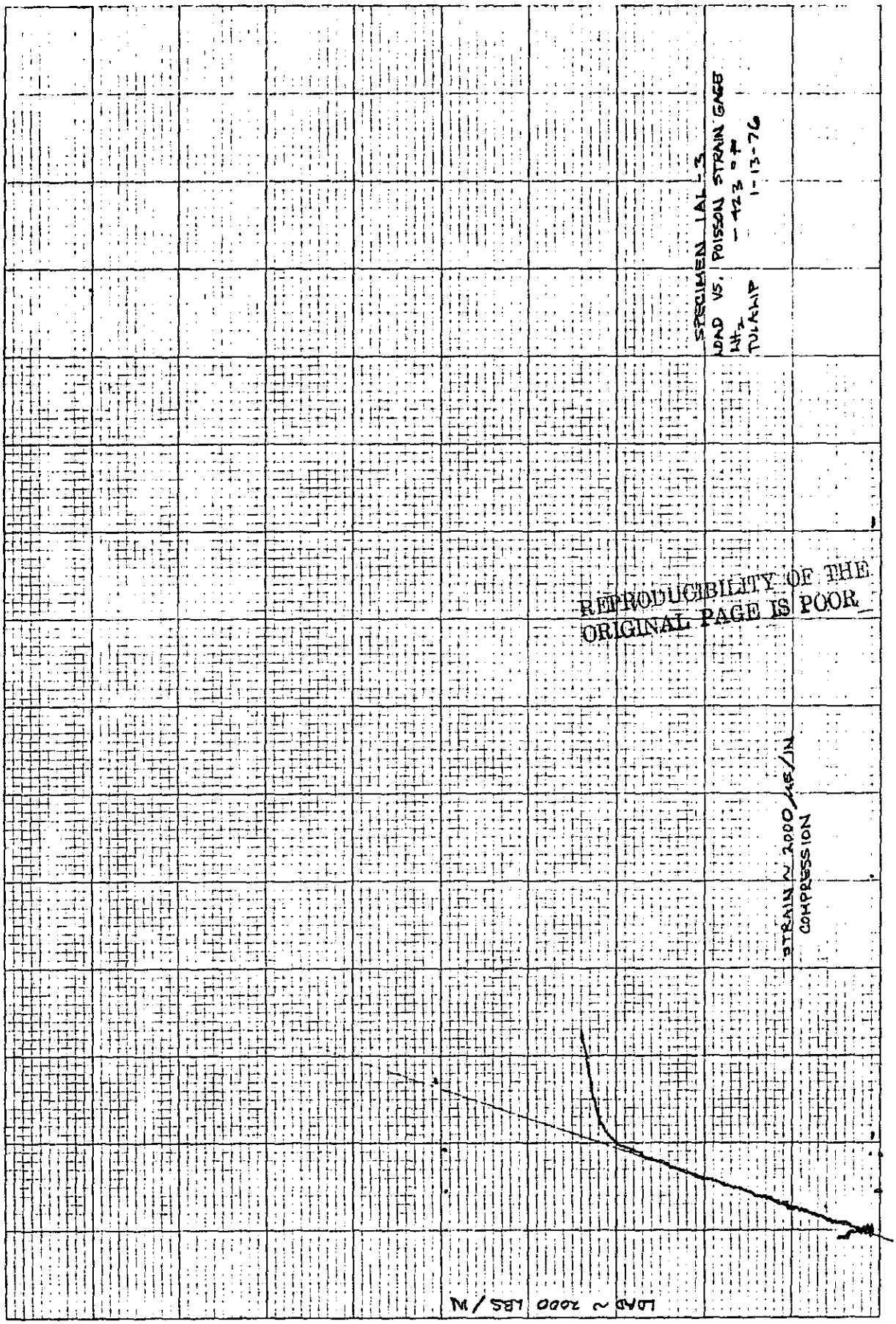

TENSILE LOAD LBS
100
300
600
2000
400
1000
200
0
0
2AL-1
-2
AXIAL STRAIN IN/IN
STRAIN RATE IN/IN/MIN
LOAD RATE /MIN
.001
CALC
CHECK
APPD
BOEING
TPR
EWA
PAGE OF



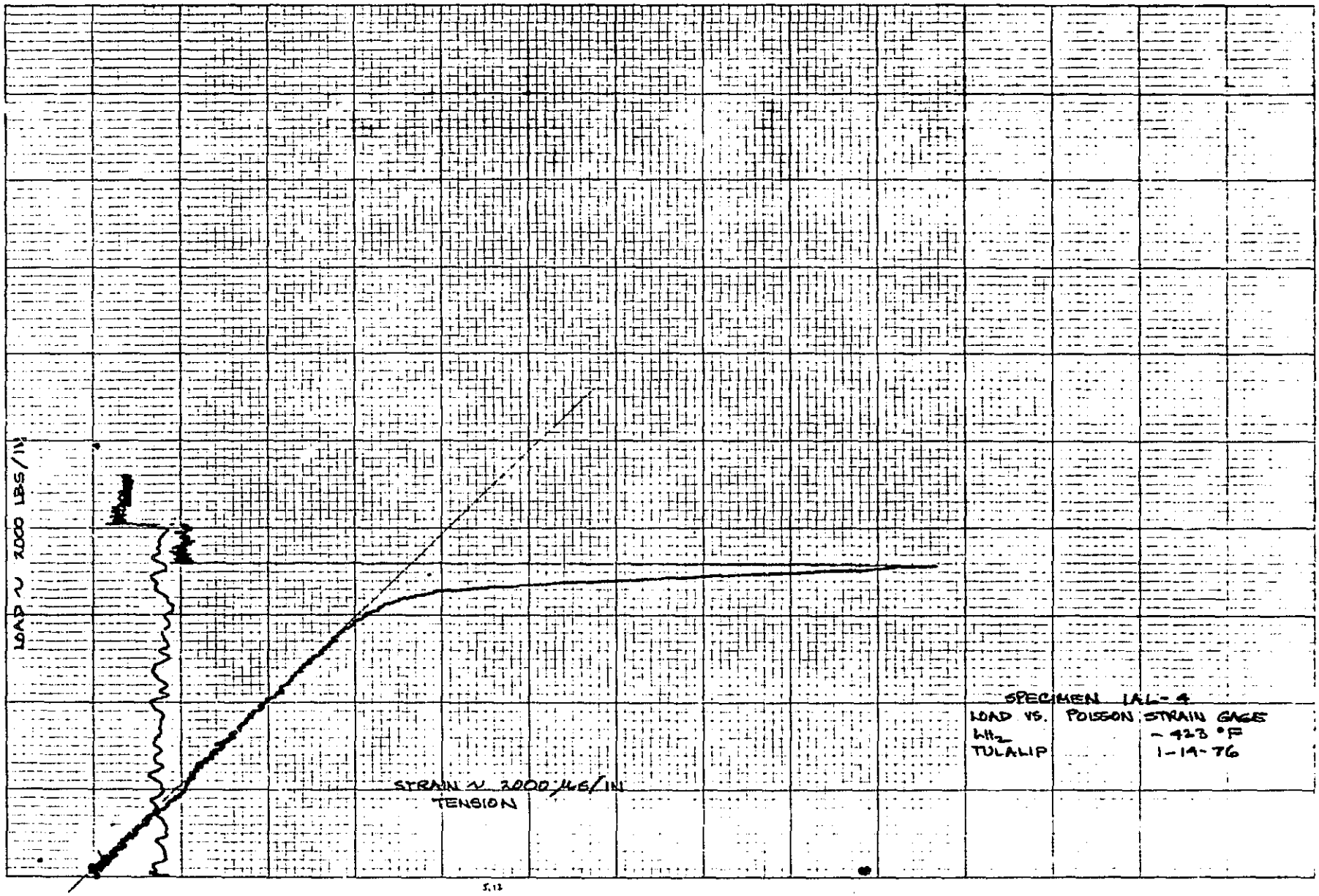

6,100 LBS ULTIMATE
4330 LBS YIELD
LOAD ~ 1000 LBS/IN
SPECIMEN ATI-4
LOAD VS EXTENSOMETER
LH2 -423 °F
TUNNEL 1-7-76
ELONGATION IN 2 IN. GAGE
.004 IN/IN THRU YIELD
.090 IN/IN AFTER


LOAD ~ 2000 LBS/IN
ULTIMATE
8850 LBS
YIELD
6350 LBS
ELONGATION IN 2 IN GAGE LENGTH
.004 IN/IN THRU YIELD
.040 IN/IN AFTER
SPECIMEN 1AL-3
LOAD VS. EXTENSOMETER
LH2 -423° F
TULAMP 1-13-76





AL-4
1-14-76



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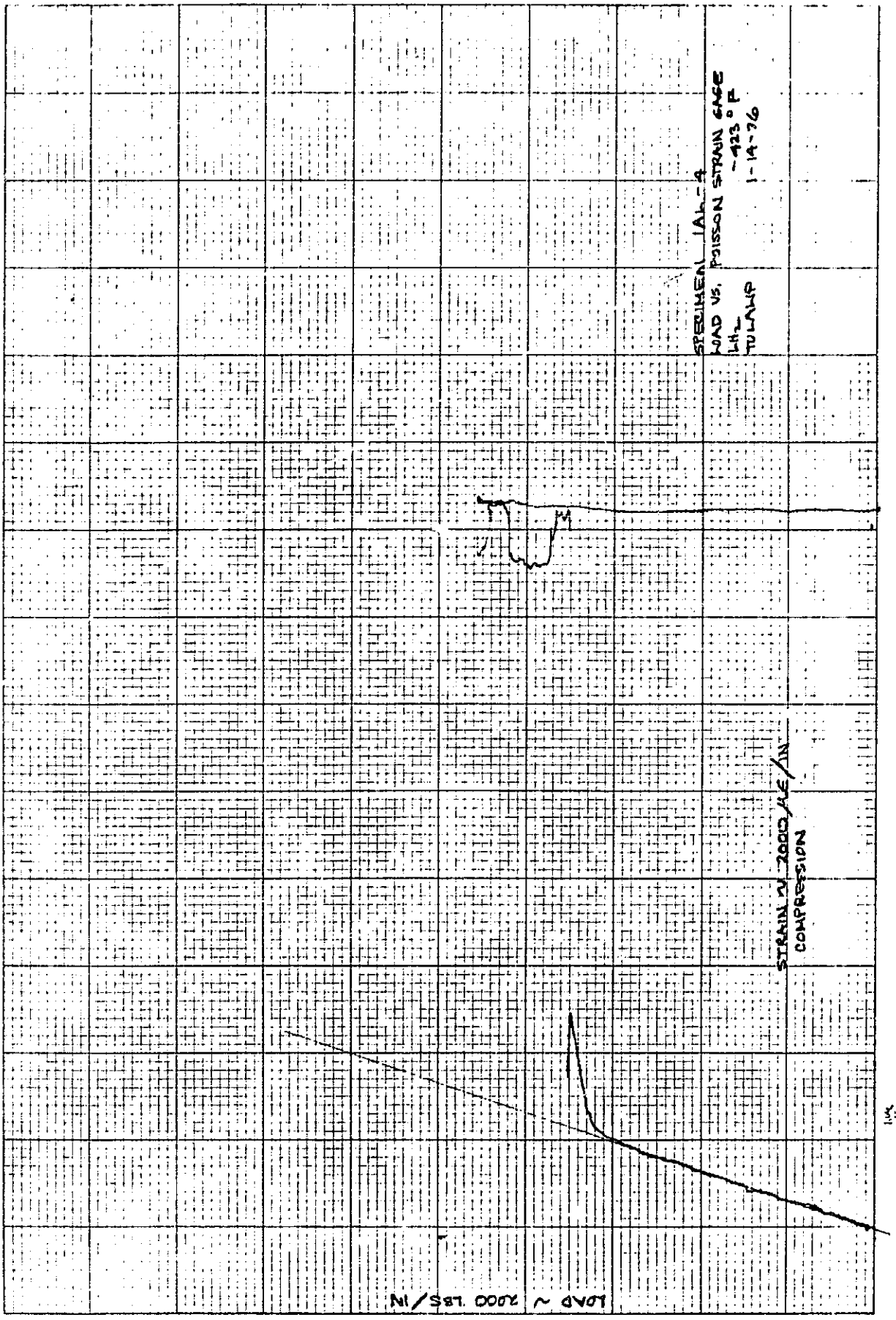
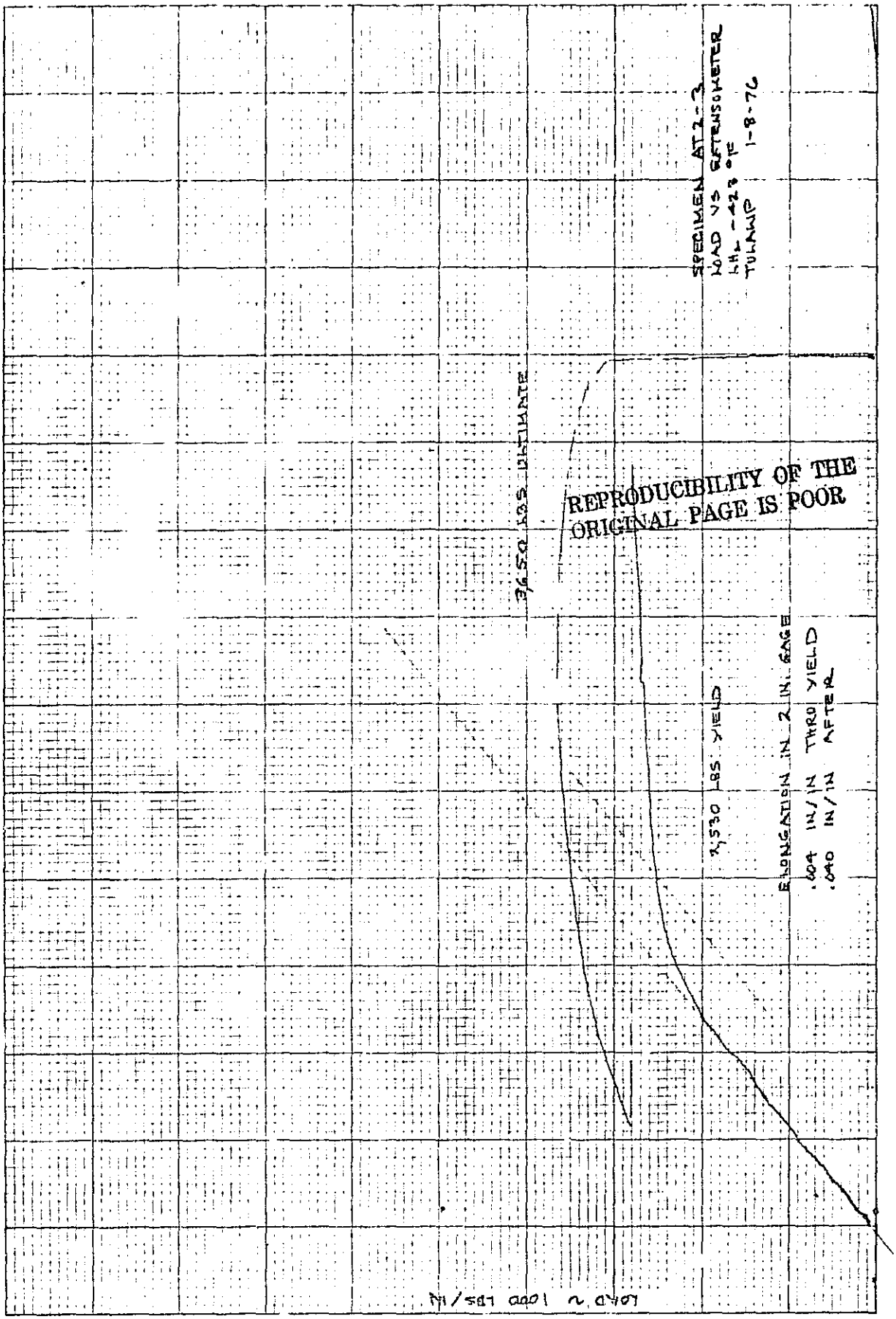
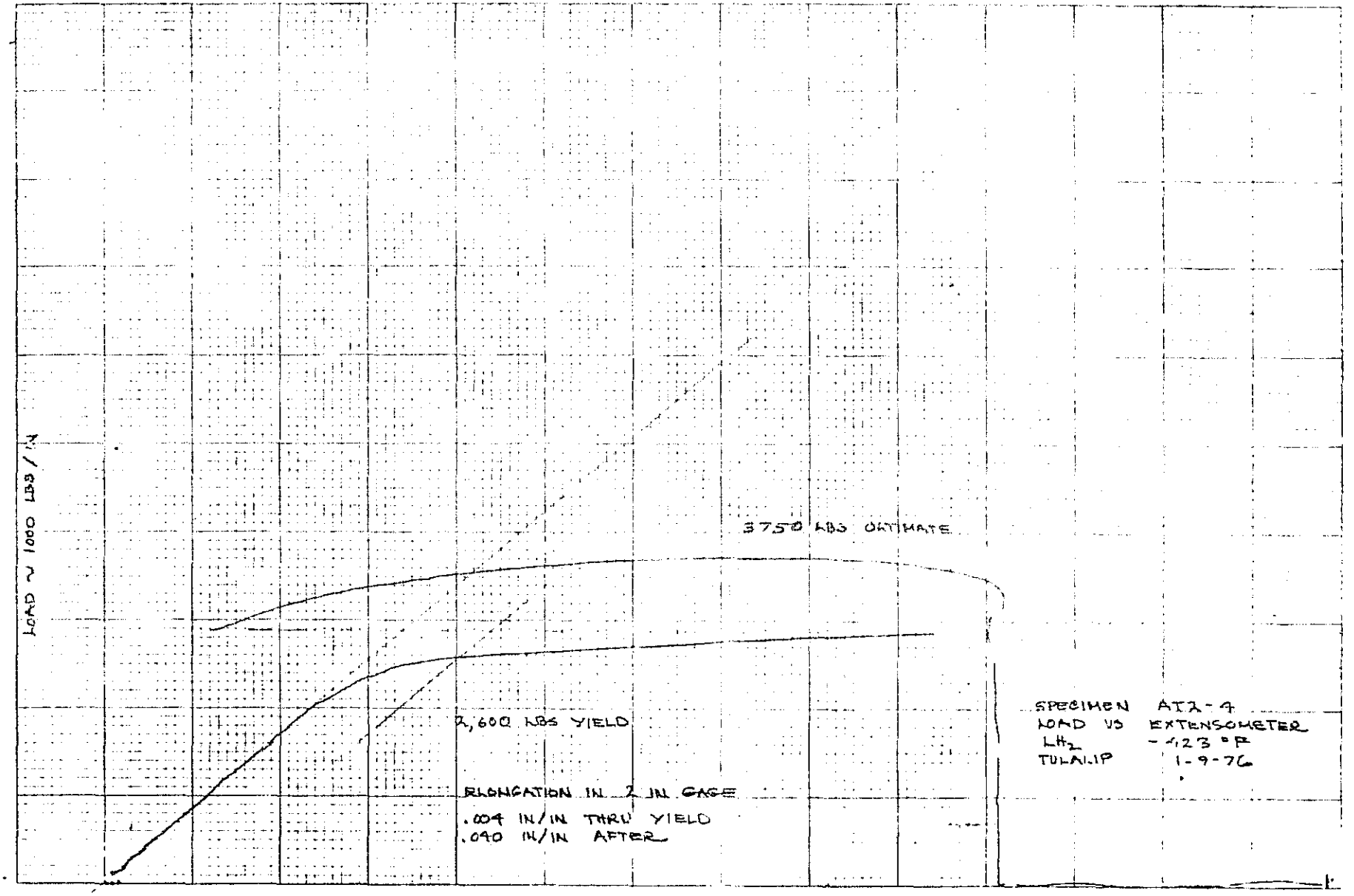
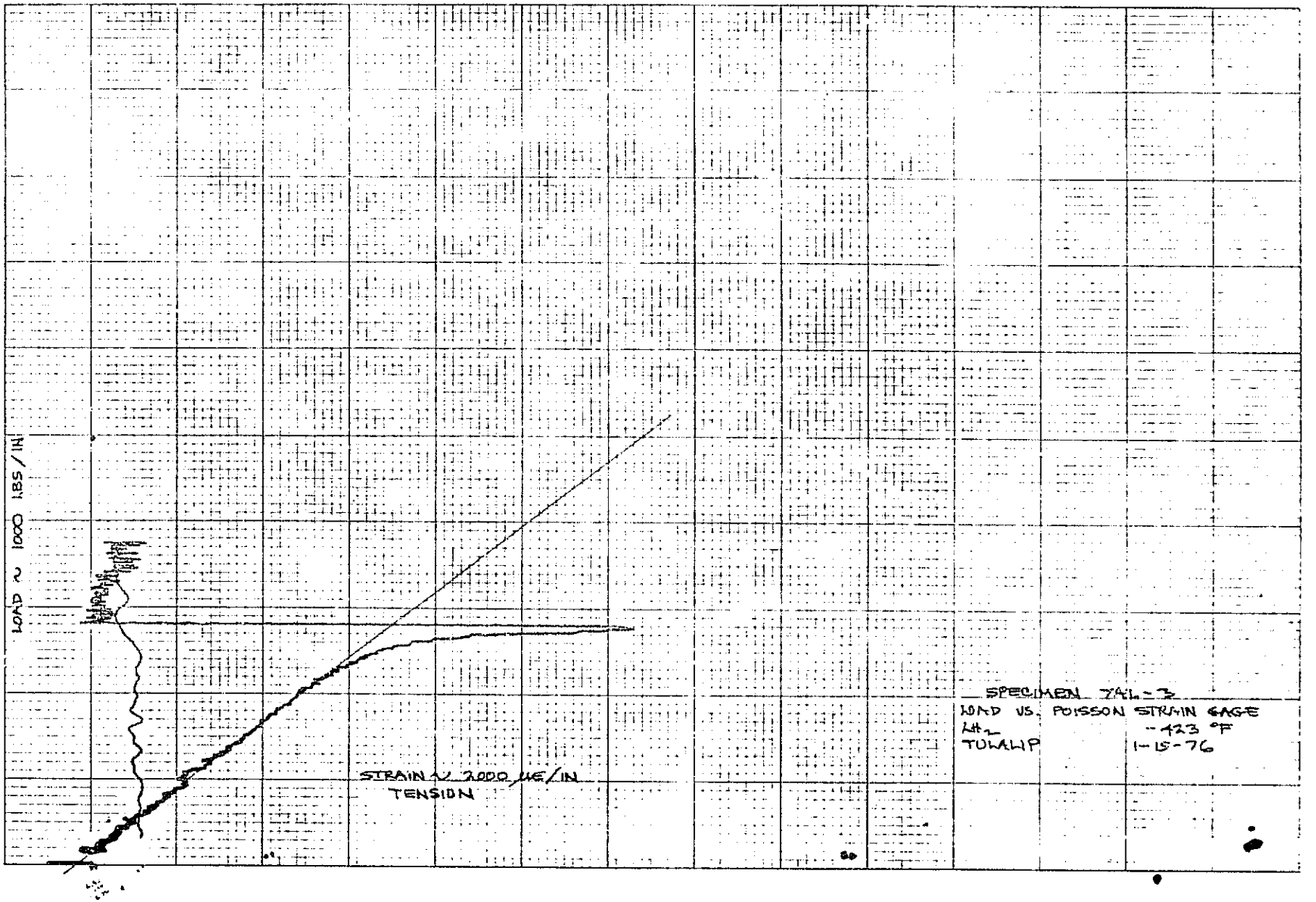




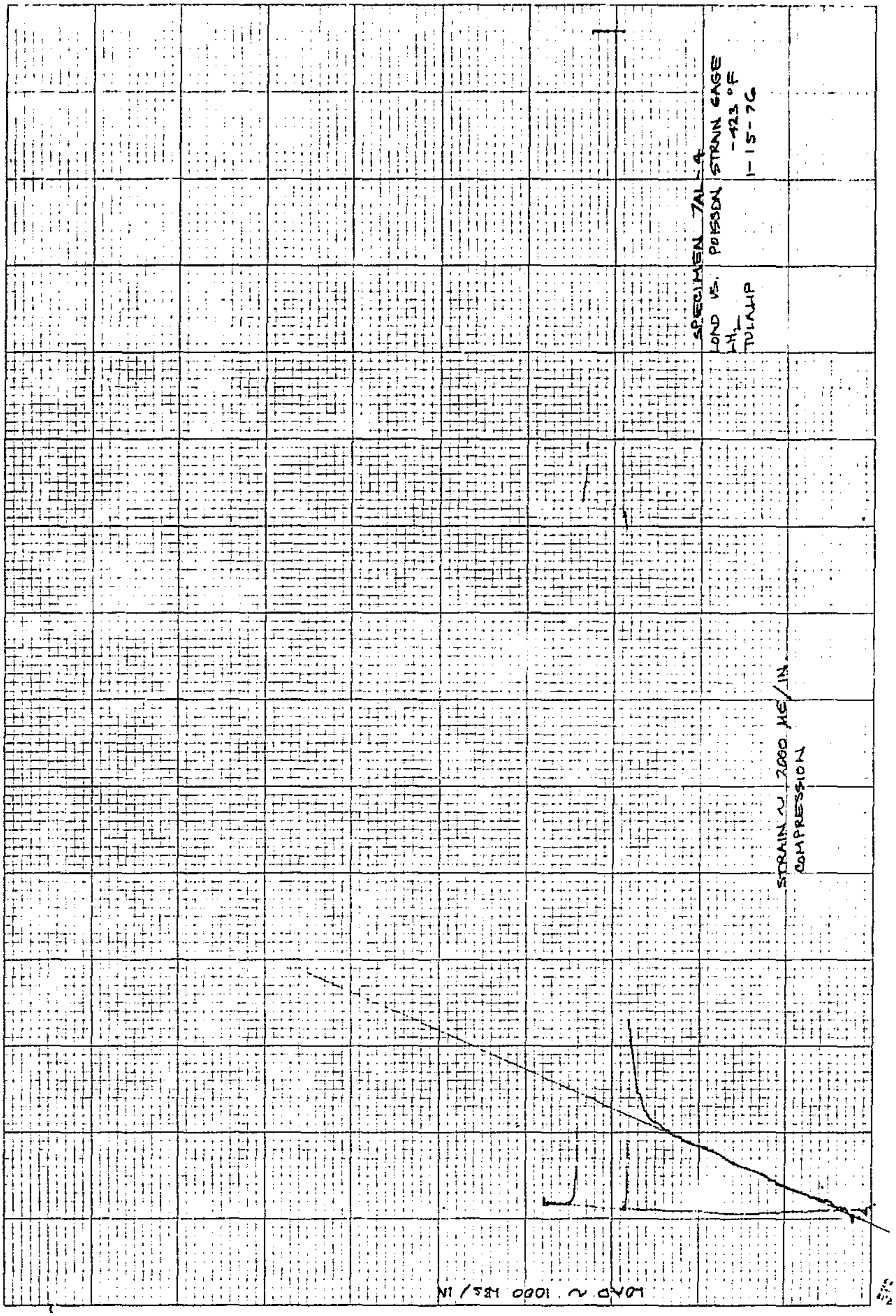
AT2-4


LOAD ~ 1000 LBS / KN
3750 LBS ULTIMATE
2,600 LBS YIELD
ELONGATION IN 2 IN GAGE
.004 IN/IN THRU YIELD
.090 IN/IN AFTER
SPECIMEN AT2-4
LOAD VS EXTENSOMETER
LH2 -423 °F
TULA.IP 1-9-76

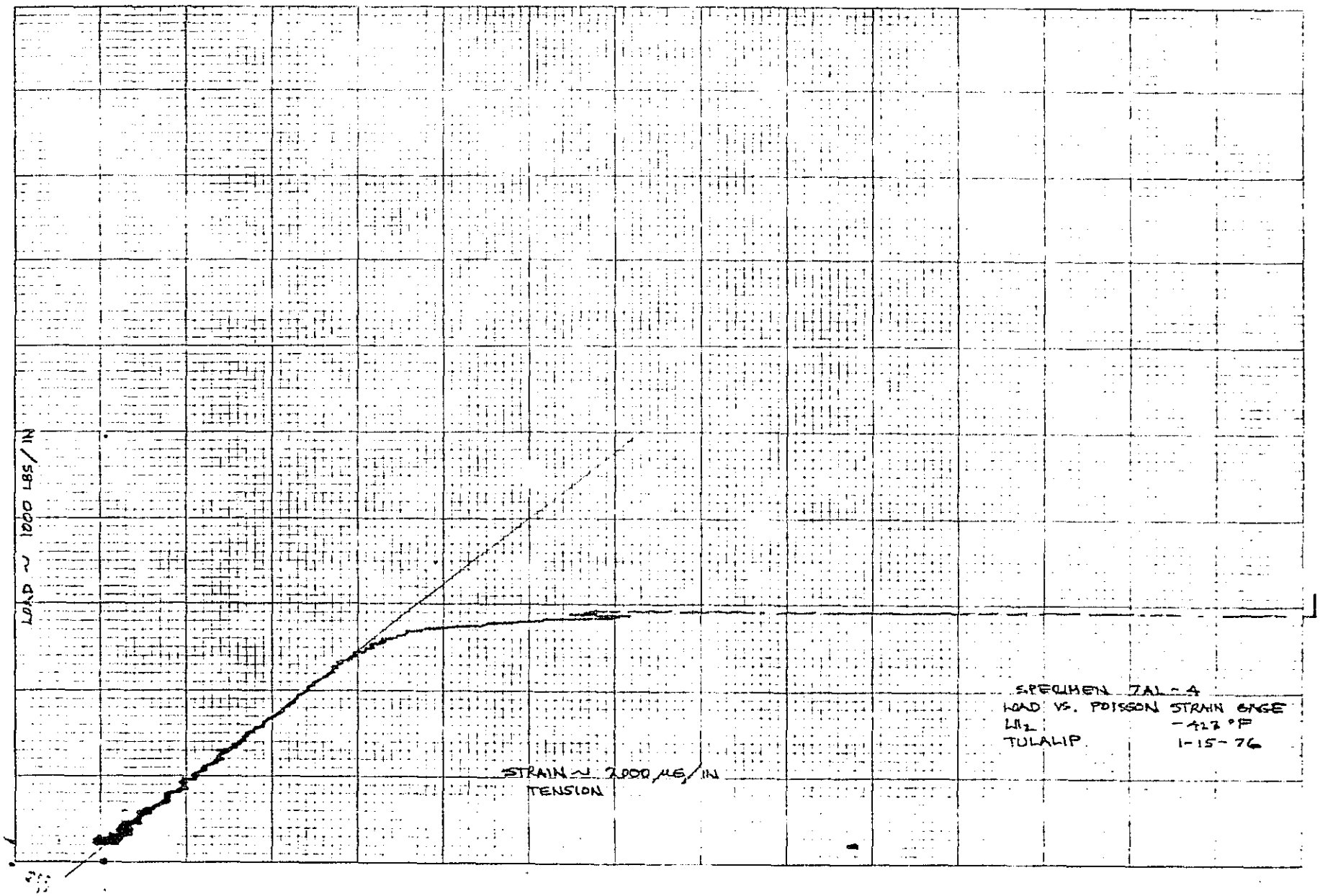
7AL-3
1-14-76


LOAD ~ 1000 LBS/IN
STRAIN ~ 2000 μE/IN
TENSION
SPECIMEN 7AL-3
LOAD VS. POISSON STRAIN GAGE
-423 °F
1-15-76
TOWALIP

7AL-4


SPECIMEN 7AL-4
LOAD VS. POISSON STRAIN GAGE
-423 °F
LH2
1-15-76
STRAIN ~ 2000 με/IN.
COMPRESSION
LOAD ~ 1000 LBS/IN

7AL-4
1-15-76



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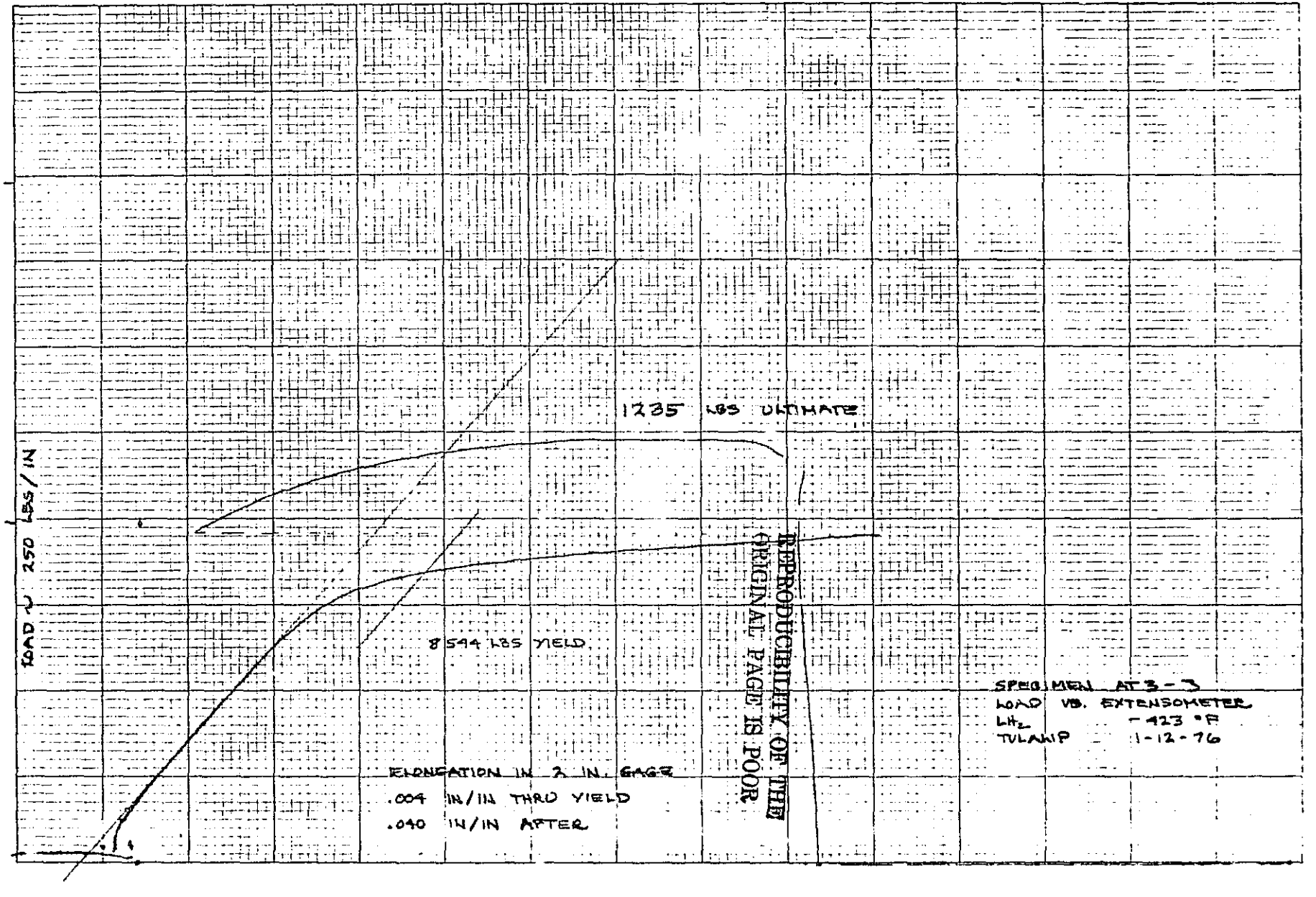
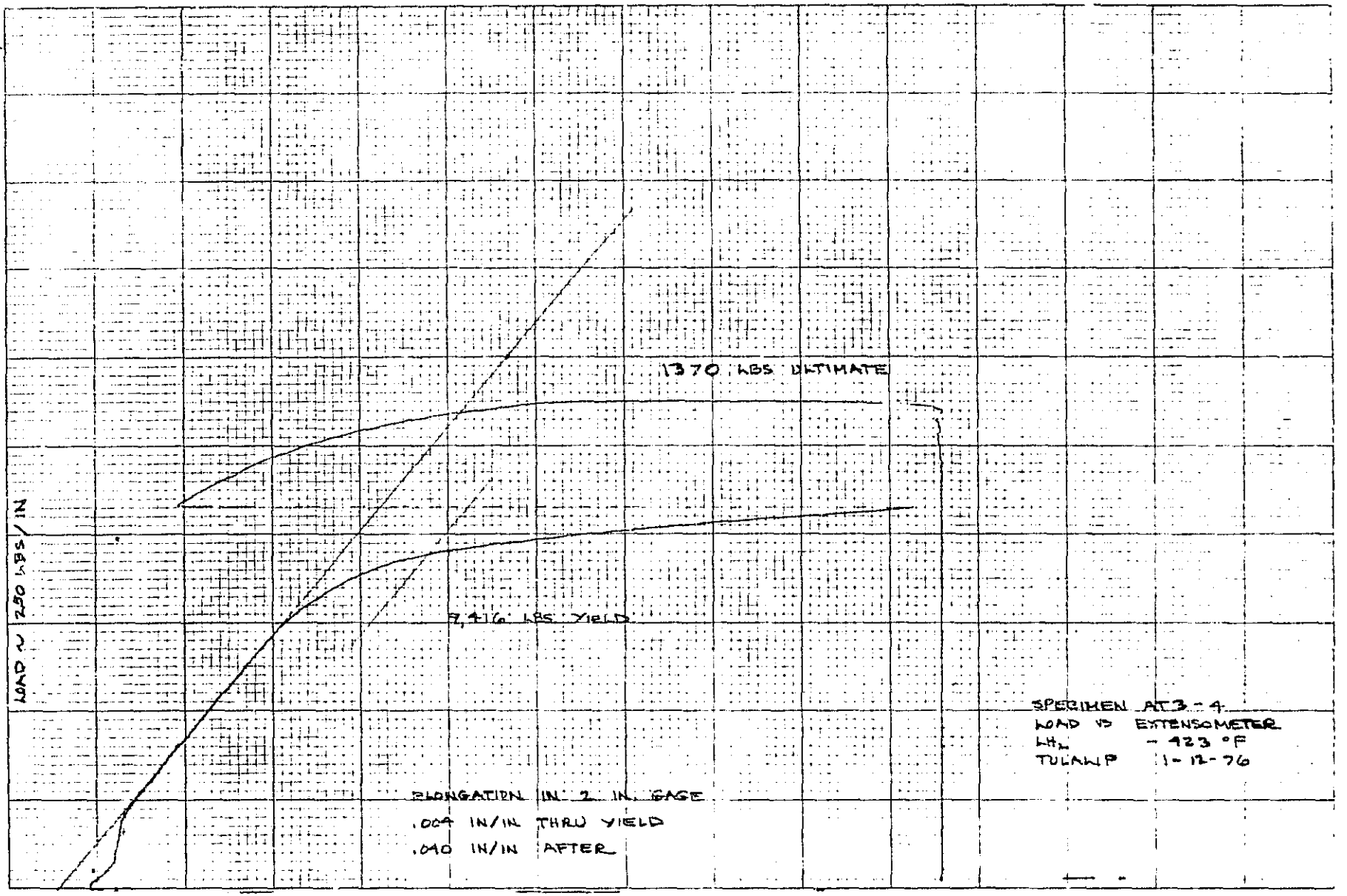
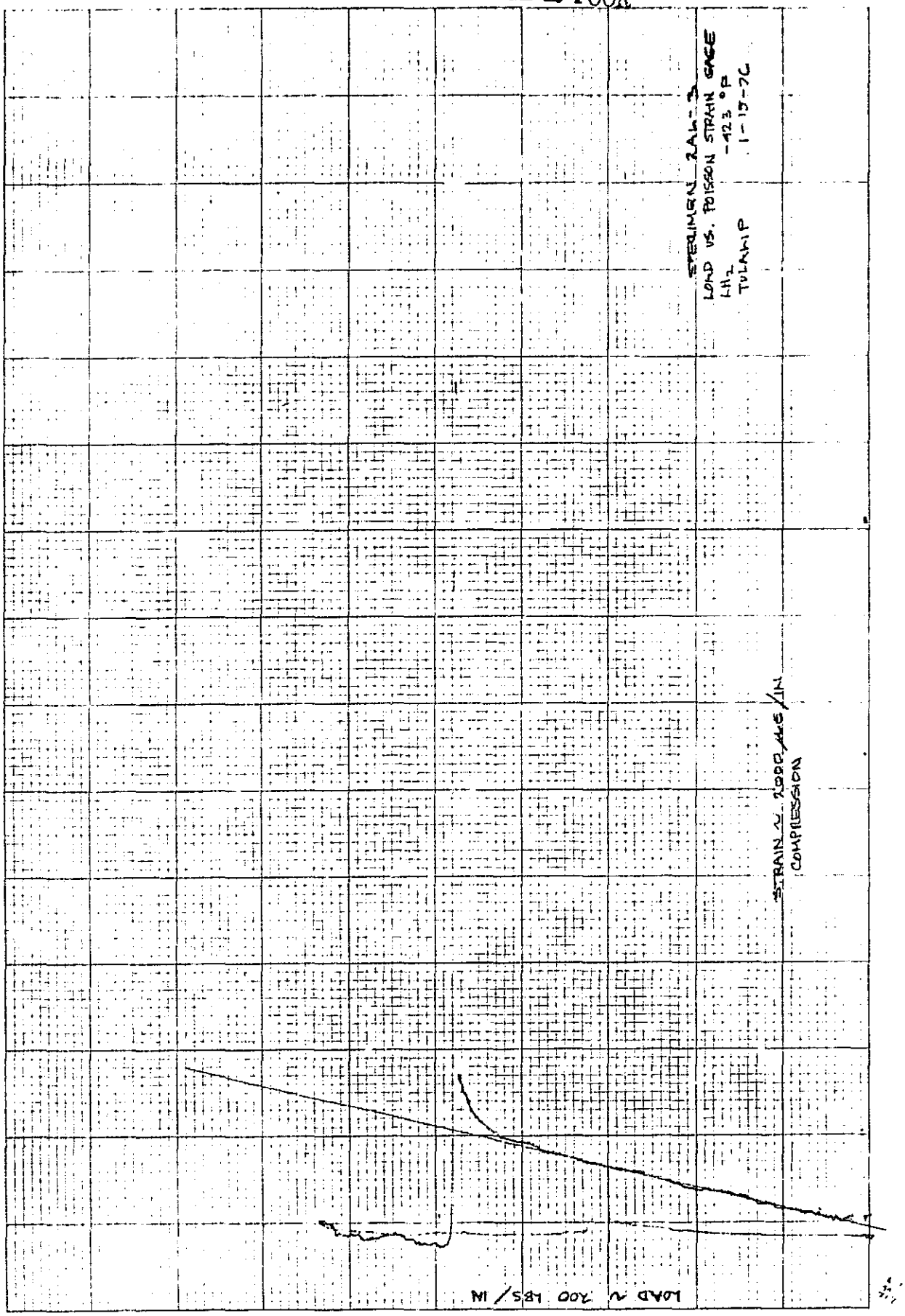
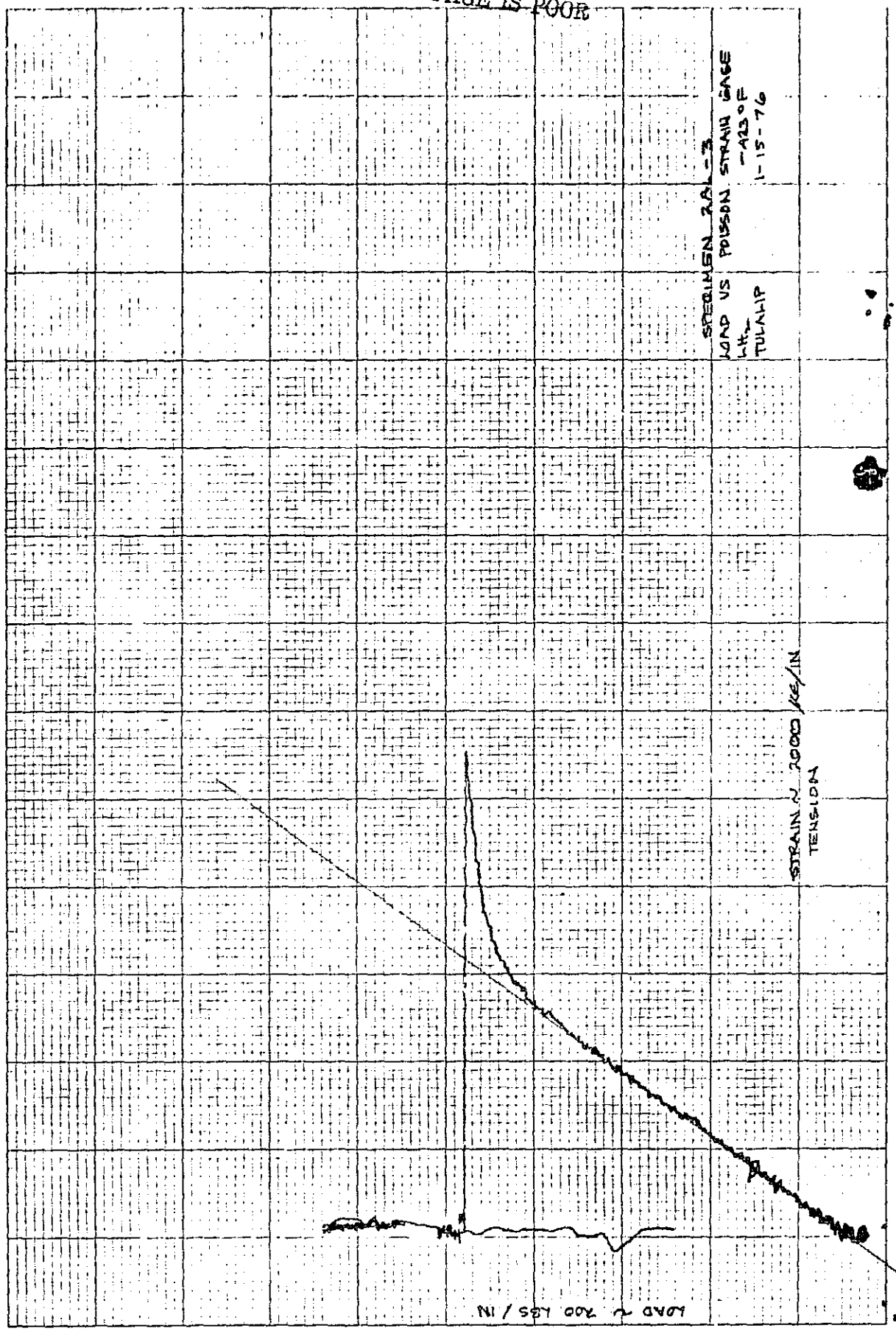
K&E 10 X 10 TO THE INCH 47 0703



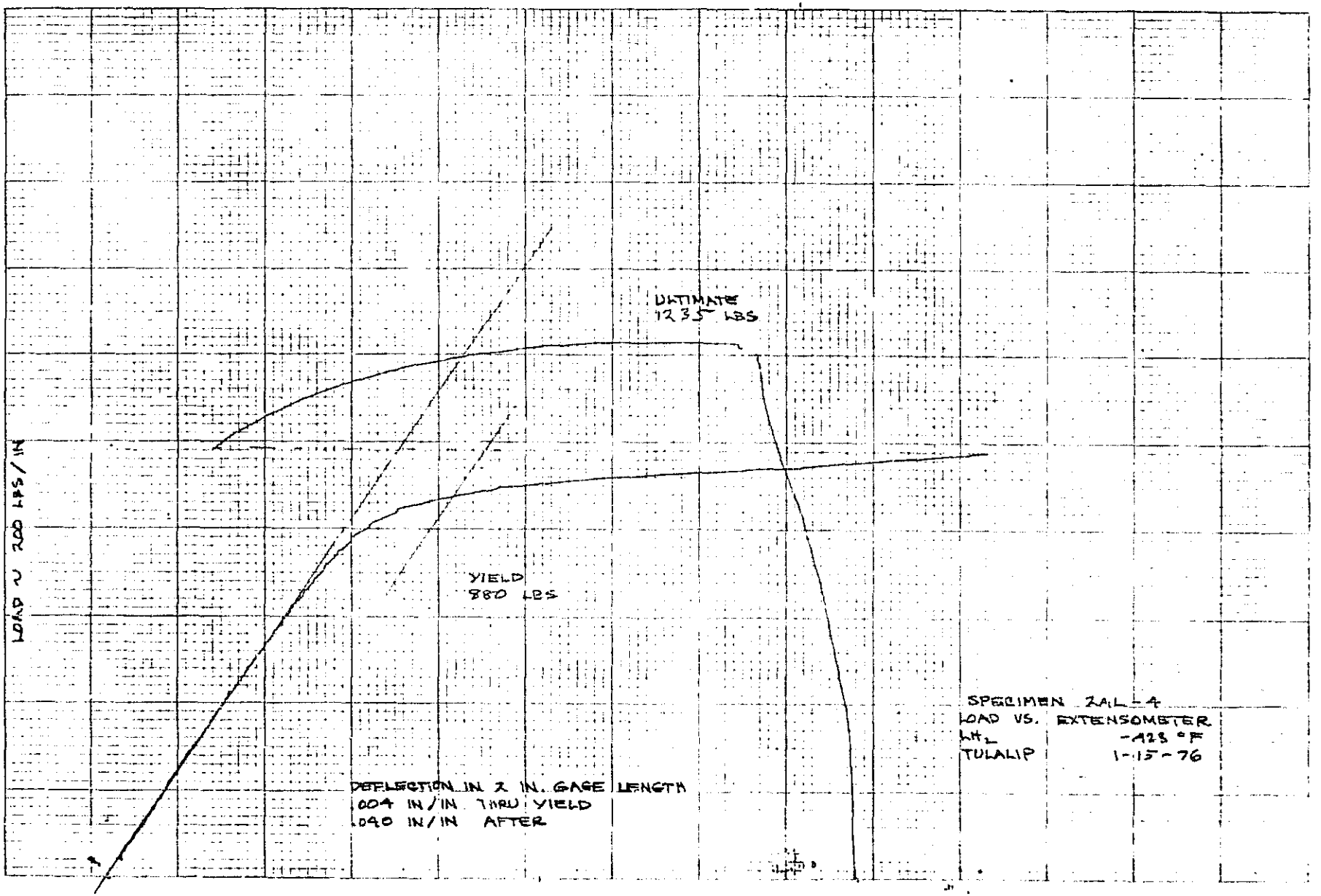


SPECIMEN ZAL-3
LOAD VS. EXTENSOMETER
-423°F
1-15-76
TULALIP
DEFLECTION IN 2 IN GAGE LENGTH
.004 IN/IN THRU YIELD
.040 IN/IN AFTER
YIELD 880 KIPS
ULTIMATE 1265 KIPS
LOAD ~ 200 KIPS/IN



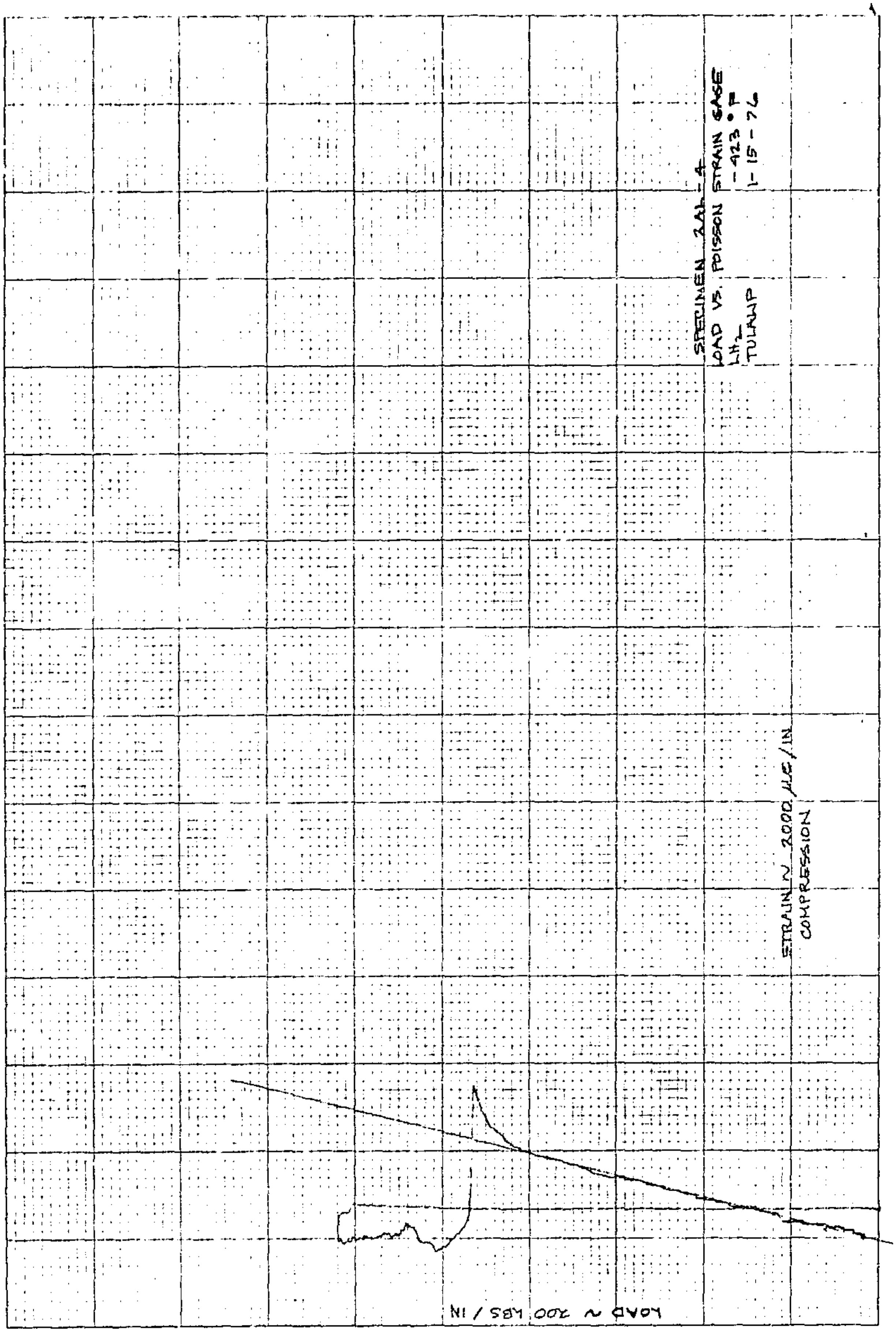


2AL-4
1-15-76



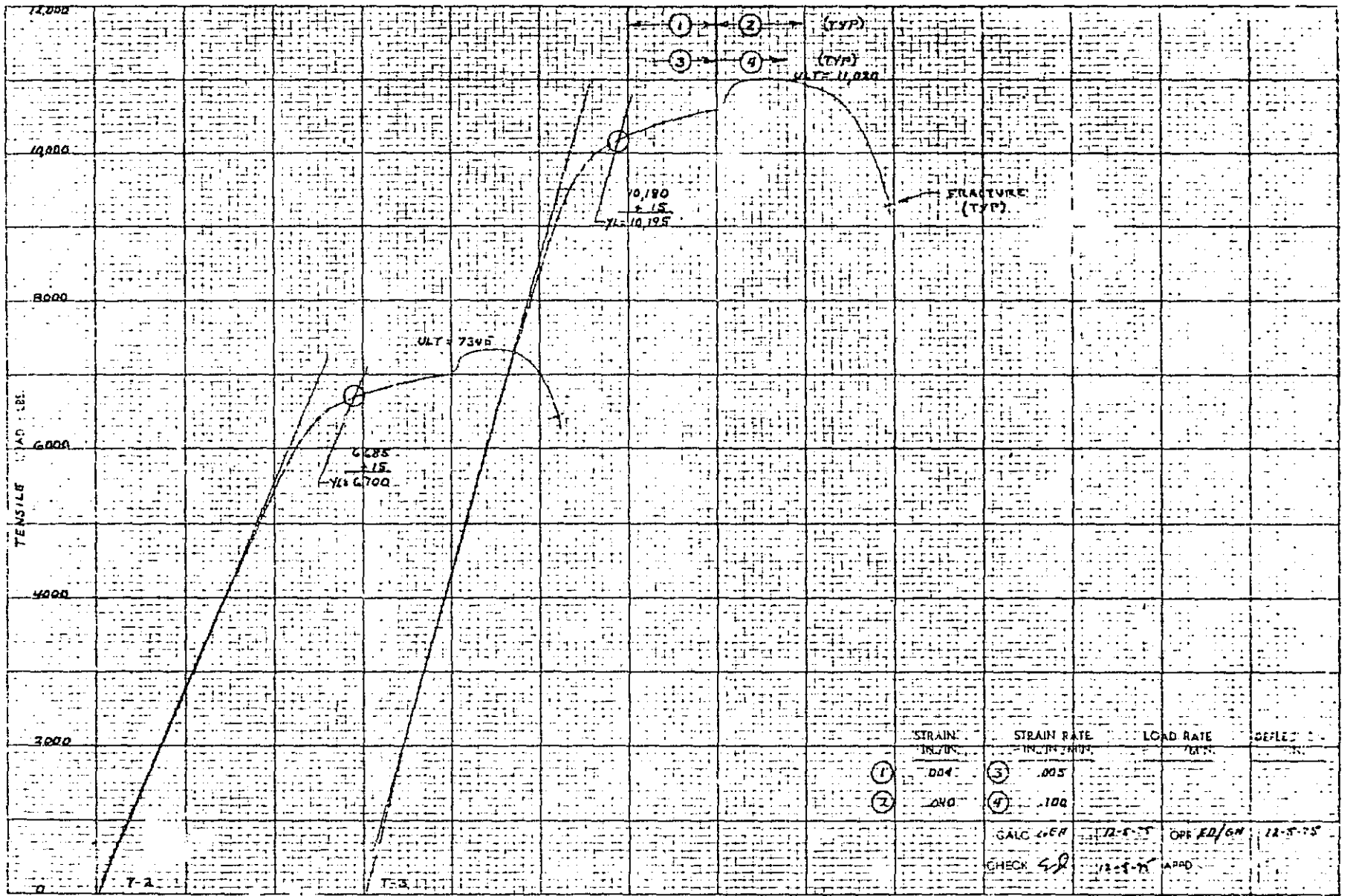
176

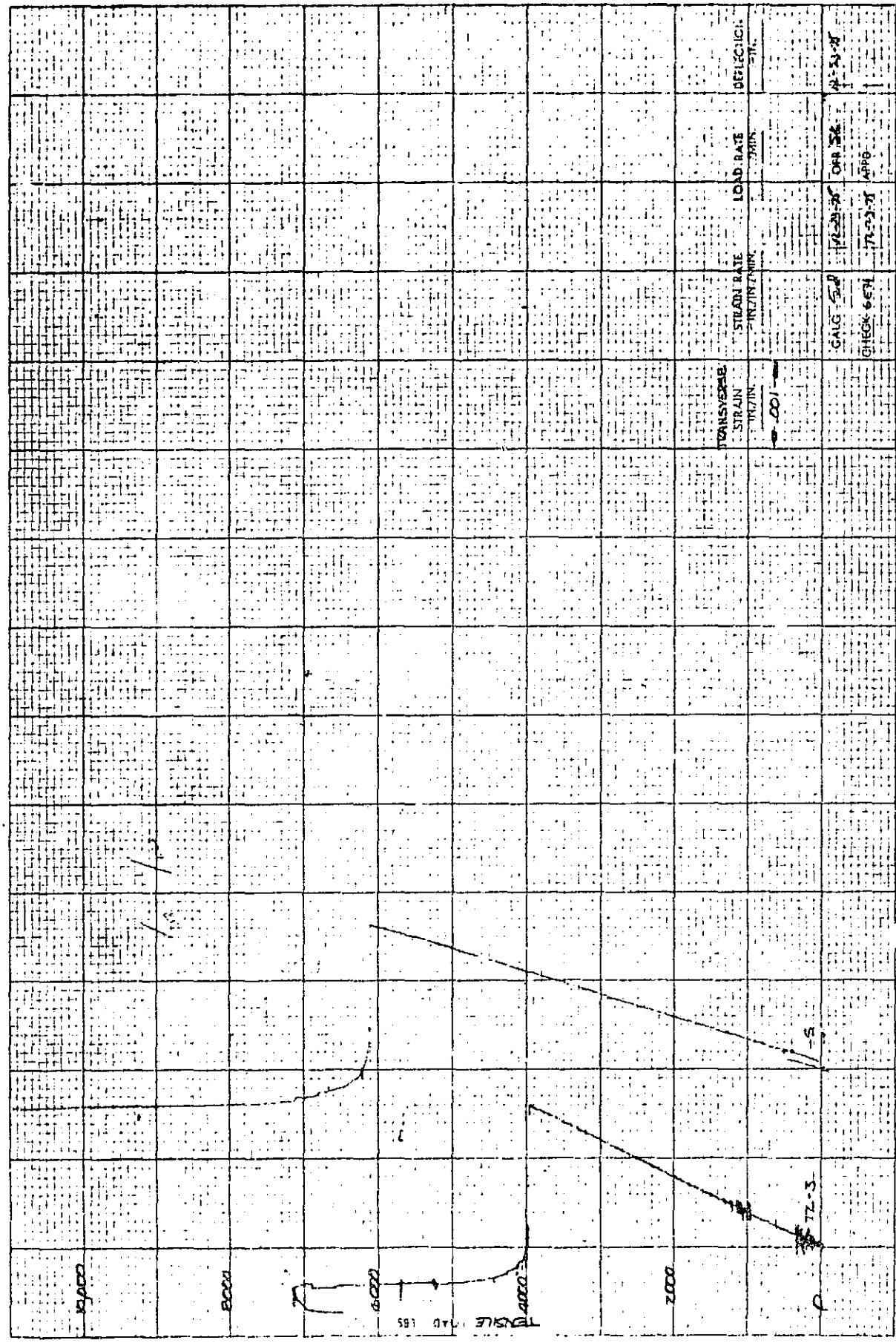
K+E 10 X 10 TO THE INCH 47 0703

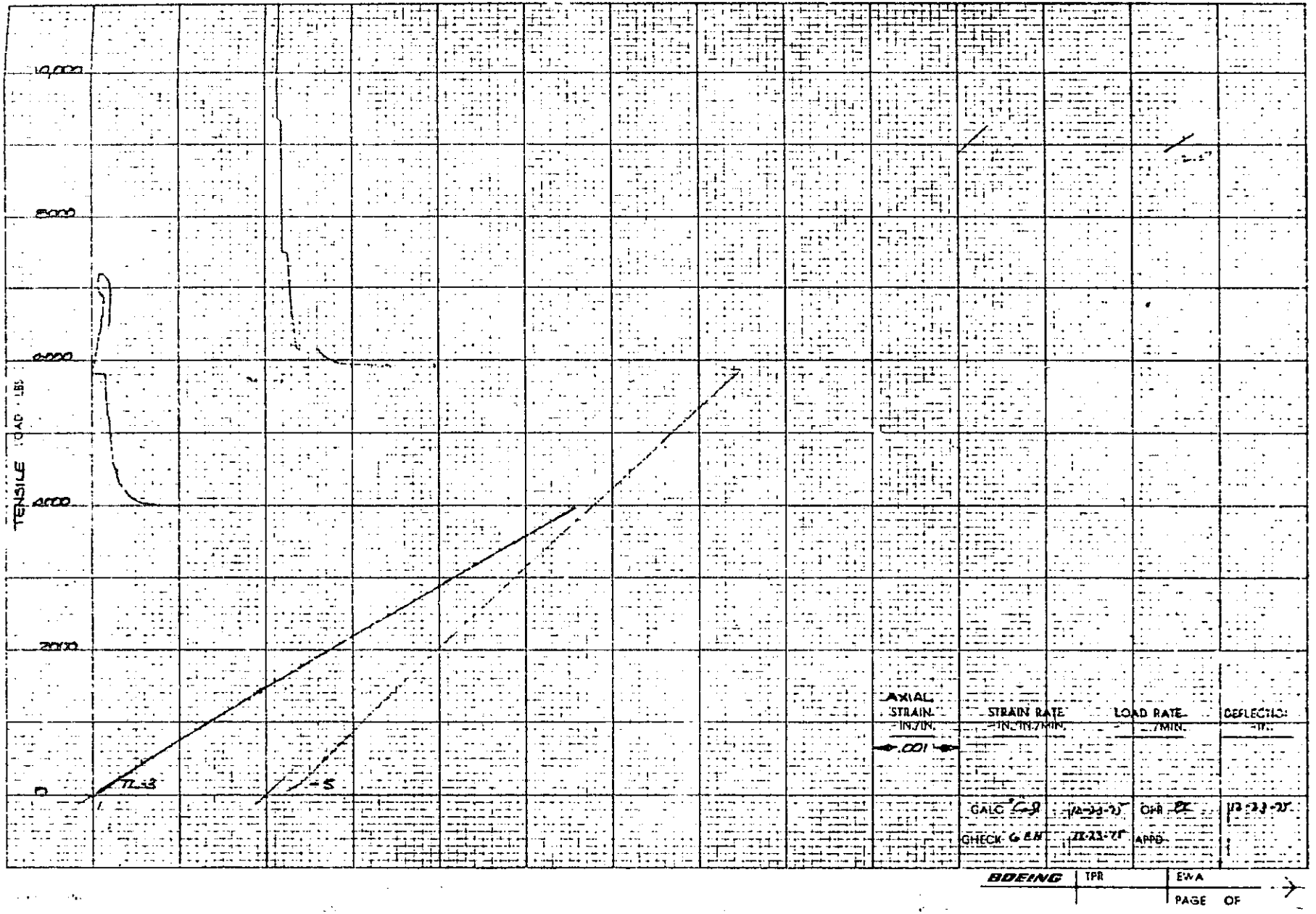


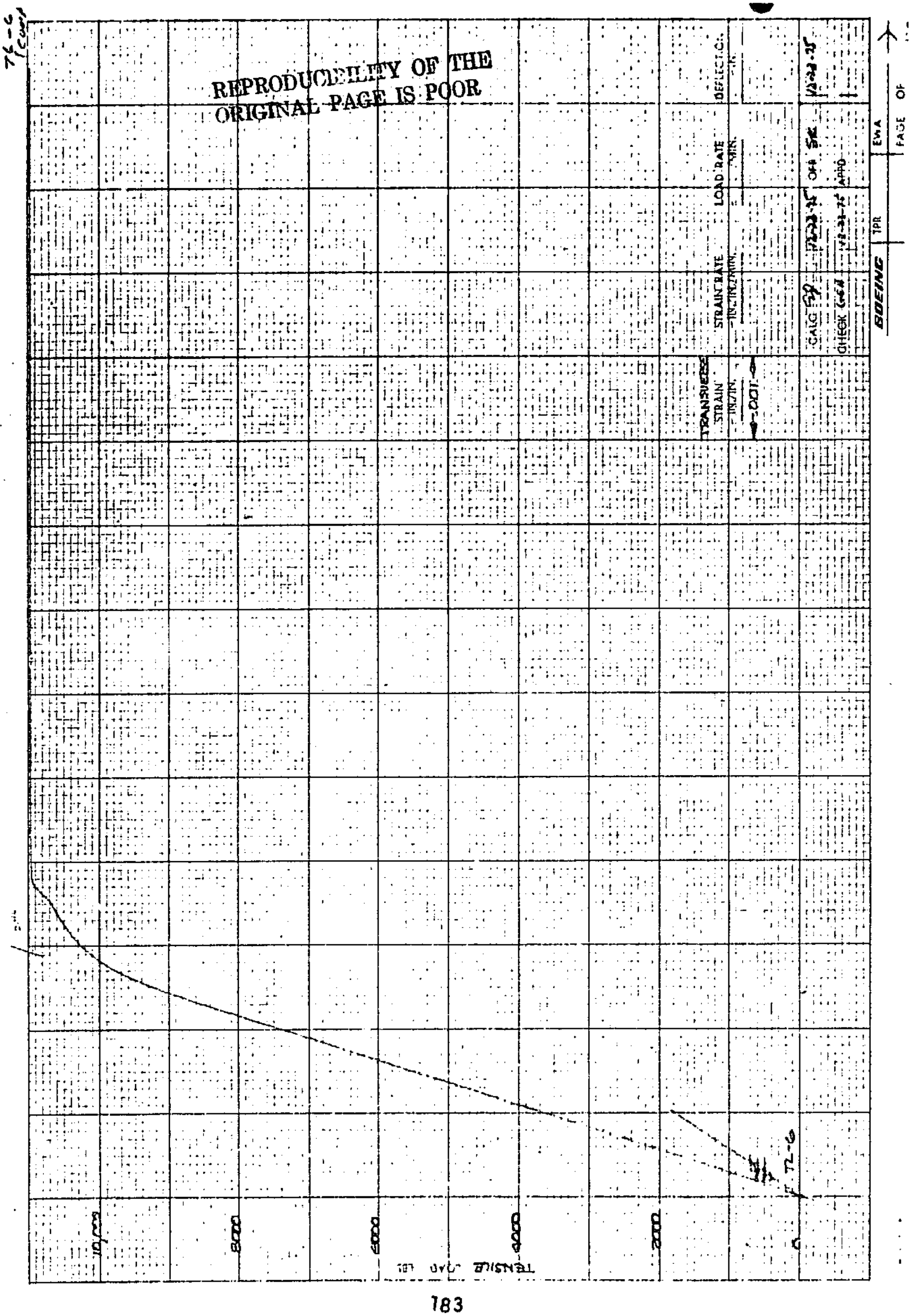
SPECIMEN 2AL-4
LOAD VS. POISSON STRAIN GAGE
LH2 -423 °F
TULAHP 1-15-76
STRAIN ~ 2000 µε/IN
COMPRESSION
LOAD ~ 200 LBS / IN

ZAL-4
1-15-76

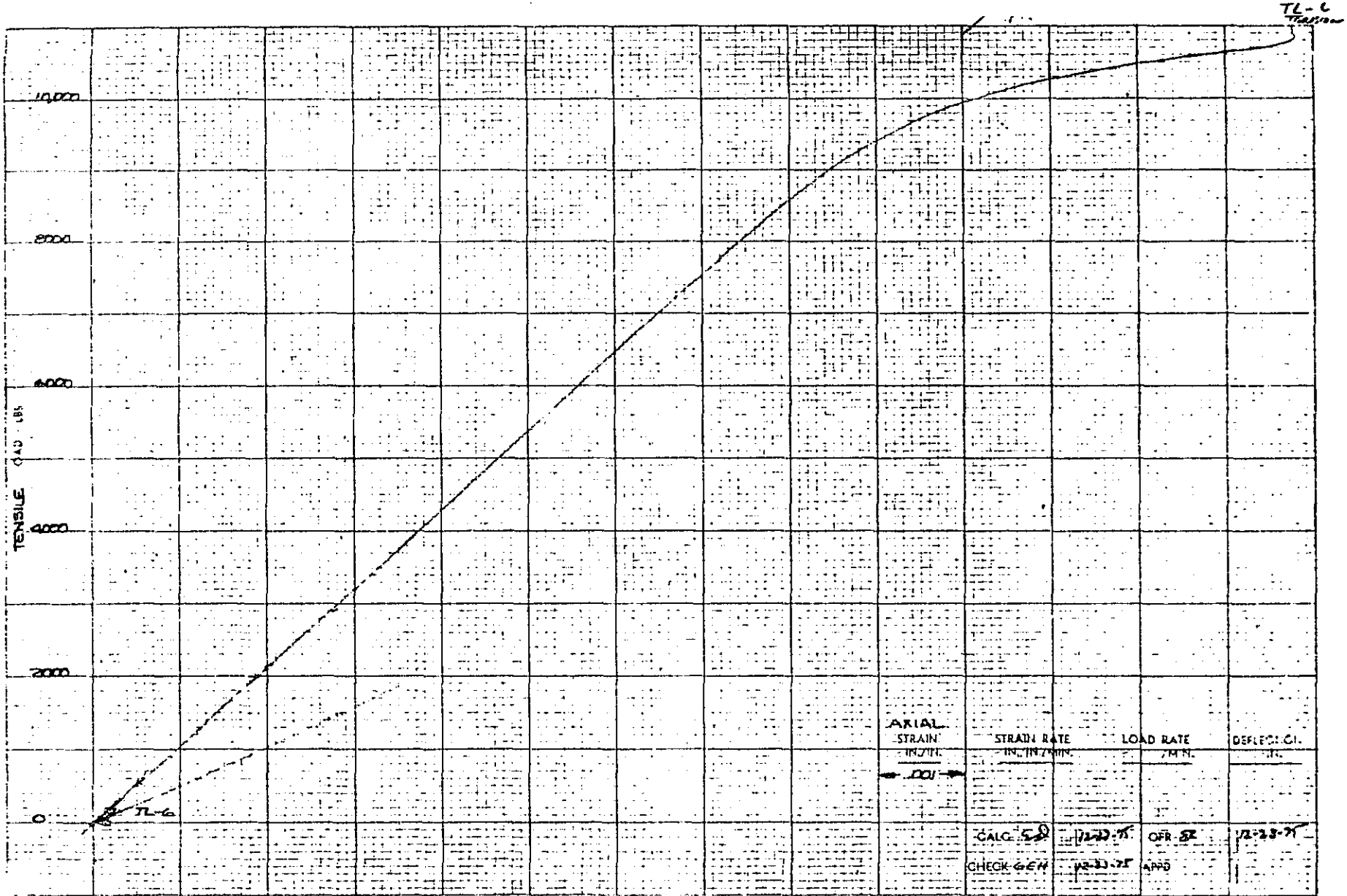


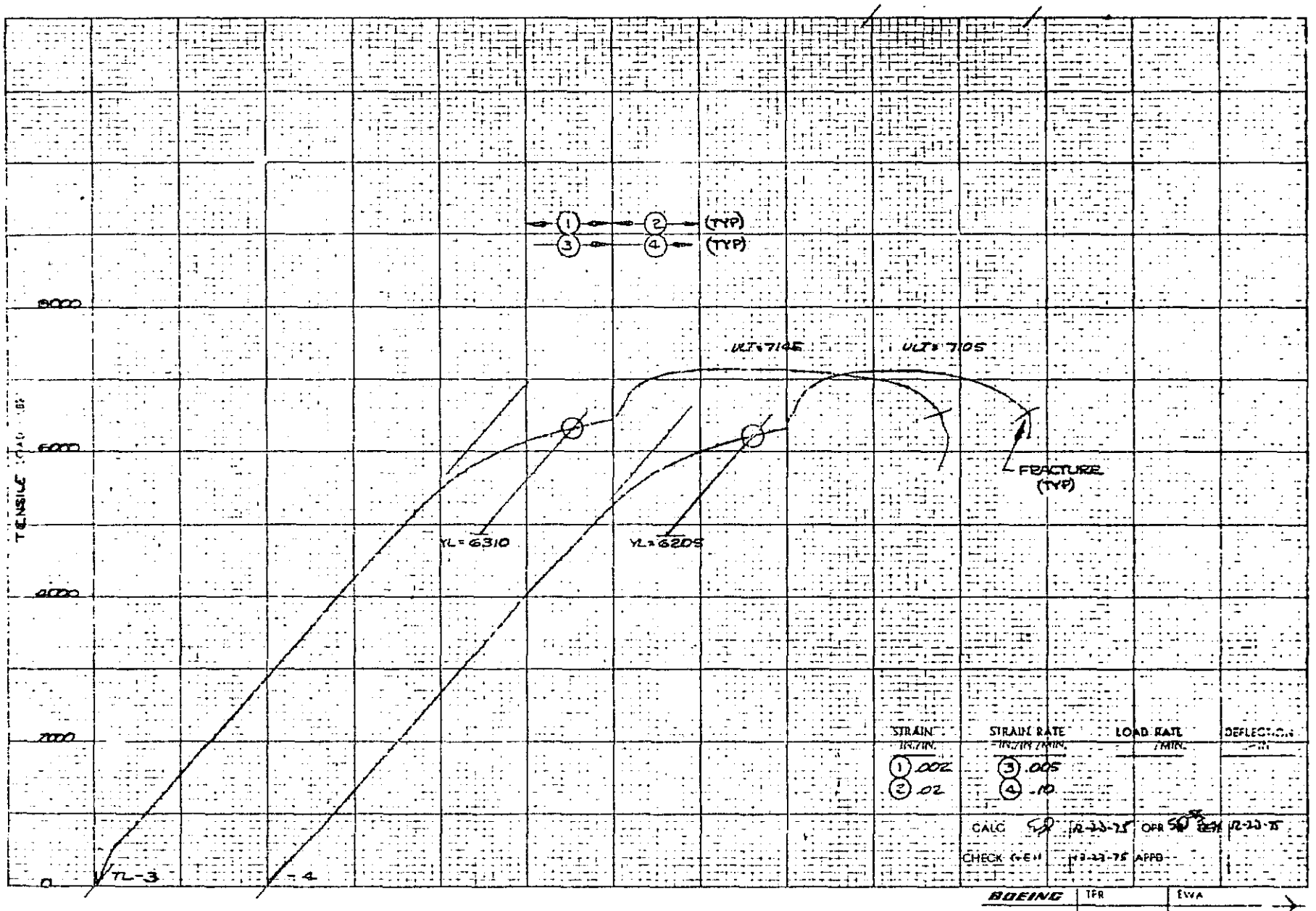


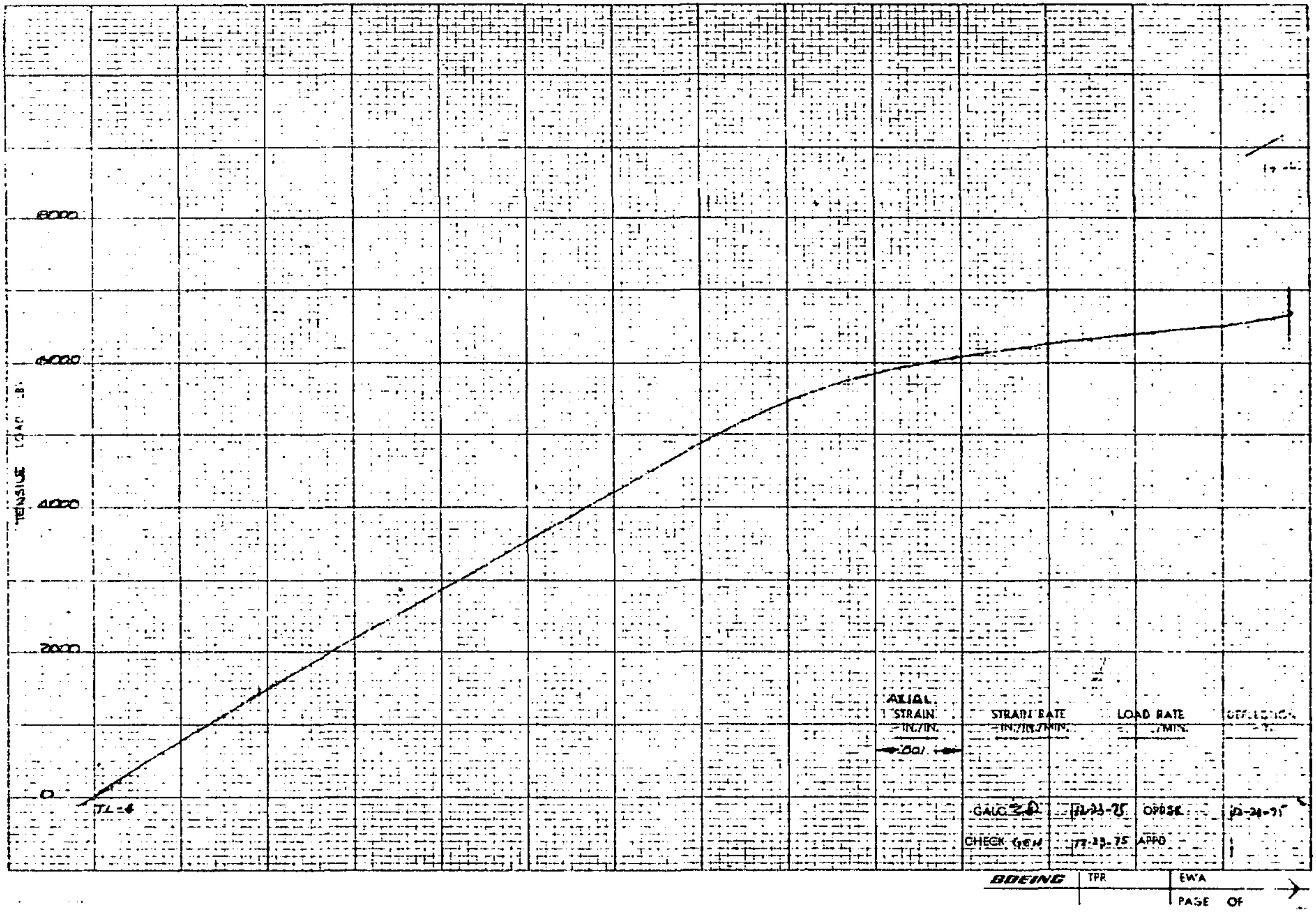




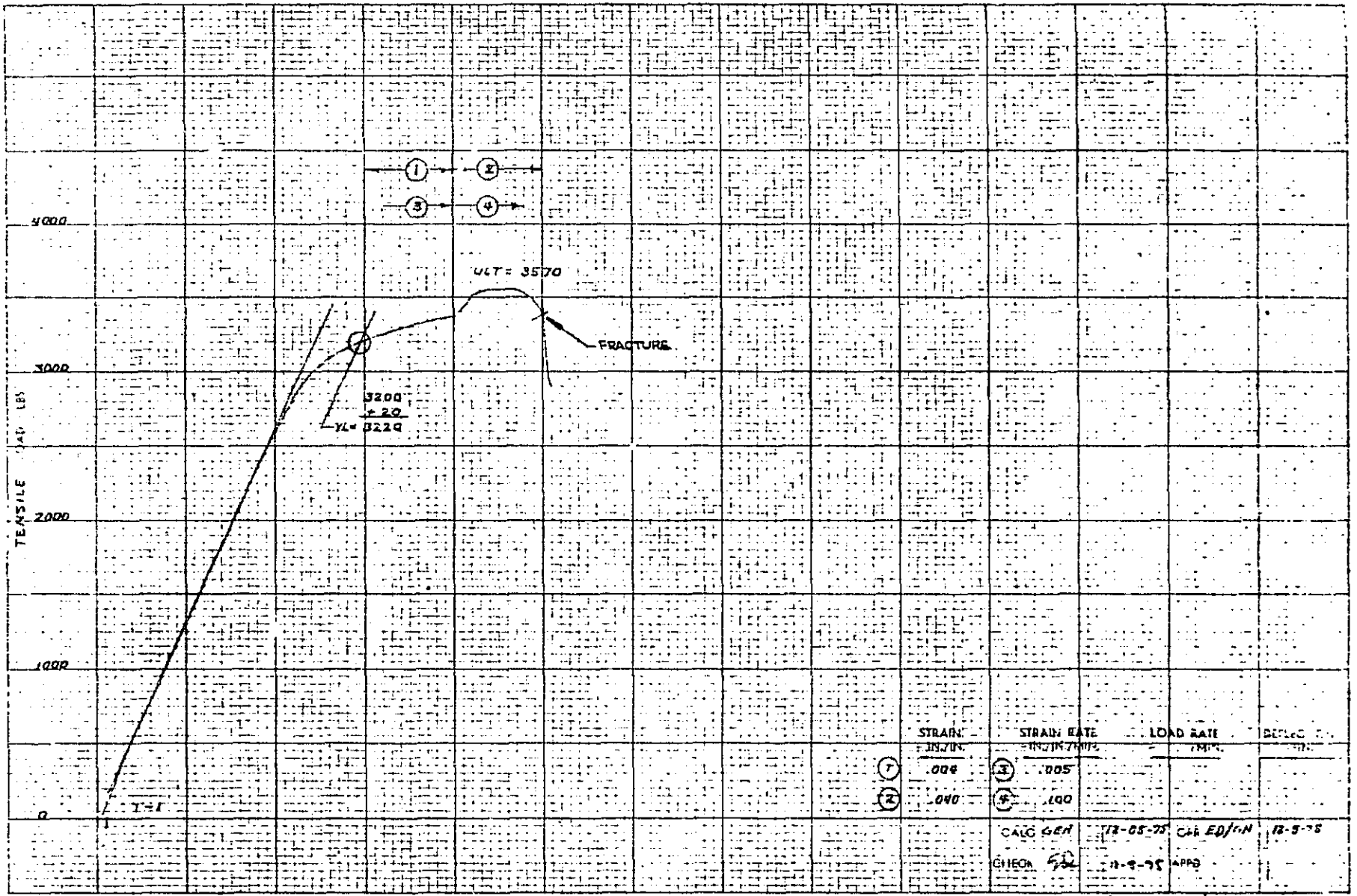
TL-6
Tension

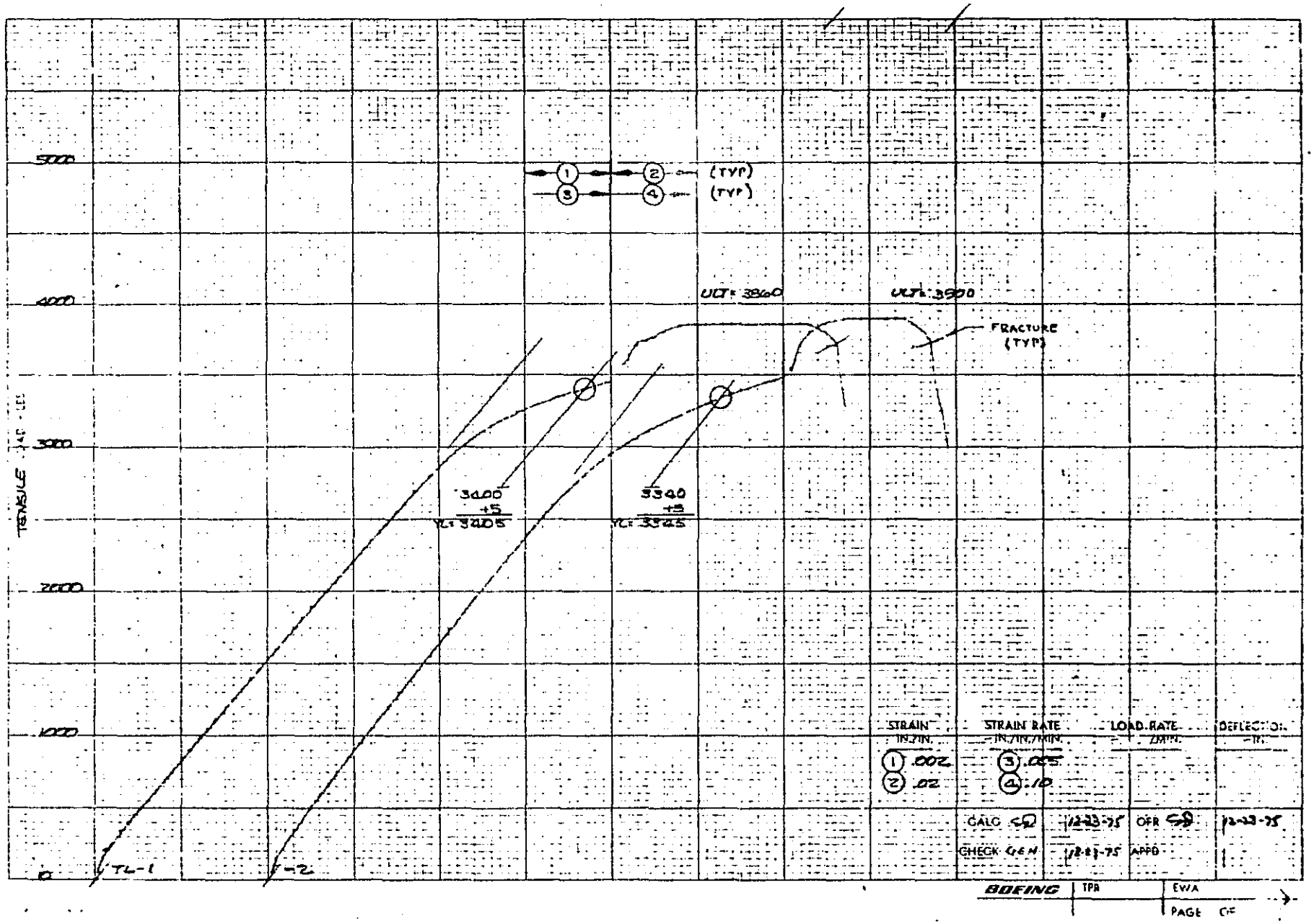


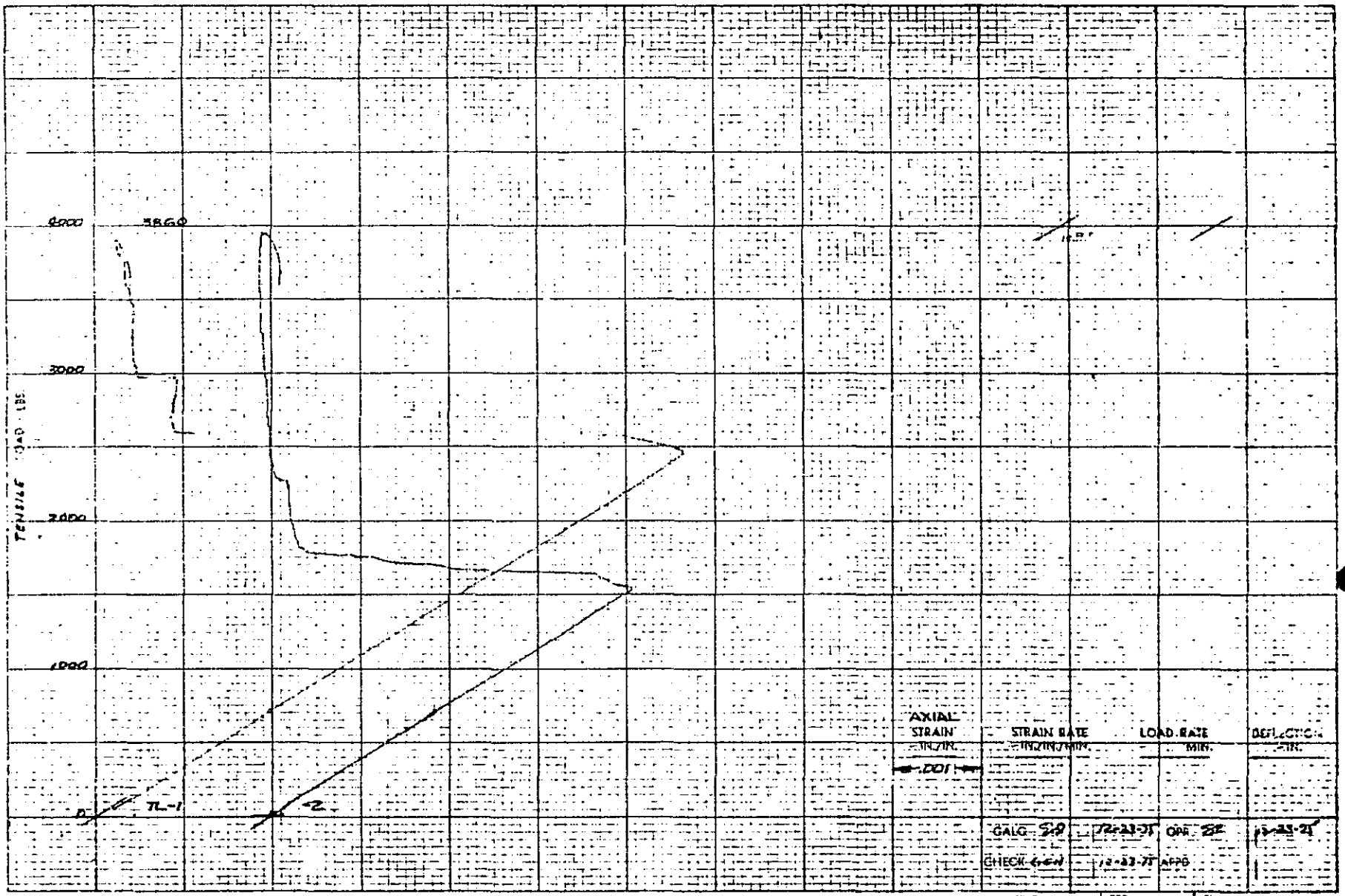


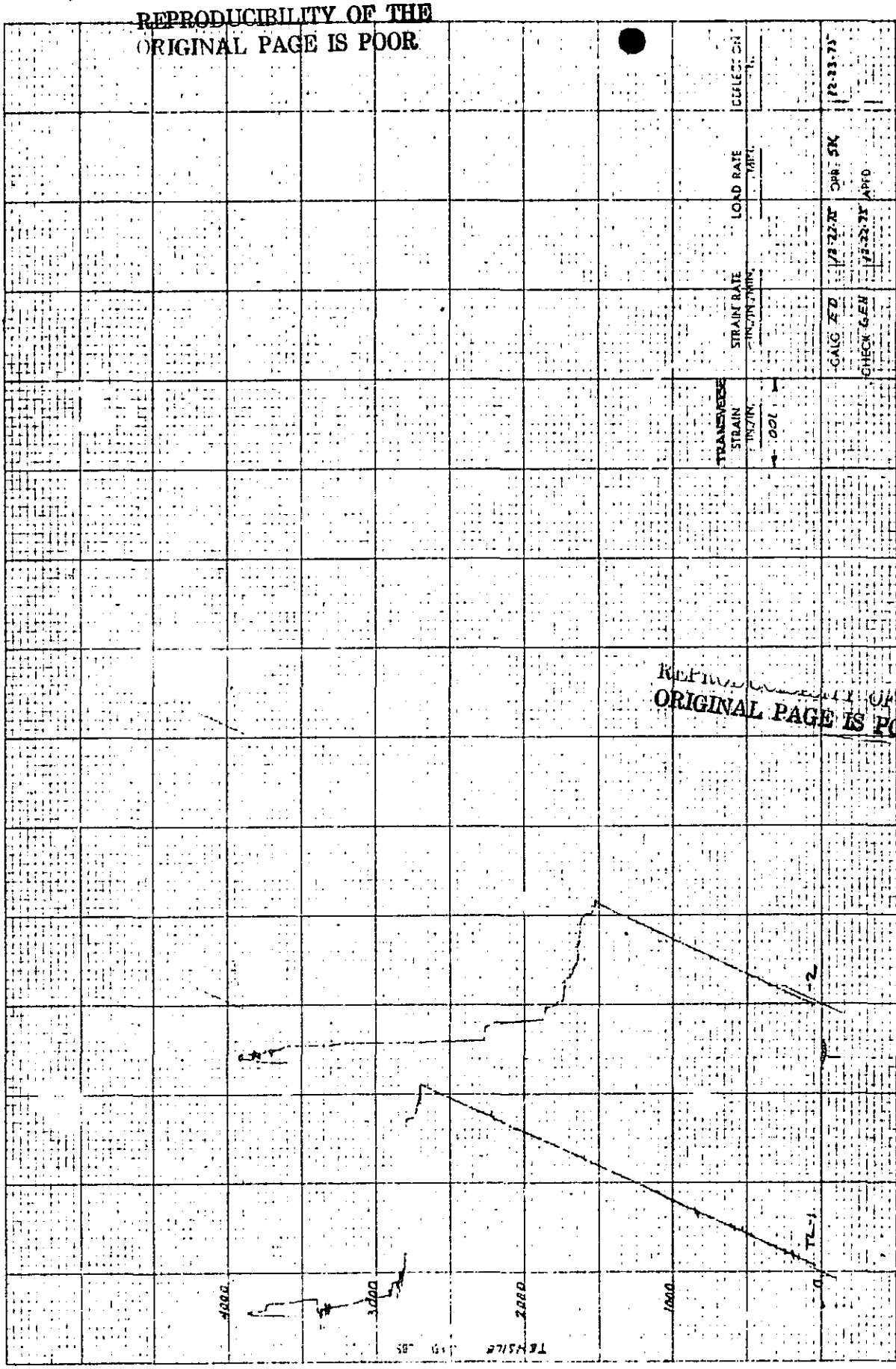


For machine only

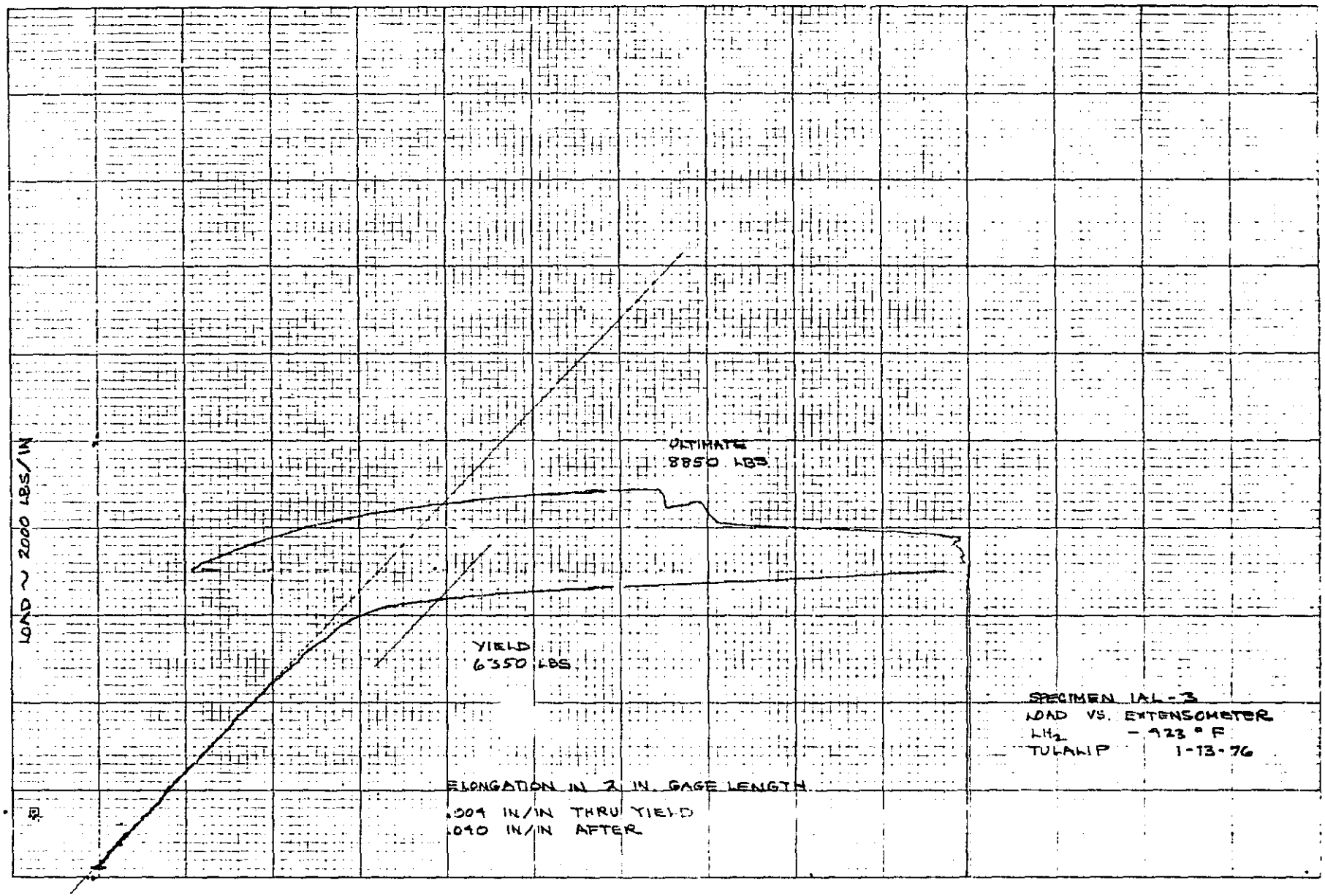


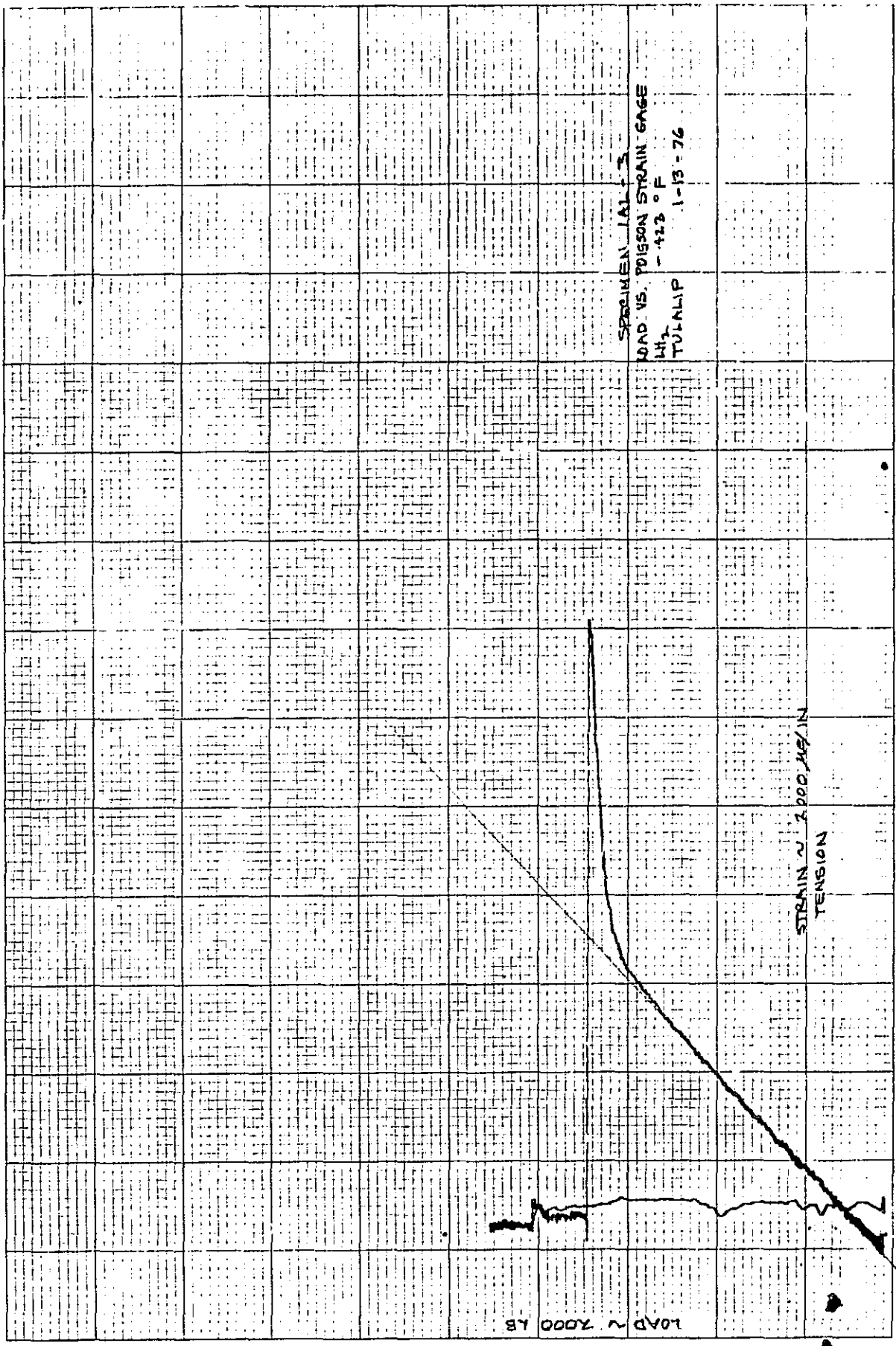

5000
4000
3000
2000
1000
0
TENSILE
(TYP)
(TYP)
ULT: 3860
ULT: 3900
FRACTURE (TYP)
3400 +5
YL: 3405
3340 +5
YL: 3345
TL-1
T-2
STRAIN IN./IN.
STRAIN RATE IN./IN./MIN.
LOAD RATE PSI/MIN.
DEFLECTION IN.
1 .002
2 .02
3 .005
4 .10
CALC
CHECK GEN
APPD
OFR
12-23-75
12-23-75
BOEING
TPR
EWA
PAGE OF

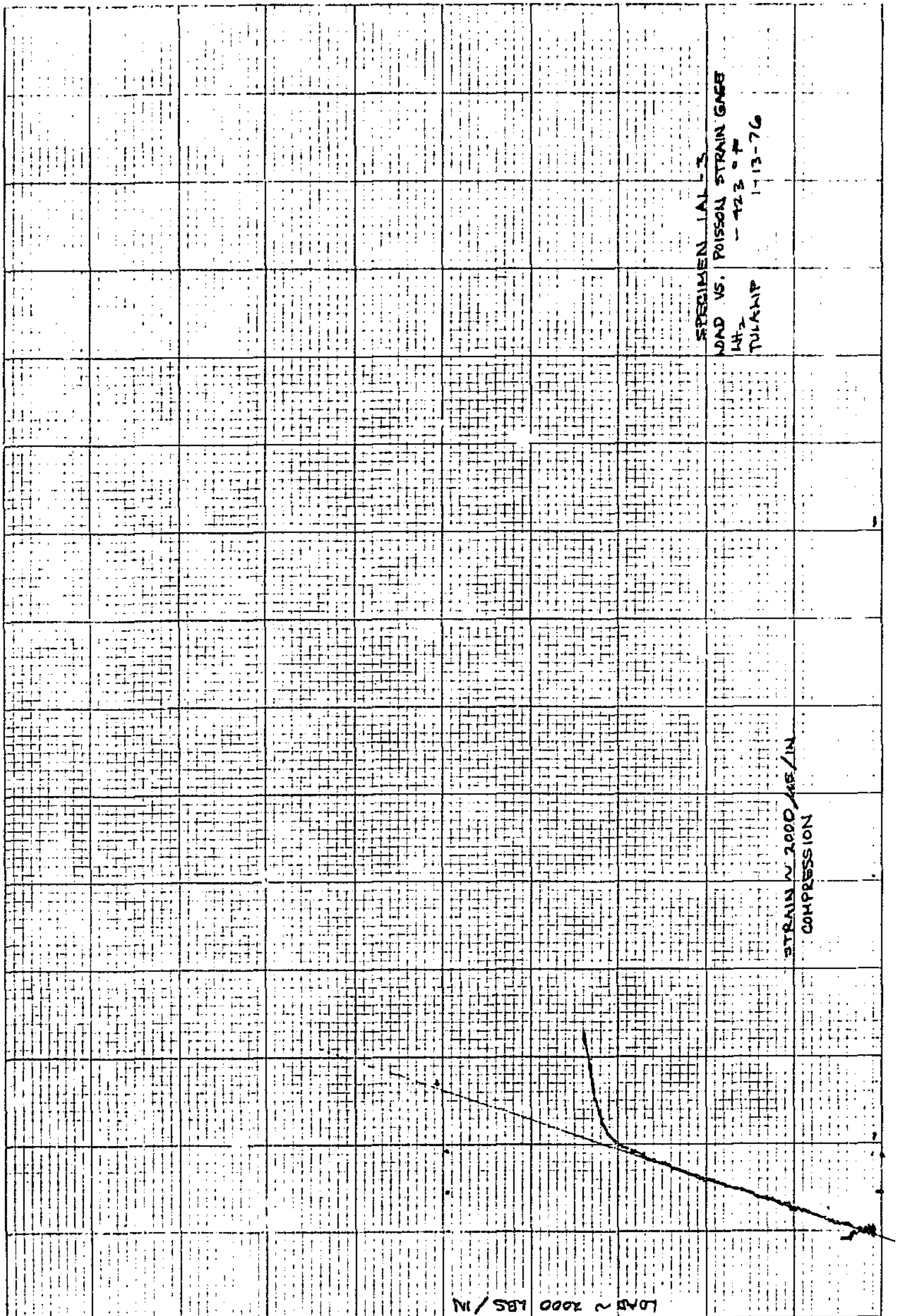


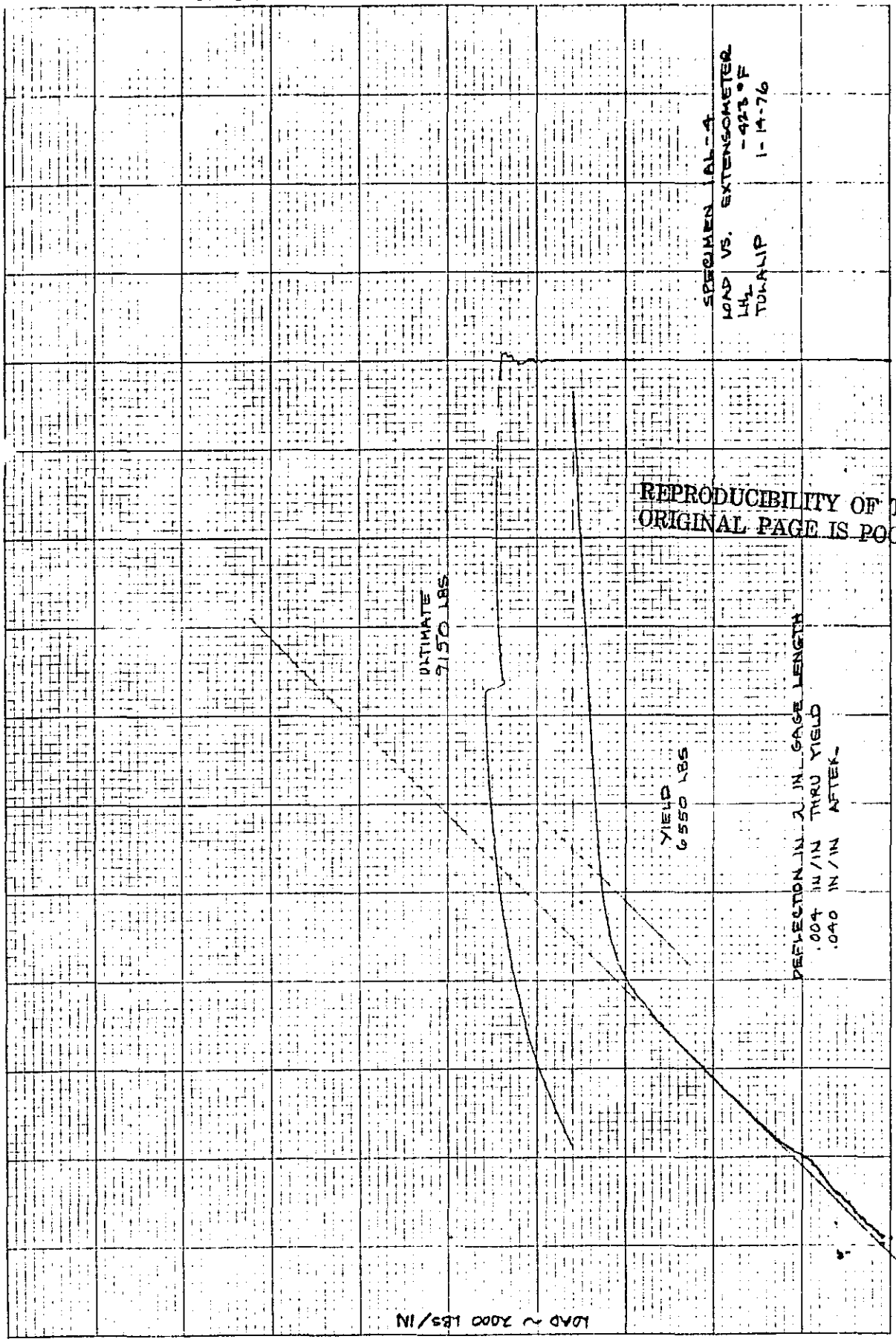


C-3


LOAD ~ 2000 LBS/IN
ULTIMATE
8850 LBS
YIELD
6350 LBS
SPECIMEN 1AL-3
LOAD VS. EXTENSOMETER
LH2 -423°F
TULAHP 1-13-76
ELONGATION IN 2 IN. GAGE LENGTH
.009 IN/IN THRU YIELD
.090 IN/IN AFTER

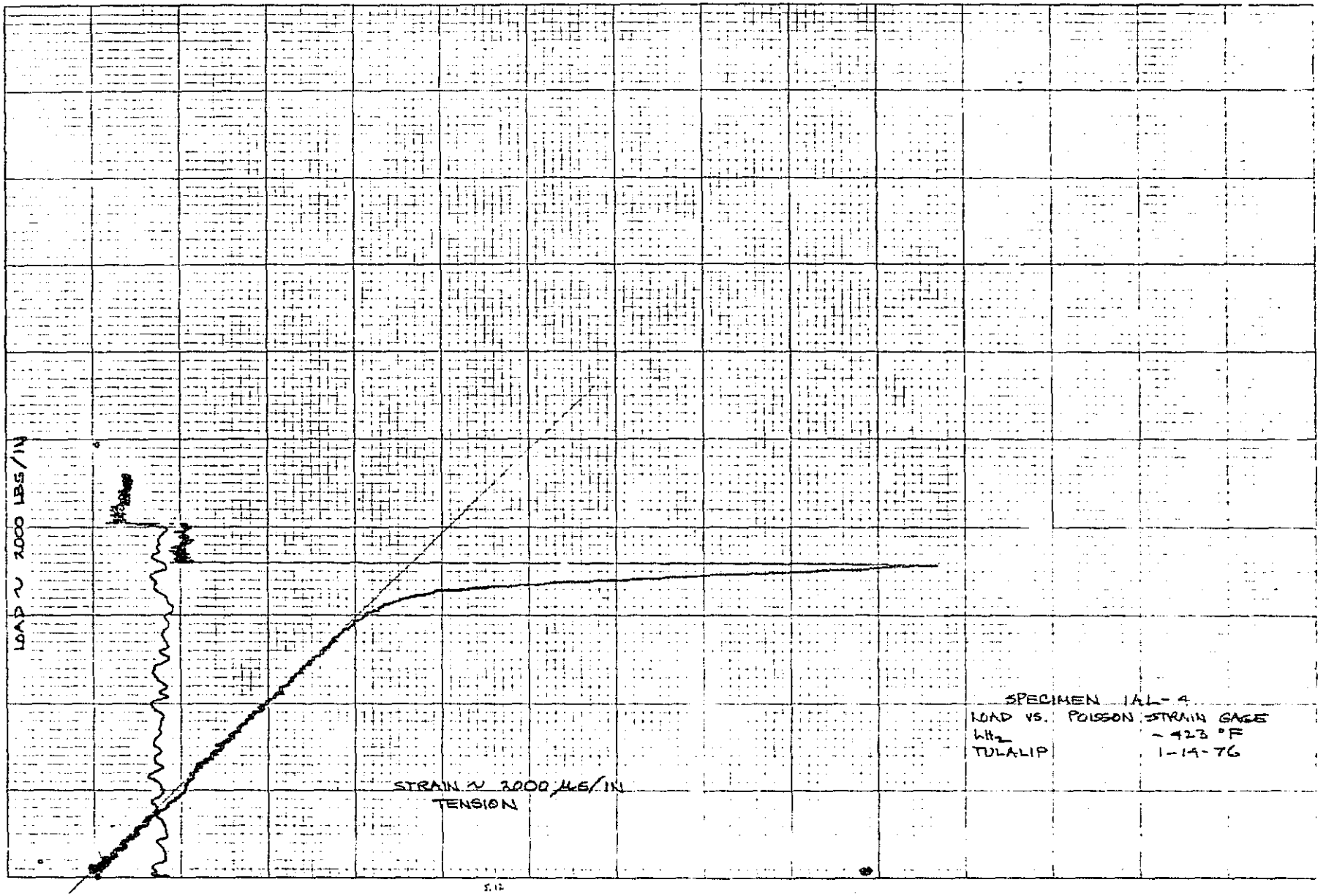



SPECIMEN IAL-3
LOAD VS. POISSON STRAIN GAGE
W2 -423°F
TULALIP 1-13-76
STRAIN ~ 2000 µε/IN
COMPRESSION
LOAD ~ 2000 LBS/IN



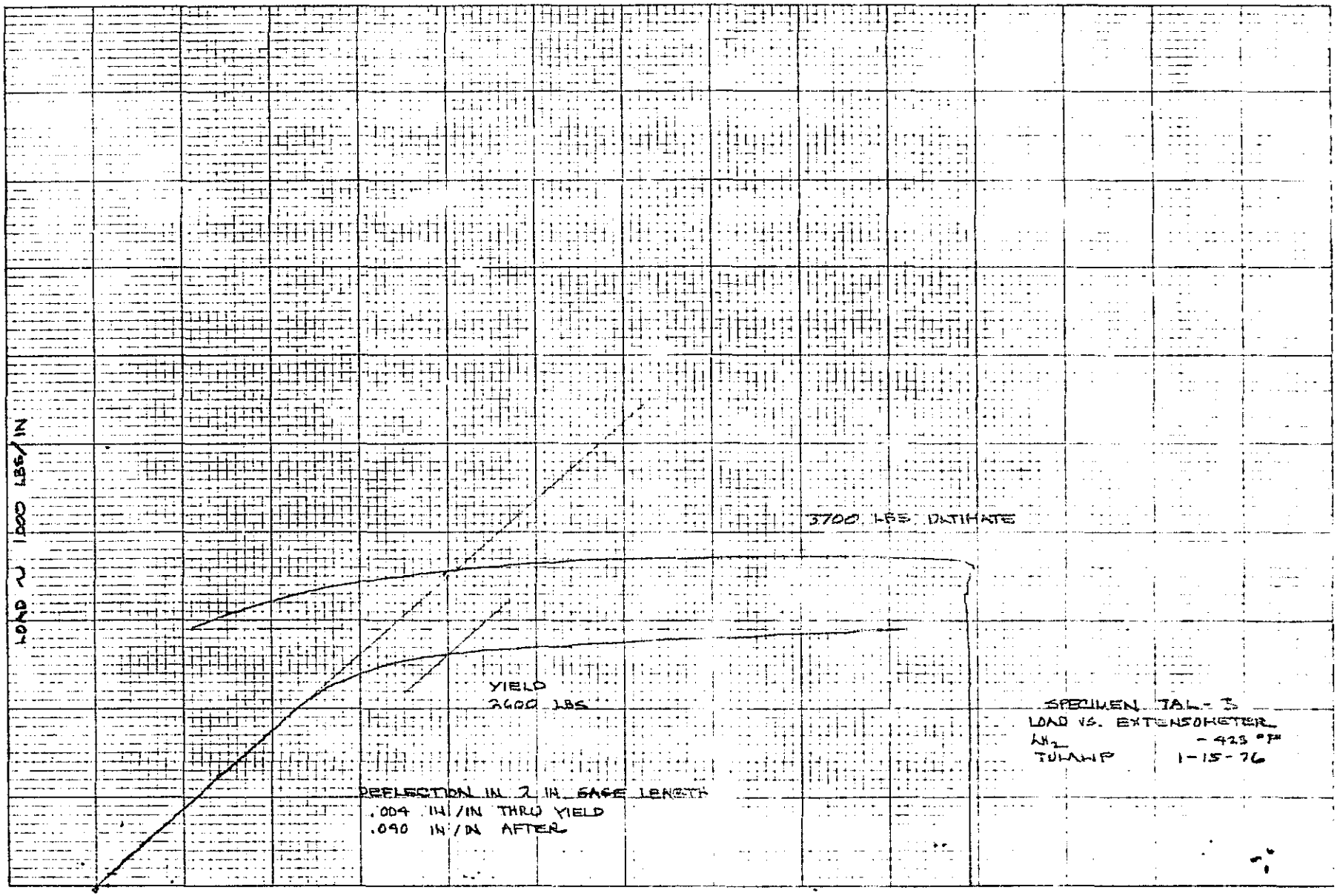
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

AL-4
1-14-76

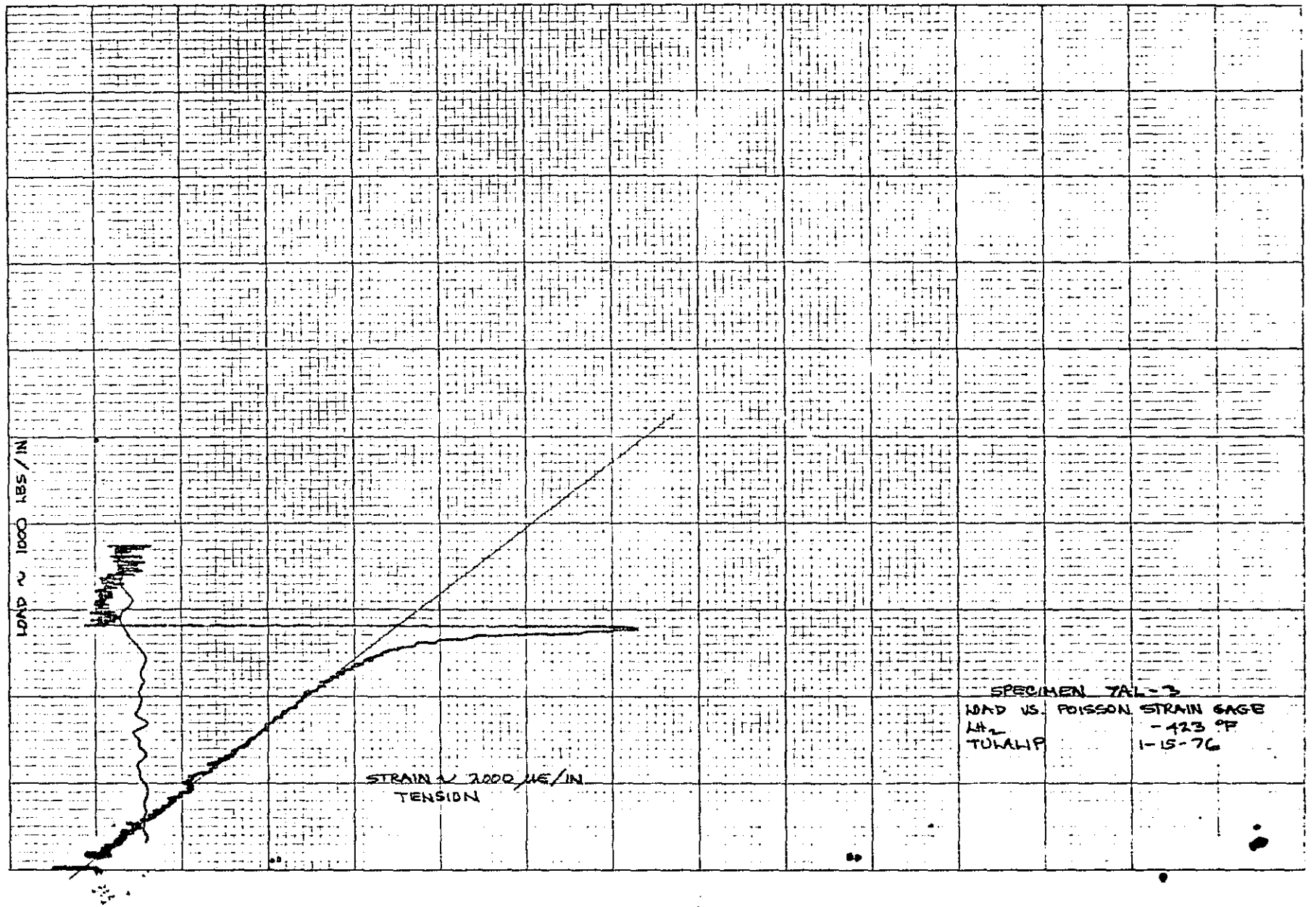

LOAD ~ 2000 LBS/IN
STRAIN ~ 2000 μE/IN
TENSION
SPECIMEN AL-4
LOAD VS. POISSON STRAIN GAGE
LH2 ~423 °F
TULALIP 1-14-76

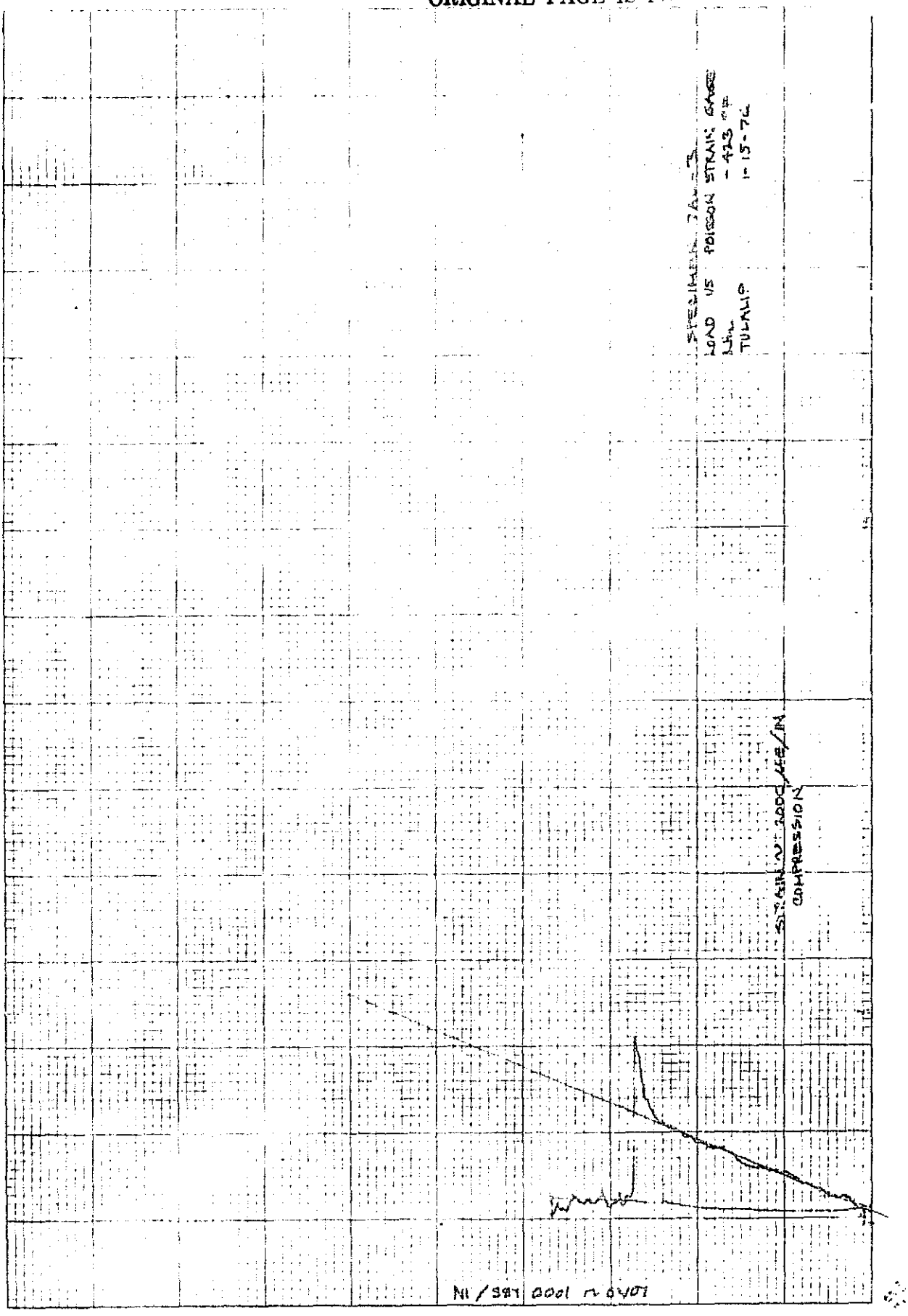
SPECIMEN 1AL-4
LOAD VS. POISSON STRAIN GAGE
-423°F
1-14-76
LHe
TULANE
STRAIN @ 2000 μE/IN
COMPRESSION
LOAD ~ 2000 LBS/IN

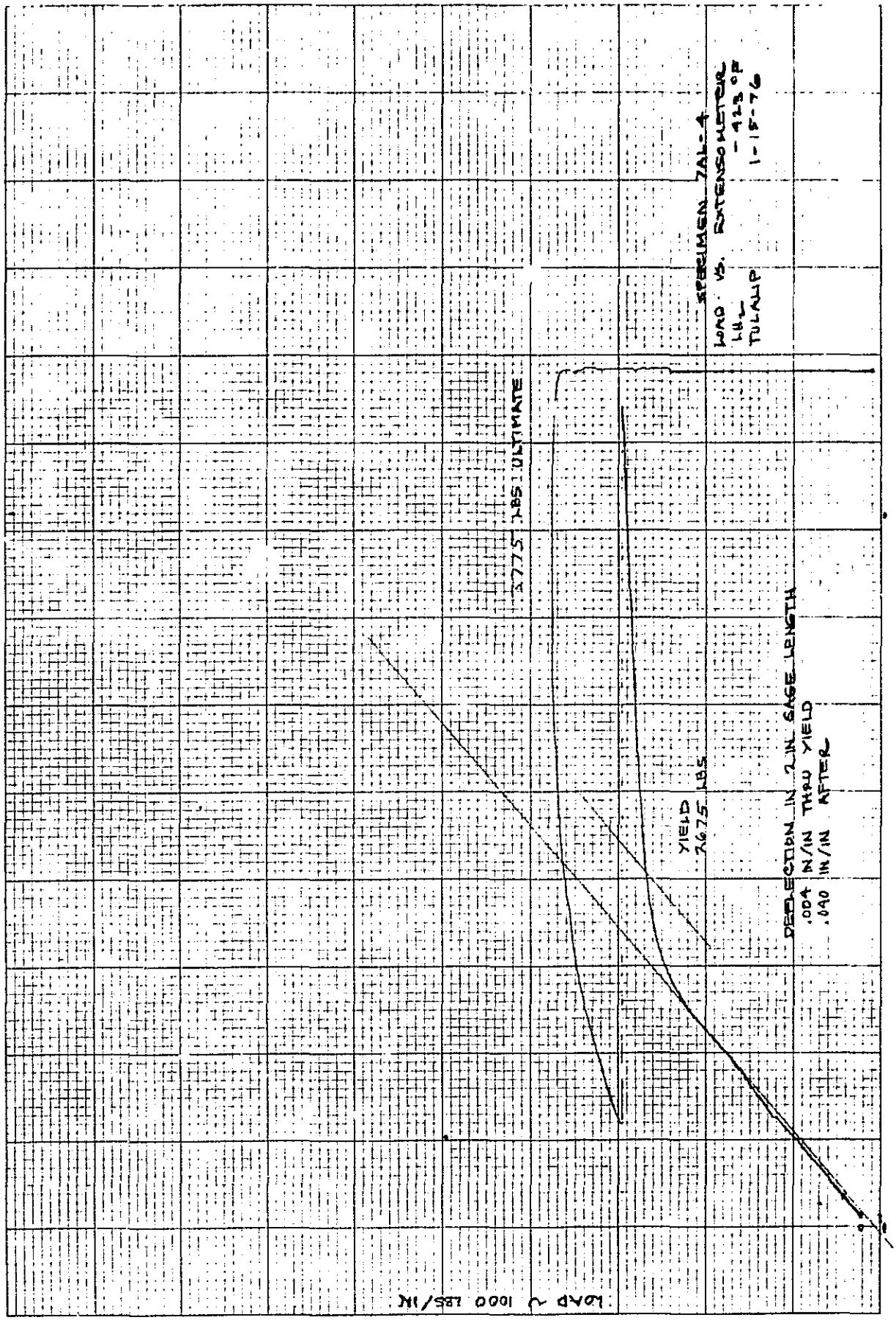
1AL-4
1-14-76


LOAD N 1000 LBS/IN
3700 LBS. ULTIMATE
YIELD
3600 LBS
DEFLECTION IN 2 IN GAGE LENGTH
.004 IN/IN THRU YIELD
.090 IN/IN AFTER
SPECIMEN TAL-5
LOAD VS. EXTENSOMETER
-423 °F
TULAMP
1-15-76

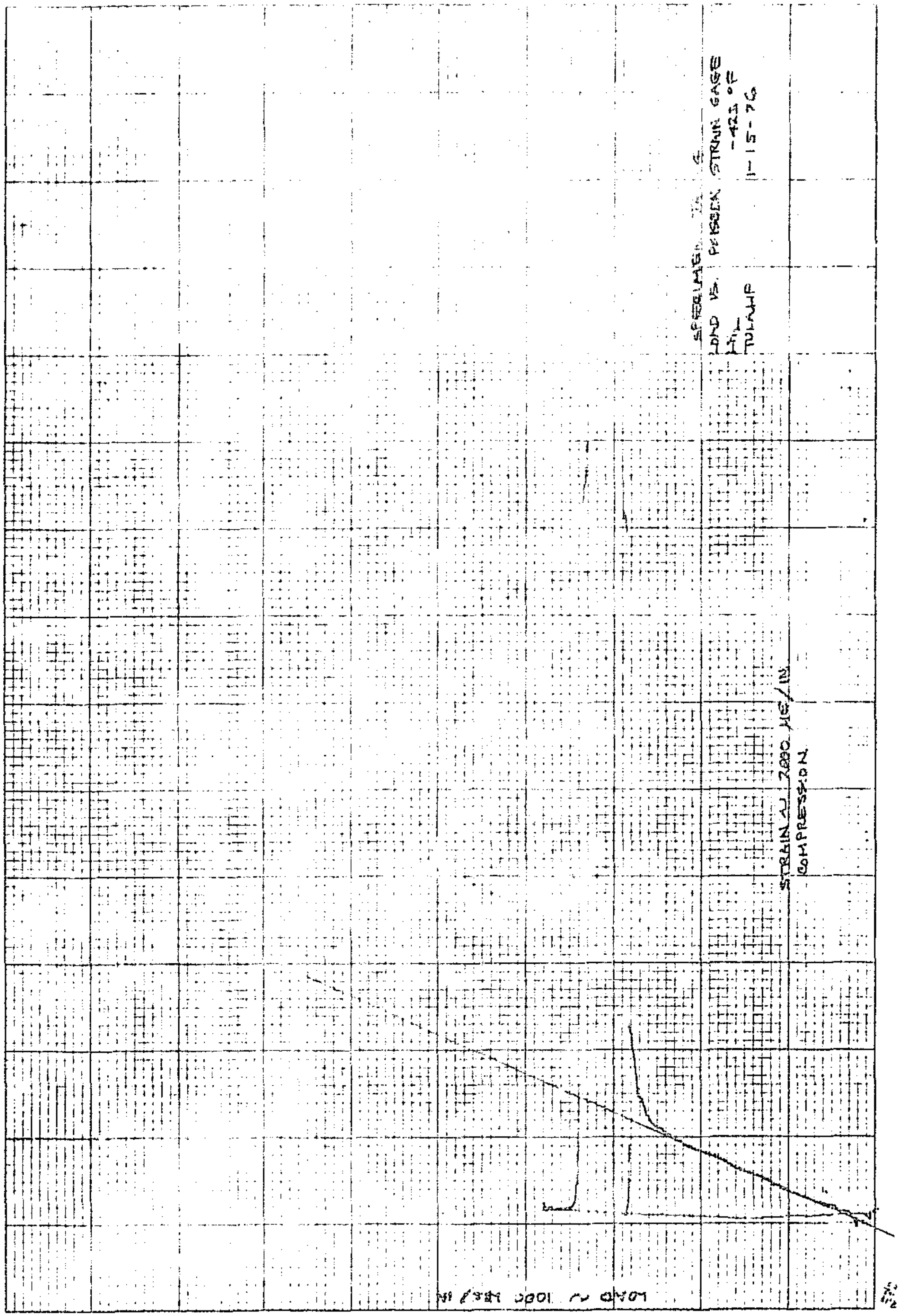
7AL-3
1-14-76

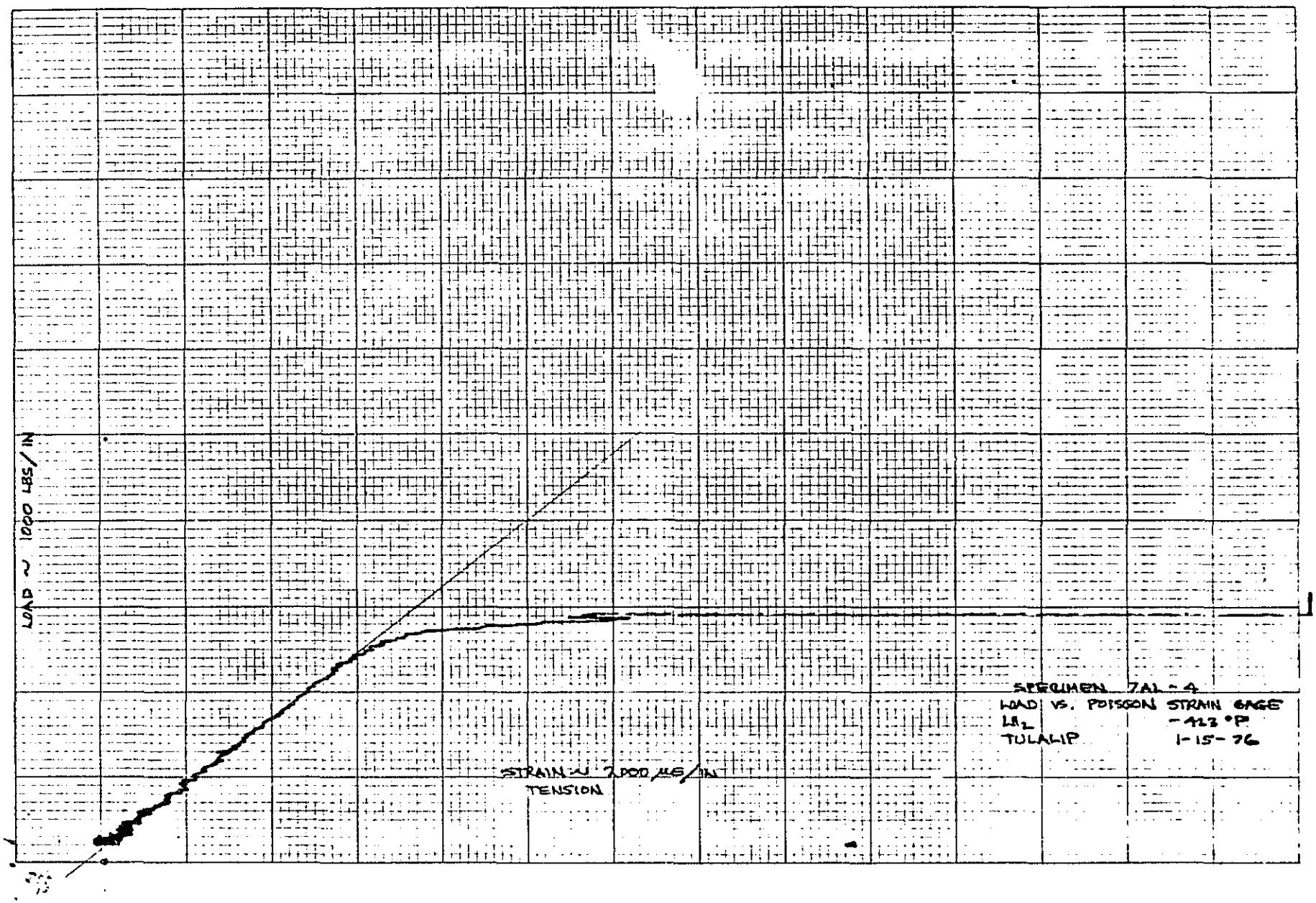

LOAD ~ 1000 LBS/IN
STRAIN ~ 2000 μE/IN
TENSION
SPECIMEN 7AL-3
LOAD VS. POISSON STRAIN GAGE
LH2
-423 °F
TULALIP
1-15-76

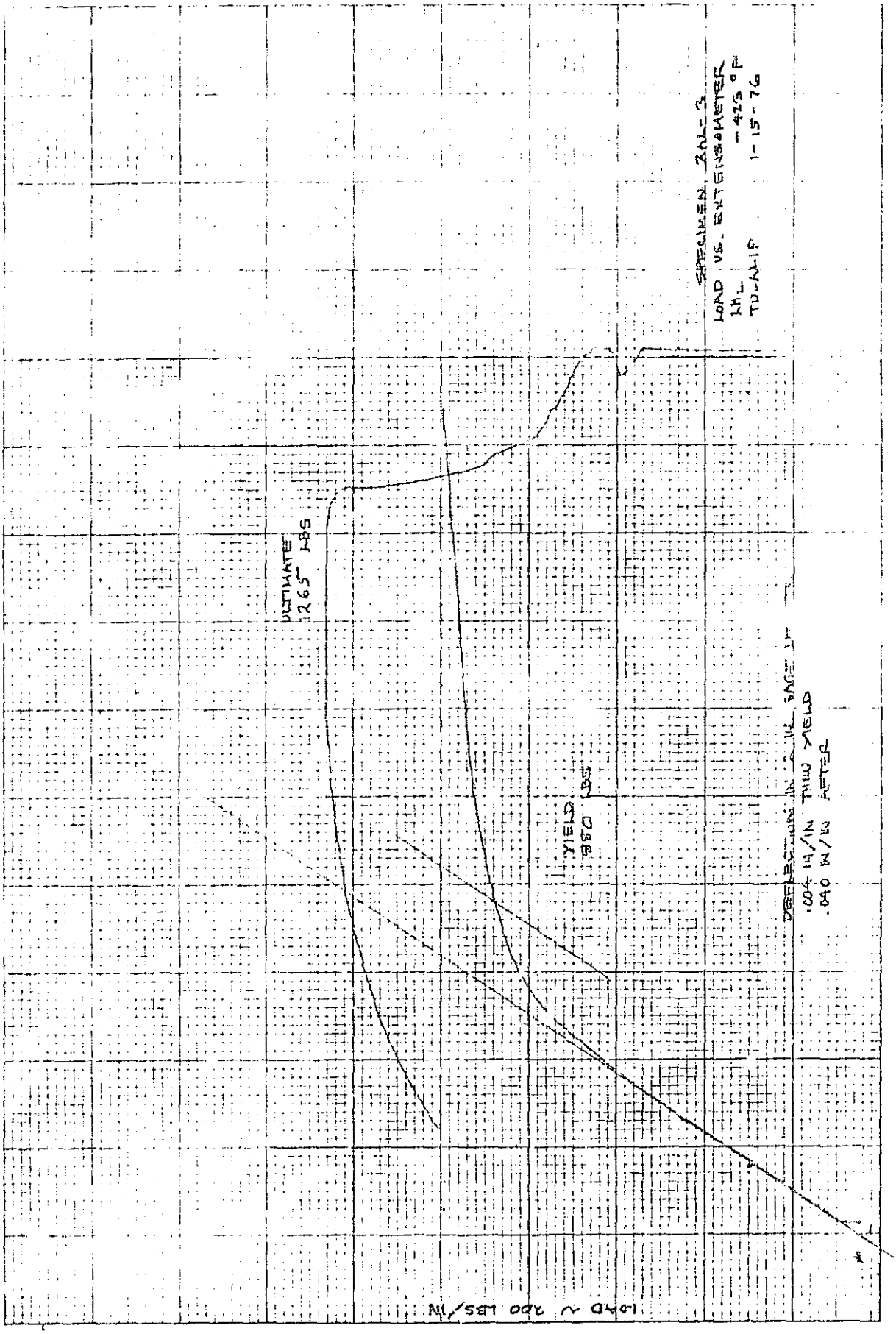


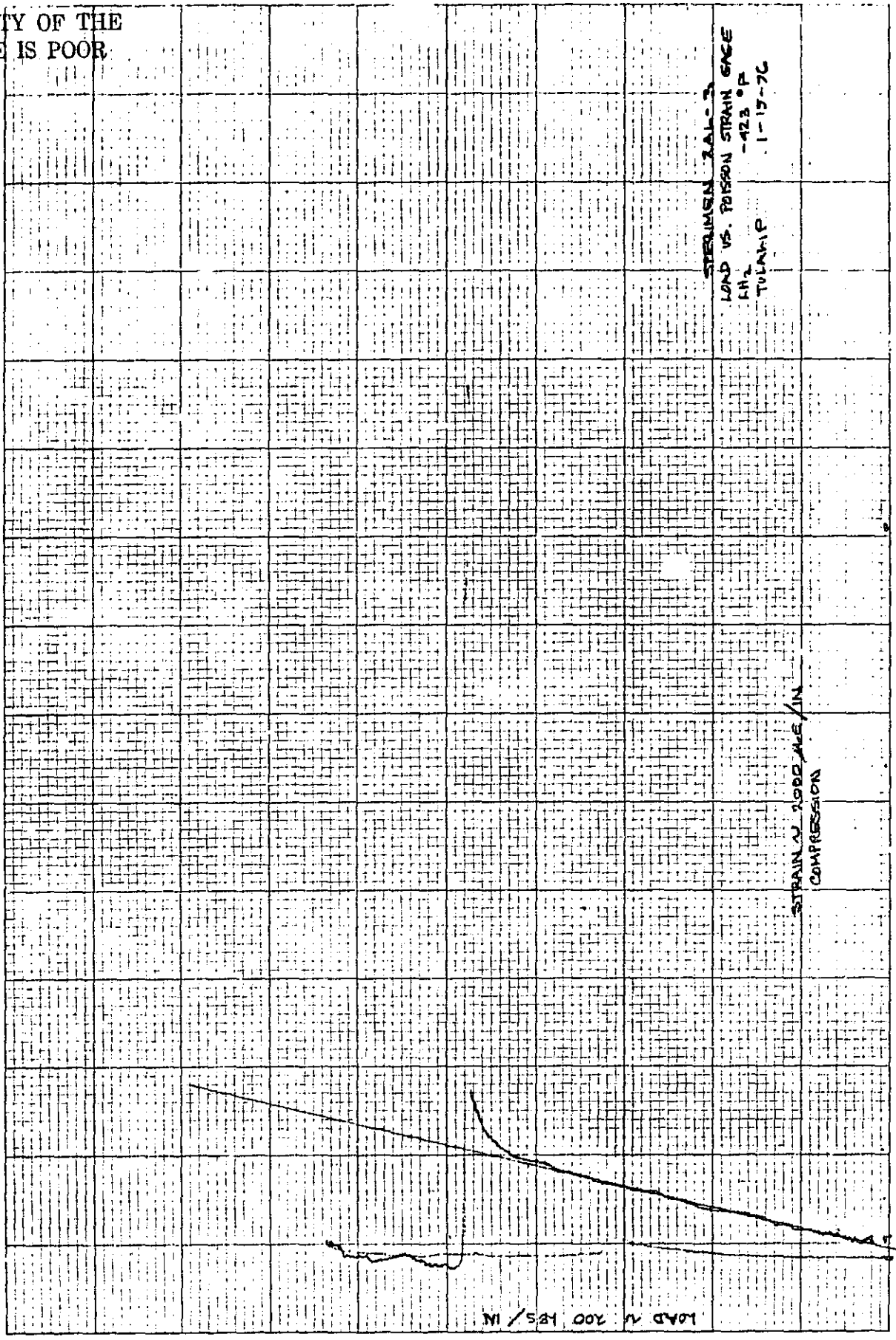


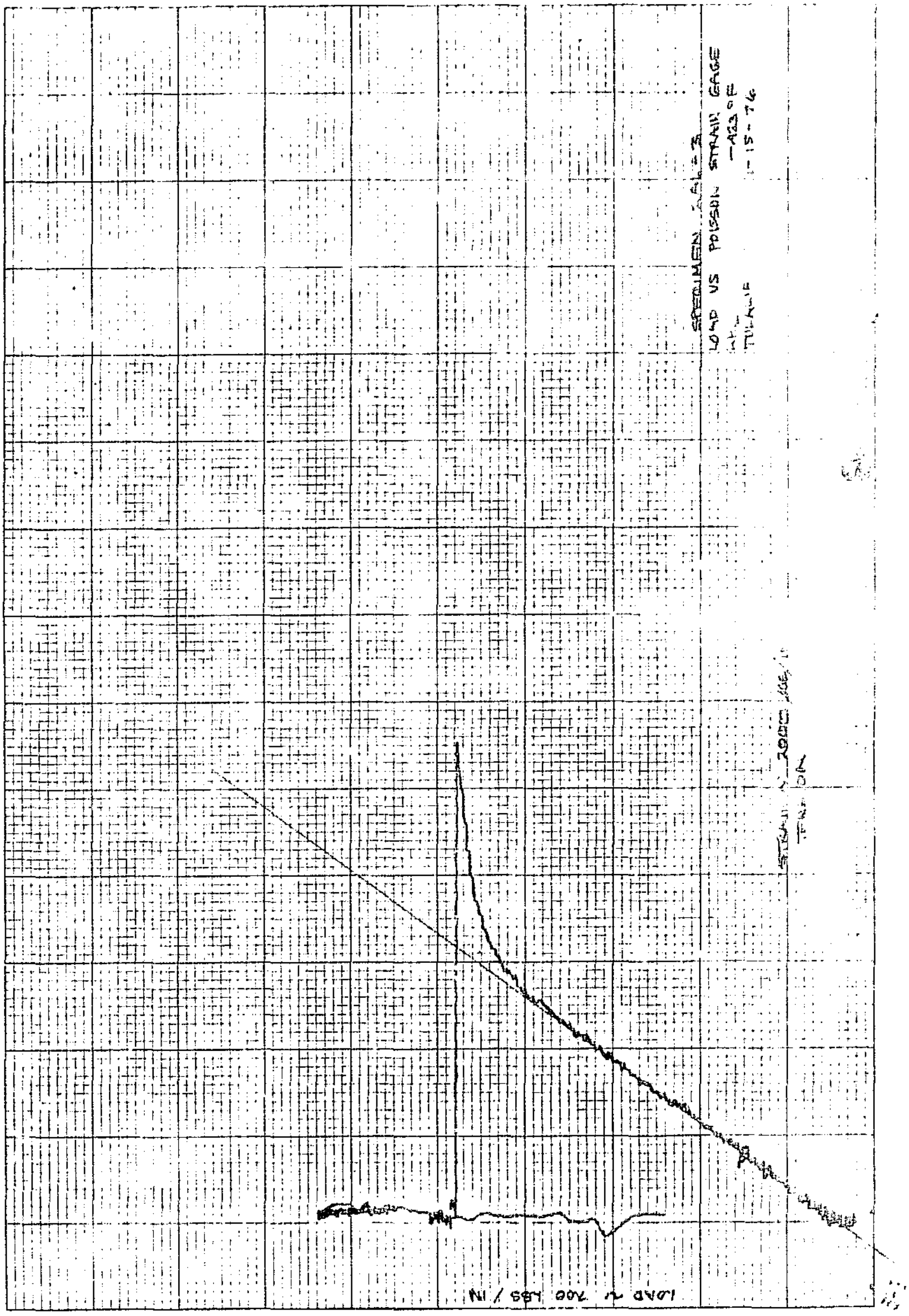
7AL-4


SPECIMEN ... 6
LOAD VS. FRISCEN STRAIN GAGE
-423 °F
1-15-76
STRAIN ~ 2000 ΜE/IN
COMPRESSION
LOAD ~ 1000 LBS / IN

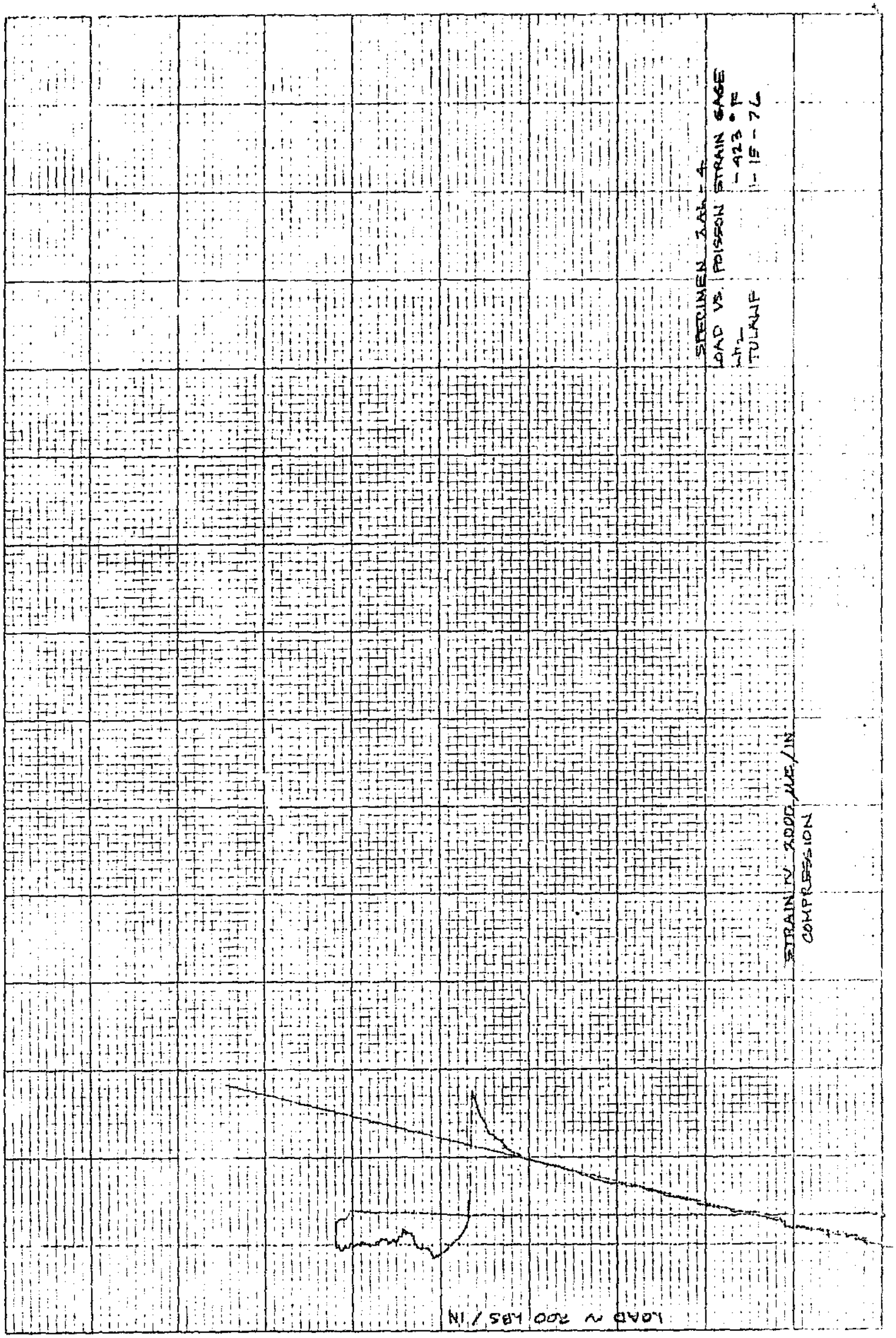

7AL-4
1-15-76
203
LOAD ~ 1000 LBS/IN
STRAIN ~ 7,000 μE/IN
TENSION
SPECIMEN 7AL-4
LOAD VS. POISSON STRAIN GAGE
LR2 -423 °F
TULALIP 1-15-76






LOAD VS POISSON STRAIN GAGE
-423 °F
1-15-76
LOAD ~ 700 LBS / IN

3AL-4
1-15-76


SPECIMEN 3Ah-4
LOAD VS. POISSON STRAIN GAGE
-423 °F
1-15-76
STRAIN ~ 2000 µE/IN
COMPRESSION
LOAD ~ 200 LBS/IN

2AL-4
1-15-76