INTERIM SUMMARY REPORT OF TENSILE TESTS USING X-42 PLATE SPECIMENS for the Office of Pipeline Safety

Hydrostatic Tests and Pressure Reversal
Technical Task Directive WN-1

Oak Ridge National Laboratory
Oak Ridge, Tn

January 29, 1997

OAK RIDGE NATIONAL LABORATORY
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POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8045

February 7, 1997

Mr. Joseph Robertson
Office of Pipeline Safety
OPS Western Region
Golden Hills Centre, Suite A-250
12600 West Colfax Ave.
Lakewood, CO 80215-3736

Dear Joe:

Transmittal of TTD WN-1 January 1997 Monthly Report

Enclosed is the TTD WN-I project monthly report for January 1997. If you have any questions concerning the enclosed information, please contact Frank Swinson (423-574-0730).

Sincerely yours,

Tony Wright

Anthony L. Wright
Oak Ridge OPS Support
Program Manager

ALW:cmp

Enclosure

Distribution: S. K. Iskander
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POST OFFICE BOX 2009
OAK RIDGE, TN 37831-8045

January 29, 1997

Mr. Gopala Vinjamuri
U.S. Department of Transportation
Research and Special Programs Administration
Office of Pipeline Safety
400 7th Street, SW, Room 2335
Washington, DC 20590-0001

Dear Gopala:

Transmittal of TTD WN-1 Report: "Characterization Tests On Two Pipeline Materials"

Enclosed is the report on the material characterization tests that were performed as part of TTD WN-1. If you have any questions on this report, please contact Frank Swinson (423-574-0730).

Sincerely yours,

Tony Wright

Anthony L. Wright
Oak Ridge OPS Support
Program Manager

ALW:cmp

Enclosure

Distribution: P. Ramirez, OPS
W. F. Swinson
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INTRODUCTION:

Tests are being conducted to examine and identify the cause and effect of pressure reversal that sometimes occur during hydrostatic pressure testing of pipelines. The concern being that hydrostatic testing may in some instances reduce rather than establish the integrity of a pipeline.

The first phase of this work was to examine tensile specimens made from **X-42** and **X-52** pipe material. This report will give a summary of the tests conducted on the tensile specimens from **X-42** pipe material. The pipe material being used comes from US Steel and is **16** inch **OD** pipe with **3/8** wall thickness. On the next two pages is a copy of the company's Material Test Report. In addition more detailed mechanical properties for the pipe material have been determined within the Oak Ridge National Laboratory and is submitted as a separate report. The separate report contains property values not only for the **X-42** pipe material but for **X-52** pipe material which will be used in later tests. Figure 1 illustrates the tensile specimens, which each contain a machined flaw, nominally **2** inches in length by **0.200** inch deep by **0.015** inch thick. Each end of the flaw has a transition radius of **0.200** inch which runs from the bottom of the flaw to the surface.

It is noted that the size of the flaw was selected first so that pressure reversals could be developed in the specimens and so that the specimens could be readily tested in the confines of the laboratory. No attempt was made in selecting the size of the flaw to maximize pressure reversal. However, being able to trigger a pressure reversal allows for the opportunity to investigate the variables that contribute to pressure reversal and meet the objectives of this investigation.

The following is a summary of the data collected on each **X-42** plate specimen tested. Comments on each data entry are given in parentheses and are located just after each entry.

A division of USX Corporation

INSPECTION CERTIFICATE (TYPE B - IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049)

USS, USX, USX are trademarks of USX Corporation

MILL ORDER/ITEM NO.	SHIPPERS NO.	P.O. NUMBER	INVOICE NUMBER

MATERIAL COND.	O.D. in (mm)	WALL in (mm)
AS-ROLLED	16.000(406.400)	0.375 (9.525)

IDENT/PRODUCTION	FLAT	BEND	GRAIN SIZE	M/U COLLAPSE	CHARPY V-NOTCH IMPACT TESTING: DIR	TEST LOC	TEMP	SIZE	TEST COND	FT-LBS 1	2	3	AVG	% SHEAR 1	2	3	AVG
F22902	OK																
F22903	OK																
** END OF DATA THIS SHEET **																	

TEST / INSPECTION	YES	RESULTS / COMMENTS
FULL LENGTH VISUAL	X	
FUU LENGTH EMI	X	OD X OD/ID ___ L X UT ___
FULL LENGTH MPI		
FULL LENGTH UT		OD ___ OD/ID ___ L ___ UT ___
END AREA INSPECTION (PLAIN END)		MPI ___ UT ___
SPECIAL END AREA (SEA) INSP		MPI ___ UT ___
FULL LENGTH DRIFT		DRIFT MANDREL SIZE:
FULL LENGTH UT OF WELD	X	OD OD/ID X L X L/T

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MANUFACTURED, SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS THE REQUIREMENTS IN SUCH RESPECTS.

PREPARED BY THE OFFICE OF: F.J. MIKULSKI MGR. MET. & Q.A. USS TUBULAR PRODUCTS

DATE 07/23/96

2

MILL ORDER/ITEM NO	SHIPPERS NO	P.O NUMBER	KHCLE I.D.	
DM16525 01		S13-60762		

SOLD TO ADDRESS	MAIL TO ADDRESS	VENDOR
CONSOLIDATED PIPE & SUPPLY CO INC P O BOX 2472 BIRMINGHAM ALA 35201-2472	CONSOLIDATED PIPE & SUPPLY CO INC P O BOX 2472 BIRMINGHAM ALA 35201-2472	USS TUBULAR PRODUCTS 301 FOURTH AVE. MCKEESPORT, PA 15132

SPECIFICATION AND GRADE

PIPE CARBON EW STD PIPE API 5L-X41ST EDITION DTD 4/1/95 GRADE B/X42 AND ASTM A53-X95 GRADE B TRIPLE STENCIL ASME SA53-X1995 EDITION 1995 ADDENDUM GRADE B BL

CONSOLIDATED PIPE & SUPPLY CO. INC.
THIS MILLTEST REPORT APPLIES TO:

CUSTOMER PRODUCTION TOOL

P.O.# MM 931

MATERIAL COND: AS-ROLLED | O.D. 16.000 (406.400) in (mm) | WALL: 0.375 (9.525) in (mm)

PRODUCT IDENTIFICATION	TENSIL TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH IN	YIELD PSI	EXT % .50	TENSILE PSI	Y/T	ELONG % (IN 2")	HARDNESS SCALE	MIN HYDRO PSI	DWELL (SEC)
				MIN 42000 MAX		MIN 60000 MIX	MAX	MIN 28.0	MIN MAX	1670	10
F22902	STRIP/T/B	AR	1.500	56780	.50	82150	0.69	33.e		1670	10
F22903	STRIP/T/B	AR	1.500	55840	.50	81110	0.69	39.0		1670	10
		**	END OF	DATA THIS	SHEET	**					

LEGEND: L - LONGITUDINAL U - UPSET T - TRANSVERSE N - NORMALIZED QT - QUENCHED & TEMPERED SR - STRESS RELIEVED AR - AS ROLLED B - BODY W - WELD

PRODUCT IDENTIFICATION	TYPE		C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO				C.E.*
F22902	HEAT		20	91	009	01e	159	02	02	a4	004	032		007								
F22902	PROO		20	93	011	010	160	02	02	84	008	027		005								
F22902	PROO		19	94	009	009	150	03	02	03	006	030		005								
F22903	HEAT		21	94	007	012	171	02	01	03	003	028		$04								
F22903	PROD		21	95	011	010	170	3 2	02	03	007	027		005								
F22903	PROD		21	96	011	010	160	02	02	03	007	030		005								
					EYD	OF	DATA	THIS	SHEET	**												

*C E IS BASED ON THE FOLLOWING EQUATION(S)

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT.

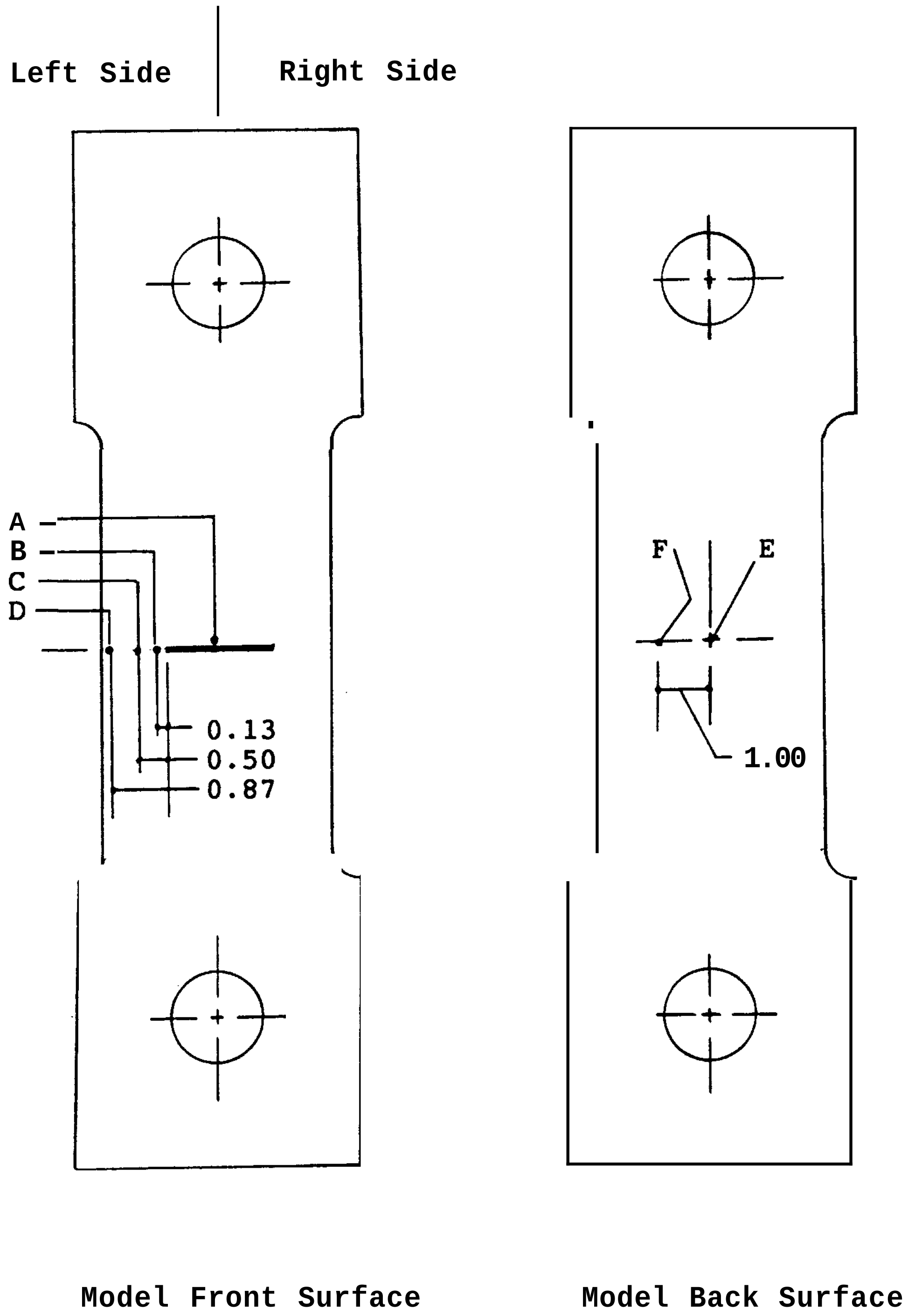


Figure 1. Strain Gage Locations

STRAIN GAGE LOCATIONS:
Each of the tensile specimens were instrumented with strain gages. Each specimen had three and sometimes four gages for monitoring the strain as the models were tested. The gage locations in each model were not always the same as gages were placed at different locations to find the model points that would be most helpful in monitoring pressure reversal. Figure 1 illustrates the location of points where the three or four gages on each model might be positioned. Strain from gages at these locations will be referenced as follows:

- eback= the strain from a gage aligned axially at point E.
- epara= the strain from a gage aligned parallel to the flaw at point A.
- eperp= the strain from'a gage aligned perpendicular to the flaw at point A.
- elft-cor= the strain from a gage located axially at point B and is as close to the left corner of the flaw as the gage backing would allow.
- ert-cor= the strain from a gage located axially at the complement to point B (right corner of flaw) and is as close to the right corner of the flaw as the gage backing would allow.
- **e0.5lft=** the strain from a gage located axially at point C, and is the mid-point between the flaw corner and the model boundary.
- eedge= the strain from a gage located axially at point D, and is as close to the left model boundary as the gage backing will allow.
- eF= the strain from a gage aligned axially at point F.
- displ= the load cylinder displacement in inches.

TEST NOTES FOR EACH SPECIMEN:

Each tensile specimen has been assigned a number for identification:

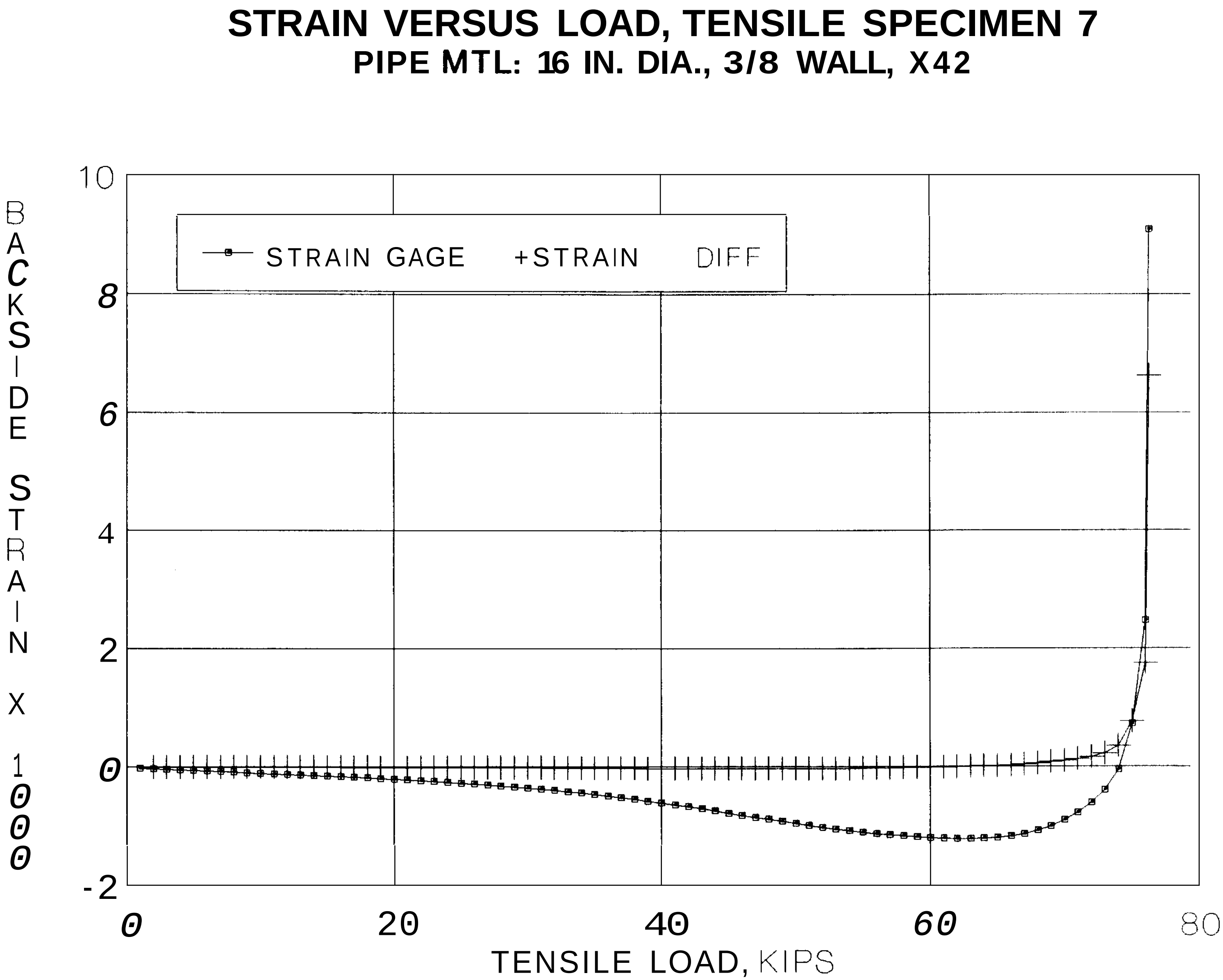
Specimen Numbers 1-10 refer to specimens from X-42 plate without an ERW seam.
11-21 refer to specimens from X-42 material with an ERW seam.
31-40 refer to specimens from **X-52** plate without an ERW seam.
41-50 refer to specimens from **X-52** material with an ERW seam.

--Specimen #**7, X-42** base material. The model failed in the flaw; but, due to the lack of sufficient load cylinder stroke, the specimen did not separate into two parts. The load rate was **50** kips/hr.

Time,hrs	Load,lbs	eback	elft-cor	ert-cor	displ
0	**0**	**0**	**0**	**0**	**3.340**
(Test started. The displacement is the initial load cylinder stroke setting.)					
1.25	**62325**	**-1222**	**8820**	**9323**	**3.880**
(The back strain gage has a characteristic negative value in the first part of the load cycle due to a large induced equilibrium moment. The minimum back gage strain value for this specimen was **-1222** micro-strain. It should be noted that the back gage for this model was located **0.5** inch to the left of point E and therefore is not the maximum strain in the flaw region. As load is applied the back surface of the model in the region of the flaw necks down. The minimum strain point for the back gage appears to be where necking begins.)					
1.28	**63775**	**-1217**	**9648**	**10230**	**3.980**
(At this point the right corner gage failed.)					
1.29	**64475**	**-1209**	**10093**	**---**	**4.035**
(At this point the left corner gage failed.)					
1.48	**74100**	**0**	---	---	**5.193**
(The back gage after showing negative strain values has at this point returned to zero strain and is increasing with load.)					
1.53	**76300**	**9093**	**---**	**---**	**5.658**
(Data just prior to failure.)					

The flaw extended through the wall thickness first before trying to extend in length. There was considerable necking in the region of the flaw from the back surface of the specimen. The magnitude of the necking is on the order of **0.06** inch and represents a significant decrease **(34%** decrease) in the cross sectional area in this region.

A plot of the back gage strain and the slope (difference) of the back gage strain curve versus load is shown on the next page.



STRAIN VERSUS LOAD, TENSILE SPECIMEN 7
PIPE MTL: 16 IN. DIA., 3/8 WALL, X42
STRAIN GAGE
+STRAIN
DIFF
BACKSIDE STRAIN X 10000
10
8
6
4
2
0
-2
0
20
40
60
80
TENSILE LOAD, KIPS

--Specimen #13, X-42 with ERW Seam. Test run Nov.1996. The purpose of this test was to further prove the data collection and load systems using a model with an ERW seam. The model was loaded at constant load rate (50 kips/hr). Excessive yielding in the regions of the model that surround the 1 3/4 inch diameter holes, which transmit the machine tensile load to the specimen, prevented failure. There was not enough stroke from the loading cylinder to over come the excessive (elongation) yielding in the model. This problem was corrected by attaching reinforcing bars to the models to better distribute the load from the 1 3/4 inch diameter load pins into the models.

--Specimen #2, X-42 base material. Tested 12-6-96. The model failed first in the flaw and then separated. The load rate was 50 kips/hr.

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
0	0	0	0	0	0	1.128

(Test started)

1.16	63675	-192	3301	-246	15	1.247

(Minimum strain from back strain gage occurred at this load and the magnitude is much smaller than the minimum strain recorded for Specimen #7. These specimens are made from 16 inch diameter pipe that has been flattened but true flatness, of course, cannot be achieved. Each specimen starts with a small curvature that is different than any of the others. Other anomalies occur because the load cannot be exactly in line with a specimen having a slight initial curvature and because necking of material will not always occur at precisely the same load. Therefore it would be unusual for the back gage minimum strain value to be the same from specimen to specimen. It is interesting that the loads when these minimum strain values occur are close in magnitude.)

1.33	72900	0	8960	-417	-123	1.350

(Data recorded when the back gage reached zero strain. As the load increases beyond this point the back gage response tends toward exponential.)

1.37	75250	544	10040	-481	-204	1.379

(The left corner gage failed at this point as can be seen on the attached graph.)

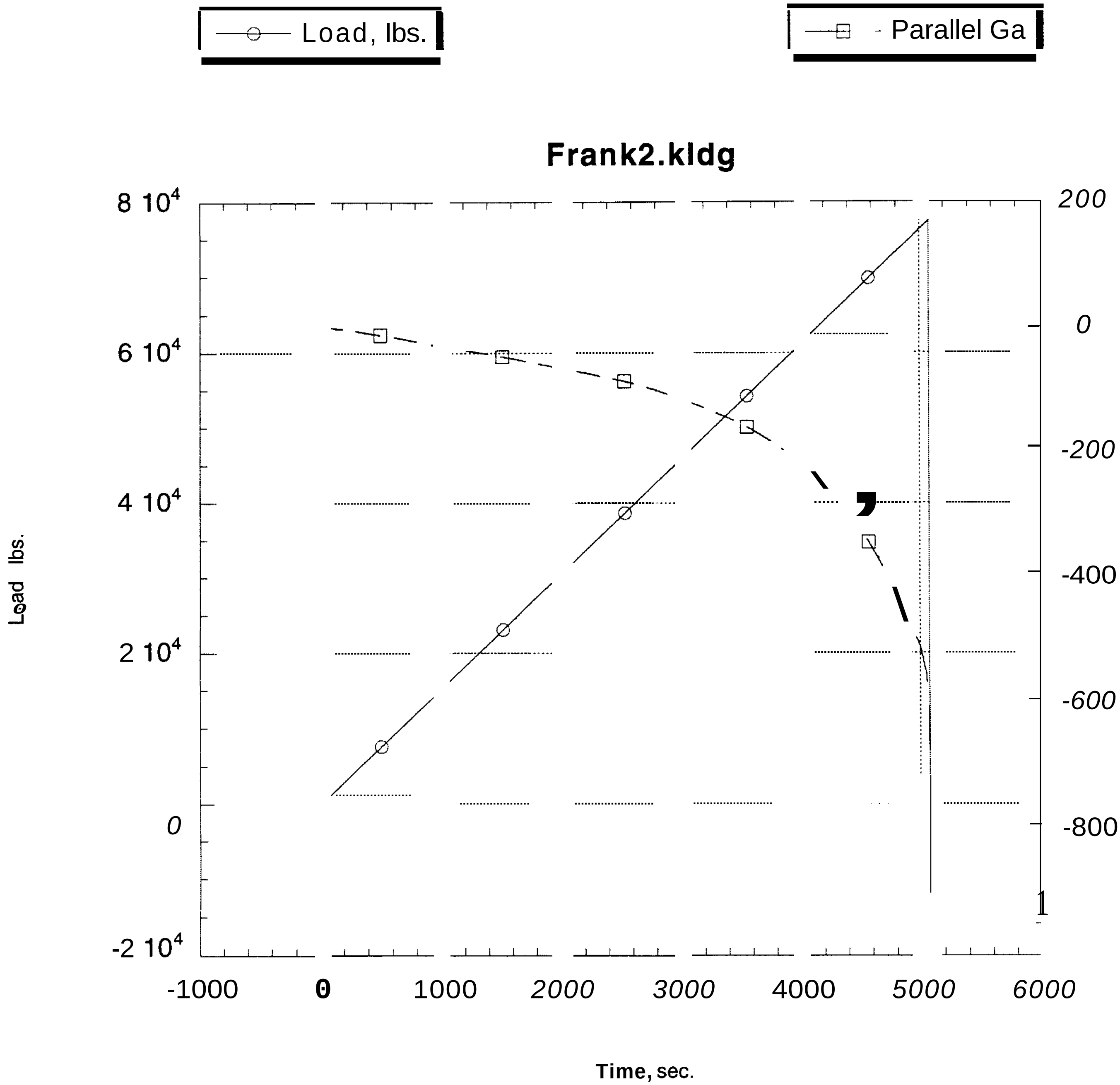
1.41	77425	18175	---	-639	-362	1.428

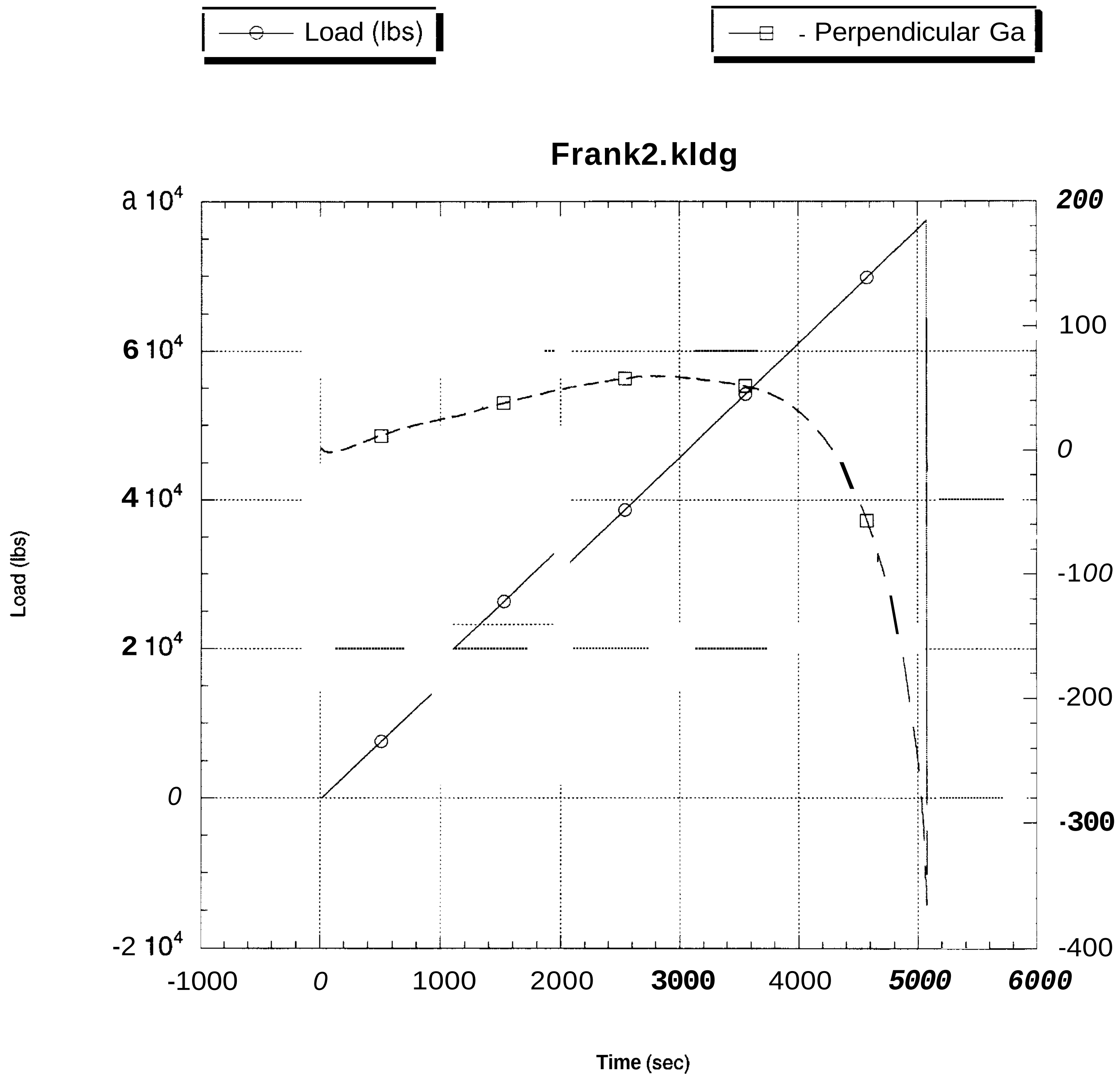
(This is very close to the failure load and is the point where the strain from the back gage overloads the circuit for this channel.)

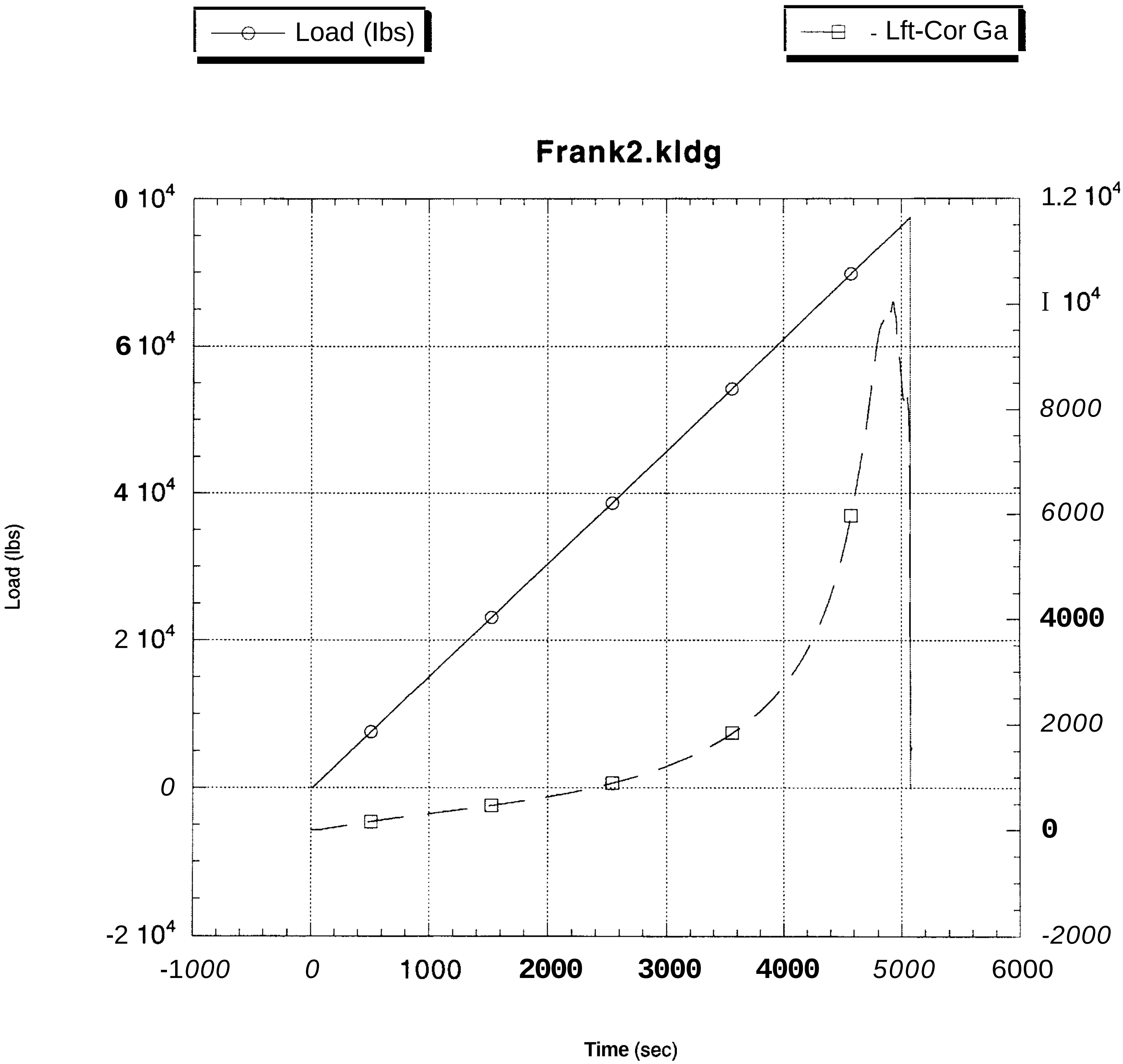
1.41	77475	---	---	-786	-361	1.446

(This is the failure point and the most reliable and sensitive data point comes from the parallel gage. Immediately after failure the reading on this gage jumped by over 100 micro-strain. The failure load for this specimen differs with the failure load for specimen #7 by 1.5%)

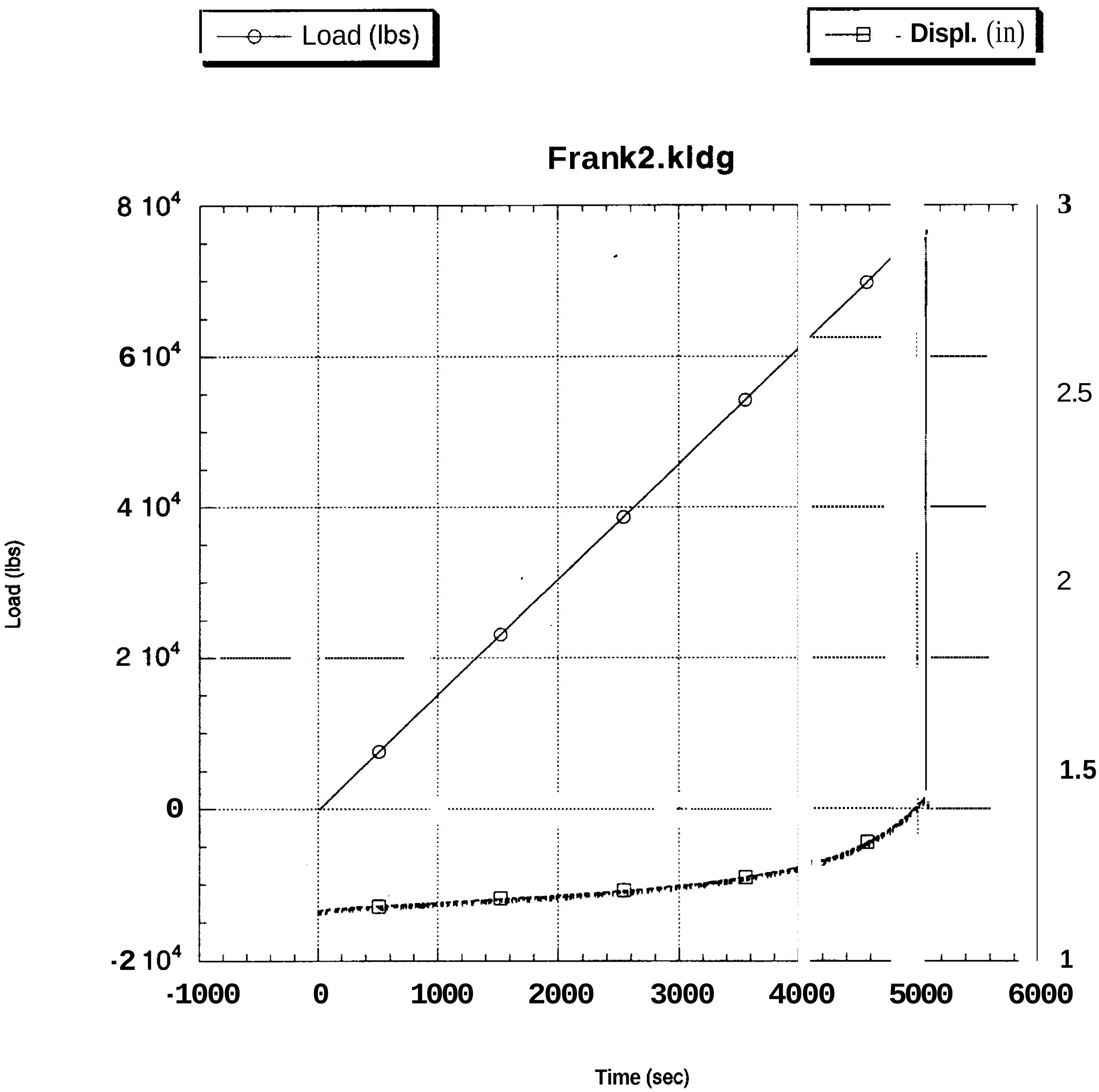
Plots of load and parallel strain versus time, of load and perpendicular strain versus time, of load and left corner strain versus time, and load and cross head deflection versus time are attached.


Load, lbs.
Parallel Ga
Frank2.kldg
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
200
0
-200
-400
-600
-800
Load lbs.
-1000
0
1000
2000
3000
4000
5000
6000
Time, sec.


Load (lbs)
- Perpendicular Ga
Frank2.kldg
a 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
200
100
0
-100
-200
-300
-400
-1000
0
1000
2000
3000
4000
5000
6000
Time (sec)
Load (lbs)



Load (lbs)
- Lft-Cor Ga
Frank2.kldg
0 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
1.2 10^4
I 10^4
8000
6000
4000
2000
0
-2000
-1000
0
1000
2000
3000
4000
5000
6000
Load (lbs)
Time (sec)


Load (lbs)
- Displ. (in)
Frank2.kldg
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
3
2.5
2
1.5
1
-1000
0
1000
2000
3000
4000
5000
6000
Time (sec)
Load (lbs)

--Specimen #3, X-42 base material. Tested 12-10-96 through 12-13-96. The purpose of this test was to see how close to the failure load (assumed to be that of Specimen #2 of 77425 lb. with constant load rate) before failure would propagate. Data includes:

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
0	0	0	0	0	0	1.131

(Test started.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
1.11	61200	-105	3485	-212	19	1.234

(Minimum strain on back gage and the first load hold. The load represents 79% of the assumed failure load taken from Specimen #2.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
72.60	61300	7	1766	-42	--	1.253

(End of the first load hold. The strain values show considerable change within this constant load pause. Because things were changing so much the perpendicular gage was removed and replaced with a dummy gage during this interval to see if temperature change or instrument drift was a problem with this test. Temperature change and instrument drift were not responsible for the strain changes. It is suspected that when the back gage strain reaches it's minimum value, necking and some flaw extension are beginning. It is apparent that time is a significant variable in this process and should be considered a primary variable in a pressure reversal study.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
72.63	63000	4	1802	-45	--	1.255

(This is the beginning of the second load pause and is 81% of the assumed failure load of Specimen #2.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
142.00	63000	-33	1756	-144	--	1.245

(This is the end of the second load pause. Initially the strains varied with time but not to the extent that occurred in the first load pause. After changing with time initially, the strains became essentially constant.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
142.16	69700	104	3799	-224	--	1.301

(This is the beginning of the third load pause and is 90% of the assumed failure load taken from Specimen #2.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
146.21	69775	216	---	-257	--	1.319

(This is the end of the third load pause. It was evident from the response of the left corner gage in comparison to the changes in the other strain gages that it has failed.)

Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
146.58	73550	556	---	-303	--	1.337

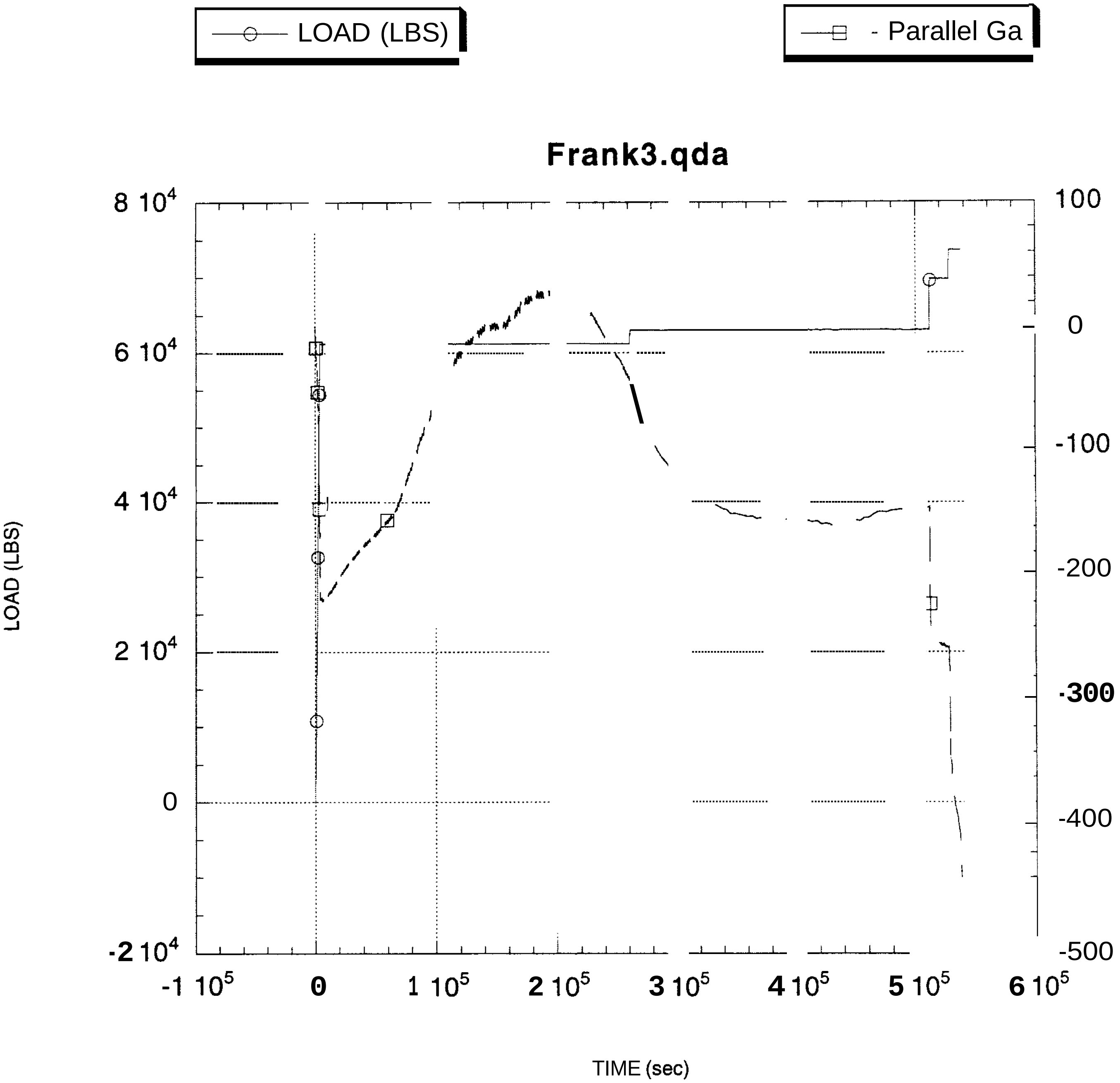
(This marks the beginning of the fourth and final load pause.)

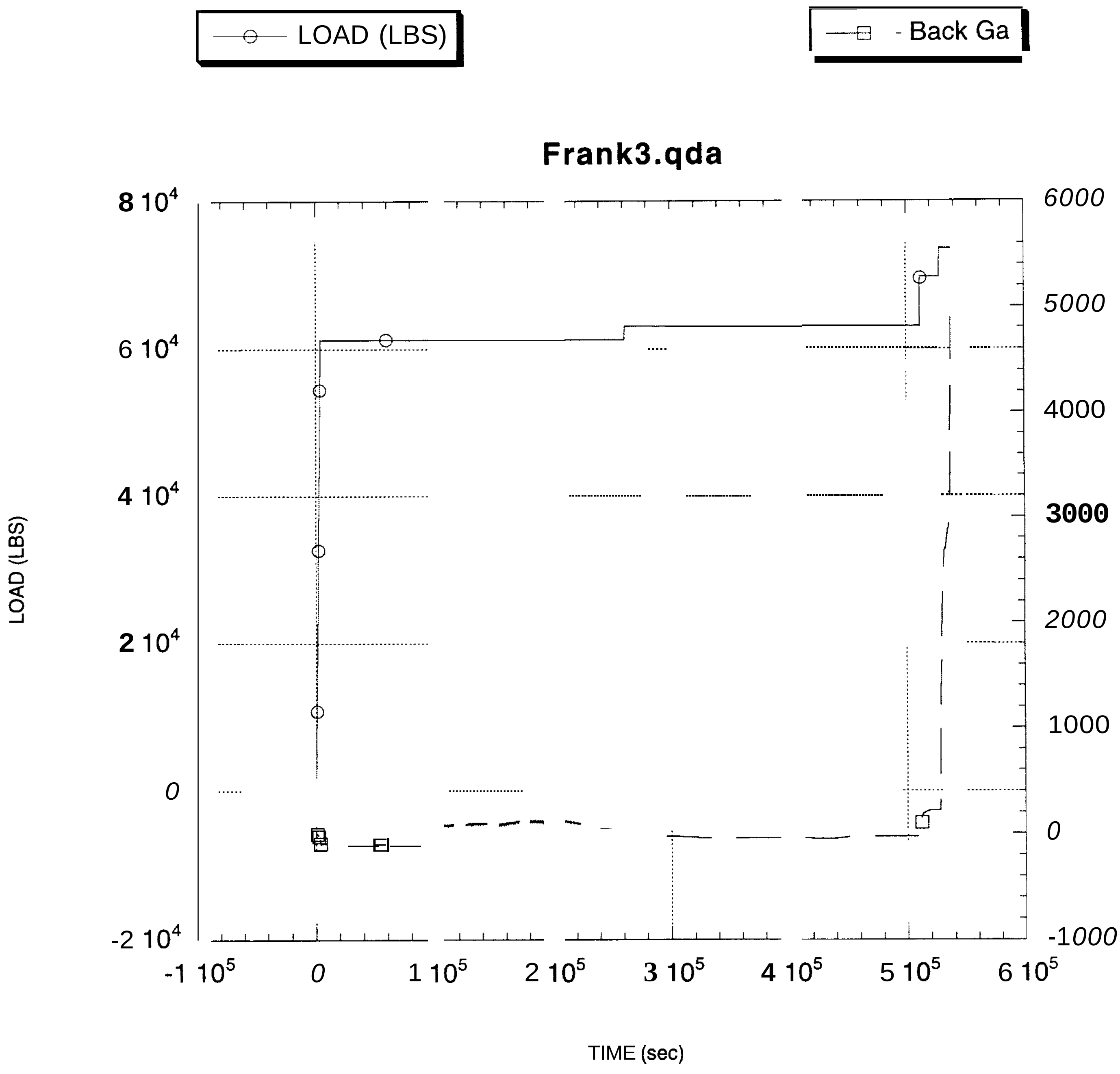
Time,hrs	Load,lbs	eback	elft-cor	epara	eperp	displ
150.00	73650	11940	---	-511	--	1.380

(This is the last recorded data before failure. The back gage response has become exponential. The load is 95% of the assumed failure load taken from Specimen #2. This test does suggest that flaws will change at loads that are on the order of 80% of the straight away failure load; but, these changes do stabilize in time. Flaws will change and become unstable at loads on the order of *95%* of the straight away failure load. The percentages given should be taken as trends because the straight away failure load for this specimen is unknown and, therefore, the failure load from Specimen #2 is assumed to apply.)

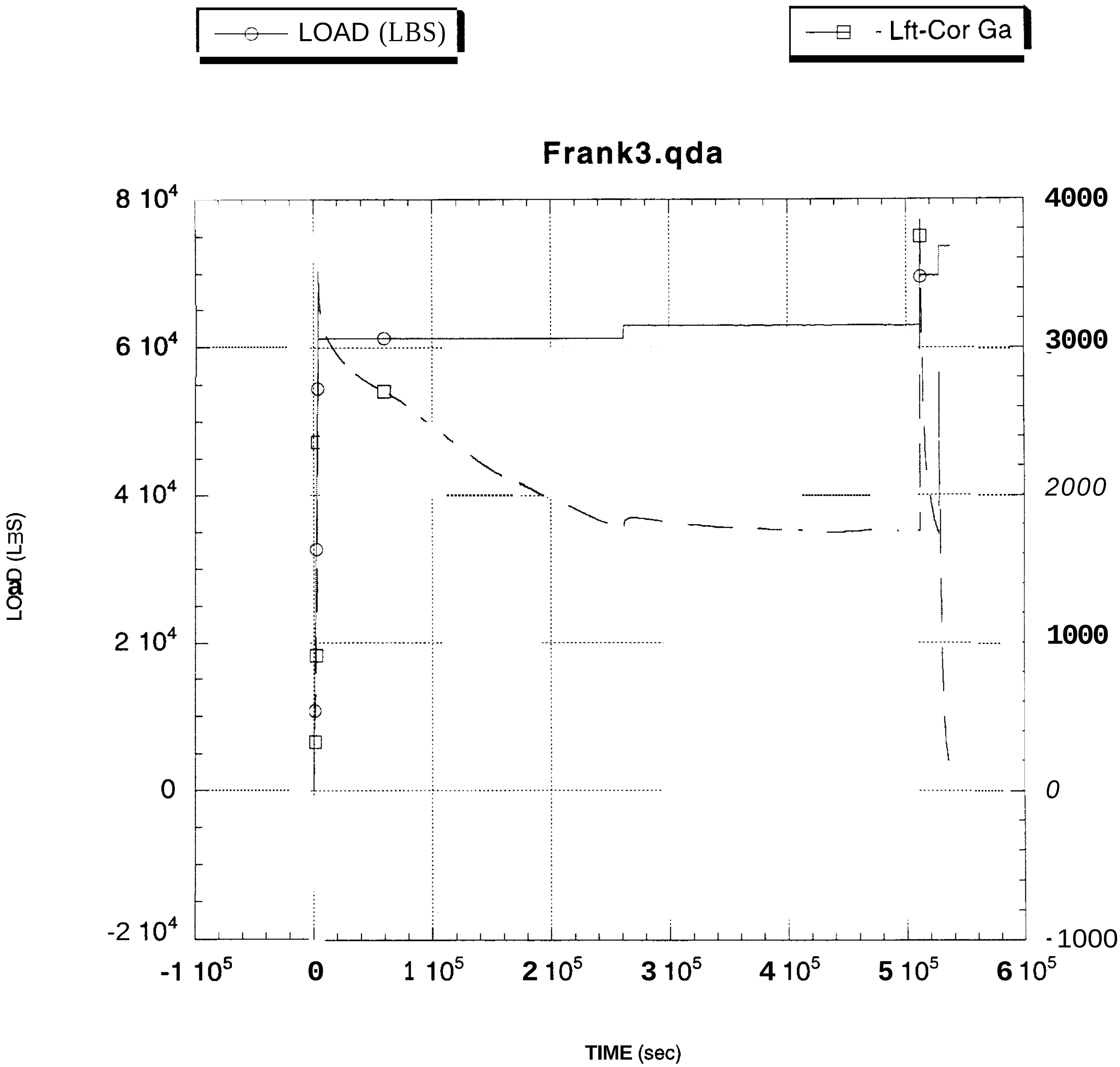
If the failure stress is calculated using the procedure recommended by the American Gas Association, flaw damage starts at 86% of the predicted failure.

Graphs of load and parallel strain versus time, of load and back strain versus time, of load and left corner strain, load and strain from the perpendicular gage versus time, and of load and cross head displacement versus time are attached.

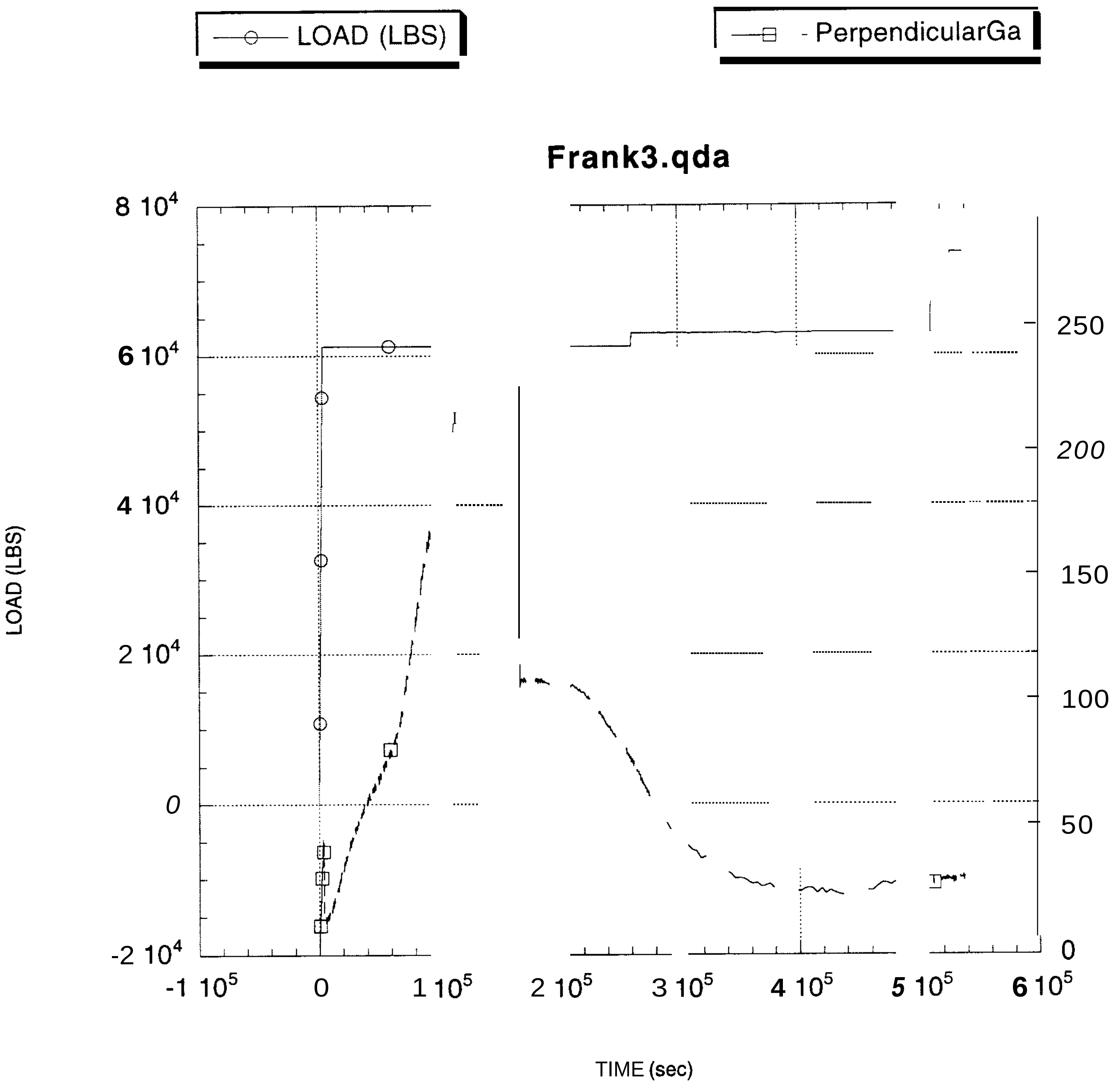

LOAD (LBS)
- Parallel Ga
Frank3.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
100
0
-100
-200
-300
-400
-500
-1 10^5
0
1 10^5
2 10^5
3 10^5
4 10^5
5 10^5
6 10^5
LOAD (LBS)
TIME (sec)

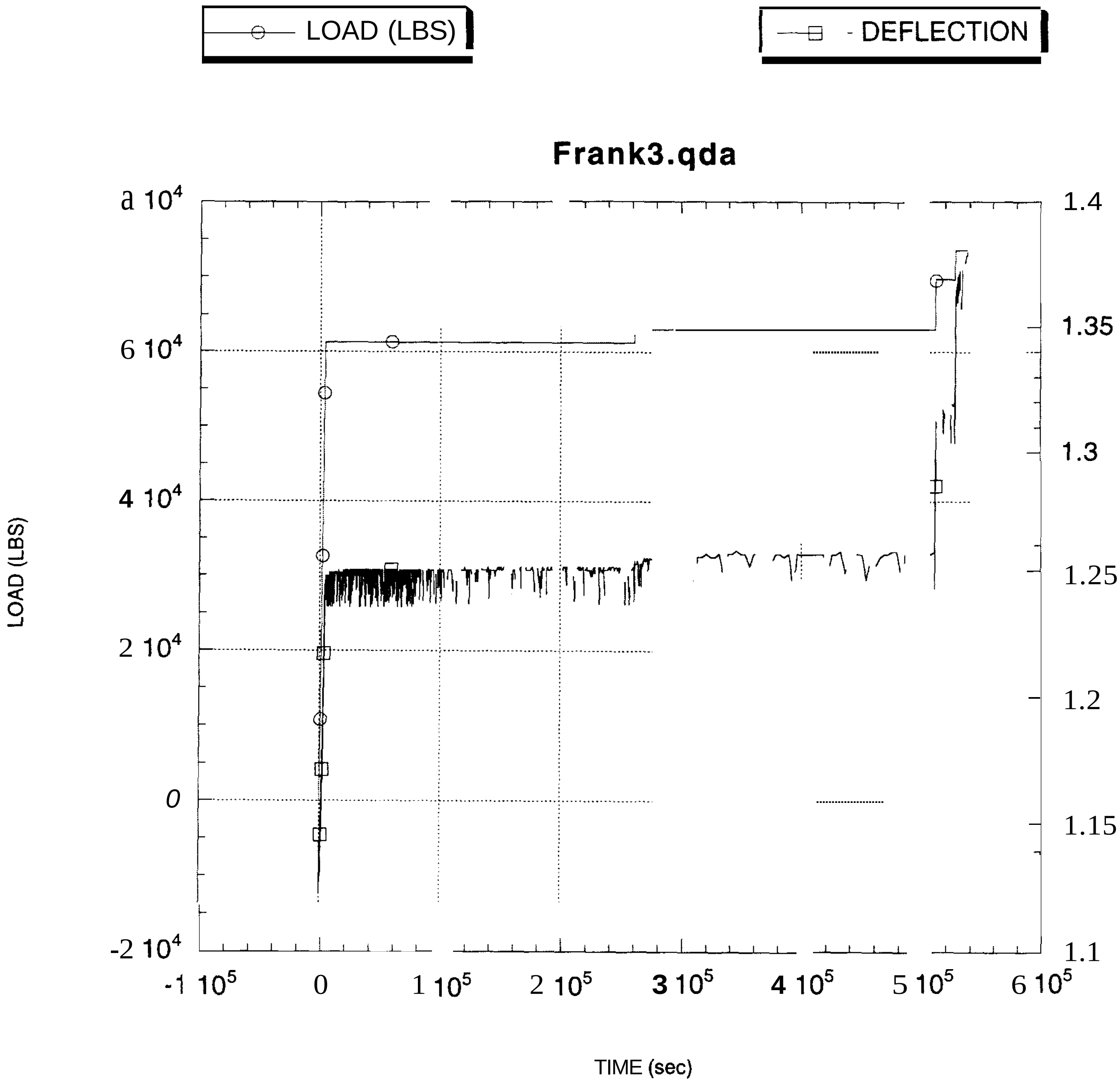


LOAD (LBS)
- Back Ga
Frank3.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
6000
5000
4000
3000
2000
1000
0
-1000
-1 10^5
0
1 10^5
2 10^5
3 10^5
4 10^5
5 10^5
6 10^5
TIME (sec)



LOAD (LBS)
- Lft-Cor Ga
Frank3.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
4000
3000
2000
1000
0
-1000
-1 10^5
0
1 10^5
2 10^5
3 10^5
4 10^5
5 10^5
6 10^5
TIME (sec)
LOAD (LBS)


LOAD (LBS)
- PerpendicularGa
Frank3.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
250
200
150
100
50
0
-1 10^5
0
1 10^5
2 10^5
3 10^5
4 10^5
5 10^5
6 10^5
TIME (sec)



LOAD (LBS)
- DEFLECTION
Frank3.qda
a 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
1.4
1.35
1.3
1.25
1.2
1.15
1.1
-1 10^5
0
1 10^5
2 10^5
3 10^5
4 10^5
5 10^5
6 10^5
LOAD (LBS)
TIME (sec)

--Specimen #**1, X-42** base material. Tested **12-20-96.** The purpose of this test was to see if a pressure reversal could be achieved. Gages were located on the back surface at the center of specimen, at the left corner of the flaw, at the right corner of the flaw, and on the back surface opposite the right corner gage. The corner gages failed before the model failed and do not furnish useful data. The gage on the back surface opposite the right corner gage begin immediately on loading in the tension direction, while the back surface central gage started in compression. This seems to indicate that the moment effect applied at the central gage dissipates rapidly. The load history and gage response is noted in the following.

Time,hrs	Load,lbs	eback	elft-cor	ert-cor	eF	displ
0	**0**	**0**	**0**	**0**	**0**	**1.131**
(First load cycle started.)						
1.20	**65725**	**-601**	**4630**	**4455**	**1169**	**1.269**
(The back strain gage had a minimum reading at this load on first load cycle. The gage at location "F" gave a positive reading from the start of the test indicating that the equilibrium moment at location "E" dissipated quickly from E to F. This is significant in understanding why the flaw extends through the wall thickness before extending in length.)						
1.35	**73850**	**-2**	**5555**	**8110**	**3018**	**1.357**
(At this load the strain at the back gage is approximately zero and will start increasing rapidly)						
1.36	**74150**	**159**	---	---	**3225**	**1.362**
(This is the maximum load point on the first load cycle. The left corner strain gage and the right corner strain gage have yielded and further data is not valid from these gages.)						
1.37	0	-5	**---**	---	**1729**	**1.256**
(End **of** the first load cycle. Residual strains are large)						
1.58	**0**	**97**	---	**---**	**1716**	**1.250**
(Start of the second load cycle. Significant change in the strains are evident since the load was reduced to zero and indicates the importance of the time variable in this study.)						
2.87	**70075**	**550**	**---**	---	**3179**	**1.369**
(First load pause on the second load cycle.)						
3.27	**70050**	**576**	---	---	**3202**	**1.370**
(End of first pause on the second load cycle.)						
3.35	**74350**	**790**	---	---	**3485**	**1.386**
(Maximum load on the second load cycle.)						
3.37	**0**	**498**	**---**	---	**1965**	**1.286**
(End of the second load cycle. The residual strain continues to increase with each load cycle.)						
4.37	**0**	**512**	---	**---**	**1958**	**1.285**
(Start of the third load cycle.)						
5.89	**75025**	**1434**	---	---	**3885**	**1.414**
(Maximum load on the third load cycle.)						
5.91	**0**	**1156**	---	**---**	**2291**	**1.311**
(End of the third load cycle.)						
5.93	0	**1124**	**---**	---	**2286**	**1.309**

(Start of the fourth load cycle.)

7.32 72025 1727 --- --- 3844 1.413

(First load pause on the fourth load cycle.)

23.64 72075 1736 --- --- 3956 1.415

(End of the first load pause on the fourth load cycle.)

23.71 76000 2468 --- --- 5030 1.429

(Maximum load on the fourth load cycle.)

23.72 0 2323 --- --- 3365 1.324

(End of the fourth load cycle.)

23.73 0 2354 --- --- 3358 1.324

(Start of the fifth load cycle.)

25.23 72050 3318 --- --- 5020 1.426

(First load pause on the fifth load cycle.)

26.07 72050 3334 --- --- 5040 1.426

(End of the first load pause on the fifth load cycle.)

26.23 73000 3361 --- --- 5070 1.428

(Start of the second load pause on the fifth load cycle.)

28.08 73100 3434 --- --- 5120 1.429

(End of the second load pause on the fifth load cycle.)

28.14 75950 3809 --- --- 5505 1.429

(Maximum load on the fifth load cycle.)

28.15 0 3573 --- --- 3859 1.332

(End of the fifth load cycle.)

28.17 0 3539 --- --- 3838 1.331

(Start of the sixth load cycle.)

30.12 75700 4815 --- --- 5795 1.442

(Maximum load on the sixth load cycle.)

30.15 0 5240 --- --- 4750 1.347

(End of the sixth load cycle. Note that the back gage residual strain is more than the loaded strain. The strain on this gage continued to increase even while the load was being reduced to zero and is an indication that the flaw region is changing.)

30.32 9512 5675 --- --- 5165 1.375

(The initial data for the seventh load cycle was not recorded. This data entry was the first data recorded for the seventh load cycle.)

31.48 73000 6190 --- --- 6425 1.444

(Data for the beginning of the first load pause of the seventh load cycle.)

47.70 73100 6335 --- --- 6605 1.466

(End **of** the first load pause on the seventh load cycle.)

47.77 76925 10735 --- --- 6680 1.487

(Data at maximum load on the seventh load cycle. Strain on the back surface is becoming large.)

47.79 0 12640 --- --- 3577 1.390

(Data at the end of the seventh load cycle. The residual strain on the back surface is more than twice what it was at the end of the sixth load cycle.)

50.81 0 12765 --- --- 3211 1.390

(Start of the eighth and final load cycle.)

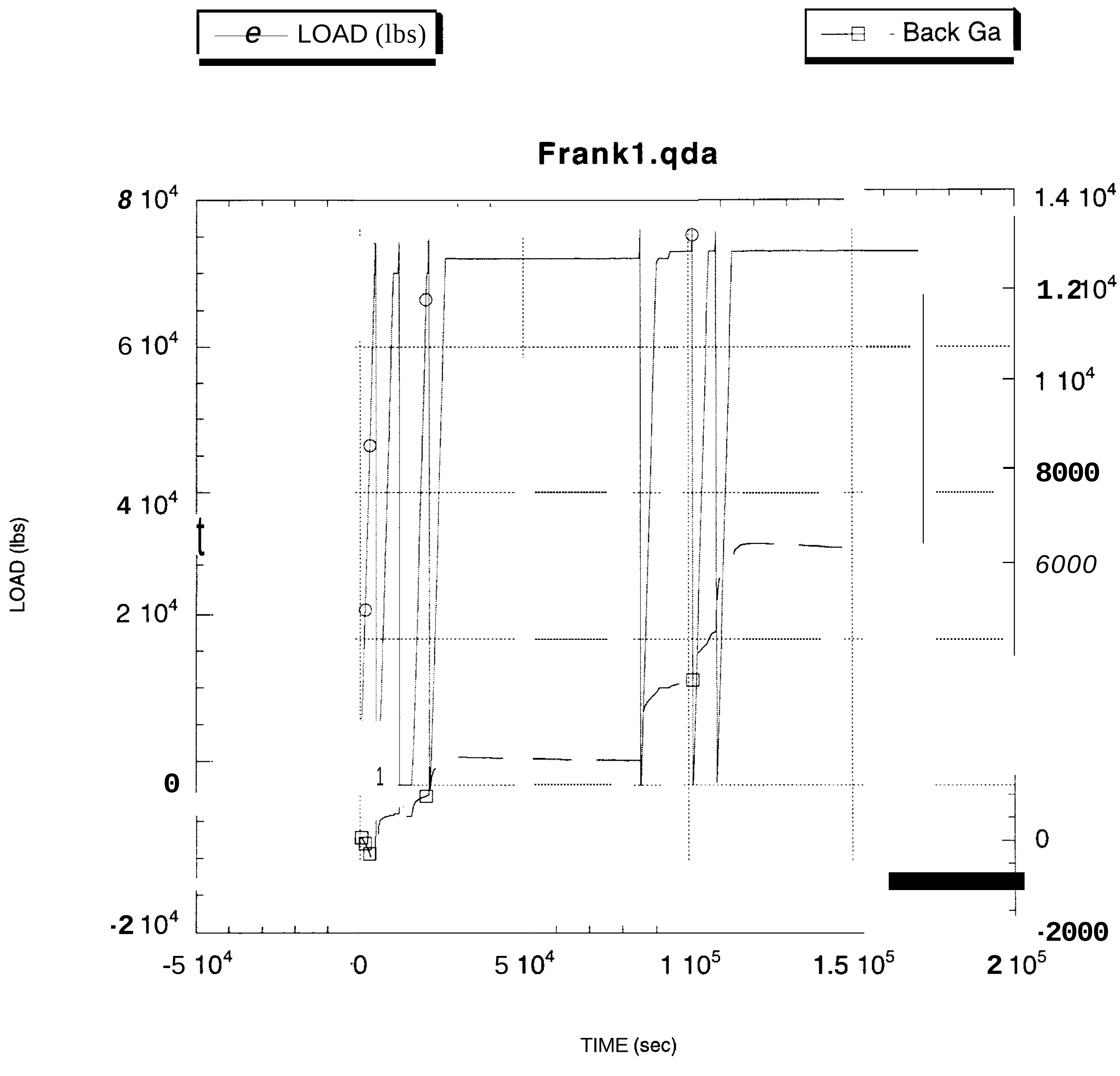
53.60 73025 17020 --- --- 2546 1.489

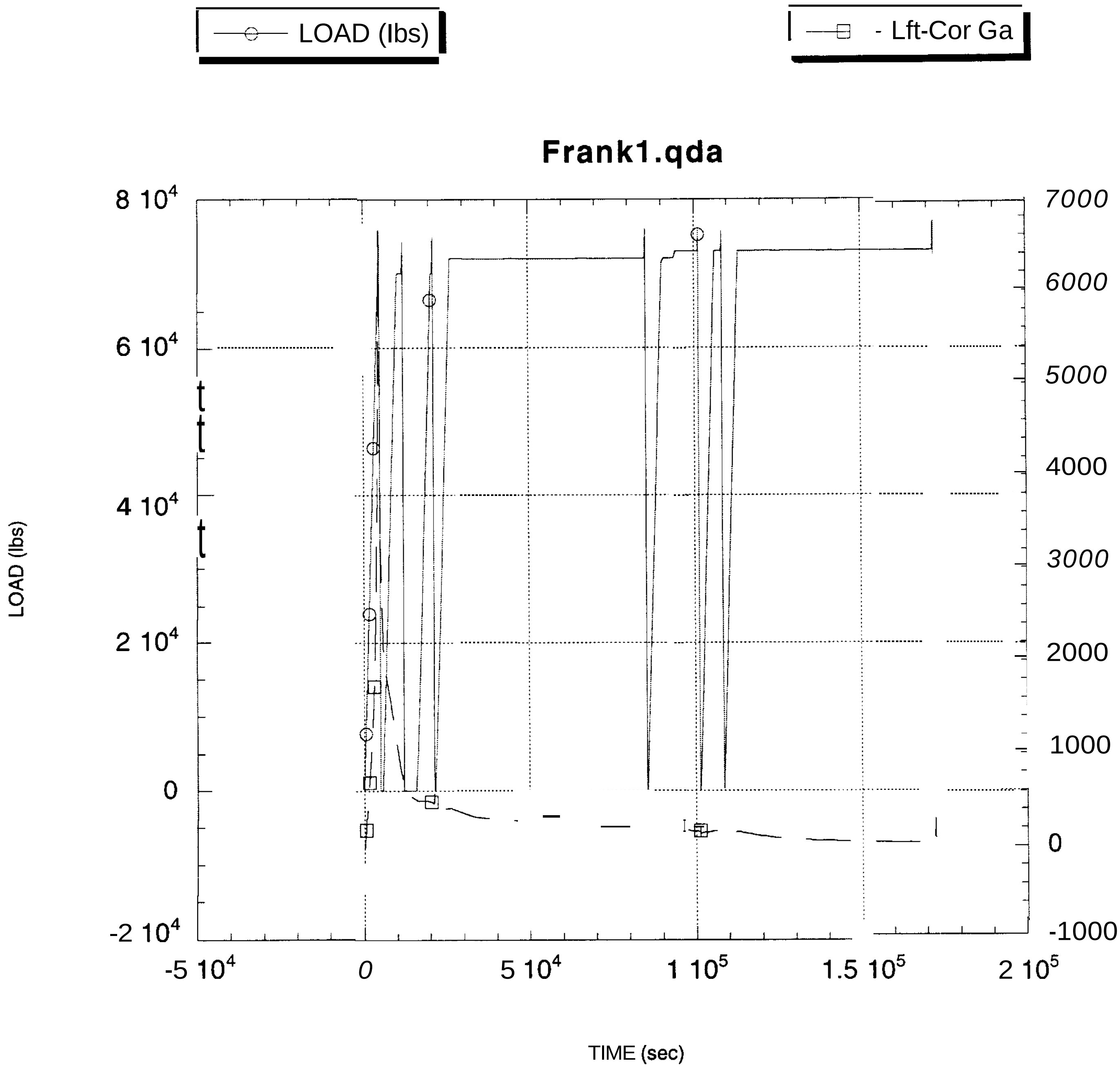
(Data for the first load pause on the eighth load cycle. The back surface strain is very large and failure can be expected.)

54.15 73025 26000 --- --- 2584 1.490

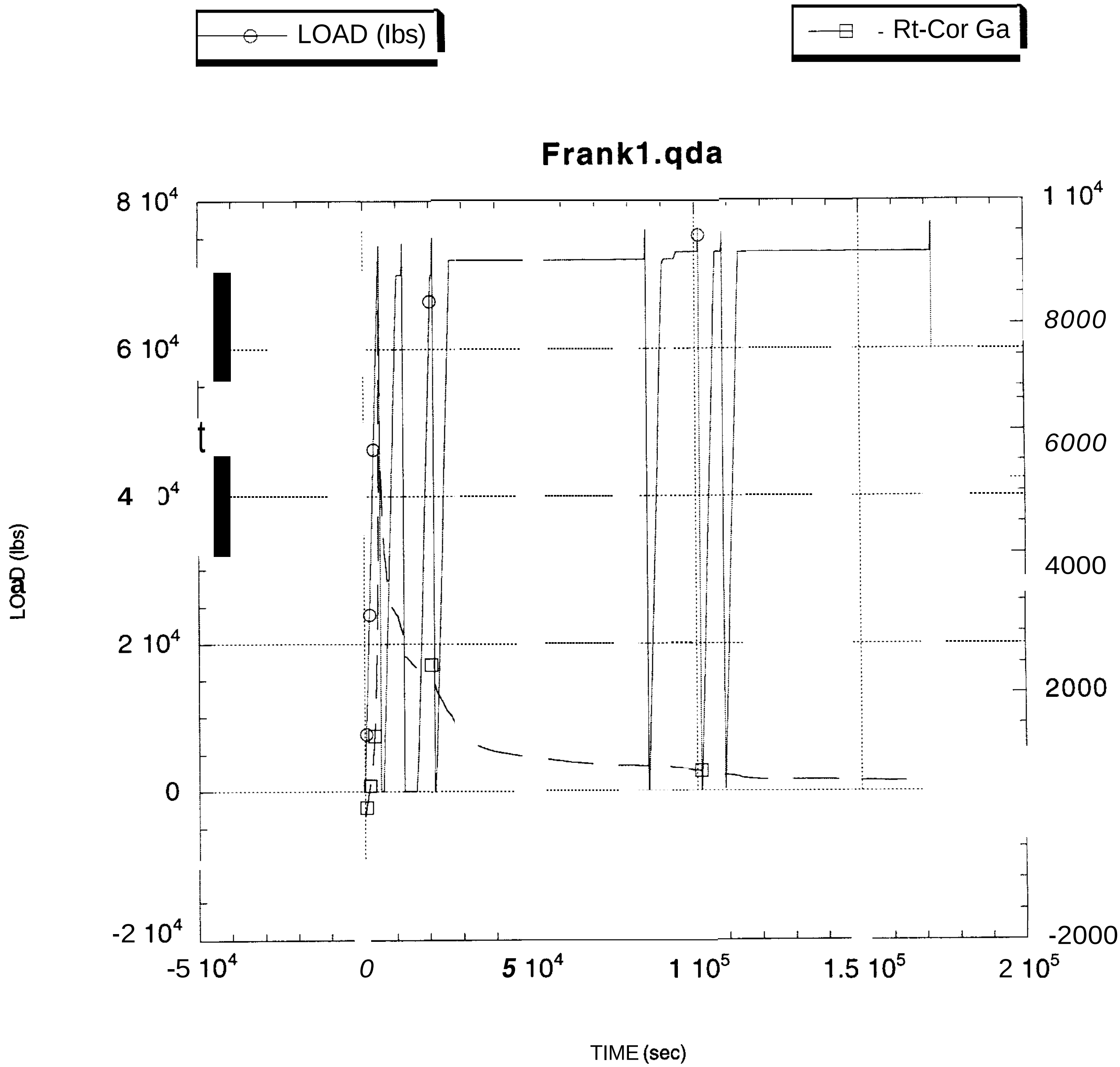
(Data just prior to failure. This calculates to be a 5.1% pressure reversal. The back surface at the flaw region necked toward the front surface. Using a dial indicator the indentation (necking) was measured to be 0.066 inch which represents 1/3 of the wall thickness at this location. The reduction in cross sectional area in the flaw region is a contributor to final failure.)

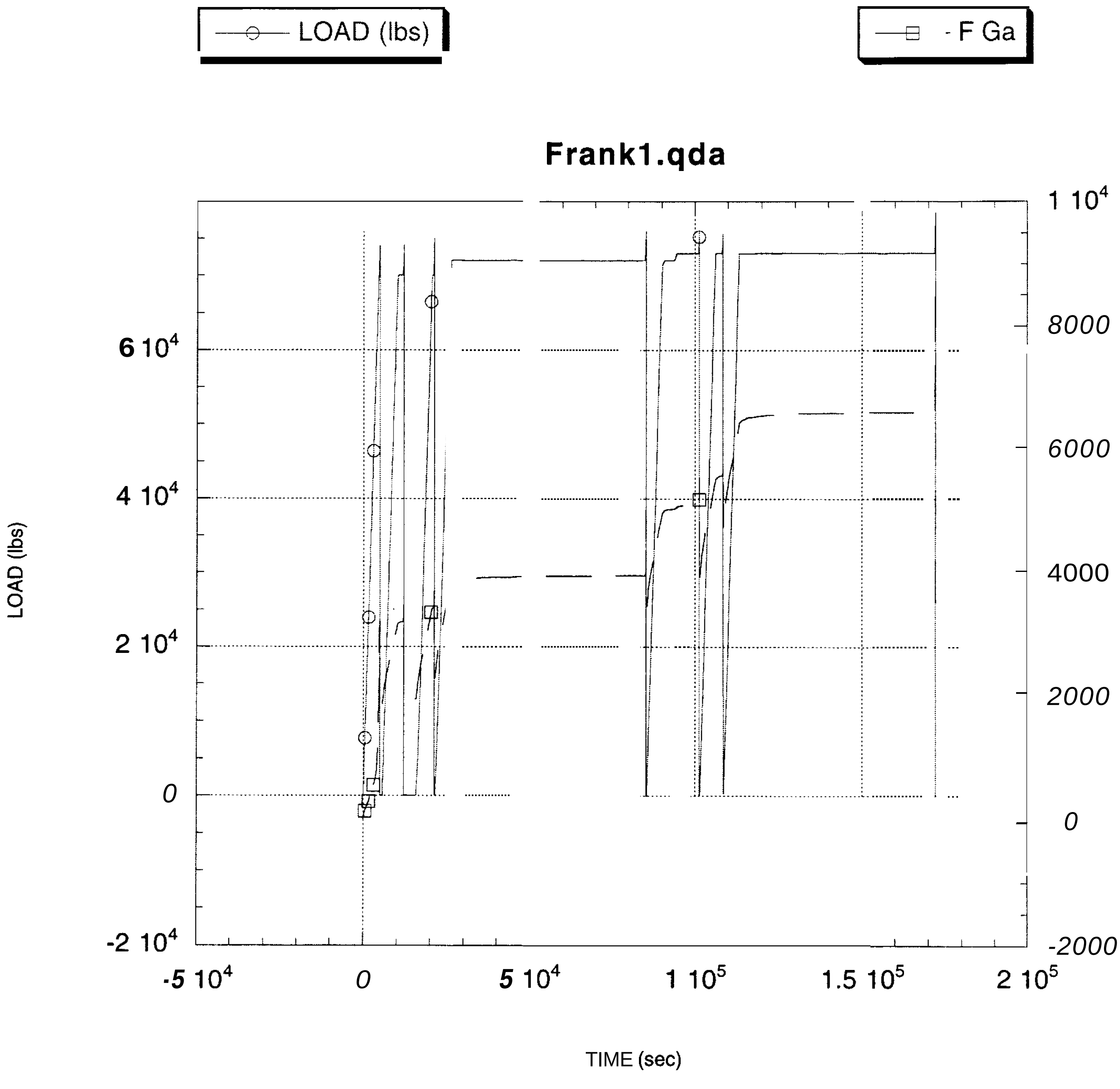
Graphs of load and back gage strain versus time, of load and left corner strain versus time, of load and right corner strain versus time, of load and strain at point F versus time, and of load and cross head displacement versus time are attached. Inspecting the corner strain plots it can be seen that these gages yielded on the first load cycle. The residual strain as seen in the back gage response continues to build with each load cycle until failure. At the end of the seventh load cycle, the computer data storage capacity was exceeded and a second data storage was created. What this means is that the graphs include data through the first seven load cycles but not the eighth load cycle.

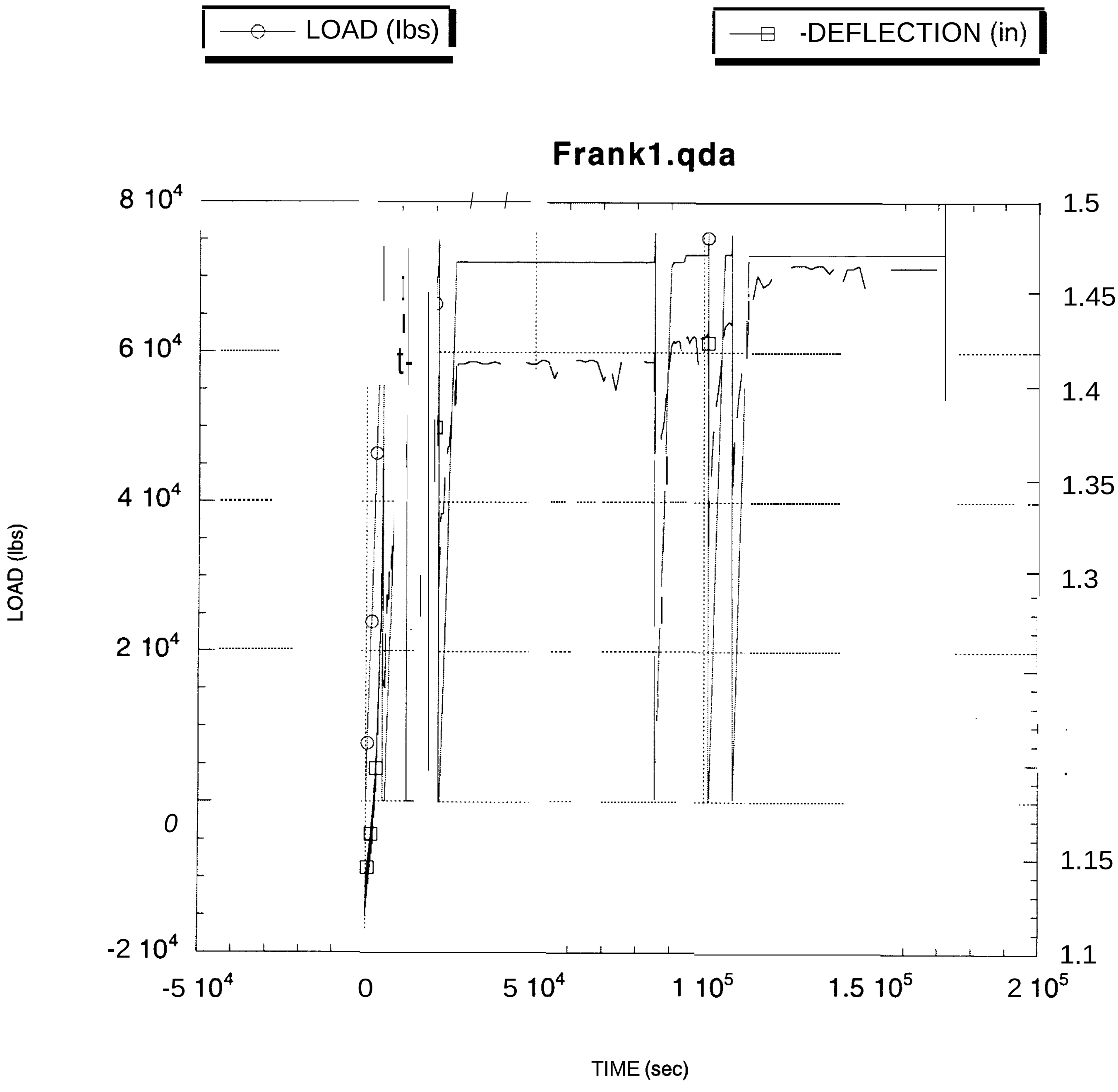

LOAD (lbs)
Back Ga
Frank1.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
1.4 10^4
1.2 10^4
1 10^4
8000
6000
0
-2000
-5 10^4
0
5 10^4
1 10^5
1.5 10^5
2 10^5
LOAD (lbs)
TIME (sec)



LOAD (lbs)
- Lft-Cor Ga
Frank1.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
7000
6000
5000
4000
3000
2000
1000
0
-1000
-5 10^4
0
5 10^4
1 10^5
1.5 10^5
2 10^5
LOAD (lbs)
TIME (sec)


LOAD (lbs)
- Rt-Cor Ga
Frank1.qda
8 10^4
6 10^4
2 10^4
0
-2 10^4
1 10^4
8000
6000
4000
2000
-2000
-5 10^4
0
5 10^4
1 10^5
1.5 10^5
2 10^5
LOAD (lbs)
TIME (sec)


LOAD (lbs)
F Ga
Frank1.qda
LOAD (lbs)
TIME (sec)
6 10^4
4 10^4
2 10^4
0
-2 10^4
1 10^4
8000
6000
4000
2000
0
-2000
-5 10^4
0
5 10^4
1 10^5
1.5 10^5
2 10^5


LOAD (lbs)
-DEFLECTION (in)
Frank1.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
1.5
1.45
1.4
1.35
1.3
1.15
1.1
-5 10^4
0
5 10^4
1 10^5
1.5 10^5
2 10^5
TIME (sec)
LOAD (lbs)

--Specimen #**4**, **X-42** base material: Test conducted **12-27-96.**

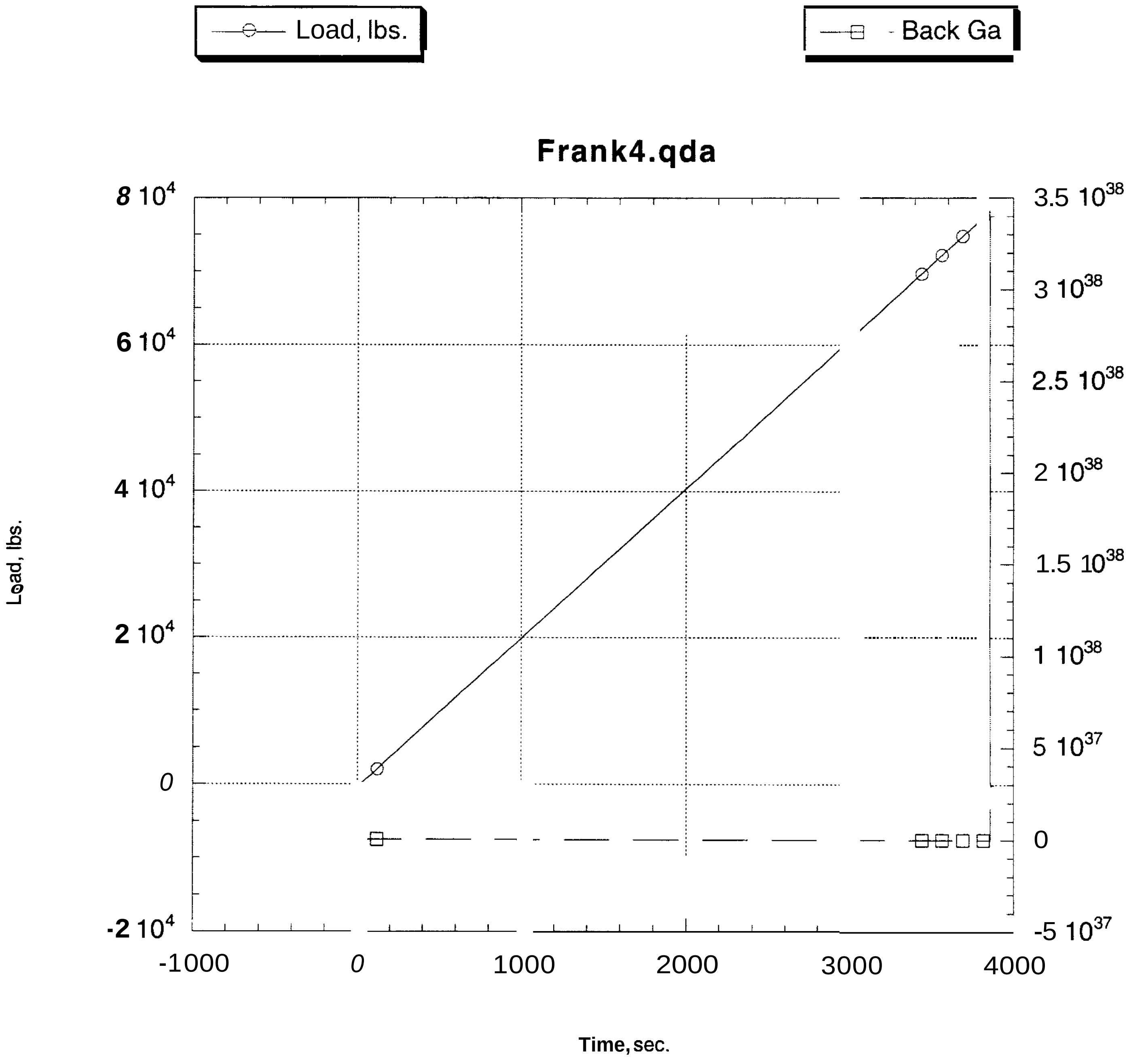
The purpose of this test was to try for a larger pressure reversal. This was to be accomplished by increasing the load as much as possible before reducing to zero. The result was that the specimen failed just prior to the time that the load was to be reduced. The data will now be helpful in comparing with the base line data of Specimen **#2** for the variability of failure data. The gages were located with one on the central back surface, one located on the front surface **0.5** inch from the left flaw corner, one at the right corner of the flaw, and one on the front surface center line, parallel to the flaw and at the flaw edge.

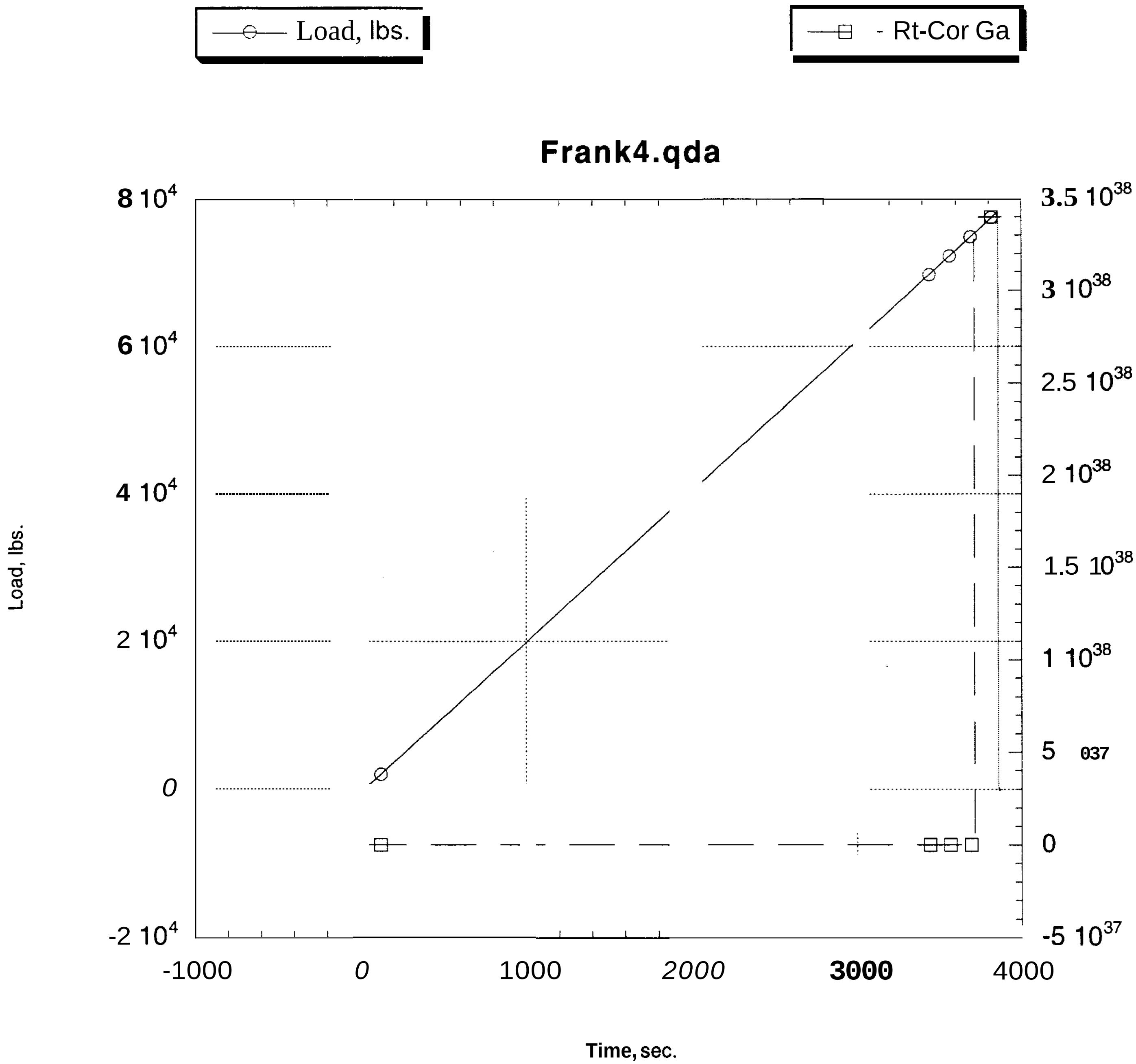
The data included:

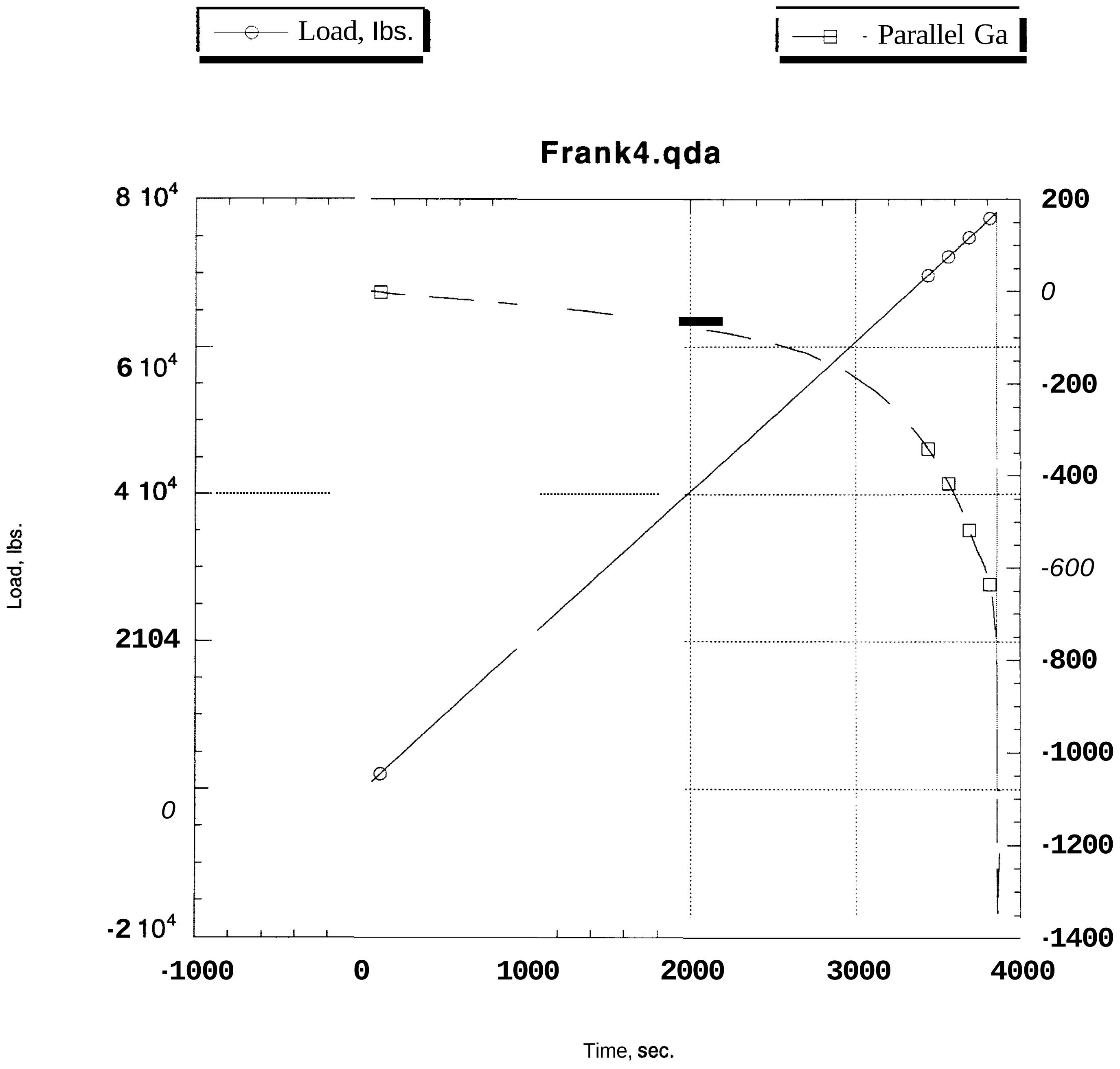
Time,sec	Load,lbs	eback	e0.51ft	ert-cor	epara	displ
0	0	0	**0**	**0**	**0**	**1.130**
(test initiated)						
0.90	**65675**	**-194**	**5650**	**6955**	**-254**	**1.270**
(largest negative strain on back surface gage)						
1.01	**73600**	0	**10860**	**16235**	**-464**	**1.330**
(zero strain at back surface gage)						
1.03	**75250**	**203**	**13045**	**20470**	**-537**	**1.360**
(The right corner gage failed)						
1.07	**78150**	**9090**	**20140**	**----**	**-766**	**1.410**
(The right corner gage failed)						
1.07	**78225**	**16685**	**----**	**----**	**-878**	**1.430**
(The specimen failed)						

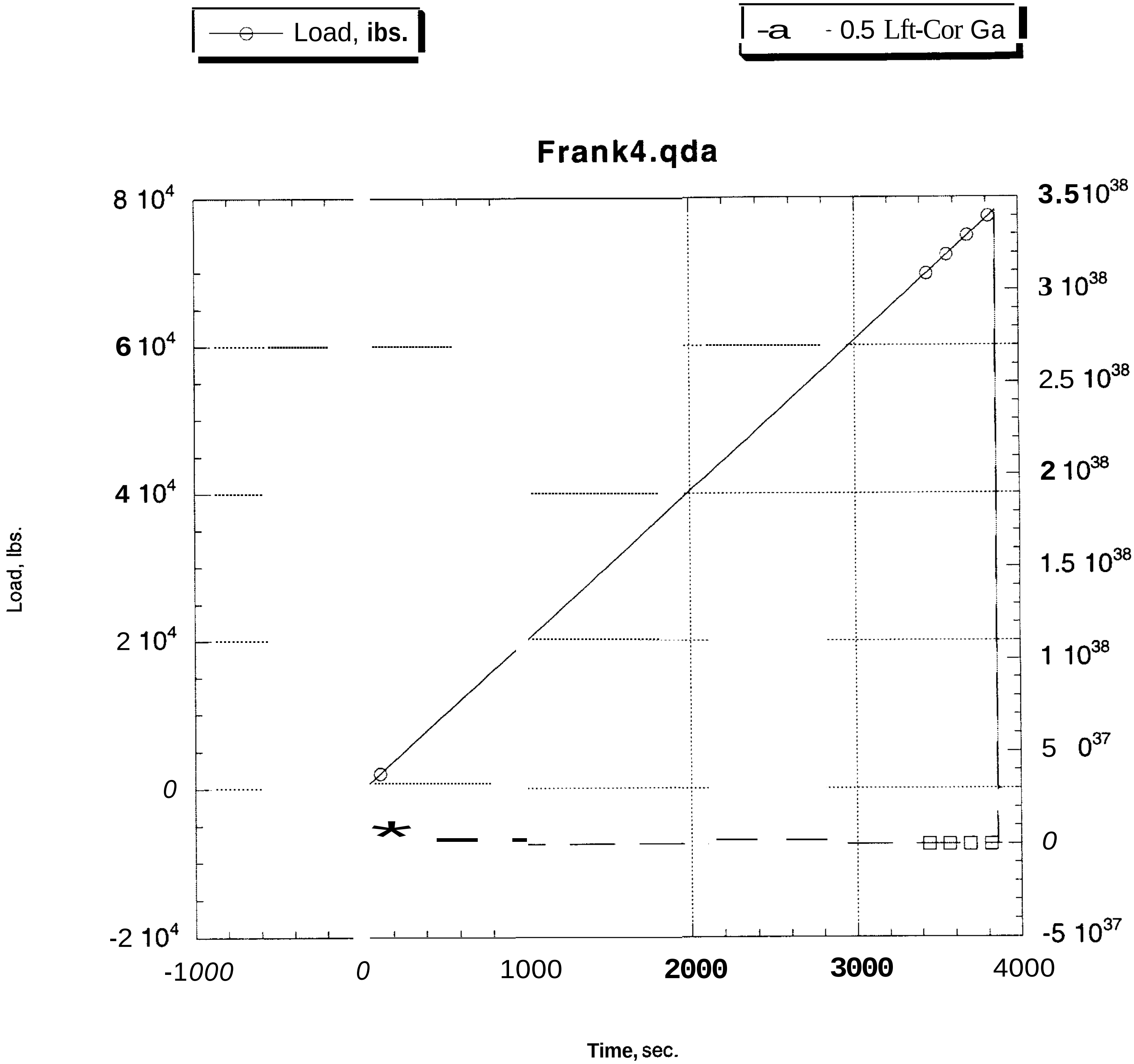
The failure surface appeared the same as described for Specimen #l. The necking depression was measured to be **0.062** inch.

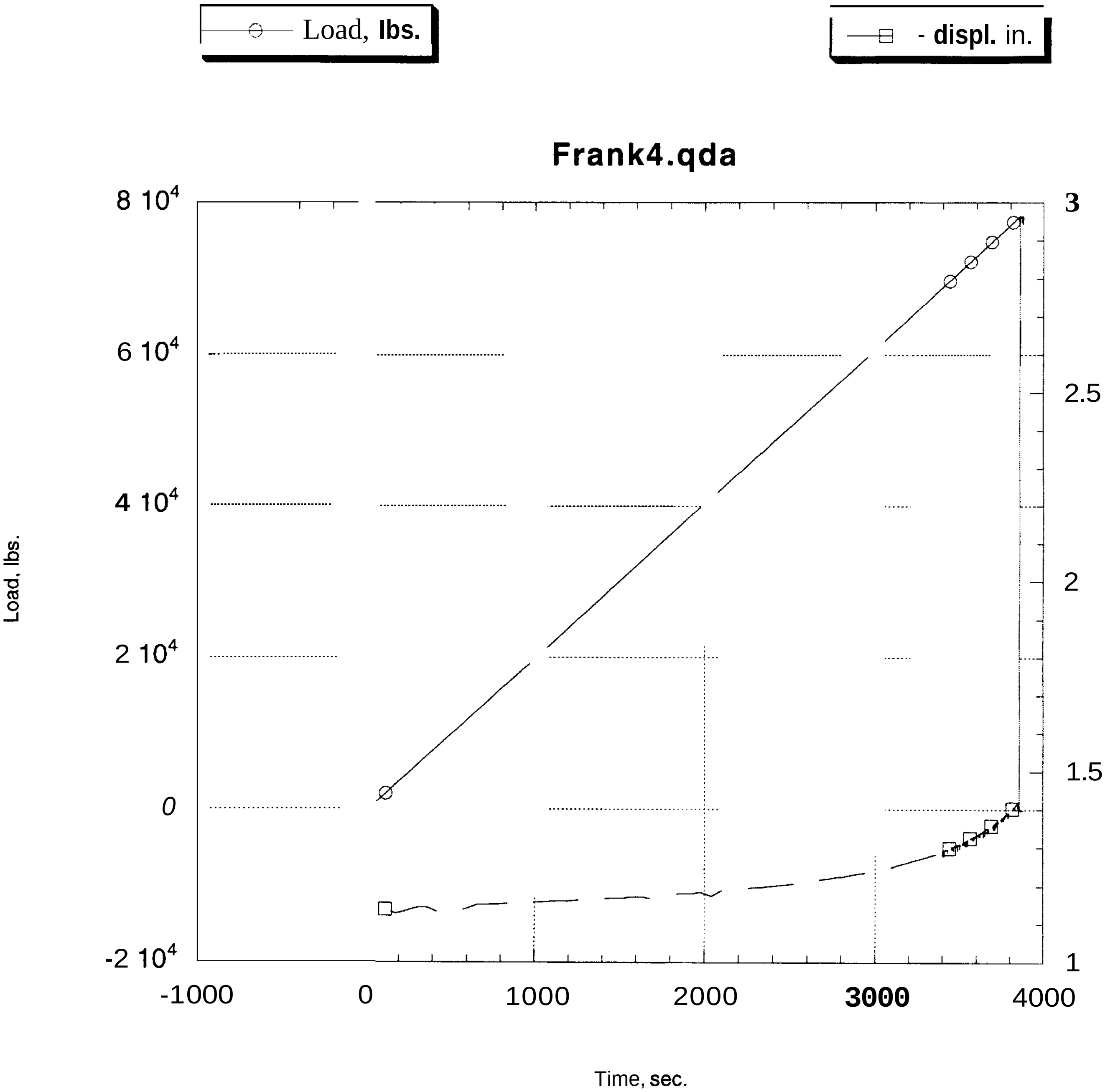
Graphs of load and back gage strain versus time, of load and right corner strain versus time, of load and parallel gage strain versus time, of load and strain at point C versus time, and of load and cross head displacement versus time are attached.


Load, lbs.
Back Ga
Frank4.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
3.5 10^38
3 10^38
2.5 10^38
2 10^38
1.5 10^38
1 10^38
5 10^37
0
-5 10^37
-1000
0
1000
2000
3000
4000
Load, lbs.
Time, sec.


Load, lbs.
- Rt-Cor Ga
Frank4.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
3.5 10^38
3 10^38
2.5 10^38
2 10^38
1.5 10^38
1 10^38
5 10^37
0
-5 10^37
-1000
0
1000
2000
3000
4000
Time, sec.
Load, lbs.


Load, lbs.
Parallel Ga
Frank4.qda
8 10^4
6 10^4
4 10^4
2104
0
-2 10^4
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1000
0
1000
2000
3000
4000
Load, lbs.
Time, sec.


Load, ibs.
-a - 0.5 Lft-Cor Ga
Frank4.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
3.5 10^38
3 10^38
2.5 10^38
2 10^38
1.5 10^38
1 10^38
5 0^37
0
-5 10^37
-1000
0
1000
2000
3000
4000
Load, lbs.
Time, sec.



Load, lbs.
- displ. in.
Frank4.qda
8 10^4
6 10^4
4 10^4
2 10^4
0
-2 10^4
3
2.5
2
1.5
1
-1000
0
1000
2000
3000
4000
Load, lbs.
Time, sec.