AFWAL-TR-88-3026
VOLUME II

DURABILITY AND DAMAGE TOLERANCE OF BISMALEIMIDE COMPOSITES

VOLUME II: APPENDIX OF CRACK GROWTH AND LOW-VELOCITY IMPACT DATA

S.T. TYAHLA AND P.S. MCCLELLAN JR.

McDonnell Aircraft Company
McDonnell Douglas Corporation
P.O. Box 516
St. Louis, Missouri 63166

JUNE 1988

Final Report for Period 13 September 1985 - 15 January 1988

FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6553

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture use, or sell any patented invention that may in any way be related thereto.

This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

HOWARD J. STORR, JR, 2nd Lt, USAF
Project Engineer

TONY G. GERARDI, ACTING CHIEF
Structural Integrity Branch
Structures Division

FOR THE COMMANDER

FREDERICK L. DIETRICH, Colonel, USAF
Chief, Structures Division

"If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify AFWAL/FIBEC, W-PAFB, OH 45433 to help us maintain a current mailing list".

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFWAL/TR-88-3026, Vol II
6a. NAME OF PERFORMING ORGANIZATION McDonnell Aircraft Company/ McDonnell Douglas Corporation 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Wright Aeronautical Laboratories (AFWAL/FIBEC)
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 516 St. Louis, Missouri 63166	7b. ADDRESS (City, State, and ZIP Code) Wright-Patterson Ohio 45433
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable) AFWAL/FIBEC	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Contract F33615-85-C-3212
8c. ADDRESS (City, State, and ZIP Code) Wright-Patterson AFB OH 45433-6553	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 62201F; PROJECT NO. 2401; TASK NO. 01; WORK UNIT ACCESSION NO. 94
11. TITLE (Include Security Classification) Durability and Damage Tolerance of Bismaleimide Composites Volume II: Appendix of Crack Growth and Low Velocity Impact Data	
12. PERSONAL AUTHOR(S) S. Timothy Tyahla and Paul S. McClellan, Jr.	
13a. TYPE OF REPORT Final Technical Report 13b. TIME COVERED FROM Sept 85 TO Jan 88 14. DATE OF REPORT (Year, Month, Day) 88 Jun 15. PAGE COUNT 246	
16. SUPPLEMENTARY NOTATION	

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Composite Materials, Bismaleimide, Fracture Toughness, Tough Resins, Stress Analysis, Static Strength, Low Energy Impact, Damage Tolerance.
11	04		
13	13		

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This program was the evaluation of durability and damage tolerance of bismaleimide (BMI) composites. BMI resins have been developed for structural applications in 350°F to 450°F environments. This represents an improvement over epoxy resin capability of approximately 100°F.

In Task I of this program we experimentally evaluated two second generation BMI systems (IM6/3100 and IM6/F650) and compared their performance with that of baseline systems AS1/3501-6 and T300/V378A. The intermediate modulus fiber IM6 was chosen as the common fiber for both material systems because its high strength and stiffness are properties that are important for future fighter design.

In Task II basic material properties were determined. The data included moisture absorption, glass transition temperature, thermal spike susceptibility, lamina properties, and interlaminar fracture toughness test results. Lamina properties and fracture toughness test data were used to correlate laminate behavior exhibited in Task III.

(continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☒ OTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Lt. H. Joseph Storr	22b TELEPHONE (Include Area Code) (513) 255-6104 22c OFFICE SYMBOL AFWAL/FIBEC

19. Abstract (cont.)

In Task III laminate structural characterizations of IM6/3100 and IM6/F650 were completed. Tests were performed on coupons that represented configurations found in typical aircraft designs. Specimens were fabricated and tested in notched and unnotched conditions to represent design applications.

In Task IV the better system (IM6/3100) was chosen to fabricate stiffened panels for evaluation of the bismaleimide's durability and damage tolerance in a structural configuration. Static and fatigue tests were performed on panels with and without impact damage.

FOREWORD

The work reported herein was performed by the McDonnell Aircraft Company (MCAIR) of the McDonnell Douglas Corporation (MDC), St. Louis, Missouri, under Air Force Contract F33615-85-C-3212, "Durability and Damage Tolerance of Bismaleimide Composites", for the Air Force Wright Aeronautical Laboratories, Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. Lt. David L. Graves (AFWAL/FIBEC) and Lt. H. Joseph Storr (AFWAL/FIBEC) were the Air Force Project Engineers. The work described was conducted during the period 13 September 1985 through 15 January 1988.

The work was managed by the MCAIR Structural Research Department with Harold D. Dill as Program Manager and S. Timothy Tyahla as Principal Investigator. Program testing was conducted under the direction of Paul S. McClellan, Jr., MCAIR Nonmetallics and Chemical Processes Laboratory.

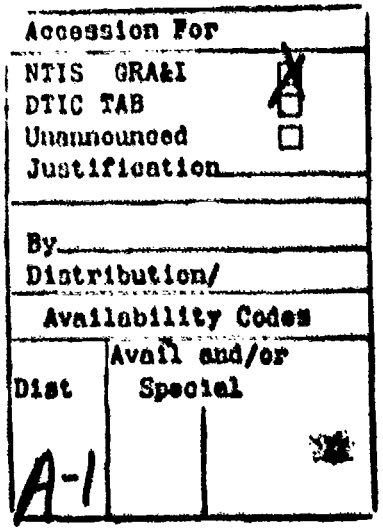


TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Concluded)

APPENDIX A

CRACK GROWTH PLOTS

A.1 CTD DATA

MODE I CRACK GROWTH DATA
IM6/3100 -- CTD ENVIRONMENT

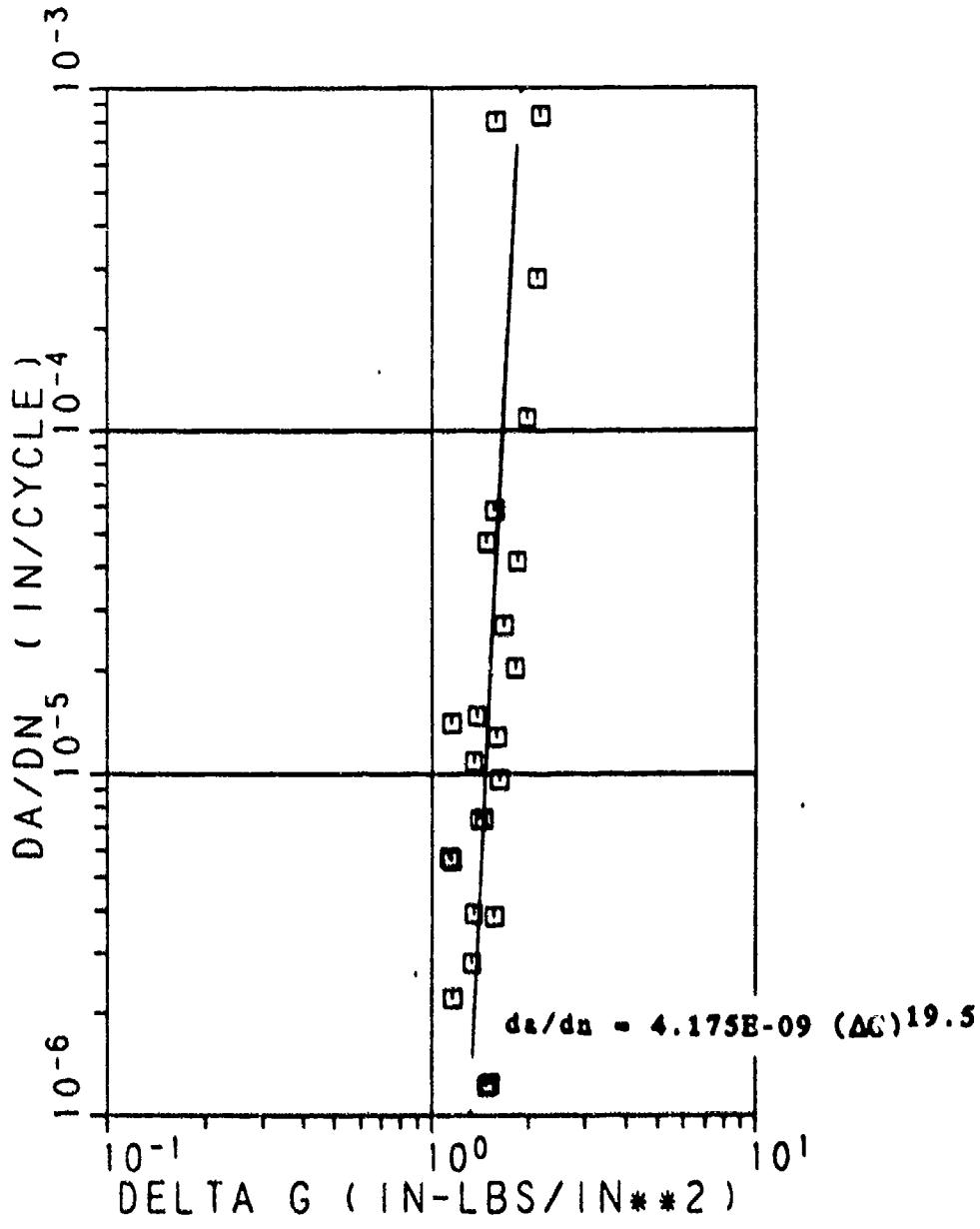


Figure A-1. IM6/3100 Mode I at CTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-63
IM6/3100 -- CTD ENVIRONMENT

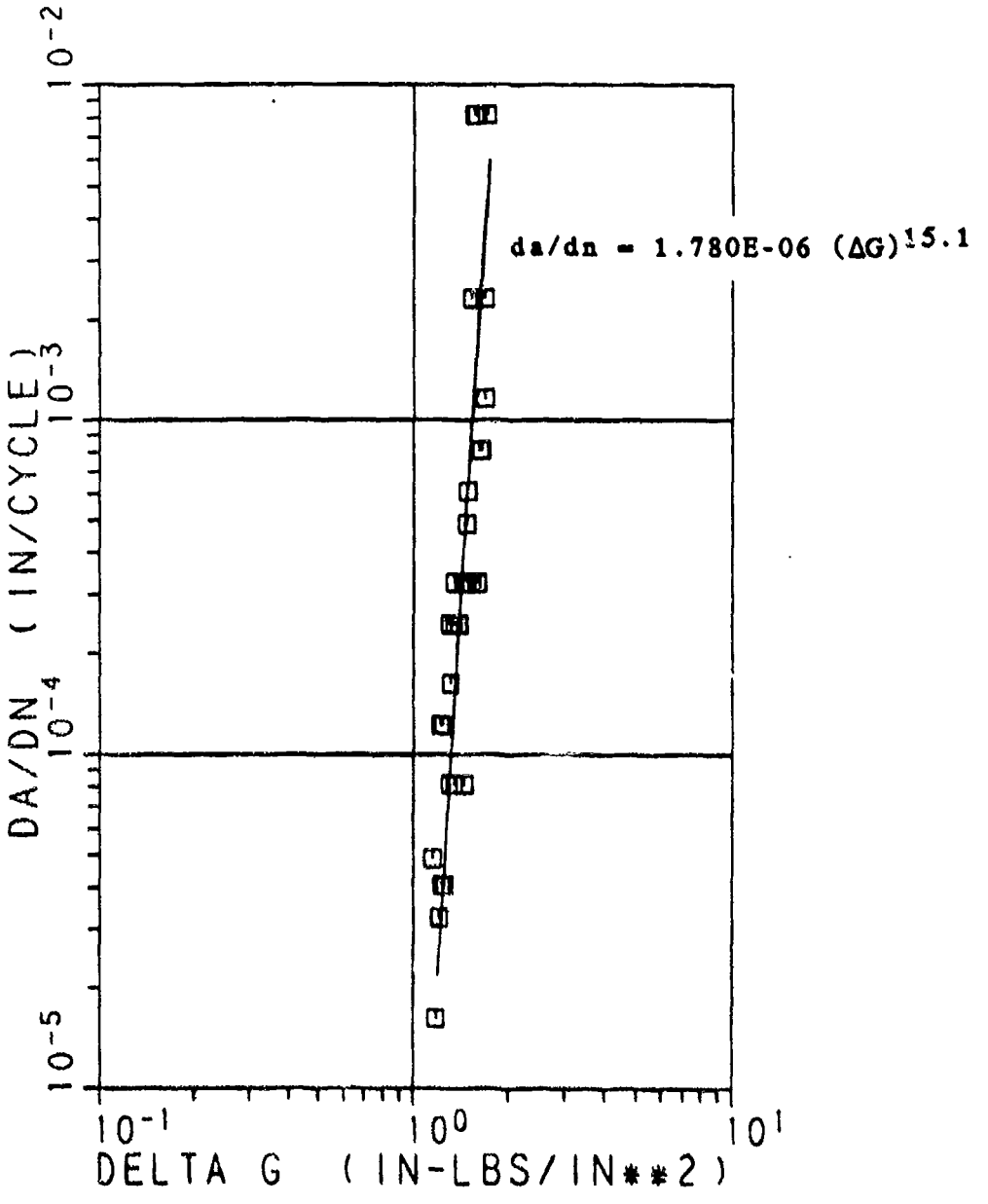


Figure A-2. IM6/3100 Mixed Mode (CLS-63) at CTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-82
IM6/3100 -- CTD ENVIRONMENT

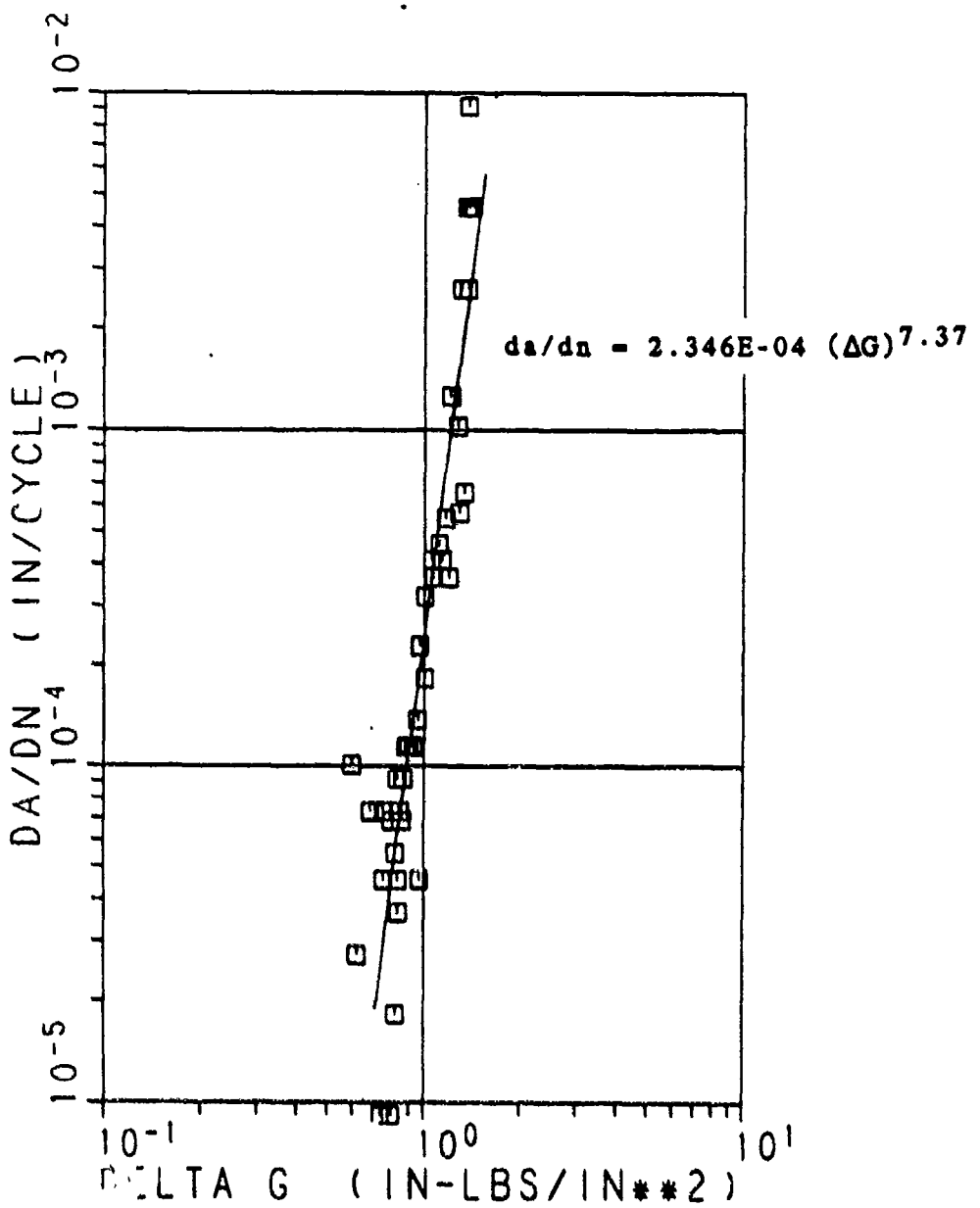


Figure A-3. IM6/3100 Mixed Mode (CLS-82) at CTD Conditions

MODE II CRACK GROWTH DATA
IM6/3100 -- CTD ENVIRONMENT

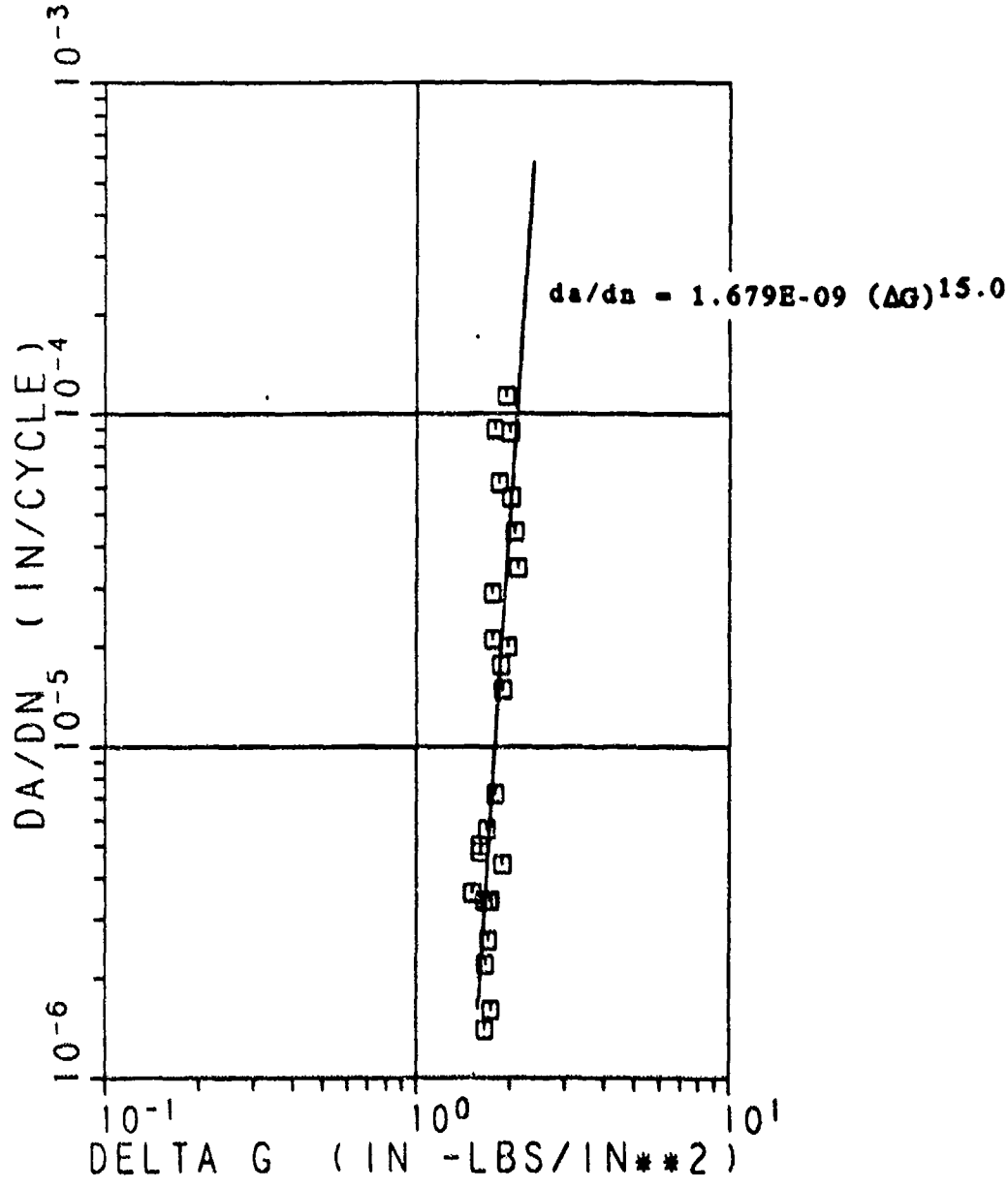


Figure A-4. IM6/3100 Mode II at CTD Conditions

MODE I CRACK GROWTH DATA
IM6/F650 -- CTD ENVIRONMENT

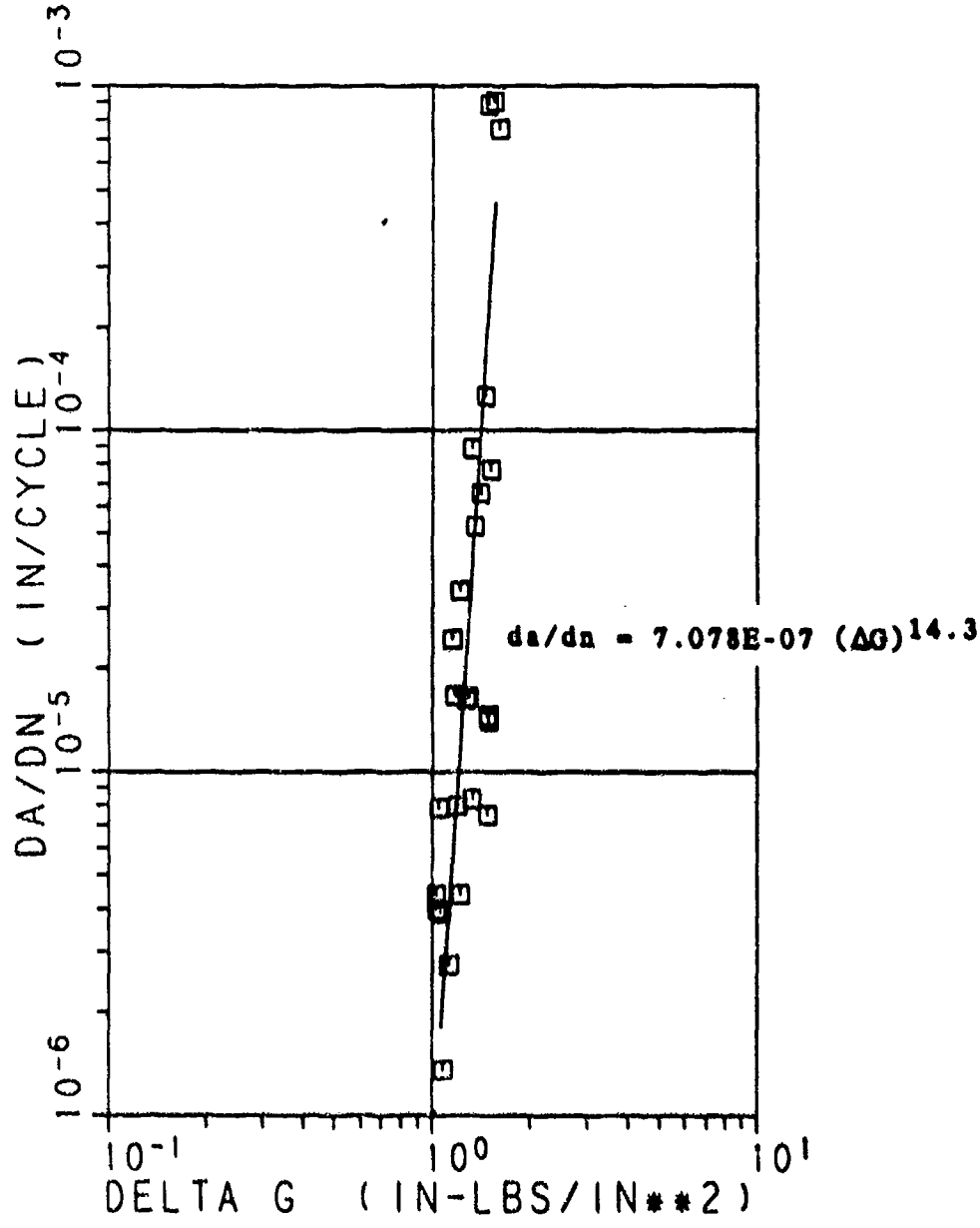


Figure A-6. IM6/F650 Mode I at CTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-63
IM6/F650 -- CTD ENVIRONMENT

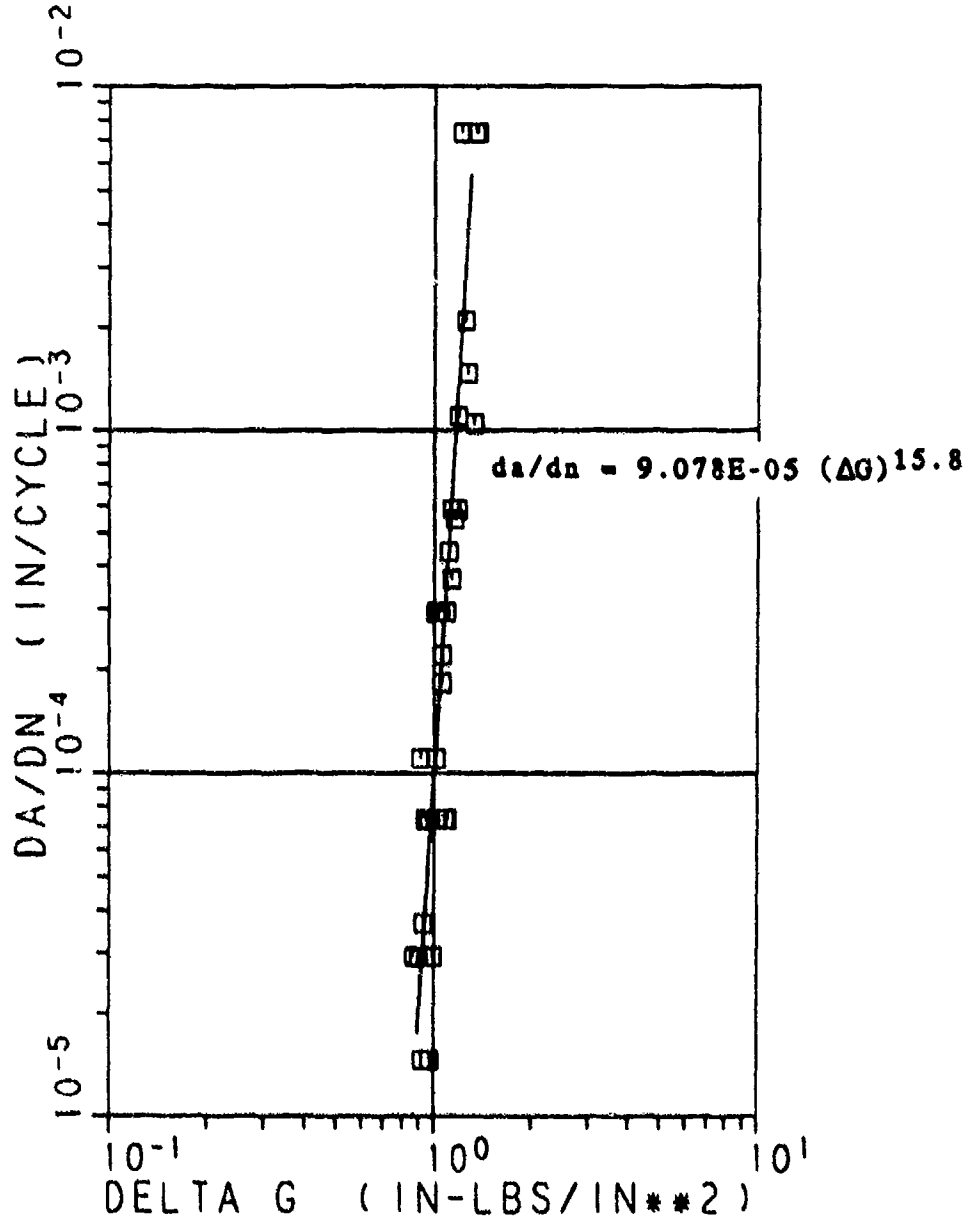


Figure A-6. IM6/F650 Mixed Mode (CLS-63) at CTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-82
IM6/F650 -- CTD ENVIRONMENT

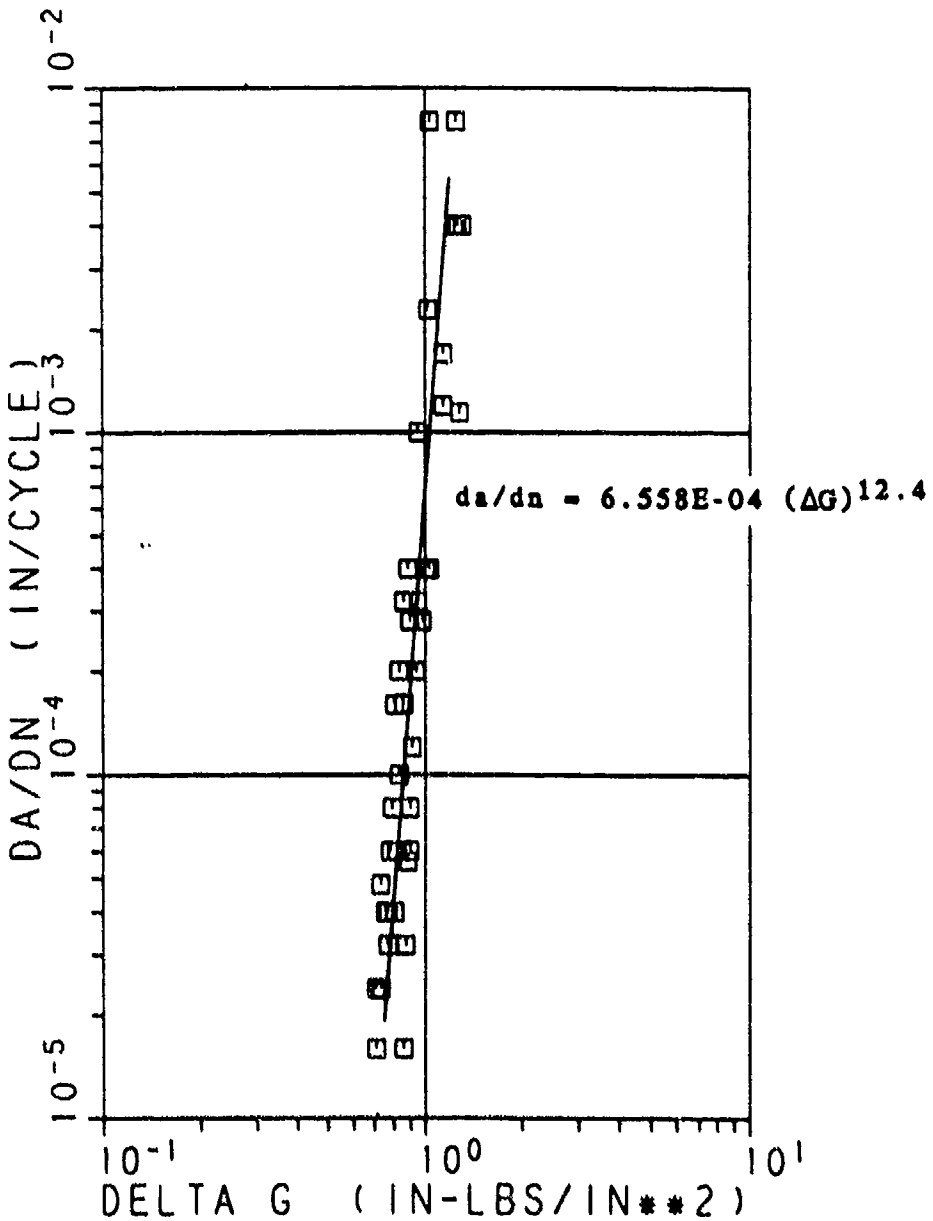


Figure A-7. IM6/F650 Mixed Mode (CLS-82) at CTD Conditions

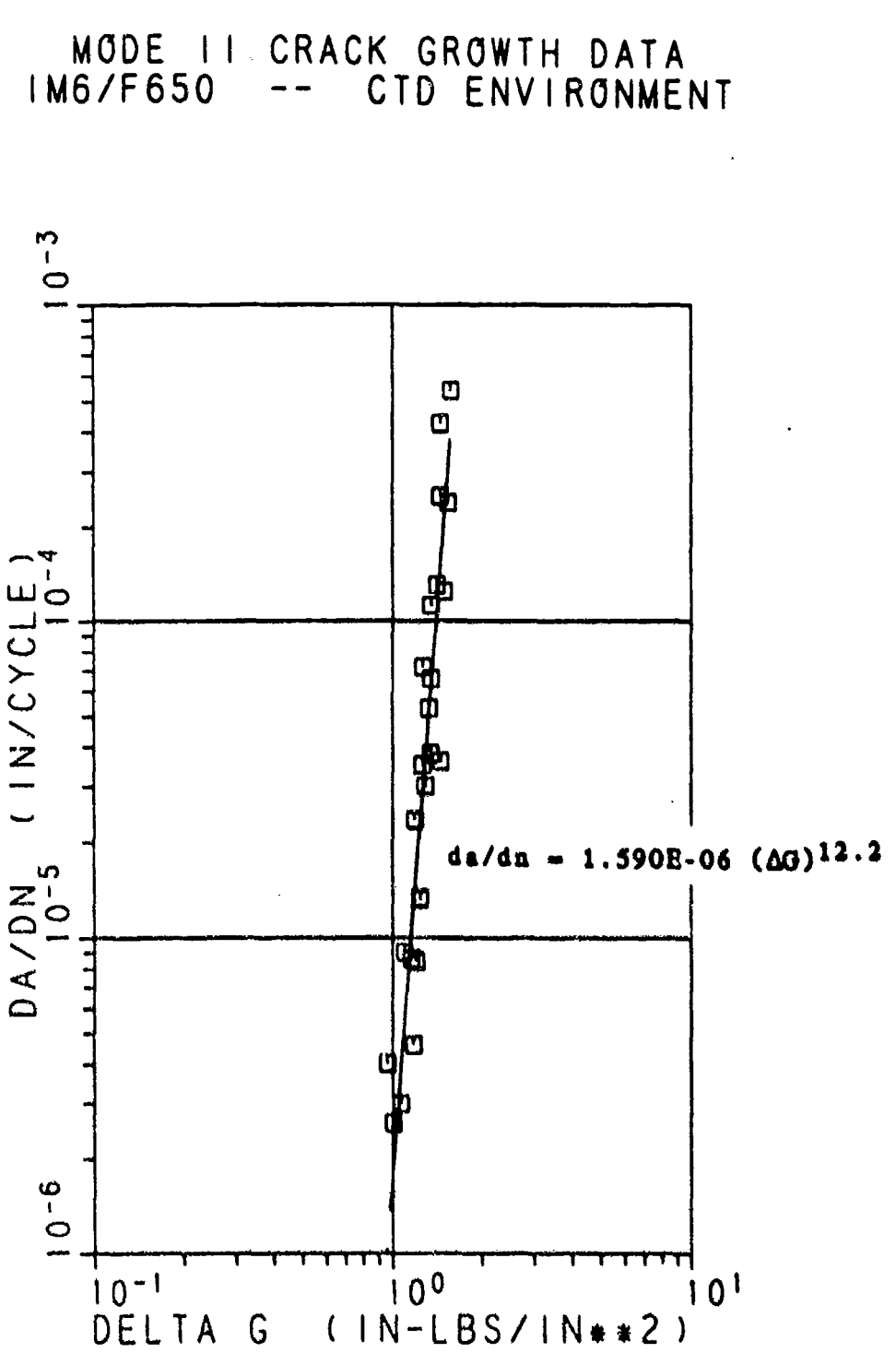


Figure A-8. IM6/F650 Mode II at CTD Conditions

A.2 RTD DATA

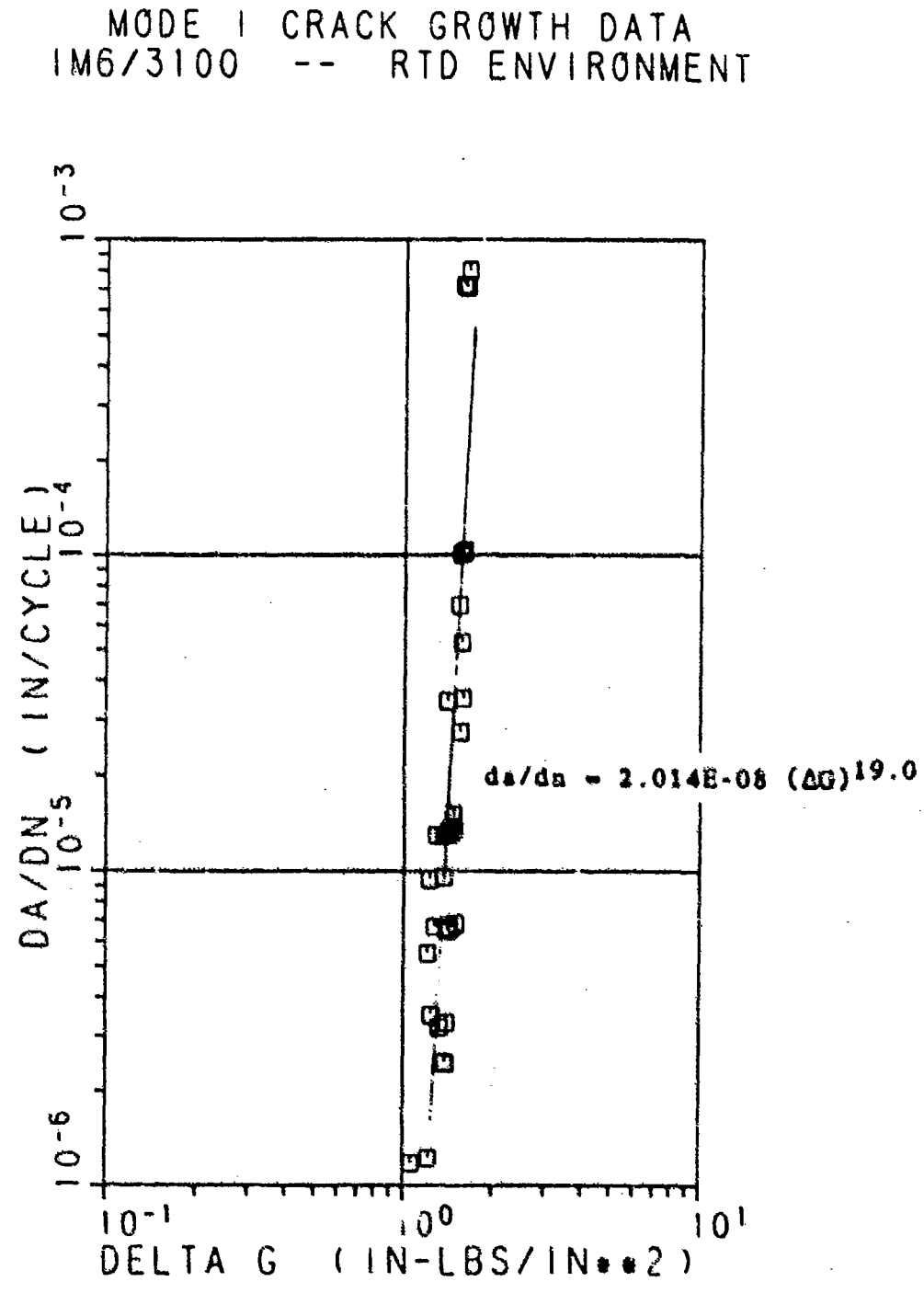


Figure A-8. IM6/3100 Mode I at RTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-63
IM6/3100 -- RTD ENVIRONMENT

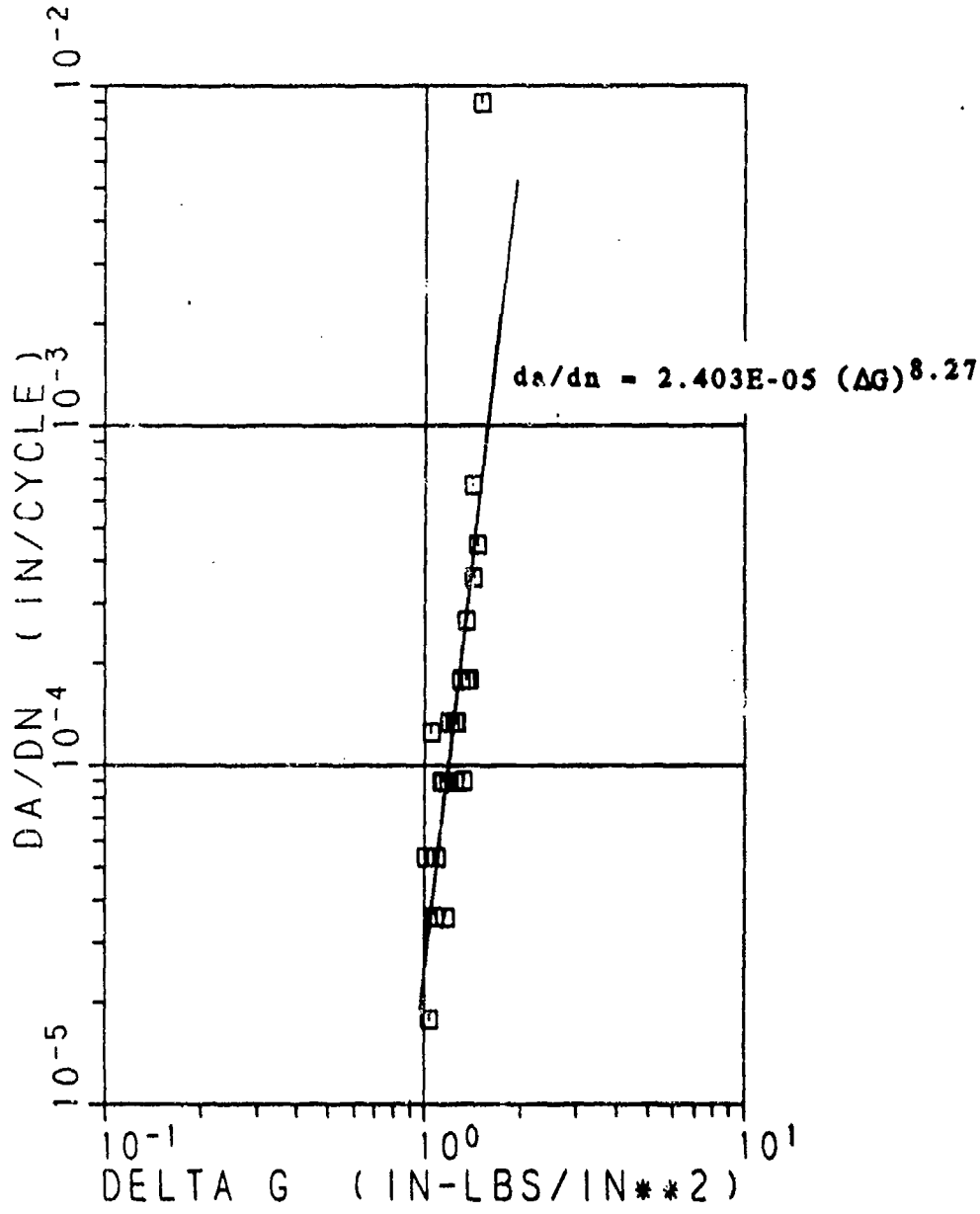


Figure A-10. IM6/3100 Mixed Mode (CLS-63) at RTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-82
IM6/3100 -- RTD ENVIRONMENT

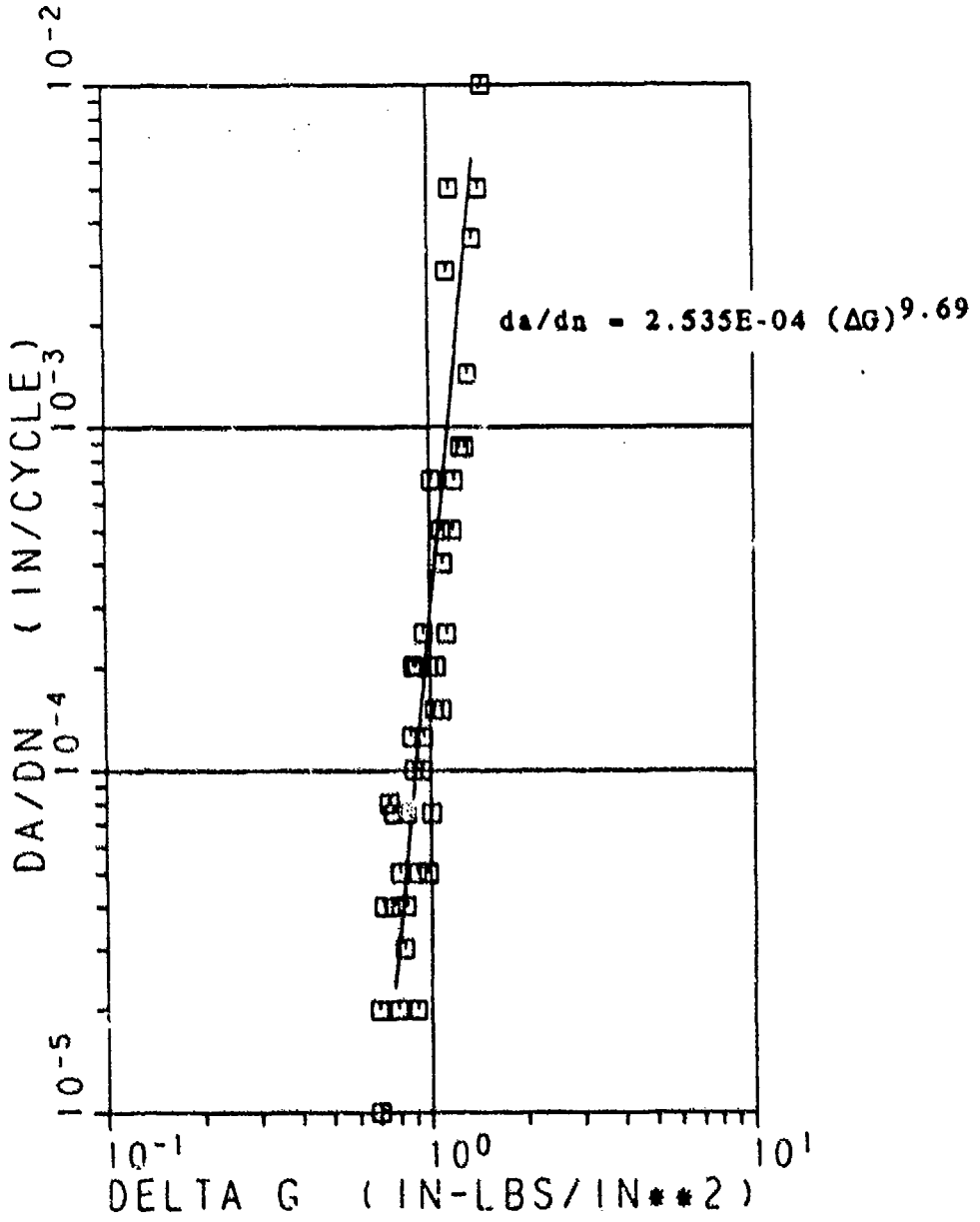


Figure A-11. IM6/3100 Mixed Mode (CLS-82) at RTD Conditions

MODE II CRACK GROWTH DATA
IM6/3100 -- RTD ENVIRONMENT

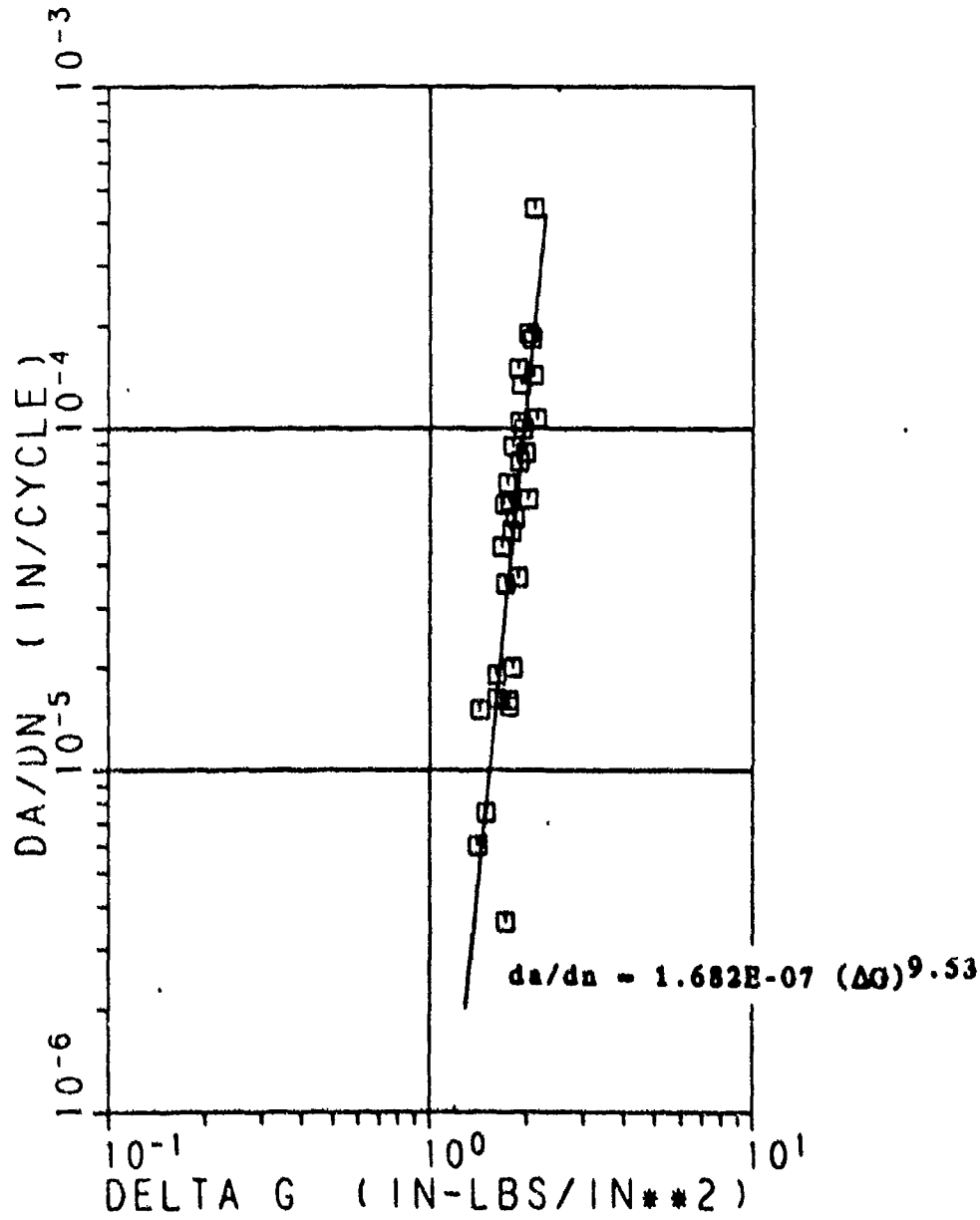


Figure A-12. IM6/3100 Mode II at RTD Conditions

MODE I CRACK GROWTH DATA
IM6/F650 -- RTD ENVIRONMENT

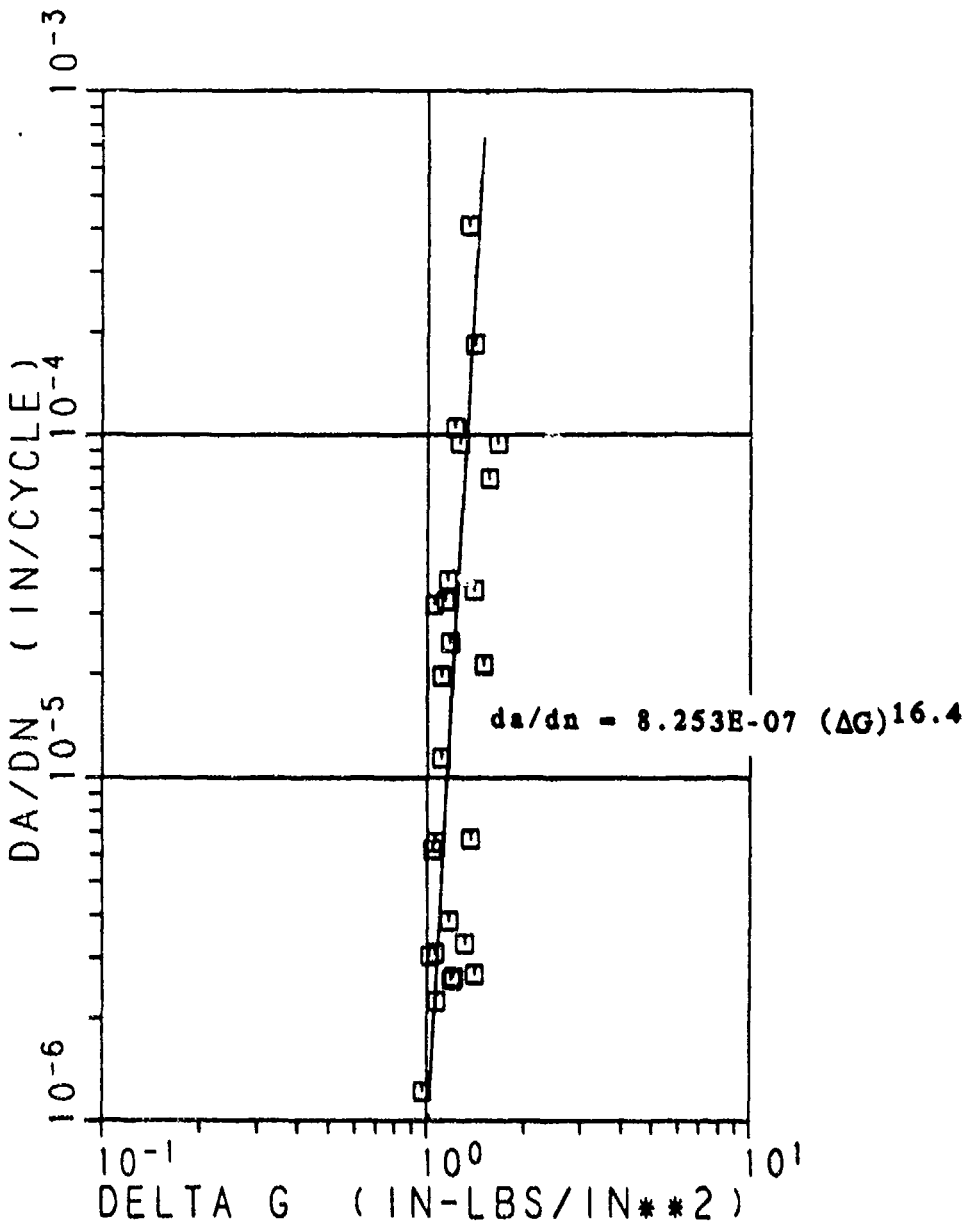


Figure A-13. IM6/F650 Mode I at RTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-63
IM6/F650 -- RTD ENVIRONMENT

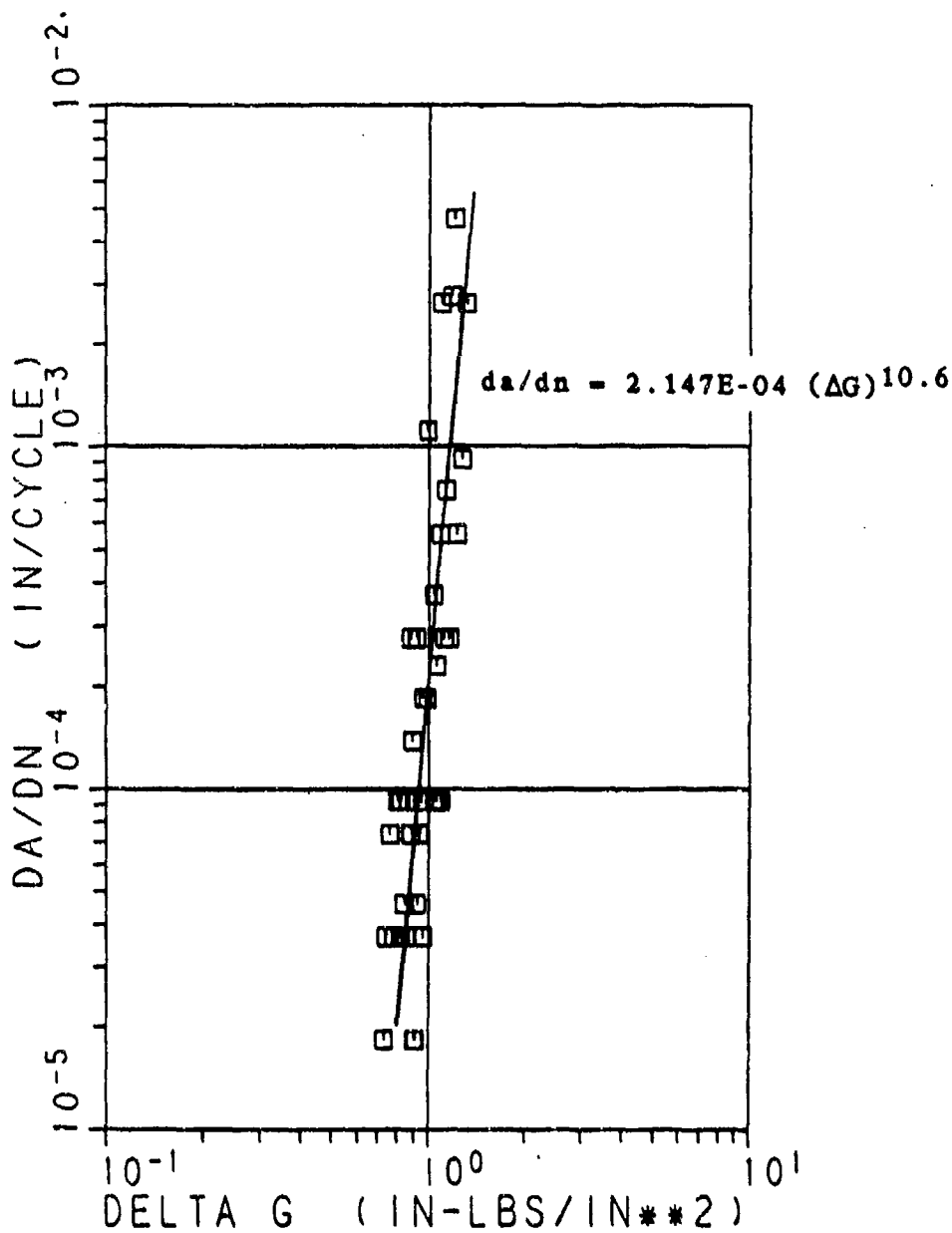


Figure A-14. IM6/F650 Mixed Mode (CLS-63) at RTD Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-82
IM6/F650 -- RTD ENVIRONMENT

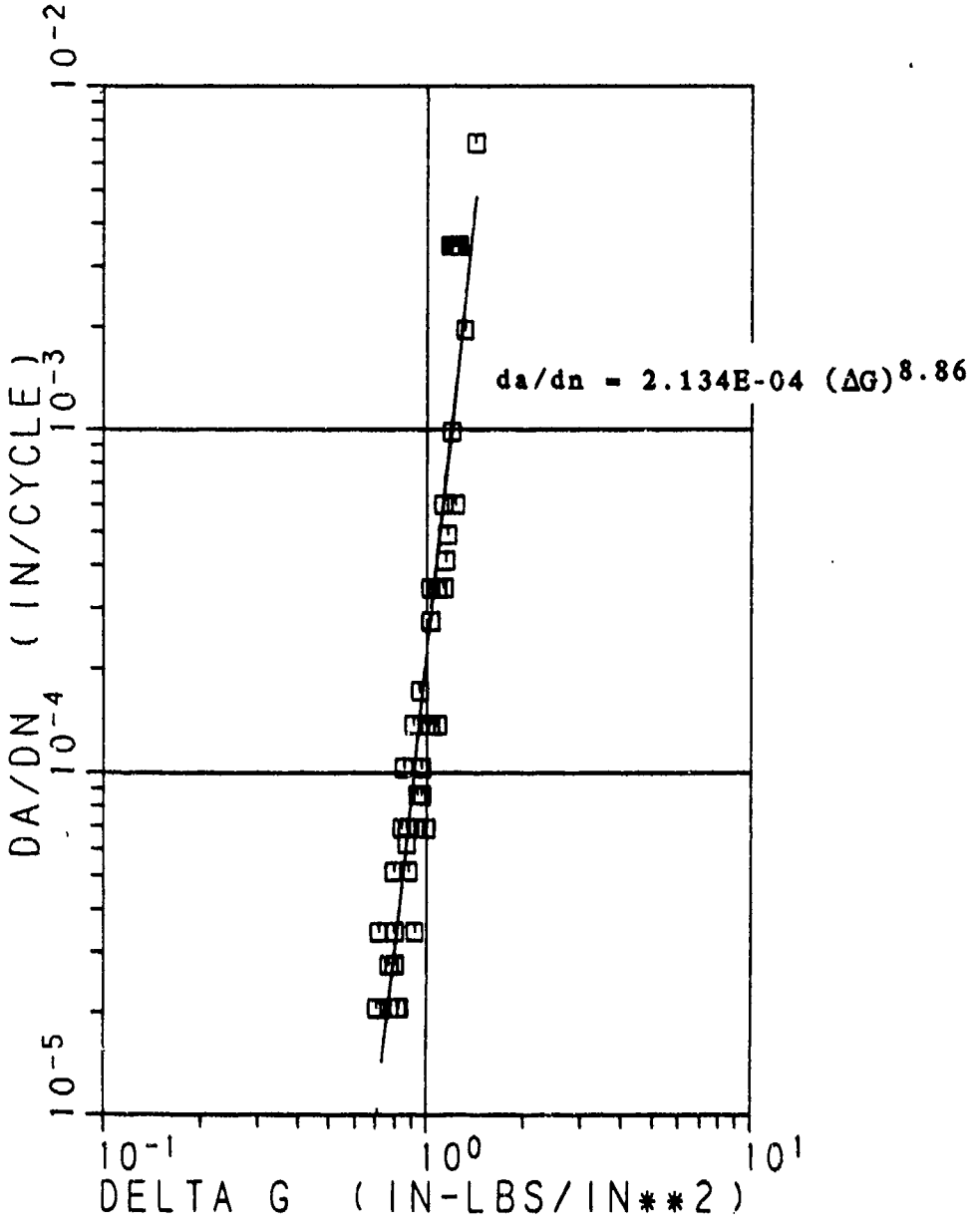


Figure A-15. IM6/F650 Mixed Mode (CLS-82) at RTD Conditions

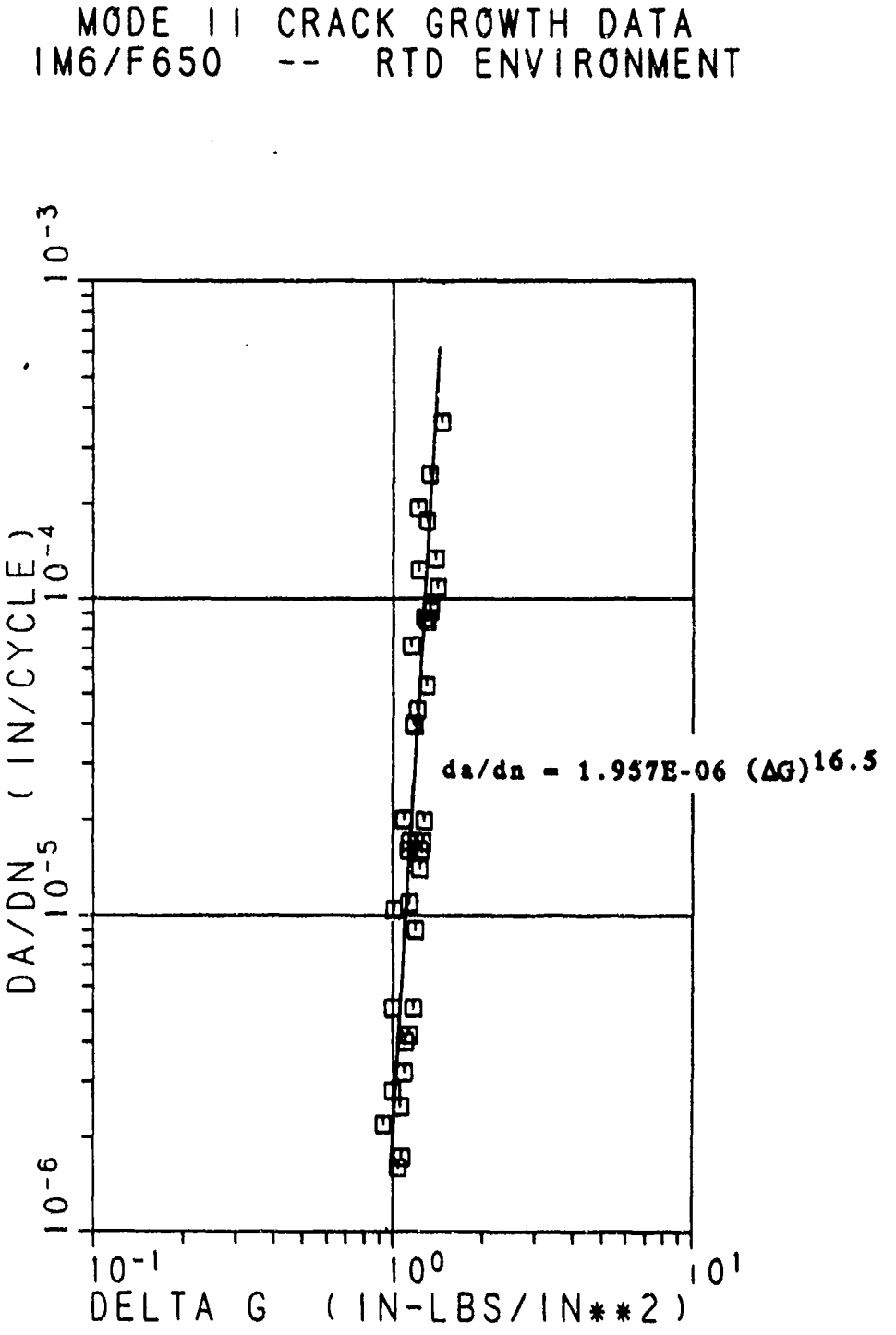


Figure A-16. IM6/F650 Mode II at RTD Conditions

A.3 ETW DATA

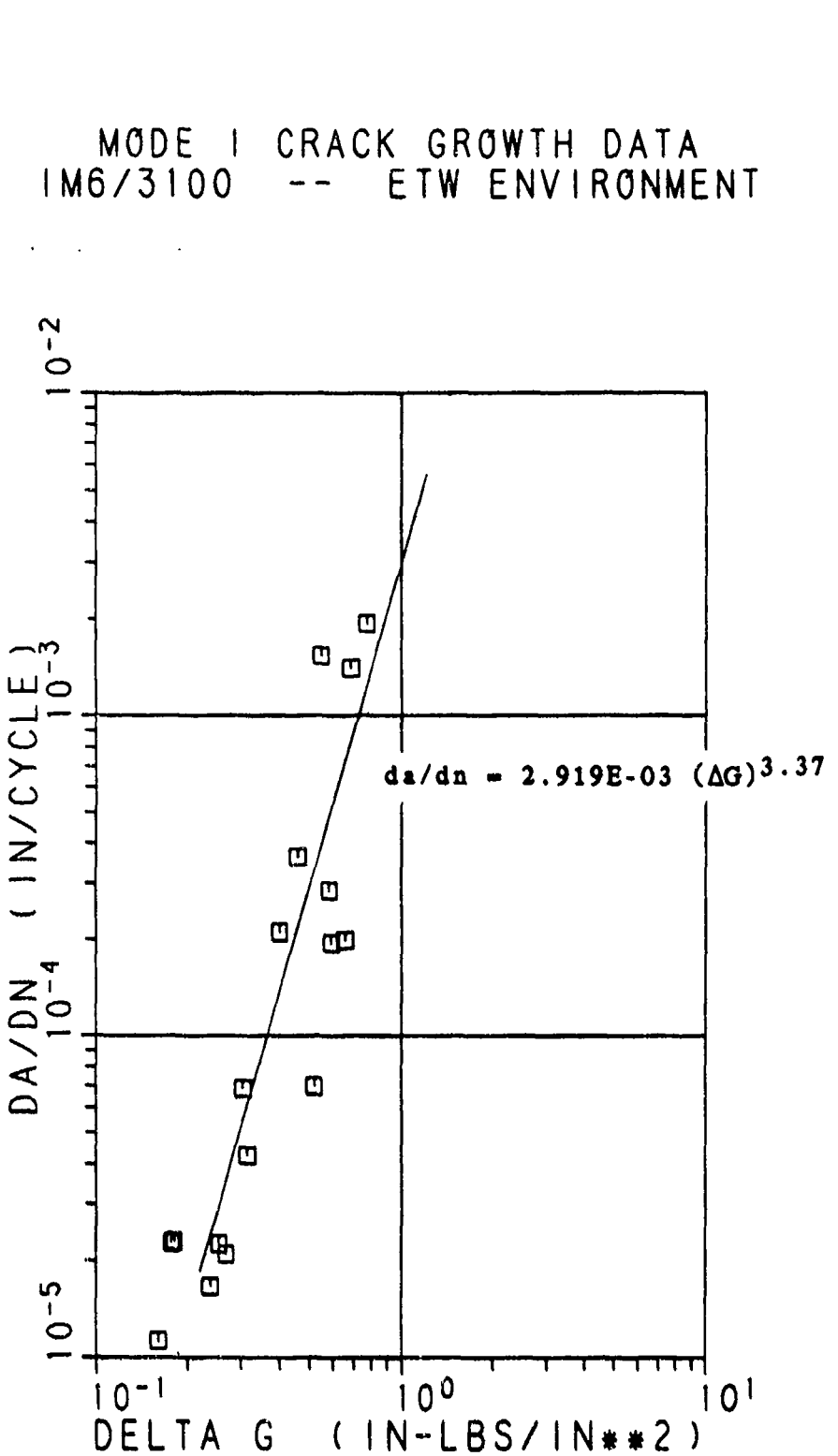


Figure A-17. IM6/3100 Mode I at ETW Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-63
IM6/3100 -- ETW ENVIRONMENT

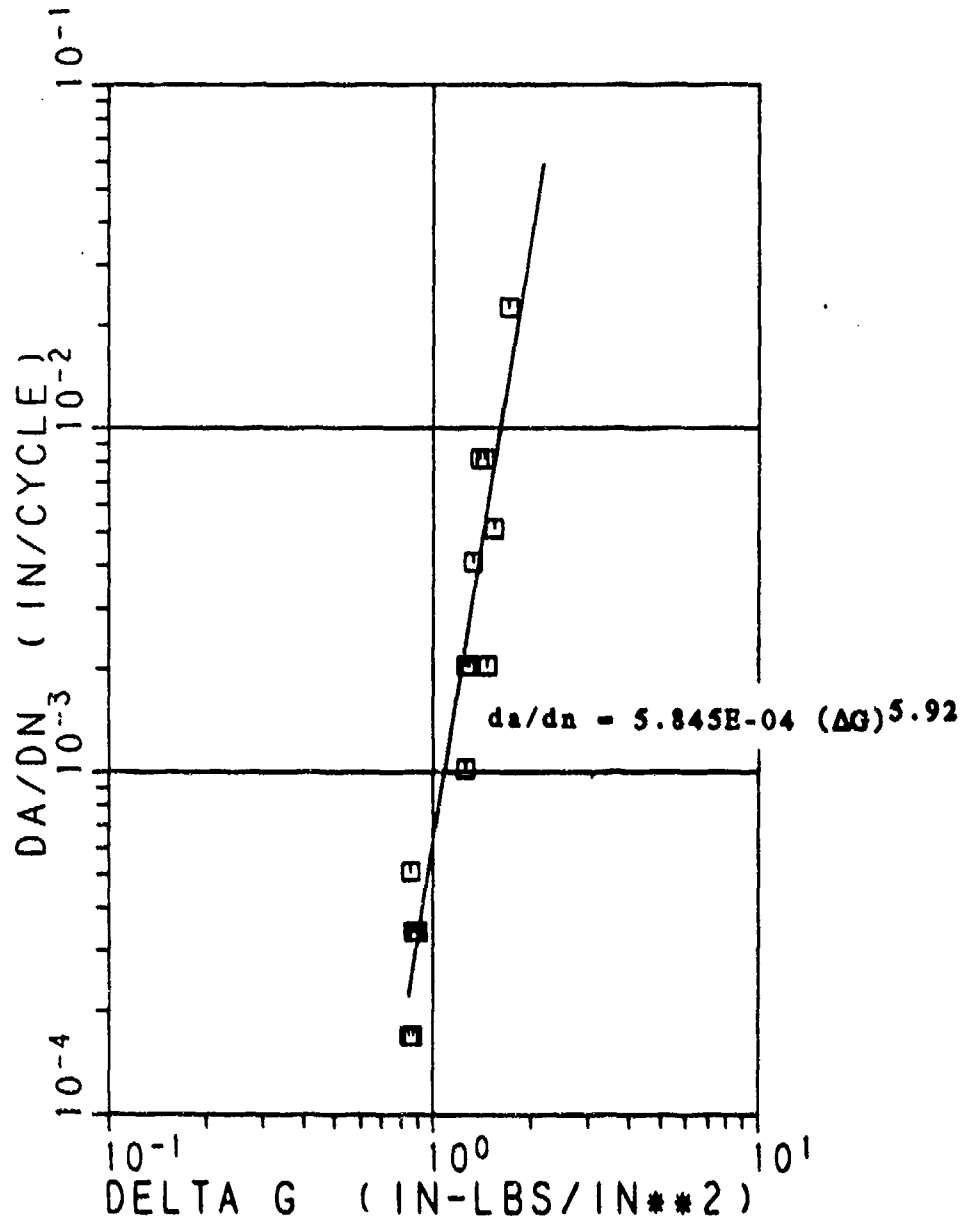


Figure A-18. IM6/3100 Mixed Mode (CLS-63) at ETW Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-82
IM6/3100 -- ETW ENVIRONMENT

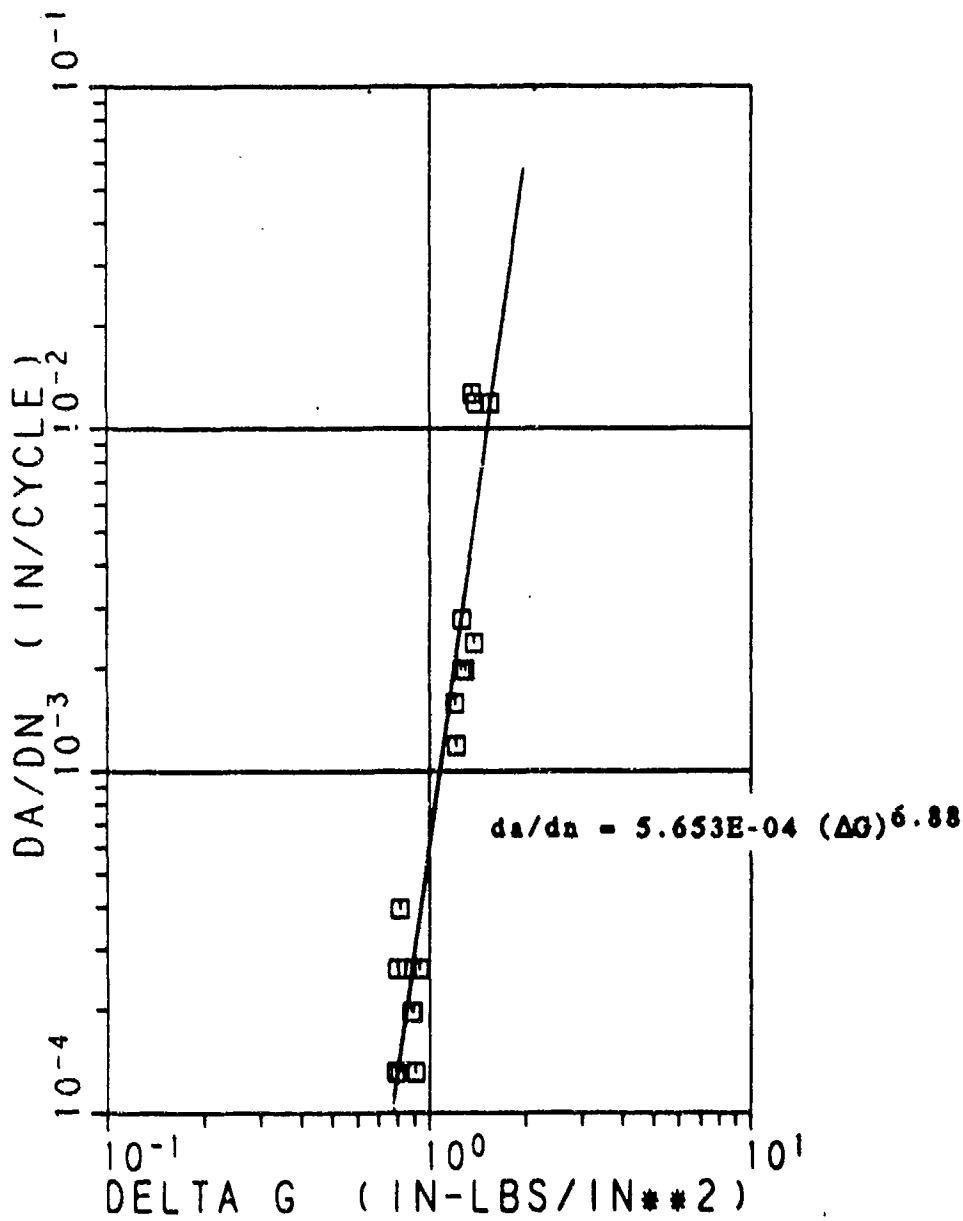


Figure A-19. IM6/3100 Mixed Mode (CLS-82) at ETW Conditions

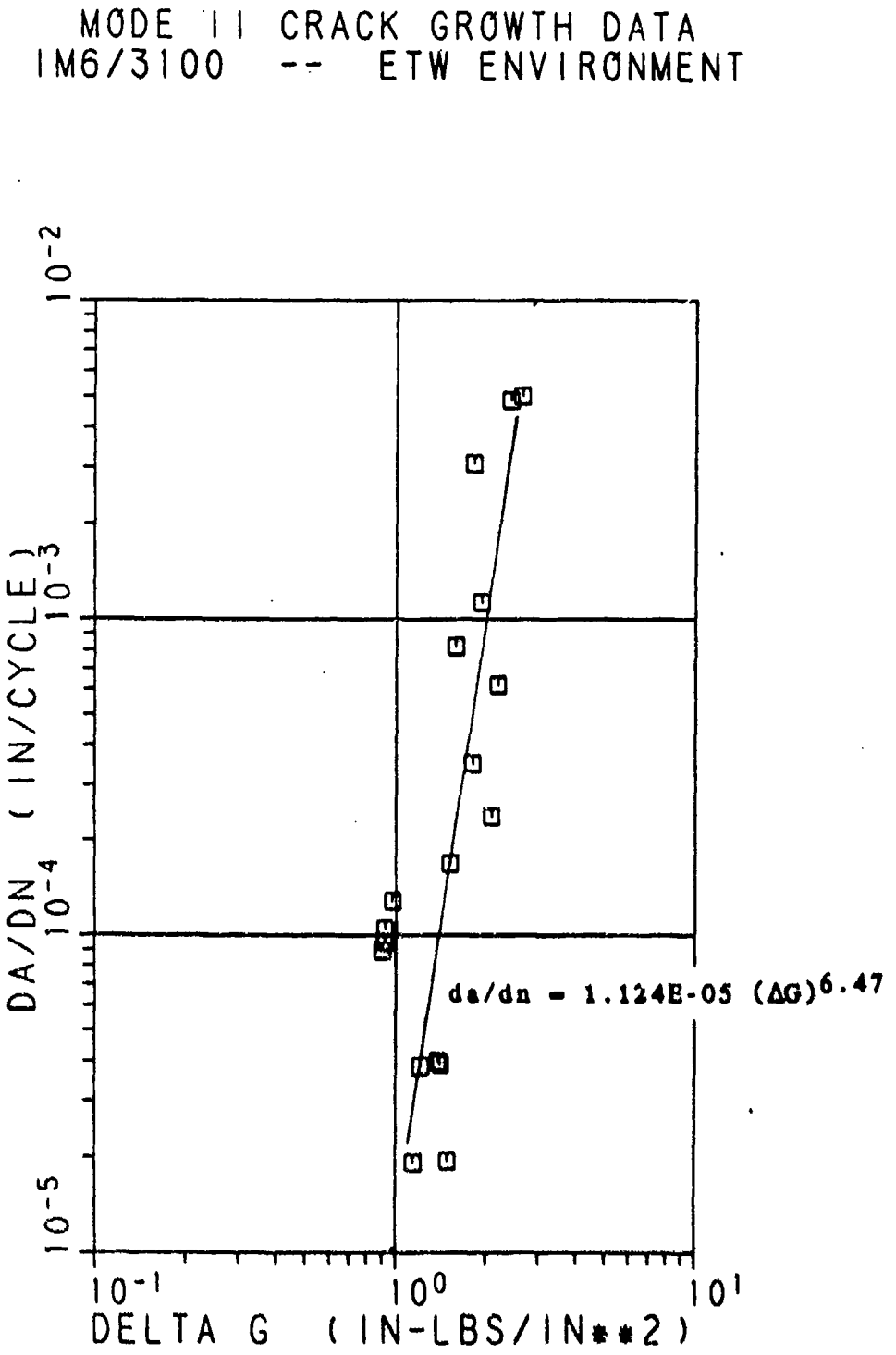


Figure A-20. IM6/3100 Mode II at ETW Conditions

MODE I CRACK GROWTH DATA
IM6/F650 -- ETW ENVIRONMENT

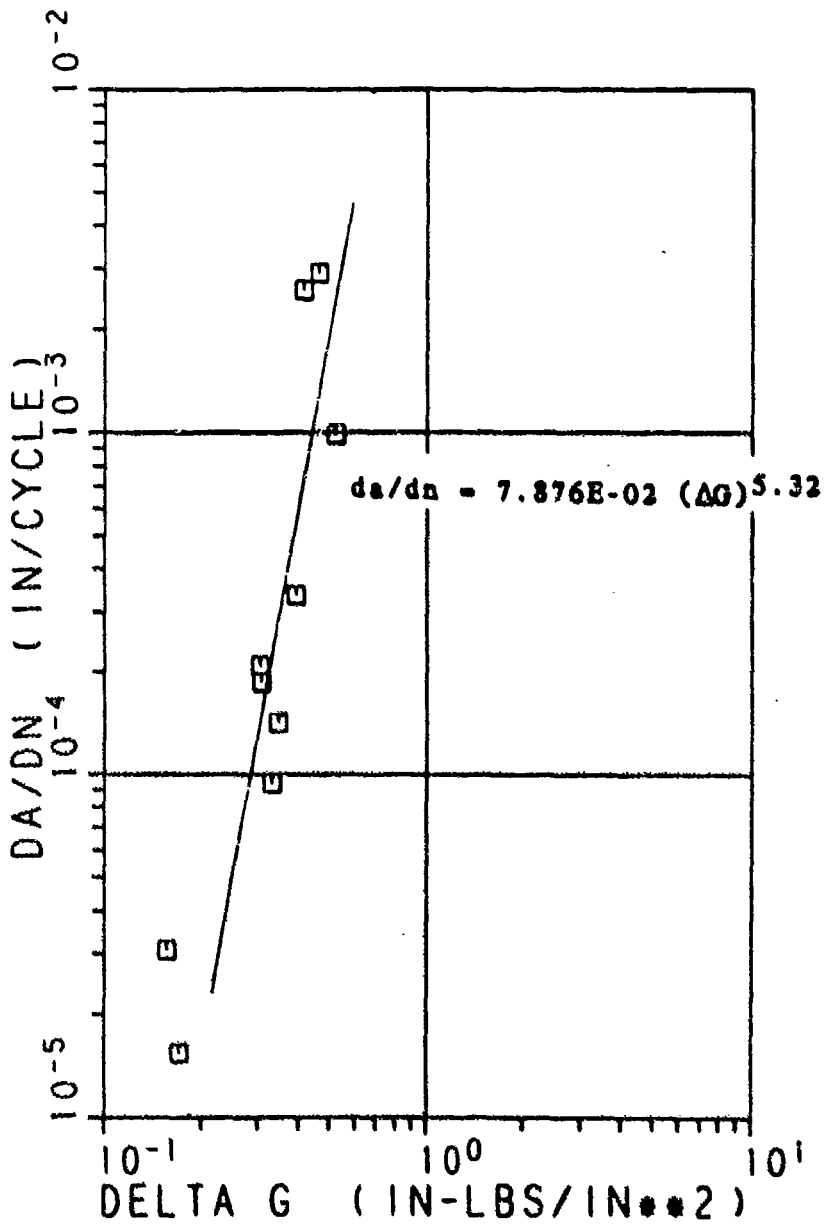


Figure A-21. IM6/F650 Mode I at ETW Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-63
IM6/F650 -- ETW ENVIRONMENT

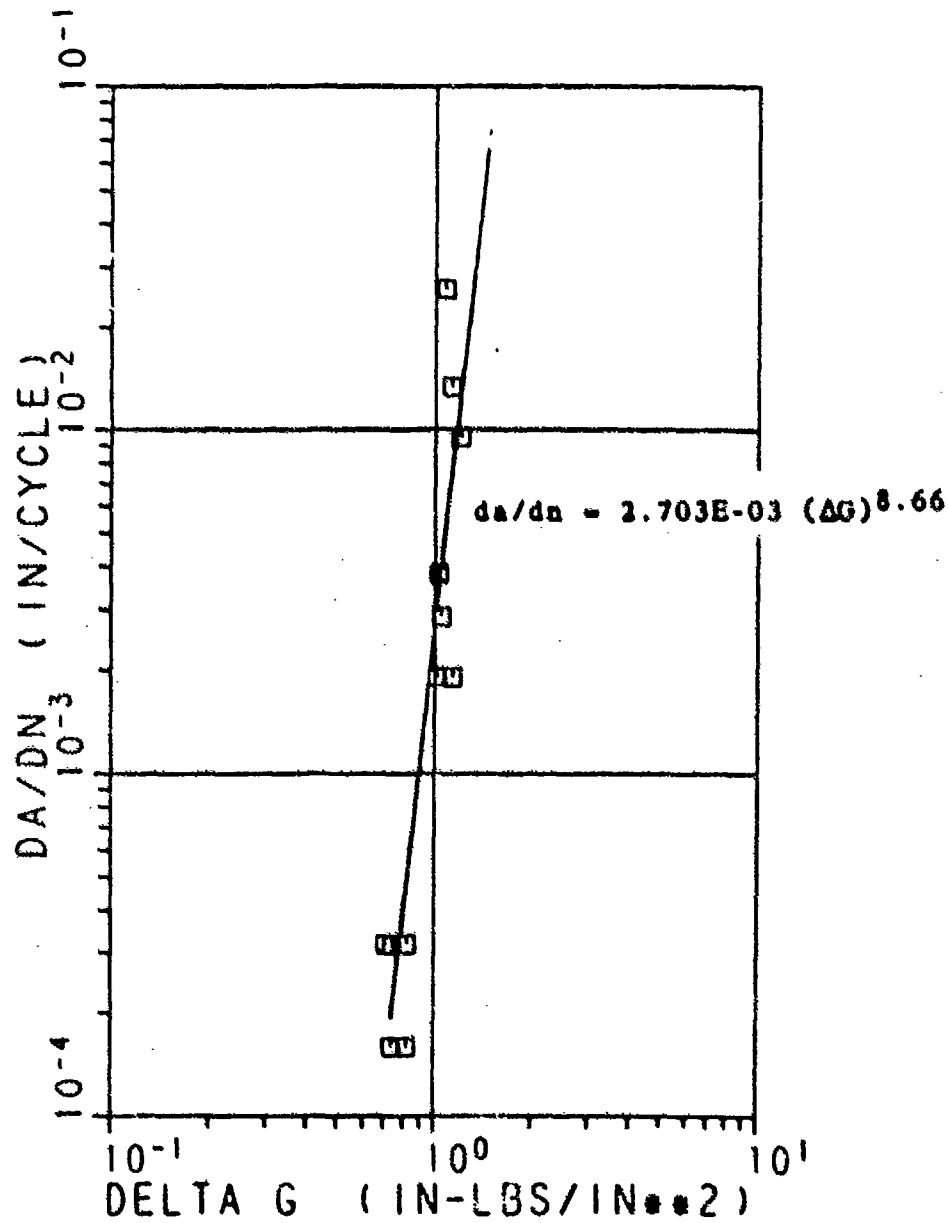


Figure A-22. IM6/F650 Mixed Mode (CLS-63) at ETW Conditions

MIXED MODE CRACK GROWTH DATA -- CLS-82
IM6/F650 -- ETW ENVIRONMENT

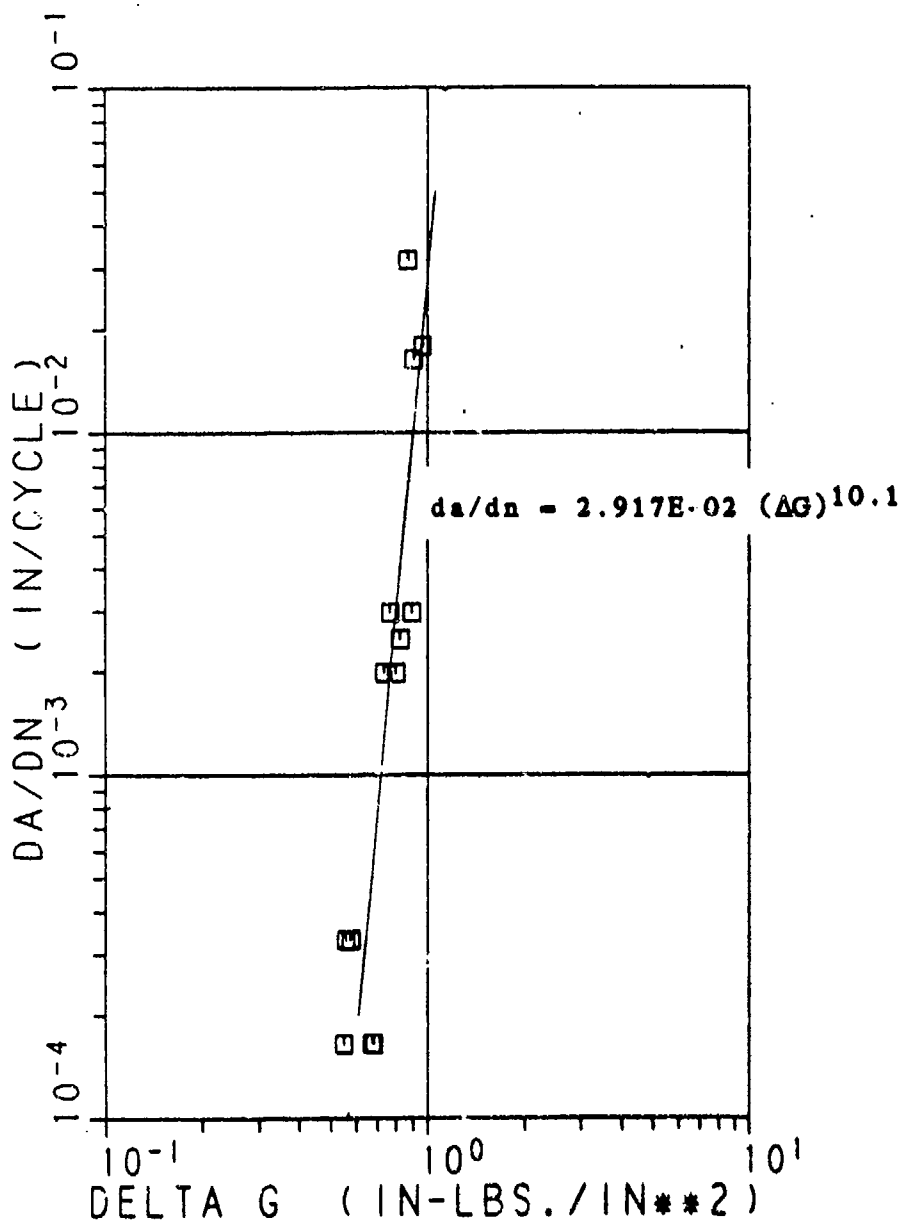


Figure A-23. IM6/F650 Mixed Mode (CLS-82) at ETW Conditions

MODE II CRACK GROWTH DATA
IM6/F650 -- ETW ENVIRONMENT

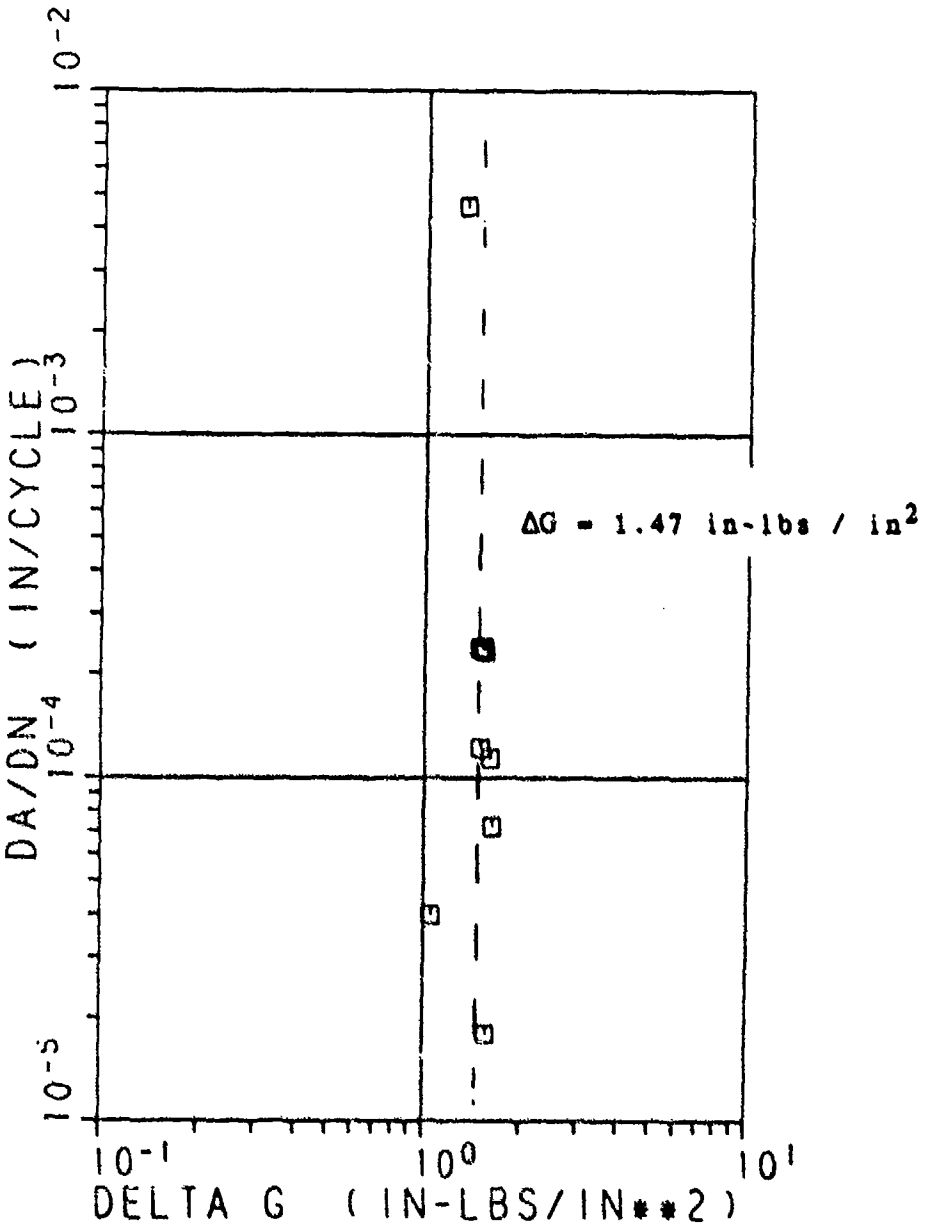


Figure A-24. IM6/F650 Mode II at ETW Conditions

APPENDIX B

IMPACT DAMAGE/RESIDUAL STRENGTH DATA

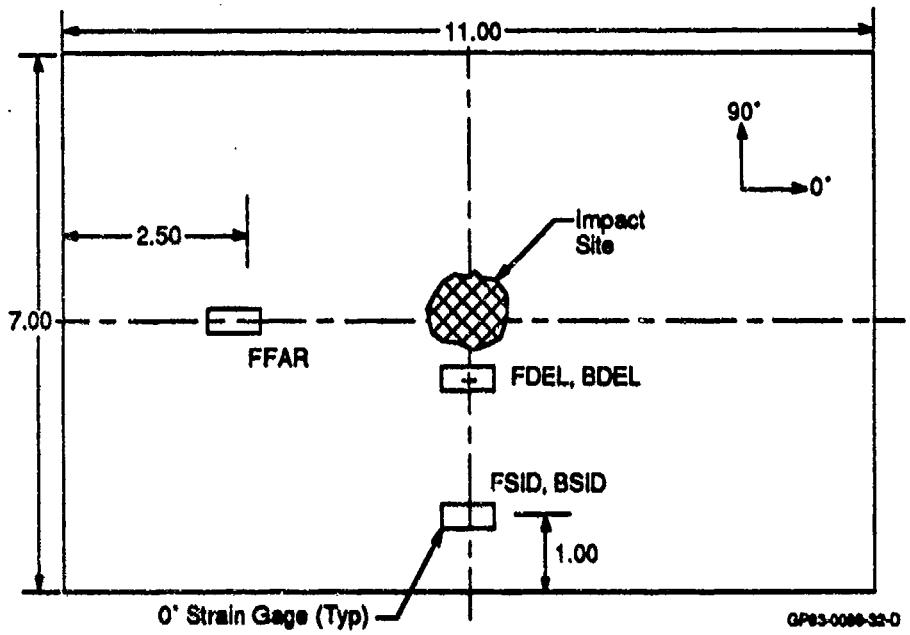
The low-velocity impact damage work performed on 11 inch by 7 inch panels is summarized in this appendix. The data is separated into the three groups: maximum non-visible damage, thin laminate damage, and visible damage. Each section includes a summary table listing data for one representative panel from each of the test conditions. Each table is followed by three types of data sheets for the RTD panels included in the table. The first type of data sheet shows plots of acceleration and back-surface strain as functions of time (during impact). In some cases, two impacts were done on a panel when the first impact failed to produce sufficient damage. For those panels, there are two sheets showing plots of acceleration and back-surface strain. The second type of sheet shows a C-scan of the impact damage. The third type of sheet shows a load vs. strain plot for five strain gages that monitored the residual compression behavior of each panel.

C-scans are not included for panels tested under ETW conditions for residual compression strength. Since these panels were impacted under RTD conditions, the C-scans would not be significantly different from the C-scans reported for analogous RTD panels.

The summary table includes three impact energy levels. Nominal impact energy is the level that was targeted for the panel. Potential impact energy is the energy based on the height and weight of the impactor. Kinetic impact energy is the energy based on the mass of the impactor and its velocity as measured by optical sensors just prior to striking the panel surface. The impact energies are followed by the maximum acceleration (G_{max}) and the maximum back-surface bending strain (ε_{max}) that occurred during impact. Maximum load can be determined by multiplying impactor weight by G_{max}. Dent depth and delamination width (from C-scans) describe the impact damage state. Finally residual strength and strain are listed.

The third data sheet for each panel shows a load-strain plot for the five locations shown in Figure B-1. The symbol labeled FFAR on the plot represents the front-face (impact side) far field strain response. The symbols

FSID and BSID represent the strain responses, 1 inch in from the side of the panel, on the front-face and back-face of the panel respectively. The symbols FDEL and BDEL represent the strain responses adjacent to the impact delamination on the front-face and back-face of the panel respectively.



Notes: (1) FFAR = Front, Far-Field Strain
(2) FDEL = Front, Delamination Edge Strain
(3) BDEL = Back, Delamination Edge Strain
(4) FSID = Front, Panel Side Strain
(5) BSID = Back, Panel Side Strain

Figure B-1. Definition of Panel Strain Gage Locations

B.1 MAXIMUM NON-VISIBLE IMPACT DAMAGE

Material	Specimen Number	Layup	Thickness (in.)	Impactor Weight (lb)	Nominal Impact Energy (ft-lb)	Potential Impact Energy (ft-lb)	Kinetic Impact Energy (ft-lb)	G_{max}	ϵ_{max} (μin./in.)	Dent Depth (in.)	Delamination Width (in.)	Residual Strength (ksi)	Residual Strain (μin./in.)
RTD													
	1-12-2		0.114	3.83	8	8.52	8.32	315	11,880	0.005	1.1	32.1	6,200
IM6/3100	1-11-2	10/80/10	0.221	3.83	14	14.91	14.21	706	14,740	0.009	2.1	26.8	5,400
	1-13-1		0.451	7.82	17.5/23	18.6/24.4	18.1/—	949	9,630	0.008	3.9	29.2	6,150
	1-14-2		0.110	3.83	14	14.91	14.44	421	7,150	0.006	1.5	38.5	3,200
IM6/3100	1-20-2	50/40/10	0.224	7.82	23	24.44	23.58	555	14,530	0.011	3.4	30.8	2,600
	1-15-2		0.453	19.47	42	44.62	—	546	11,720	0.012	3.7	36.2	3,450
	2-12-2		0.106	3.83	6	6.38	6.26	268	8,440	0.007	1.4	21.4	3,800
IM6/F650	2-11-3	10/80/10	0.216	3.83	7	7.44	7.32	633	11,730	0.010	1.8	21.2	4,250
	2-13-1		0.436	7.82	20	21.24	20.47	707	9,690	0.012	3.6	22.5	4,500
	2-14-1		0.111	3.83	14	7.44	—	256	14,620	0.007	1.7	32.0	2,700
IM6/F650	2-20-2	50/40/10	0.219	7.82	10	10.62	10.35	305	4,400	0.012	2.0	28.1	2,500
	2-15-2		0.443	19.47	35	37.32	—	756	9,340	0.017	3.0	26.5	2,500
ETW													
	1-12-4		0.114	3.83	8	8.52	—	335	15,070	0.005	—	22.9	3,900
IM6/3100	1-11-5	10/80/10	0.222	3.83	14	14.91	14.13	874	15,740	0.009	—	21.2	5,000
	1-13-4		0.449	7.82	23	24.44	23.43	1,076	10,580	0.006	—	24.8	5,150
	1-14-4		0.110	3.83	14	14.91	14.34	462	18,160	0.005	—	32.6	2,050
IM6/3100	1-20-4	50/40/10	0.225	7.82	23	24.44	23.43	520	14,540	0.008	—	25.4	2,650
	1-15-4		0.451	7.82	17.5/23	24.44	—	963	9,110	0.010	—	28.5	2,600
	2-12-5		0.106	3.83	6	6.38	—	257	10,830	0.007	—	17.5	3,100
IM6/F650	2-11-6	10/80/10	0.216	3.83	7	7.44	7.28	649	9,650	0.011	—	17.5	3,500
	2-13-5		0.436	7.82	15	15.97	15.56	790	7,570	0.010	—	17.1	2,550
	2-14-5		0.111	3.83	14	7.44	7.32	299	13,160	0.006	—	23.5	1,800
IM6/F650	2-20-4	50/40/10	0.219	7.83	10	10.62	10.31	375	5,910	0.012	—	21.6	1,550
	2-15-4		0.441	7.82	35	43.08	35.61	927	9,710	0.016	—	18.9	1,500

GP83-0089-2-T

Figure B-2. Maximum Non-Visible Impact Damage Data Table

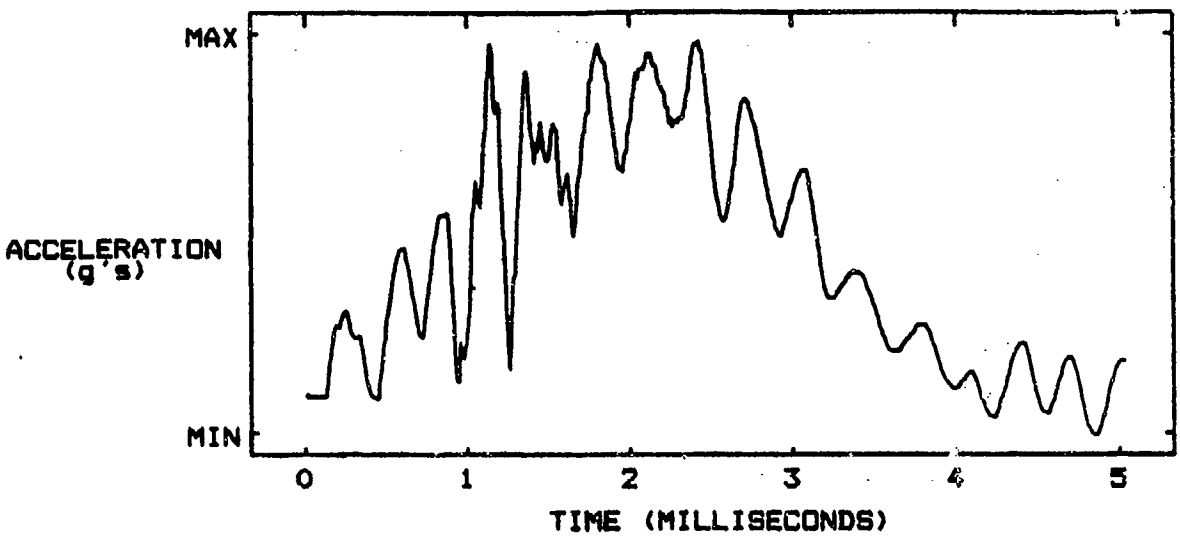
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-12-2 THICKNESS .114 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 26.7 IN

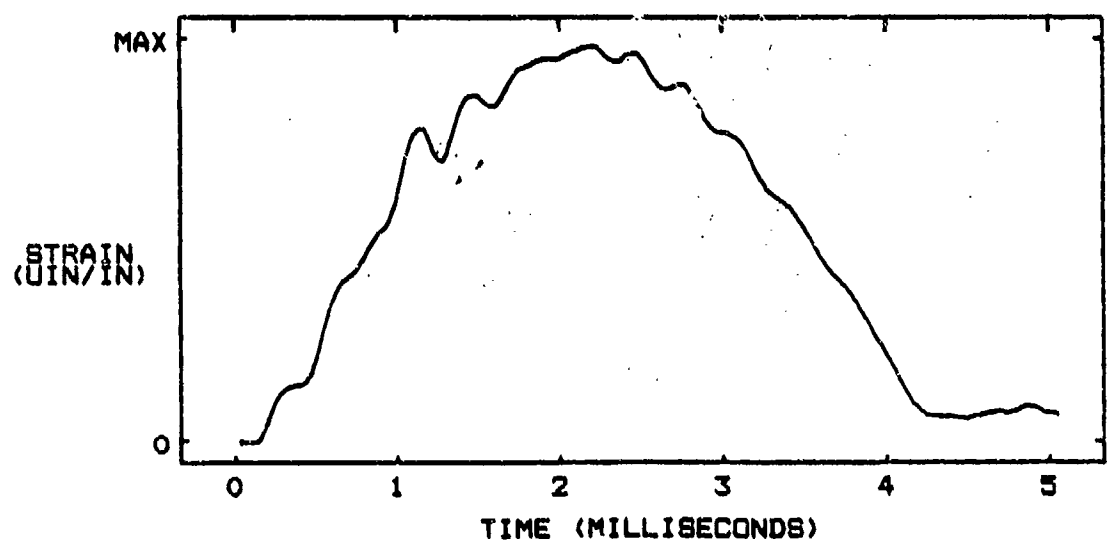
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -33.2 g's MAXIMUM ACCELERATION 315.43g's

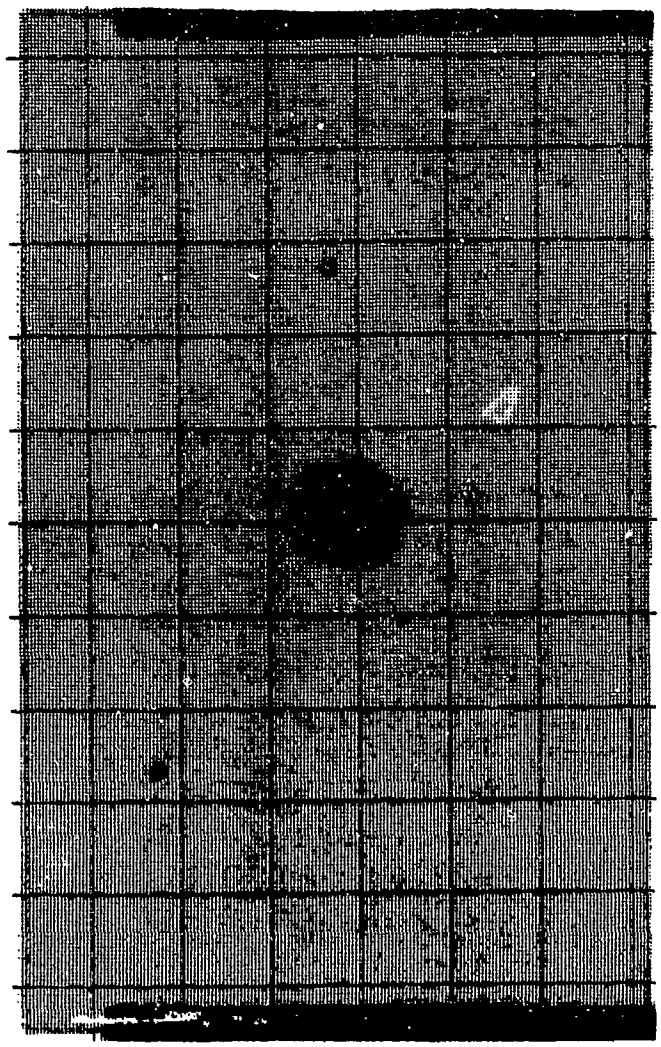
INTEGRATED TOTAL VELOCITY 230.19 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 11882 UIN/IN

Figure B-3. Panel 1-12-2 Impact Response Data



Specimen 1-12-2

Figure B-4. Panel 1-12-2 C-Scan

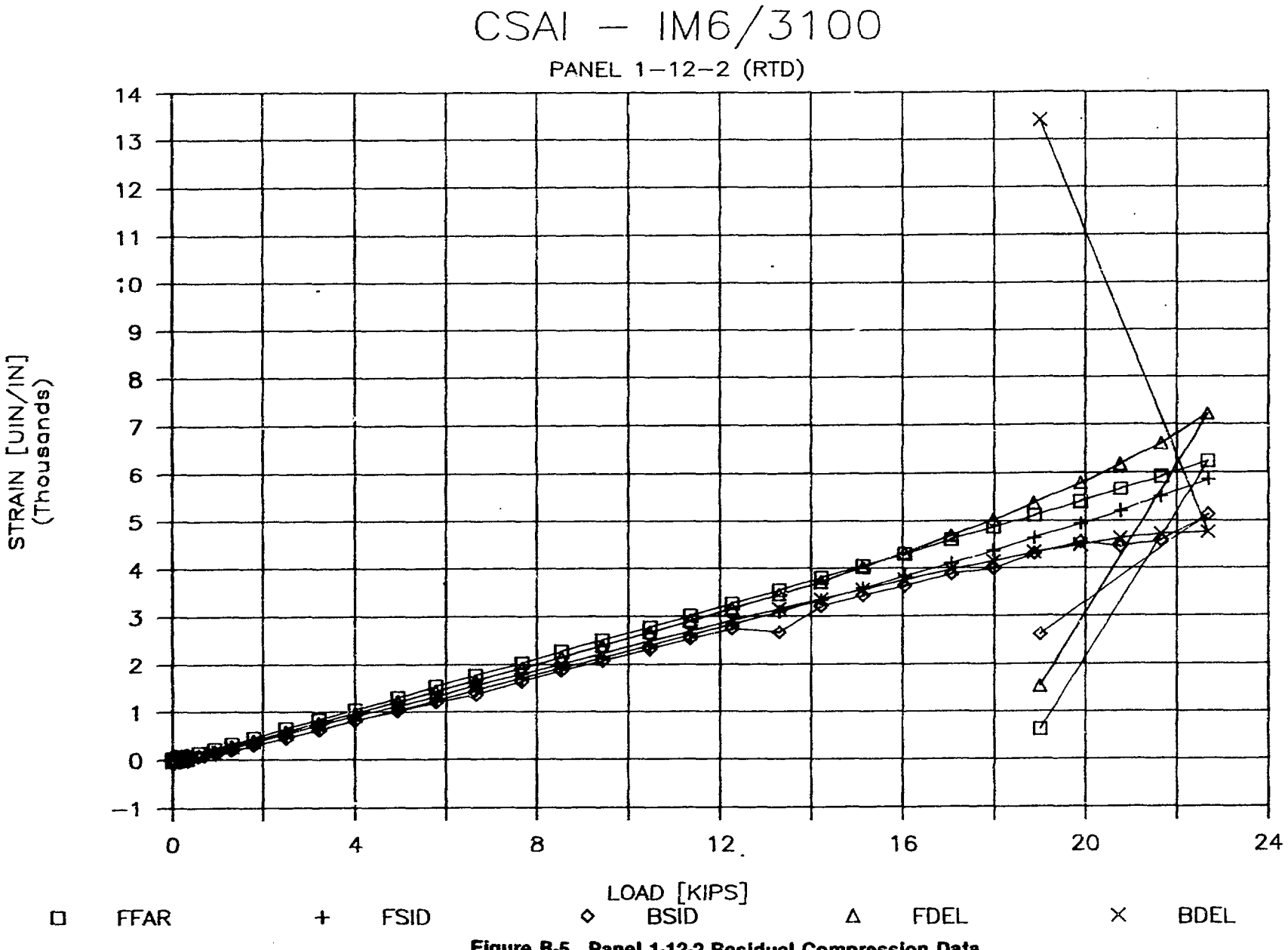


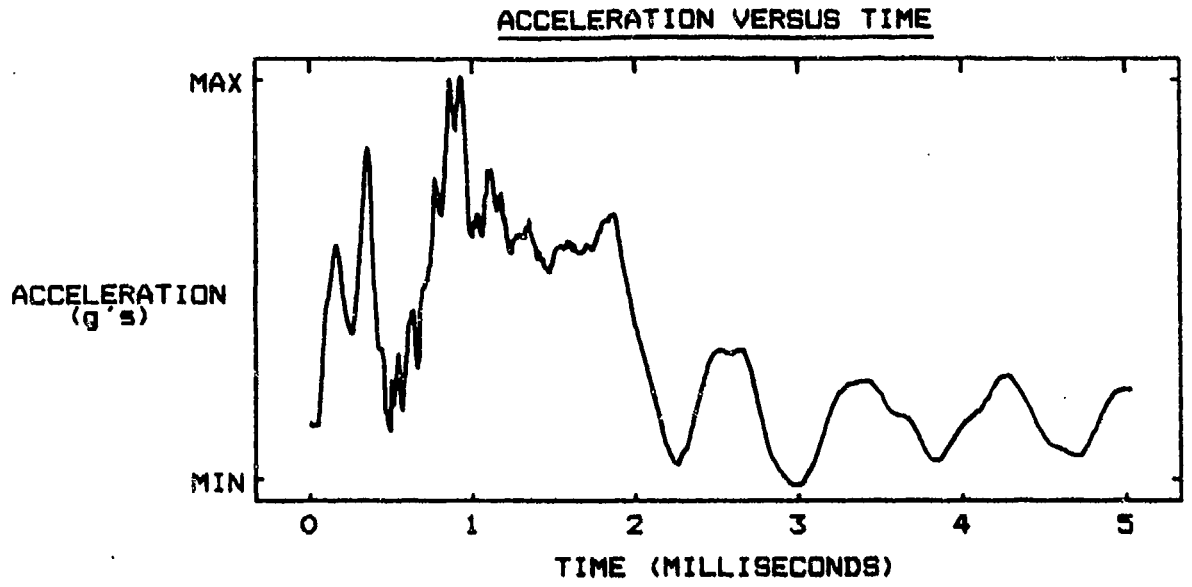
Figure B-5. Panel 1-12-2 Residual Compression Data

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

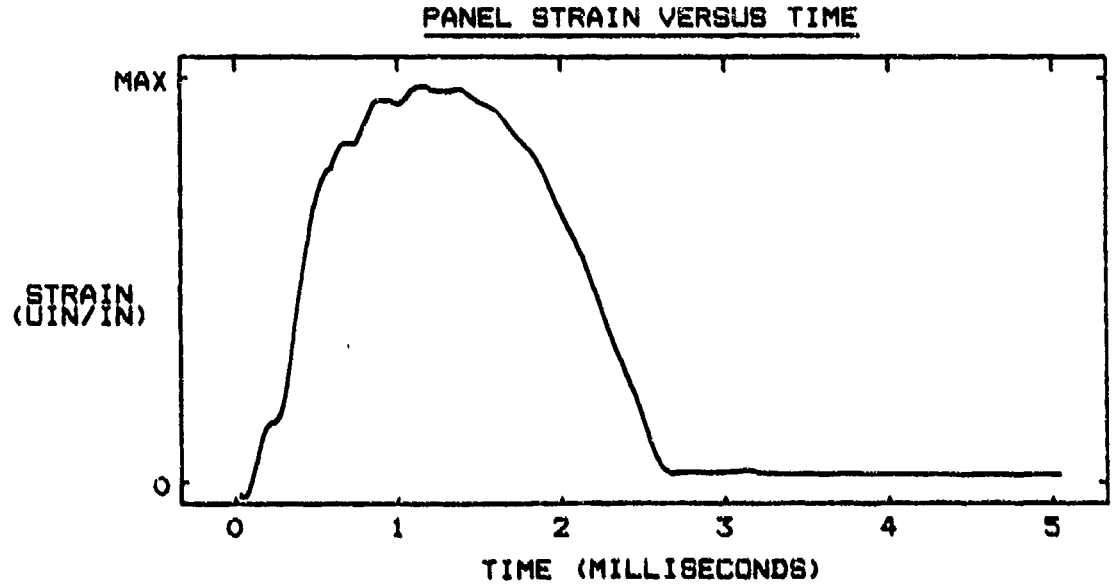
SPECIMEN I.D. 1-11-2 THICKNESS .221 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 46.7 IN



MINIMUM ACCELERATION -126 g's MAXIMUM ACCELERATION 706.0 g's

INTEGRATED TOTAL VELOCITY 271.88 IN/SEC



MAXIMUM STRAIN 14740 UIN/IN

Figure B-6. Panel 1-11-2 Impact Response Data

Specimen 1-11-2

Figure B-7. Panel 1-11-2 C-Scan

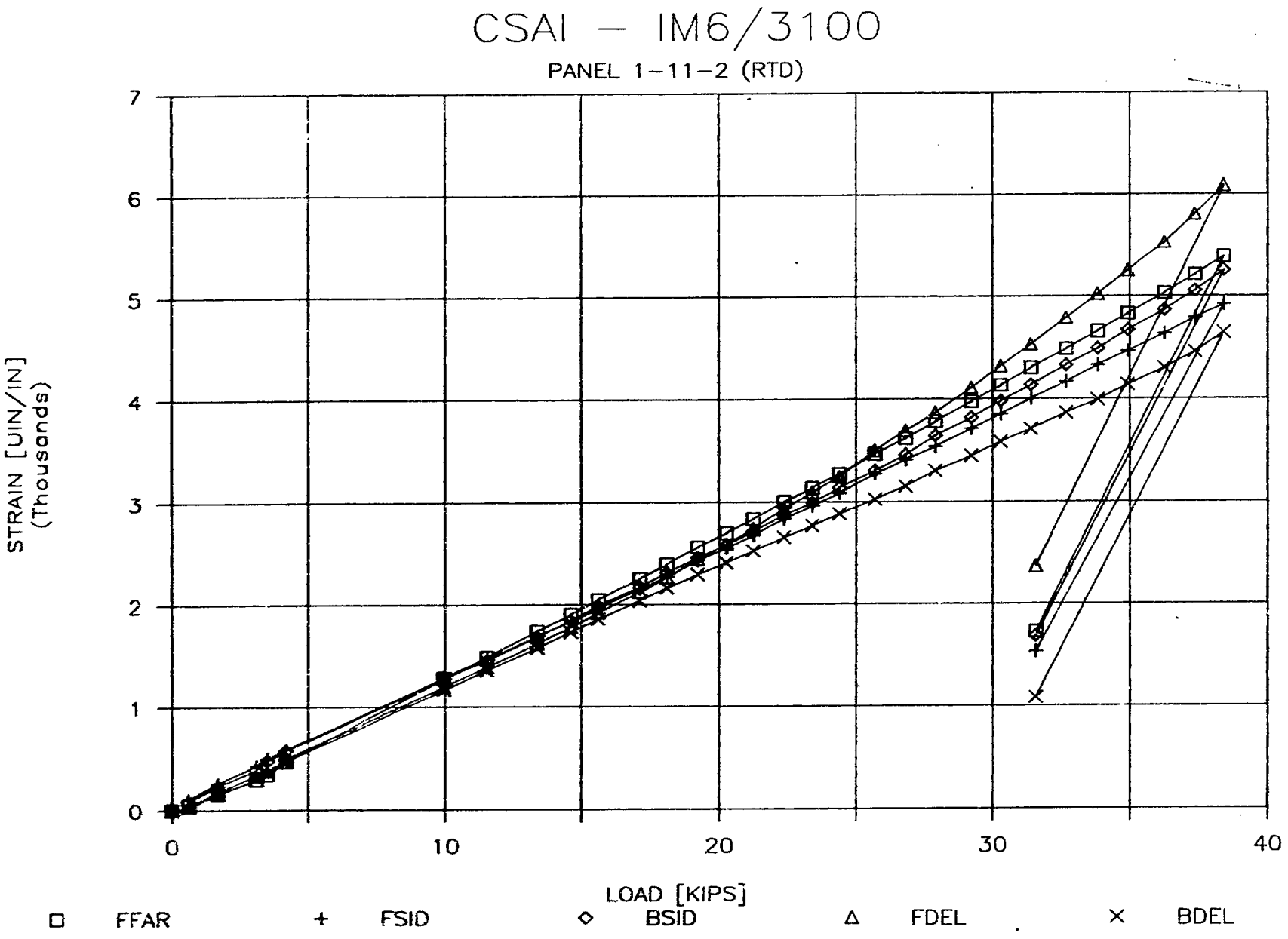


Figure B-8. Panel 1-11-2 Residual Compression Data

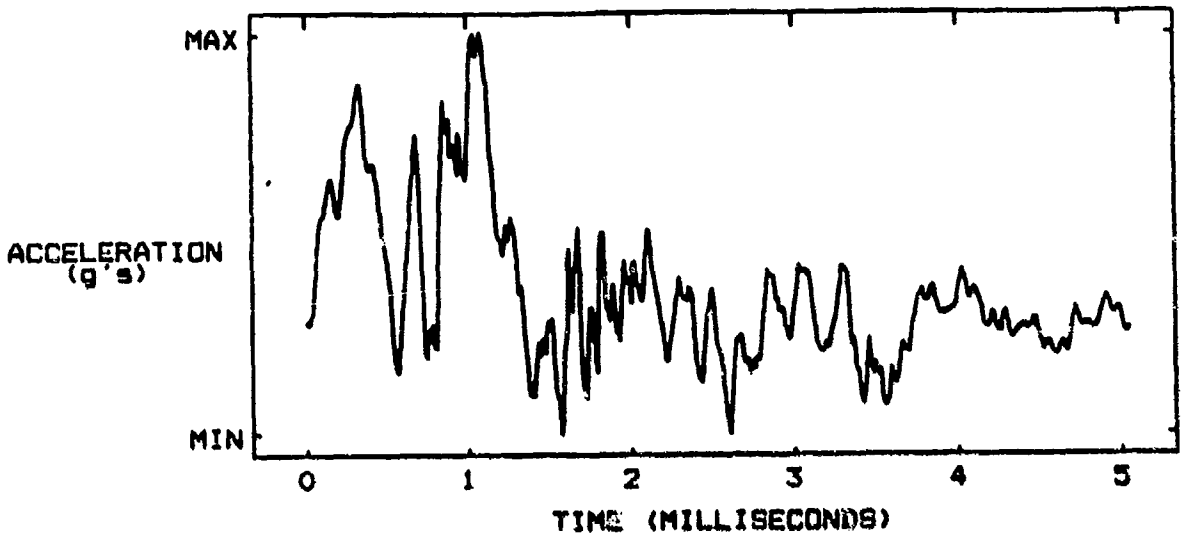
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-13-1.1 THICKNESS .451 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 28.5 IN

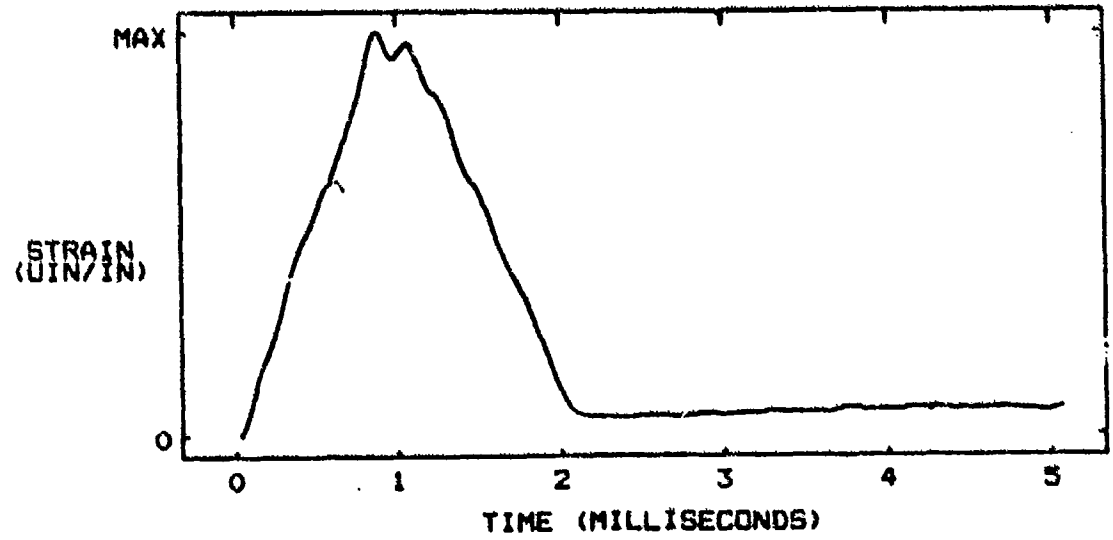
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -363 g's MAXIMUM ACCELERATION 949.22 g's

INTEGRATED TOTAL VELOCITY 188.26 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9632.8 UIN/IN

Figure B-9. Panel 1-13-1 First Impact Response Data

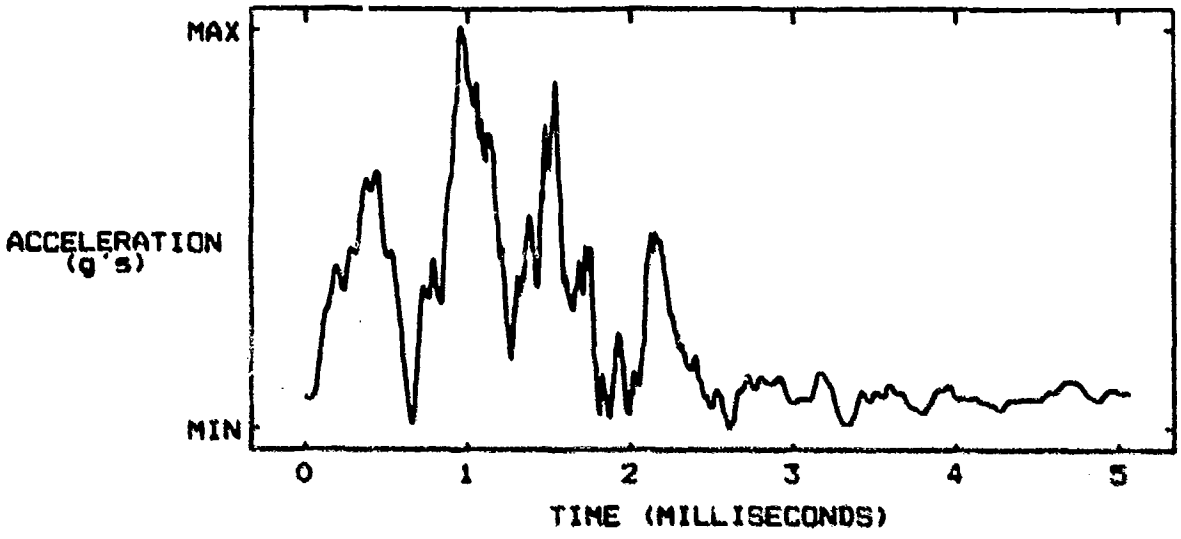
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-13-1.2 THICKNESS .451 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 37.5 IN

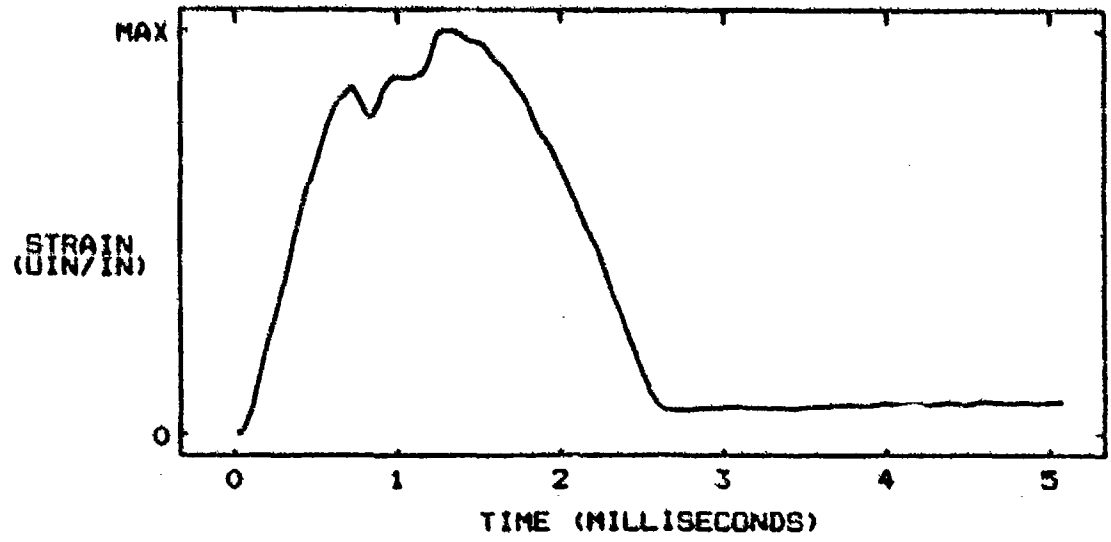
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -60.5 g's MAXIMUM ACCELERATION 837.89 g's

INTEGRATED TOTAL VELOCITY 260.22 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 12294 UIN/IN

Figure B-10. Panel 1-13-1 Second Impact Response Data

Specimen 1-13-1

Figure B-11. Panel 1-13-1 C-Scan

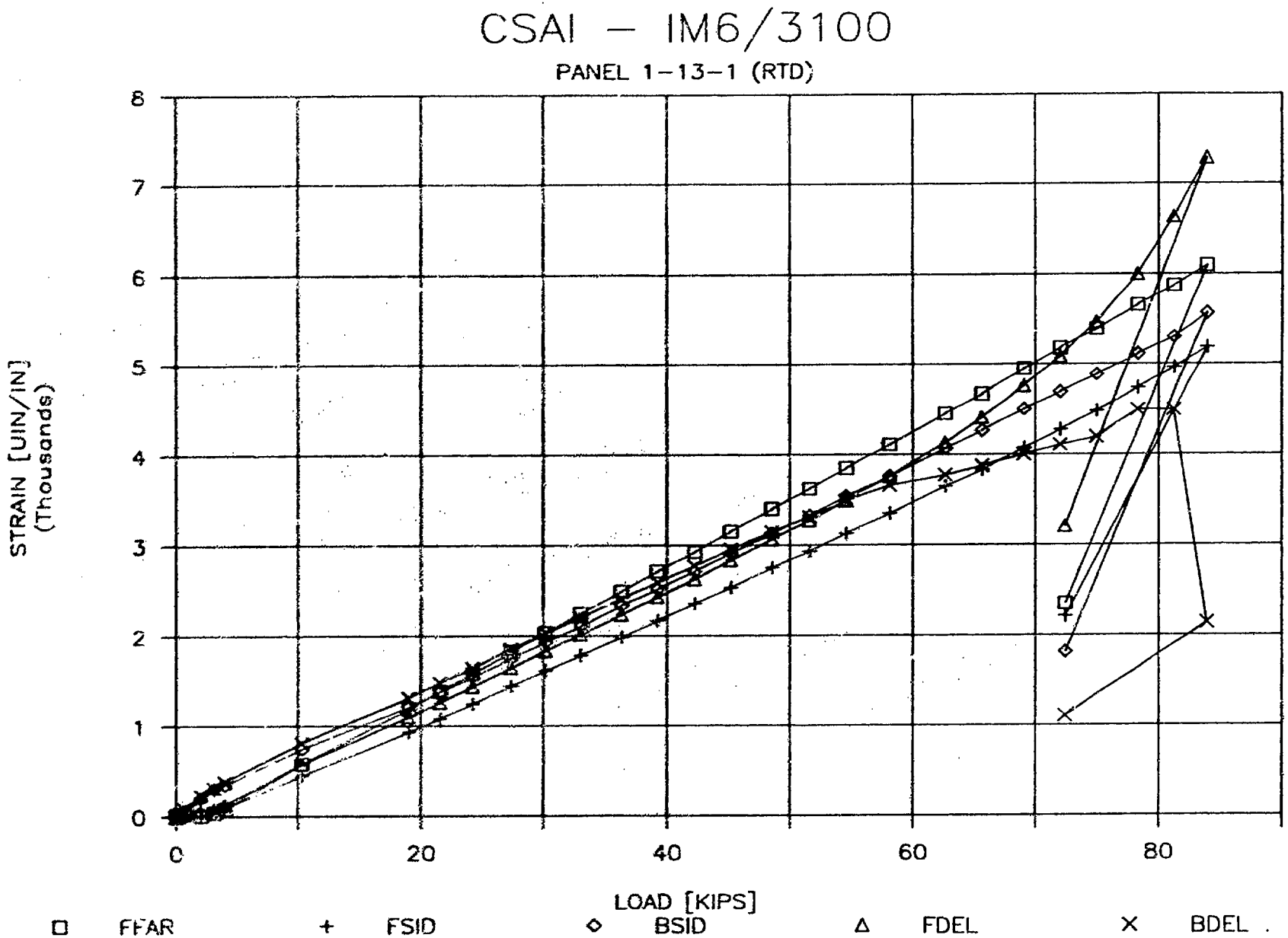


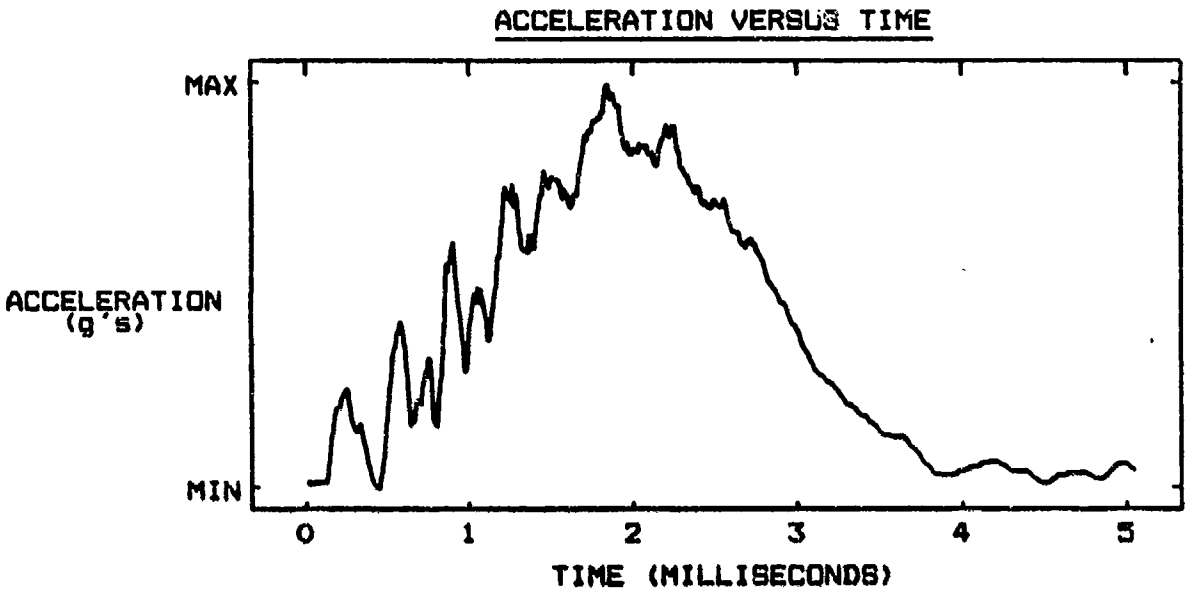
Figure B-12. Panel 1-13-1 Residual Compression Data

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

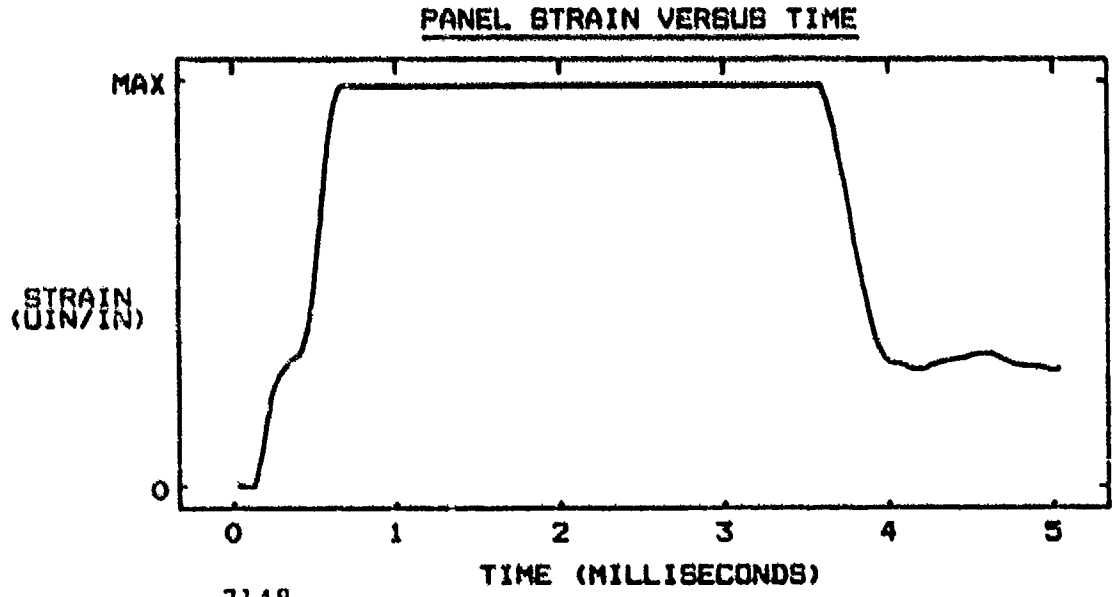
SPECIMEN I.D. 1-14-2 THICKNESS .110 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 46.7 IN



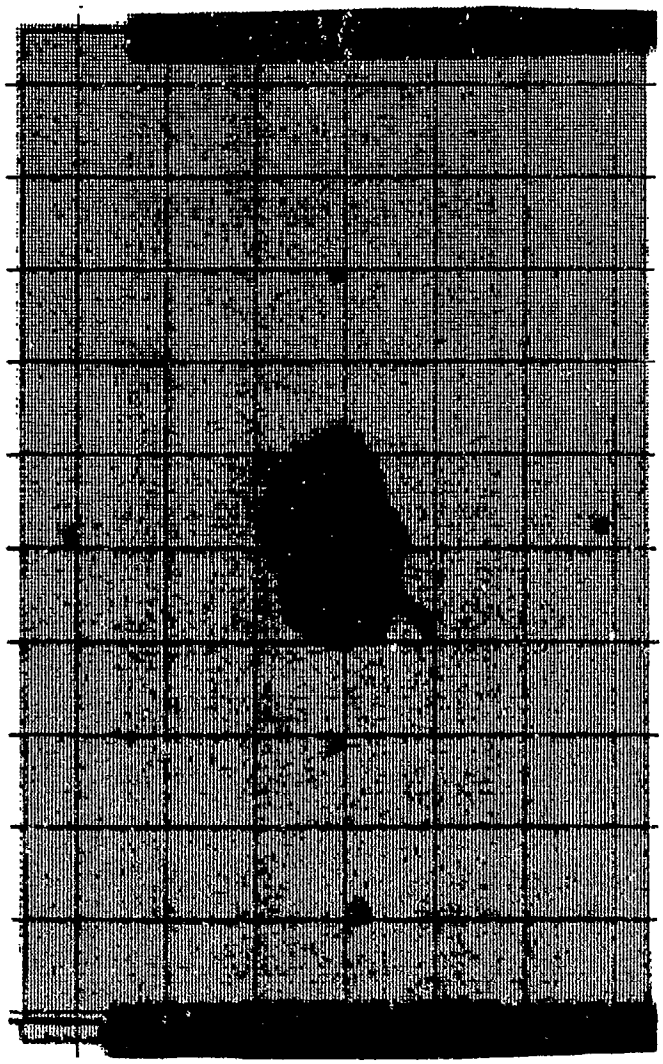
MINIMUM ACCELERATION -6 g's MAXIMUM ACCELERATION 421 g's

INTEGRATED TOTAL VELOCITY 291.3 IN/SEC



MAXIMUM STRAIN 7148 UIN/IN

Figure B-13. Panel 1-14-2 Impact Response Data



Specimen 1-14-2

Figure B-14. Panel 1-14-2 C-Scan

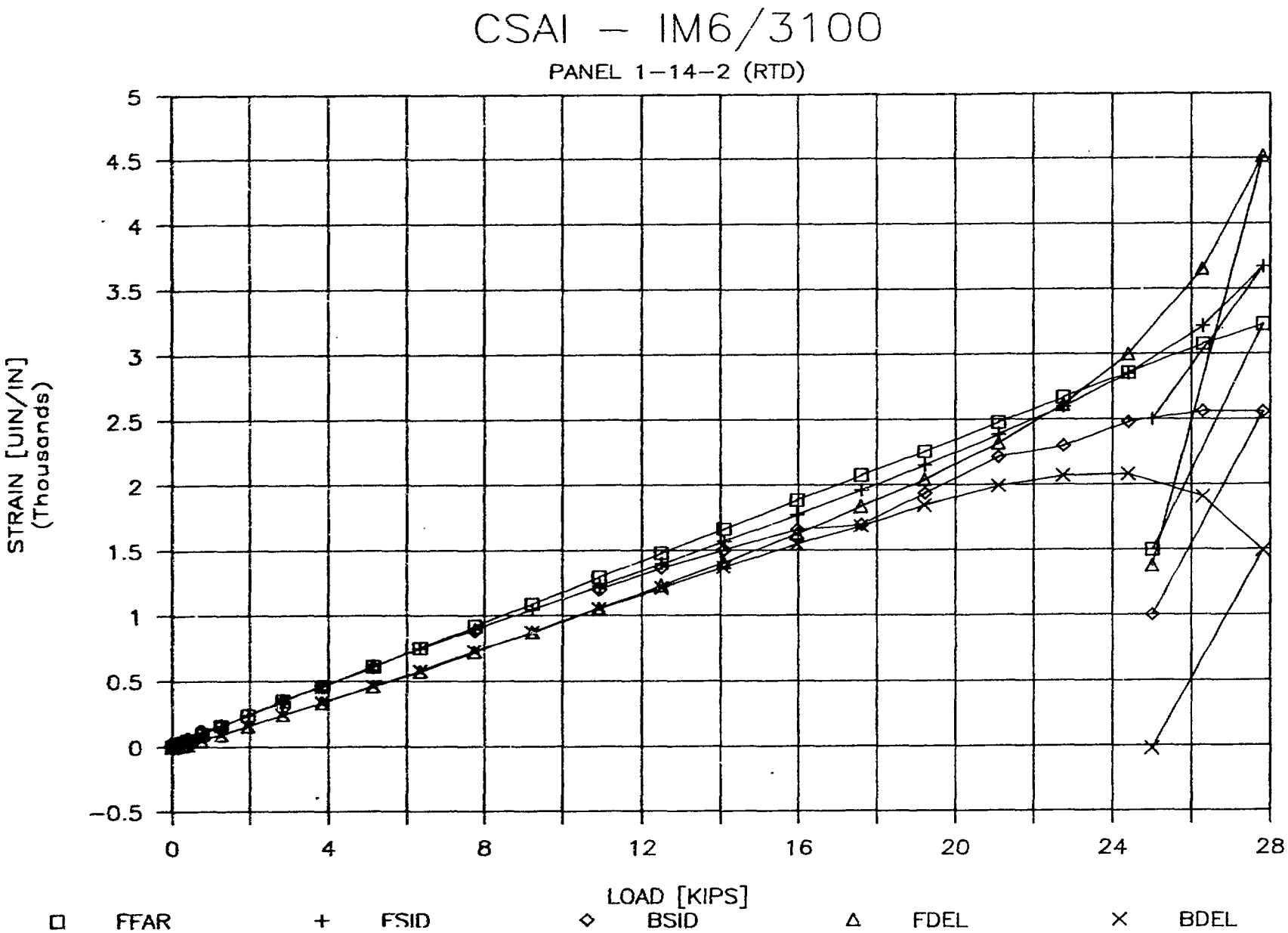


Figure B-15. Panel 1-14-2 Residual Compression Data

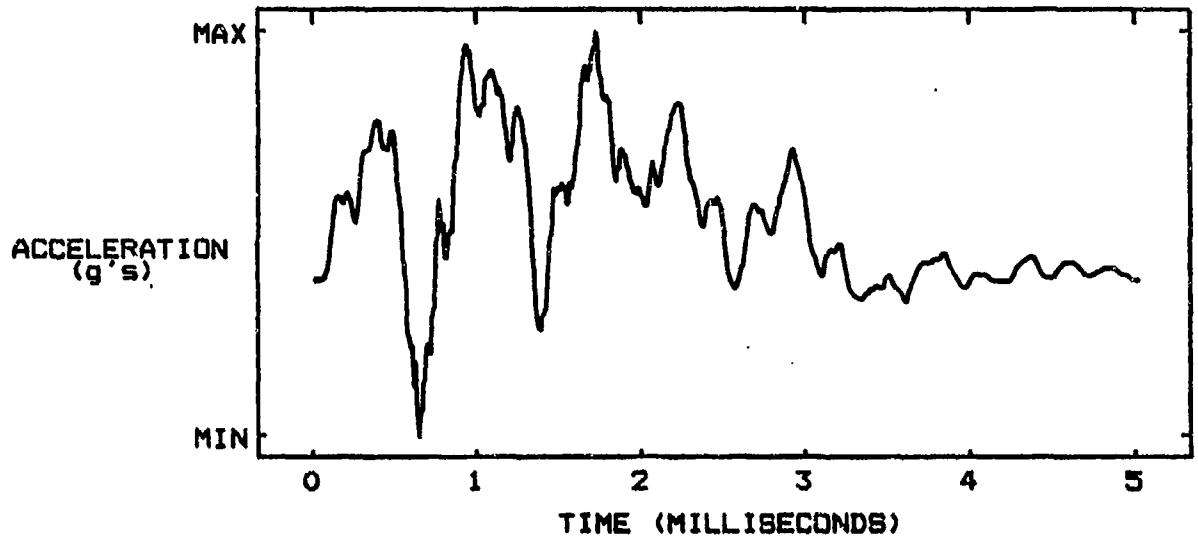
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-20-2 THICKNESS .224 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 37.5 IN

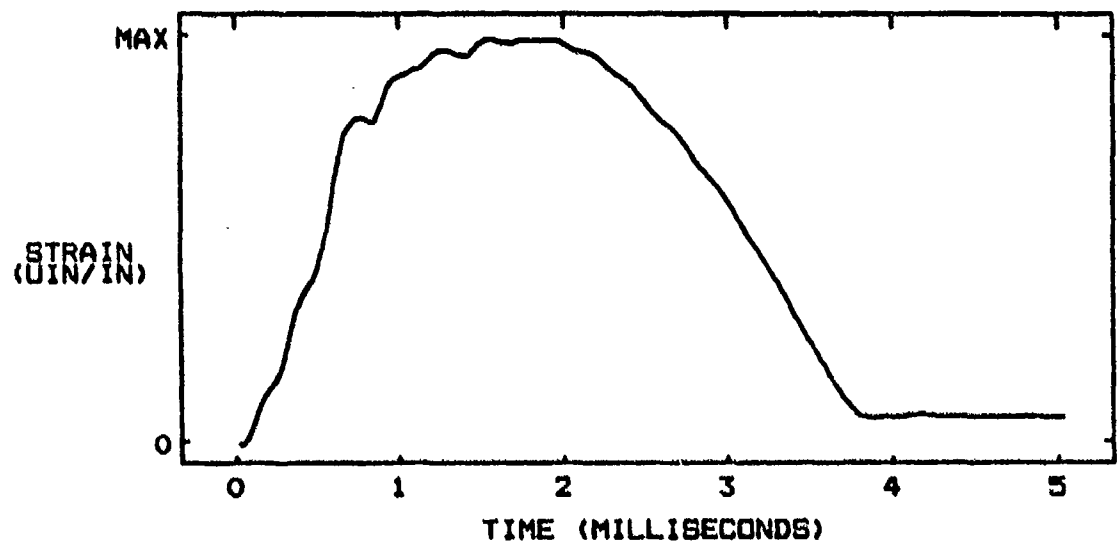
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -353 g's MAXIMUM ACCELERATION 554.7 g's

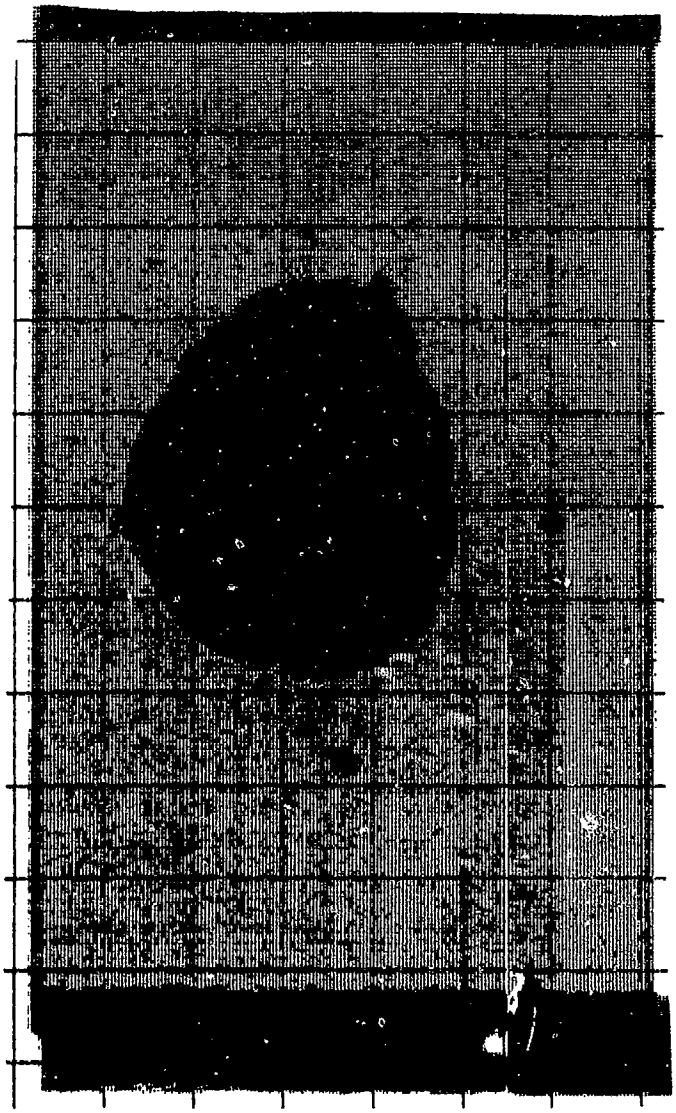
INTEGRATED TOTAL VELOCITY 248.57 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 14534 UIN/IN

Figure B-16. Panel 1-20-2 Impact Response Data



Specimen 1-20-2

Figure B-17. Panel 1-20-2 C-Scan

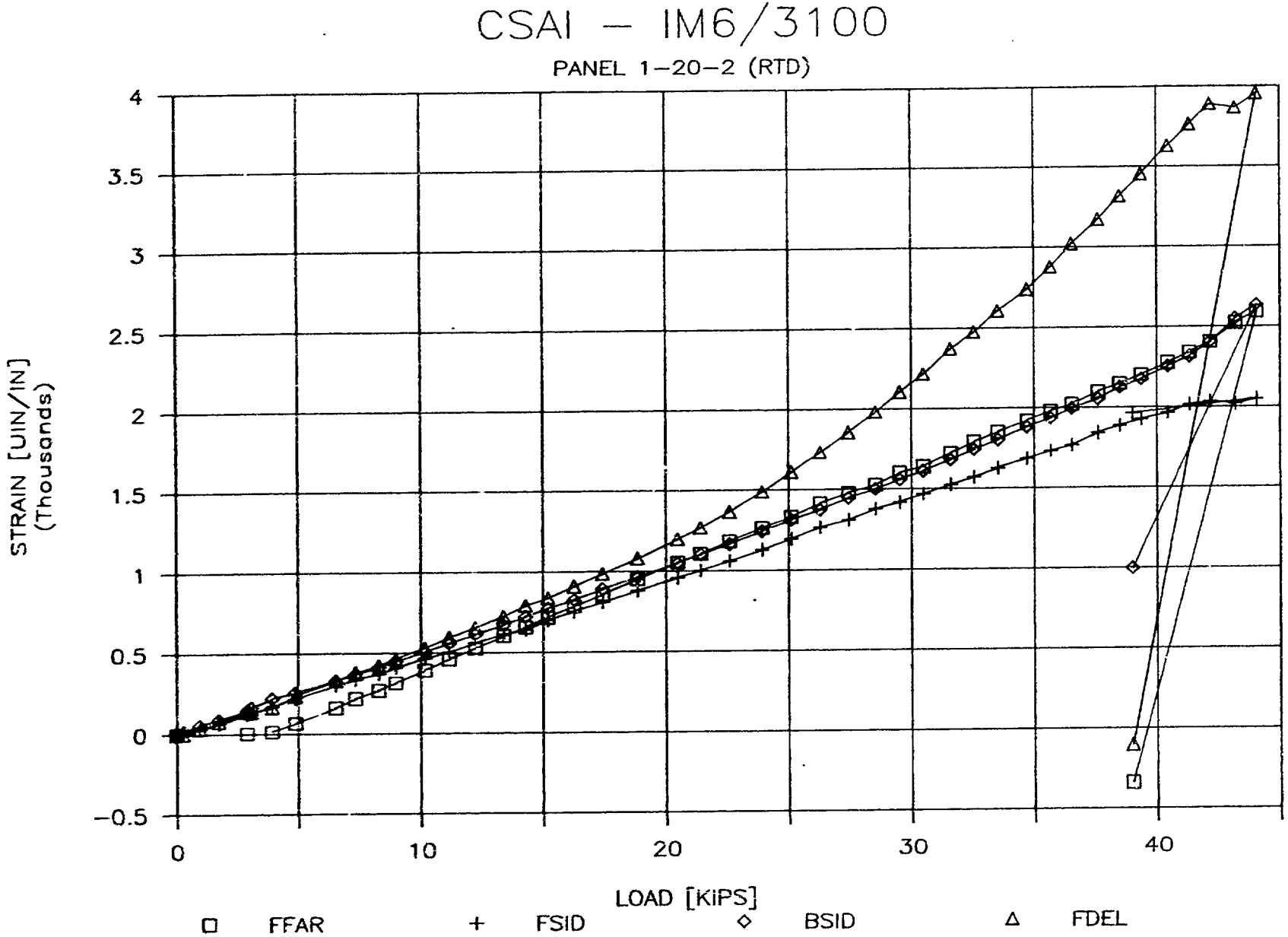


Figure B-18. Panel 1-20-2 Residual Compression Data

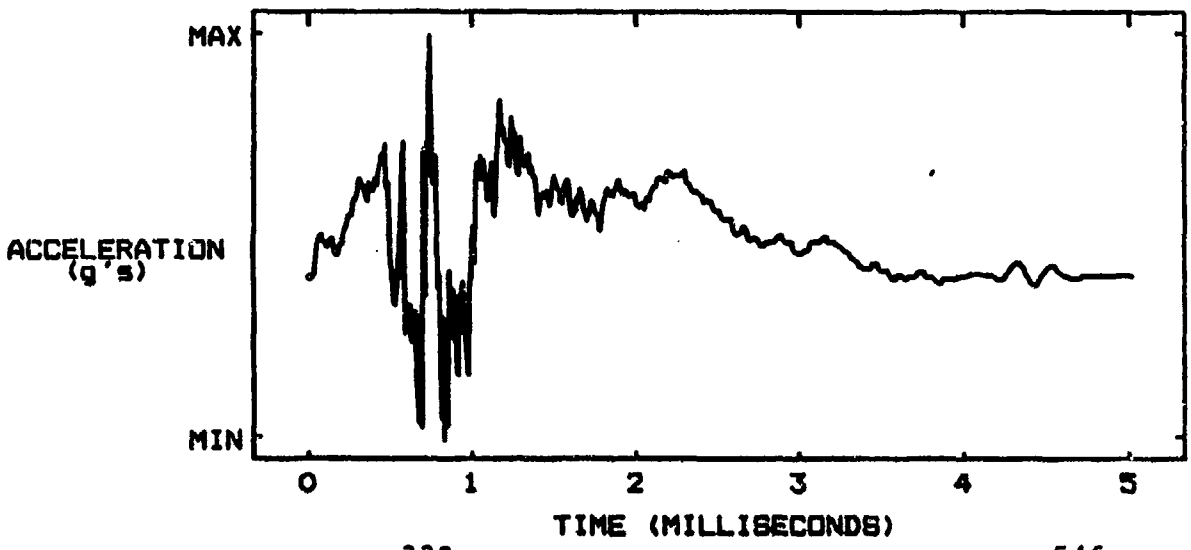
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-15-2 THICKNESS .453 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 27.5 IN

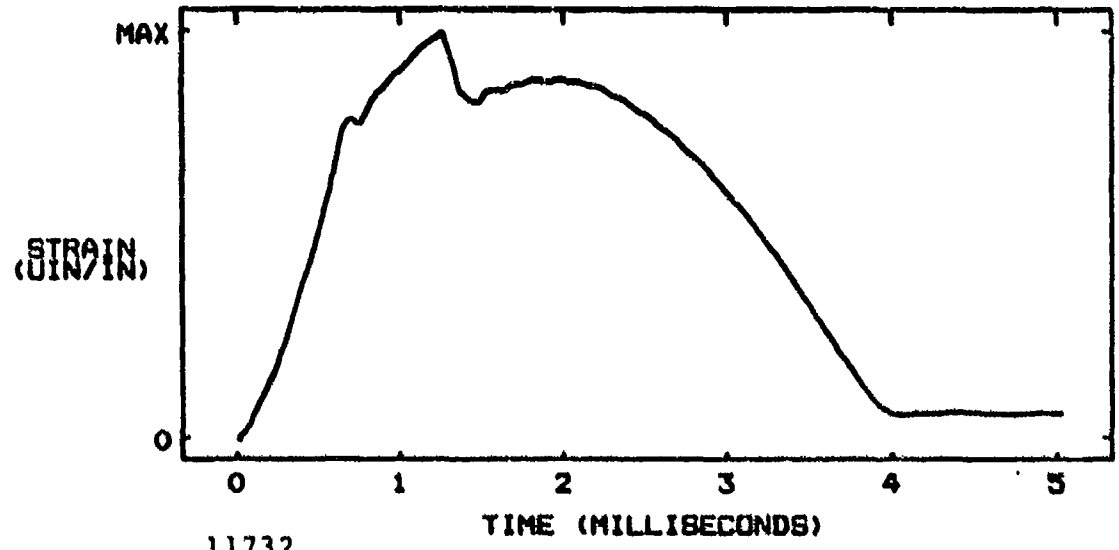
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -332 g's MAXIMUM ACCELERATION 546 g's

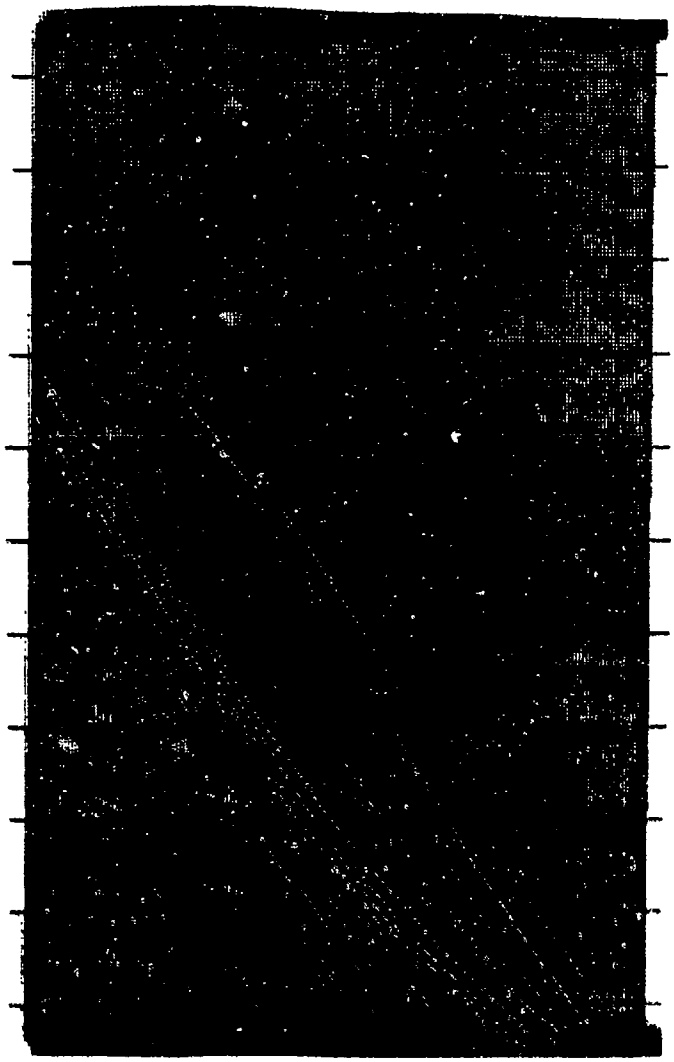
INTEGRATED TOTAL VELOCITY 166.56 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 11732 UIN/IN

Figure B-19. Panel 1-15-2 Impact Response Data



Specimen 1-15-1

Figure B-20. Panel 1-15-1 C-Scan

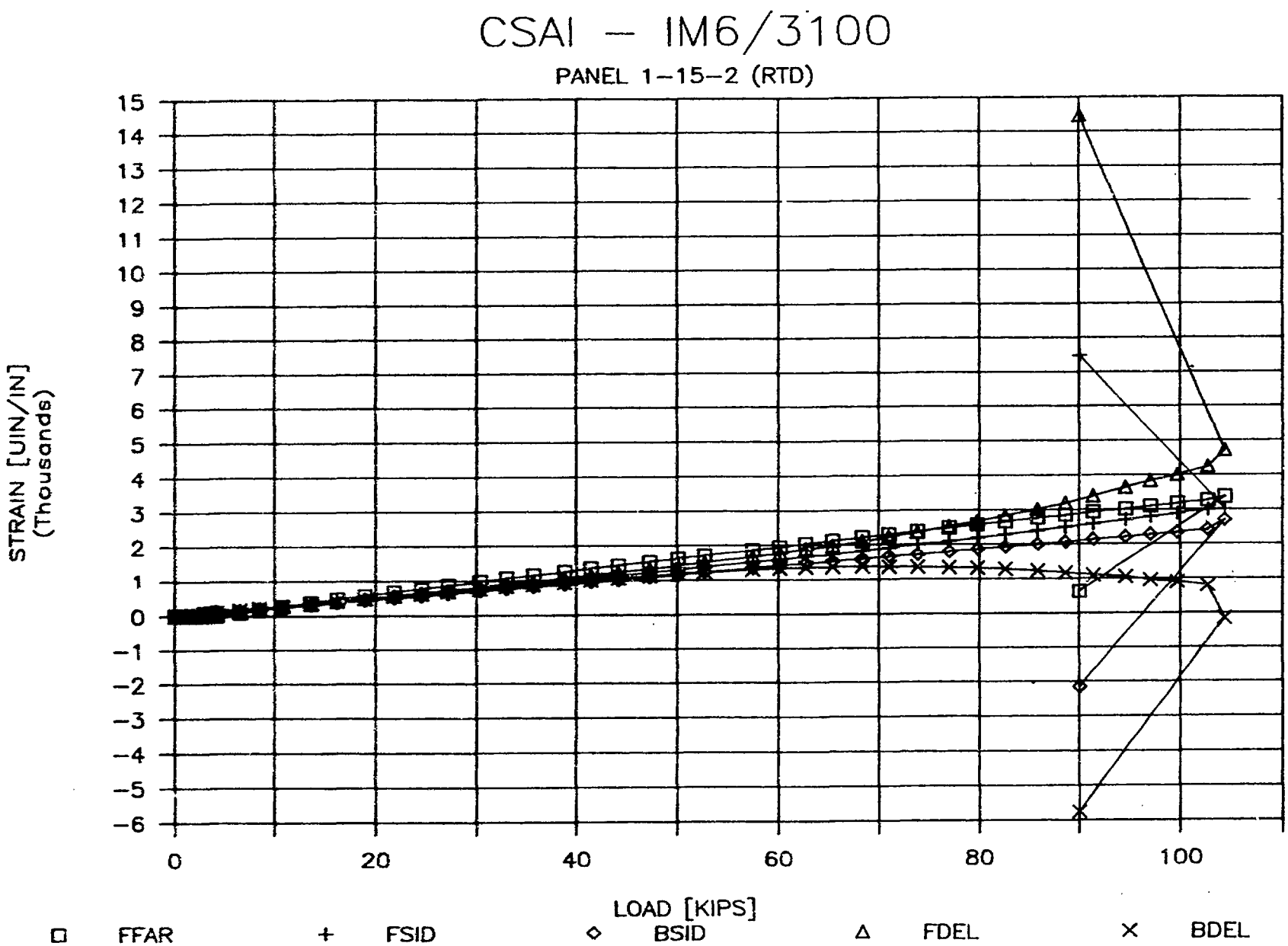


Figure B-21. Panel 1-15-2 Residual Compression Data

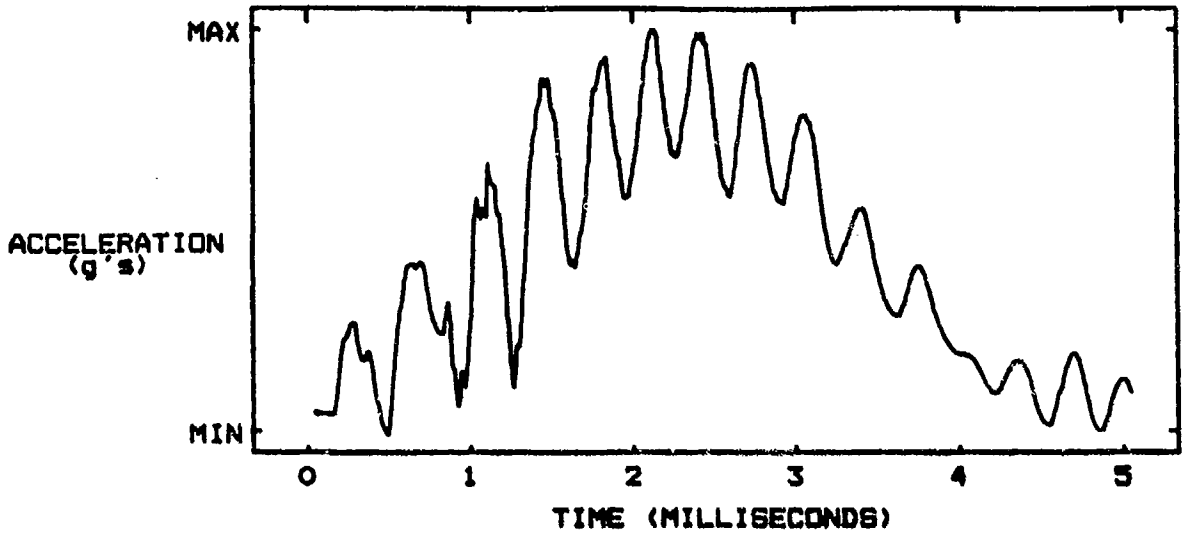
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-12-2 THICKNESS .106 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 20.0 IN

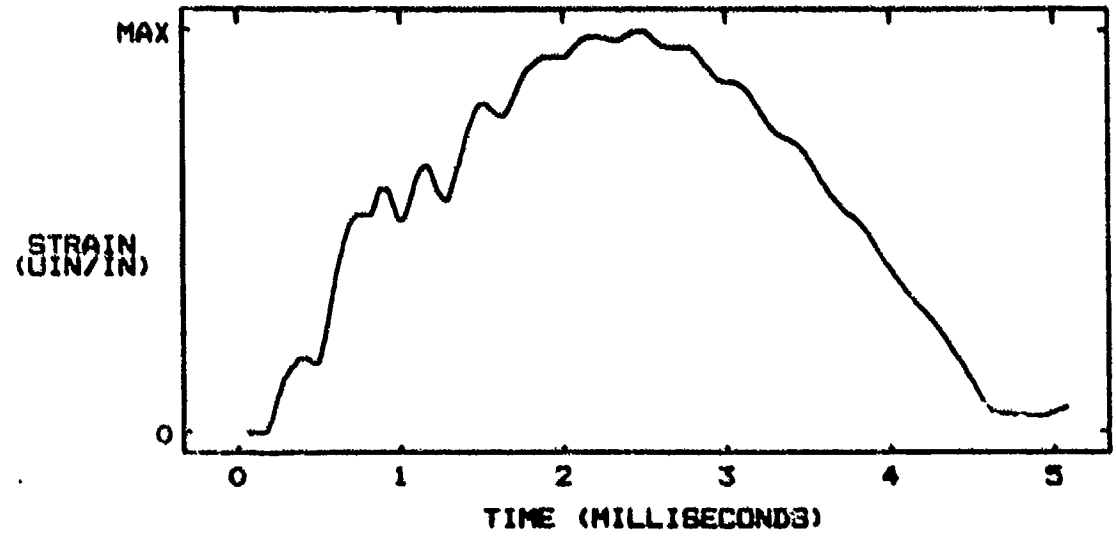
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -136.4 g's MAXIMUM ACCELERATION 267.58 g's

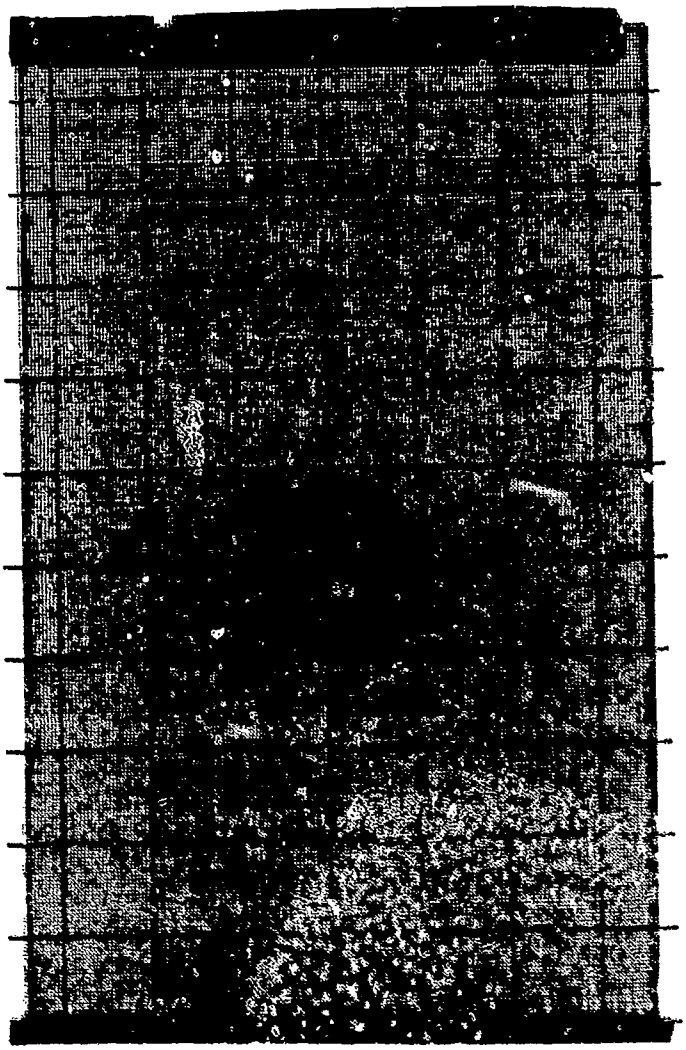
INTEGRATED TOTAL VELOCITY 202.55 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 8442.8 UIN/IN

Figure B-22. Panel 2-12-2 Impact Response Data



Specimen 3-12-2

Figure B-23. Panel 2-12-2 C-Scan

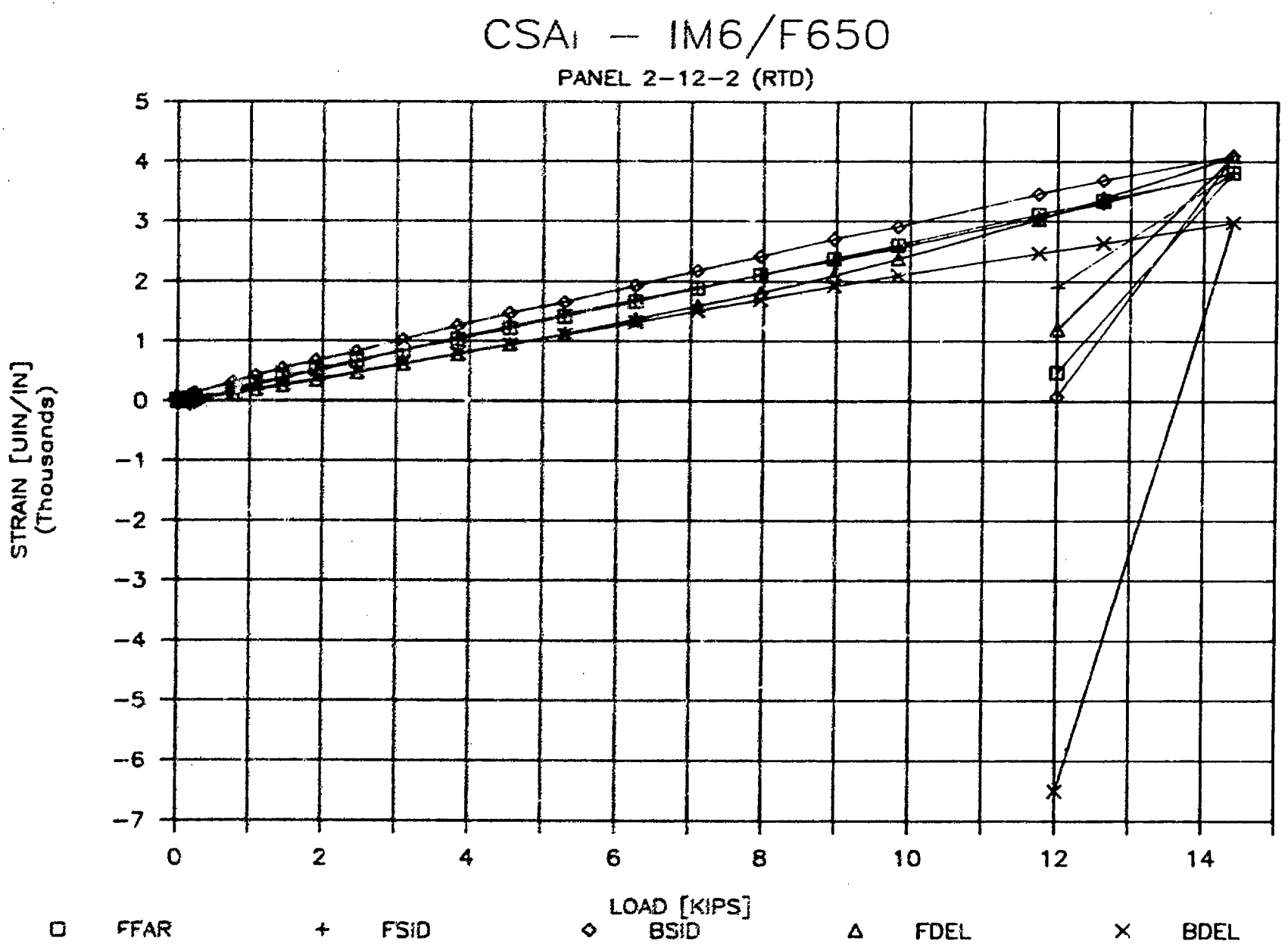


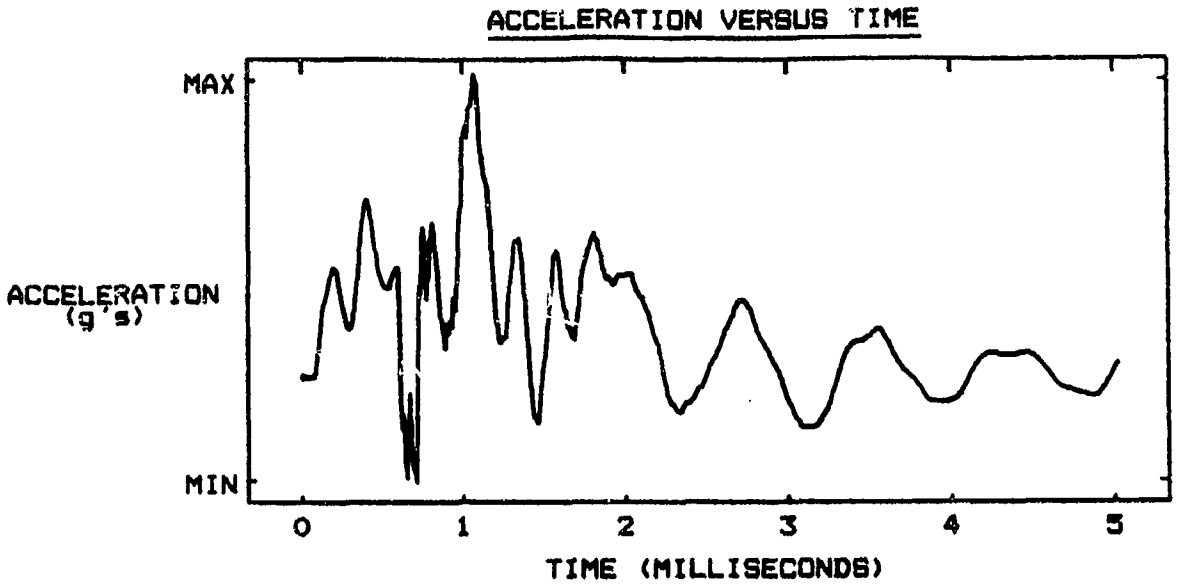
Figure B-24. Panel 2-12-2 Reidual Compression Data

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

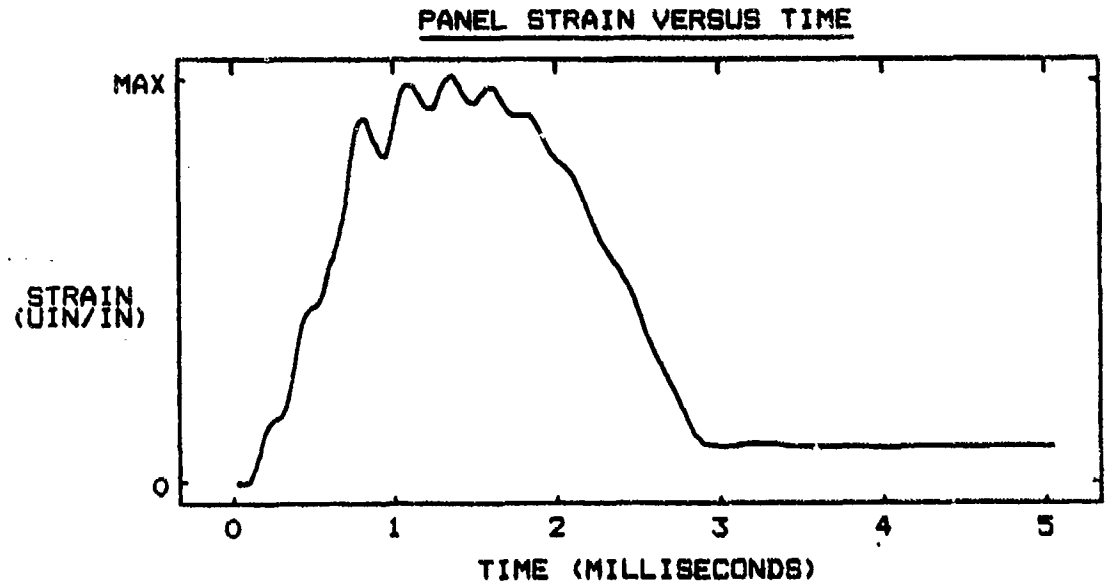
SPECIMEN I.D. 2-11-3 THICKNESS .216 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 23.3 IN



MINIMUM ACCELERATION -246 g's MAXIMUM ACCELERATION 632.81g's

INTEGRATED TOTAL VELOCITY 165.79 IN/SEC

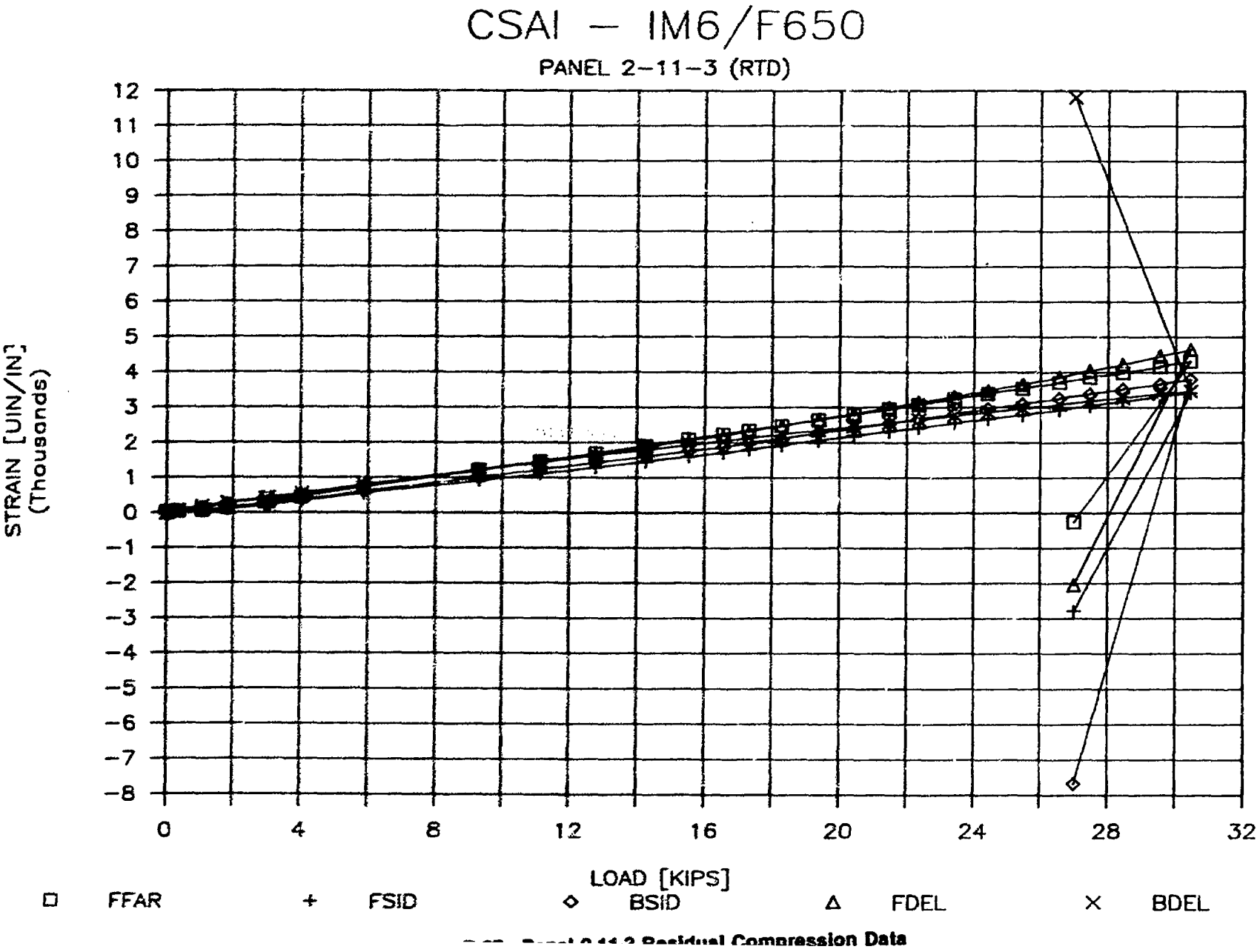


MAXIMUM STRAIN 11732 UIN/IN

Figure B-25. Panel 2-11-3 Impact Response Data

Specimen 2-11-3

Figure B-26. Panel 2-11-3 C-Scan



Panel 2-11-3 Residual Compression Data

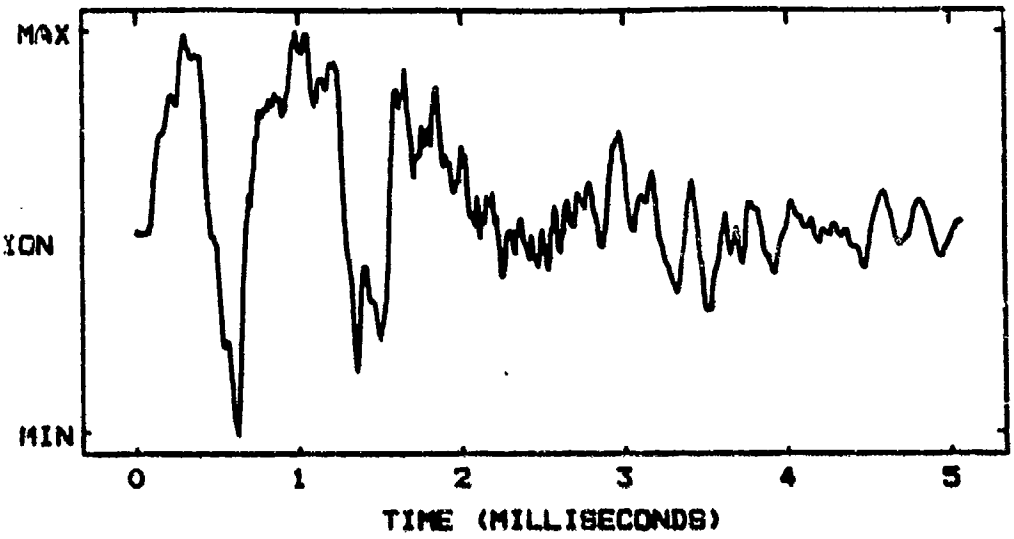
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-13-1 THICKNESS .436 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 32.6 IN

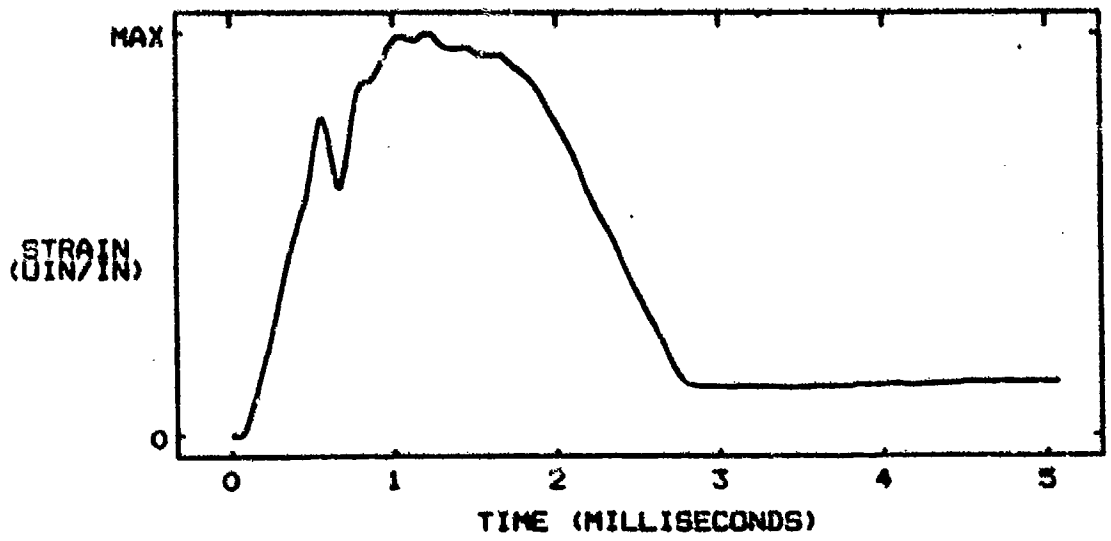
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -775 g's MAXIMUM ACCELERATION 707 g's

INTEGRATED TOTAL VELOCITY 208.11 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9689 UIN/IN

Figure B-28. Panel 2-13-1 Impact Response Data

Specimen 2-13-1

Figure B-29. Panel 2-13-1 C-Scan

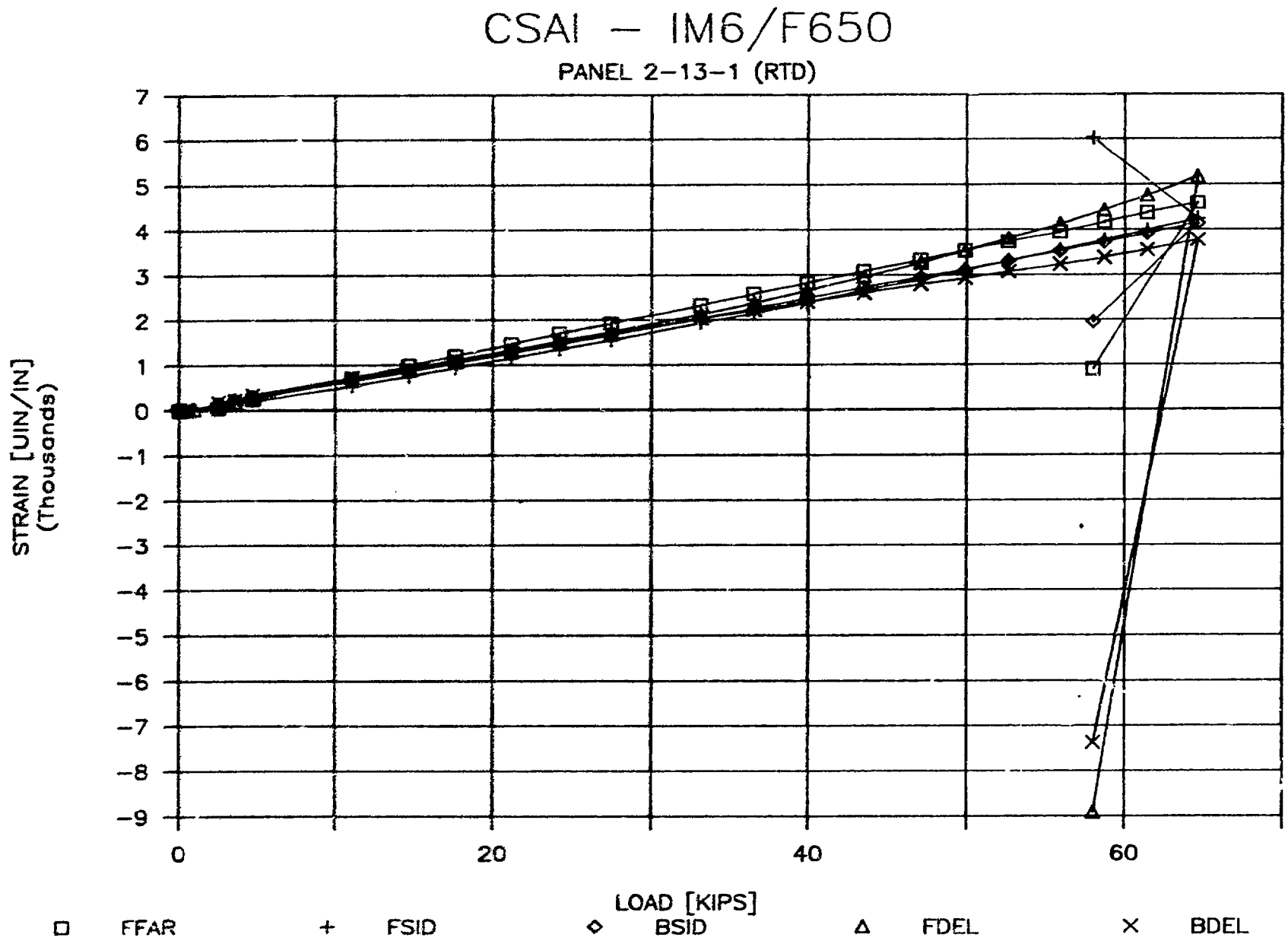


Figure B-30. Panel 2-13-1 Residual Compression Data

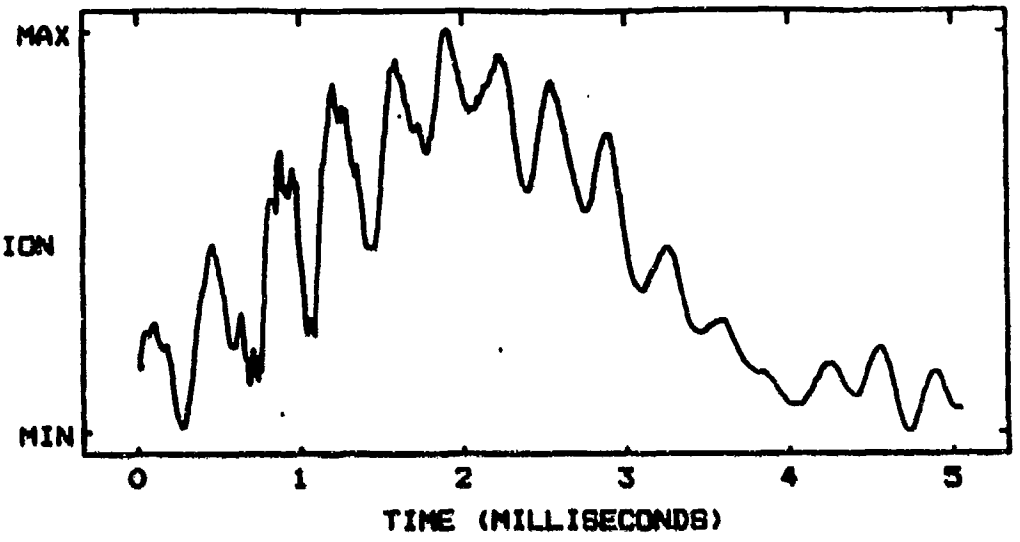
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14-1 THICKNESS .111 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 23.3 IN

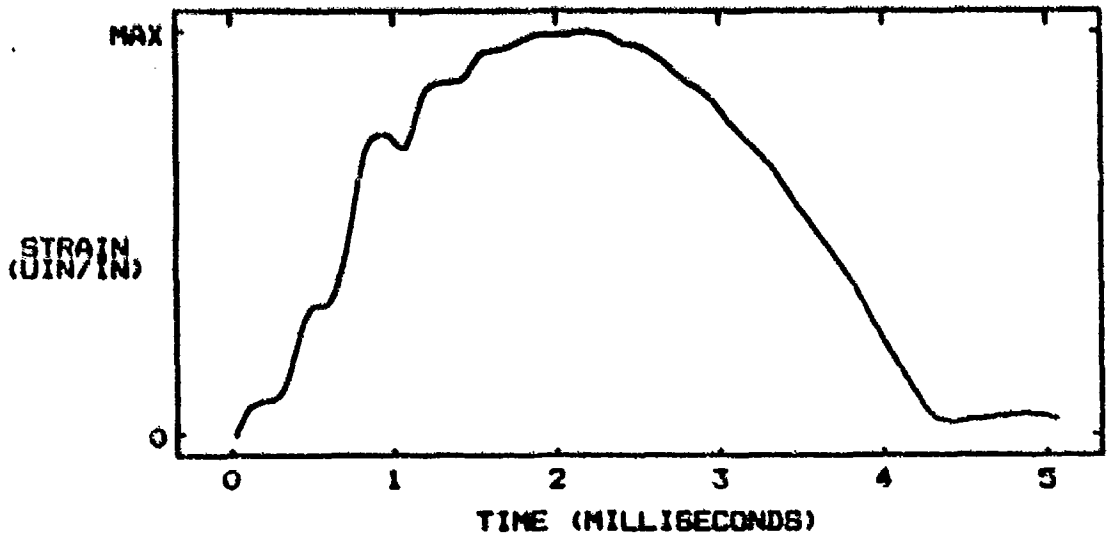
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -46 g's MAXIMUM ACCELERATION 256 g's

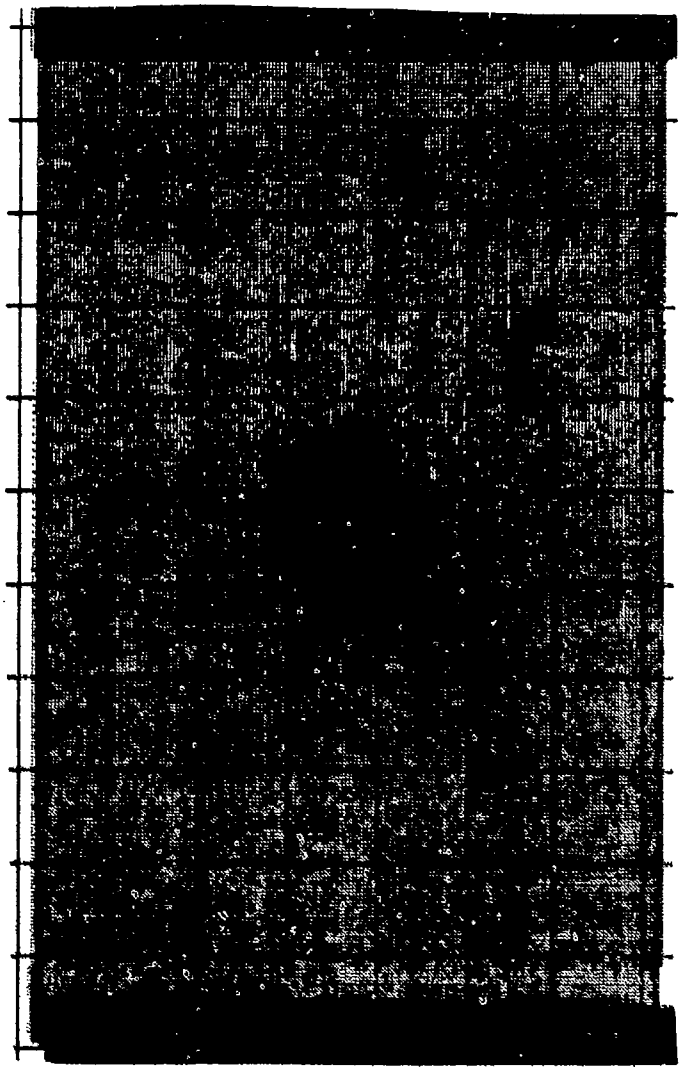
INTEGRATED TOTAL VELOCITY 161.5 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 14618 UIN/IN

Figure 8-31. Panel 2-14-1 Impact Response Data



Specimen 2-14-1

Figure B-32. Panel 2-14-1 C-Scan

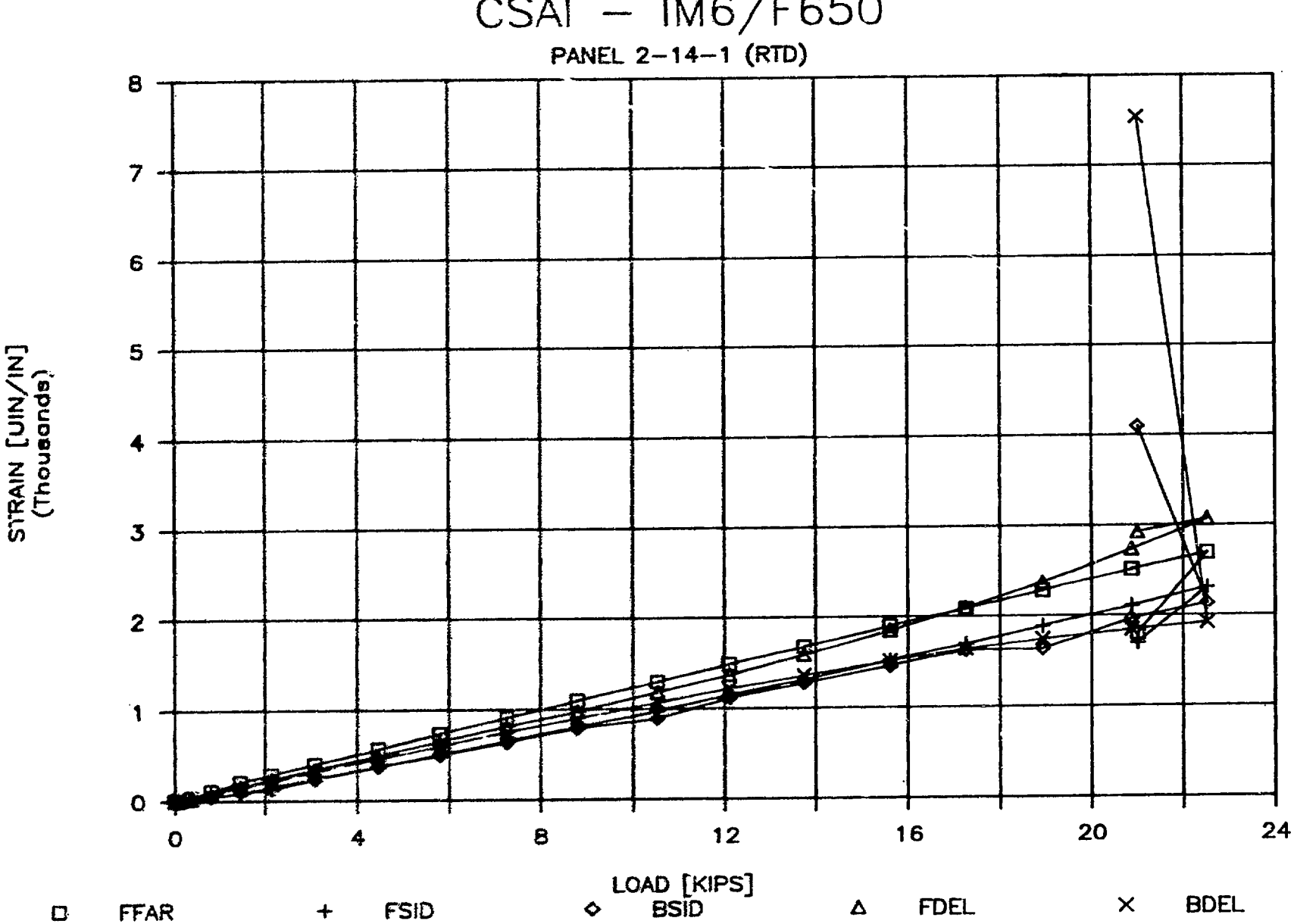


Figure B-33. Panel 2-14-1 Residual Compression Data

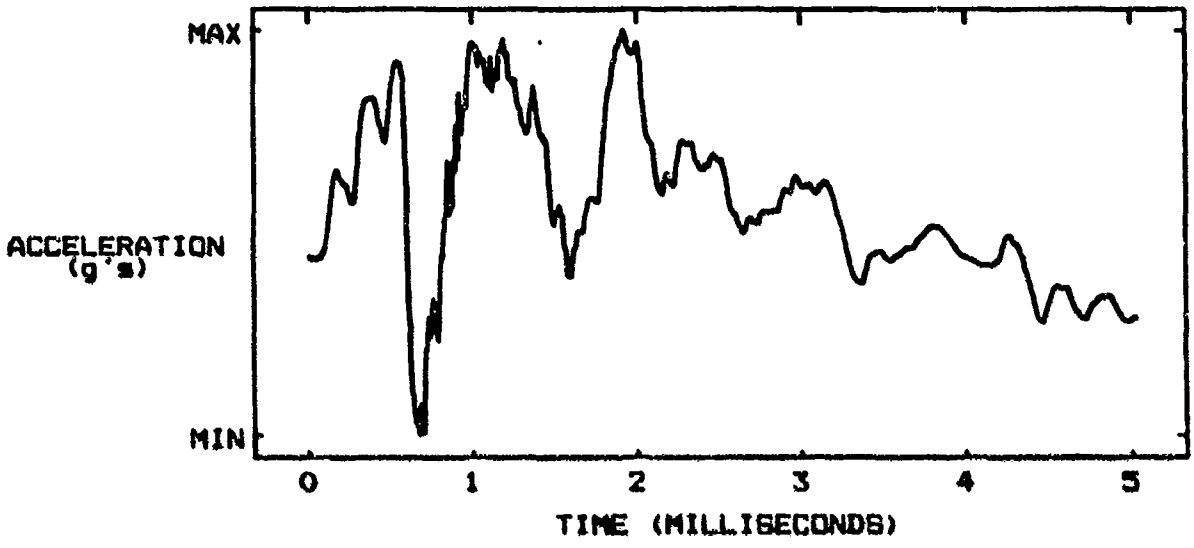
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-20-2 THICKNESS .219 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 16.3 IN

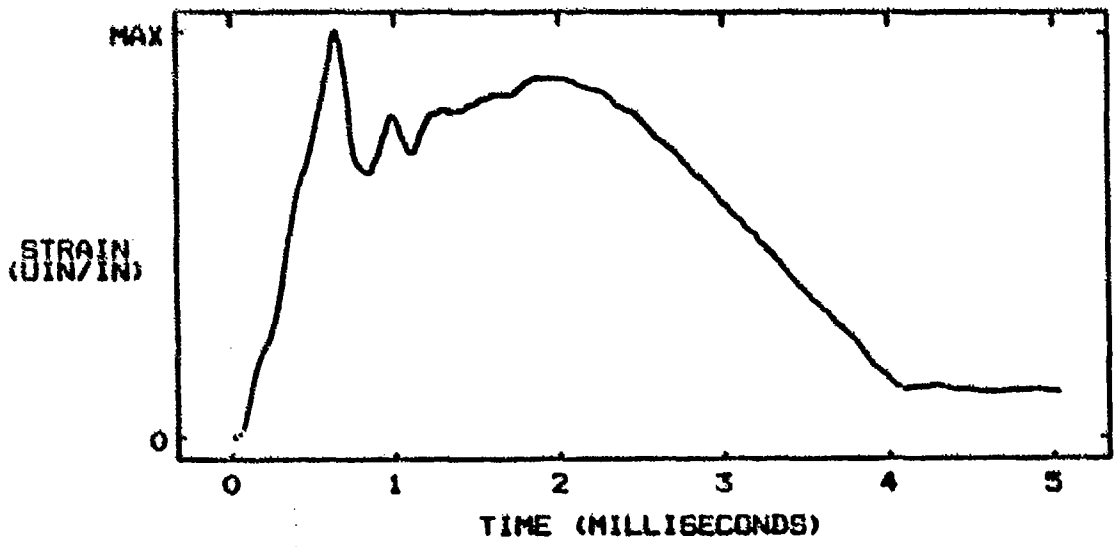
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -230 g's MAXIMUM ACCELERATION 304.7 g's

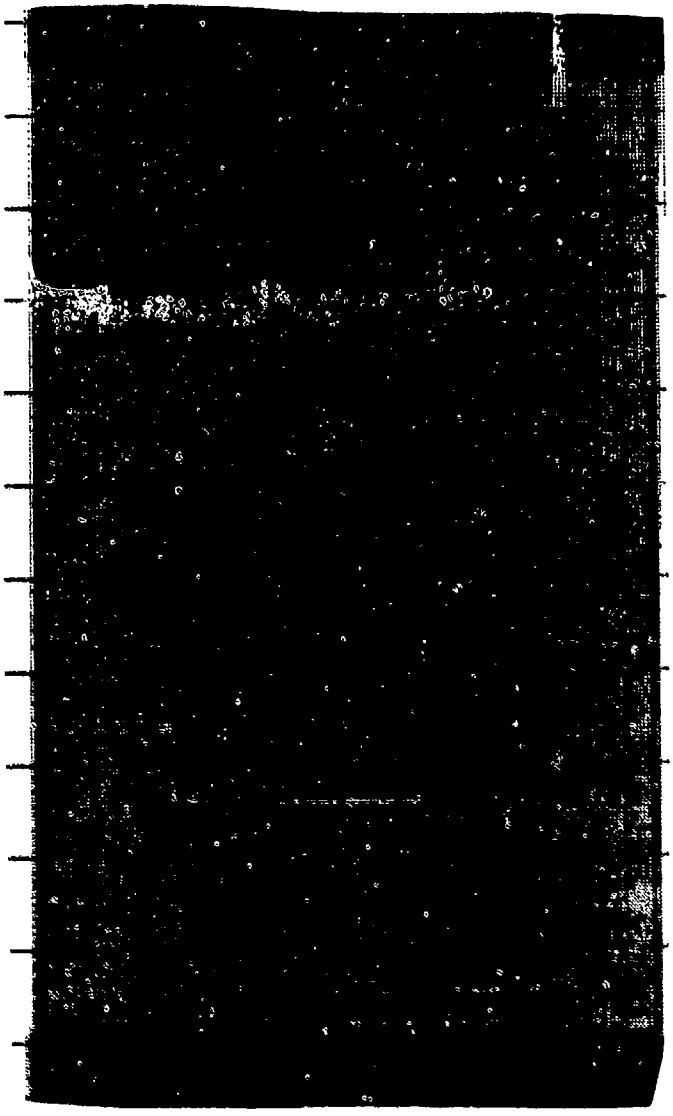
INTEGRATED TOTAL VELOCITY 150 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 4404.3 UIN/IN

Figure B-34. Panel 2-20-2 Impact Response Data



Specimen 2-20-2

Figure B-35. Panel 2-20-2 C-Scan

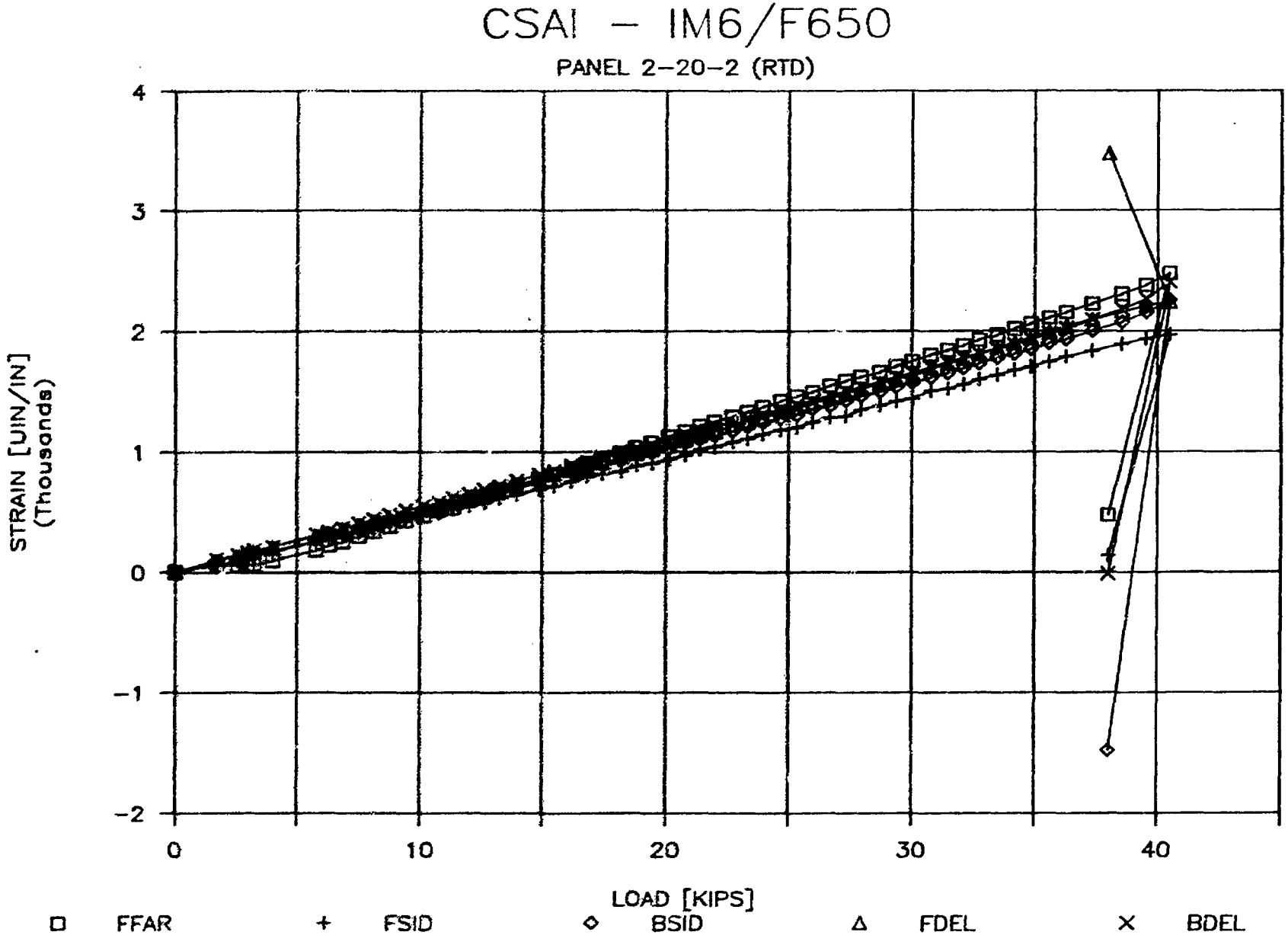


Figure B-36. Panel 2-20-2 Residual Compression Data

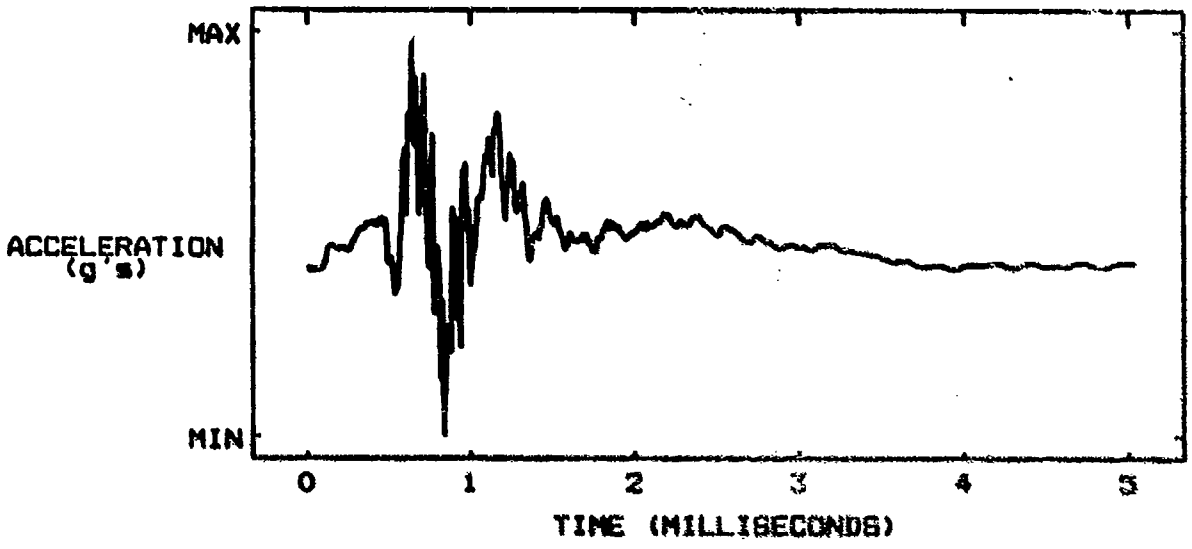
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-15-2 THICKNESS .443 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 23 IN

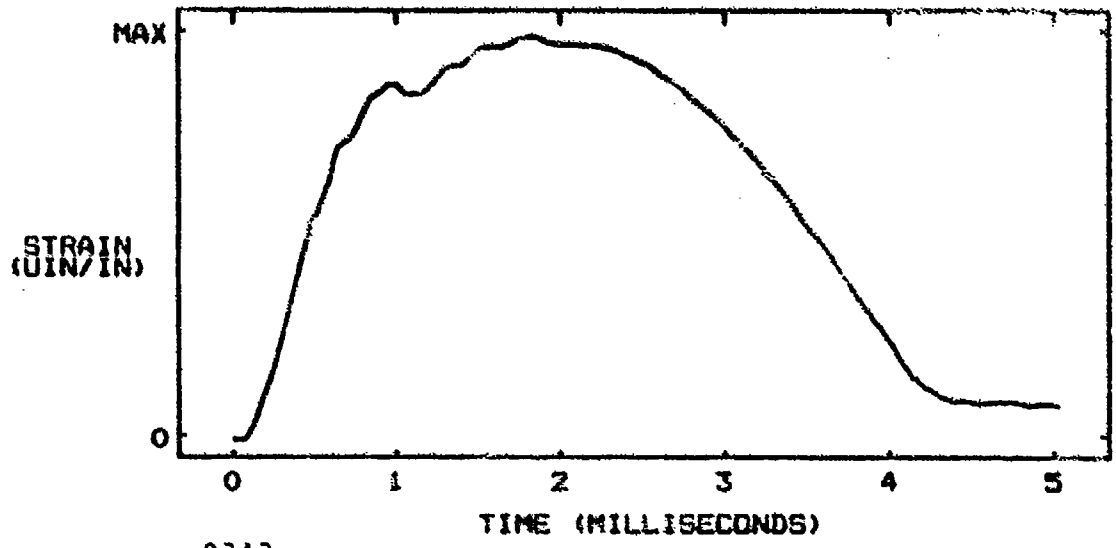
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -659 g's MAXIMUM ACCELERATION 756 g's

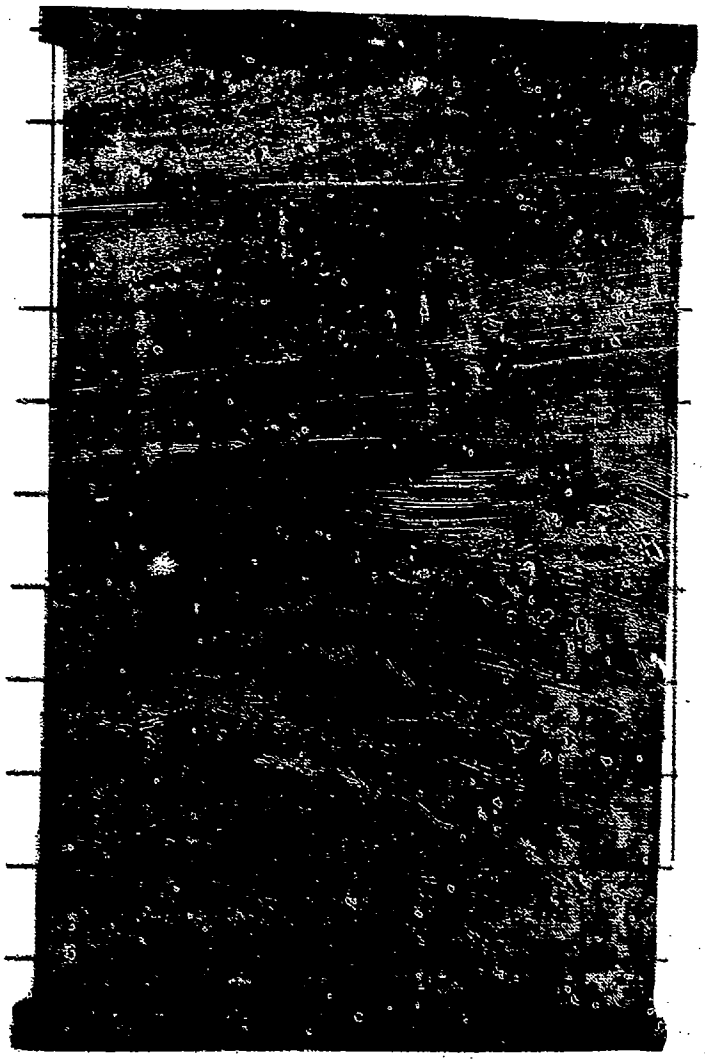
INTEGRATED TOTAL VELOCITY 202.49 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9343 UIN/IN

Figure B-37. Panel 2-15-2 Impact Response Data



Specimen 2-15-2

Figure B-38. Panel 2-15-2 C-Scan

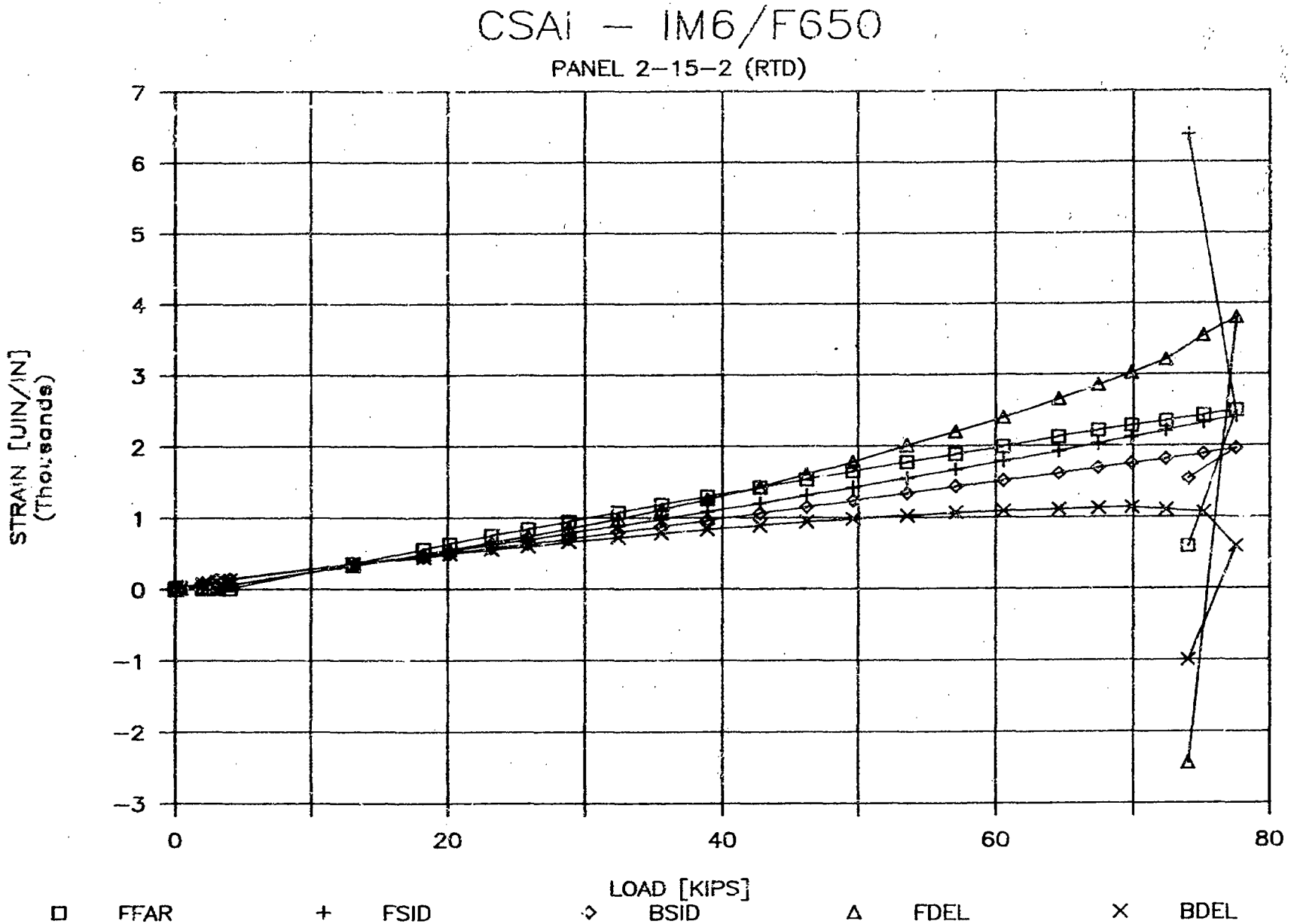


Figure B-39. Panel 2-15-2 Residual Compression Data

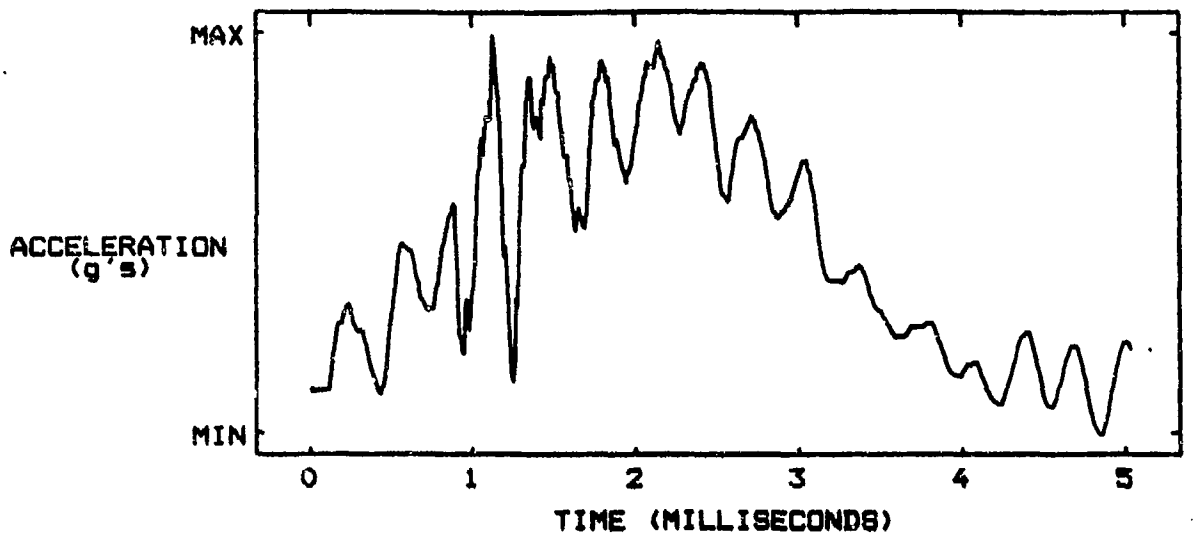
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-12-4 THICKNESS .114 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 26.7 IN

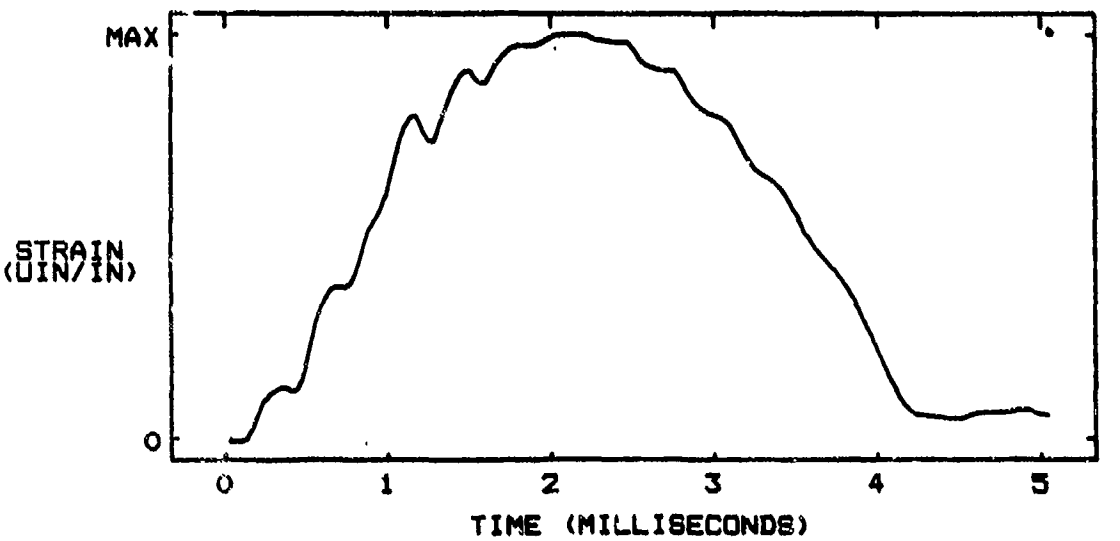
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -35.3 g's MAXIMUM ACCELERATION 334.96 g's

INTEGRATED TOTAL VELOCITY 241.46 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 15068 UIN/IN

Figure 8-40. Panel 1-12-4 Impact Response Data

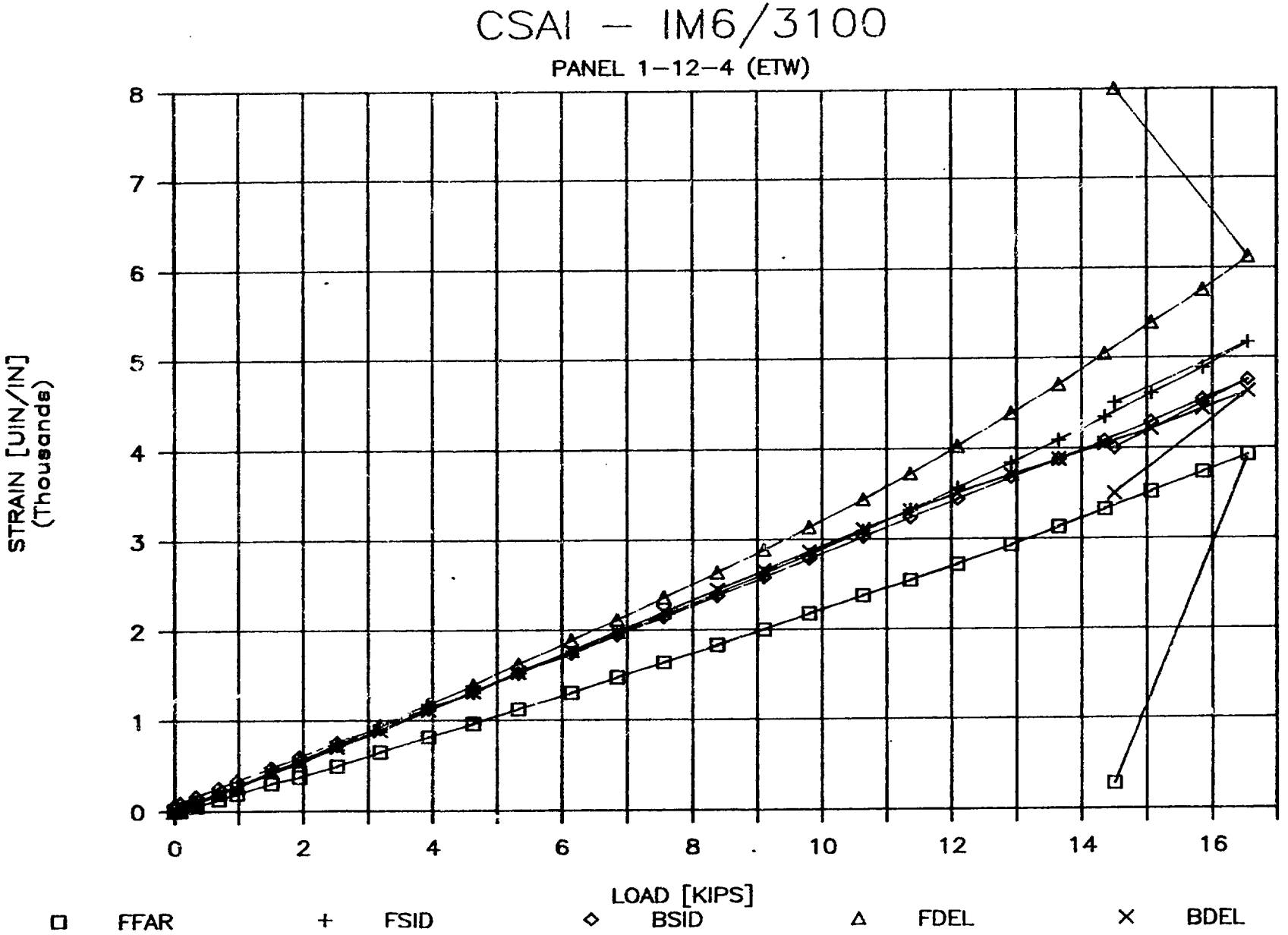


Figure B-41. Panel 1-12-4 Residual Compression Data

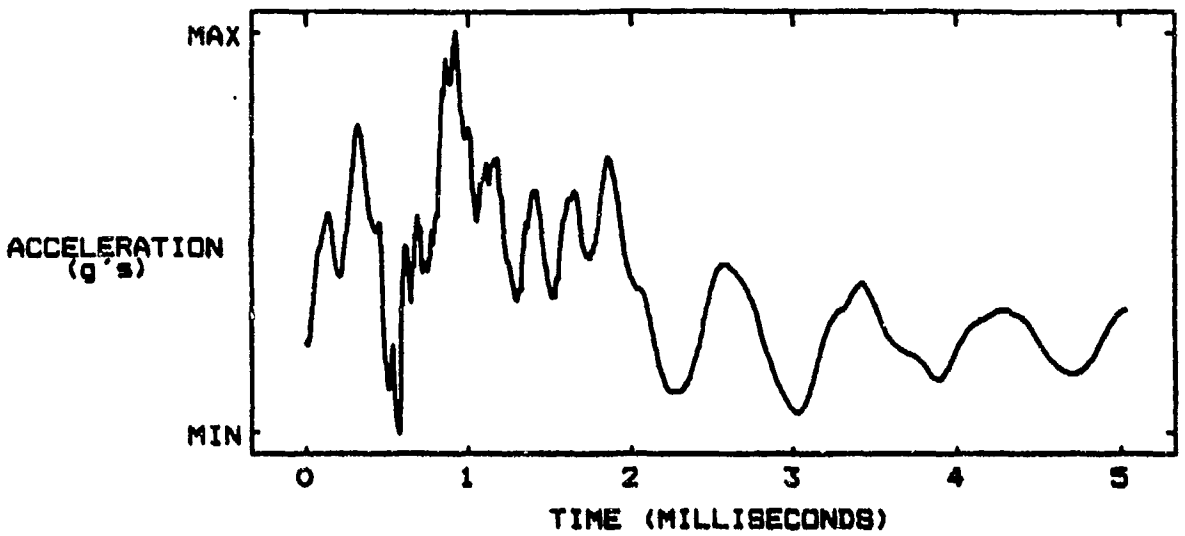
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-11-5 THICKNESS .222 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 46.7 IN

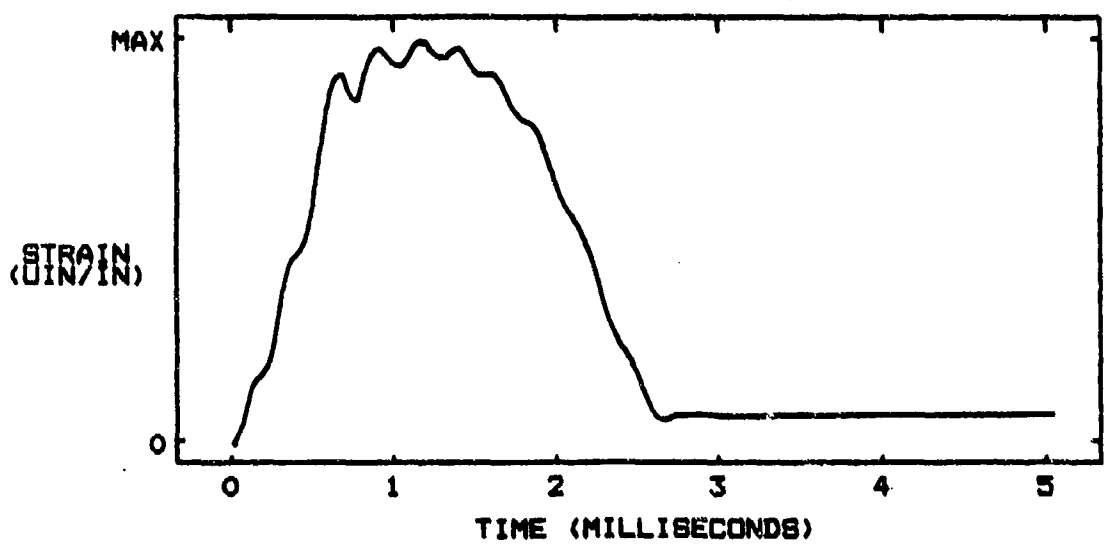
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -251 g's MAXIMUM ACCELERATION 874 g's

INTEGRATED TOTAL VELOCITY 260.65 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 15742 UIN/IN

Figure B-42. Panel 1-11-5 Impact Response Data

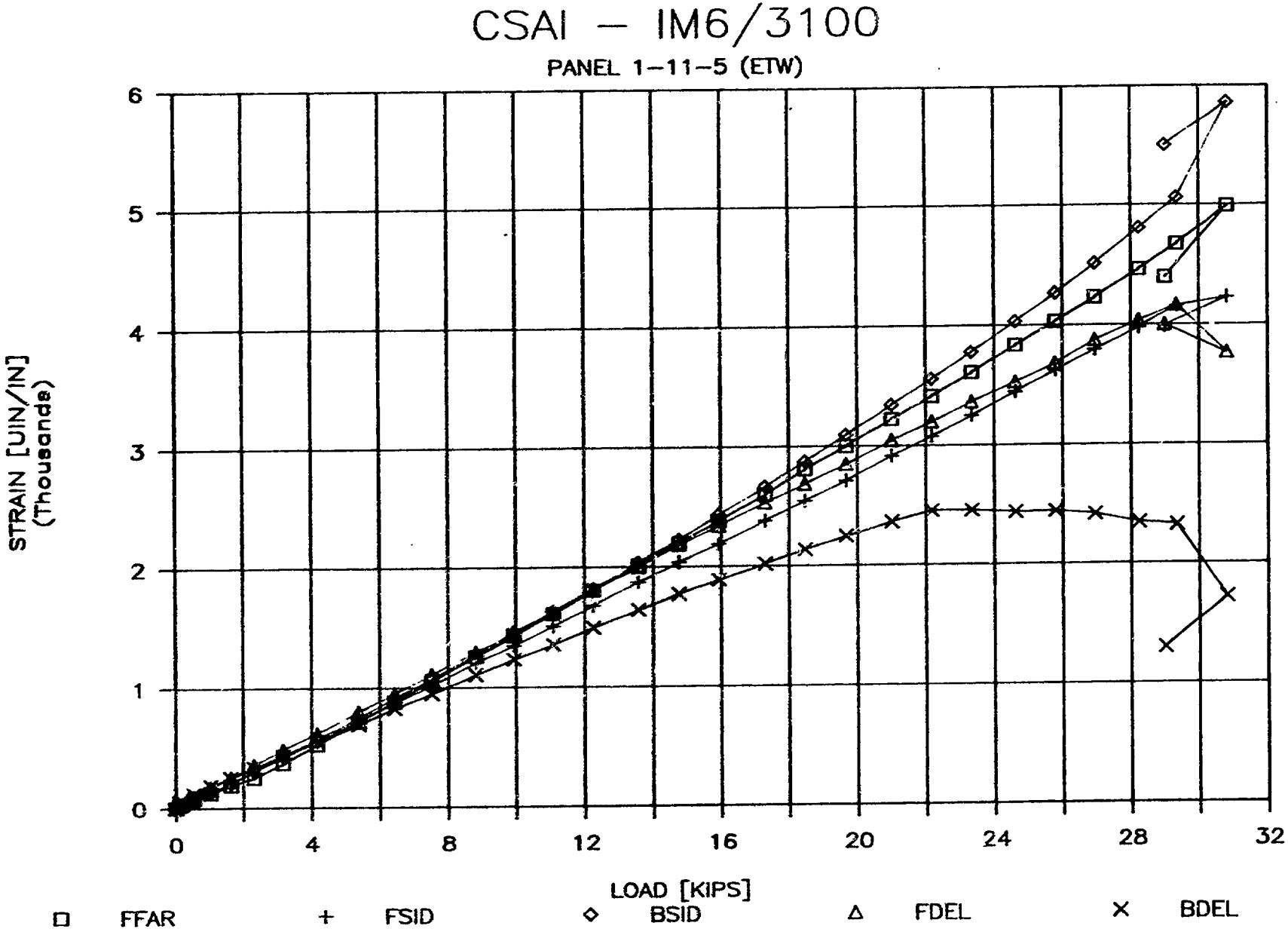


Figure B-43. Panel 1-11-5 Residual Compression Data

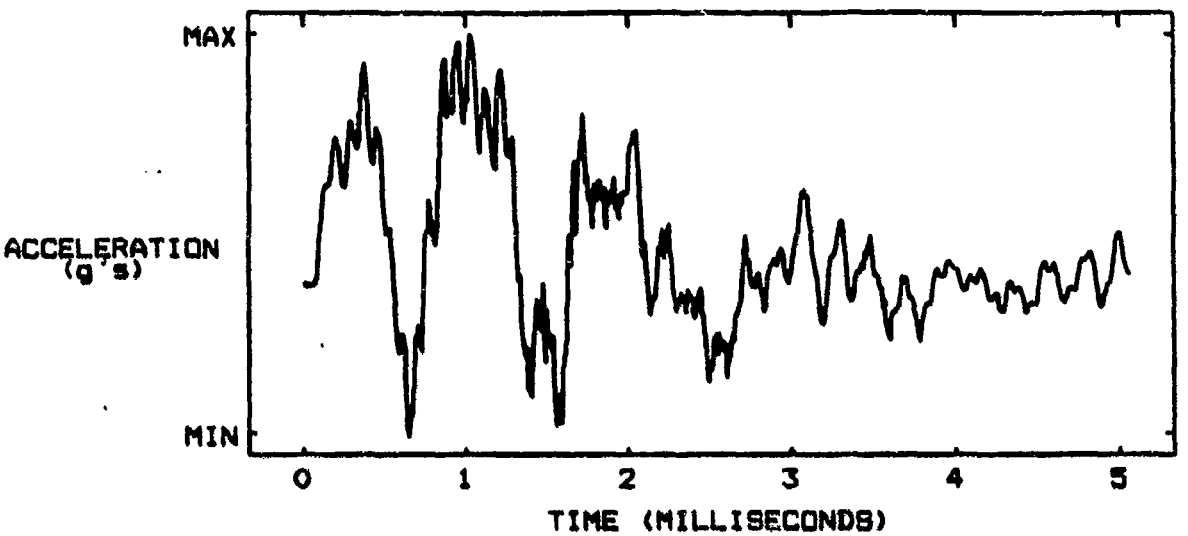
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-13-4 THICKNESS .449 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 37.5 IN

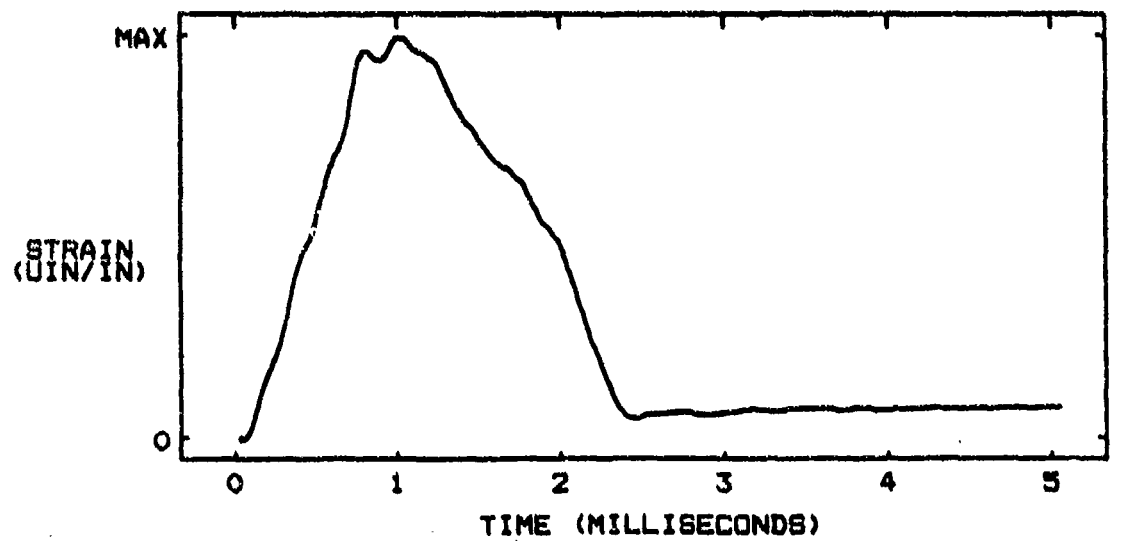
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -656 g's MAXIMUM ACCELERATION 1076 g's

INTEGRATED TOTAL VELOCITY 257.6 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 10580 UIN/IN

Figure B-44. Panel 1-13-4 Impact Response Data

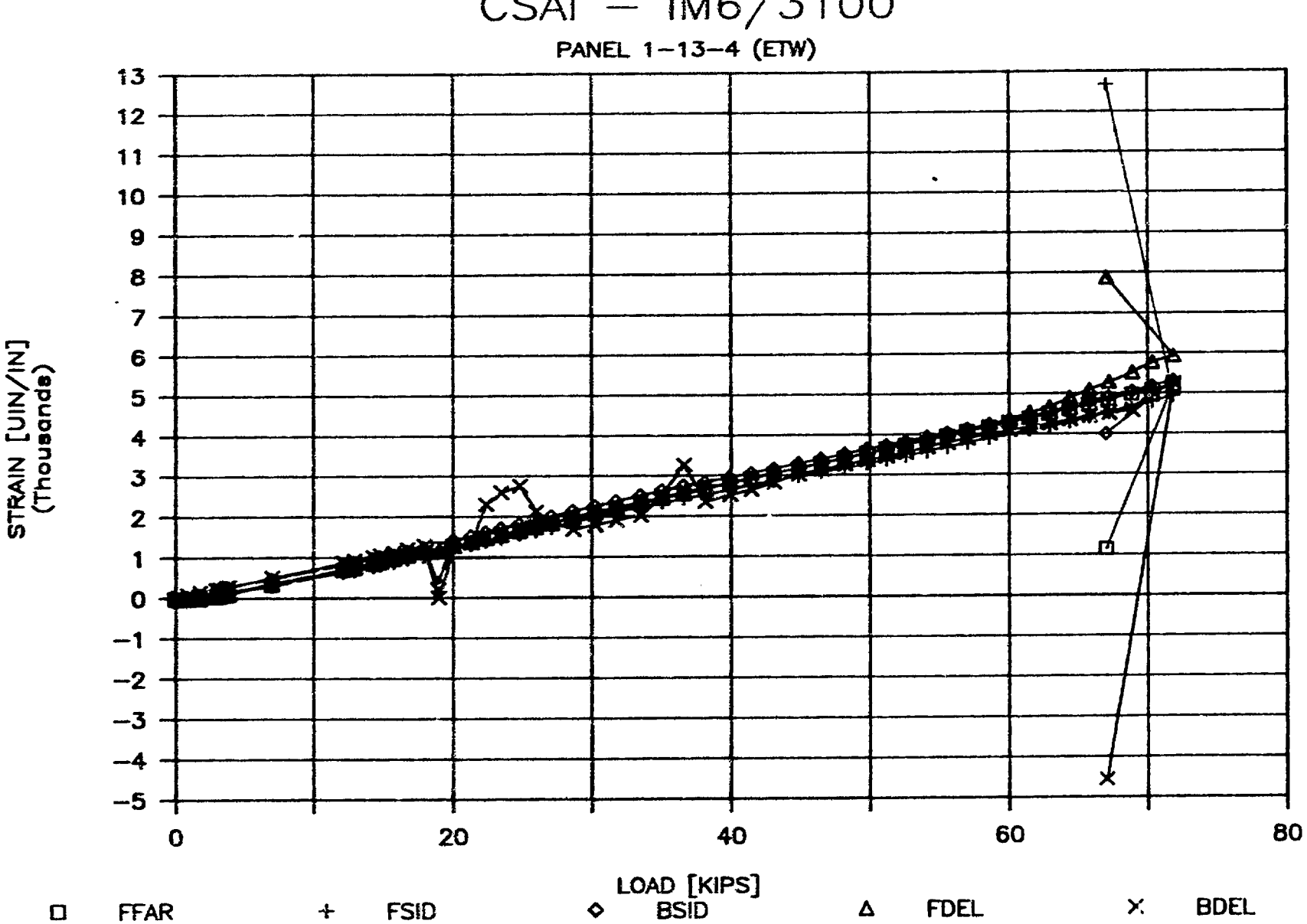


Figure B-45. Panel 1-13-4 Residual Compression Data

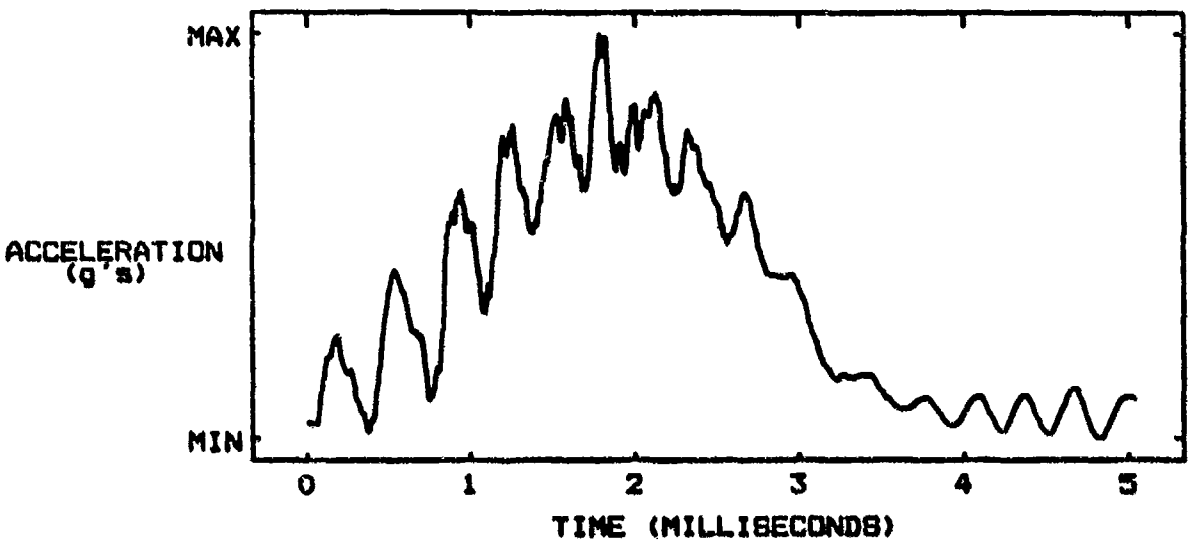
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-14-4 THICKNESS .110 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 46.7 IN

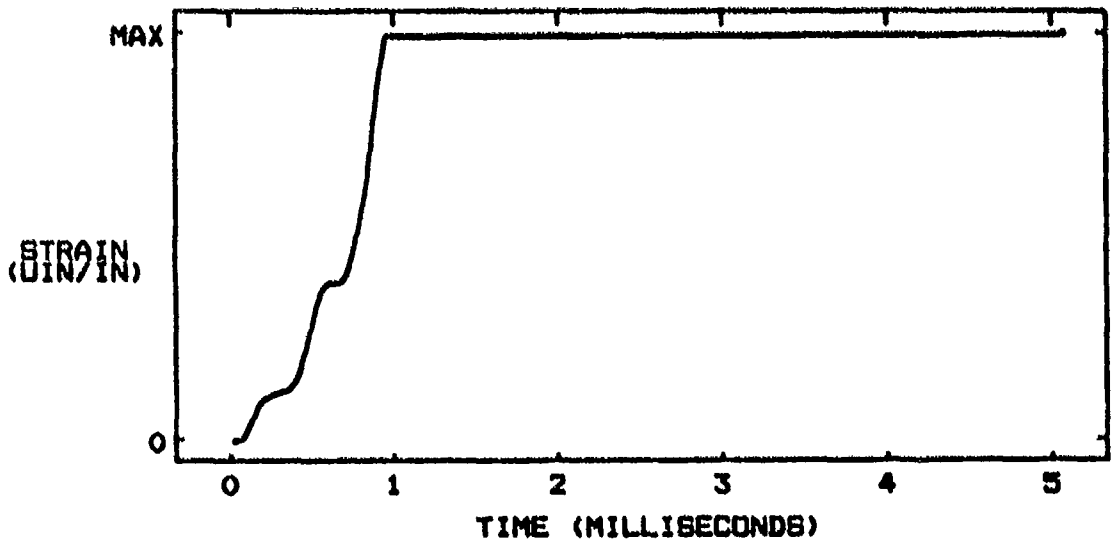
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -21 g's MAXIMUM ACCELERATION 462 g's

INTEGRATED TOTAL VELOCITY 276.79 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 18160 UIN/IN

Figure B-46. Panel 1-14-4 Impact Response Data

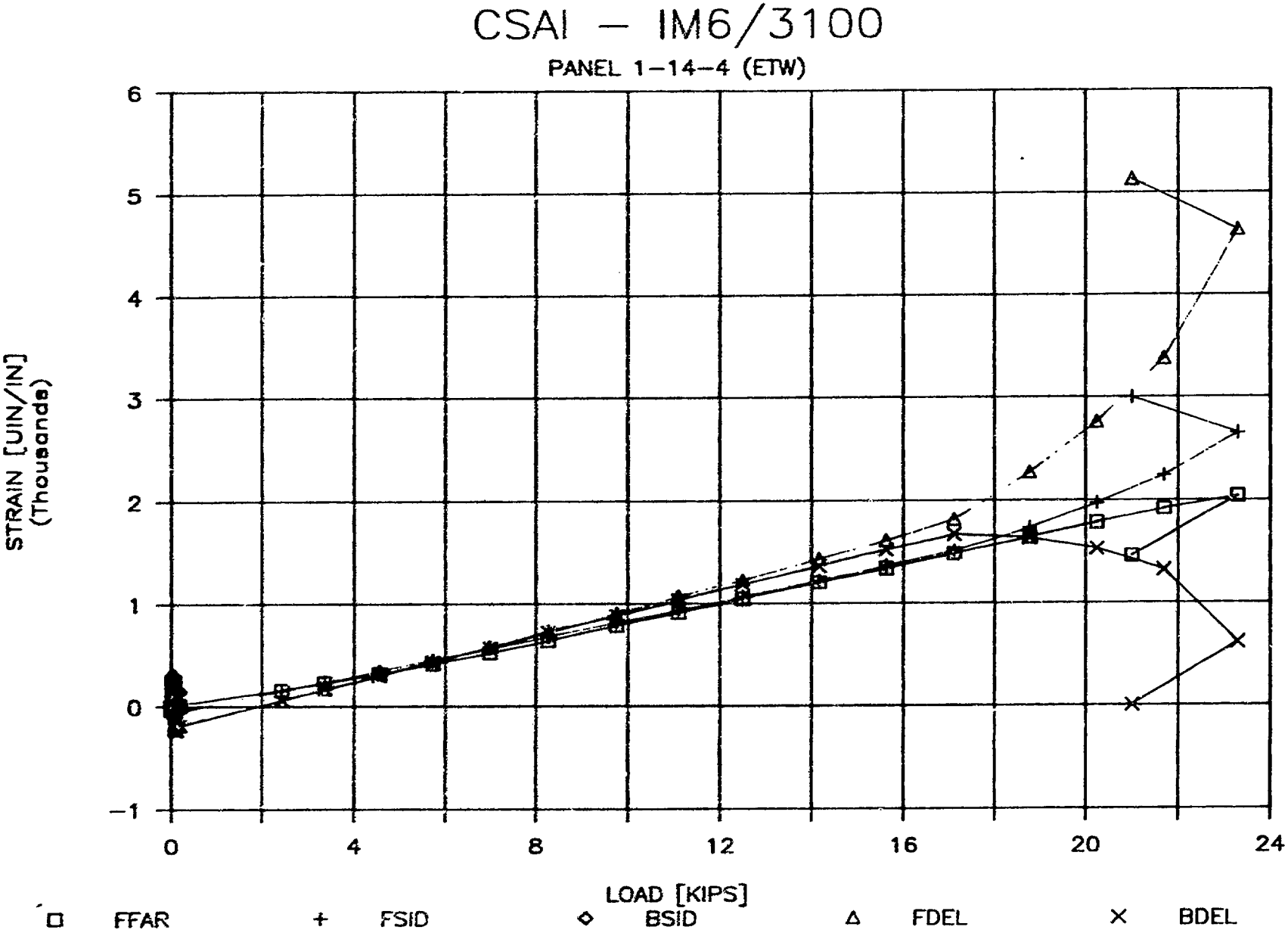


Figure B-47. Panel 1-14-4 Residual Compression Data

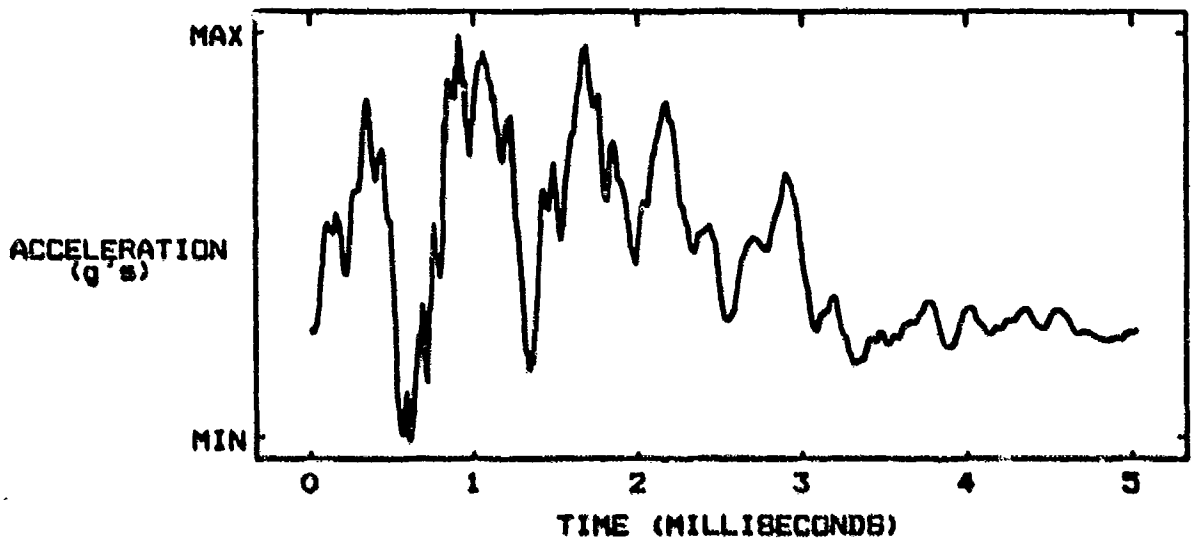
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-20-4 THICKNESS .225 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 37.5 IN

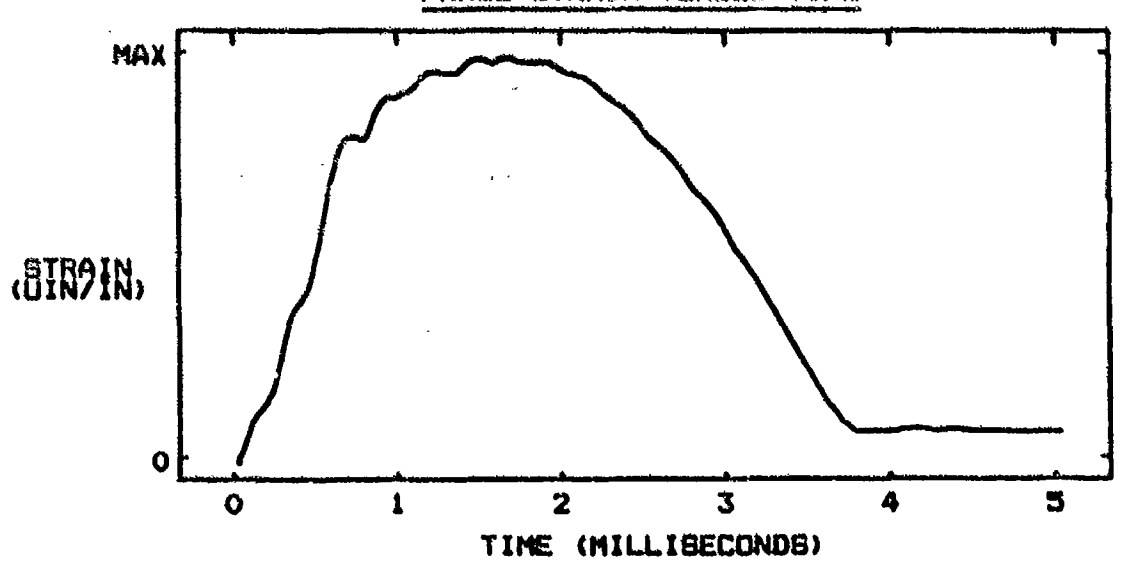
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -191 g's MAXIMUM ACCELERATION 520 g's

INTEGRATED TOTAL VELOCITY 252.85 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 14543 UIN/IN

Figure B-48. Panel 1-20-4 Impact Response Data

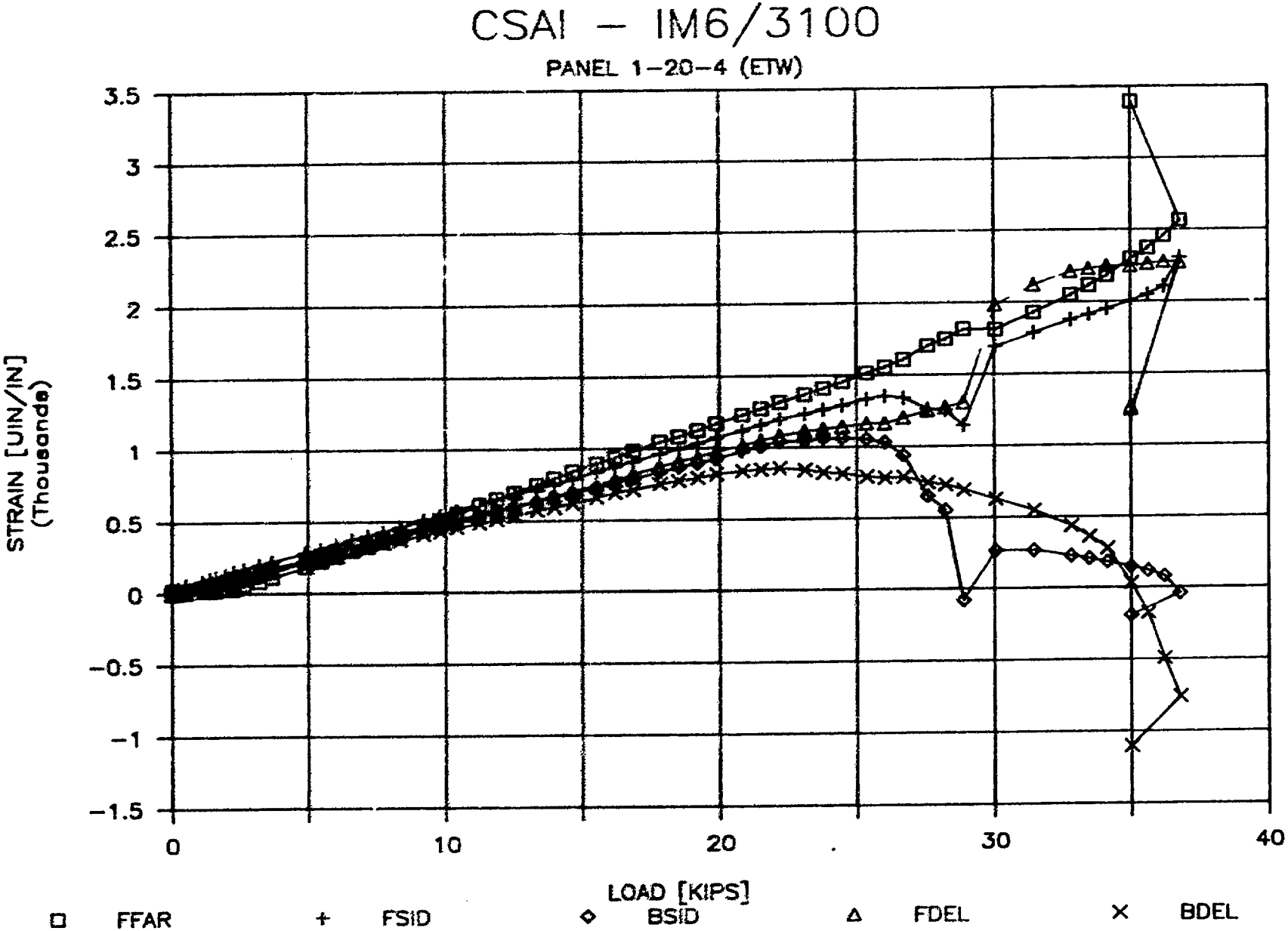


Figure 8-49. Panel 1-20-4 Residual Compression Data

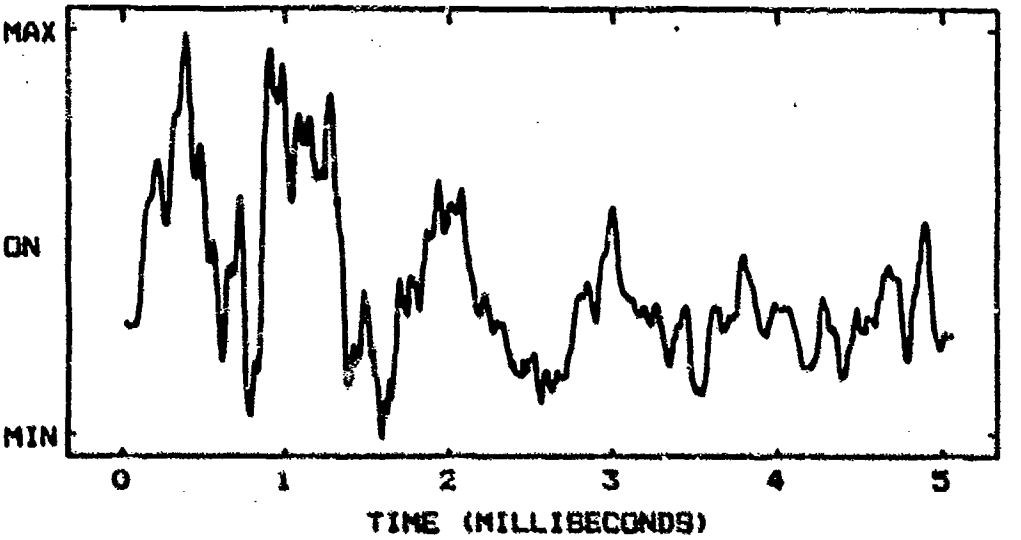
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-15-4.1 THICKNESS .451 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 37.5 IN

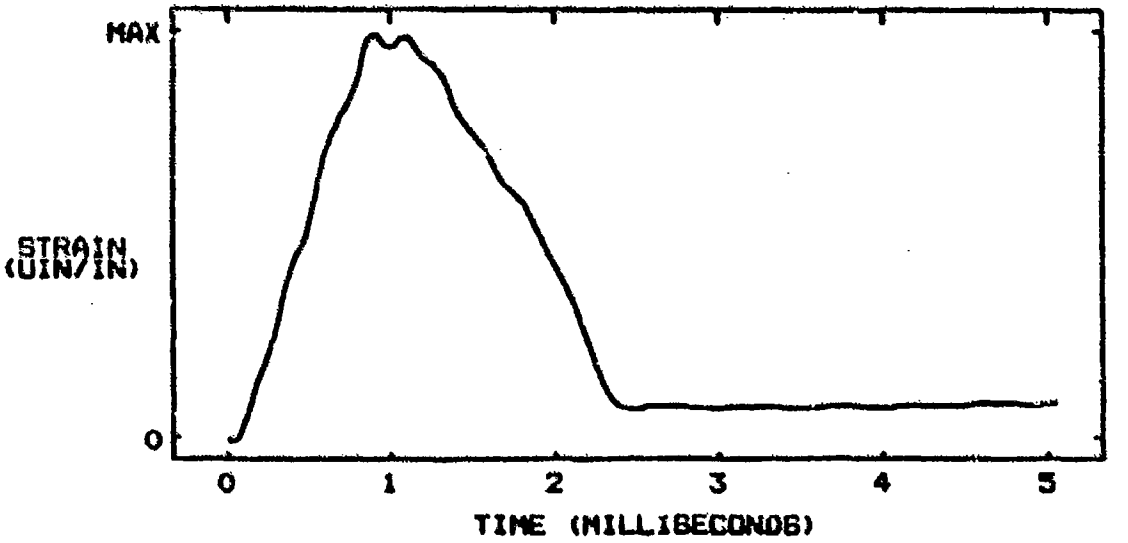
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -375 g's MAXIMUM ACCELERATION 962.9 g's

INTEGRATED TOTAL VELOCITY 230.37 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9108 UIN/IN

Figure B-50. Panel 1-15-4 First Impact Response Data

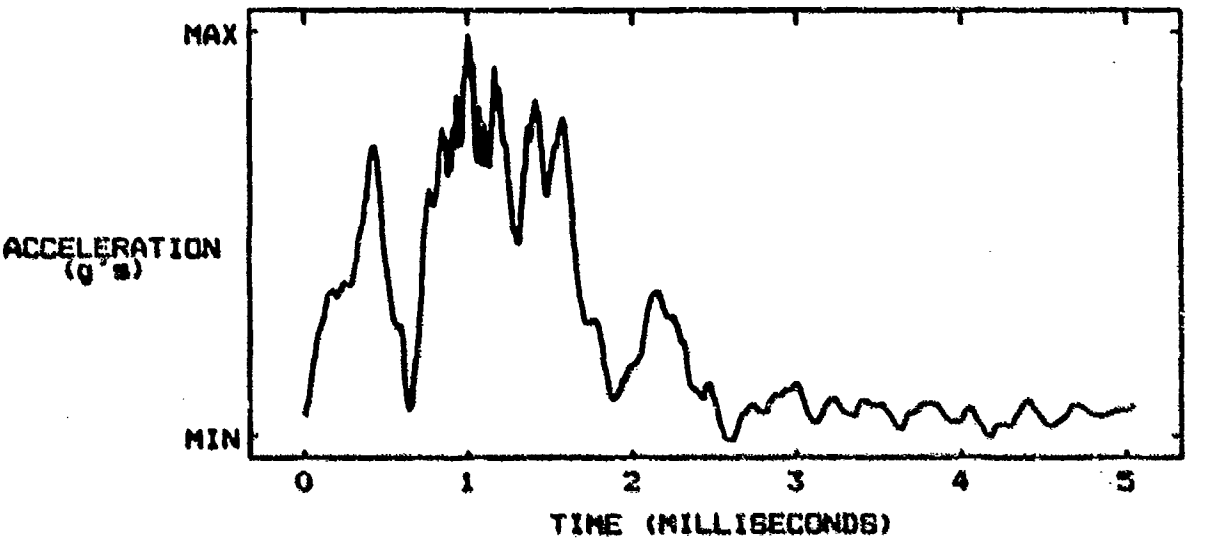
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-15-4.2 THICKNESS .451 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 37.5 IN

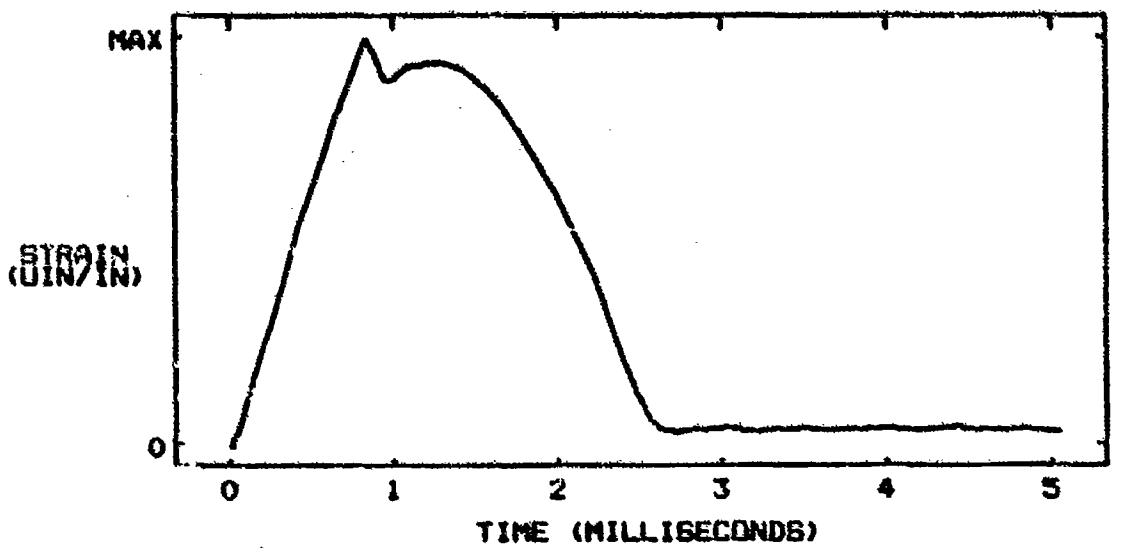
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -37 g's MAXIMUM ACCELERATION 583.9 g's

INTEGRATED TOTAL VELOCITY 232.58 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9520 UIN/IN

Figure B-51. Panel 1-15-4 Second Impact Response Data

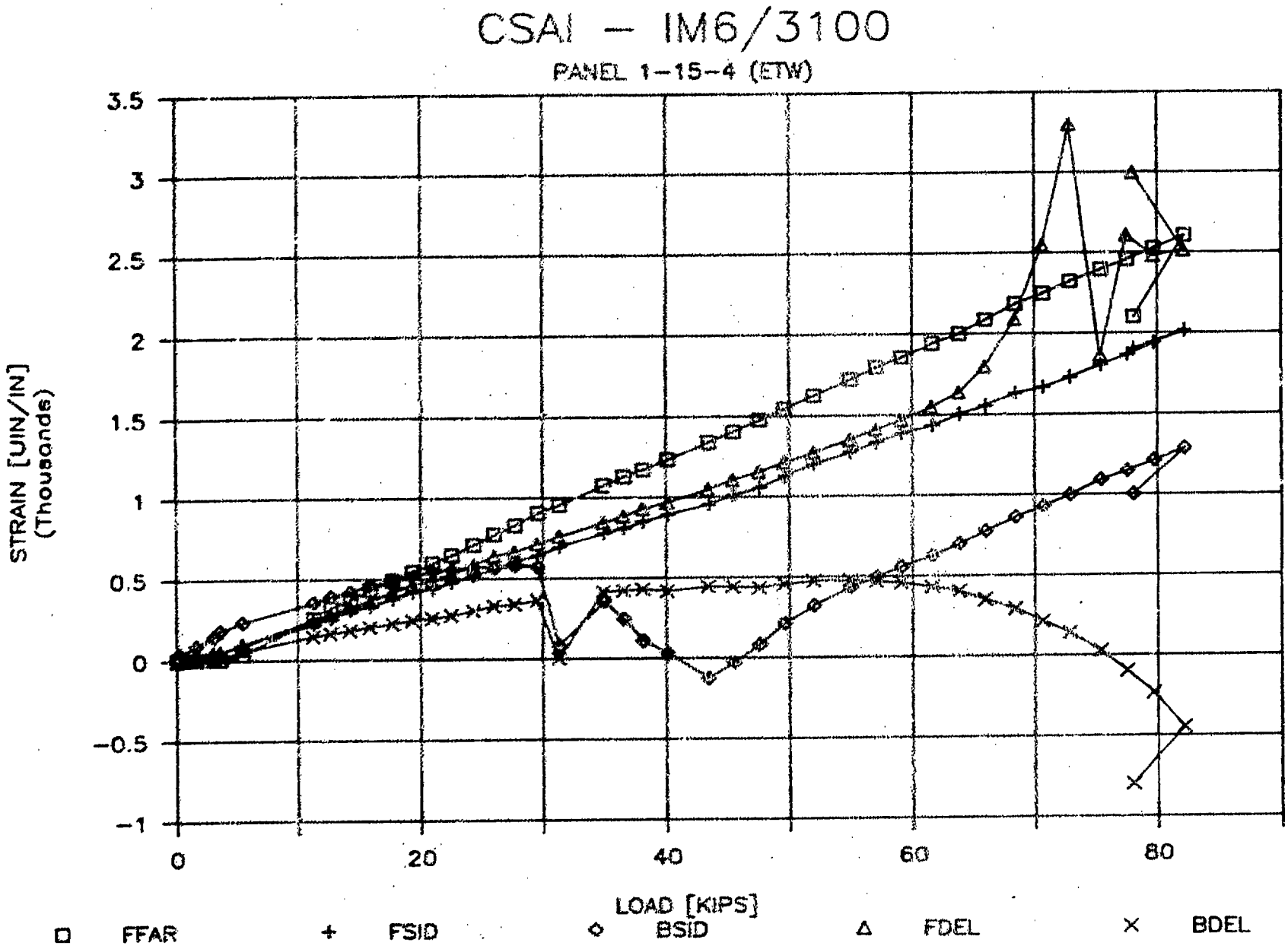


Figure B-52. Panel 1-15-4 Residual Compression Data

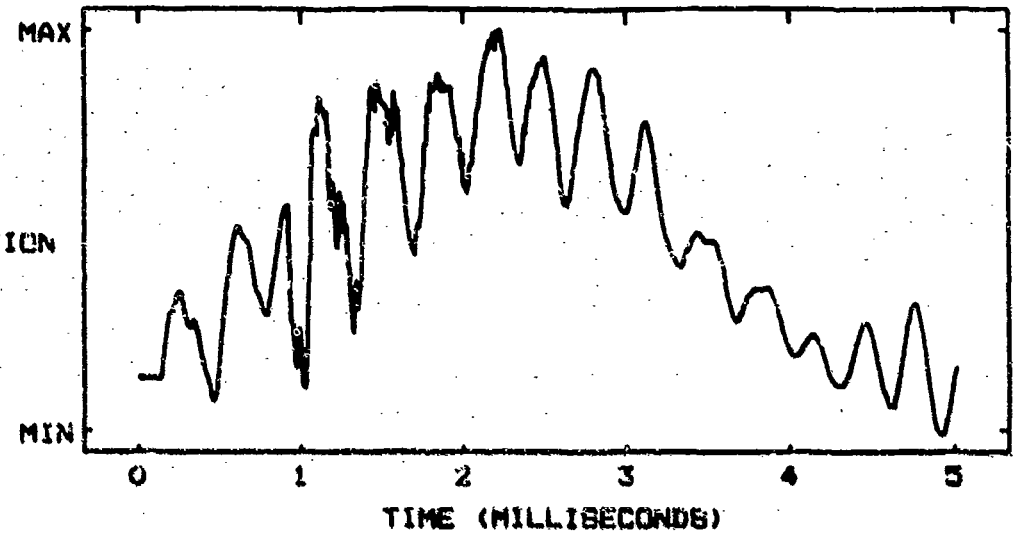
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-12-5 THICKNESS .106 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 20.0 IN

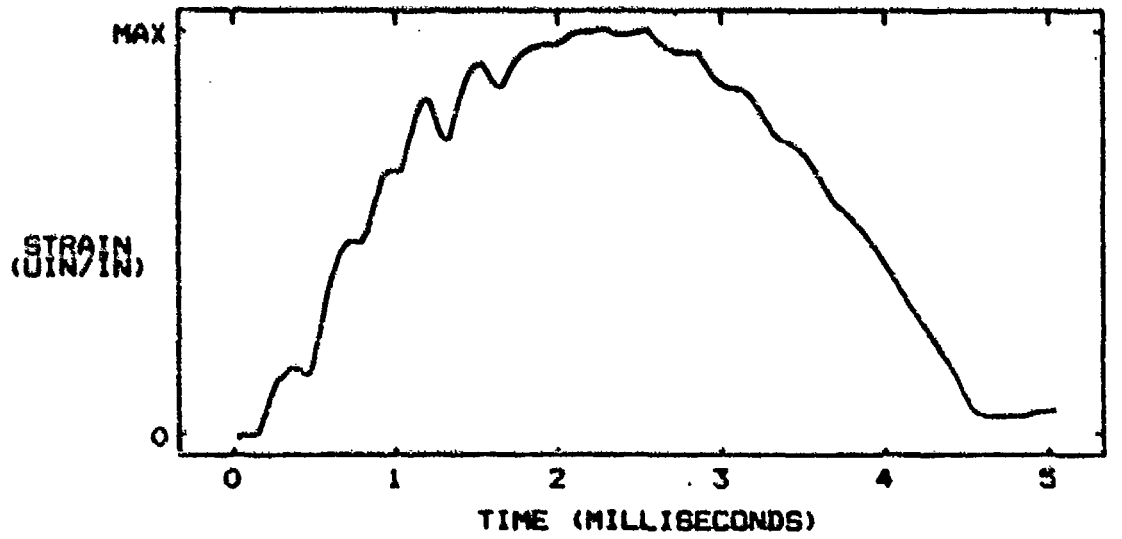
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -.44 g's MAXIMUM ACCELERATION 256.84 g's

INTEGRATED TOTAL VELOCITY 187 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 10833 UIN/IN

Figure B-53. Panel 2-12-5 Impact Response Data

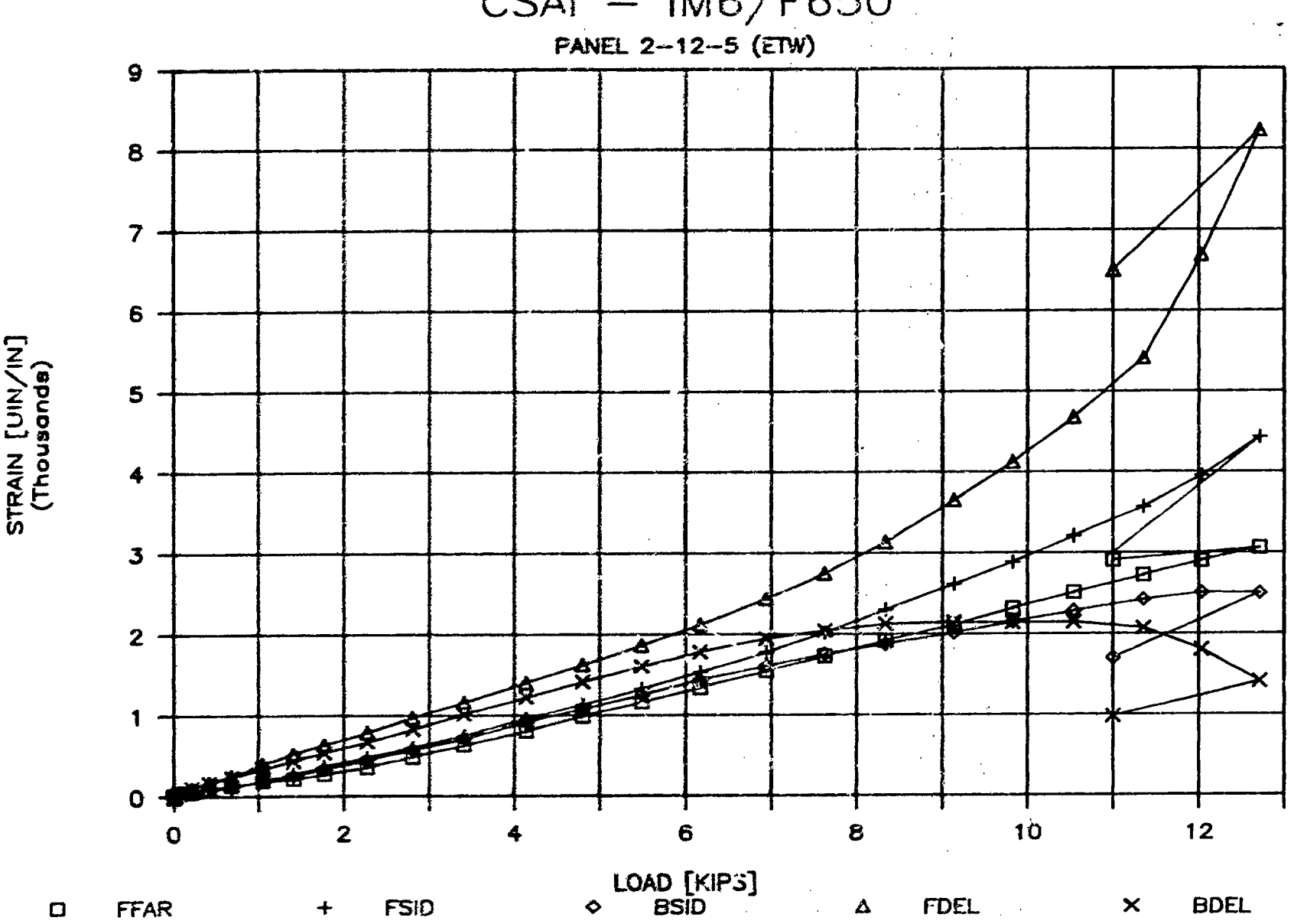


Figure B-54. Panel 2-12-5 Residual Compression Data

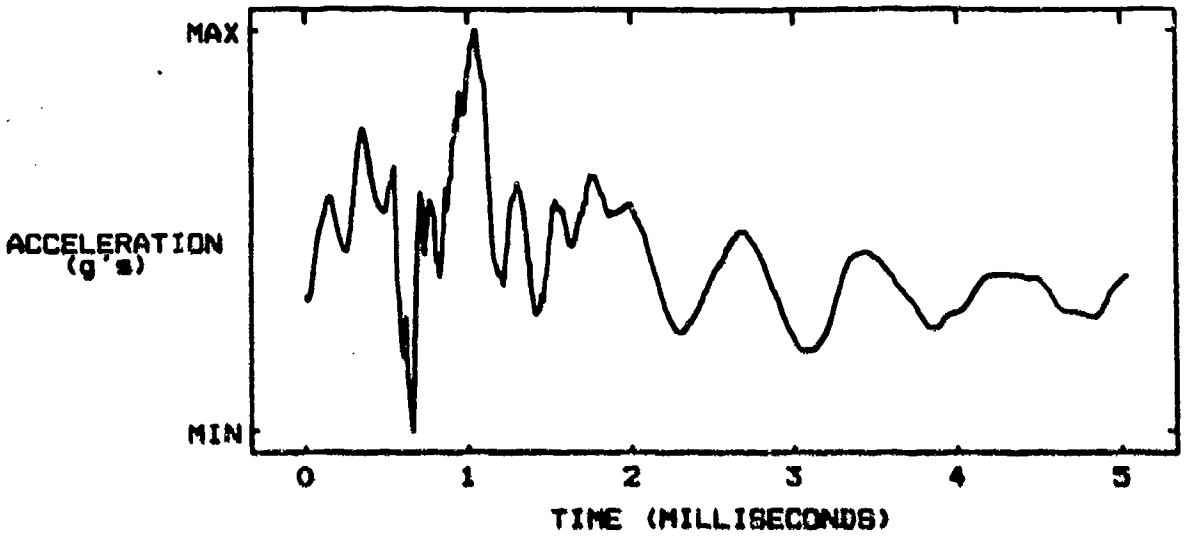
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-11-6 THICKNESS .216 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 23.3 IN

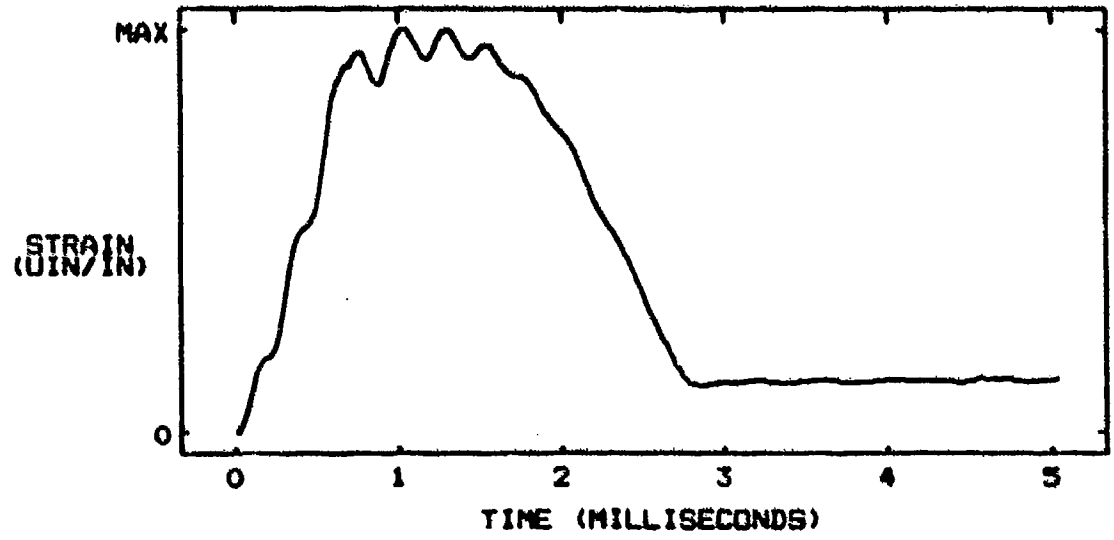
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -321 g's MAXIMUM ACCELERATION 649.41 g's

INTEGRATED TOTAL VELOCITY 169.14 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9651.6 UIN/IN

Figure B-55. Panel 2-11-6 Impact Response Data

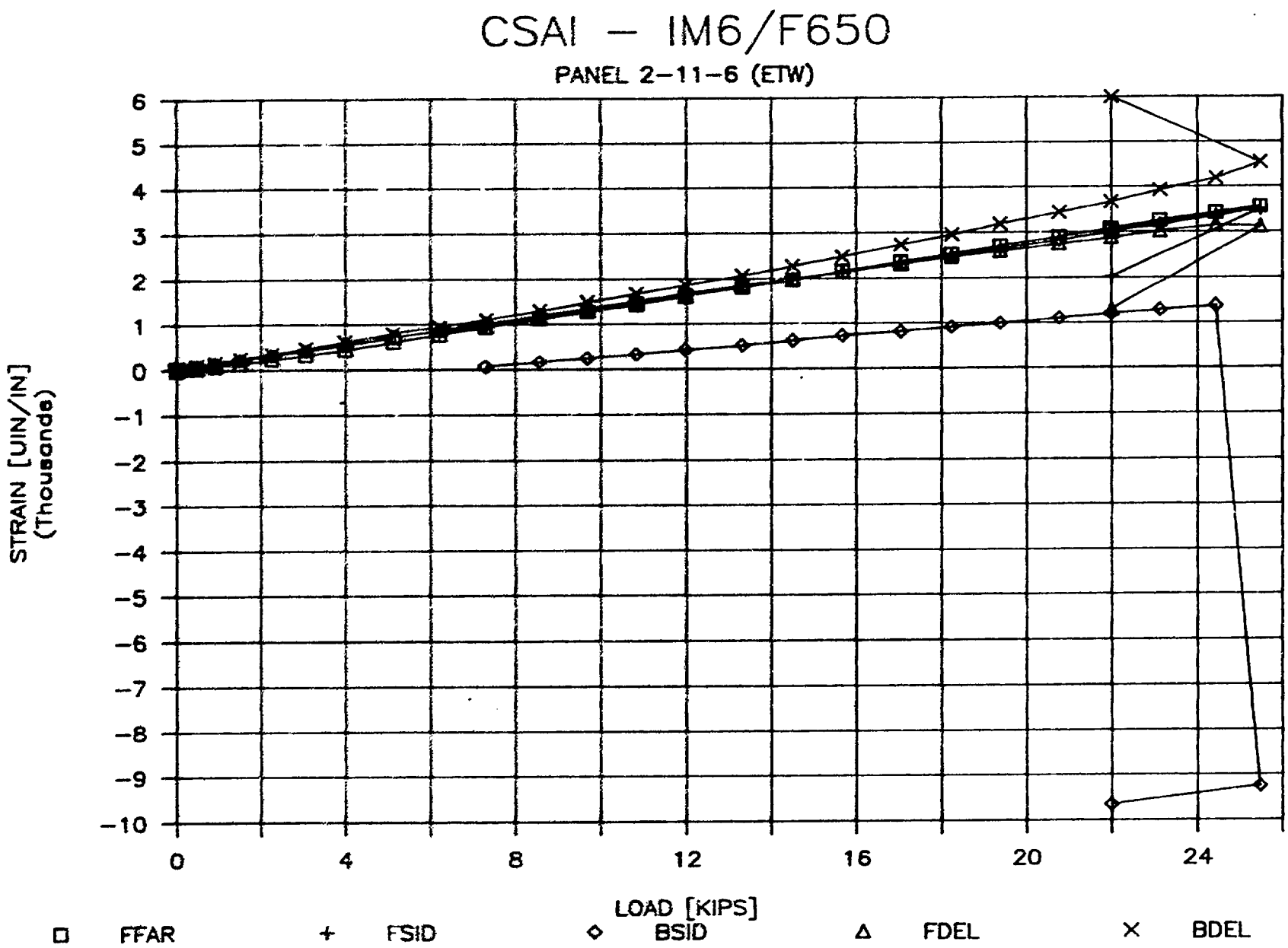


Figure B-56. Panel 2-11-6 Residual Compression Data

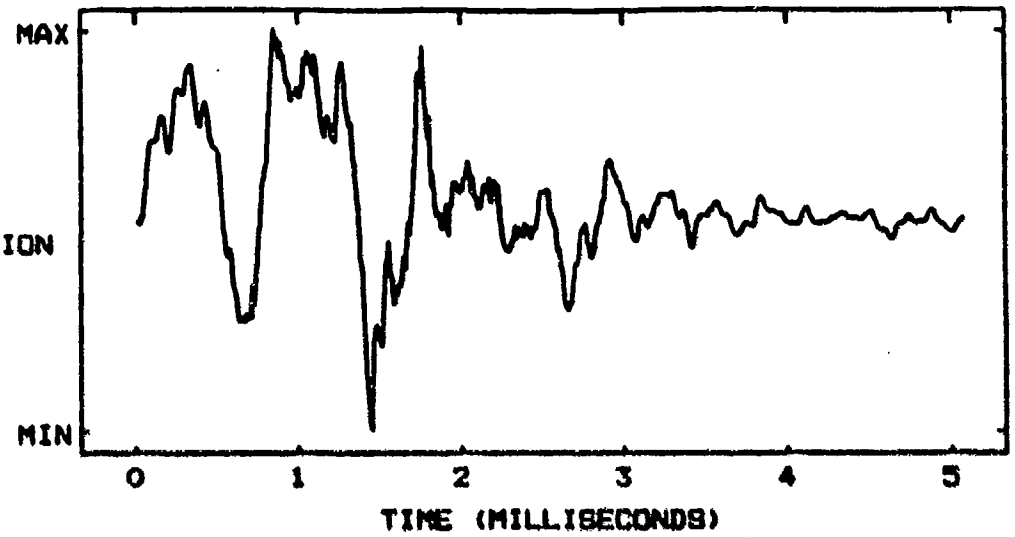
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-13-5 THICKNESS .436 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 24.5 IN

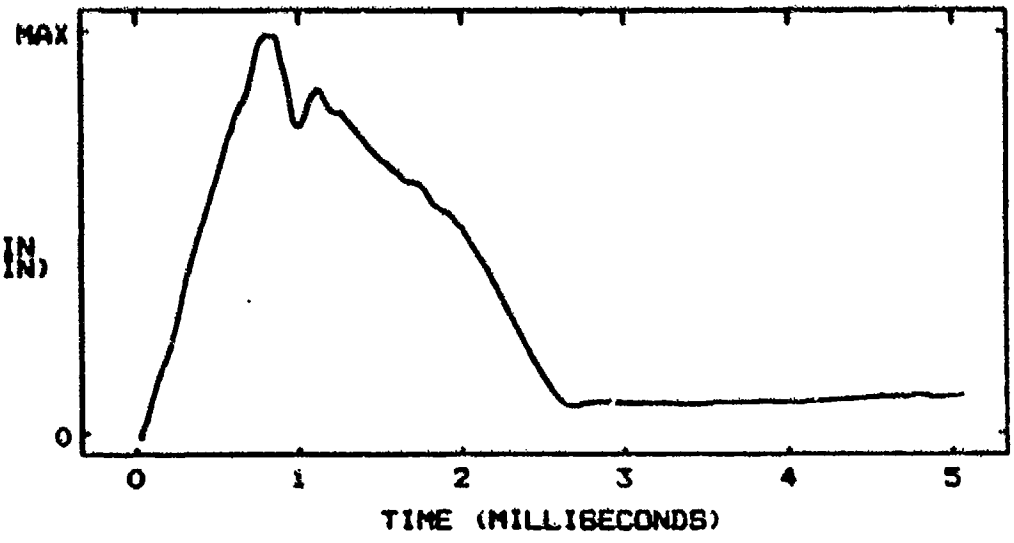
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -857 g's MAXIMUM ACCELERATION 790 g's

INTEGRATED TOTAL VELOCITY 146.83 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 7571 UIN/IN

Figure 8-57. Panel 2-13-5 Impact Response Data

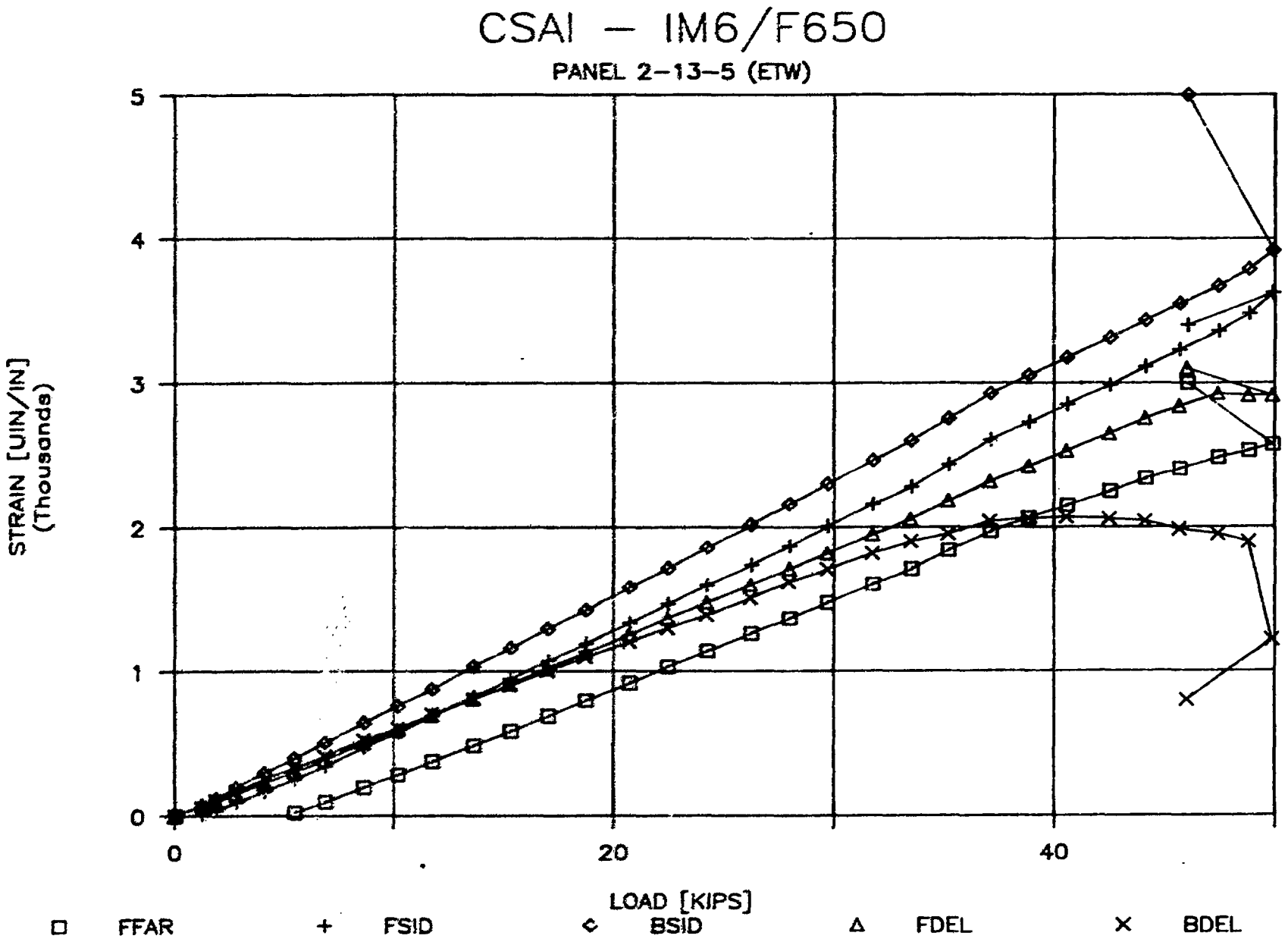


Figure B-58. Panel 2-13-5 Residual Compression Data

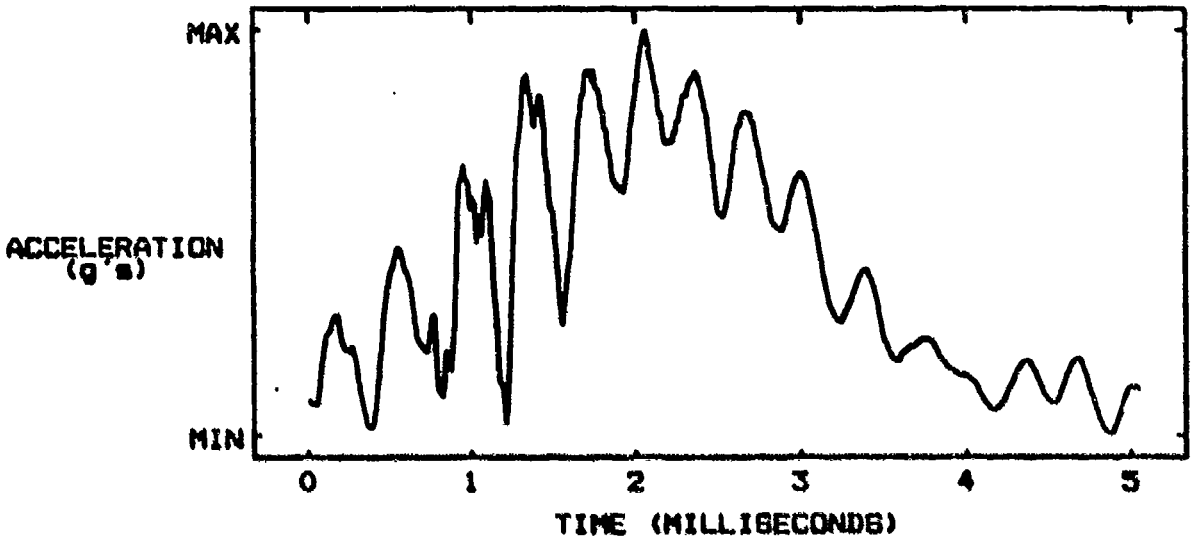
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14-5 THICKNESS .111 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 23.3 IN

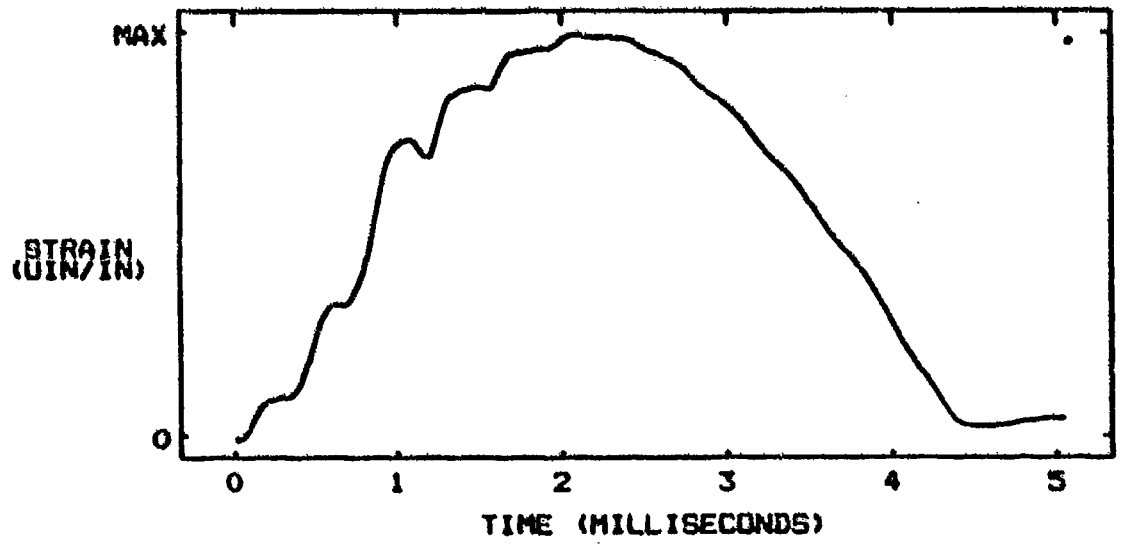
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -27 g's MAXIMUM ACCELERATION 298.7 g's

INTEGRATED TOTAL VELOCITY 198.36 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 13156 UIN/IN

Figure B-59. Panel 2-14-5 Impact Response Data

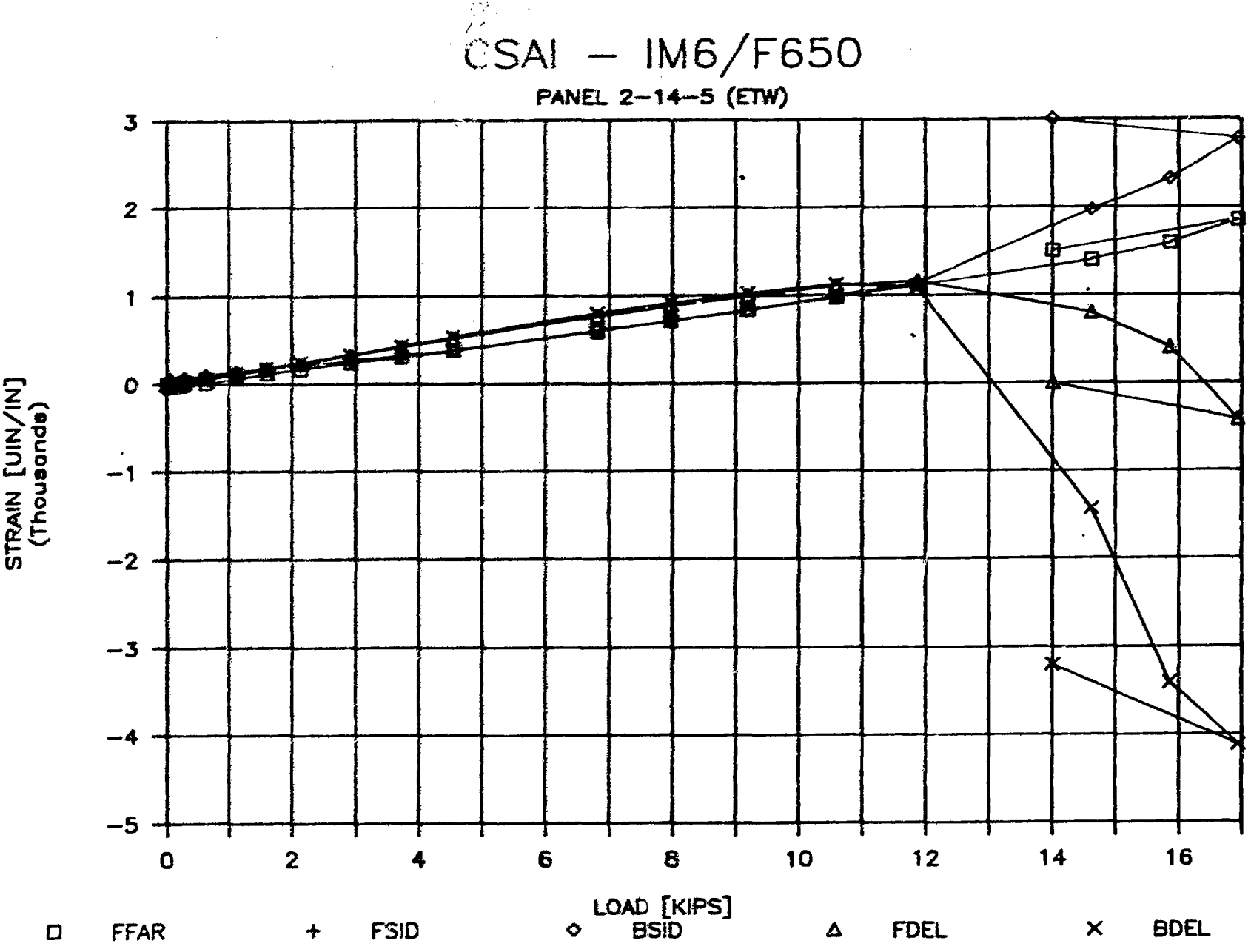


Figure B-60. Panel 2-14-5 Residual Compression Data

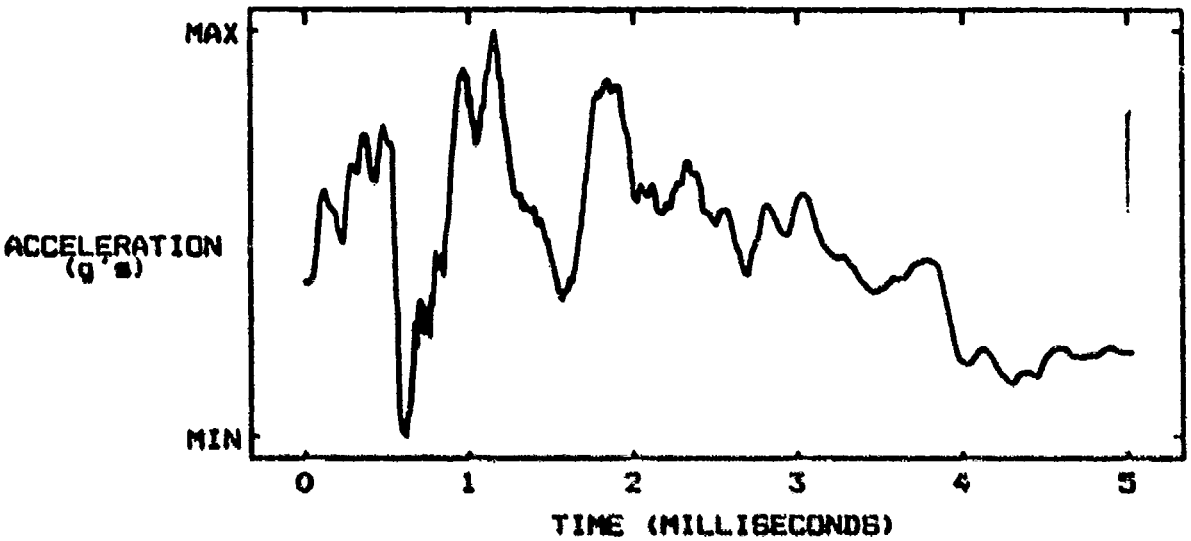
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-20-4 THICKNESS .219 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 16.3 IN

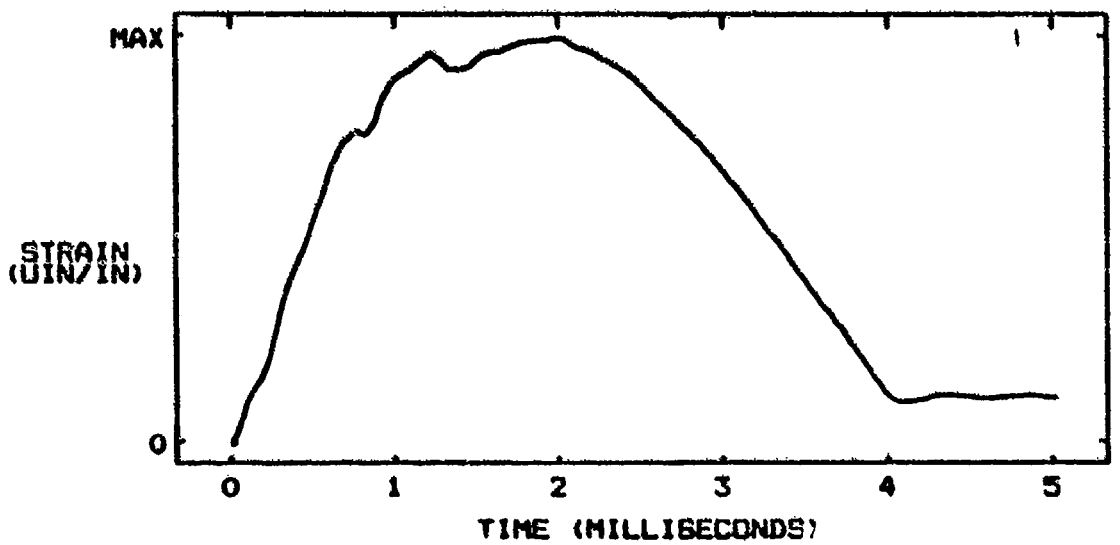
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -228 g's MAXIMUM ACCELERATION 375 g's

INTEGRATED TOTAL VELOCITY 150.2 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 5912 UIN/IN

Figure B-61. Panel 2-20-4 Impact Response Data

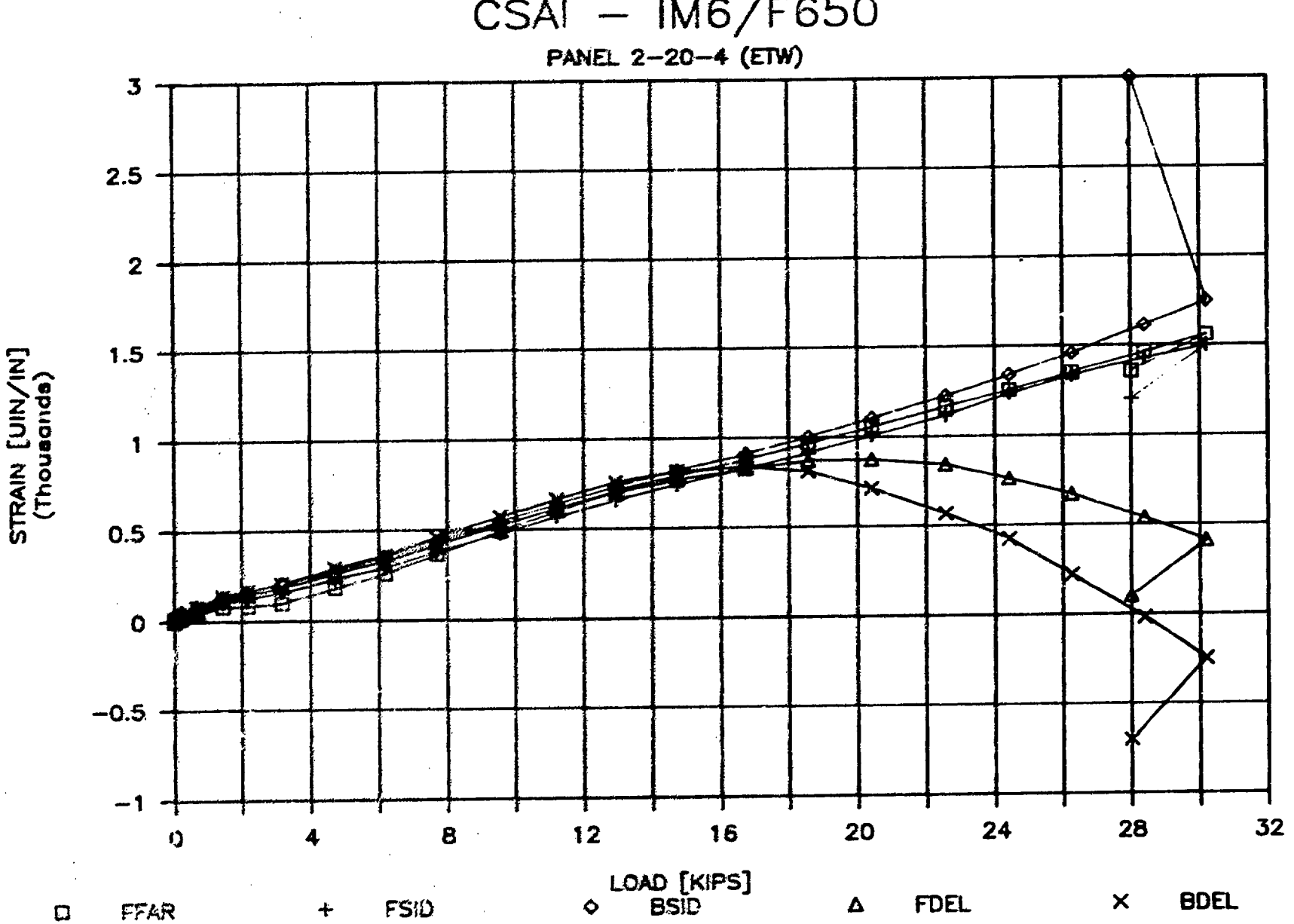


Figure B-62. Panel 2-20-4 Residual Compression Data

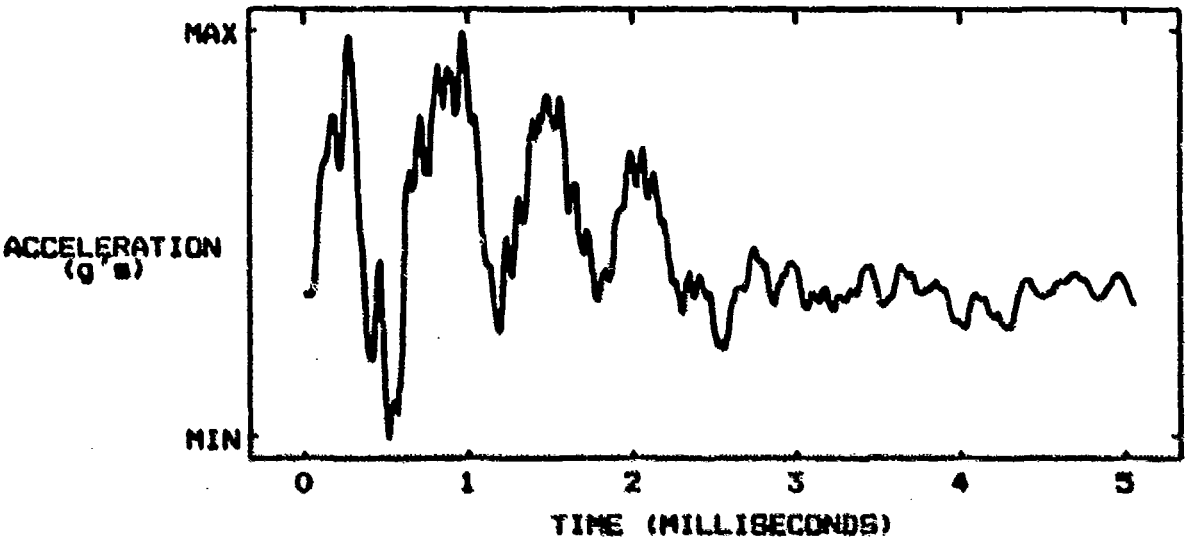
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-15-4 THICKNESS .441 IN

DROP CARRIAGE WT. 7.82 LBS DROP HEIGHT 66.1 IN

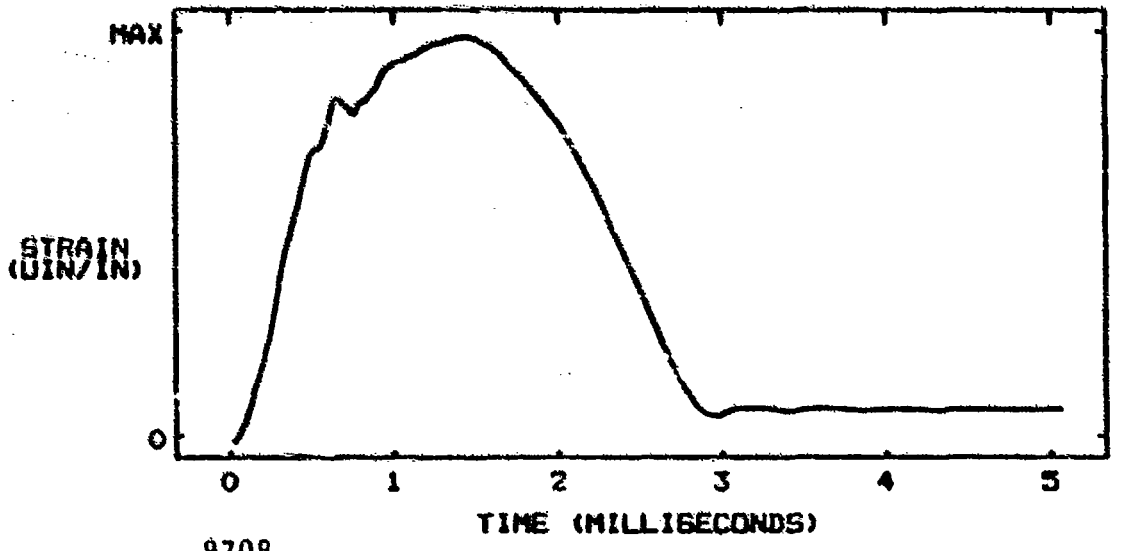
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -502 g's MAXIMUM ACCELERATION 927 g's

INTEGRATED TOTAL VELOCITY 281.65 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9708 UIN/IN

Figure B-63. Panel 2-15-4 Impact Response Data

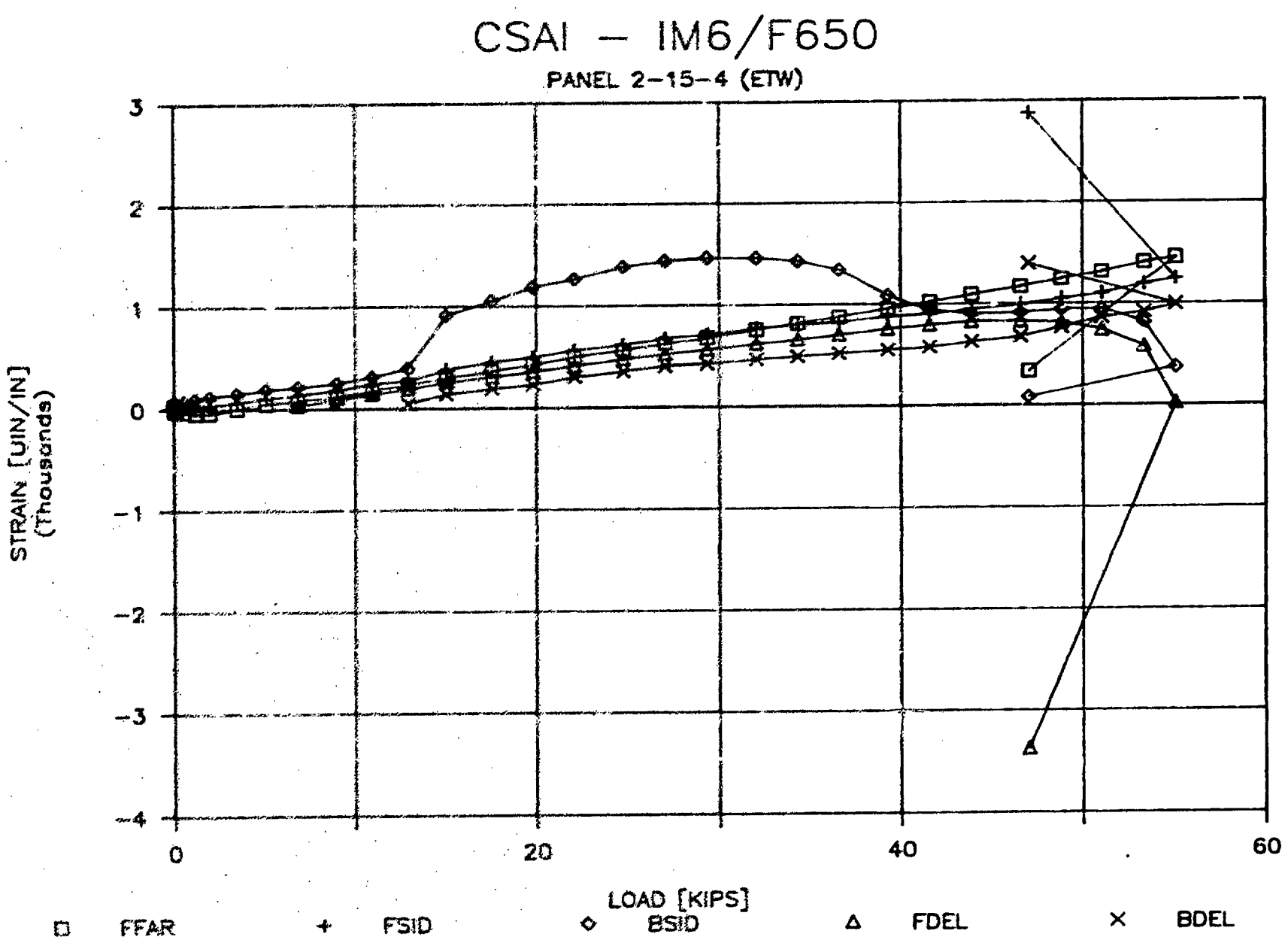


Figure B-64. Panel 2-15-4 Residual Compression Data

B.2 THIN LAMINATE IMPACT DAMAGE

Material	Specimen Number	Layup	Thickness (in.)	Impactor Weight (lb)	Nominal Impact Energy (ft-lb)	Potential Impact Energy (ft-lb)	Kinetic Impact Energy (ft-lb)	G_{max}	ϵ_{max} (μin./in.)	Dent Depth (in.)	Delamination Width (in.)	Residual Strength (ksi)	Residual Strain (μin./in.)
RTD													
	1-16-2		0.024	3.83	5	5.33	5.26	111	1,420	0.001	0.2	11.5	1,800
IM6/3100	1-12A-1	0/100/0	0.045	3.83	5	5.33	—	149	780	0.004	0.4	17.0	4,500
	1-17-2		0.068	3.83	5	5.33	5.13	201	1,134	0.004	0.7	20.8	9,300
	1-18-1		0.025	3.83	5	5.33	5.17	109	1,725	0.025	0.6	15.5	2,150
IM6/3100	1-14A-1	50/0/50	0.046	3.83	5	5.33	5.17	160	1,400	0.004	0.5	23.4	2,500
	1-19-2		0.065	3.83	5	5.33	5.15	177	1,250	0.004	0.8	28.6	2,000
	2-16-1		0.022	3.83	5	5.33	5.22	128	280	0.011	1.0	9.1	—
IM6/F650	2-12A-1	0/100/0	0.044	3.83	5	5.33	5.20	137	1,090	0.005	0.6	13.7	6,000
	2-17-2		0.064	3.83	5	5.33	—	177	500	0.005	0.9	16.5	5,800
	2-18-2		0.023	3.83	5	5.33	5.20	75	1,330	<0.001	0.5	11.0	1,700
IM6/F650	2-14A-1	50/0/50	0.043	3.83	5	5.33	5.15	157	1,120	0.005	0.9	20.3	1,300
	2-19-2		0.064	3.83	5	5.33	5.17	166	1,020	0.005	1.1	19.2	1,450
ETW													
	1-16-4		0.024	3.83	5	5.33	5.24	114	630	<0.001	—	8.9	1,300
IM6/3100	1-12A-5	0/100/0	0.045	3.83	5	5.33	5.26	151	820	0.004	—	12.5	12,500
	1-17-5		0.069	3.83	5	5.33	5.17	198	1,160	0.004	—	12.1	18,000
	1-18-6		0.025	3.83	5	5.33	5.20	108	1,440	0.002	—	19.6	1,250
IM6/3100	1-14A-4	50/0/50	0.046	3.83	5	5.33	5.17	160	1,520	0.004	—	27.2	2,100
	1-19-5		0.065	3.83	5	5.33	5.22	147	1,040	0.004	—	18.7	2,400
	2-16-5		0.022	3.83	5	5.33	—	98	314	0.001	—	6.1	700
IM6/F650	2-12A-4	0/100/0	0.043	3.83	5	5.33	5.26	140	792	0.004	—	9.3	10,500
	2-17-6		0.064	3.83	5	5.33	5.17	169	1,070	0.005	—	9.7	8,600
	2-18-5		0.022	3.83	5	5.33	5.20	88	1,440	0.015	—	11.7	650
IM6/F650	2-14A-5	50/0/50	0.044	3.83	5	5.33	5.15	149	1,160	0.004	—	20.0	2,100
	2-19-6		0.062	3.83	5	5.33	5.17	146	1,110	0.004	—	16.6	1,300

GP83-0088-3-T

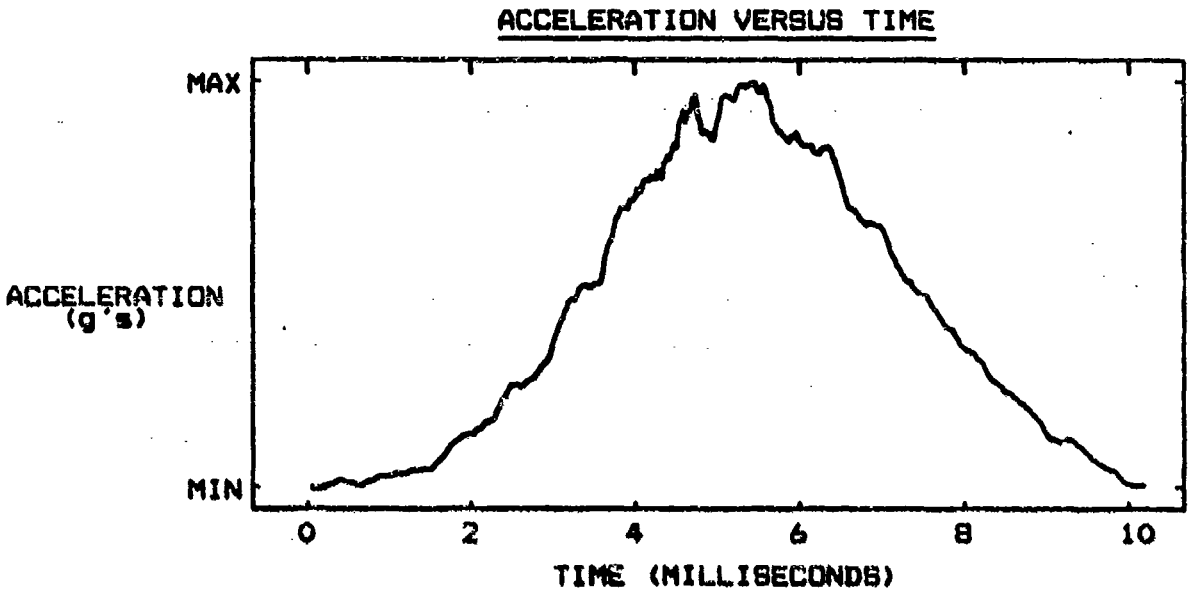
Figure B-65. Thin Laminate Impact Damage Data Table

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

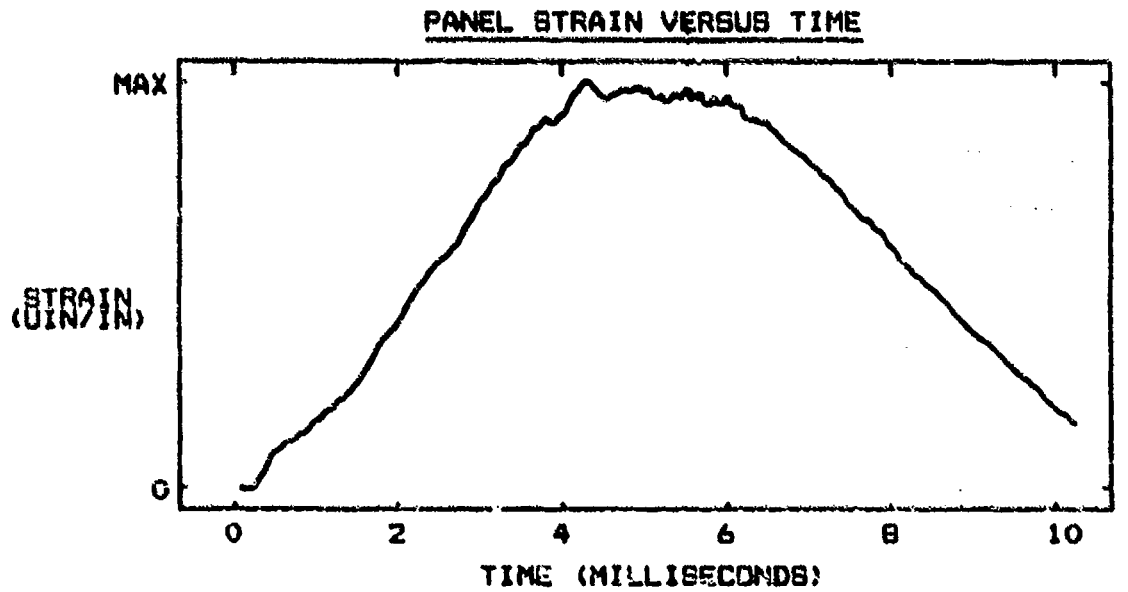
SPECIMEN I.D. 1-16-2.1 THICKNESS .024 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN



MINIMUM ACCELERATION 0.0 g's MAXIMUM ACCELERATION 111 g's

INTEGRATED TOTAL VELOCITY 175.96 IN/SEC



MAXIMUM STRAIN 1415 UIN/IN

Figure B-68. Panel 1-16-2 First Impact Response Data

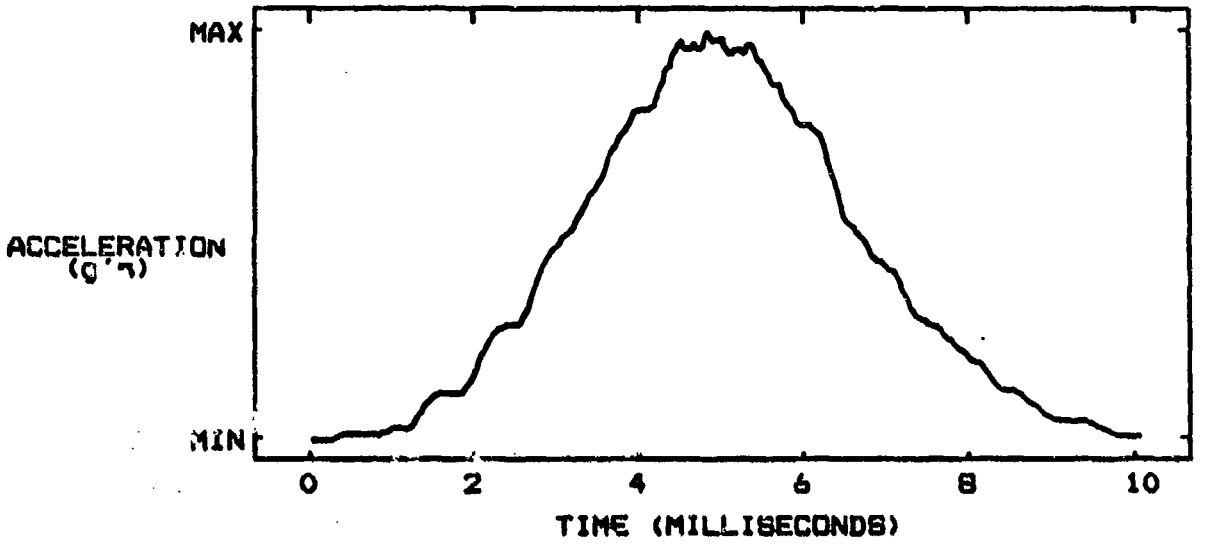
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-16-2.2 THICKNESS .024 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

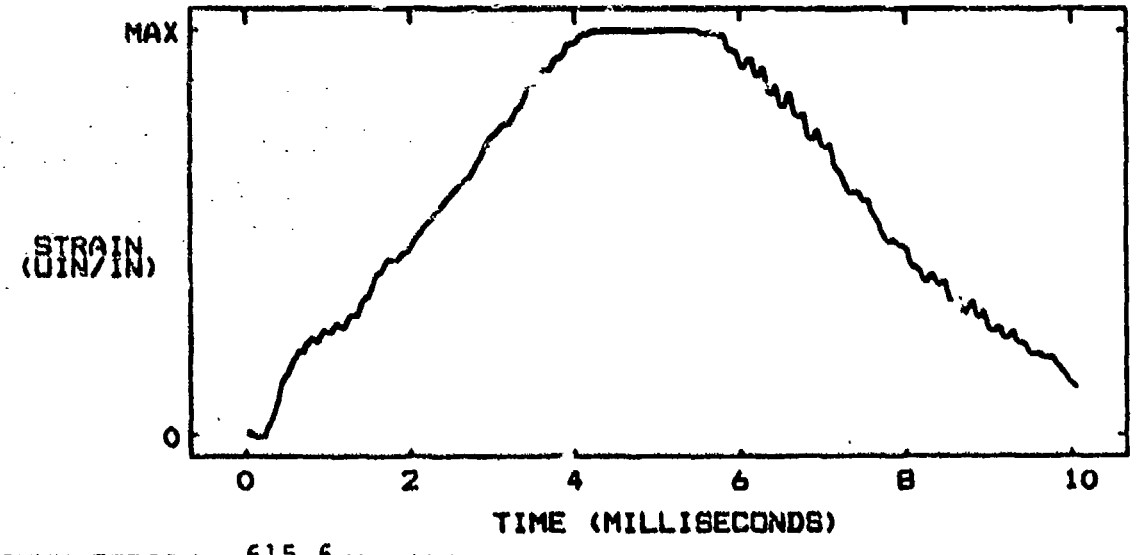
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION 0.0 g's MAXIMUM ACCELERATION 119 g's

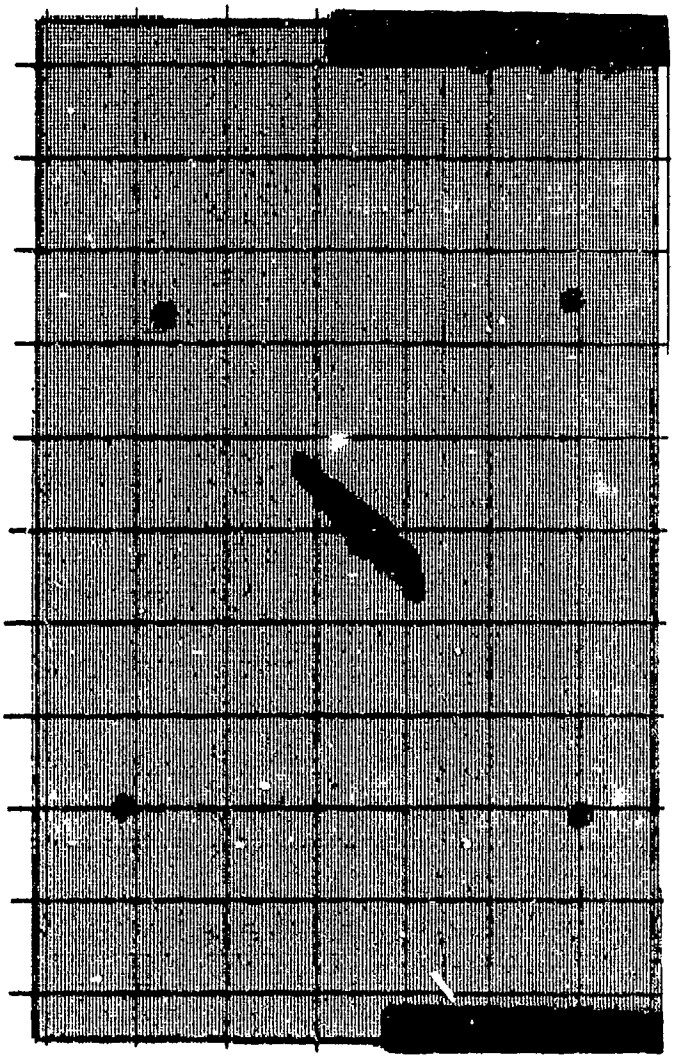
INTEGRATED TOTAL VELOCITY 177.92 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 615.6 UIN/IN

Figure B-67. Panel 1-16-2 Second Impact Response Data



Specimen 1-16-2

Figure B-68. Panel 1-16-2 C-Scan

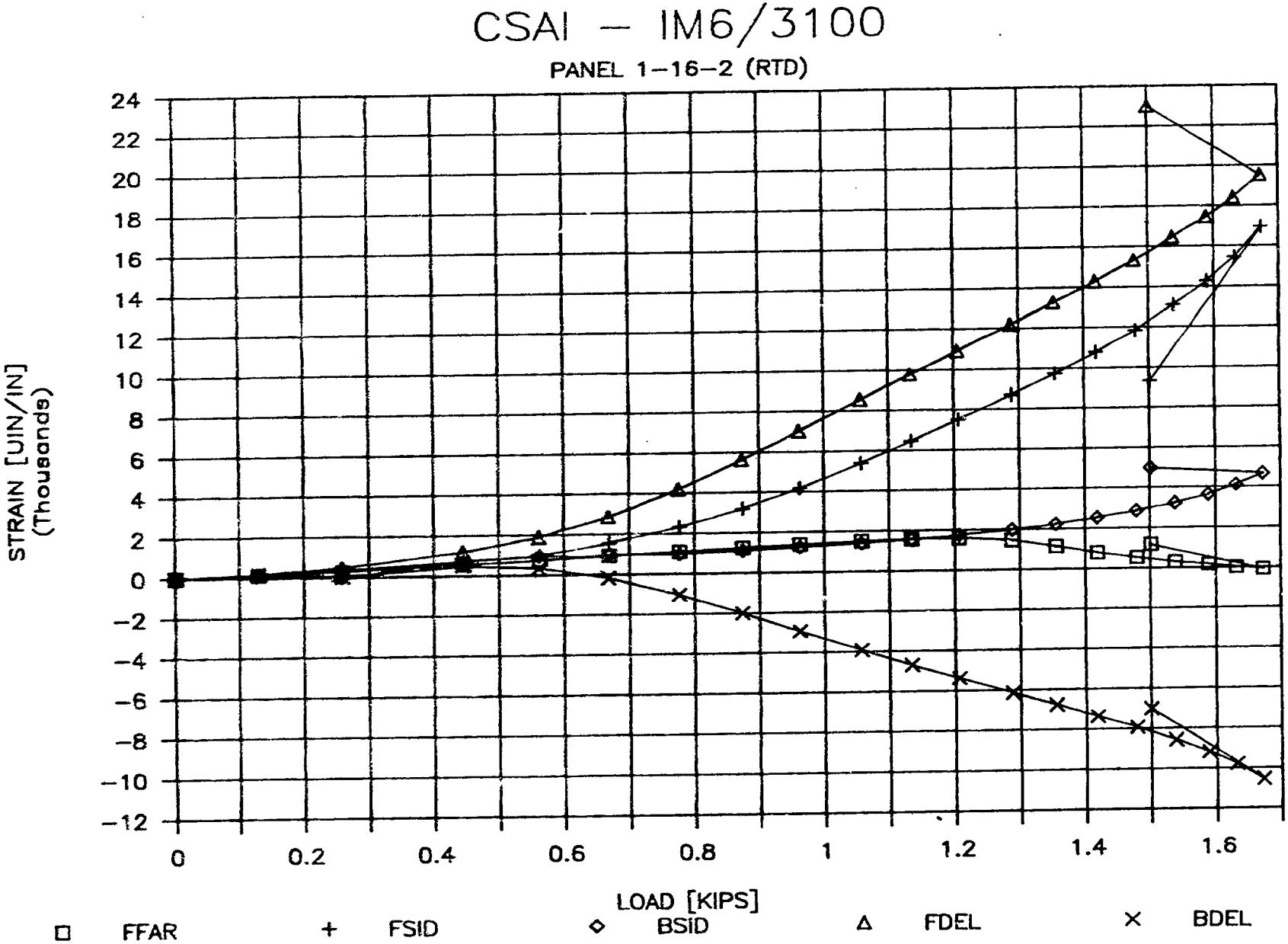


Figure B-69. Panel 1-16-2 Residual Compression Data

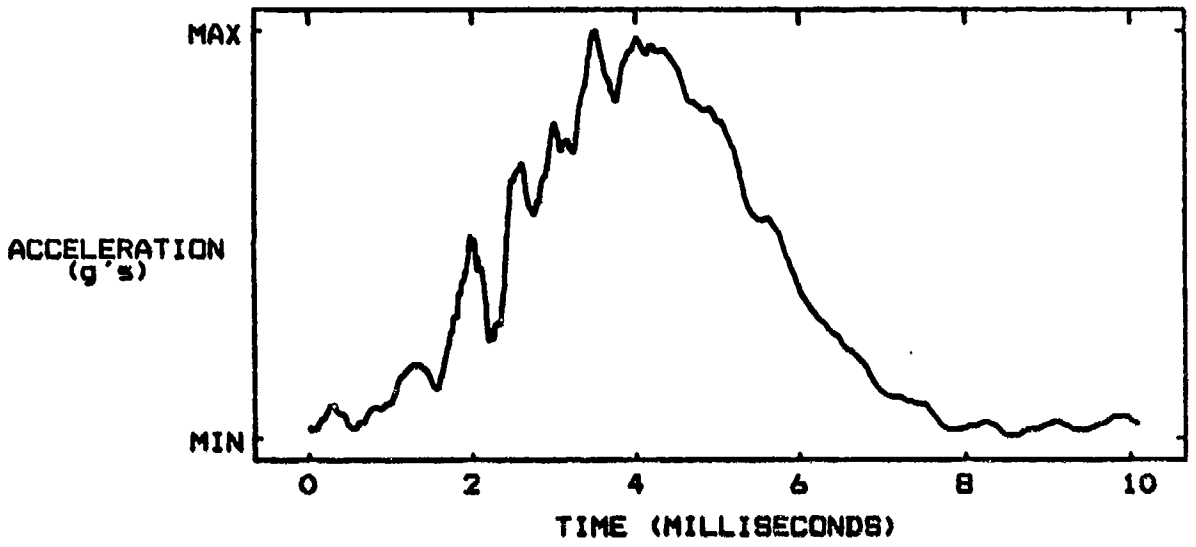
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-12A-1.1 THICKNESS .045 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

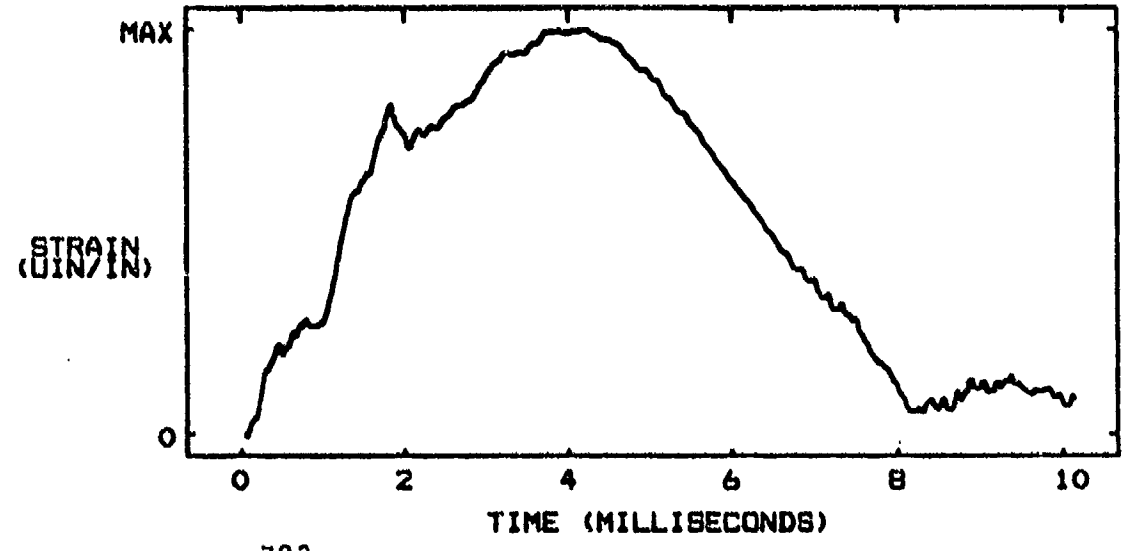
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -3.0 g's MAXIMUM ACCELERATION 149 g's

INTEGRATED TOTAL VELOCITY 186.68 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 782 UIN/IN

Figure B-70. Panel 1-12A-1 First Impact Response Data

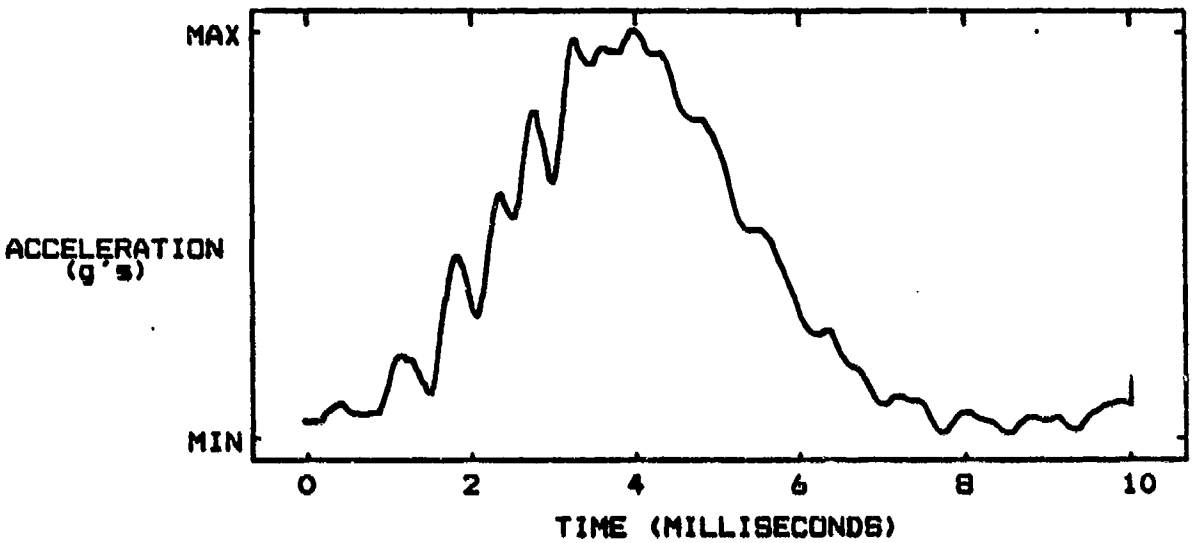
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-12A-1.2 THICKNESS .044 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

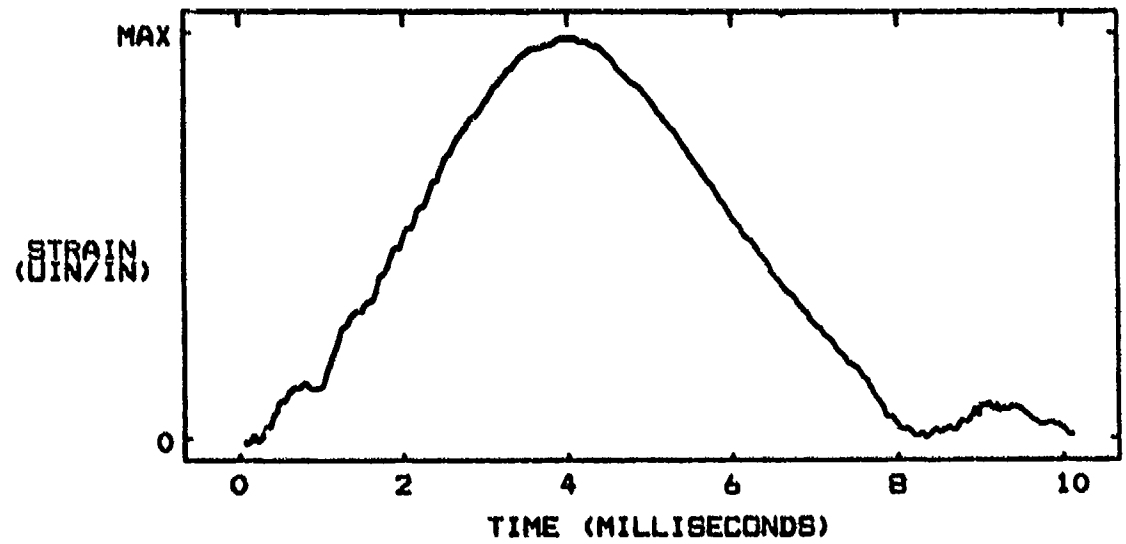
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -6.0 g's MAXIMUM ACCELERATION 153 g's

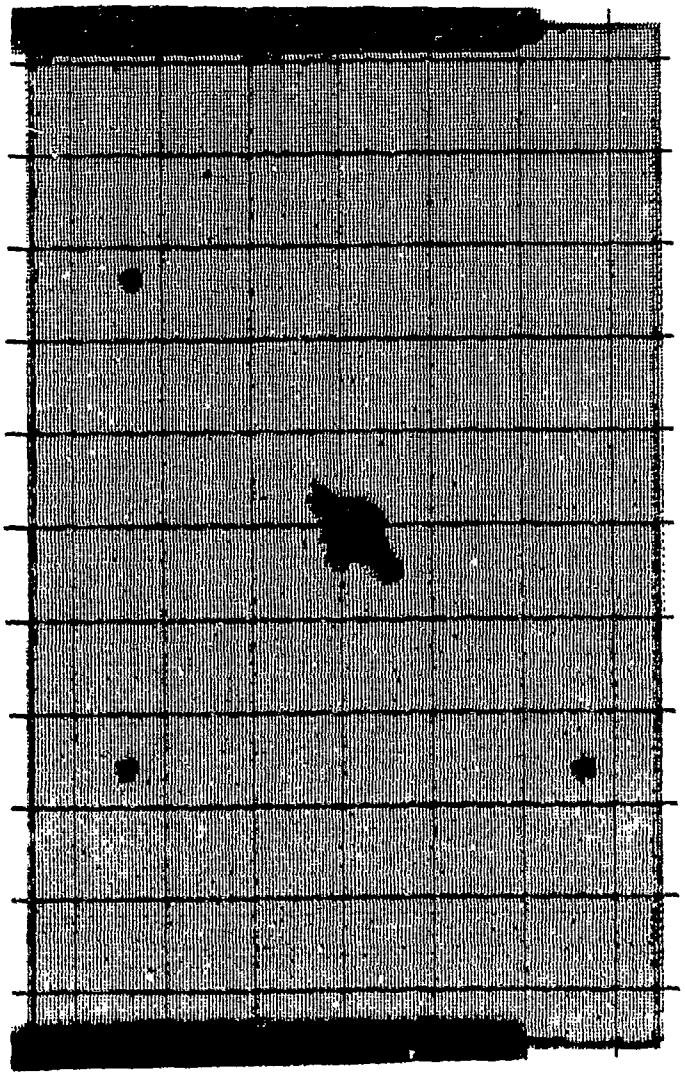
INTEGRATED TOTAL VELOCITY 187.28 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1121 UIN/IN

Figure B-71. Panel 1-12A-1 Second Impact Response Data



Specimen 1-12A-1

Figure 8-72. Panel 1-12A-1 C-Scan

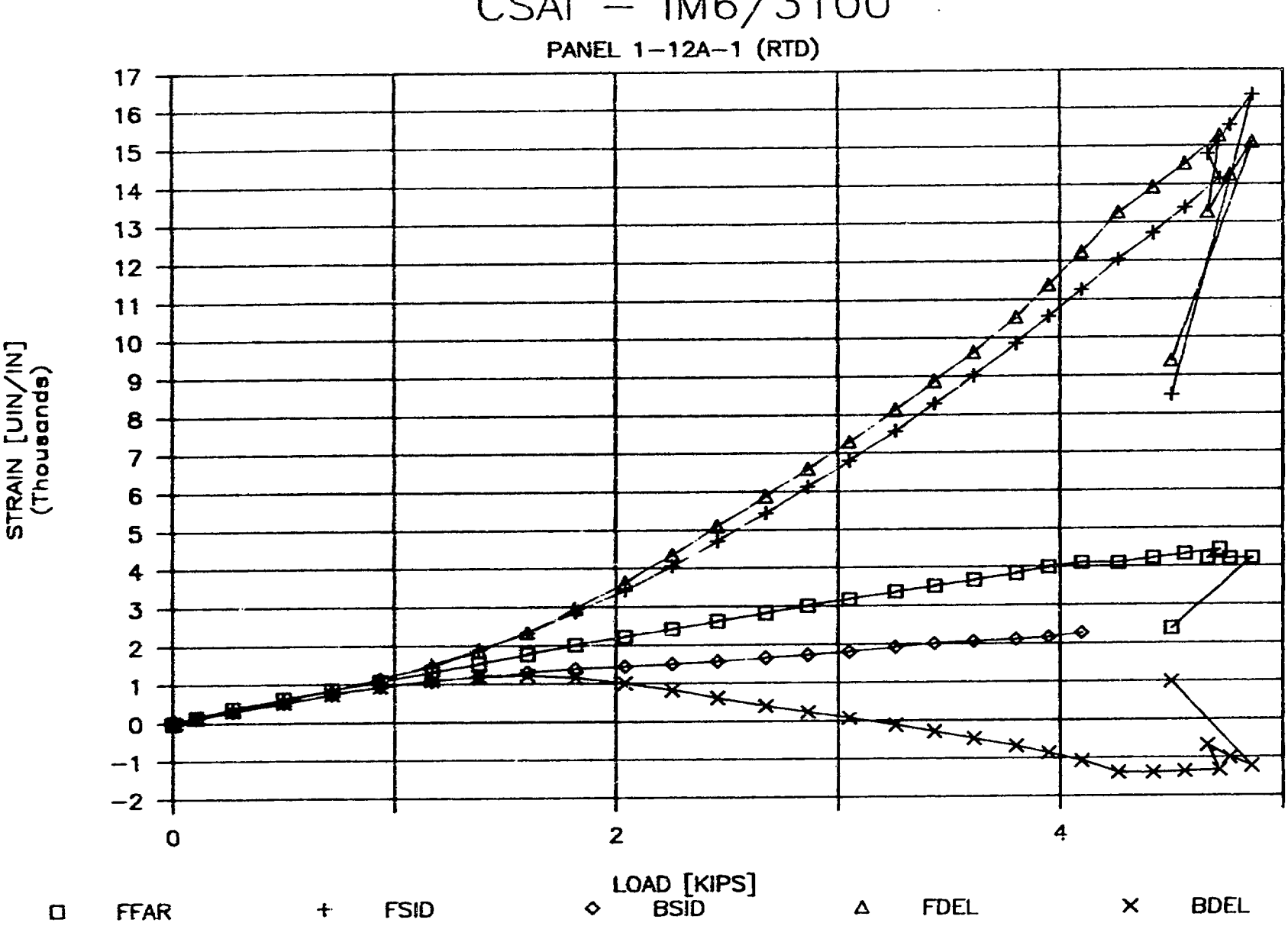


Figure B-73. Panel 1-12A-1 Residual Compression Data

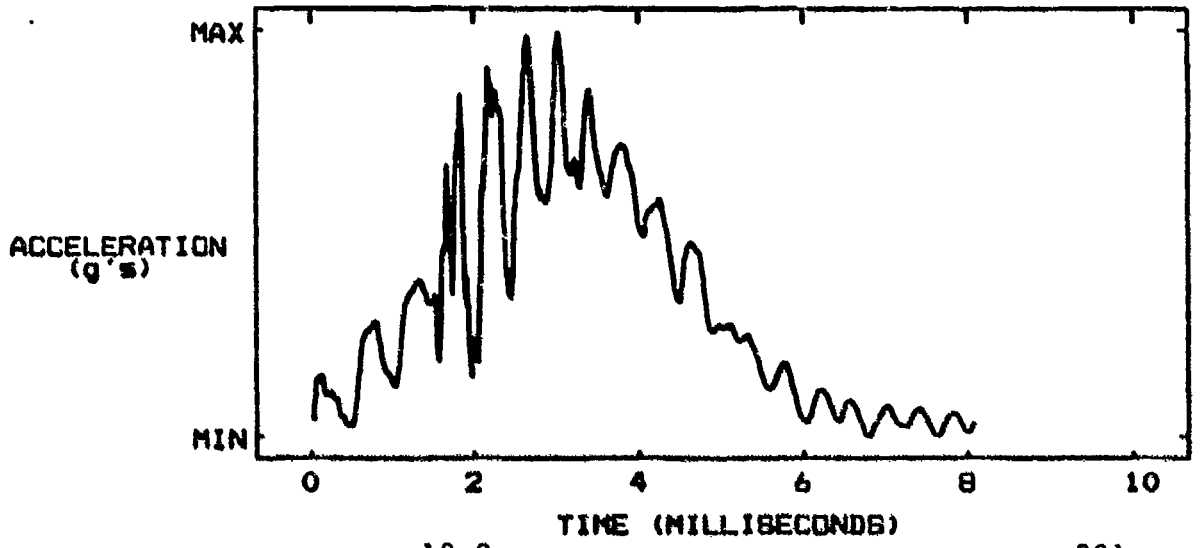
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-17-2 THICKNESS .068 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

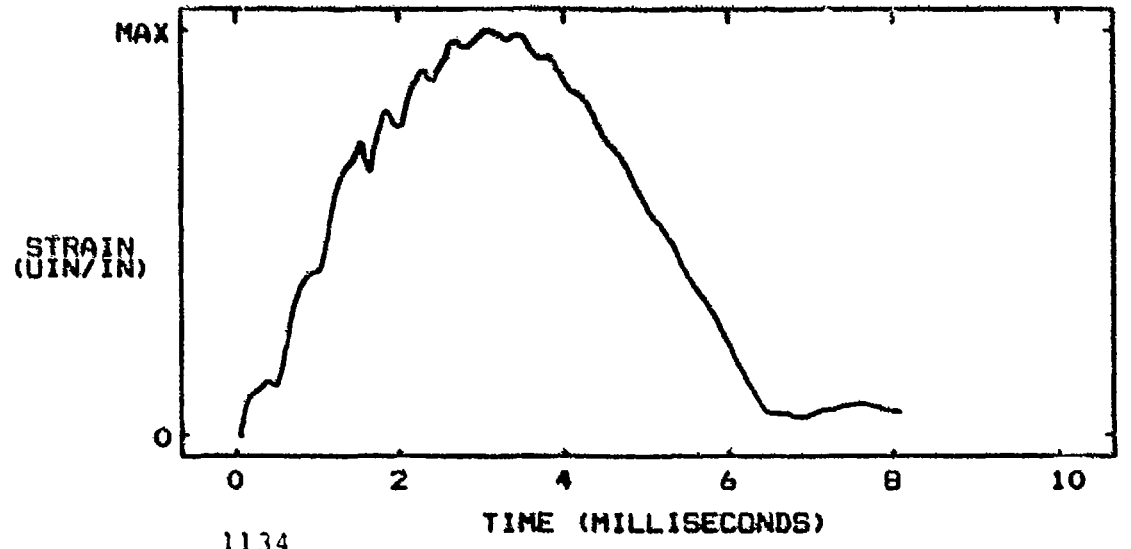
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -10.0 g's MAXIMUM ACCELERATION 201 g's

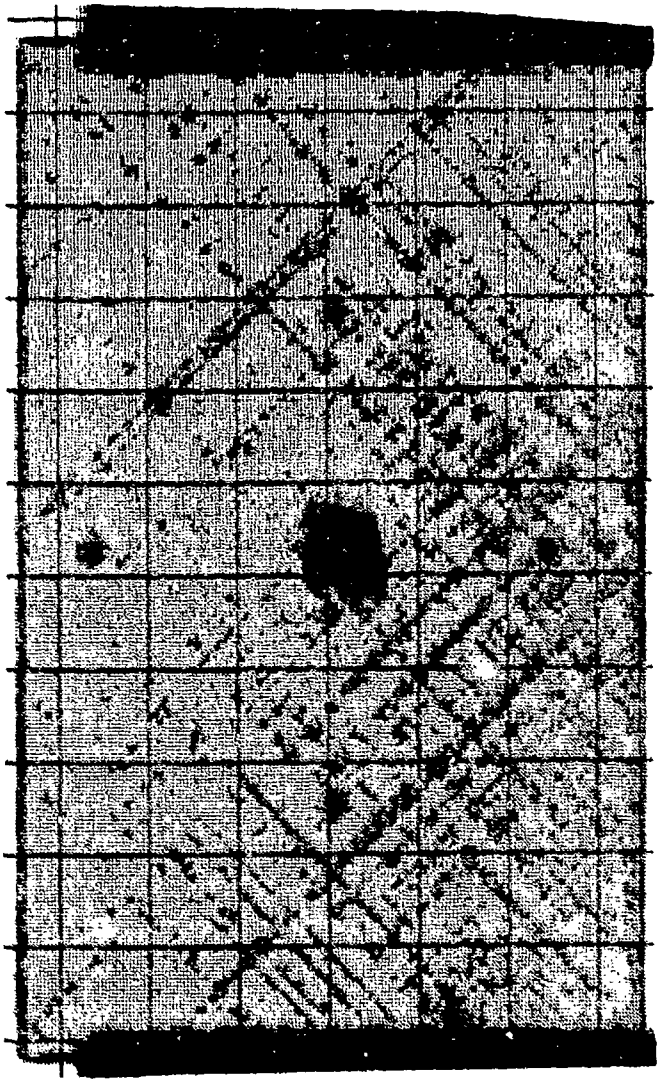
INTEGRATED TOTAL VELOCITY 179.38 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1134 UIN/IN

Figure 5-74. Panel 1-17-2 Impact Response Data



Specimen 1-17-2

Figure B-75. Panel 1-17-2 C-Scan

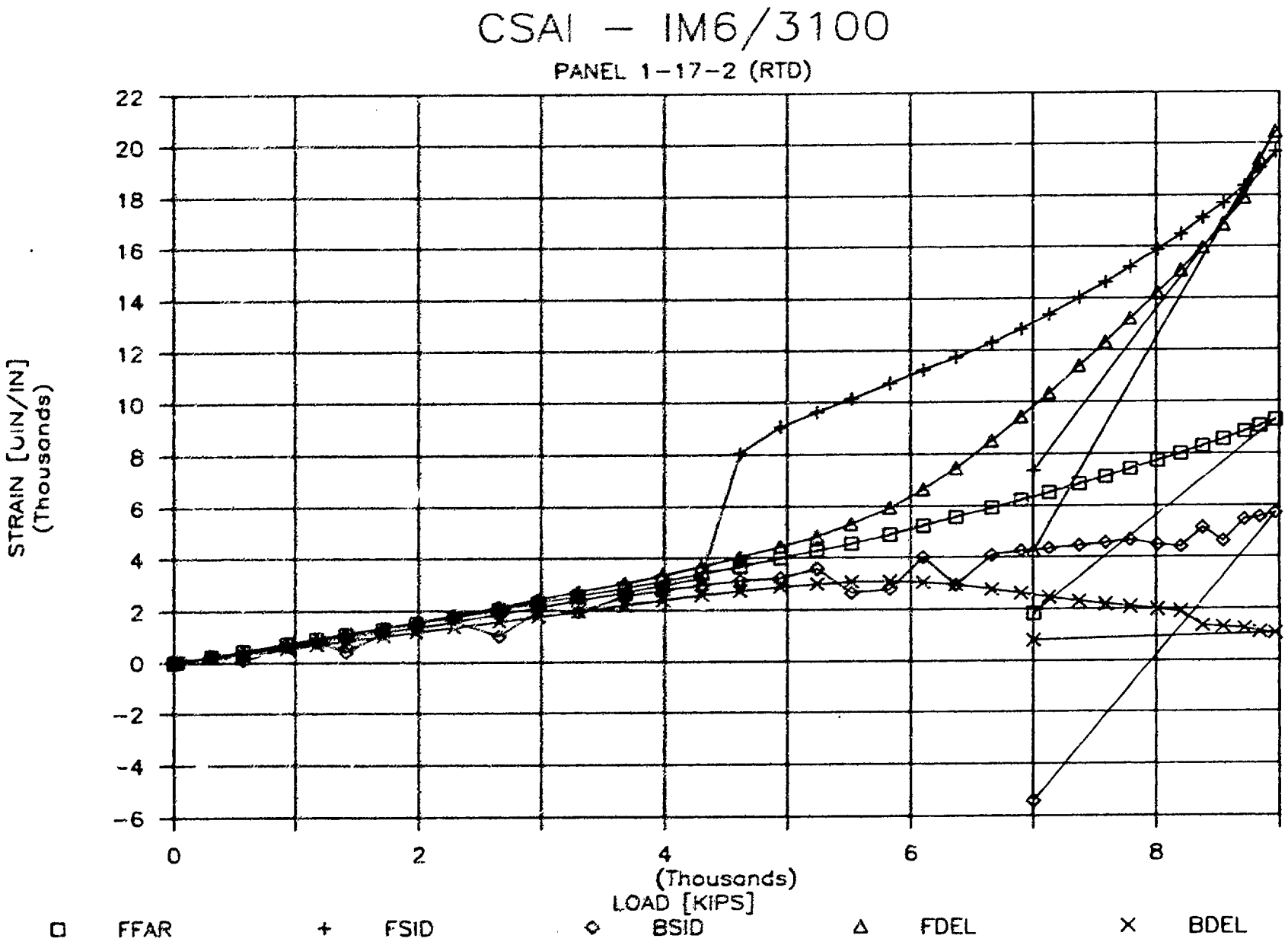


Figure B-76. Panel 1-17-2 Residual Compression Data

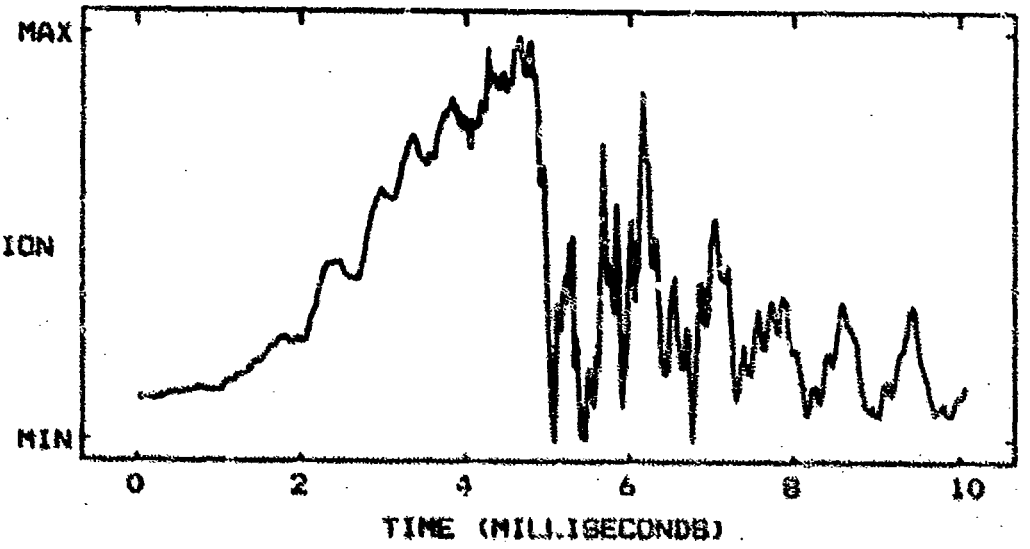
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-18-1 THICKNESS .025 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

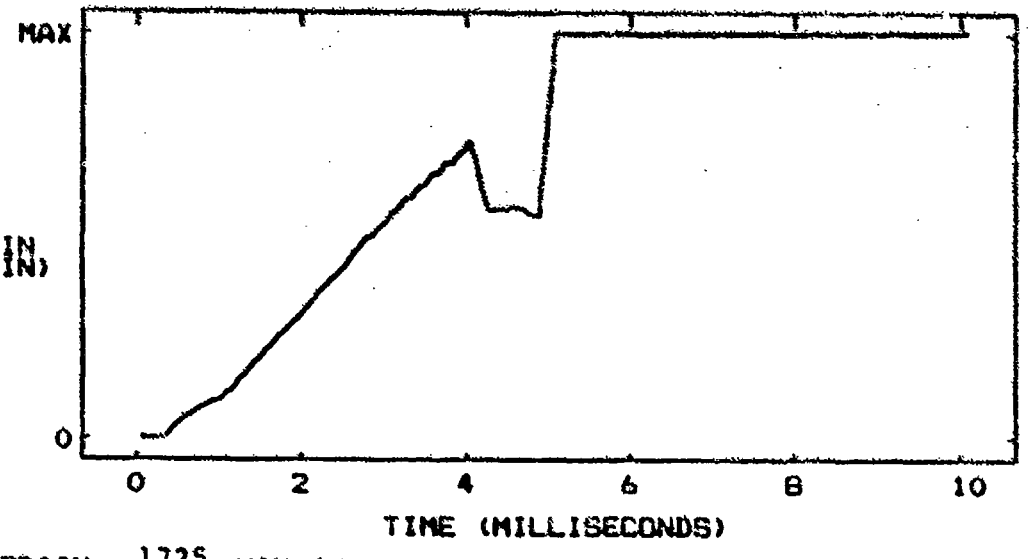
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -13.0 g's MAXIMUM ACCELERATION 109 g's

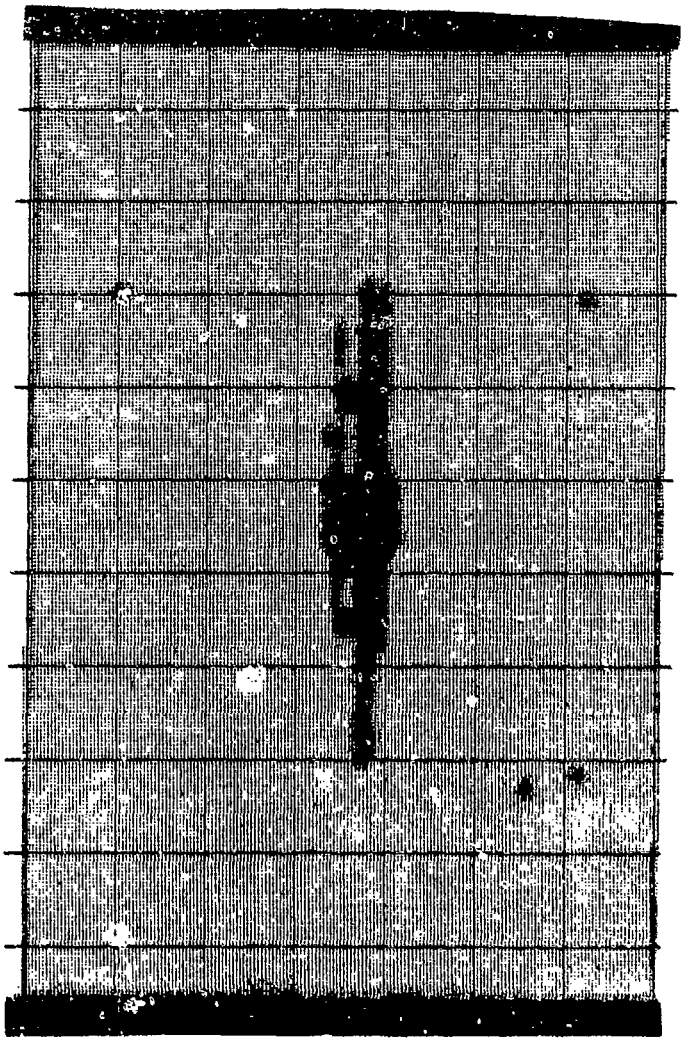
INTEGRATED TOTAL VELOCITY 118.21 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1725 UIN/IN

Figure B-77. Panel 1-18-1 Impact Response Data



Specimen 1-18-1

Figure B-76. Panel 1-18-1 C-Scan

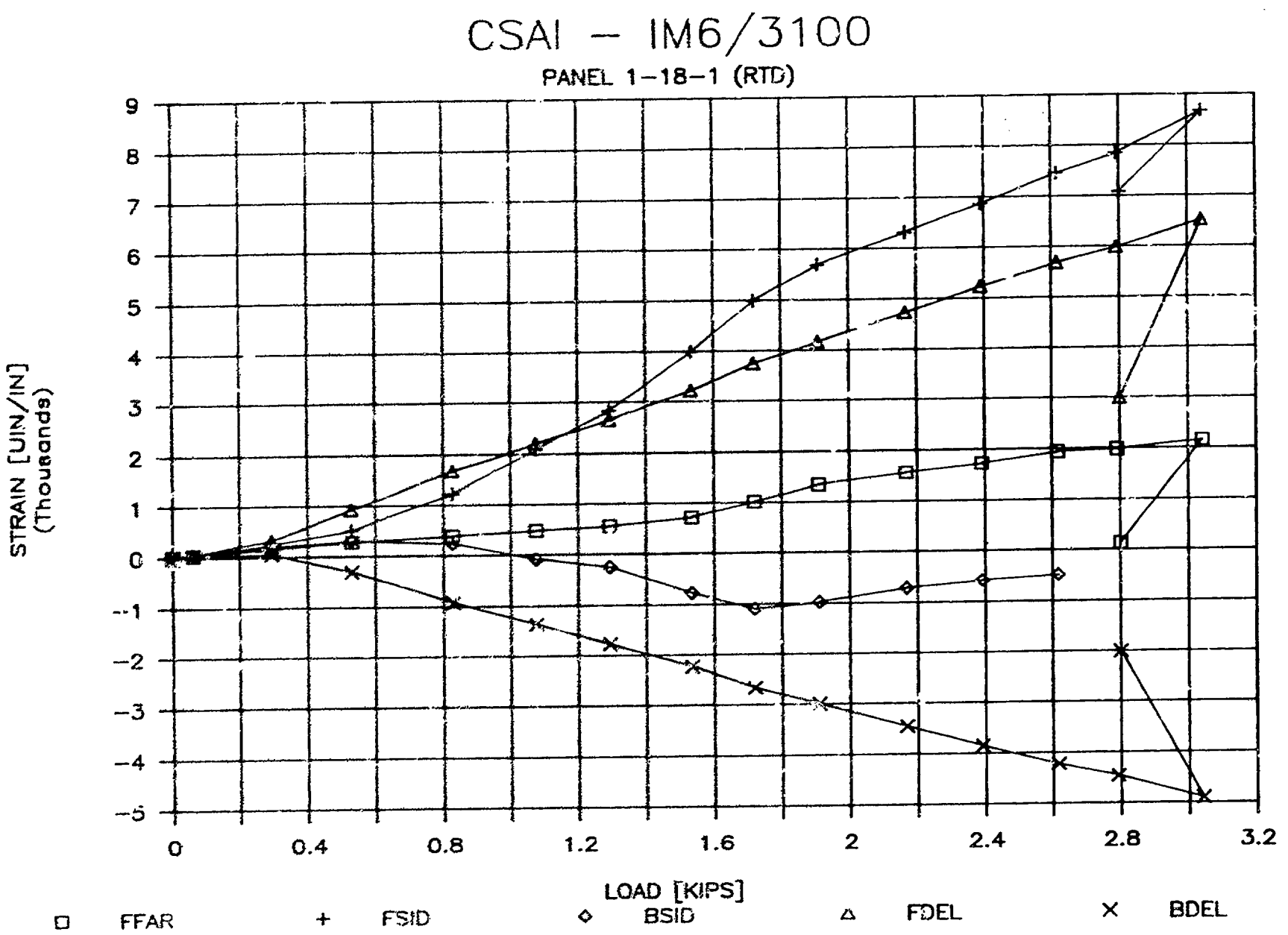


Figure 3-78. Panel 1-18-1 Residual Compression Data

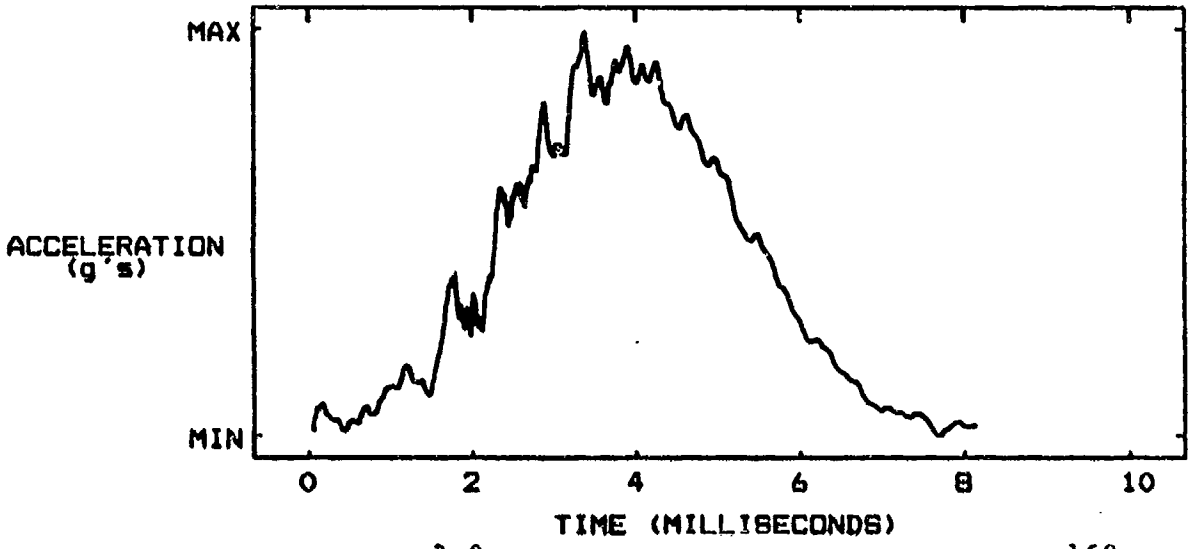
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-14A-1.1 THICKNESS .046 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

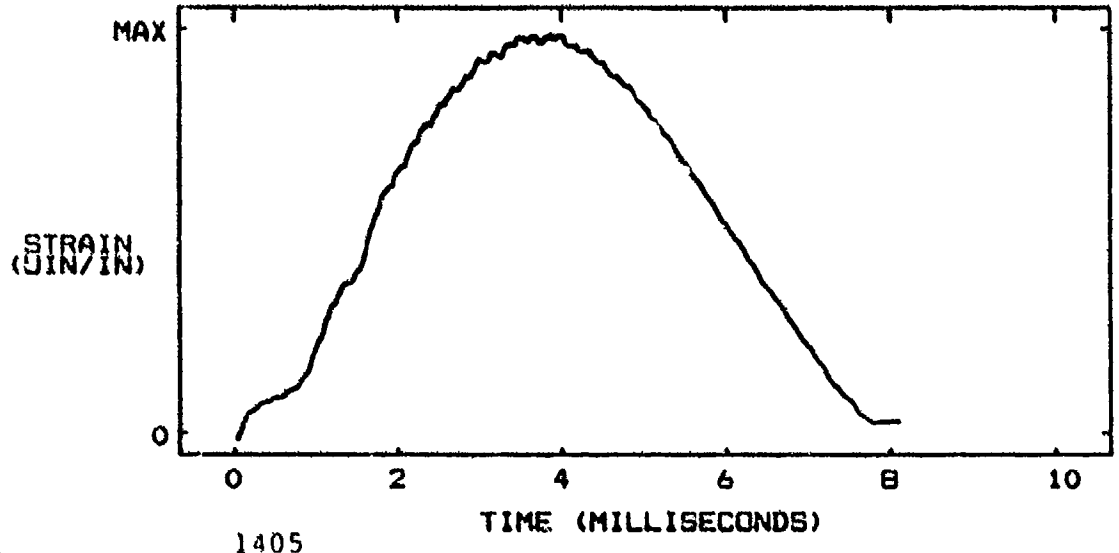
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -3.0 g's MAXIMUM ACCELERATION 160 g's

INTEGRATED TOTAL VELOCITY 187.07 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1405 UIN/IN

Figure B-80. Panel 1-14A-1 First Impact Response Data

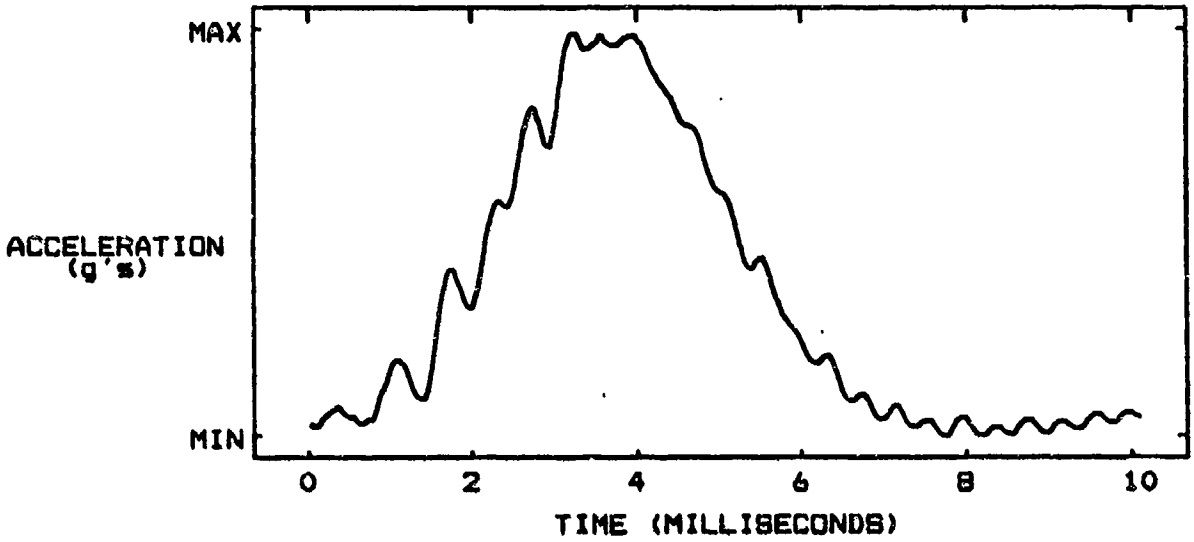
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-14A-1.2 THICKNESS .046 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

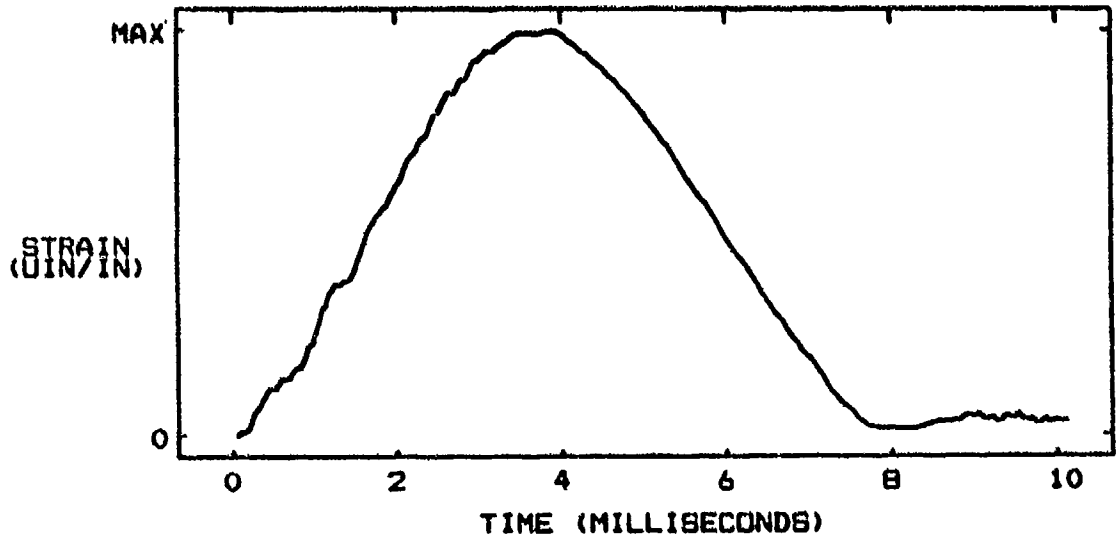
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -5.0 g's MAXIMUM ACCELERATION 157 g's

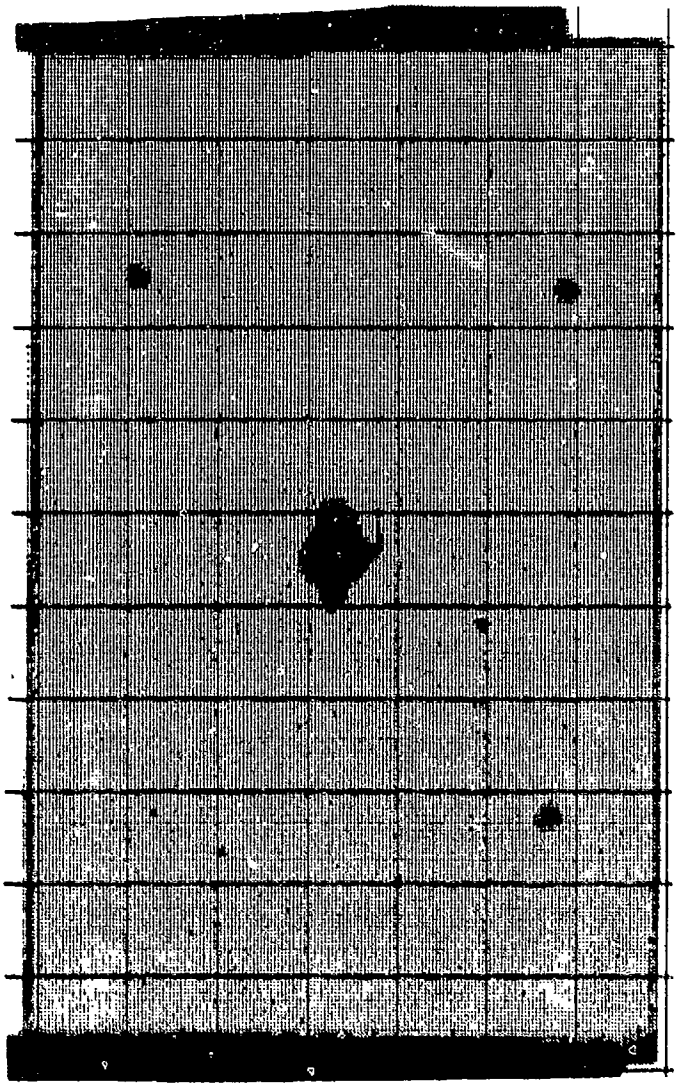
INTEGRATED TOTAL VELOCITY 187.78 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1462 UIN/IN

Figure B-81. Panel 1-14A-1 Second Impact Response Data



Specimen 1-14A-1

Figure B-82. Panel 1-14A-1 C-Scan

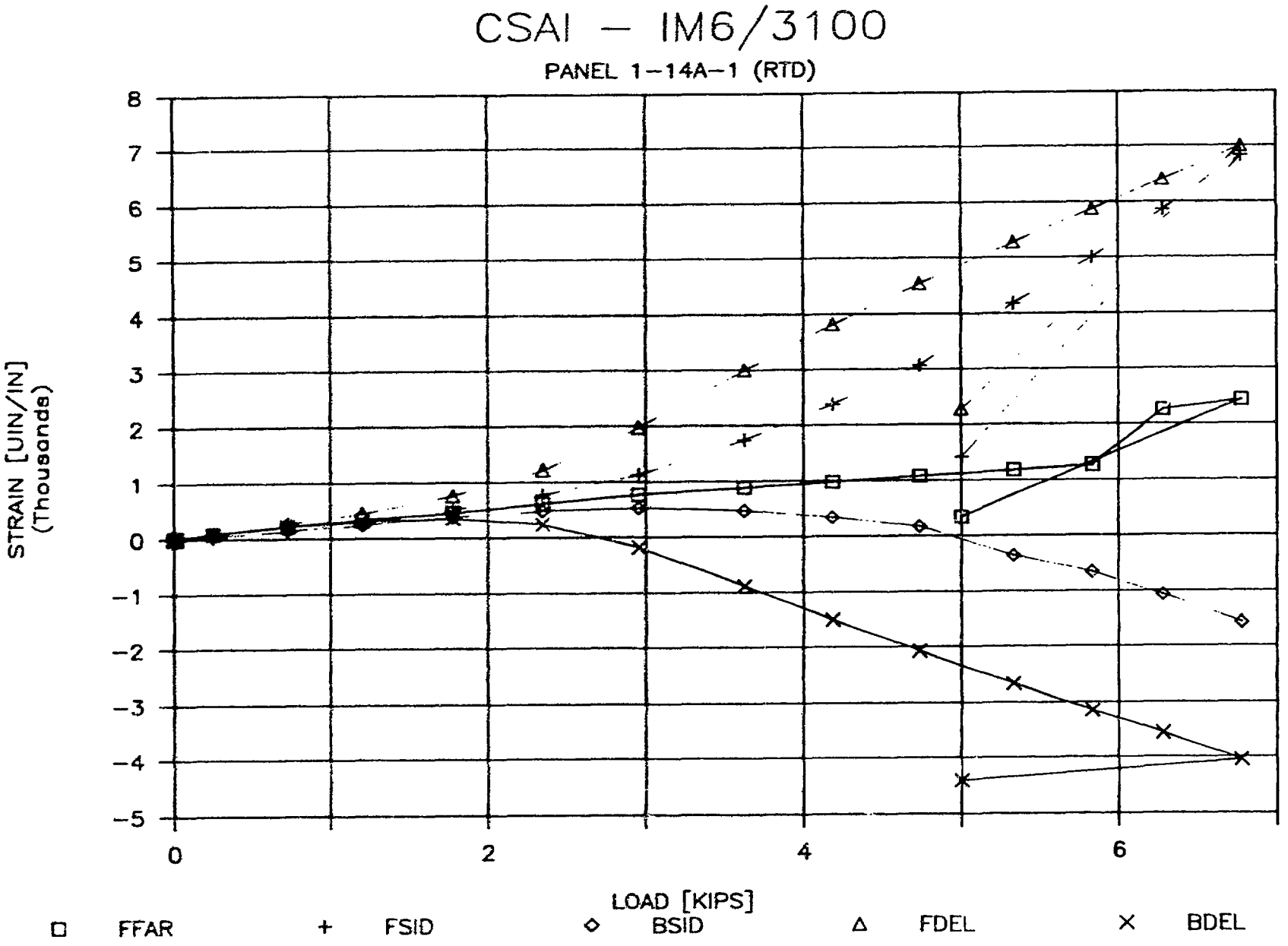


Figure B-83. Panel 1-14A-1 Residual Compression Data

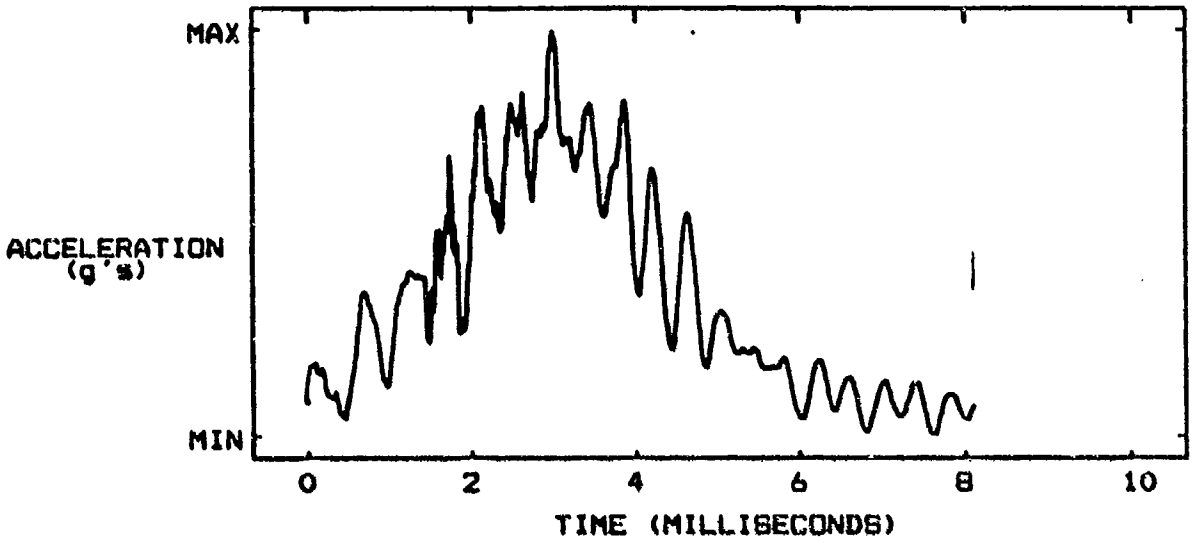
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-19-2.1 THICKNESS .065 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

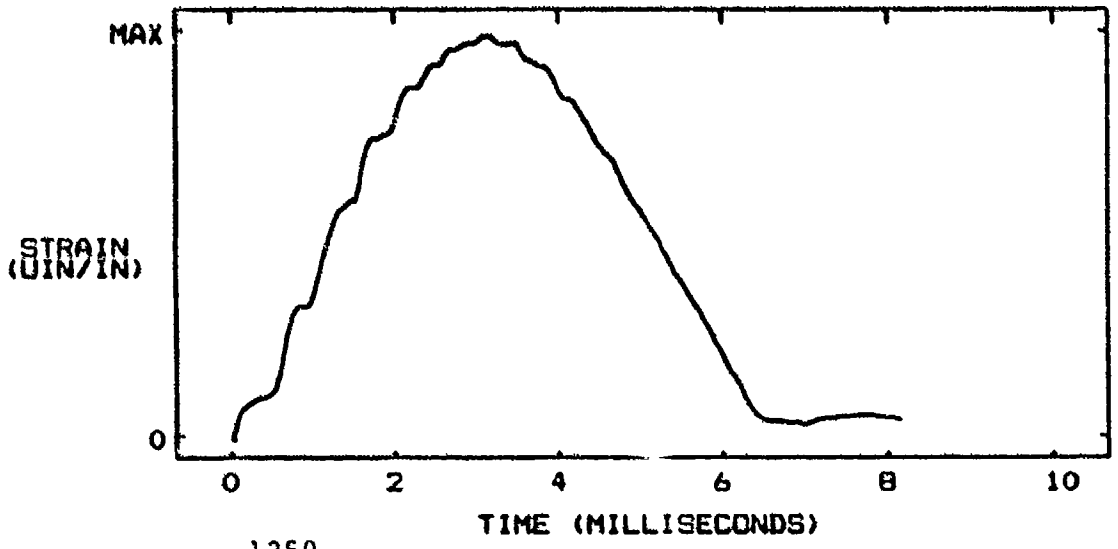
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -16.0 g's MAXIMUM ACCELERATION 177 g's

INTEGRATED TOTAL VELOCITY 150.25 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1250 UIN/IN

Figure B-84. Panel 1-19-2 First Impact Response Data

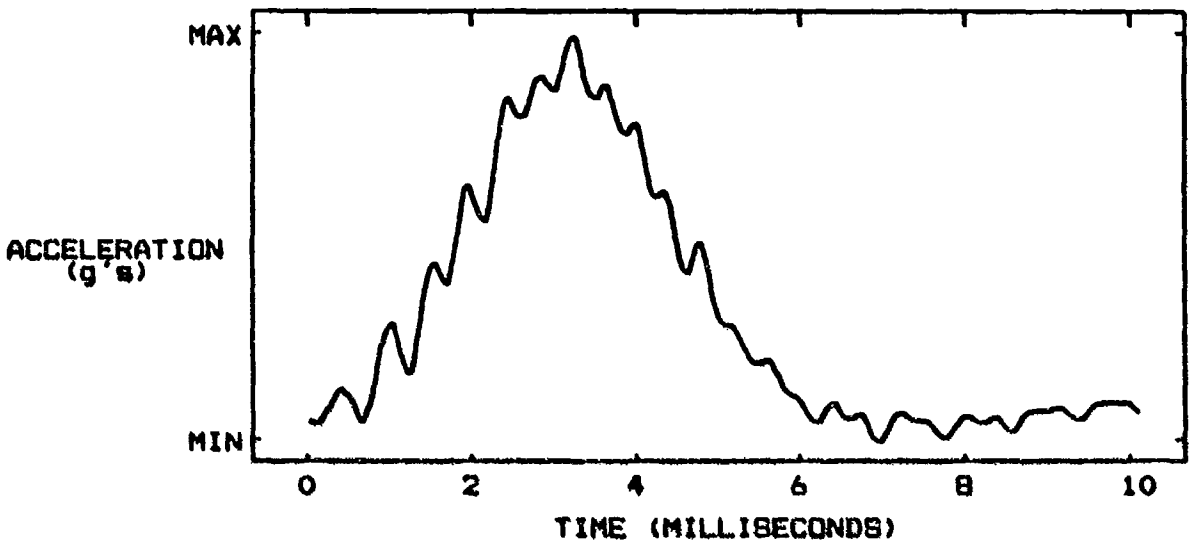
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-19-2.2 THICKNESS .065 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

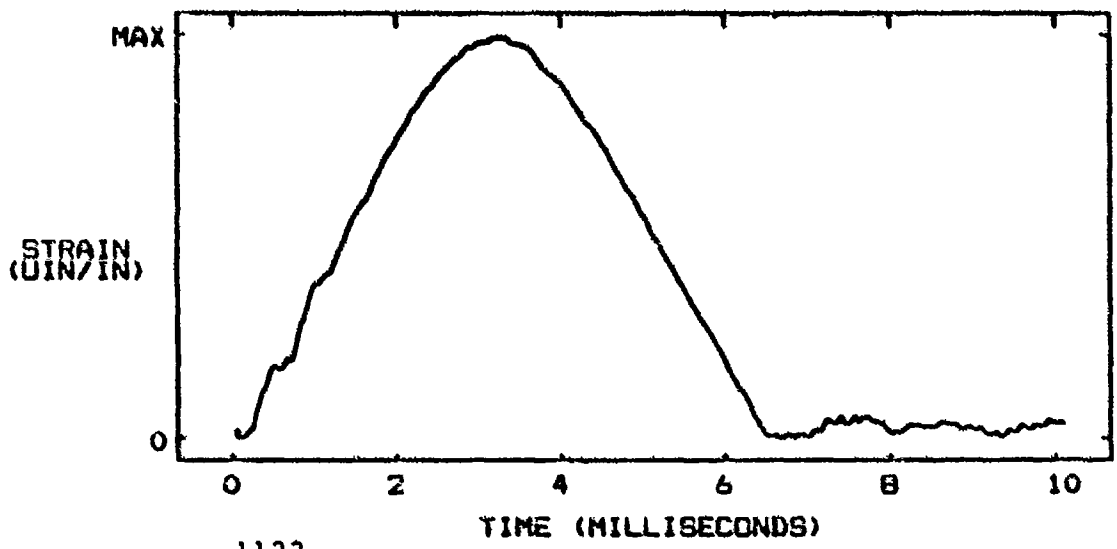
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -8.0 g's MAXIMUM ACCELERATION 172 g's

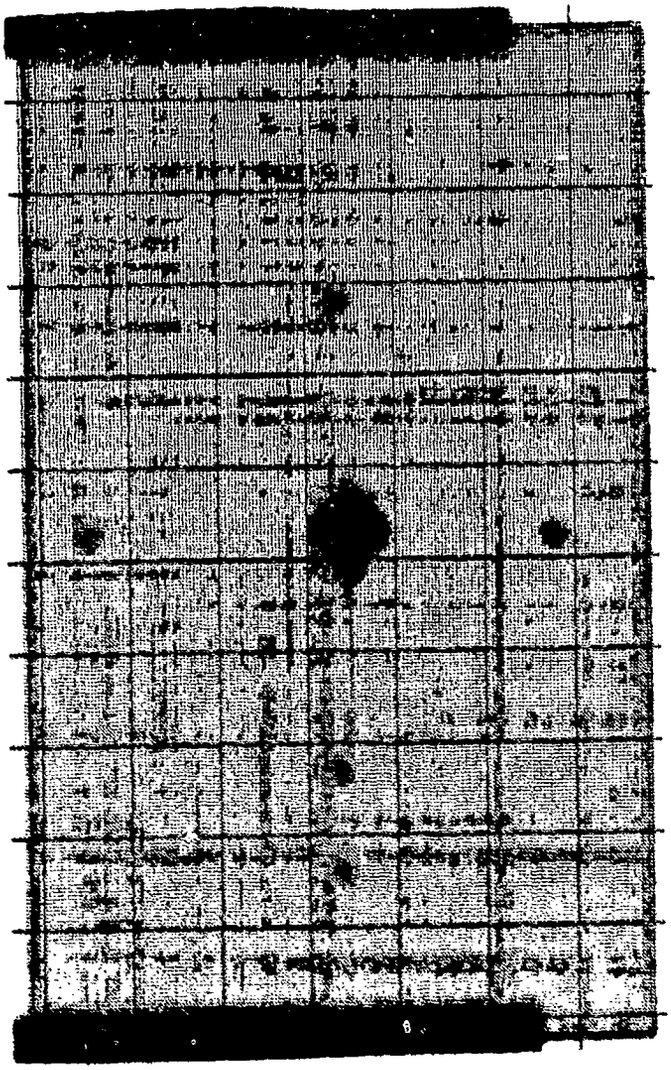
INTEGRATED TOTAL VELOCITY 179.72 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1122 UIN/IN

Figure B-85. Panel 1-19-2 Second Impact Response Data



Specimen 1-19-2

Figure B-88. Panel 1-19-2 C-Scan

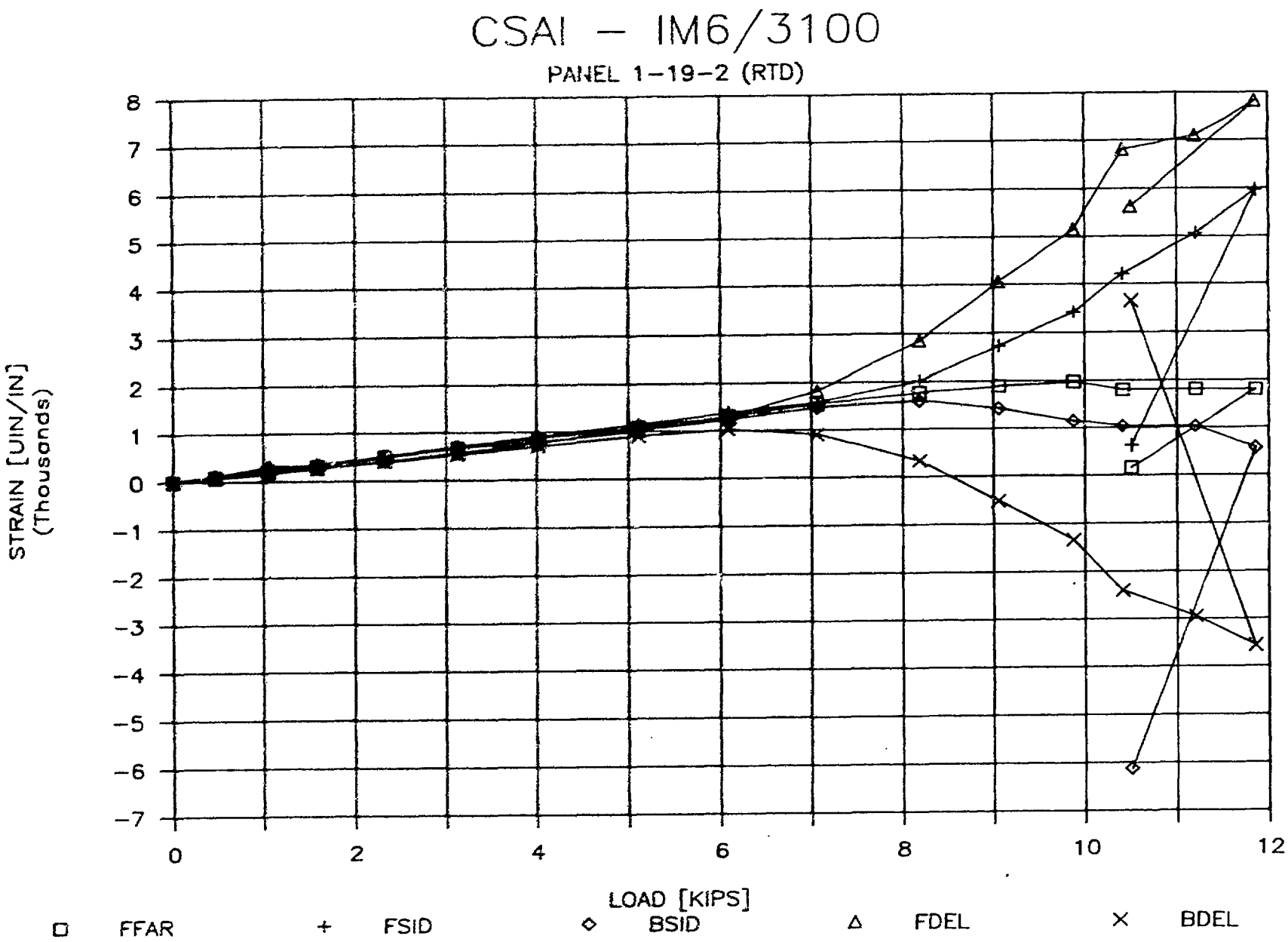


Figure B-87. Panel 1-19-2 Residual Compression Data

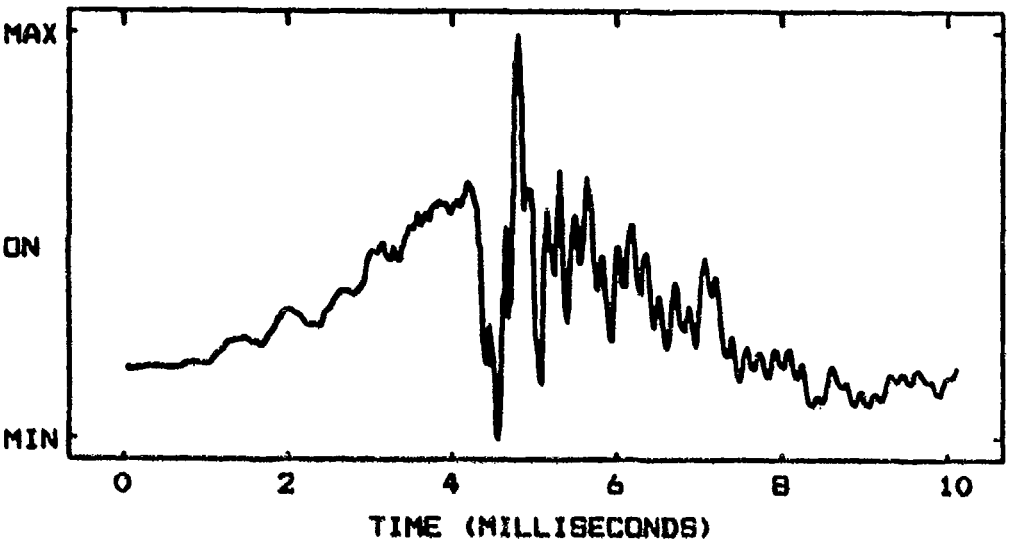
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-16-1 THICKNESS .022 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

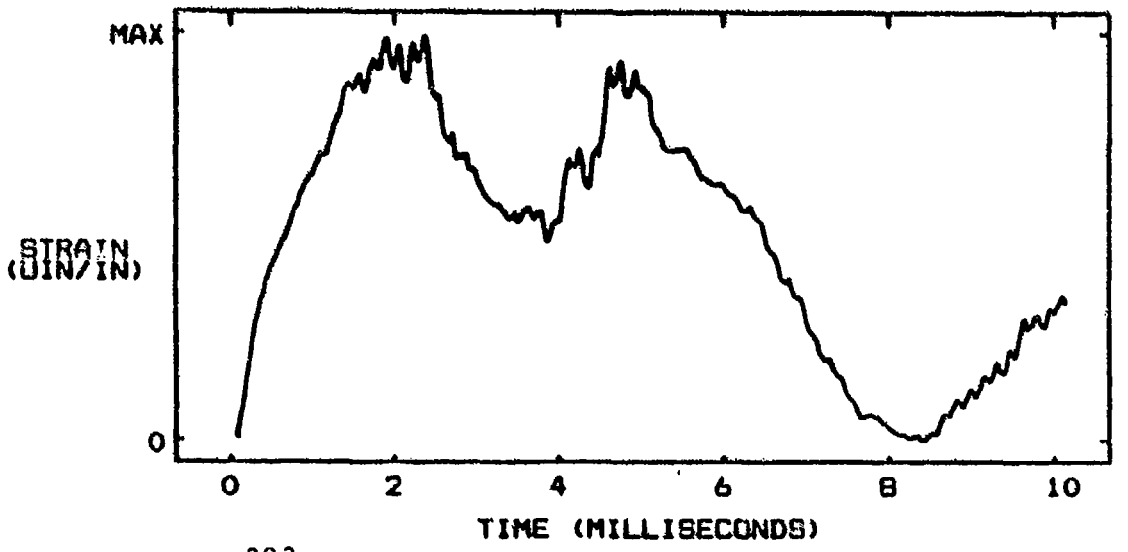
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -27.0 g's MAXIMUM ACCELERATION 127.8 g's

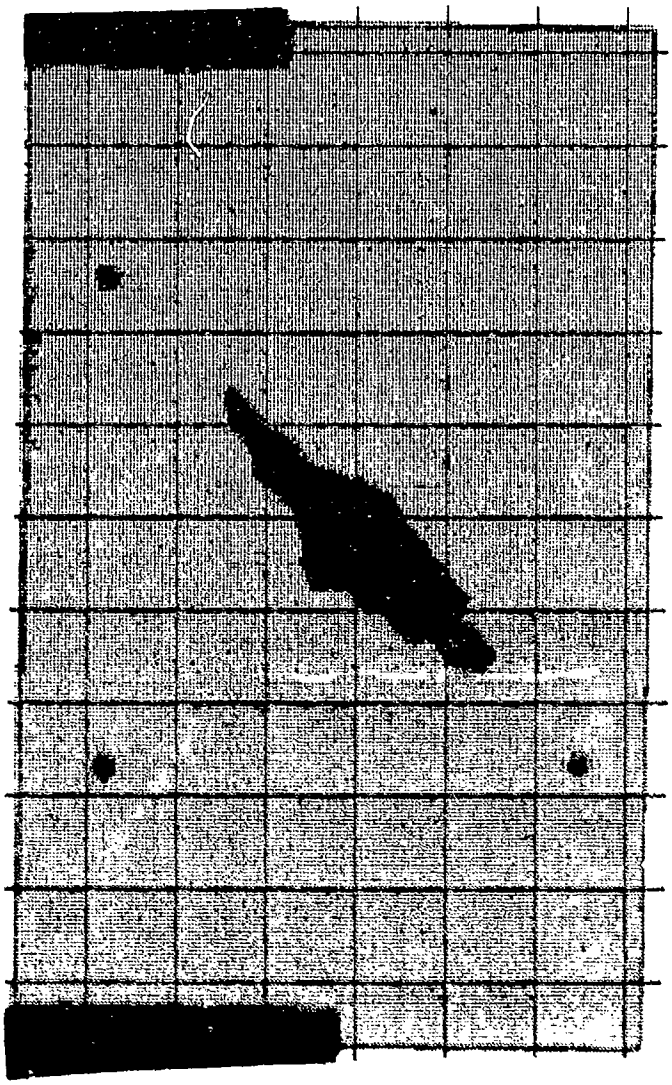
INTEGRATED TOTAL VELOCITY 76.04 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 283 UIN/IN

Figure B-88. Panel 2-16-1 Impact Response Data



Specimen 2-16-1

Figure B-89. Panel 2-16-1 C-Scan

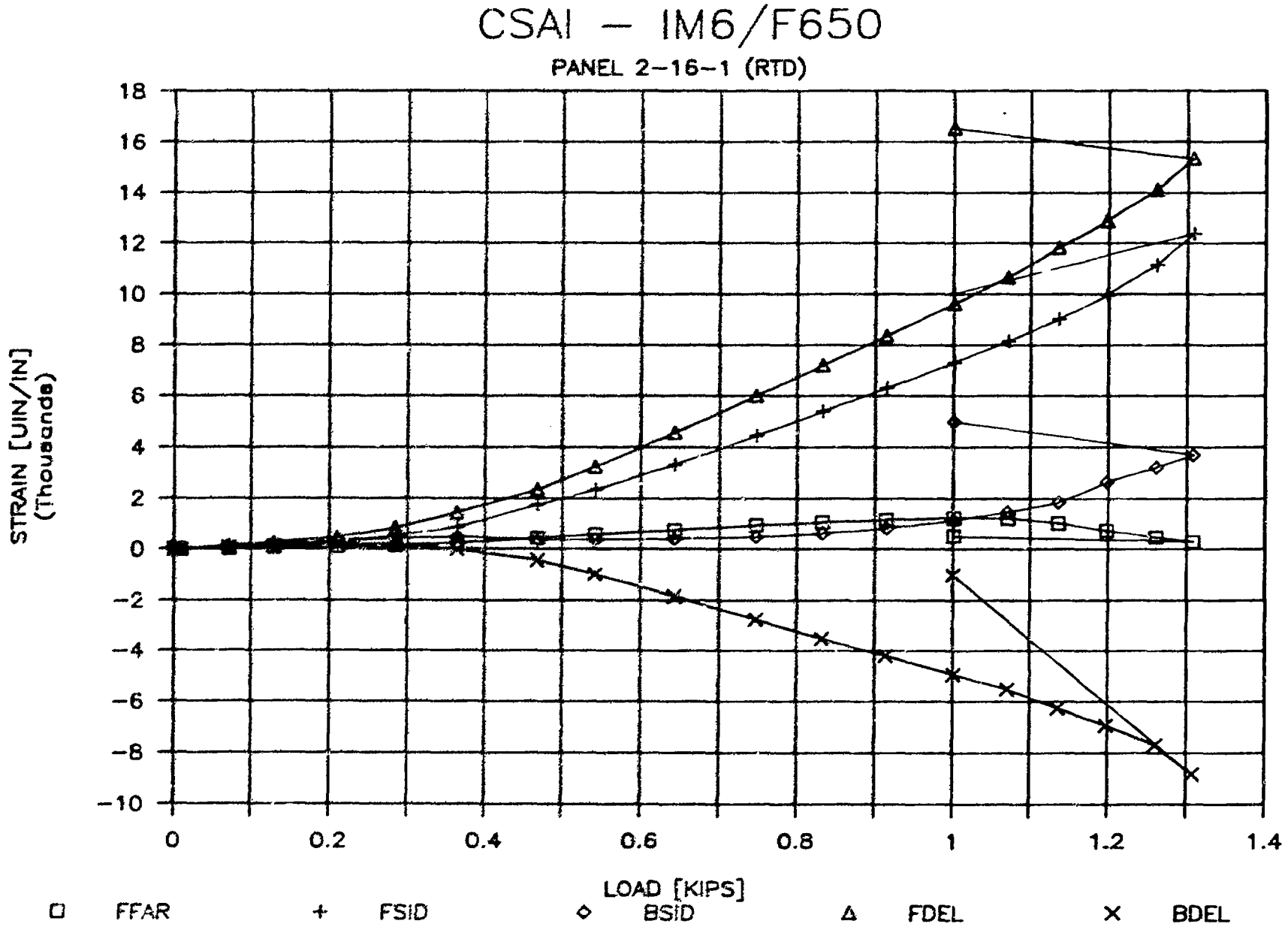


Figure B-90. Panel 2-16-1 Residual Compression Data

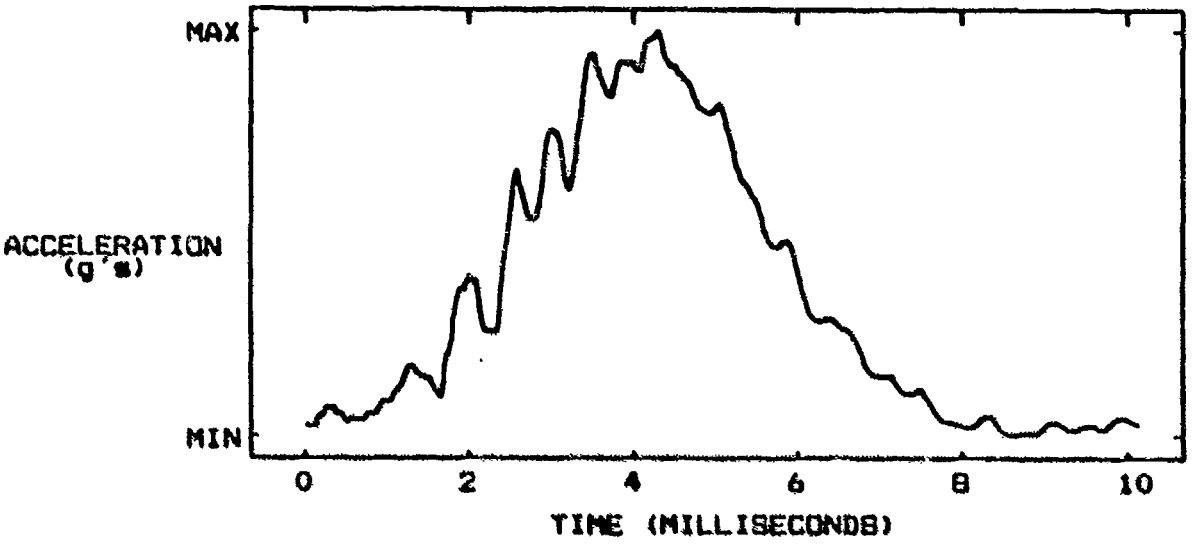
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-12A-1 THICKNESS .044 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

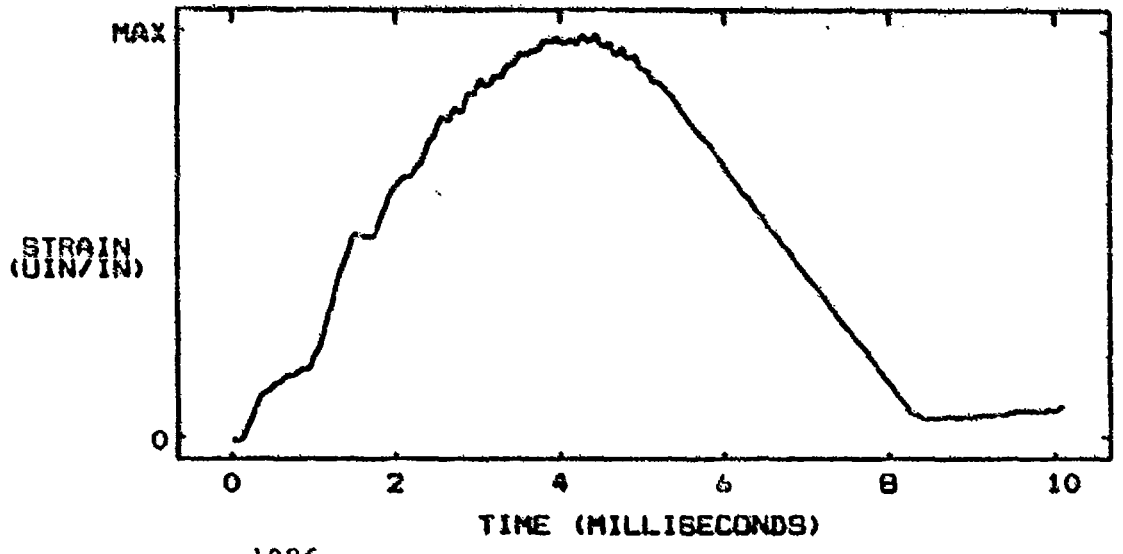
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -3.0 g's MAXIMUM ACCELERATION 137 g's

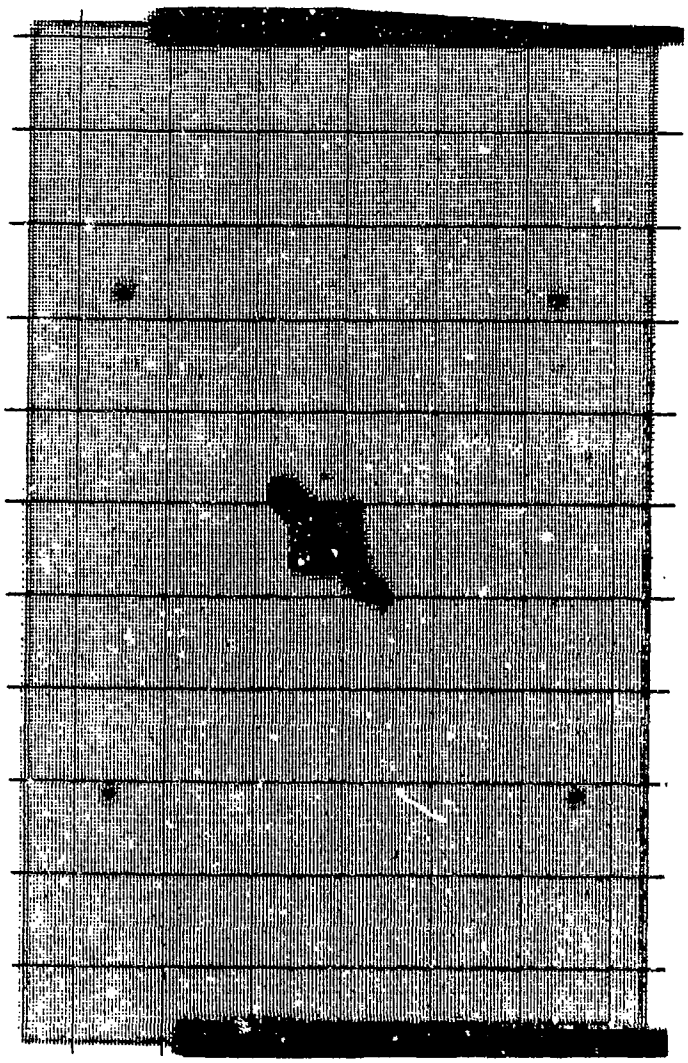
INTEGRATED TOTAL VELOCITY 167.2 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1086 UIN/IN

Figure B-91. Panel 2-12A-1 Impact Response Data



Specimen 2-12A-1

Figure B-92. Panel 2-12A-1 C-Scan

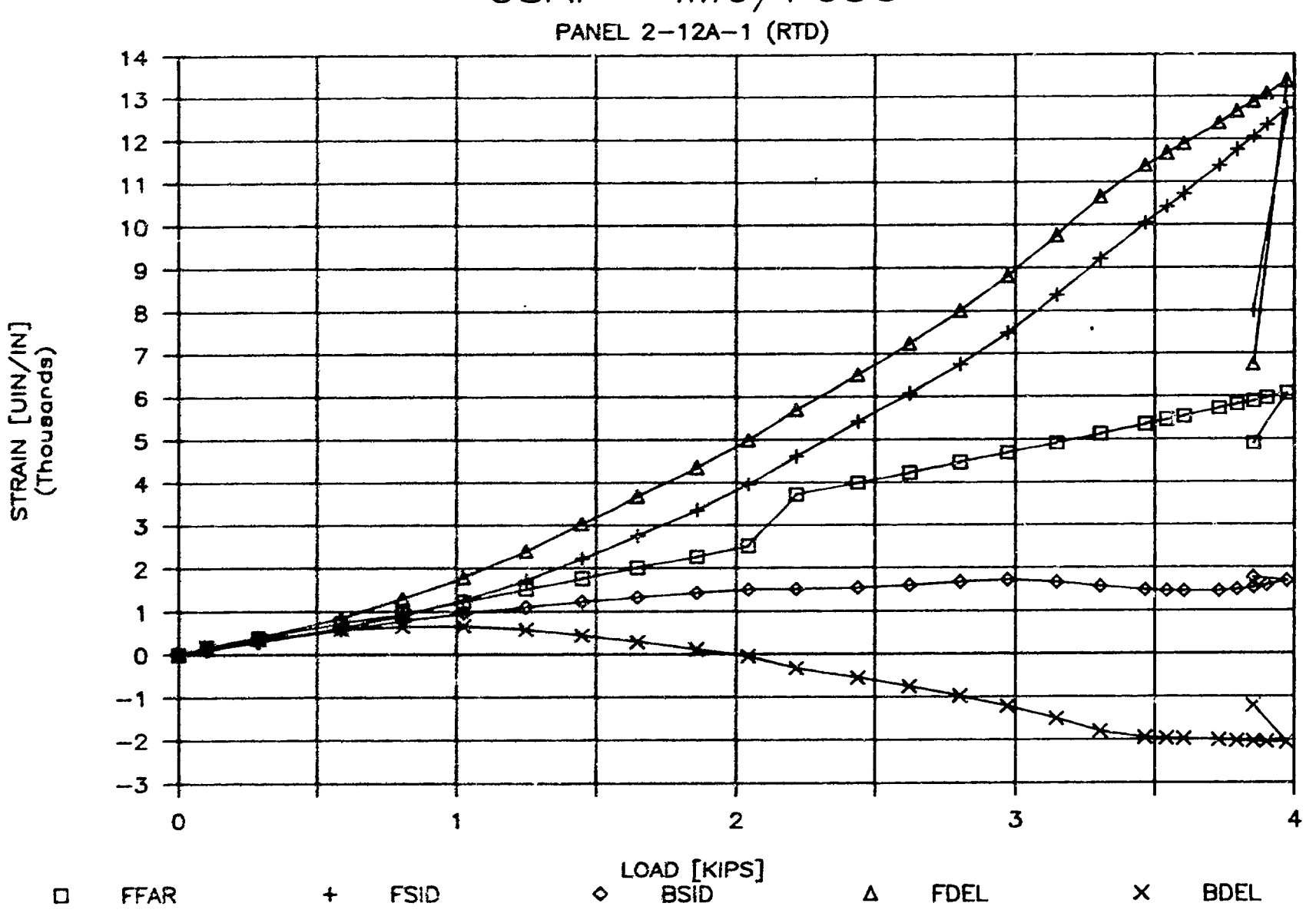


Figure B-93. Panel 2-12A-1 Residual Compression Data

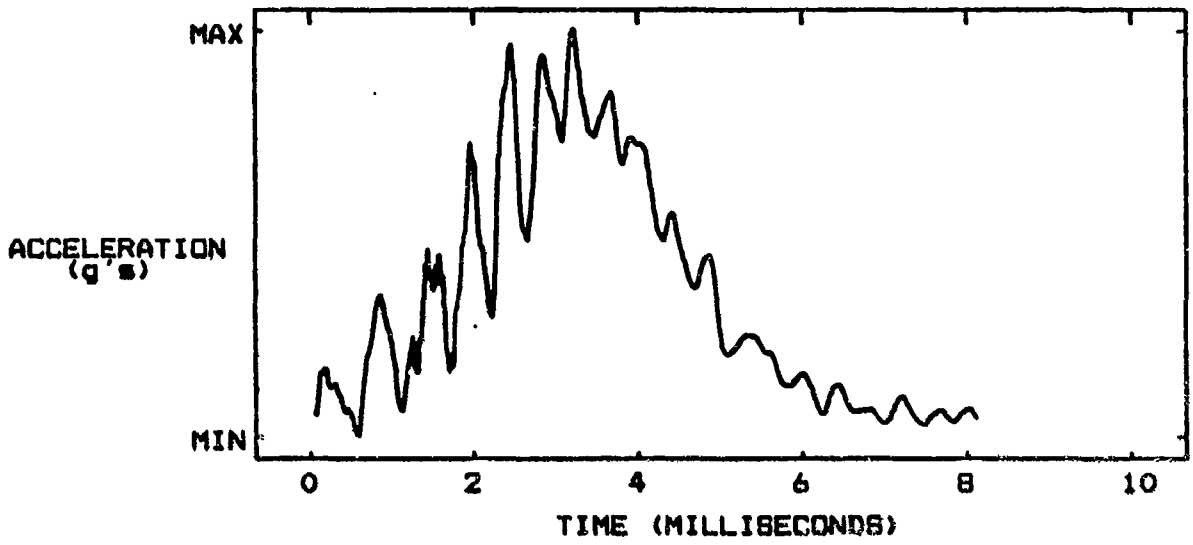
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-17-2 THICKNESS .064 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

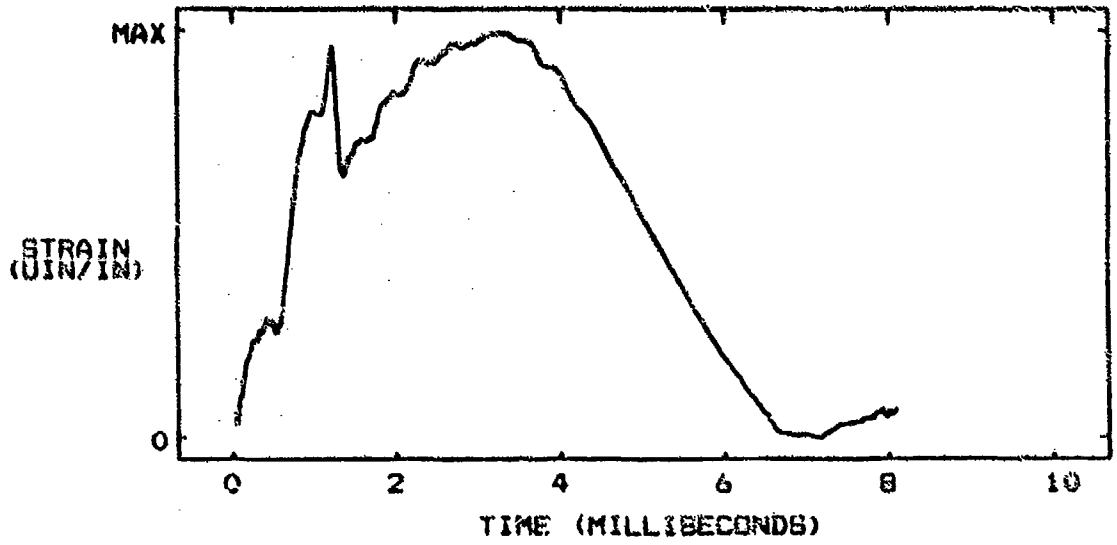
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -10.0 g's MAXIMUM ACCELERATION 176.72 g's

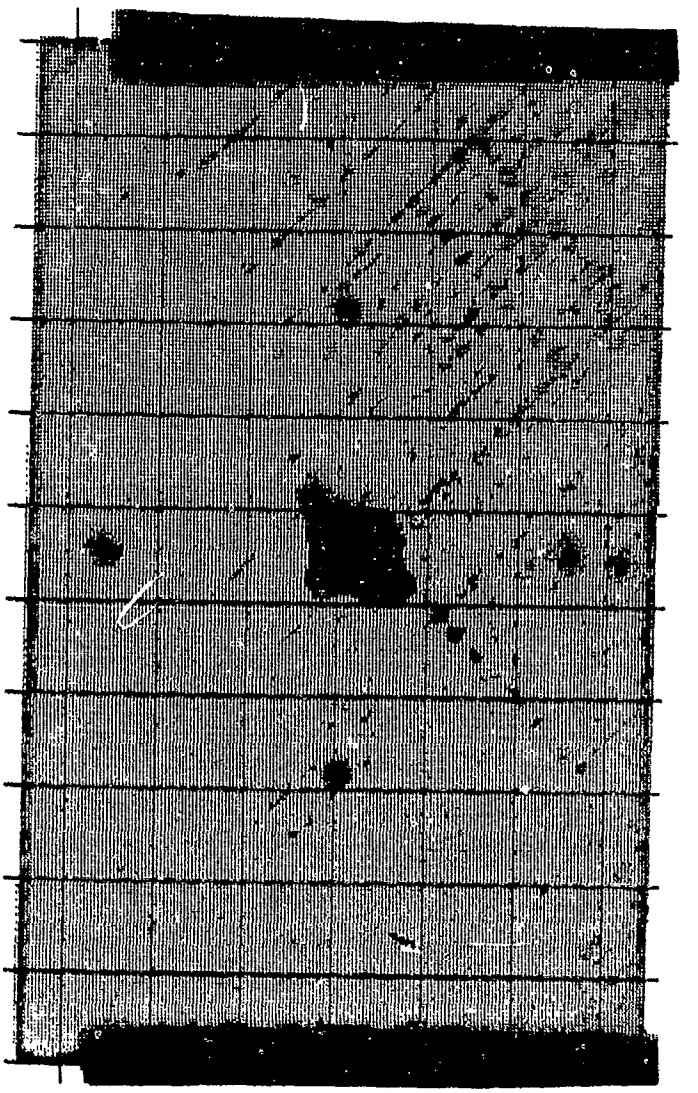
INTEGRATED TOTAL VELOCITY 162.73 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 495 UIN/IN

Figure B-94. Panel 2-17-2 Impact Response Data



Specimen 2-17-2

Figure B-95. Panel 2-17-2 C-Scan

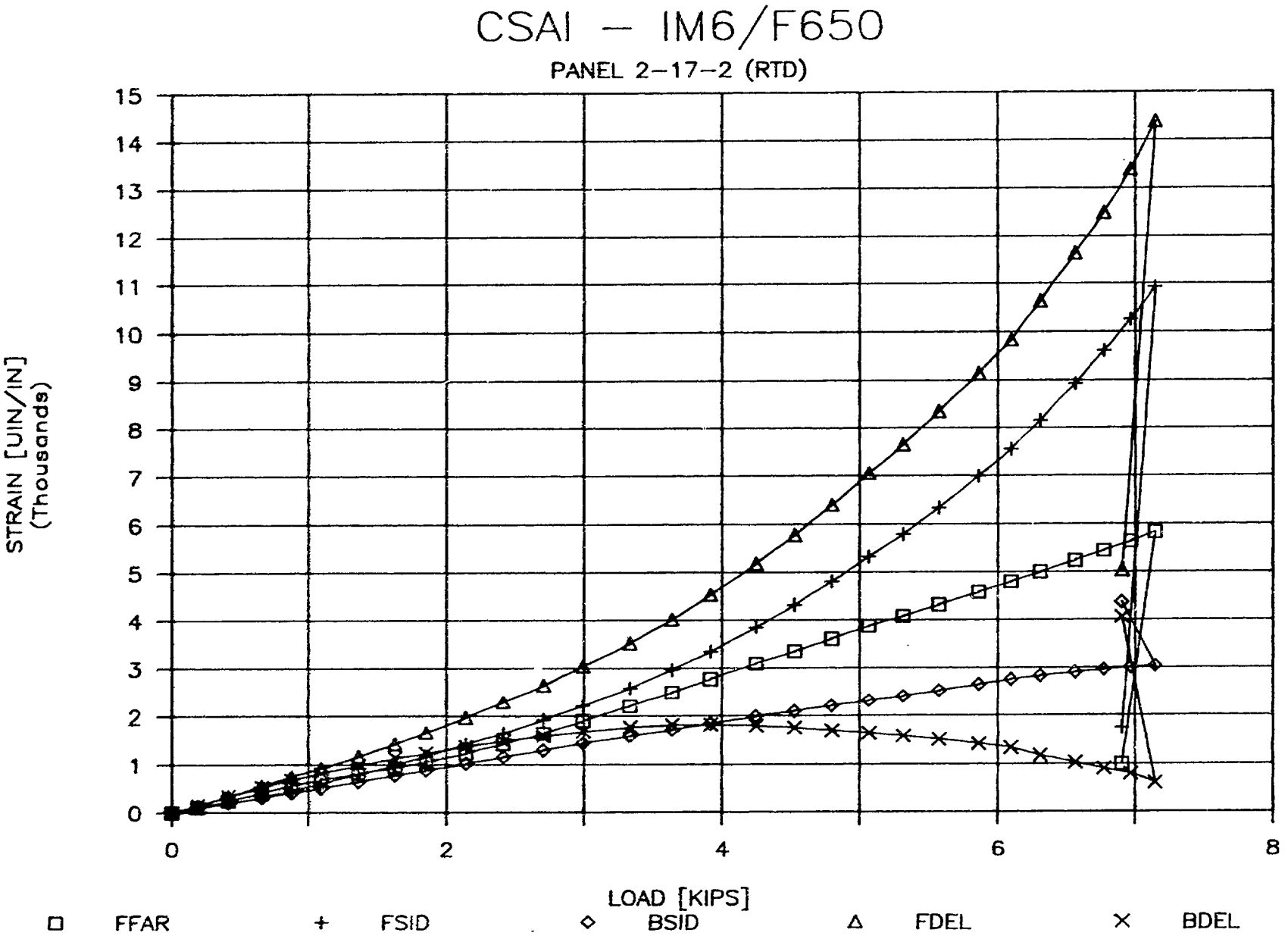


Figure B-96. Panel 2-17-2 Residual Compression Data

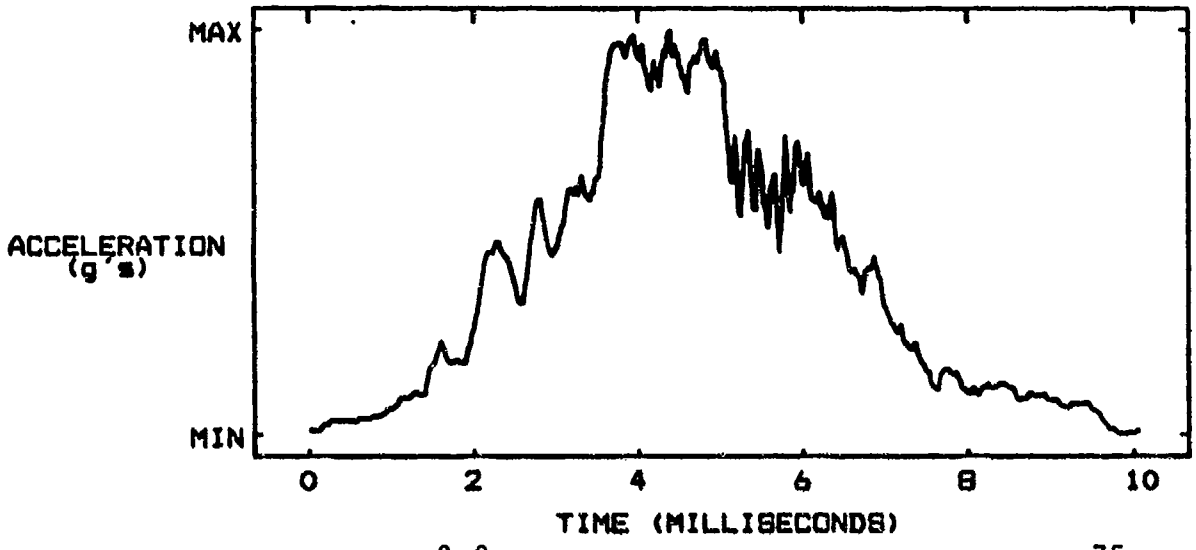
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-18-2 THICKNESS .023 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

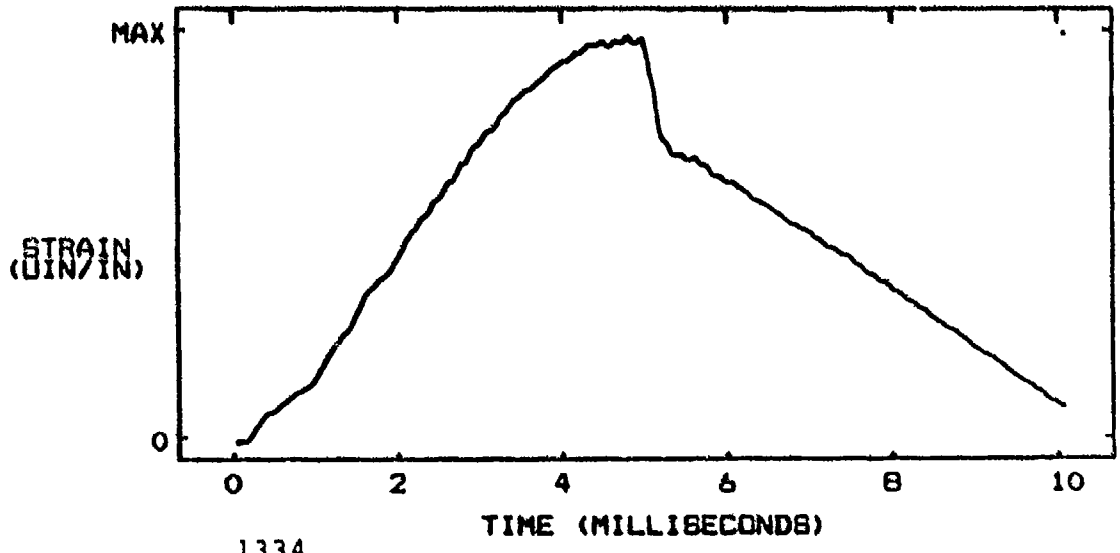
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION 0.0 g's MAXIMUM ACCELERATION 75 g's

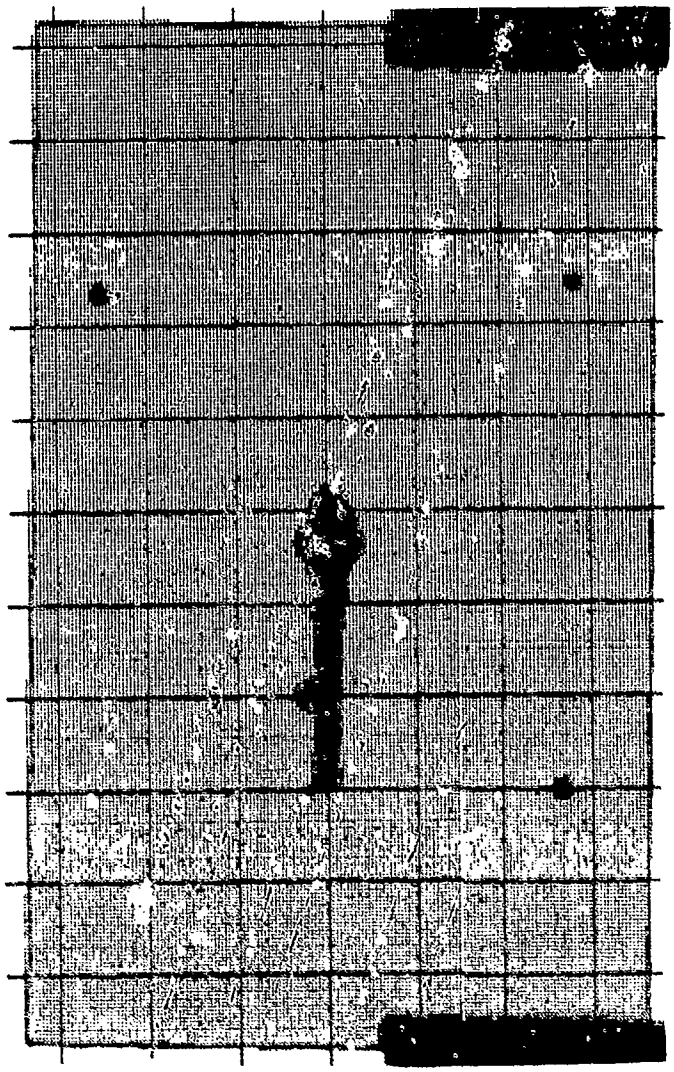
INTEGRATED TOTAL VELOCITY 111.21 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1334 UIN/IN

Figure 8-97. Panel 2-18-2 Impact Response Data



Specimen 2-18-2

Figure B-88. Panel 2-18-2 C-Scan

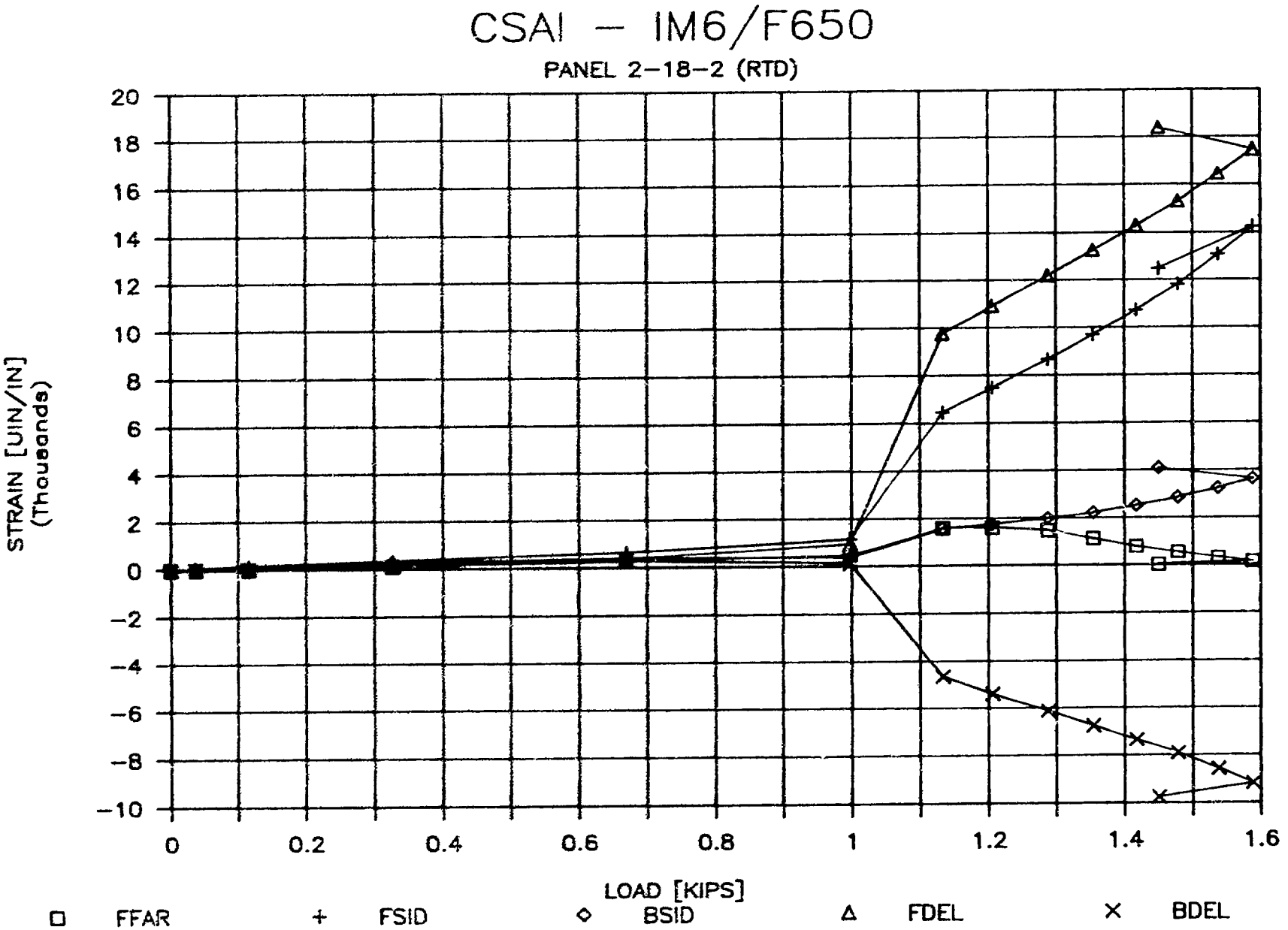


Figure B-99. Panel 2-18-2 Residual Compression Data

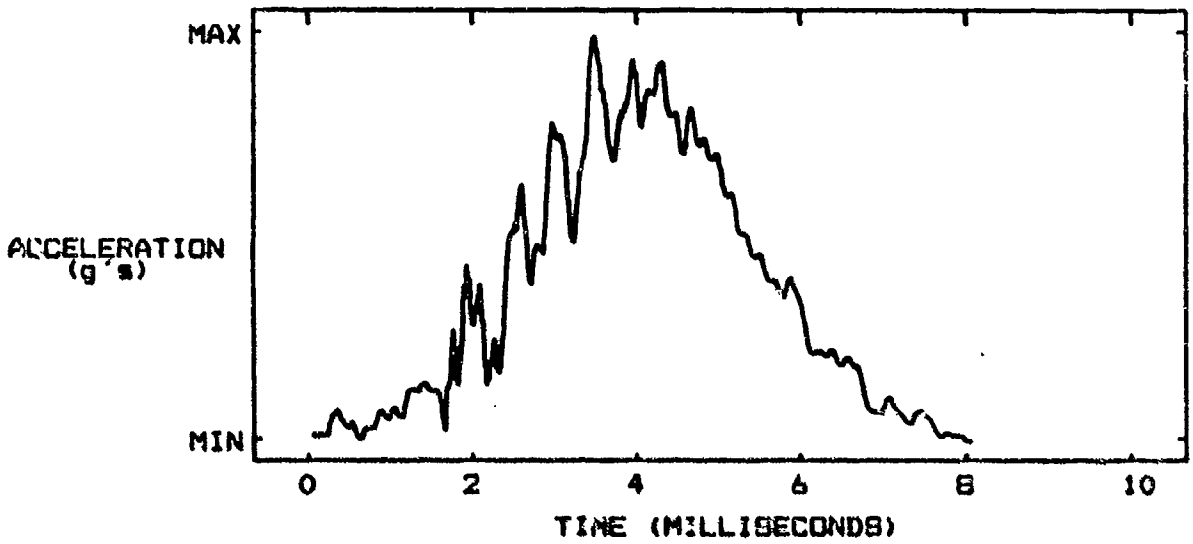
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14A-1.1 THICKNESS .043 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

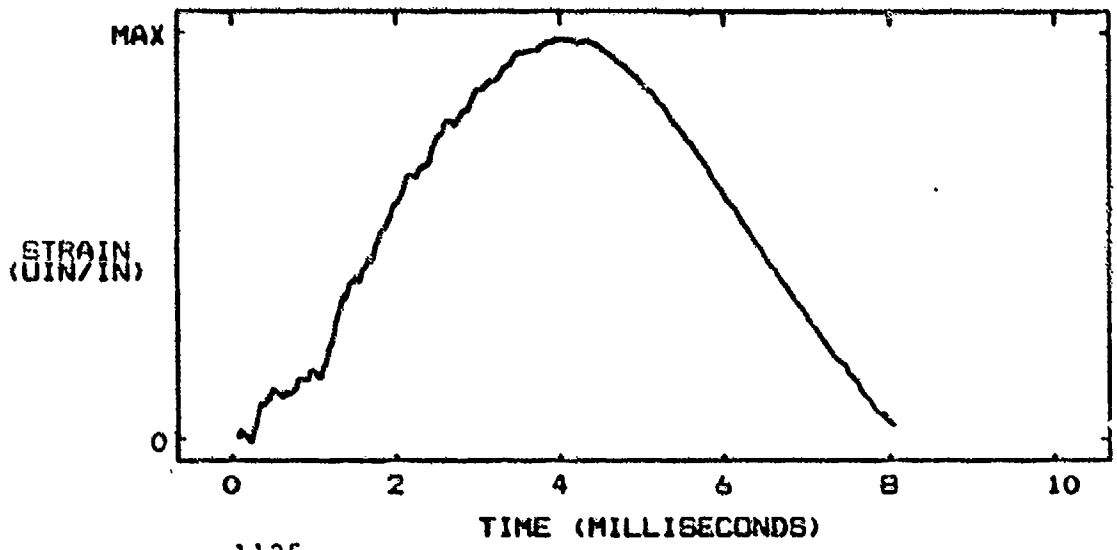
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -3.0 g's MAXIMUM ACCELERATION 157 g's

INTEGRATED TOTAL VELOCITY 169.29 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1125 UIN/IN

Figure B-100. Panel 2-14A-1 First Impact Response Data

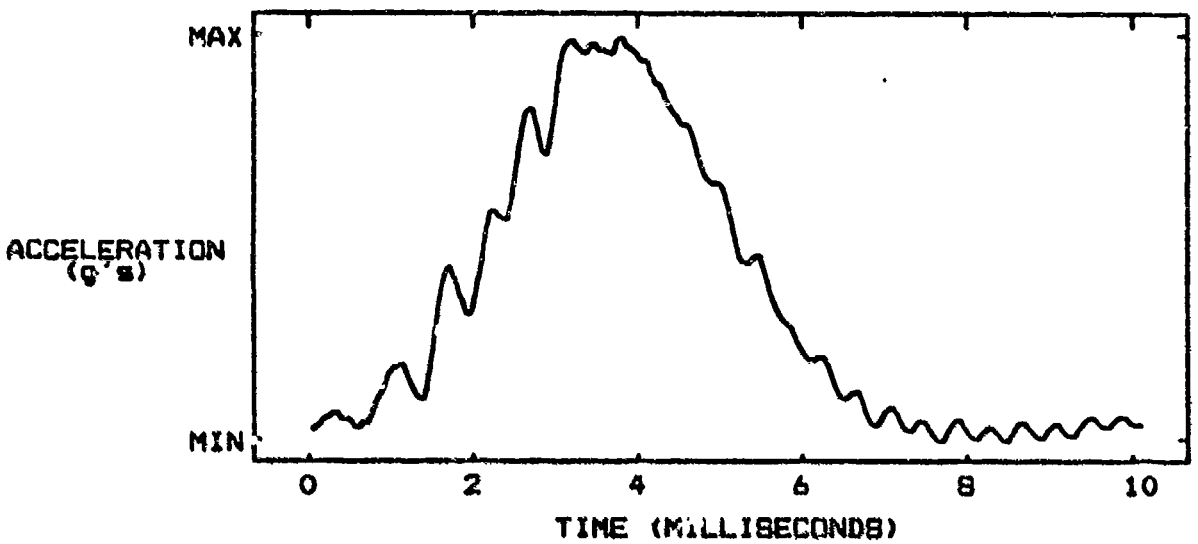
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14A-1.2 THICKNESS .043 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

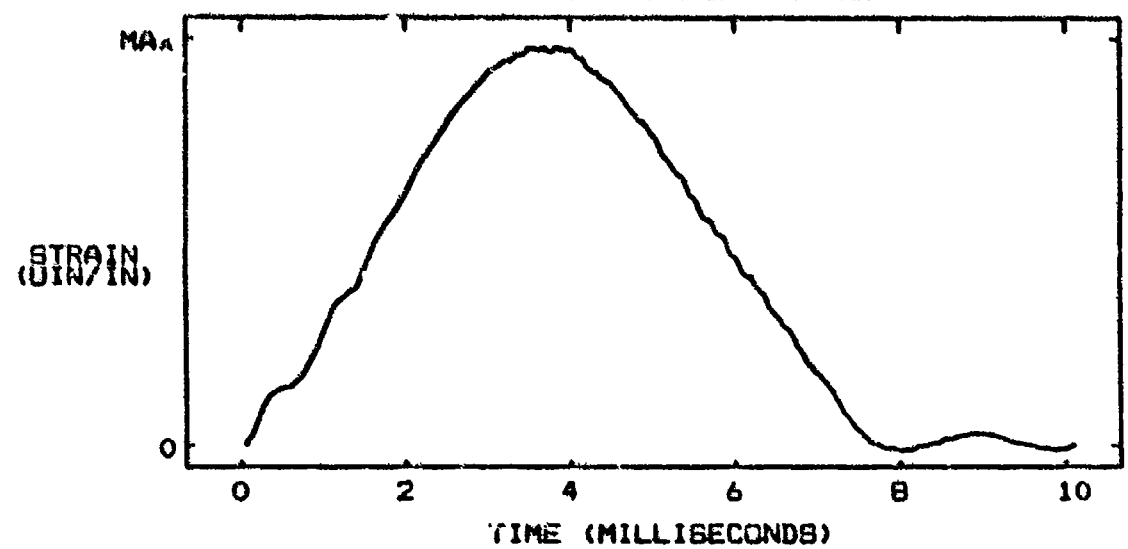
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -5.0 g's MAXIMUM ACCELERATION 158 g's

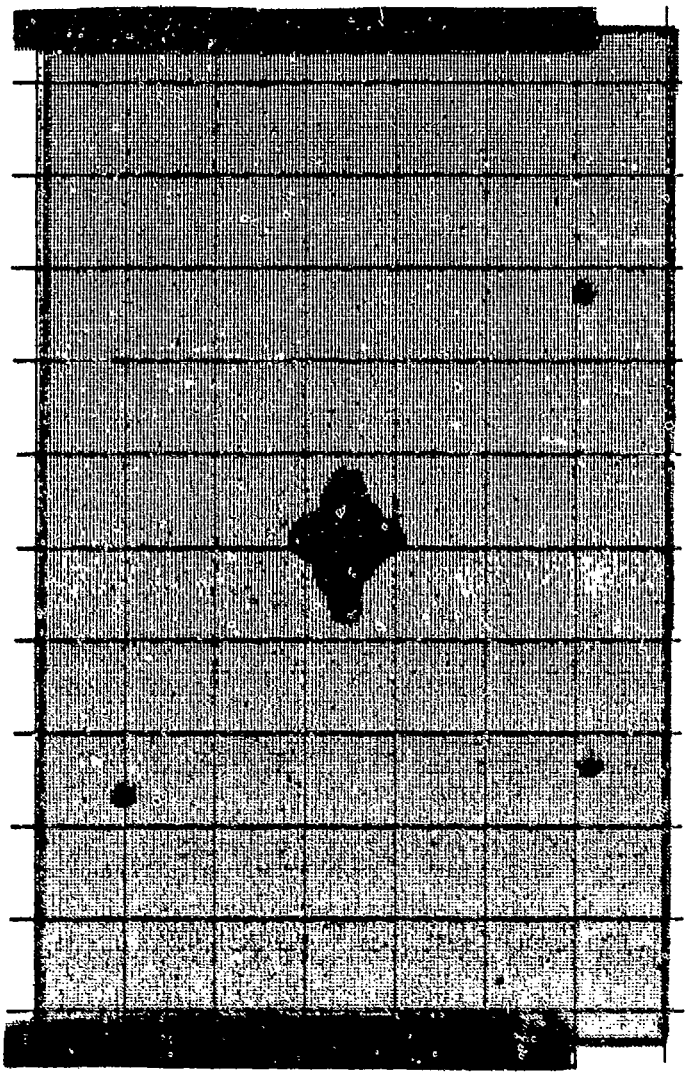
INTEGRATED TOTAL VELOCITY 191.44 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1231 UIN/IN

Figure B-101. Panel 2-14A-1 Second Impact Response Data



Specimen 2-14A-1

Figure B-102. Panel 2-14A-1 C-Scan

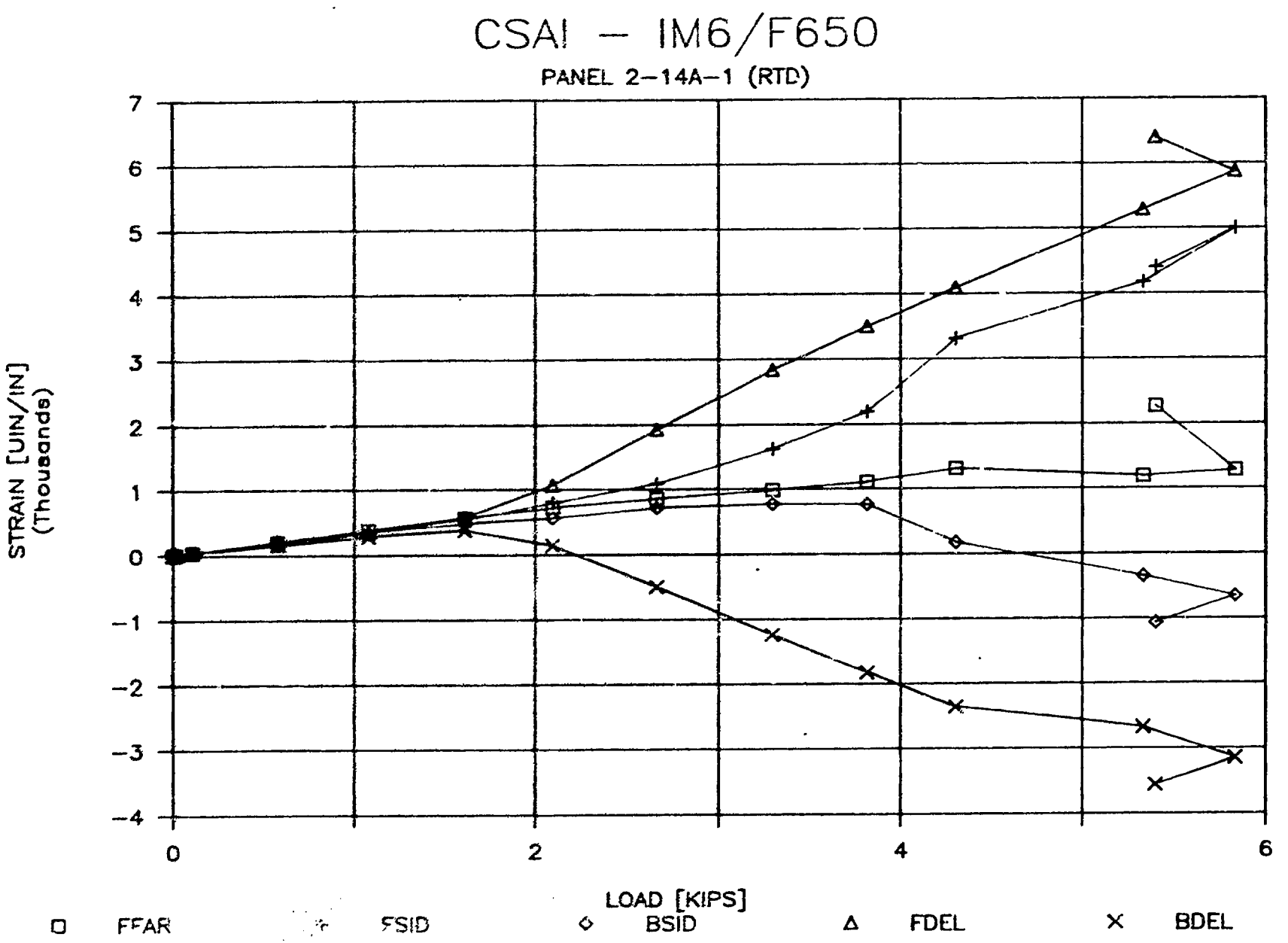


Figure B-103. Panel 2-14A-1 Residual Compression Data

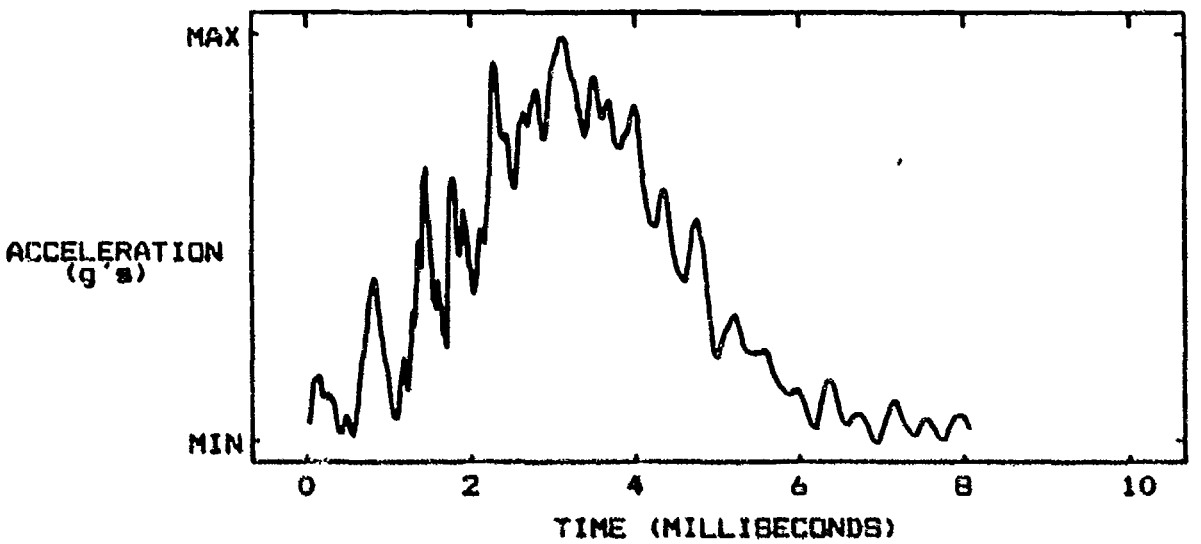
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-19-2.1 THICKNESS .064 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

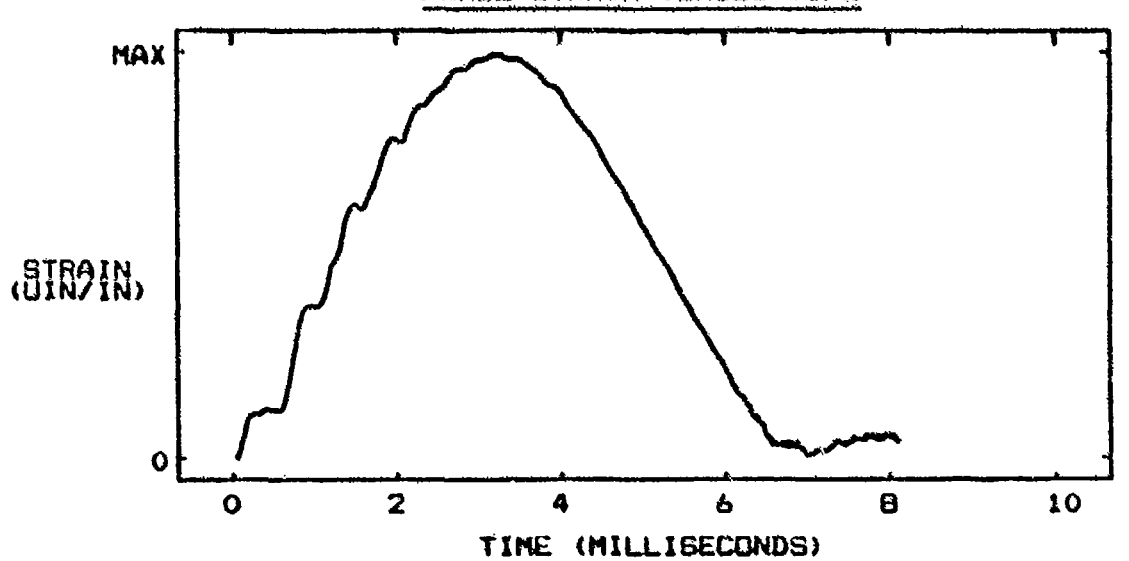
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -6.0 g's MAXIMUM ACCELERATION 166 g's

INTEGRATED TOTAL VELOCITY 166.77 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1025 UIN/IN

Figure B-104. Panel 2-19-2 First Impact Response Data

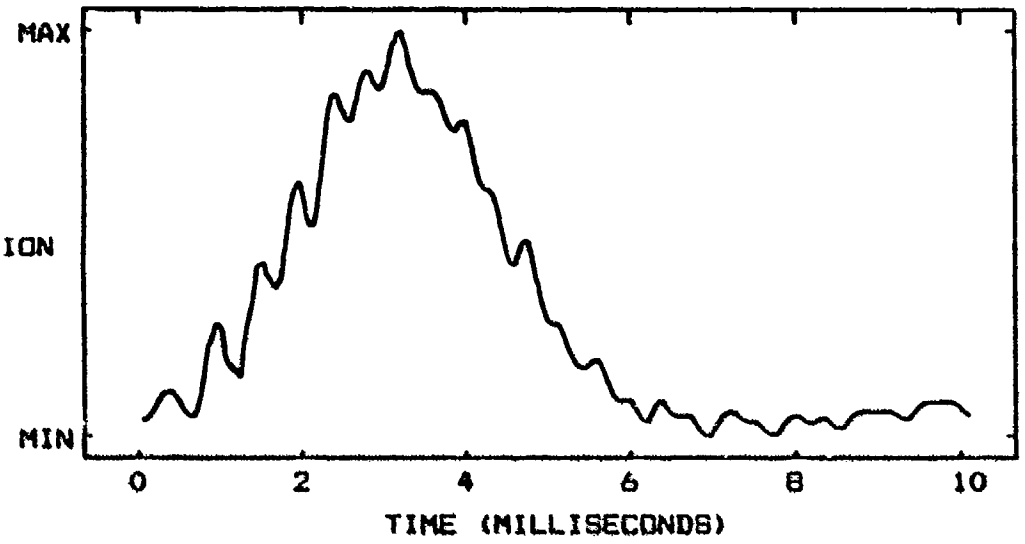
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-19-2.2 THICKNESS .064 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

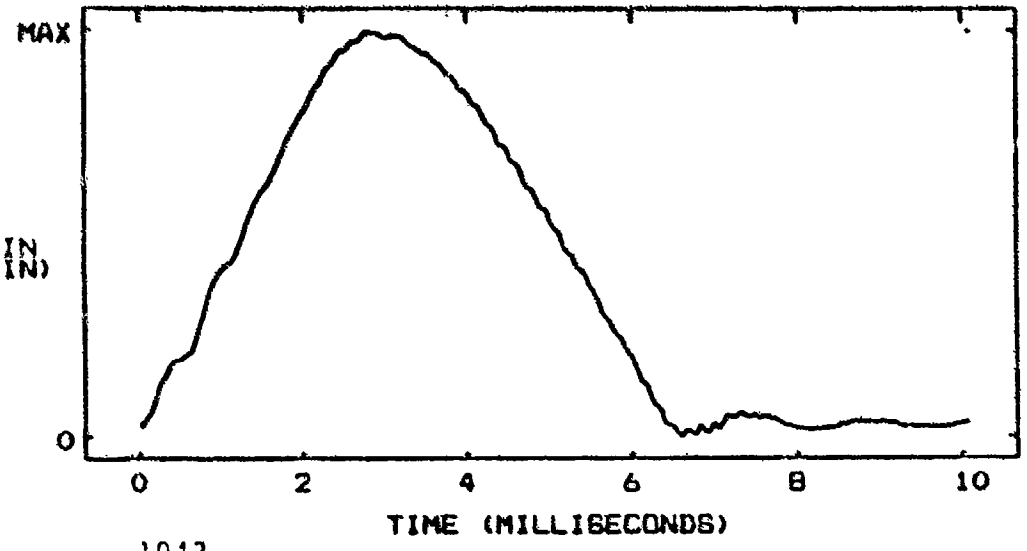
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -8.0 g's MAXIMUM ACCELERATION 175 g's

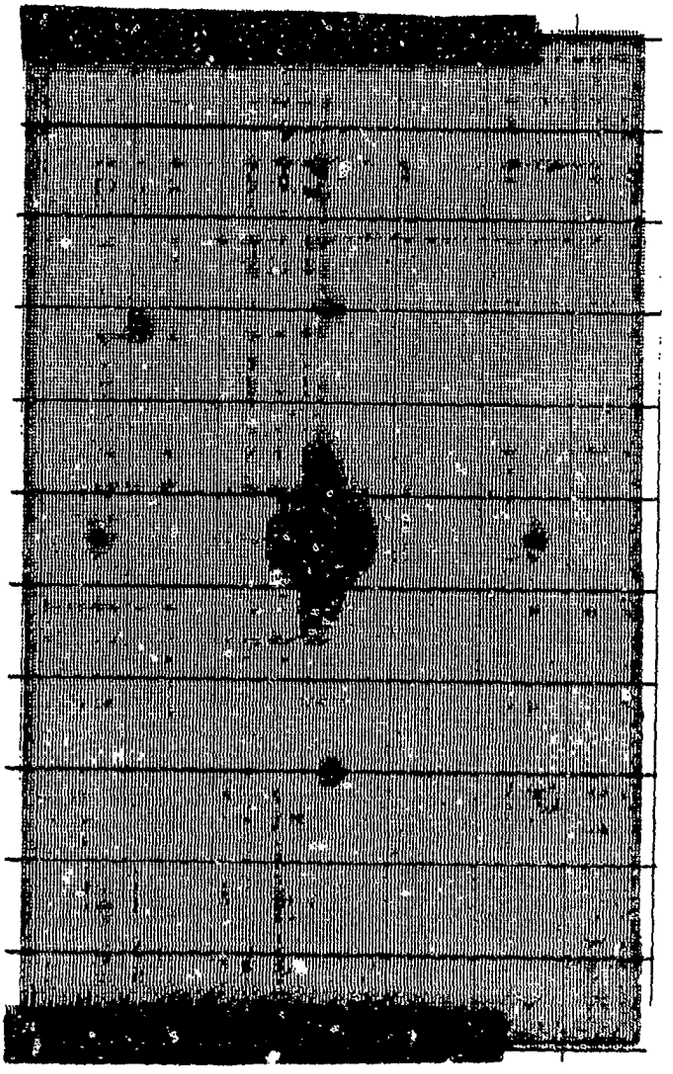
INTEGRATED TOTAL VELOCITY 181.06 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1042 UIN/IN

Figure 8-105. Panel 2-19-2 Second Impact Response Data



Specimen 2-19-2

Figure B-106. Panel 2-19-2 C-Scan

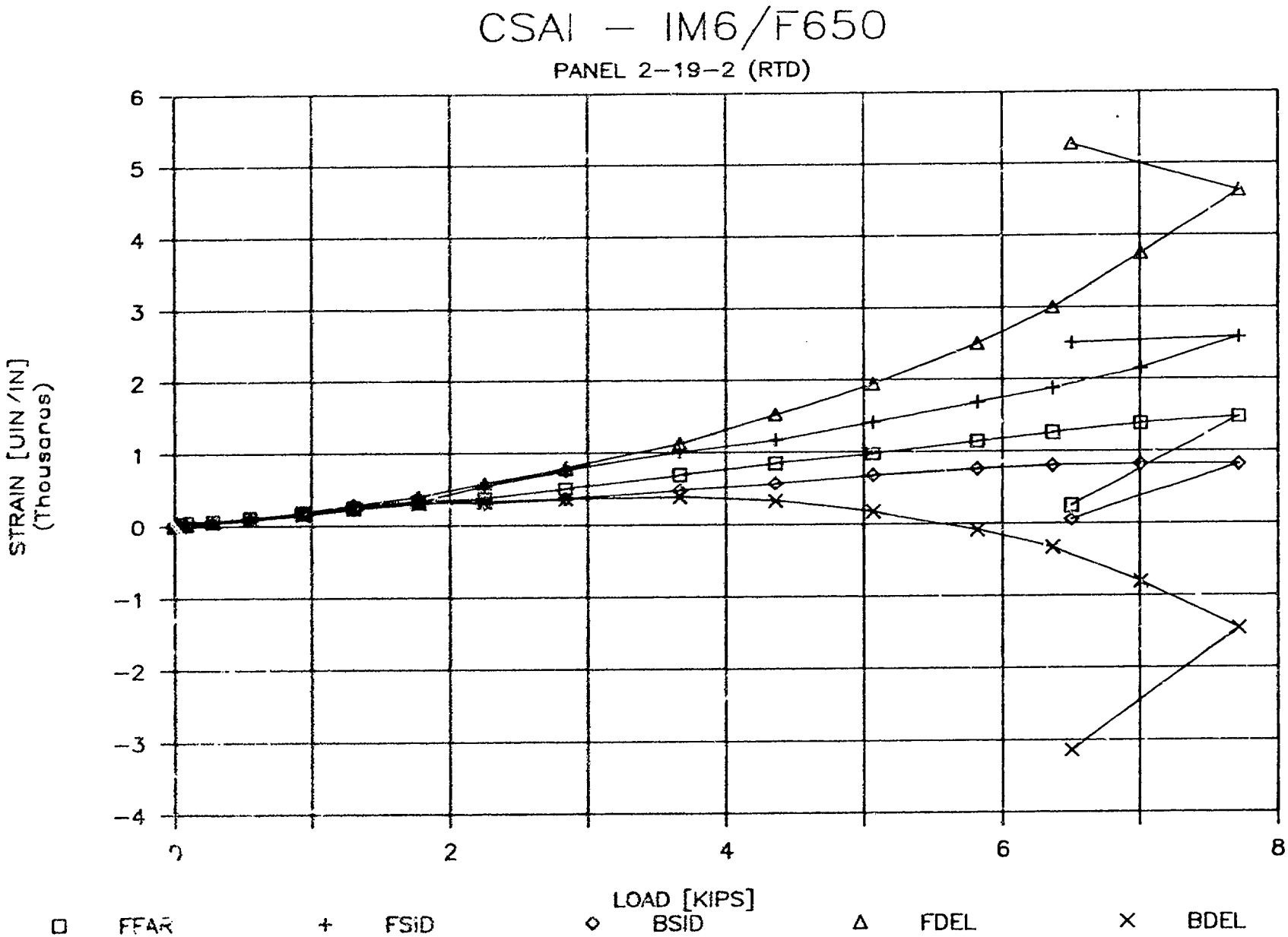


Figure B-107. Panel 2-19-2 Residual Compression Data

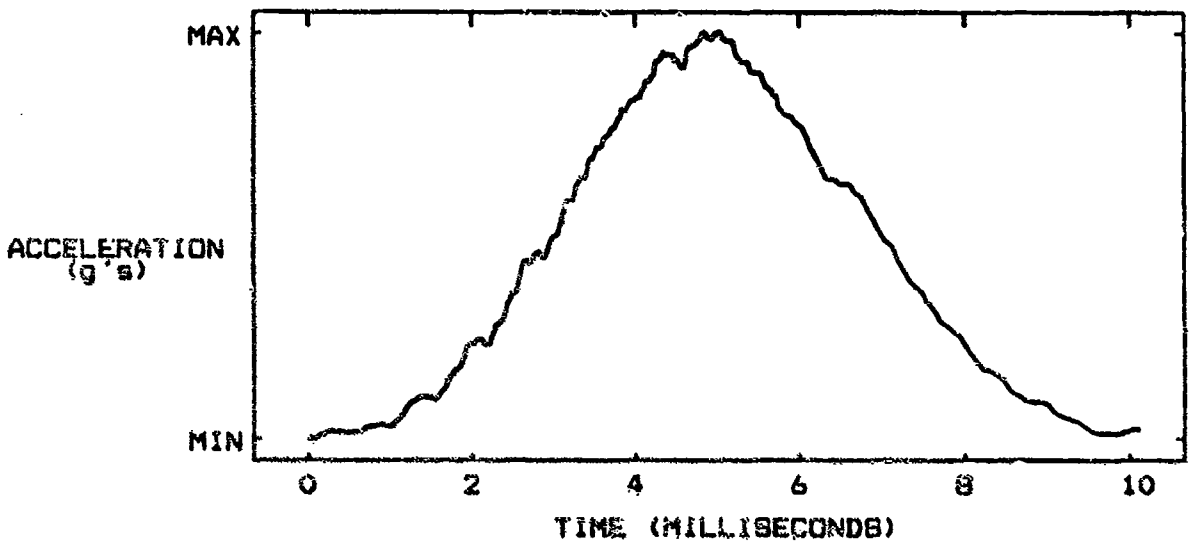
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-16-4 THICKNESS .024 IN

DROP CARRIAGE WT. 3.03 LBS DROP HEIGHT 16.7 IN

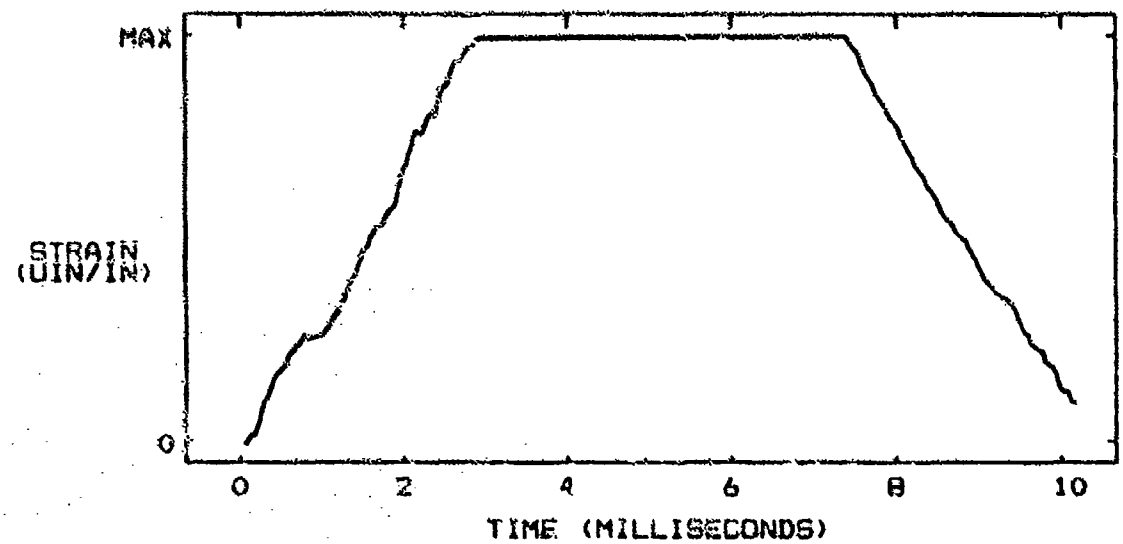
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION 0.0 g's MAXIMUM ACCELERATION 114 g's

INTEGRATED TOTAL VELOCITY 179.22 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 628.6 UIN/IN

Figure B-108. Panel 1-16-4 Impact Response Data

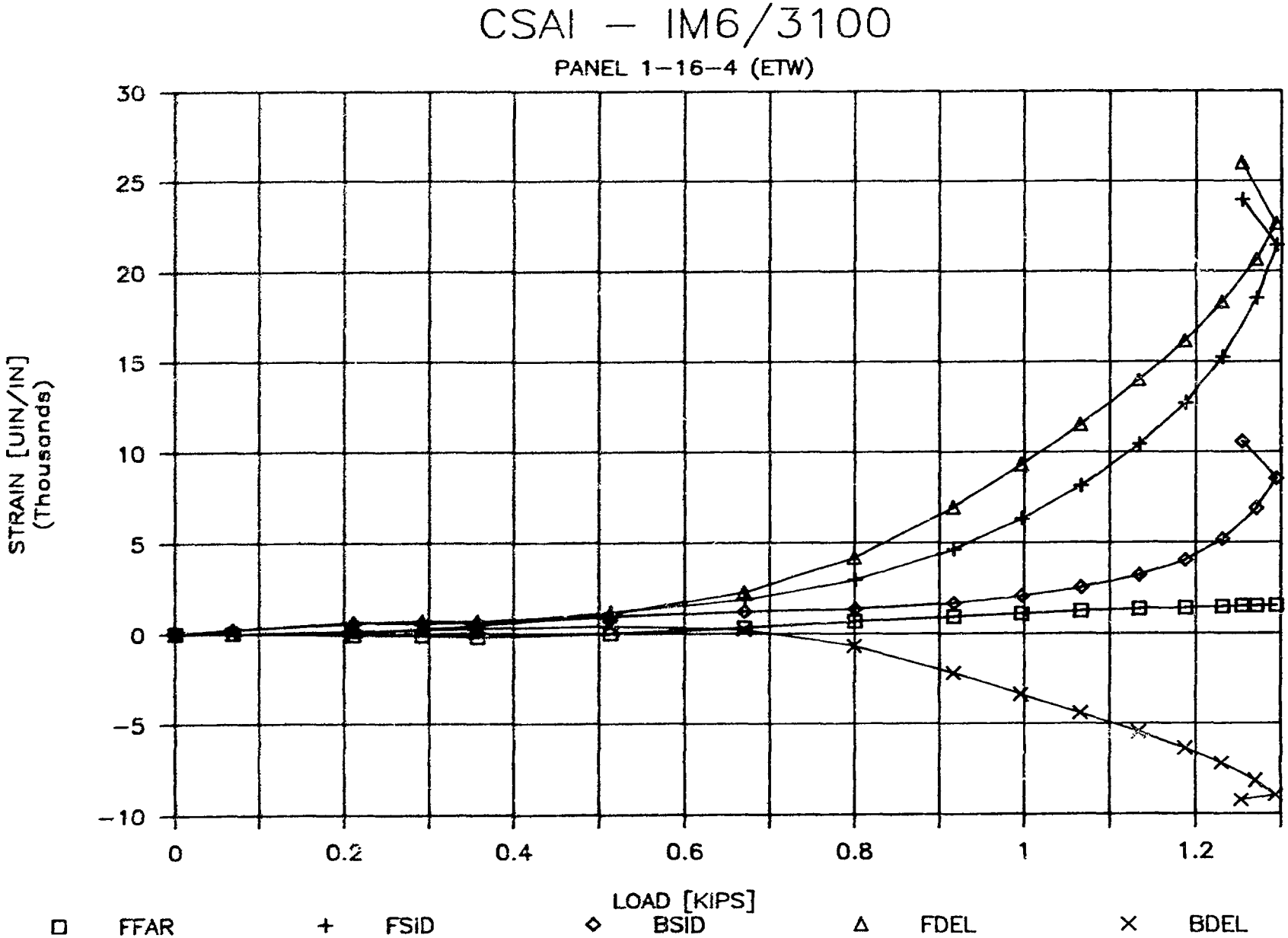


Figure B-109. Panel 1-16-4 Residual Compression Data

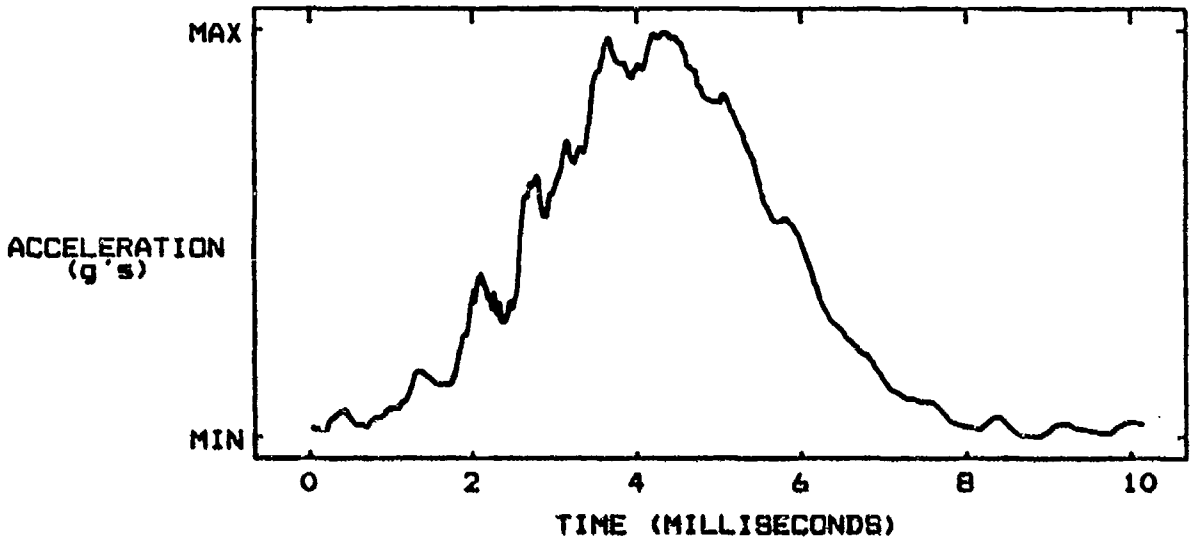
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-12A-5 THICKNESS .045 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

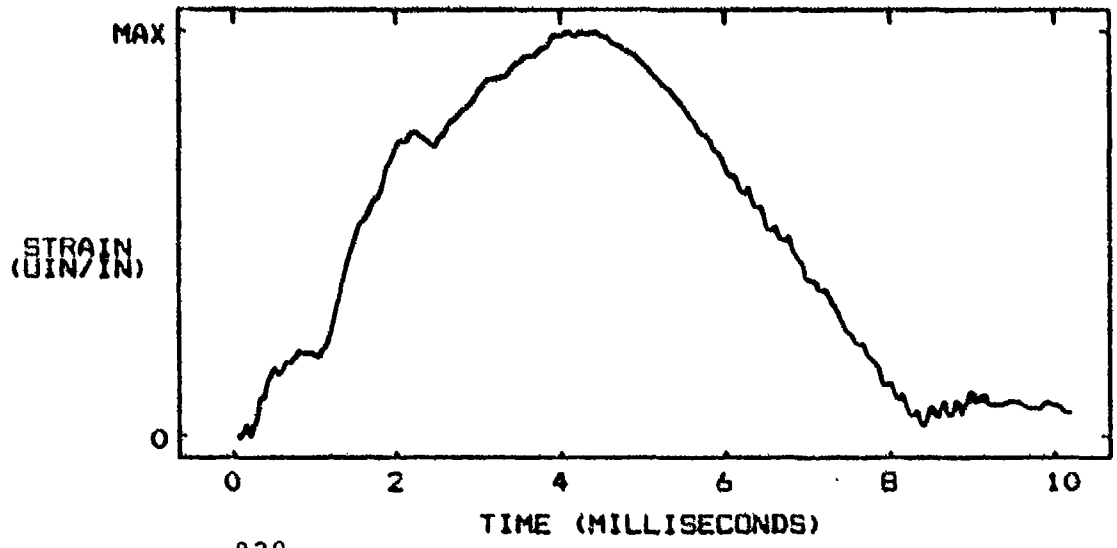
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -4.0 g's MAXIMUM ACCELERATION 151 g's

INTEGRATED TOTAL VELOCITY 187.27 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 820 UIN/IN

Figure B-110. Panel 1-12A-5 Impact Response Data

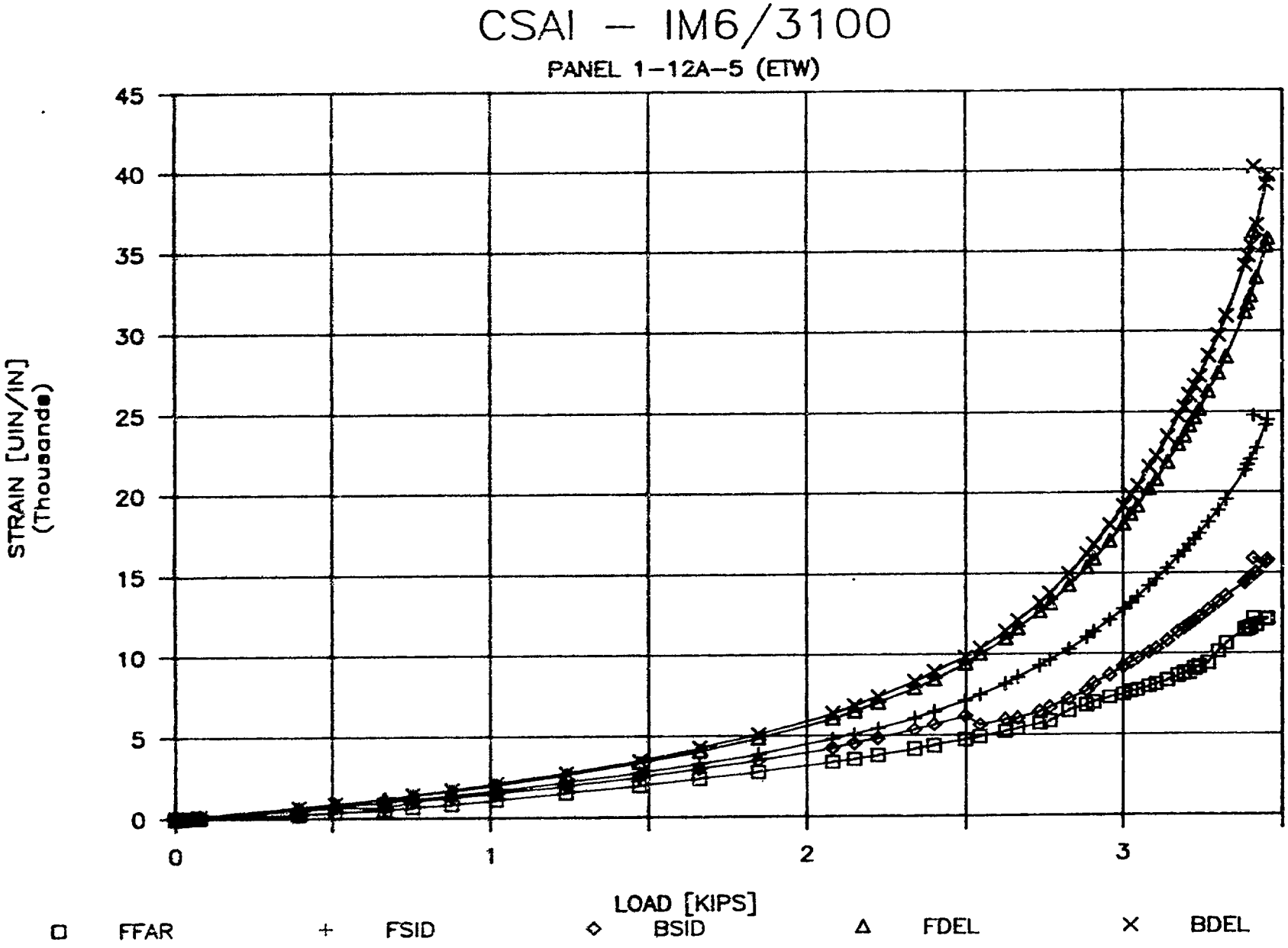


Figure B-111. Panel 1-12A-5 Residual Compression Data

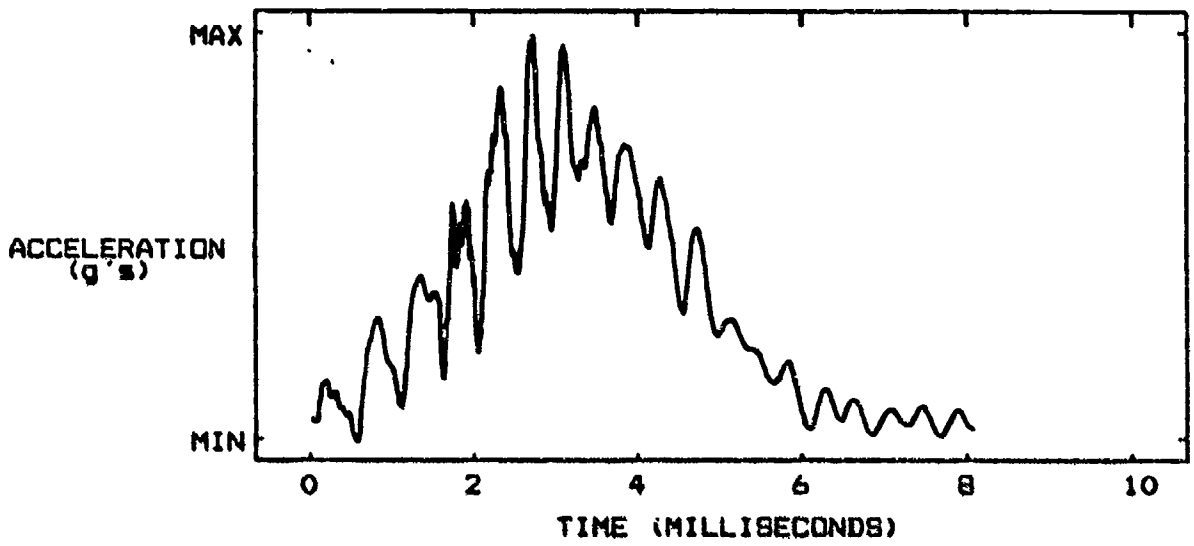
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-17-5 THICKNESS .069 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

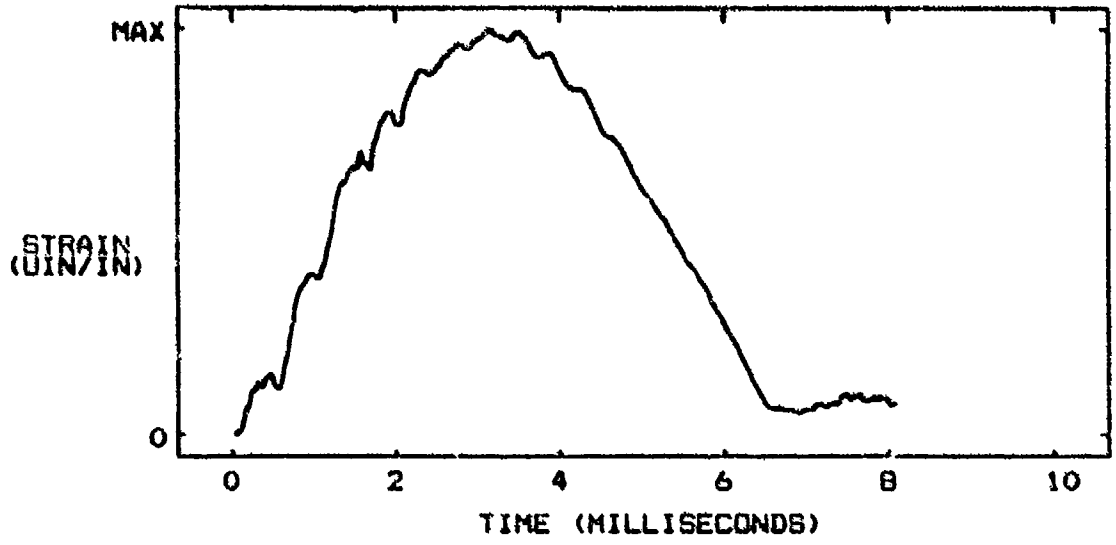
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -11.0 g's MAXIMUM ACCELERATION 197.5 g's

INTEGRATED TOTAL VELOCITY 175.41 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1102 UIN/IN

Figure B-112. Panel 1-17-5 Impact Response Data

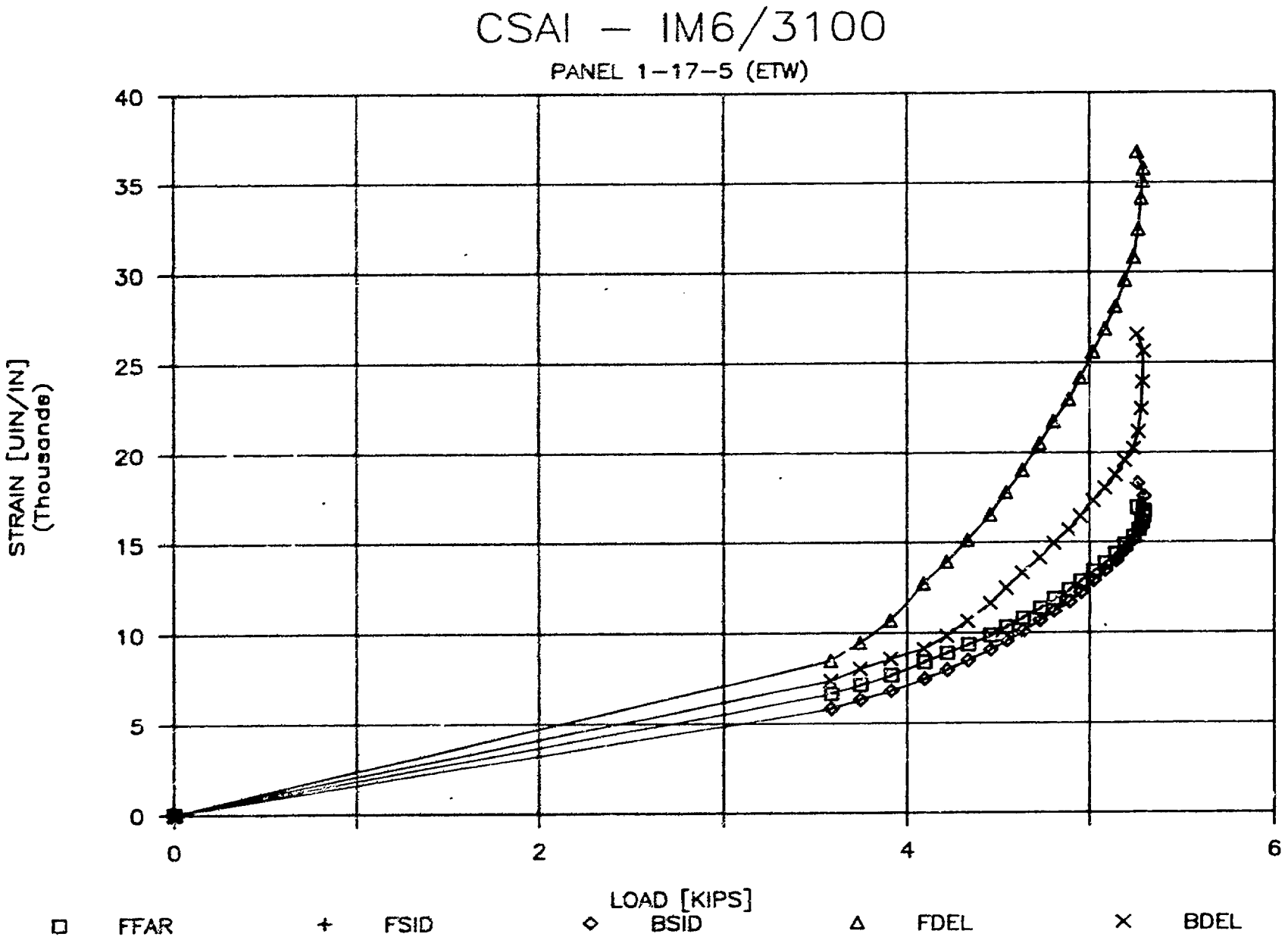


Figure B-113. Panel 1-17-5 Residual Compression Data

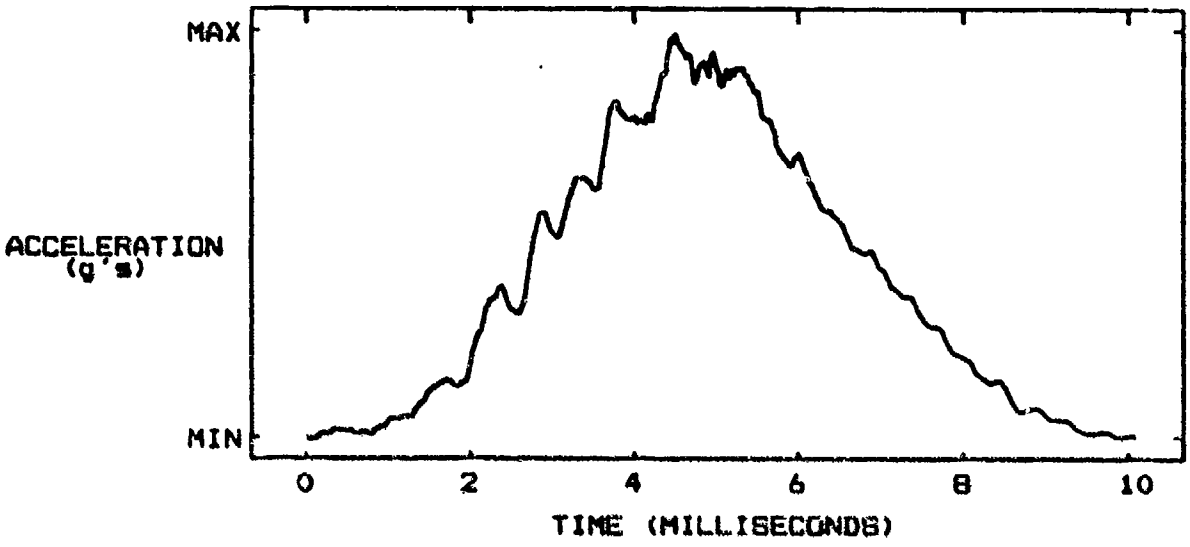
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-18-6 THICKNESS .025 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

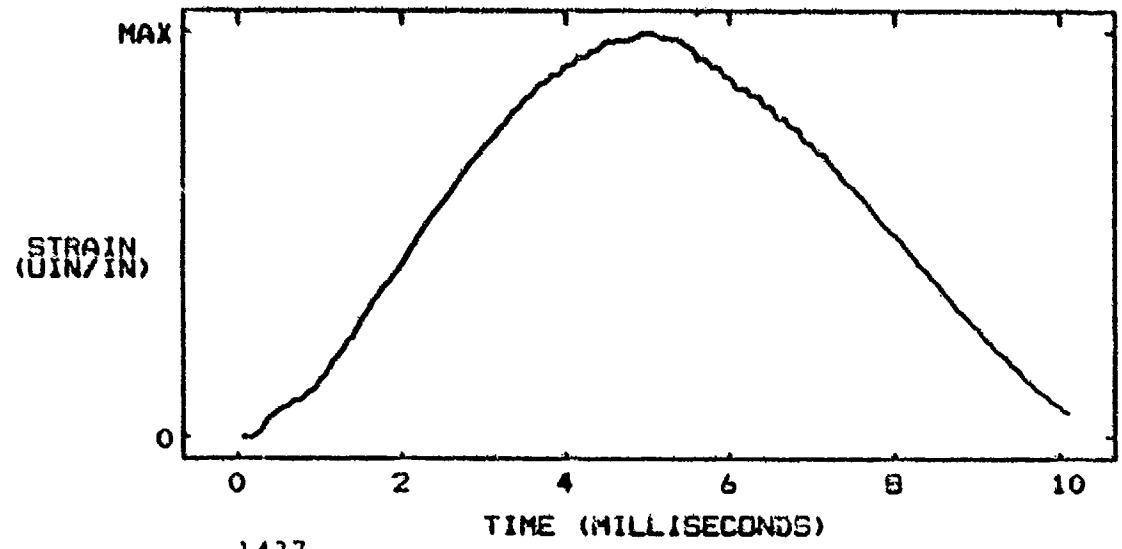
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION 0.0 g's MAXIMUM ACCELERATION 108 g's

INTEGRATED TOTAL VELOCITY 159.68 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1437 UIN/IN

Figure B-114. Panel 1-18-6 Impact Response Data

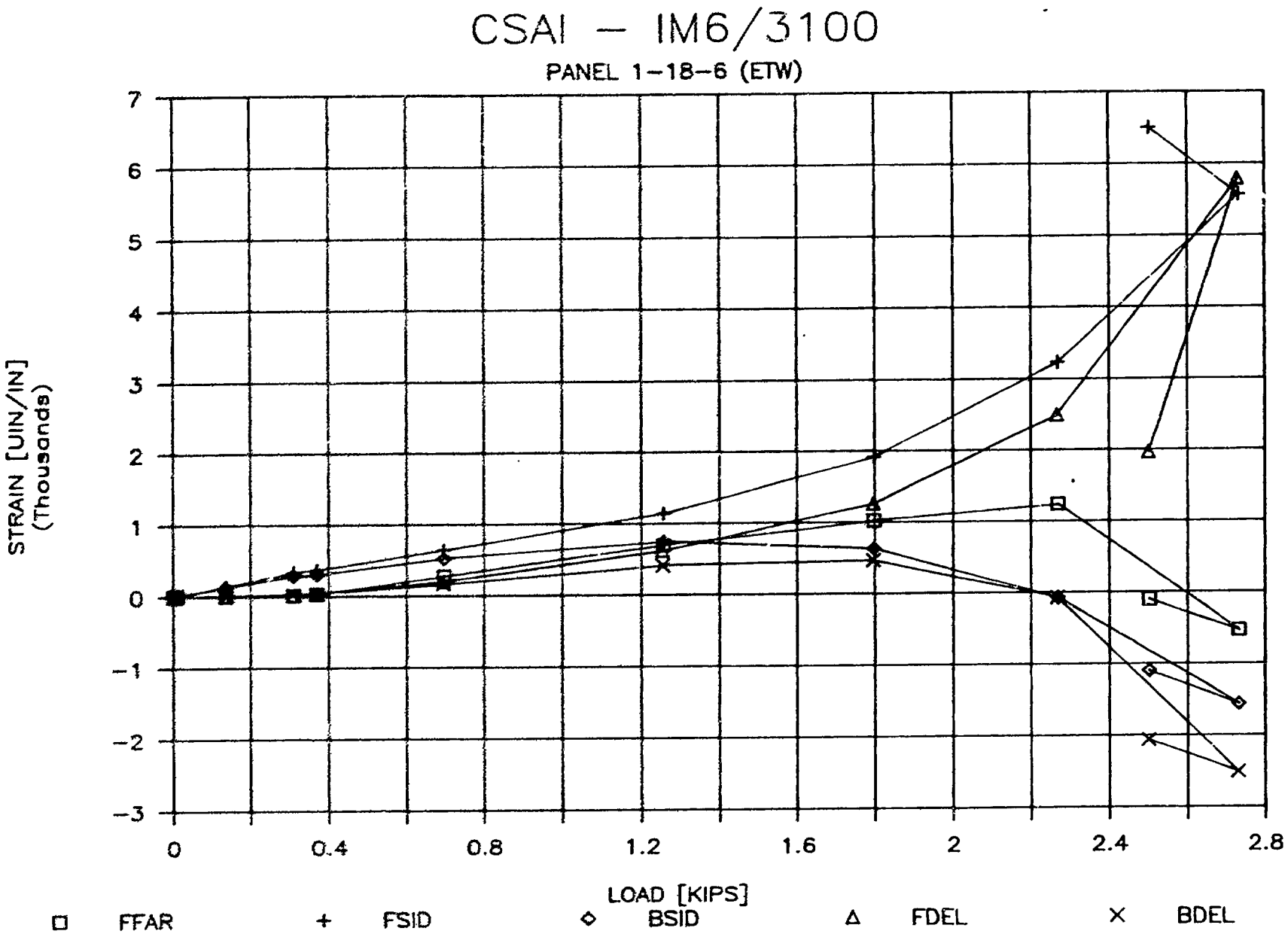


Figure B-115. Panel 1-18-6 Residual Compression Data

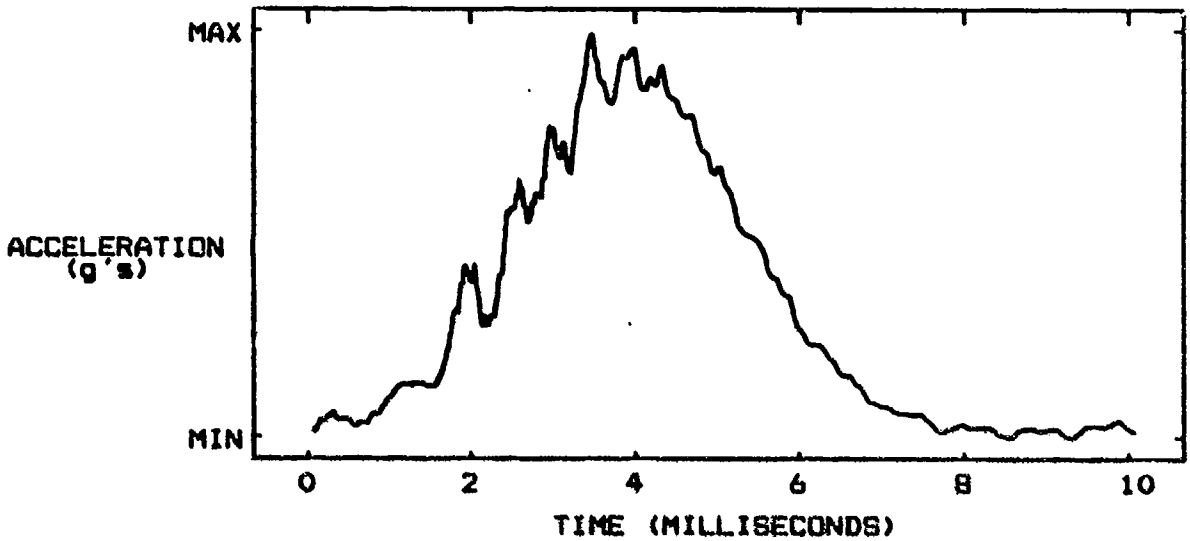
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-14A-4 THICKNESS .046 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

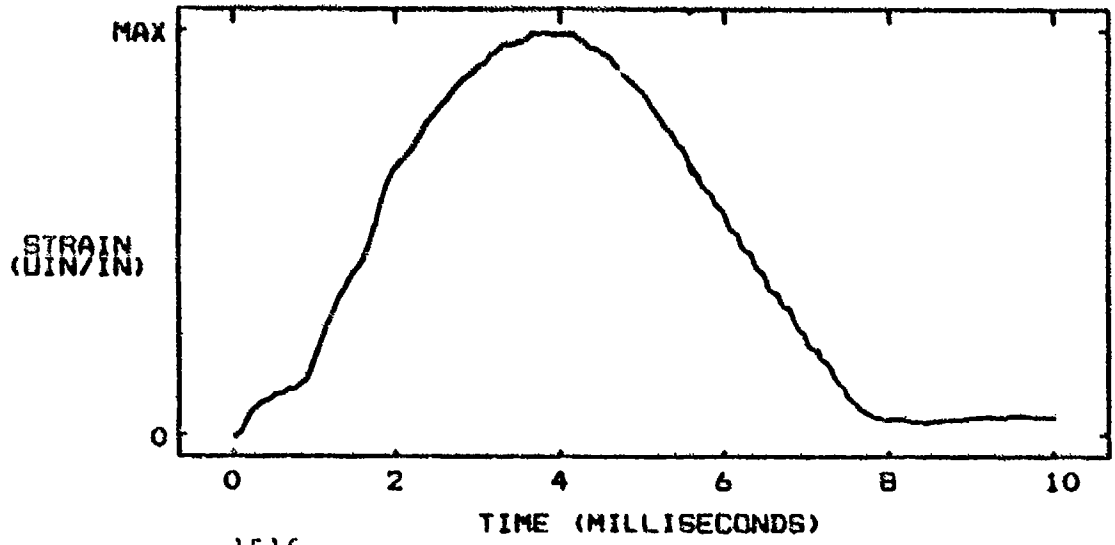
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -4.0 g's MAXIMUM ACCELERATION 160 g's

INTEGRATED TOTAL VELOCITY 183.45 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1516 UIN/IN

Figure D-116. Panel 1-14A-4 Impact Response Data

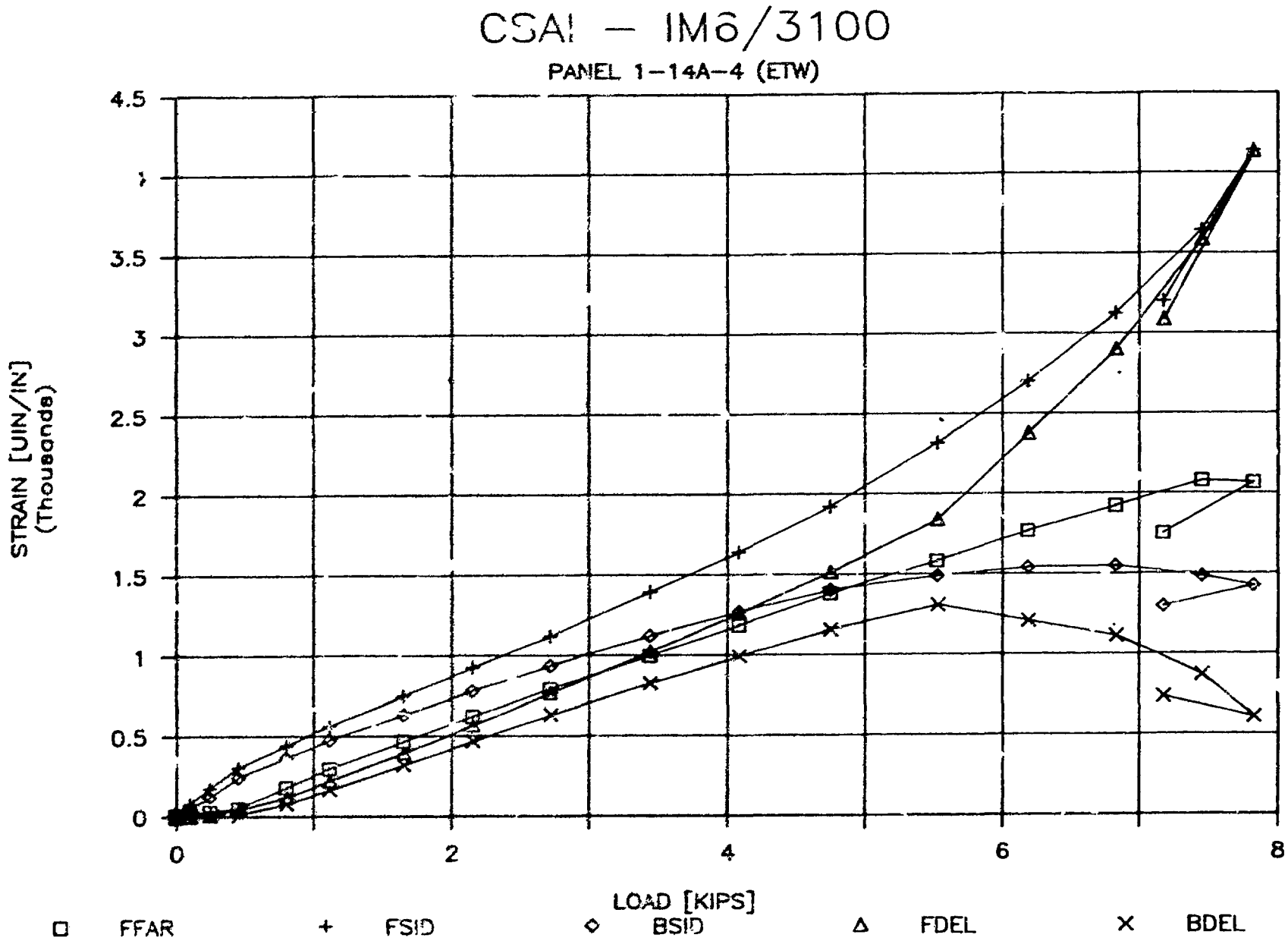


Figure B-117. Panel 1-14A-4 Residual Compression Data

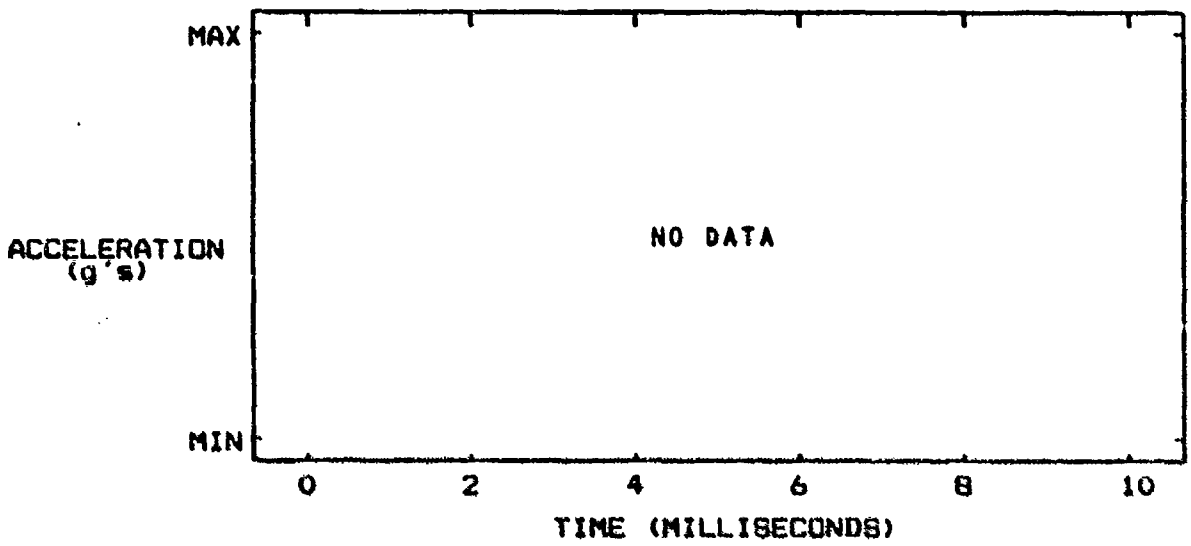
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-19-5.1 THICKNESS .065 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

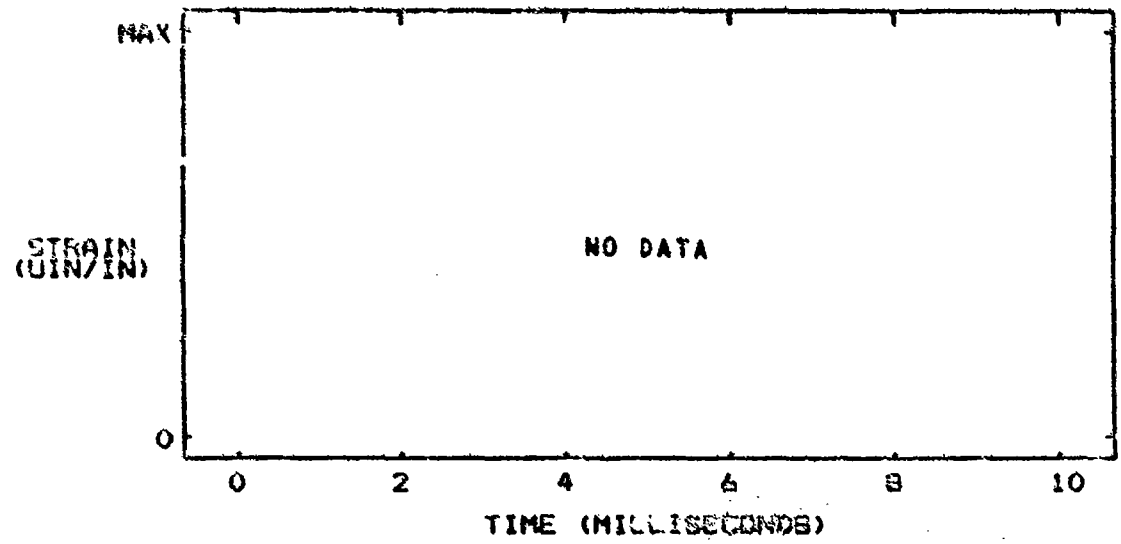
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION _____ g's MAXIMUM ACCELERATION _____ g's

INTEGRATED TOTAL VELOCITY _____ IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN _____ UIN/IN

Figure B-118. Panel 1-19-5 First Impact Response Data

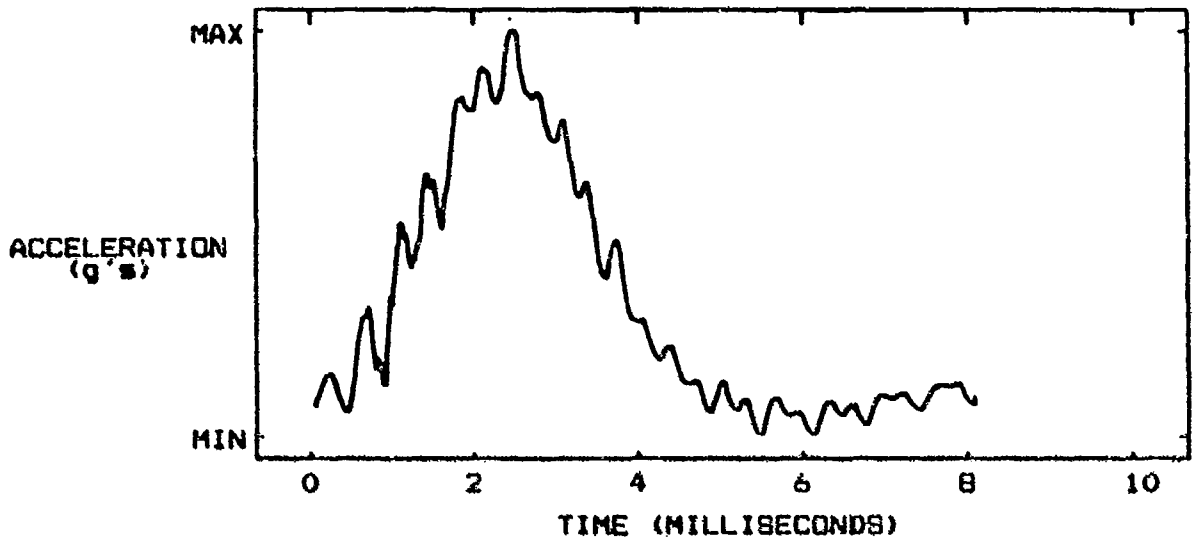
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. I-19-5.2 THICKNESS .065 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

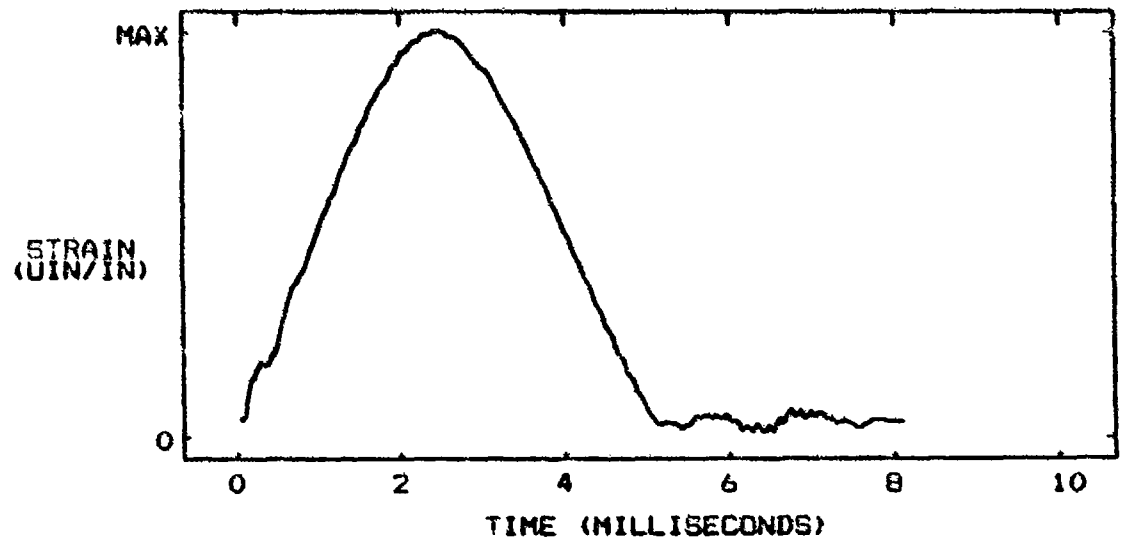
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -12.0 g's MAXIMUM ACCELERATION 147 g's

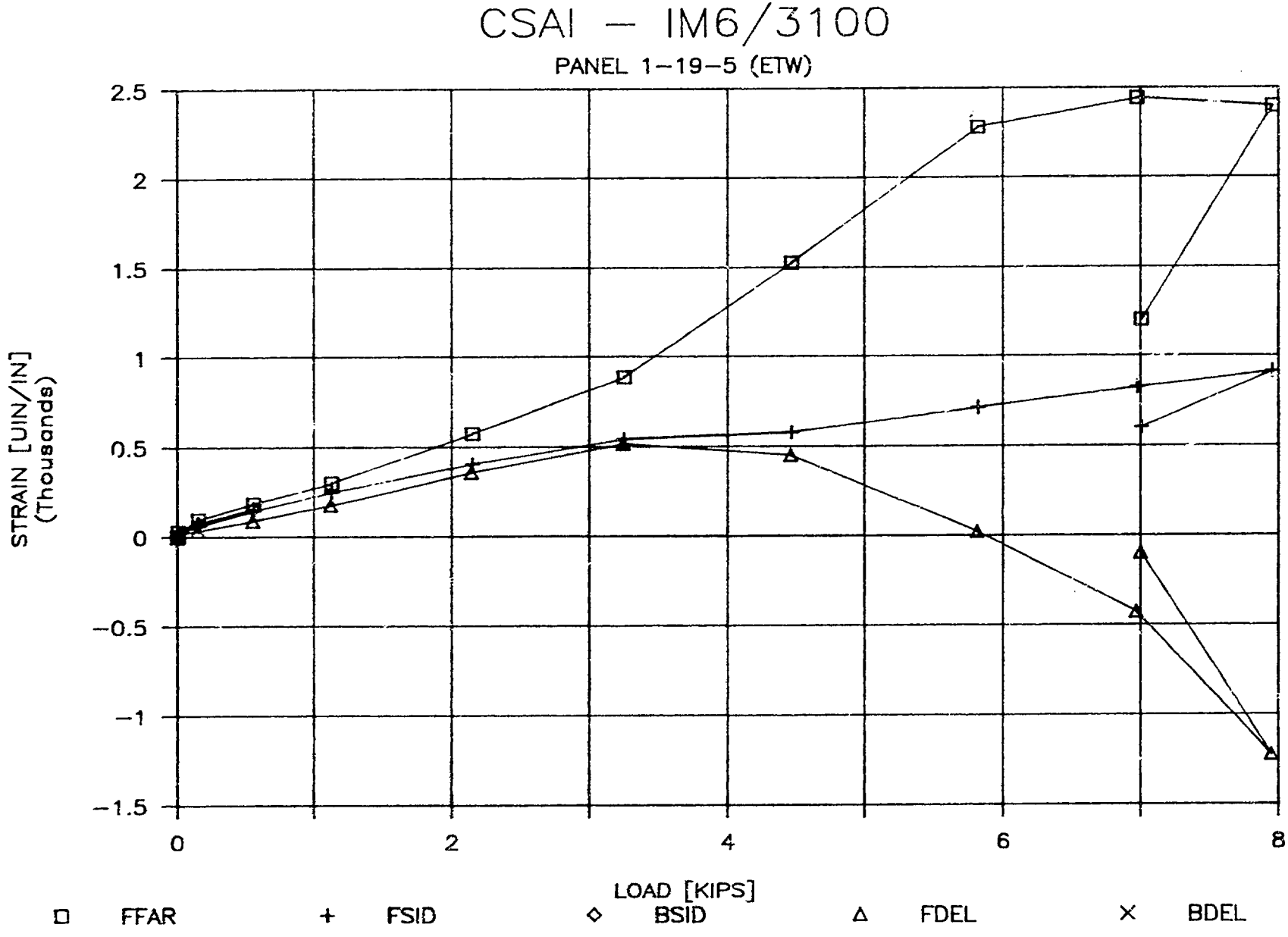
INTEGRATED TOTAL VELOCITY 146.31 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1041 UIN/IN

Figure B-119. Panel 1-19-5 Second Impact Response Data


CSAI – IM6/3100
PANEL 1–19–5 (ETW)
STRAIN [UIN/IN]
(Thousands)
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
2
4
6
8
LOAD [KIPS]
FFAR
FSID
BSID
FDEL
BDEL

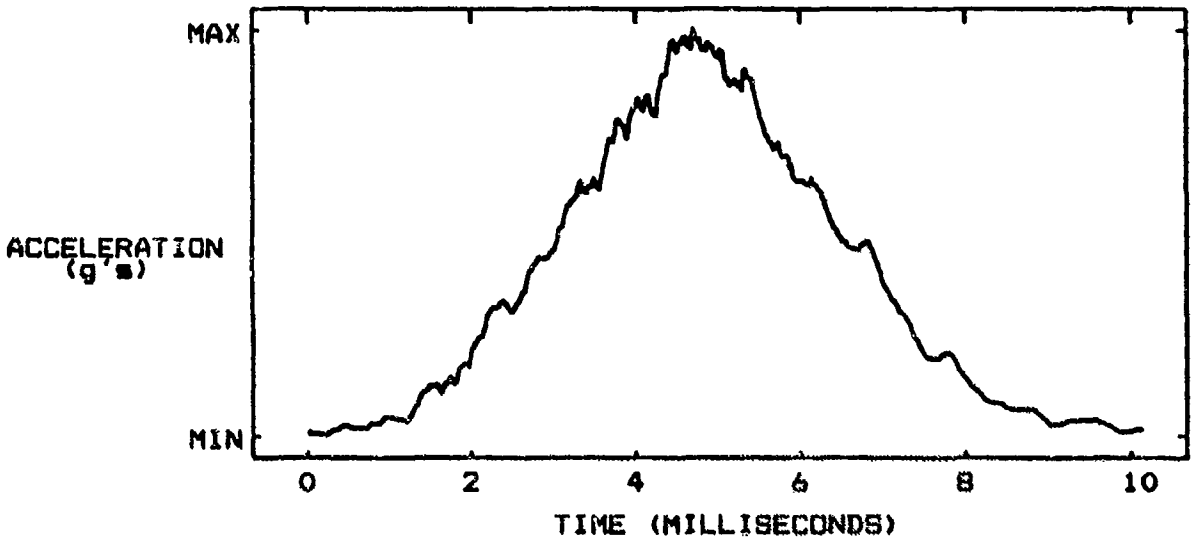
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-16-5 THICKNESS .022 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

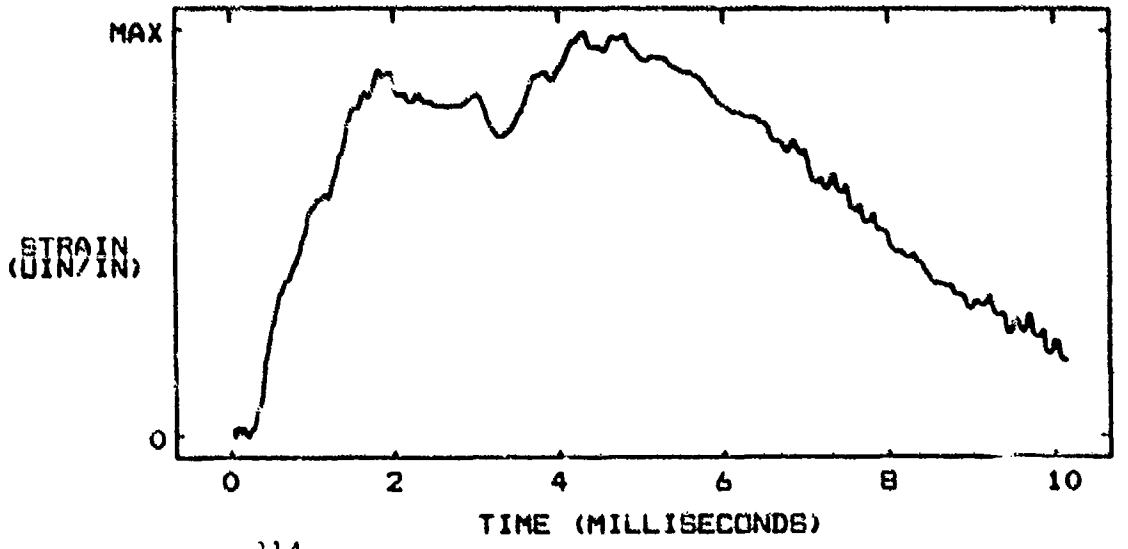
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION 0.0 g's MAXIMUM ACCELERATION 98 g's

INTEGRATED TOTAL VELOCITY 135.15 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 314 UIN/IN

Figure 8-121. Panel 2-16-5 Impact Response Data

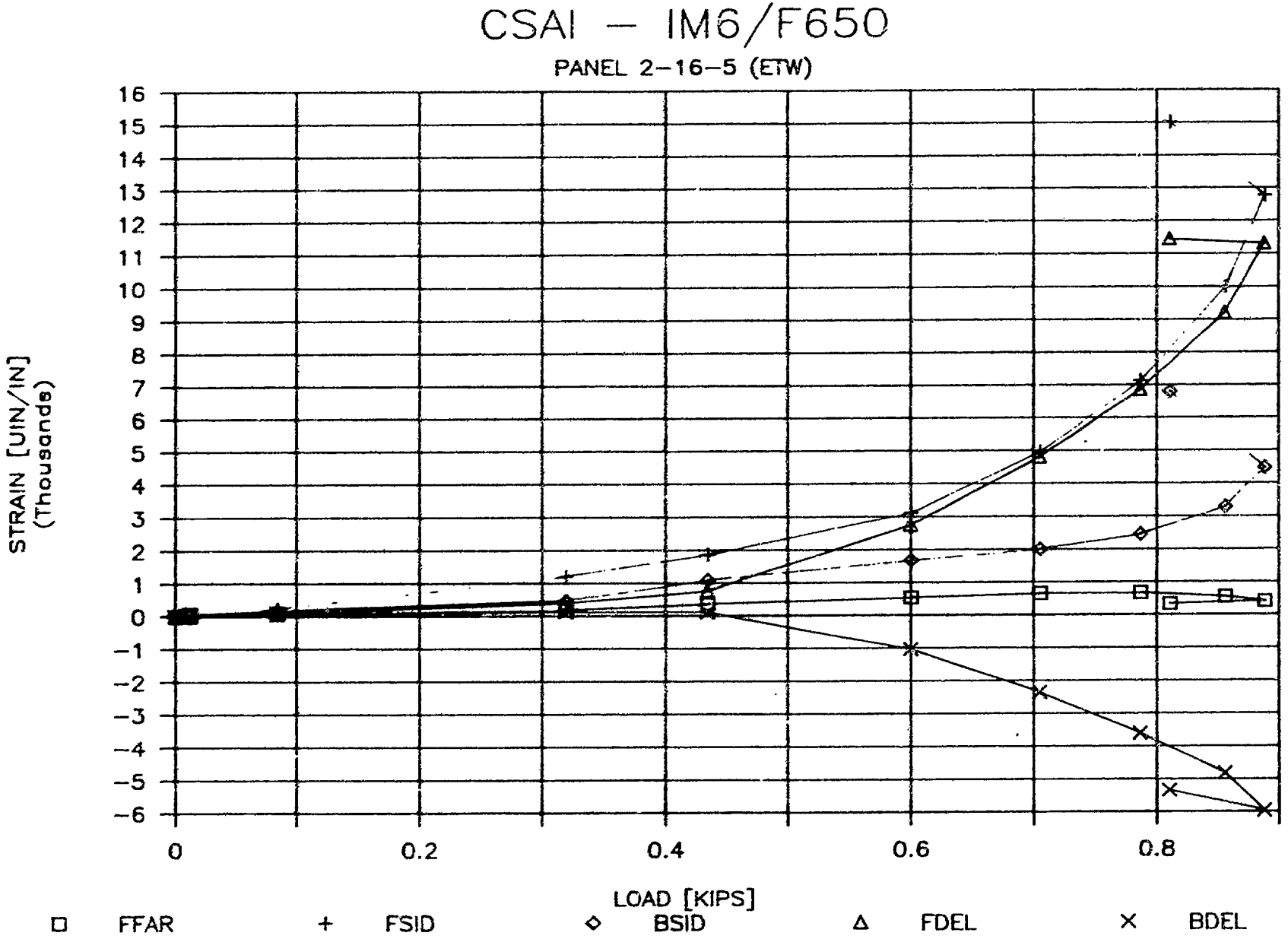


Figure B-122. Panel 2-16-5 Residual Compression Data

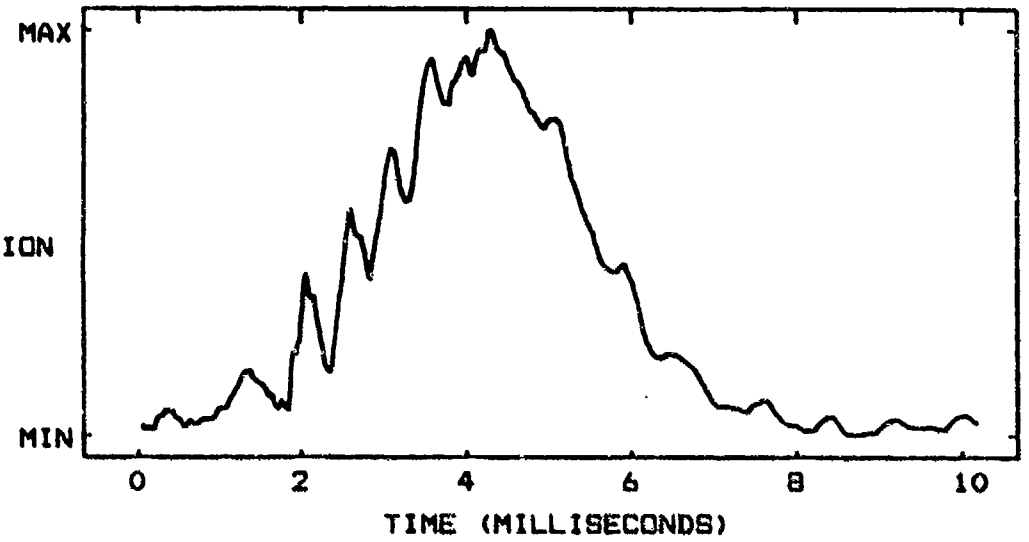
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-12A-4 THICKNESS .043 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

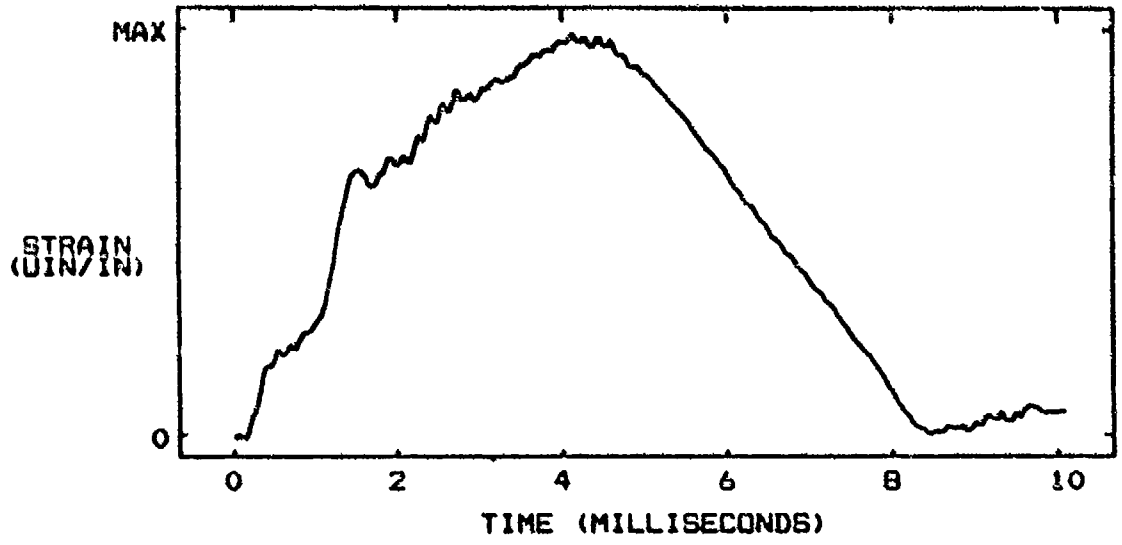
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -3.0 g's MAXIMUM ACCELERATION 140 g's

INTEGRATED TOTAL VELOCITY 154.29 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 792 UIN/IN

Figure B-123. Panel 2-12A-4 Impact Response Data

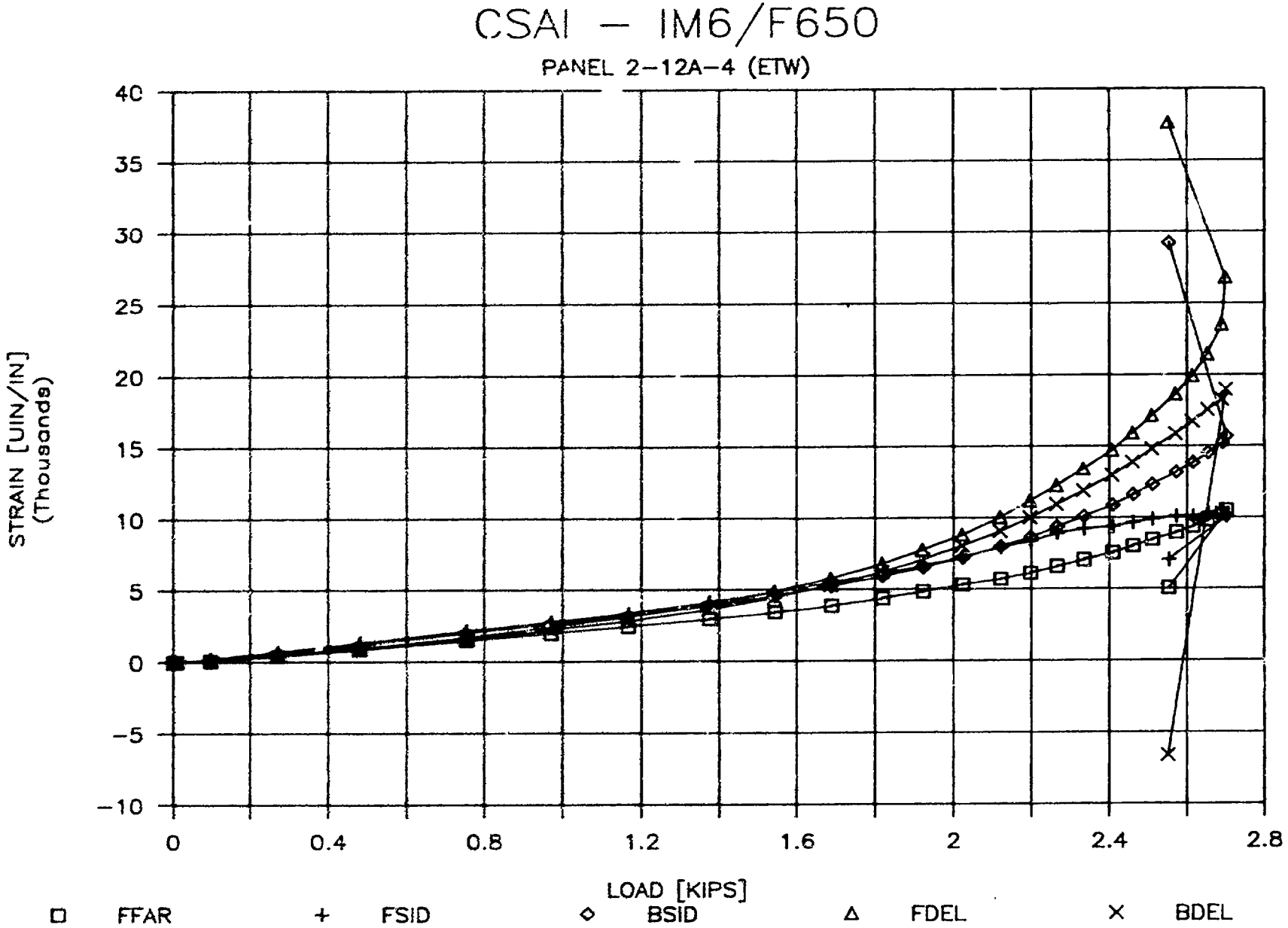


Figure B-124. Panel 2-12A-4 Residual Compression Data

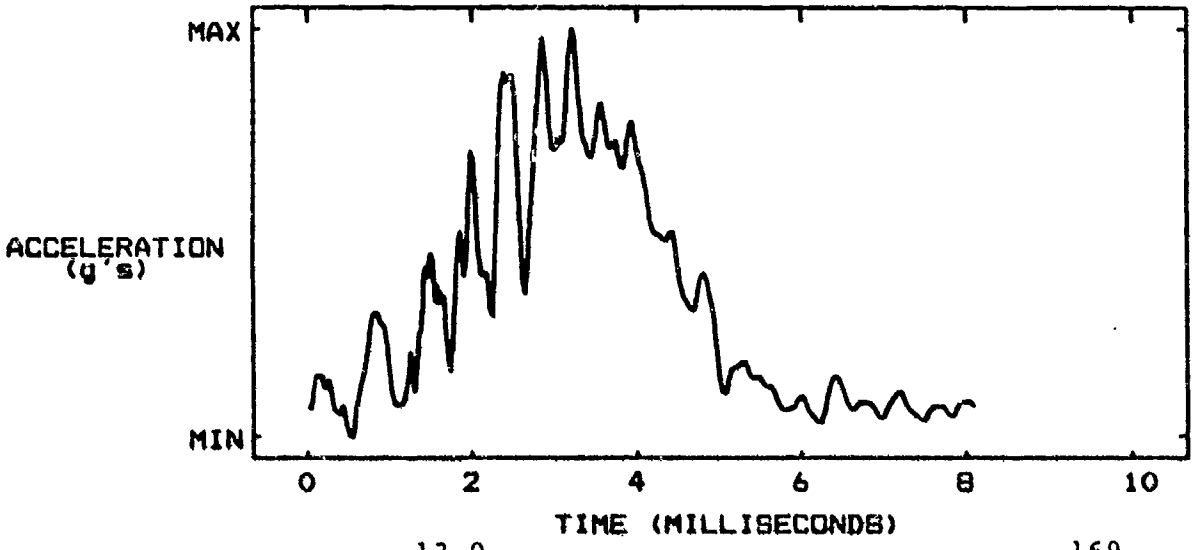
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-17-6 THICKNESS .064 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

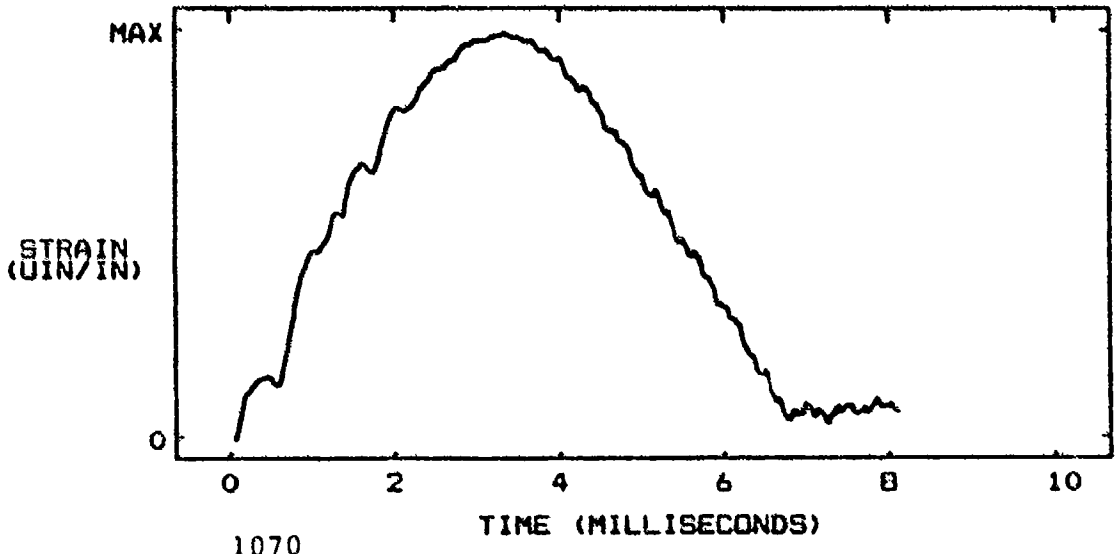
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -13.0 g's MAXIMUM ACCELERATION 169 g's

INTEGRATED TOTAL VELOCITY 136.72 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1070 UIN/IN

Figure B-125. Panel 2-17-6 Impact Response Data

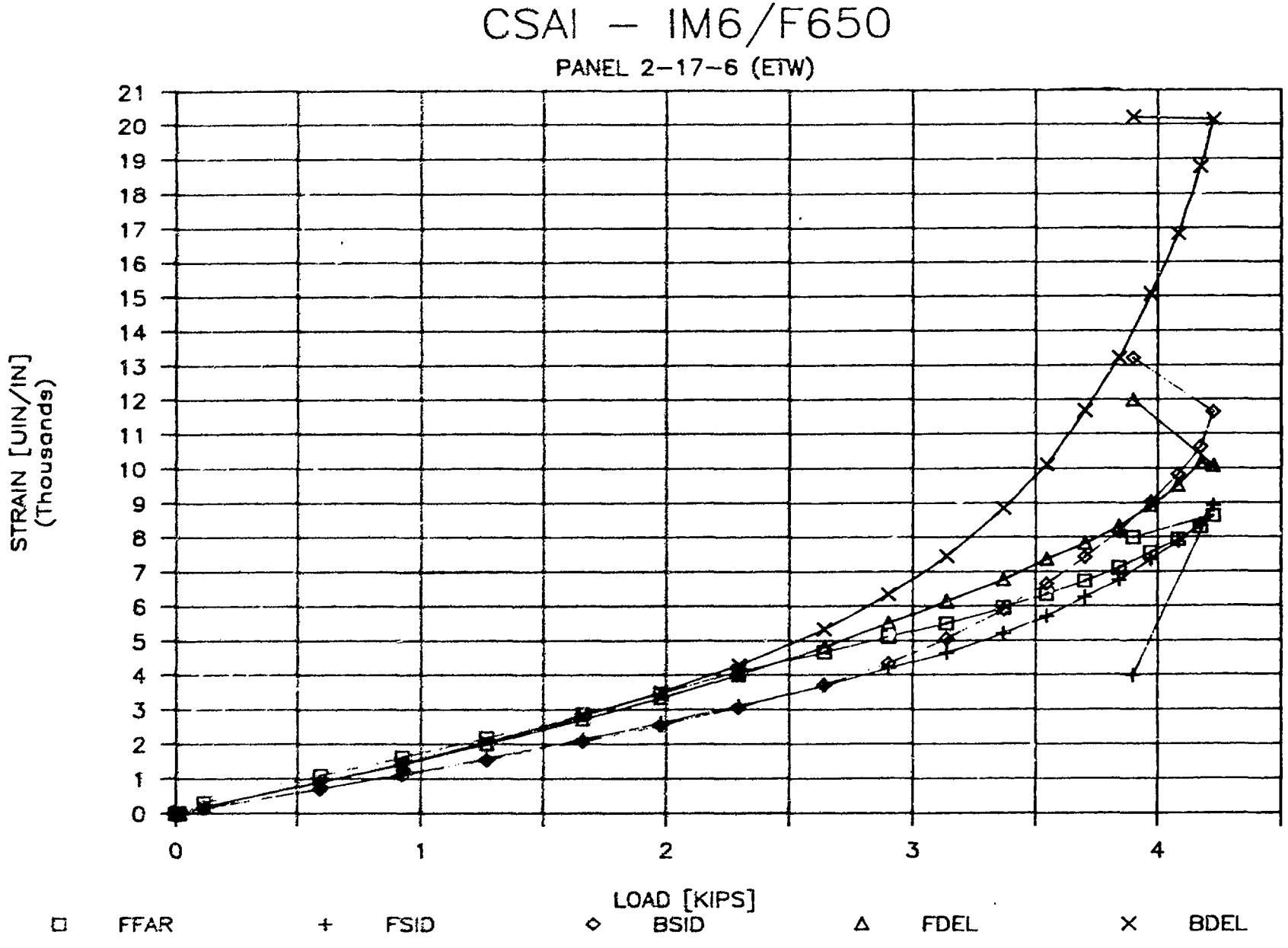


Figure B-126. Panel 2-17-6 Residual Compression Data

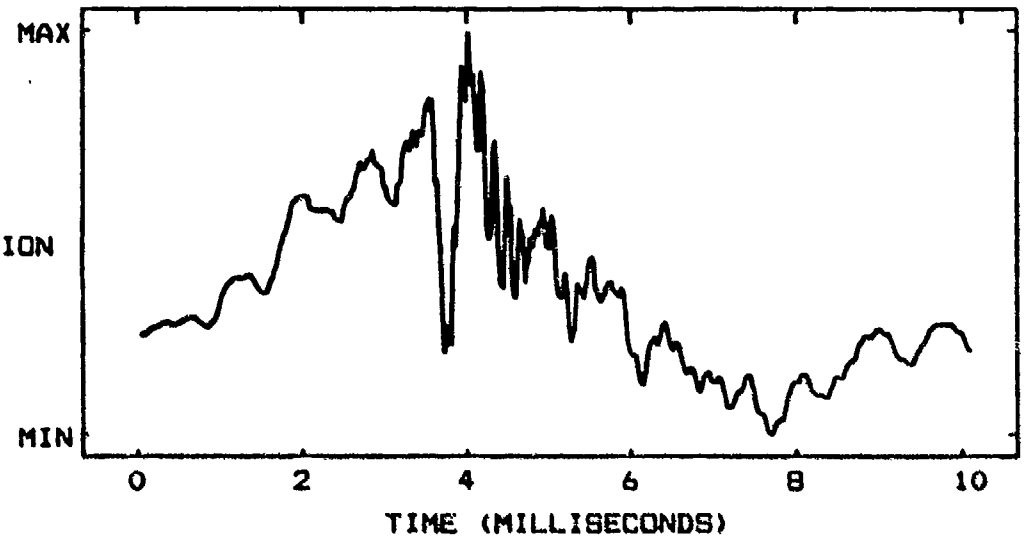
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-18-5 THICKNESS .022 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

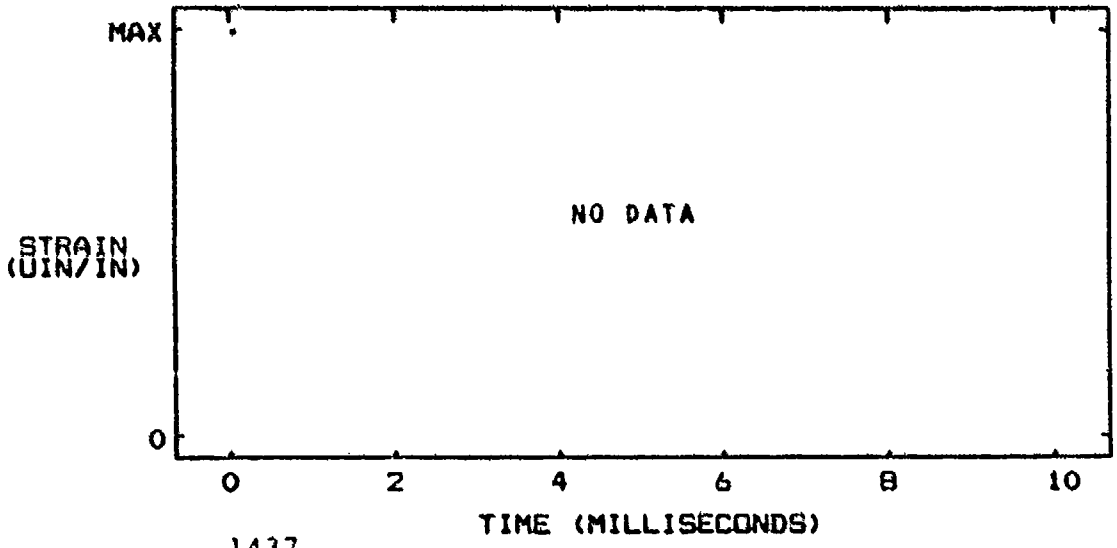
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -28.0 g's MAXIMUM ACCELERATION 88 g's

INTEGRATED TOTAL VELOCITY 61.3 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1437 UIN/IN

Figure B-127. Panel 2-18-5 Impact Response Data

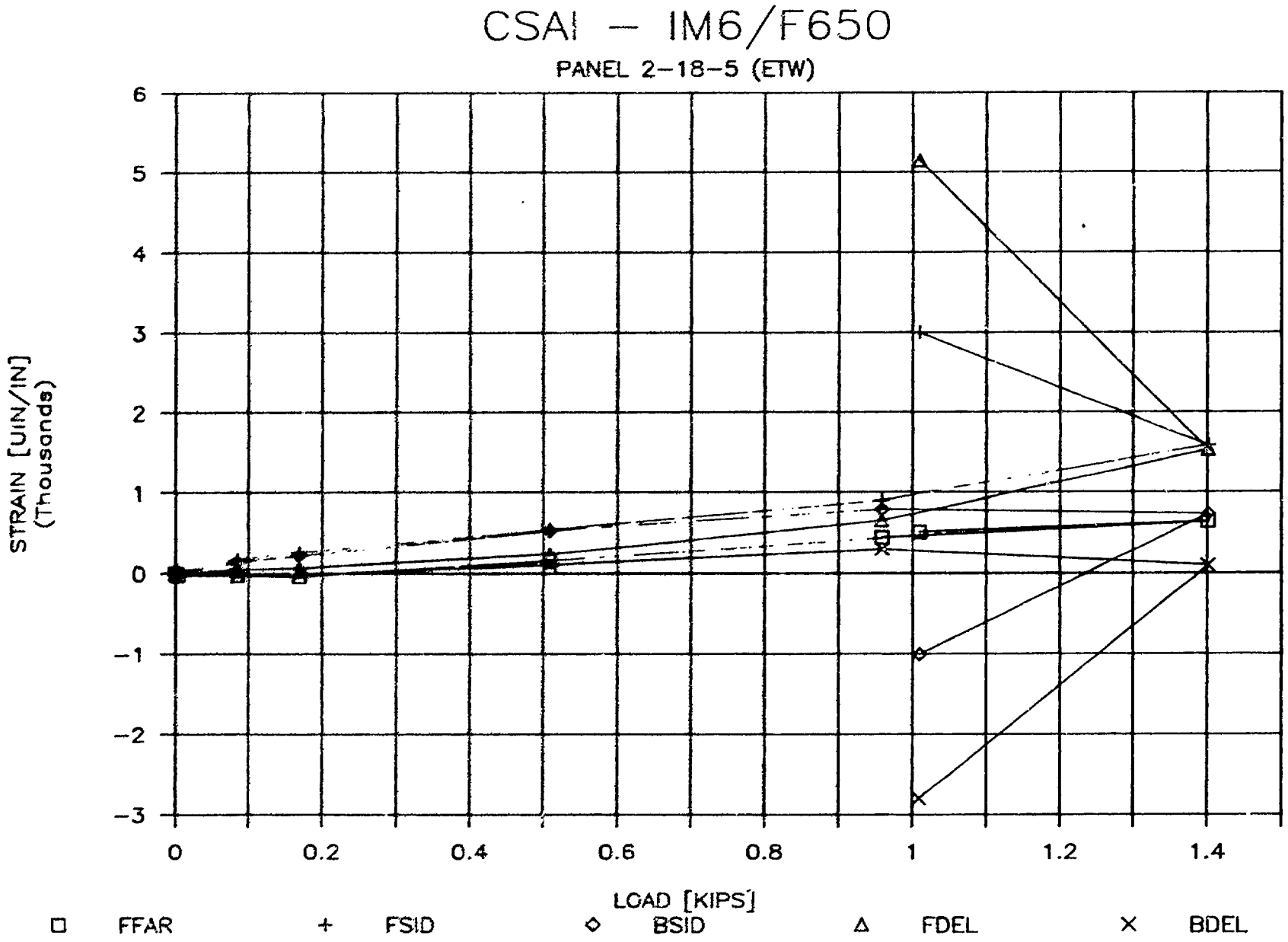


Figure B-128. Panel 2-18-5 Residual Compression Data

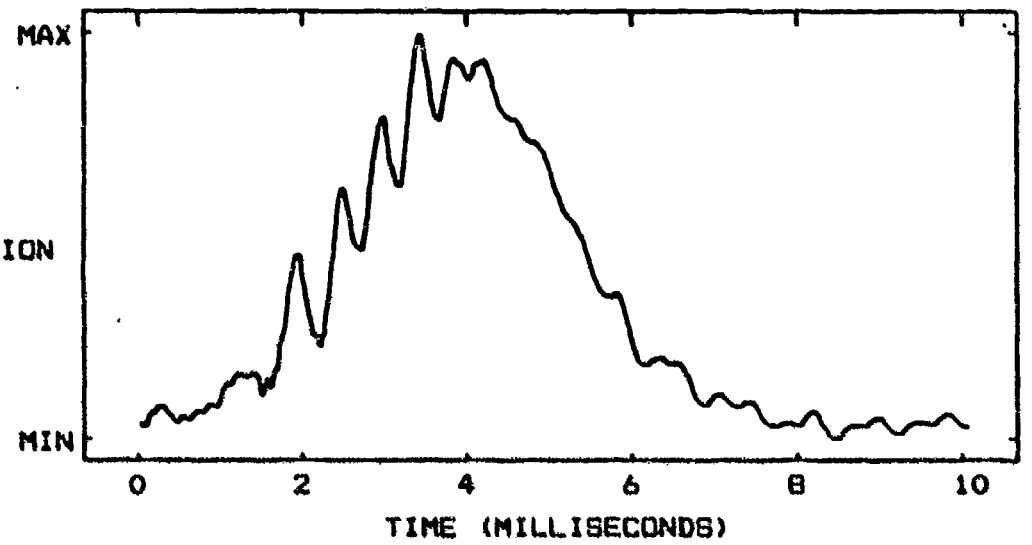
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14A-5.1 THICKNESS .044 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

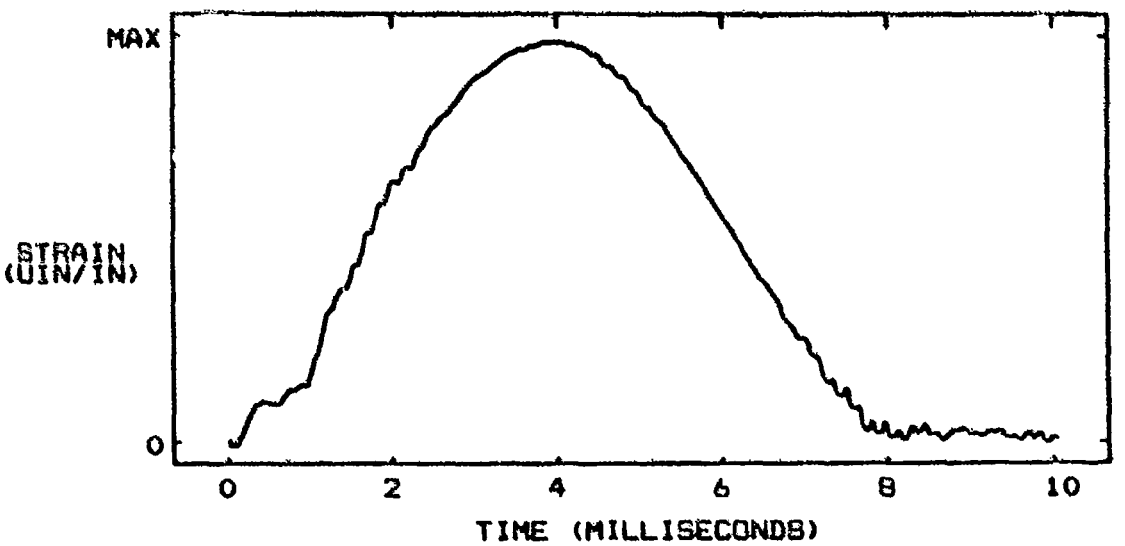
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -6.0 g's MAXIMUM ACCELERATION 149 g's

INTEGRATED TOTAL VELOCITY 166.05 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1165 UIN/IN

Figure B-129. Panel 2-14A-5 First Impact Response Data

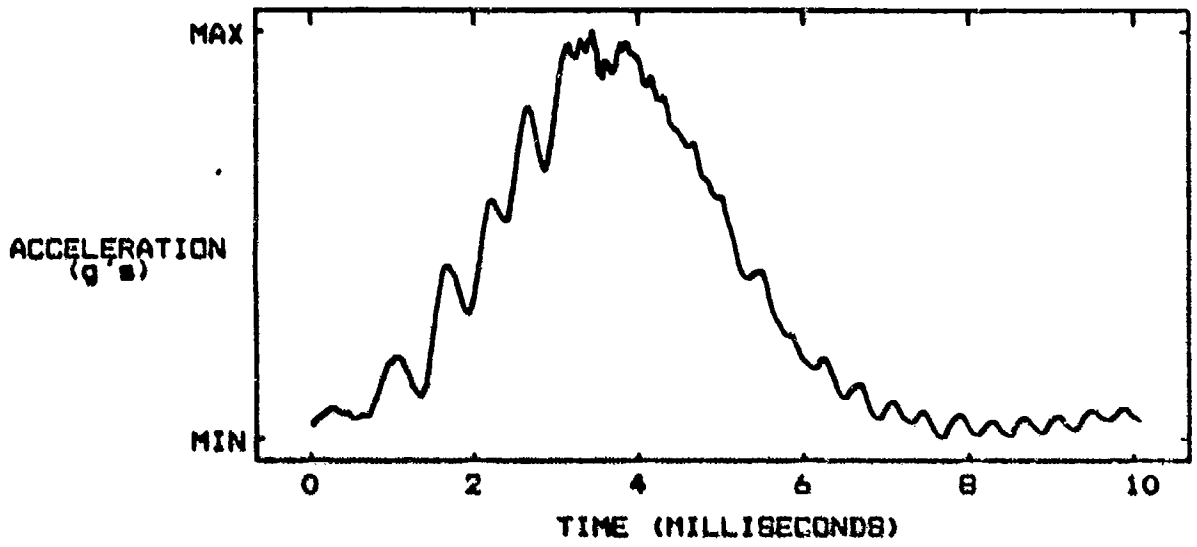
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14A-5.2 THICKNESS .044 IN

DROP CARRIAGE WT. 3.83 LBS DROP HEIGHT 16.7 IN

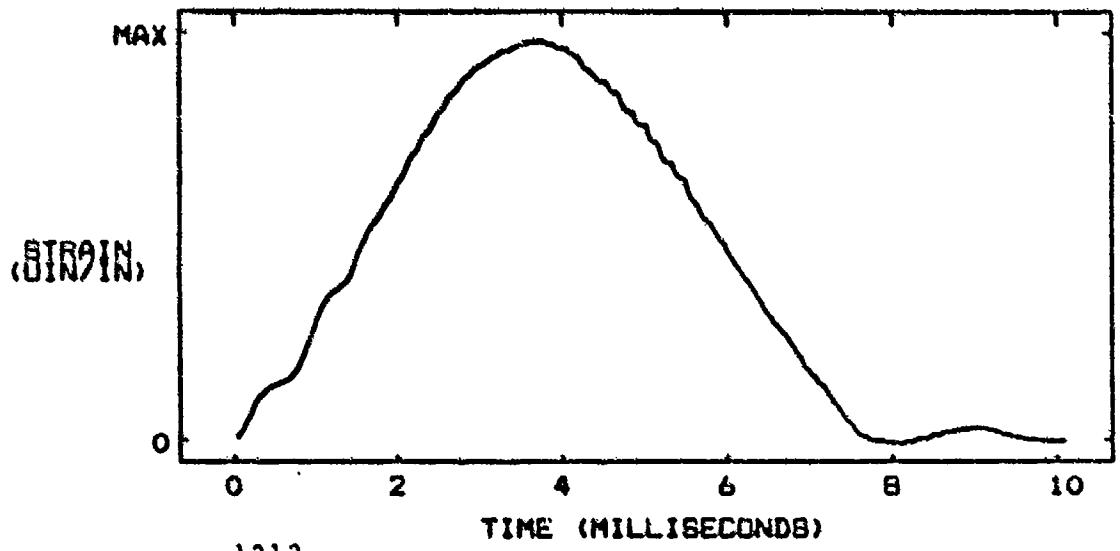
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -5.0 g's MAXIMUM ACCELERATION 154 g's

INTEGRATED TOTAL VELOCITY 178.27 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1212 UIN/IN

Figure 8-130. Panel 2-14A-5 Second Impact Response Data

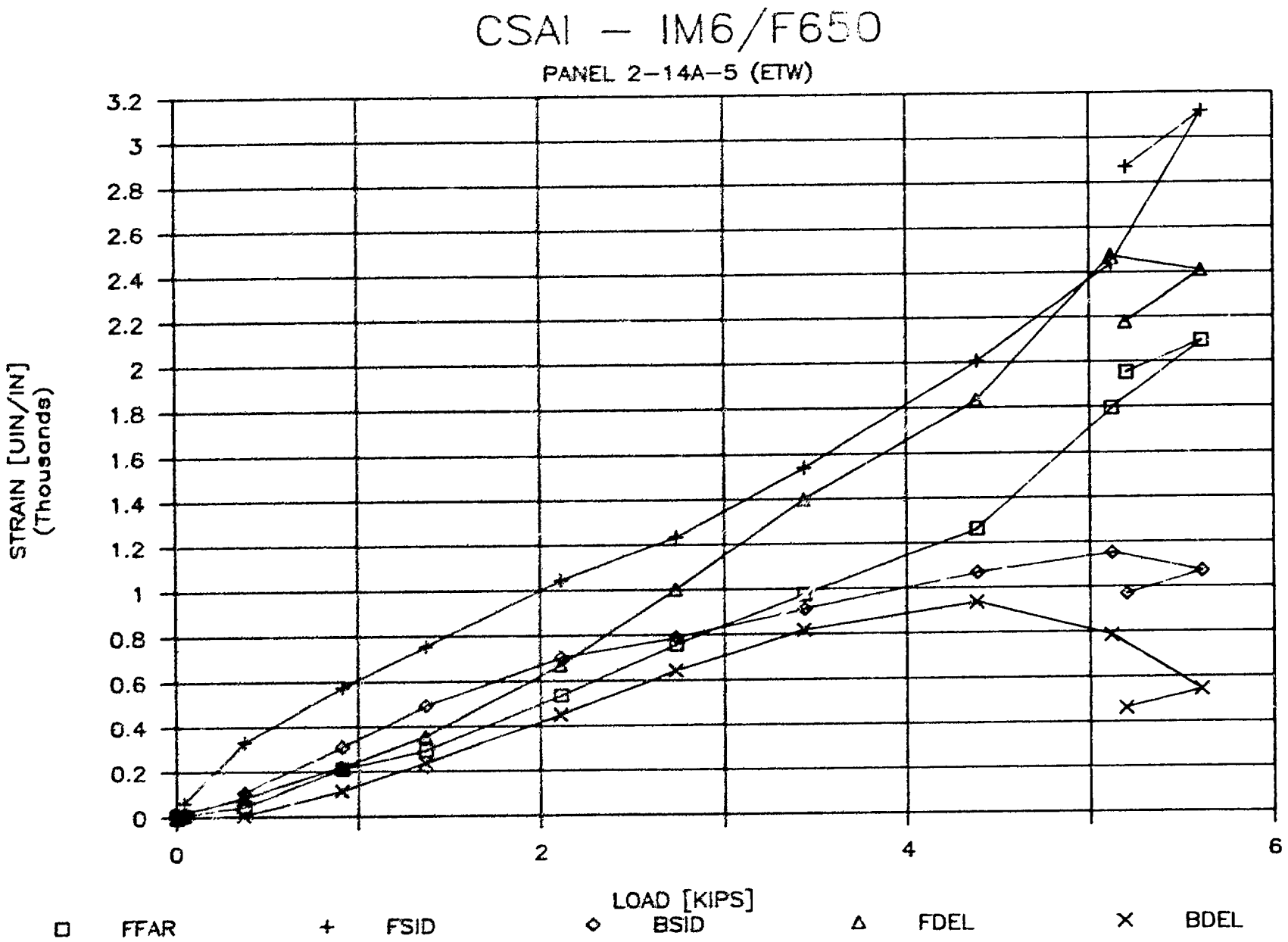


Figure B-131. Panel 2-14A-5 Residual Compression Data

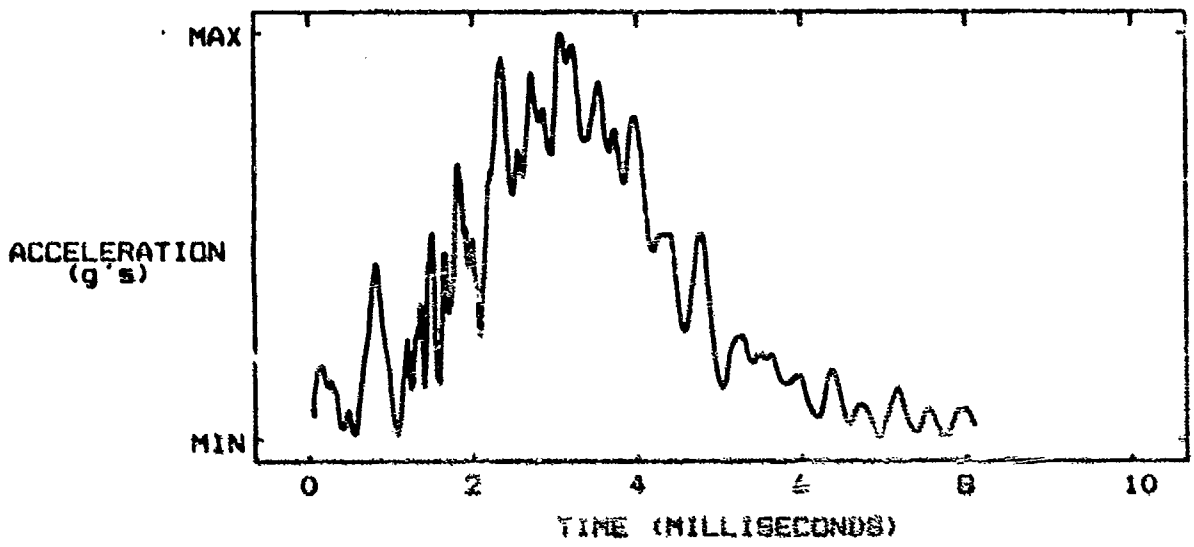
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F630

SPECIMEN I.D. 2-19-6 THICKNESS .062 IN

DROP CARRIAGE WT. 3.83 LBR DROP HEIGHT 16.7 IN

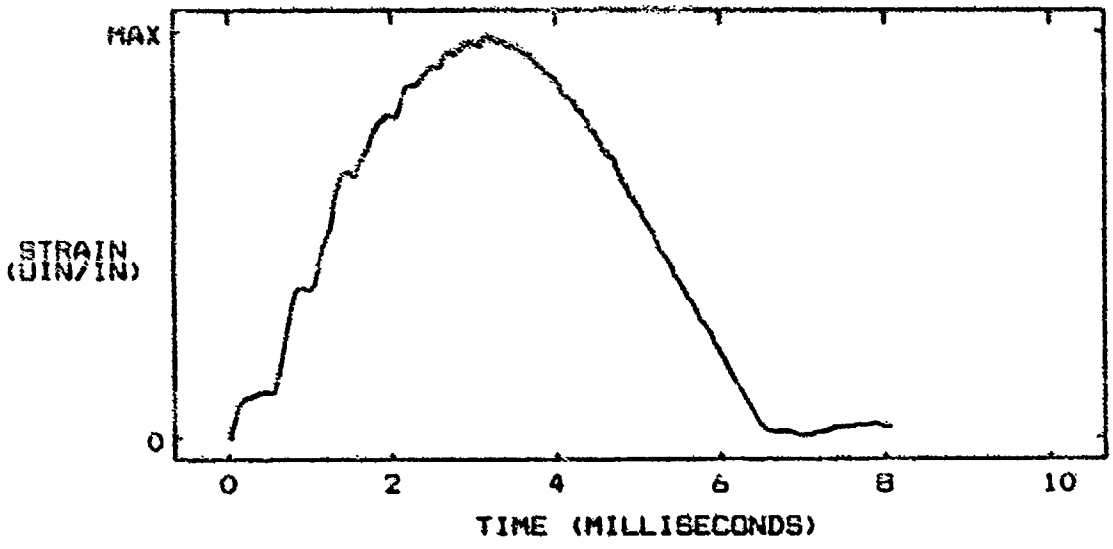
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -8.0 g's MAXIMUM ACCELERATION 146 g's

INTEGRATED TOTAL VELOCITY 132.04 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 1110 UIN/IN

Figure B-132. Panel 2-19-6 Impact Response Data

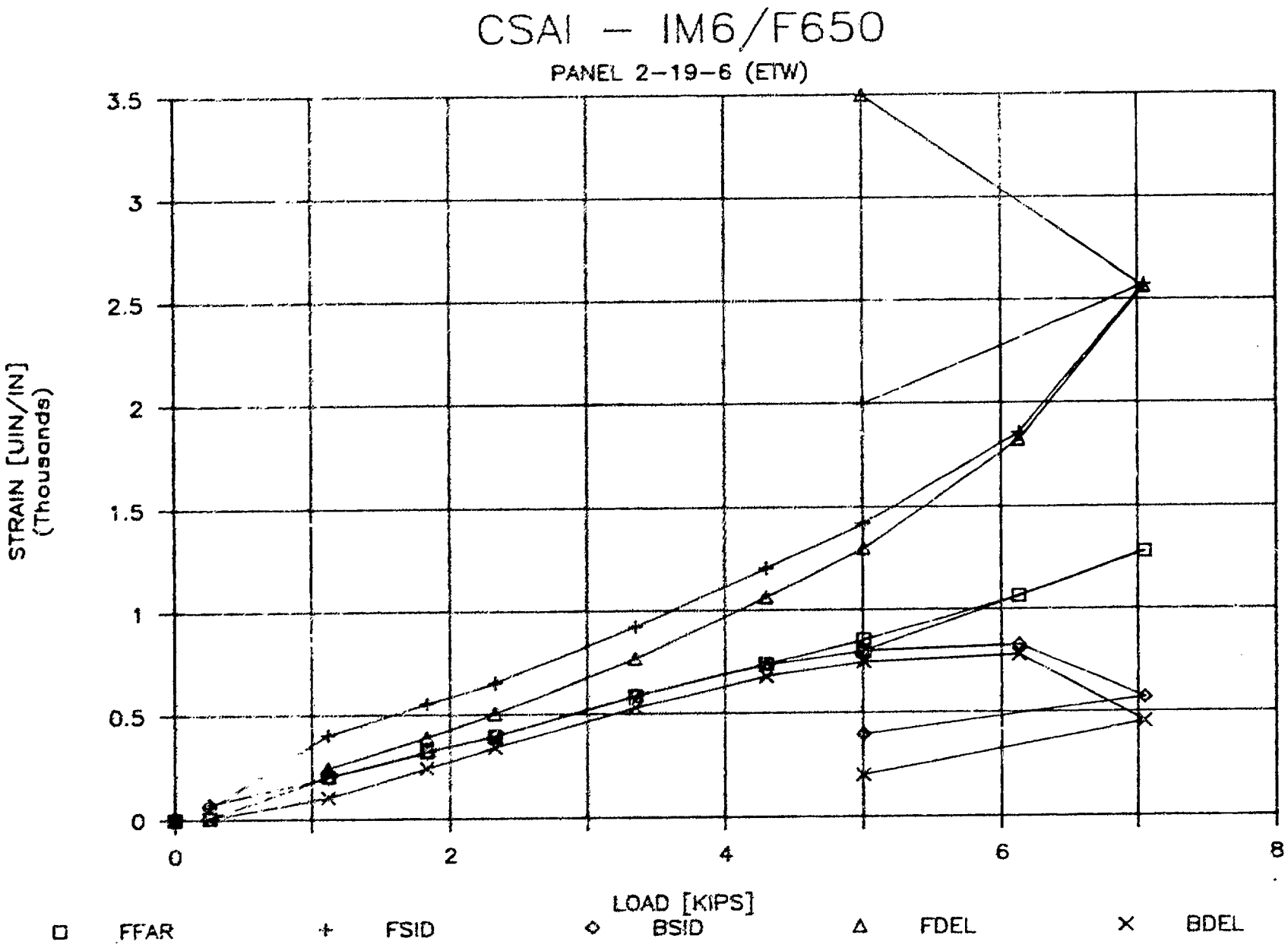


Figure B-133. Panel 2-19-6 Residual Compression Data

B.3 VISIBLE IMPACT DAMAGE

Material	Specimen Number	Layup	Thickness (in.)	Impactor Weight (lb)	Nominal Impact Energy (ft-lb)	Potential Impact Energy (ft-lb)	Kinetic Impact Energy (ft-lb)	G_{max}	ϵ_{max} (μin./in.)	Dent Depth (in.)	Delamination Width (in.)	Residual Strength (ksi)	Residual Strain (μin./in.)
RTD													
	1-12-8		0.113	19.47	60	63.76	—	185	28,860	0.200	2.0	20.1	3,300
IM6/3100	1-11-8	10/80/10	0.222	19.47	100	106.44	—	541	—	0.083	5.3	16.3	2,700
	1-13-8		0.448	19.47	100	106.44	—	639	14,320	0.017	5.0	20.2	3,750
	1-14-9		0.110	19.47	45	47.86	44.70	250	11,330	0.118	1.8	28.1	1,750
IM6/3100	1-20-8	50/40/10	0.224	19.47	100	106.44	96.96	205	20,990	0.103	5.3	23.0	1,000
	1-15-7		0.453	19.47	100	106.44	96.16	991	14,090	0.020	4.9	28.6	2,500
	2-12-9		0.107	19.47	55	58.57	52.51	353	12,280	0.096	5.3	9.9	1,600
IM6/F650	2-11-9	10/80/10	0.216	19.47	100	106.44	96.16	607	20,500	0.072	5.6	12.0	1,900
	2-13-7		0.436	19.47	100	106.44	—	923	15,070	0.028	5.2	13.9	2,700
	2-14-8		0.112	19.47	45	47.86	44.70	308	9,250	0.090	5.2	18.8	4,850
IM6/F650	2-20-7	50/40/10	0.218	19.47	100	106.44	96.16	402	11,920	0.049	5.5	16.9	700
	2-15-8		0.439	19.47	100	106.44	96.16	590	13,610	0.030	5.2	19.8	1,450
ETW													
	1-12-12		0.114	19.47	60	63.76	57.24	199	36,730	0.130	—	14.4	2,700
IM6/3100	1-11-12	10/80/10	0.223	19.47	100	106.44	94.59	559	36,540	0.091	—	14.7	2,500
	1-13-12		0.452	19.47	100	106.44	—	752	17,070	0.017	—	14.9	3,300
	1-14-11		0.109	19.47	45	61.98	43.97	701	10,730	0.120	—	21.8	2,450
IM6/3100	1-20-11	50/40/10	0.225	19.47	100	106.44	95.37	617	19,830	0.090	—	18.1	1,750
	1-15-11		0.452	19.47	100	106.44	96.96	1,928	14,300	0.020	—	21.7	2,000
	2-12-11		0.106	19.47	45	47.86	—	242	17,300	0.110	—	9.2	1,930
IM6/F650	2-11-11	10/80/10	0.217	19.47	100	106.44	93.81	222	20,090	0.045	—	9.4	1,200
	2-13-11		0.431	19.47	100	106.44	—	420	12,240	0.027	—	11.8	2,300
	2-14-11		0.110	19.47	45	61.98	43.73	430	17,180	0.086	—	17.3	1,800
IM6/F650	2-20-12	50/40/10	0.216	19.47	100	106.44	—	701	17,290	0.052	—	14.2	600
	2-15-10		0.440	19.47	100	106.44	96.16	181	12,410	0.027	—	15.6	1,150

GP83-0069-1-T

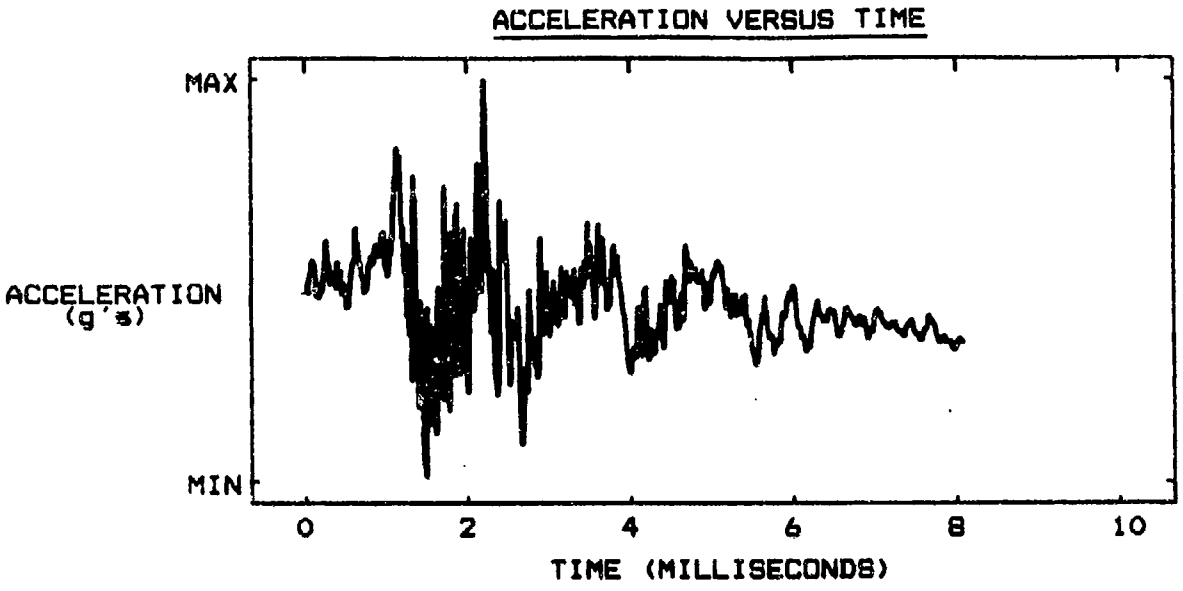
Figure B-134. Visible Impact Damage Data Table

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

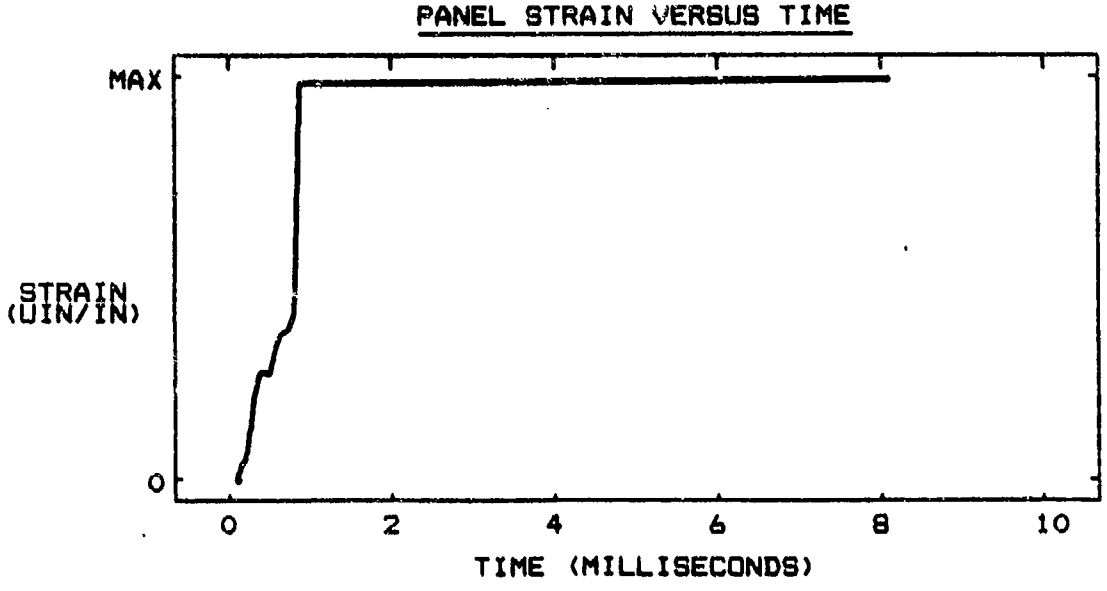
SPECIMEN I.D. 1-12-8 THICKNESS .113 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 39.3 IN



MINIMUM ACCELERATION -170 g's MAXIMUM ACCELERATION 185.0 g's

INTEGRATED TOTAL VELOCITY -67.0 IN/SEC



MAXIMUM STRAIN 28861 UIN/IN

Figure B-135. Panel 1-12-8 Impact Response Data

Specimen 1-12-8

Figure B-136. Panel 1-12-8 C-Scan

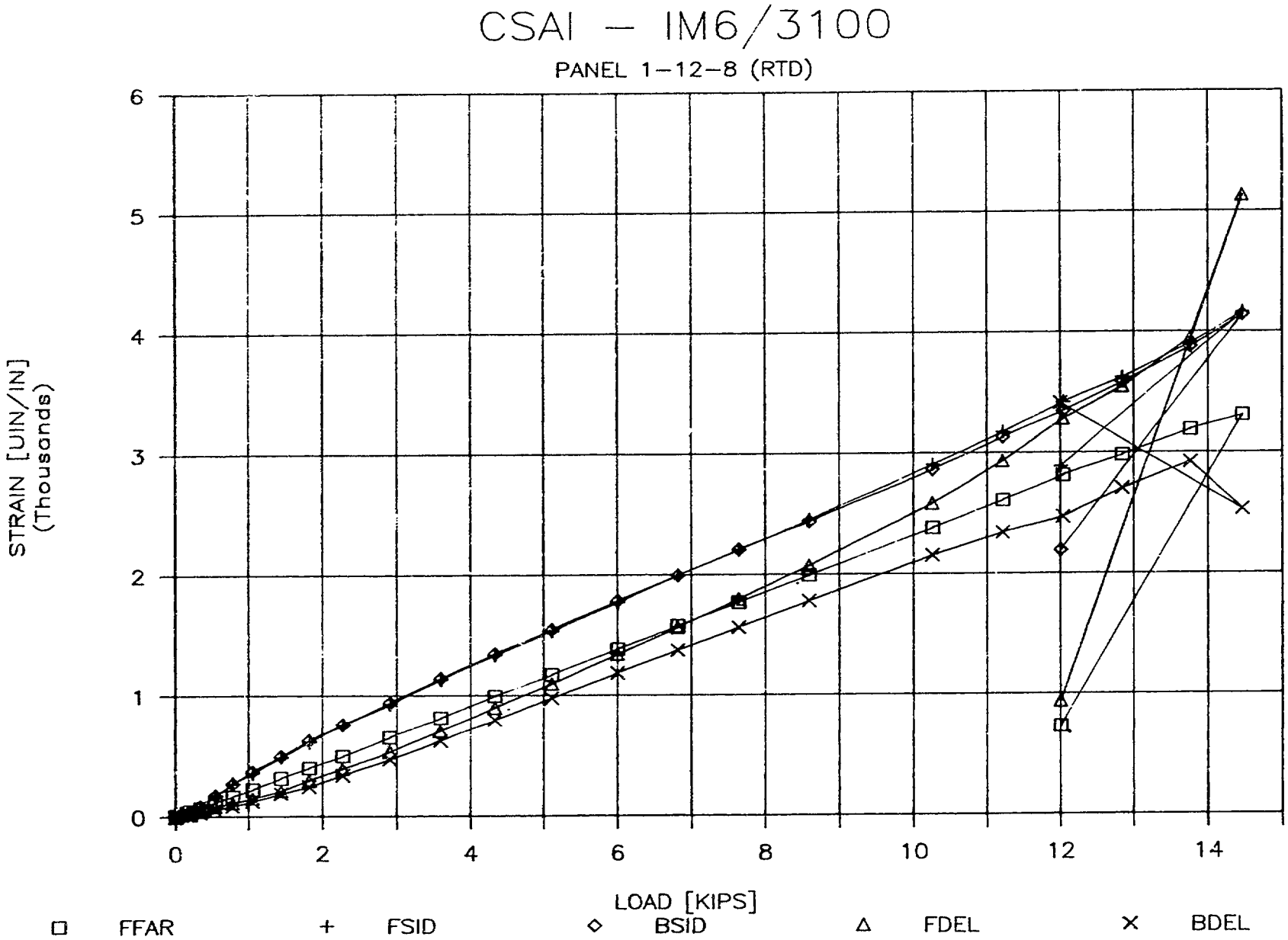


Figure B-137. Panel 1-12-8 Residual Compression Data

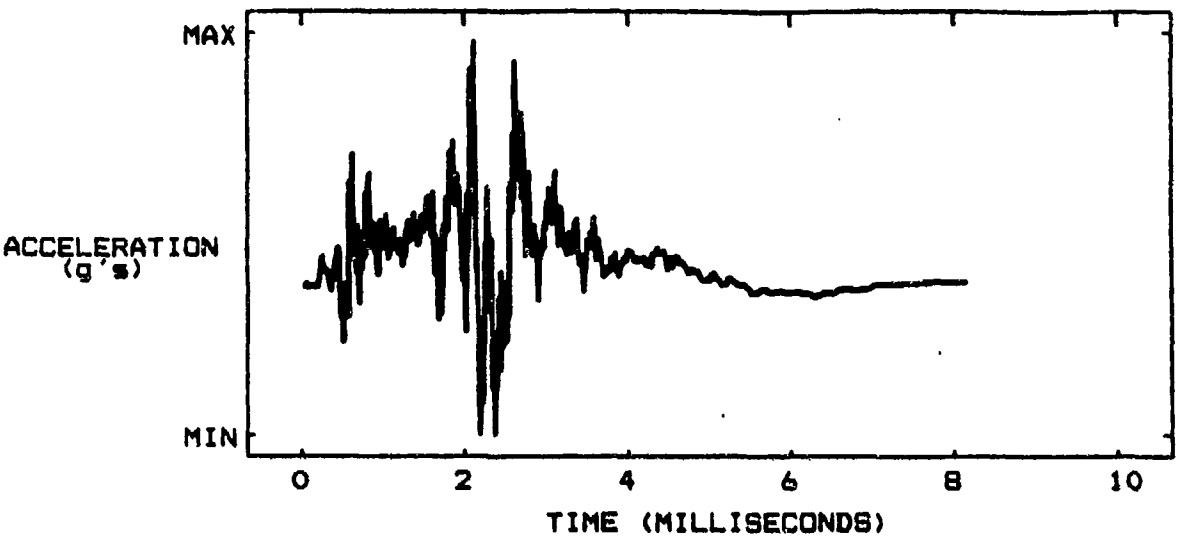
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-11-8 THICKNESS .222 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

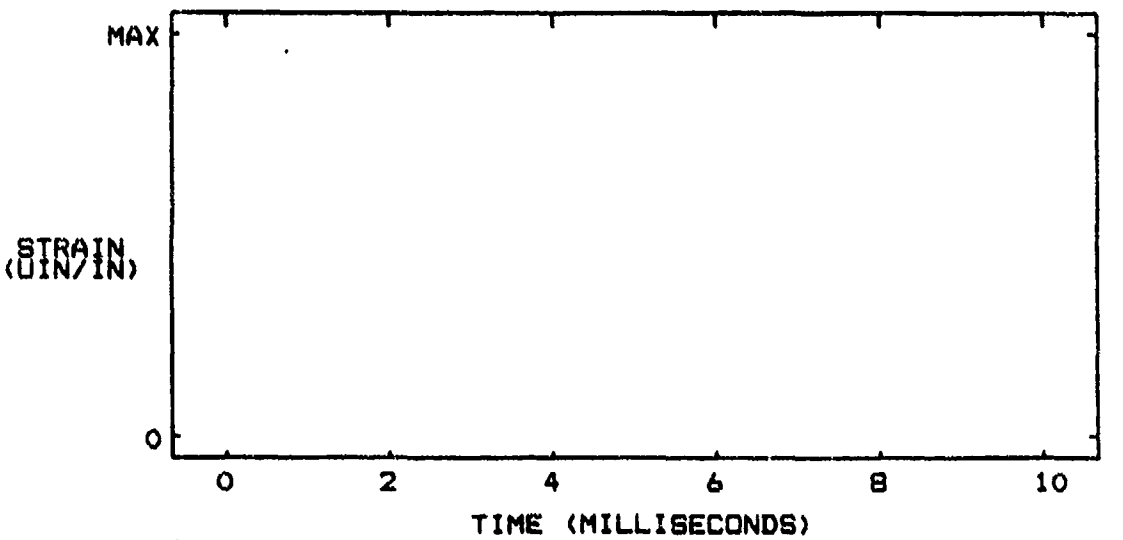
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -320 g's MAXIMUM ACCELERATION 541 g's

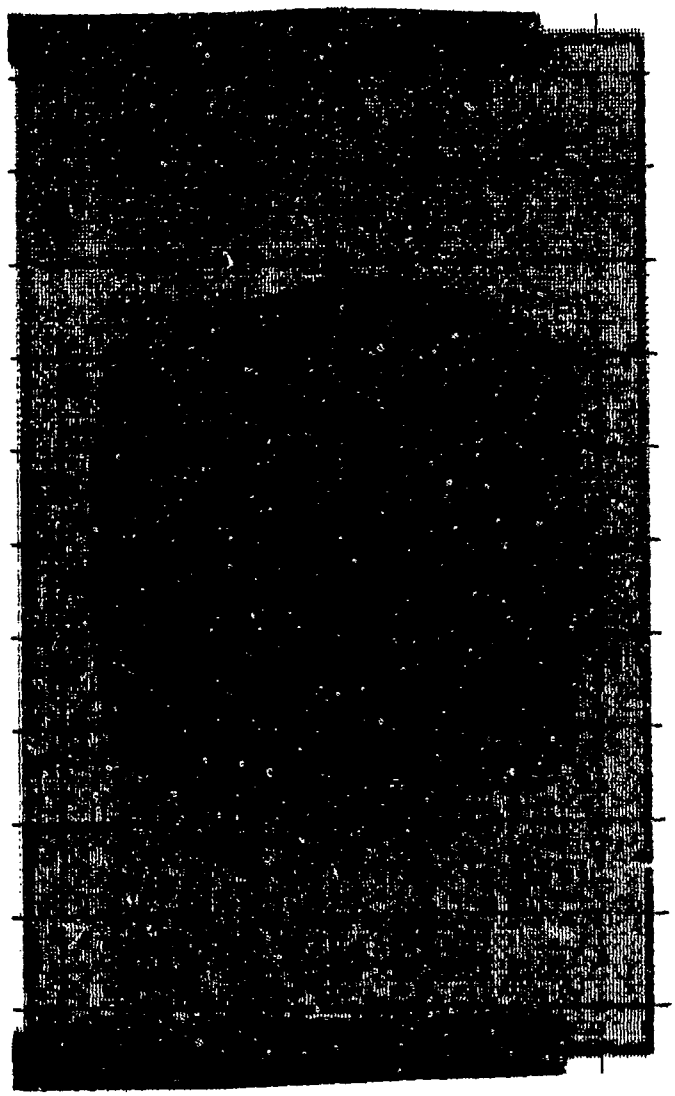
INTEGRATED TOTAL VELOCITY 139.56 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN no data UIN/IN

Figure B-138. Panel 1-11-8 Impact Response Data



Specimen 1-11-8

Figure B-139. Panel 1-11-8 C-Scan

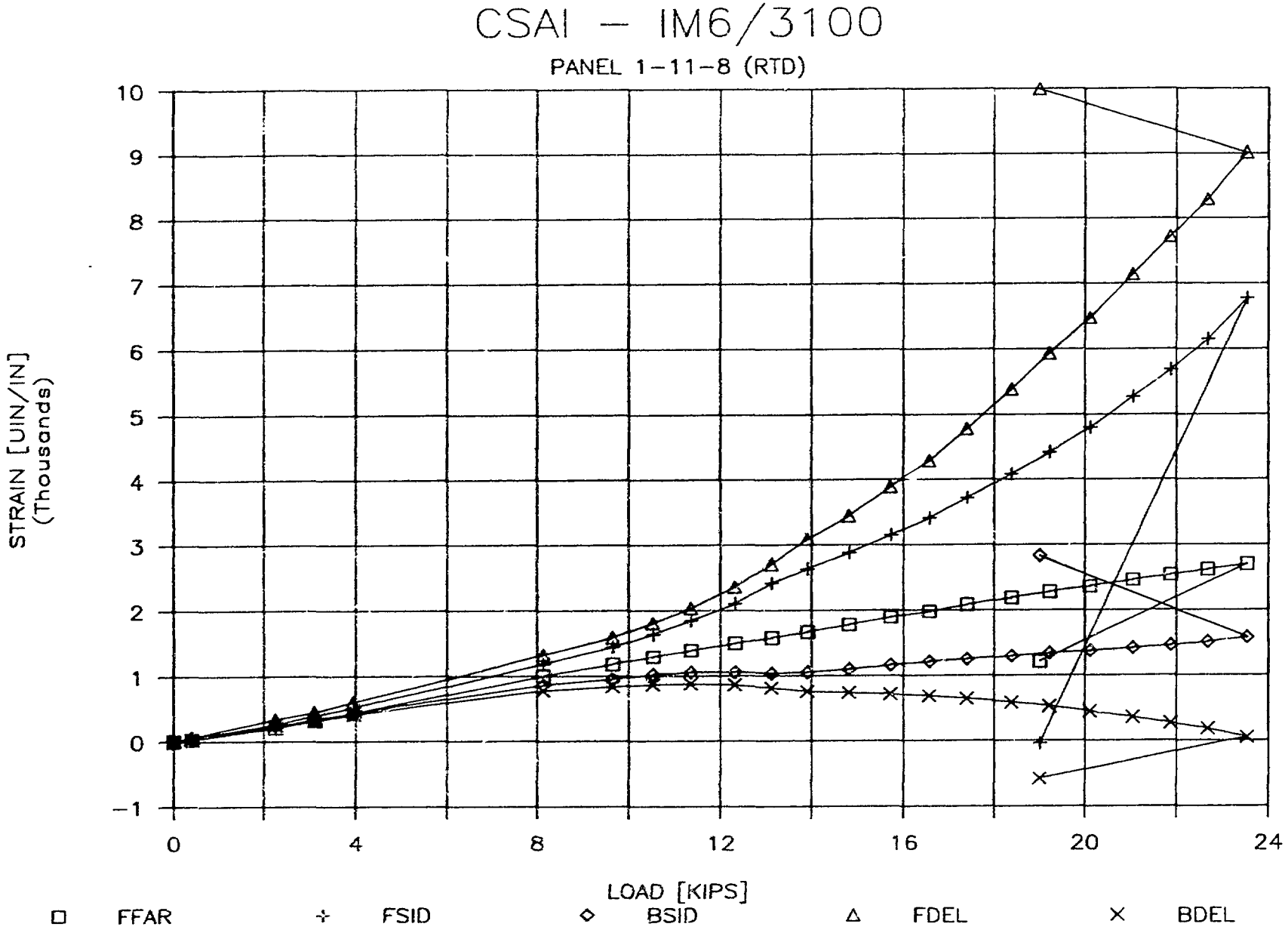


Figure B-140. Panel 1-11-8 Residual Compression Data

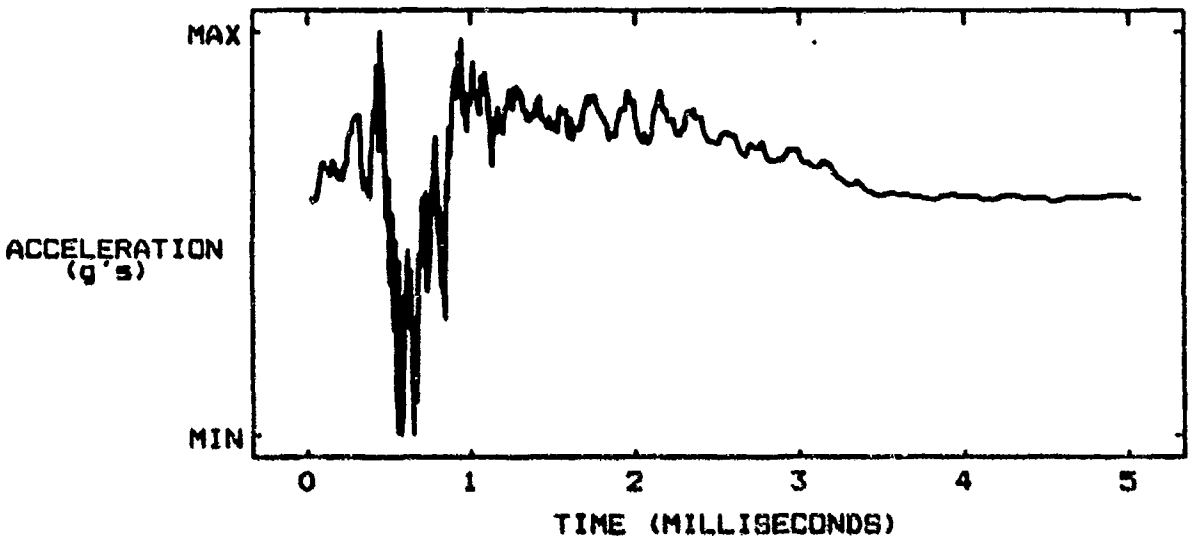
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-13-8 THICKNESS .448 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

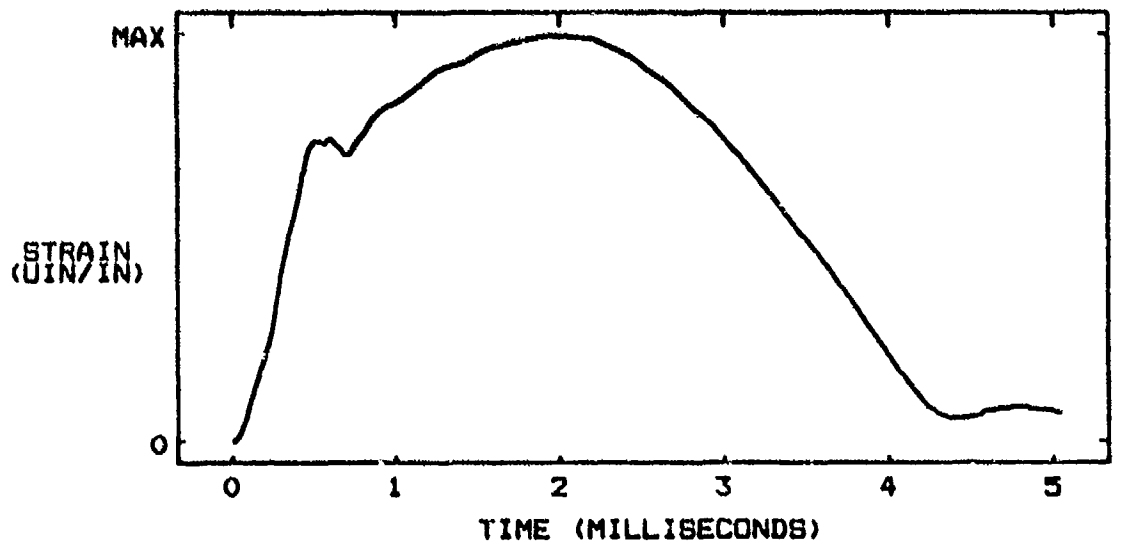
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -893 g's MAXIMUM ACCELERATION 639.00 g's

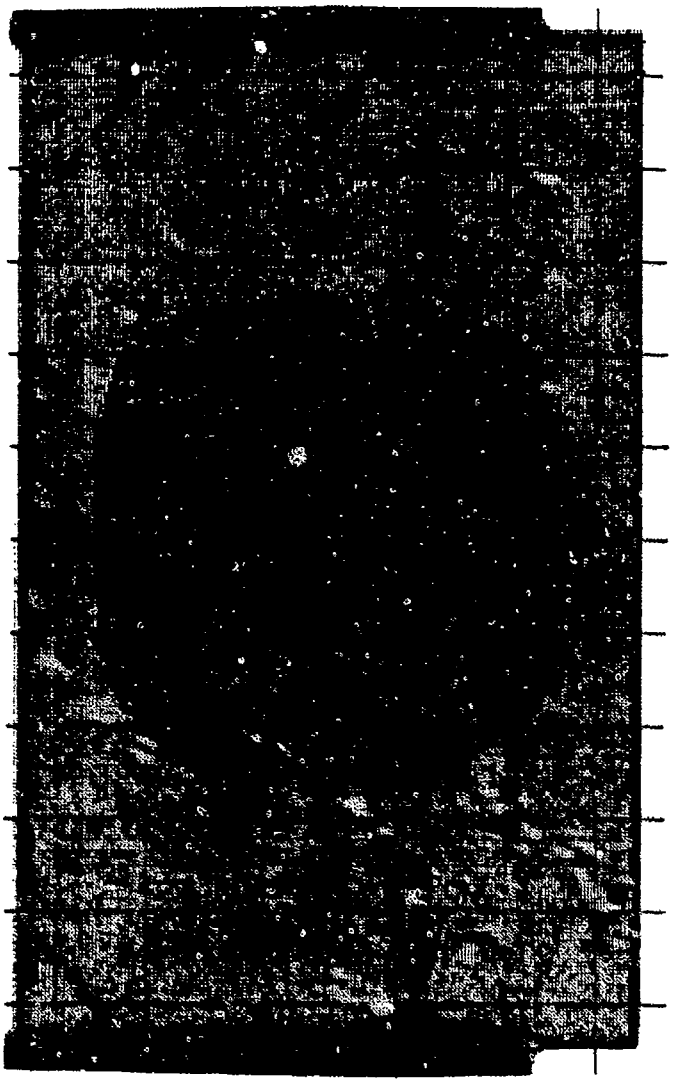
INTEGRATED TOTAL VELOCITY 241.962 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 14318 UIN/IN

Figure B-141. Panel 1-13-8 Impact Response Data



Specimen 1-13-8

Figure B-142. Panel 1-13-8 C-Scan

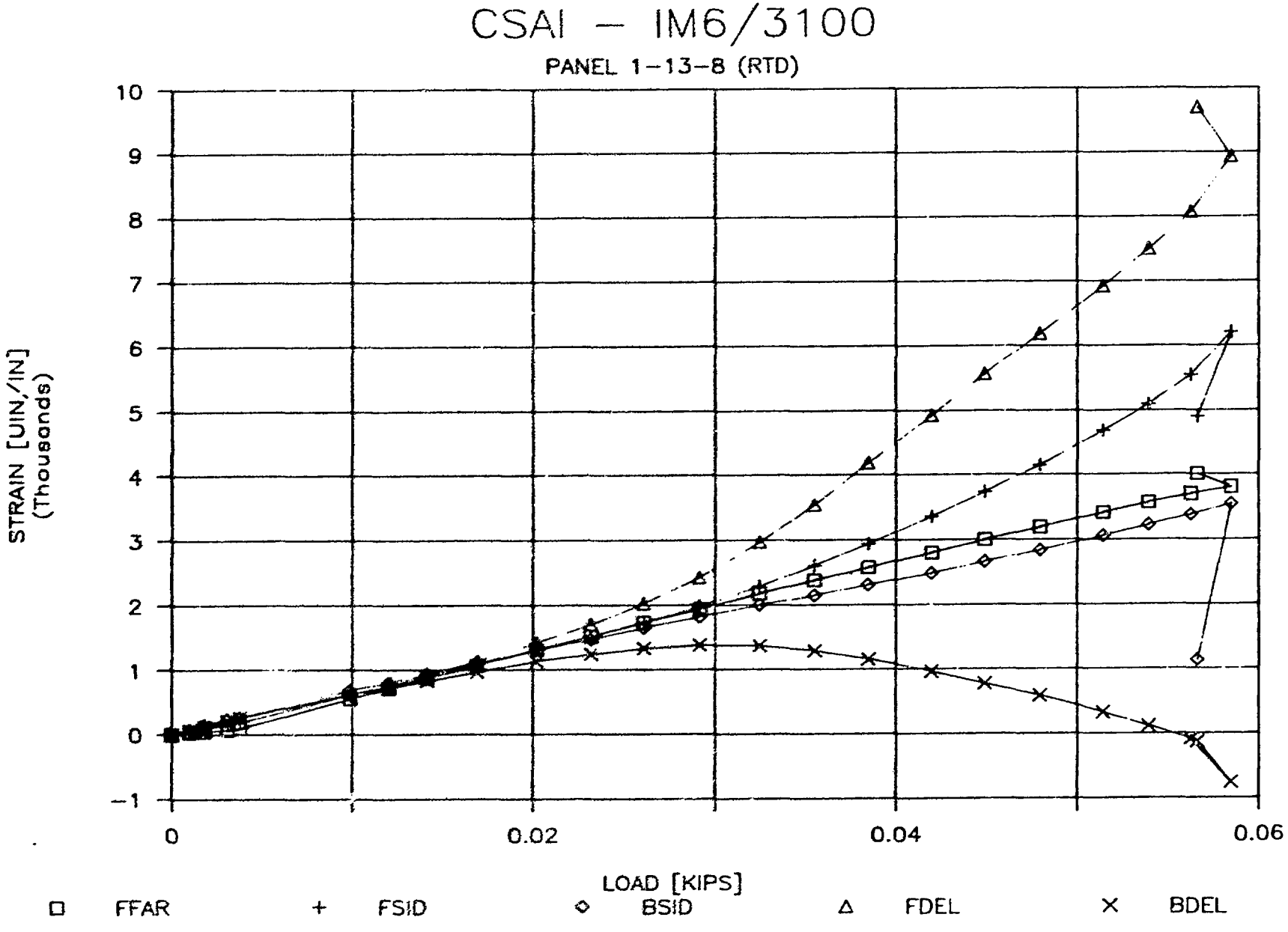


Figure B-143. Panel 1-13-8 Residual Compression Data

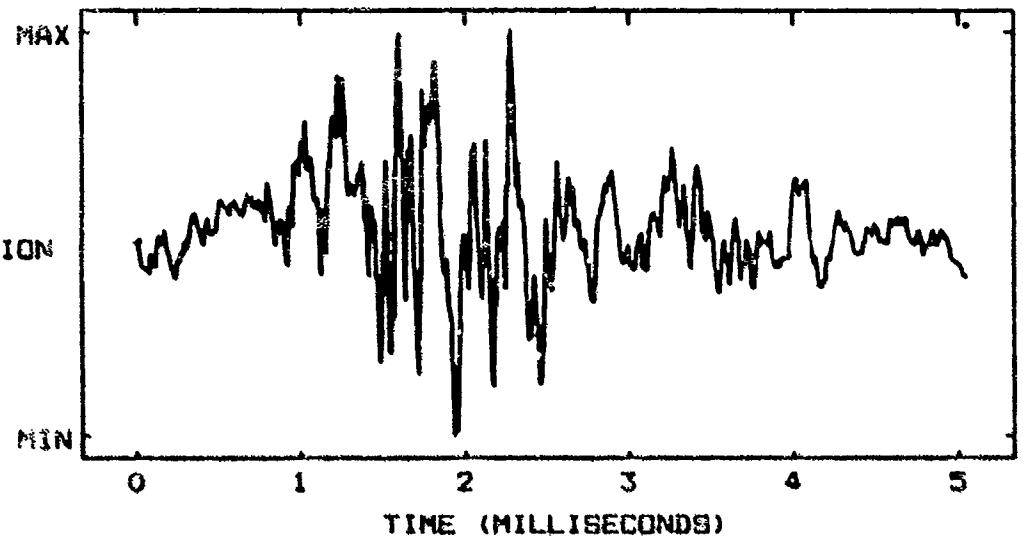
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-14-9 THICKNESS .110 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 29.5 IN

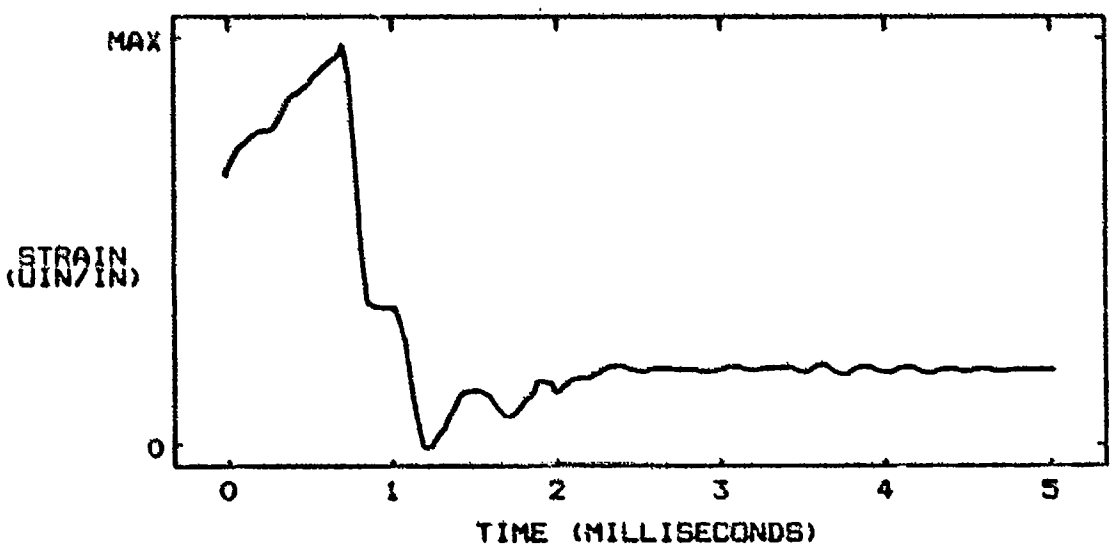
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -227.3 g's MAXIMUM ACCELERATION 250 g's

INTEGRATED TOTAL VELOCITY 25.302 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 11329 UIN/IN

Figure 8-144. Panel 1-14-9 Impact Response Data

Specimen 1-14-9

Figure B-145. Panel 1-14-9 C-Scan

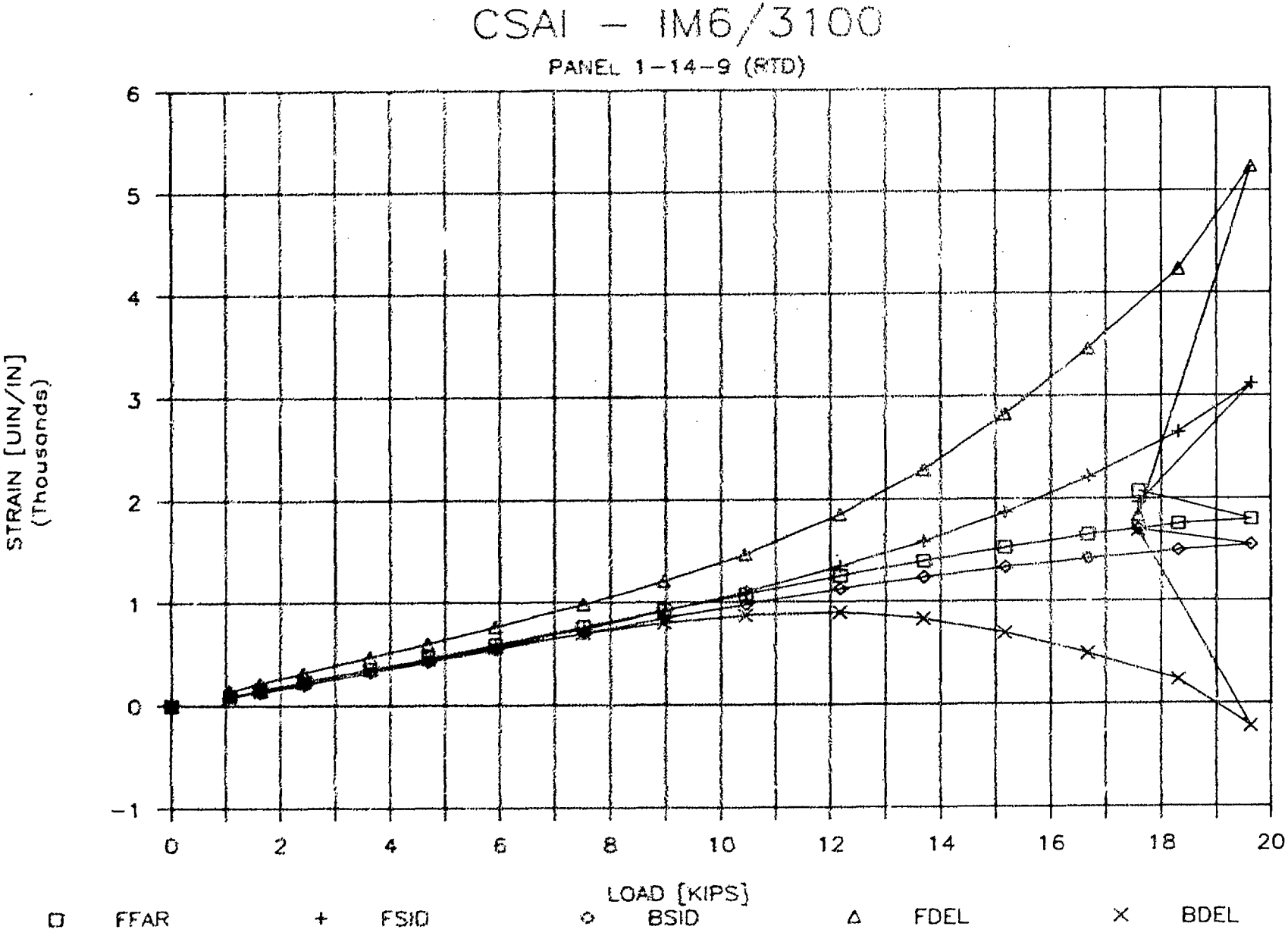


Figure B-146. Panel 1-14-9 Residual Compression Data

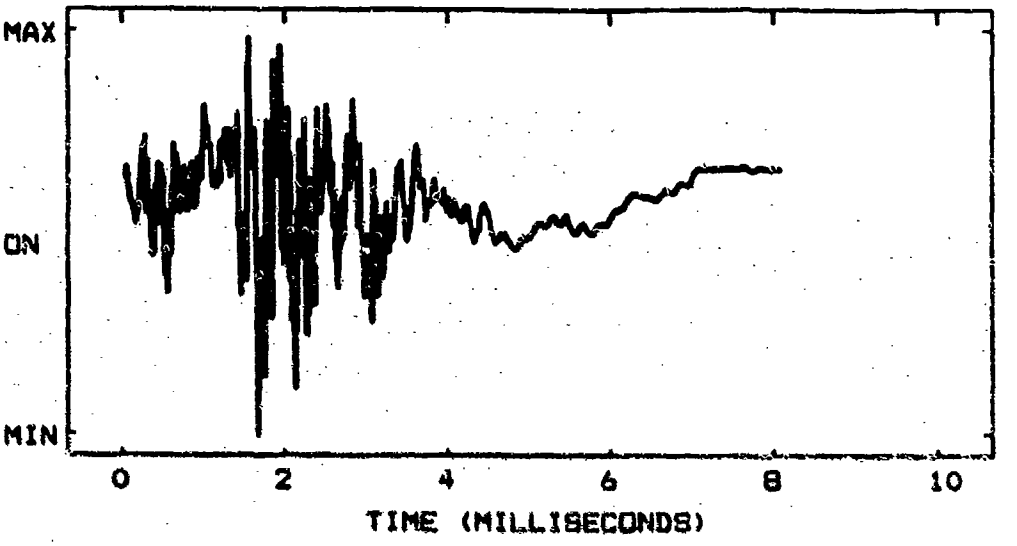
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-20-8 THICKNESS .224 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

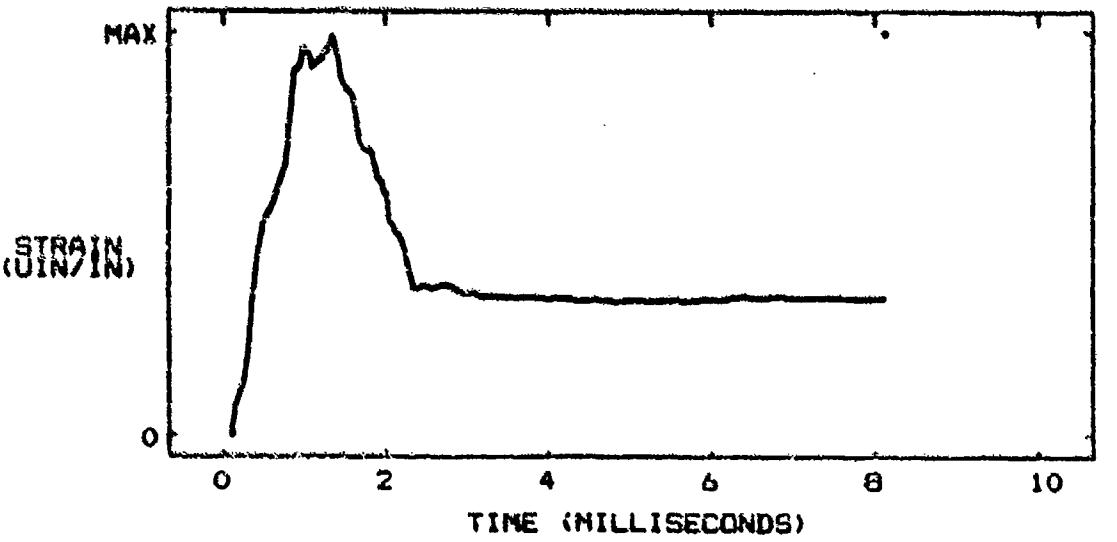
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -410 g's MAXIMUM ACCELERATION 205.00g's

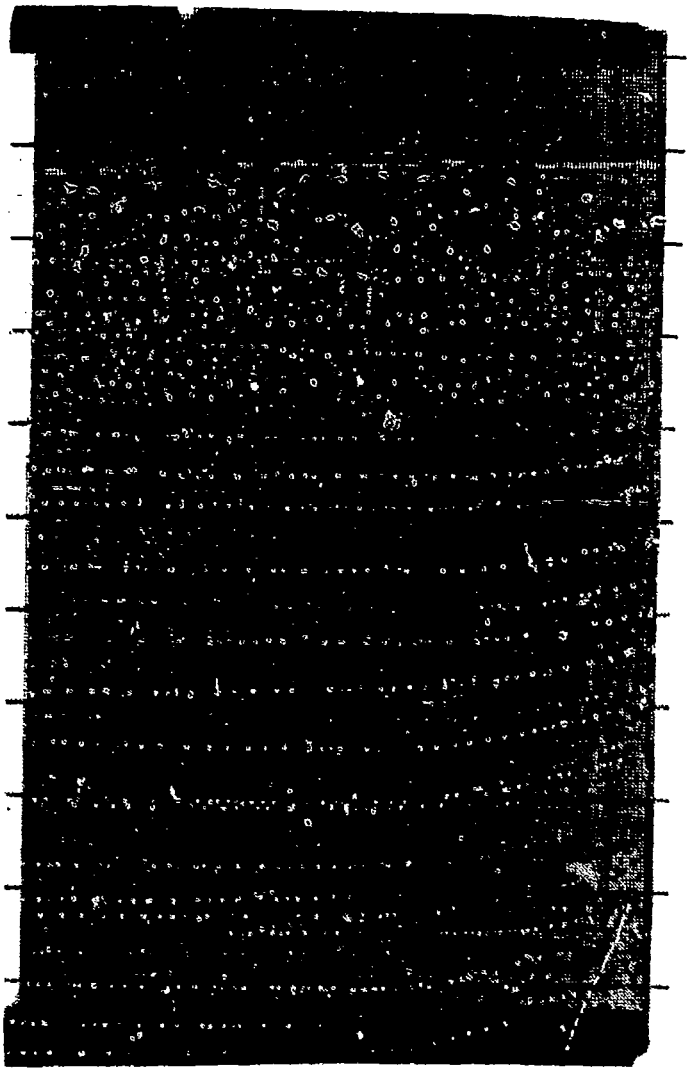
INTEGRATED TOTAL VELOCITY -122.6 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 20990 UIN/IN

Figure 8-147. Panel 1-20-8 Impact Response Data



Specimen 1-20-8

Figure B-148. Panel 1-20-8 C-Scan

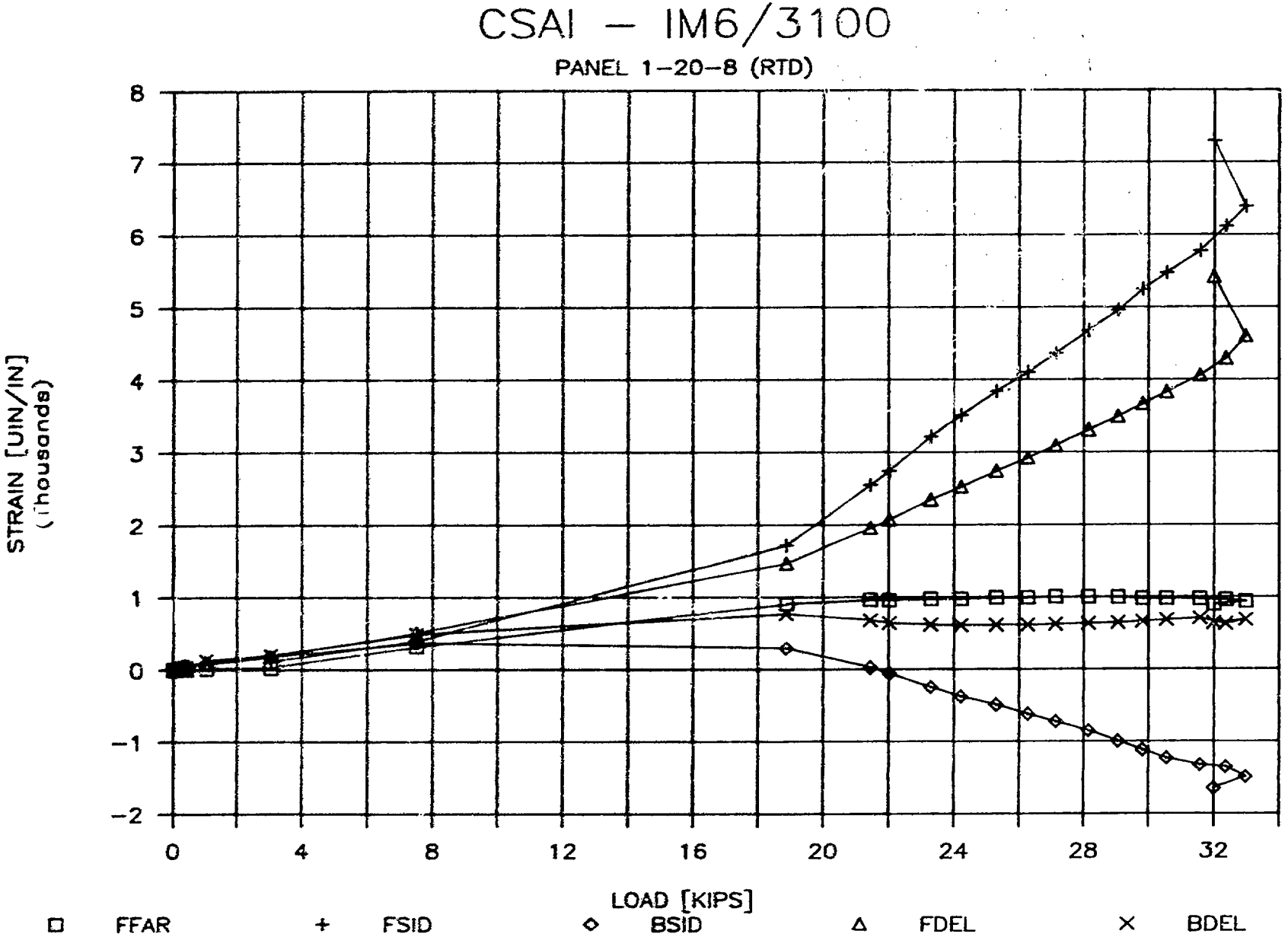


Figure B-149. Panel 1-20-8 Residual Compression Data

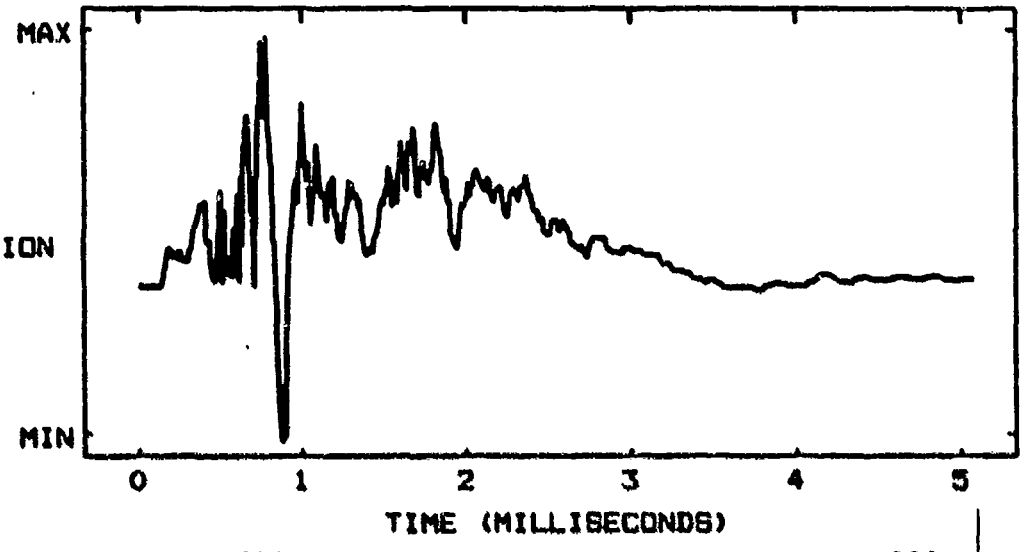
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-15-7 THICKNESS .453 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

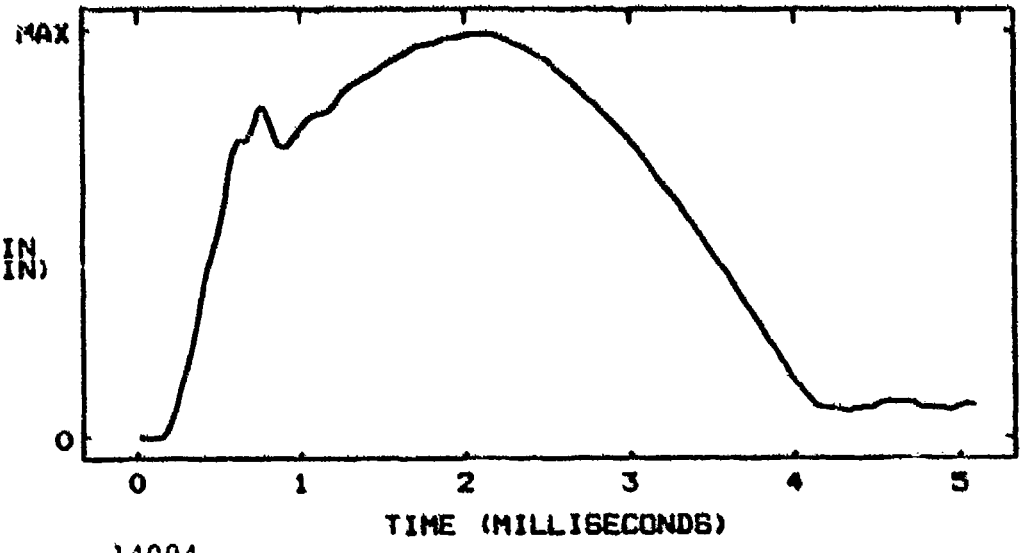
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -610 g's MAXIMUM ACCELERATION 991 g's

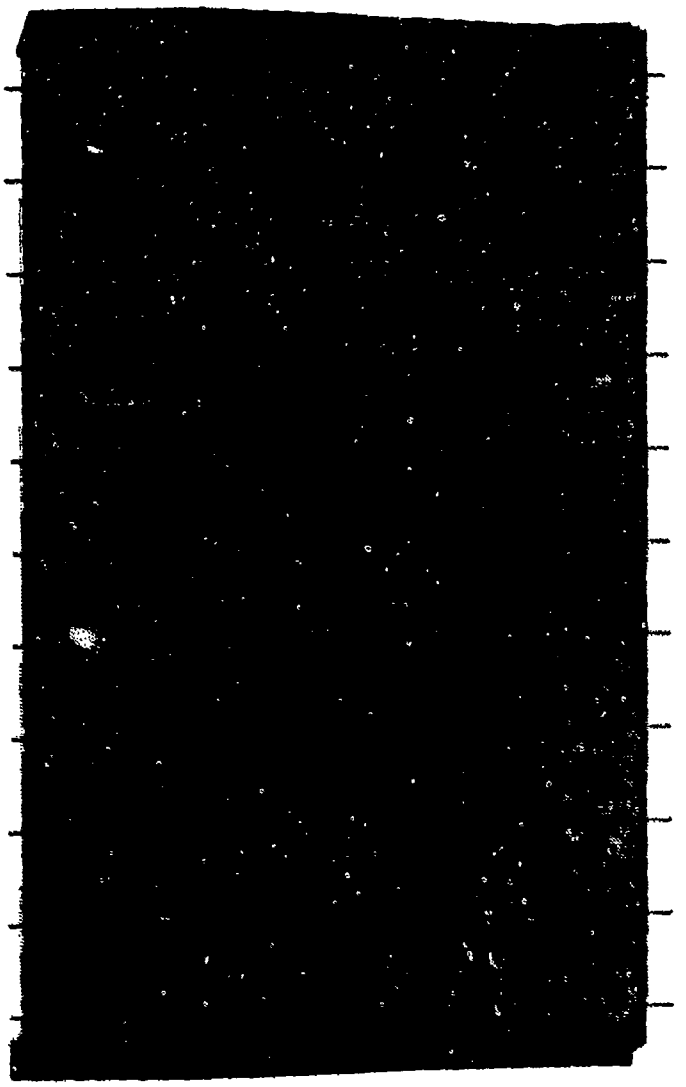
INTEGRATED TOTAL VELOCITY 350.34 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 14094 UIN/IN

Figure B-150. Panel 1-15-7 Impact Response Data



Specimen 1-15-7

Figure B-151. Panel 1-15-7 C-Scan

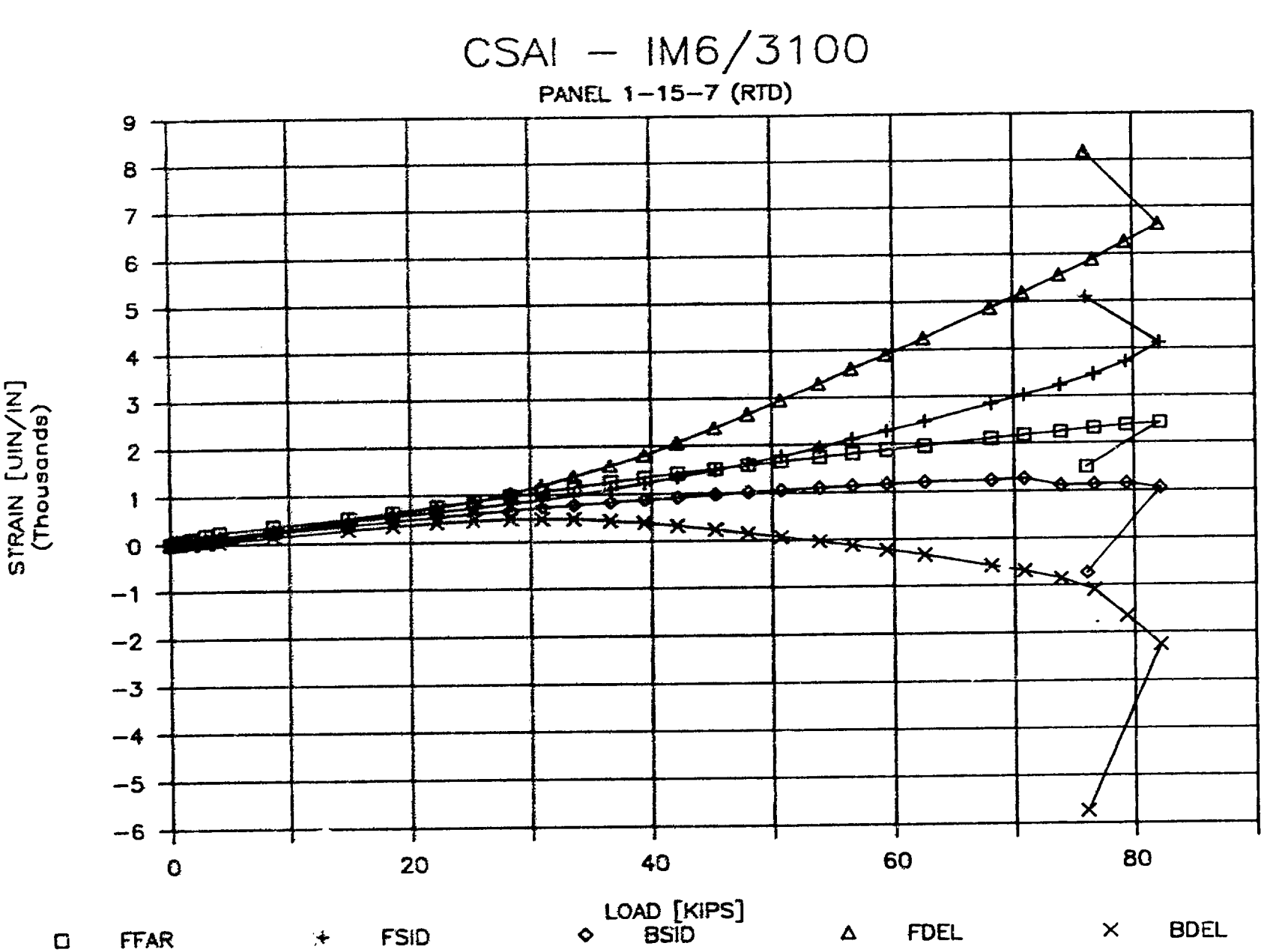


Figure B-152. Panel 1-15-7 Residual Compression Data

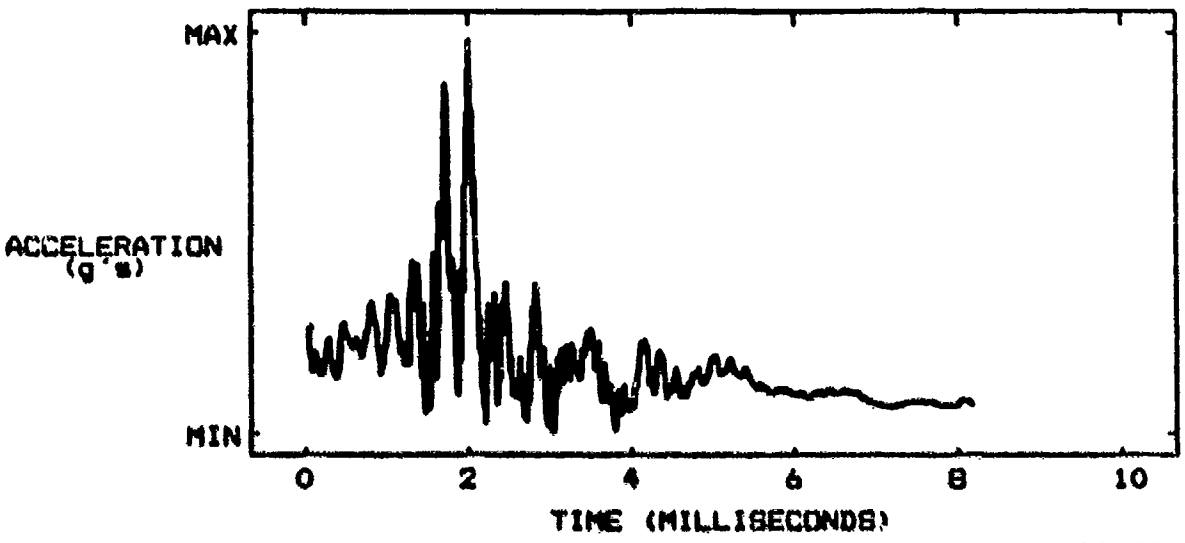
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-12-9 THICKNESS .107 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 36.1 IN

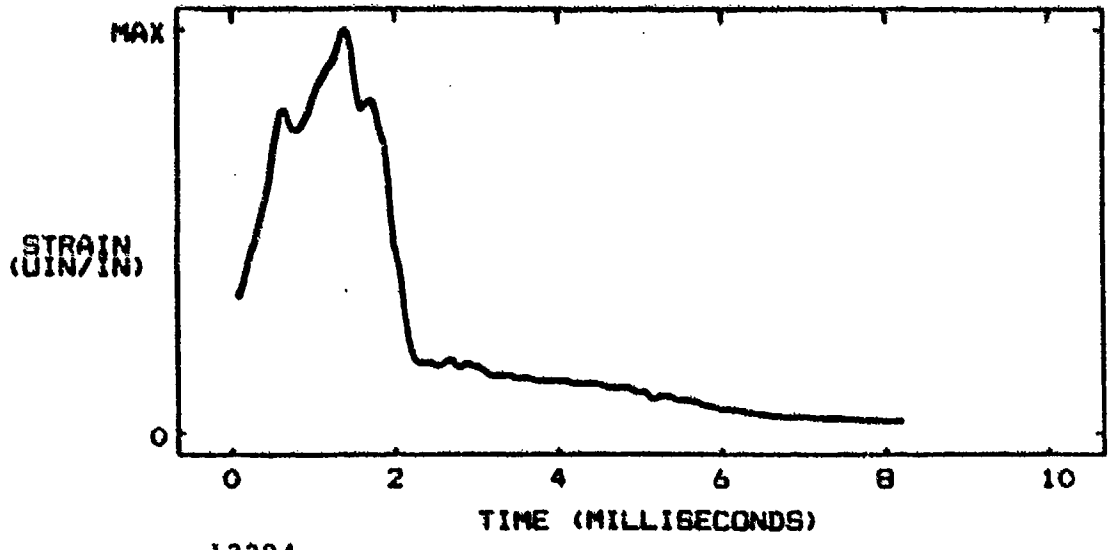
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -125 g's MAXIMUM ACCELERATION 353.20 g's

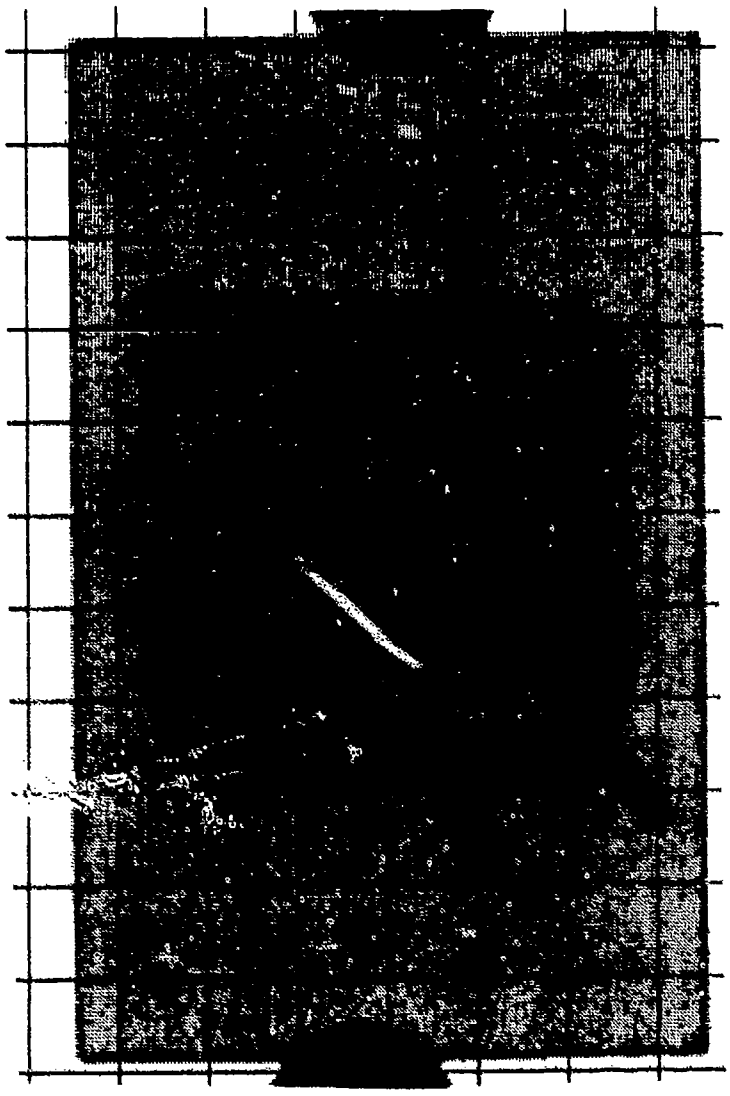
INTEGRATED TOTAL VELOCITY -184.82 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 12294 UIN/IN

Figure 8-153. Panel 2-12-9 Impact Response Data



Specimen 2-12-9

Figure B-154. Panel 2-12-9 C-Scan

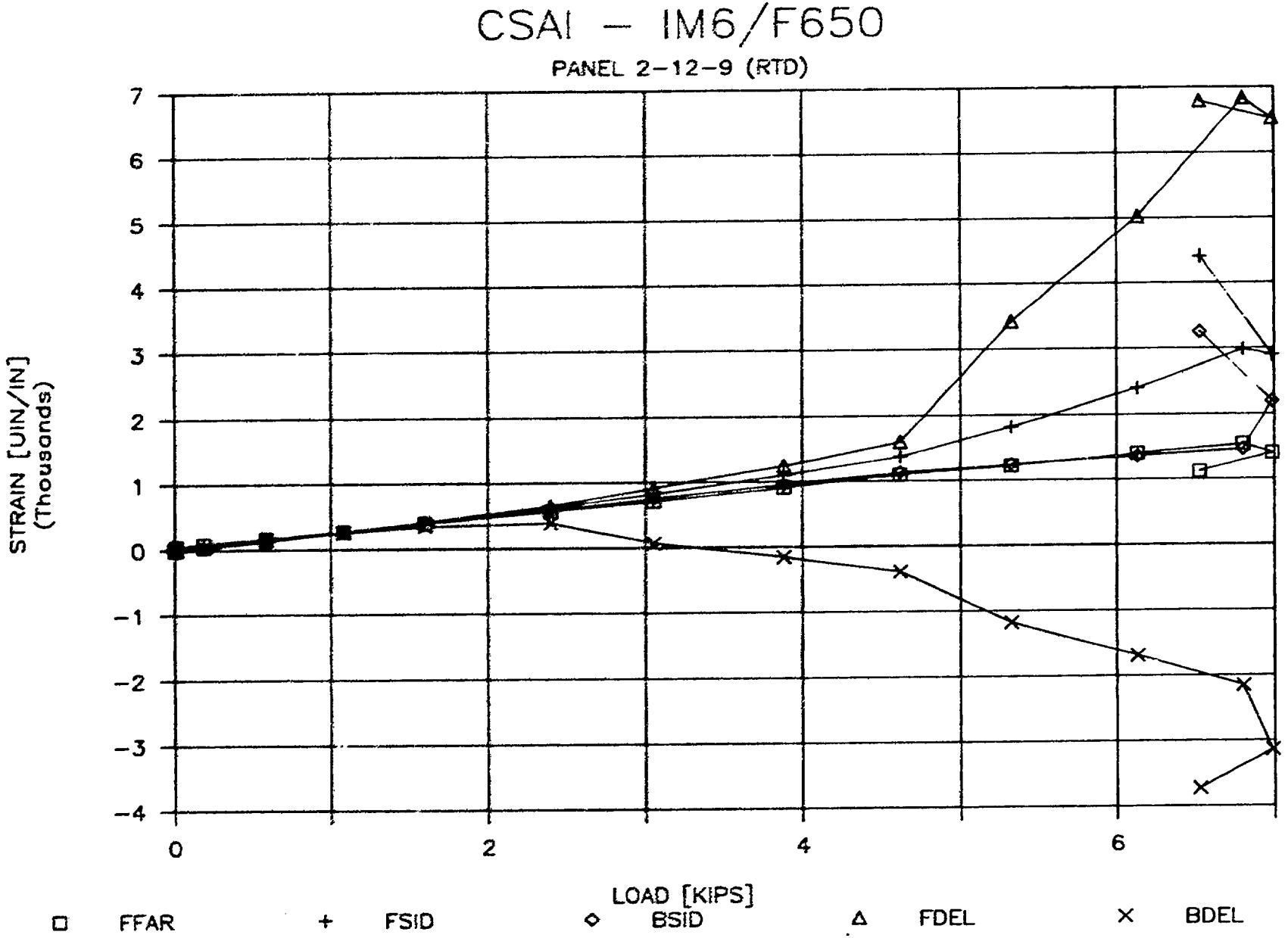


Figure B-155. Panel 2-12-9 Residual Compression Data

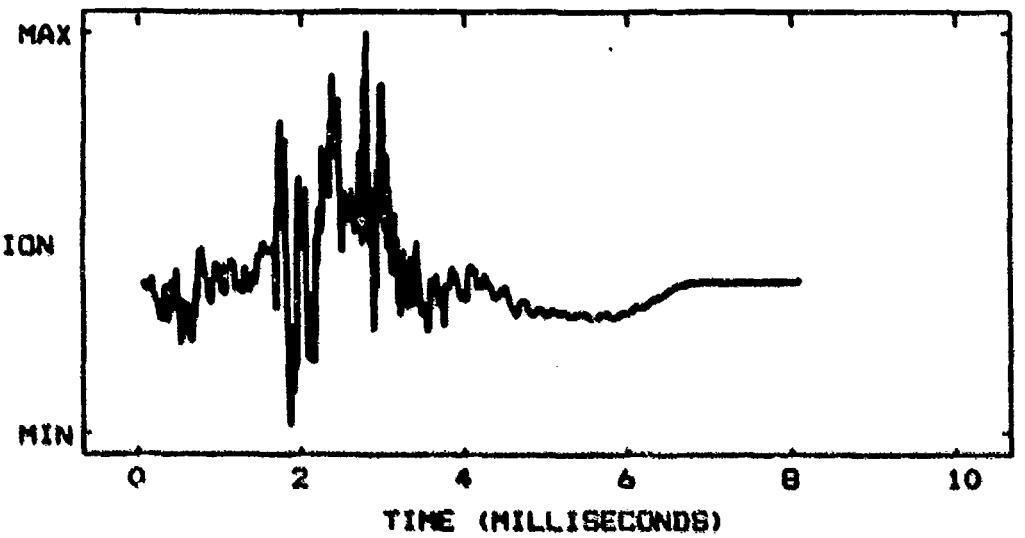
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-11-9 THICKNESS .216 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

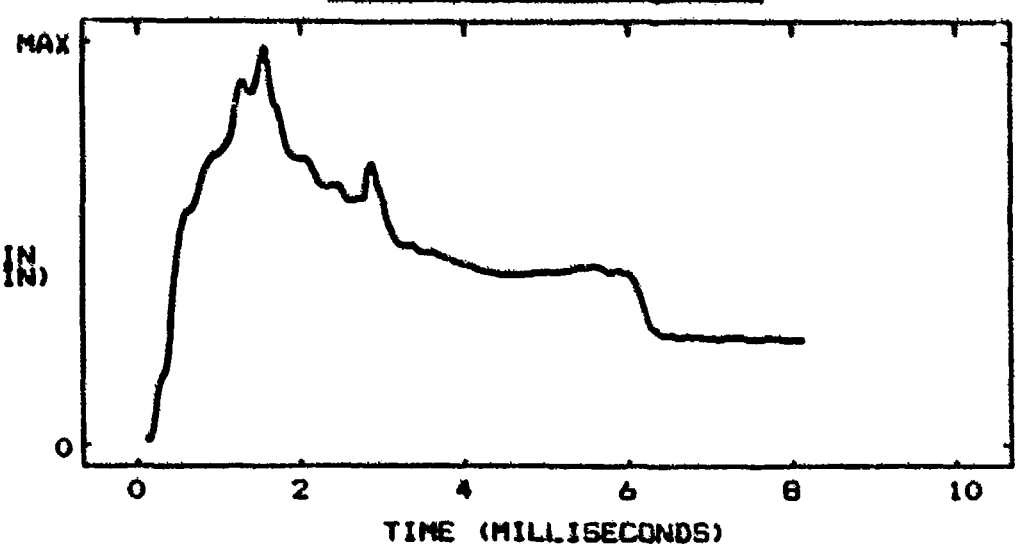
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -363 g's MAXIMUM ACCELERATION 607.00g's

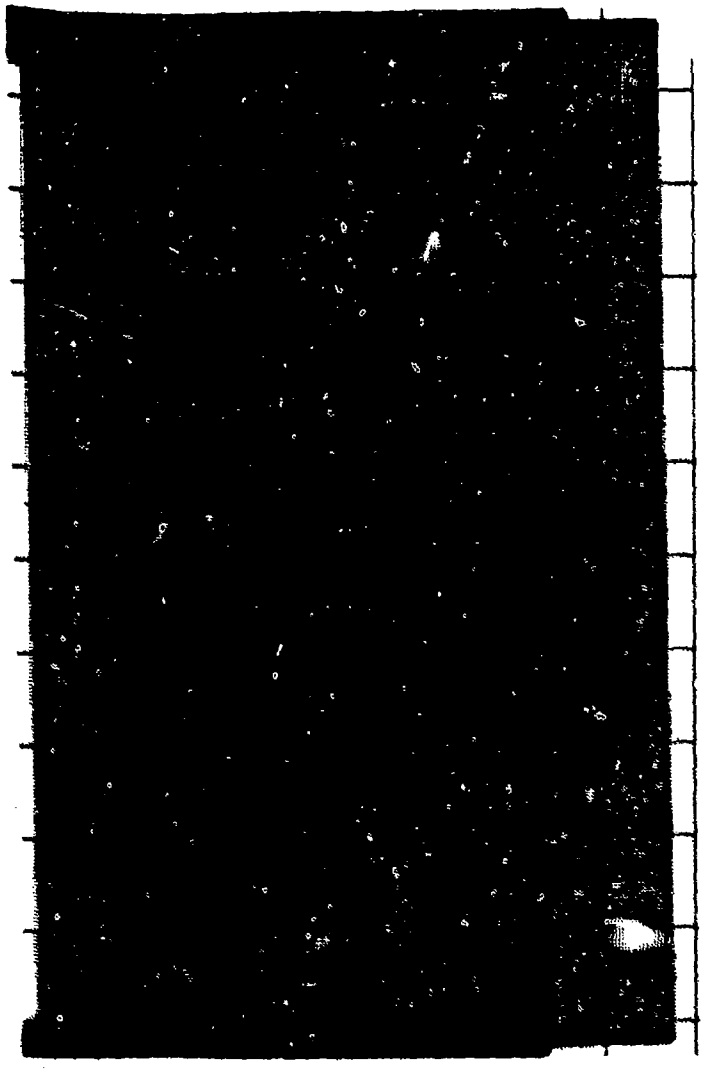
INTEGRATED TOTAL VELOCITY 32.599 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 20503 UIN/IN

Figure B-158. Panel 2-11-9 Impact Response Data



Specimen 2-11-9

Figure B-157. Panel 2-11-9 C-Scan

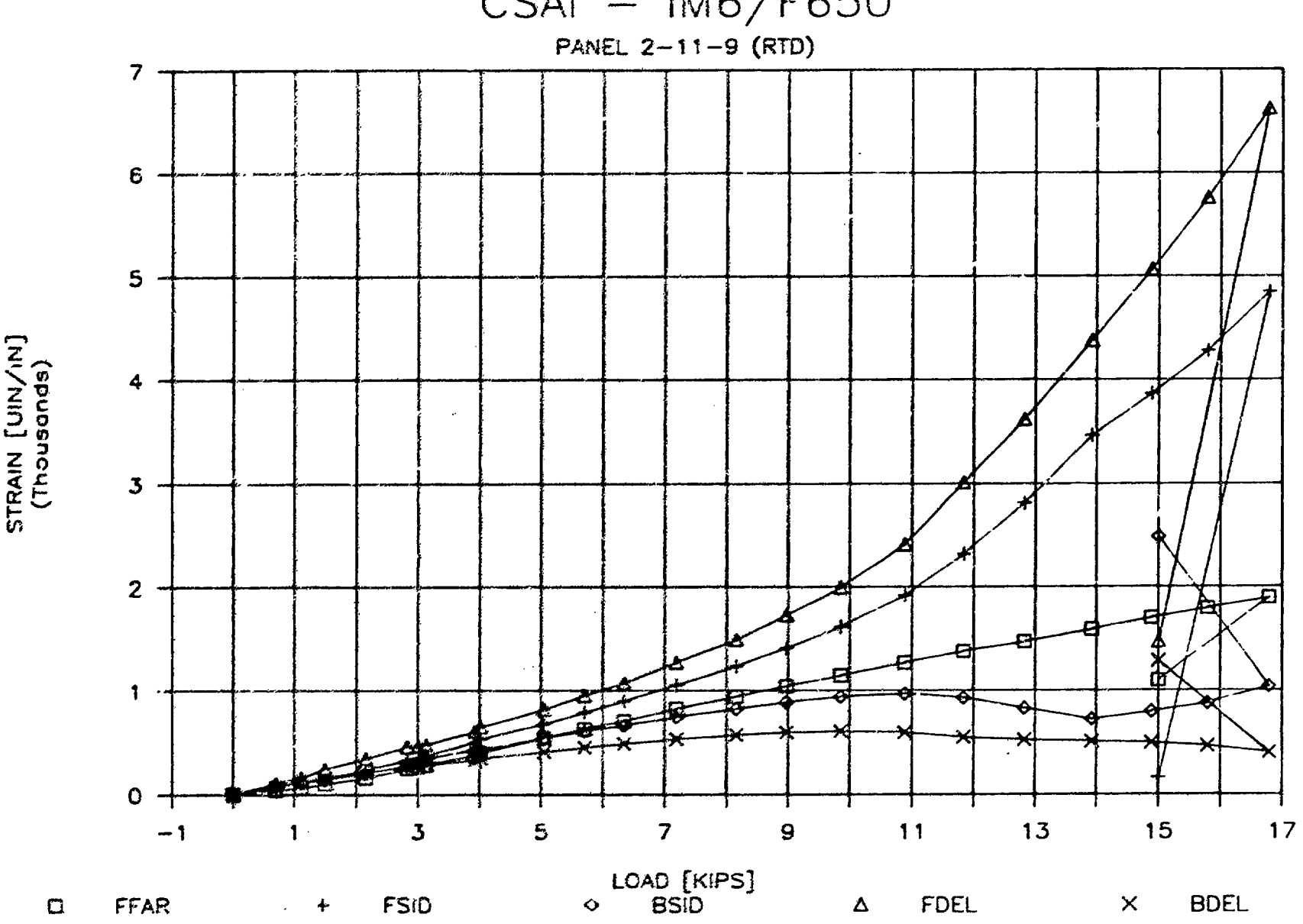


Figure 8-158. Panel 2-11-9 Residual Compression Data

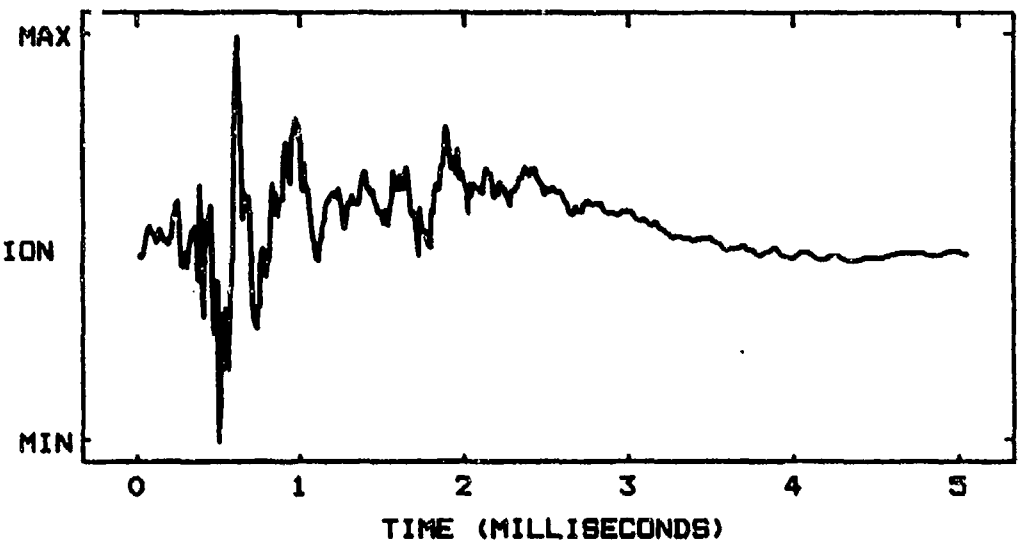
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-13-7 THICKNESS .436 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

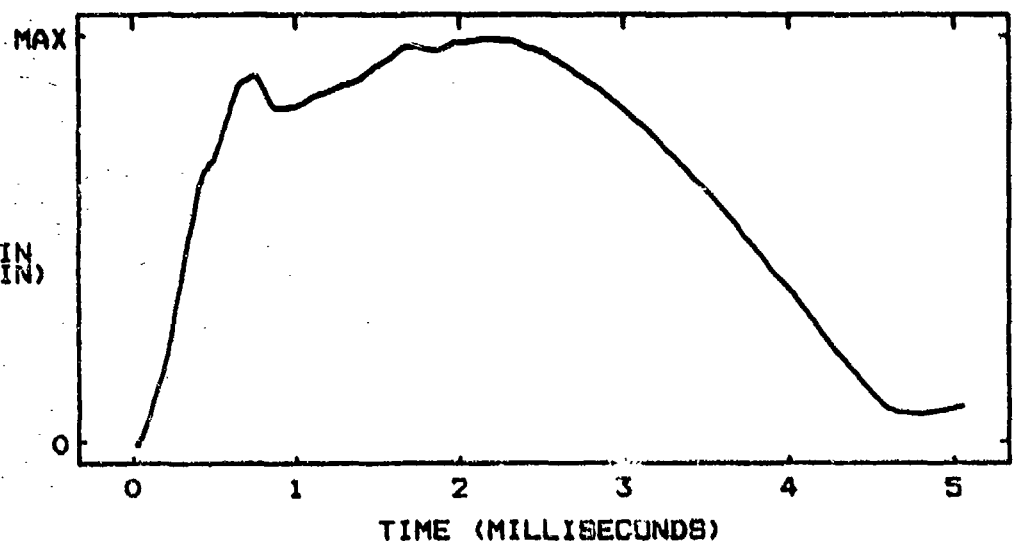
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -470 g's MAXIMUM ACCELERATION 922.80 g's

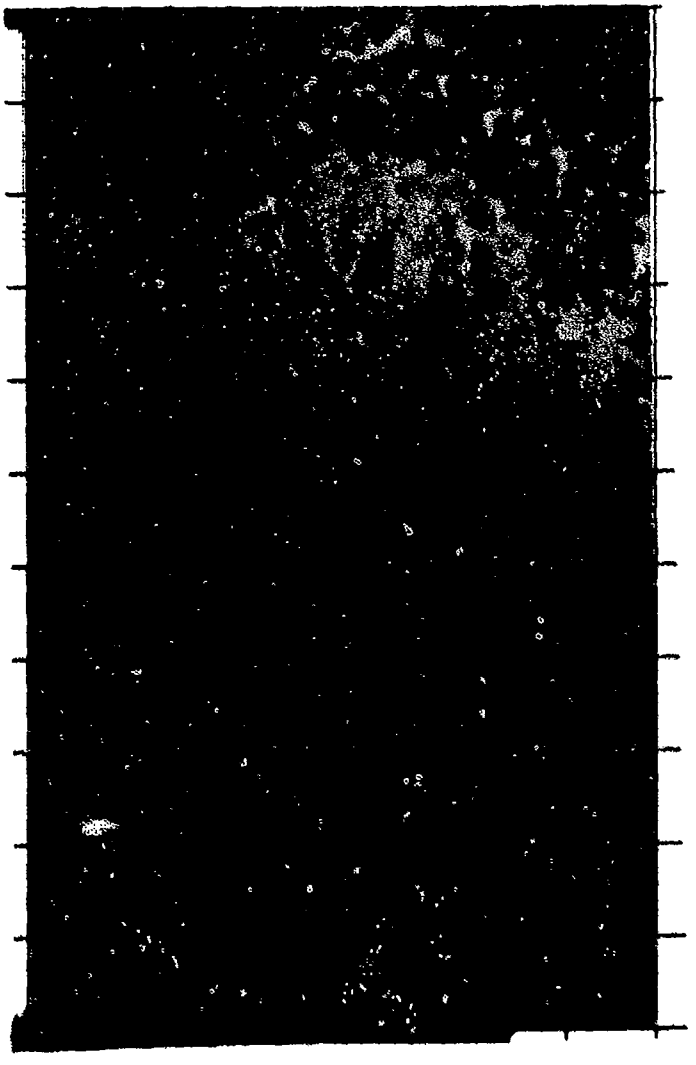
INTEGRATED TOTAL VELOCITY 253.27 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 15068 UIN/IN

Figure B-159. Panel 2-13-7 Impact Response Data



Specimen 2-13-7

Figure B-160. Panel 2-13-7 C-Scan

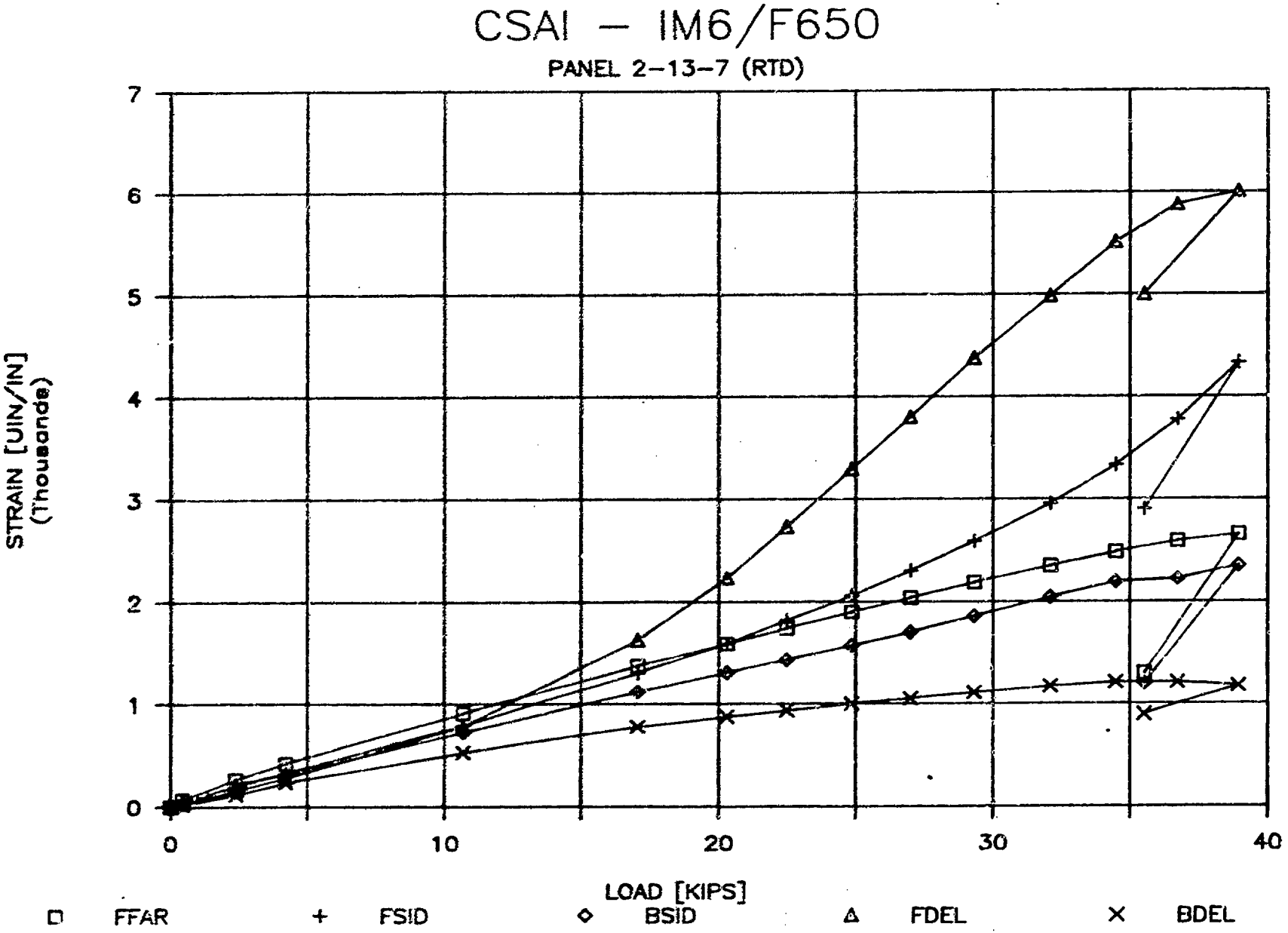


Figure B-161. Panel 2-13-7 Residual Compression Data

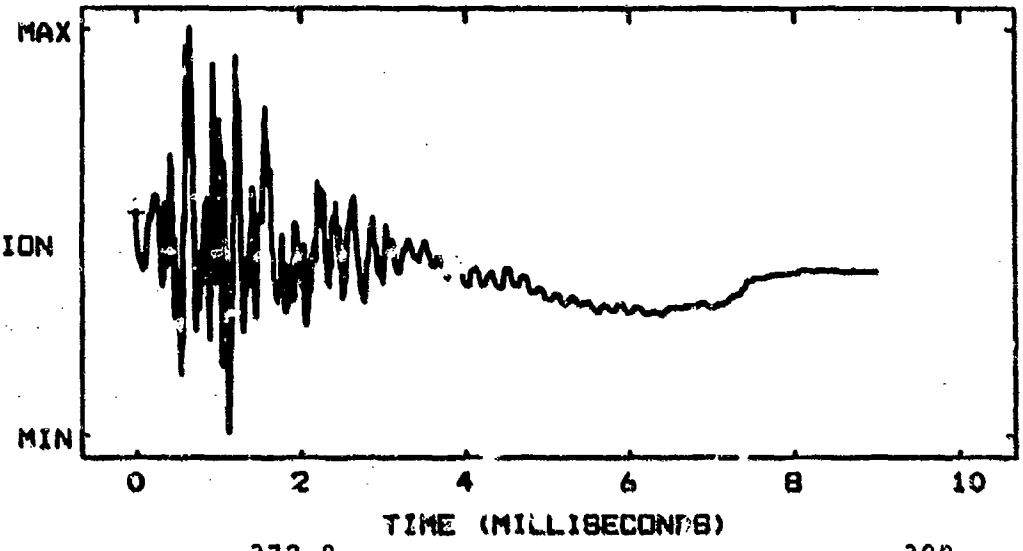
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 2-14-8 THICKNESS .112 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 29.5 IN

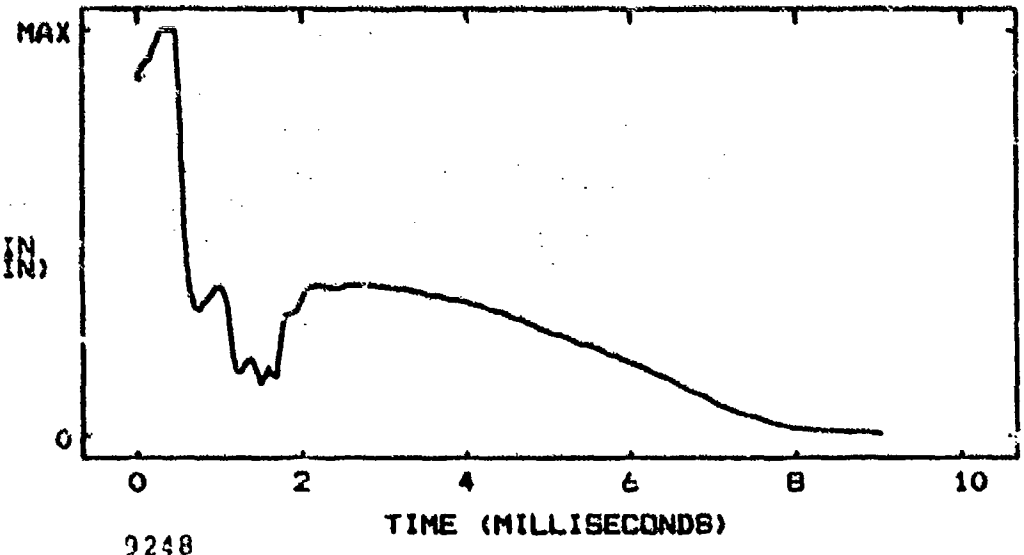
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -372.8 g's MAXIMUM ACCELERATION 308 g's

INTEGRATED TOTAL VELOCITY -36.271 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 9248 UIN/IN

Figure B-162. Panel 2-14-8 Impact Response Data

Specimen 2-14-8

Figure B-163. Panel 2-14-8 C-Scan

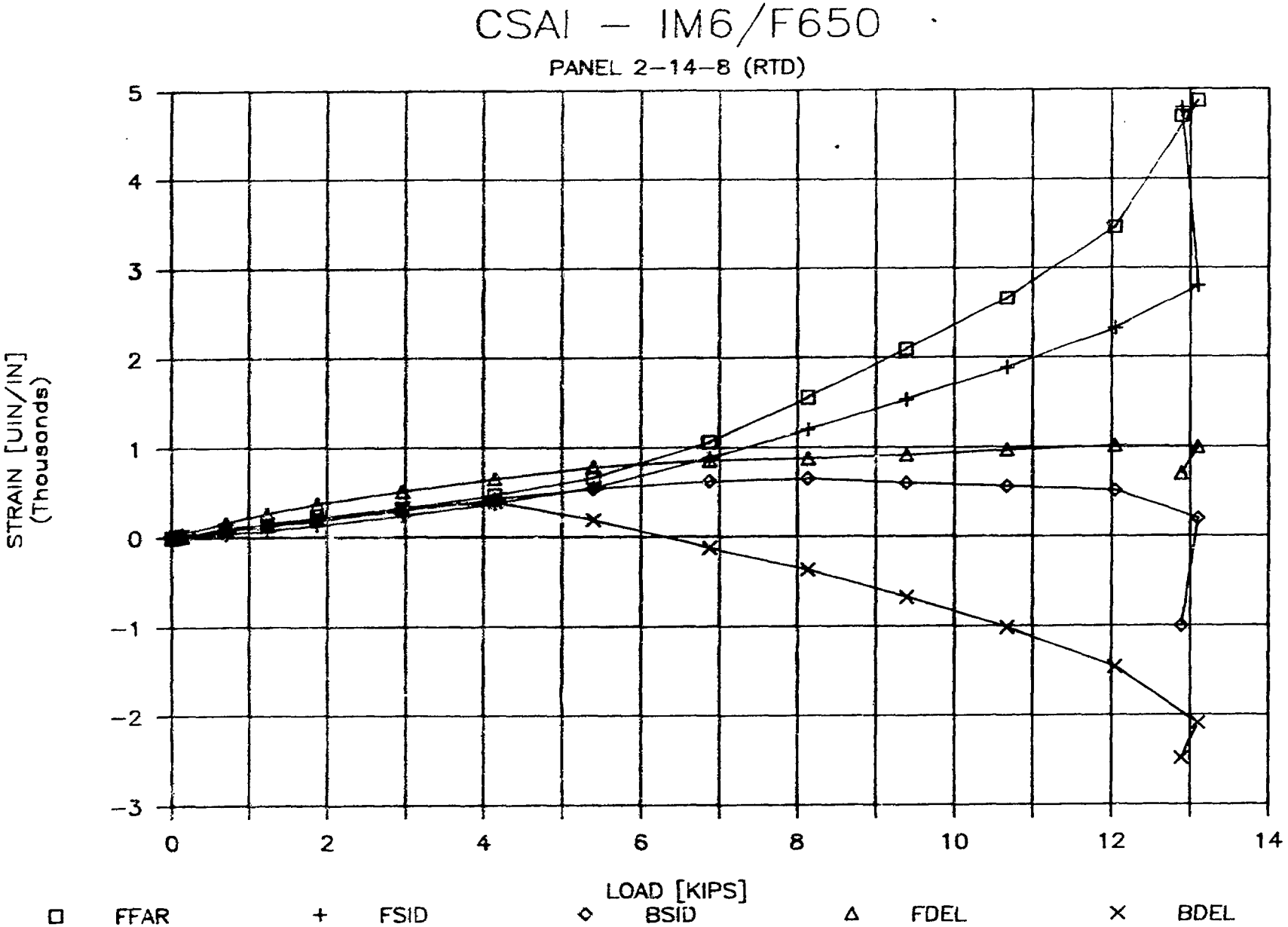


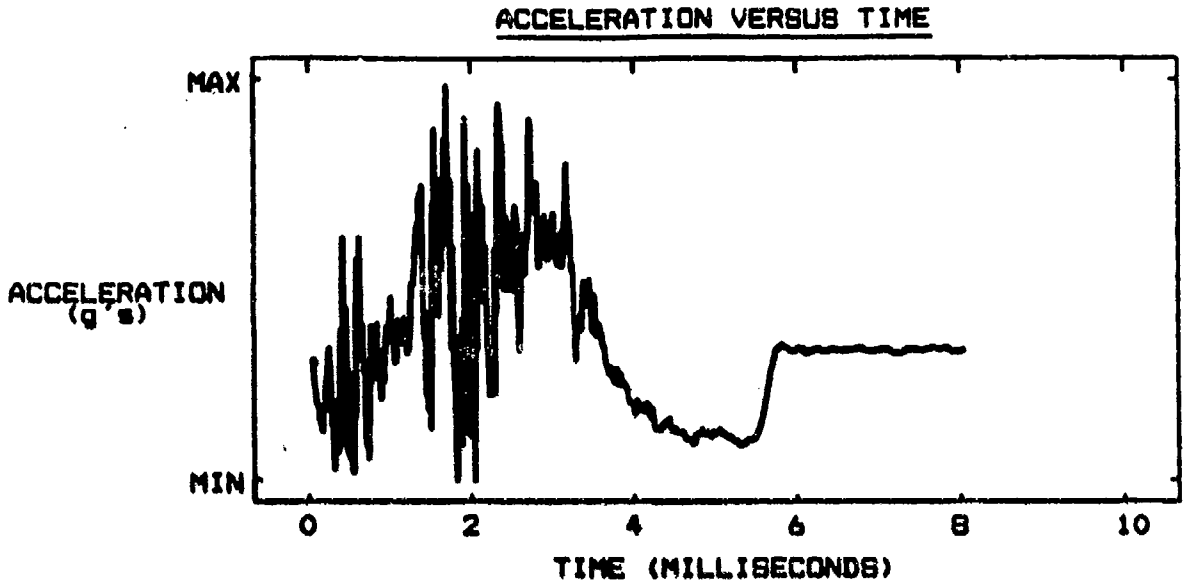
Figure B-164. Panel 2-14-8 Residual Compression Data

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

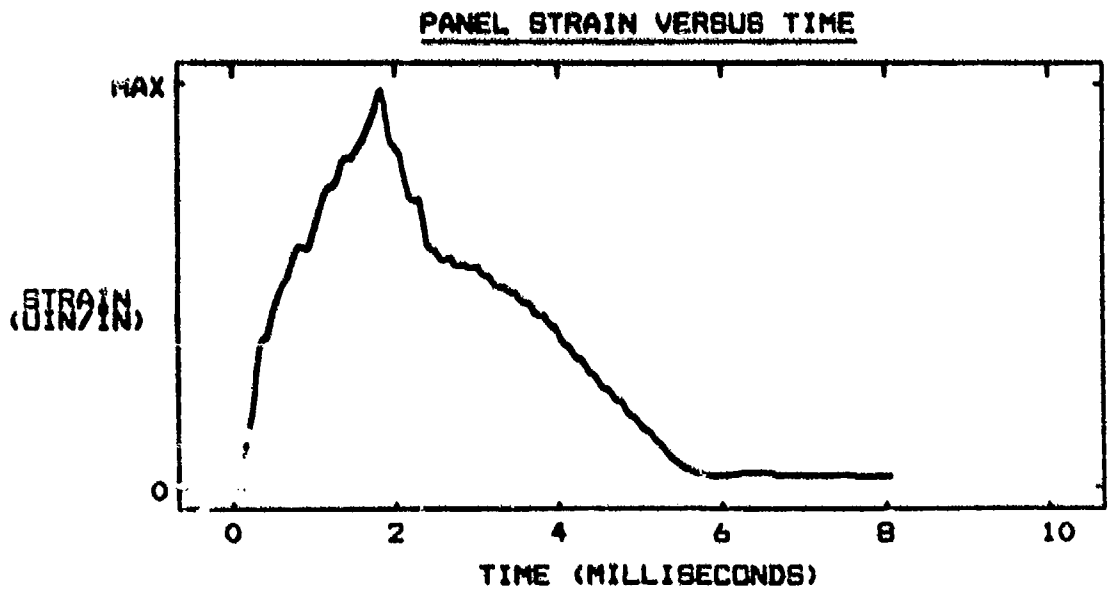
SPECIMEN I.D. 2-20-7 THICKNESS .218 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN



MINIMUM ACCELERATION -161 g's MAXIMUM ACCELERATION 402.34g's

INTEGRATED TOTAL VELOCITY 69.964 IN/SEC



MAXIMUM STRAIN 11919 UIN/IN

Figure B-165. Panel 2-20-7 Impact Response Data

Specimen 2-20-7

Figure B-166. Panel 2-20-7 C-Scan

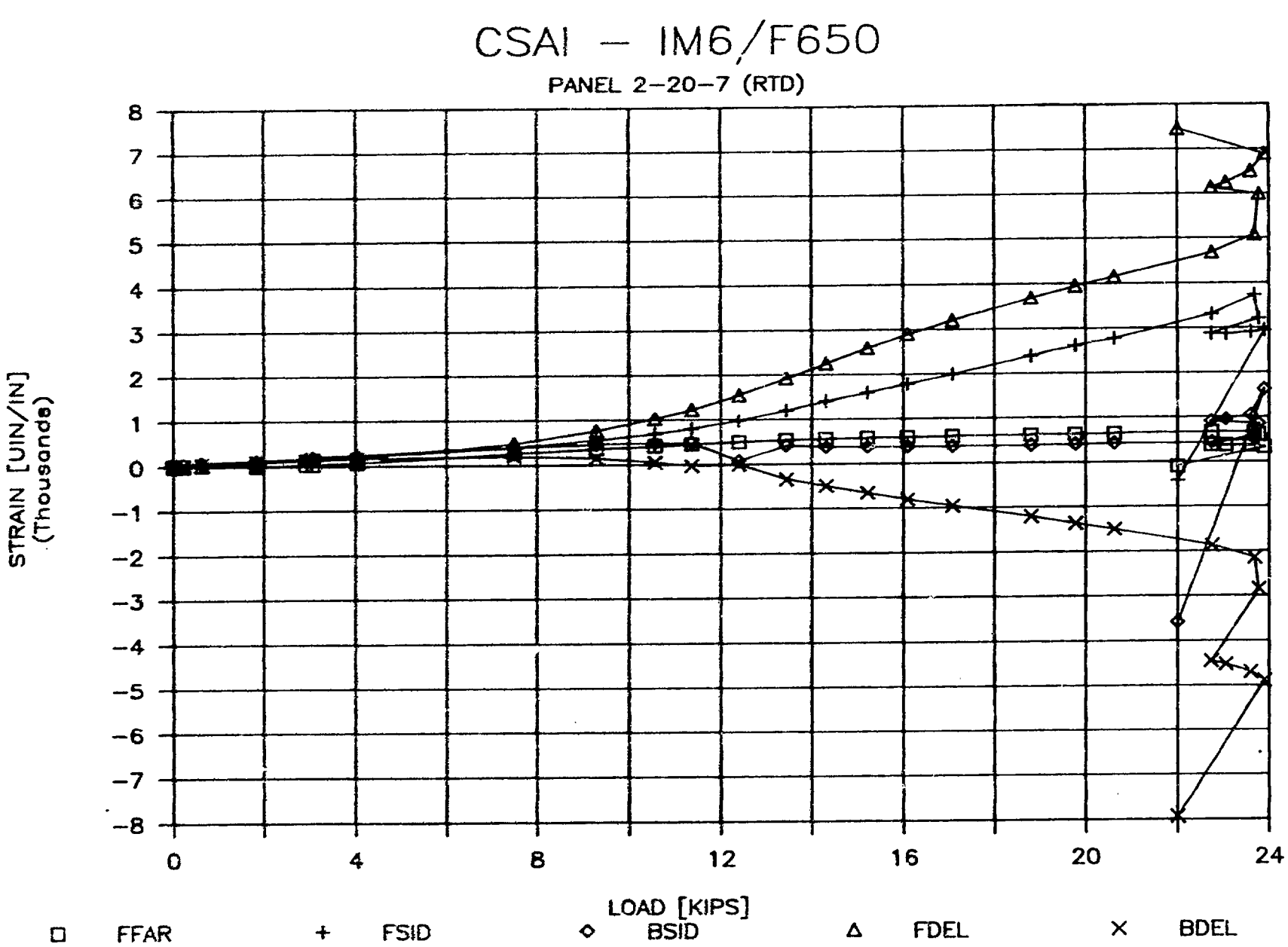


Figure B-167. Panel 2-20-7 Residual Compression Data

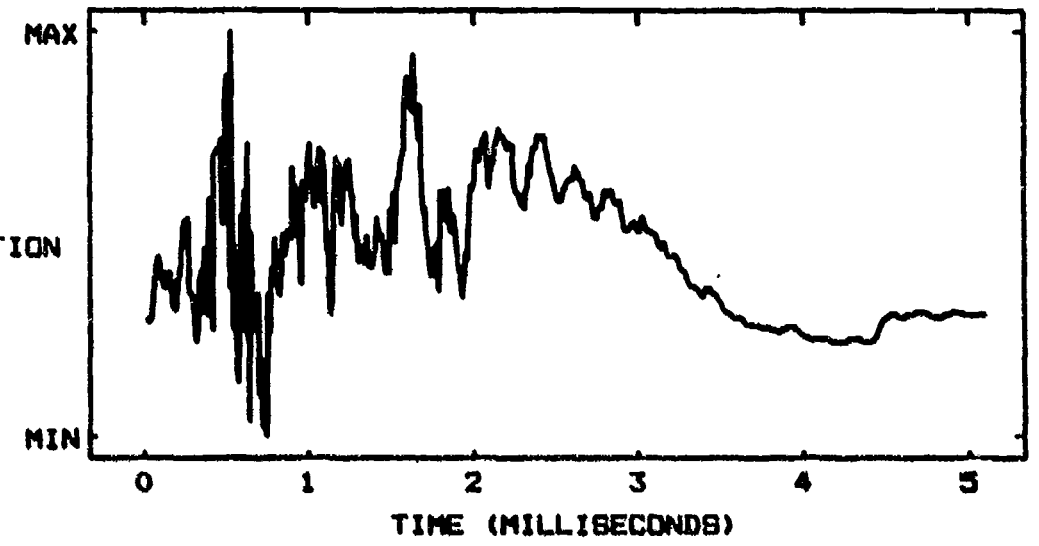
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-15-8 THICKNESS .439 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

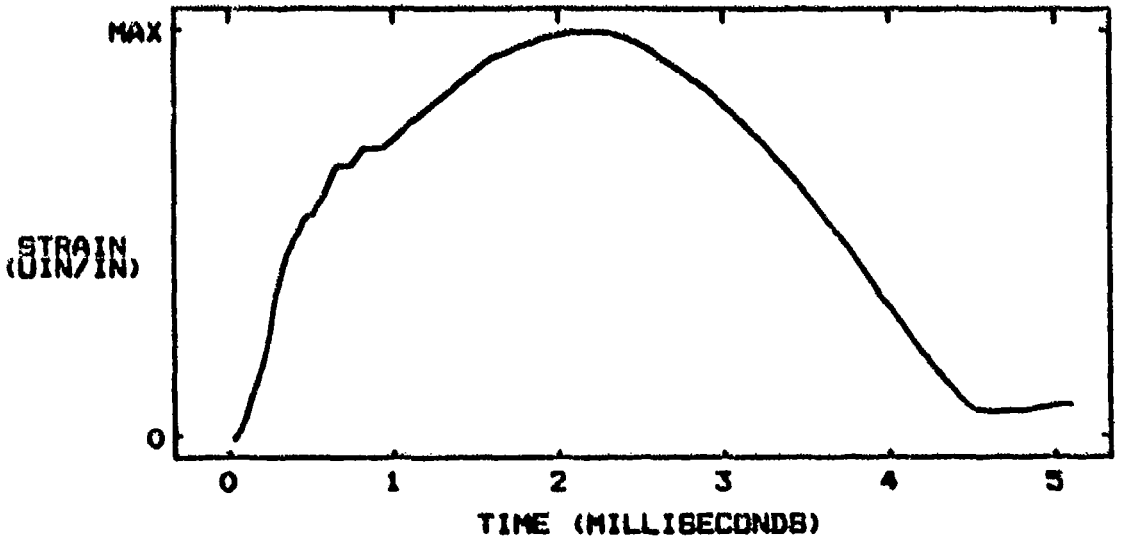
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -610 g's MAXIMUM ACCELERATION 590 g's

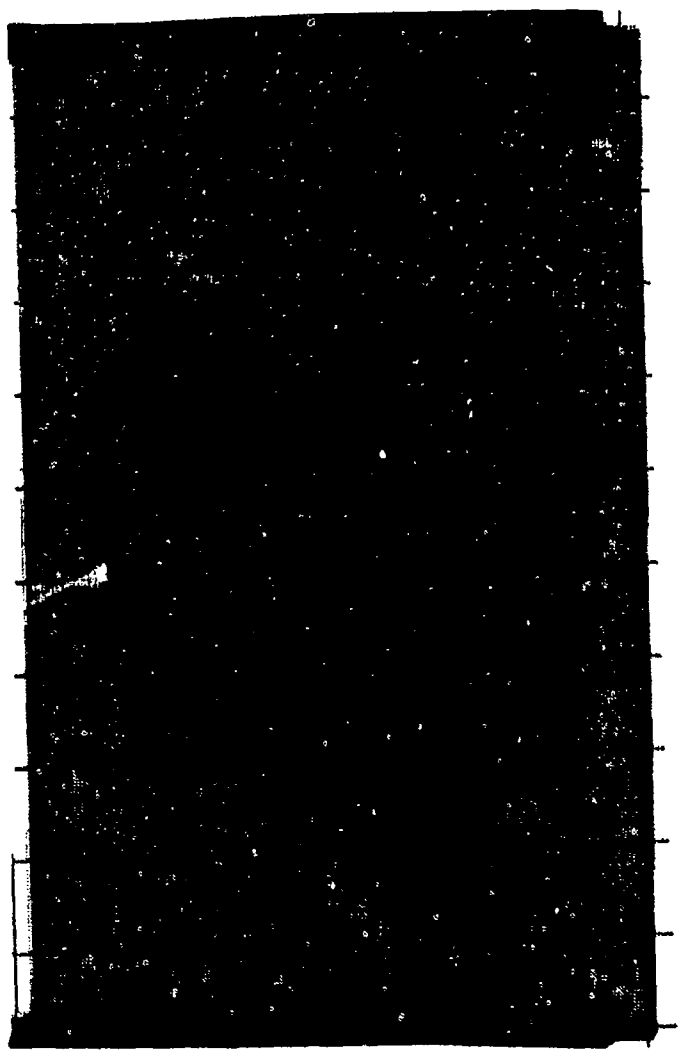
INTEGRATED TOTAL VELOCITY 256 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 13606 UIN/IN

Figure 8-168. Panel 2-15-8 Impact Response Data



Specimen 2-15-8

Figure B-169. Panel 2-15-8 C-Scan

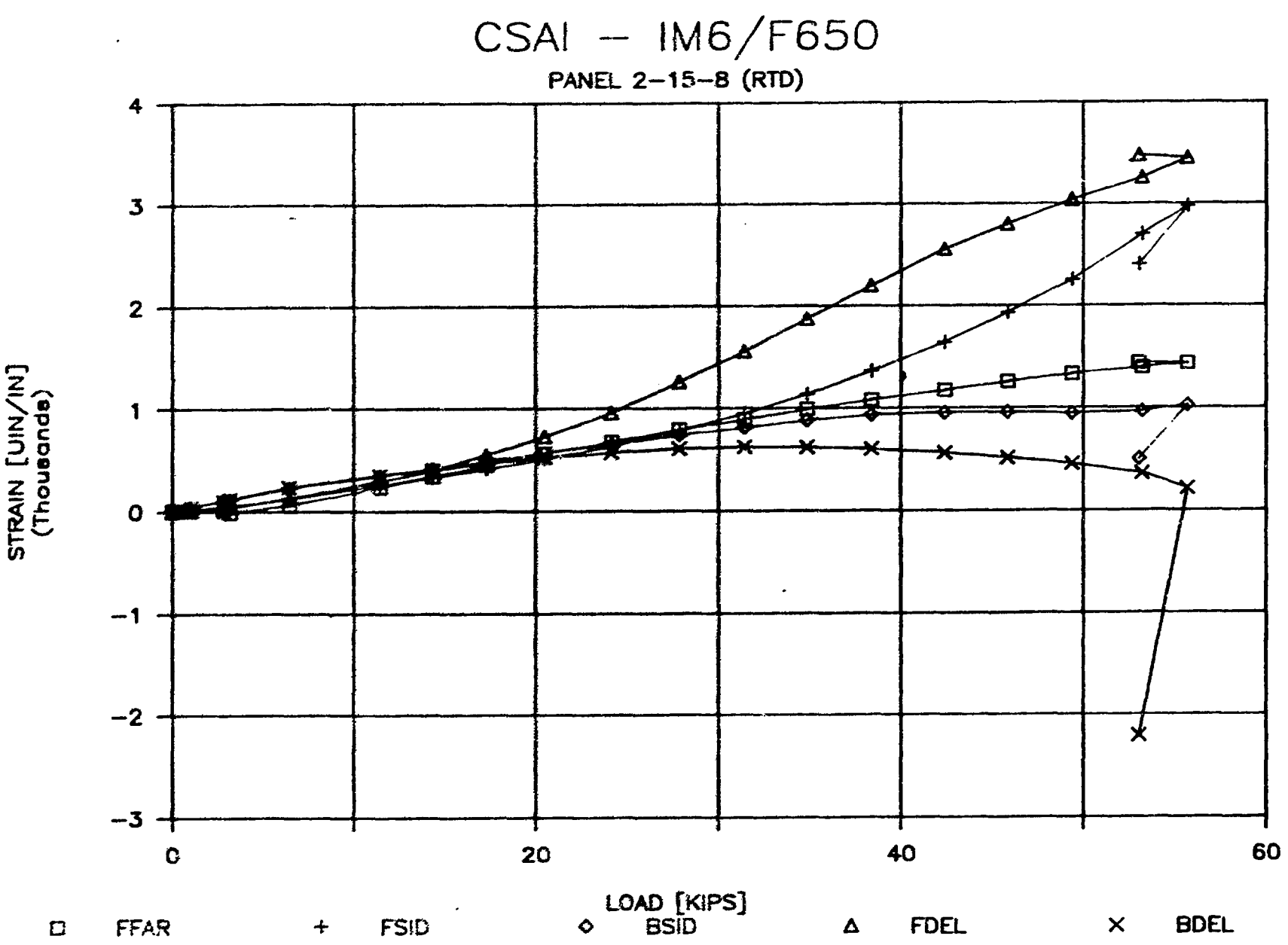


Figure B-170. Panel 2-15-8 Residual Compression Data

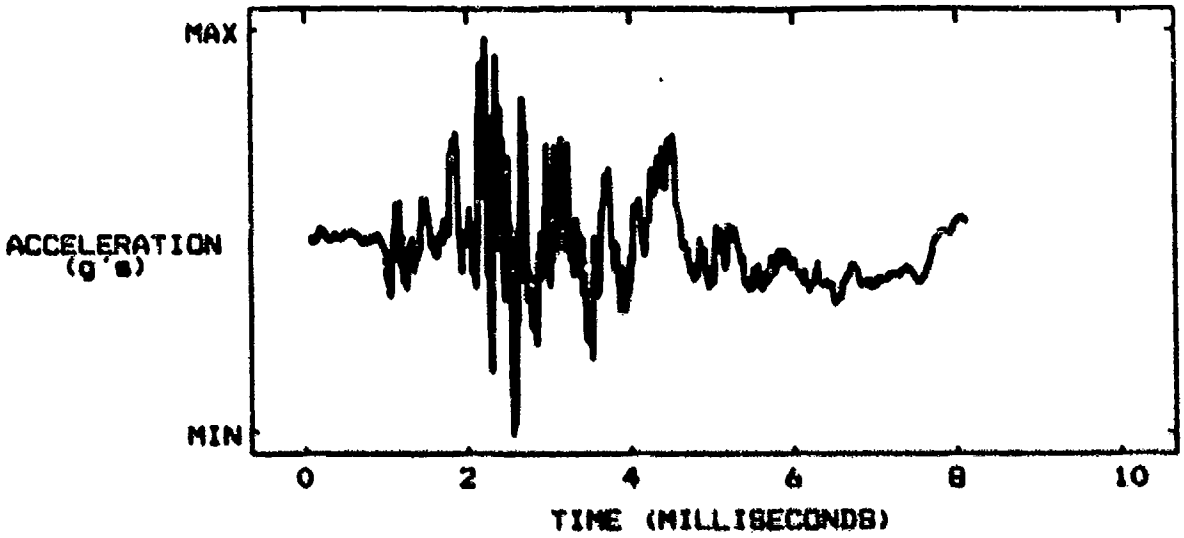
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-12-12 THICKNESS .114 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 39.3 IN

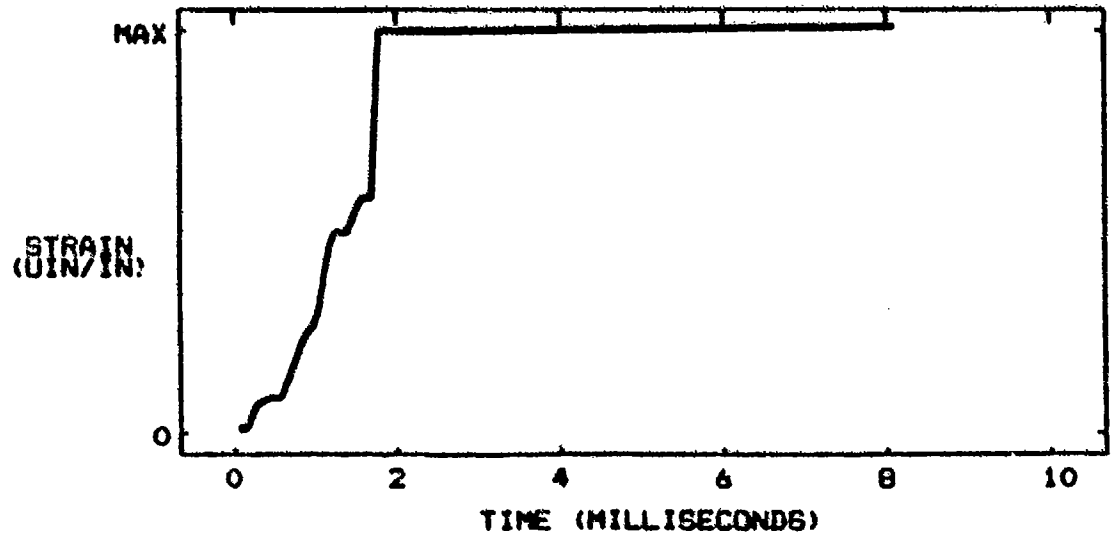
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -180 g's MAXIMUM ACCELERATION 199.0 g's

INTEGRATED TOTAL VELOCITY 2.6016 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 36732 UIN/IN

Figure 8-171. Panel 1-12-12 Impact Response Data

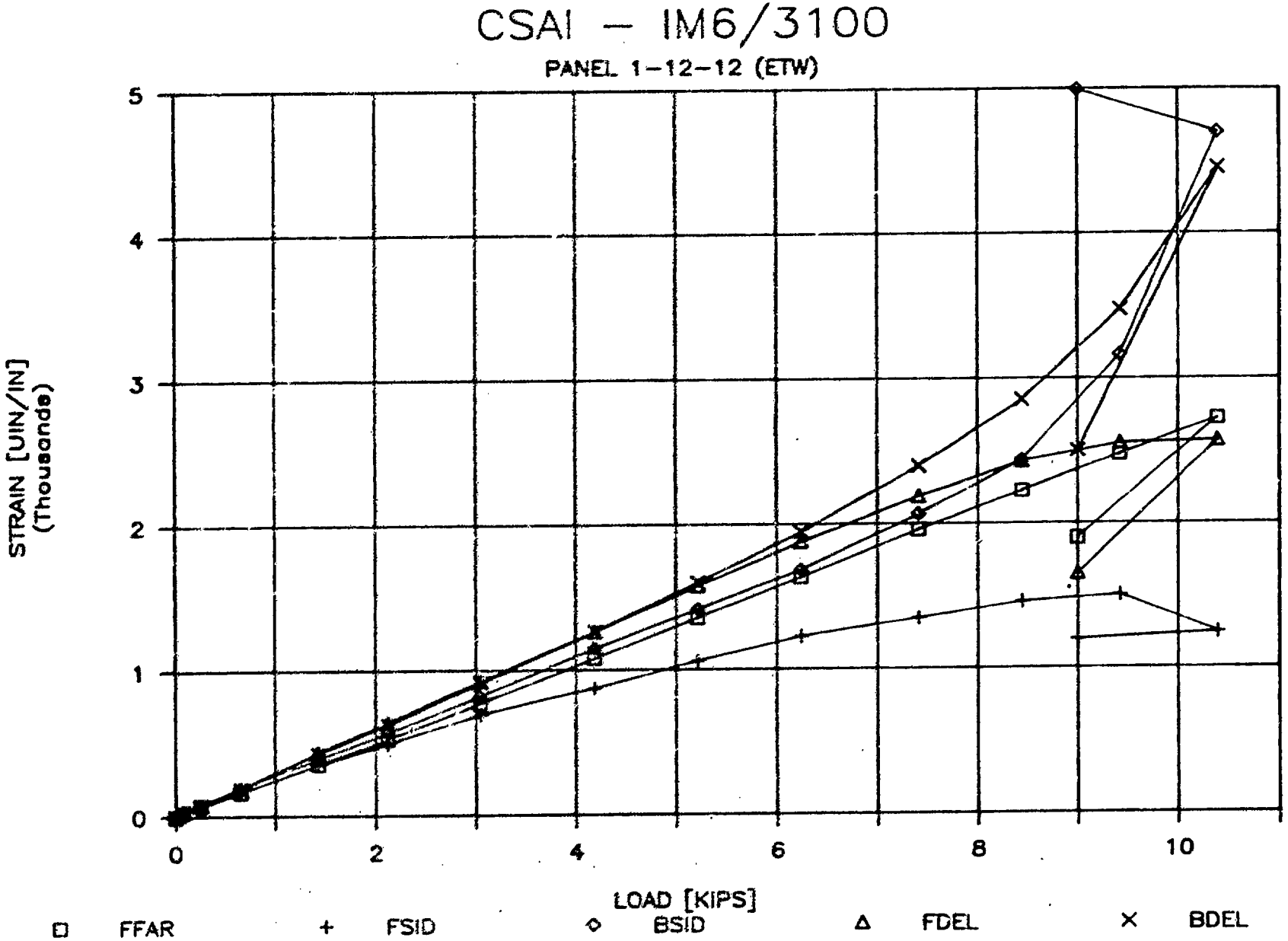


Figure B-172. Panel 1-12-12 Residual Compression Data

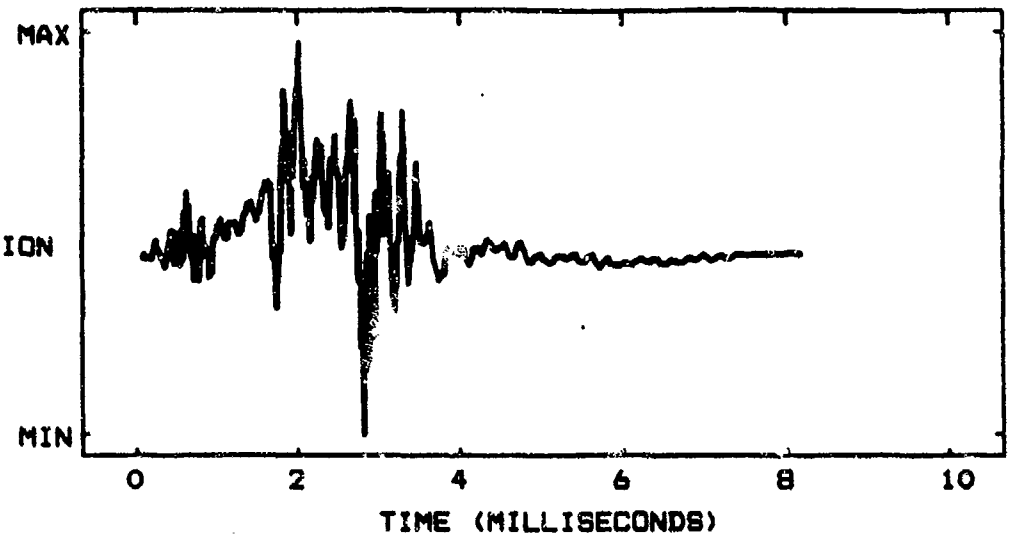
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-11-12 THICKNESS .223 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

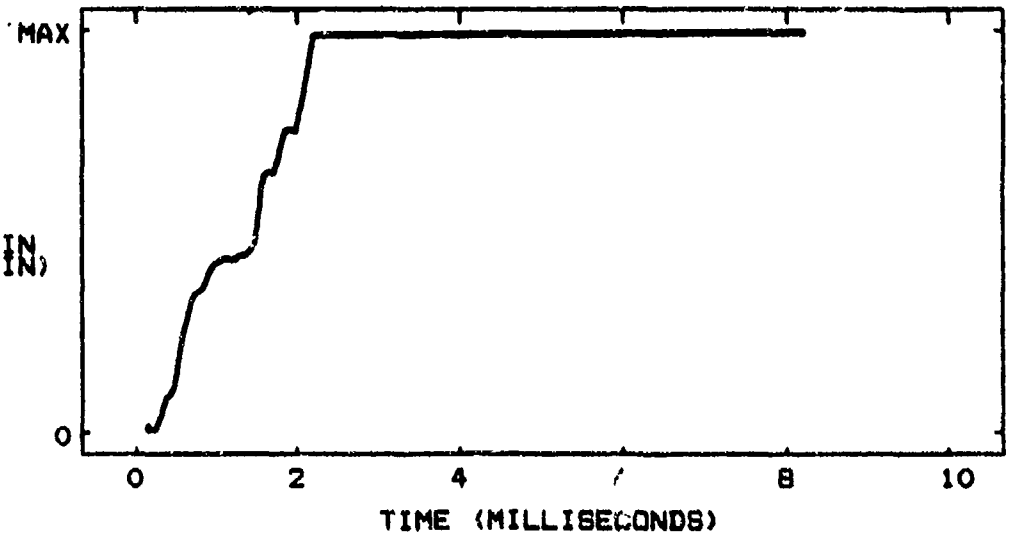
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -435 g's MAXIMUM ACCELERATION 558.59 g's

INTEGRATED TOTAL VELOCITY 149.99 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 36545 UIN/IN

Figure B-173. Panel 1-11-12 Impact Response Data

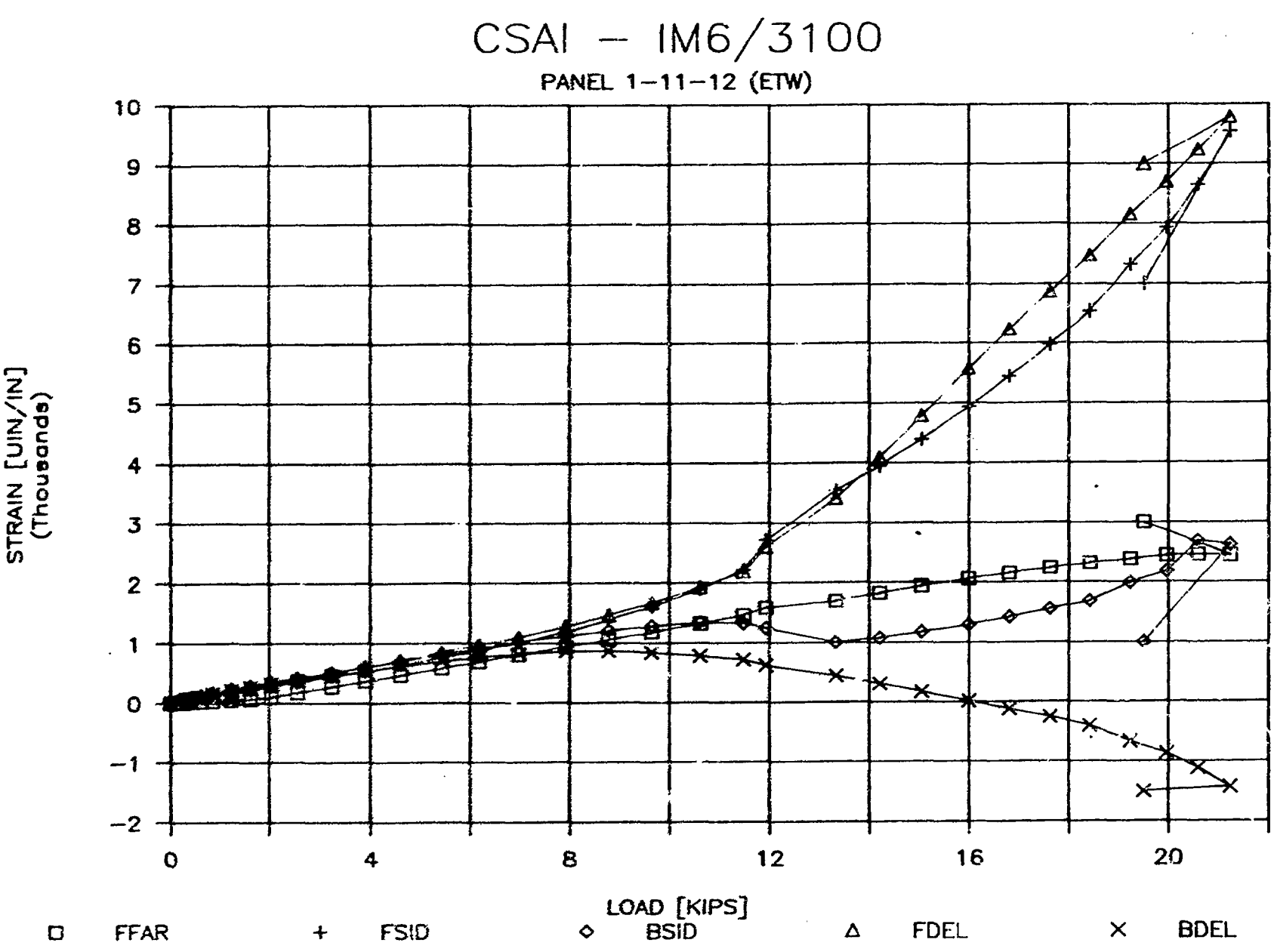


Figure B-174. Panel 1-11-12 Residual Compression Data

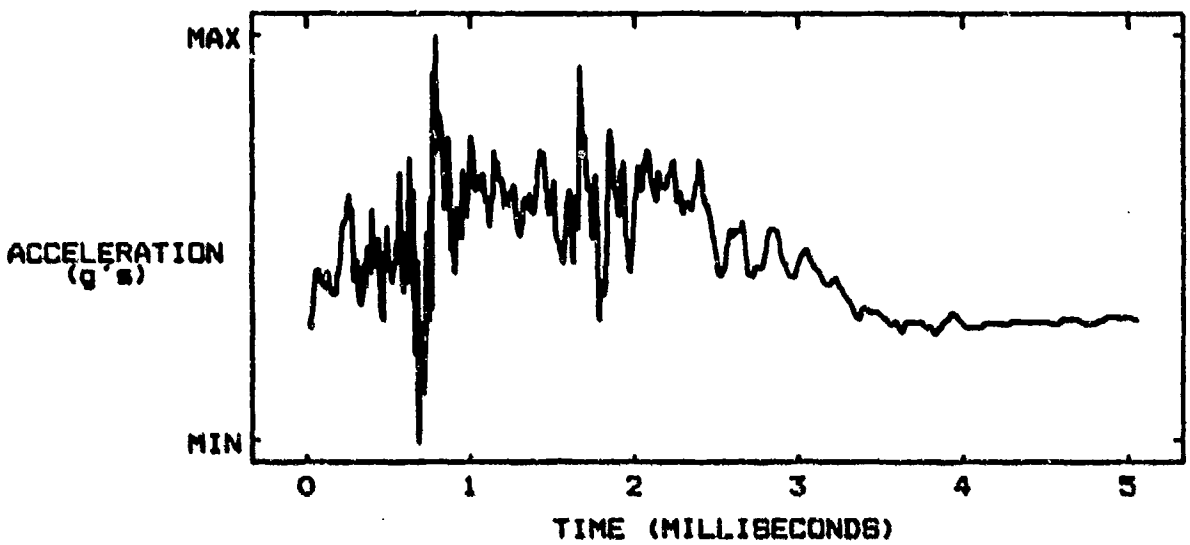
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

SPECIMEN I.D. 1-13-12 THICKNESS .452 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

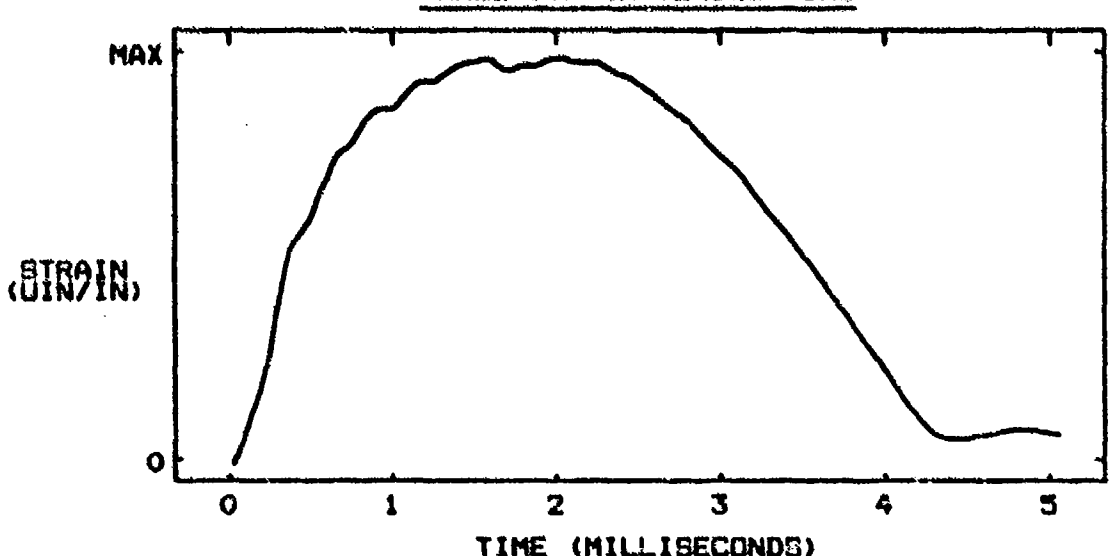
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -300 g's MAXIMUM ACCELERATION 752 g's

INTEGRATED TOTAL VELOCITY 323.14 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 17073 UIN/IN

Figure B-175. Panel 1-13-12 Impact Response Data

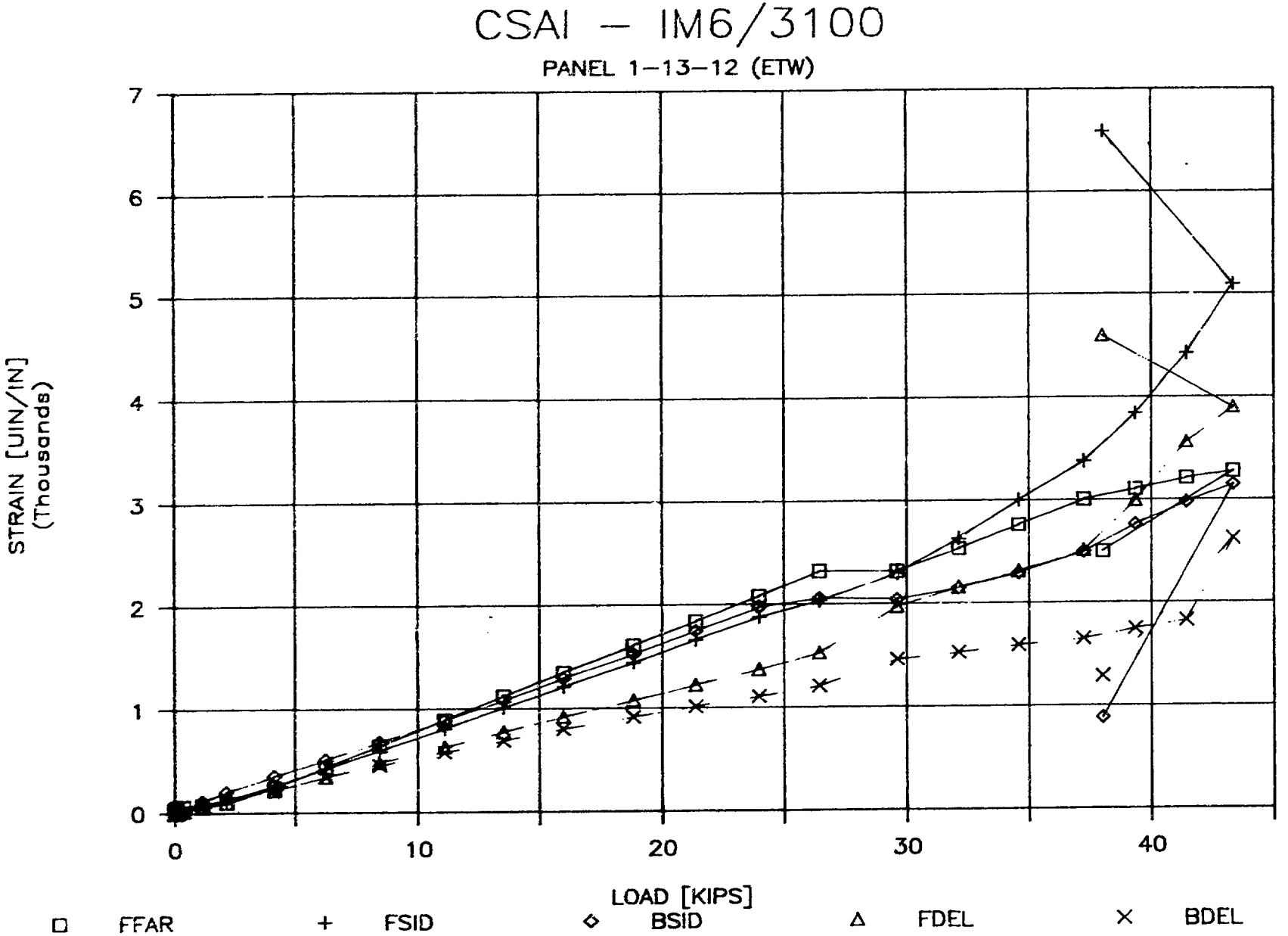


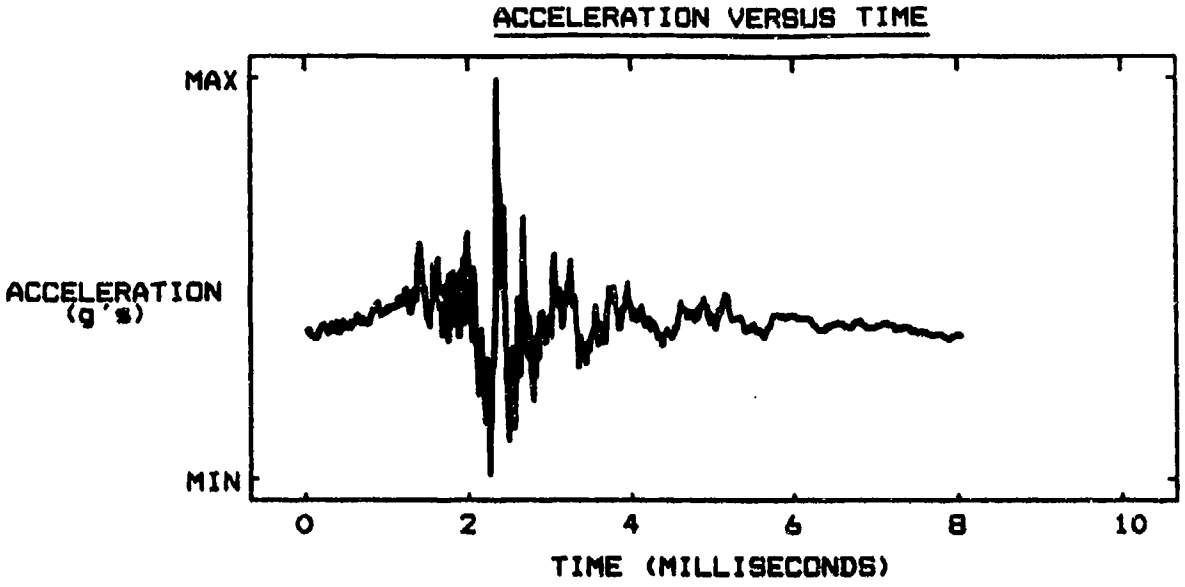
Figure B-176. Panel 1-13-12 Residual Compression Data

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

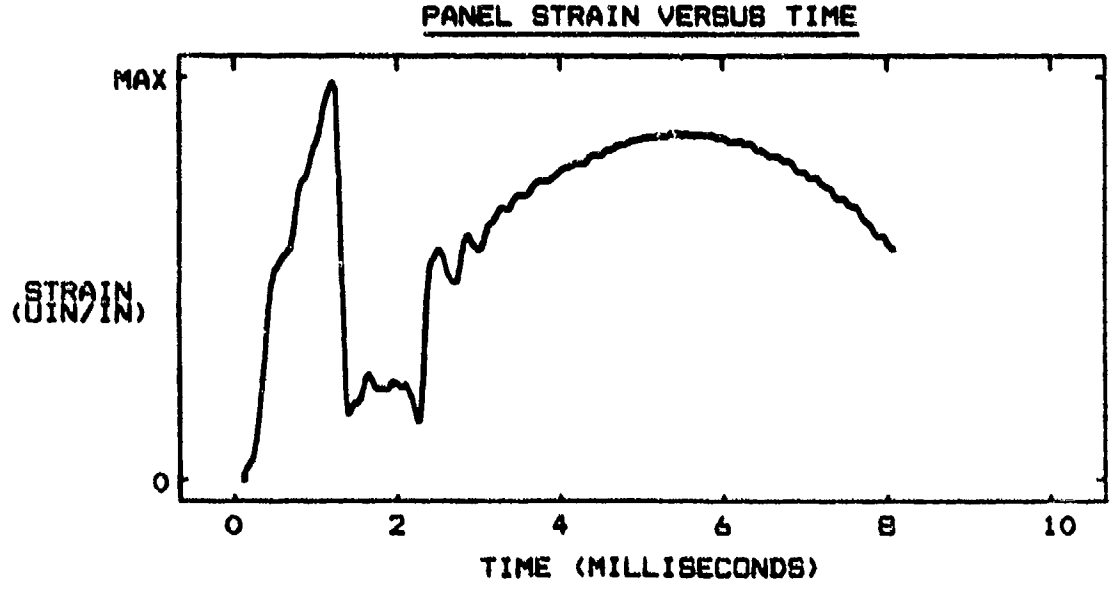
SPECIMEN I.D. 1-14-11 THICKNESS .109 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 38.2 IN



MINIMUM ACCELERATION -415 g's MAXIMUM ACCELERATION 701.17g's

INTEGRATED TOTAL VELOCITY 50.093 IN/SEC



MAXIMUM STRAIN 10729 UIN/IN

Figure B-177. Panel 1-14-11 Impact Response Data

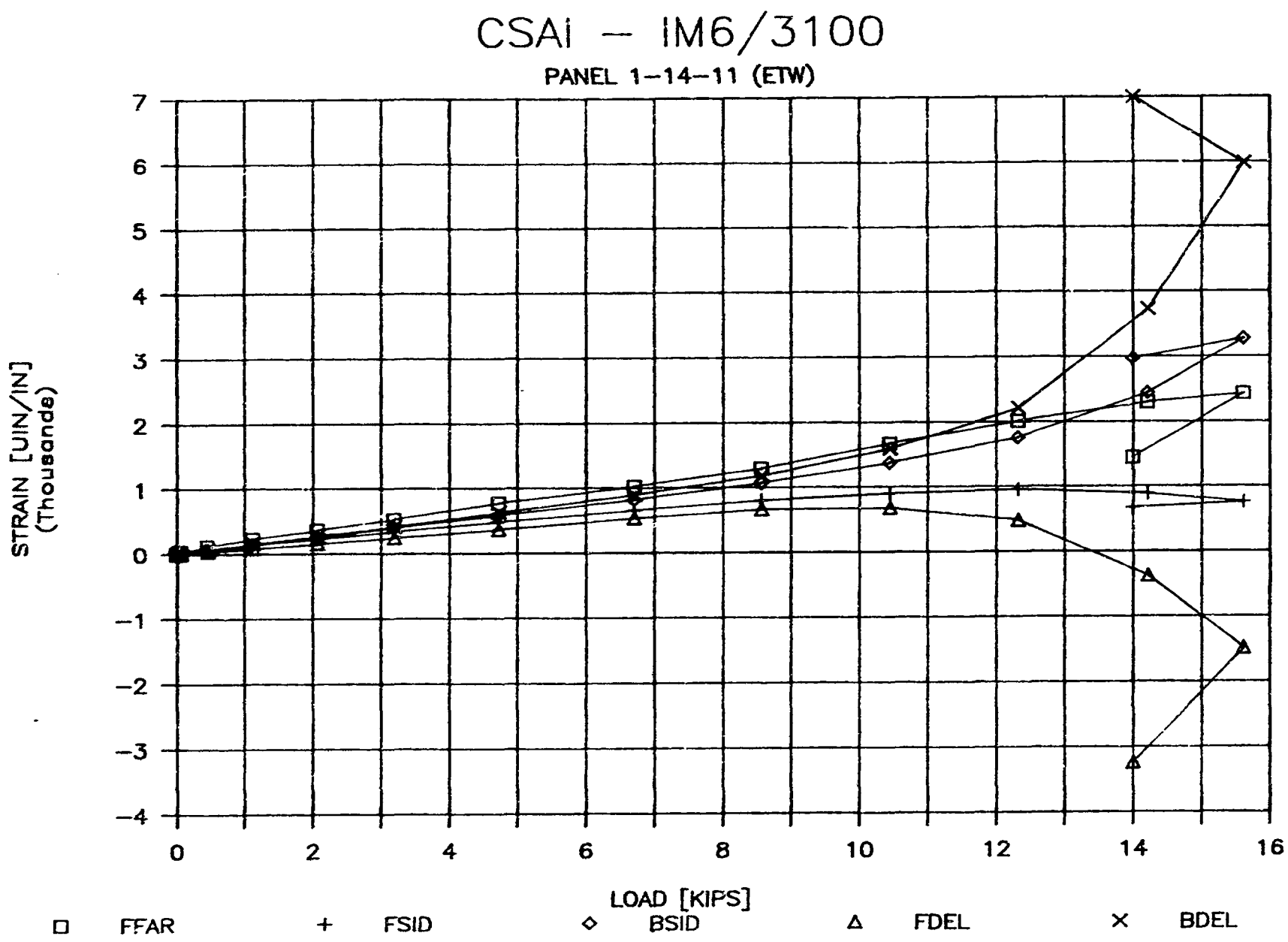


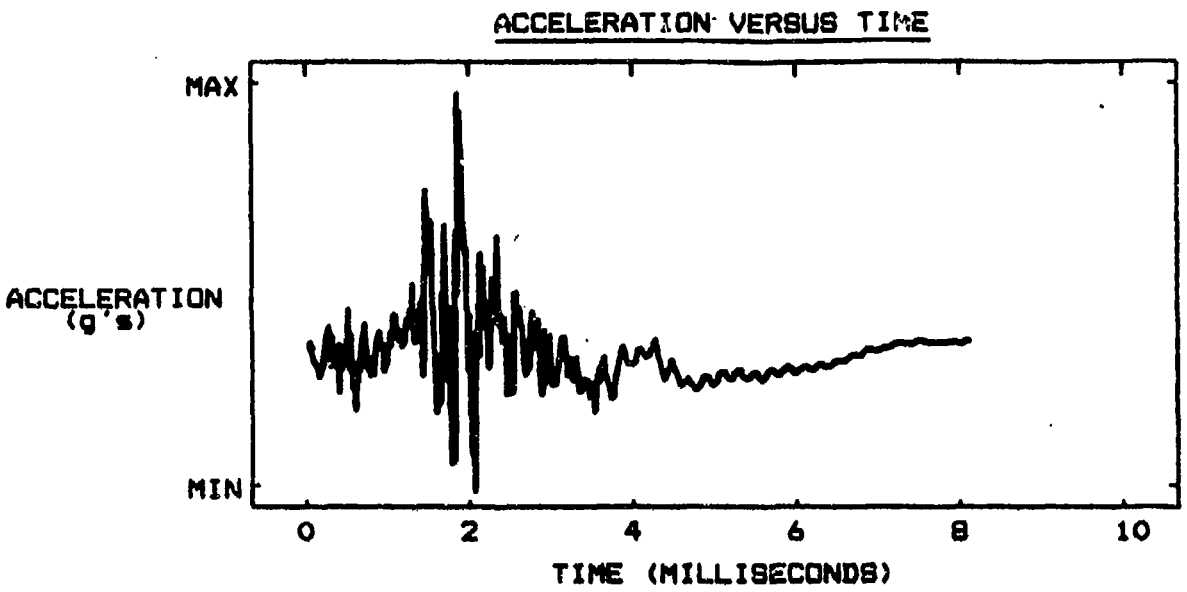
Figure B-178. Panel 1-14-11 Residual Compression Data

LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/3100

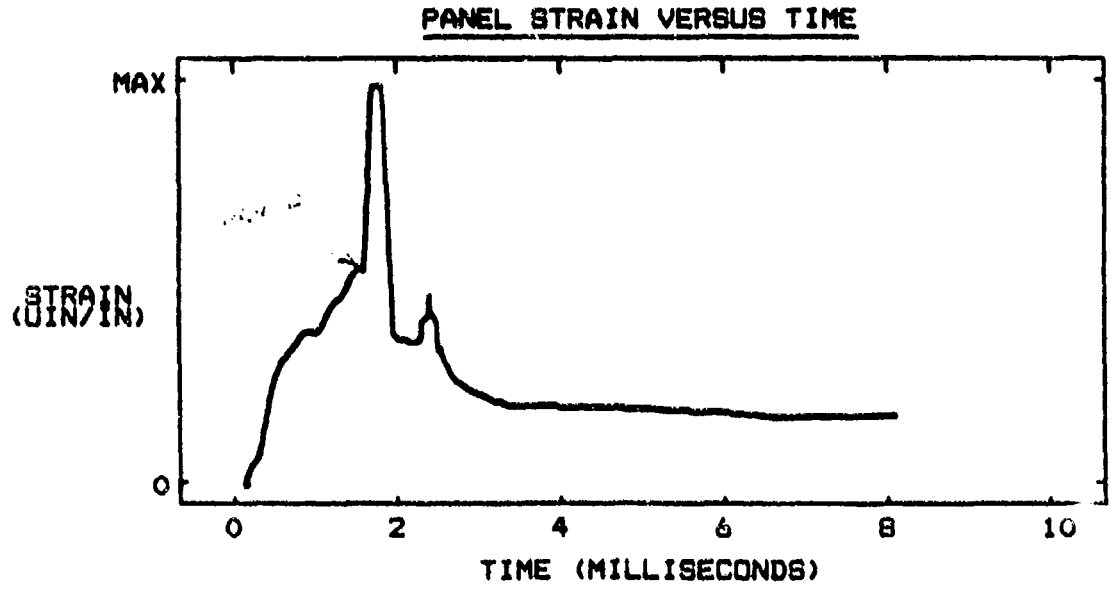
SPECIMEN I.D. 1-20-11 THICKNESS .225 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN



MINIMUM ACCELERATION -330 g's MAXIMUM ACCELERATION 617.19g's

INTEGRATED TOTAL VELOCITY -61.751IN/SEC



MAXIMUM STRAIN 19829 UIN/IN

Figure B-179. Panel 1-20-11 Impact Response Data

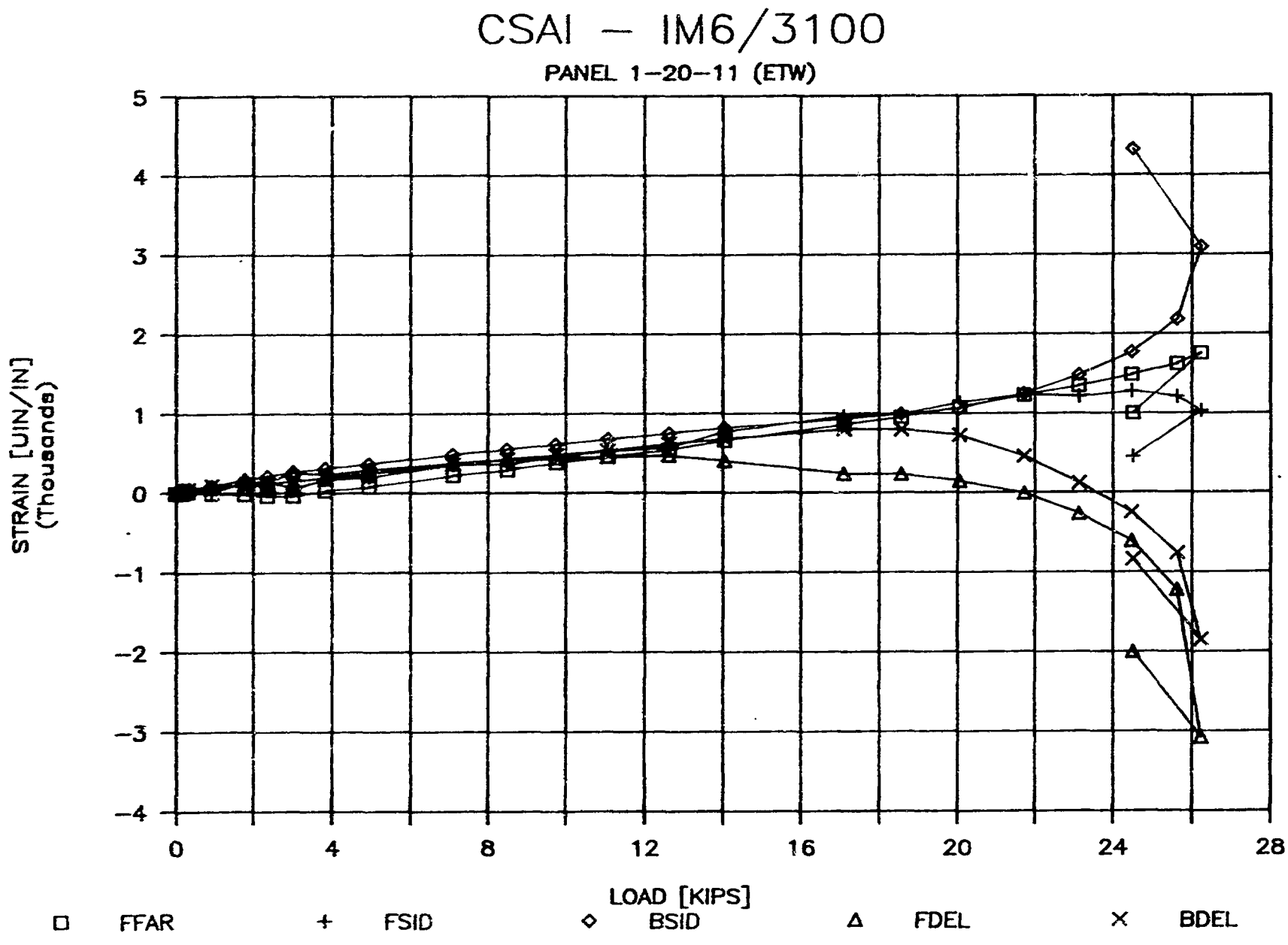


Figure B-180. Panel 1-20-11 Residual Compression Data

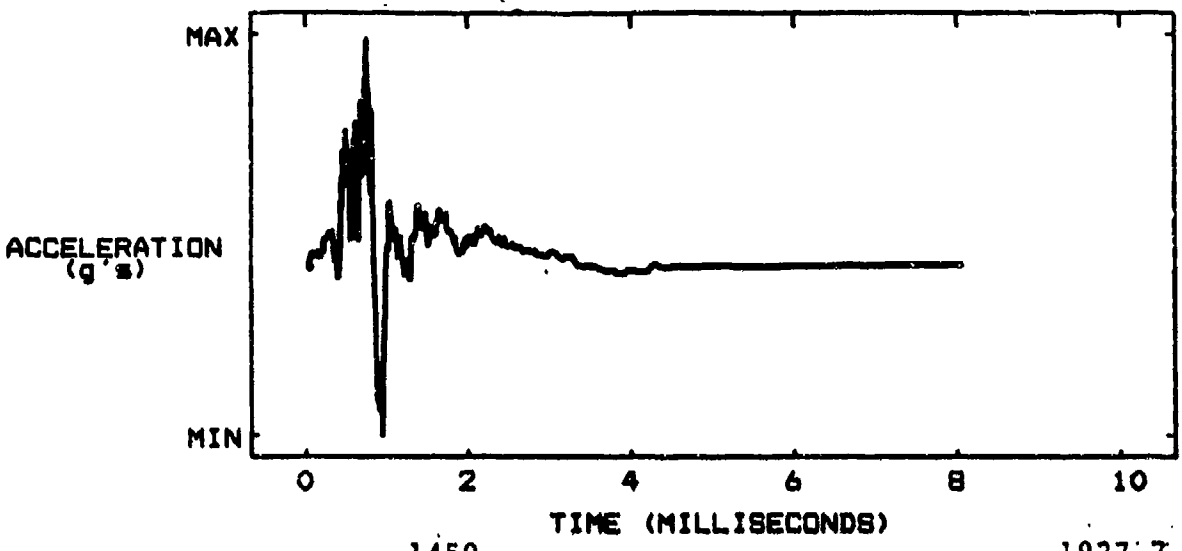
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 1-15-11 THICKNESS .452 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

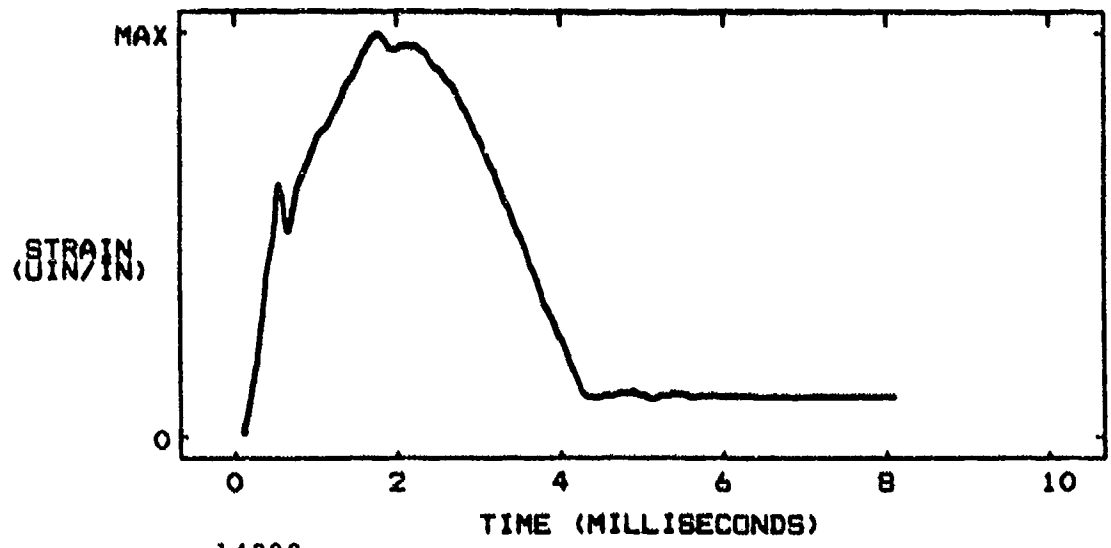
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -1450 g's MAXIMUM ACCELERATION 1927.7 g's

INTEGRATED TOTAL VELOCITY 269.12 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 14299 UIN/IN

Figure B-181. Panel 1-15-11 Impact Response Data

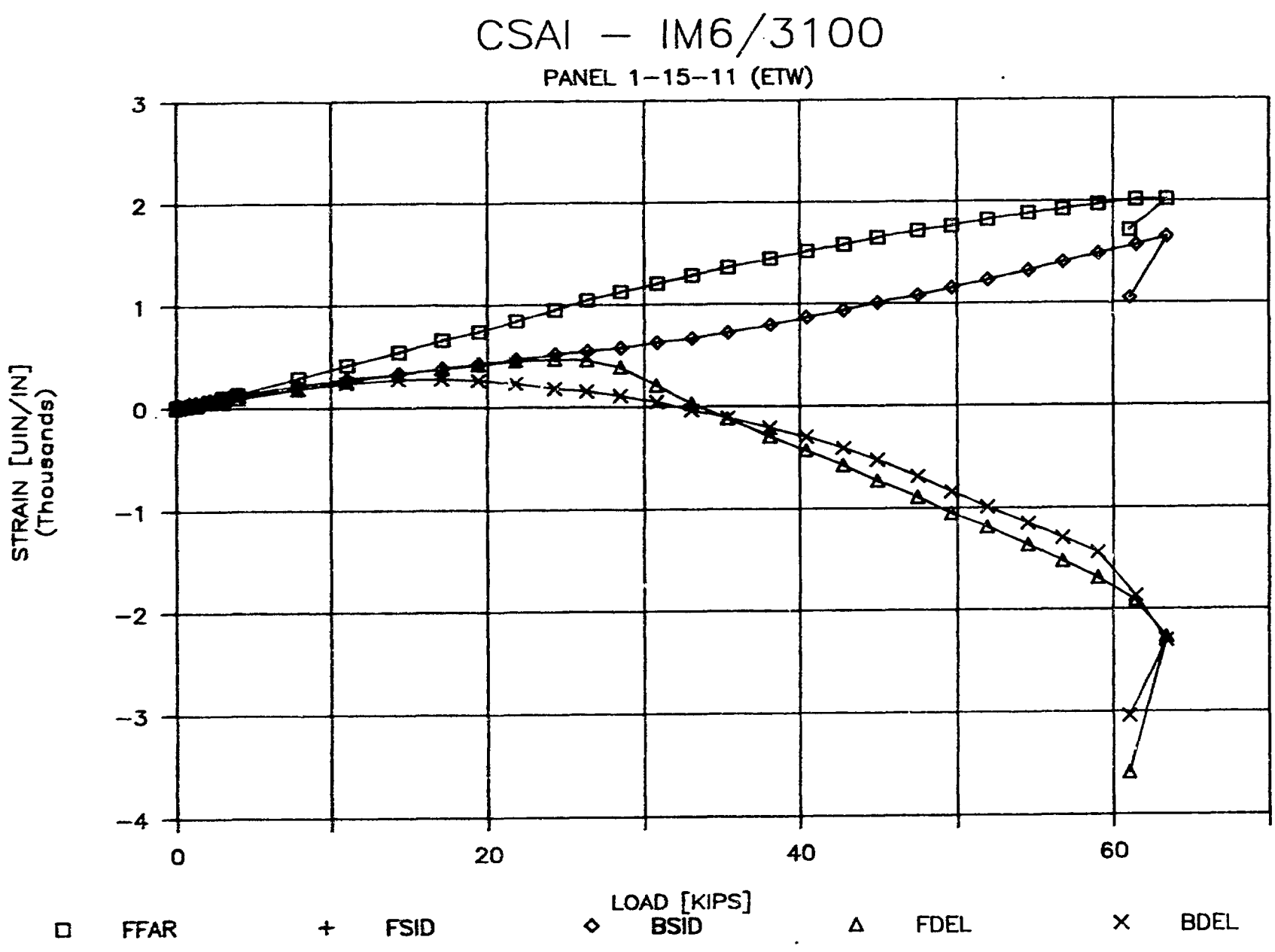


Figure B-182. Panel 1-15-11 Residual Compression Data

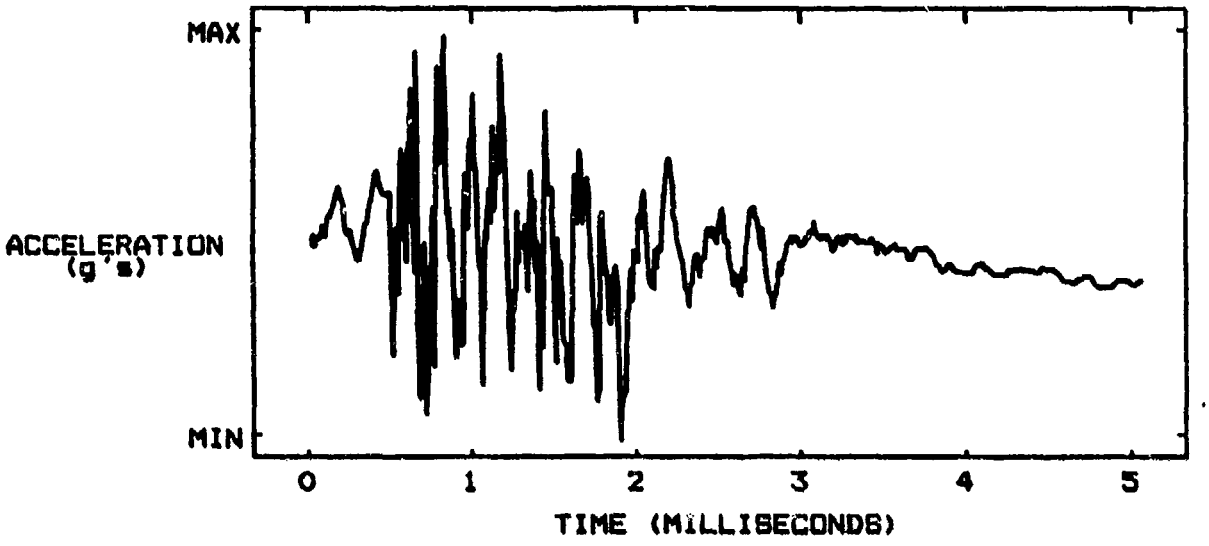
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-12-11 THICKNESS .106 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 29.5 IN

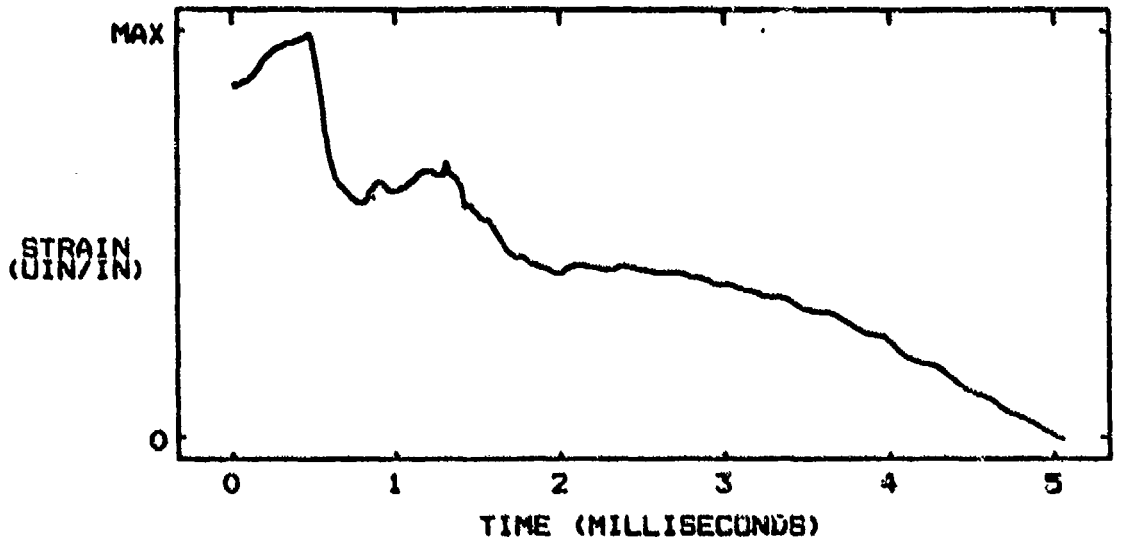
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -179 g's MAXIMUM ACCELERATION 242.00 g's

INTEGRATED TOTAL VELOCITY -319.42 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 17303 UIN/IN

Figure B-183. Panel 2-12-11 Impact Response Data

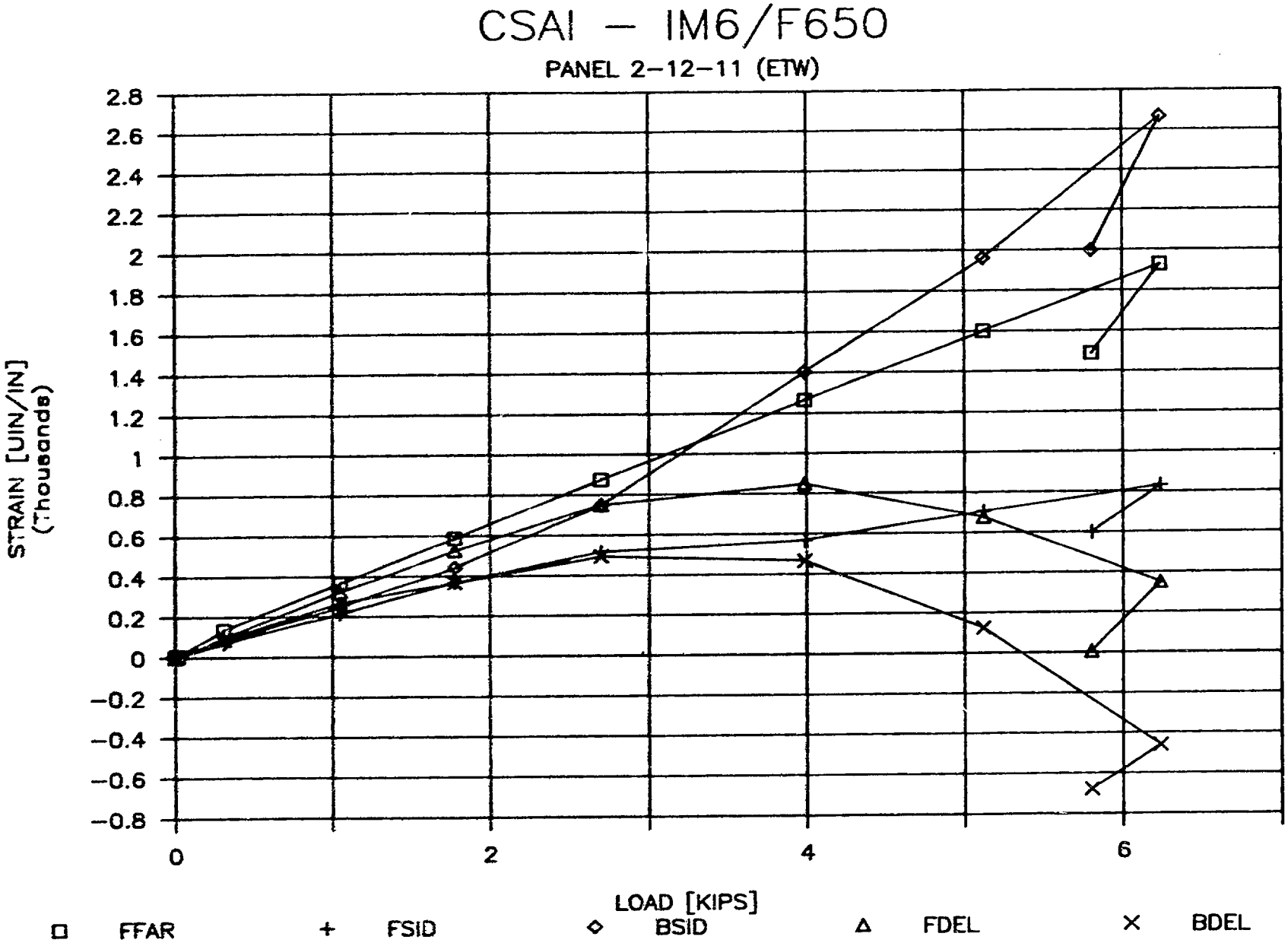


Figure B-184. Panel 2-12-11 Residual Compression Data

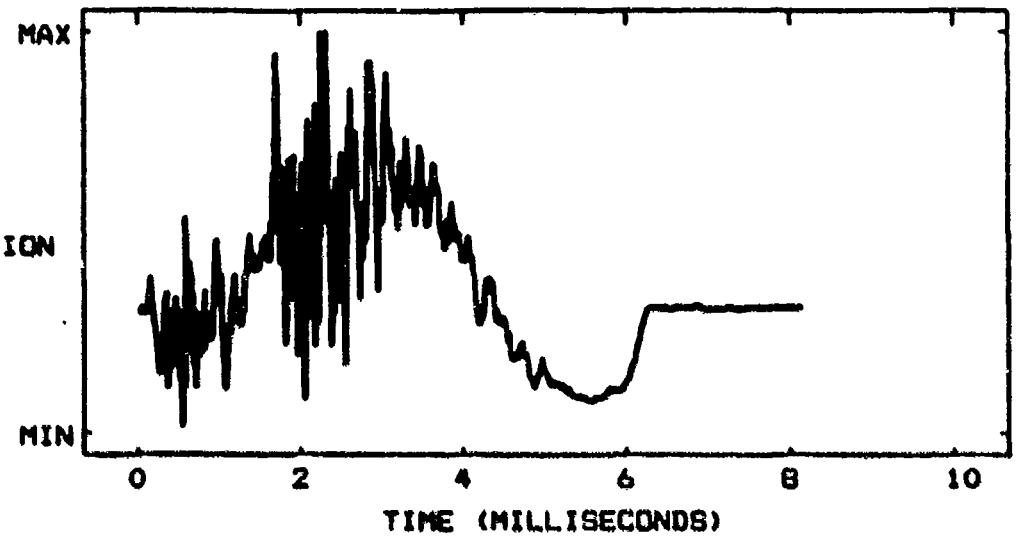
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-11-11 THICKNESS .217 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

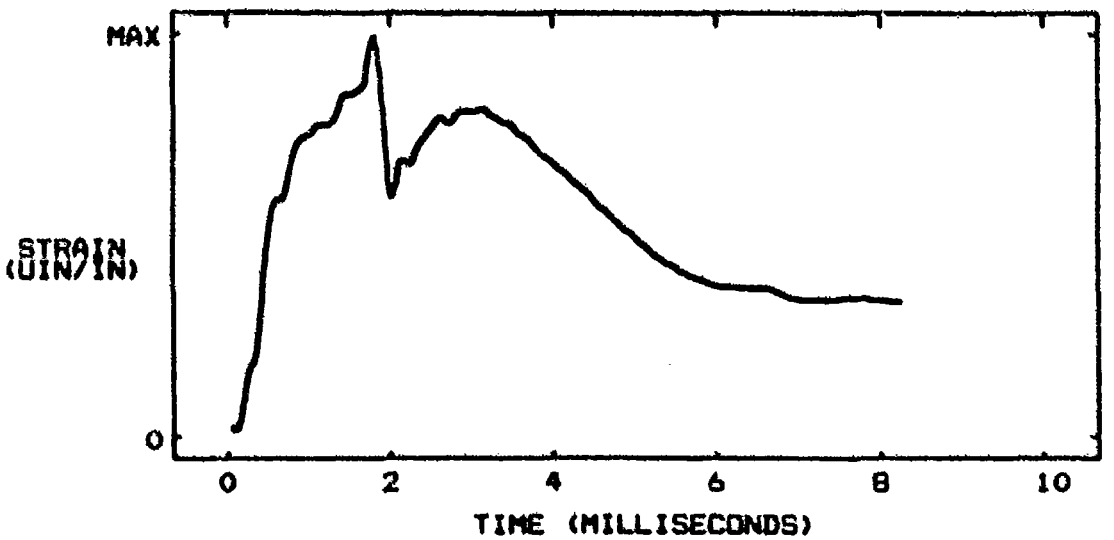
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -97 g's MAXIMUM ACCELERATION 222.00 g's

INTEGRATED TOTAL VELOCITY 60.749 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 20090 UIN/IN

Figure B-185. Panel 2-11-11 Impact Response Data

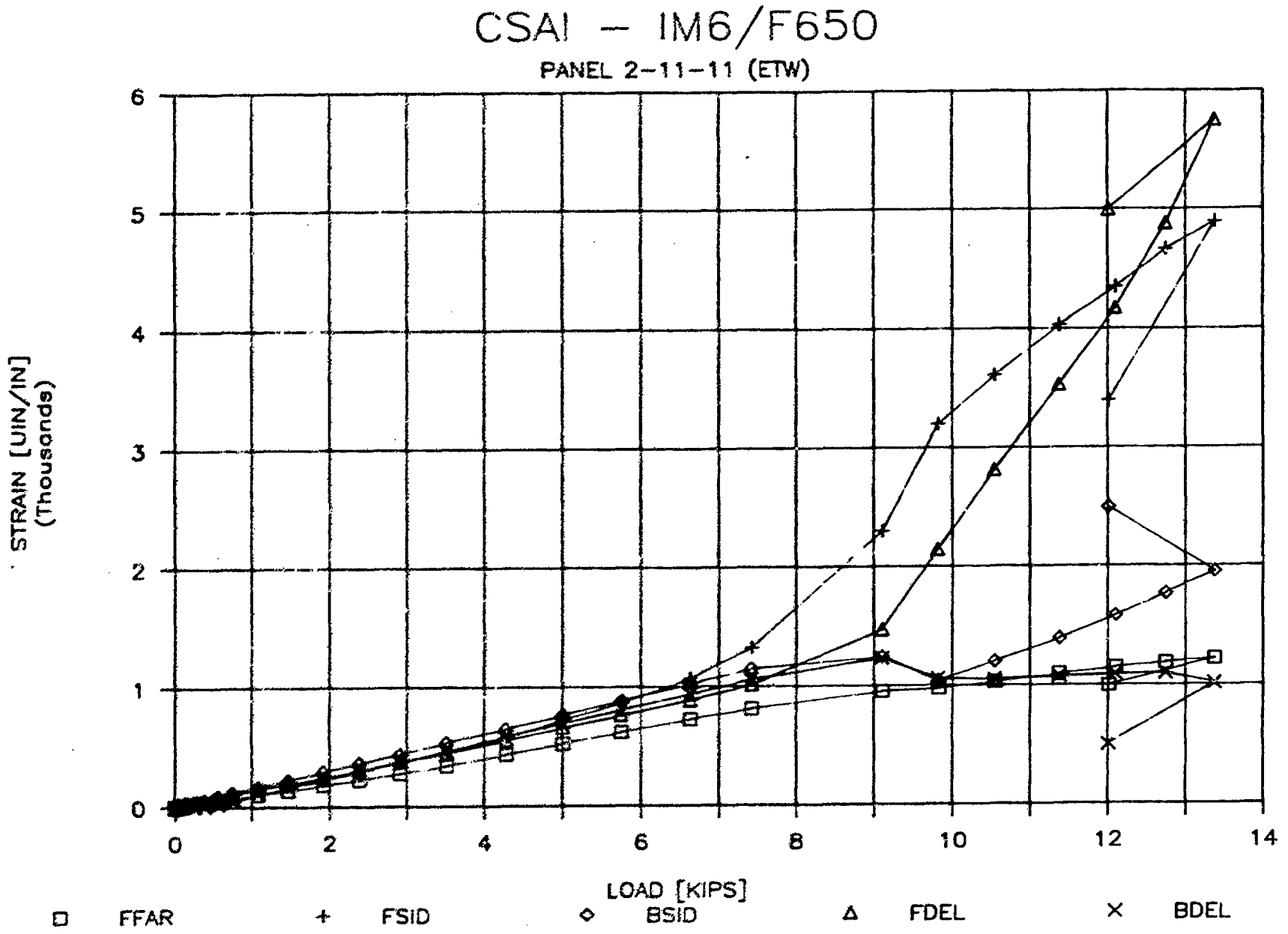


Figure 8-186. Panel 2-11-11 Residual Compression Data

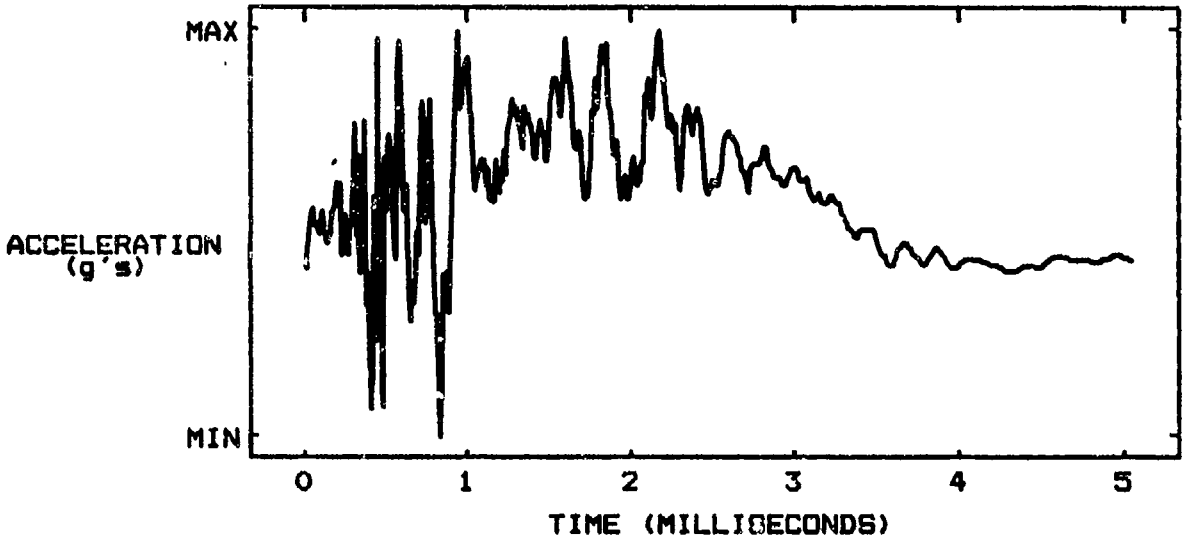
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-13-11 THICKNESS .437 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

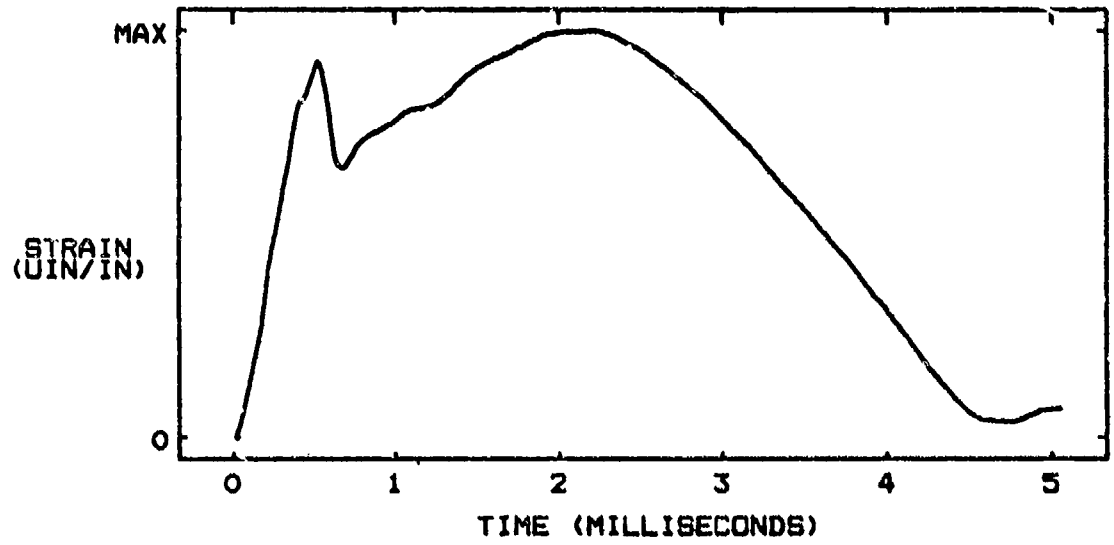
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -702.7 g's MAXIMUM ACCELERATION 420 g's

INTEGRATED TOTAL VELOCITY 273.73 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 12237 UIN/IN

Figure B-187. Panel 2-13-11 Impact Response Data

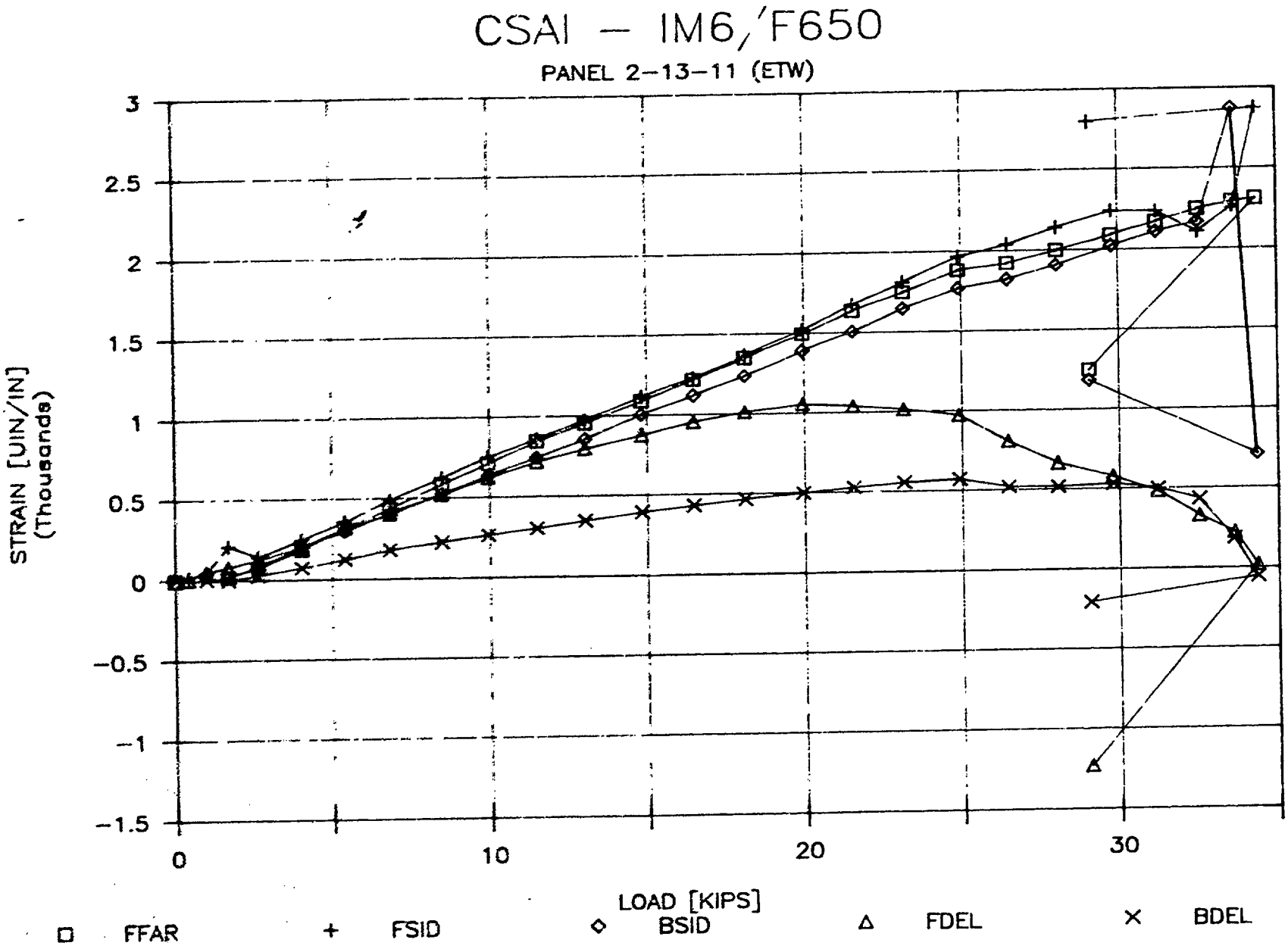


Figure B-188. Panel 2-13-11 Residual Compression Data

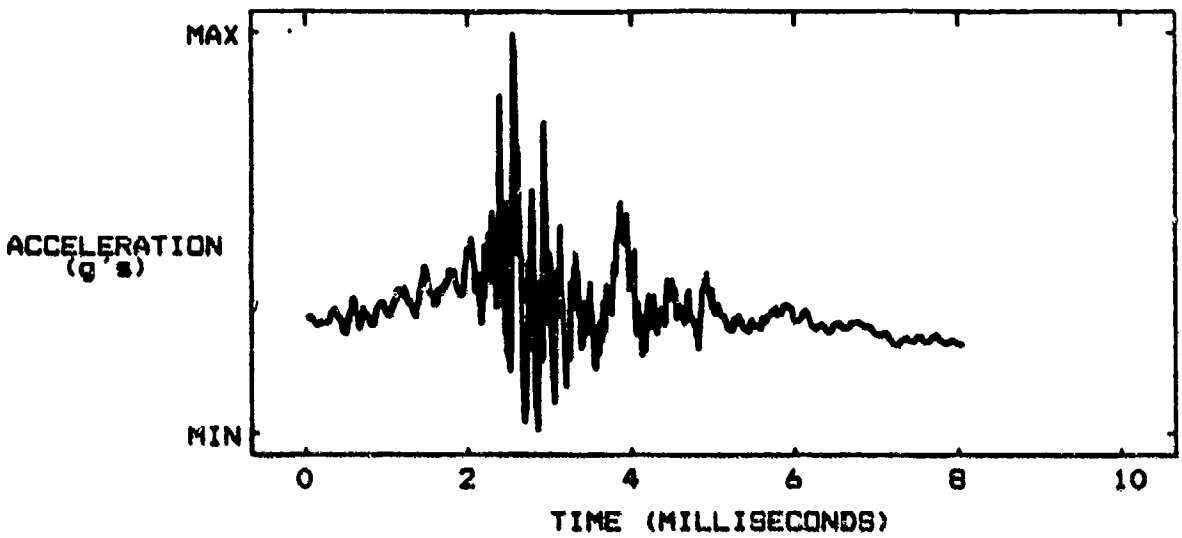
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-14-11 THICKNESS .110 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 38.2 IN

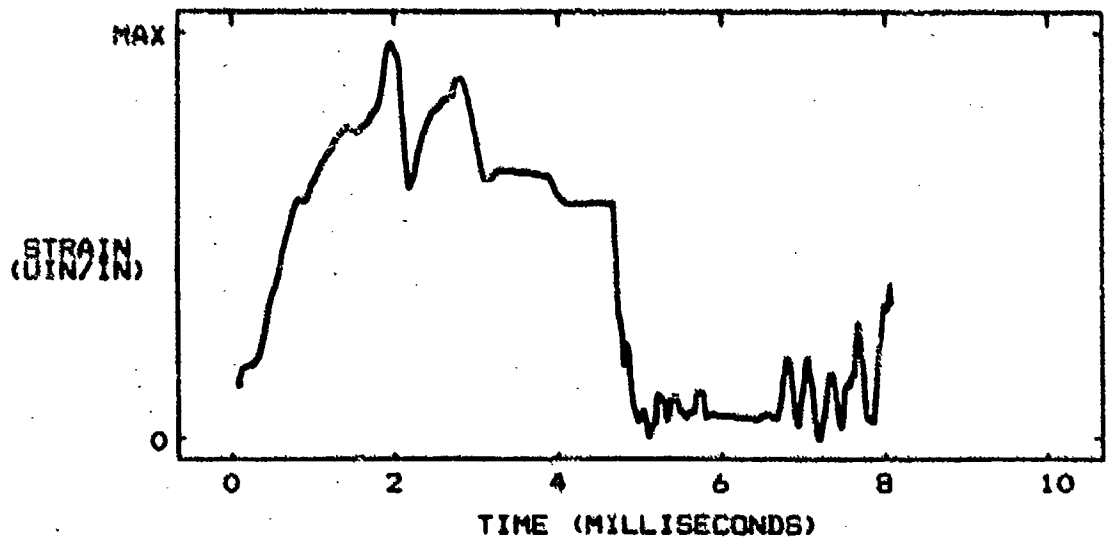
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -172 g's MAXIMUM ACCELERATION 430.00g's

INTEGRATED TOTAL VELOCITY 33.010 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 17185 UIN/IN

Figure B-169. Panel 2-14-11 Impact Response Data

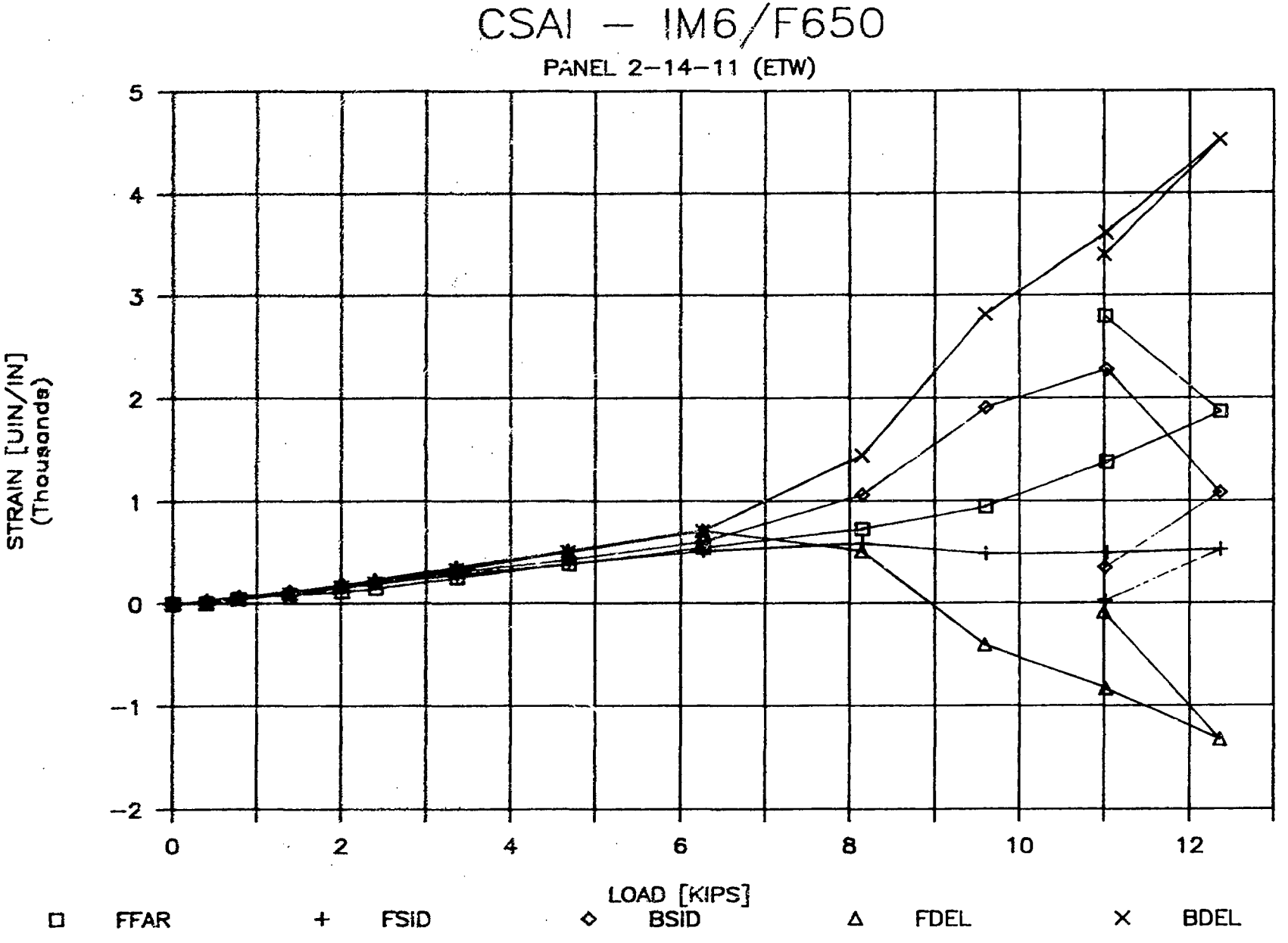


Figure B-190. Panel 2-14-11 Residual Compression Data

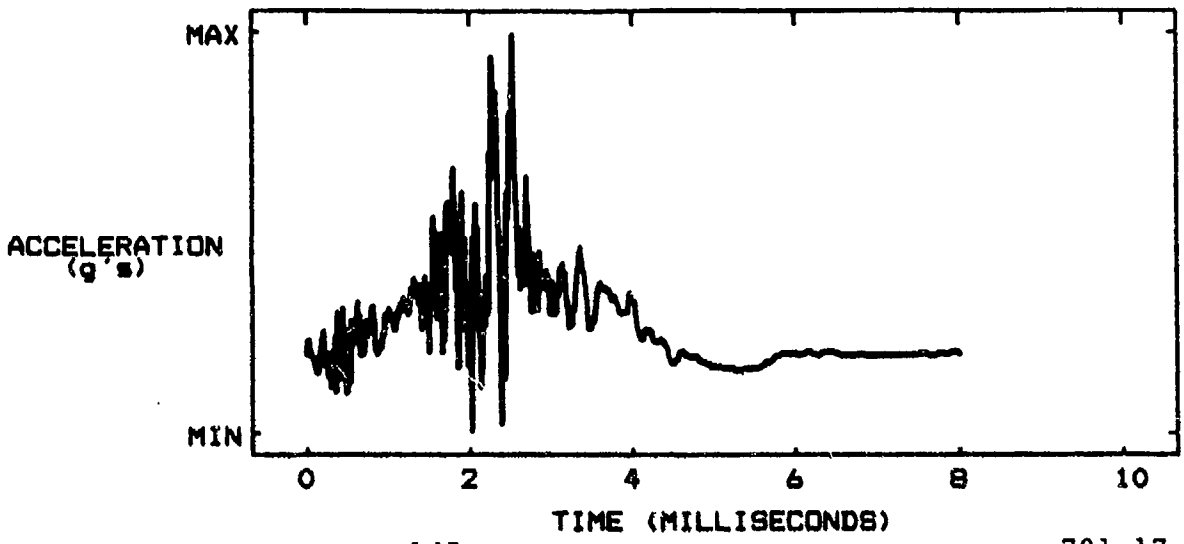
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-20-12 THICKNESS .216 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

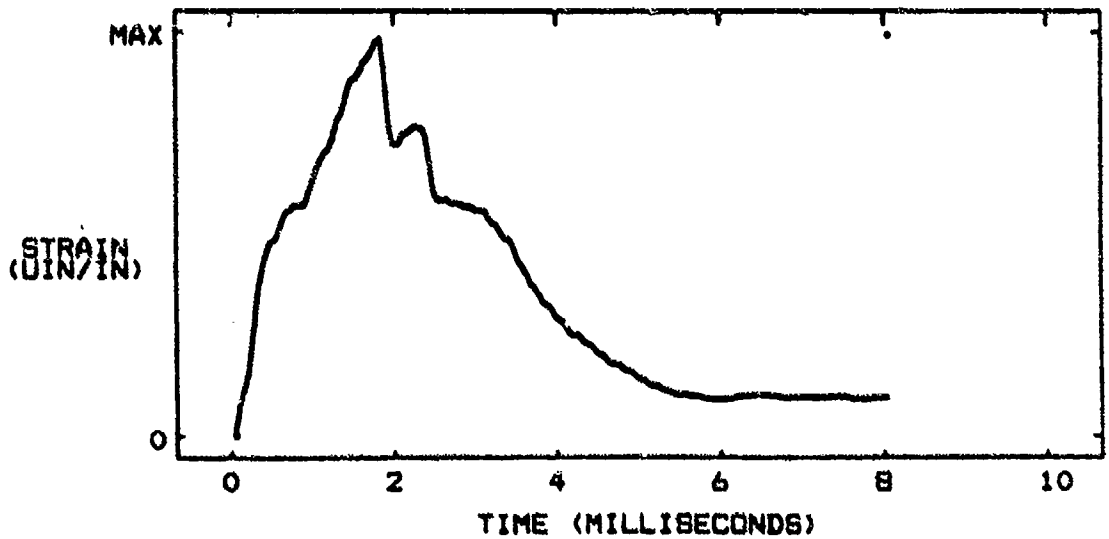
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -165 g's MAXIMUM ACCELERATION 701.17 g's

INTEGRATED TOTAL VELOCITY 182.59 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 17288 UIN/IN

Figure B-191. Panel 2-20-12 Impact Response Data

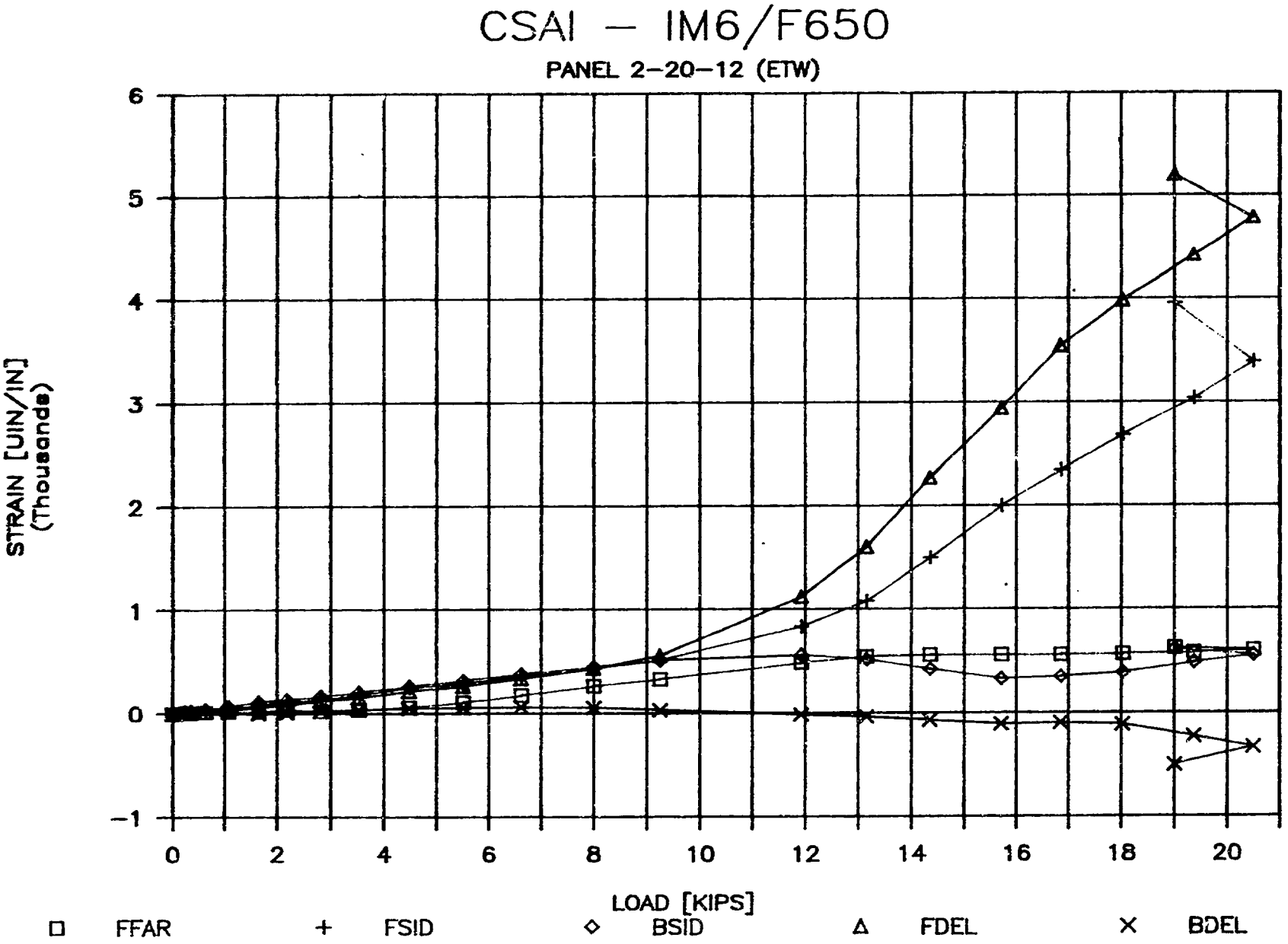


Figure B-192. Panel 2-20-12 Residual Compression Data

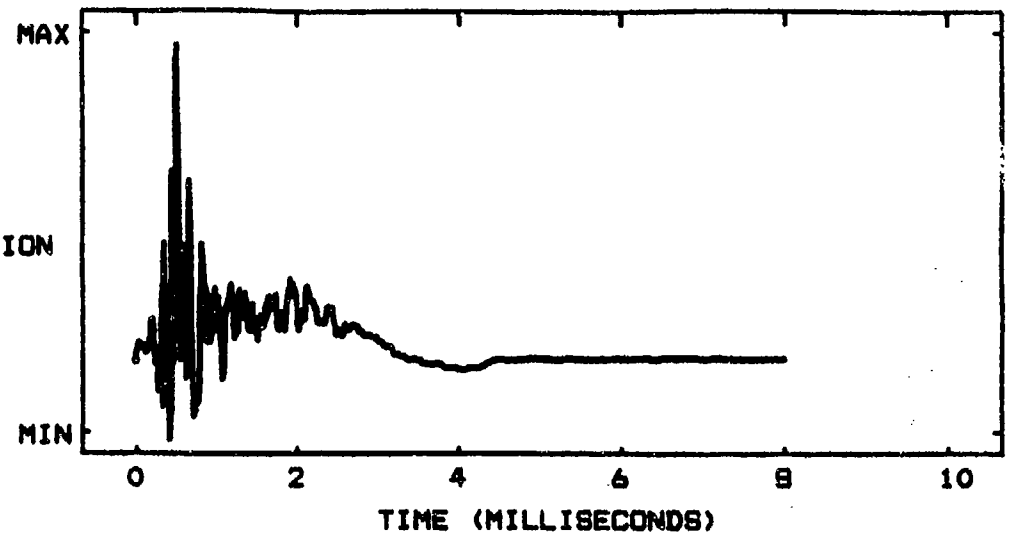
LVID SPECIMEN DATA

MATERIAL SYSTEM IM6/F650

SPECIMEN I.D. 2-15-10 THICKNESS .440 IN

DROP CARRIAGE WT. 19.47 LBS DROP HEIGHT 65.6 IN

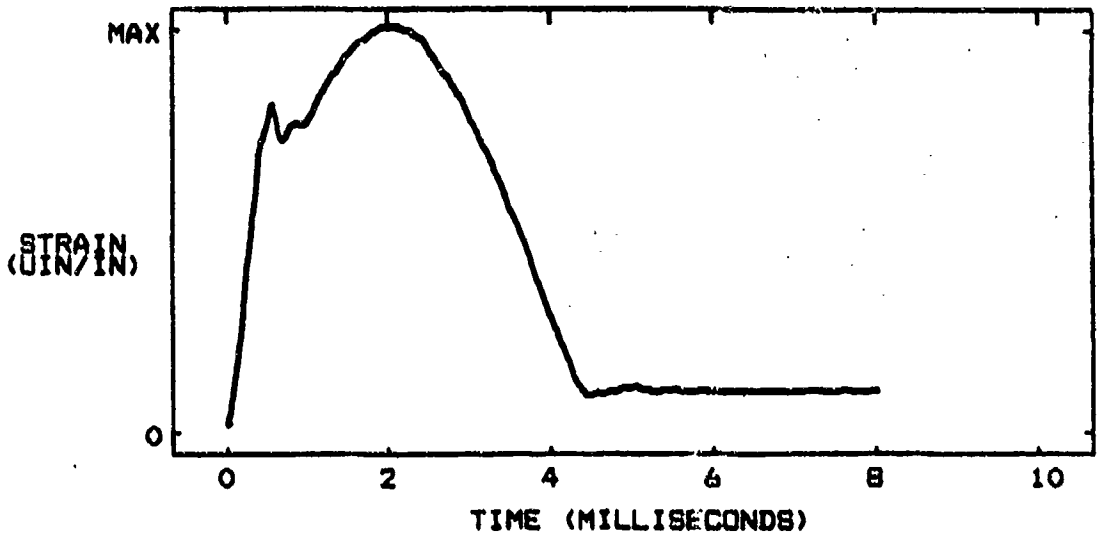
ACCELERATION VERSUS TIME



MINIMUM ACCELERATION -38 g's MAXIMUM ACCELERATION 181.00 g's

INTEGRATED TOTAL VELOCITY -3.0295 IN/SEC

PANEL STRAIN VERSUS TIME



MAXIMUM STRAIN 12406 UIN/IN

Figure B-193. Panel 2-15-10 Impact Response Data

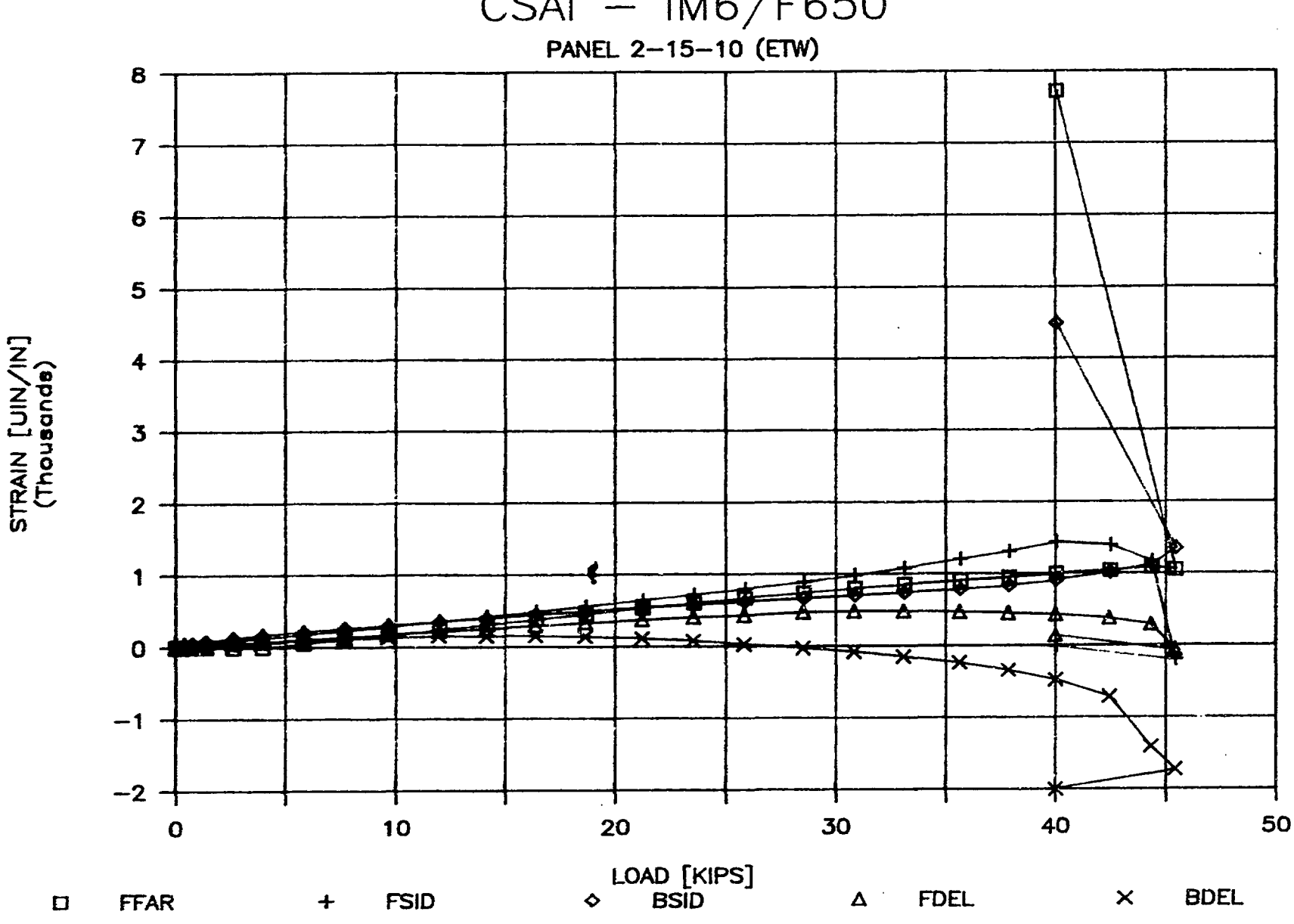


Figure B-194. Panel 2-15-10 Residual Compression Data