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Crush Characteristics for 1981 through 1983 Honda Civics

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
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McLean, Virginia 22101-2296

FOREWORD

This report documents a research study conducted at the Federal Outdoor Impact Laboratory (FOIL) to determine the crush characteristics of the 1981 through 1983 Honda Civic two-door sedans. Four tests were conducted in support of a computer simulation effort to model this vehicle. All of the vehicles were crash tested in the frontal collision condition. Three of the tests were into the instrumented rigid pole, one centered and two with offsets to the right and left of center to strike the "hard" and "soft" spots of the vehicle. The fourth test was into a single leg 6-kg/m (4-lb/ft) u-channel sign post embedded in soil. The results of the rigid pole tests function as a baseline for modeling the front-end crush of the Honda Civic. The u-post test is in support of a simulated crash of the same conditions.

This report (FHWA-RD-94-079) contains test data, photographs taken with high-speed film, and a summary of the test results for each of the four tests conducted. The sign system tested was a direct burial support system embedded in "strong" soil (a highly compacted soil mixture). All of the tests were conducted at a nominal speed of 32 km/h (20 mi/h).

This report will be of interest to all States DOT's, FHWA headquarters, regional and division personnel, and highway safety researchers interested in the crashworthiness of roadside sign systems.

Lyle Saxton, Director
Office of Safety and Traffic Operations
Research and Development

NOTICE

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16. Abstract

This test report contains the test results from a series of four crash tests conducted at the Federal Outdoor Impact Laboratory (FOIL) located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia. The tests were frontal crash tests involving 1981 through 1983 Honda Civic two-door sedans. Three Honda Civics impacted the FOIL's instrumented rigid pole and one impacted a single leg 6-kg/m (4-lb/ft) u-channel sign post embedded in strong soil. The objective of these tests was to provide crush characteristic data in support of a computer simulation effort to model a 1981 through 1983 Honda Civic. The results are presented as data plots of acceleration vs. time, velocity vs. time, displacement vs. time, force vs. displacement, and force vs. time. The data plots were derived from vehicle accelerometer data and rigid pole load cell data. The data from the three rigid pole tests serve as a good baseline for modeling the front-end crush of a Honda Civic. The one u-post sign support test provides good data to help model the interaction between a Honda Civic and a small sign support mounted in strong soil.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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SCOPE

The purpose of this report is to document the test results from a series of four crash tests conducted at the Federal Outdoor Impact Laboratory (FOIL) located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia. The tests were frontal crash tests involving 1981 through 1983 Honda Civic two-door sedans. Three Honda Civics impacted the FOIL's instrumented rigid pole and one impacted a single leg 6-kg/m (4-lb/ft) u-channel sign post embedded in strong soil. The objective of these tests was to provide crush characteristic data in support of a computer simulation effort to model a 1981 through 1983 Honda Civic. The results are presented as data plots of acceleration vs. time, velocity vs. time, displacement vs. time, force vs. displacement, and force vs. time. The data plots were derived from vehicle accelerometer data and rigid pole load cell data.

TEST MATRIX

The tests were conducted using 1981 through 1983 Honda Civics. The Honda Civics were configured in the frontal impact configuration using the necessary carriages and cables. The target vehicle weight was 839 kg (1850 lb). However, the vehicles were be tested without the hood in order to film the engine components during the test. Without the hood the target vehicle test weight was 830 kg (1830 lb). The tests were performed at a nominal test speed of 32 km/h (20 mi/h) and at different impact locations along the vehicle bumper. Table 1 summarizes the test parameters for the four Honda tests.

Table 1. Summary of test conditions

Test number	Test date	Test article	Impact location
93F008	6-9-93	Rigid pole	Center
93F009	6-30-93	Rigid pole	457 mm left of center left bumper support
93F010	7-20-93	6 kg/m u-post	228 mm left of center
93F011	8-4-93	Rigid pole	254 mm right of center
1 mm = 0.04 in			

VEHICLE

The test vehicles were 1981 through 1983 Honda Civic 2-door sedans with manual transmissions. Prior to the tests, the vehicle's fluids were drained and their inertial properties and their center-of-gravity heights determined using the FOIL inertia measurement device (IMD). These measurements were taken on each vehicle in the vehicle's original curb weight configuration and then a second time after they were configured for testing. Inertial measurements were taken a third time on each vehicle with its hood removed. The vehicles were stripped of certain components to allow for the installation of all data acquisition equipment, transducers and guidance system components. The batteries remained in the vehicles for the crash tests. After ballasting and removal of the hood, the vehicle test weights were 830 kg (1830 lb). The vehicles were tested without an anthropomorphic dummy. The vehicles were placed on the FOIL runway such that the centerline of the vehicle was parallel to the runway centerline. Table 2 summarizes inertial properties of the four test vehicles in their original curb weight configuration and in the test weight configuration with and without the hood. Dimensions of the Honda Civic are shown in figure 1. Figure 2 is a sketch of the vehicle's engine compartment.

Table 2. Inertial properties of 1982-1983 Honda Civics.

Test Number	Make	Yr	Weight (kg)	Height (mm)*	Long. Cg (mm)**	Pitch kg•m²	Roll kg•m²	Yaw kg•m²
Curb Weight Configuration								
93F008	Honda	82	810	569	787	1,038	320	1,197
93F009	Honda	83	832	576	802	1,007	283	1,147
93F010	Honda	83	835	584	808	994	262	1,170
93F011	Honda	83	844	589	827	1,022	294	1,184
Ballasted Configuration								
93F008	Honda	82	839	582	835	996	285	1,228
93F009	Honda	83	839	566	838	1,048	327	1,156
93F010	Honda	83	839	569	813	855	309	1,173
93F011	Honda	83	839	587	818	1,006	298	1,156
Test Configuration, No Hood								
93F008	Honda	82	830	561	835	1,034	313	1,175
93F009	Honda	83	830	566	838	1,024	318	1,163
93F010	Honda	83	830	566	813	701	299	1,147
93F011	Honda	83	830	579	818	991	297	1,146

* Height of vehicle center-of-gravity.
** Longitudinal center-of-gravity, distance behind front axle.

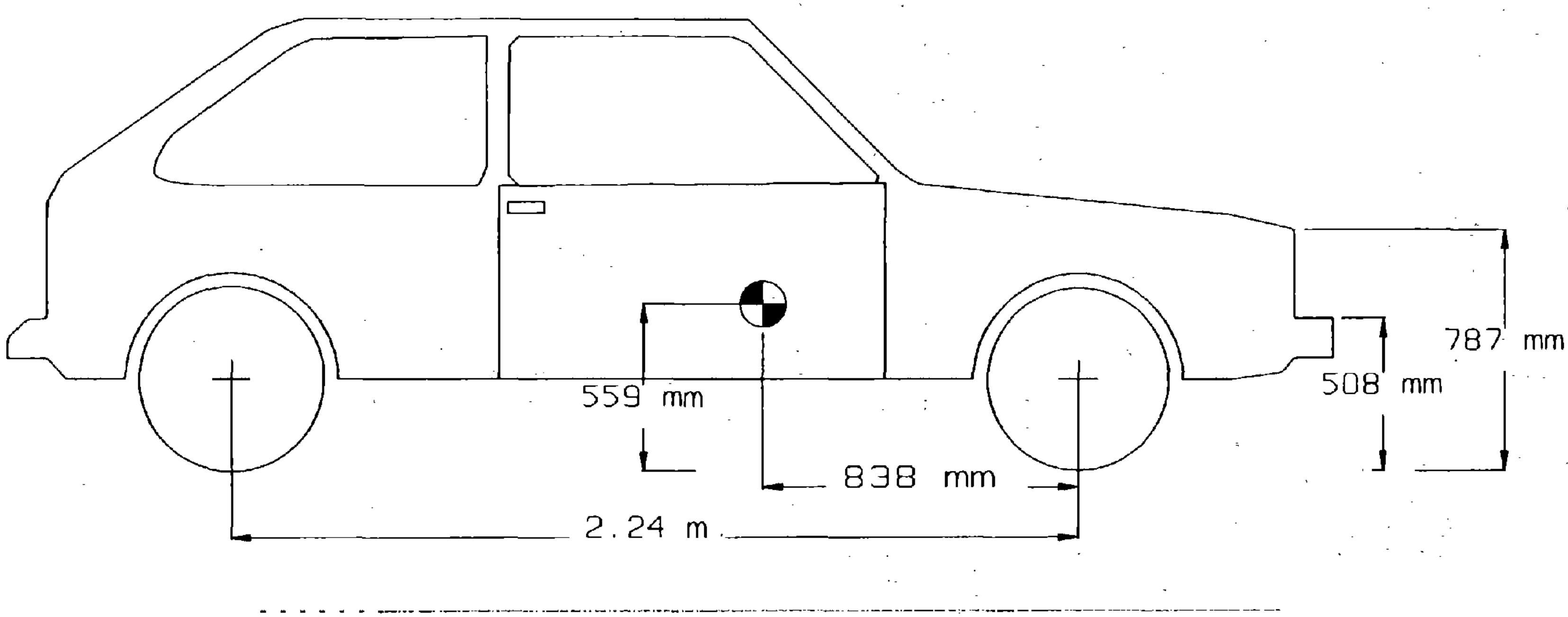


Figure 1. Sketch of 1981 through 1983 Honda Civic.

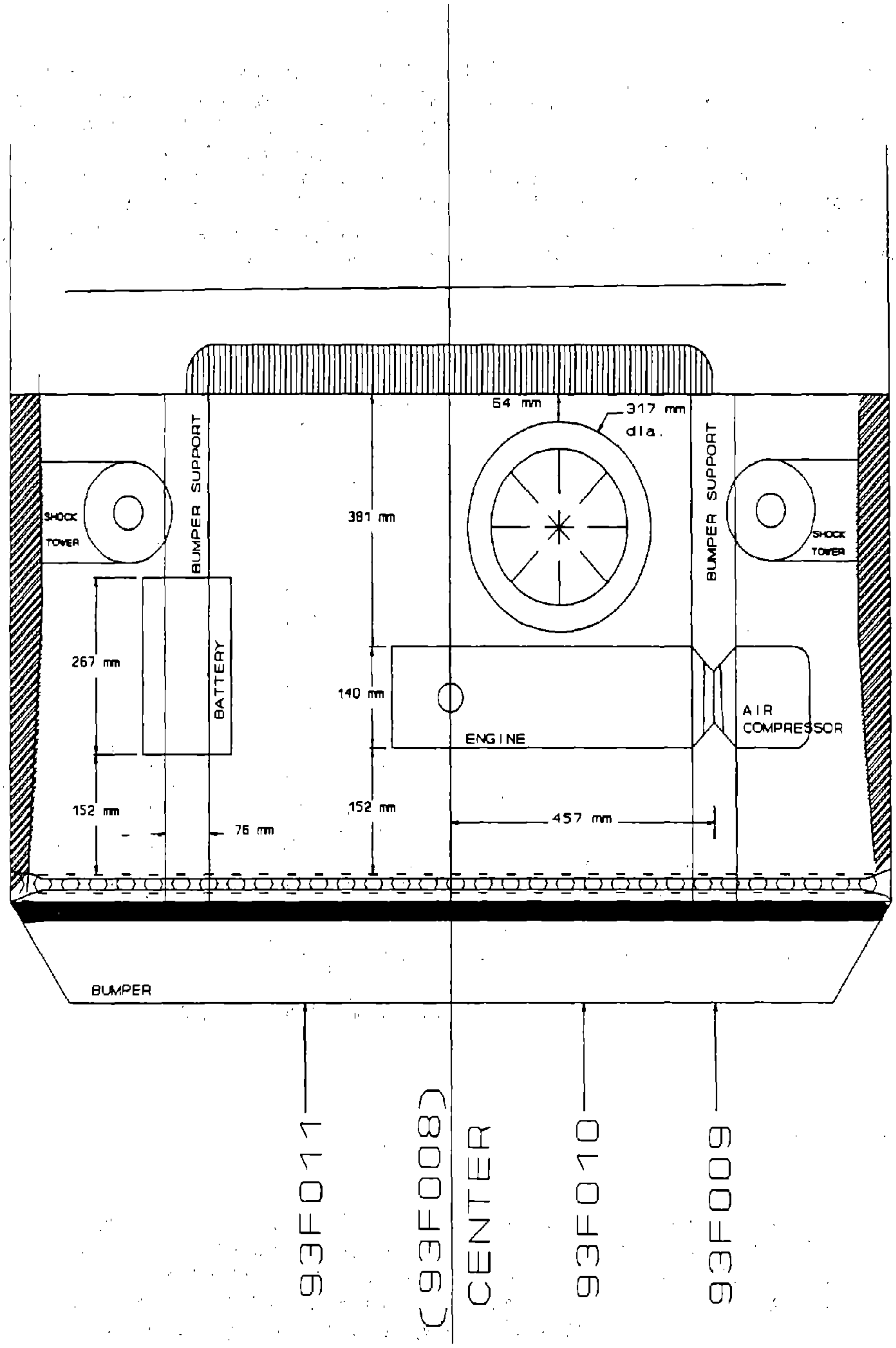


Figure 2. Sketch of vehicle's engine compartment.

RIGID POLE

Three vehicles impacted the FOIL's rigid instrumented pole in its frontal impact configuration. The rigid pole was designed as a narrow fixed object mounted rigidly to the FOIL runway. The rigid pole consists of a semicircular section of extra-heavy-walled, 203-mm (8-in) pipe, 16 mm (5/8 in) thick. The semicircular impact face is supported by two connecting rods which run through guide bearings attached to the main structure, to two load cells bolted to the back of the main rigid structure. The load cells were installed 279 mm (11 in) and 838 mm (33 in) above ground. Figure 3 is a sketch of the FOIL instrumented rigid pole.

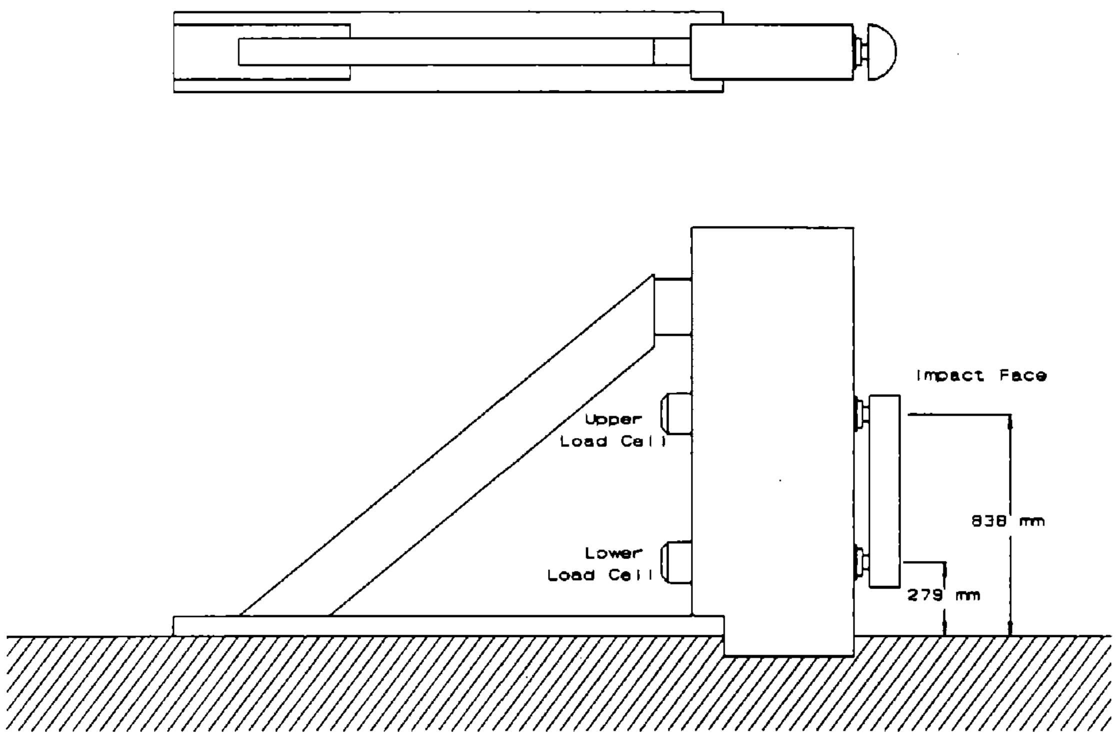


Figure 3. FOIL rigid pole, frontal impact mode.

U-CHANNEL POST

One vehicle impacted a single leg 6-kg/m (4-lb/ft) u-channel sign support. The u-channel was installed 1.2-m (4-ft) deep in strong soil. The strong soil was backfilled around the sign post and compacted in 152-mm (6-in) lifts until the final grade was reached. An aluminum sheet sign panel 0.8 m by 0.8 m (2.5 ft by 2.5 ft) was attached to the u-post 2.1 m (7 ft) above ground. The sign post was positioned in the strong soil such that the vehicle impacted the u-post 228 mm (9 in) to the left (driver side) of the vehicle's centerline. Figure 4 is a sketch of the single leg sign post.

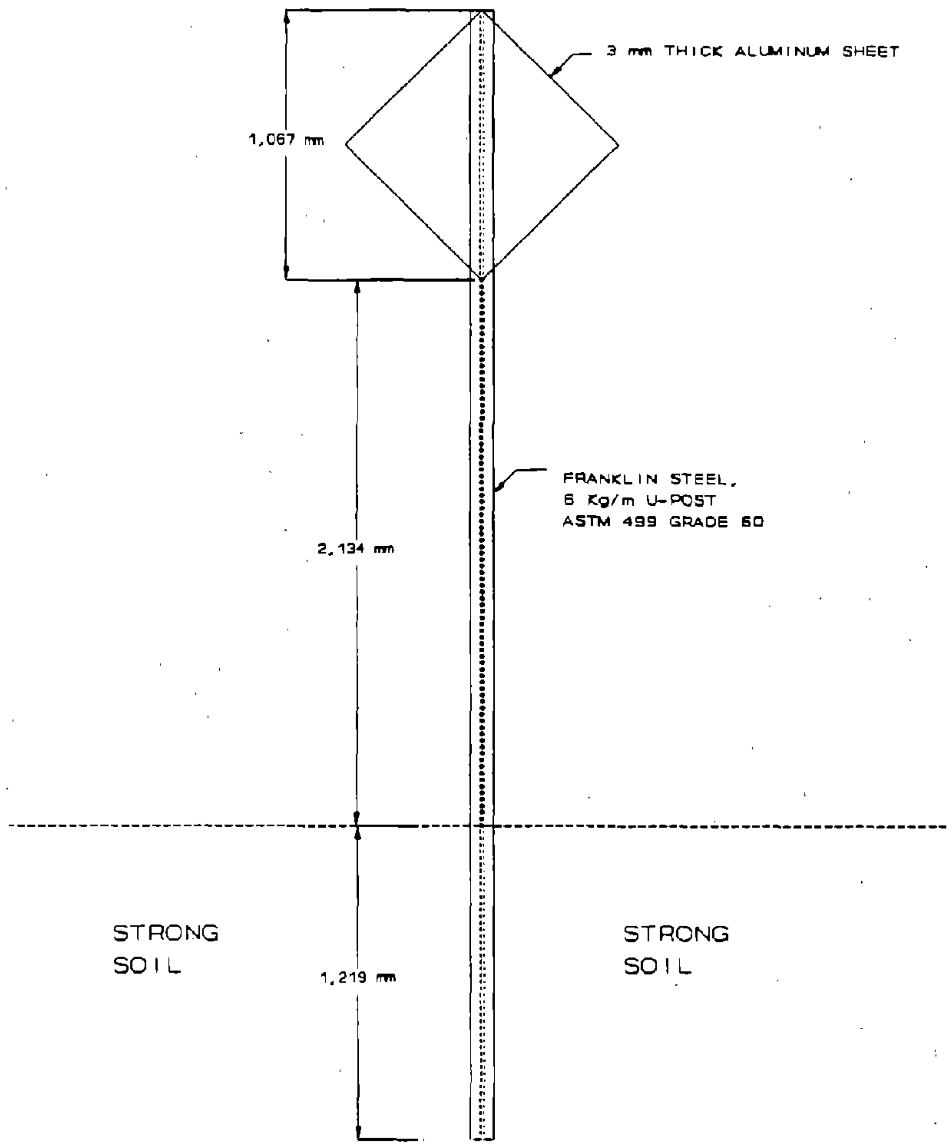


Figure 4. Sketch of u-post sign support for test 93F010.

DATA ACQUISITION

For each of the three tests, speed trap, accelerometer, and load cell data were collected to measure the crush characteristics of the Honda Civic.

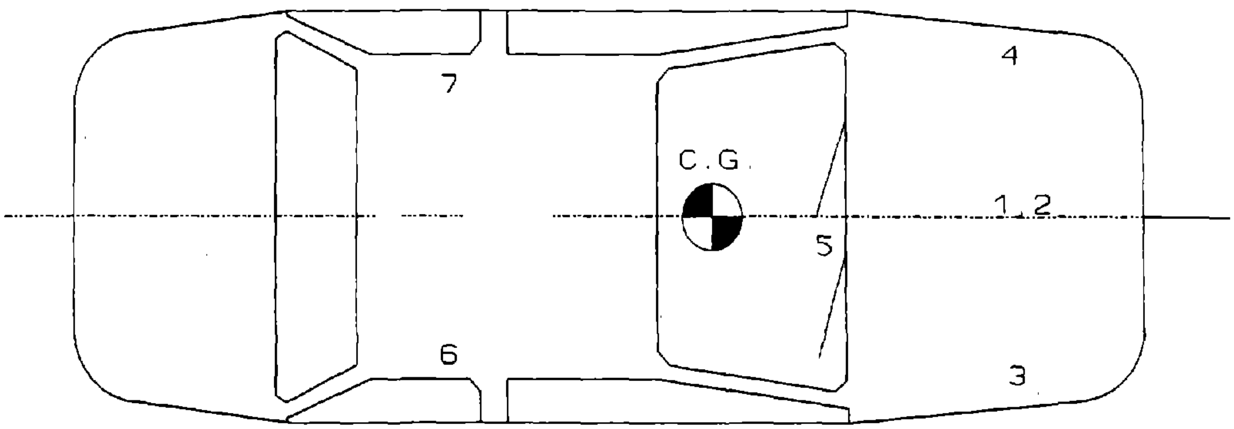
a. Speed Trap. The speed trap was used to determine the vehicular speed just prior to impact. The center of the speed trap was placed approximately 3.7 m (12 ft) before the rigid pole and the u-channel sign support. The speed trap consisted of a set of five contact switches fastened to the runway at 0.3-m (1-ft) intervals. As the vehicles passed over the switches, electronic pulses were recorded on analog tape.

b. Transducer Data Package. A total of 16 channels of electronic data were collected during each crash test. Ten channels of data were collected via the FOIL on-board data acquisition system. The 10 channels included 7 uni-axial accelerometers oriented in the x-axis, positioned and mounted in accordance with the Federal Motor Vehicle Safety Standard 208 (FMVSS 208) and one tri-axial rate transducer mounted at the vehicle's center-of-gravity to measure vehicle rotational data in the roll, pitch, and yaw axes.[1] The on-board data acquisition system supplies transducers with excitation voltage, pre filters data with a 4,000-Hz analog filter, digitally samples the data at 12,500 Hz, and stores the data internally.

The remaining data channels were collected via the FOIL off-board tape recorder system. The tape recorder system recorded center-of-gravity data consisting of two x-axis accelerometers and one accelerometer in the y- and z-axes. The transducers were mounted to a steel mounting block which was bolted the test vehicles floor-pan tunnel. It was mounted at the longitudinal and lateral center-of-gravity as determined by the FOIL IMD. The average vertical center-of-gravity for the Honda Civic in the test configuration was 569 mm (22.4 in) above ground. The transducer mounting block was mounted 336 mm (15 in) above ground. In addition to the center-of-gravity accelerometers the tape recorder system also recorded data from the FOIL rigid pole's two load cells. For each of the four tests, the test vehicles were instrumented in the same manner. The accelerometers were mounted in or as close to the same position in each vehicle. No load cell data were recorded during the u-channel sign support test. After the test, the tape recorder is played back through a 500-Hz analog filter and into an ADC which samples the data at 2000 Hz. Table 3 summarizes the data collected via the FOIL umbilical cable. Figure 5 summarizes the data collected via the FOIL on-board data acquisition system. Figure 5 includes the cartesian coordinates of the accelerometer placements in accordance with FMVSS 208.

Table 3. Data channel assignments for the FOIL tape recorder system.

Channel No.	Transducer	Data type	Transducer full scale	Transducer location (X,Y,Z,) position
1	Accelerometer	X-axis	100 g	0, 0, -156
2	Accelerometer	Y-axis	100 g	0, 0, -156
3	Accelerometer	Z-axis	100 g	0, 0, -93
4	Accelerometer	X-axis	100 g	0, 0, -124
5	Load cell	Rigid pole force	111 kN	Upper load cell 838 mm above ground
6	Load cell	Rigid pole force	222 kN	Lower load cell 279 mm above ground
7	Tape switches	Speed	1.5 Volts	Runway



Location	Data	Full scale	(X,Y,Z) position from Cg (mm)
1	Top of motor	2000 g	1,118, 89, 269
2	Bottom of motor	2000 g	978, 89, -353
3	Right control arm	2000 g	838, -546, -213
4	Left control arm	2000 g	838, 546, -213
5	Top of instrument panel	2000 g	203, 0, 269
6	Left side under rear seat	2000 g	-889, 483, -213
7	Right side under rear seat	2000 g	-889, -457, -213
8,9,10	Tri-axial rate transducer,	500 deg/s	0, 0, -93
25.4 mm = 1 in			

Figure 5. Summary of ODAS data collected and FMVSS 208 accelerometer positions.

c. <u>High-Speed Photography.</u> The crash tests were photographed using five high-speed cameras with an operating speed of 500 frames/s. The high-speed film was analyzed for impact speed and acceleration data. In addition to the high-speed cameras, one real-time camera and two 35-mm still cameras were used to document the test. Table 4 summarizes the cameras used and their respective placement.

Table 4. Summary of camera placement.				
Camera	Type	Film speed frames/s	Lens (mm)	Location
1	LOCAM II	500	75	Right 90° to impact
2	LOCAM II	500	50	Right 90° to impact
3	PHOTEC	500	80	Right side 45° to impact
4	LOCAM II	500	50	Left side 45° to impact
5	LOCAM II	500	10	Overhead
6	BOLEX	24	ZOOM	Documentary
7	CANNON AE-1	still	ZOOM	Documentary
8	CANNON AE-1	still	ZOOM	Documentary

DATA ANALYSIS

Data were collected via the FOIL analog tape recorder system, including speed trap data, the FOIL ODAS III on-board data acquisition system and high-speed film.

a. <u>Speed Trap</u>. As the vehicles passed over the speed trap, electronic pulses from the five contact switches were recorded to analog tape. The tape was played back through a Data Translation ADC in conjunction with a COMPAQ SYSTEMPRO computer. The time intervals between the first pulse and each of the subsequent four pulses were then obtained using the analysis software provided with the ADC. The time-displacement data were then entered into a computer spreadsheet and a linear regression was performed to determine the best-line fit of the data points. The impact velocity was then determined from the slope of the best-line fit of the time-displacement data.

b. <u>Transducer Data Package.</u> After the test data were digitally converted and stored, the data from the tape recorder system and the ODAS III system were converted to the ASCII format, zero bias removed and digitally filtered using a digital Butterworth low-pass filter. The data from the crash tests were digitally filtered with a cut-off frequency of 100 Hz. The data were input to a spreadsheet for analysis.

The center-of-gravity accelerometer data were integrated twice to produce velocity and displacement traces. A force vs. time trace was generated by multiplying the acceleration data by the mass of the vehicle and plotting the product with time. Acceleration vs. time traces were plotted for all FMVSS 208 accelerometers. Displacement traces were generated for the rear seat accelerometers by double integrating the rear seat acceleration and plotting the result vs. time.

The load cells measured forces at two separate locations on the rigid pole. The two forces obtained were summed together to generate the entire force for the event. Using the force vs. time trace, an acceleration trace was produced by dividing the force vs. time trace by the mass of the vehicle. Velocity and displacement traces were generated by a single and double integration of the acceleration trace. A force vs. displacement trace was generated from the load cell data. The force vs. displacement trace depicts the crush characteristic for the Honda Civic for the given impact location.

The load cells measured the forces on the rigid pole at two separate locations. The two load cells were attached to a single, common rigid pole impact-face. Using torque equations, a resultant load height on the rigid pole vs. displacement (crush) was generated. This plot is important because it depicts the location (height) on the vehicle which was producing the load. The resultant load height varied to some extent as the vehicle crushed inward. As contact between different structures in the vehicle occurred the resultant load's vertical location shifted.

c. High-Speed Photography. Each crash event was recorded on 16-mm film by five high-speed cameras. The camera perpendicular to the vehicle trajectory with a 50-mm lens was the only camera used for high-speed film analysis. Analysis of each crash event was performed using an NAC Film Motion Analyzer model 160-F in conjunction with an IBM PC-AT. The motion analyzer digitized the 16-mm film, reducing the image to cartesian coordinates. The cartesian coordinate data were then imported into a computer spreadsheet for analysis. Using the cartesian coordinate data, a displacement vs. time history of each test was obtained. A linear regression was performed on the first 20 data points of the displacement vs. time traces to determine the impact velocities of the vehicles. The entire displacement vs. time traces were then differentiated to produce a velocity trace. The velocity data were then exported from the spreadsheet and filtered using a digital Butterworth low-pass filter with a cut-off frequency of 20 Hz. The filtered velocity was imported into the original spreadsheet and a second differentiation was performed on the filtered velocity trace to produce an acceleration trace. The total force was determined by multiplying the peak acceleration by the mass of the vehicle.

RESULTS

The Honda Civics were accelerated to a nominal velocity 32 km/h (20 mi/h) prior to impacting the rigid pole and u-post sign support. The Honda Civics were aligned with the rigid pole and u-post sign support in accordance with the test matrix. During each of the rigid pole tests, the test vehicles rebounded with a small negative velocity. During the u-post test the Honda Civic struck the u-post 228 mm (9 in) left of the vehicles centerline. The vehicle flattened the sign support and continued down stream. A bend in the u-post was recorded 0.305 m (1 ft) below ground. The u-post incurred a vertical tear in the center of the web 483 mm (19 in) in length. The vehicle proceeded over the sign post and came to rest 7 m (23 ft) down range with a final yaw angle of 33 degrees. The yaw angle was induced by a steering failure rather than from the sign post. Table 5 summarizes the impact speed, static crush measured after the test, load cell data, accelerometer data, and the film data. The crush values under the load cell and accelerometer data headings in table 5 were the maximum values obtained from the double integration of the acceleration traces. Figures 6 through 9 are crush sketches for tests 93F008 through 93F011, respectively. Figures 10 through 17 are pre- and post-test photographs of each crash test. The data plots from each of the four Honda Civic crash tests are presented in appendix A.

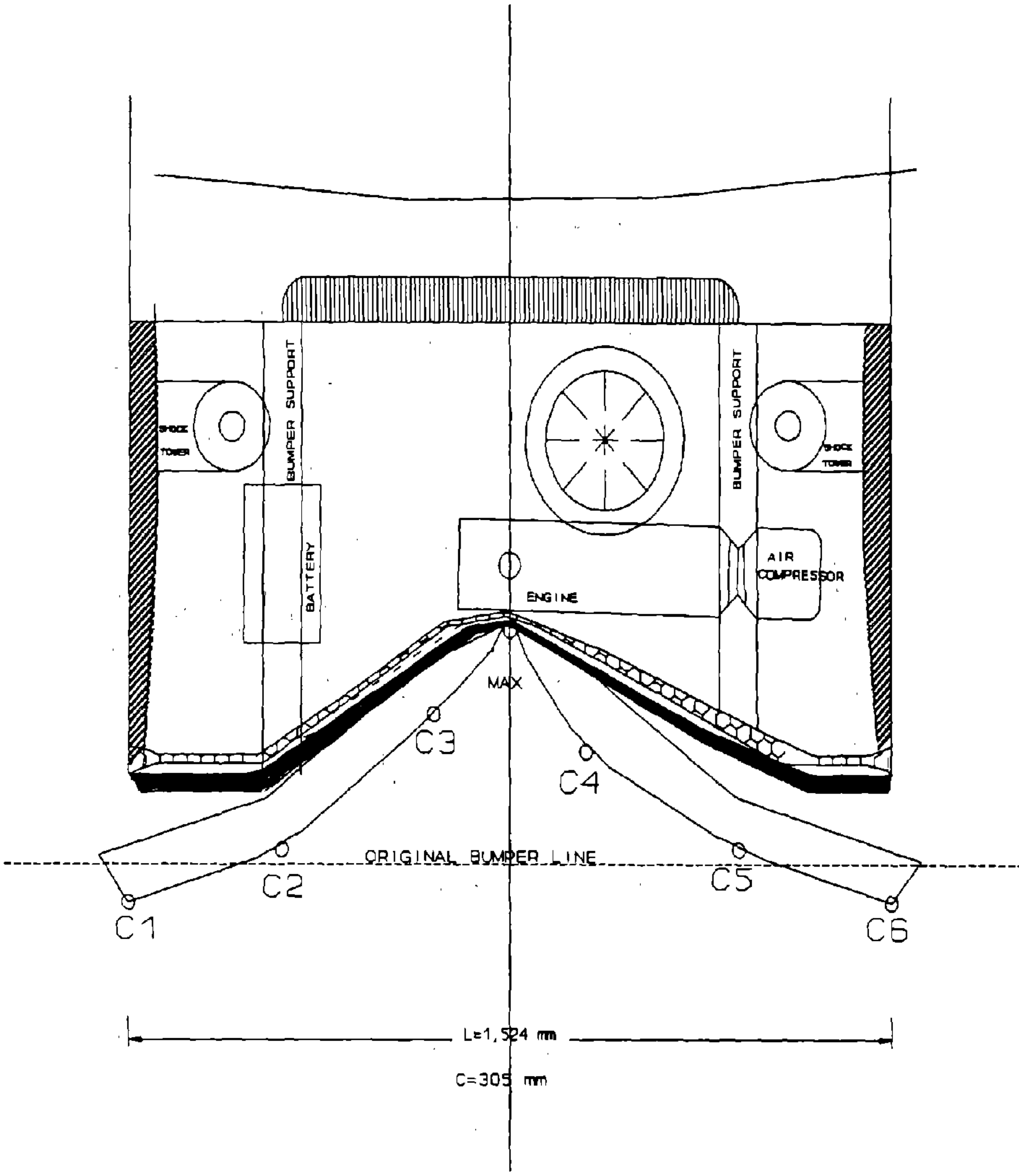
Table 5. Summary of crash testing of 1981-1983 Honda Civics.

Test Number	Impact Speed (km/h)		Load cell Data			Accelerometer Data			Film Data			Static Crush (mm)
	Speed Trap	Film	Force (1000 N)	ΔV (m/s)	Crush (mm)	Force (1000 N)	ΔV (m/s)	Crush (mm)	Force (1000 N)	ΔV (m/s)	Crush (mm)	
93F008	33.1	32.7	180.7	11.9	450	223.6	11.5	490	180.8	10.9	465	394
93F009	33.1	32.8	120.0	11.2	520	180.7	10.6	550	141.7	9.3	548	438
93F010	33.1	32.4	NA	NA	NA	54.0	6.1	NA	43.2	5.7	NA	216
93F011	33.2	32.5	122.9	11.3	580	169.2	10.6	550	122.2	10.8	472	437

NA = Not Applicable   1 mm = 0.04 in   1 N = 0.22 lbf   1 m = 3.28 ft

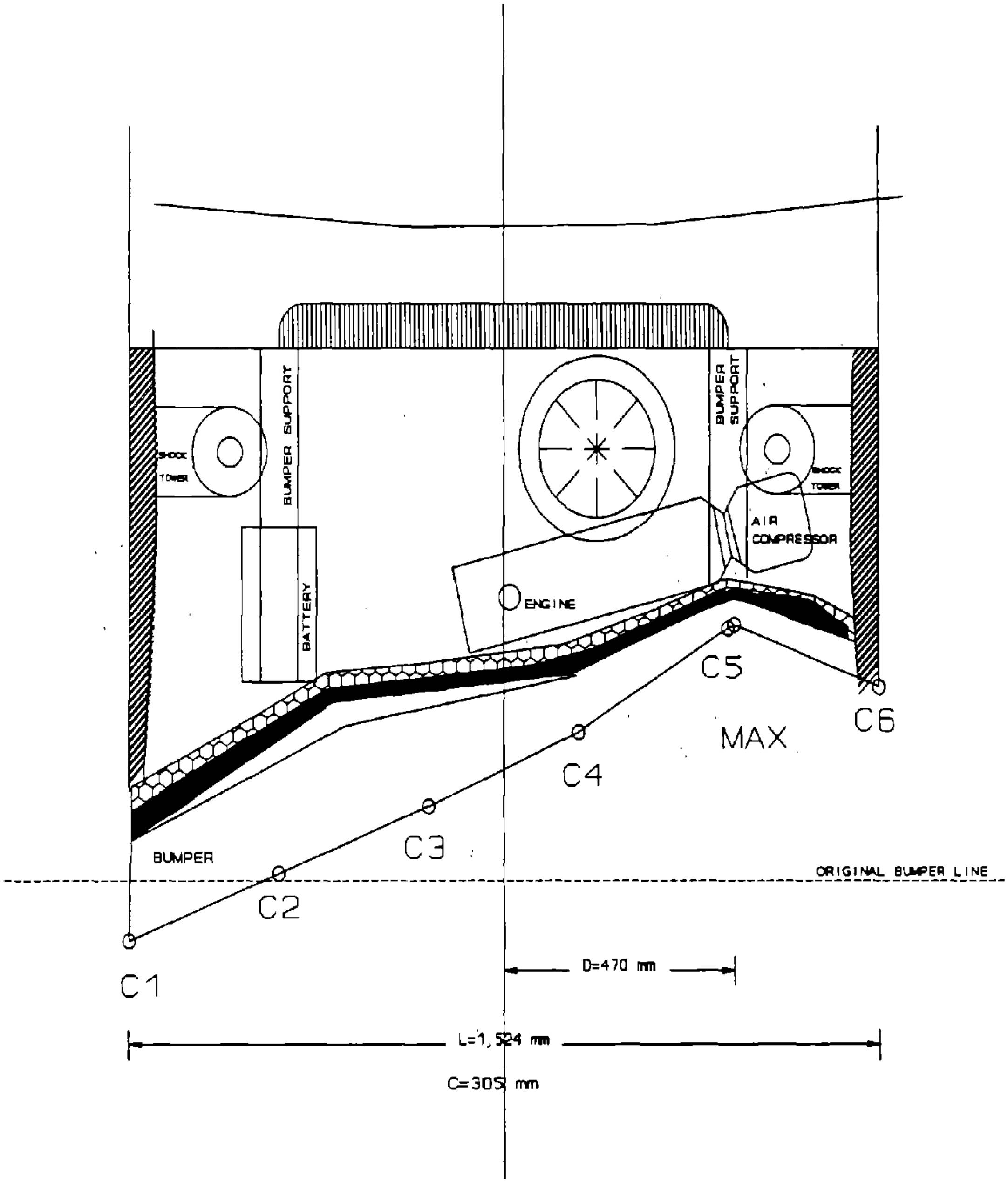
CONCLUSIONS

The data plots contained in appendix A and the results presented in table 5 show that the crush characteristics for the Honda Civic vary with impact location. This stands to reason considering the different geometry and structures along the vehicle's front end. The data from each test can be used as baseline data when designing a model of a vehicle for computer simulation. Three different sets of crush characteristics, one for each impact location along the vehicle front-end were determined. The u-channel sign support test provides actual crash test data to help model the interaction between a Honda Civic and a single leg small sign support mounted in strong soil. Individual component data provides detailed information about the mechanics of specific sub-structures within the vehicle frame.



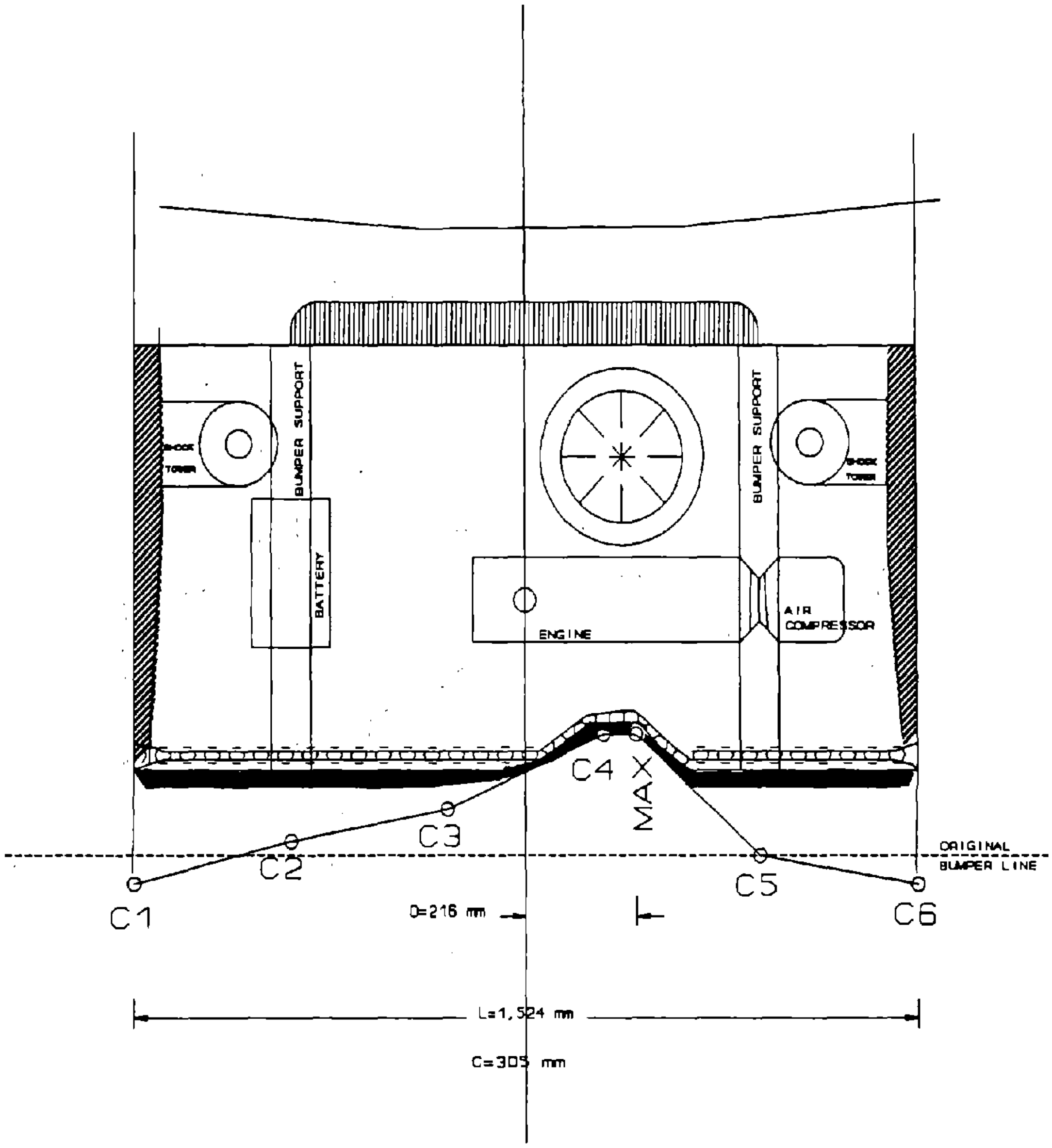
C1=-64 mm
C2=51 mm
C3=254 mm
C4=191 mm
C5=51 mm
C6=-64 mm
MAX=394 mm

Figure 6. Crush sketch for test 93F008.



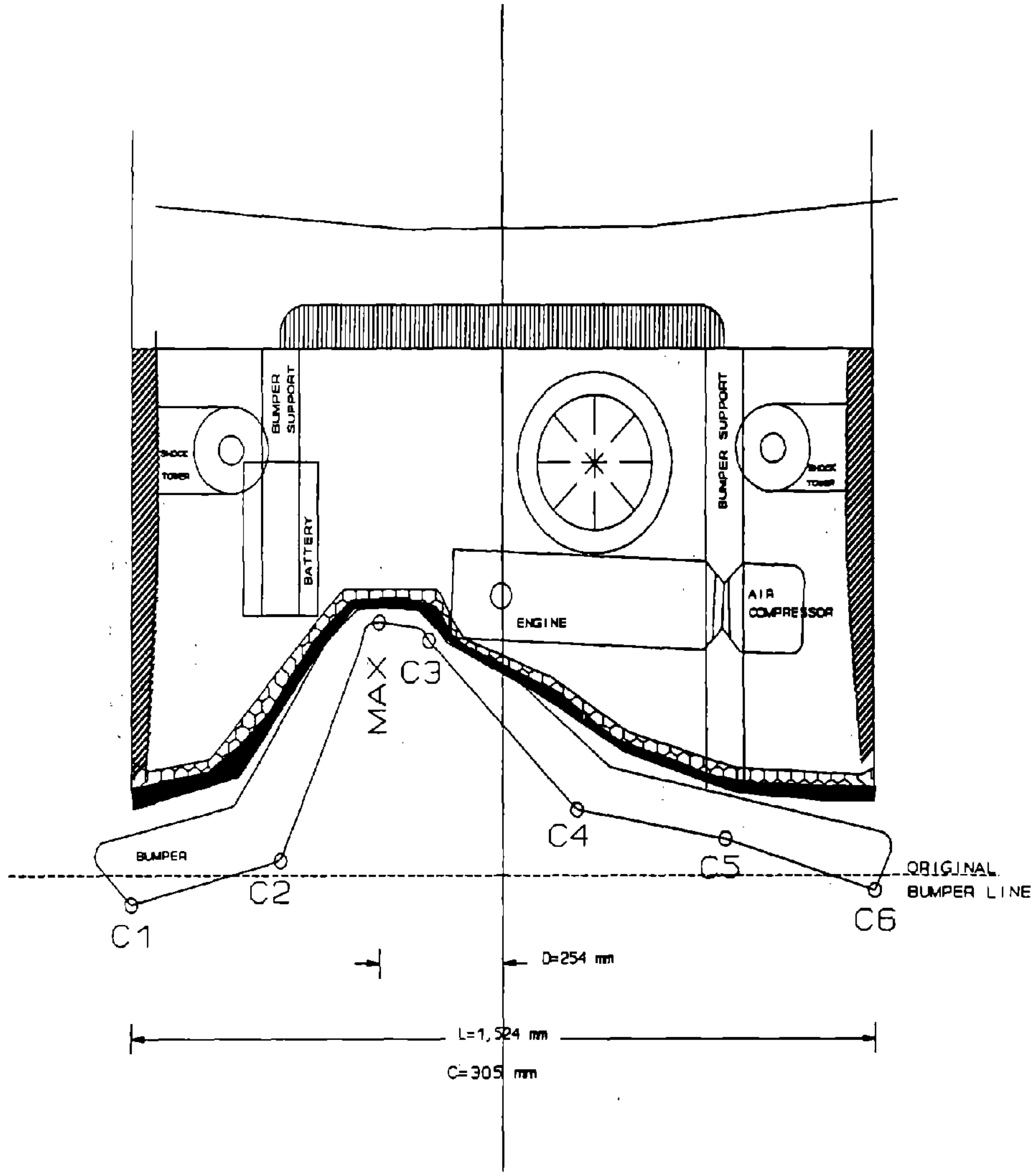
C1=-102 mm
C2=12.7 mm
C3=127 mm
C4=254 mm
C5=432 mm
C6=330 mm
MAX=438 mm

Figure 7. Crush sketch for test 93F009.



C1=-51 mm
C2=25 mm
C3=83 mm
C4=216 mm
C5=0 mm
C6=-51 mm
MAX=216 mm

Figure 8. Crush sketch for test 93F010.



C1=-51 mm
C2=25 mm
C3=406 mm
C4=114 mm
C5=64 mm
C6=-25 mm
MAX=437 mm

Figure 9. Crush sketch for test 93F011.

Figure 10. Pre-test photographs, test 93F008.

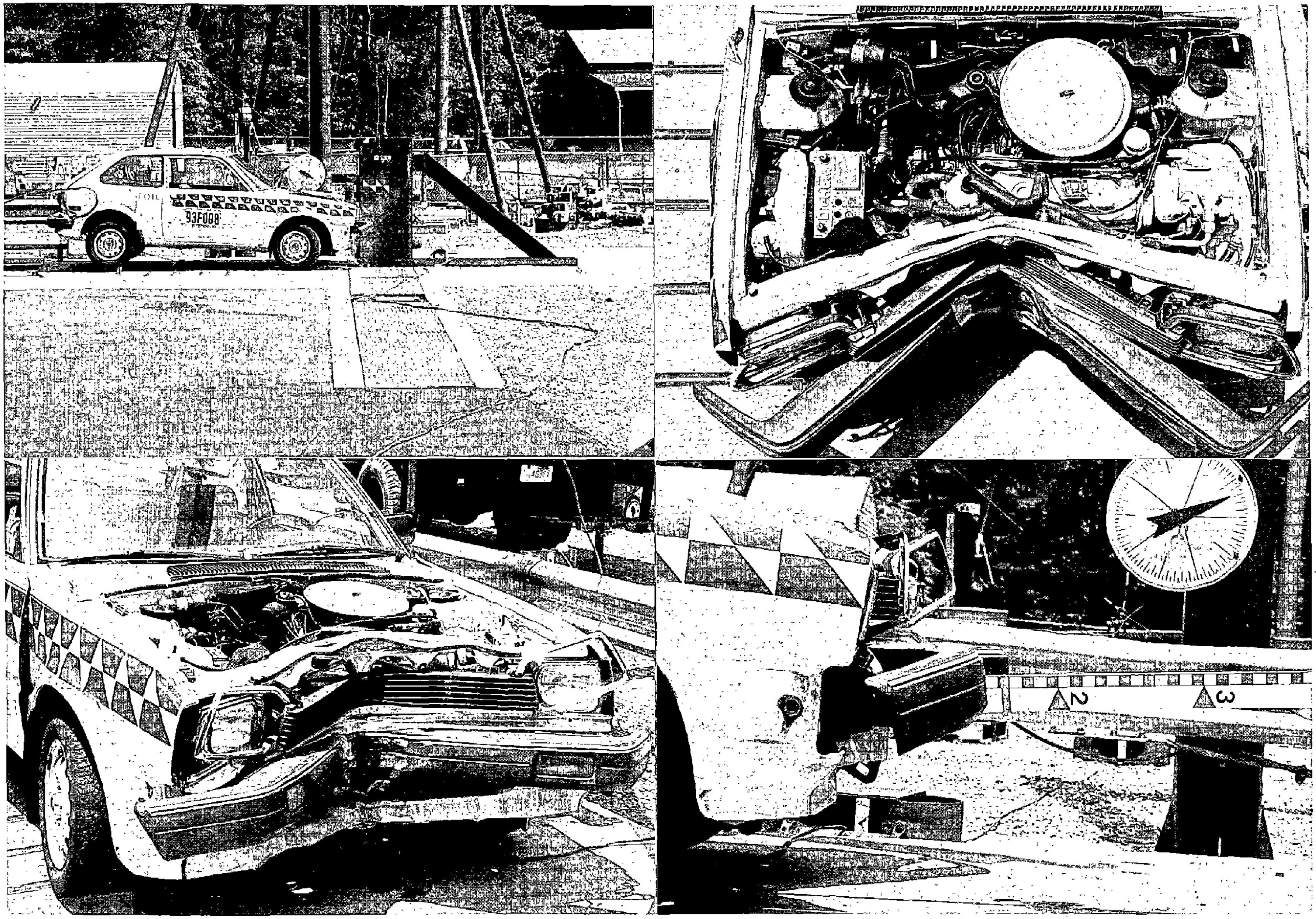


Figure 11. Post-test photographs, test 93F008.

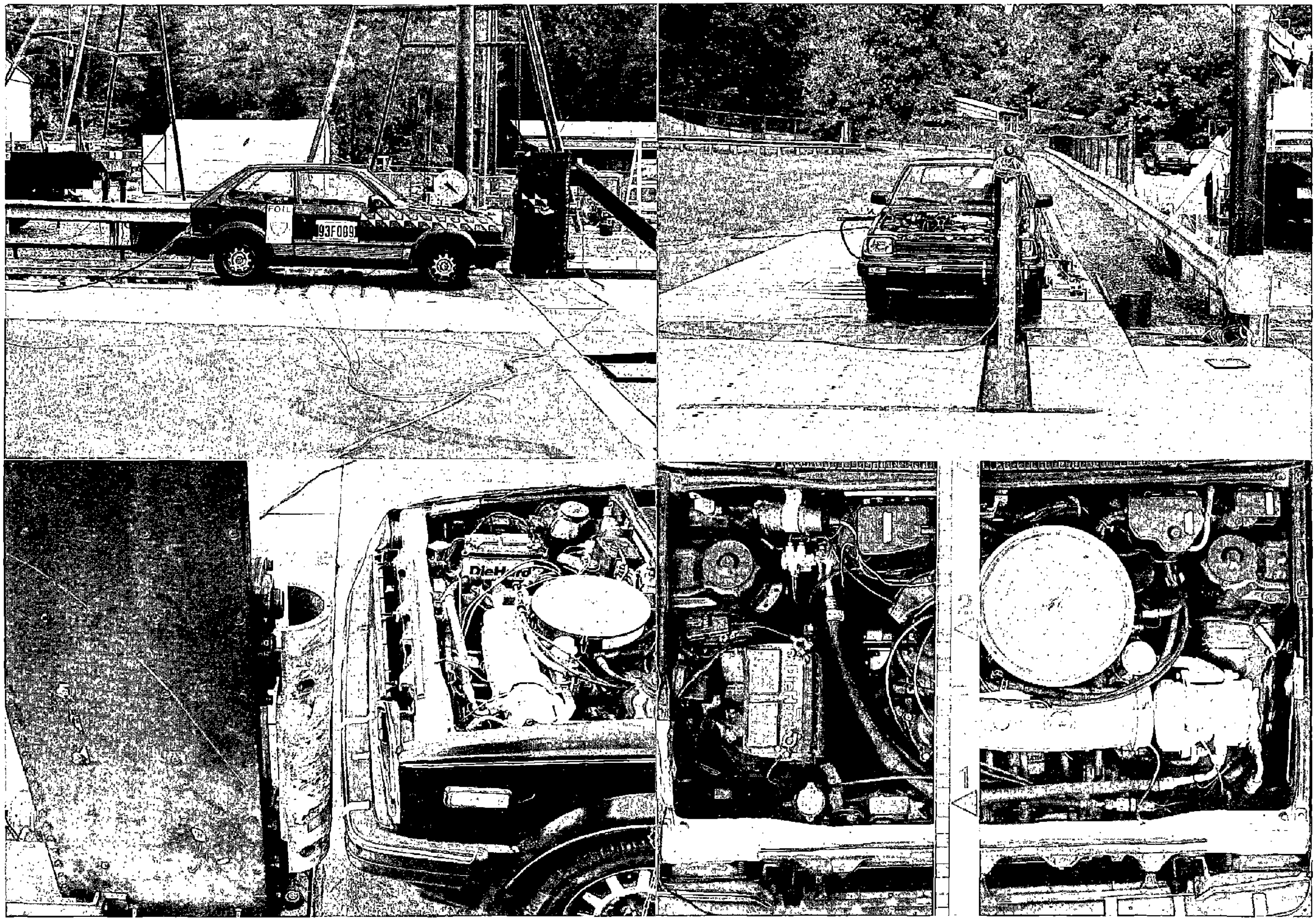


Figure 12. Pre-test photographs, test 93F009.

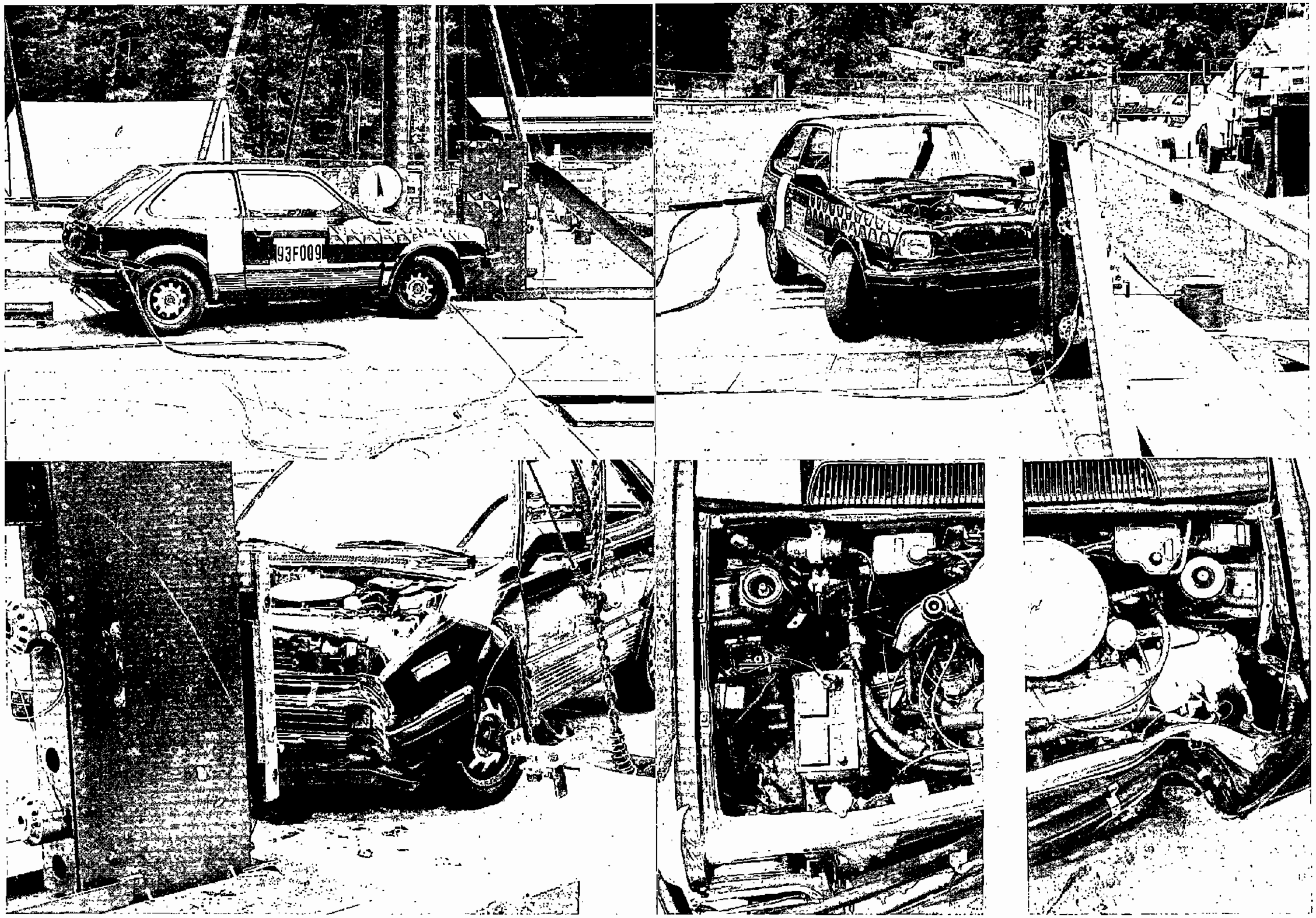


Figure 13. Post-test photographs, test 93F009.

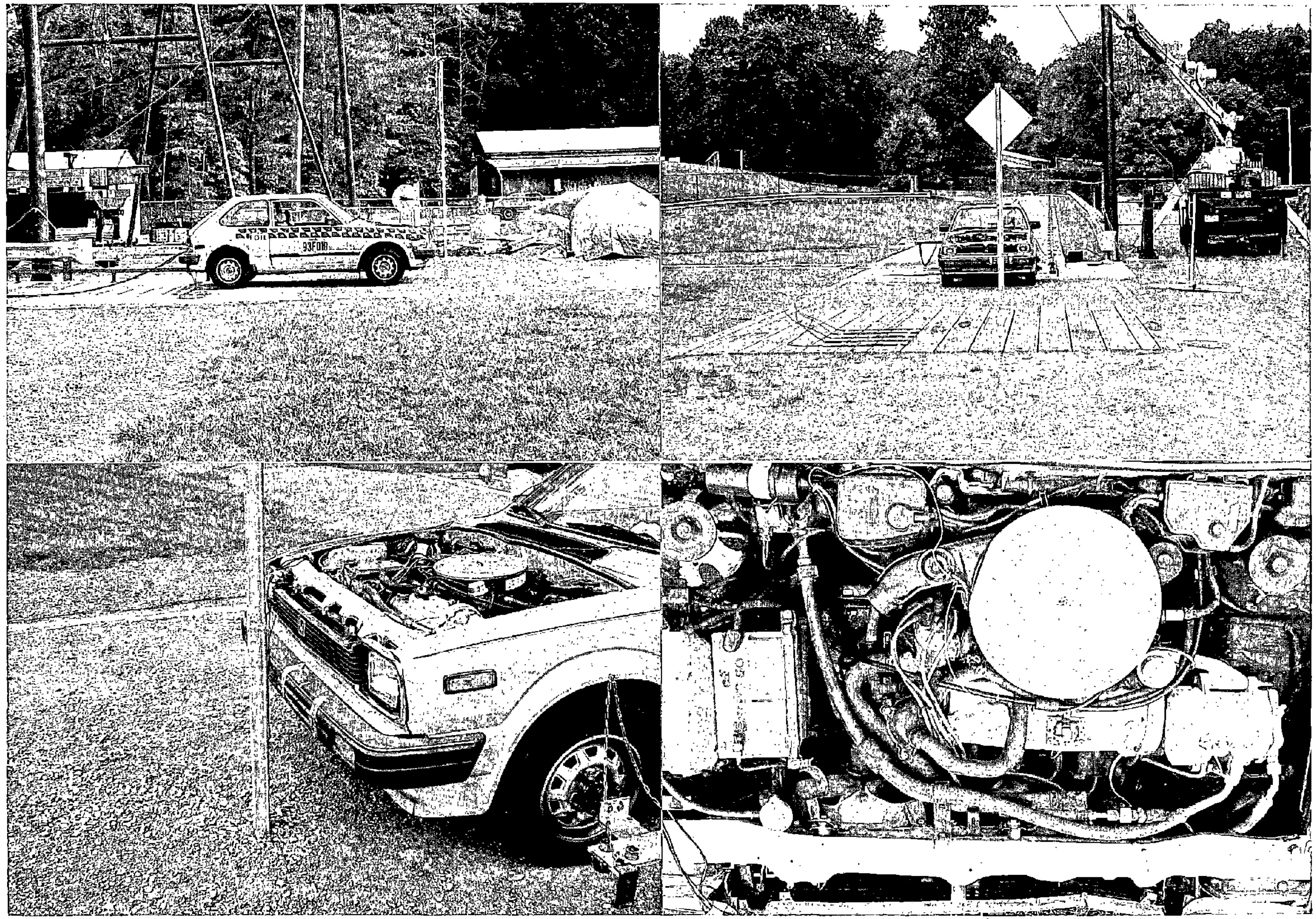


Figure 14. Pre-test photographs, test 93F010.

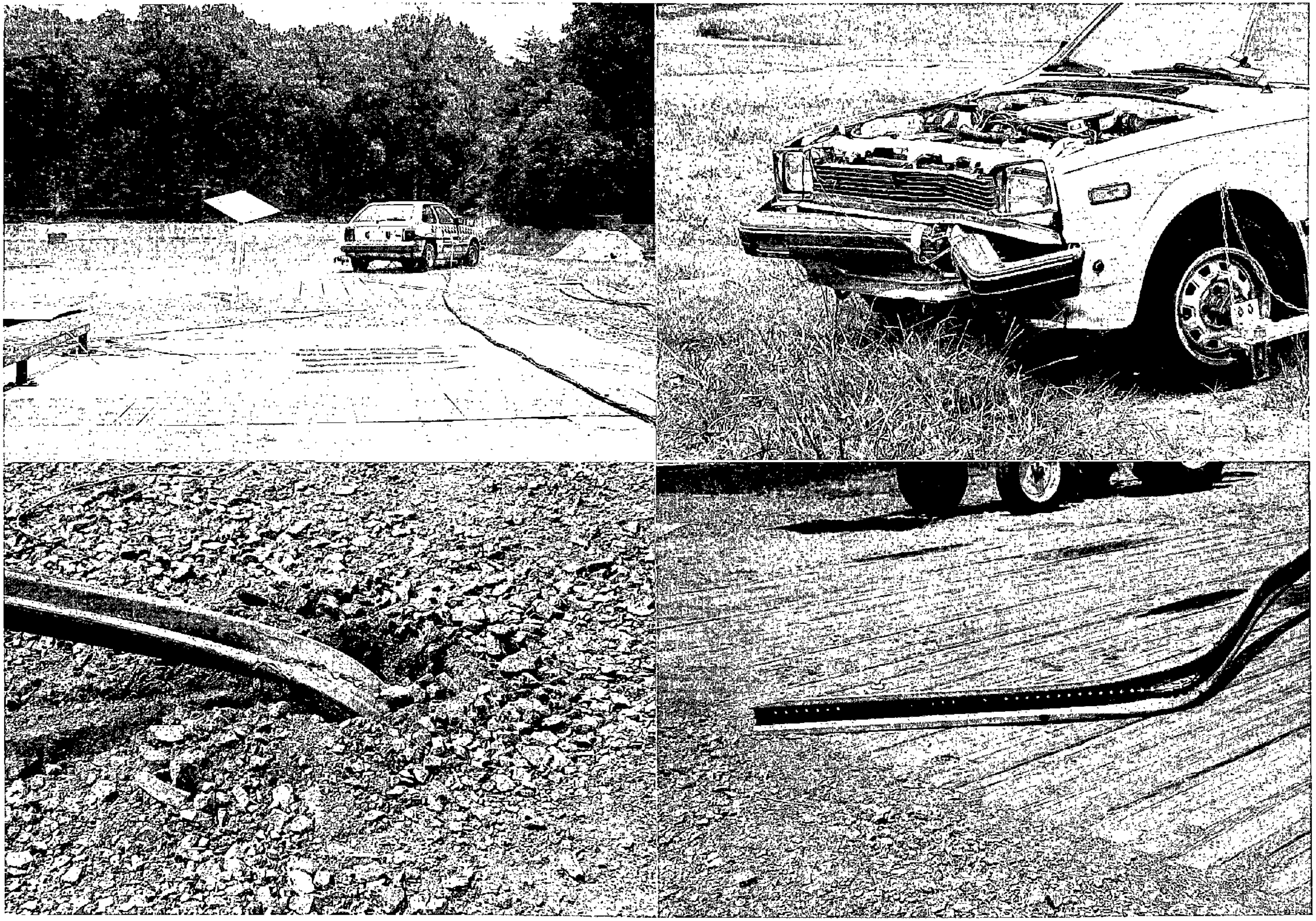


Figure 15. Post-test photographs, test 93F010.

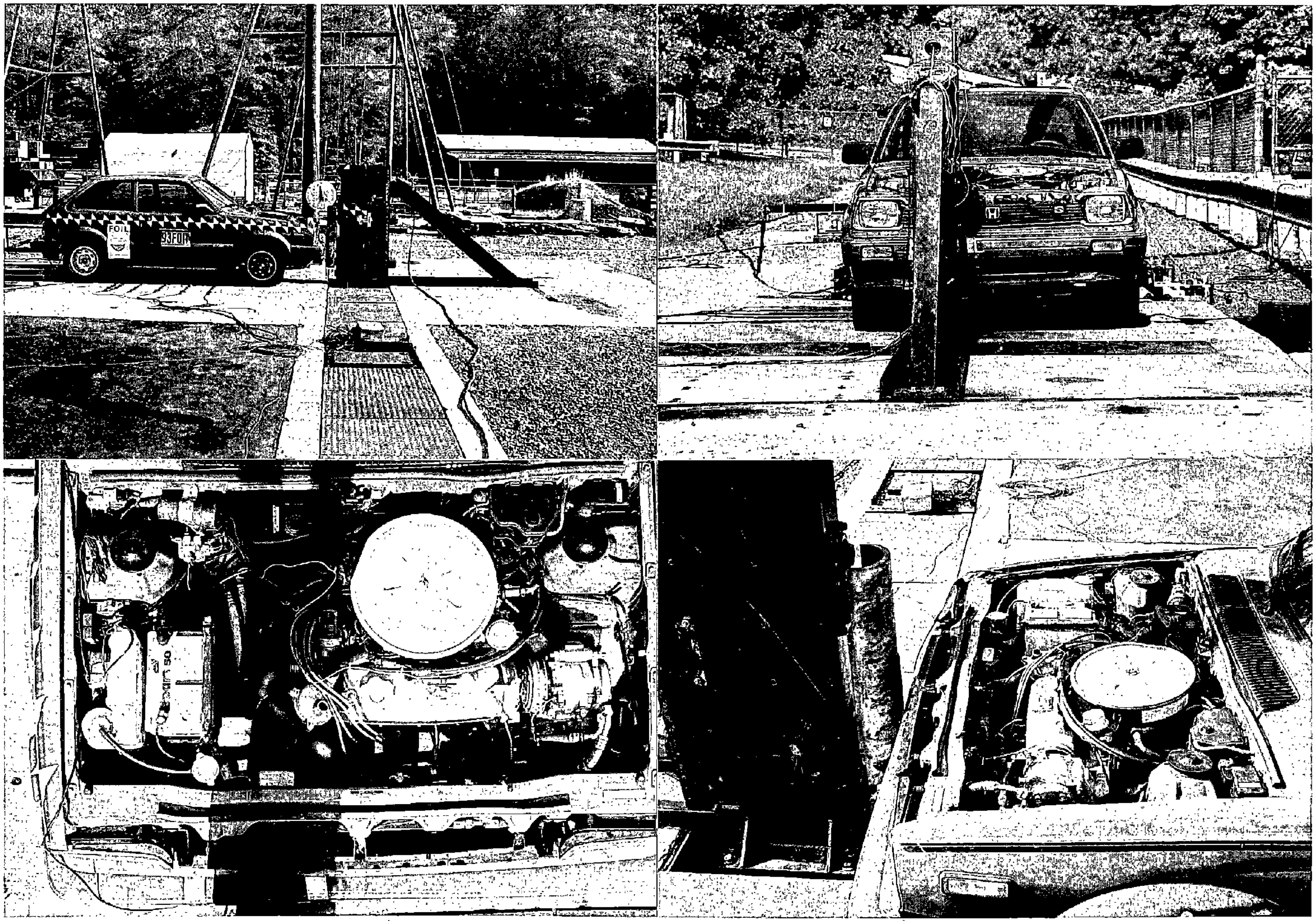


Figure 16. Pre-test photographs, test 93F011.

Figure 17. Post-test photographs, test 93F011.

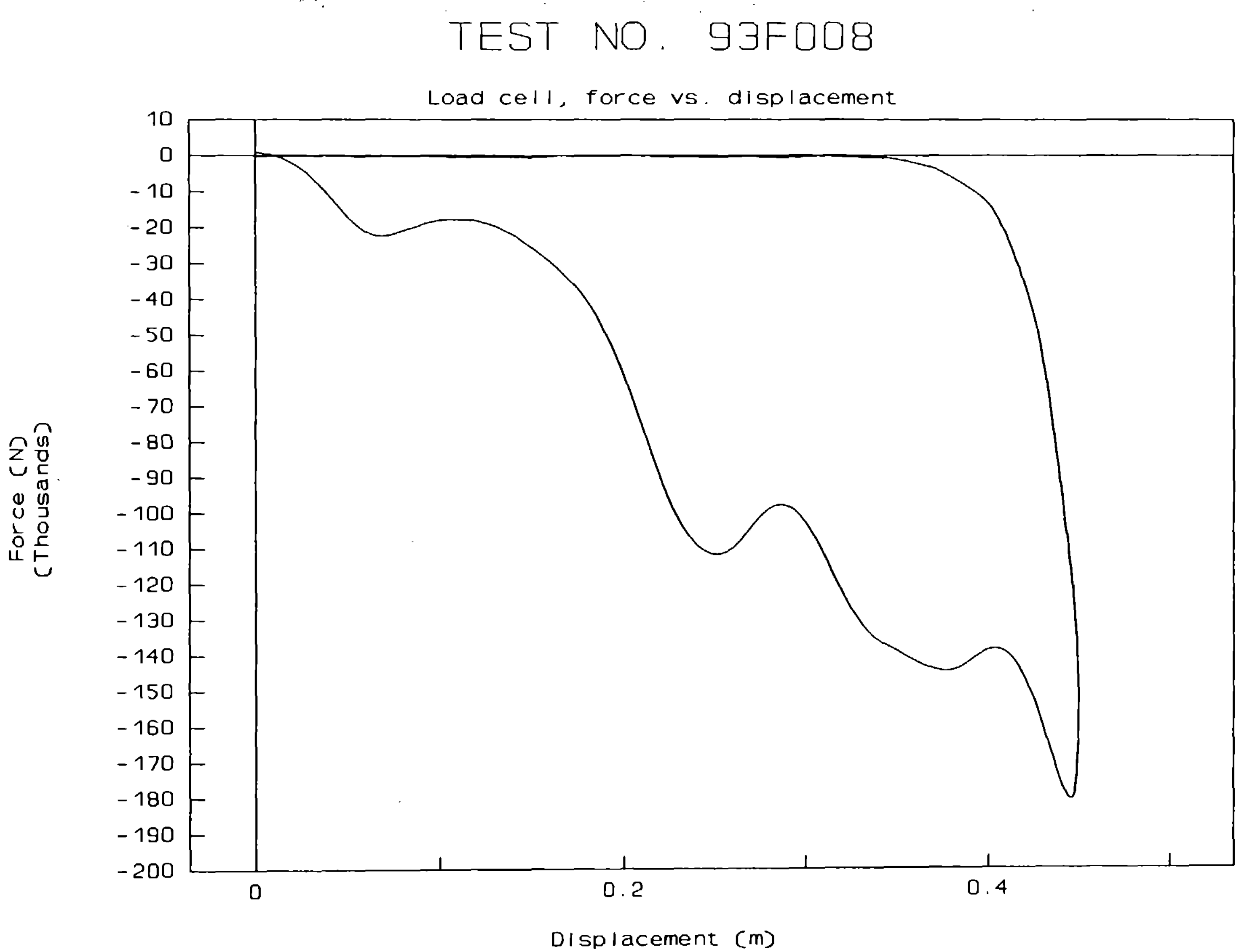


Figure 18. Load cell, force vs. displacement, test 93F008.

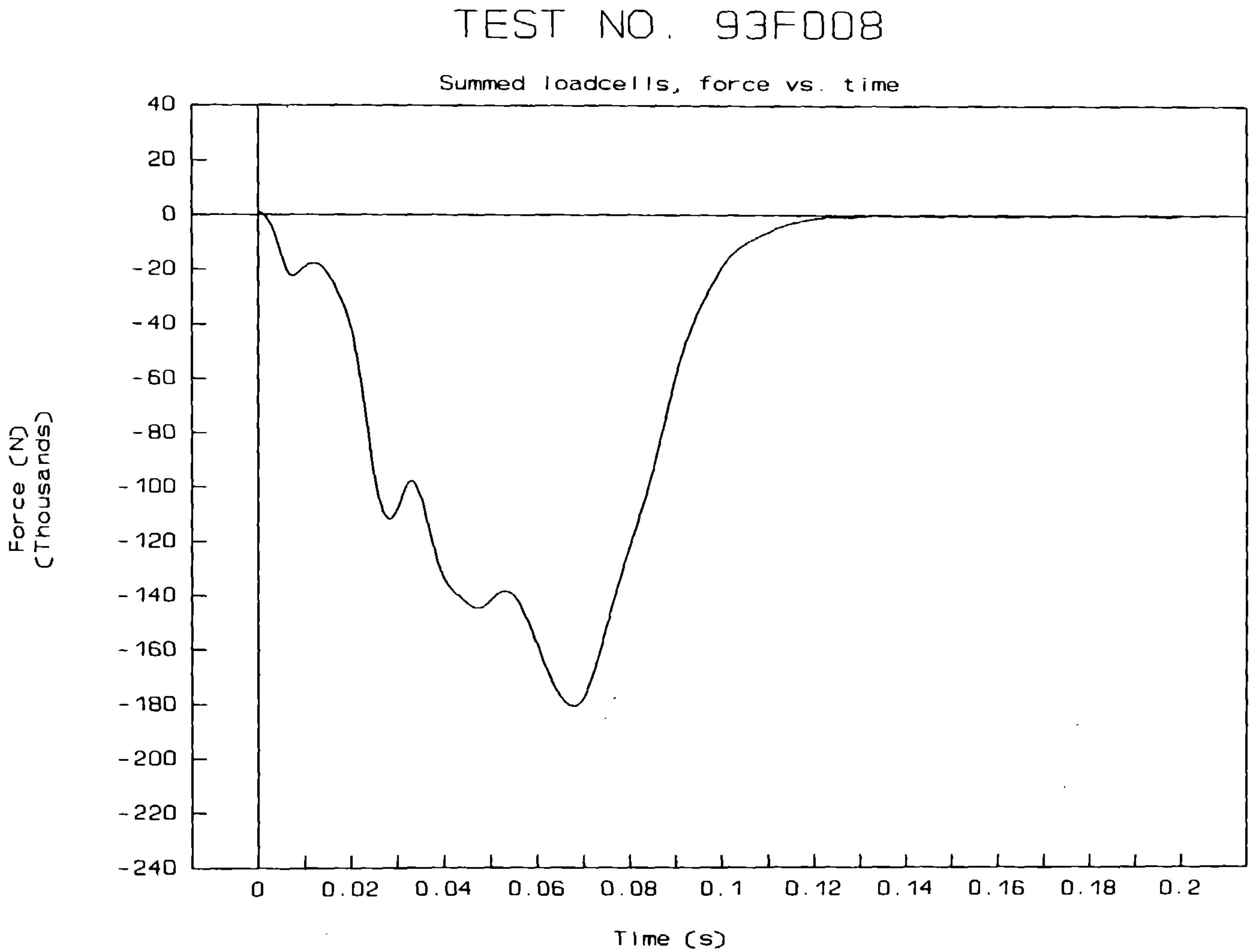


Figure 19. Summed load cells, force vs. time, test 93F008.

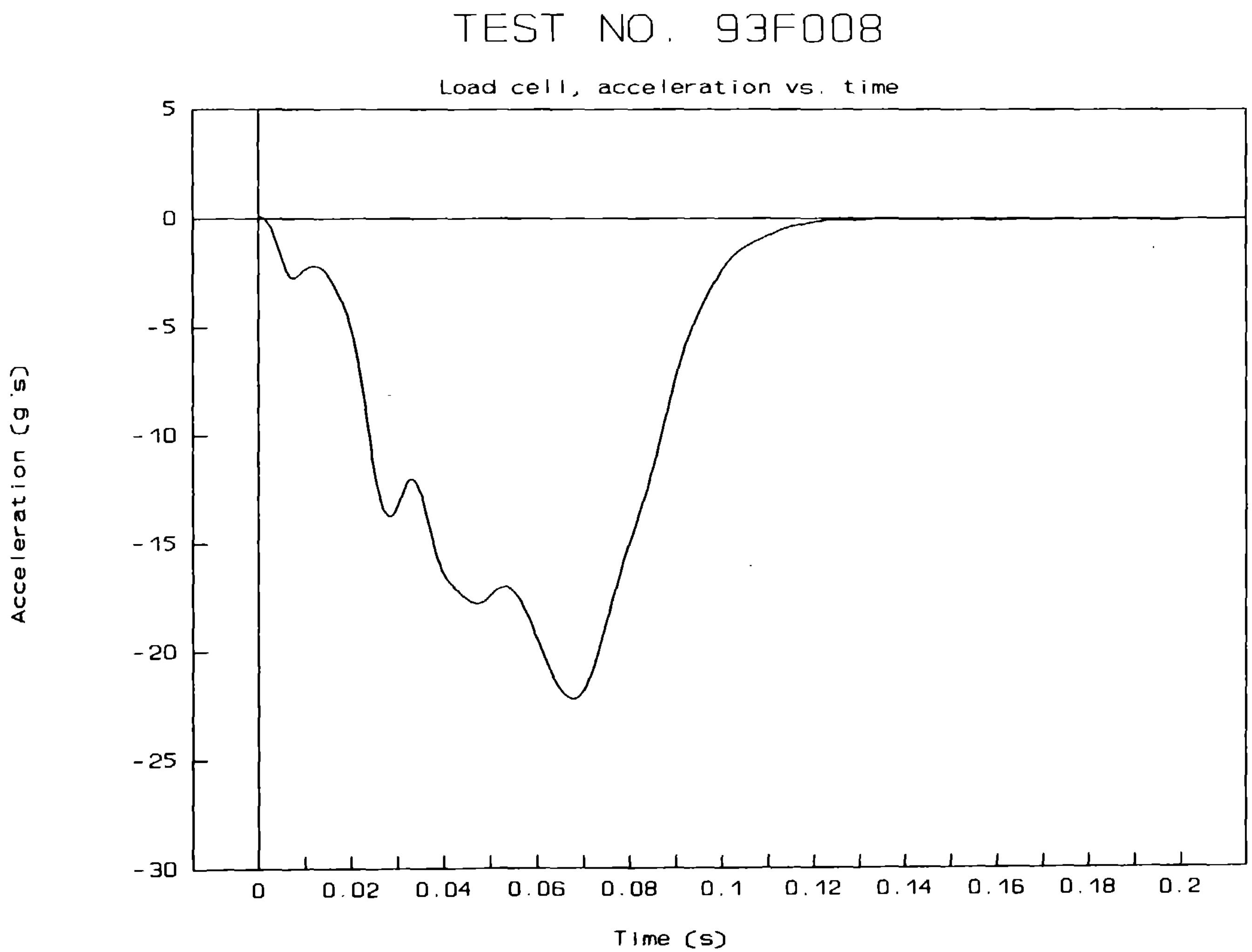


Figure 20. Load cell, acceleration vs. time, test 93F008.

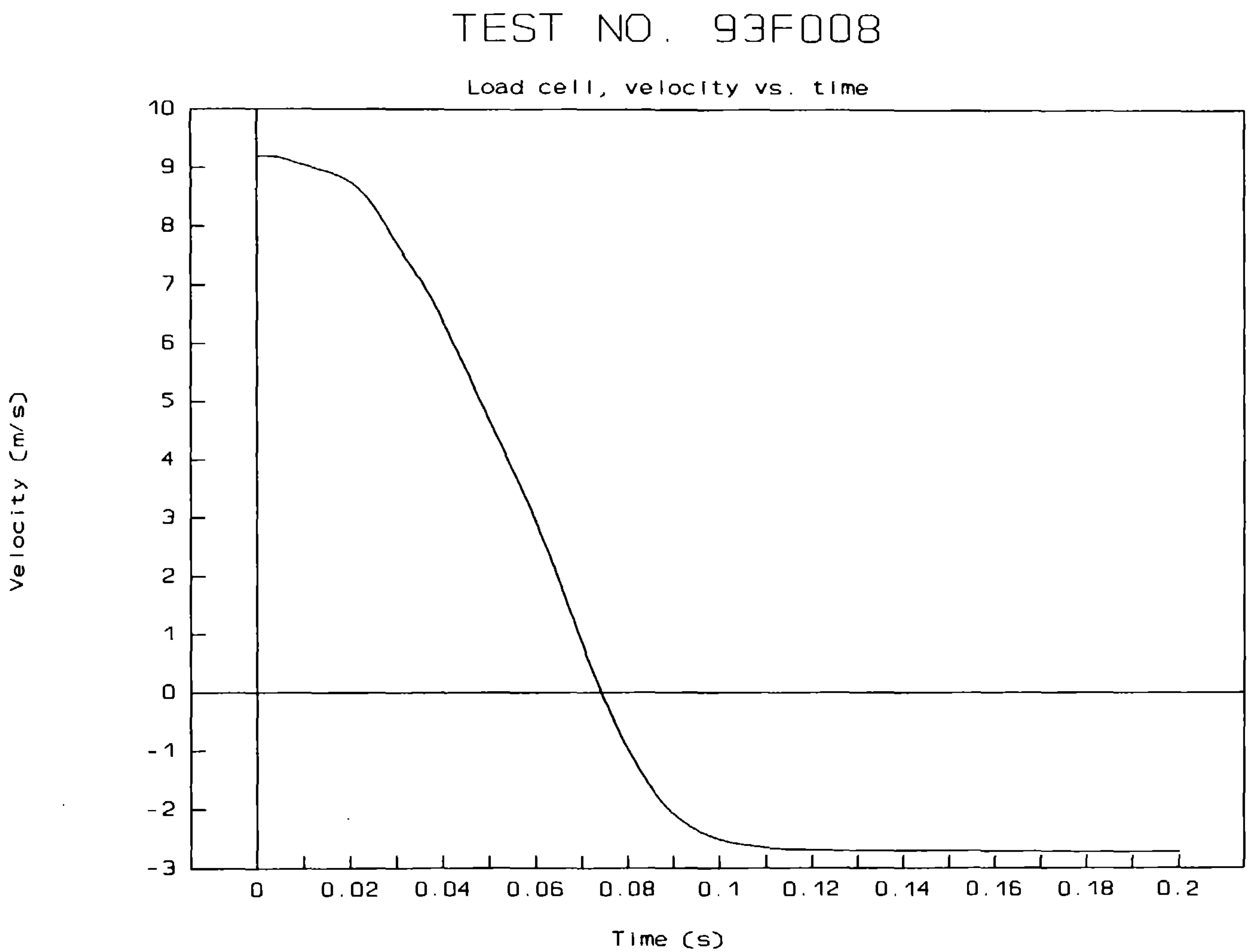


Figure 21. Load cell, velocity vs. time, test 93F008.

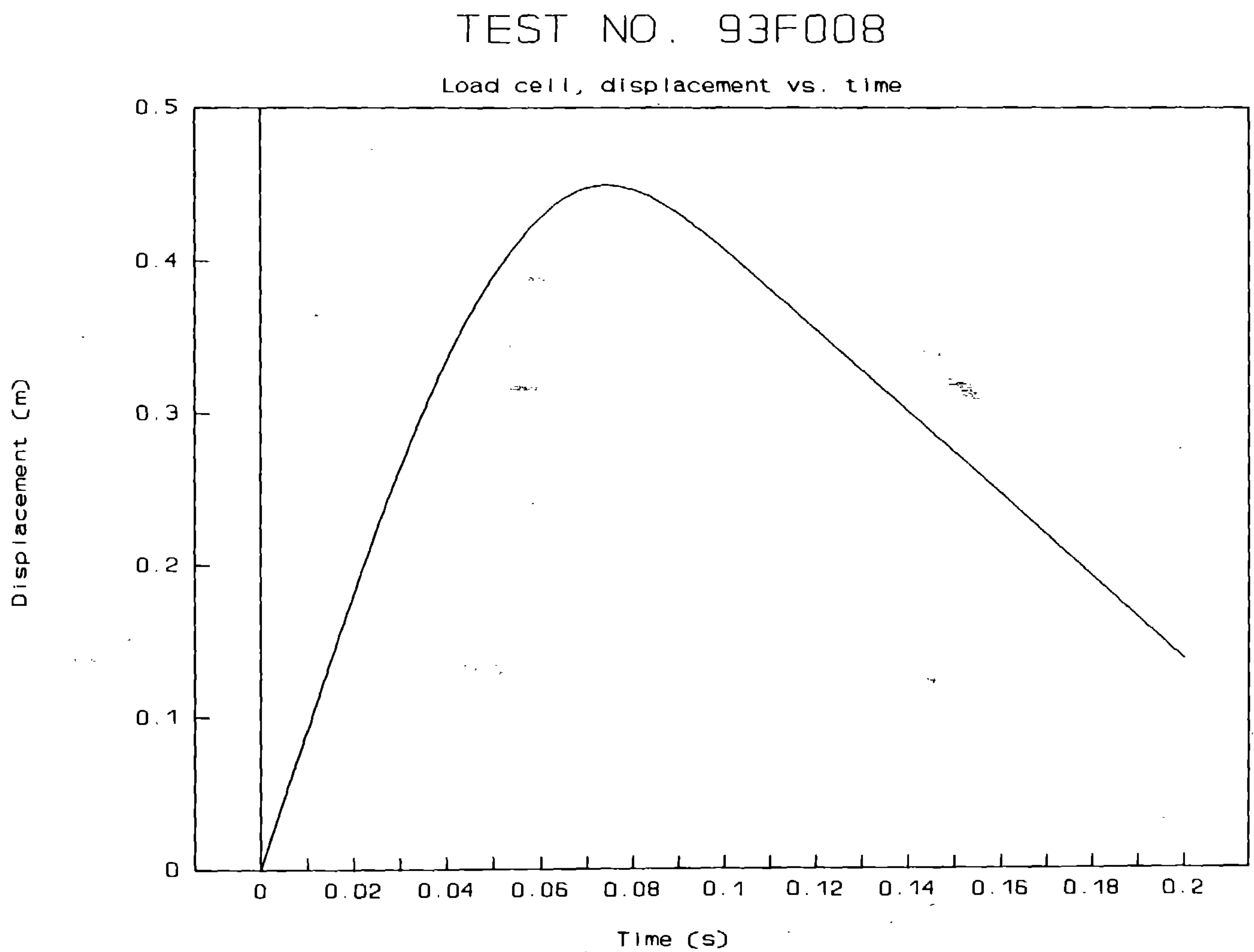


Figure 22. Load cell, displacement vs. time, test 93F008.

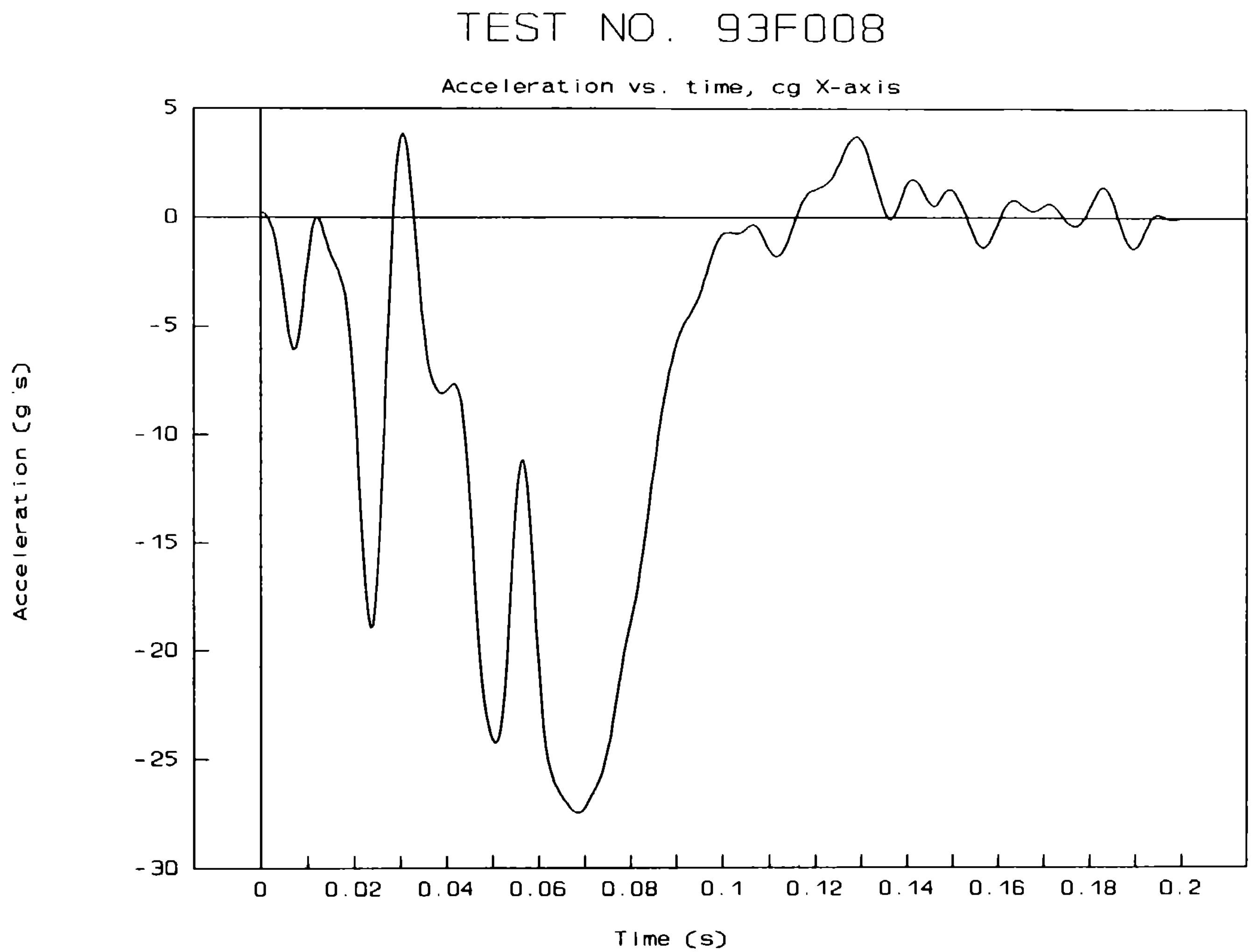


Figure 23. Acceleration vs. time, cg X-axis, test 93F008.

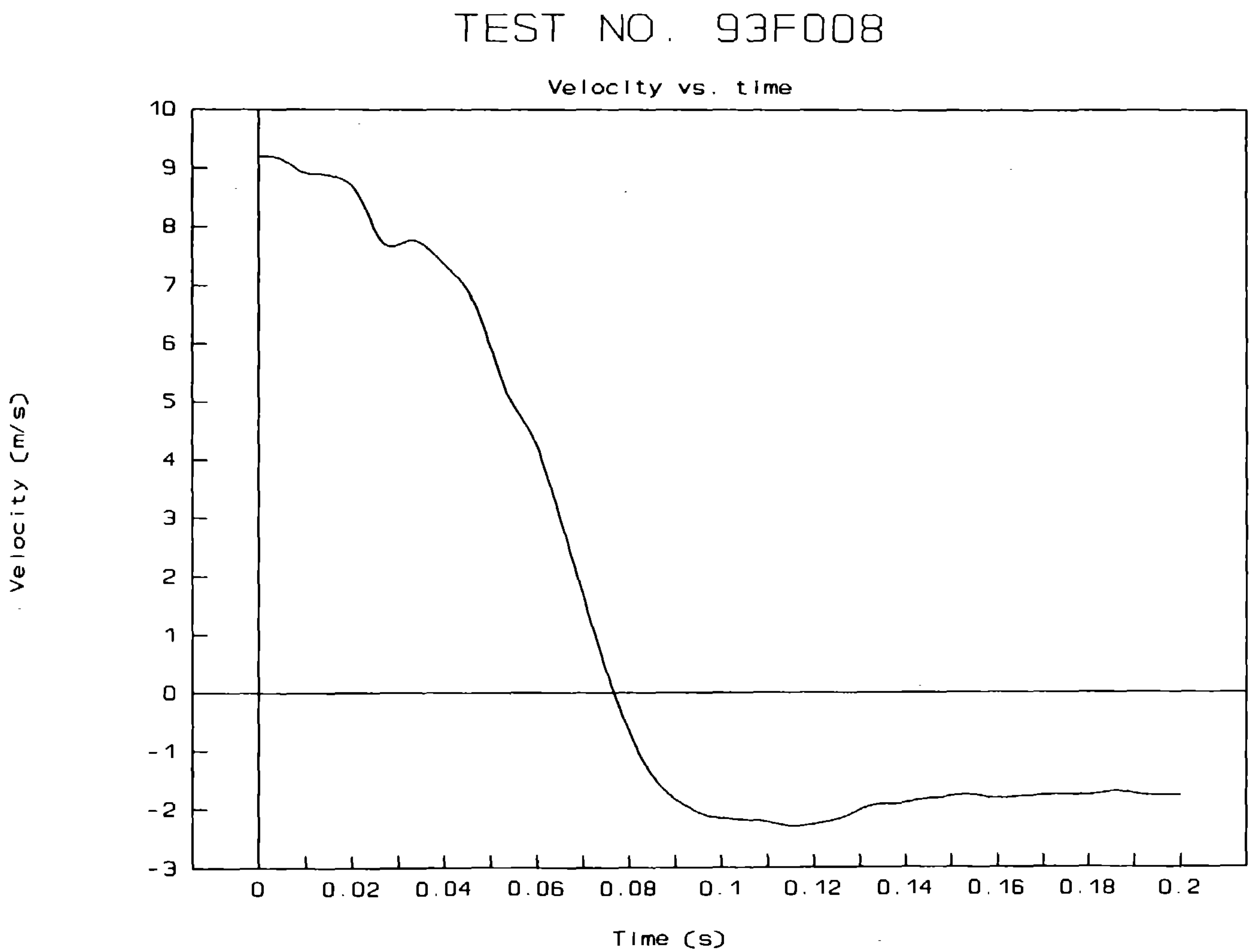


Figure 24. Velocity vs. time, test 93F008.

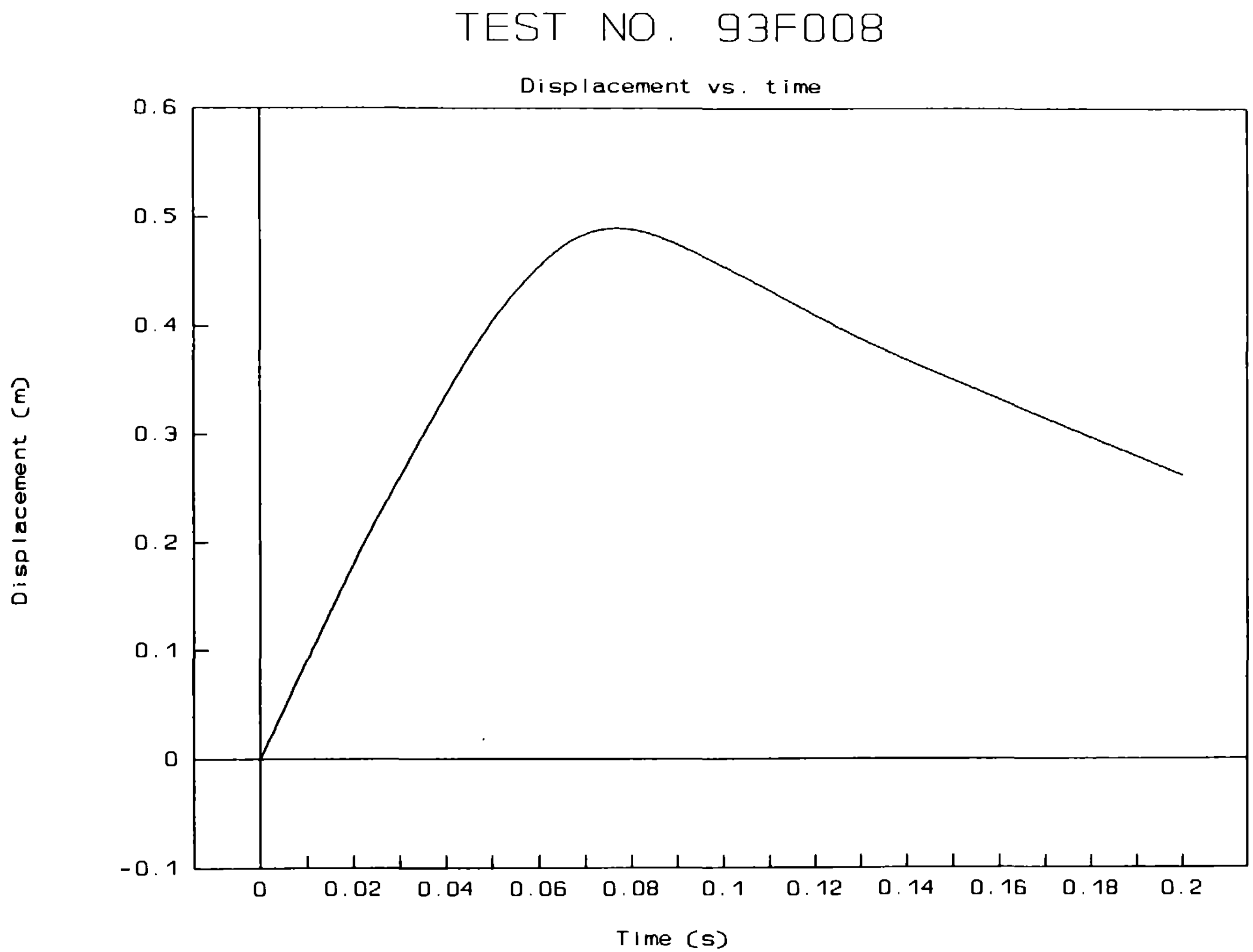


Figure 25. Displacement vs. time, test 93F008.

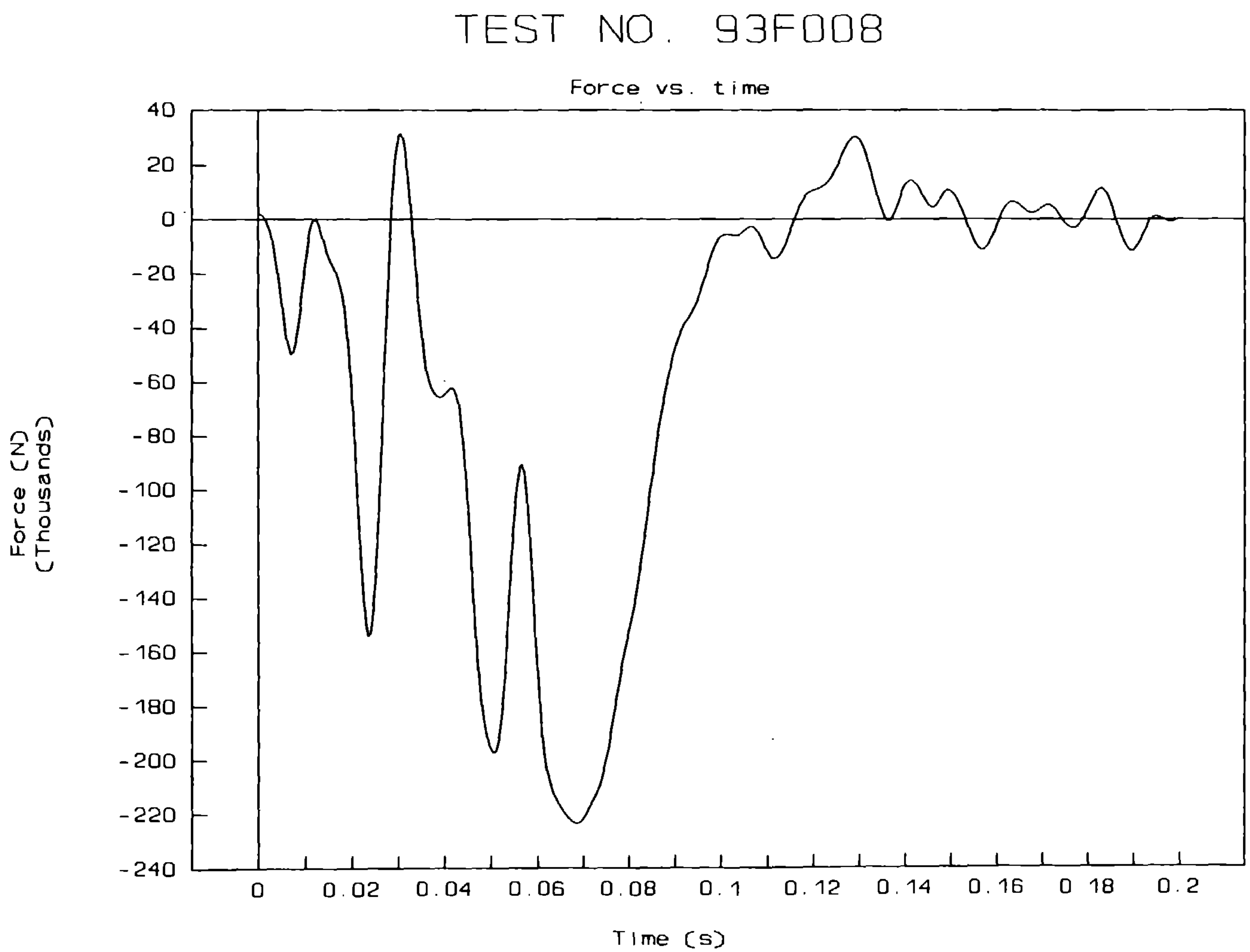


Figure 26. Force vs. time, test 93F008.

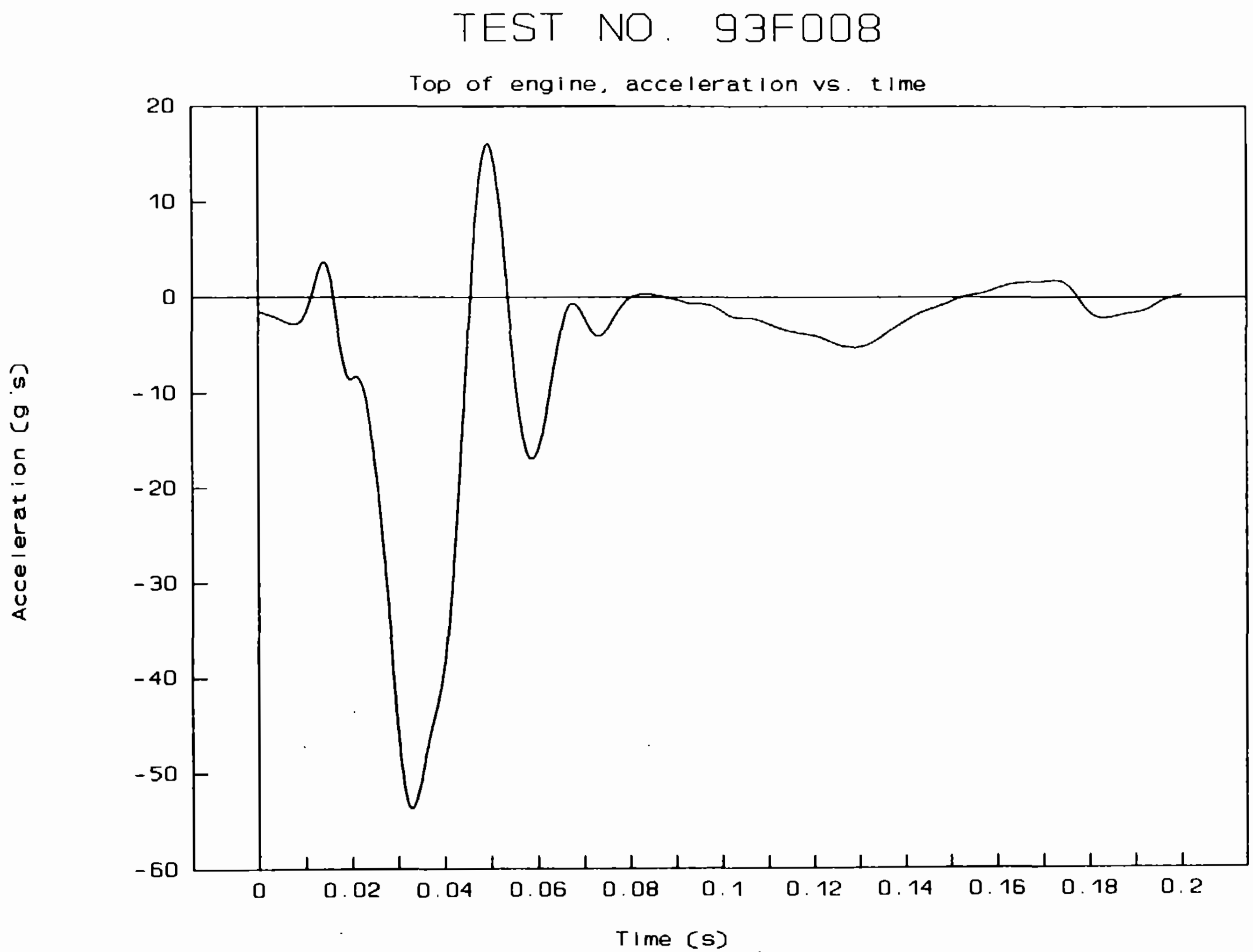


Figure 27. Top of engine, acceleration vs. time, test 93F008.

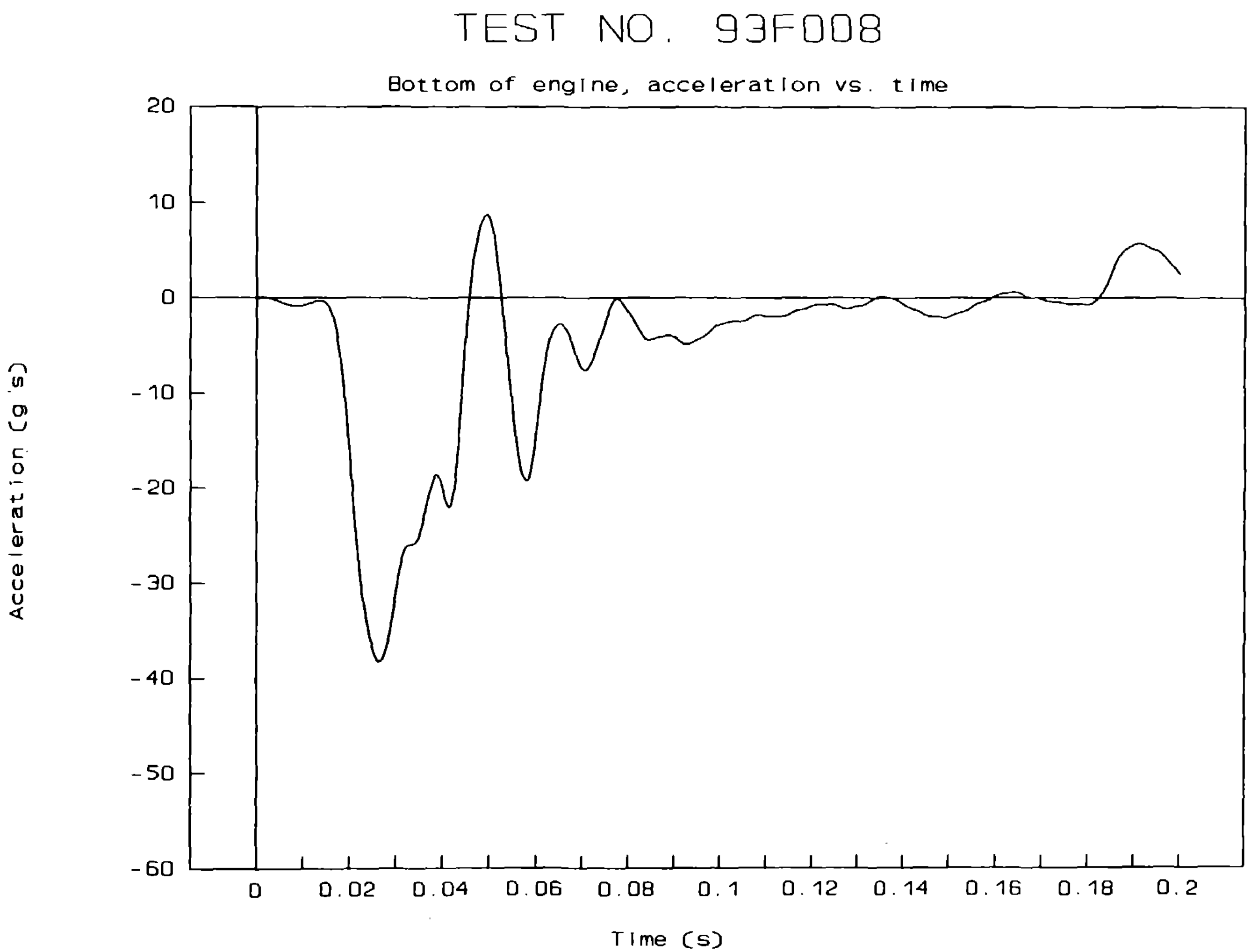


Figure 28. Bottom of engine, acceleration vs. time, test 93F008.

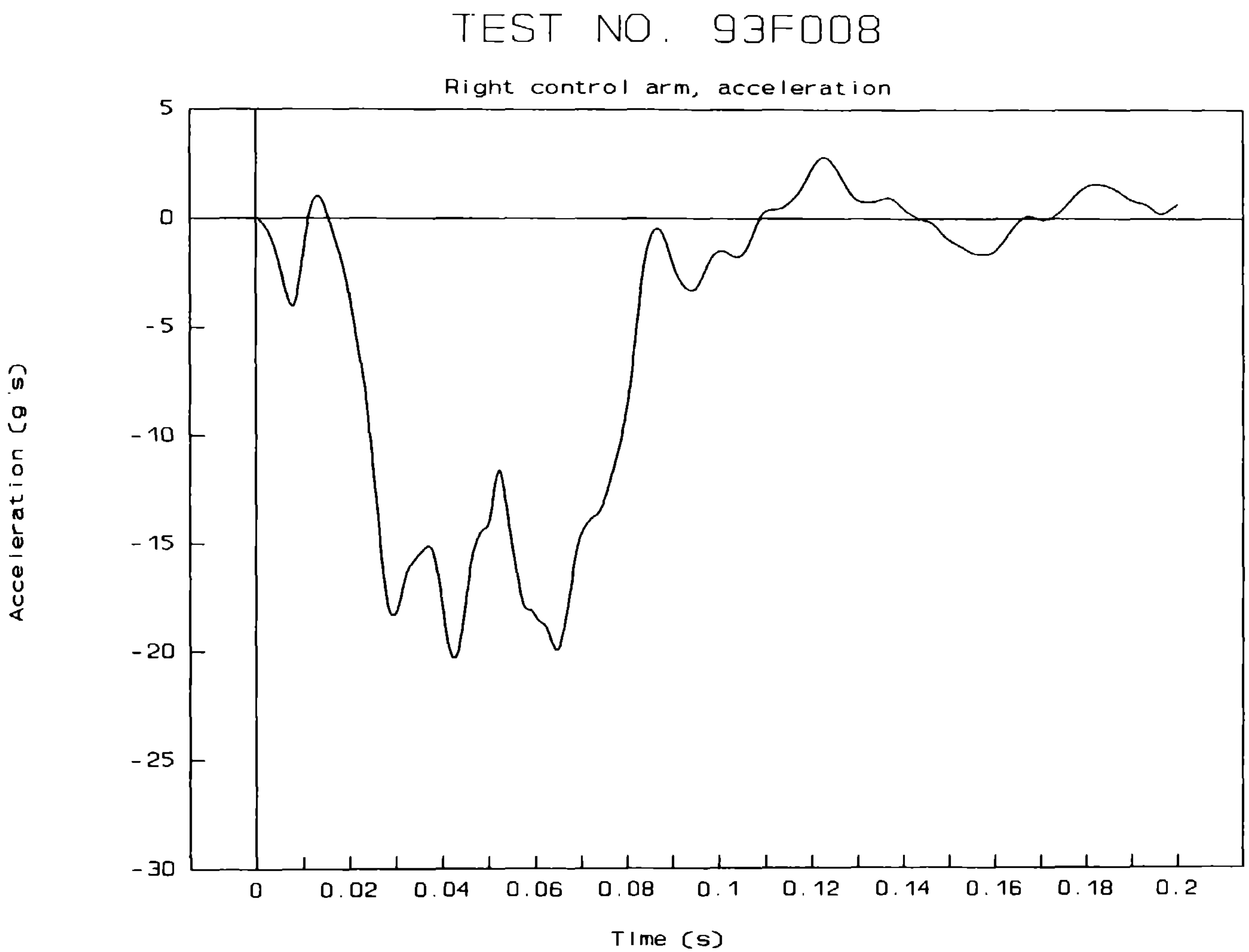


Figure 29. Right control arm, acceleration vs. time, test 93F008.

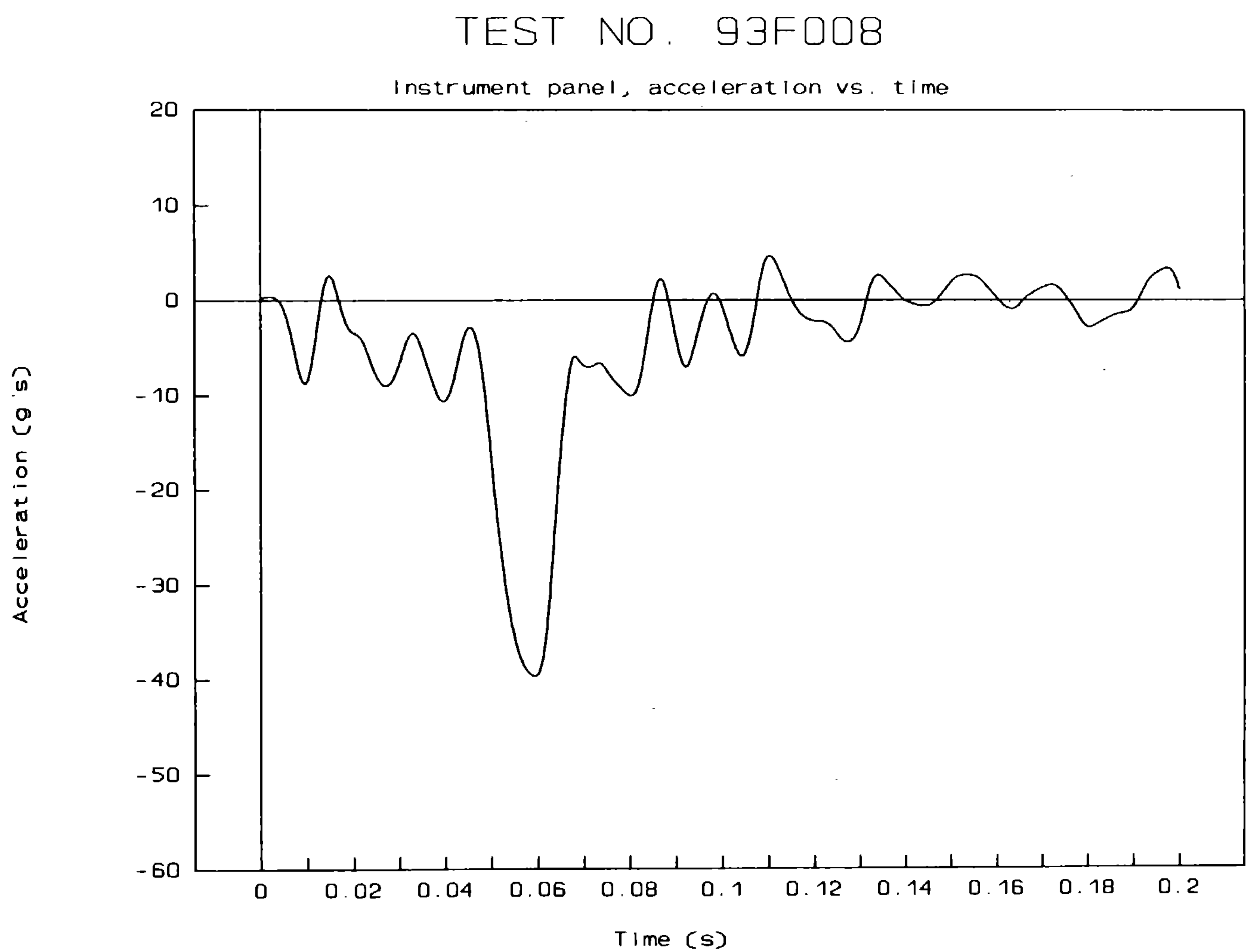


Figure 30. Instrument panel, acceleration vs. time, test 93F008.

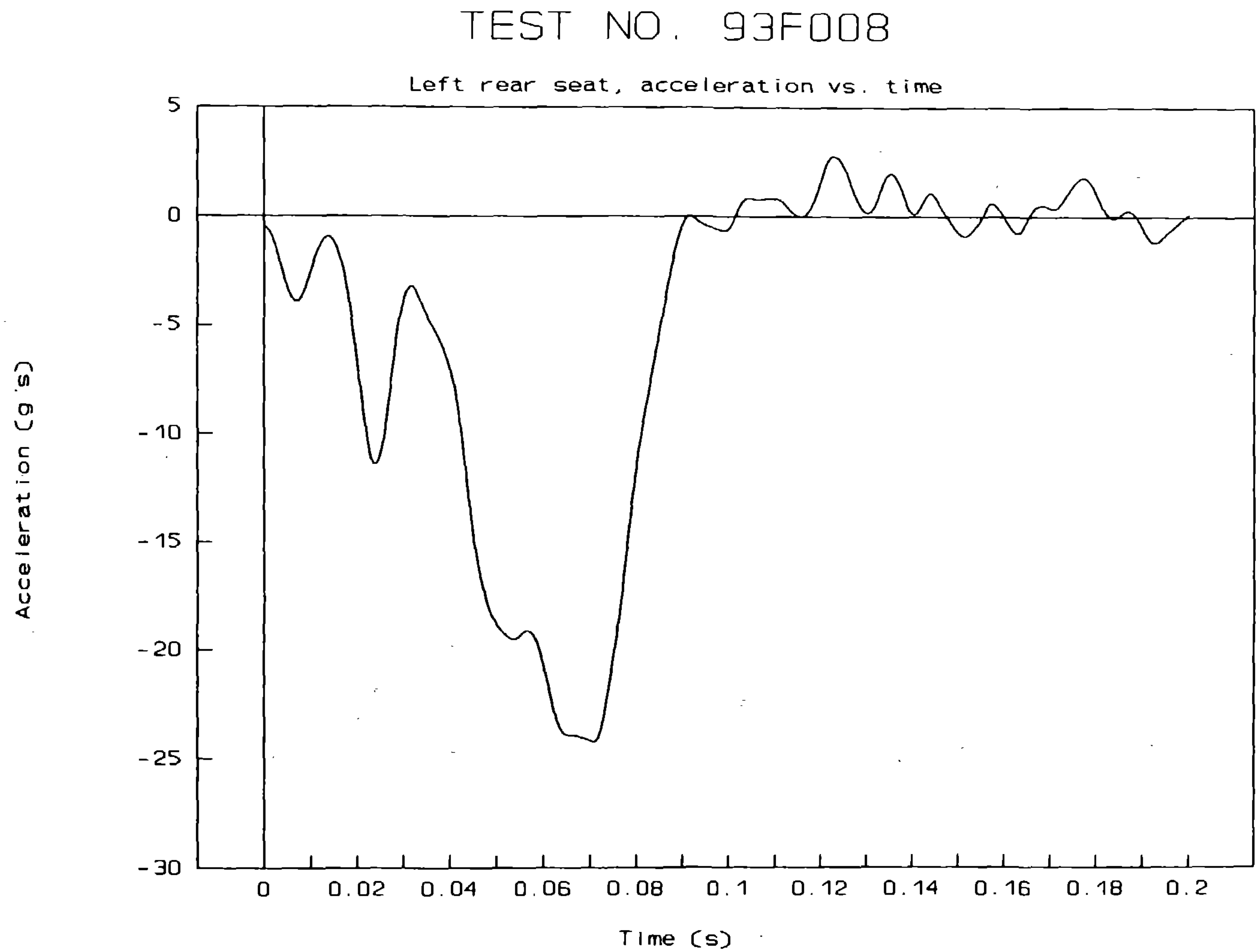


Figure 31. Left rear seat, acceleration vs. time, test 93F008.

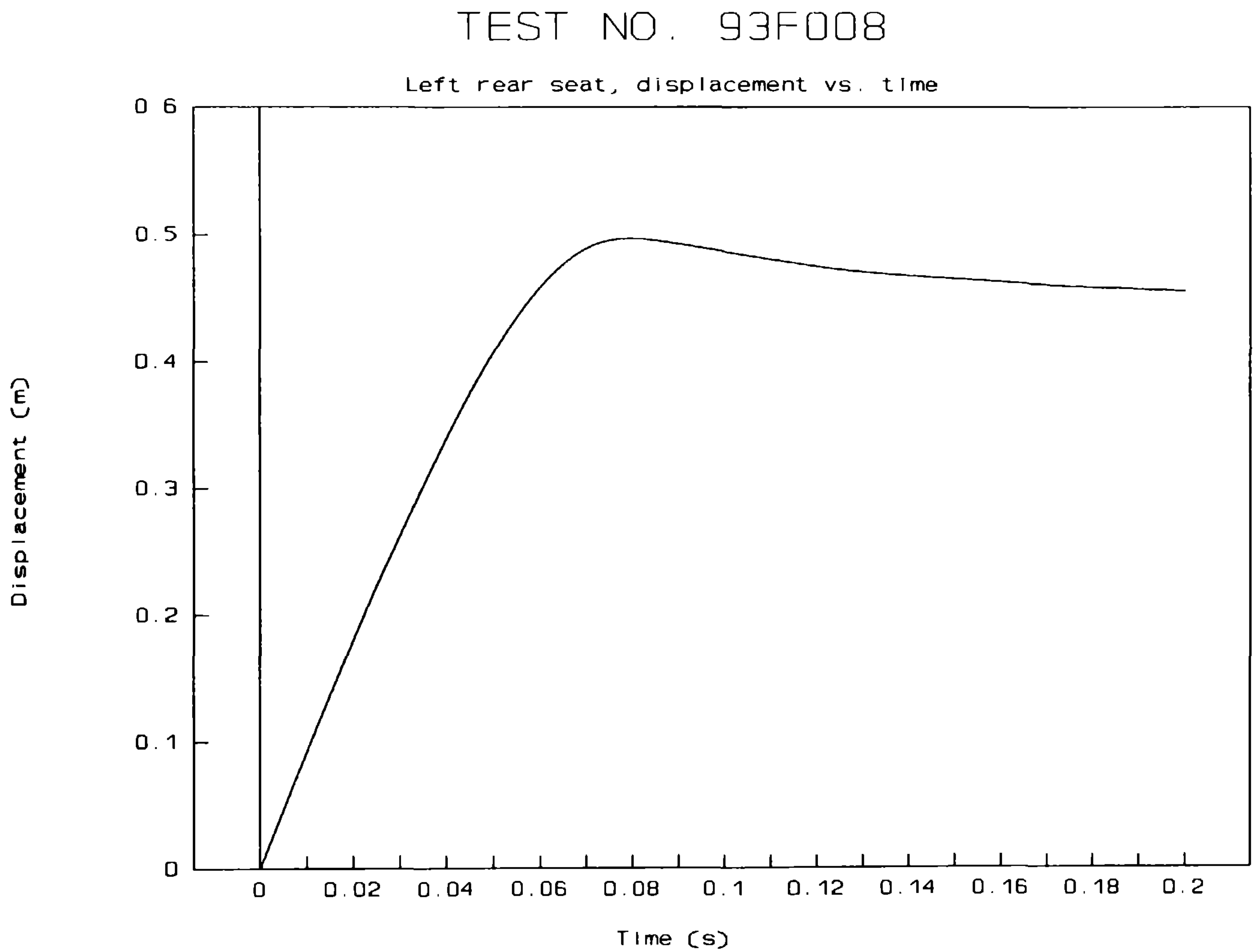


Figure 32. Left rear seat, displacement vs. time, test 93F008.

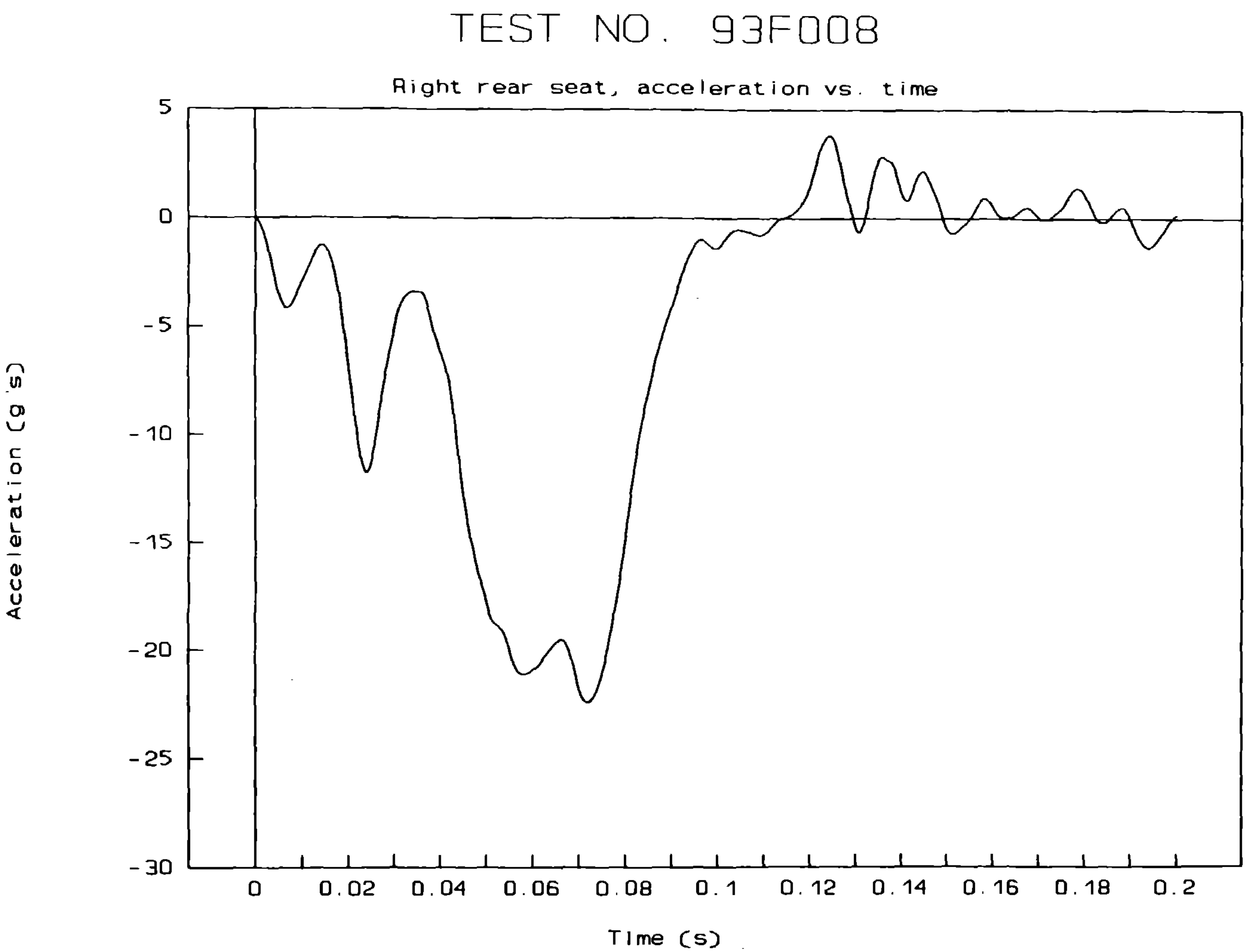


Figure 33. Right rear seat, acceleration vs. time, test 93F008.

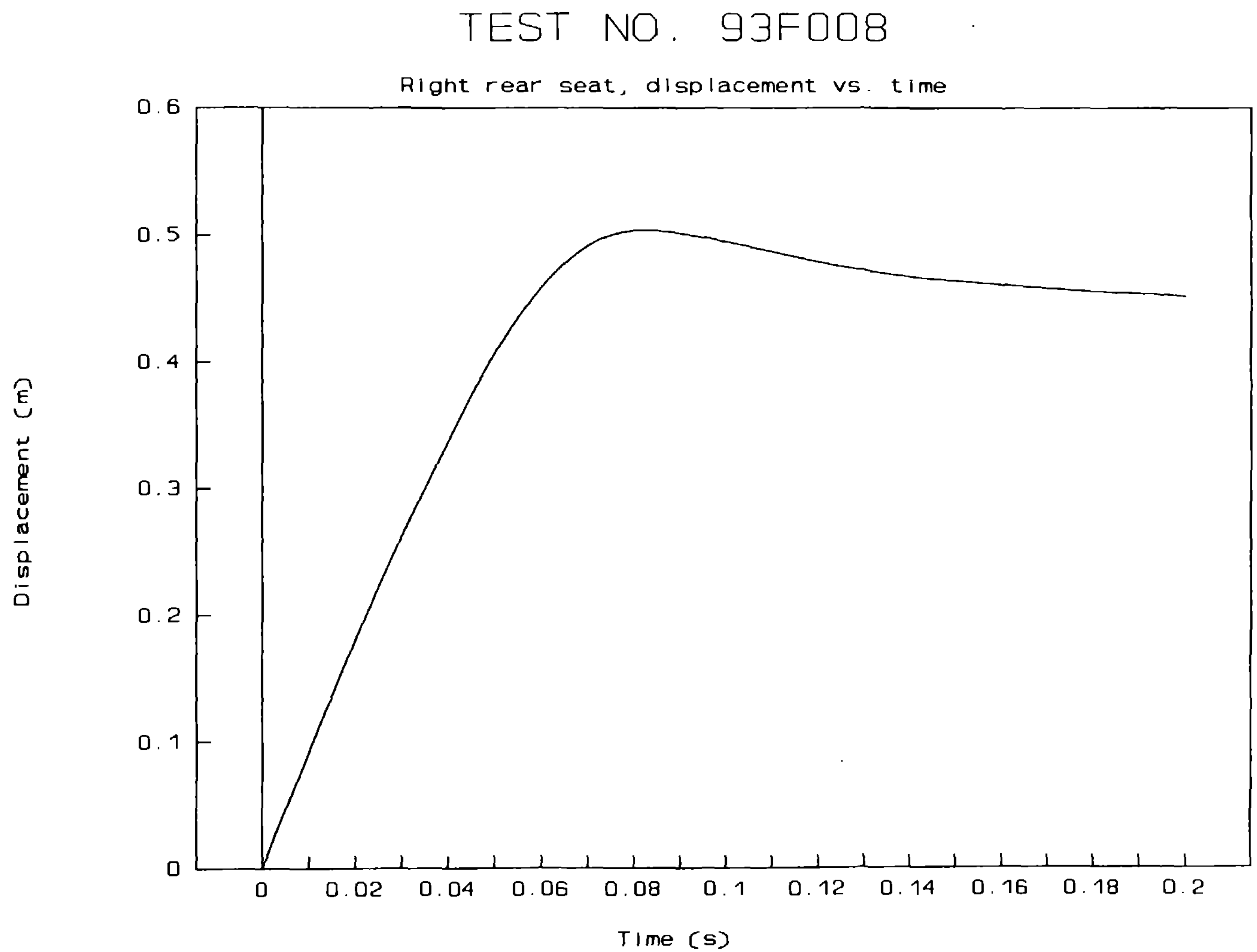


Figure 34. Right rear seat, displacement vs. time, test 93F008.

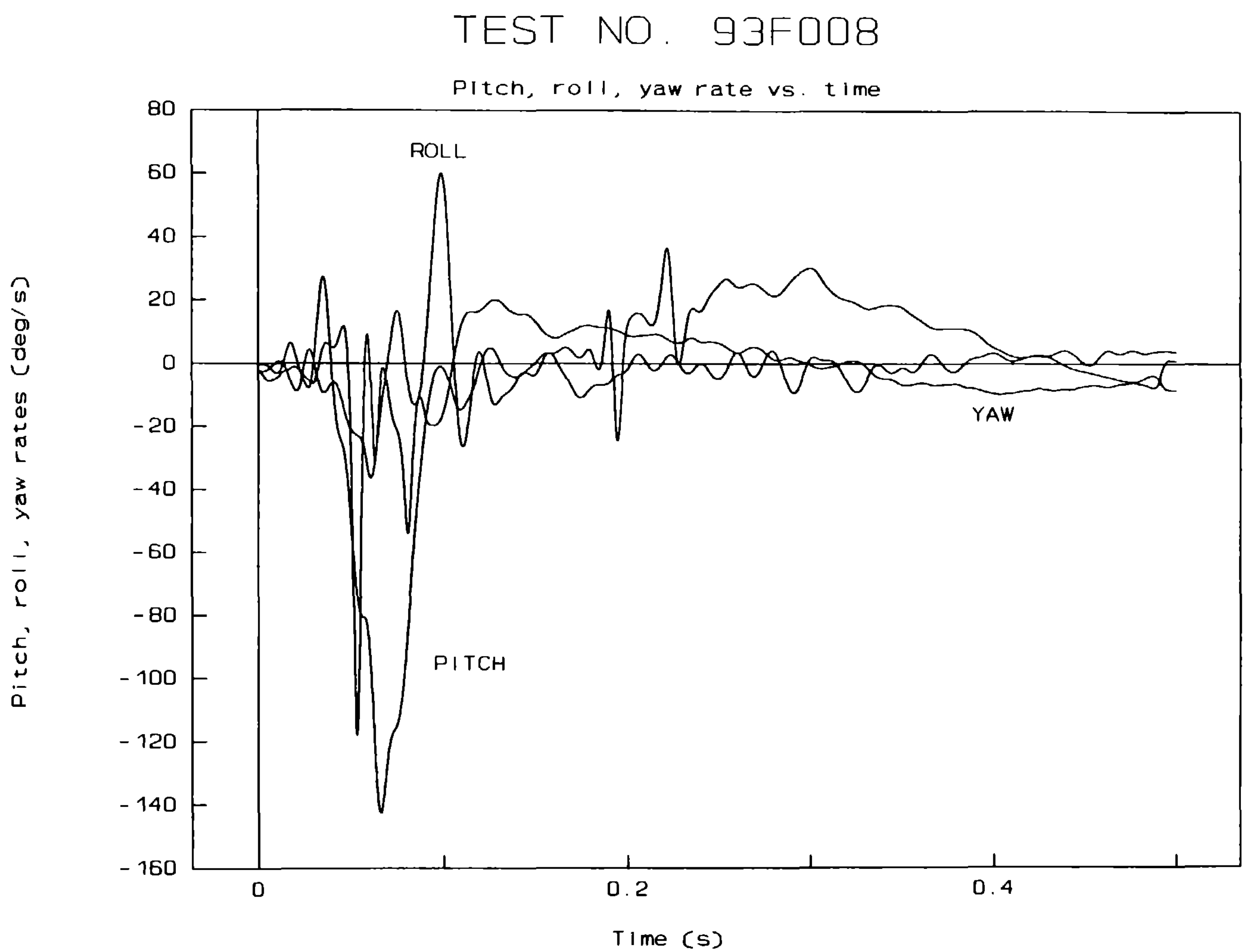


Figure 35. Pitch, roll, yaw rate vs. time, test 93F008.

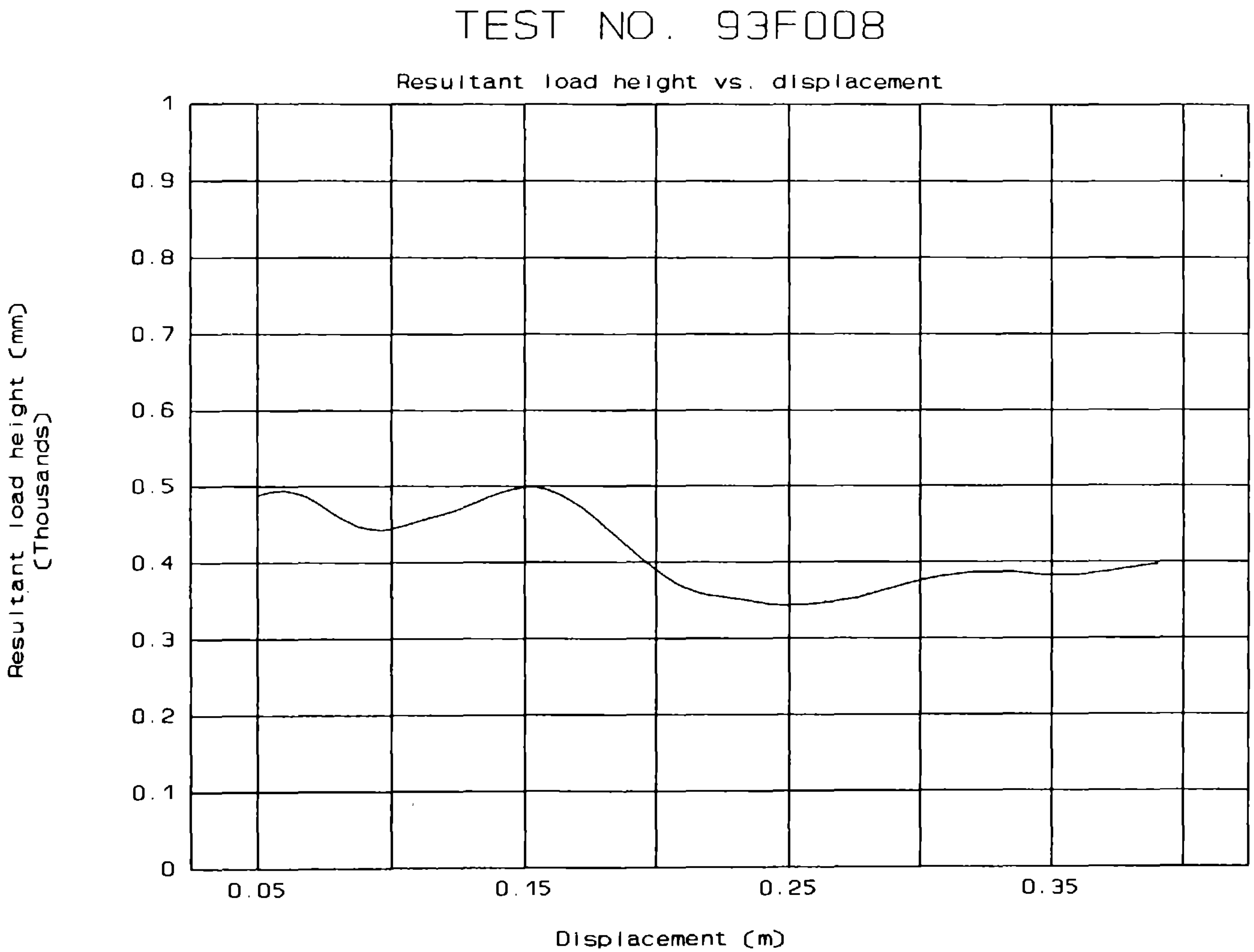


Figure 36. Resultant load height vs. displacement, test 93F008.

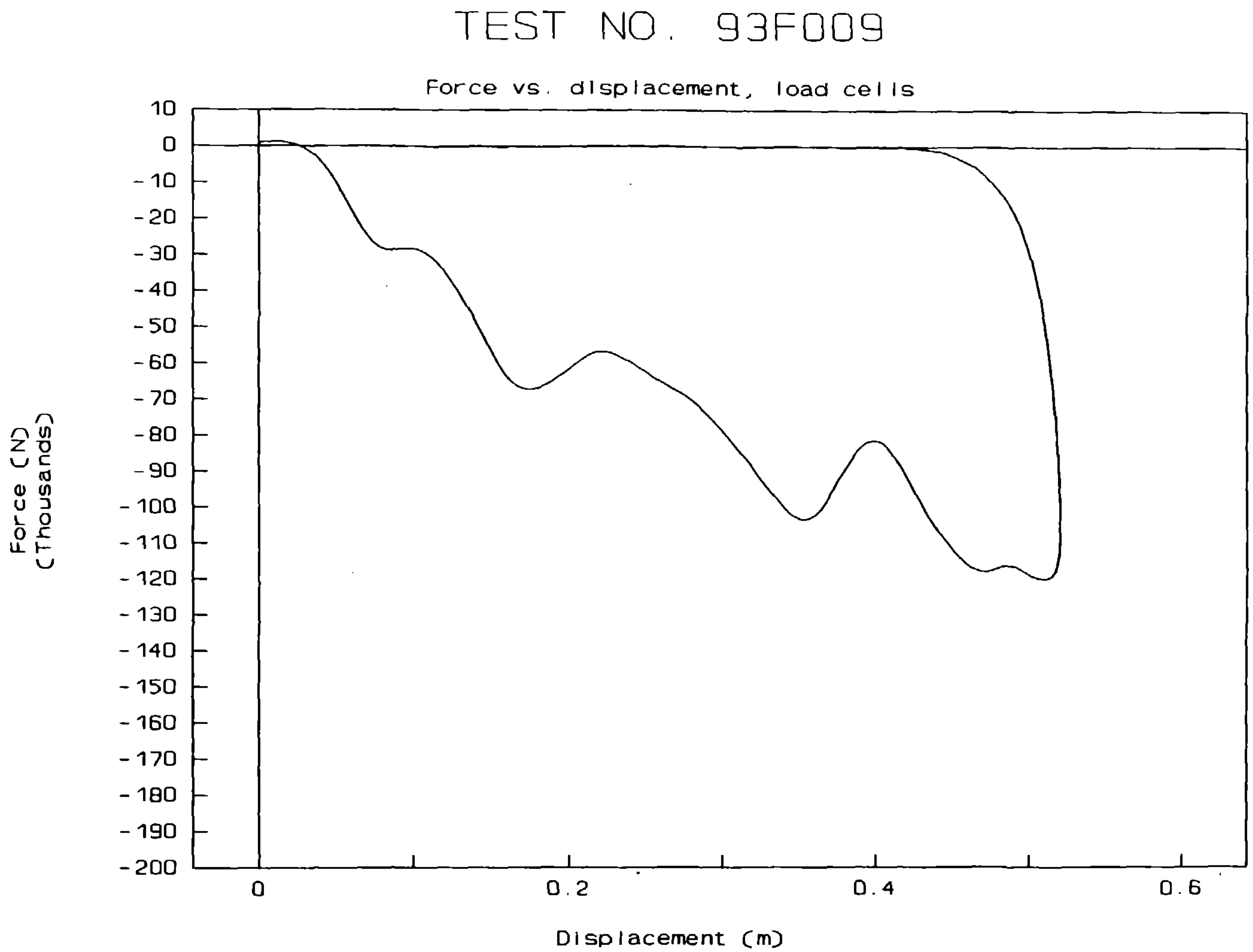


Figure 37. Force vs. displacement, load cells, test 93F009.

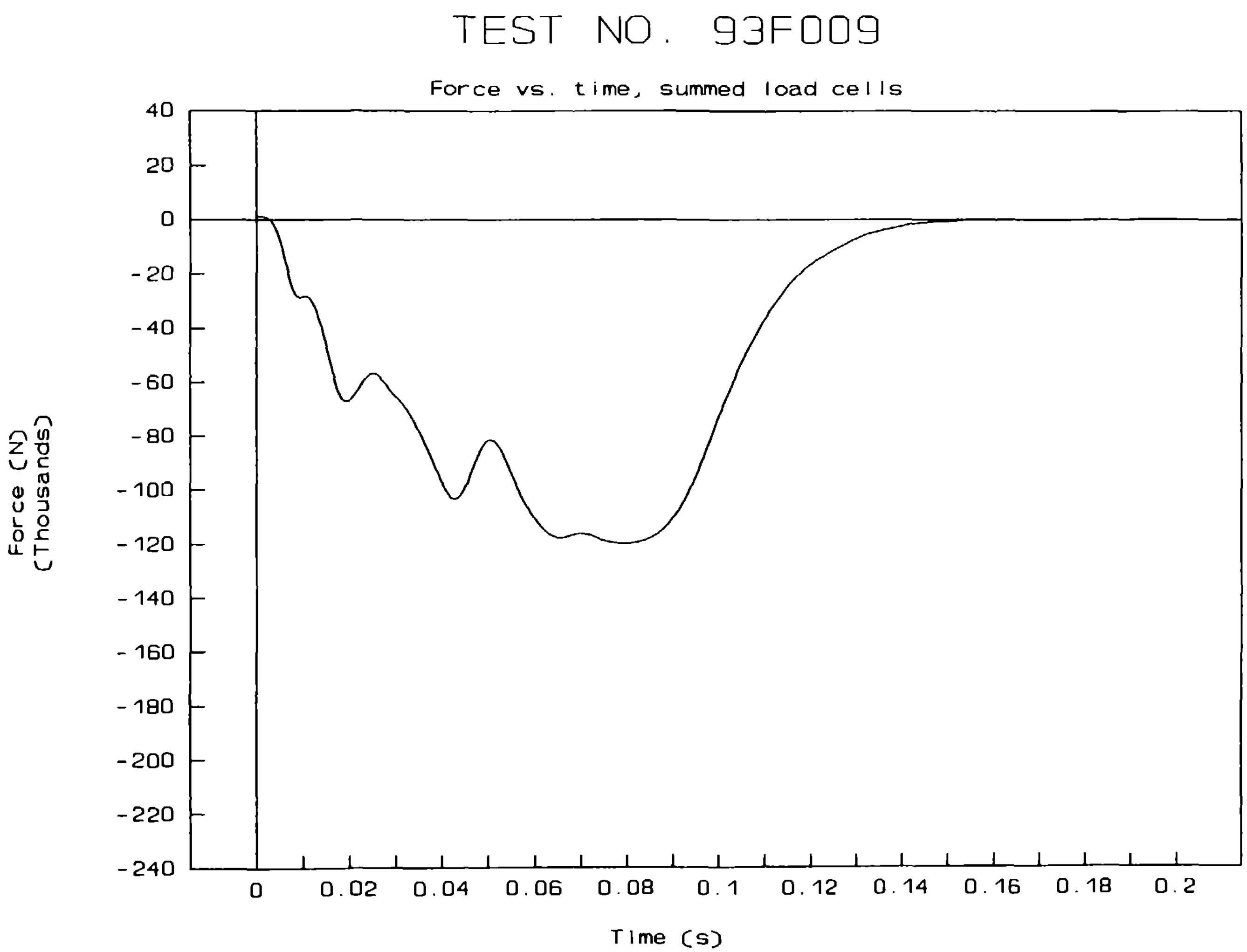


Figure 38. Force vs. time, summed load cells, test 93F009.

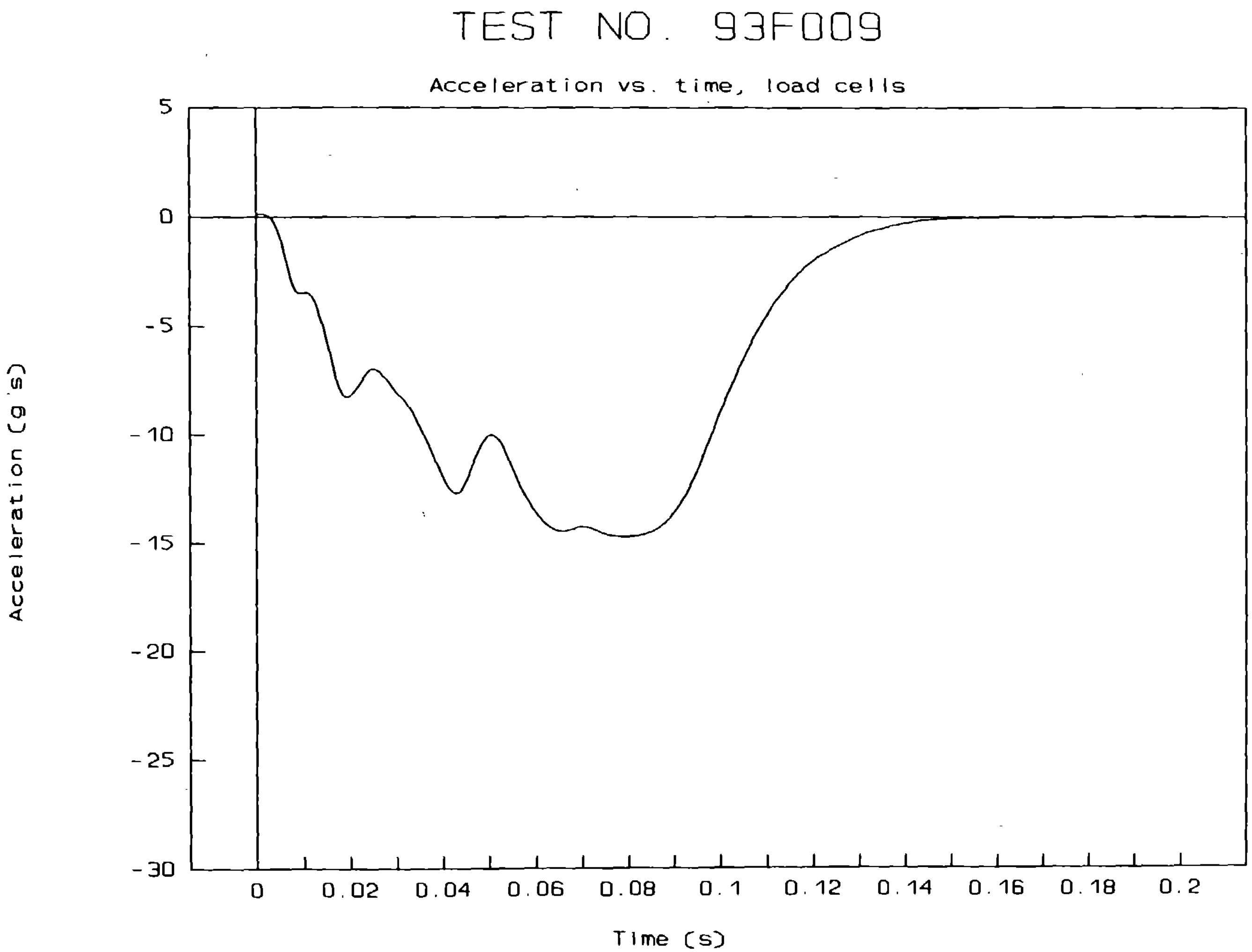


Figure 39. Acceleration vs. time, load cells, test 93F009.

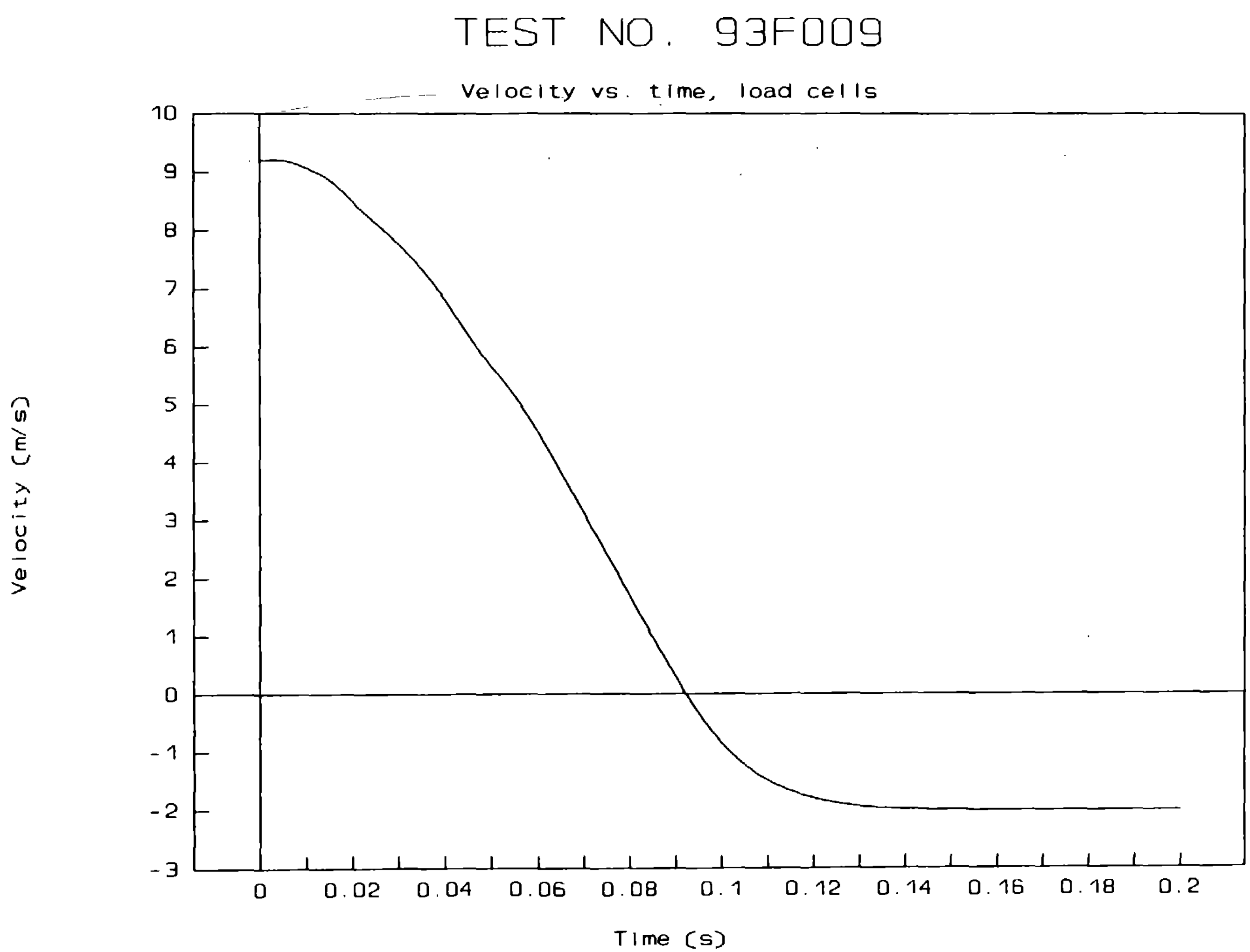


Figure 40. Velocity vs. time, load cells, test 93F009.

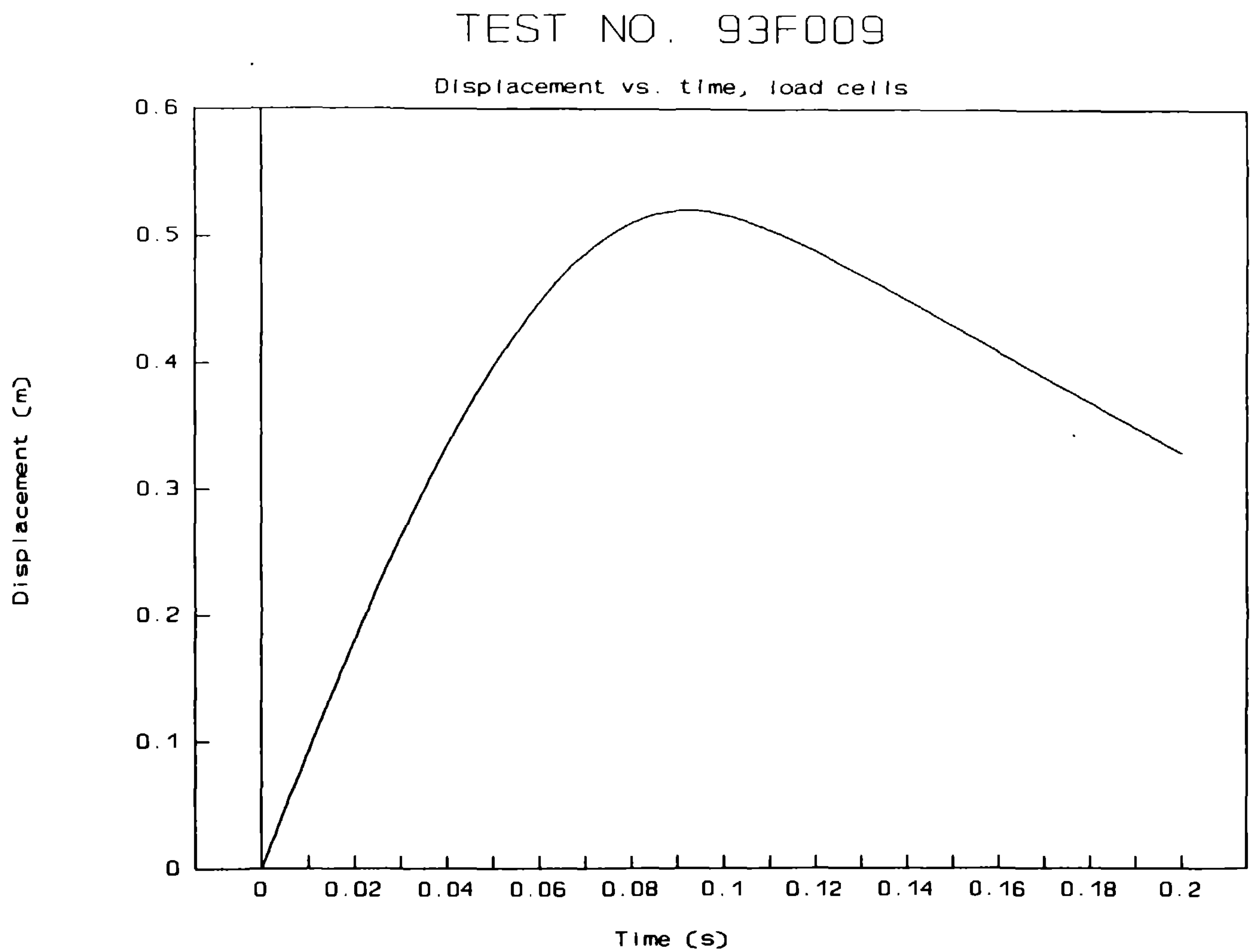


Figure 41. Displacement vs. time, load cells, test 93F009.

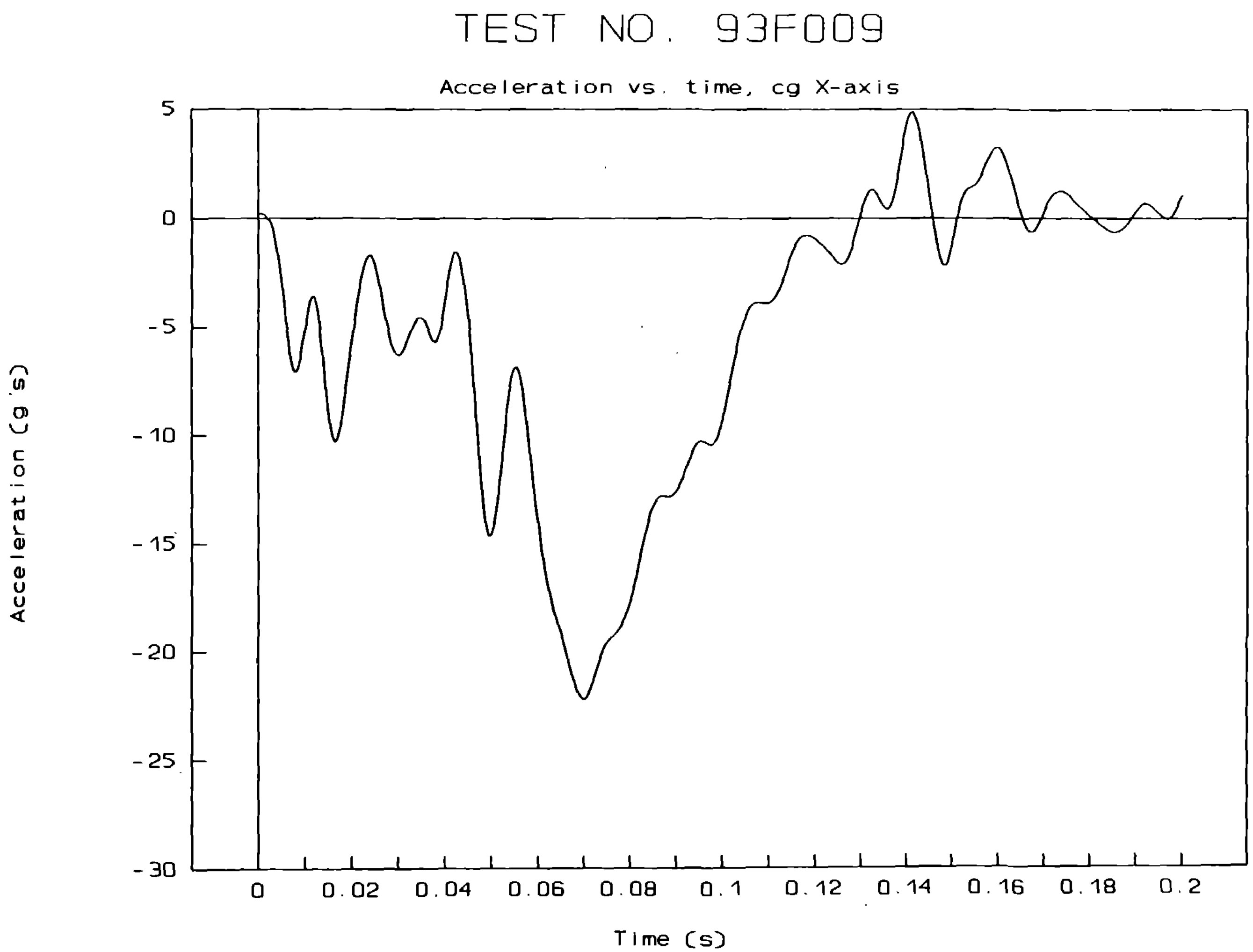


Figure 42. Acceleration vs. time, cg X-axis, test 93F009.

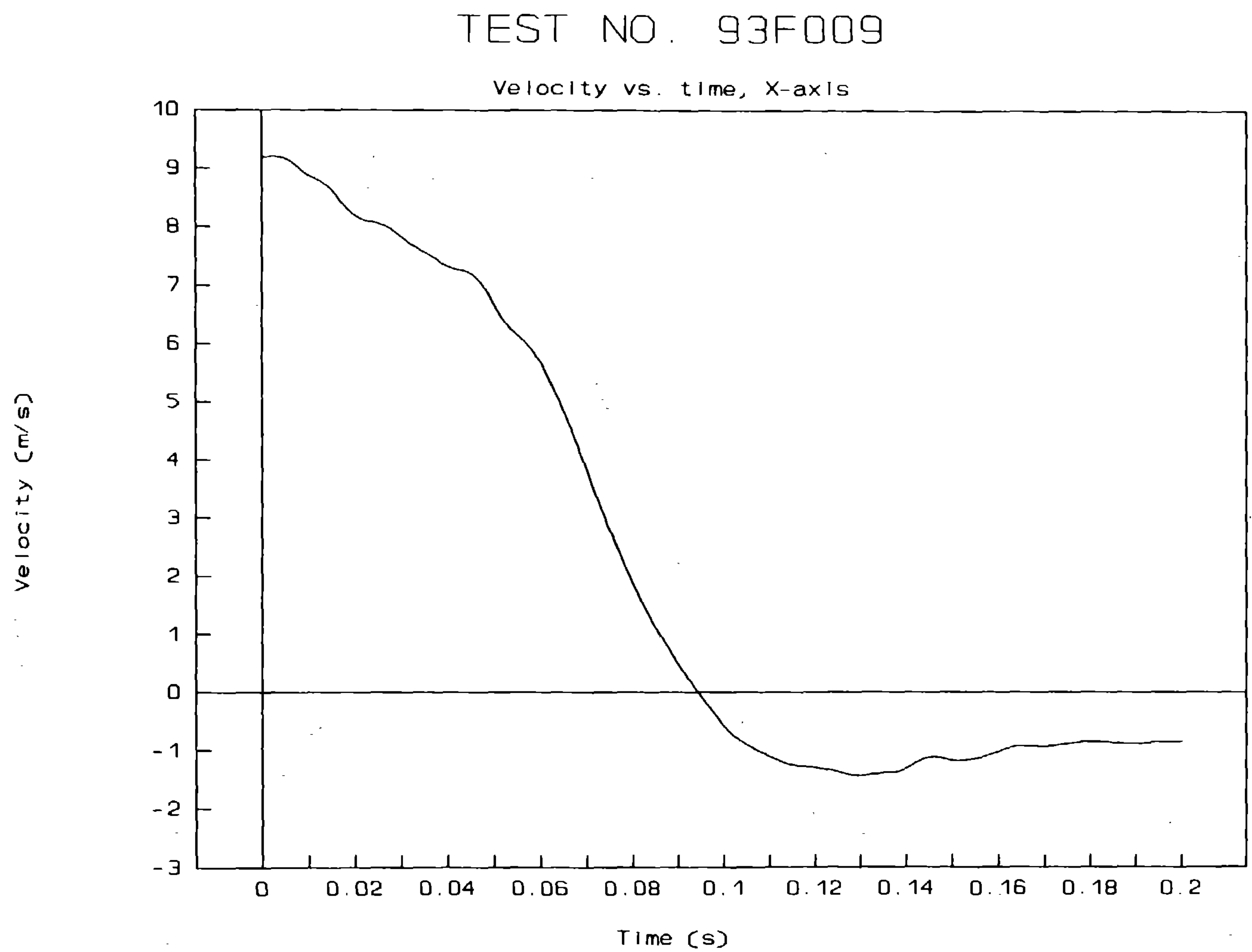


Figure 43. Velocity vs. time, X-axis, test 93F009.

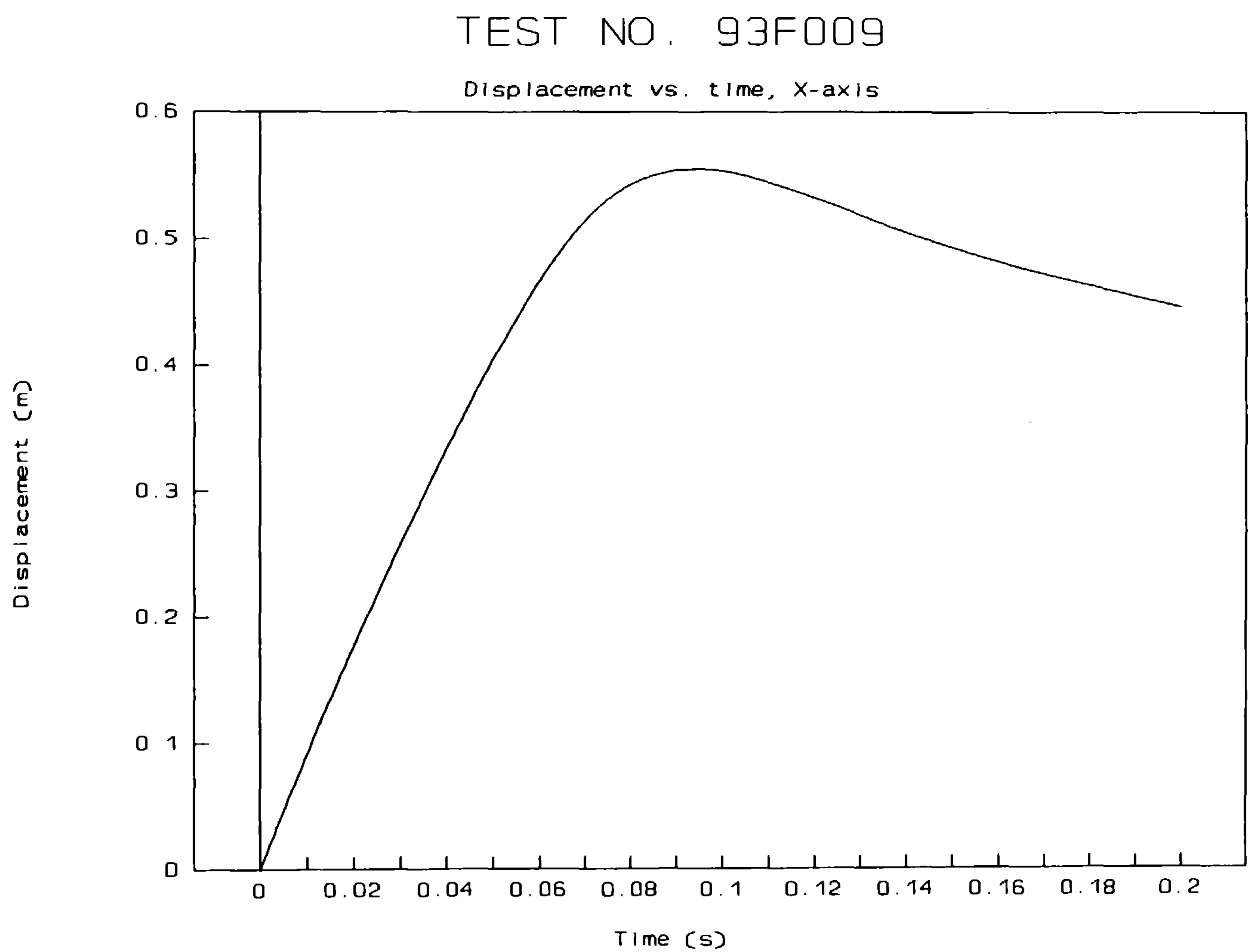


Figure 44. Displacement vs. time, X-axis, test 93F009.

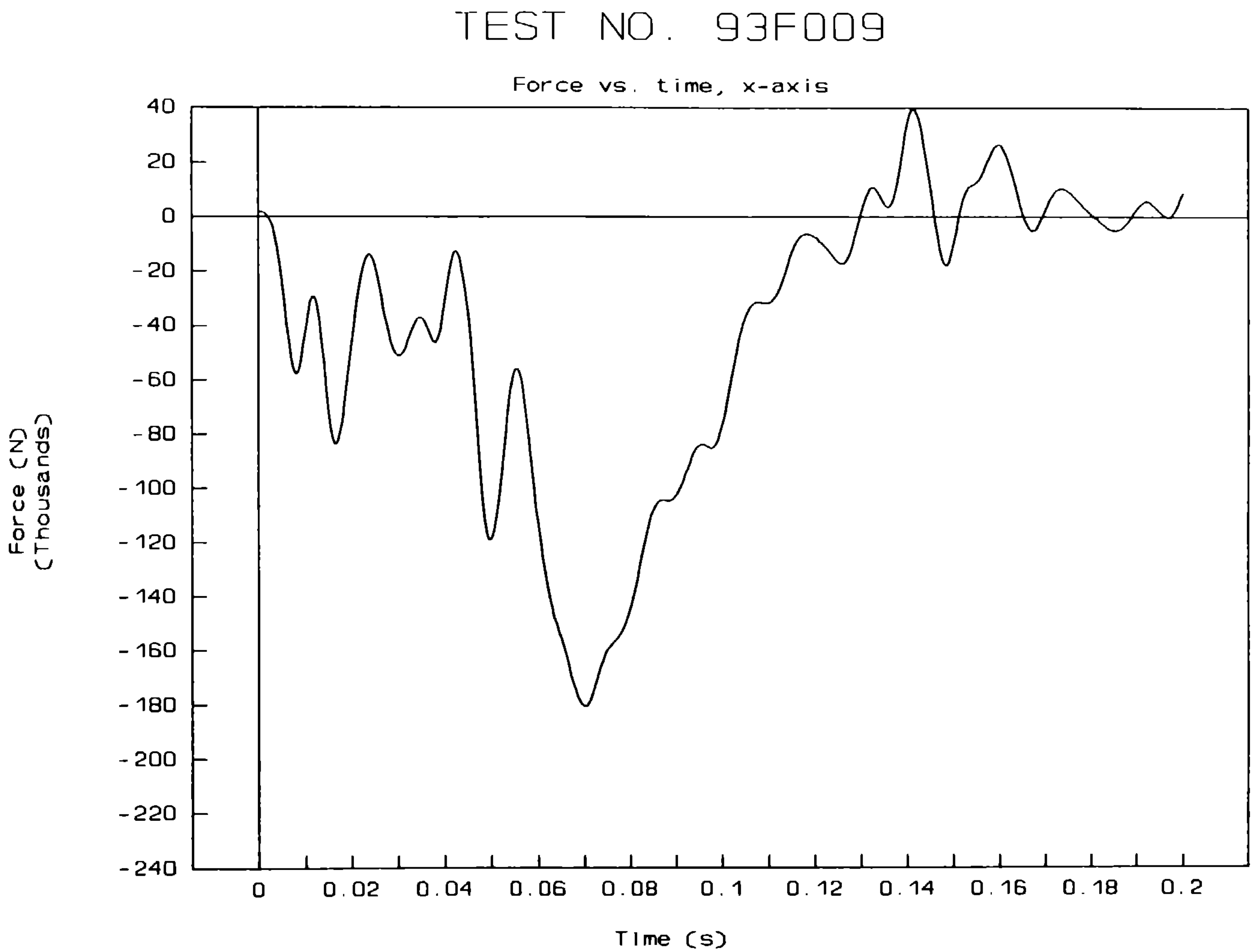


Figure 45. Force vs. time, X-axis, test 93F009.

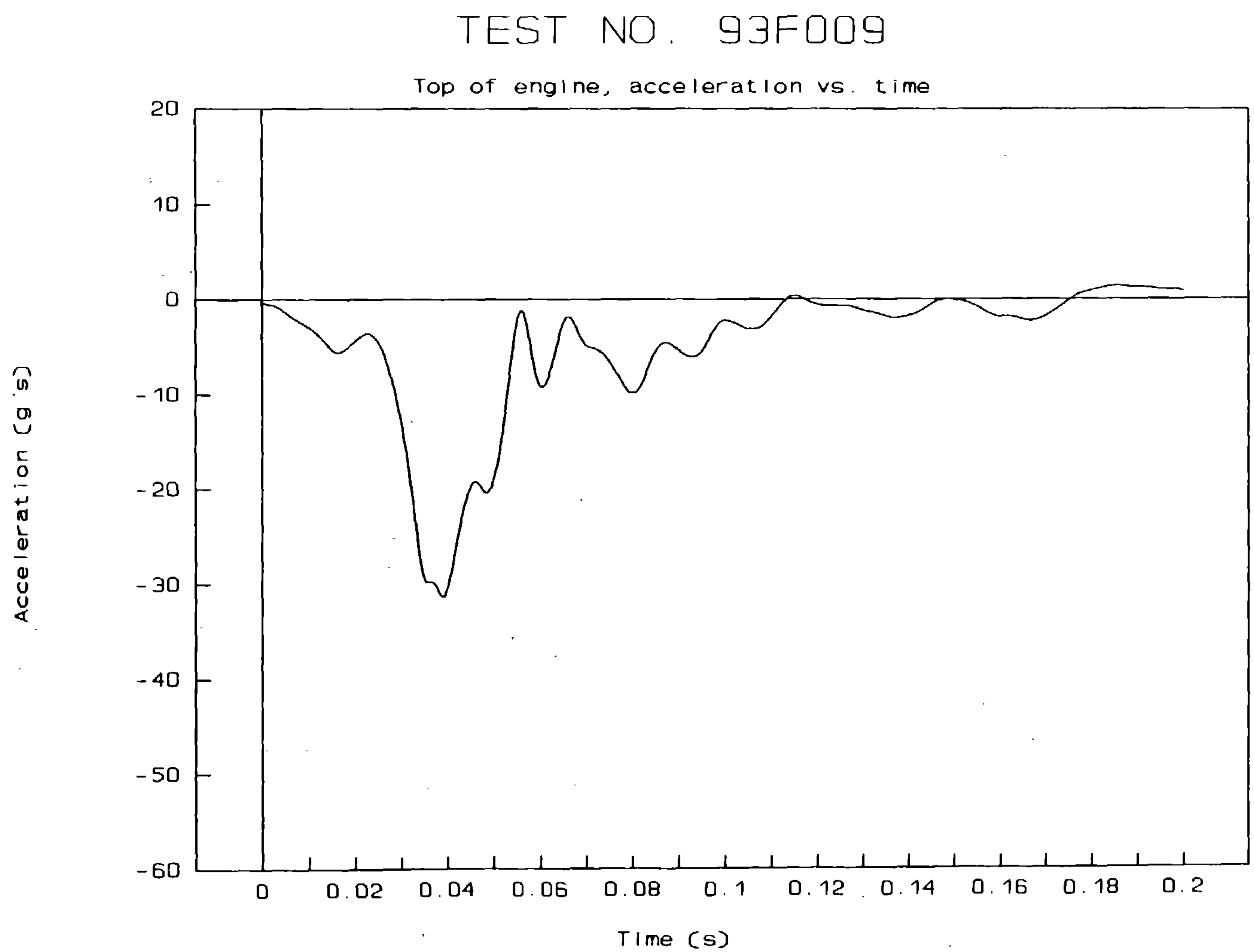


Figure 46. Top of engine, acceleration vs. time, test 93F009.

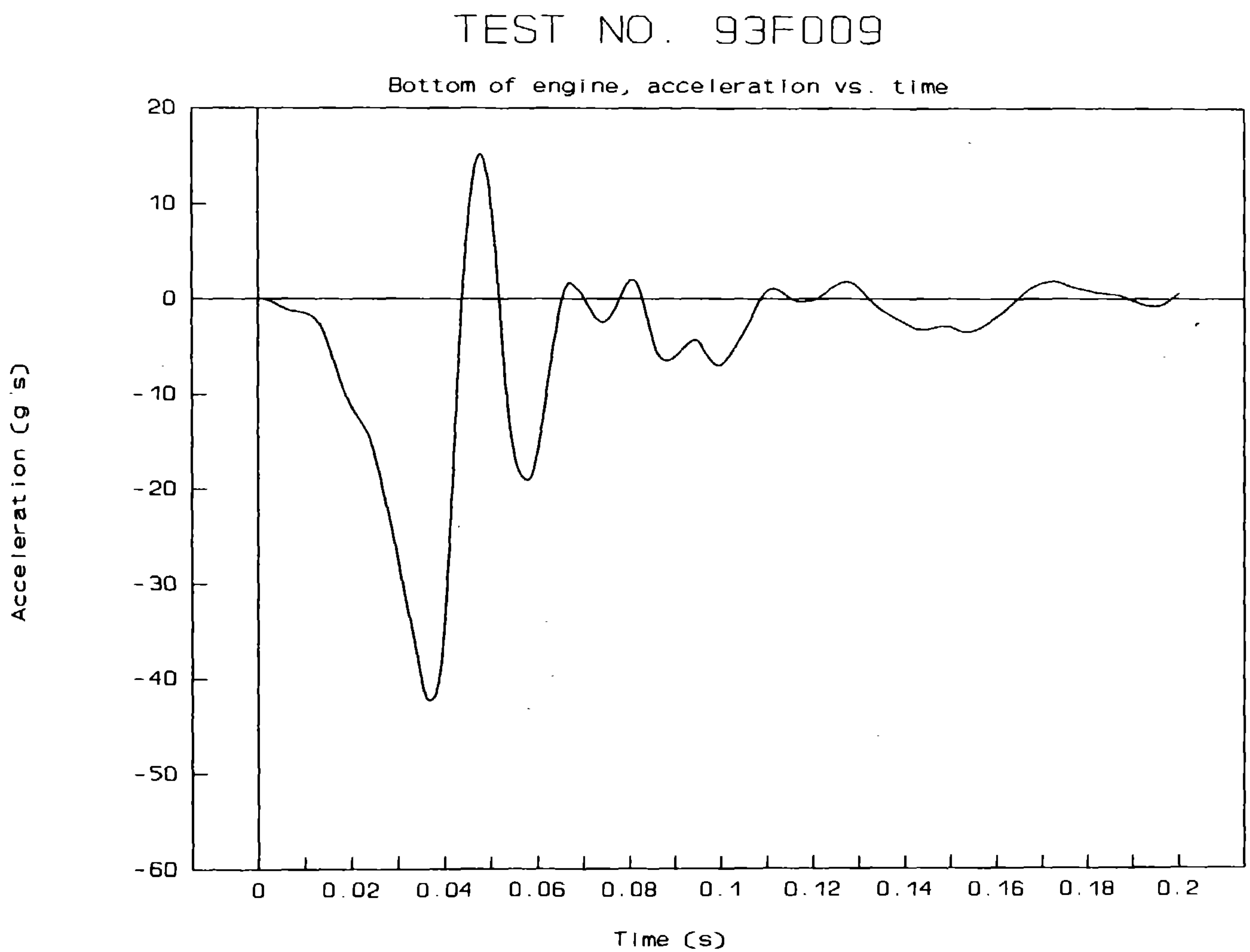


Figure 47. Bottom of engine, acceleration vs. time, test 93F009.

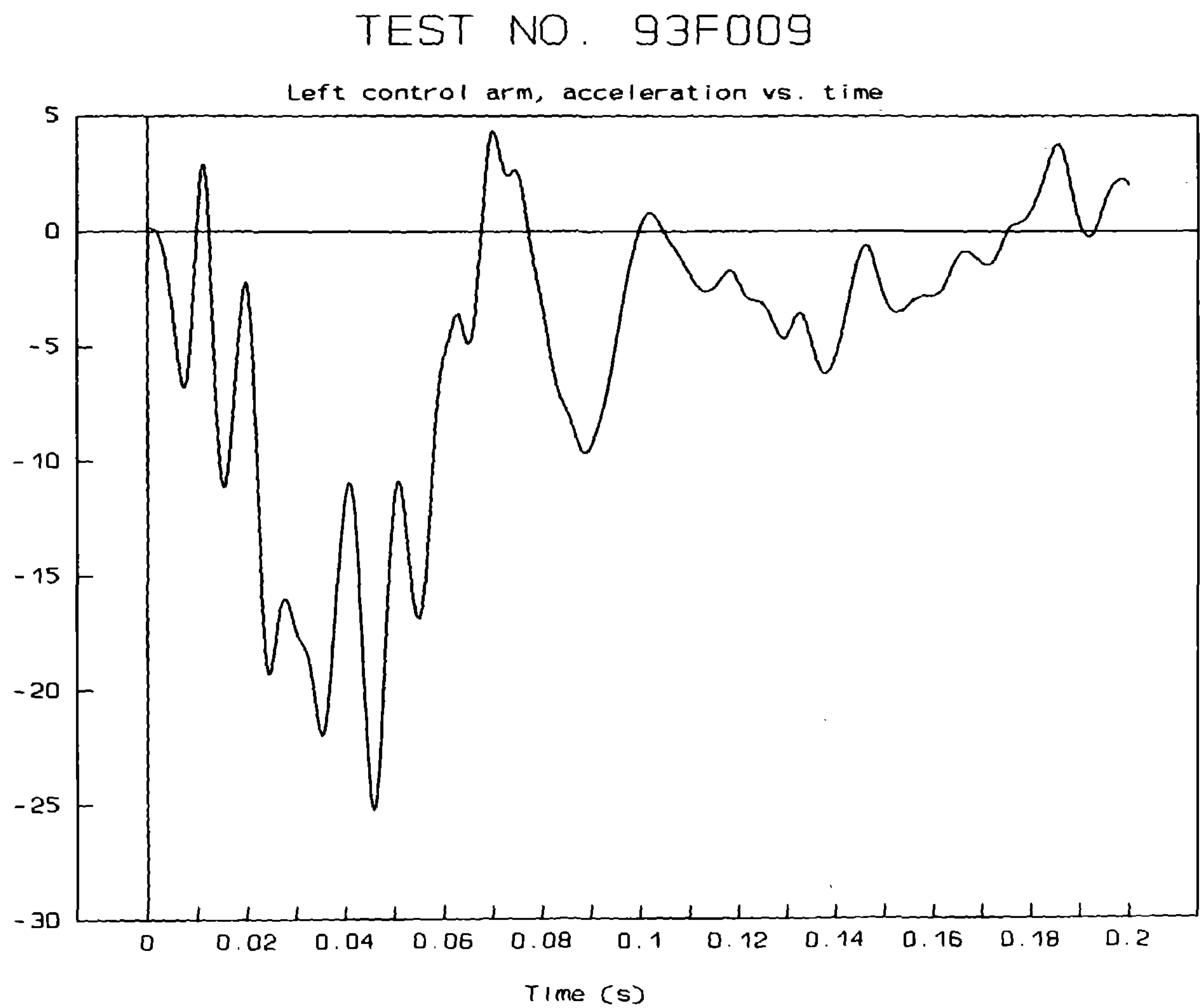


Figure 48. Left control arm, acceleration vs. time, test 93F009.

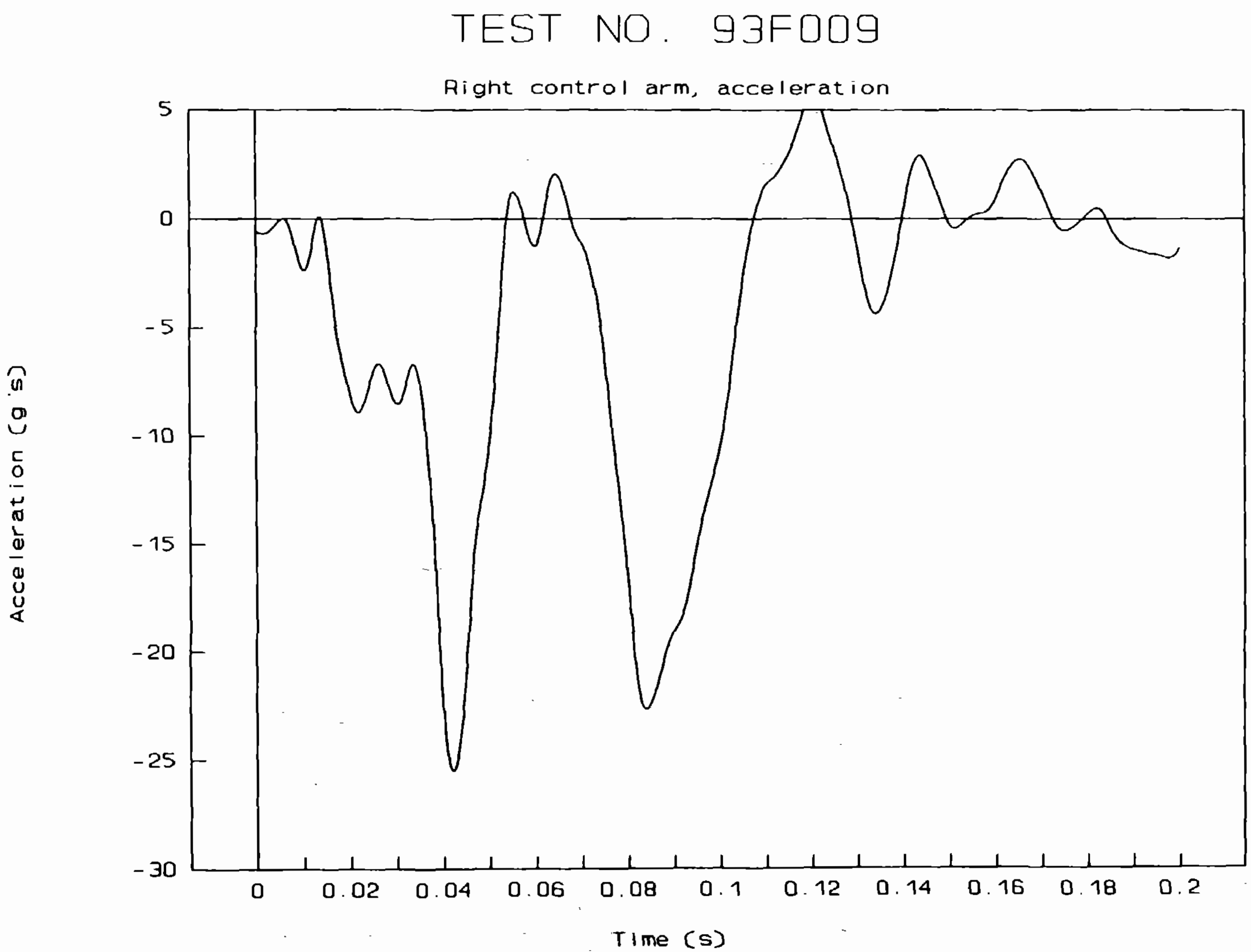


Figure 49. Right control arm, acceleration vs. time, test 93F009.

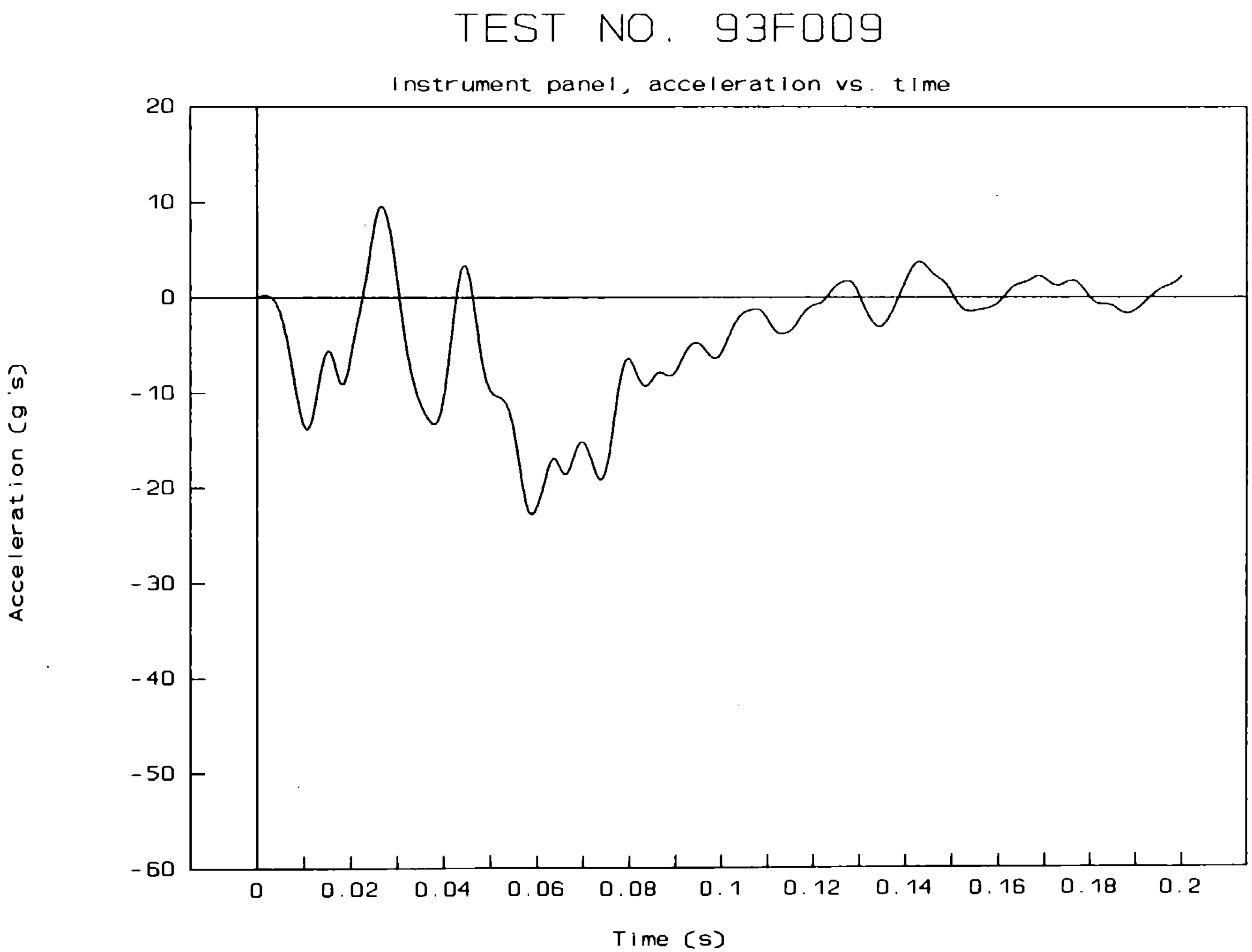


Figure 50. Instrument panel, acceleration vs. time, test 93F009.

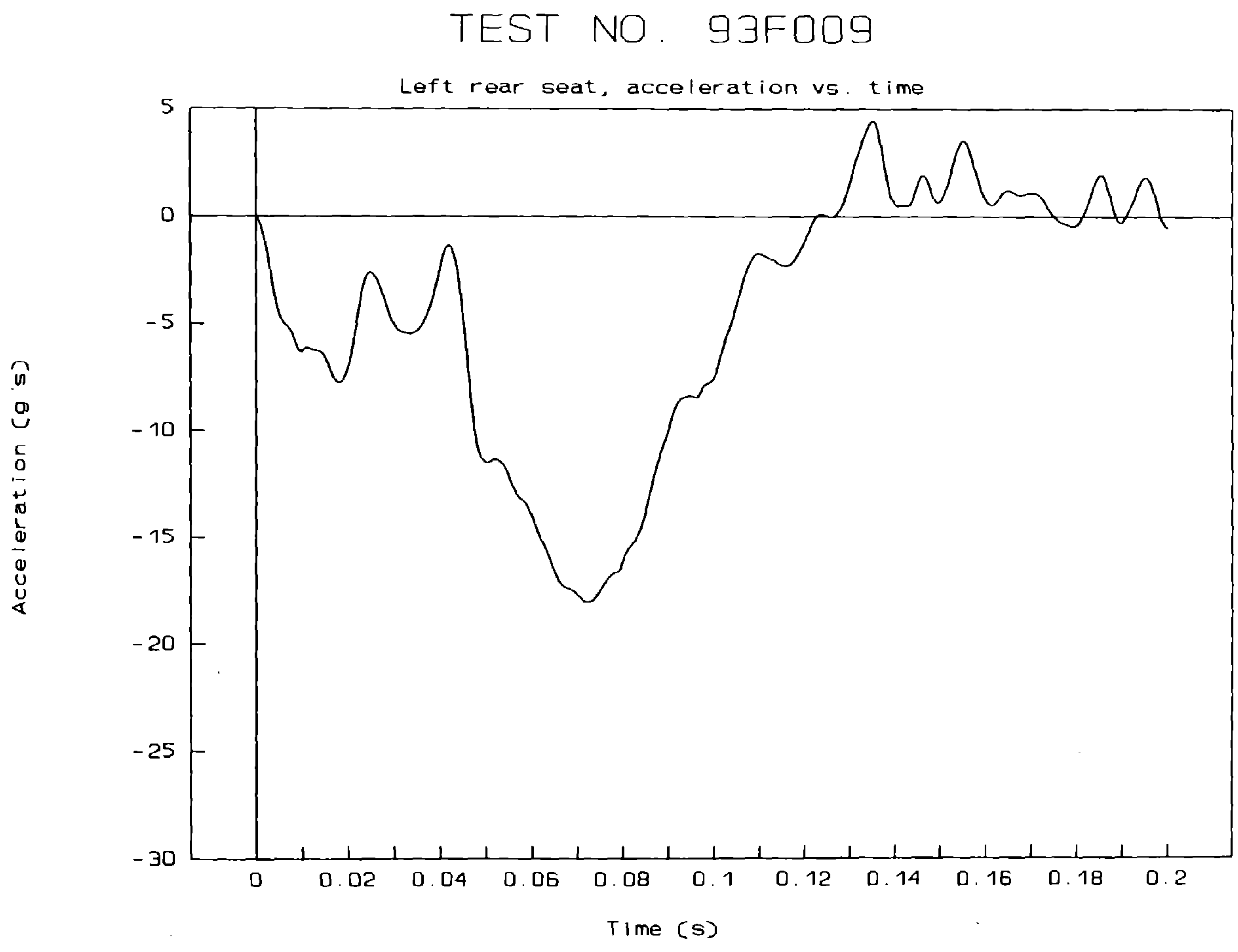


Figure 51. Left rear seat, acceleration vs. time, test 93F009.

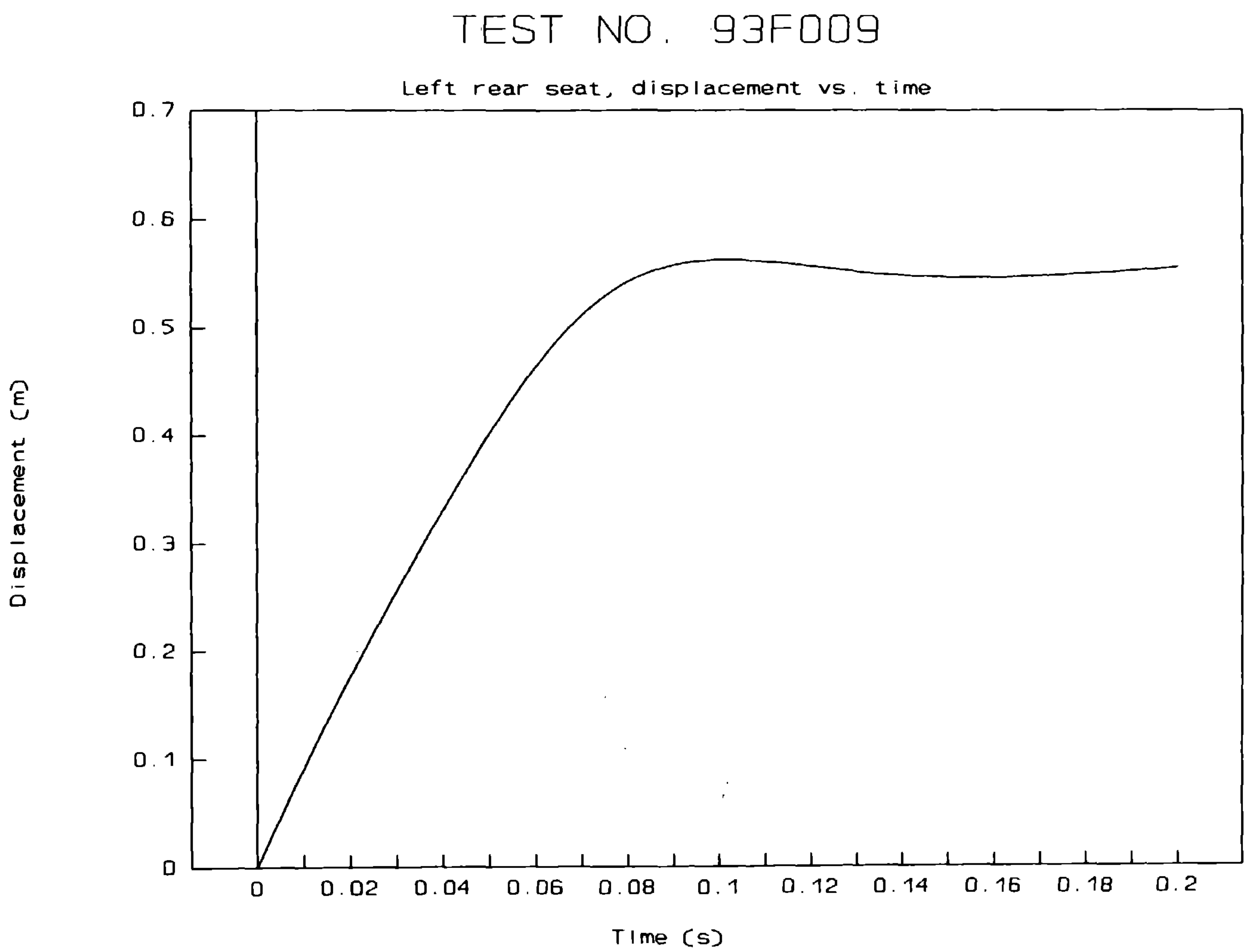


Figure 52. Left rear seat, displacement vs. time, test 93F009.

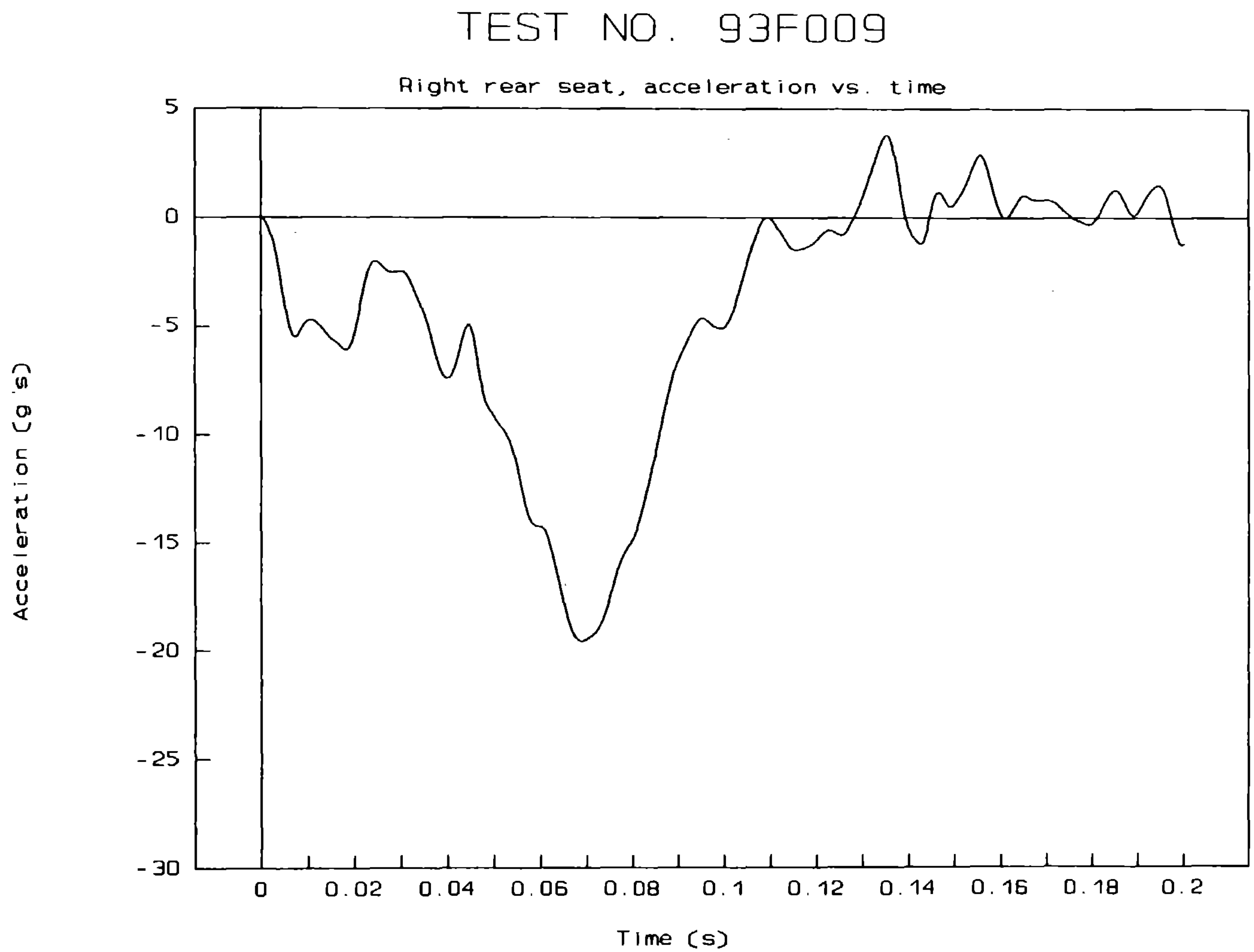


Figure 53. Right rear seat, acceleration vs. time, test 93F009.

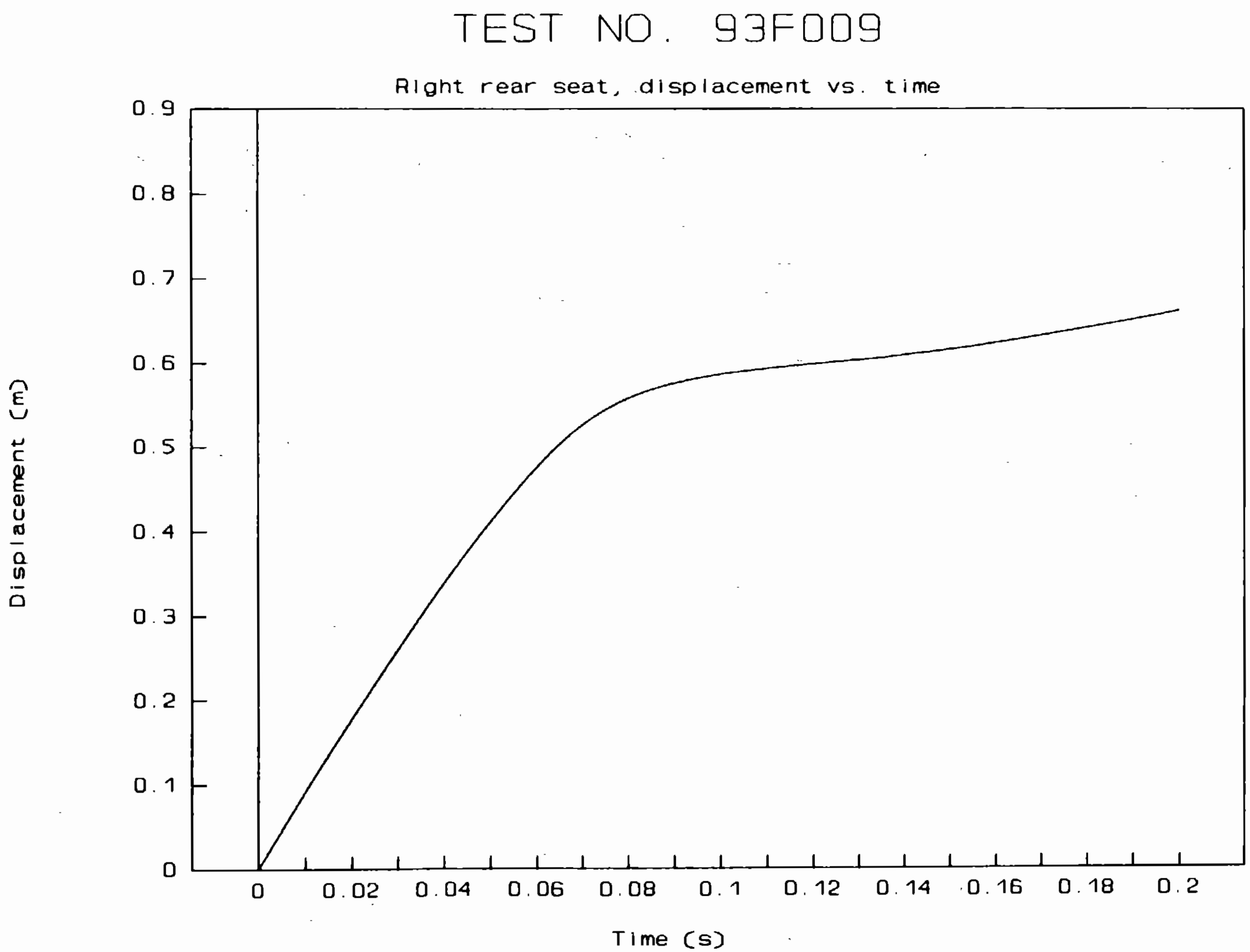


Figure 54. Right rear seat, displacement vs. time, test 93F009.

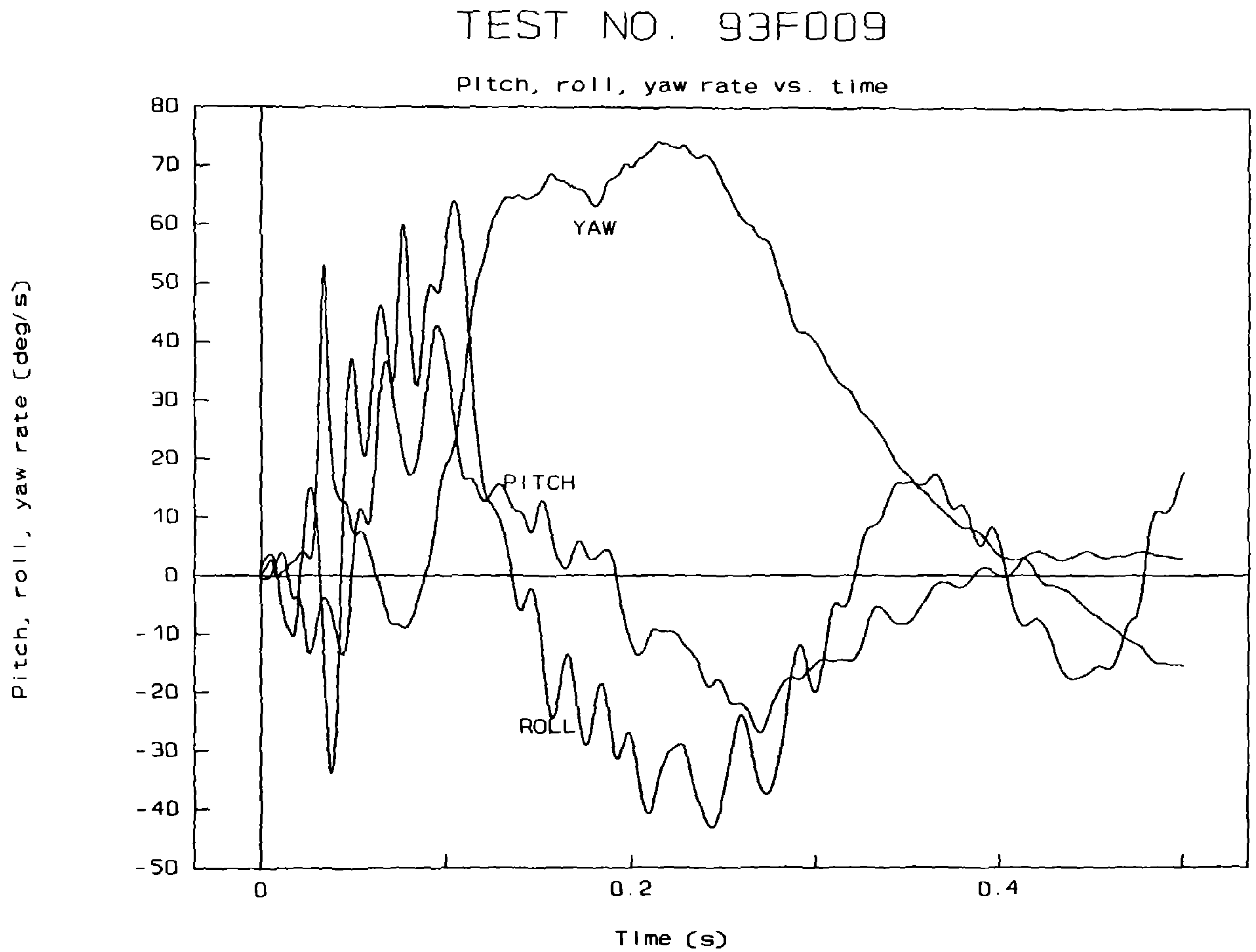


Figure 55. Pitch, roll, yaw rate vs. time, test 93f009.

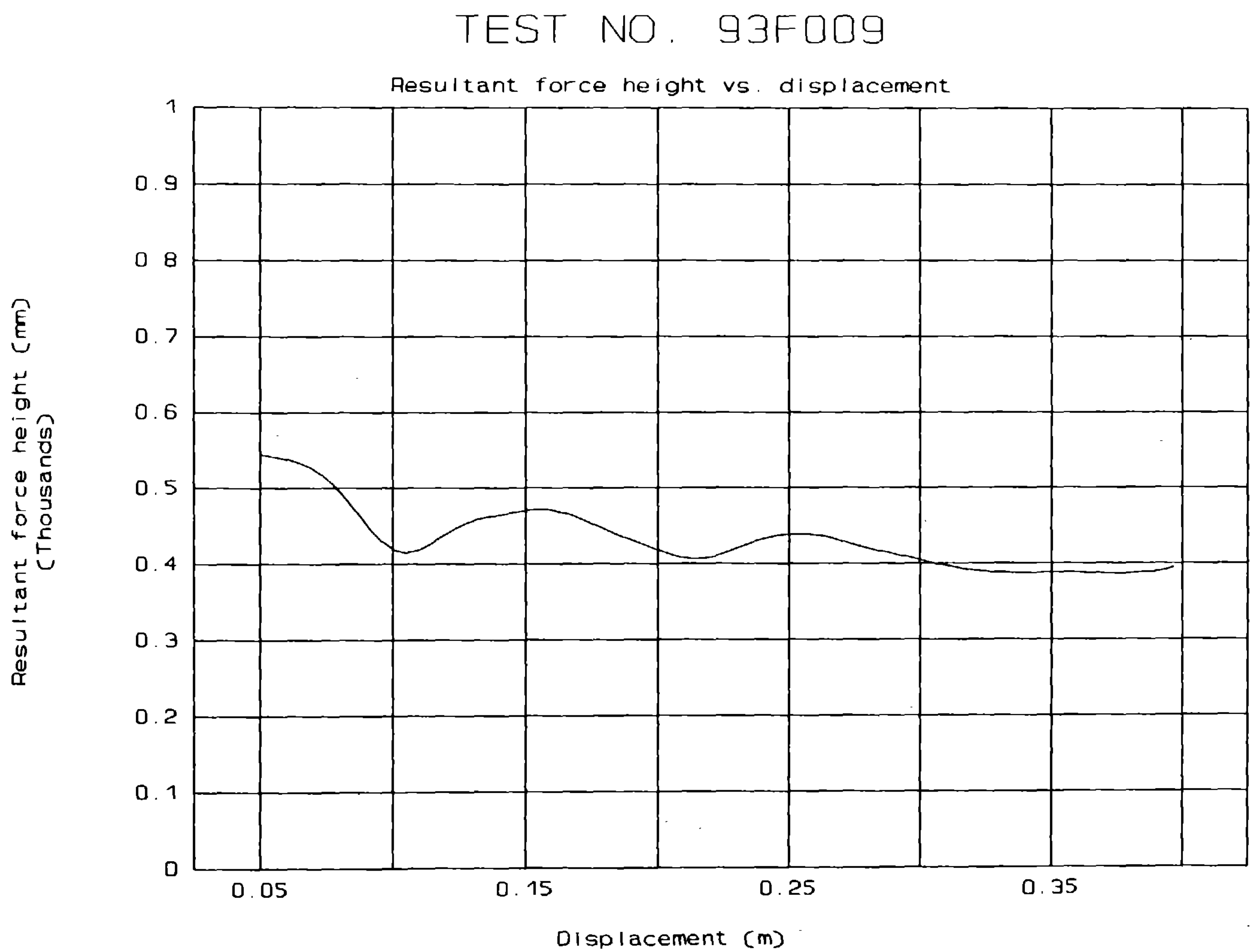


Figure 56. Resultant force height vs. displacement, test 93F009.

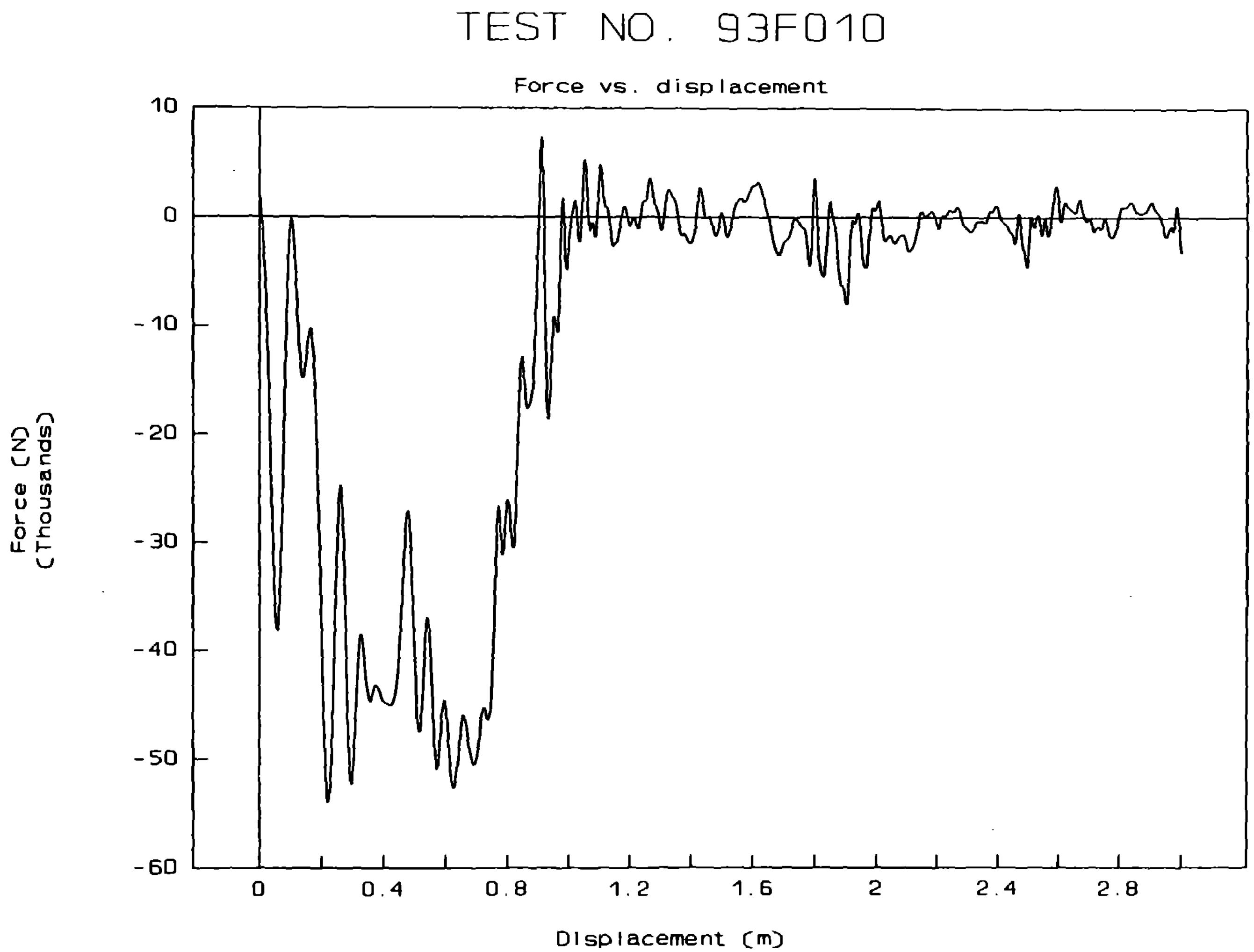


Figure 57. Force vs. displacement, test 93F010.

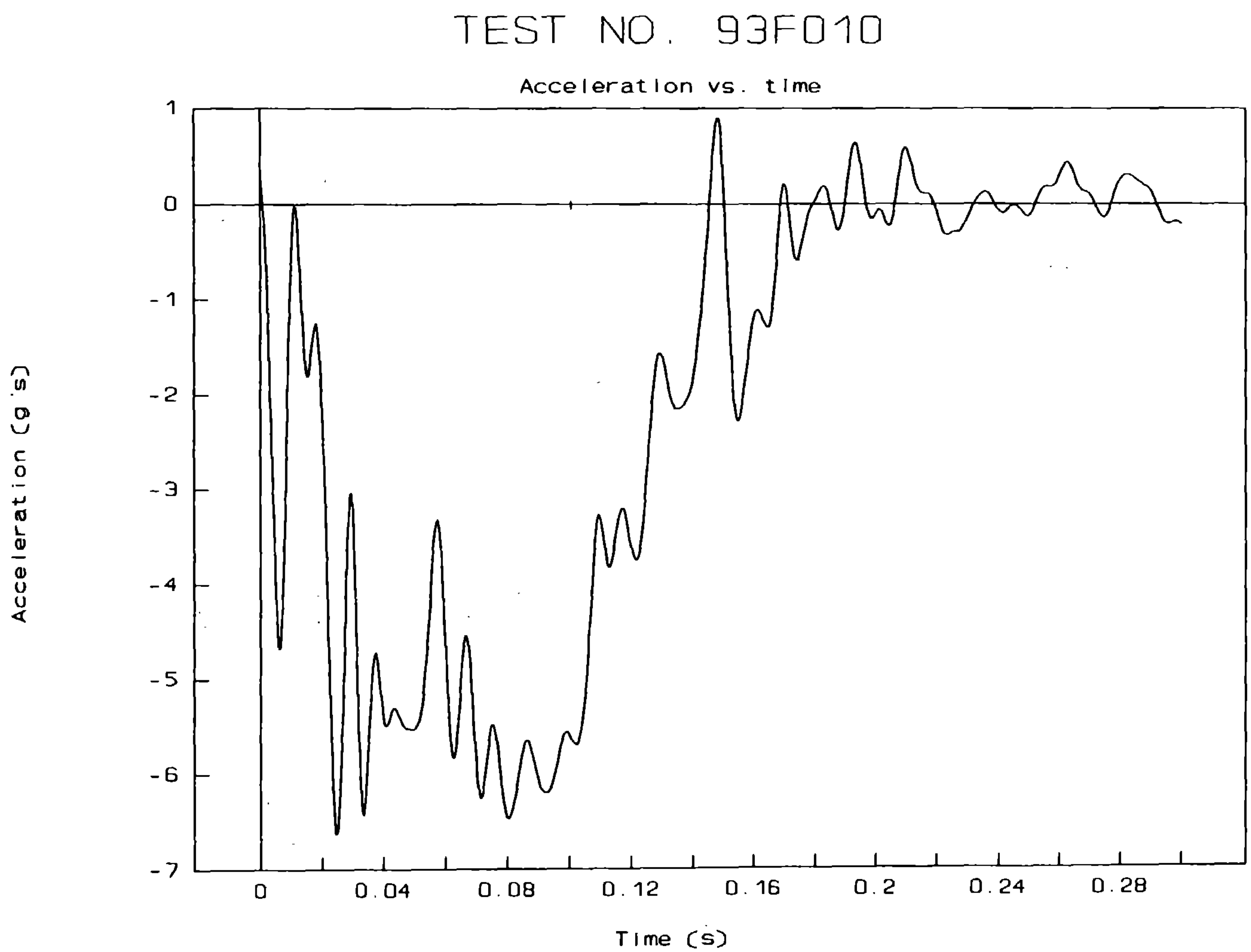


Figure 58. Acceleration vs. time, test 93F010.

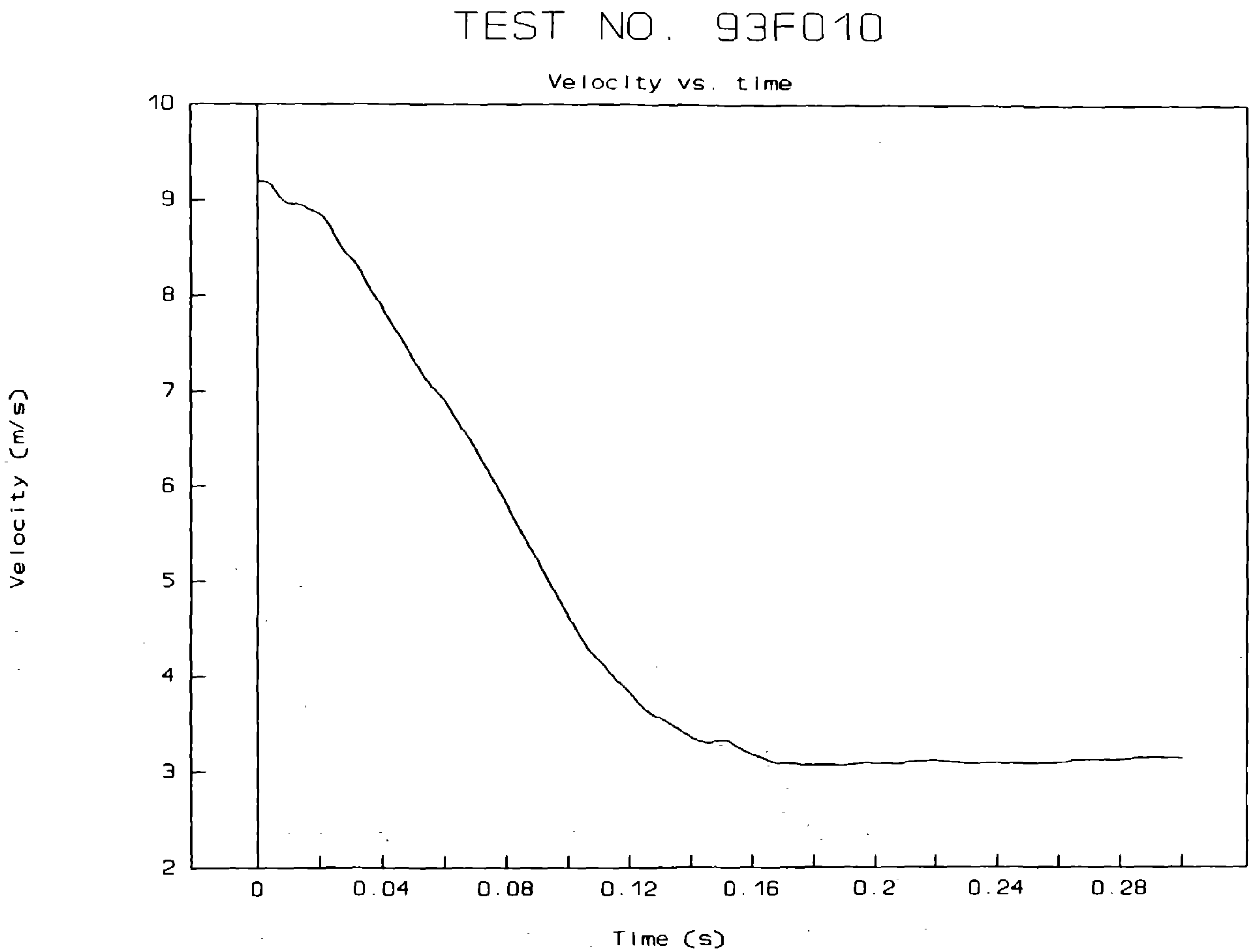


Figure 59. Velocity vs. time, test 93F010.

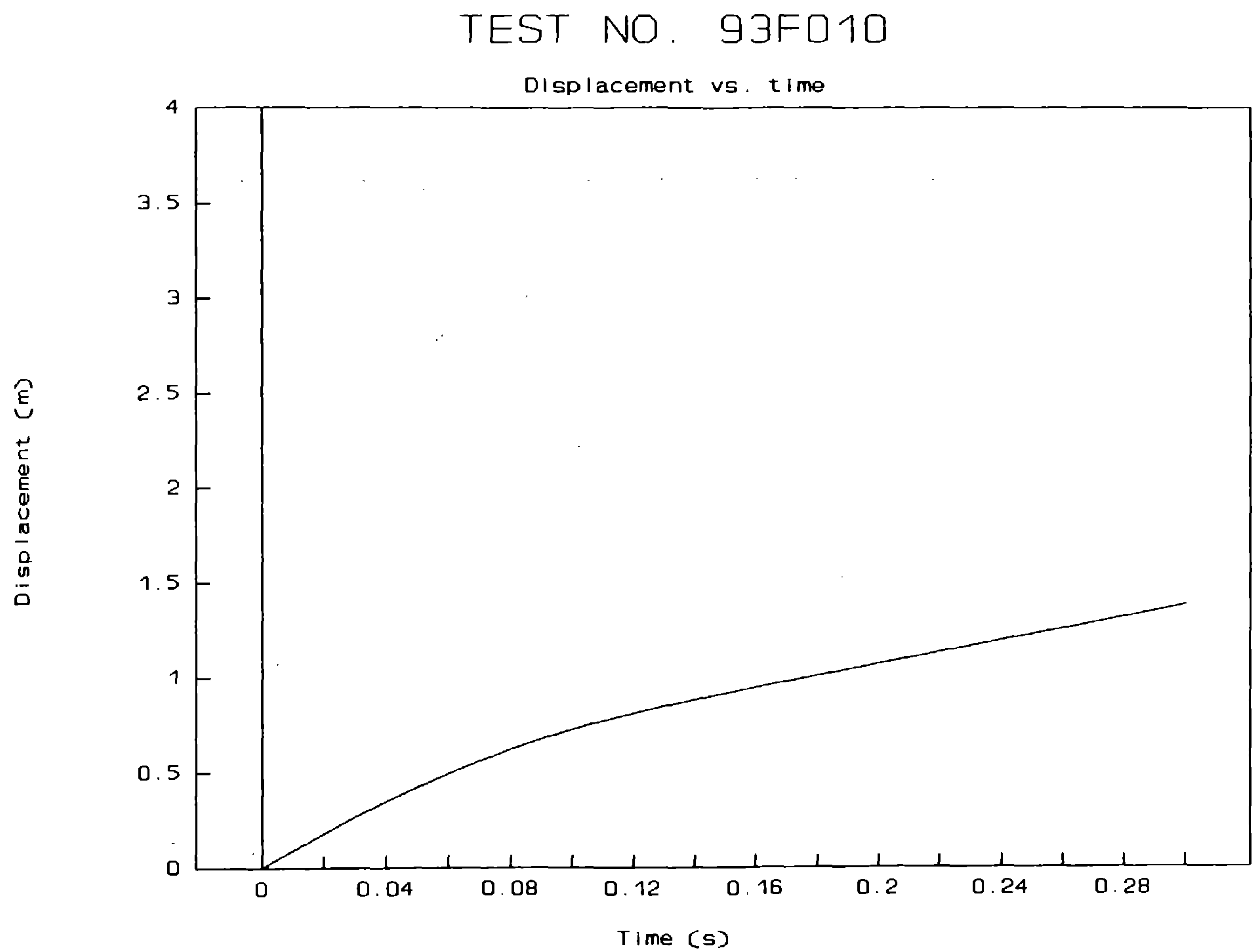


Figure 60. Displacement vs. time, test 93F010.

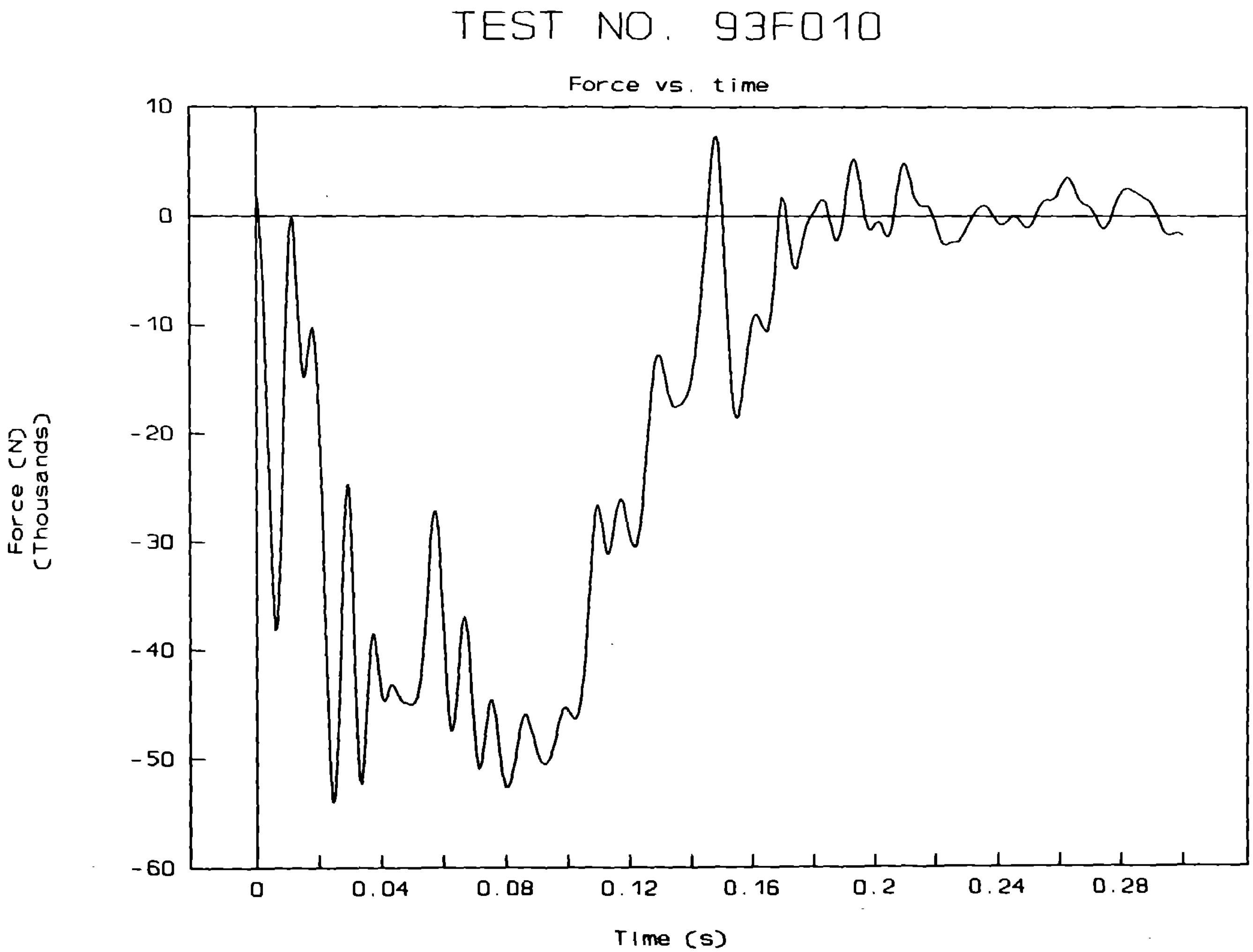


Figure 61. Force vs. time, test 93F010.

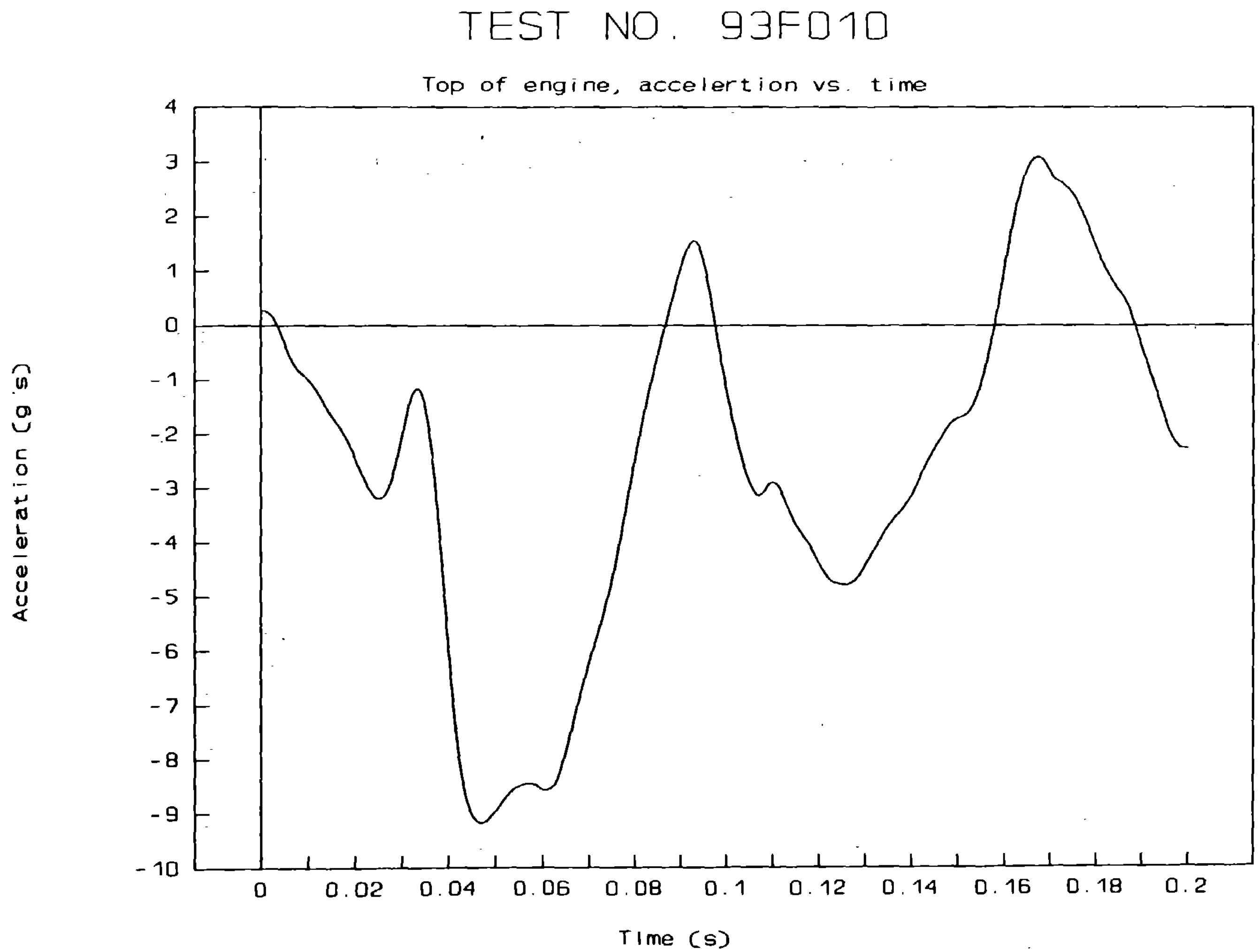


Figure 62. Top of engine, acceleration vs. time, test 93F010.

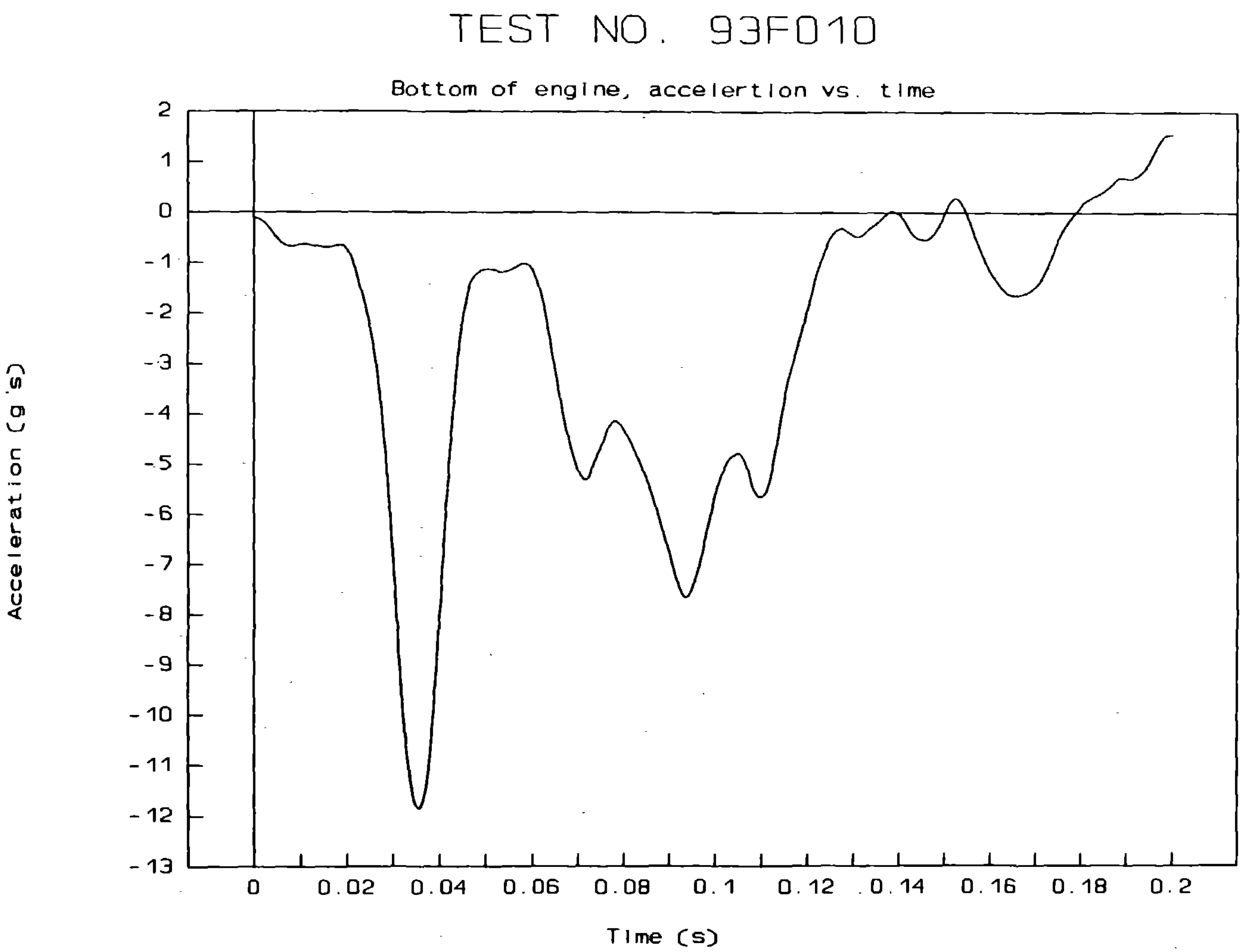


Figure 63. Bottom of engine, acceleration vs. time, test 93F010.

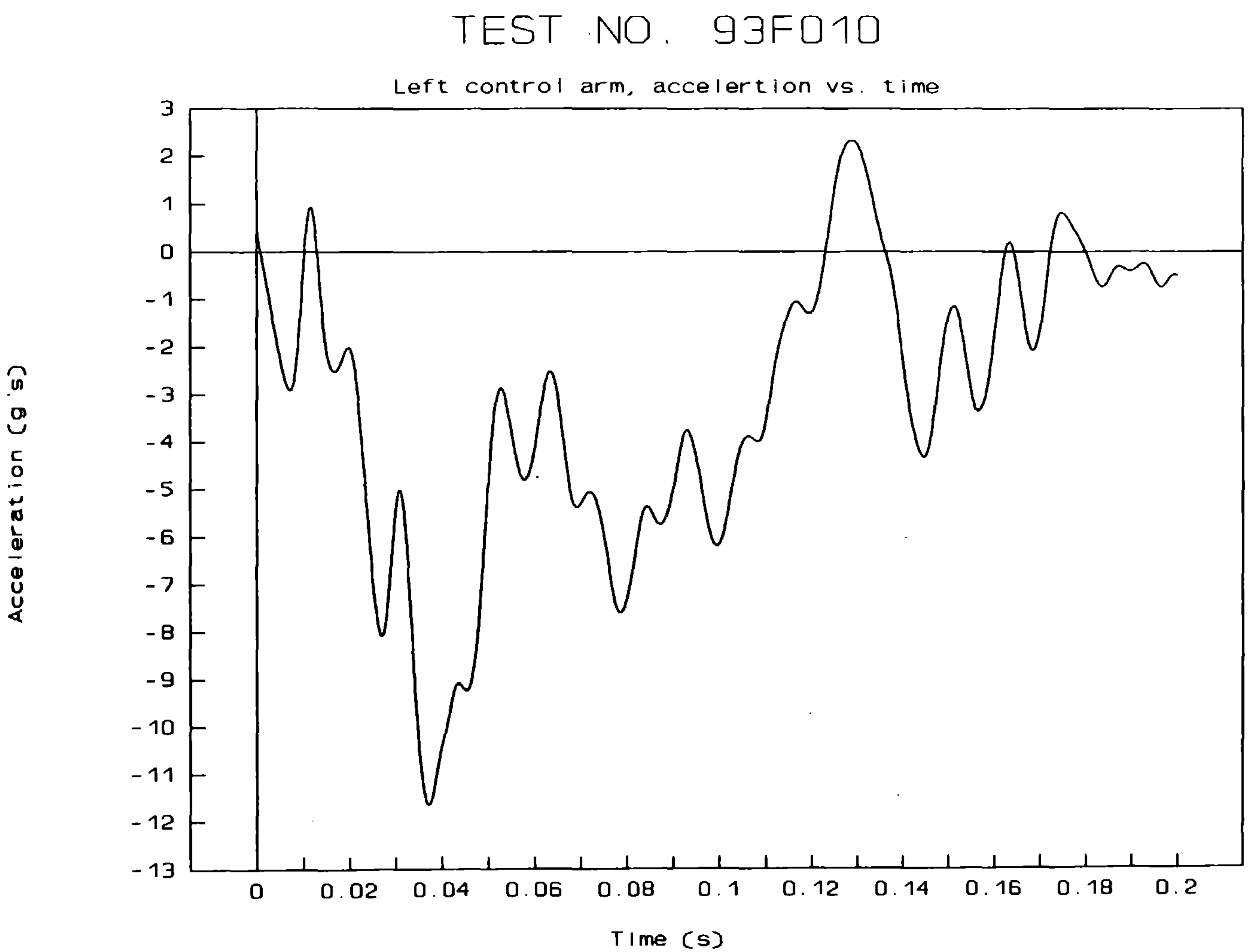


Figure 64. Left control arm, acceleration vs. time, test 93F010.

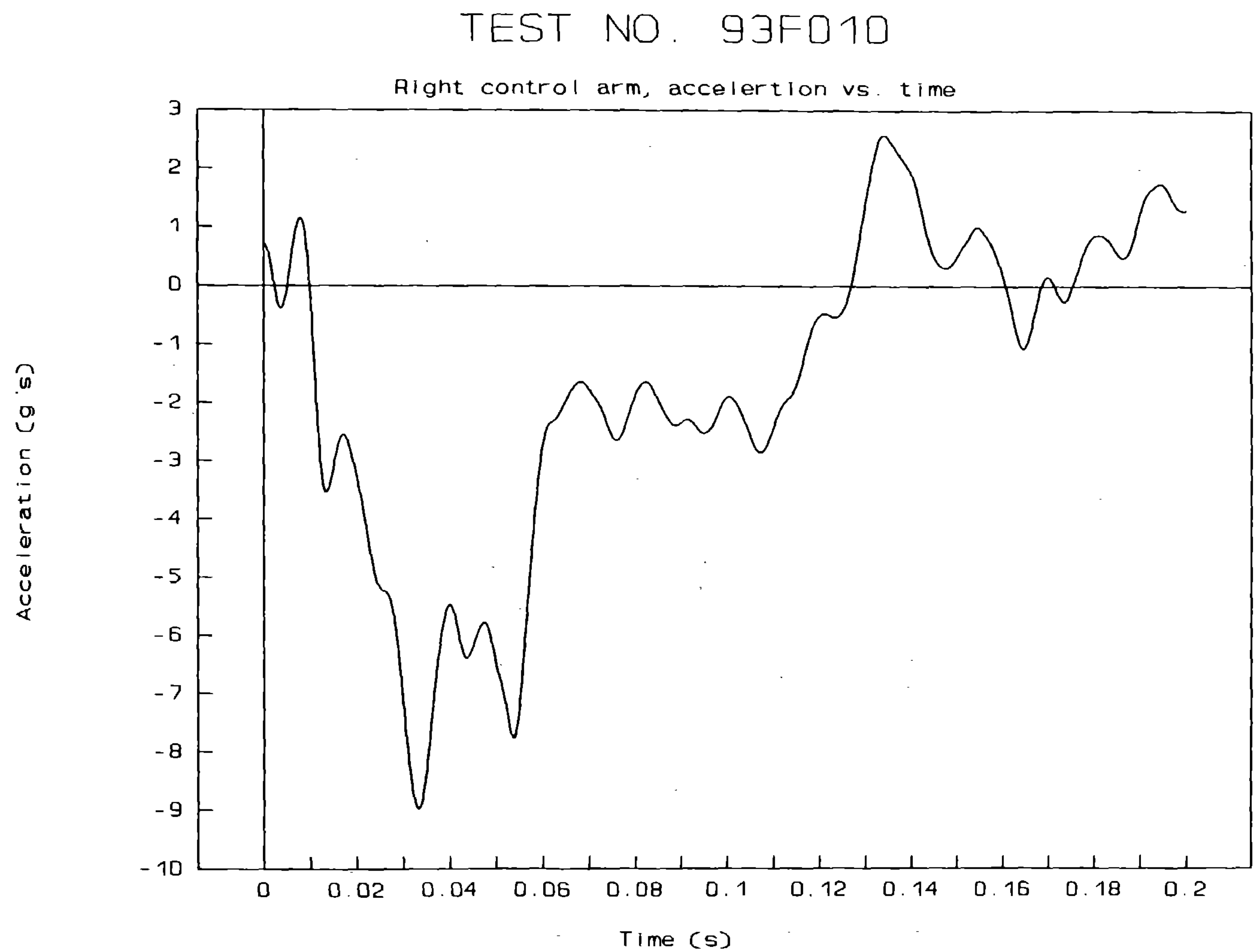


Figure 65. Right control arm, acceleration vs. time, test 93F010.

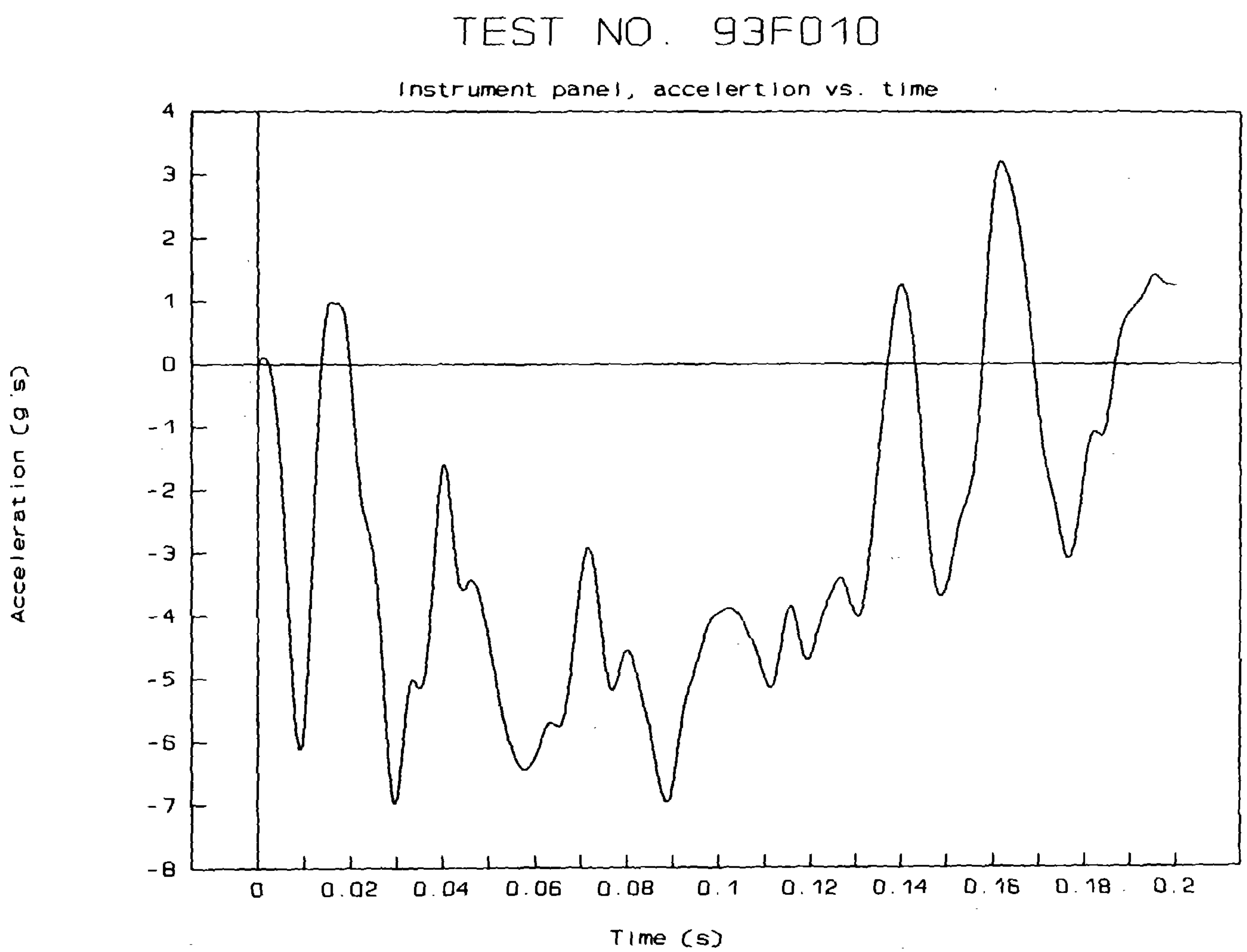


Figure 66. Instrument panel, acceleration vs. time, test 93F010.

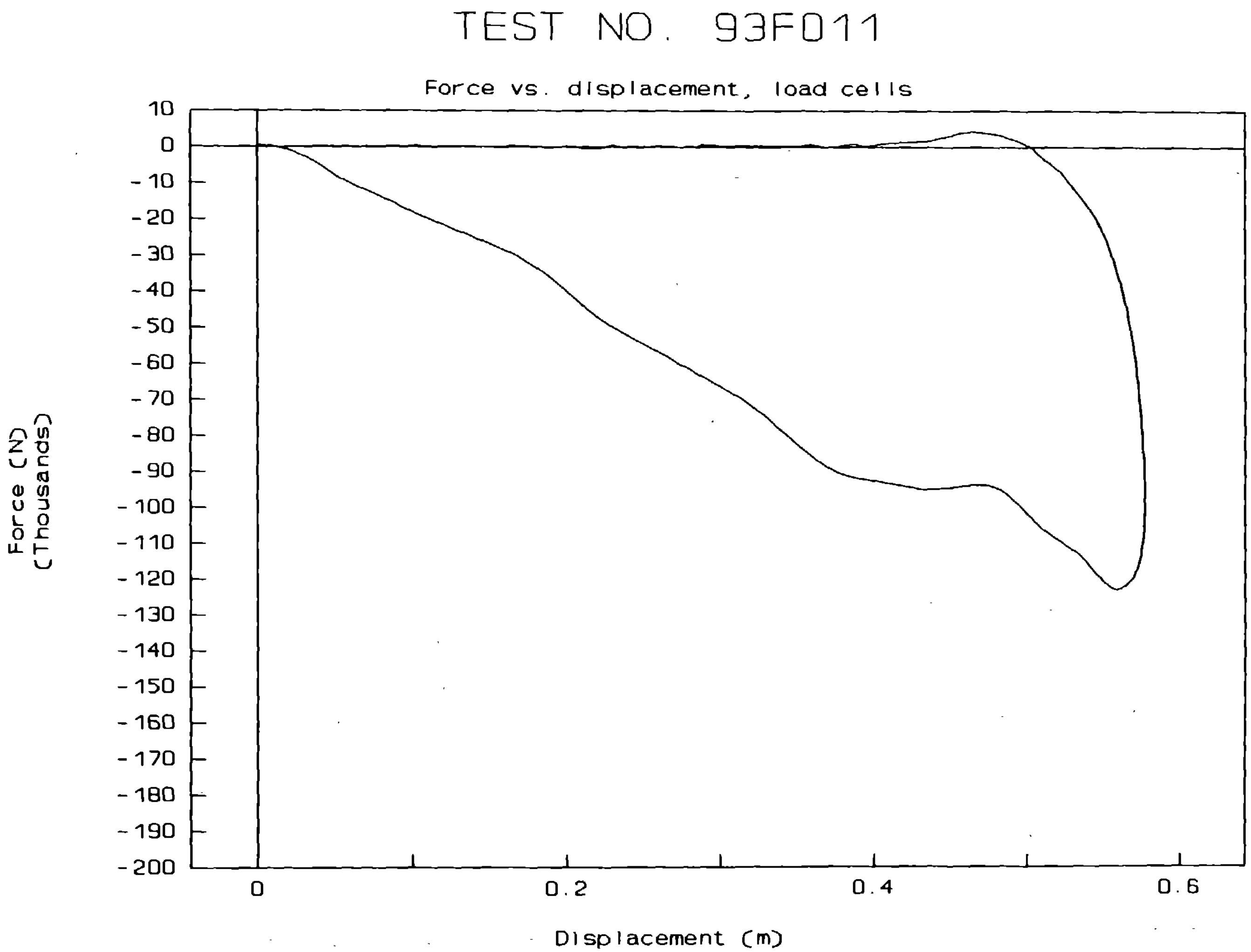


Figure 67. Force vs. displacement, load cells, test 93F011.

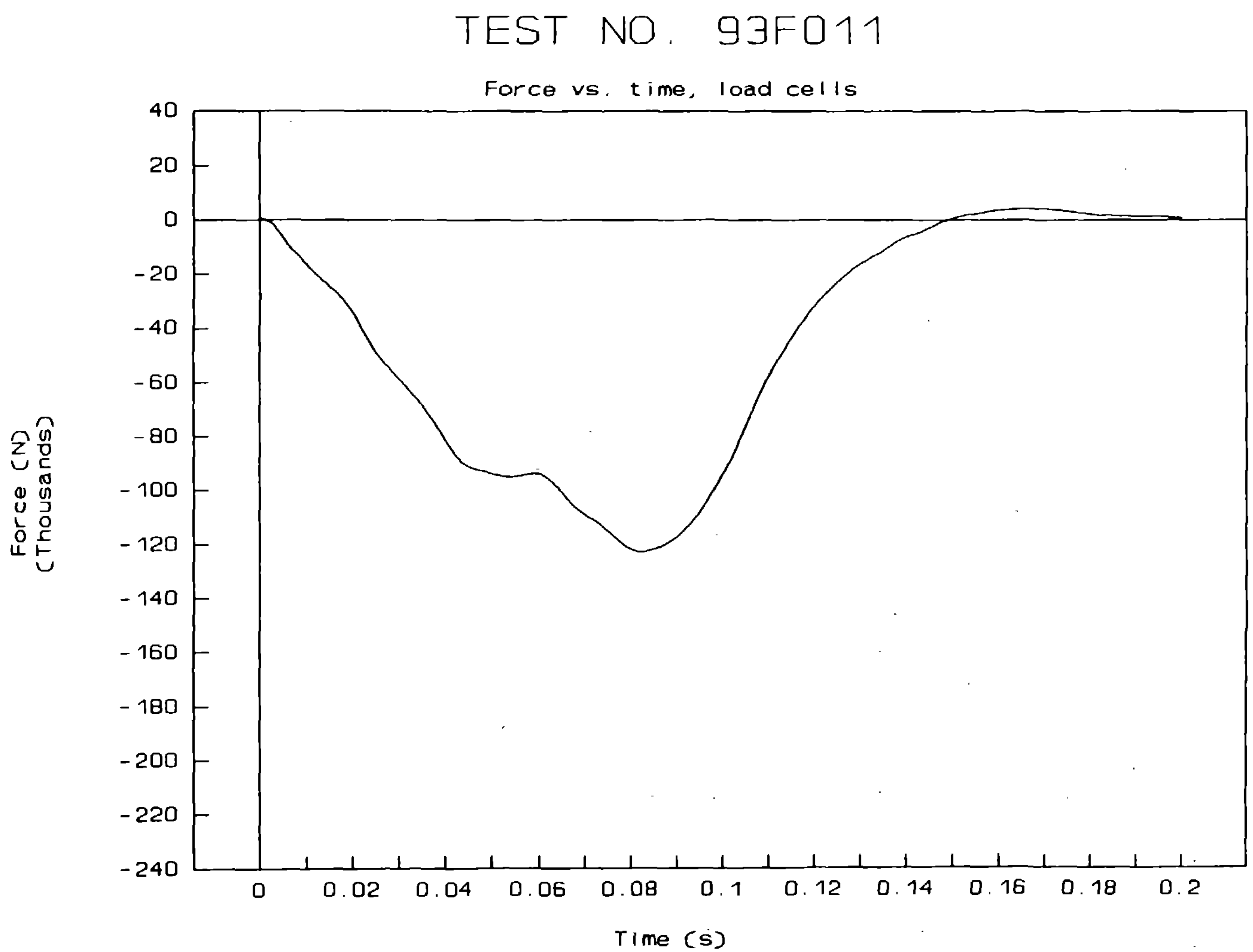


Figure 68. Force vs. time, load cells, test 93F011.

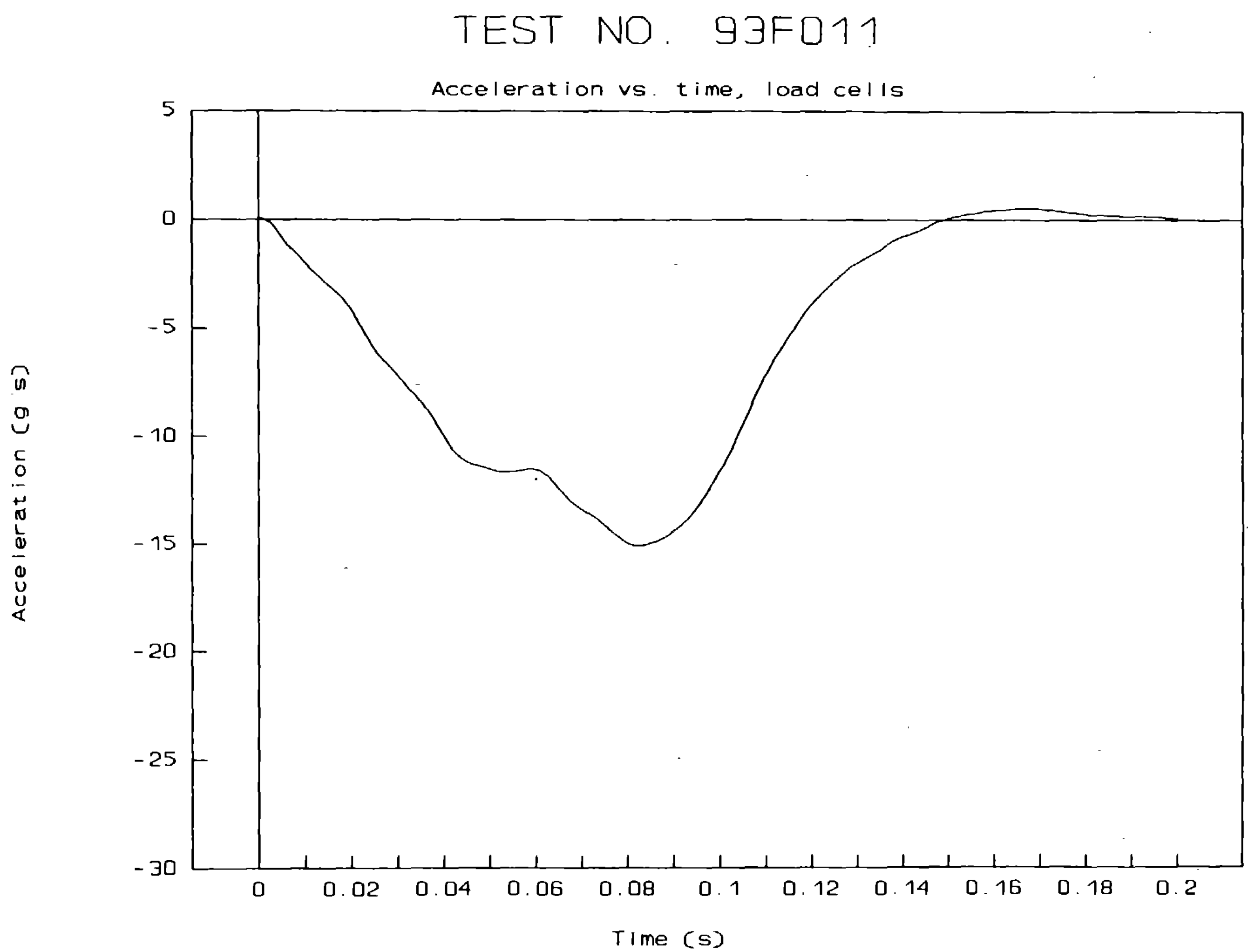


Figure 69. Acceleration vs. time, load cells, test 93F011.

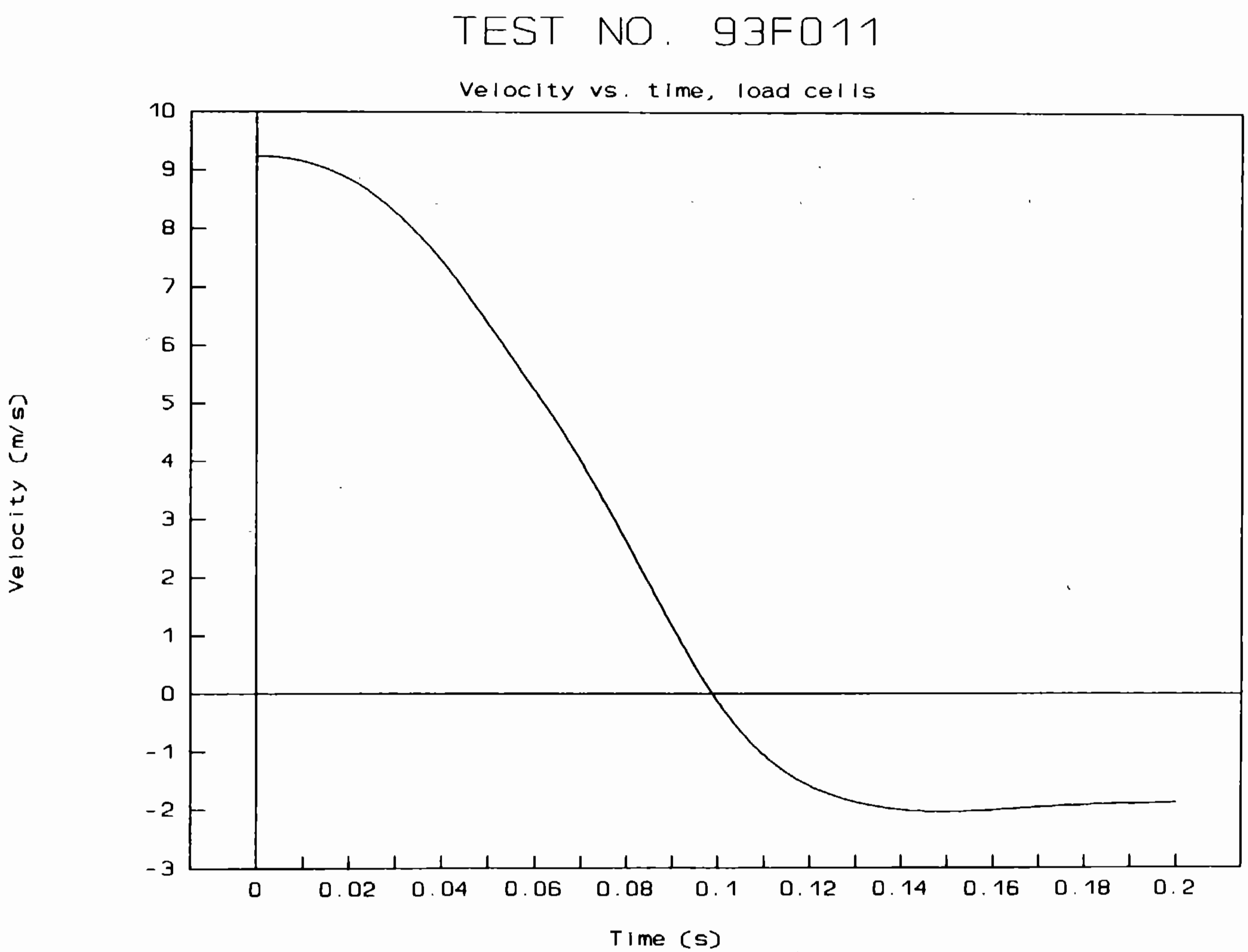


Figure 70. Velocity vs. time, load cells, test 93F011.

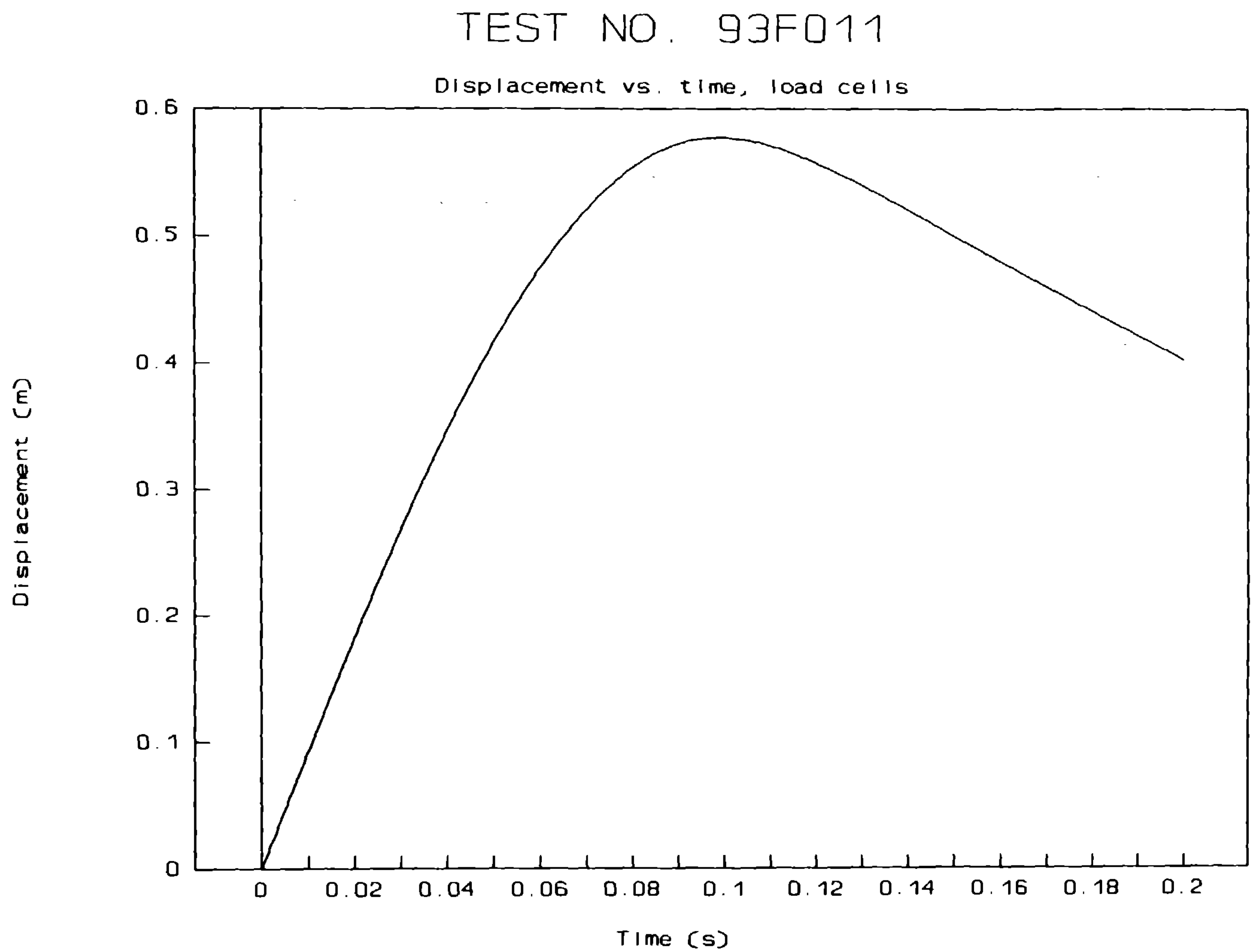


Figure 71. Displacement vs. time, load cells, test 93F011.

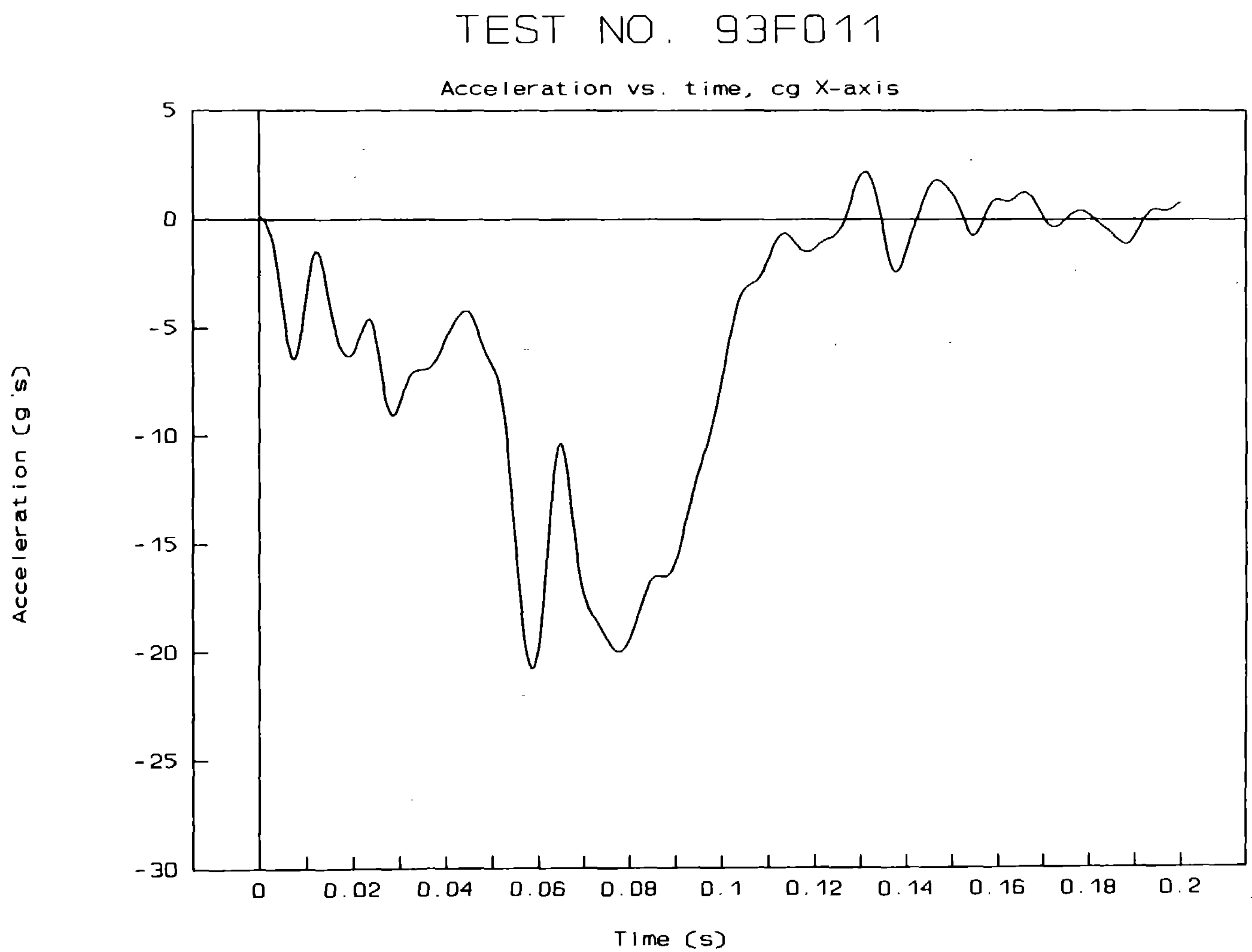


Figure 72. Acceleration vs. time, cg X-axis, test 93F011.

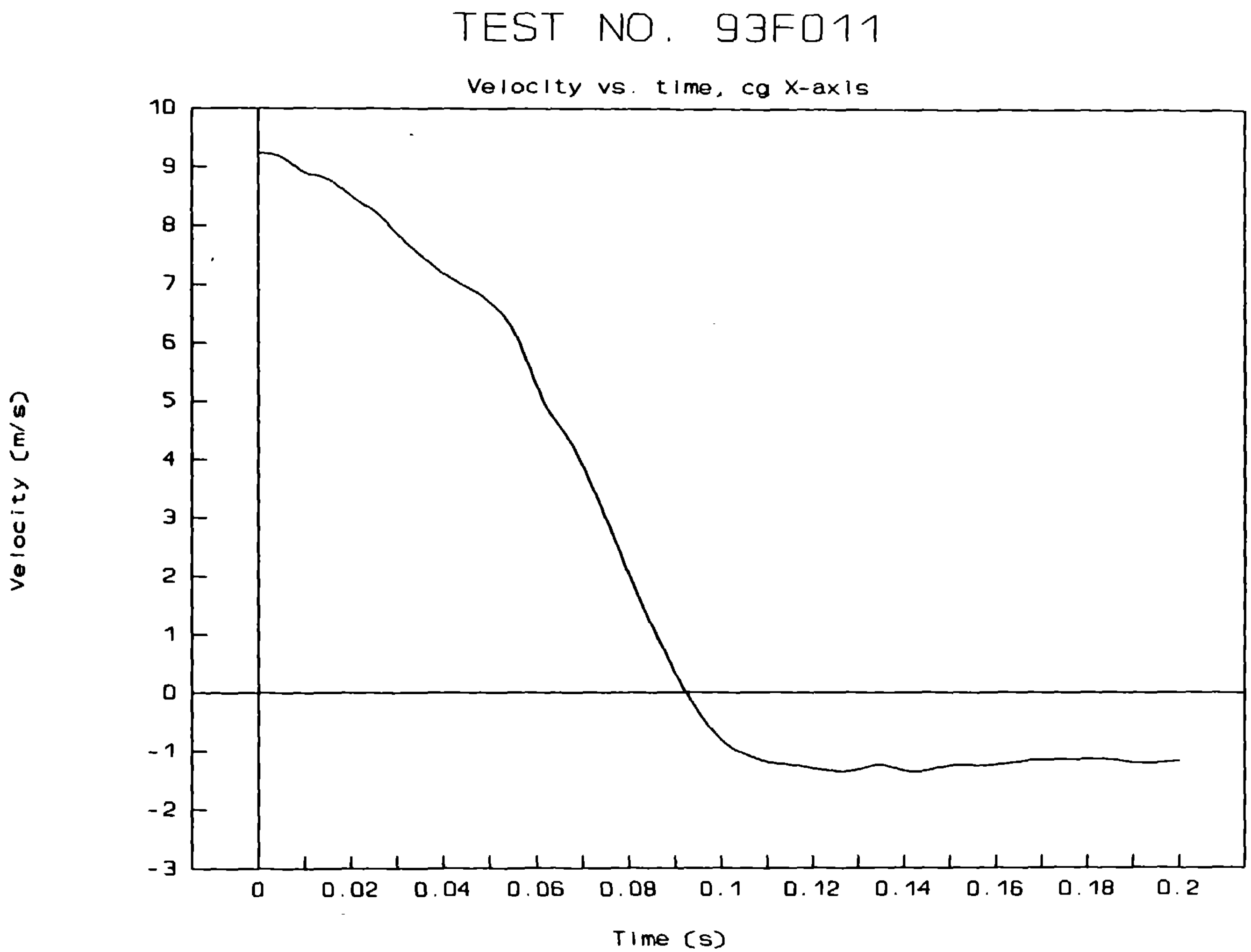


Figure 73. Velocity vs. time, cg X-axis, test 93F011.

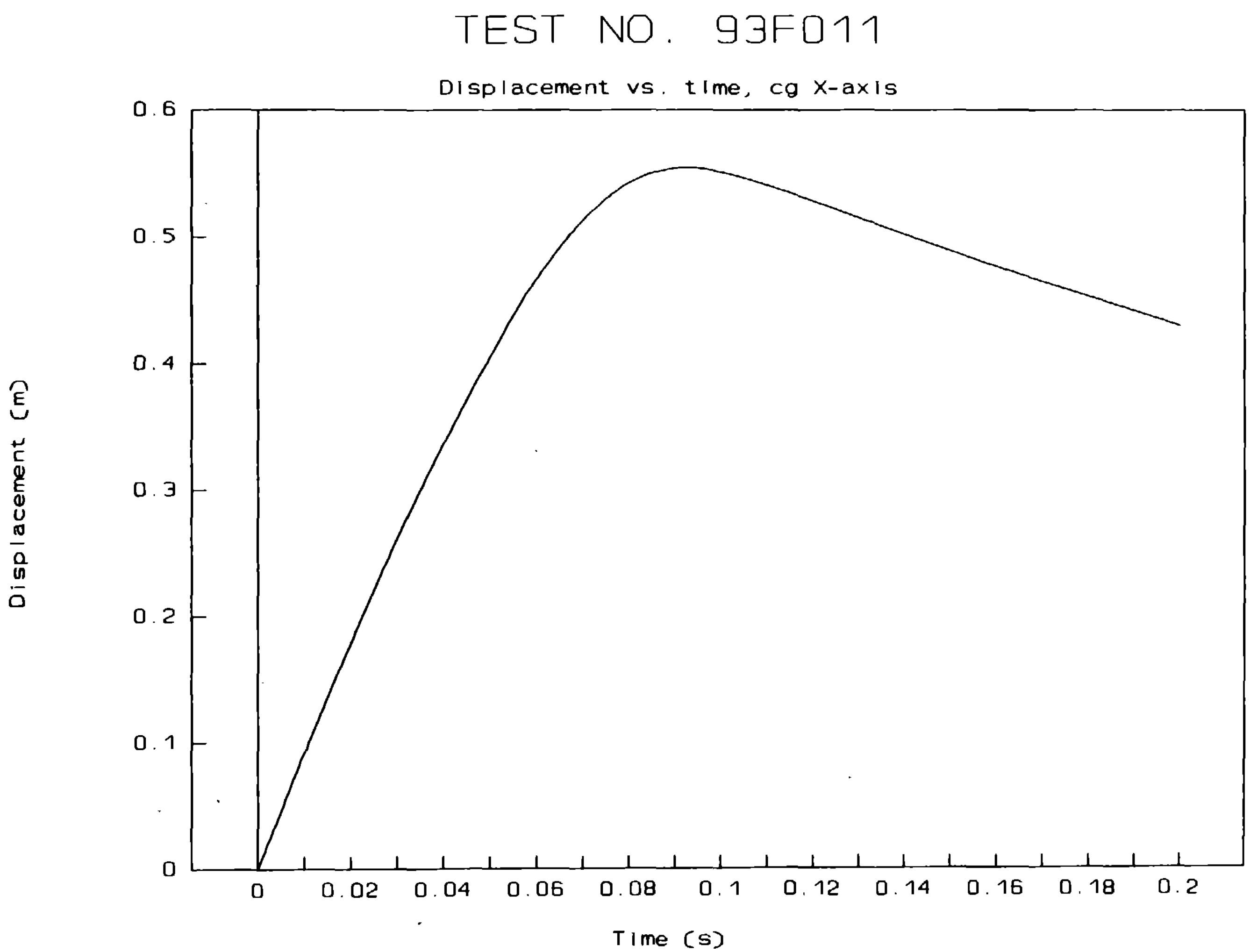


Figure 74. Displacement vs. time, cg X-axis, test 93F011.

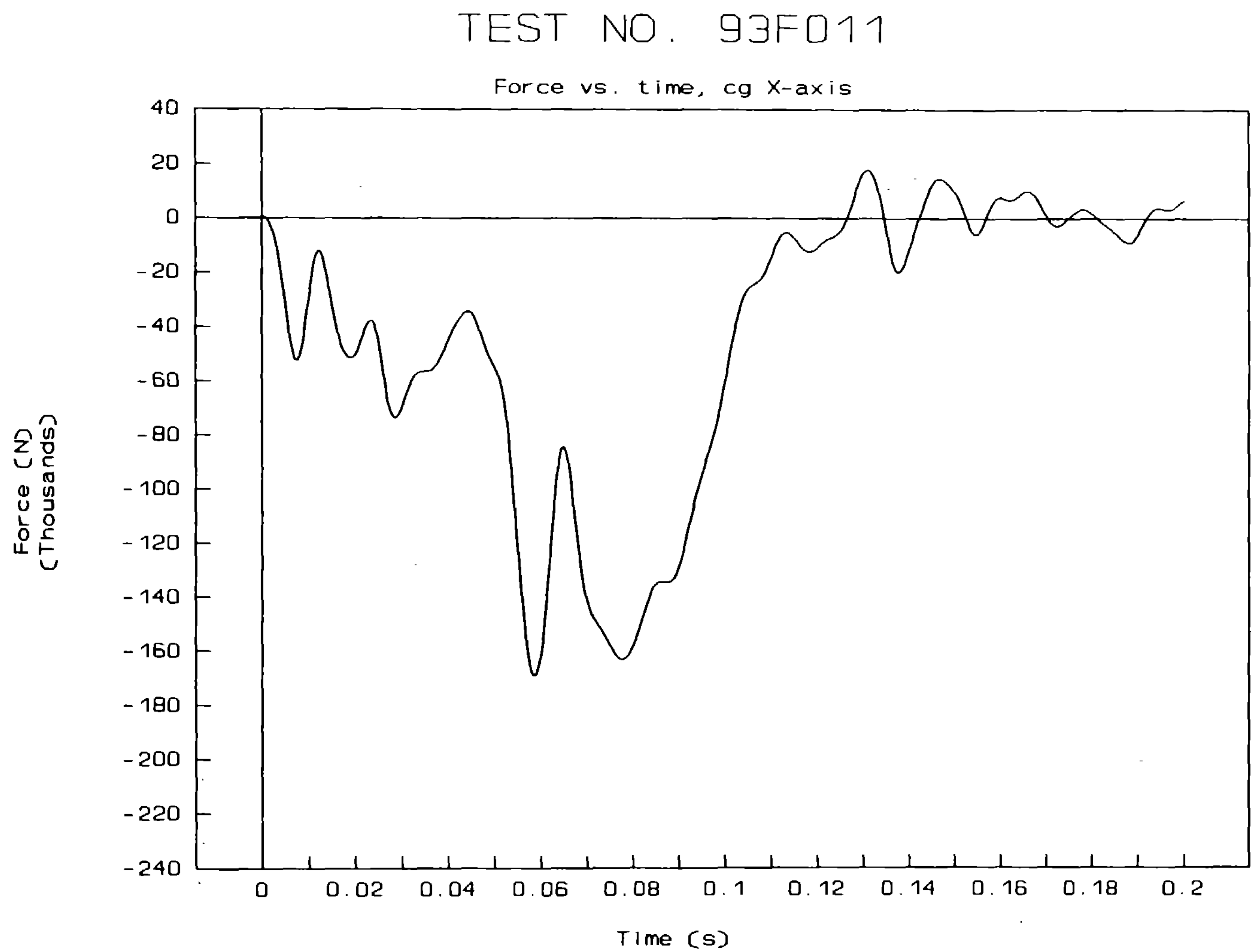


Figure 75. Force vs. time, cg X-axis, test 93F011.

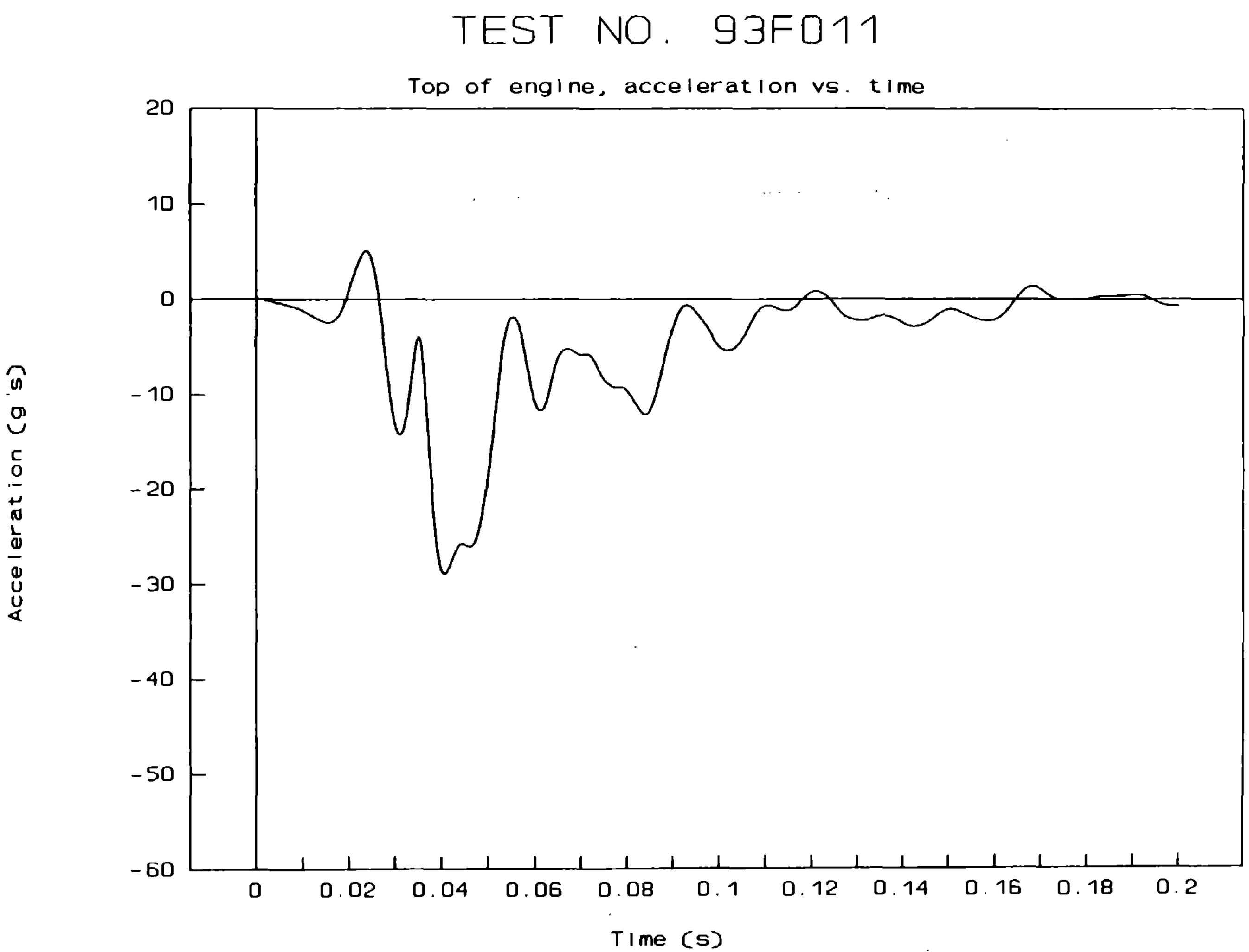


Figure 76. Top of engine, acceleration vs. time, test 93F011.

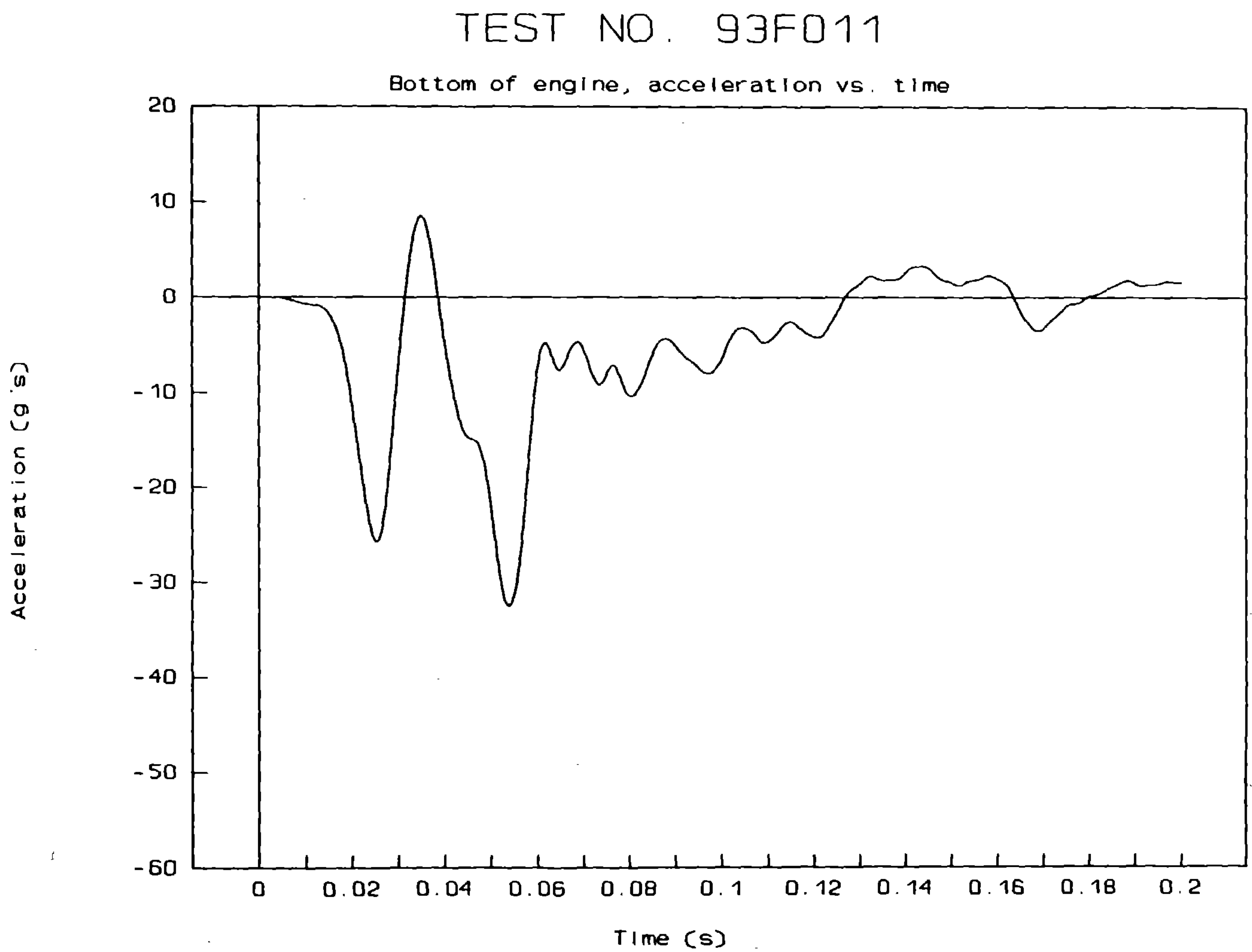


Figure 77. Bottom of engine, acceleration vs. time, test 93F011.

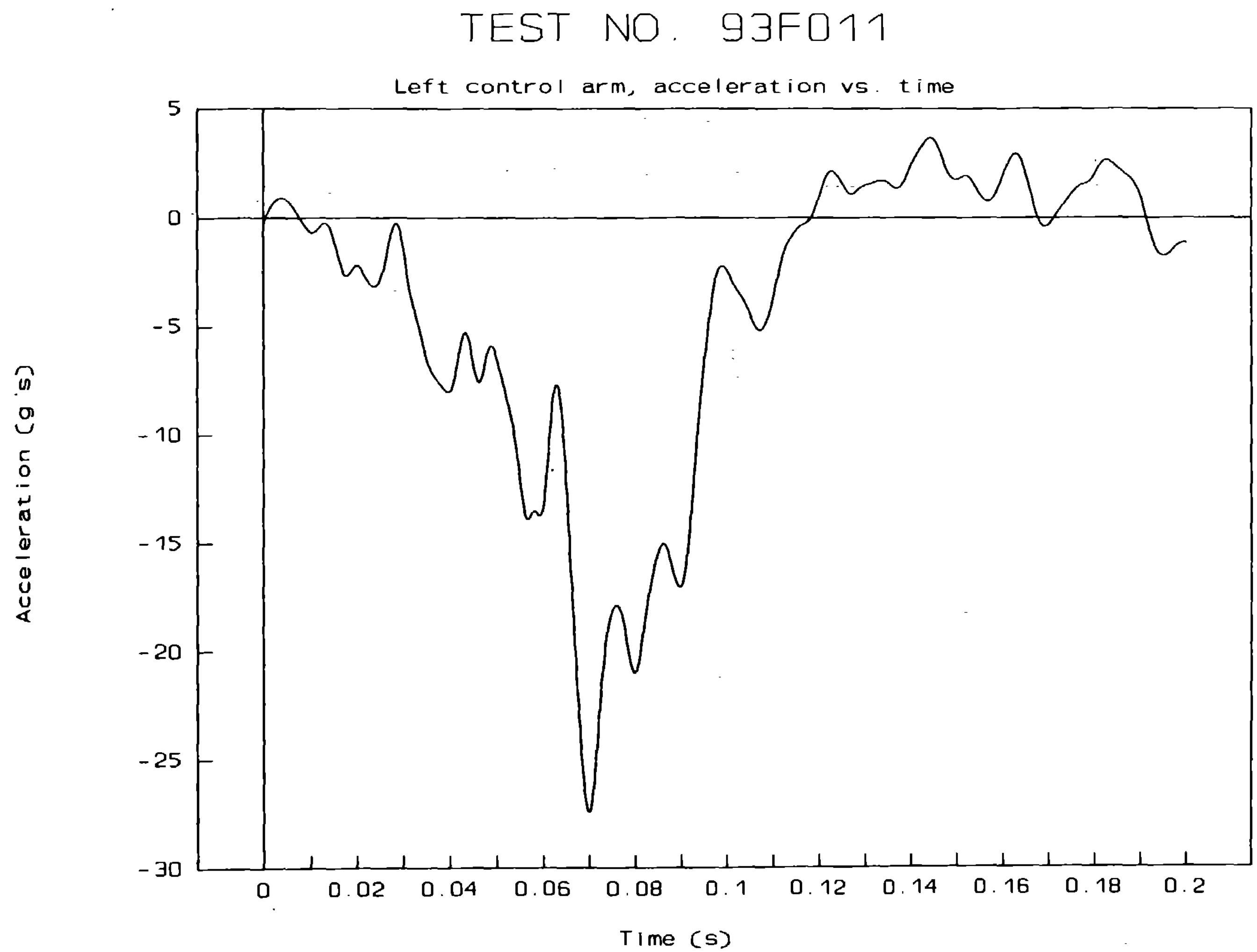


Figure 78. Left control arm, acceleration vs. time, test 93F011.

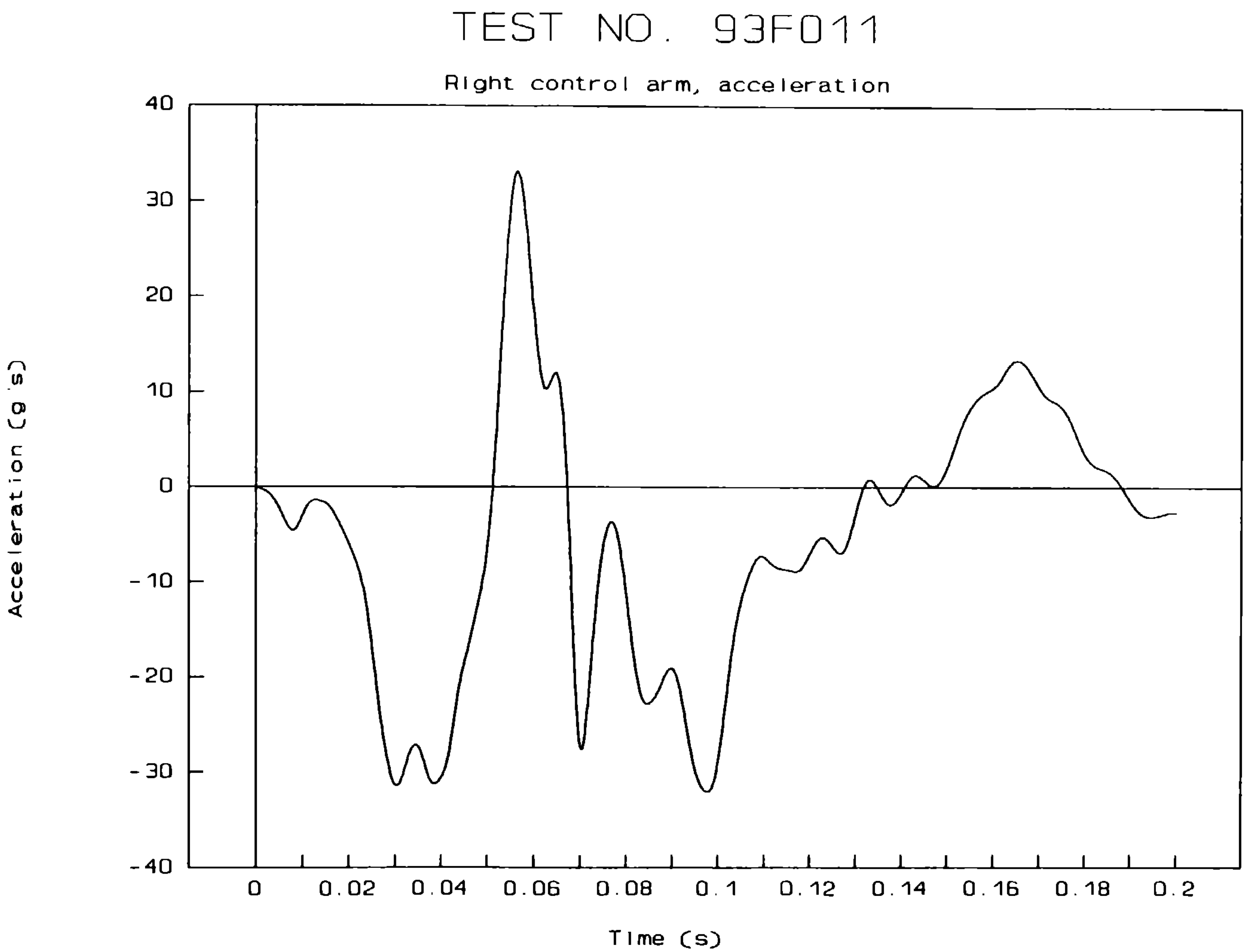


Figure 79. Right control arm, acceleration vs. time, test 93F011.

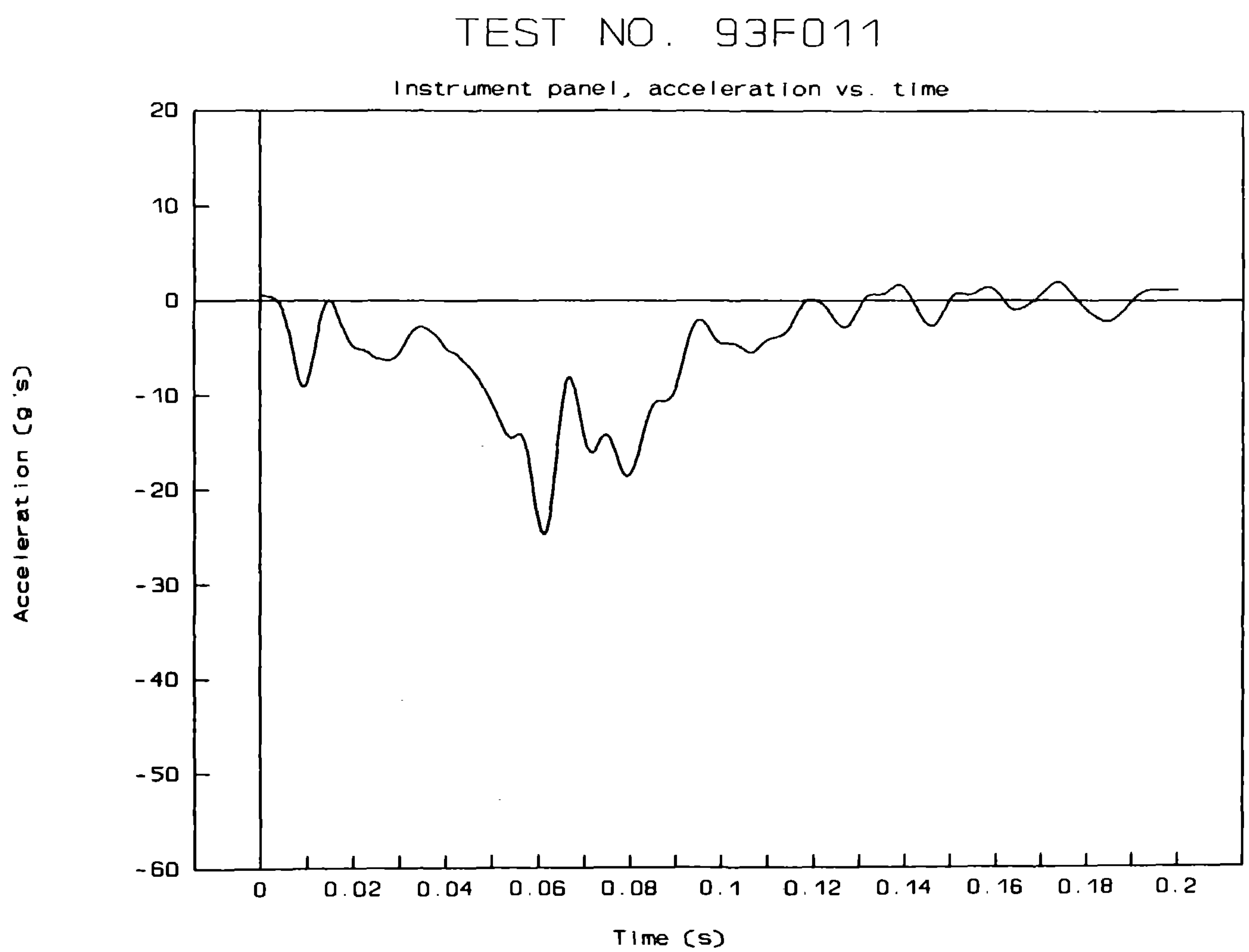


Figure 80. Instrument panel, acceleration vs. time, test 93F011.

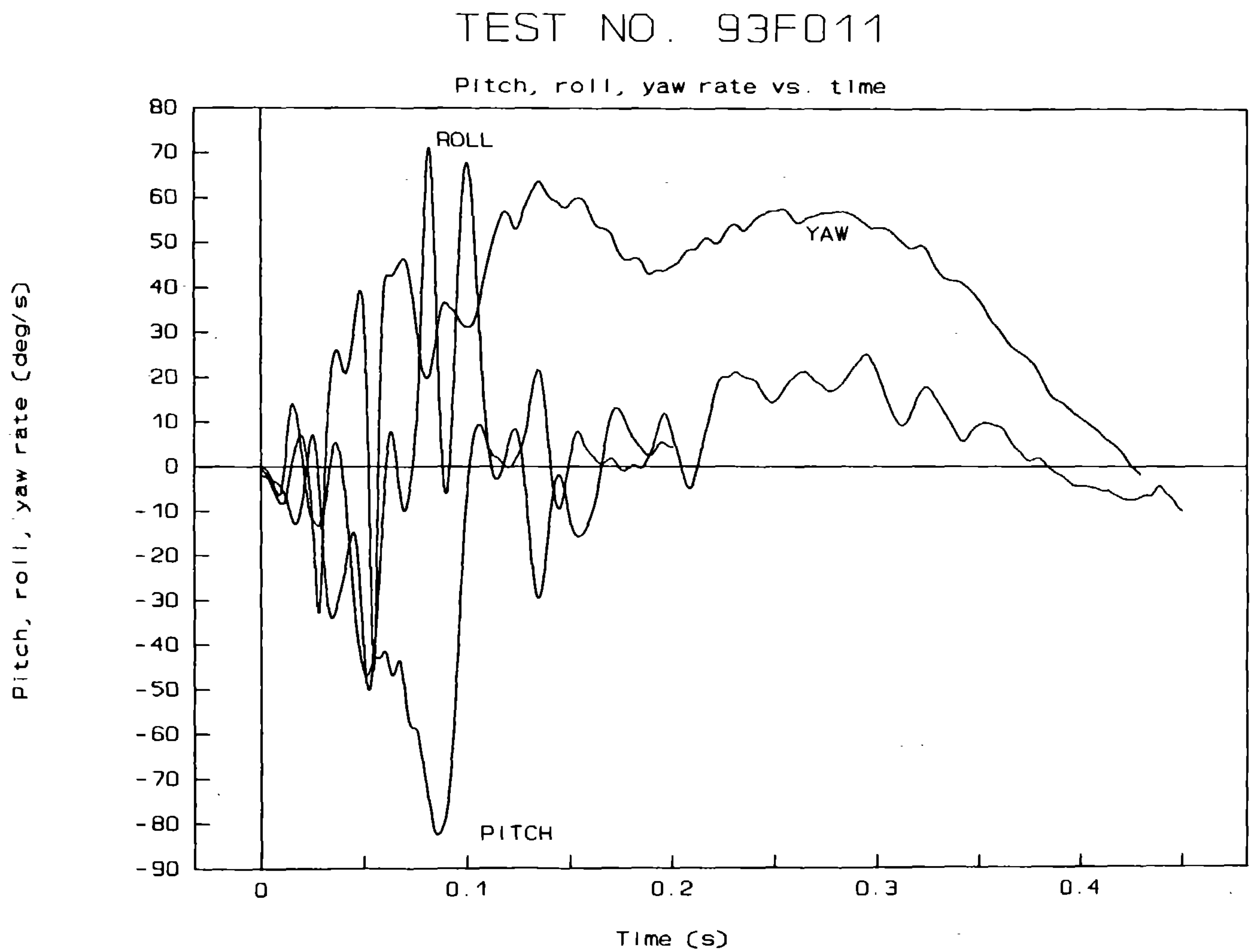


Figure 81. Pitch, roll, yaw rate vs. time, test 93F011.

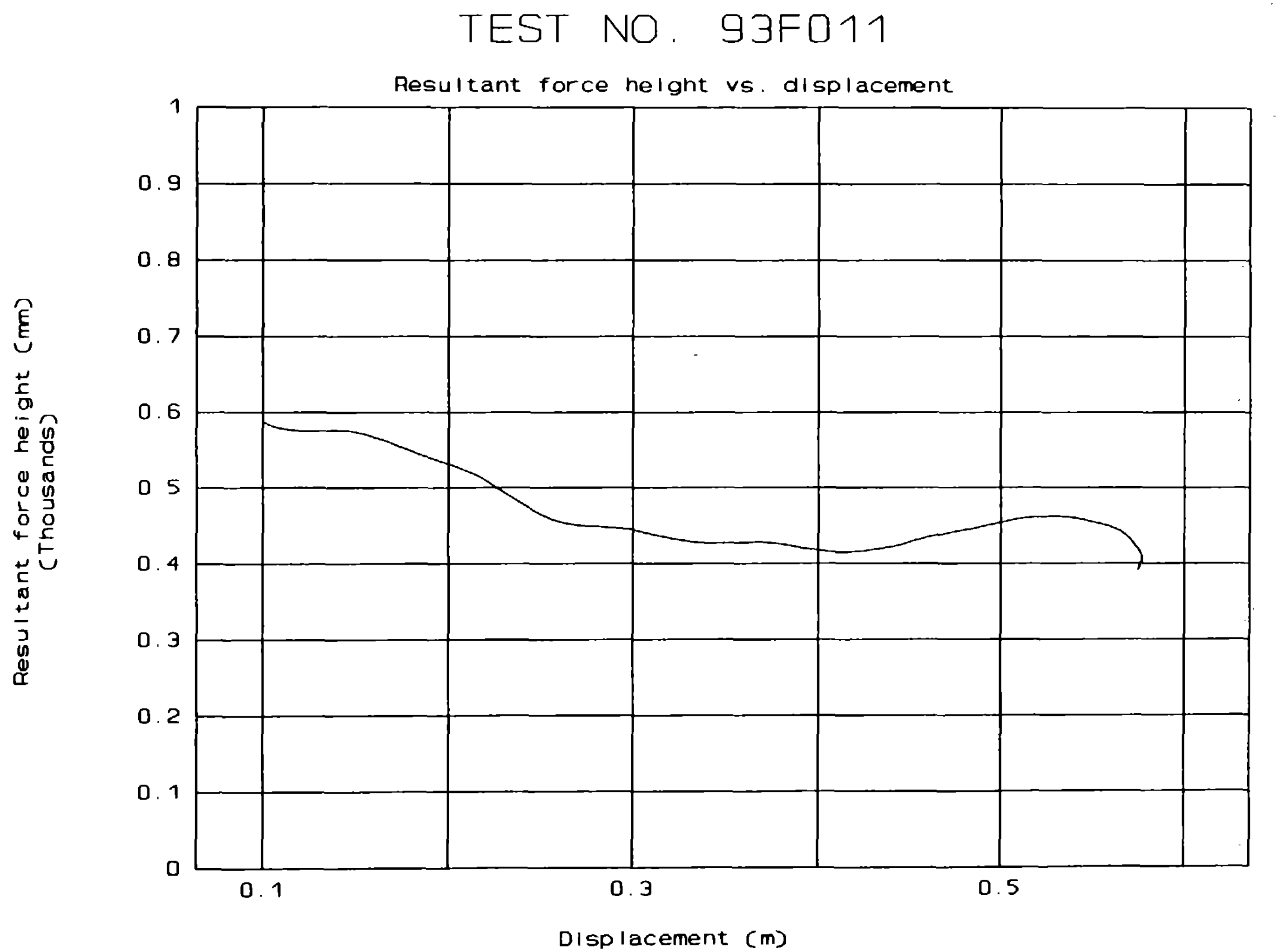


Figure 82. Resultant force height vs. displacement, test 93F011.

REFERENCES

Number

(1) NHTSA. *Laboratory Test Procedure for Federal Motor Vehicle Safety Standard 208,* National Highway Traffic Safety Administration, Washington, D.C., May 1992.