1995 Honda Accord LX Broadside Collision With a Narrow Fixed Object: FOIL Test Number 98S007

PUBLICATION NO. FHWA-RD-99-024

PB99-130312

NOVEMBER 1998

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
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FOREWORD

The National Highway Traffic Safety Administration (NHTSA) enlisted the Federal Highway Administration (FHWA) to aid in the development of laboratory test procedures to be used in an amended version of Federal Motor Vehicle Safety Standard (FMVSS) 201. This new test procedure could be used in the evaluation of dynamic side-impact protection systems (e.g., air bags). A test methodology was produced from four crash tests between 1995 Honda Accord LX four-door sedans and the FOIL 300K rigid pole (test numbers 97S003, 97S004, 97S005 and 97S006), referenced in this report. Once the test procedures were established, three additional broadside crash tests were conducted to demonstrate the practicality and feasibility of the new test procedures. The three vehicles used for these tests were a 1994 Ford Explorer XLT, a 1994 Toyota pickup truck, and a 1995 Honda Accord LX (this report). In addition to evaluating new test procedures, this last crash test in the series also included investigating child occupant kinematics. A 6-year-old child dummy was supplied by the NHTSA and placed in the left rear outboard seat of the Honda Accord.

This report (FHWA-RD-99-024) contains test data, photographs taken with high-speed film, and a summary of the test results.

This report will be of interest to all State departments of transportation, FHWA headquarters, region and division personnel, and highway safety researchers interested in the crashworthiness of roadside safety hardware.

A. George Ostensen, Director
Office of Safety and Traffic
Operations Research and Development

NOTICE

Technical Report Documentation Page

1. Report No. FHWA-RD-99-024	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle 1995 HONDA ACCORD LX BROADSIDE COLLISION WITH A NARROW FIXED OBJECT: FOIL TEST NUMBER 98S007		5. Report Date November 1998
		6. Performing Organization Code
7. Author(s) Christopher M. Brown	PB99-130312	8. Performing Organization Report No.
9. Performing Organization Name and Address MiTech Incorporated 8484 Georgia Avenue, Suite 950 Silver Spring, MD 20910		10. Work Unit No. (TRAIS) 3A5F3142
		11. Contract or Grant No. DTFH61-94-C-00008
12. Sponsoring Agency Name and Address Office of Safety and Traffic Operations R&D Federal Highway Administration 6300 Georgetown Pike McLean, VA 22101-2296		13. Type of Report and Period Covered Test Report, May 1998
		14. Sponsoring Agency Code

15. Supplementary Notes
Contracting Officer's Technical Representative (COTR)- Richard King, HSR-20

16. Abstract
This report contains the test procedures, test setup and test results from the last of three broadside crash tests conducted at the Federal Highway Administration (FHWA) Federal Outdoor Impact Laboratory (FOIL), located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia. The National Highway Traffic Safety Administration (NHTSA) enlisted FHWA to aid in the development of laboratory test procedures to be used in an amended version of Federal Motor Vehicle Safety Standard (FMVSS) 201. Four previous crash tests with a Honda Accord LX and the FOIL 300K instrumented rigid pole (test numbers 97S003, 97S004, 97S005, and 97S006) produced a test methodology for conducting broadside vehicle crash tests of dynamic side-impact head protection systems (e.g. air bags). Once the test procedures were established, these three additional broadside crash tests were conducted to demonstrate the practicality and feasibility of the new test procedures. The three vehicles used for these tests were a 1994 Ford Explorer XLT, a 1994 Toyota pickup truck, and a 1995 Honda Accord LX (this test). This test also included investigating child occupant kinematics. A 6-year-old child dummy was placed in the rear seat of the struck side of the vehicle.

17. Key Words Honda Accord LX, broadside, rigid pole, head injury criteria, FOIL	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	100	

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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.

Symbol	When You Know	Multiply By	To Find	Symbol
		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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INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) enlisted the Federal Highway Administration (FHWA), specifically the Federal Outdoor Impact Laboratory (FOIL), to aid in the development of laboratory test procedures to be used in an amended version of Federal Motor Vehicle Safety Standard (FMVSS) 201 (Occupant Protection in Interior Impact).[1] The amendment would include a 90-degree broadside collision between a passenger vehicle and a narrow fixed object. This new test procedure could be used in the evaluation of dynamic side-impact protection systems (e.g., air bags). Four crash tests were conducted in support of this research. The four tests conducted at the FOIL were broadside collisions between 1995 Honda Accord LX four-door sedans and the FOIL's 300K rigid pole. The results from the four Honda Accord tests can be found in four separate test reports, one for each test conducted: *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S003*[2], *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S004*[3], *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S005*[4], and *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S006*[5]. These four crash tests produced a test methodology for conducting broadside vehicle crash tests of dynamic side-impact head protection systems (air bags). Once the test procedures were established, three additional broadside crash tests were conducted. The tests were conducted to demonstrate the practicality and feasibility of the new test procedures. Three different types of vehicles were represented in this series of tests. The three vehicles used for these tests were a 1994 Ford Explorer XLT (sport utility), 1994 Toyota pickup truck (small pickup truck), and 1995 Honda Accord LX (four-door sedan).

SCOPE

This report documents the test procedures and results from a single broadside crash test between a 1995 Honda Accord LX and the FOIL 300K instrumented rigid pole. The test was conducted at FHWA's FOIL located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia. The purpose of this test was to assess the level of practicality, repeatability, and feasibility of the new FMVSS 201 test procedures. The test procedures and test setup were similar to procedures followed for a previously conducted crash test of a 1995 Honda Accord LX (FOIL test number 97S005). The test procedures for vehicle preparation, dummy preparation and calibration, and photographic coverage follow directly from FMVSS 214.[6] However, the new FMVSS 201 test procedures included propelling a vehicle in a sideways manner into a fixed 255-mm diameter pole. The seating procedure used for this type of test utilized FMVSS 214 seating procedures to establish an initial dummy position, then the position was altered according to recently established procedures. The dummy was positioned in the final location by altering the seat back angle and track adjustment until a minimum clearance of 50-mm between the rear of the dummy's head and the vehicle B-pillar was achieved. In addition to evaluating new test procedures, the test also included investigating child occupant kinematics. A 6-year-old child dummy was placed in the rear seat of the struck side of the vehicle. The child dummy was instrumented with 20 sensors and an additional onboard camera was placed in the rear passenger window to observe the child dummy during a broadside collision with a narrow fixed object. Because of FOIL data acquisition limitations, several vehicle sensors were removed to accommodate the additional child dummy sensors. The child dummy was positioned in the rear seat by placing the dummy in the center of the seat and staightening the arms and legs.

The FOIL utilizes a drop tower system for propulsion and two steel rails bolted to a concrete runway for vehicle guidance during broadside testing. The rails were extended to within 0.3 m of the rigid pole to ensure impact location, speed, and SID/HIII (side-impact dummy/hybrid III) stability. The concept of the vehicle remaining on the two rails raised some concern. The concern was that the rails would impede the natural collapse or crush of the vehicle and thus interfere with the accuracy of the SID/HIII data. However, the intent of these tests was to validate a test procedure for head protection system evaluation, and it was determined that the event of interest (dummy contact with the pole) would be complete before significant crush of the vehicle. The FOIL broadside test procedures required that the test vehicle's tires were off the ground while the test vehicle rested on the side-impact monorail. The rail height (to 305 mm) and vertical carriage height allowed the tires of the Honda to hang free without contact with the ground.

NHTSA supplied a calibrated SID/HIII dummy and a calibrated 6-year-old child HYBRID III dummy for the crash test. Head injury criteria (HIC) and thoracic trauma index (TTI) calculations were performed on the data from the SID/HIII's head and thorax accelerometers. The HIC and TTI values were used to determine the severity of the test and to compare previous and subsequent broadside tests to evaluate the repeatability of the test procedures.

TEST MATRIX

One broadside crash test involving a 1995 Honda Accord LX and the FOIL's instrumented 300K rigid pole was conducted. The target vehicle test weight was intended to be between the vehicle curb weight (empty, as received from the dealership) and the fully loaded weight (curb weight plus ballast to simulate the vehicle cargo capacity, a child dummy, and one SID/HIII). The target test speed for this test was 29 km/h. The rigid pole was installed with its centerline aligned with the center-of-gravity (cg) of the SID/HIII's head. Table 1 outlines the pertinent test parameters of the broadside crash test.

Table 1. Test matrix.	
FOIL number	98S007
Date	May 7, 1998
Vehicle	1995 Honda Accord LX
Weight (total)	1501 kg
SID/HIII Modified neck bracket	One positioned in driver seat HYBRID III neck
HYBRID III 6-year-old child	One positioned in left rear outboard seat - behind driver SID/HIII
Fuel tank	91% capacity with stoddard solvent
Crab angle	90°
Speed (nominal)	29 km/h
Impact location	Pole aligned with SID/HIII head
Test article	FOIL 300K instrumented rigid pole

TEST VEHICLE

The test vehicle was a 1995 Honda Accord LX four-door sedan with an automatic transmission and a four cylinder 2.2 L motor. Table 2 describes the vehicle and optional equipment.

Table 2. Vehicle description and statistics.	
Vehicle make	Honda
Vehicle model	1995 Honda Accord LX
Vehicle identification number (VIN)	1HGCD5633SA012643
Engine	2.2 L, 4 cylinder
Transmission	4-speed Automatic
Drive chain	Front wheel drive
Wheel base	2718 mm
Wheel track	1511 mm
Fuel capacity	64.3 L
Tested capacity of stoddard solvent	58.7 L (91%)
Seat type	Bucket, lever
Position of front seats for test	75 mm forward of center
Seat back angle (measured on back of seat)	19.5°
Steering wheel adjustment for test	Center

Table 2. Vehicle description and statistics (continued).

OPTIONS					
x	Air conditioning		Traction control	x	Clock
	Tinted glass		All wheel drive		Roof rack
x	Power steering	x	Cruise control	x	Console
x	Power windows	x	Rear defroster	x	Driver air bag
x	Power door locks		Sun roof/T-top	x	Passenger air bag
	Power seat(s)	x	Tachometer	x	Front disc brakes
x	Power brakes	x	Tilt steering		Rear disc brakes
x	Anti-lock brakes	x	AM/FM radio		Other

WEIGHTS (kg)	**DELIVERED**	**FULLY LOADED**	**TEST MODE**
Right front	407	415	432
Left front	404	435	447
Right rear	241	285	294
Left rear	252	314	329
TOTAL	**1304**	**1449**	**1502**
ATTITUDE (mm)	**DELIVERED**	**FULLY LOADED**	**TEST MODE**
Right front	683	669	665
Left front	694	671	674
Right rear	681	652	654
Left rear	682	652	654
ATTITUDE (degrees)	**DELIVERED**	**FULLY LOADED**	**TEST MODE**
Passenger	.9 negative	.6 negative	.7 negative
Driver	0	.2 negative	.2 negative
Front	0.4 negative	.6 negative	.5 negative
Rear	1.0 negative	.7 negative	.6 negative
Cg (mm) measurements	**DELIVERED**	**FULLY LOADED**	**TEST MODE**
Behind front axle	1028	1124	1127
Lateral	760	781	780

The test vehicle was prepared for testing following procedures outlined in FMVSS 201 (similar to FMVSS 214). NHTSA supplied an OSCAR to measure the three-dimensional coordinate of the SID/HIII's hip-point (H-point) relative to the vehicle's driver door striker. This H-point measurement was used the morning of the test to place the SID/HIII in its initial position before final positioning. The OSCAR was not used to locate the 6-year-old child dummy's H-point.

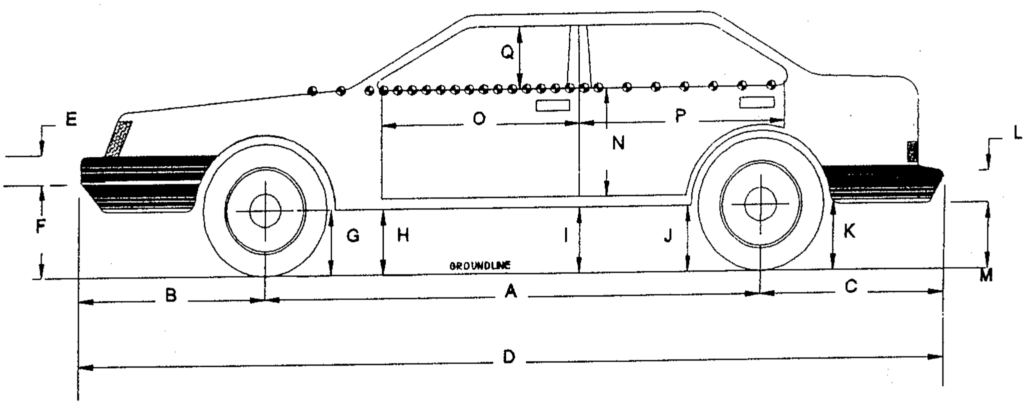
The vehicle weight and four sill attitudes were measured in each of the three modes or configurations described in FMVSS 201. The first was the "as delivered" mode. This configuration consisted of the test vehicle as delivered from a dealership with its fuel tank filled to between 92- and 94-percent capacity with petroleum naphtha, a stoddard solvent (although actual for this test was only 91 percent). The second mode, cargo or "fully loaded" mode, consisted of the vehicle with one dummy placed in the driver seat, a child dummy in the rear seat, and 45 kg of simulated cargo placed in the rear cargo space along the vehicle centerline. The final mode was the "as tested" mode. This configuration consisted of the vehicle fully instrumented for testing, excluding the 45 kg of simulated cargo but including instrumentation, guidance carriages, one child dummy, and one SID/HIII dummy. The four sill attitude measurements, vehicle weight distribution, and other measurements are presented in table 2. The vehicle attitudes while in position on the guidance rails were adjusted to within 0.5 degrees of the "test mode" measurements recorded while the vehicle was on the ground.

Included in the test mode configuration were the two side-impact carriages. The main monorail carriage rides down the main I-section monorail. The monorail carriage was bolted 200 mm forward of the vehicle's longitudinal cg. The main monorail carriage supports approximately 95 percent of the total vehicle weight. The monorail carriage includes a tow pin protruding out 200 mm rearward such that the tow cable pulled at the vehicle cg. The tow location allows for the least possible yaw to be induced by the tow system. The propulsion used was a gravity assist system. The FOIL utilizes a weight stack and a 6-to-1 mechanical advantage to accelerate the test vehicle. The total weight on the weight stack was reduced to 2310 kg to prevent the SID/HIII from tipping during acceleration. The rear carriage was bolted to the bumper of the test vehicle and rides along a 50-mm steel angle. The rear carriages typically supports 5 percent of the total vehicle weight. Each carriage was constructed from aluminum and remained fastened to the test vehicle throughout the test. To prevent significant interference by the carriages, the carriages were bolted to the test vehicle using small diameter hardware quality bolts. The bolts were to shear quickly in the event the carriages made substantial contact with a structural member.

The fuel tank useable capacity (obtained from the NHTSA) was 64.3 L. The fuel tank was filled with 58.7 L (91 percent of capacity) of petroleum naphtha (stoddard solvent) that has the same density as gasoline but is less volatile. The tank was filled to reflect a more realistic weight of a passenger vehicle on the road. The petroleum naphtha also provided a means to observe any fuel system component leakage after the test. The original lead-acid battery in a charged state remained in the engine compartment. The battery was disconnected to prevent frontal air bag deployment. The vehicle test weight, including the dummy, instrumentation, cameras, ballast, and stoddard solvent was 1501 kg. The SID/HIII weight was 80 kg. The 6-year-old child dummy weighed 23 kg.

Target tape and circular targets were placed on the test vehicle in accordance with FMVSS 201. The 25-mm yellow and black target tape was placed along the struck side of the vehicle at five elevations. The elevations included the lower door sill, the mid-door height, occupant H-point height, top-door sill, and roof sill. The target tape was used to measure pre- and post-test side profile measurements to determine vehicle damage or crush. The FOIL used a 2.5-m long by 1.4-m high peg board placed along the driver (left) side of the vehicle to measure the vehicle profile. The board's position was referenced from two points directly across from the impact location on the right side of the vehicle. This was done to ensure that the reference location would not be severely damaged. The two points were chosen directly across from impact because the least amount of bowing occurs directly across from impact. It was necessary to position the board in the same position relative to the vehicle after the crash test to obtain accurate crush measurements. The pre- and post-test profile measurements are shown in figure 7 later in this report.

A list and sketches of the vehicle's physical parameters are shown in table 2 and figure 1, respectively. Figure 1 includes post-test damage measurements.



	PRE-TEST	POST-TEST	⌂CHANGE
A	2720	2464	-256
B	905	914	9
C	1014	1022	8
D	4639	4400	-239
E	109	109	0
F*	409 / 406	438	32
G*	280 / 260	275	15
H*	280 / 260	272	12
I*	290 / 259	305	46
J1*	290 / 255	321	66
J2*	198 / 163	189	26
K*	347 / 315	337	22
L	215	215	0
M*	376 / 350	383	33
N	665	658	-7
O	1110	821	-289
P	818	709	-109
Q	421	463	42

* These measurements were taken in the "as delivered" and in the "as tested" configuration, respectively.

Figure 1. Vehicle physical parameters in millimeters.

INSTRUMENTED DUMMY

One SID/HIII, serial number 26, was placed in the driver seat of the Honda Accord LX. The SID/HIII was supplied by NHTSA and was calibrated by a NHTSA-approved dummy calibration facility before shipment to the FOIL. The SID/HIII is a combination of the standard SID torso with the neck and head replaced with a HYBRID III dummy's neck and head. The neck bracket was removed from the SID and replaced with a new neck bracket specifically designed for the SID/HIII. This provided the necessary bolt pattern and alignment for a HYBRID III neck and head assembly. The dummy is a surrogate occupant representing a 50^{th} percentile male. It was noted that the dummy's head had a slight twist about the neck. This may have been the result of the attachment between the neck and head, or between the neck and head assembly and the dummy's torso. Figure 2 is a sketch of the modifications made to the SID/HIII. The dummy was shipped with the necessary hardware for assembly. Tools at the FOIL were used to assemble the SID/HIII. The SID/HIII was clothed using white thermal underwear and hard sole leather shoes supplied by NHTSA. Eighteen extension cables were supplied with the SID/HIII. The extensions allowed for installation of connectors necessary for attachment to the FOIL data acquisition system without removing the standard dummy connectors. The transducers within the dummy were of the half bridge type and therefore completion resistors were soldered into the connectors at the data acquisition system interface.

The morning of the test, the SID/HIII was positioned in the driver seat in accordance with FMVSS 214. The data acquired from the OSCAR was used to place the dummy H-point at the correct location. After the dummy was positioned in the standard FMVSS 214 position, the seat back and seat track were adjusted to place the SID/HIII forward of the B-pillar. The target minimum clearance between the rear of the dummy's head and the B-pillar was 50 mm. The following procedure was followed for positioning the dummy:

1. Position the SID/HIII per FMVSS 214. This position served as a baseline starting position.

2. If the minimum head-to-B-pillar clearance of 50 mm was not present, then the seat back angle was adjusted (if adjustment was possible) as much as 5 degrees.

3. If the minimum head-to-B-pillar clearance of 50 mm was not achieved, the seat track was adjusted in one-detent increments until either the minimum clearance was achieved, or the most forward adjustment was reached, or until there was knee interference between the dash or steering column.

4. If the minimum head-to-B-pillar clearance of 50 mm was not achieved, the seat back angle was adjusted in one-notch increments until either the minimum clearance was achieved, or the full upright locked position was reached.

5. If the minimum head-to-B-pillar clearance of 50 mm could not be achieved after the above four steps, the test would be conducted without the minimum clearance.

The minimum clearance was achieved after step 3. The seat back angle was adjusted approximately 5 degrees and the seat track was adjusted 77 mm (3 detents) forward from the center position. The original seat back angle was 25.4 degrees from the vertical position. The seat back angle was adjusted two detents. The first detent forward was less than a 5-degree increment, therefore, the seat was adjusted to the second detent which resulted in a 6-degree total difference from the original FMVSS 214 seat back angle. The final seat back angle was 19.5 degrees as measured from the back side of the seat back. No interference between the SID/HIII's knees and the dash was observed, however, the knees made slight contact with the steering column. The knees were spread enough to eliminate knee-steering column contact. Using FMVSS 214 as a guide and alignment tools supplied by NHTSA, the SID/HIII's feet, legs, thighs, pelvis, torso, and head were positioned just before the test. Pertinent SID/HIII-to-interior longitudinal and lateral clearance measurements are shown in figures 3 and 4. Several different color chalks were put on the side surfaces of the dummy to determine the contact points between the dummy and the vehicle's interior, as shown in table 3 below.

Table 3. SID/HIII chalk colors.

DUMMY PART	**COLOR**
Face	Blue
Top of head	Lime
Left side of head	Yellow
Back of head	Light blue
Left hip	Red
Left shoulder	Orange

P572M HEAD/NECK/TORSO ASSEMBLY

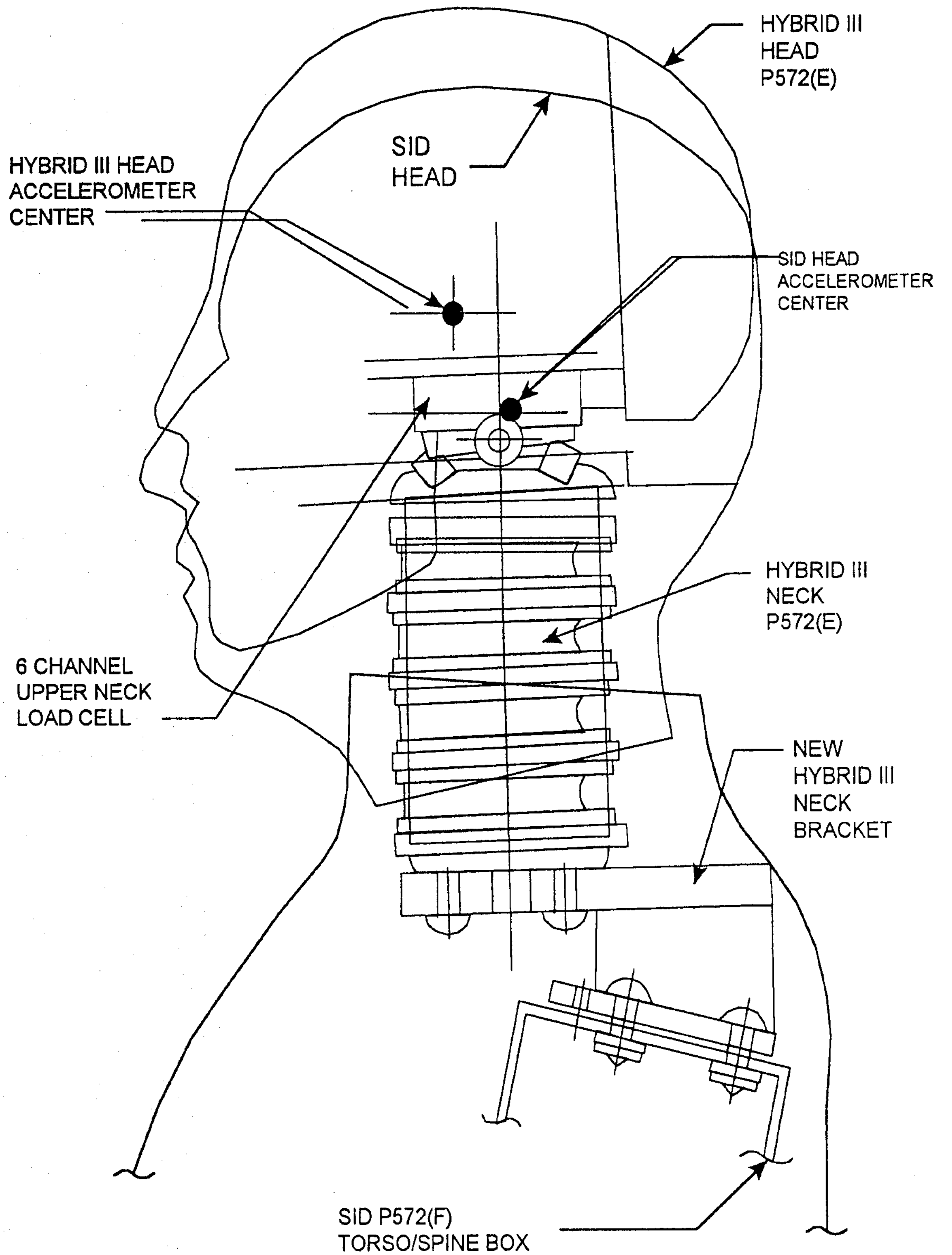
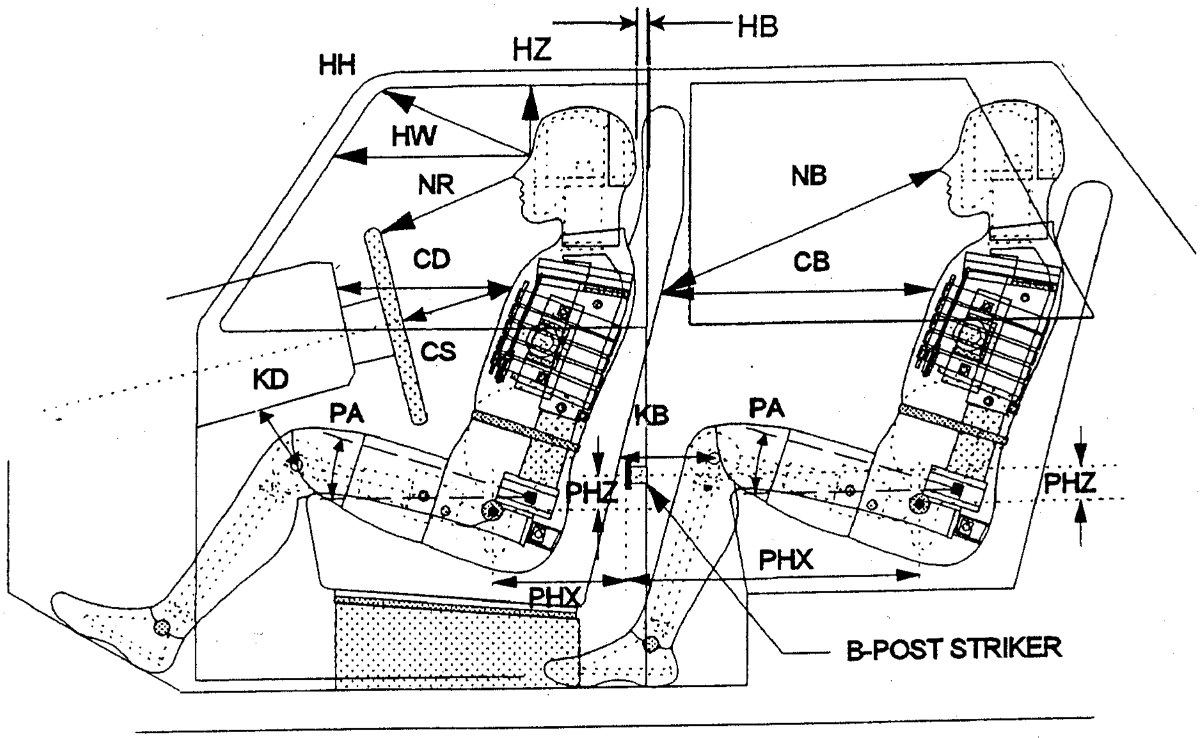


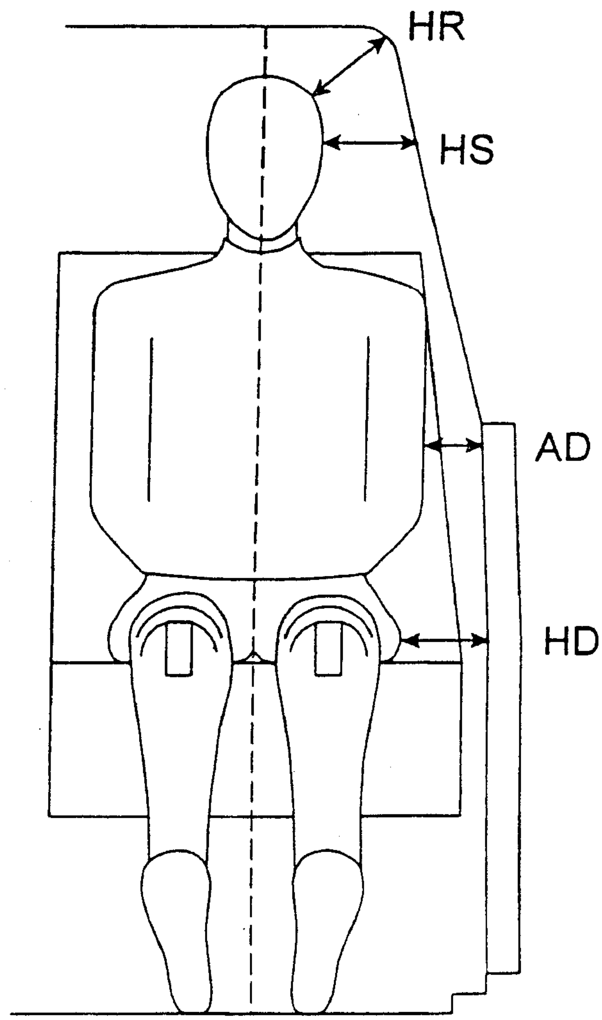
Figure 2. HYBRID III neck and head assembly on SID/HIII #26.



LEFT SIDE VIEW

MEASUREMENT (mm)	DRIVER SID/HIII ID# 26	CHILD DUMMY
HB	58	N/A
HH	281	N/A
HW	432	N/A
HZ	170	430
NR/NB	419	677
CD/CB	578	660
CS	269	N/A
KDL(KDA°)	162(36°)	470(12.5°)
KDR(KDA°)	168(33.4°)	463(10.9°)
PA°	28.7°	N/A
PHX	171	N/A
PHY	230	N/A
PHZ	155	N/A

Figure 3. SID/HIII longitudinal clearance and position measurements.



MEASUREMENT (mm)	DRIVER SID/HIII ID #26	CHILD DUMMY
HR	140	280
HS	210	338
AD	105	225
HD	136	235

Figure 4. SID/HIII lateral clearance and position measurements.

6-YEAR-OLD CHILD DUMMY

One 6-year-old child HYBRID III dummy was placed in the left rear outboard seat of the Honda Accord. The 6-year-old child dummy was supplied by NHTSA and was calibrated by a NHTSA-approved dummy calibration facility before shipment to the FOIL. The child dummy was shipped with the necessary hardware for assembly. Tools at the FOIL were used to assemble the child dummy. The child dummy was clothed using green thermal underwear and sneakers supplied by NHTSA. The HYBRID III child dummy was normally used for frontal-impact testing. The HYBRID III came equipped with 28 sensors. However, because of FOIL data acquisition system channel limitations, only 20 data channels were recorded. Extension cables were supplied with the child dummy. The extensions allowed for installation of connectors necessary for attachment to the FOIL data acquisition system without removing the standard dummy connectors. The transducers within the dummy were of the half bridge type (except for load cell data) and, therefore, completion resistors were soldered into the connectors at the data acquisition system interface.

The morning of the test, the child dummy was positioned in the left rear outboard seat. No seat adjustments were possible in the rear seats. An OSCAR was not used to determine the H-point reference location, instead the child dummy was positioned following the procedure below:

1. The child dummy was centered in the rear seat, the buttocks (first) and the child back (second) were set firmly against the seat back cushion.

2. The legs were extended. The knees were not bent (although if it were possible, they should be bent).

3. The arms were straightened out in front of the dummy then lowered until each hand contacted the seat cushion.

4. The child dummy was restrained using ONLY the lap belt portion of the three-point belt system. The shoulder belt was placed behind the child dummy.

Pertinent child dummy-to-interior longitudinal and lateral clearance measurements are shown in figures 3 and 4. Several different color chalks were put on the side surfaces of the dummy to determine the contact points between the dummy and the vehicle's interior, as shown in table 4 below.

Table 4. Child dummy chalk colors.	
DUMMY PART	**COLOR**
Face	Blue
Top of head	Lime
Left side of head	Yellow
Back of head	Light blue
Left hip	Red
Left shoulder	Orange

RIGID POLE

The FOIL instrumented 300K rigid pole was designed to measure vehicle frontal and side crush characteristics. The rigid pole was set up in the side-impact configuration. The rigid pole side-impact configuration consisted of four solid half-circle steel impact faces mounted to two load cells via two high-strength connecting rods per face (eight load cells total). The diameter of the pole impact faces was 255 mm. The load cells measured the forces exerted on the pole at each location. This provided insight into what structures on the vehicle produced the significant loads. Because of channel limitations, data from the top two load cells was not recorded. The Honda Accord's profile was not high enough to make contact with the top impact-face. The data channels were used to record other pertinent electronic data. Data from six load cells were recorded during this test. The 300K rigid pole was mounted in line with the target impact location, aligned with the cg of the dummy's head. The rigid pole can be moved laterally in either direction in 50-mm increments. The pole was placed in the FOIL foundation pit aligned with the dummy head cg. If the rigid pole mounting plate did not align properly with the holes of the foundation base plate, it was moved to the closest bolt hole position. This pole position restriction can produce a maximum ±25-mm misalignment between the dummy head cg and the rigid pole centerline.

A spike (e.g., sharpened welding rod) was affixed to one impact face to verify the impact location by physically puncturing the vehicle body. Figure 5 is a sketch of the FOIL 300K rigid pole (side-impact configuration).

INSTRUMENTATION

Electronic data from the crash test were recorded via two data acquisition systems, the FOIL umbilical cable system, and the FOIL onboard data acquisition system (ODAS). A total of 53 channels of electronic data were recorded. The FOIL data acquisition systems recorded the maximum channel capacity. Five less vehicle sensors and two less rigid pole load cells were recorded than in previous FMVSS 201 broadside crash tests conducted at the FOIL. This enabled 20 data channels to be assigned to the 6-year-old child dummy sensors. The umbilical cable system recorded 13 data channels and the remaining 40 data channels were recorded by the ODAS. In addition to electronic data, high-speed cameras were used to record the test on film, which was analyzed to acquire pertinent test data. The following is a summary of the electronic data collected:

Vehicle instrumentation.

• Cg triaxial accelerometer (A_x,A_y,A_z)	3 channels
• Cg redundant accelerometer for A_y	1 channel
• An accelerometer on driver seat (A_y)	1 channel
• Cg triaxial rate sensor (pitch,roll,yaw)	3 channels

SID/HIII instrumentation.

• Triaxial accelerometer dummy head (A_x,A_y,A_z)	3 channels
• Four dummy rib accelerometers (A_y)	4 channels
• Two dummy T12 spine accelerometers (A_y)	2 channels
• One dummy pelvis accelerometer (A_y)	1 channel
• Six dummy neck sensors (F_x,F_y,F_z,M_x,M_y,M_z)	6 channels

6-year-old child HYBRID III instrumentation.

• Triaxial accelerometer dummy head(A_x,A_y A_z)	3 channels
• Triaxial accelerometer dummy chest (A_x,A_y,A_z)	3 channels
• Triaxial accelerometer dummy pelvis (A_x,A_y,A_z)	3 channels
• Six dummy upper neck sensors (F_x,F_y,F_z,M_x,M_y,M_z)	6 channels
• Two dummy lower neck sensors (F_y,M_x)	2 channels
• Three dummy lumbar sensors (F_y,F_z,M_x)	3 channels

Rigid pole instrumentation.

• Six rigid pole load cell channels (F_y)	6 channels

Miscellaneous.

• Impact and speed trap switches	2 channels
• 1 kHz timing signal for analog tape	1 channel

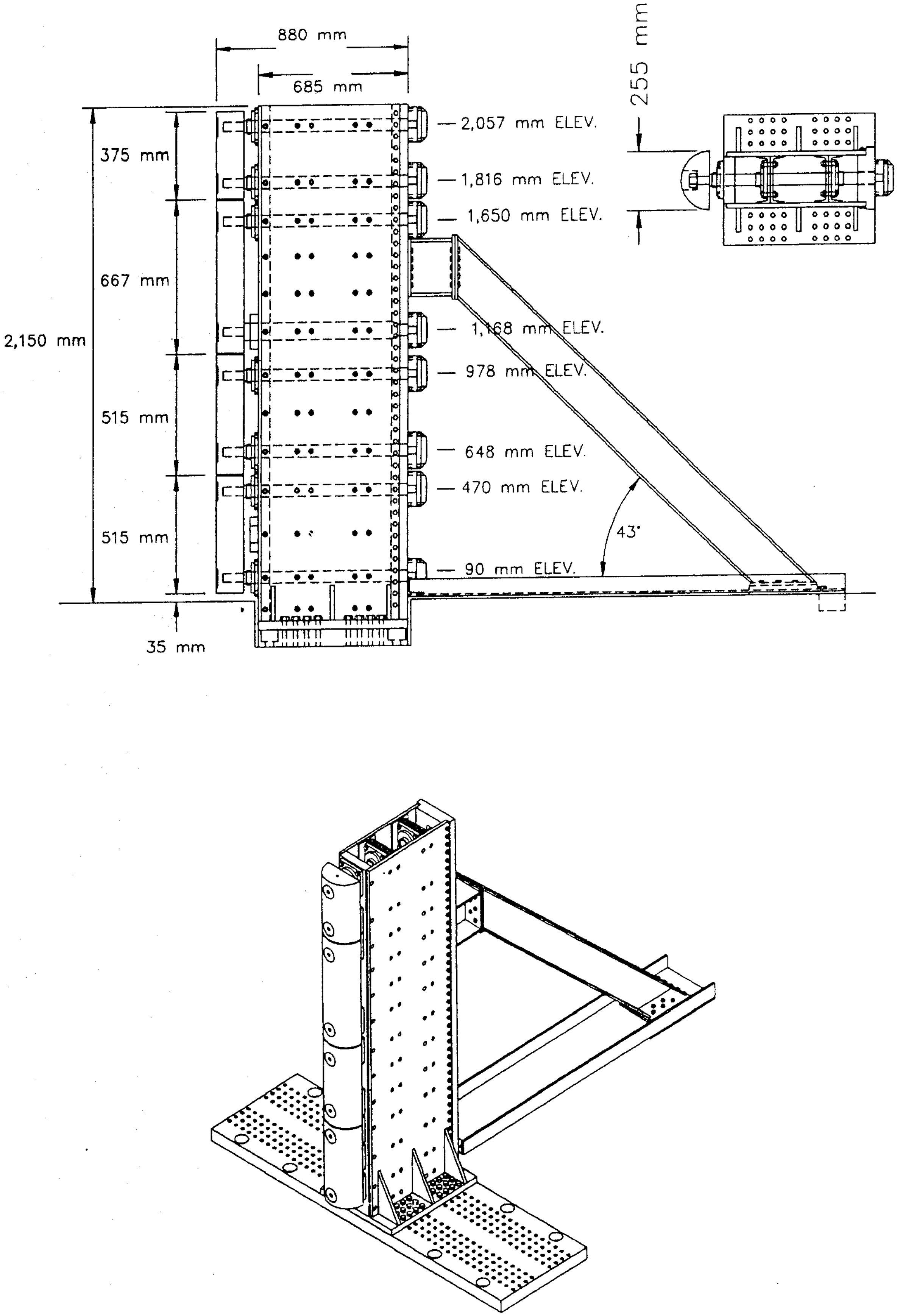


Figure 5. FOIL 300K instrumented rigid pole.

Table 5 provides specific channel assignments. The first 40 channels were ODAS channels including the 26 instrumented dummy channels (shaded entries). The remaining channels were recorded via the umbilical cable tape recorder system.

Two methods for mounting accelerometers were used to affix the sensors to the test vehicle. The accelerometers were supplied with two small machine screws and a small 12-mm aluminum block. The first method used the accelerometer screws to mount the accelerometer to a small 25-mm^2, 6-mm thick steel plate, that was mounted to the vehicle using self-tapping sheet metal screws. This method was employed for the driver seat accelerometer. The second method used the aluminum block screwed to the small square-steel plate, that was welded to a larger, thicker plate. The larger plate was fastened to the vehicle using large self-tapping screws. This method was used for the accelerometers affixed to the engine block and in the trunk.

Onboard data acquisition system

The ODAS collected 40 channels of data. The data were from cg, driver seat, three rate transducers, 16 SID/HIII channels, and 20 6-year-old child dummy channels. The output from the sensors were pre-filtered, digitally sampled, and digitally stored within the ODAS units mounted directly to the test vehicle inside the occupant compartment. The ODAS units are factory set with a 4000 Hz analog pre-filter and a digital sampling rate of 12,500 Hz.

Tape recorder-umbilical

The FOIL umbilical cable system utilizes a 90-m cable between the vehicle transducers, rigid pole load cells, or other sensors and a rack of 10 signal conditioning amplifiers. The output from the amplifiers was recorded on 25-mm magnetic tape via tape recorder. After the test, the tape was played back through anti-aliasing filters then input to a data translation analog-to-digital converter (ADC). The sample rate was set to 5,000 Hz. The system recorded outputs from the six rigid pole load cells, three cg accelerometers, the monorail speed trap, and an impact contact switch to electronically mark first contact between the vehicle and rigid pole. The speed trap signals and the impact contact switch were not conditioned before being recorded.

The speed trap consisted of a single micro switch mounted to the monorail 4.2 m from the rigid pole. The wheels from the main side-impact carriage trip the switch as the vehicle passes over the speed trap. The distance between the two main carriage wheels is 1015 mm.

Table 5. Summary of instrumentation.			
ODAS III onboard data system			
Reference & Channel	**Transducer**	**Max. range**	**Data description**
1	Accelerometer	2000 g's	Head, X-axis
2	Accelerometer	2000 g's	Head, Y-axis
3	Accelerometer	2000 g's	Head, Z-axis
4	Accelerometer	2000 g's	Upper rib, Y-axis (P)
5	Accelerometer	2000 g's	Upper rib, Y-axis (R)
6	Accelerometer	2000 g's	Lower rib, Y-axis (P)
7	Accelerometer	2000 g's	Lower rib, Y-axis (R)
8	Accelerometer	2000 g's	Lower spine, Y-axis, T12 (P)
9	Accelerometer	2000 g's	Lower spine, Y-axis, T12 (R)
10	Accelerometer	2000 g's	Pelvis, Y-axis
11	Load cell	9000 N	Neck force, X-axis
12	Load cell	9000 N	Neck force, Y-axis
13	Load cell	9000 N	Neck force, Z-axis
14	Load cell	282 N·m	Neck moment, X moment
15	Load cell	282 N·m	Neck moment, Y moment
16	Load cell	340 N·m	Neck moment, Z moment
17	Accelerometer	2000 g's	6-yr old head, X-axis
18	Accelerometer	2000 g's	6-yr old head, Y-axis
19	Accelerometer	2000 g's	6-yr old head, Z-axis
20	Accelerometer	2000 g's	6-yr old chest, X-axis
21	Accelerometer	2000 g's	6-yr old chest, Y-axis
22	Accelerometer	2000 g's	6-yr old chest, Z-axis
23	Accelerometer	2000 g's	6-yr old pelvis, X-axis
24	Accelerometer	2000 g's	6-yr old pelvis, Y-axis
25	Accelerometer	2000 g's	6-yr old pelvis, Z-axis
26	Load cell	9000 N	6-yr old upper neck force, X-axis

Table 5. Summary of instrumentation (continued).

27	Load cell	9000 N	6-yr old upper neck force, Y-axis
28	Load cell	13,350 N	6-yr old upper neck force, Z-axis
29	Load cell	282 N·m	6-yr old upper neck moment, X moment
30	Load cell	282 N·m	6-yr old upper neck moment, Y moment
31	Load cell	282 N·m	6-yr old upper neck moment, Z moment
32	Load cell	4450 N	6-yr old lower neck force, Y-axis
33	Load cell	226 N·m	6-yr old lower neck moment, X moment
34	Load cell	4450 N	6-yr old lumbar force, Y-axis
35	Load cell	7,000 N	6-yr old lumbar force, Z-axis
36	Load cell	226 N·m	6-yr old lumbar moment, X moment
37	Accelerometer	100 g's	Y-axis, cg data
38	Rate transducer	500 deg/s	Pitch rate, cg
39	Rate transducer	500 deg/s	Roll rate, cg
40	Rate transducer	500 deg/s	Yaw rate, cg
Umbilical cable, tape recorder system.			
1	Accelerometer	100 g's	Cg, Y-axis
2	Accelerometer	100 g's	Cg, X-axis
3	Accelerometer	100 g's	Cg, Z-axis
4	Accelerometer	2000 g's	Driver seat track
5	Load Cell	222 kN	Upper middle face, upper load cell
6	Load Cell	111 kN	Upper middle face, lower load cell
7	Load Cell	222 kN	Lower middle face, upper load cell
8	Load Cell	222 kN	Lower middle face, lower load cell

Table 5. Summary of instrumentation (continued).			
9	Load Cell	222 kN	Bottom face, upper load cell
10	Load Cell	222 kN	Bottom face, lower load cell
11	Contact switch	1.5 Volts	Time of impact, T0
12	Micro switch	1.5 Volts	Mono-rail speed trap
13	Generator	1.5 Volts	1 kHz reference signal

High-speed photography

A total of 10 high-speed cameras were used to record the side-impact collision. All high-speed cameras were loaded with Kodak color-daylight film 2253. The cameras operated at 500 frames per second and were positioned for best viewing of the contact between the Honda Accord and the 300K rigid pole. Three 35-mm still cameras and one 16-mm real-time telecine camera were used to document the pre- and post-crash environment. Table 6 lists each camera and lens used and the three-dimensional location of the camera lens. The three-dimensional coordinates were measured from the ground underneath the center of the semicircular impact faces of the rigid pole (origin) to the camera lenses. The camera numbers in table 6 are shown in figure 6. The interior of the two left-side doors were painted flat white for better onboard camera image quality.

Table 6. Camera configuration and placement.

Camera Number	Type	Film speed (frames/s)	Lens (mm)	Orientation/ Location (m)
1	LOCAM II	500	50	90° to impact right side (21.3, 0.91, 0.10)
2	LOCAM II	500	100	90° to impact right side (22.2, 0.08, 1.9)
3	LOCAM II	500	50	45° oblique right side (11.4, 11.3, 0.8)
4	PHOTEC	500	80	45° oblique right side (21.3, 15.1, 0)
5	LOCAM II	500	75	45° left side (10.1, 14.0, 0.10)
6	LOCAM II	500	35	45° left side (11, 14.1, 0.7)
7	LOCAM II	500	25	180° to impact behind pole (0, 13.9, 0.8)

Table 6. Camera configuration and placement (continued).				
8	LOCAM II	500	12.5	overhead, over rigid pole (0, 0, 7.9)
9	LOCAM II	500	5.7	onboard rear passenger window
10	LOCAM II	500	5.7	onboard passenger window
11	BOLEX	24	zoom	documentary
12	CANON A-1 (prints)	still	zoom	documentary
13	CANON A-1 (slides)	still	zoom	documentary

Black and yellow circular targets, and black and yellow target tape 25-mm wide, were placed on the Honda Accord and rigid pole for film-data collection purposes. Circular targets and target tape were placed on the vehicle for certain vehicle measurements and for film analysis. The 25-mm tape was placed on the driver side of the vehicle at five levels or elevations referenced from the ground. The levels were:

- LEVEL 1 -- Axle centerline or lower door sill top height.
- LEVEL 2 -- Occupant H-point height.
- LEVEL 3 -- Mid-door height.
- LEVEL 4 -- Window sill height.
- LEVEL 5 -- Top of window height on roof rail.

In addition, target tape was placed vertically on the driver side of the vehicle coincident with the pole impact location. Target tape was also placed on top of the vehicle in the following locations:

- Along the longitudinal centerline the full length of the vehicle, excluding windows.
- Laterally across the roof perpendicular to the centerline tape and coincident with the rigid pole impact location.
- Laterally across the roof perpendicular to the centerline tape and coincident with the vehicle B-pillar.

Target tape was placed laterally on the front and rear bumpers in the YZ plane. Two vertical strips were placed on the rigid pole adjacent to and just rearward of the circular impact faces.

Black and yellow circular targets 100-mm in diameter were placed at various locations on the test vehicle for film data collection purposes. The targets were placed in the following locations:

- Driver door to denote the vehicle longitudinal cg.
- Driver door to denote the dummy H-point.

- The roof to denote the vehicle's longitudinal and lateral cg location.
- Two targets on the roof aligned with the vehicle longitudinal centerline 760 mm apart centered on the rigid pole centerline.
- Two targets aligned with the B-pillar centerline 610 mm apart centered on the vehicle's longitudinal centerline.
- Two targets on the hood aligned with the vehicle's longitudinal centerline 610 mm apart.
- Two targets on the trunk aligned with the vehicle's longitudinal centerline 255 mm apart.
- Two targets were placed on the front and back side of a vertical sheet metal stanchion fixed to the roof rearward of the B-pillar, centered on the longitudinal centerline and 610 mm apart.
- One target on top of the rigid pole's top semicircular impact face.
- Two targets on the front and rear bumper (YZ plane) 610 mm apart centered on the longitudinal centerline.

Figure 6 presents a side view of the test vehicle, showing the target tape locations. Figure 6 also contains an overhead sketch of the facility depicting the setup of the vehicle, rigid pole, test track, and the location of each high-speed camera. Positioned in each camera's view was at least one strobe light. The lights flashed when the vehicle struck the pole. This synchronized the film with the electronic data.

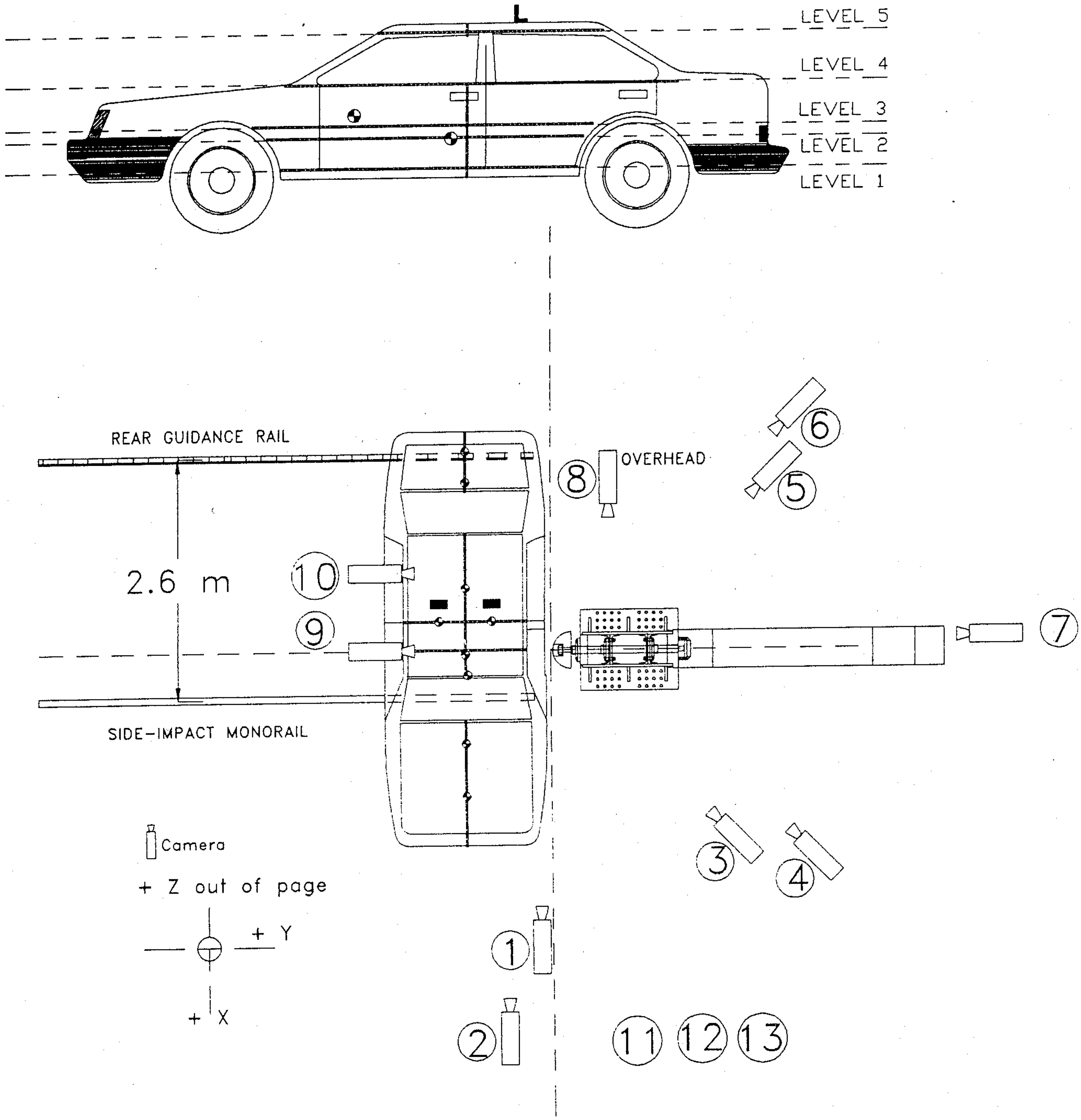


Figure 6. Camera locations and test setup.

DATA ANALYSIS

Two data acquisition systems, the ODAS unit and the umbilical cable system, along with high-speed cameras were used to record the data during the side-impact crash test.

ODAS. The data from the ODAS unit included 26 channels of dummy data, one accelerometer channel, and three rate transducer channels. The data were filtered and digitally stored within the ODAS unit during the test. The filter was factory set at 4,000 Hz. The ADC sampling rate was factory set at 12,500 Hz. After the test, the data were downloaded to a portable computer for analysis. The data were converted to the ASCII format, zero-bias removed, and digitally filtered at 1,650 Hz (Society of Automotive Engineers (SAE) class 1000). The SID/HIII, rib, spine, and pelvic data were filtered a second time using a NHTSA-supplied FIR100 filter. The class-1000 data were input into a spreadsheet for plotting. The resultant head acceleration for both dummies was calculated via a spreadsheet containing the data from the triaxial accelerometer inside each of the dummy heads. The resultant acceleration data files were fed into a HIC algorithm to compute the HIC values for the crash test. The SID/HIII pelvic injury was equal to the peak SID/HIII pelvic acceleration data. The pelvic data were filtered using the FIR100 filter, and the peak was located. The TTI was calculated from the FIR100 filtered rib and spine (T12) data. A TTI was only calculated for the SID/HIII. The following formula was used to compute the SID/HIII TTI:

$$TTI = [\text{Maximum}(4 \text{ rib channels}) + \text{Maximum}(\text{spine})] \div 2$$

Umbilical cable. Data collected via the umbilical cable tape recorder system was played back through an analog filter set at 1000 Hz. The signal was then input to a data translation ADC. The data included six load cell channels, four accelerometer channels (located at the cg and driver seat track), an impact switch, and a monorail speed trap signal. The sample rate was set to 5,000 Hz. The digital data were converted to the ASCII format, zero-bias removed, and digitally filtered to 1,650 Hz (SAE class 1000). The filtered data were input into a spreadsheet for plotting. The total force exerted on the rigid pole was computed by adding all eight load cell data signals and reading a peak from the combined force-time history.

Two square wave pulses from the lone monorail micro switch were recorded on analog tape during the crash test. The time between pulses was determined, and the speed was calculated by dividing the wheel spacing (1015 mm) by the time between micro switch pulses.

High-speed film. The high-speed 16-mm film was analyzed via an NAC 160-F film motion analysis system in conjunction with an IBM PC-AT. The overhead and one 90-degree camera were used to acquire pertinent test data. The analyzer reduced the test film frame by frame to Cartesian coordinates that were input into a spreadsheet for analysis. Using the coordinate data and the known speed of the cameras, a displacement-time history was produced. Differentiation of the displacement-time history produced the initial vehicle speed. Data measurements included initial vehicle impact speed, impact roll angle, impact yaw angle, and impact pitch angle.

RESULTS

The Honda Accord was placed on the FOIL side-impact monorail with its longitudinal centerline perpendicular to the rigid pole centerline. The morning of the test, the SID/HIII was positioned in the driver seat using the H-point data and FMVSS 214. The dummy was repositioned to the final position by adjusting the seat back angle and seat track until the proper head-to-B-pillar clearance was achieved. The final head clearance was 58 mm. The child dummy was placed in the left rear outboard seat. He was positioned following the NHTSA-supplied rear passenger seating procedure. Because of the rigid pole position limitations, the rigid pole centerline was 22 mm forward of the SID/HIII head cg. The SID/HIII was restrained using the vehicle's three-point shoulder-lap belt restraining system. The child dummy was restrained using ONLY the lap belt portion of the three-point belt system. The shoulder belt was placed behind the child dummy. Just before testing, the following was noted: the emergency brake was placed in the engaged position, the head rests were positioned in the highest adjustment, the two front seats were aligned, the windows were down, the transmission was placed in neutral, and the key was placed in the "on" position. The Honda Accord passed over the monorail speed trap, which produced an initial vehicle speed of 29.6 km/h. The initial roll angle was found to be equal to the original roll attitude measured before testing (approx. 0.5 degrees). The impact yaw angle could not be determined because of an overhead camera malfunction. Table 7 summarizes the test conditions and selected results.

Table 7. Summary of test conditions and results.

FOIL test number	98S007
Date of test	May 7, 1998
Test vehicle	1995 Honda Accord LX
Vehicle weight	1502 kg
Test article	FOIL instrumented 300K rigid pole
Temperature inside vehicle	20.9 °C
Impact speed: speed trap	29.6 km/h

Table 7. Summary of test conditions and results (cont'd).	
16-mm Film	29.3 km/h
Impact yaw angle	N/A
Head impact point	25 mm forward of head cg
Vehicle impact point (mm)	300 mm rearward of vehicle cg
Head-to-B-pillar clearance	58 mm
Traffic accident data (TAD)	9-LP-7
Vehicle damage index (VDI)	09LPAN5
SID/HIII Head Injury Criteria (HIC)	
Limit	1000 g's
Observed	3726 g's
Start time	0.059 s
Stop time	0.060 s
Interval time	0.001 s
SID/HIII Thoracic Trauma data	
Limit (4-door)	85 g's
Peak rib acceleration (FIR100)	46.5 g's
T12 spine (FIR100)	56.3 g's
Thoracic Trauma Index (TTI)	51 g's
Pelvic injury (limit 130g's)	no data
6-year-old child dummy Head Injury Criteria (HIC)	
Limit	1000 g's
Observed	234 g's
Start time	0.096 s
Stop time	0.110 s
Interval time	0.014 s

<u>Vehicle response.</u> The sharpened rod that is attached to the rigid pole punctured the vehicle on the vertical target tape centerline, denoting the intended target location. The driver door cross section and floor sill began to collapse on contact with the rigid pole. The door had collapsed by 0.032 s. The intruding door struck the dummy's shoulder at approximately 0.024 s. The rigid pole continued to penetrate the occupant

compartment, collapsing the B-pillar and rear door inward. The B-pillar struck the driver seat, the seat began to tip, drop down, and rotate 0.028 s after initial contact. The roof rail made contact with the rigid pole at 0.054 s. Double integration of the cg acceleration-time history and the total rigid pole force-time history yielded a maximum dynamic intrusion of 614 mm and 734 mm, respectively. The load cell load versus time histories did not return to zero-scale after the test. The zero-bias caused an exaggerated dynamic intrusion when integration of the total load versus time history was performed. A static measurement was taken between the front door interior surfaces before and after the test. The net change (static intrusion) was 498 mm. The driver seat collapsed and pinched the dummy's lower torso in the seat. The seat was pushed into and leaning behind the passenger seat. The intruding B-pillar caused the rear door to collapse, and the rear child-safety window shattered outward away from the child dummy at 0.034 s. However, some glass fell into the rear occupant's compartment onto the child dummy.

The impact location was 300 mm rearward of the vehicle cg. The lever induced a yaw into the vehicle after the peak load was reached. After the test, the vehicle front end had yawed 27 degrees. The vehicle rebounded away from the pole as it continued to yaw counterclockwise (as seen from above). Contact between the main carriage and monorail impeded the vehicle motion, limiting the yaw and rebound. The four-door latches remained latched during the collision. No evidence of fuel leakage or fuel system component damage was observed. The driver air bag did not deploy during the test. The peak cg acceleration was determined to be 18.4 g's (271 kN) and occurred 0.0402 s after impact. Table 8 lists the vehicle accelerometers and their three-dimensional coordinate location referenced from the right front wheel hub. The right front wheel hub was 290 mm above ground (not on guidance rails). Included in the table are peak accelerations from each accelerometer (SAE class 60 data).

Table 8. Vehicle sensor locations and peak measurements.

Sensor	X (mm)	Y (mm)	Z (mm)	Peak g's (+)	Peak g's (-)
cg accelerometer A_x	-1020	-850	+348	4.6	3.0
cg accelerometer A_y	-1020	-850	+348	1.6	17.6
cg accelerometer A_z	-1020	-850	+348	10.0	7.2
cg redundant A_y	-1020	-850	+348	2.7	17.6
Driver seat A_y	-1495	-1435	+260	13.4	92.4

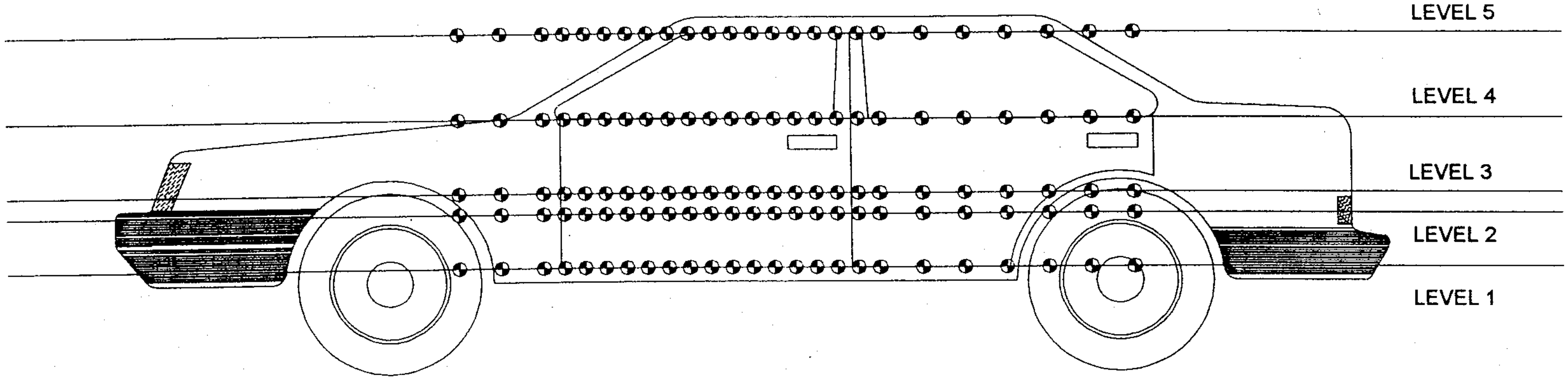
After the test, damage profile measurements were taken using two techniques. Table 9 summarizes the damage profile distance (DPD) technique. Figure 7 depicts the driver-side profile measurements before and after the test. The measurements were made using a reference line parallel to the driver side of the vehicle. The parallel line was drawn a certain distance from and perpendicular to a line formed by the passenger side sill across from the impact location. This allowed the same reference line to be drawn after the test to measure the post-test measurements. The measurements were made in 75- and 150-mm increments forward and aft of the impact point. Aft er the test, measurements were taken at the same points forward and aft, rather than measuring at the same increments. From the figure, the maximum static deflection recorded was 541 mm at the sill height 76 mm rearward of the vertical impact target tape.

Data plots of the data from transducers mounted to the test vehicle are presented in appendix A. Photographs taken from high-speed film during impact and photographs of the pre- and post-test environment are presented in appendix D.

Table 9. DPD crush measurments.

L	D	Max	LF	C1	C2	C3	C4	C5	C6	LR
1830	-324	549	-810	0	176	514	311	76	0	1020

All measurements in mm.
L = total length of crush.
D = distance from vehicle cg to mid-point of L
Max = maximum crush
LF, LR = distance from impact point to points forward and rearward where no damage was observed.
C1-6 = incremental crush measurements along L, equally spaced.



Level 1 - Sill height   Level 2 - Occupant H-point   Level 3 - Mid-door   Level 4 - Window sill   Level 5 - Window top

			Distance from impact point (mm).										
LEVEL	HEIGHT		-1219	-1050	-900	-750	-600	-450	-300	-225	-150	-75	0
5	1334	PRE									897	895	884
	1368	POST									1015	1050	1089
		CRUSH	0	0	0	0	0	0	0	0	118	155	205
4	893	PRE	610	623	622	626	616	616	622	622	626	624	623
	898	POST	578	589	598	622	652	753	848	897	946	1005	1044
		CRUSH	-32	-34	-24	-4	36	137	226	275	320	381	421
3	574	PRE		552	553	555	558	556	554	552	552	553	549
	590	POST		542	546	607	674	788	893	936	991	1028	1063
		CRUSH	0	-10	-7	52	116	232	339	384	439	475	514
2	495	PRE			545	546	551	549	548	546	541	542	541
	455	POST			557	622	685	763	861	914	976	1025	1073
		CRUSH	0	0	12	76	134	214	313	368	435	483	532
1	280	PRE			593	591	587	586	583	582	580	576	576
	280	POST			612	662	715	764	836	891	954	1015	1053
		CRUSH	0	0	19	71	128	178	253	309	374	439	477
All units of measurement are in mm.													

Figure 7. Vehicle profile measurements, test 98S007.

			Distance from impact point (mm).									
LEVEL	HEIGHT		75	150	225	300	450	600	750	900	1050	1219
5	1334	PRE	888	886	882	876	877	878	878	881		
	1368	POST	1085	1082	1090	1042	988	944	903	893		
		CRUSH	197	196	208	166	111	66	25	12	0	0
4	893	PRE	622	619	618	618	622	618	614	616	619	610
	898	POST	1074	1086	1104	1034	955	864	795	723	657	591
		CRUSH	452	467	486	416	333	246	181	107	38	-19
3	574	PRE	548	542	542	541	533	528	522	515	515	
	590	POST	1084	1051	979	922	836	745	656	531	518	
		CRUSH	536	509	437	381	303	217	134	16	3	0
2	495	PRE	538	535	533	535	527	526	524	526		
	455	POST	1079	1052	968	928	823	737	634	538		
		CRUSH	541	517	435	393	296	211	110	12	0	0
1	280	PRE	574	573	572	573	570	566	568	567		
	280	POST	1050	1021	969	902	803	704	613	528		
		CRUSH	476	448	397	329	233	138	45	-39	0	0

All units of measurement are in mm.

Figure 7. Vehicle profile measurements, test 98S007 (continued).

Occupant response. The SID/HIII remained vertical in the driver seat with only minor vibration induced by the tow and guidance system. The intruding door made first contact with the SID/HIII at the pelvis, femur, and leg 0.024 s after impact. The door and B-pillar struck the driver seat at 0.028 s. The bottom of the driver seat began to move to the right, rotate, and drop downward. The dummy leaned toward the pole, and the shoulder region struck the door at 0.032 s. The head made its first contact at 0.060 s. The dummy's head did not strike the B-pillar before striking the rigid pole. The tilt and rotation of the driver seat and the neck bending toward the pole, coupled with the initial pole alignment, caused the actual head contact point to be 25 mm forward and 50 mm above the head cg. The pole struck the head at the point where the side of the face ends and the top of the head begins. Green (top of head) and yellow (side of face) chalk found on the rigid pole verified the contact. The force on the lower portion of the dummy caused the dummy to pivot about the knees around the steering column. The left knee remained wedged between the door, dash, and steering column. The dummy's torso was first to rebound back across the vehicle, over the passenger side seat, and the neck whipped the head over, making the right side of the dummy's head hit the right shoulder.

After the test, no physical damage to the SID/HIII was observed. The dummy's final position was slumped over, leaning toward the passenger seat while his lower torso remained wedged in the driver seat. The dummy's feet remained free and were not pinched or crushed. However, the dummy's knees were wedged under and between the steering column, door panel, and dash panel. Orange chalk from the dummy's side was on the door as expected. Red chalk from the dummy's femur and leg was found on the driver door along and underneath the arm rest.

The rib and spine acceleration data produced a TTI of 51 g's. This is below the four-door vehicle limit of 85 g's specified in the FMVSS 214. The three head accelerometers produced a HIC value of 3726 g's. This value is above the 1000 g's required in the proposed FMVSS 201 amendment. The pelvis accelerometer completion resistors developed an intermittent break. No pelvic injury was recorded. Table 10 summarizes the data collected from the SID/HIII.

Table 10. Summary of SID/HIII data.

Recorded Data	Maximum positive	Maximum negative
Head X-axis acceleration (g's)	133.8	-22.7
Head Y-axis acceleration (g's)	10.4	-467.7
Head Z-axis acceleration (g's)	97.7	-211.8
X-axis neck force load cell (N)	694.9	-361.3

Table 10. Summary of SID/HIII data (continued).		
Y-axis neck force load cell (N)	386.1	-1461.5
Z-axis neck force load cell (N)	4889.9	-2003.2
X-axis neck moment load cell (1000 mm·N)	37.9	-76.7
Y-axis neck moment load cell (1000 mm·N)	14.1	-16.3
Z-axis neck moment load cell (1000 mm·N)	16.4	-20.4
Left upper rib acceleration (P)	6.1	-44.9
Left upper rib acceleration (R)	6.9	-45.8
Left lower rib acceleration (P)	9.4	-45.3
Left lower rib acceleration (R)	9.6	-46.5
Spine T12 Y acceleration (P)	20.2	-56.3
Spine T12 Y acceleration (R)	20.3	-55.2
Pelvis Y acceleration	No data	
Head and neck load data are SAE class 1000. Shaded area data are SAE class 600 (neck moment data). Remaining data obtained from FIR100 filter output.		

The values from the head accelerometers and the neck load cells were taken from class 1000 data (neck moment class 600) while the remainder are from data filtered using a FIR100 filter. Data plots from the SID/HIII transducers are presented in appendix B. All data plots are of class 1000 data.

6-year-old child dummy response. The child dummy remained vertical in the rear outboard seat with only minor vibration induced by the tow and guidance system. The intrusion by the B-pillar pushed the rear door inward. The child dummy's feet made slight contact with the leading edge of the door panel and B-pillar at 0.058 s. The contact induced a slight rotation of the child dummy in the seat. The child dummy fell over into the door panel. The head made contact with the trailing edge of the door panel at the lower window sill. The contact occurred 0.104 s after initial vehicle-to-pole contact. The child dummy bounced upward and rebounded back to the right. The child dummy did not rebound across to the right outboard seat. The child dummy's final position was leaning to the right with the legs pointed toward the front right seat.

The HIC computation was the only calculation performed on the child dummy data. The three head cg accelerometers were used to determine the resultant head acceleration. The resultant acceleration file was fed into a HIC algorithm which yield a HIC value of 234 g's (1000 g limit). The child dummy was instrumented for frontal crash testing. Therefore, TTI and pelvic injury could not be computed. Table 10 summarizes the data collected from the 6-year-old child dummy. The data contained in the table is either from SAE class 1000 or SAE class 600 data. Data plots from the child dummy transducers are presented in appendix C.

Table 11. Summary of 6-year-old child dummy data.

Recorded Data	Maximum positive (g's)	Maximum negative (g's)
Head X-axis acceleration	6.0	-16.3
Head Y-axis acceleration	2.5	-64.6
Head Z-axis acceleration	2.4	-16.2
Chest X-axis acceleration	4.4	-11.2
Chest Y-axis acceleration	2.4	-17.7
Chest Z-axis acceleration	6.2	-1.6
Pelvis X-axis acceleration	8.1	-9.6
Pelvis Y-axis acceleration	9.1	-25.5
Pelvis Z-axis acceleration	4.1	-6.2
X-axis upper neck force load cell (N)	305	-49
Y-axis upper neck force load cell (N)	204	-147
Z-axis upper neck force load cell (N)	378	-466
Upper neck X-moment load cell (m·N)	18.1	-7
Upper neck Y-moment load cell (m·N)	11.3	-20
Upper neck Z-moment load cell (m·N)	7.4	-4.3
Y-axis lower neck force load cell (N)	93	-349
Lower neck X-moment load cell (m·N)	12.2	-30.5

Table 11. Summary of 6-year-old child dummy data (cont'd).		
Y-axis lumbar force load cell (N)	206	-433
Z-axis lumbar force load cell (N)	543	-198
Lumbar X-moment load cell (m·N)	32	-15
Shaded area data are SAE class 600 (neck moment data). Remaining data are SAE class 1000.		

<u>Rigid pole.</u> The load cells measured eight separate forces on the rigid pole. The total load from summing the eight load cells was 113,100 N. The significant loads were contributed by the roof-rail, floor-sill, and middle-point of the driver's door. Table 12 summarizes the load cell data (SAE class 60). Data plots from the rigid pole load cells are presented in appendix E.

Table 12. Summary of rigid pole data.

Load cell/height (mm)	**Peak force (1000 N)**	**Time (ms)**
Middle-upper face	-21.2	61.0
Upper load cell/1,650	-8.3	61.6
Lower load cell/1,168	-13.0	60.8
Middle-lower face	-50.5	54.6
Upper load cell/978	-17.4	54.6
Lower load cell/648	-33.1	54.6
Bottom face	-47.8	59.0
Upper load cell/470	-32.0	57.8
Lower load cell/90	-18.3	74.0
Total, rigid pole	-113.1	60.8

CONCLUSIONS AND OBSERVATIONS

Visual inspection of the Honda Accord after the collision produced some immediate observations and conclusions. Fuel system and door latch integrity were not breached by the broadside collision with the FOIL's instrumented rigid pole. The impact speed and impact location were within reasonable tolerances, indicating accurate test procedures and setup. The dummy made direct contact with the rigid pole without interference from any vehicle structures, specifically the B-pillar. The direct contact yielded an HIC value (3726 g's) three times larger than values obtained during previous tests conducted where the dummy was seated with its head partially behind the B-pillar. The HIC (3726 g's) and TTI (51 g's) values from this test are similar to those computed after FOIL test number 97S005, that was conducted using similar test procedures and vehicles. The HIC, TTI and PELVIC injury for test 97S005 were 8824 g's, 68 g's, and 37.8 g's, respectively. Additional tests conducted using FMVSS 201 test procedures are FOIL test numbers 98S005 (1994 Ford Explorer) and 98S006 (1994 Toyota pickup). The results from these crash tests can be found in the reports *1994 Ford Explorer Broadside Collision with a Narrow Fixed Object: FOIL Test Number 98S005*[7] and *1994 Toyota Pickup Broadside Collision with a Narrow Fixed Object: FOIL Test Number 98S006*[8].

In cases where the B-pillar cannot serve as a countermeasure against injury during a broadside collision, a side dynamic head restraint system may aid in reducing occupant risk. The laboratory test procedures and setup described in this report may be used to evaluate the safety performance of side dynamic head restraint systems.

APPENDIX A. DATA PLOTS FROM VEHICLE ACCELEROMETERS

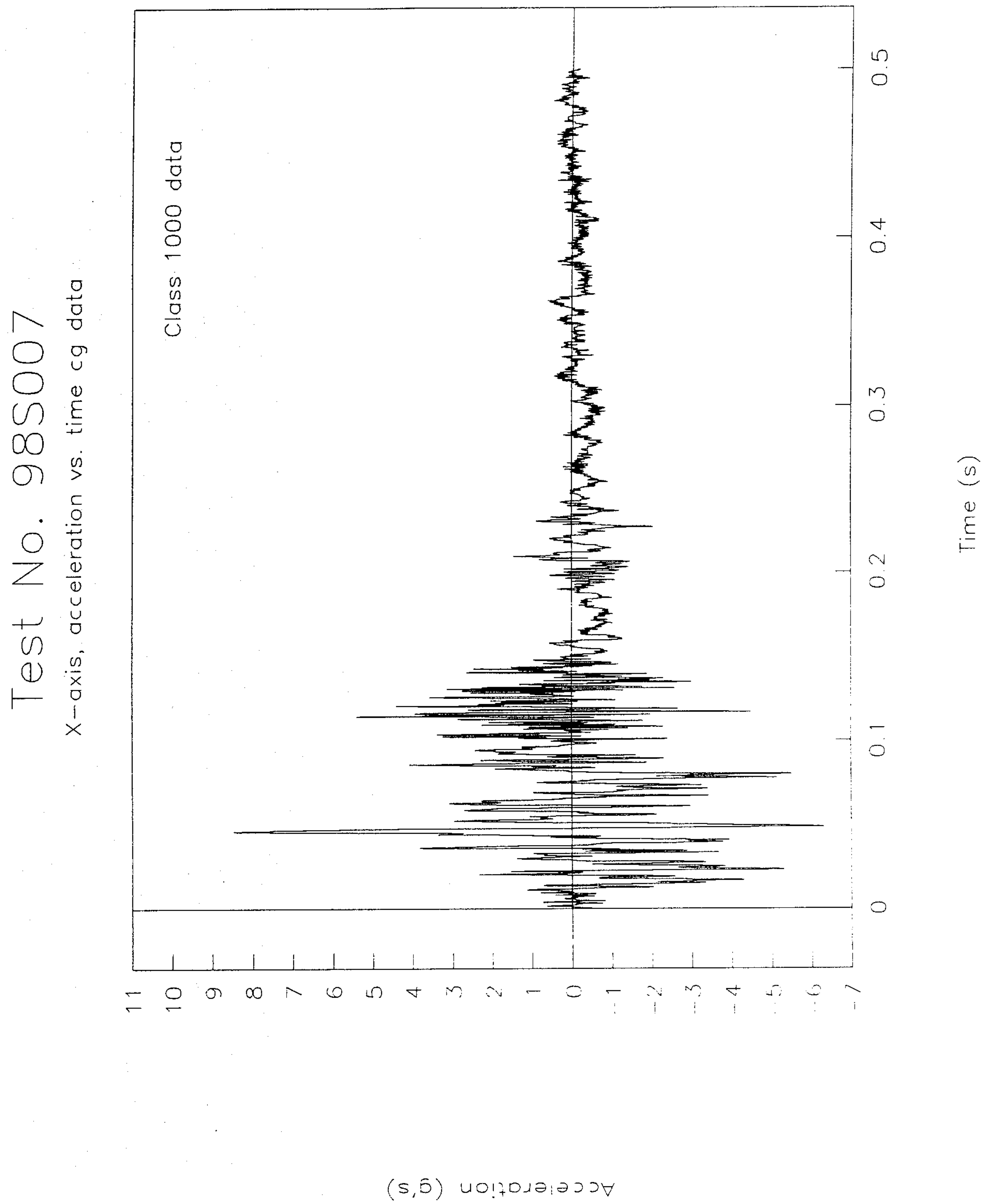


Figure 8. Acceleration vs. time, X-axis cg, test 98S007.

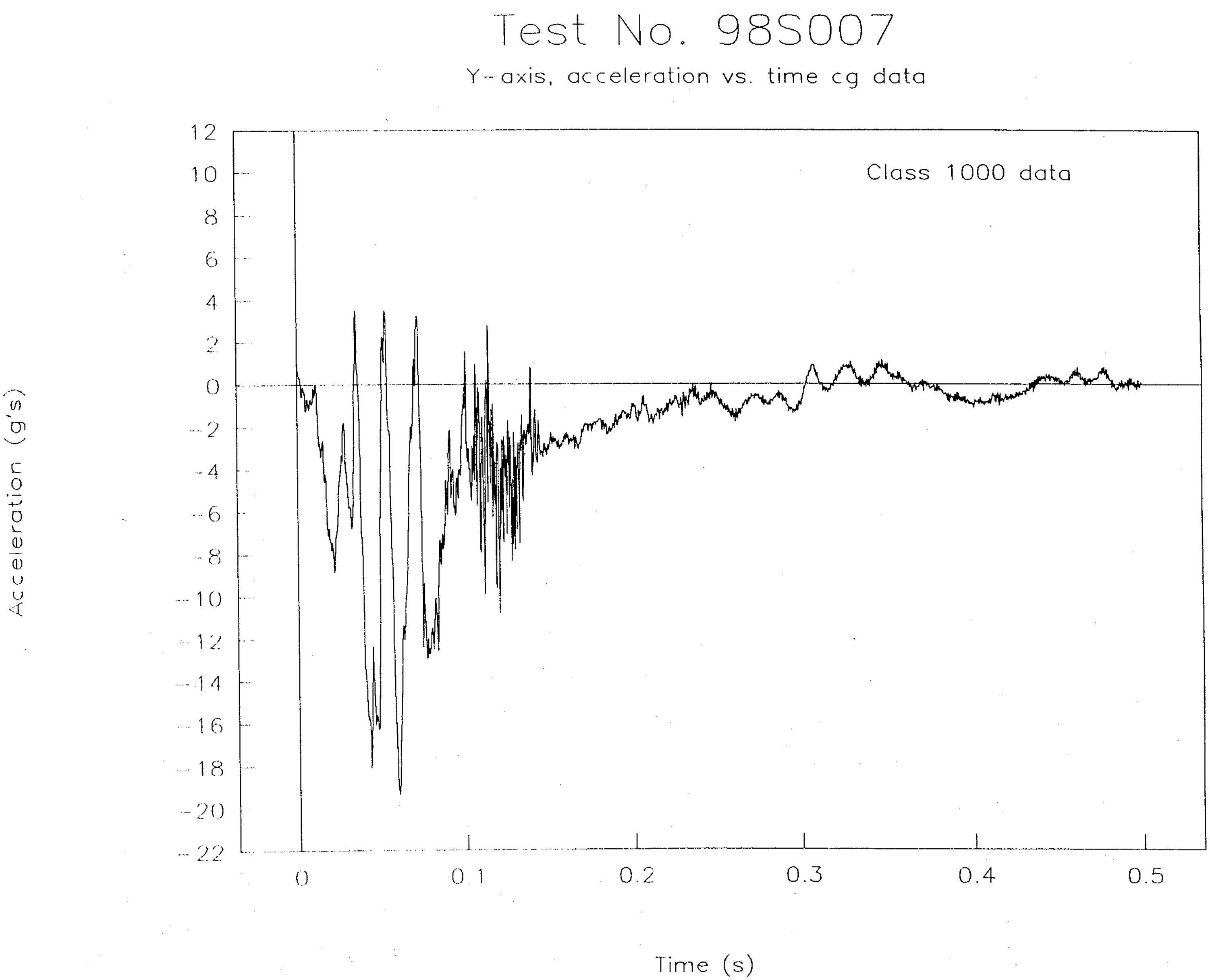


Figure 9. Acceleration vs. time, Y-axis cg, test 98S007.

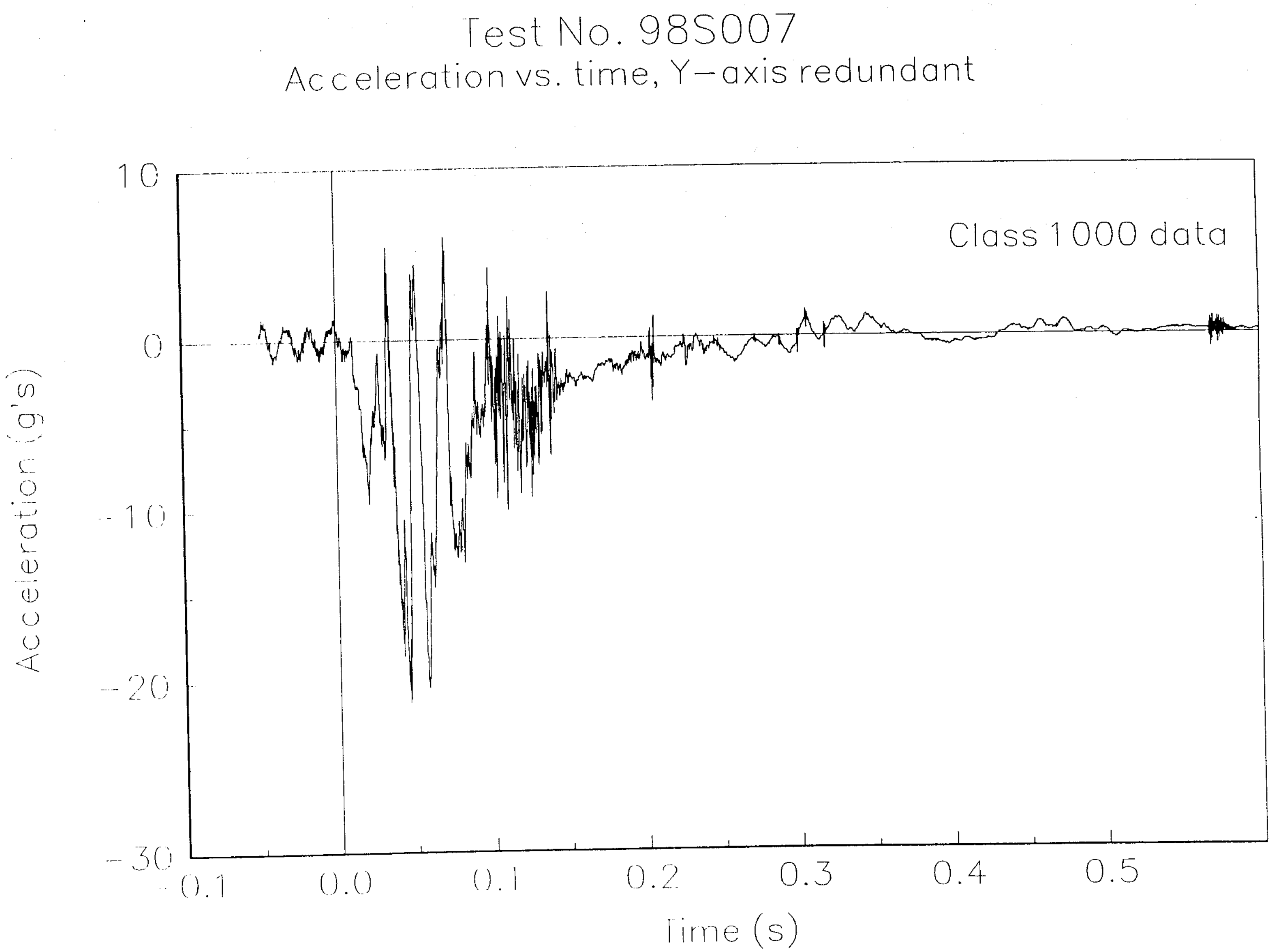


Figure 10. Acceleration vs. time, Y-axis redundant, test 98S007.

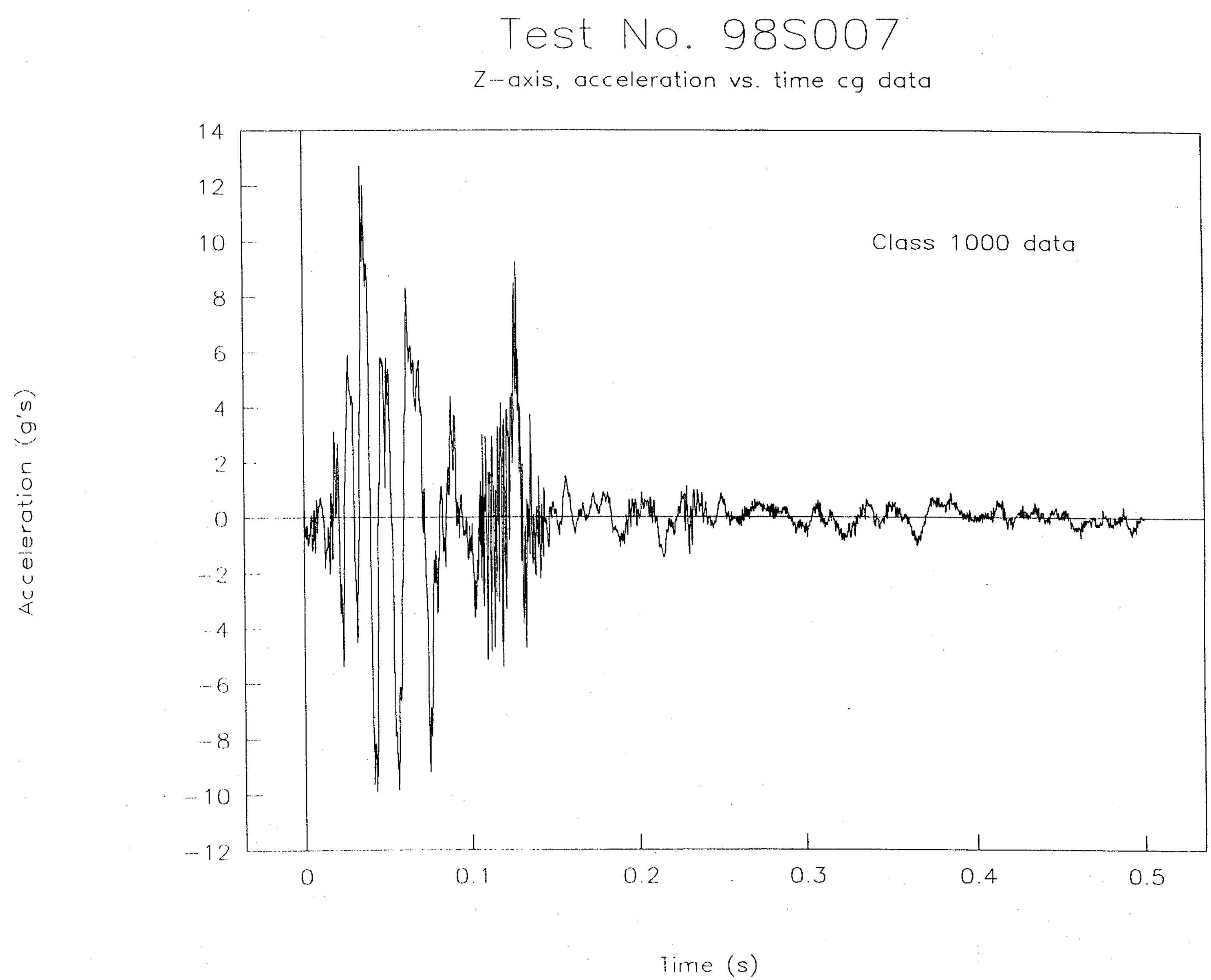


Figure 11. Acceleration vs. time, Z-axis cg, test 98S007.

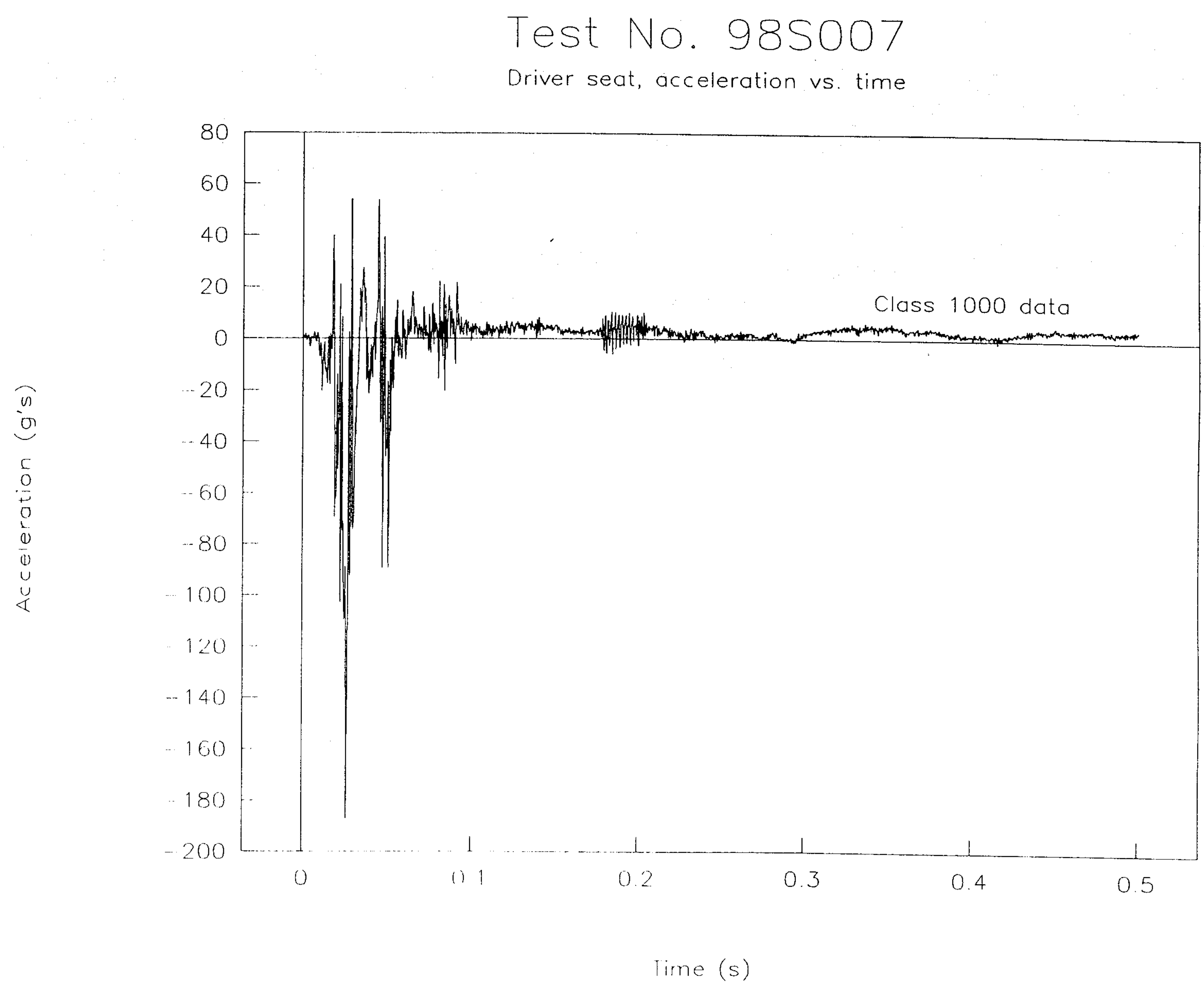


Figure 12. Acceleration vs. time, driver seat, test 98S007.

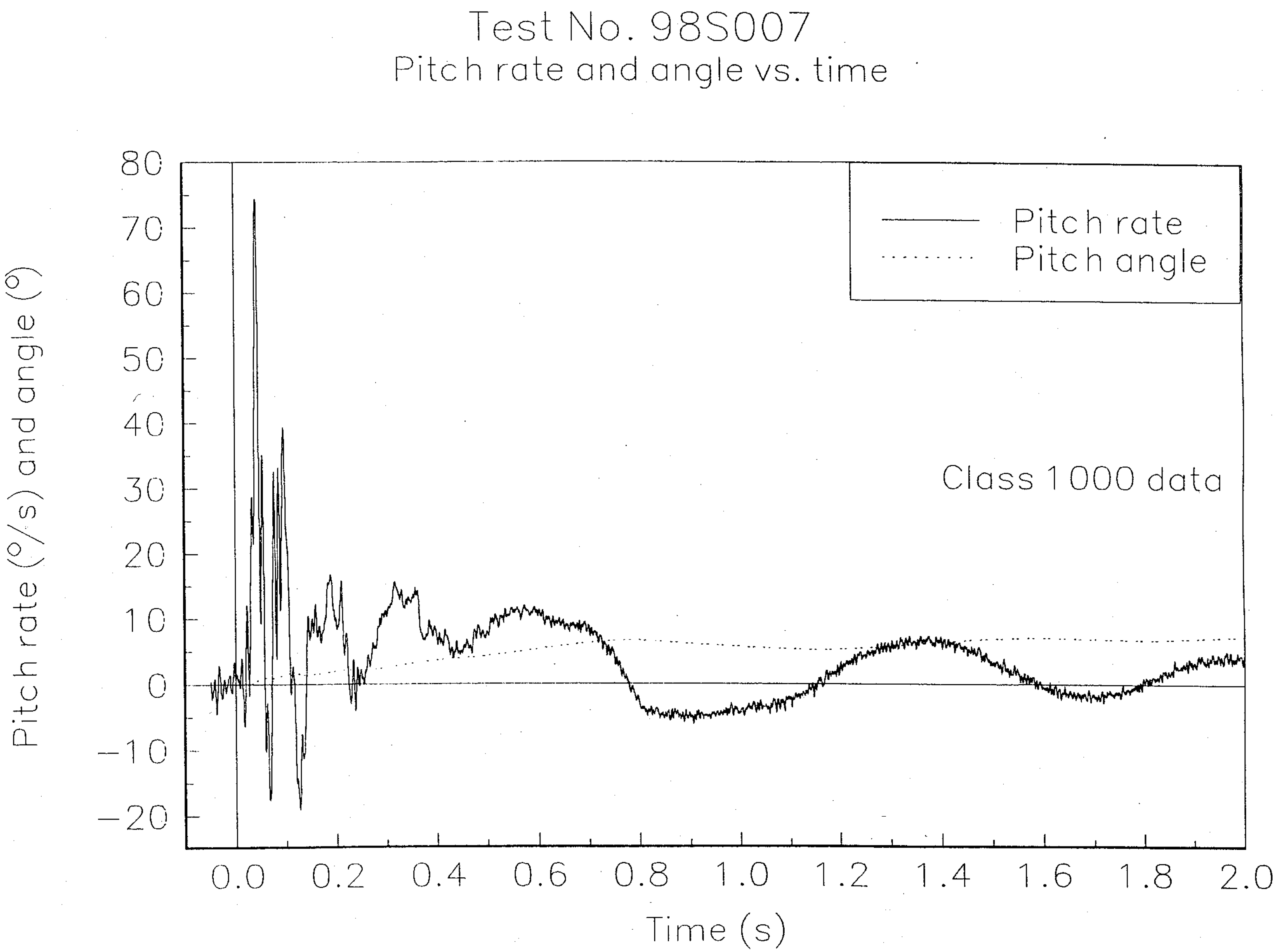


Figure 13. Pitch rate and angle vs. time, test 98S007.

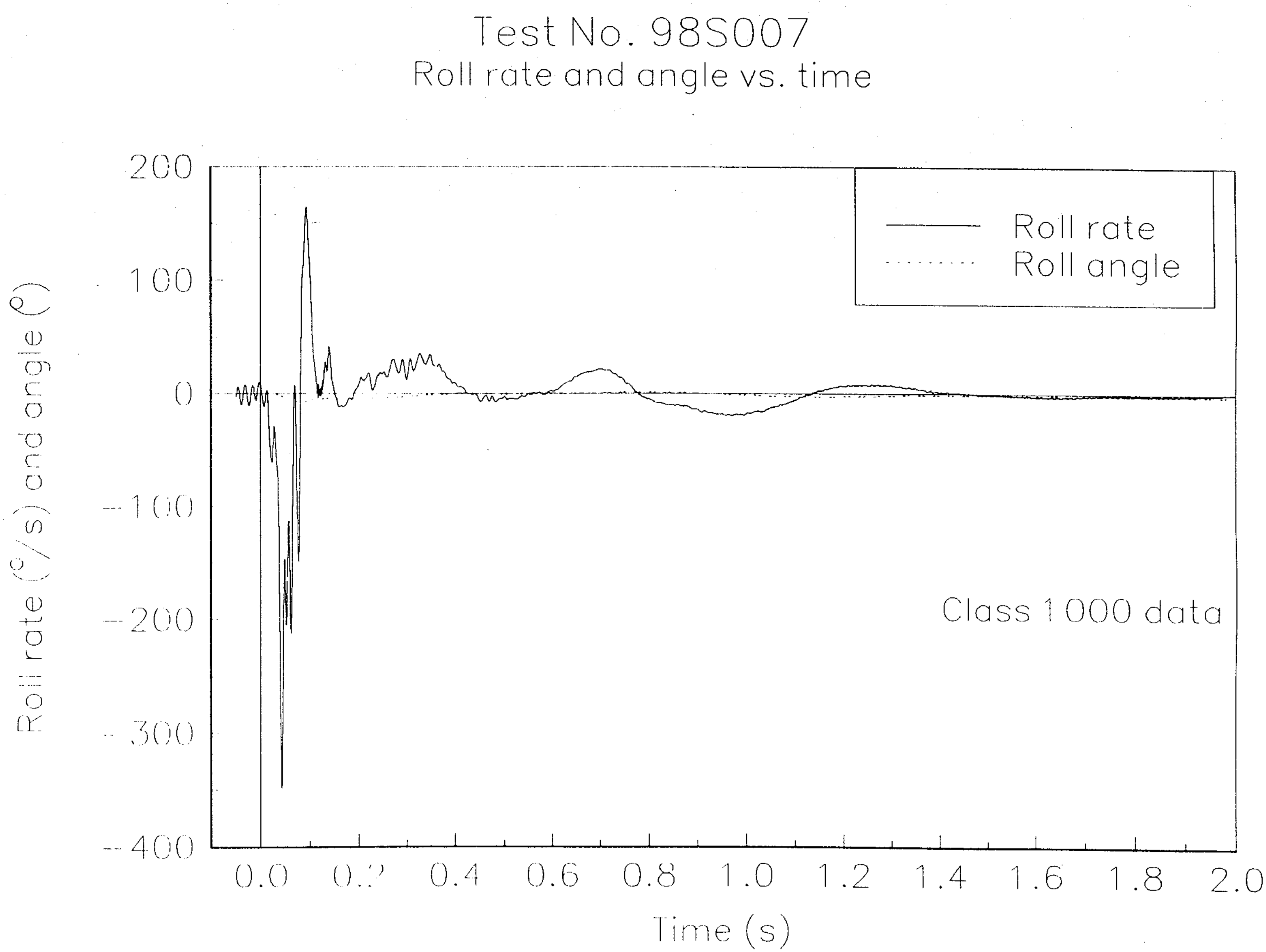


Figure 14. Roll rate and angle vs. time, test 98S007.

APPENDIX B. DATA PLOTS FROM INSTRUMENTED SID/HIII

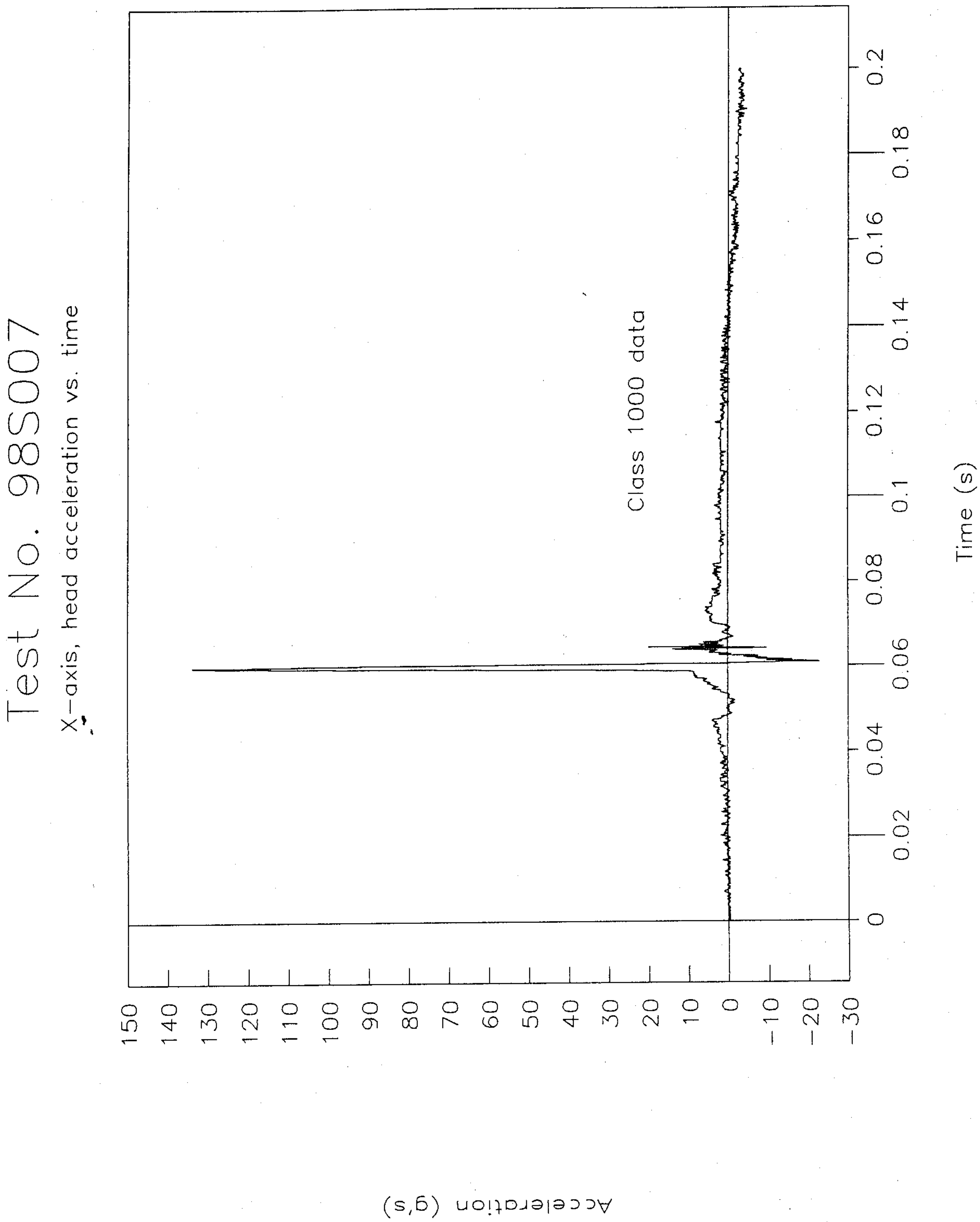


Figure 15. Acceleration vs. time, X-axis head, test 98S007.

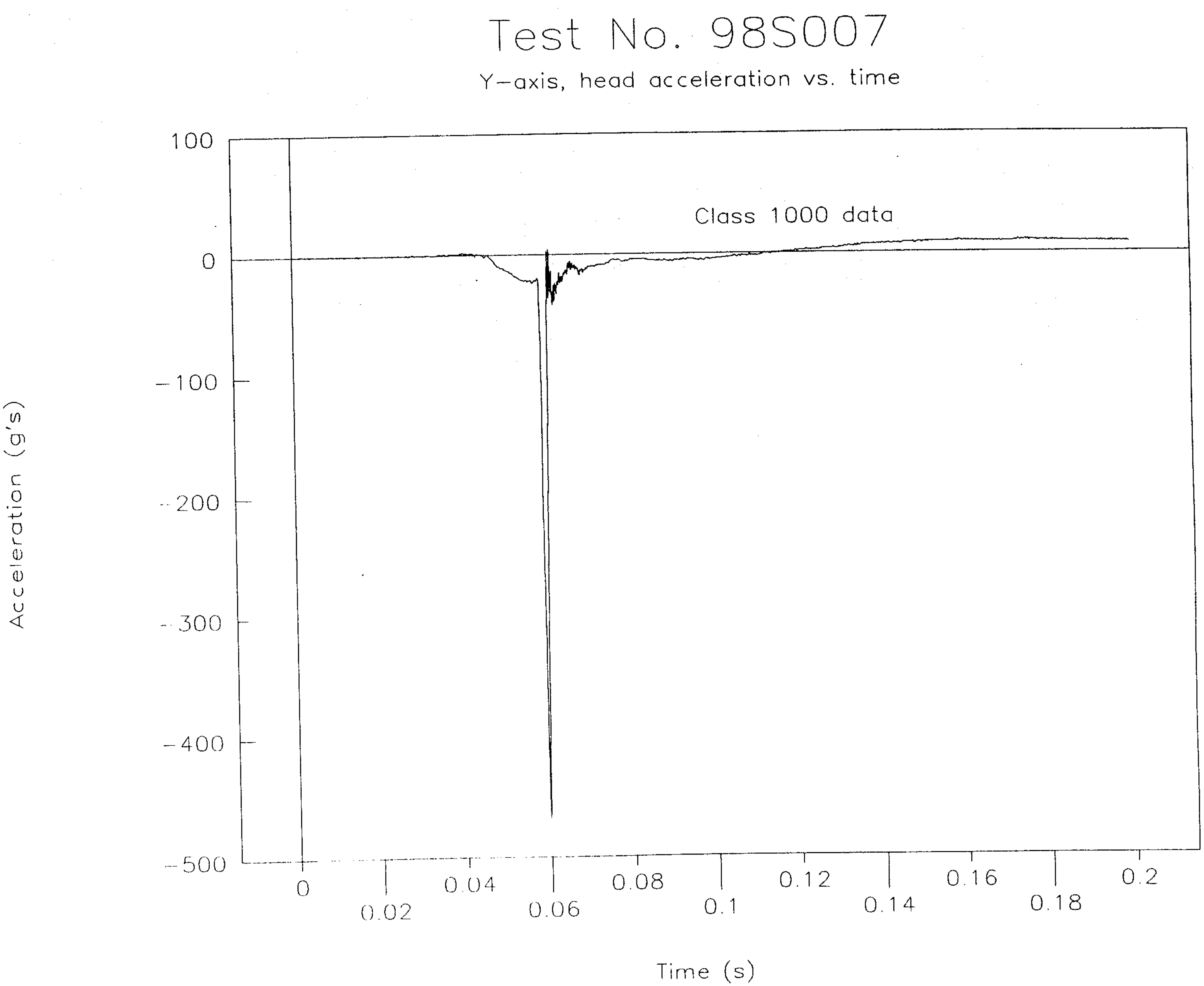


Figure 16. Acceleration vs. time, Y-axis head, test 98S007.

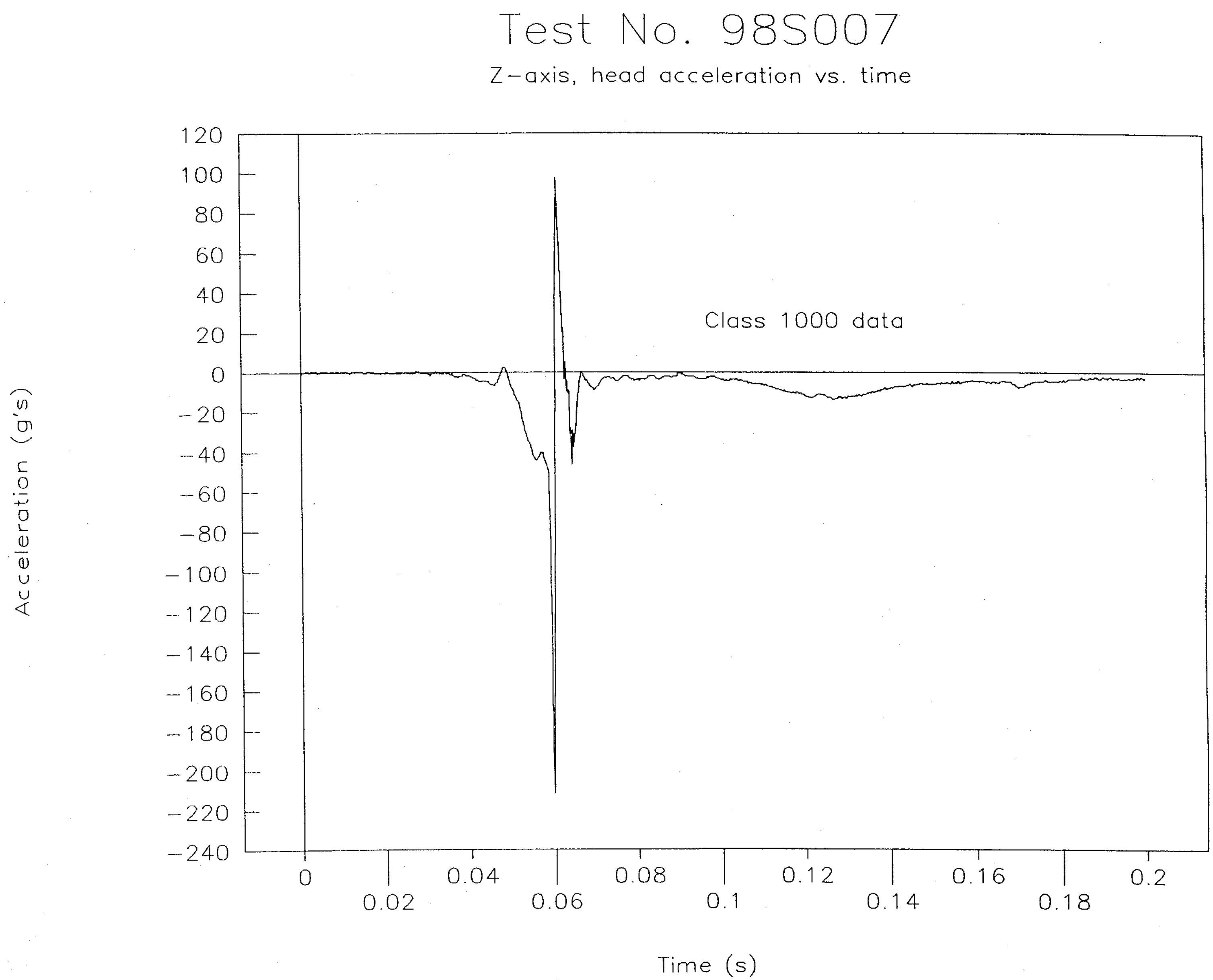


Figure 17. Acceleration vs. time, Z-axis head, test 98S007.

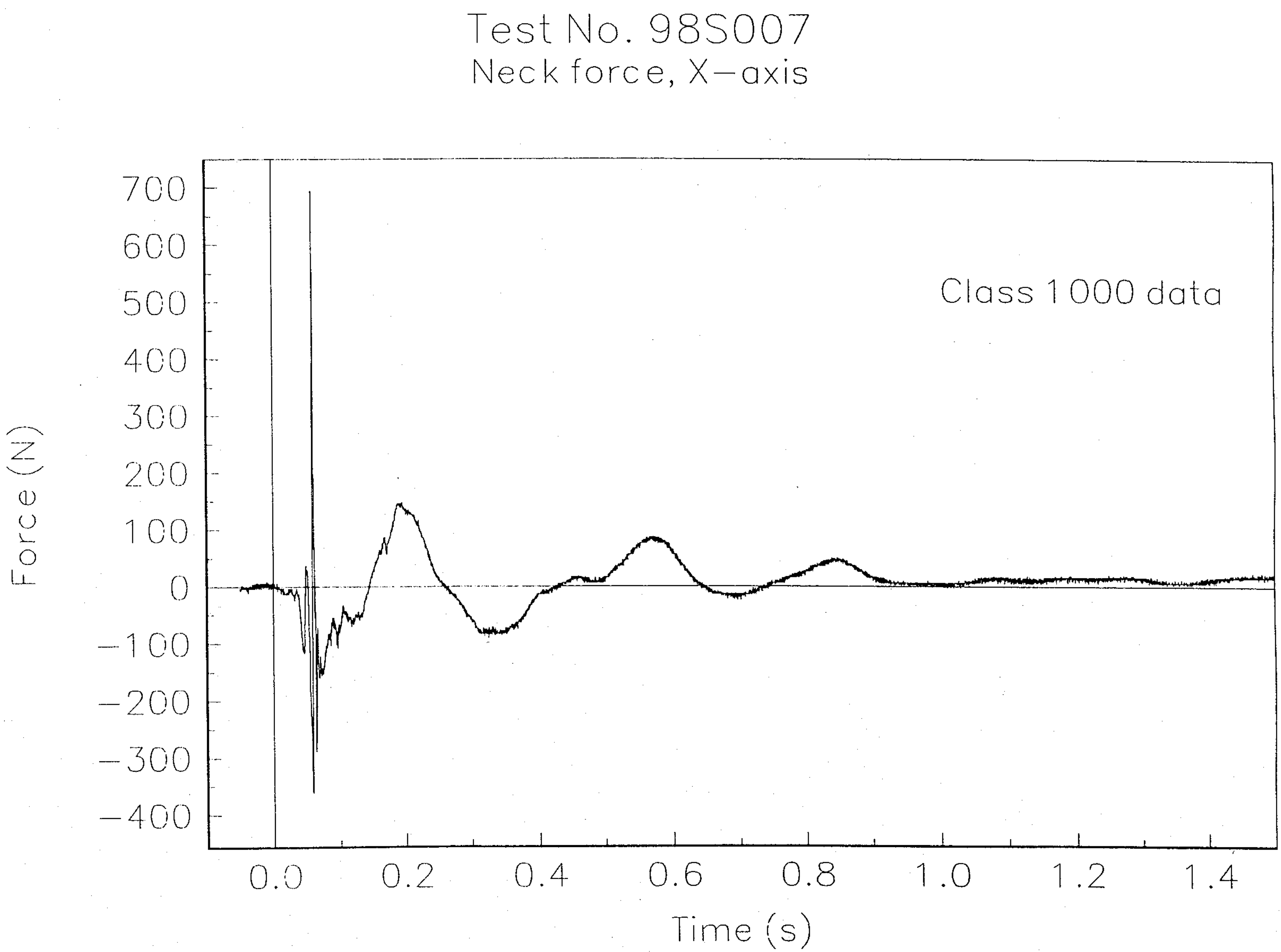


Figure 18. Force vs. time, X-axis neck, test 98S007.

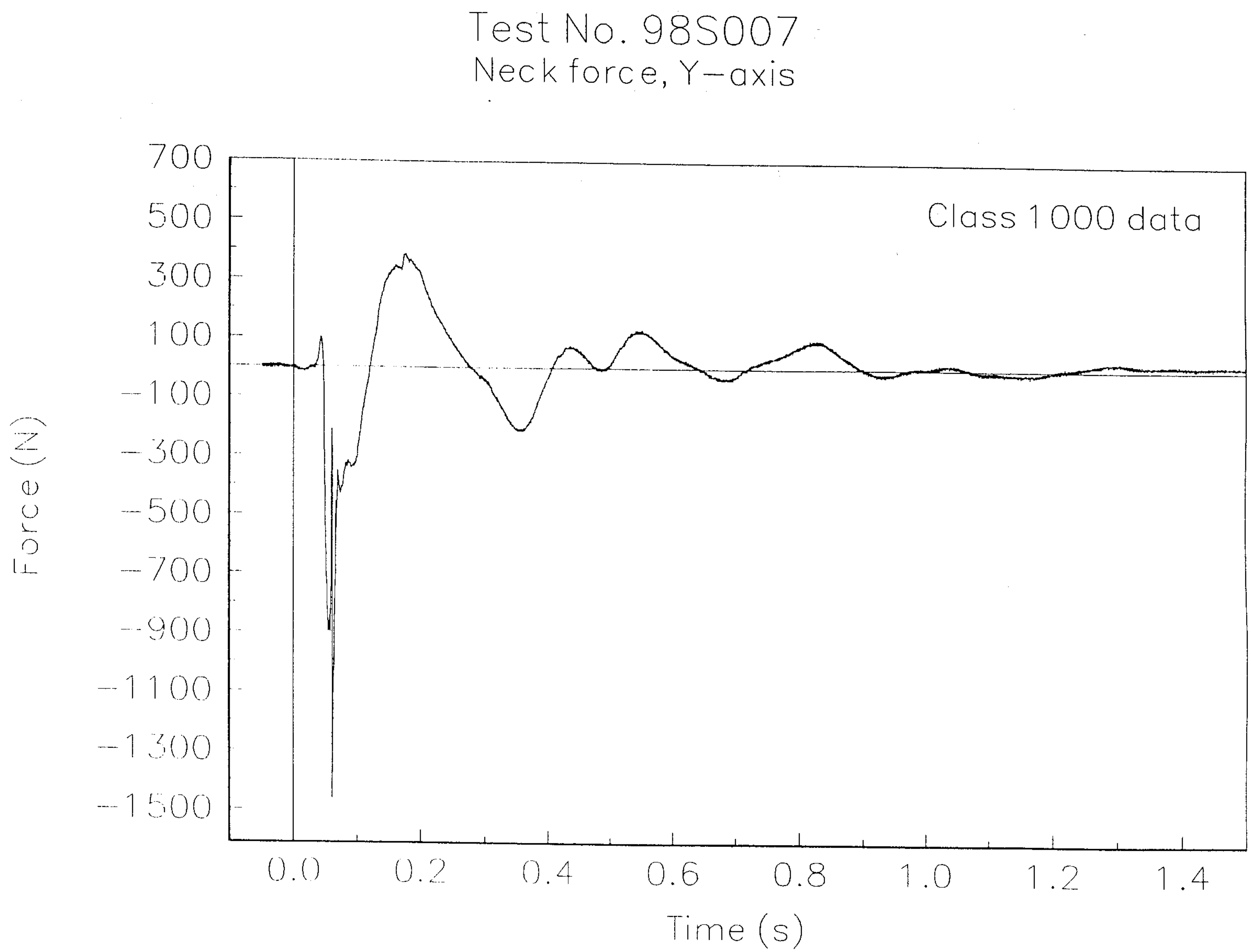


Figure 19. Force vs. time, Y-axis neck, test 98S007.

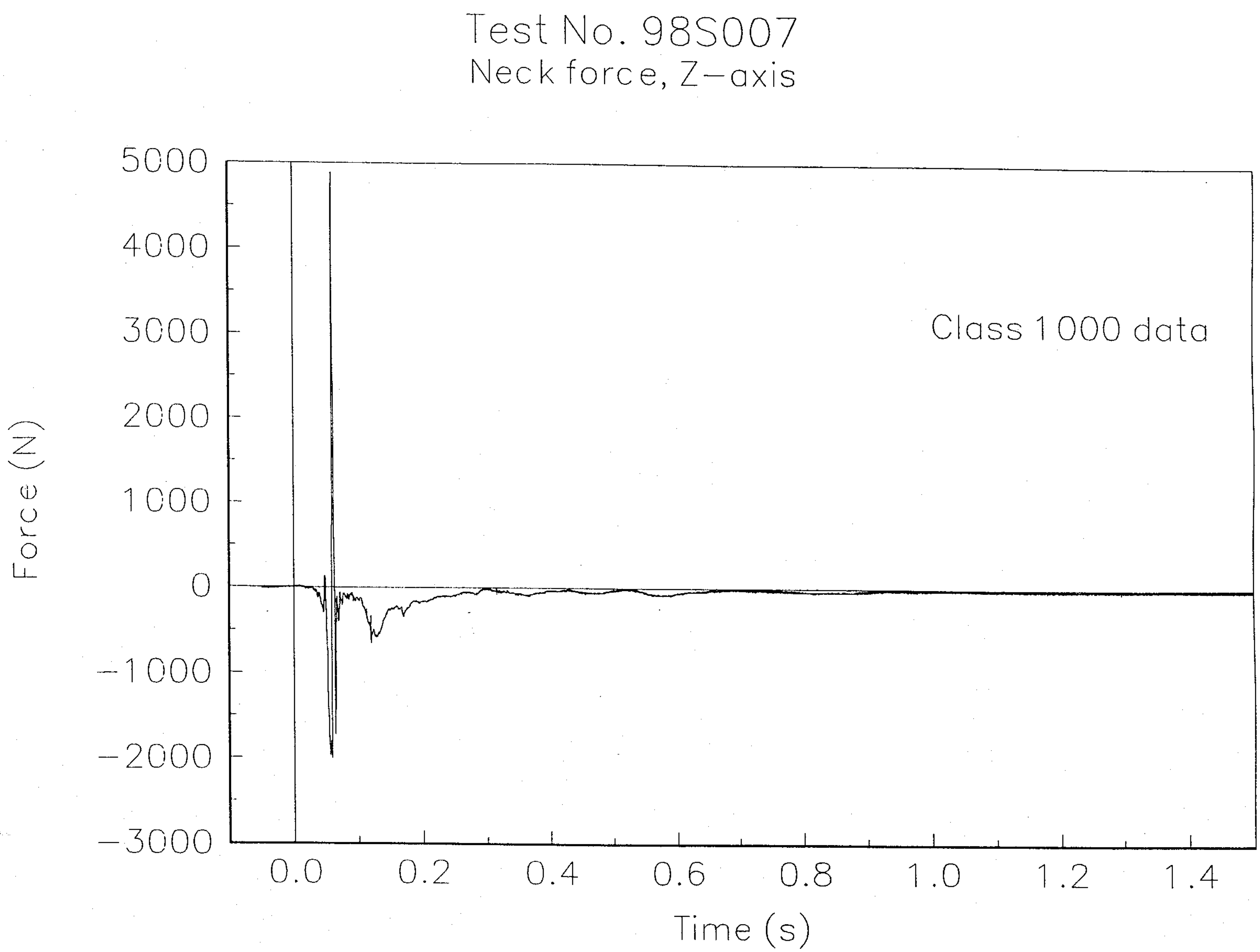


Figure 20. Force vs. time, Z-axis neck, test 98S007.

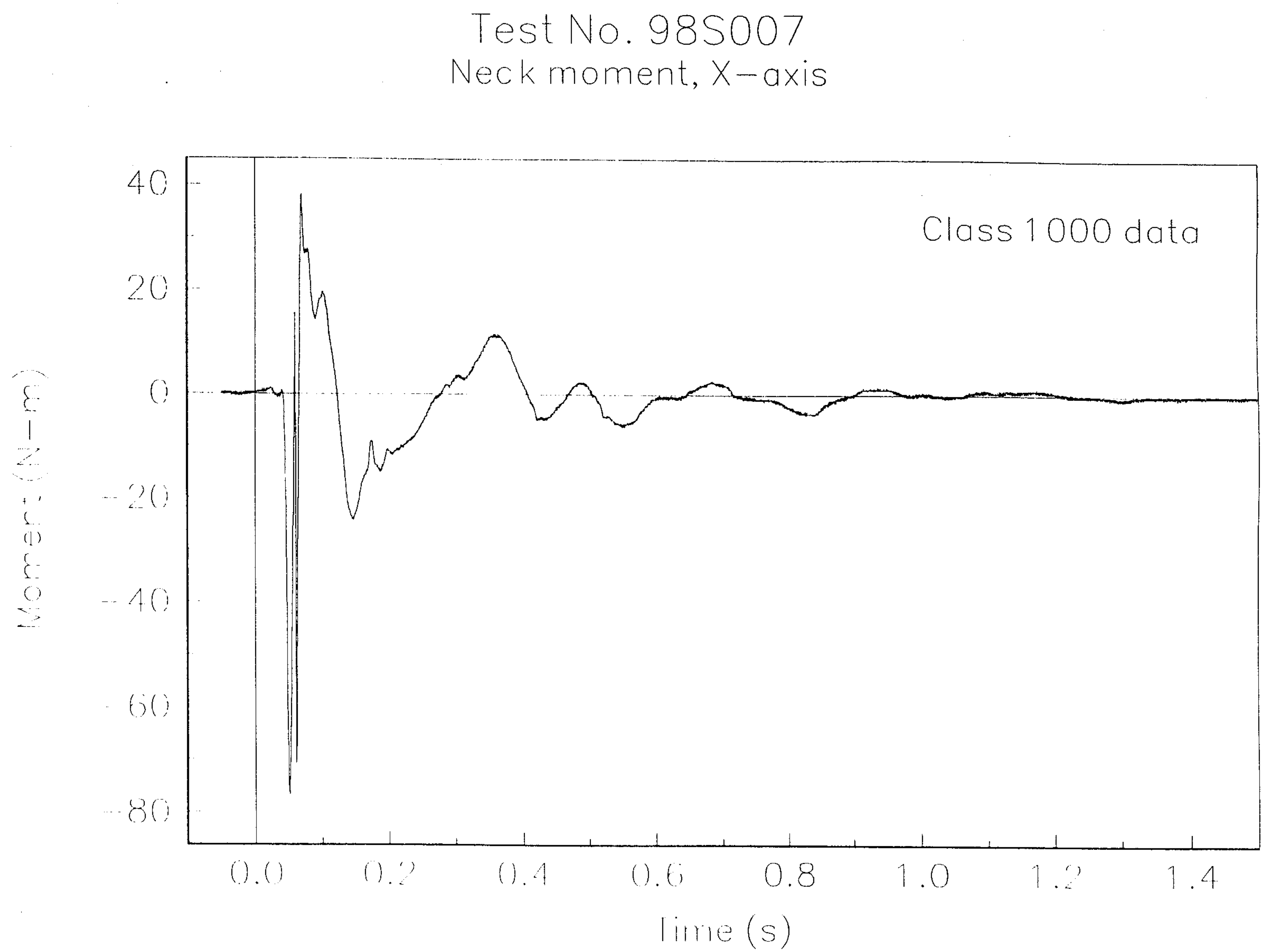


Figure 21. Moment vs. time, X-axis neck, test 98S007.

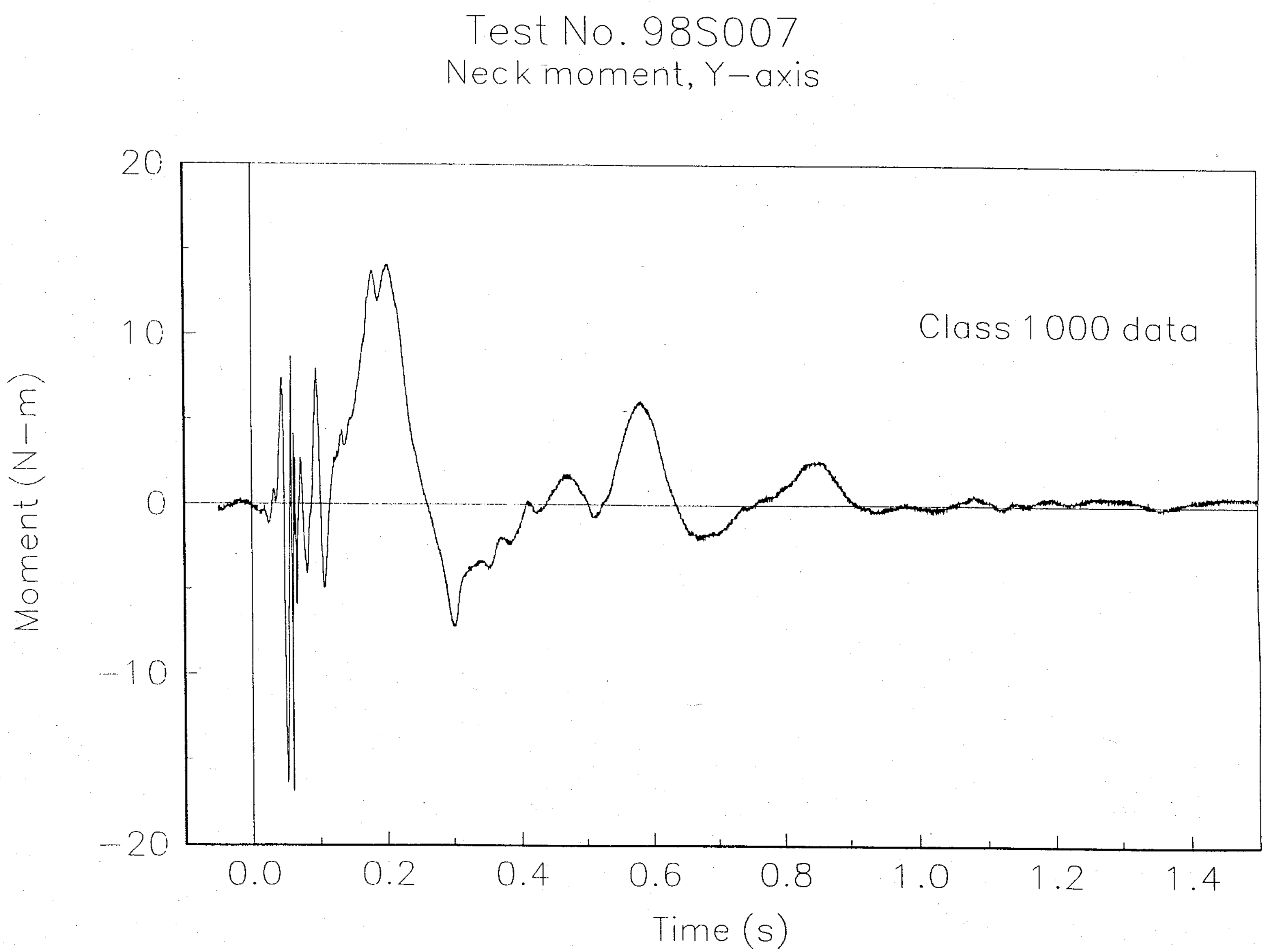


Figure 22. Moment vs. time, Y-axis neck, test 98S007.

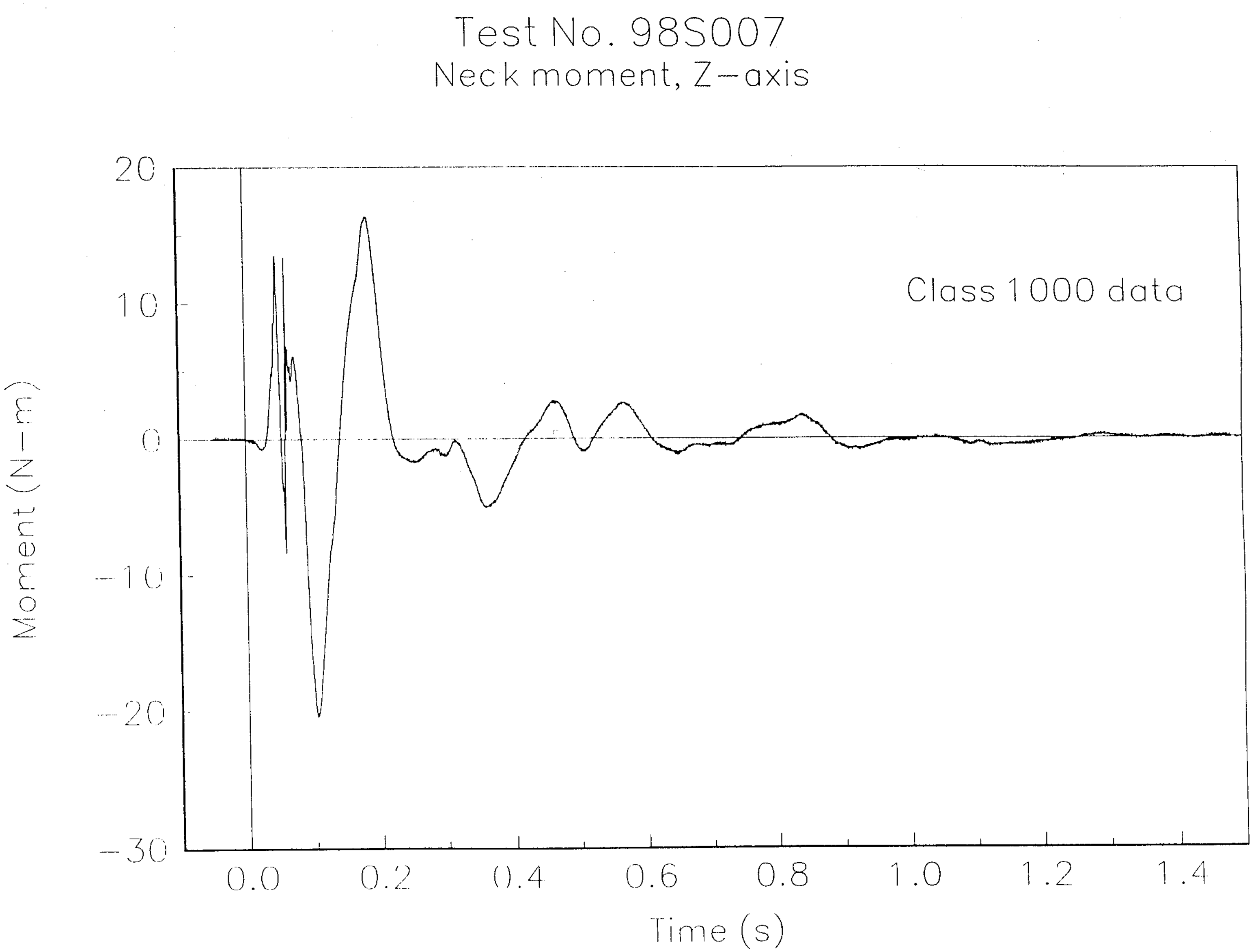


Figure 23. Moment vs. time, Z-axis neck, test 98S007.

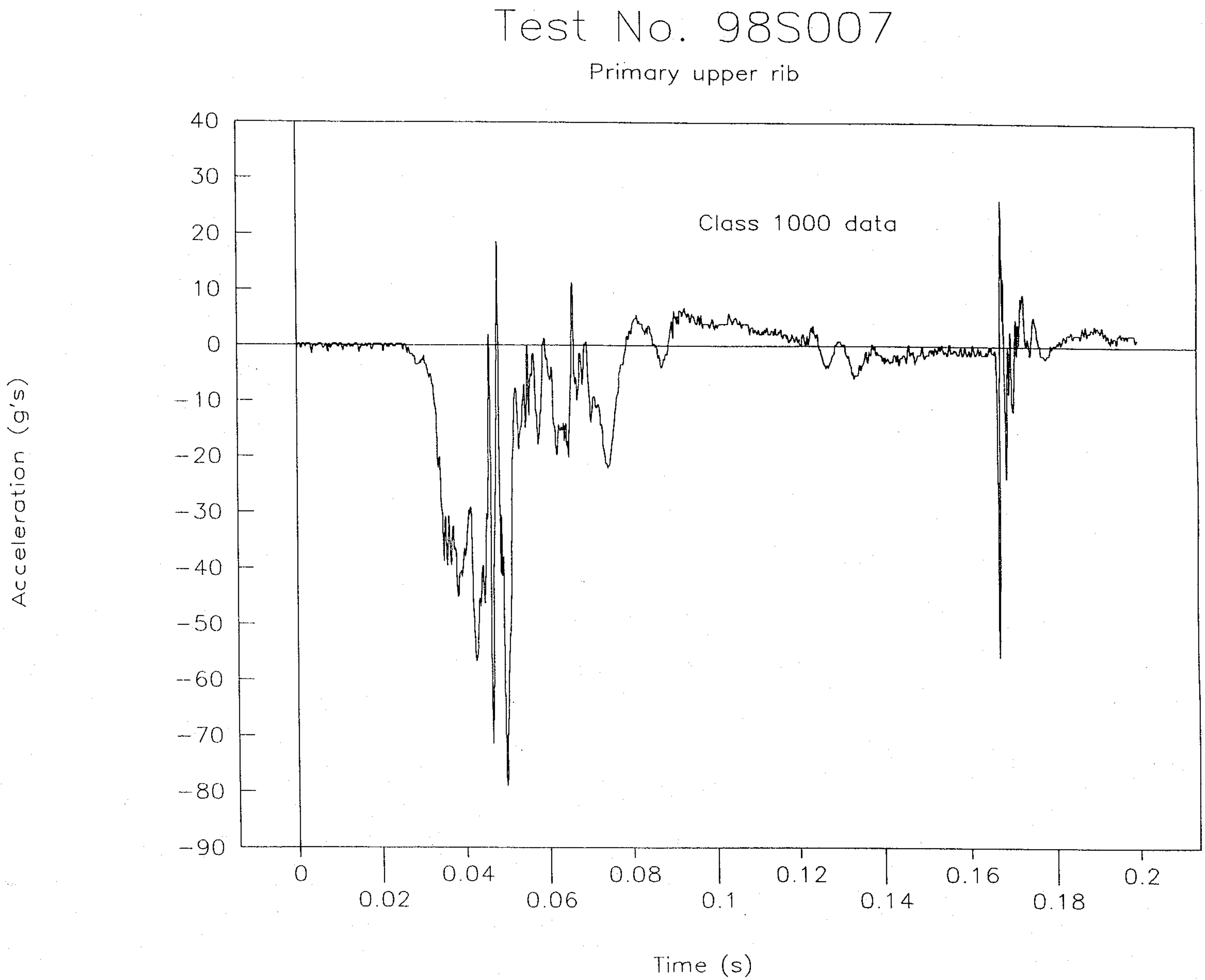


Figure 24. Acceleration vs. time, primary upper rib, test 98S007.

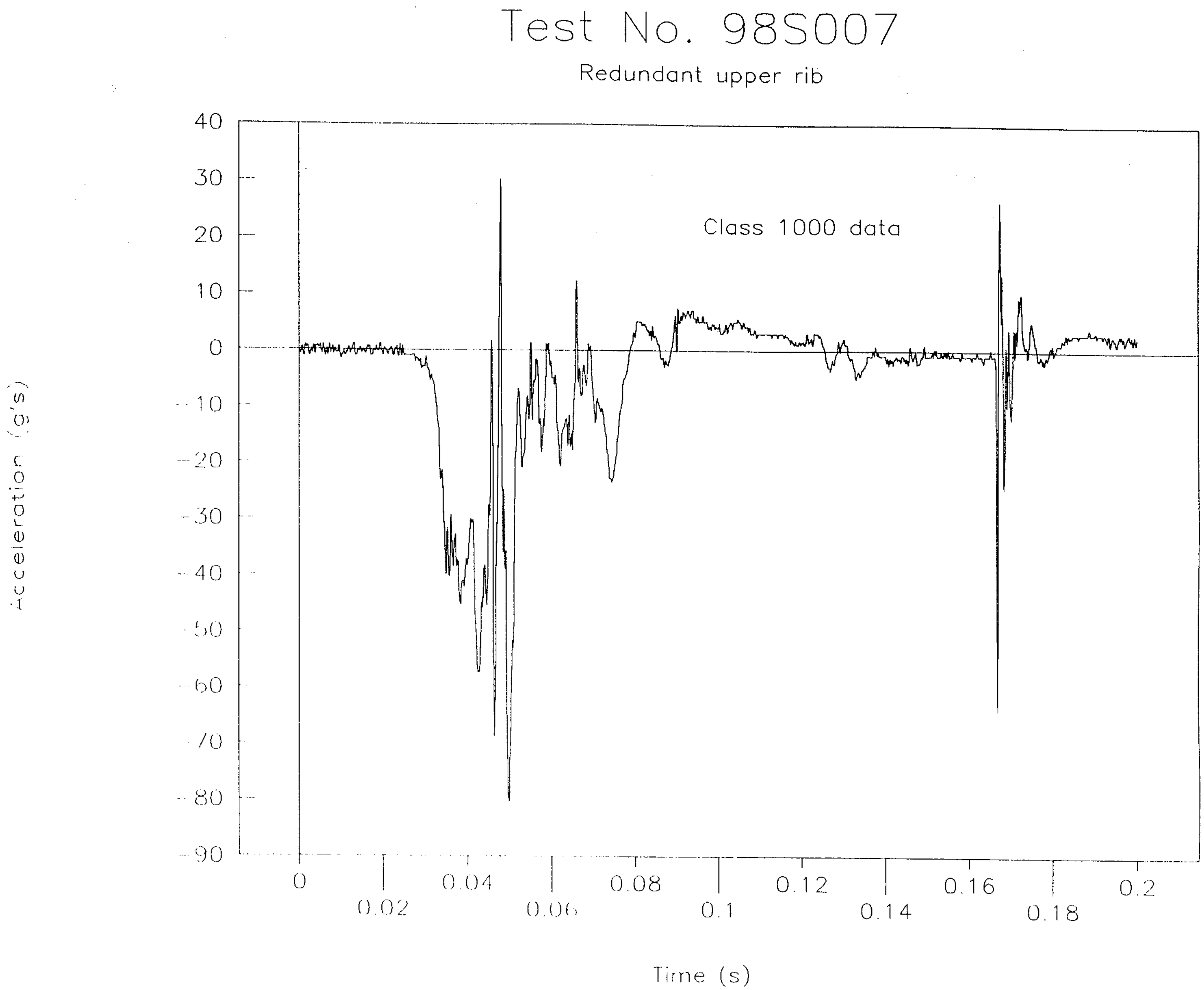


Figure 25. Acceleration vs. time, redundant upper rib, test 98S007.

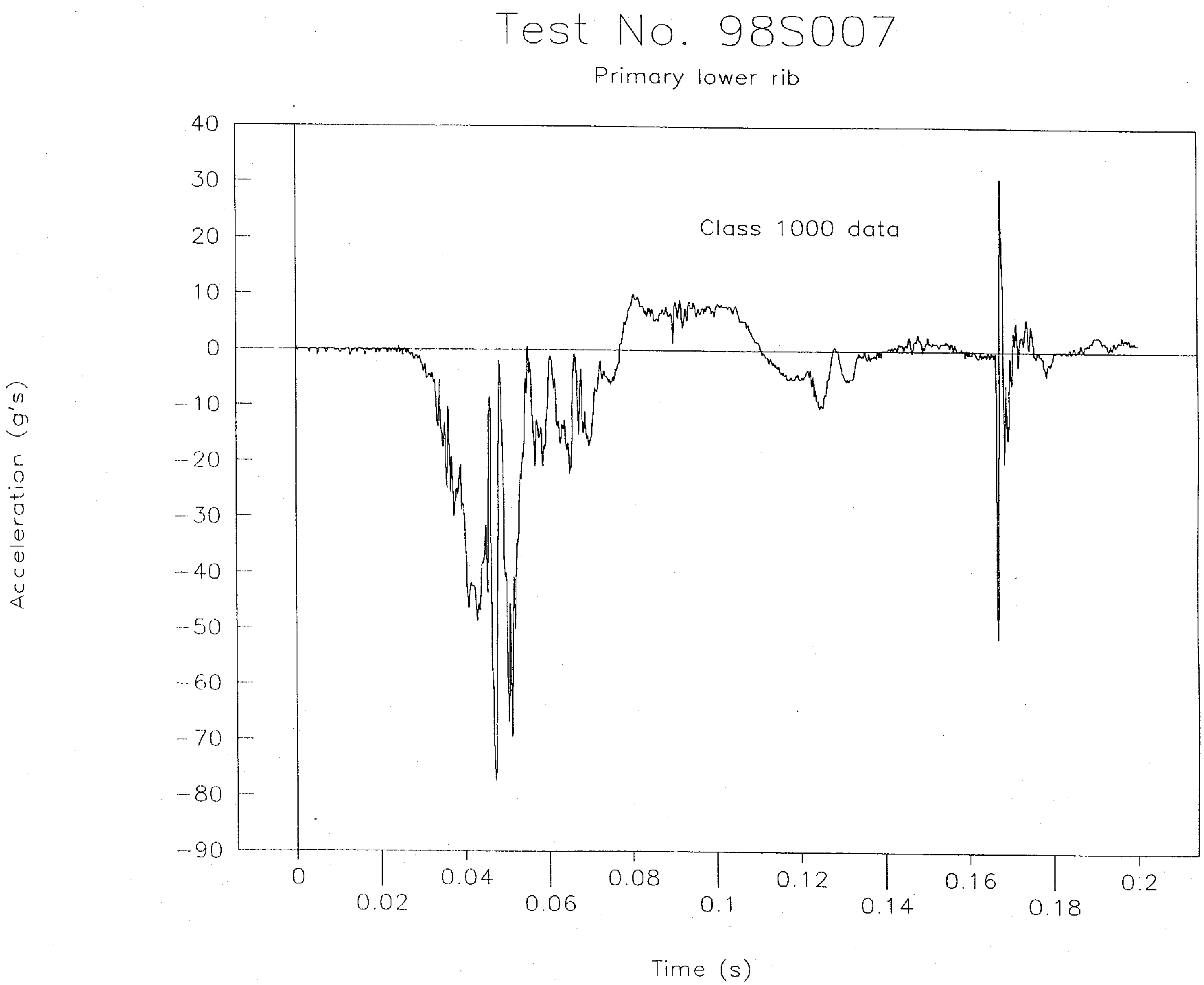


Figure 26. Acceleration vs. time, primary lower rib, test 98S007.

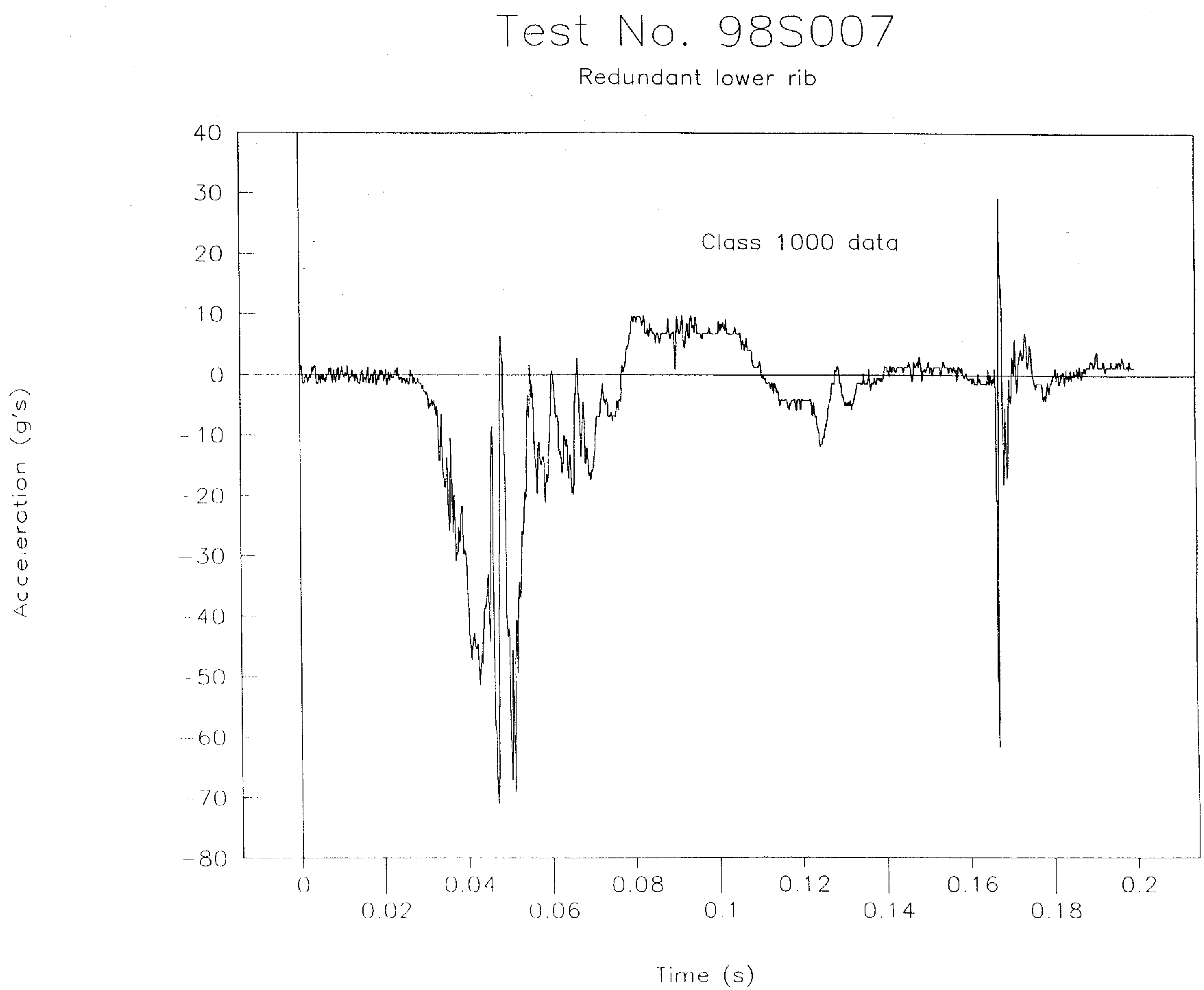


Figure 27. Acceleration vs. time, redundant lower rib, test 98S007.

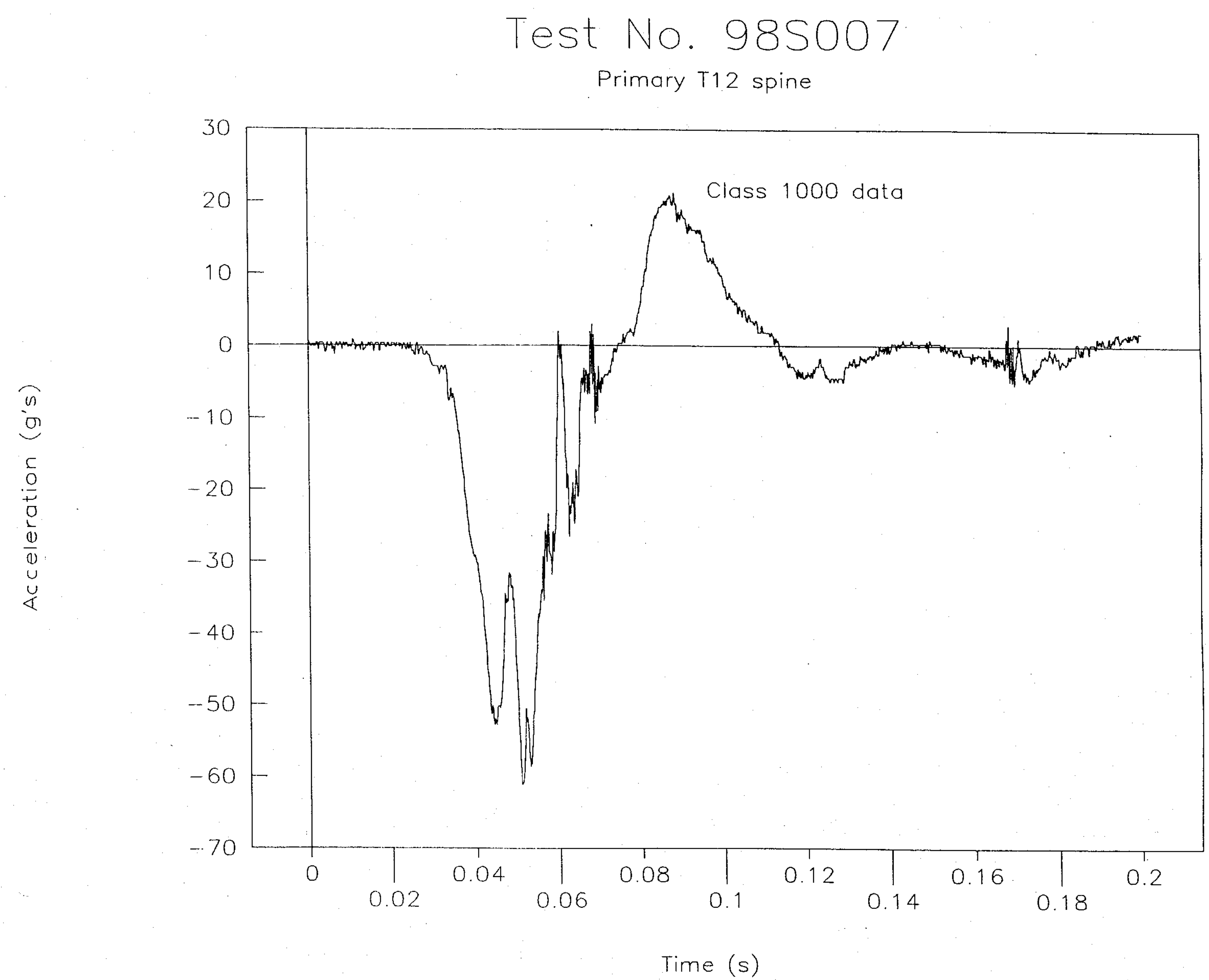


Figure 28. Acceleration vs. time, primary T12 spine, test 98S007.

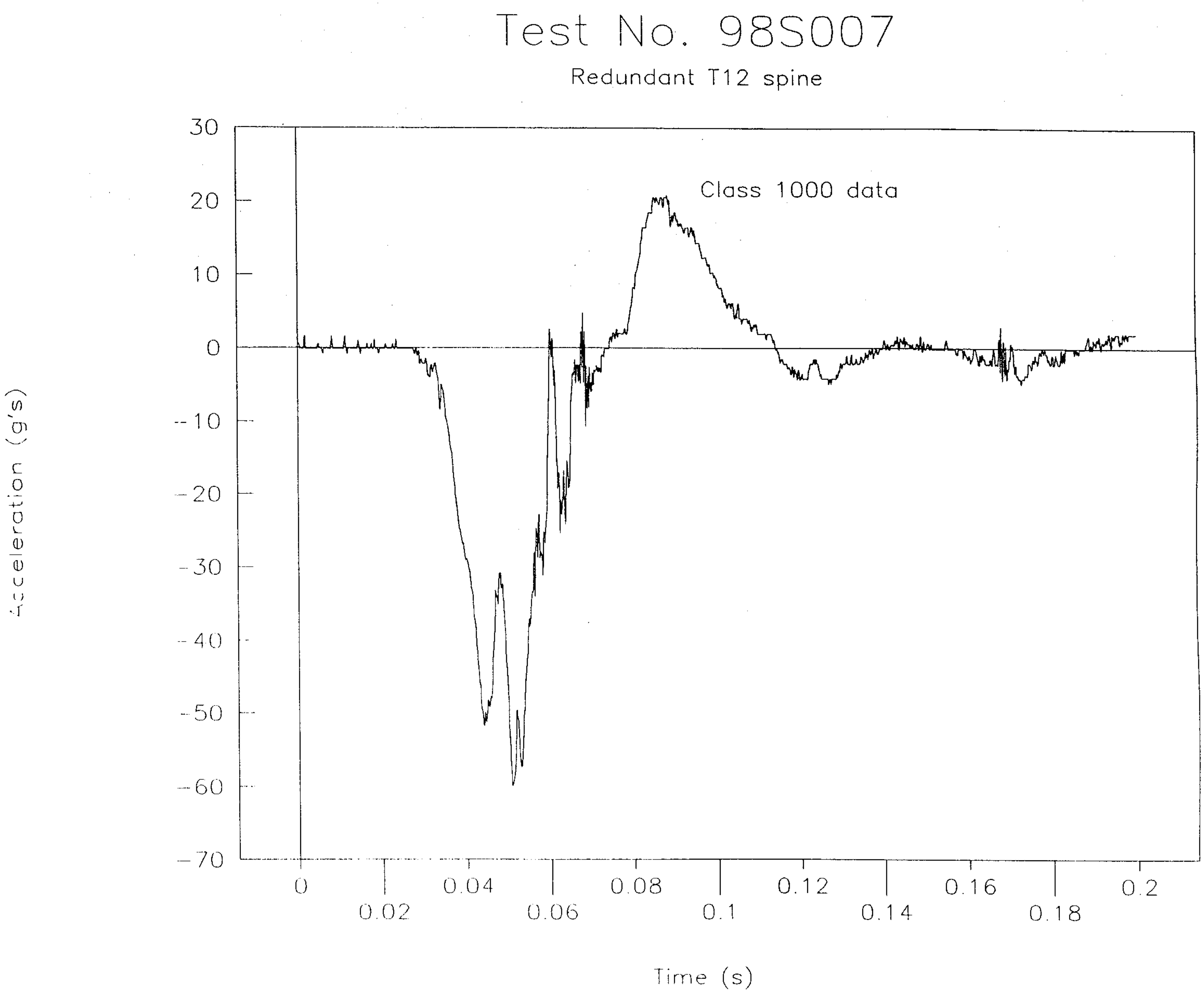


Figure 29. Acceleration vs. time, redundant T12 spine, test 98S007.

APPENDIX C. DATA PLOTS FROM INSTRUMENTED CHILD DUMMY

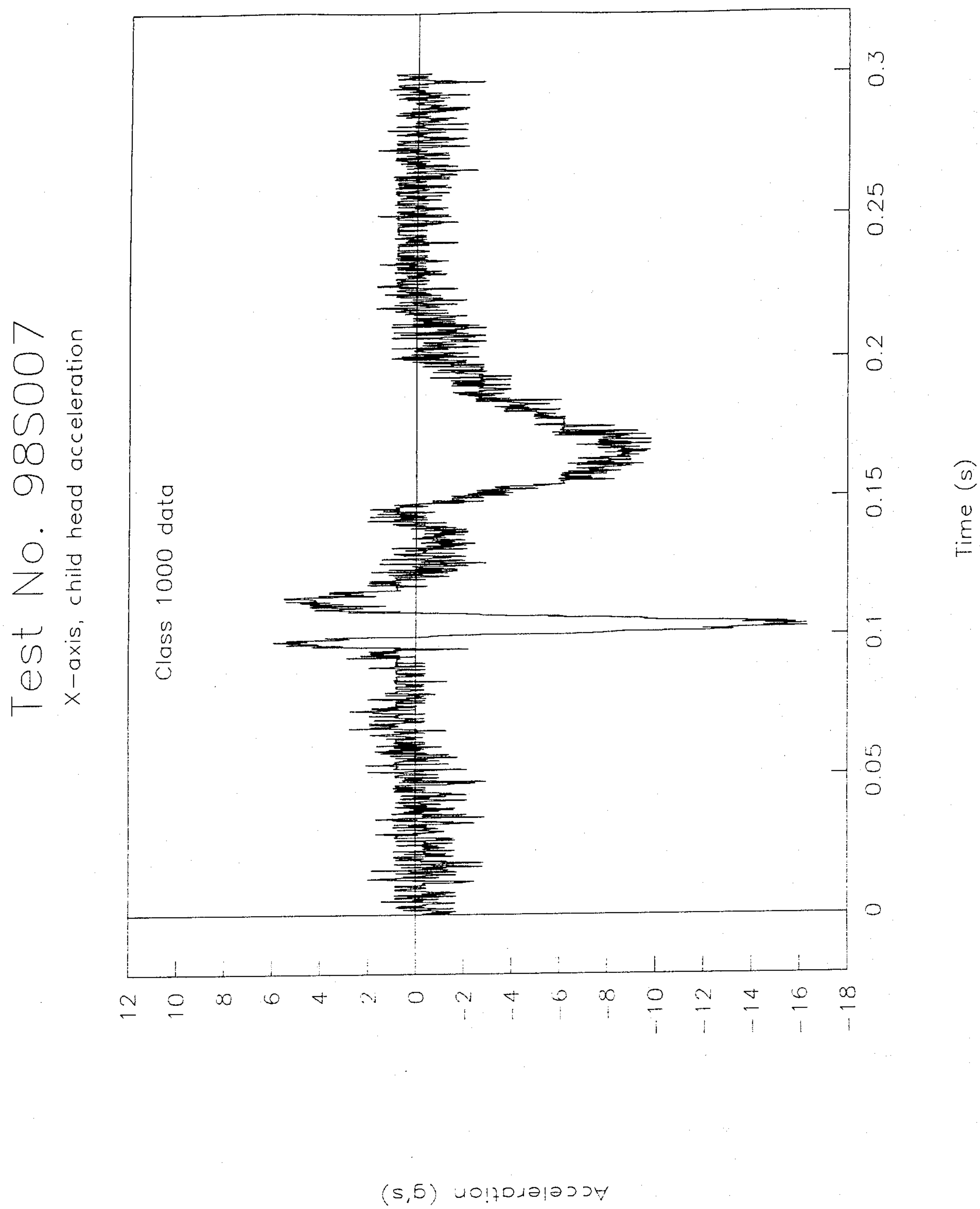


Figure 30. Acceleration vs. time, X-axis child head, test 98S007.

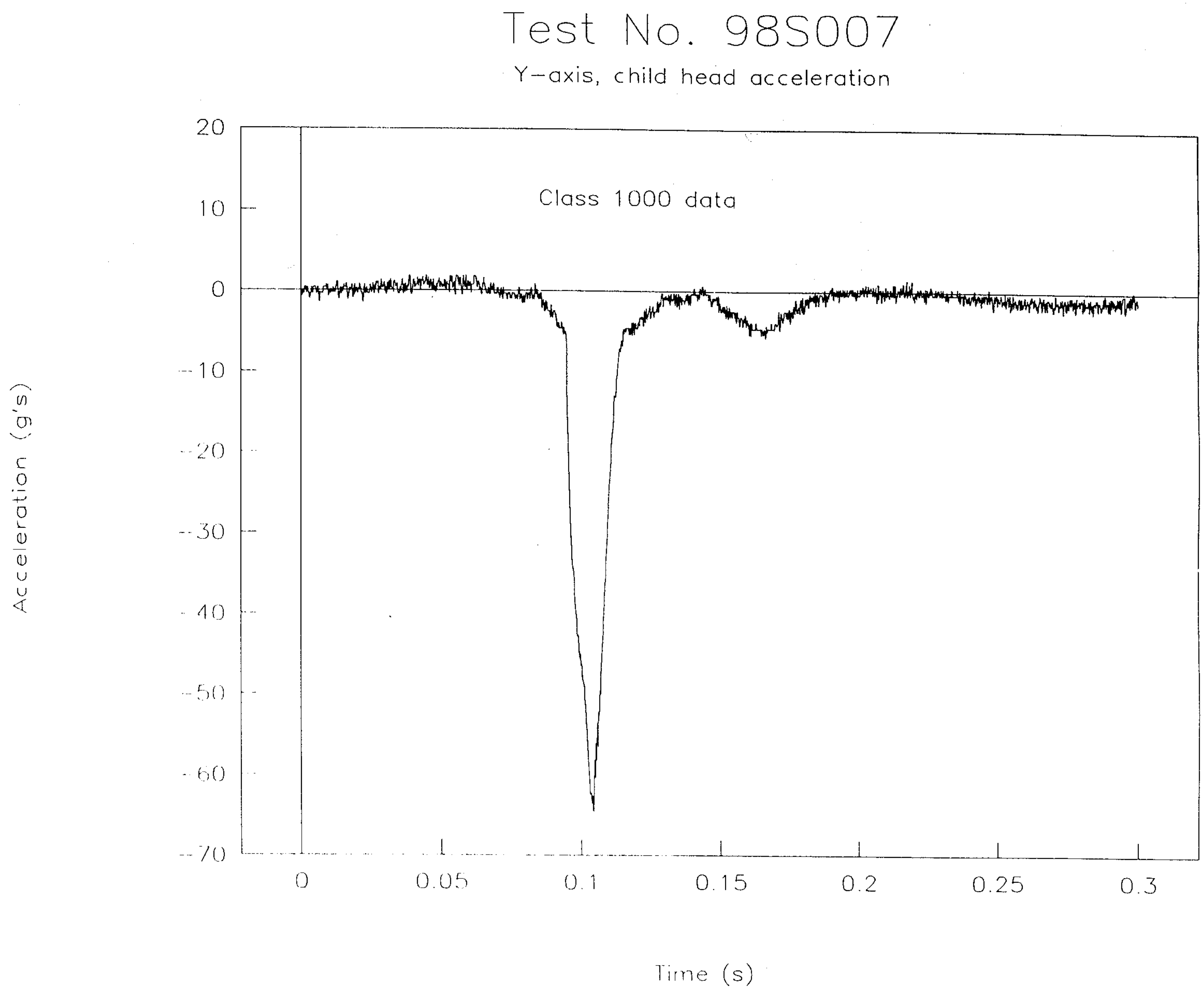


Figure 31. Acceleration vs. time, Y-axis, child head, test 98S007.

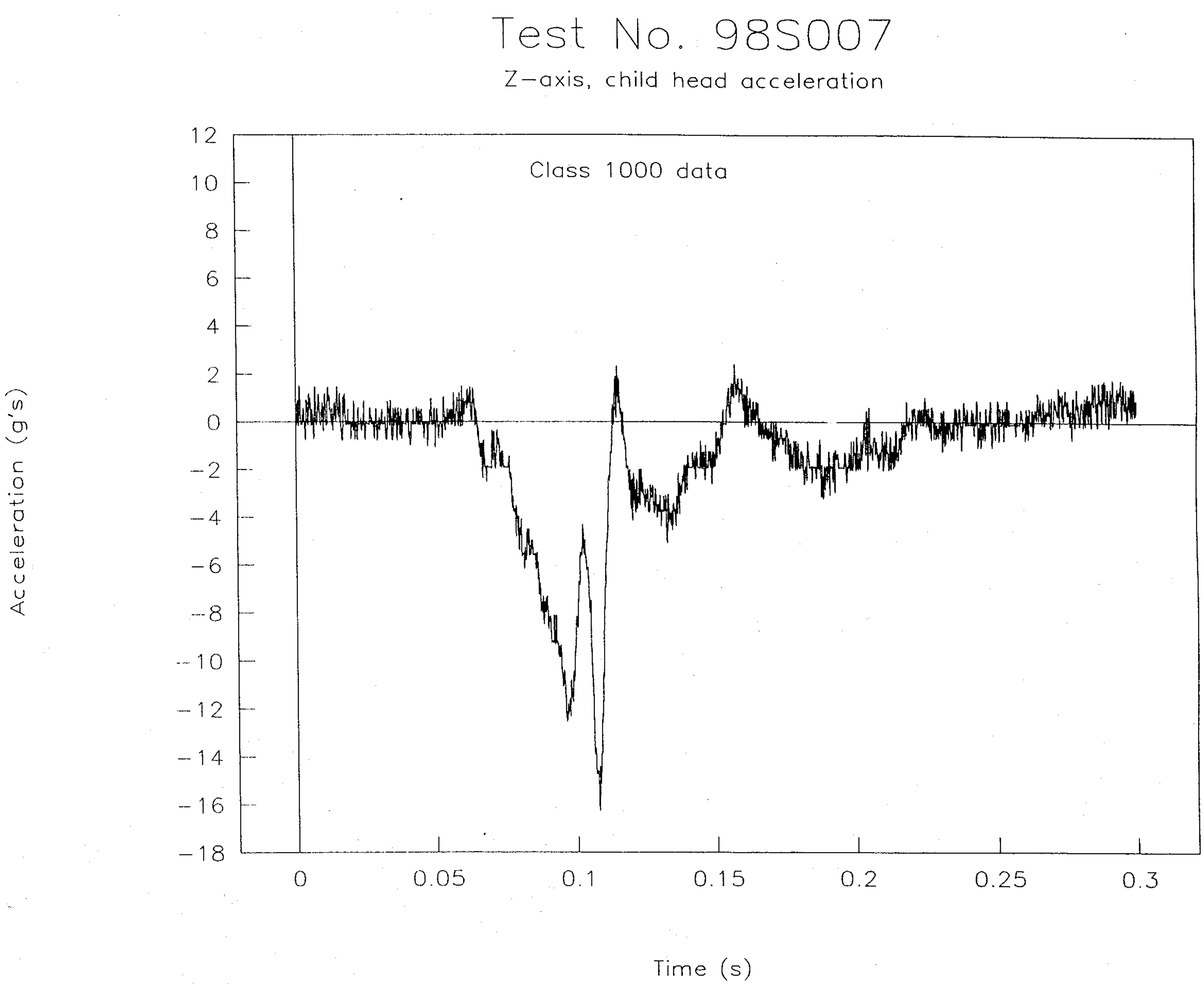


Figure 32. Acceleration vs. time, Z-axis, child head, test 98S007.

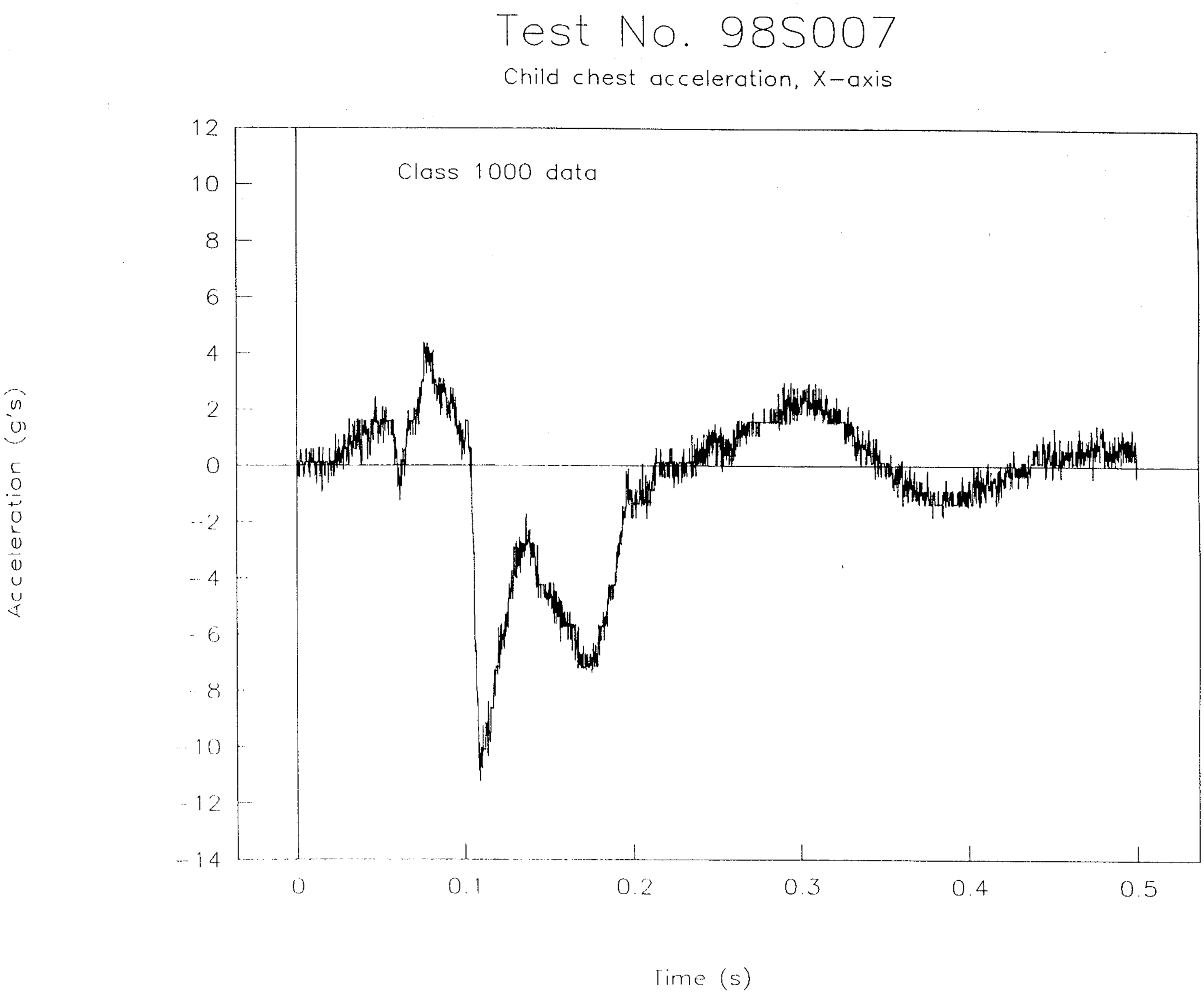


Figure 33. Acceleration vs. time, X-axis, child chest, test 98S007.

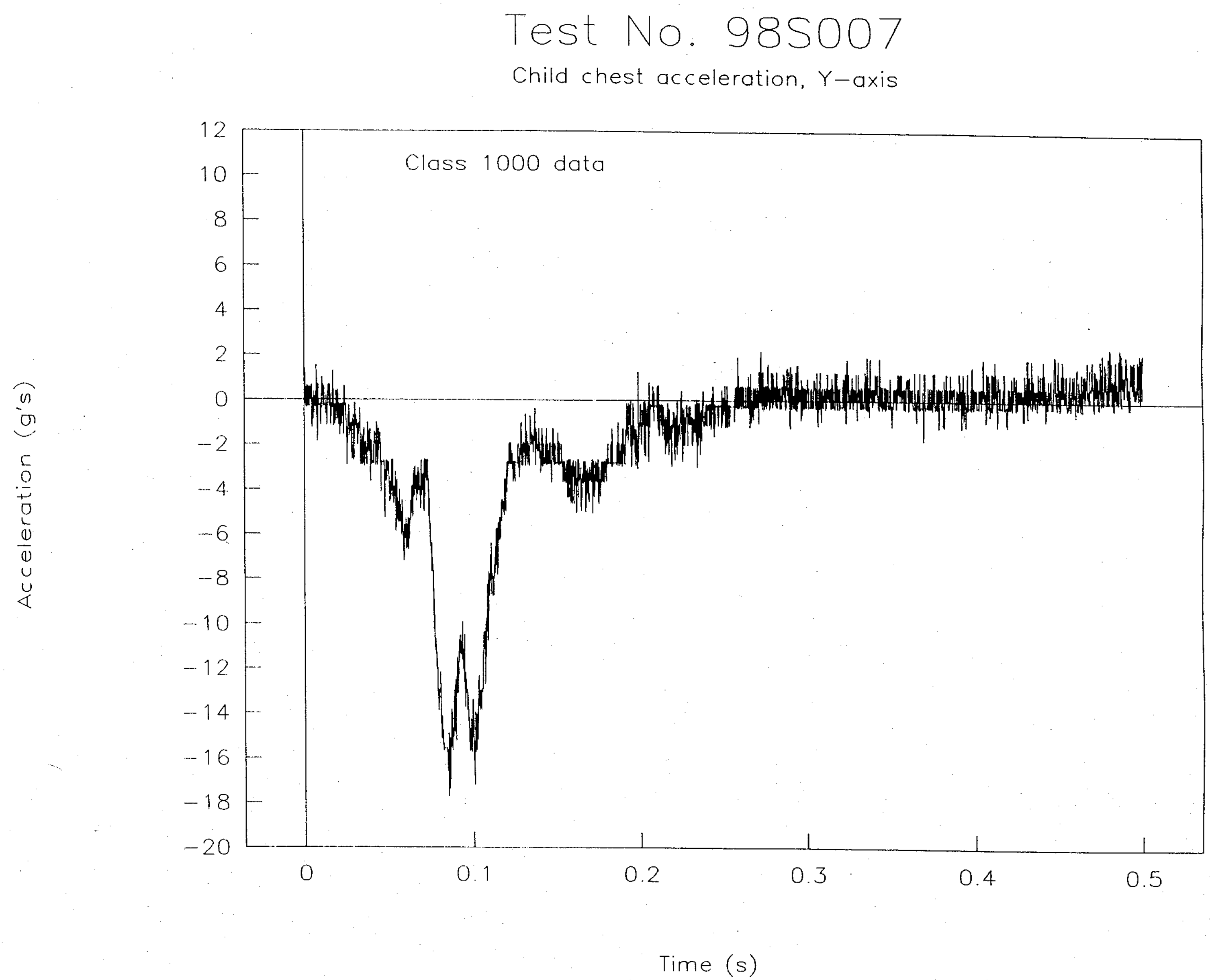


Figure 34. Acceleration vs. time, Y-axis, child chest, test 98S007.

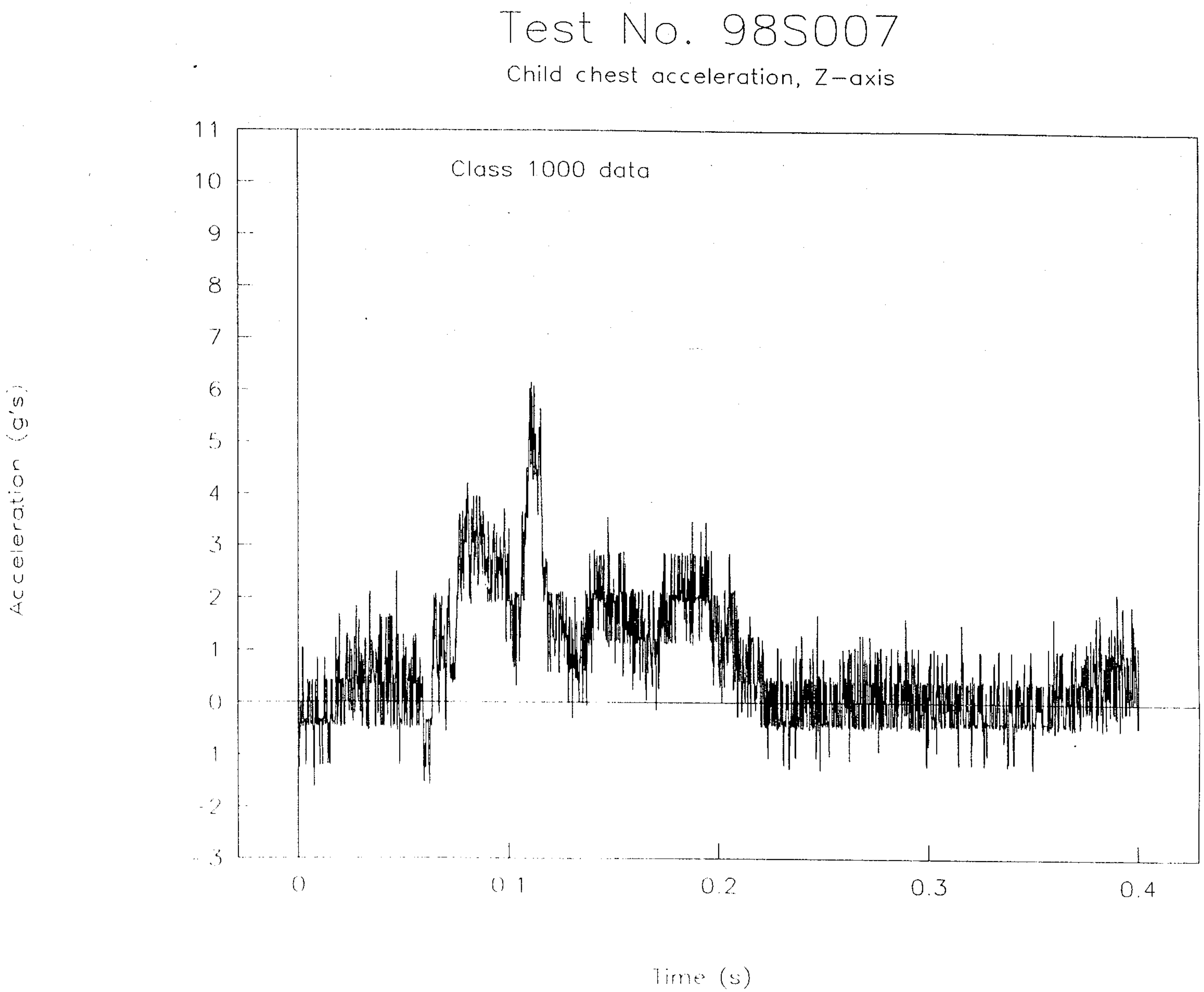


Figure 35. Acceleration vs. time, Z-axis, child chest, test 98S007.

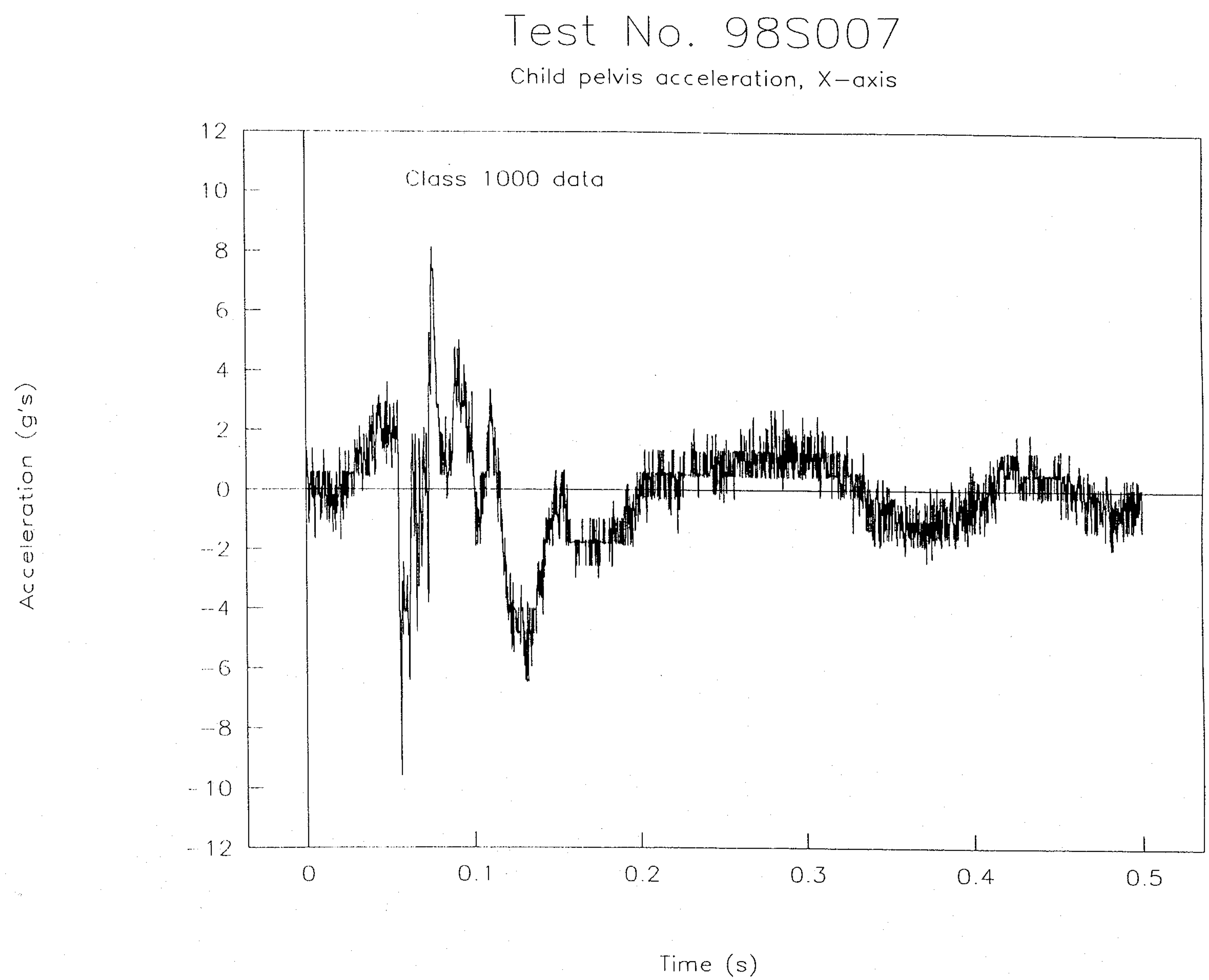


Figure 36. Acceleration vs. time, X-axis, child pelvis, test 98S007.

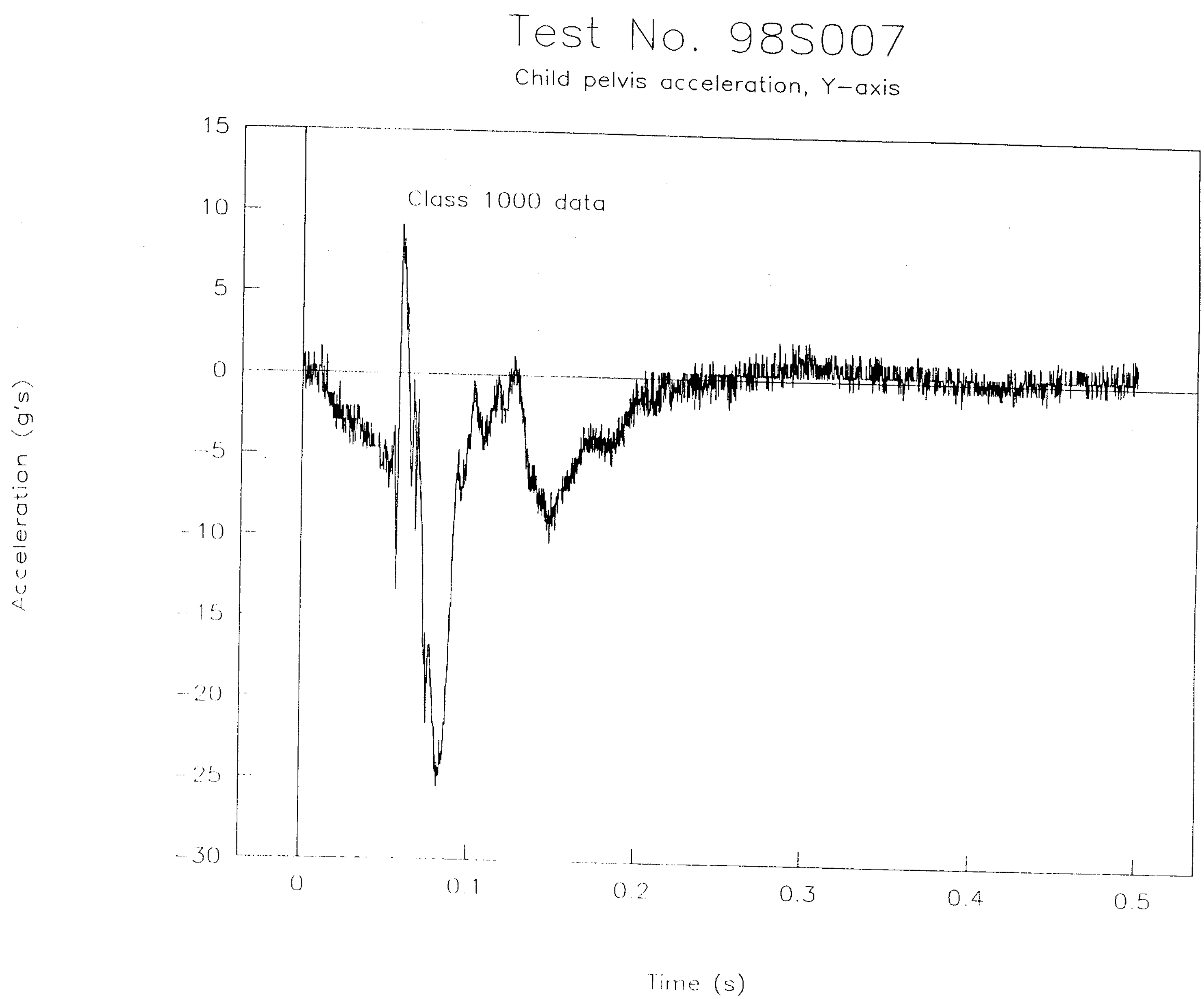


Figure 37. Acceleration vs. time, Y-axis, child pelvis, test 98S007.

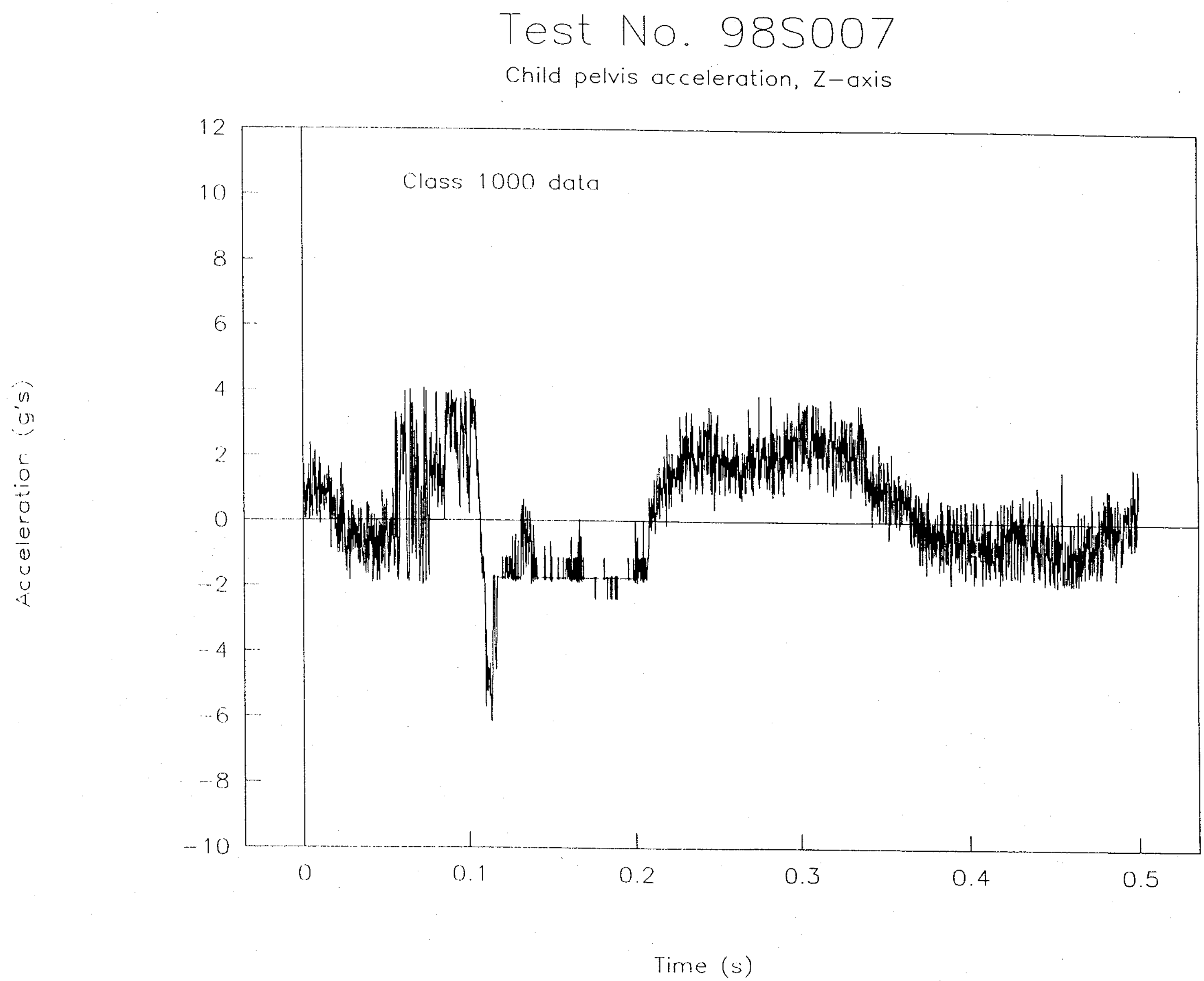


Figure 38. Acceleration vs. time, Z-axis, child pelvis, test 98S007.

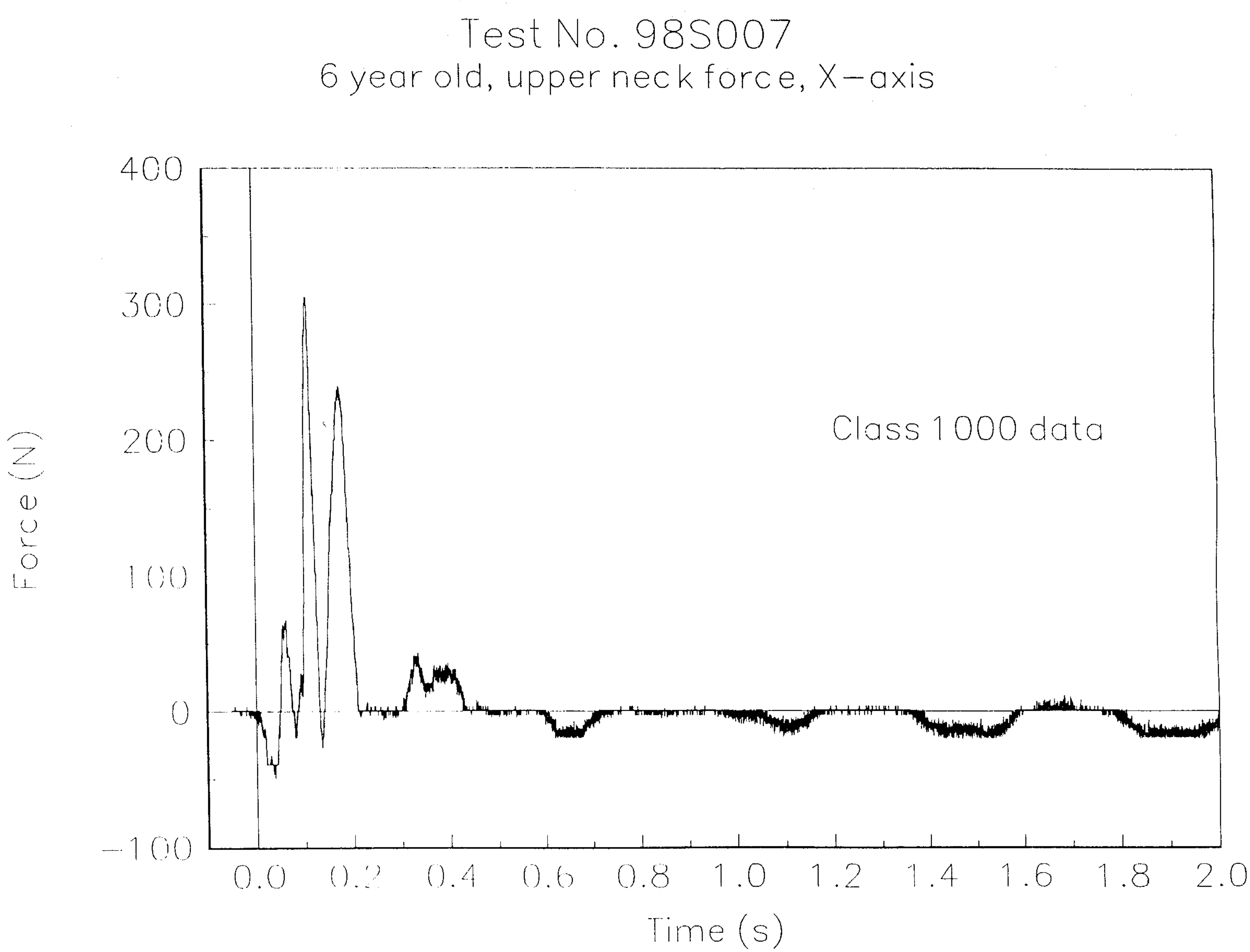


Figure 39. Force vs. time, X-axis, child upper neck, test 98S007.

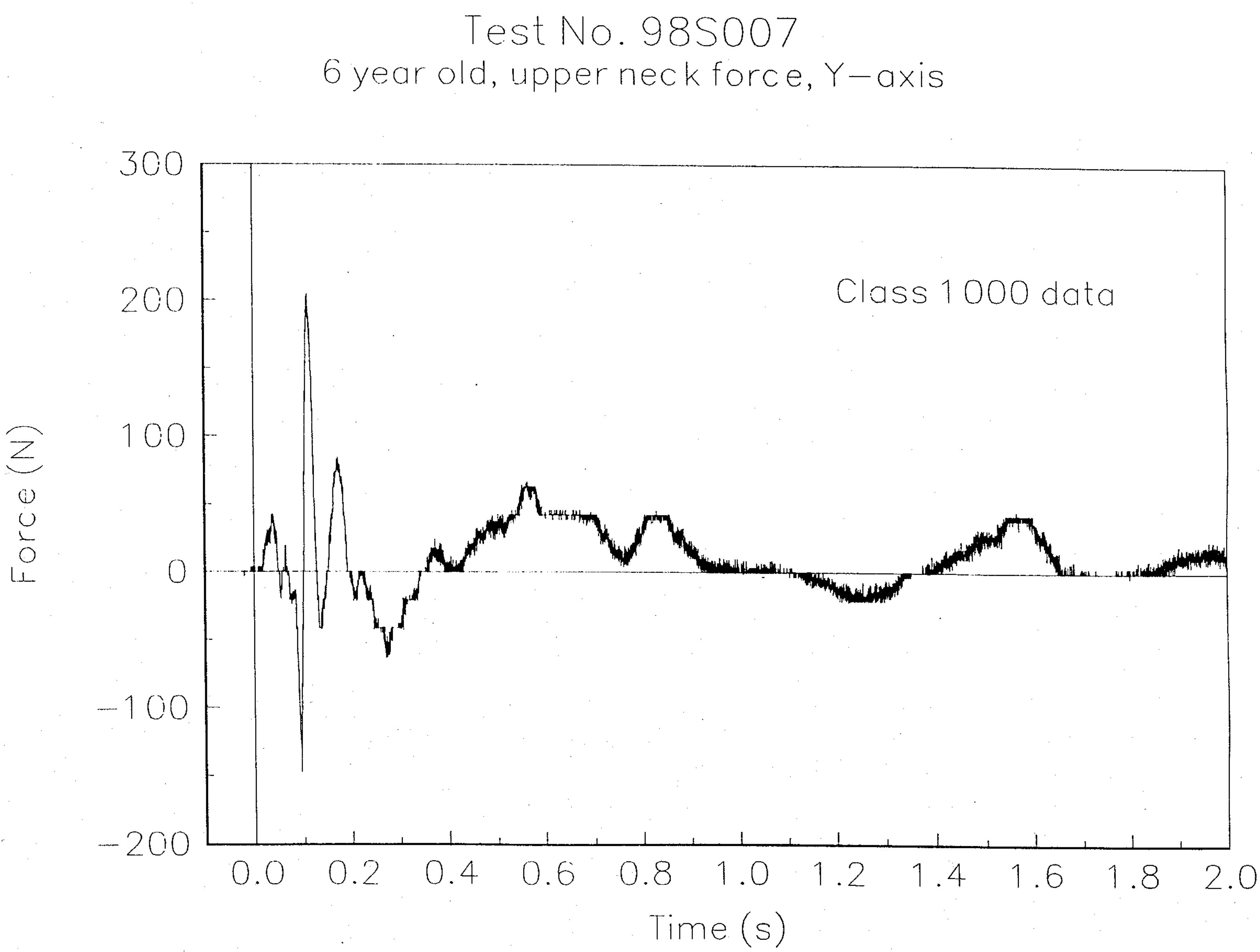


Figure 40. Force vs. time, Y-axis, child upper neck, test 98S007.

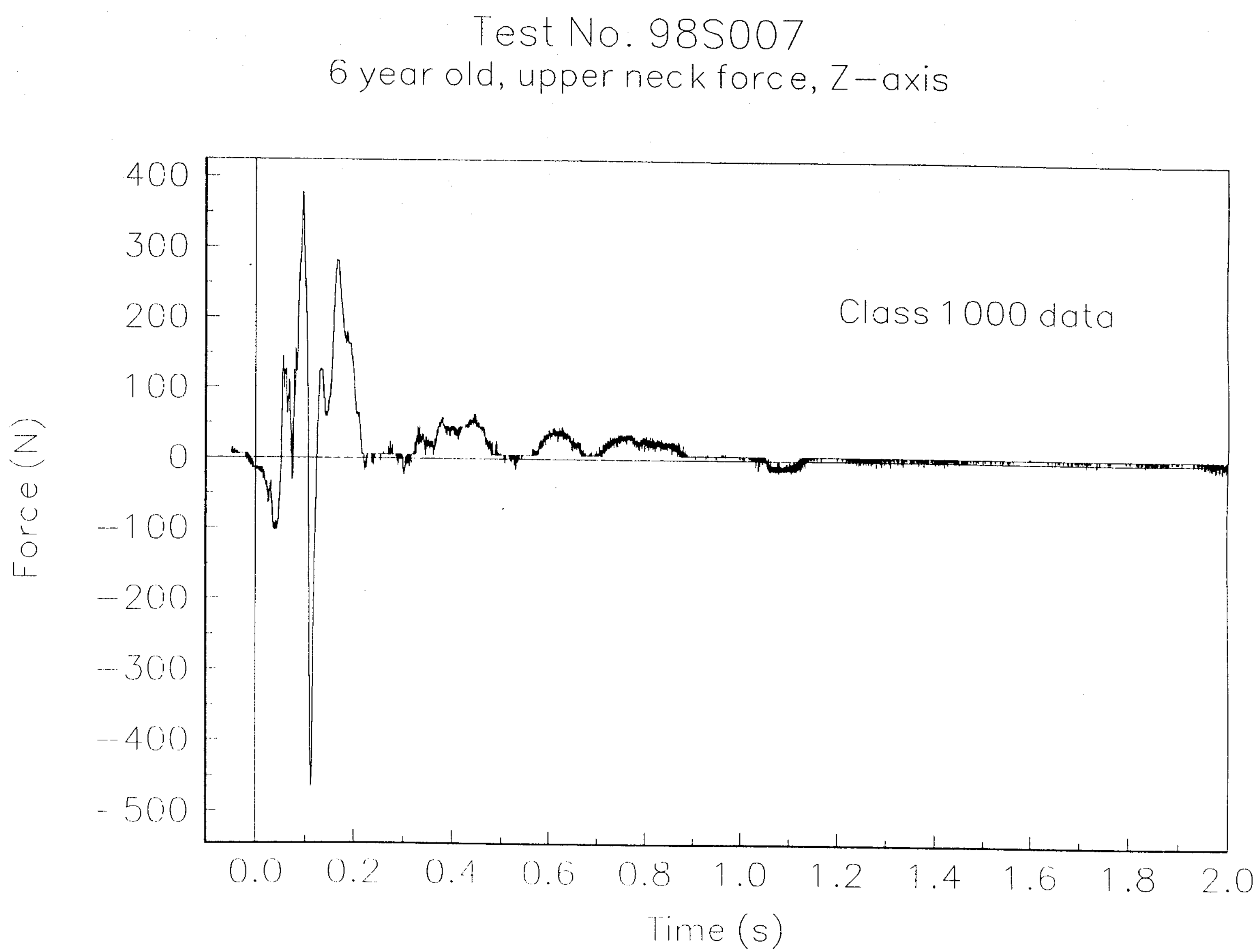


Figure 41. Force vs. time, Z-axis, child upper neck, test 98S007.

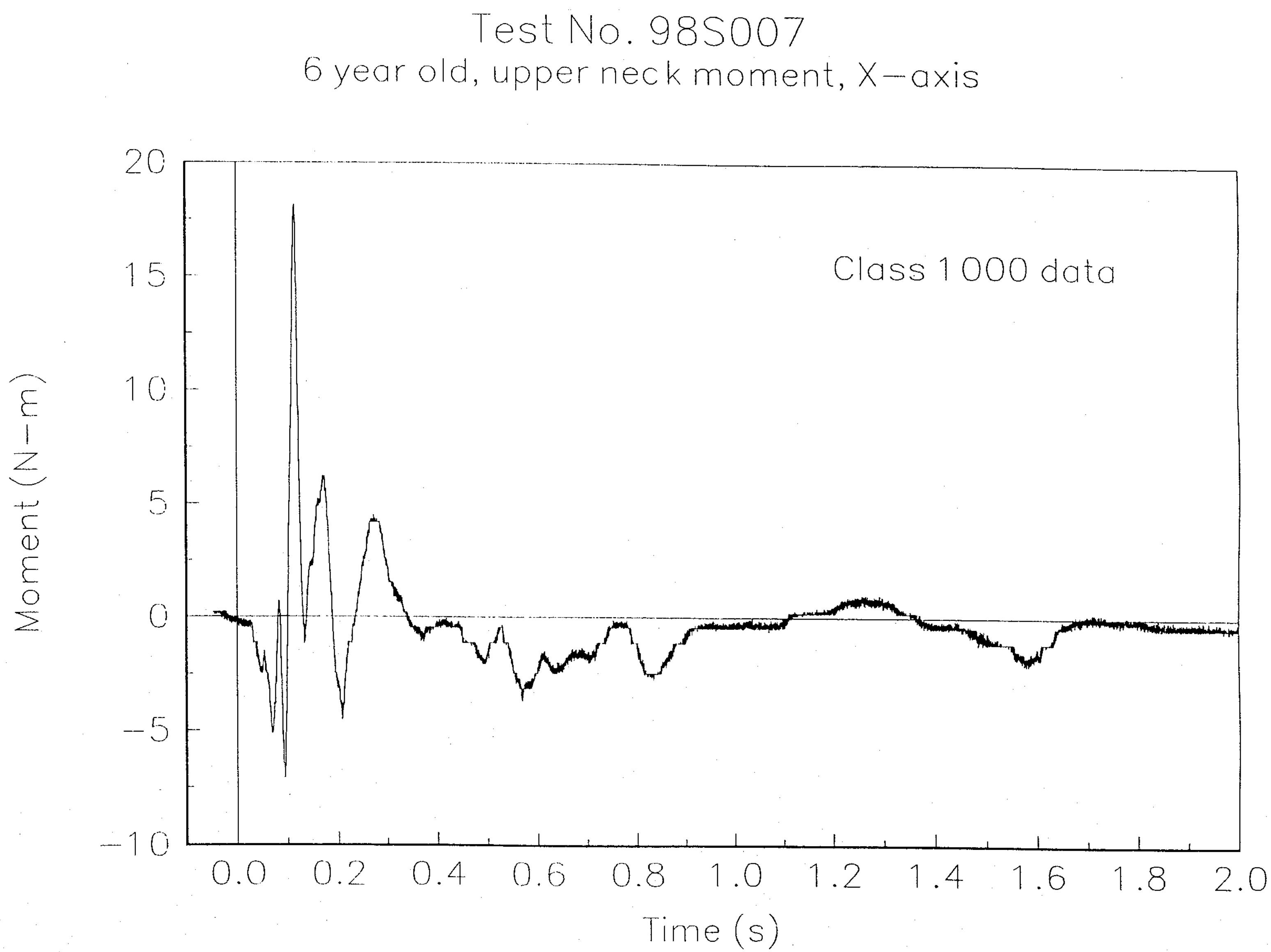


Figure 42. Moment vs. time, X-axis, child upper neck, test 98S007.

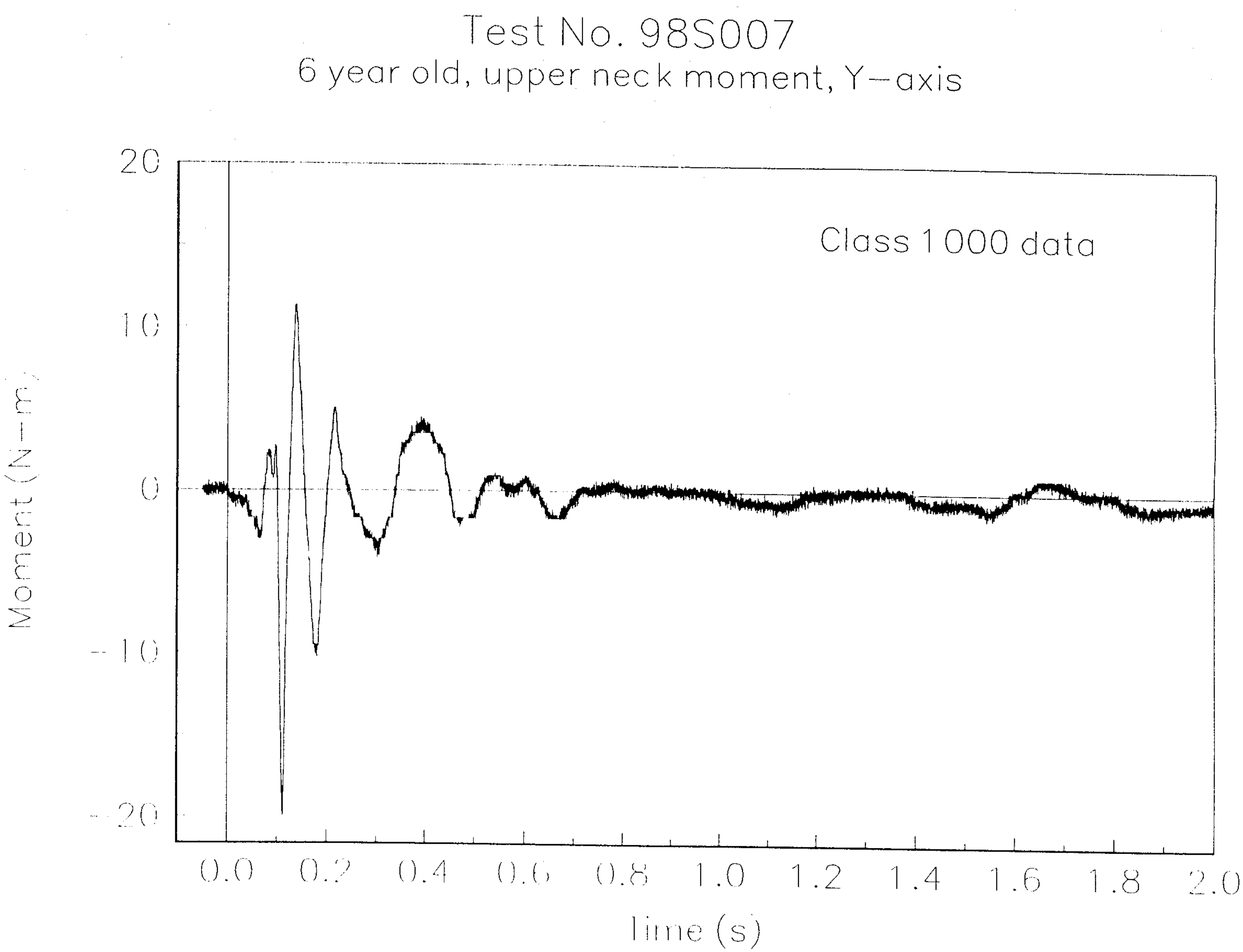


Figure 43. Moment vs. time, Y-axis, child upper neck, test 98S007.

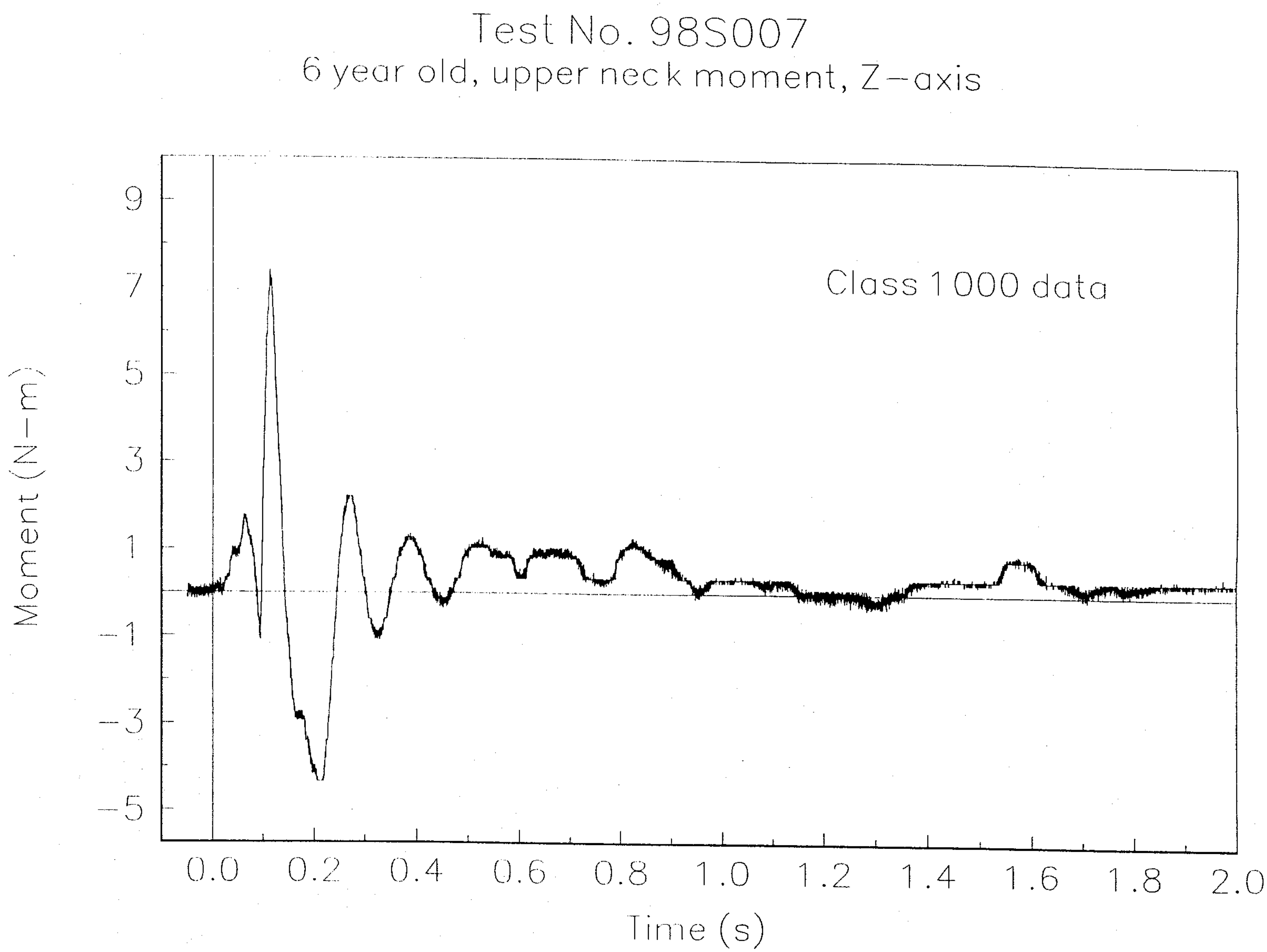


Figure 44. Moment vs. time, Z-axis, child upper neck, test 98S007.

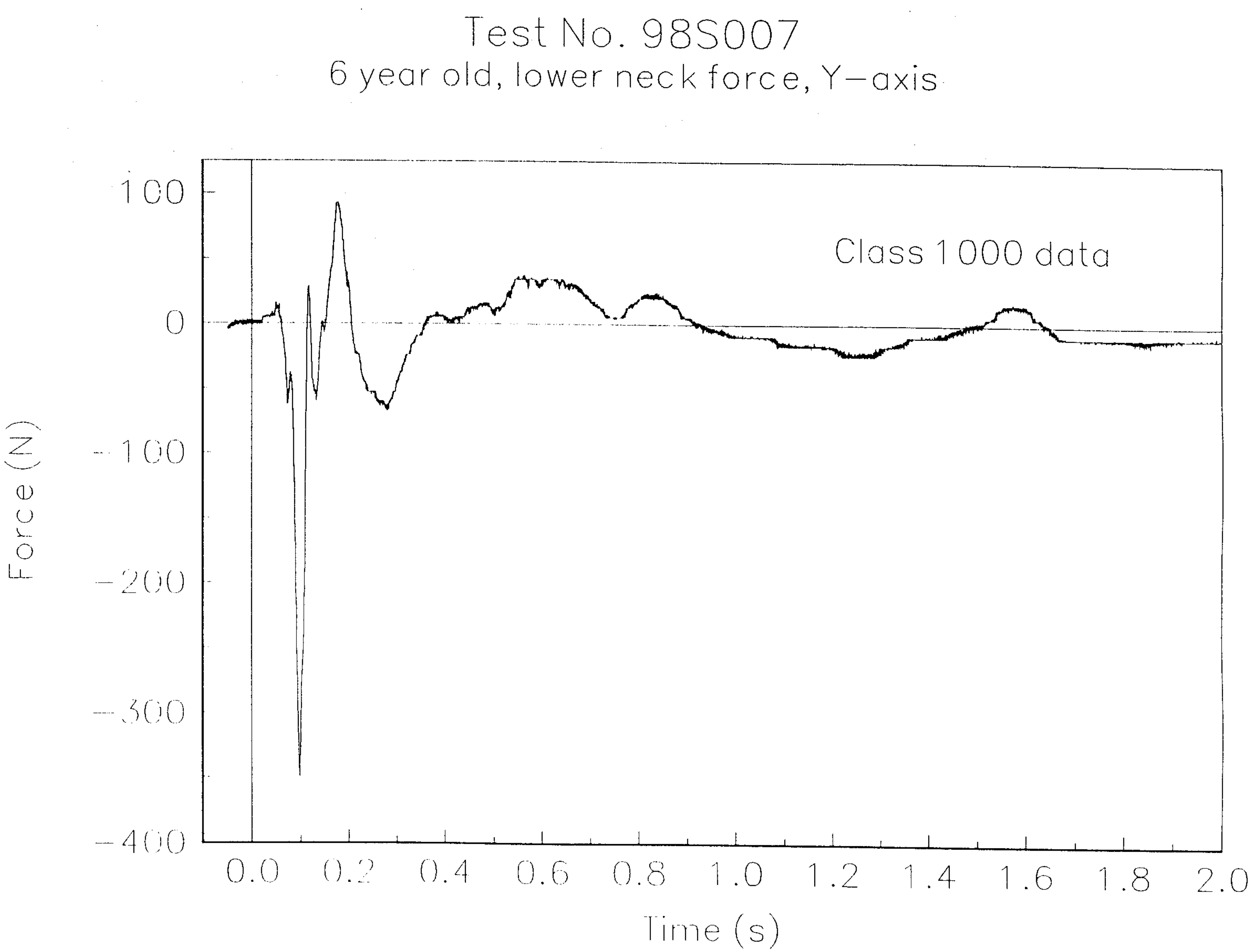


Figure 45. Force vs. time, Y-axis, child lower neck, test 98S007.

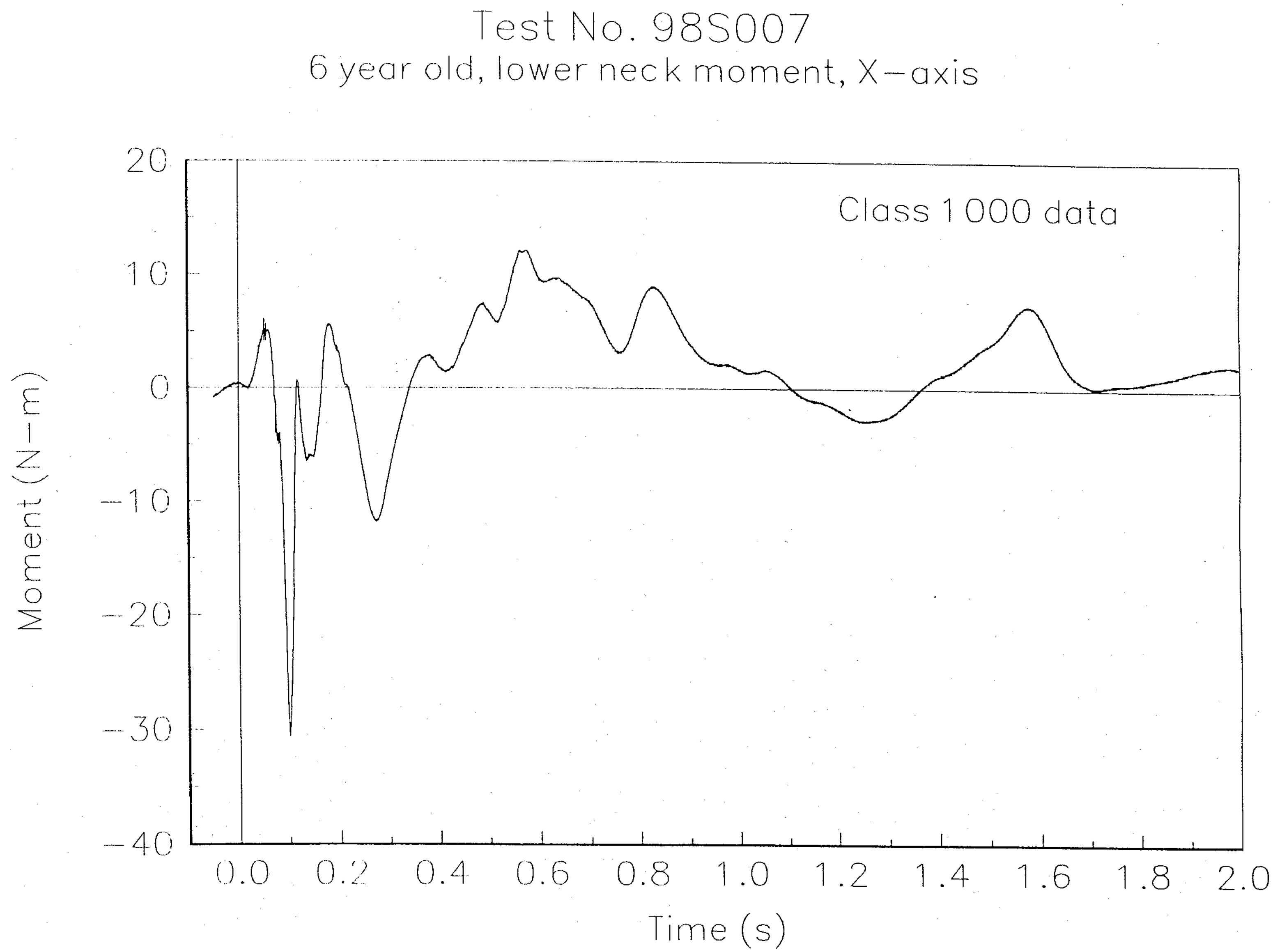


Figure 46. Moment vs. time, X-axis, child lower neck, test 98S007.

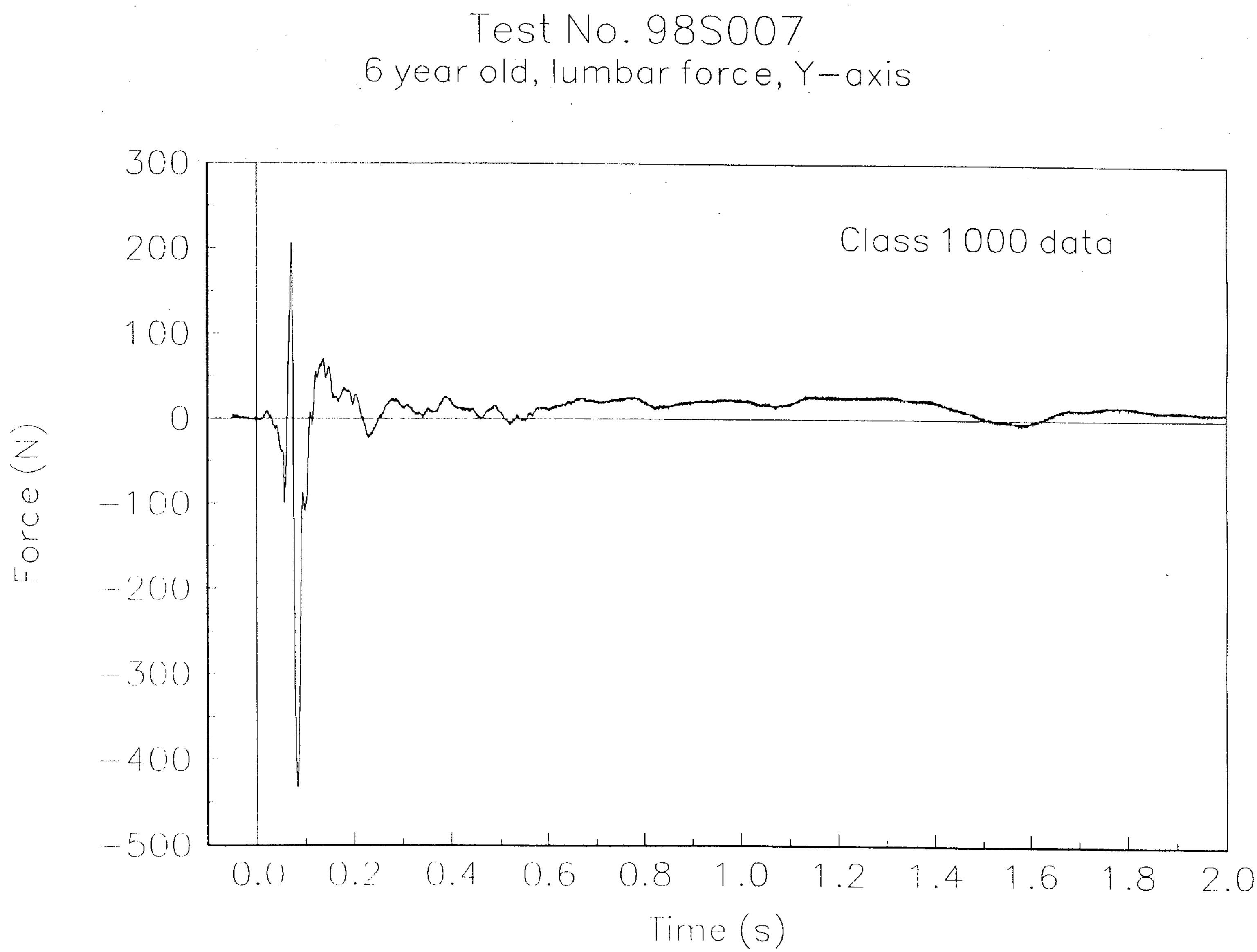


Figure 47. Force vs. time, Y-axis, child lumbar, test 98S007.

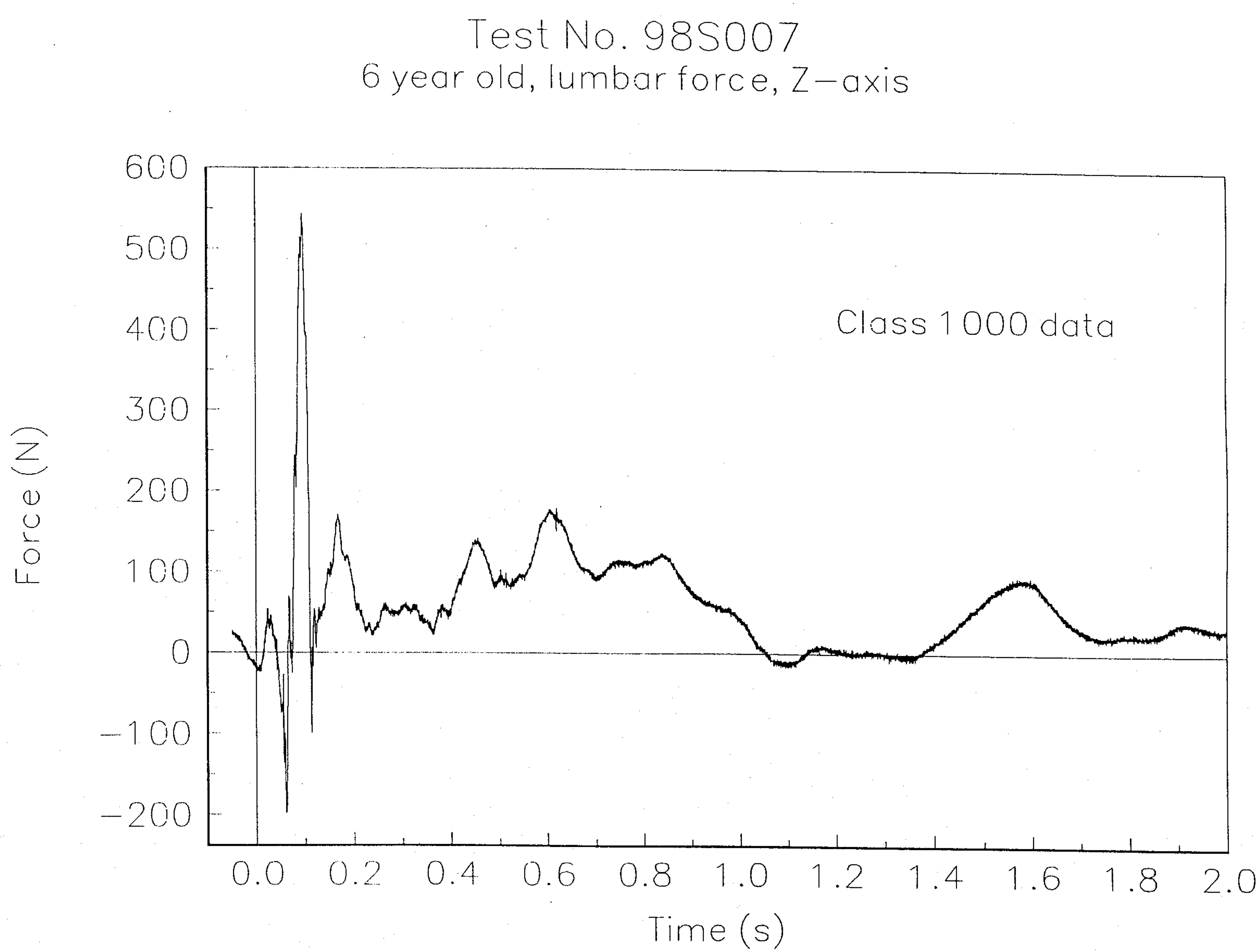


Figure 48. Force vs. time, Z-axis, child lumbar, test 98S007.

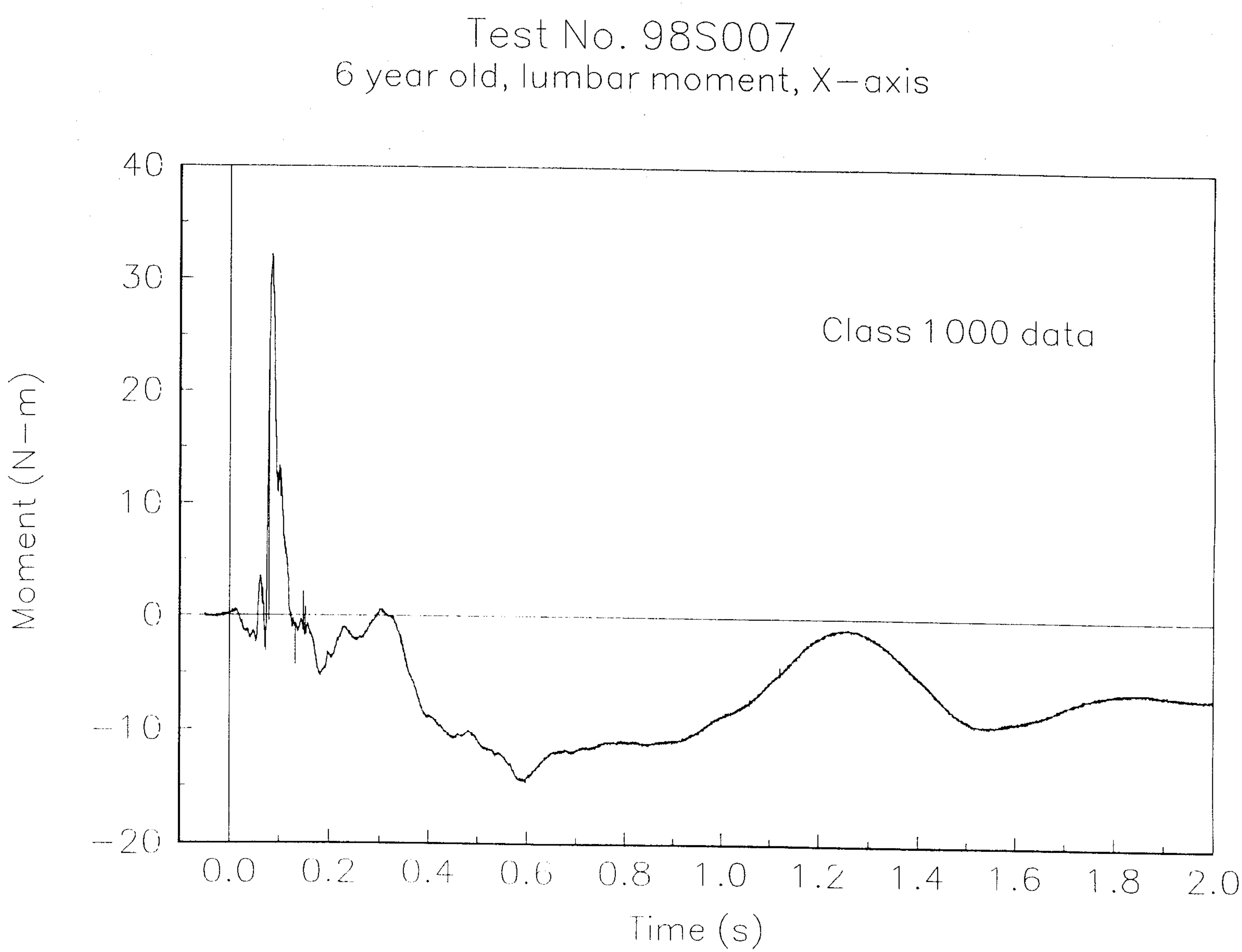


Figure 49. Moment vs. time, X-axis, child lumbar, test 98S007.

APPENDIX D. TEST PHOTOGRAPHS

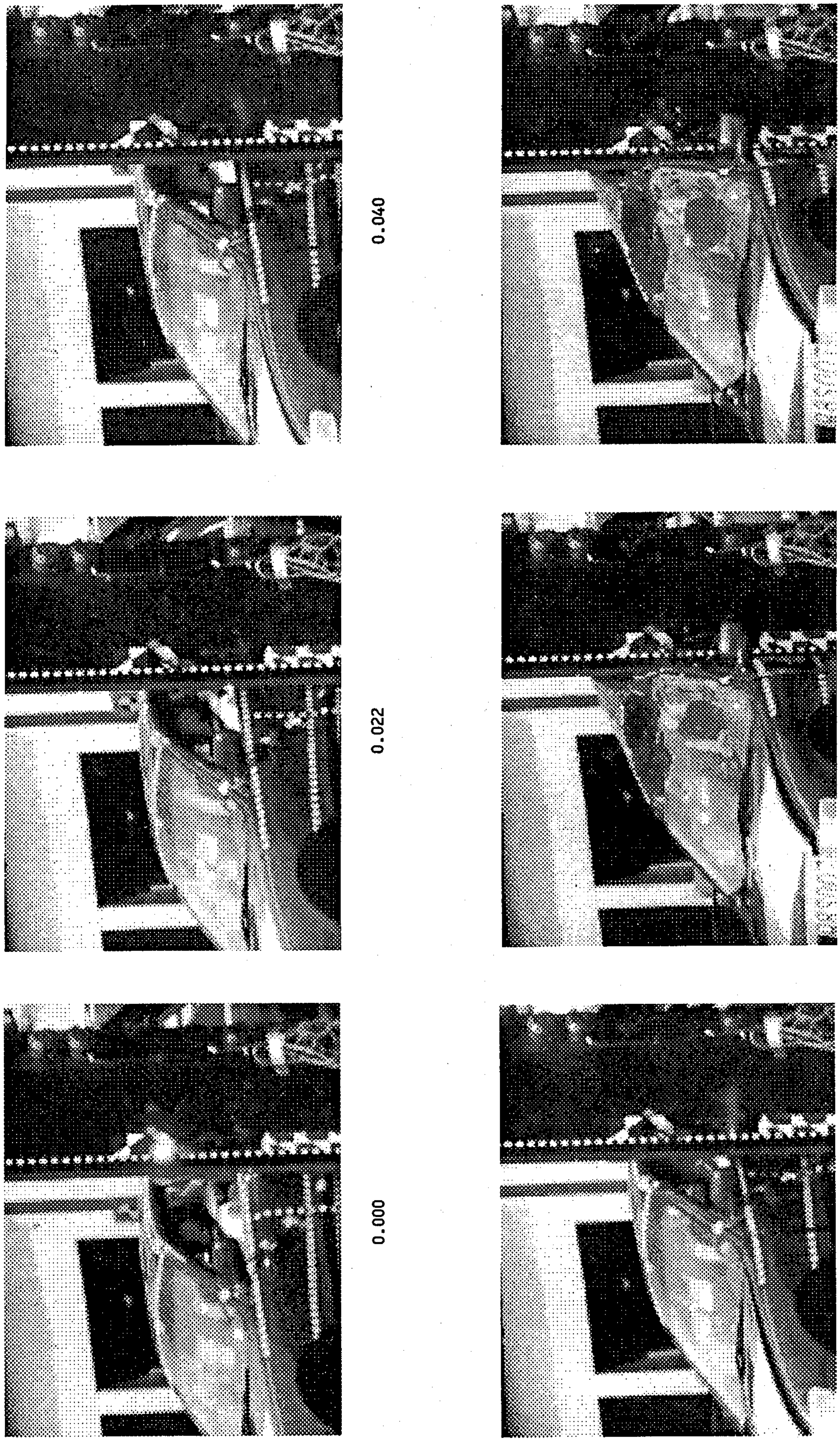
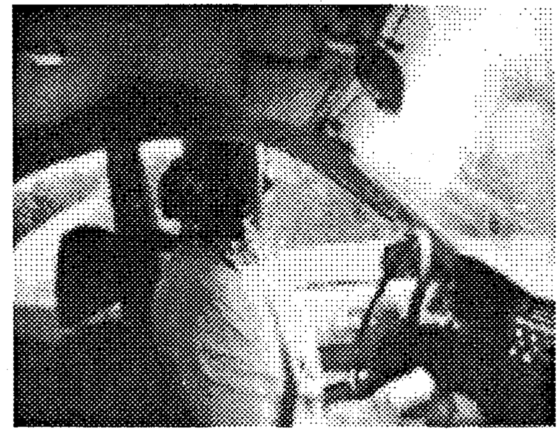


Figure 50. Test photographs during impact, test 98S007.

0.000

0.040



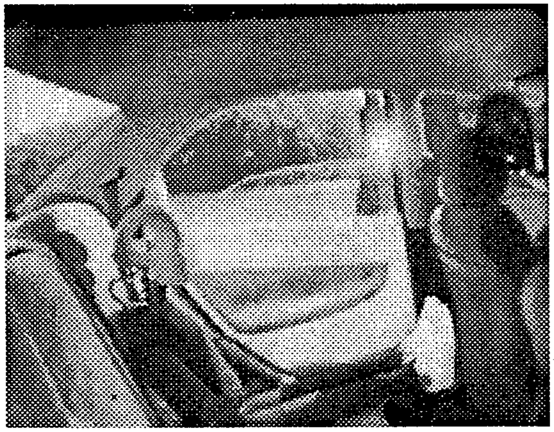
0.060

0.070

0.080

0.090

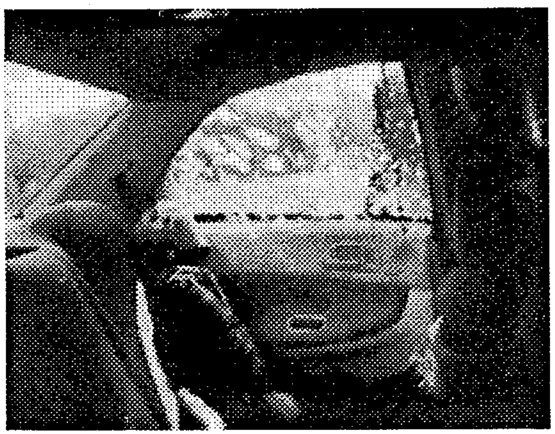
Figure 50. Test photographs during impact, test 98S007 (continued).



0.000

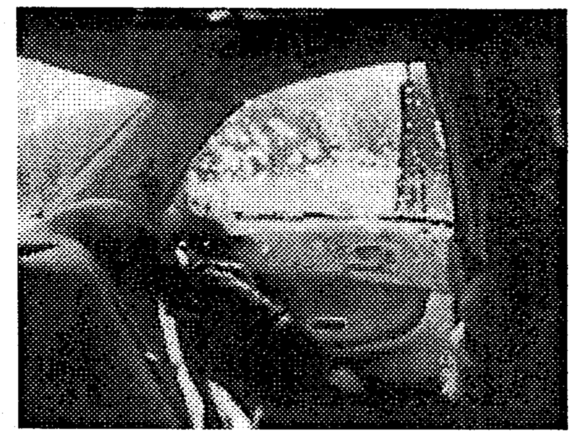
0.060

0.080



0.120

0.130



0.160

Figure 50. Test photographs during impact, test 98S007 (continued).

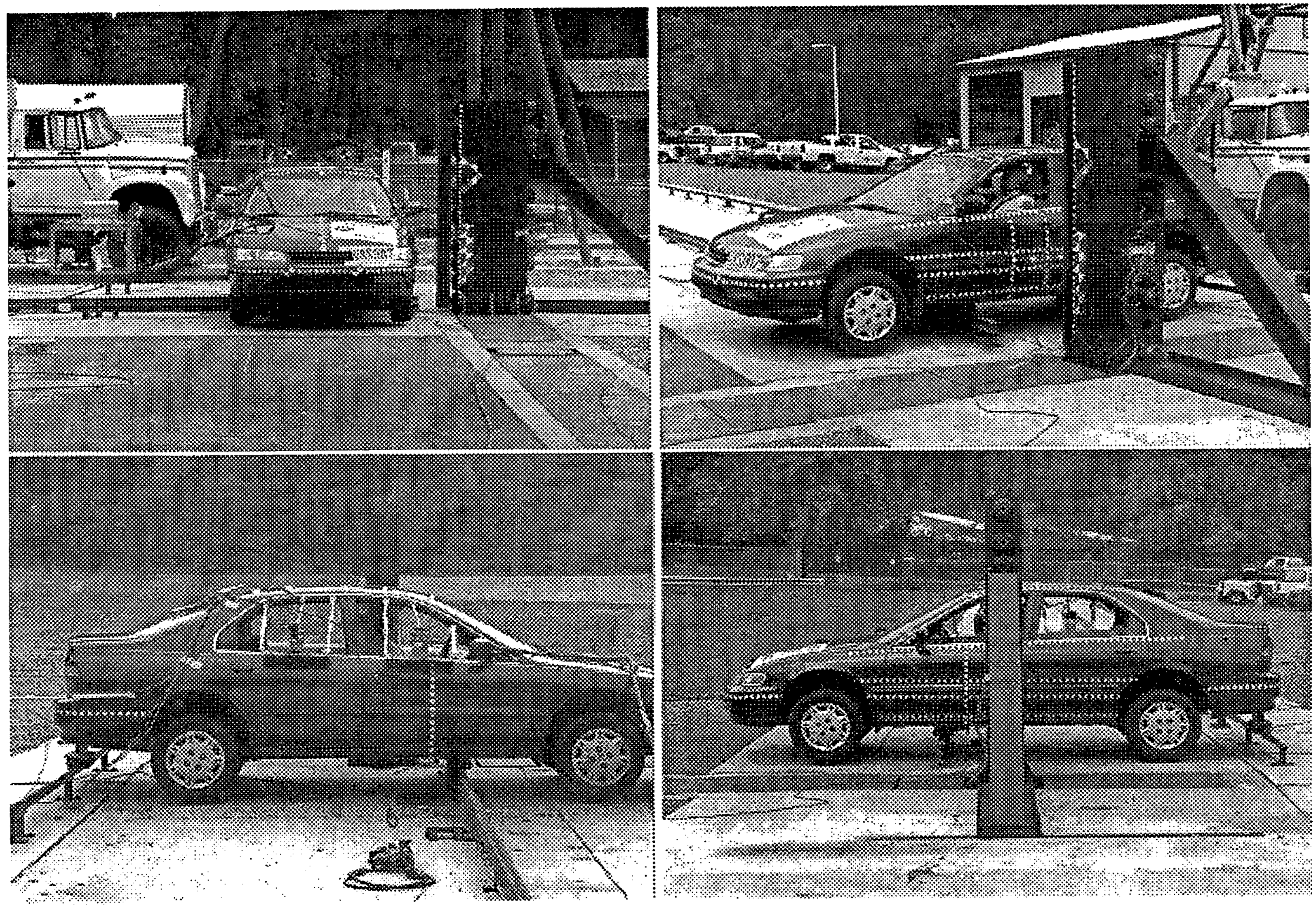


Figure 51. Pretest photographs, test 98S007.

Figure 51. Pretest photographs, test 98S007 (continued).

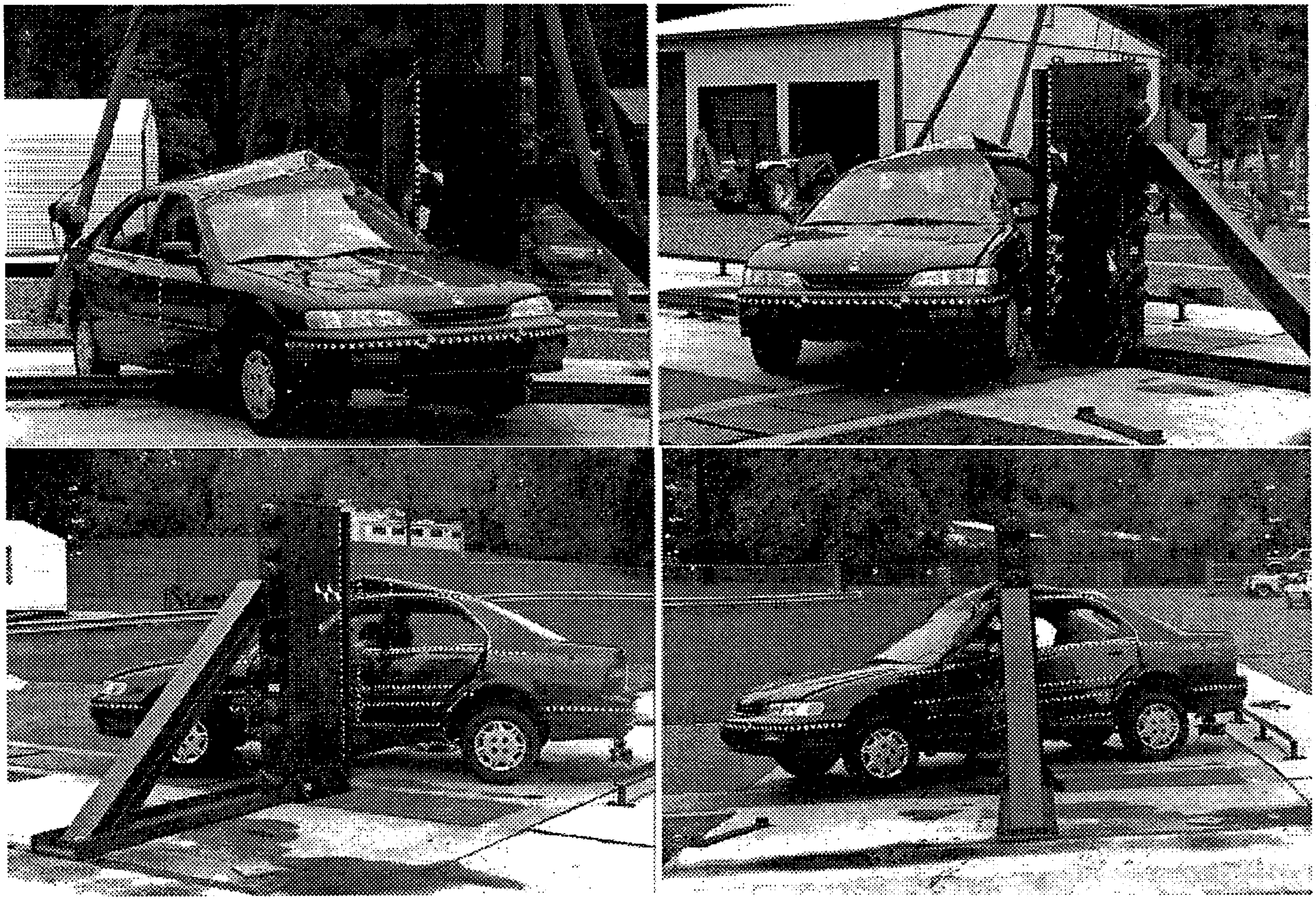


Figure 52. Post-test photographs, test 98S007.

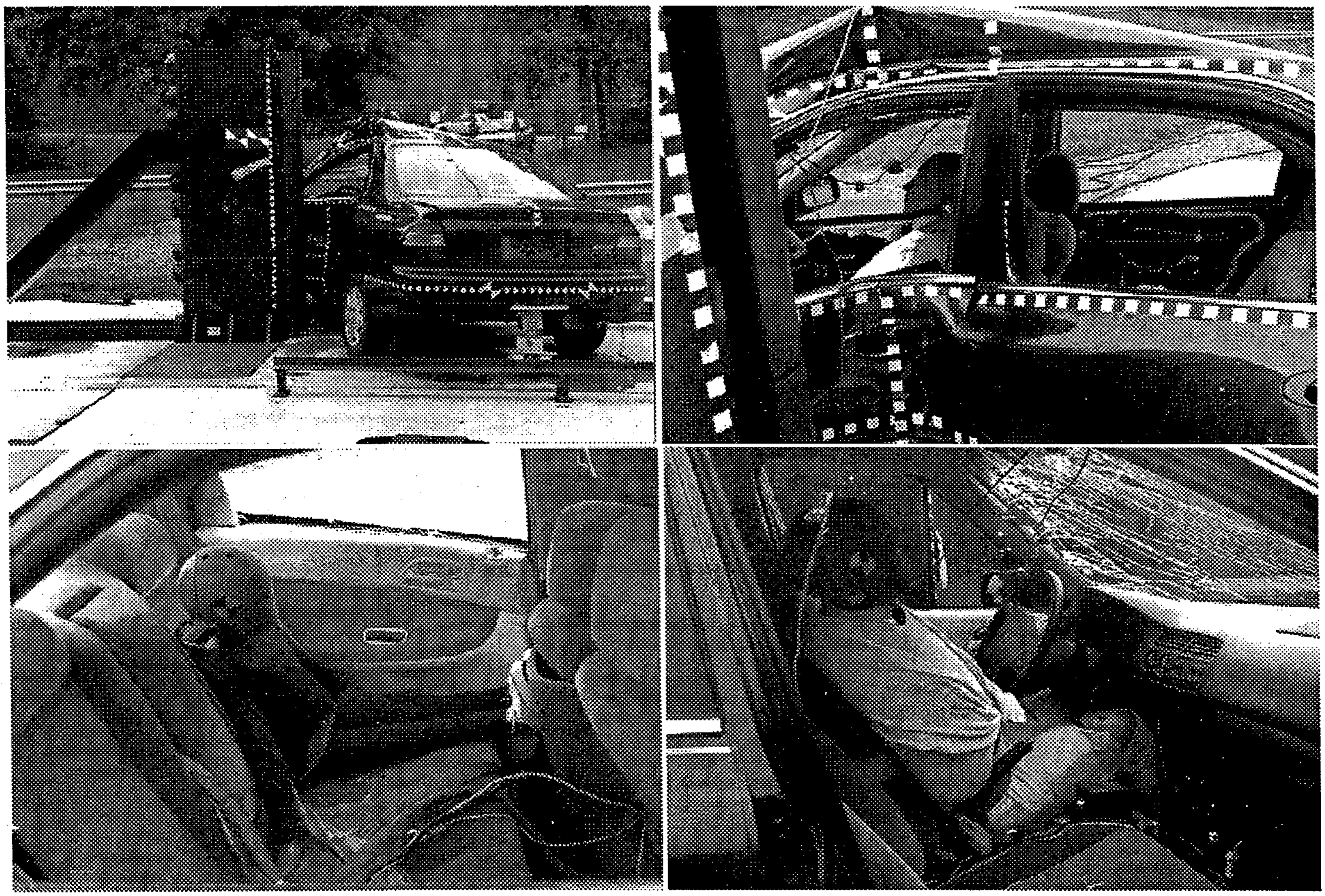


Figure 52. Post-test photographs, test 98S007 (continued).

Figure 52. Post-test photographs, test 98S007 (continued).

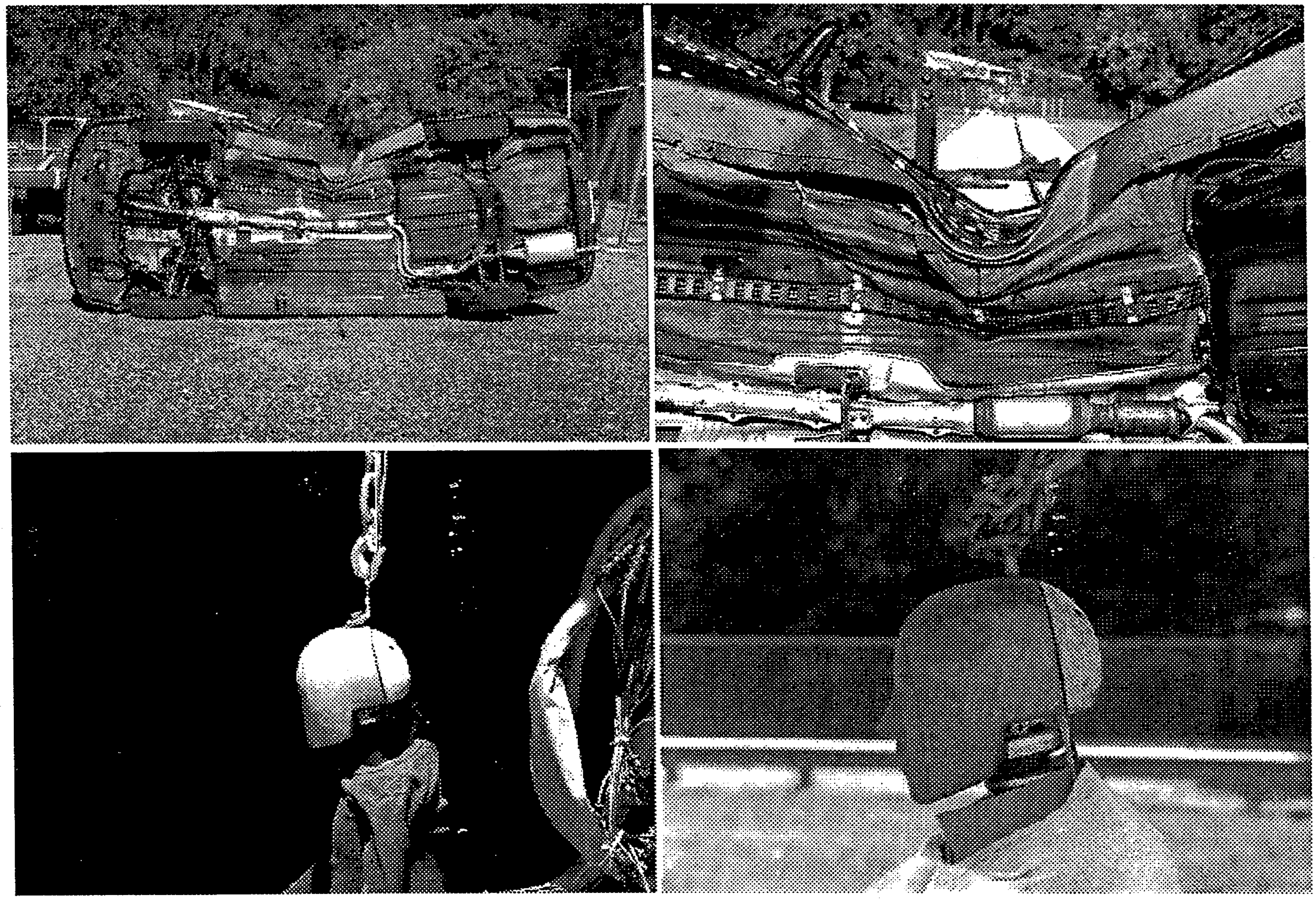


Figure 52. Post-test photographs, test 98S007 (continued).

APPENDIX E. DATA PLOTS FROM RIGID POLE LOAD CELLS

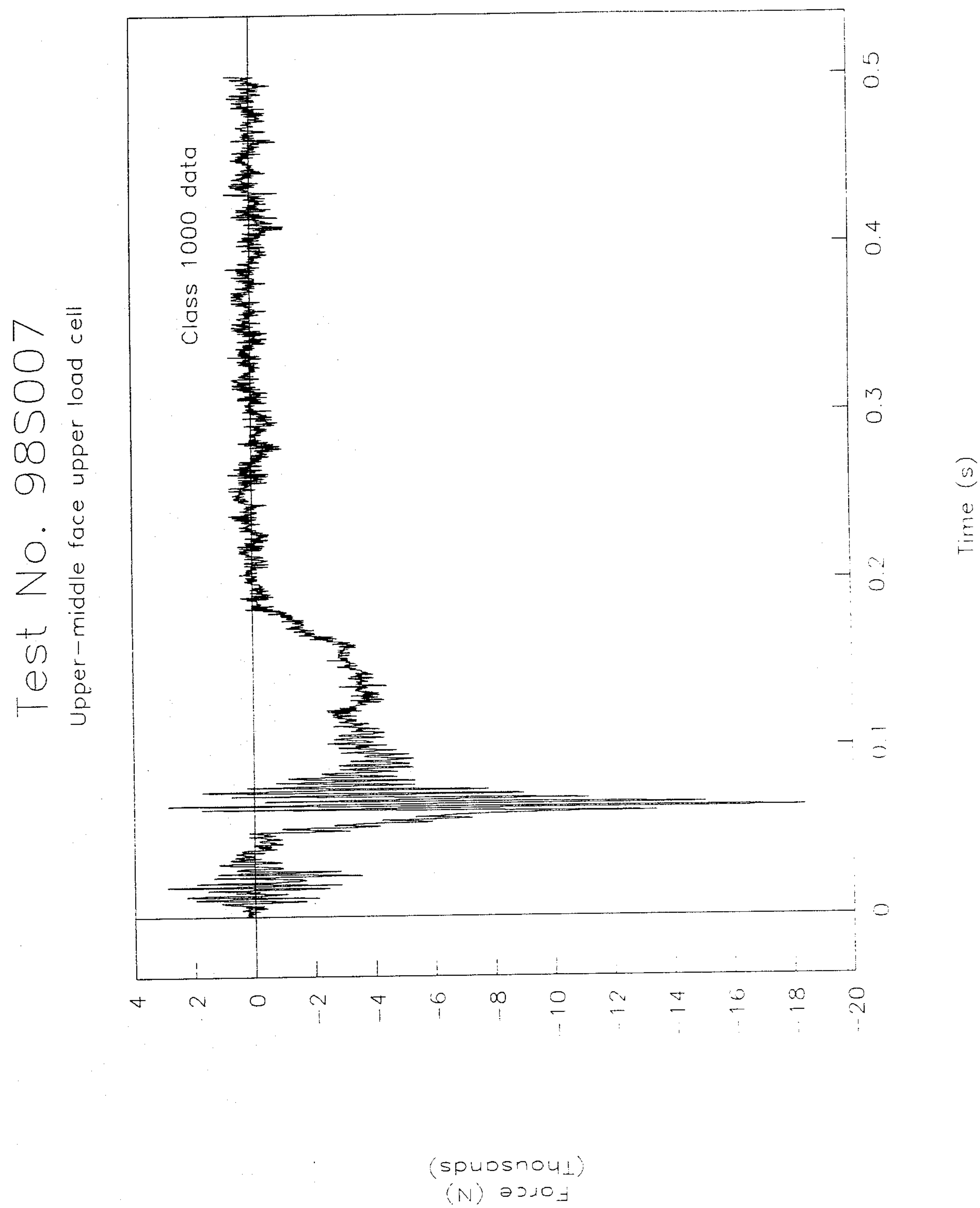


Figure 53. Rigid pole, force vs. time, upper middle face upper load cell, test 98S007.

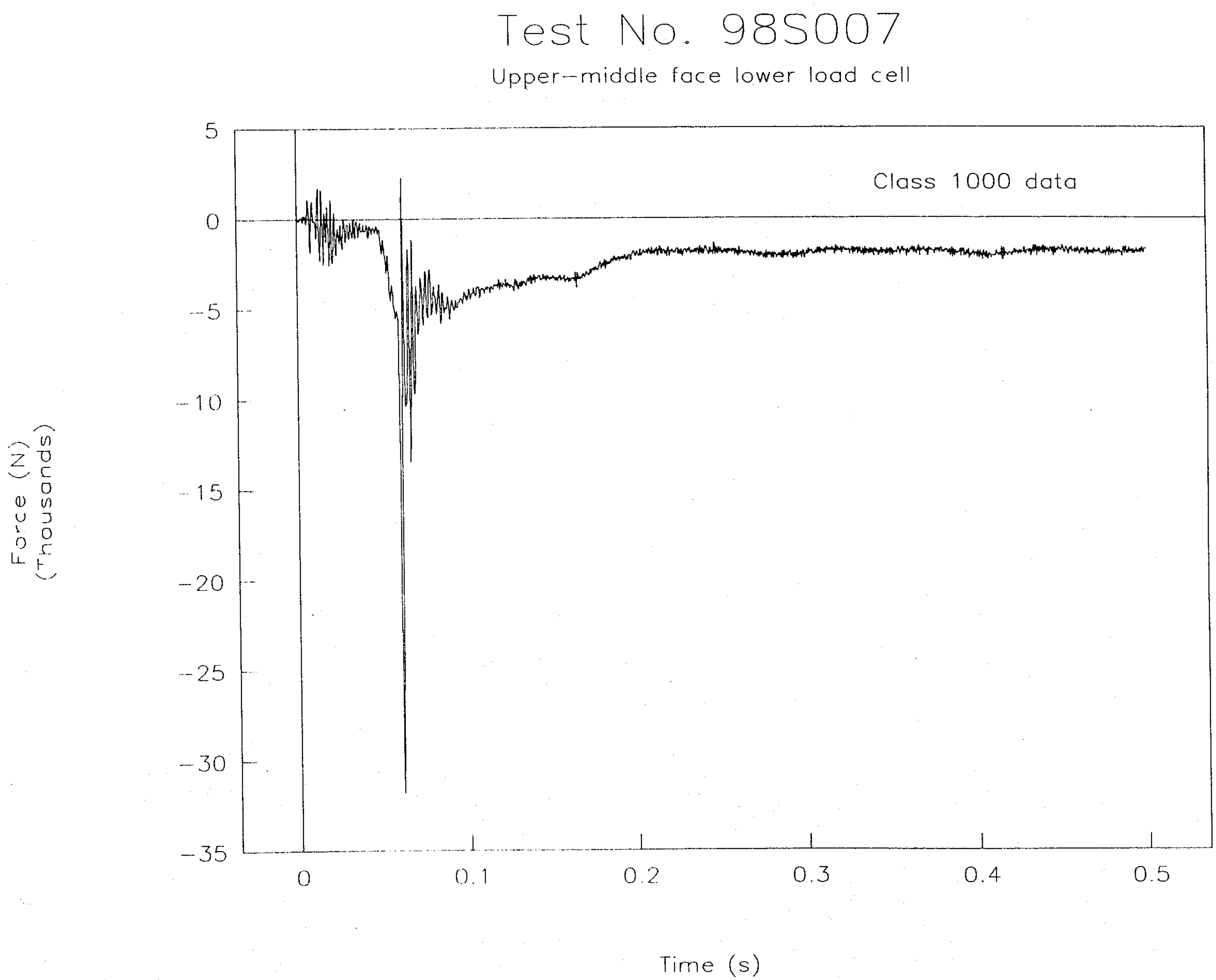


Figure 54. Rigid pole, force vs. time, upper middle face lower load cell, test 98S007.

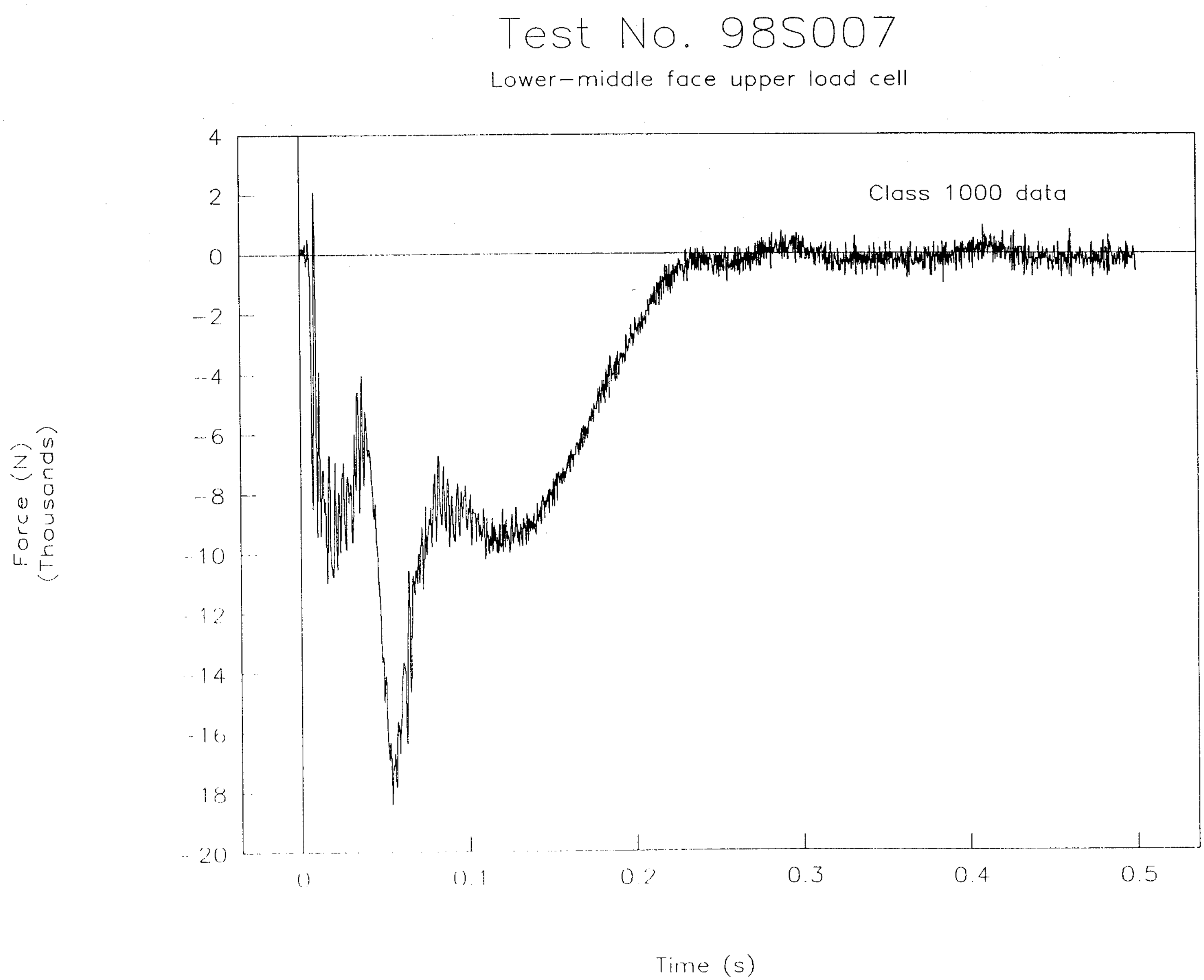


Figure 55. Rigid pole, force vs. time, lower-middle face upper load cell, test 98S007.

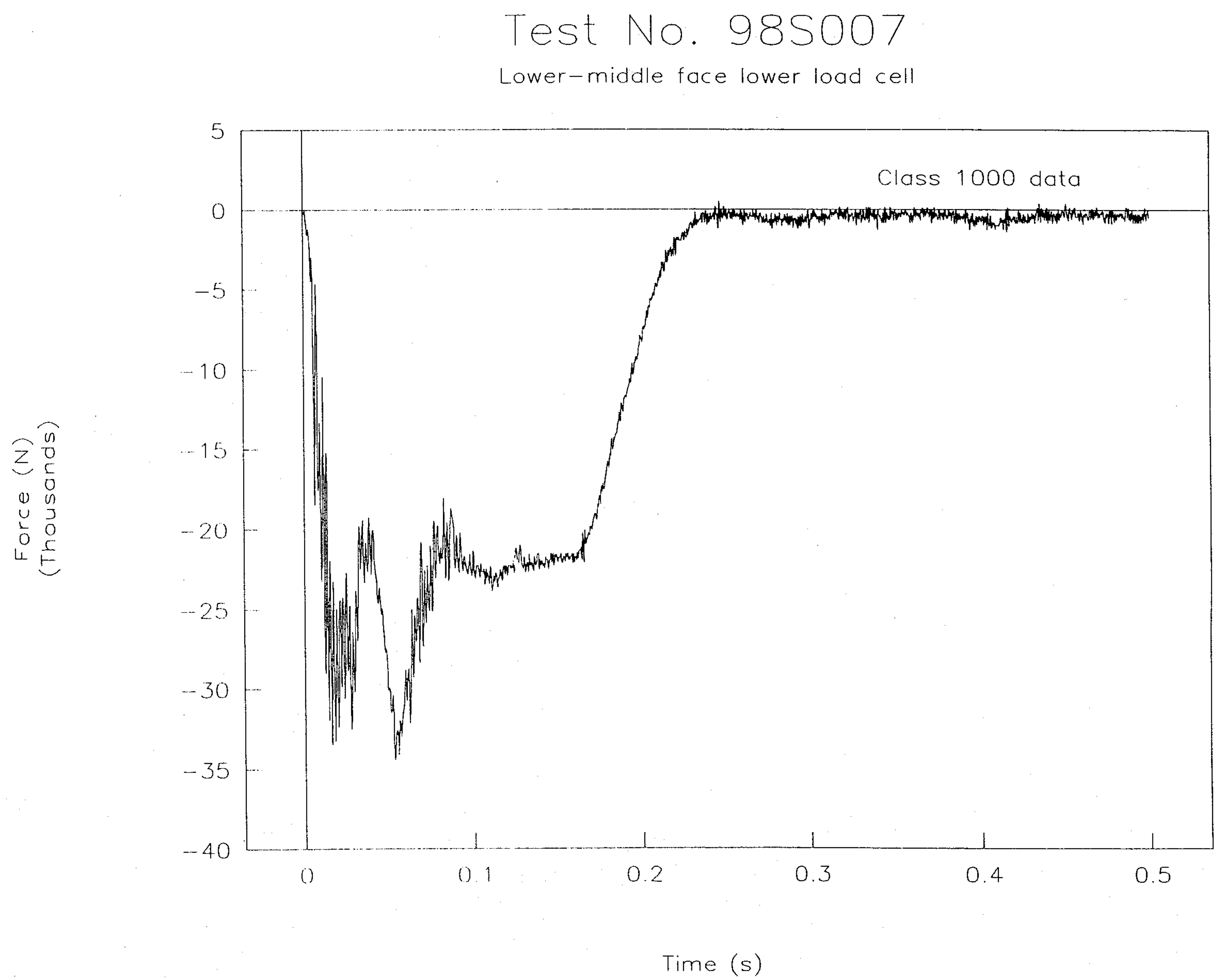


Figure 56. Rigid pole, force vs. time, lower-middle face lower load cell, test 98S007.

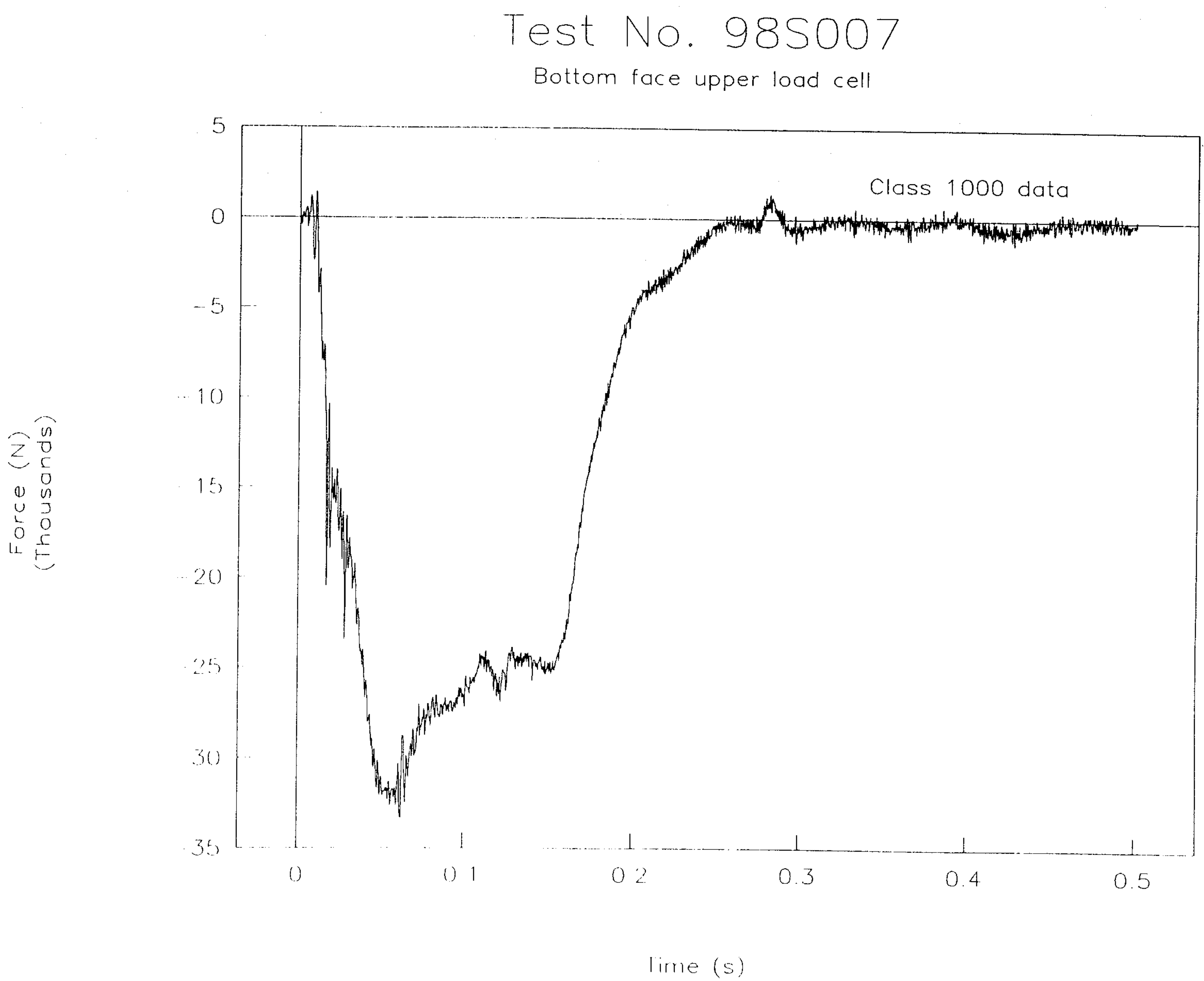


Figure 57. Rigid pole, force vs. time, bottom face upper load cell, test 98S007.

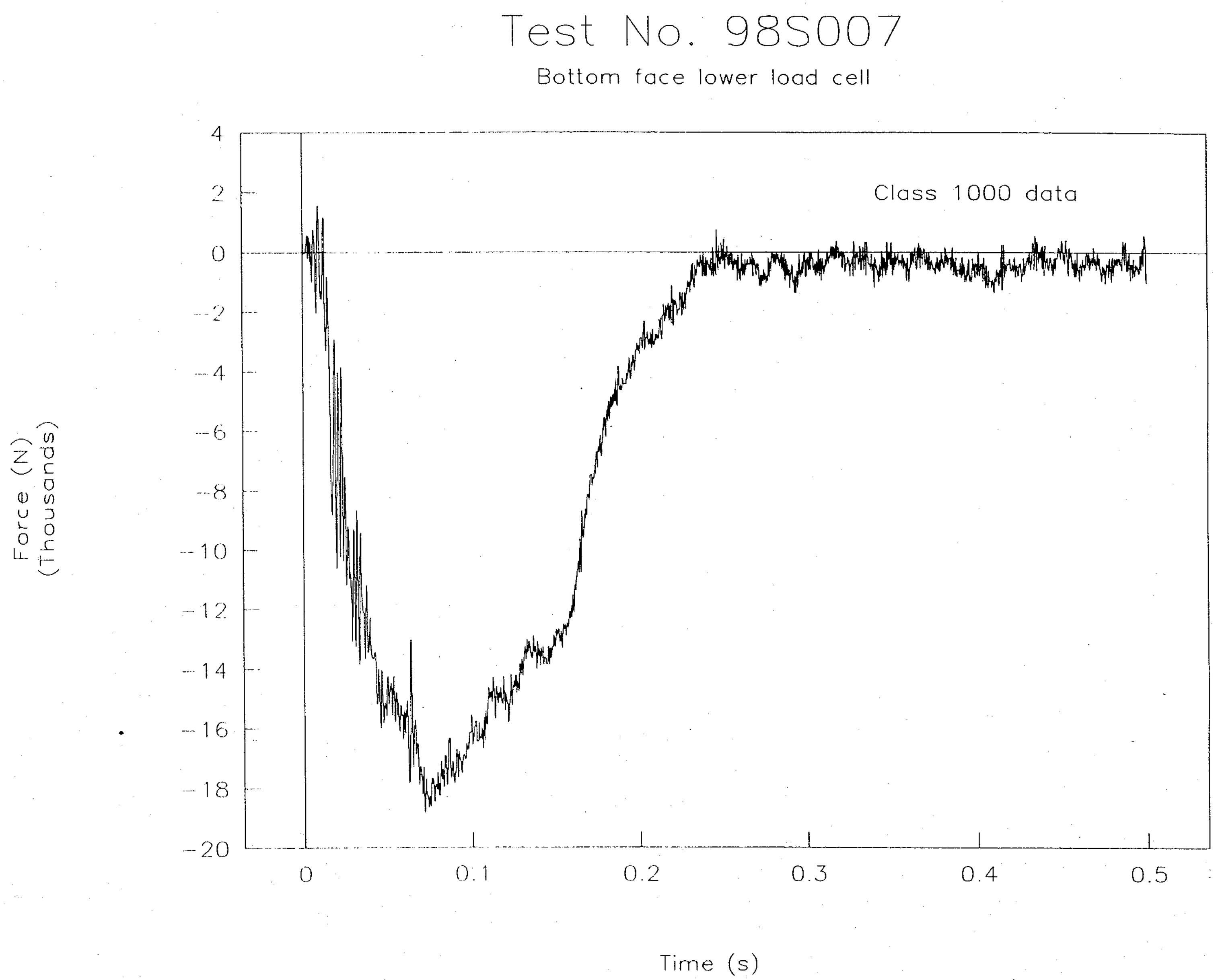


Figure 58. Rigid pole, force vs. time, bottom face lower load cell, test 98S007.

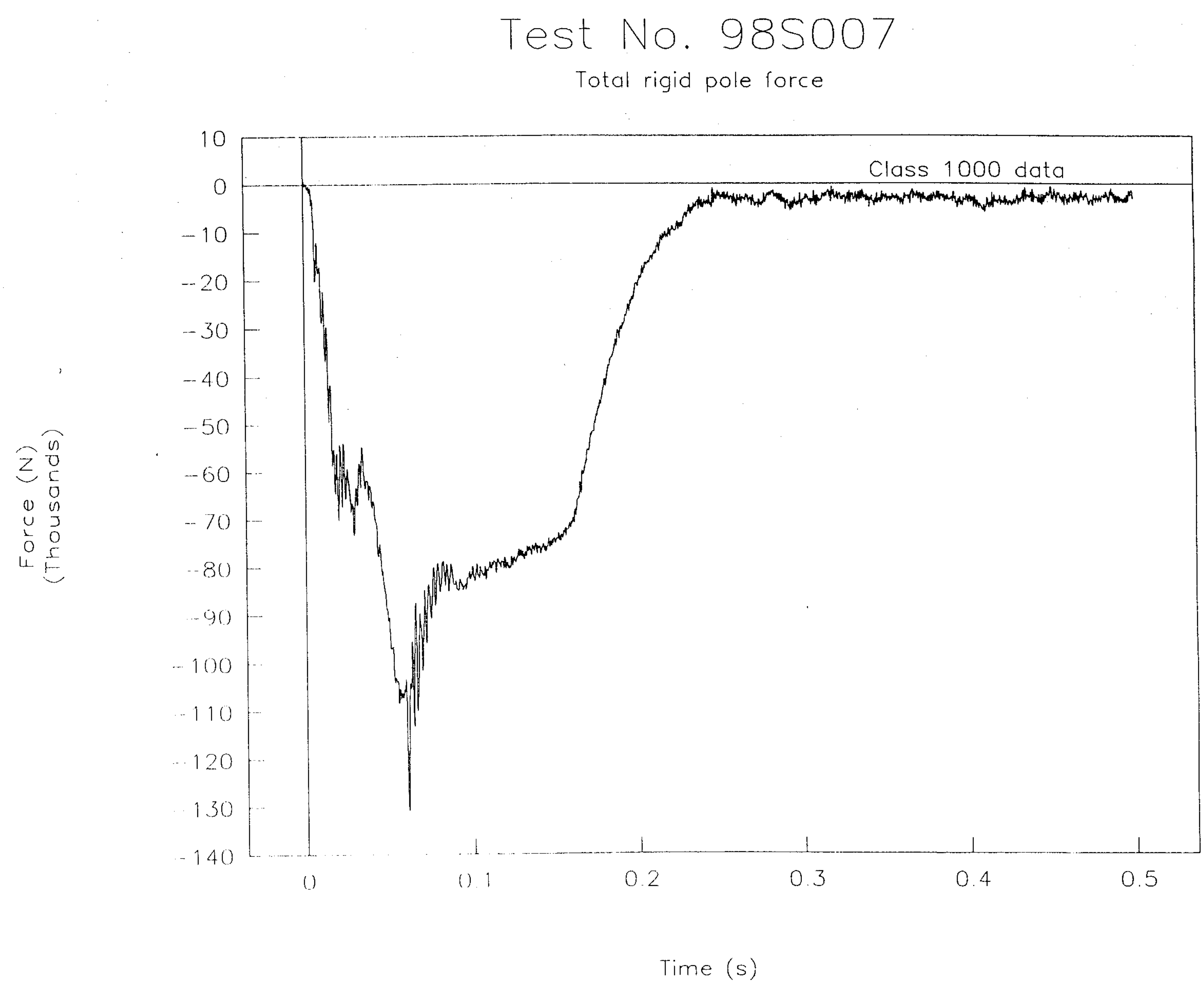


Figure 59. Total rigid pole force, test 98S007.

REFERENCES

(1) NHTSA. *Laboratory Test Procedure for Federal Motor Vehicle Safety Standard 201*, National Highway Traffic Safety Administration, Washington, DC, April 1997.

(2) Christopher M. Brown, *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S003*, Publication No. FHWA-RD-98-008, Federal Highway Administration, Washington, DC, January 1998.

(3) Christopher M. Brown, *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S004*, Publication No. FHWA-RD-98-009, Federal Highway Administration, Washington, DC, January 1998.

(4) Christopher M. Brown, *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S005*, Publication No. FHWA-RD-98-010, Federal Highway Administration, Washington, DC, January 1998

(5) Christopher M. Brown, *Honda Accord LX Broadside Collision with a Narrow Fixed Object: FOIL Test Number 97S006*, Publication No. FHWA-RD-98-011, Federal Highway Administration, Washington, DC, January 1998

(6) NHTSA. *Laboratory Test Procedure for Federal Motor Vehicle Safety Standard 214*, National Highway Traffic Safety Administration, Washington, DC, May 1992.

(7) Christopher M. Brown, *1994 Ford Explorer Broadside Collision with a Narrow Fixed Object: FOIL Test Number 98S005*, Report Number FHWA-RD-98-150, Federal Highway Administration, Washington, DC.

(8) Christopher M. Brown, 1994 Toyota Pickup Broadside Collision with a Narrow Fixed Object: FOIL Test Number 98S006, Report Number FHWA-RD-98-151, Federal Highway Administration, Washington, DC.