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16. Abstract

The New Jersey safety shaped barrier is one of the most common barriers currently in use on the Nation's highways. The barrier has successfully met all evaluation criteria set forth in National Cooperative Highway Research Program (NCHRP) Report 230. However, with the adoption of NCHRP Report 350 by the Federal Highway Administration (FHWA) as the official guidelines for crash testing of roadside safety features, it became necessary to reevaluate the New Jersey safety shaped barrier to the new guidelines. Of particular importance is the replacement of one of the design test vehicles specified in NCHRP Report 230, the 2044-kg passenger car, by a 2000-kg pickup truck (2000P) under NCHRP Report 350 guidelines. The crash test reported herein was performed as an effort to evaluate the New Jersey safety shaped barrier according to NCHRP Report 350 guidelines.

The crash test performed corresponded to NCHRP Report 350 test designation 3-11 involving a 2000P test vehicle impacting the barrier at a nominal speed and angle of 100 km/h and 25 degrees. The New Jersey safety shaped barrier met all evaluation criteria set forth in NCHRP Report 350 and the test was judged to be satisfactory.

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Unclassified	Unclassified	42	

Form DOT F 1700.7 (8-69)

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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I. INTRODUCTION

The Federal Highway Administration (FHWA) has recently adopted the new performance evaluation guidelines for roadside safety features set forth in National Cooperative Highway Research Program (NCHRP) Report 350.[1] Most of the existing roadside safety features were tested according to the previous guidelines contained in NCHRP Report 230[2] and there are questions as to how the existing roadside safety features would perform under the new guidelines. Specifically, there is concern that existing barrier systems, including the New Jersey safety shaped barrier, may not perform satisfactorily to contain and redirect the 2000P test vehicle, i.e., 2000-kg pickup truck, and the vehicle may vault or go over the barrier or roll over. A series of crash tests were therefore conducted with the 2000P test vehicle on the more commonly used guardrail systems, one of which is the New Jersey safety shaped barrier. All these pickup truck crash tests were conducted under NCHRP Report 350 test level 3 conditions, i.e., impacting the length-of-need section at a nominal speed and angle of 100 km/h and 25 degrees.

This report contains the results of a crash test conducted on the New Jersey safety shaped barrier with a 2000-kg pickup truck under NCHRP Report 350 test level 3 conditions. The purpose of the test was to determine if the barrier would perform satisfactorily with the 2000P test vehicle under the new NCHRP Report 350 requirements.

II. STUDY APPROACH

2.1 TEST ARTICLE

The New Jersey safety shaped barrier used for this crash test was actually a bridge rail constructed under a previous study. Since the New Jersey safety shaped barrier is a rigid barrier, the fact that the test installation was a bridge rail and not a roadside barrier has no effect on the results of the crash test. The total length of the test installation was 30.5 m. A cross section of the test installation is shown in figure 1 and photographs of the test installation are shown in figure 2.

The total height of the New Jersey safety shaped barrier is 813 mm. The thickness of the barrier is 381 mm at its base and 152 mm at the top. Again, since the barrier is a rigid barrier, the thickness of the barrier has no effect on the results of the crash test as long as the structural capacity of the barrier is sufficient to handle the impact force imparted by the test vehicle. For this particular test installation, the barrier has eight 13-mm diameter longitudinal bars and 16-mm diameter stirrups spaced at 203 mm center to center. The specified concrete strength was 24 804 kPa at 28 days, and specified yield strength for the steel rebars was 413 400 kPa. The barrier was attached to a cantilevered bridge deck with an overhang of 991 mm.

2.2 CRASH TEST CONDITIONS

The crash test conducted on the New Jersey safety shaped barrier was NCHRP Report 350 test designation 3-11 which involved a 2000P test vehicle impacting the length-of-need section of the barrier at a nominal speed and angle of 100 km/h and 25 degrees. The impact point was selected to be near the one-third point of the test installation. The typical purpose of this length-of-need redirection test is to evaluate the structural adequacy of the barrier in containing and redirecting the 2000P test vehicle. However, for the New Jersey safety shaped barrier, there was no question that the barrier has the required structural capacity to contain and redirect a 2000P test vehicle. The concern was more with the stability and post-impact trajectory of the test vehicle since the 2000P test vehicle has been shown to have the propensity for rolling over in similar tests with other barrier systems.

2.3 CRASH TEST AND DATA ANALYSIS PROCEDURES

The crash test and data analysis procedures were in accordance with guidelines presented in NCHRP Report 350. Brief descriptions of these procedures are presented as follows.

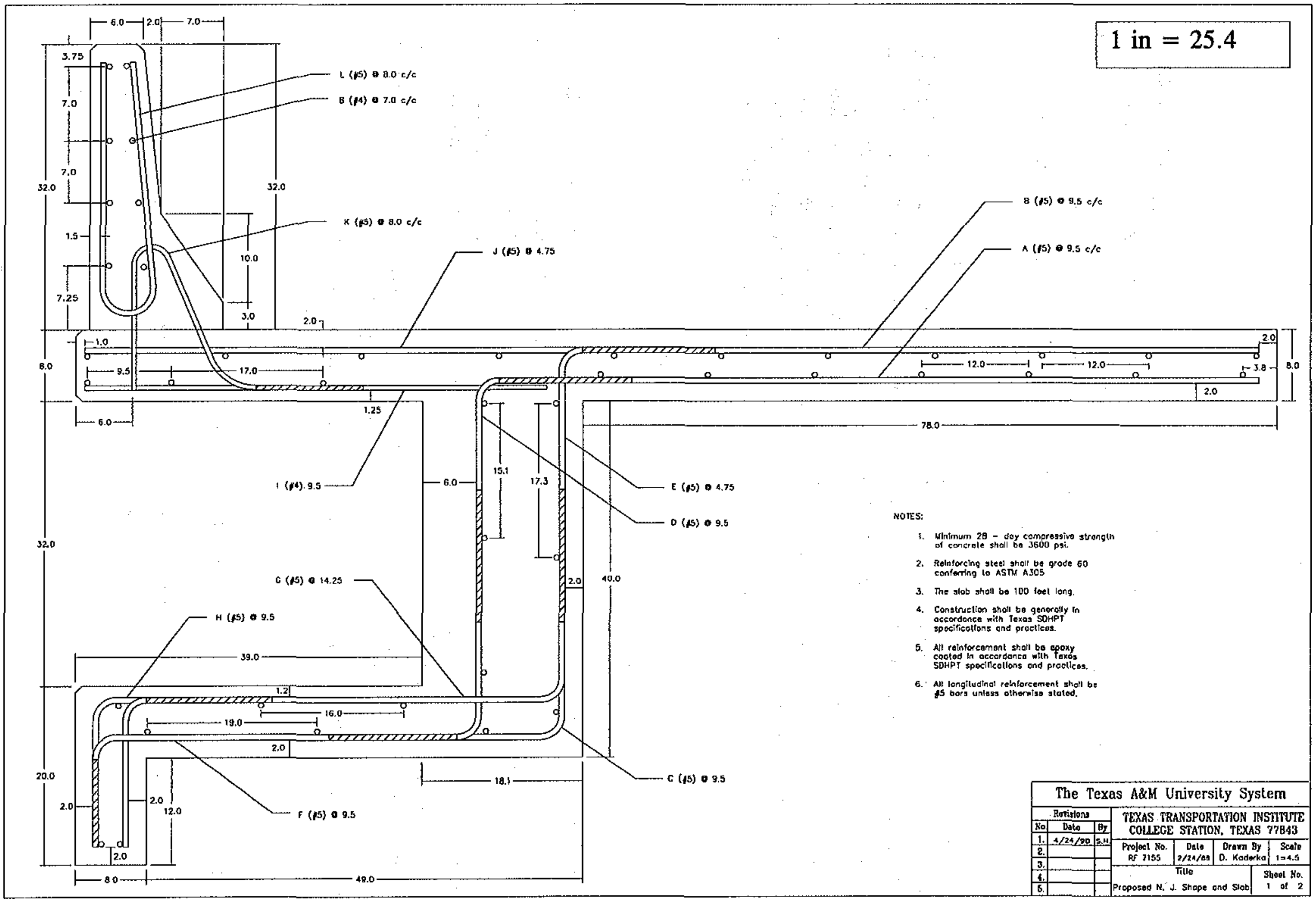
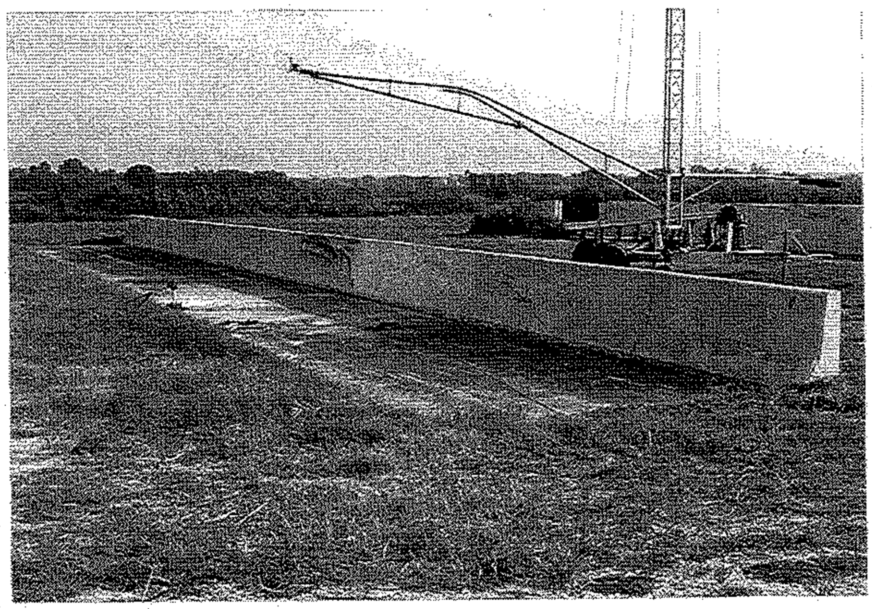


Figure 1. Details of the New Jersey safety shaped barrier test installation.



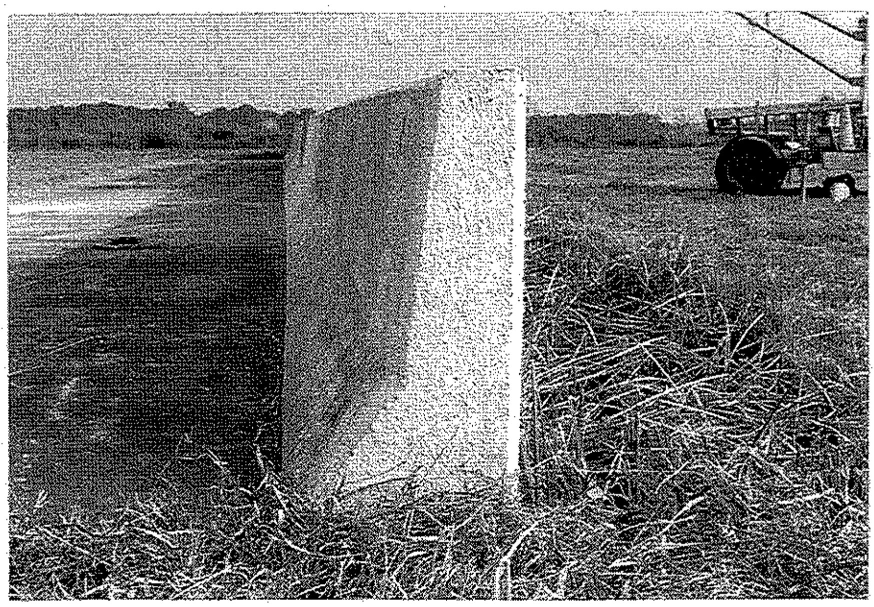


Figure 2. New Jersey safety shaped barrier test installation before test 405491-1.

2.3.1 Electronic Instrumentation and Data Processing

The test vehicle was instrumented with three solid-state angular rate transducers to measure roll, pitch and yaw rates; a triaxial accelerometer at the vehicle center-of-gravity to measure longitudinal, lateral, and vertical acceleration levels; and a triaxial accelerometer mounted in the bed of the vehicle over the rear axle to measure longitudinal, lateral, and vertical acceleration levels. The accelerometers were strain gauge type with a linear millivolt output proportional to acceleration.

The electronic signals from the triaxial accelerometers and the rate transducers were transmitted to a base station by means of constant bandwidth FM/FM telemetry link for recording on magnetic tape and for display on a real-time strip chart. Calibration signals were recorded before and after the test, and an accurate time reference signal was simultaneously recorded with the data. Pressure sensitive switches on the bumper of the impacting vehicle were actuated just prior to impact by wooden dowels to indicate the elapsed time over a known distance to provide a measurement of impact velocity. The initial contact also produced an "event" mark on the data record to establish the exact instant of contact with the barrier.

The multiplex of data channels, transmitted on one radio frequency, were received at the data acquisition station, and demultiplexed into separate tracks of Inter-Range Instrumentation Group (I.R.I.G.) tape recorders. After the test, the data were played back from the tape machines, filtered with an SAE J211 filter, and digitized using a microcomputer, for analysis and evaluation of impact performance.

In addition, the test vehicle was instrumented with five uniaxial accelerometers mounted in the following locations: (1) center top surface of instrument panel; (2) inside end of right front wheel spindle; (3) inside end of left front wheel spindle; (4) top of engine block; and (5) bottom of engine block. The exact locations of each accelerometer was measured and are reported in table 1. These accelerometers were ENDEVCO Model 7264A low mass piezoresistive accelerometers with a ±2000 g range.

The data from these uniaxial accelerometers were captured using a Prosig P4000 data acquisition system. The P4000 is a modular, distributed data acquisition system based on independent data collection elements called POD's. Each POD has 4 high-speed analog, 3 digital and T-zero inputs. The POD's sample synchronously at up to 12.5 kHz per channel with 12-bit resolution. Non-volatile memory holds up to 13 s at 10 kHz data capture. Analog inputs have integral bridge conditioning, 8-pole fixed-frequency, low-pass Butterworth 48 dB/octave anti-aliasing filter. Each channel has a fully programmable amplifier and input offset adjustment. Data capture is started by a trigger pulse from a bumper switch or a predefined g level. Twenty-five percent of the captured data is prior to the trigger signal.

The digitized data were then processed using two computer programs: DIGITIZE and PLOTANGLE. Brief descriptions of the functions of these two computer programs are provided as follows.

Table 1. Locations of vehicle accelerometers for test 405491-1.

Location	X (Distance from front bumper)	Y (Distance from centerline)	Z (Distance from ground)	Axis
Center top surface of instrument panel	-1575	0	-1295	+X
Inside end of right front wheel spindle	-889	635	-356	-Y*
Inside end of left front wheel spindle	-889	-635	-356	+X
Top of engine block	-838	25	-939	+X
Bottom of engine block	-1156	0	-381	+X
Vehicle c.g.	-2375	0	-737	+X,+Y,+Z
Vehicle rear axle	-4242	0	-889	+X,+Y,+Z

* Data corrected in graphical output to show +Y.

The DIGITIZE program uses digitized data from vehicle-mounted linear accelerometers to compute occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, and the highest 10-ms average ridedown acceleration. The DIGITIZE program also calculates a vehicle impact velocity and the change in vehicle velocity at the end of a given impulse period. In addition, maximum average accelerations over 50-ms intervals in each of the three directions are computed. For reporting purposes, the data from the vehicle-mounted triaxial accelerometers were then filtered with a 60 Hz digital filter and acceleration versus time curves for the longitudinal, lateral, and vertical directions were plotted using a commercially available software package (QUATTRO PRO). The data from the five uniaxial accelerometers were filtered with a Class 180 filter and acceleration versus time curves were plotted using QUATTRO PRO.

The PLOTANGLE program used the digitized data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.00067-s intervals and then instructs a plotter to draw a reproducible plot: yaw, pitch, and roll versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation of the vehicle-fixed coordinate system being that which existed at initial impact.

2.3.2 Anthropomorphic Dummy Instrumentation

An Alderson Research Laboratories Hybrid II, 50th percentile male anthropomorphic dummy, restrained with standard equipment lap and shoulder belts, was placed in the driver's position of the vehicle. The dummy was un-instrumented; however, an onboard high-speed camera recorded the motions of the dummy during the test period.

2.3.3 Photographic Instrumentation and Data Processing

Photographic coverage of the test included four high-speed cameras: one overhead with a field of view perpendicular to the ground and directly over the impact point; and one placed behind the rail at an angle; a third placed to have a field of view parallel to and aligned with the installation at the downstream end; and a fourth placed onboard the vehicle to record the motions of the dummy placed in the driver seat during the test sequence. A flash bulb activated by pressure sensitive tapeswitches was positioned on the impacting vehicle to indicate the instant of contact with the barrier and was visible from each camera. The films from these high-speed cameras were analyzed on a computer-linked Motion Analyzer to observe phenomena occurring during the collision and to obtain time-event, displacement and angular data. A 16-mm movie cine, a Betacam and a VHS-format video cameras and recorders, and still cameras were used for to record and document conditions of the test vehicle and installation after the test.

2.3.4 Test Vehicle Propulsion and Guidance

The test vehicle was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point, through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2 to 1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released to be free-wheeling and unrestrained. The vehicle remained free-wheeling, i.e., no steering or braking inputs, until the vehicle cleared the immediate area of the test site, at which time brakes on the vehicle were activated to bring it to a safe and controlled stop.

III. CRASH TEST RESULTS

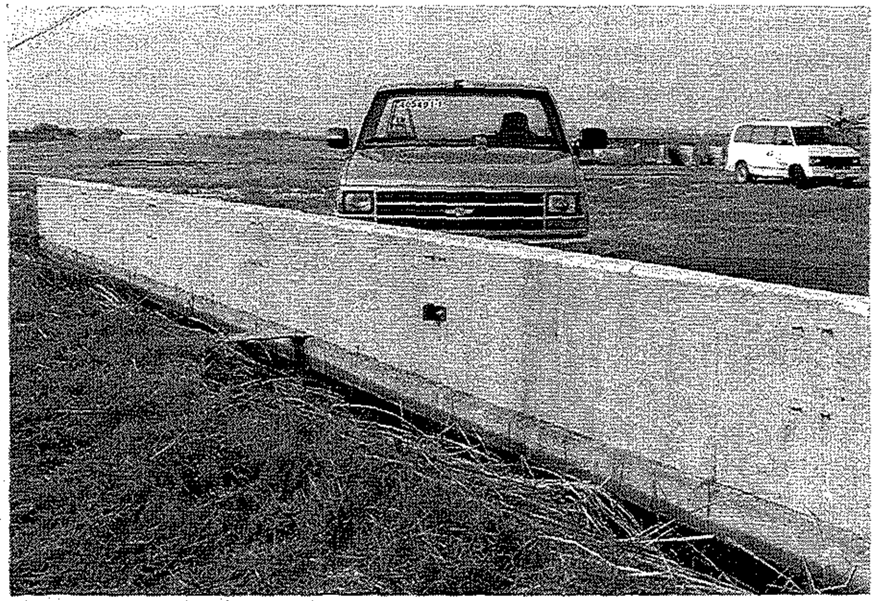
A 1991 Chevrolet 2500 pickup truck, shown in figures 3 and 4, was used for this crash test on the New Jersey safety shaped barrier (test no. 405491-1). Test inertia weight of the vehicle was 2000 kg, and its gross static weight was 2077 kg. The height to the lower edge of the vehicle bumper was 435 mm and it was 655 mm to the upper edge of the bumper. Additional dimensions and information on the vehicle are given in figure 5. The vehicle was directed into the installation using the cable reverse tow and guidance system, and was released to be free-wheeling and unrestrained just prior to impact.

3.1 TEST DESCRIPTION

The vehicle impacted the barrier 3.1 m downstream of the upstream end of the test installation at a speed of 101.2 km/h and at an angle of 25.6 degrees. At 0.019 s after initial impact, the right front tire aired out, and at 0.208 s, the right front tire reached the top of the barrier. The vehicle became parallel with the installation at 0.224 s traveling at the speed of 80.8 km/h. The vehicle became totally airborne at 0.243 s, and shortly thereafter, the front of the vehicle started to nose down. At 0.375 s, the vehicle lost contact with the safety shape, traveling at a speed of 80.6 km/h with an exit angle of 1.3 degrees. The left front wheel contacted the ground at 0.532 s, and the right front tire made contact with the ground at 0.828 s. Maximum roll angle of 34 degrees occurred at 1.079 s. At 1.181 s, the left rear wheel of the vehicle contacted the ground, and the vehicle began to yaw clockwise. Brakes were applied after the vehicle exited the test area, and the vehicle subsequently came to rest facing back toward the installation 56.4 m downstream from point of impact. Photographs of the test sequence are shown in figures 6 through 8.

3.2 DAMAGE TO TEST INSTALLATION

There was only cosmetic damage to the New Jersey safety shaped barrier, as shown in figure 9. Tire marks reached the top of the barrier starting at 0.5 m after impact and continued along the top edge of the barrier on the traffic side until loss of contact. However, the tire marks did not extend across the top of the barrier. Total length of contact of the vehicle with the barrier was 6.8 m.



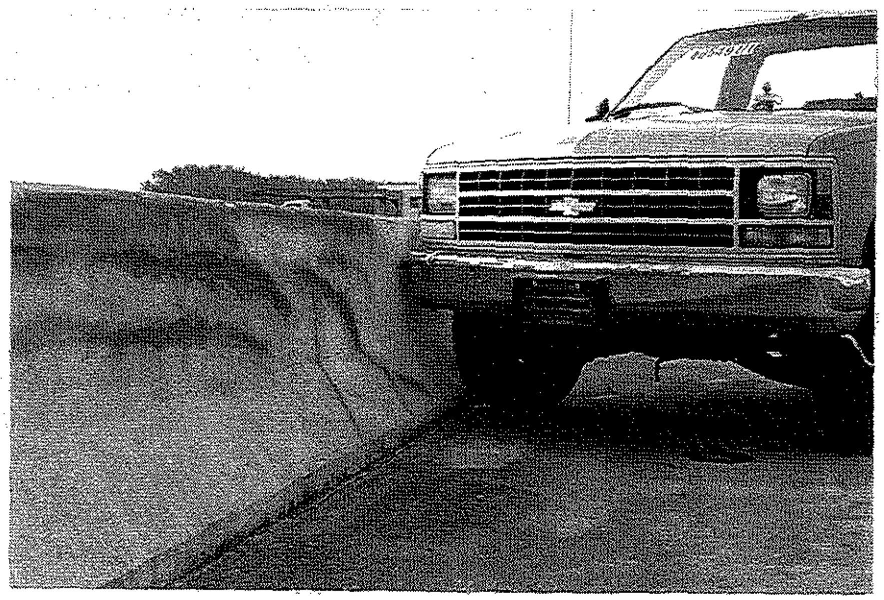


Figure 3. Vehicle/installation geometrics for test 405491-1.

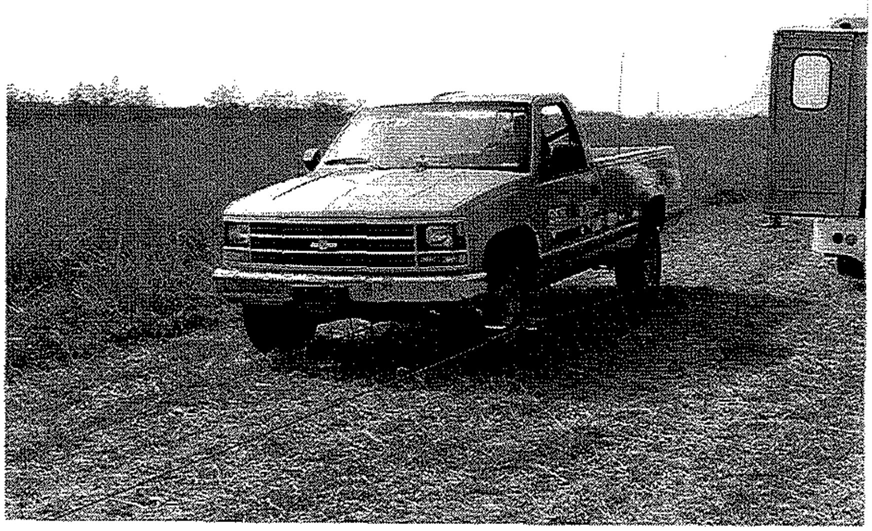


Figure 4. Vehicle before test 405491-1.

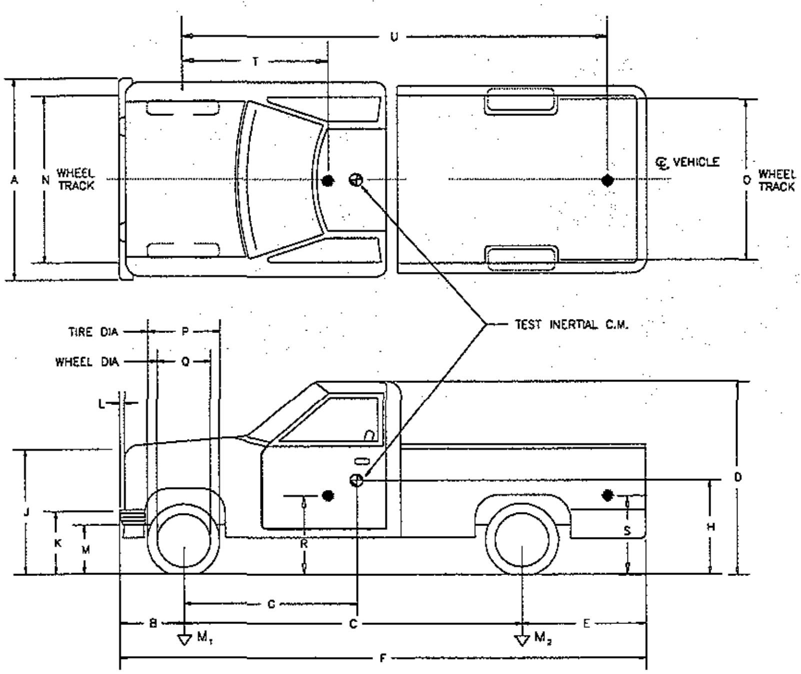
DATE: 09/06/95 TEST NO.: 405491-1 VIN NO.: 1GCGC24K3MF130540

YEAR: 1991 MAKE: Chevrolet MODEL: 2500 Pickup

TIRE INFLATION PRESSURE: ______ ODOMETER: 099387 TIRE SIZE: 245/75R16

MASS DISTRIBUTION (kg) LF 542 RF 549 LR 455 RR 454

DESCRIBE ANY DAMAGE TO VEHICLE PRIOR TO TEST:



● Denotes accelerometer location.

NOTES: ______

ENGINE TYPE: 8 cyl

ENGINE CID: 5.7 L

TRANSMISSION TYPE:

X AUTO

_ MANUAL

OPTIONAL EQUIPMENT:

DUMMY DATA:

TYPE: ______

MASS: ______

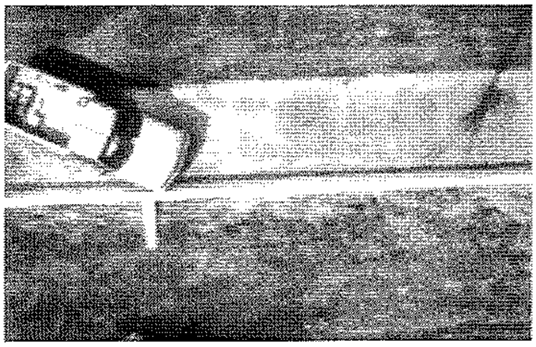
SEAT POSITION: ______

GEOMETRY - (mm)

A	1890	E	1330	J	1085	N	1585	R	737
B	760	F	5590	K	655	O	1625	S	889
C	3345	G	1520.3	L	85	P	765	T	1505
D	1835	H		M	435	Q	445	U	3345

MASS - (kg)	CURB	TEST INERTIAL	GROSS STATIC
M_1	1159	1091	1139
M_2	902	909	938
M_T	2061	2000	2077

Figure 5. Vehicle properties for test 405491-1.

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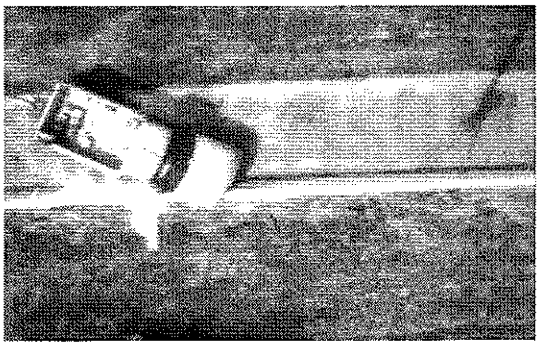
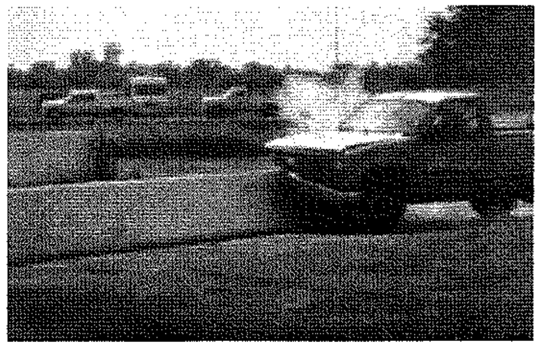

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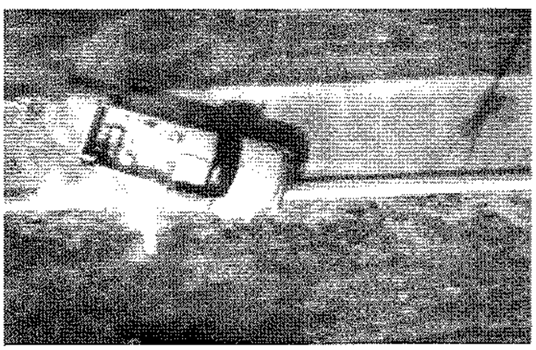
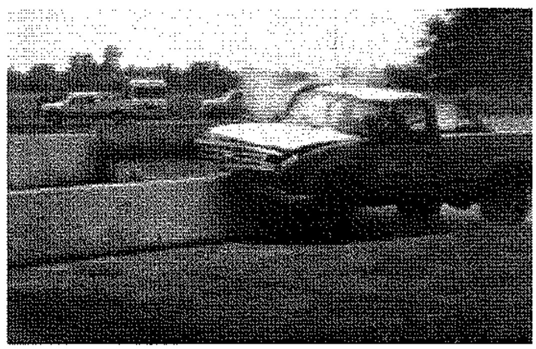

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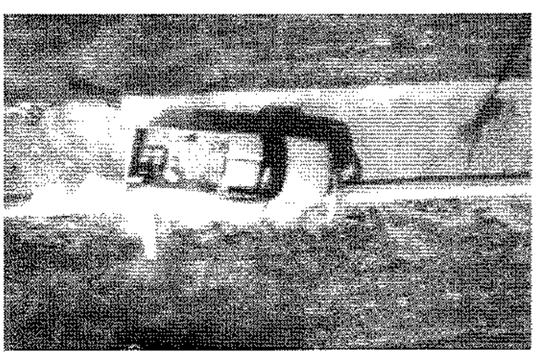
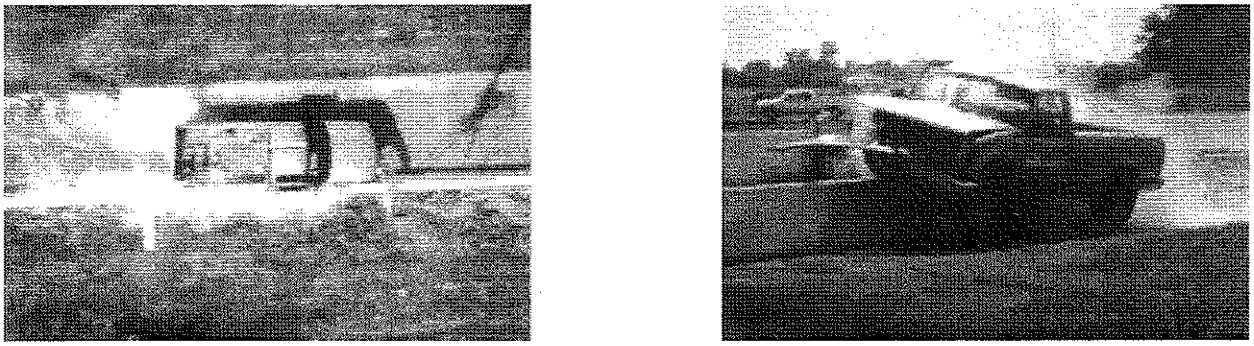



0.161 s

Figure 6. Sequential photographs for test 405491-1 (overhead and oblique views).



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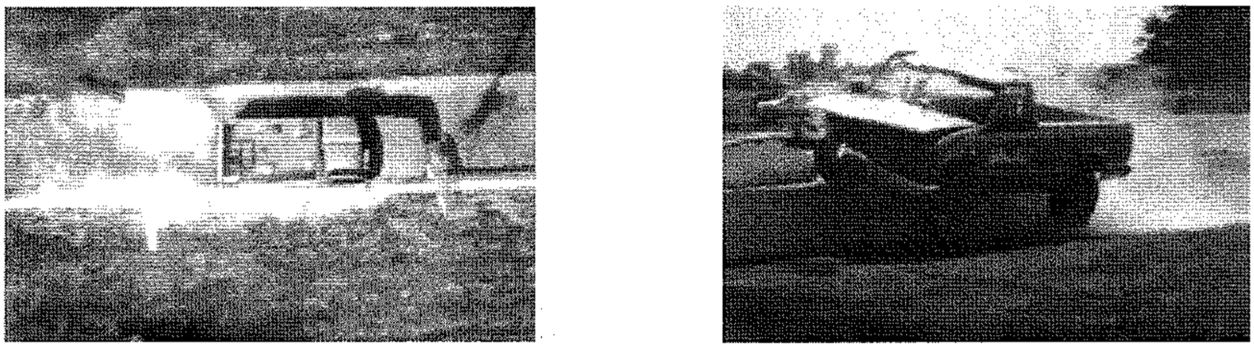

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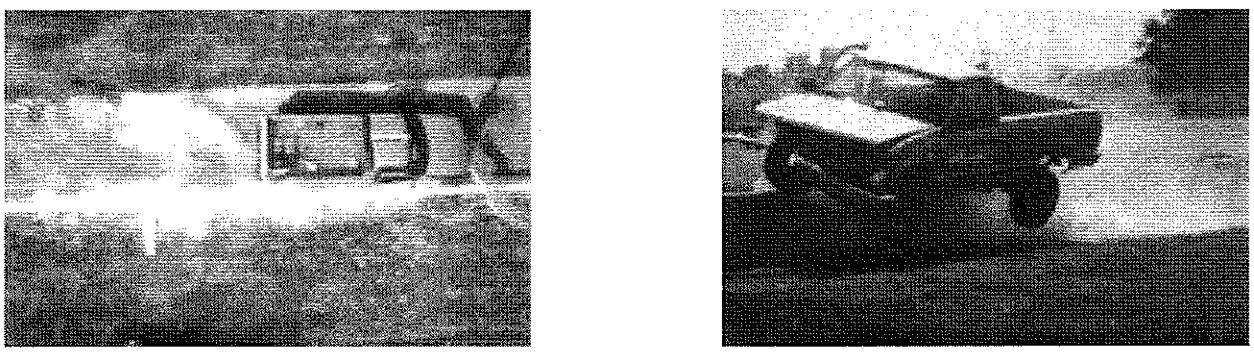

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Figure 6. Sequential photographs for test 405491-1
(overhead and oblique views) (continued).

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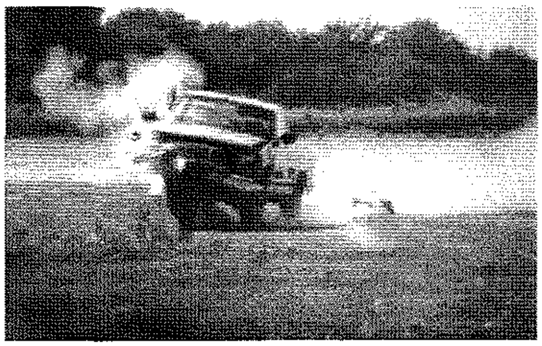

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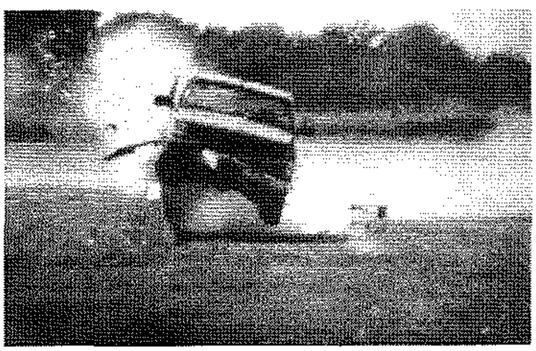

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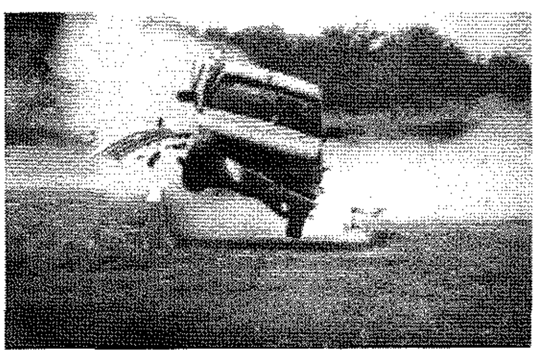

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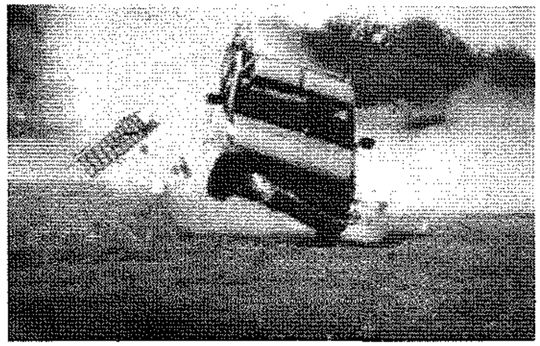

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0.735 s

0.882 s

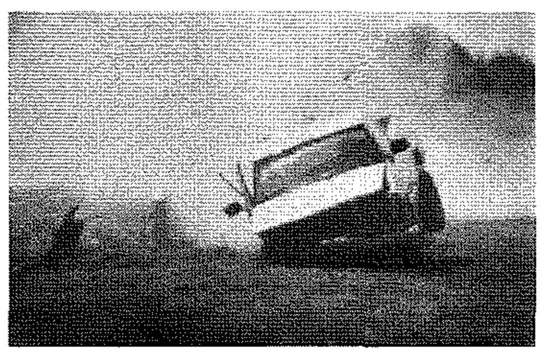

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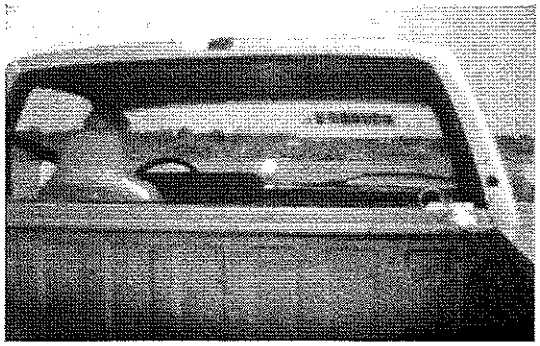
Figure 7. Sequential photographs for test 405491-1
(frontal view).



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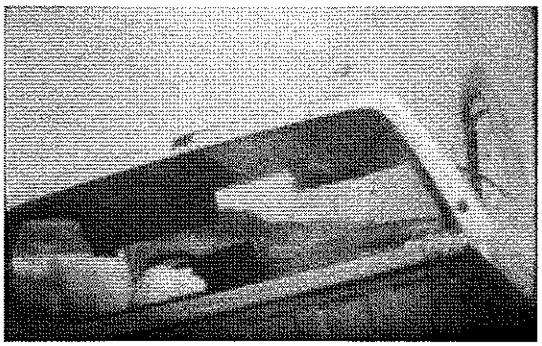

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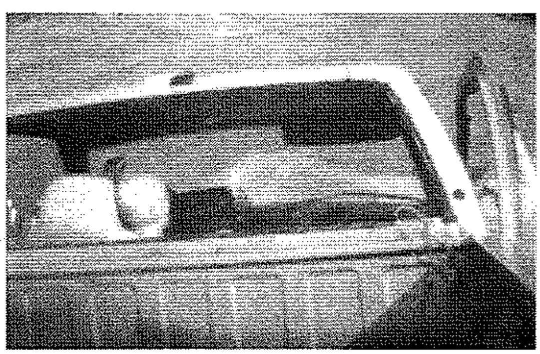

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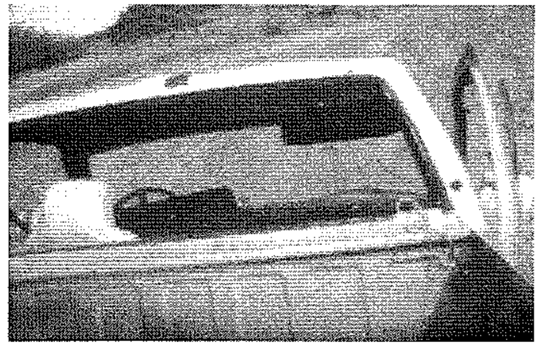

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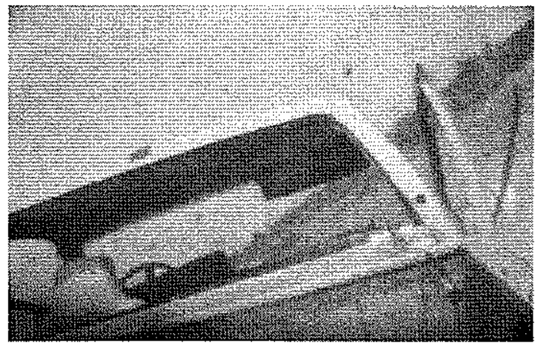
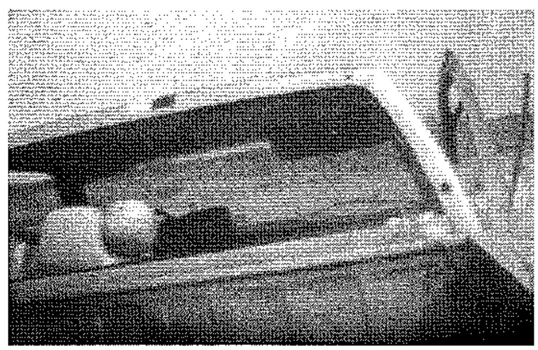
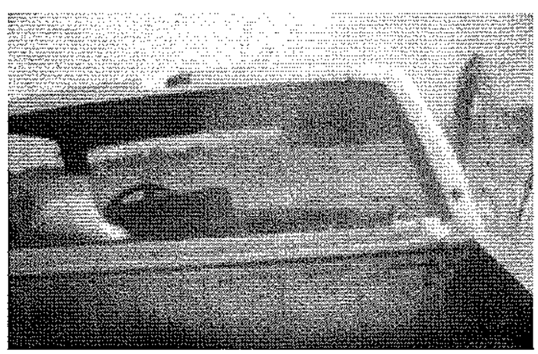


1.110 s

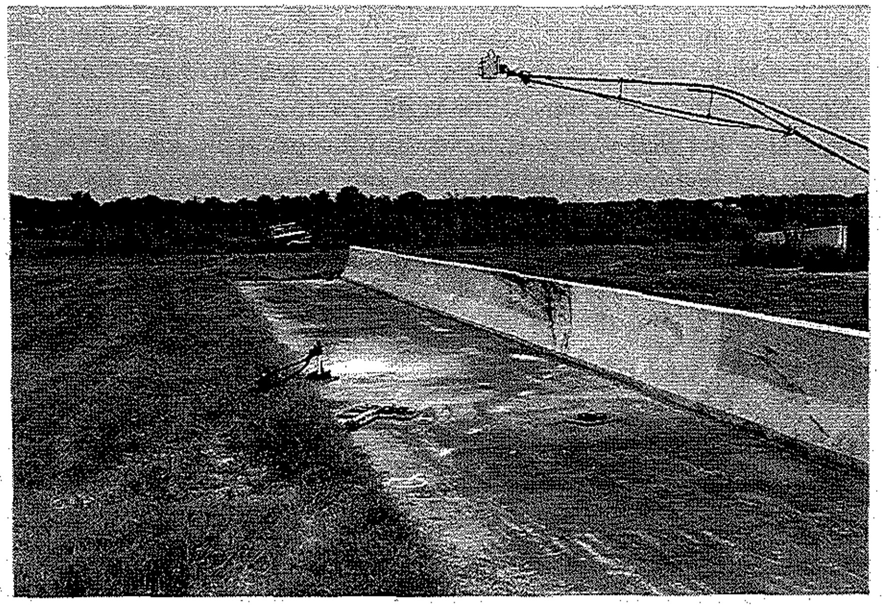


1.320 s



1.540 s

Figure 8. Sequential photographs for test 405491-1
(on-board view).



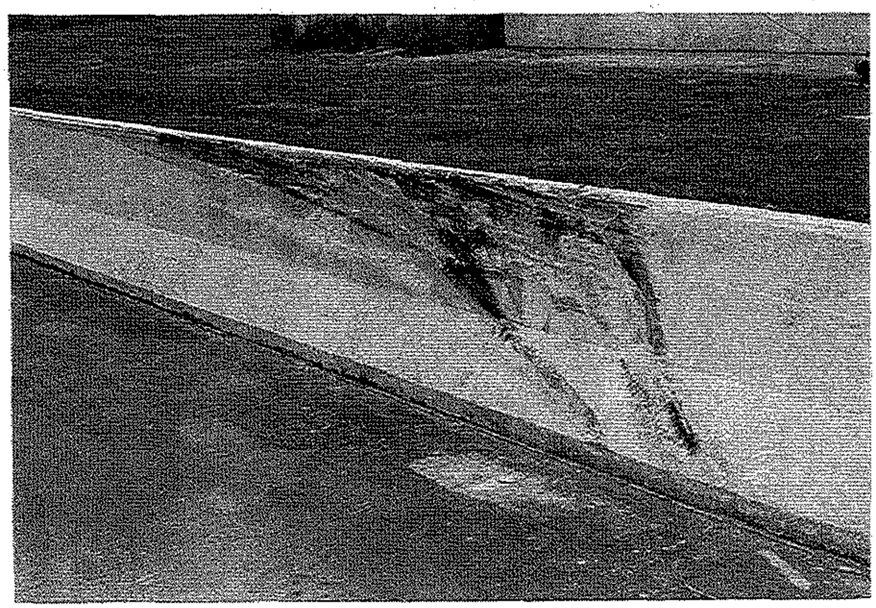


Figure 9. New Jersey safety shaped barrier test installation after test 405491-1.

3.3 VEHICLE DAMAGE

The front and right side of the vehicle were damaged during impact as shown in figure 10. The right side stabilizer bar, tie rods, and A-arms were damaged, and the right front frame was bent. Also damaged were the bumper, grill, radiator and fan, the right and left front quarter panels, the right door, and the right front and rear tires and rims. Maximum exterior crush to the vehicle was 560 mm at the right front corner at bumper height. During the collision the right side firewall was pushed toward the occupant compartment and deformed the floorpan and instrument panel, and caused stress cracks in the windshield. Maximum deformation into the occupant compartment was 84 mm at the center front firewall area. Buckling of the floorpan and damage to the instrument panel is shown in figure 11.

3.4 OCCUPANT RISK VALUES

Data from the accelerometers located at the vehicle center-of-gravity were digitized for evaluation of occupant risk and were computed as follows. In the longitudinal direction, the occupant impact velocity was 5.9 m/s at 0.161 s, the highest 0.010-s occupant ridedown acceleration was -4.5 g from 0.175 to 0.185 s, and the maximum 0.050-s average acceleration was -9.1 g between 0.010 and 0.060 s. In the lateral direction, the occupant impact velocity was 4.0 m/s at 0.143 s, the highest 0.010-s occupant ridedown acceleration was -19.6 g from 0.204 to 0.214 s, and the maximum 0.050-s average acceleration was -8.1 g between 0.176 and 0.226 s. These data and other pertinent information from the test are summarized in figure 12. Vehicle angular displacements are displayed in figure 13. Vehicular accelerations versus time traces are presented in figure 14 through 19. Five uniaxial accelerometers were mounted in various places on the vehicle and traces from these accelerometers are shown in figures 20 through 24.

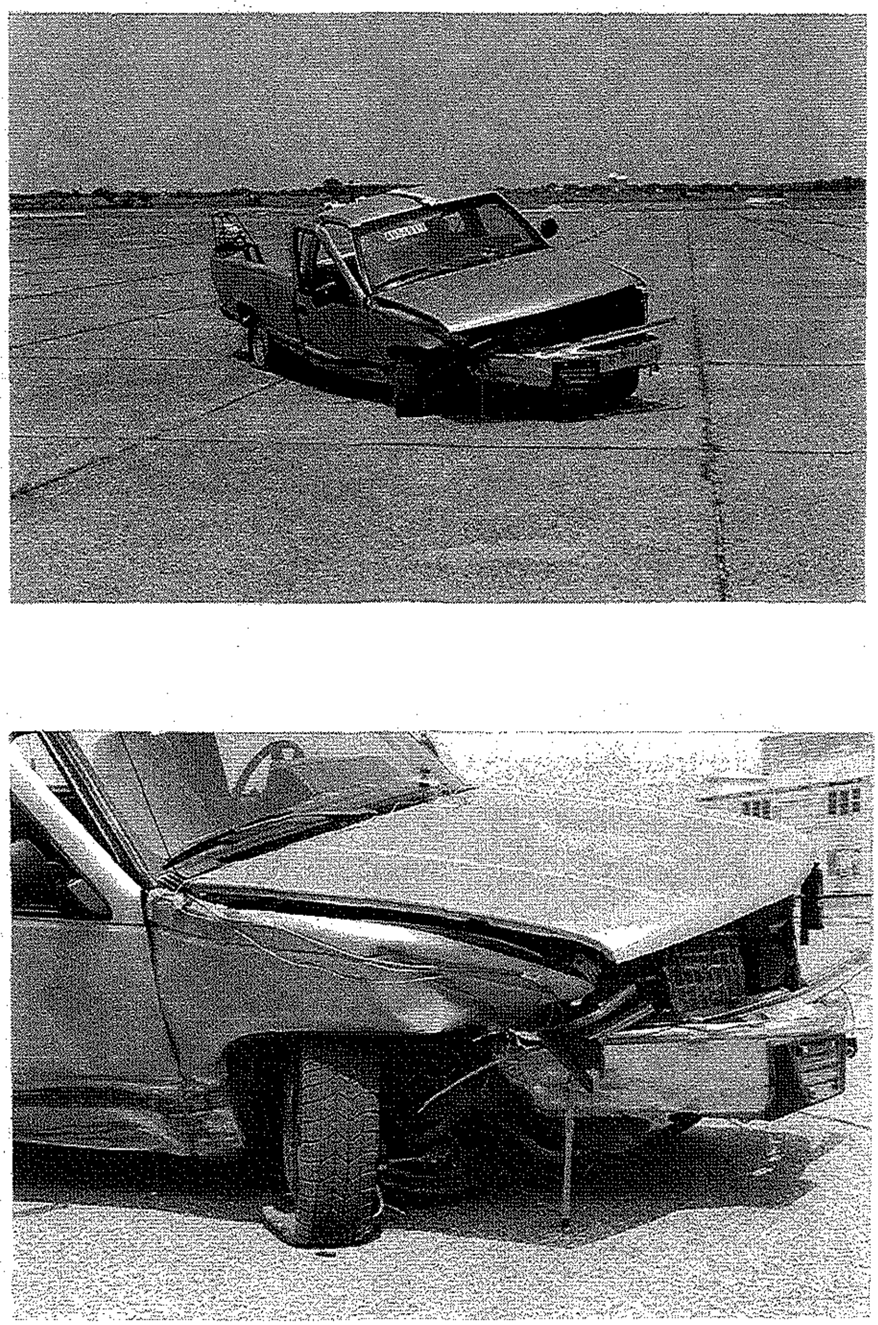
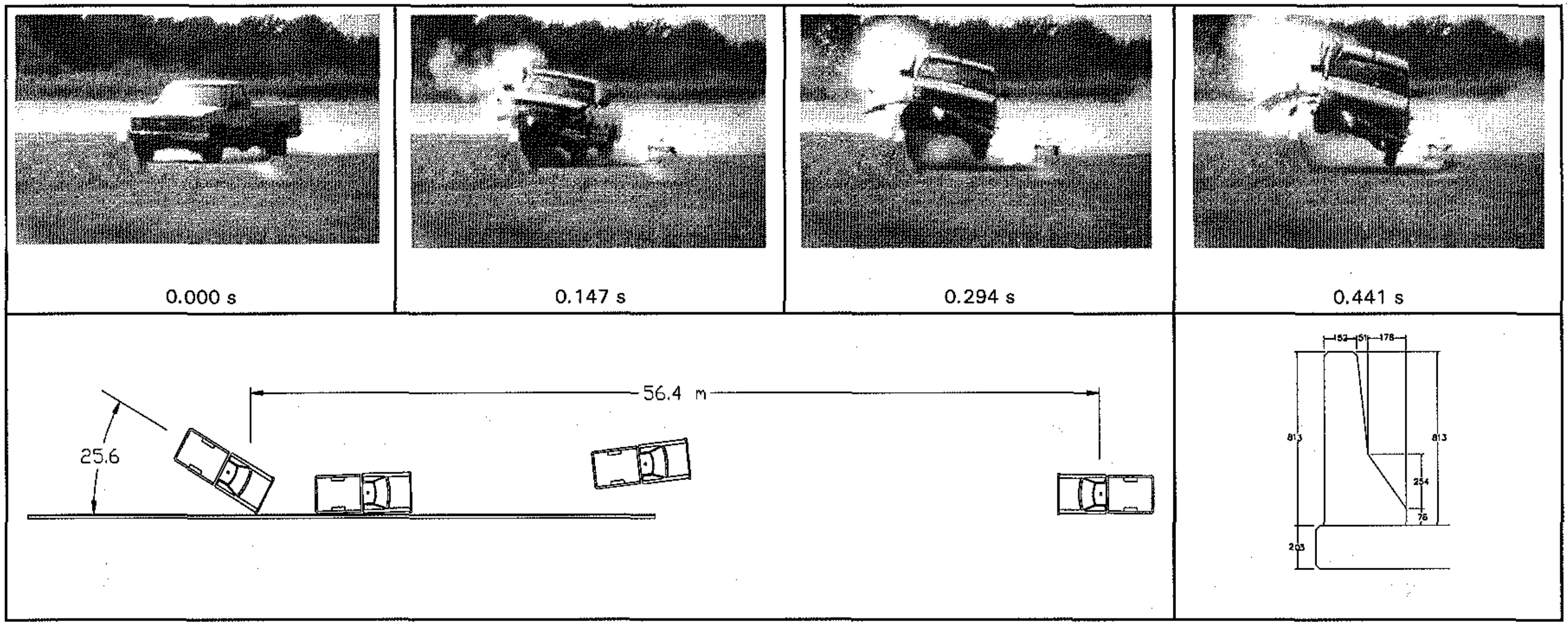


Figure 10. Vehicle after test 405491-1.

Figure 11. Interior of vehicle after test 405491-1.



General Information	
Test Agency	Texas Transportation Institute
Test No.	405491-1
Date	09/06/95
Test Article	
Type	Bridge Rail
Name or Manufacturer	New Jersey Safety Shape
Installation Length (m) .	30.5
Size and/or dimension and material of key elements	813 mm Concrete New Jersey Safety Shape
Soil Type and Condition ..	Bridge deck, dry
Test Vehicle	
Type	Production
Designation	2000P
Model	1991 Chevrolet 2500 Pickup
Mass (kg) Curb	2061
Test Inertial	2000
Dummy ...	77
Gross Static	2077

Impact Conditions	
Speed (km/h)	101.2
Angle (deg)	25.6
Exit Conditions	
Speed (km/h)	80.6
Angle (deg)	1.3
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	5.9
y-direction	4.0
THIV (optional)	
Ridedown Accelerations (g's)	
x-direction	-4.5
y-direction	-19.6
PHD (optional)	
ASI (optional)	
Max. 0.050-sec Average (g's)	
x-direction	-9.1
y-direction	-8.1
z-direction	-10.7

Test Article Deflections (m)	
Dynamic	None
Permanent	None
Vehicle Damage	
Exterior	
VDS	01RFQ5
CDC	01FREW4
Interior	
OCDI	AS0000000
Maximum Exterior Vehicle Crush (mm) ..	560
Max. Occ. Compart. Deformation (mm) ...	84
Post-Impact Behavior	
Max. Roll Angle (deg) ..	34
Max. Pitch Angle (deg) .	-21
Max. Yaw Angle (deg) .	-28

Figure 12. Summary of results for test 405491-1.

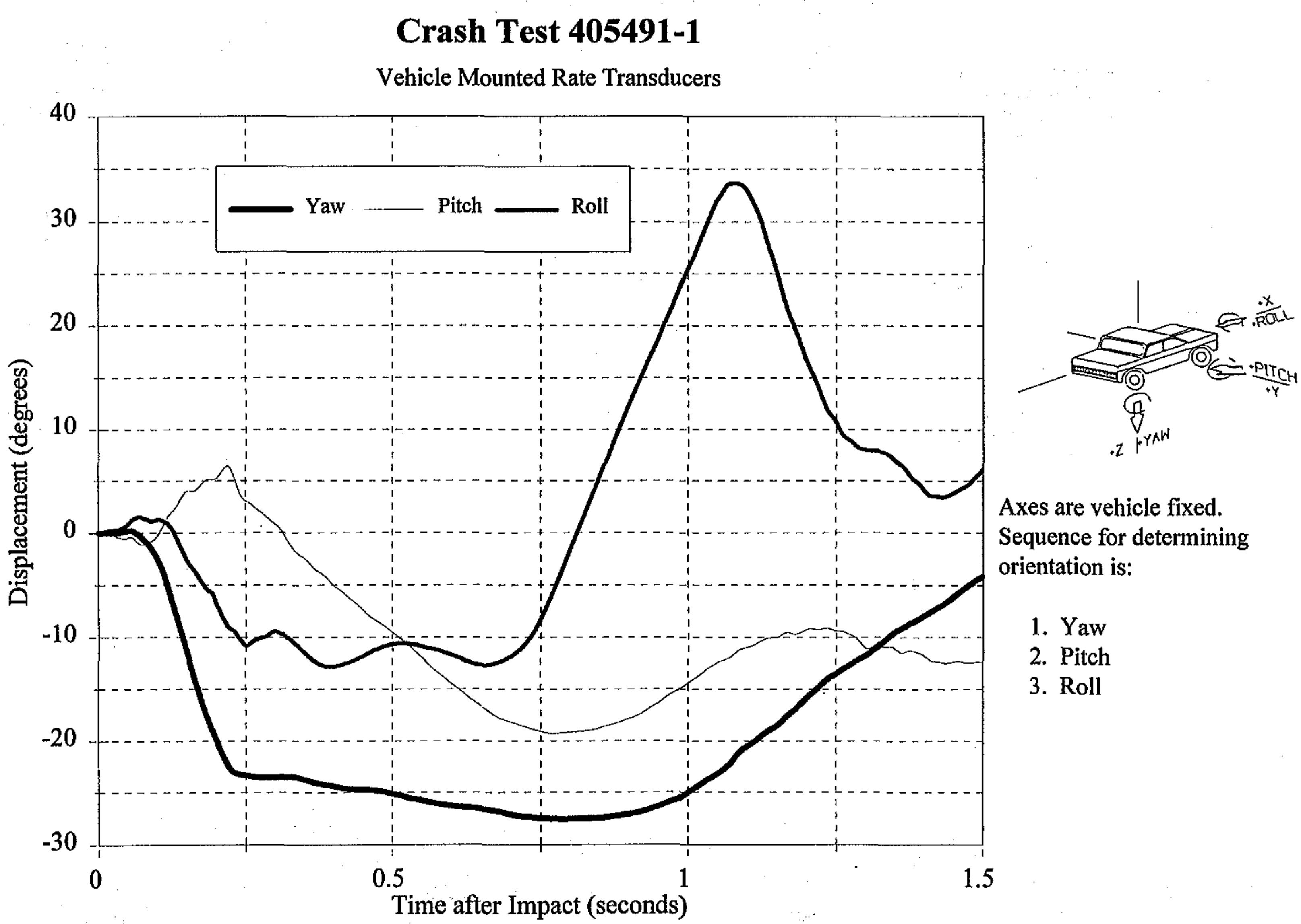


Figure 13. Vehicle angular displacements for test 405491-1.

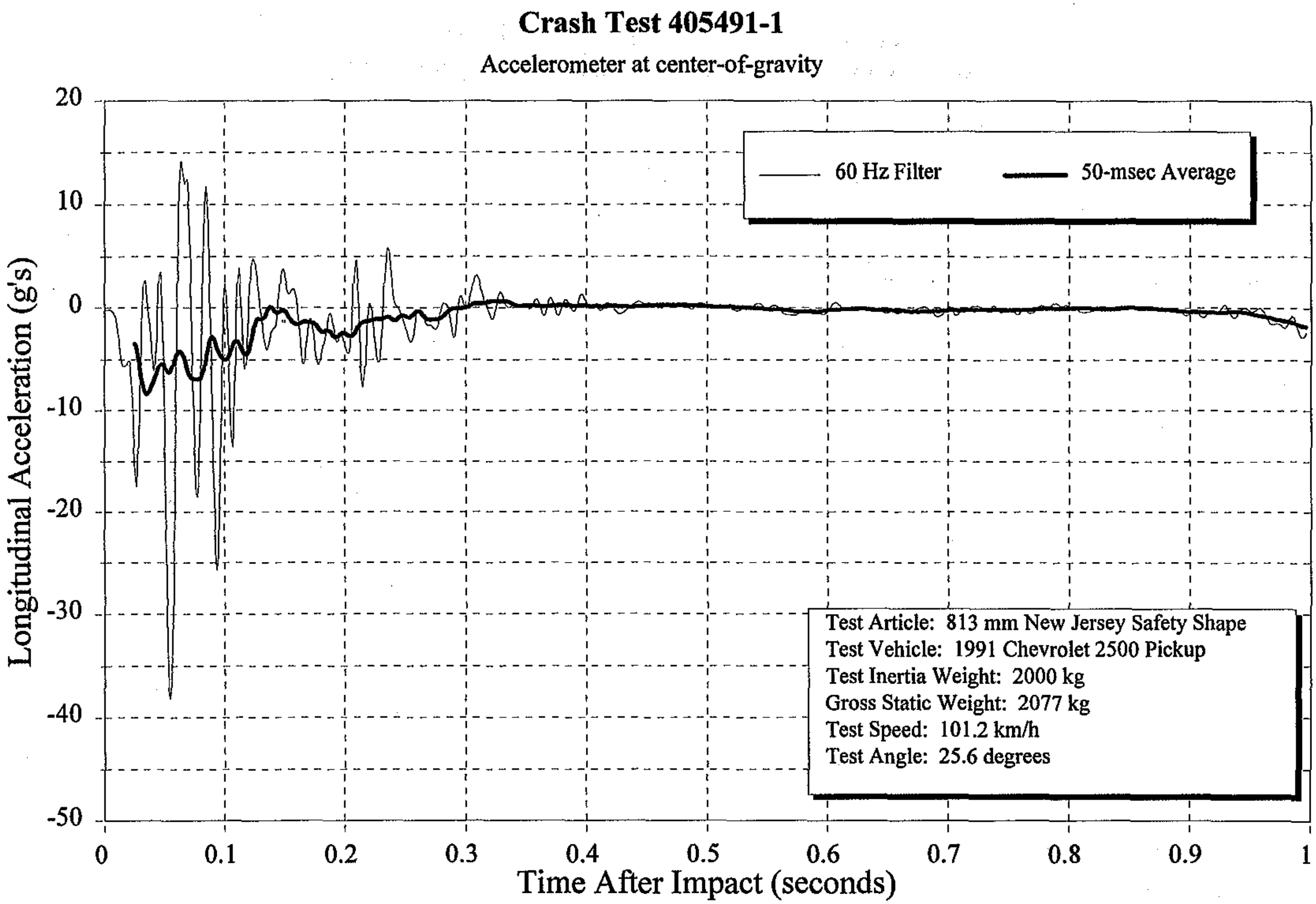


Figure 14. Vehicle longitudinal accelerometer trace for test 405491-1.
(accelerometer located at center-of-gravity)

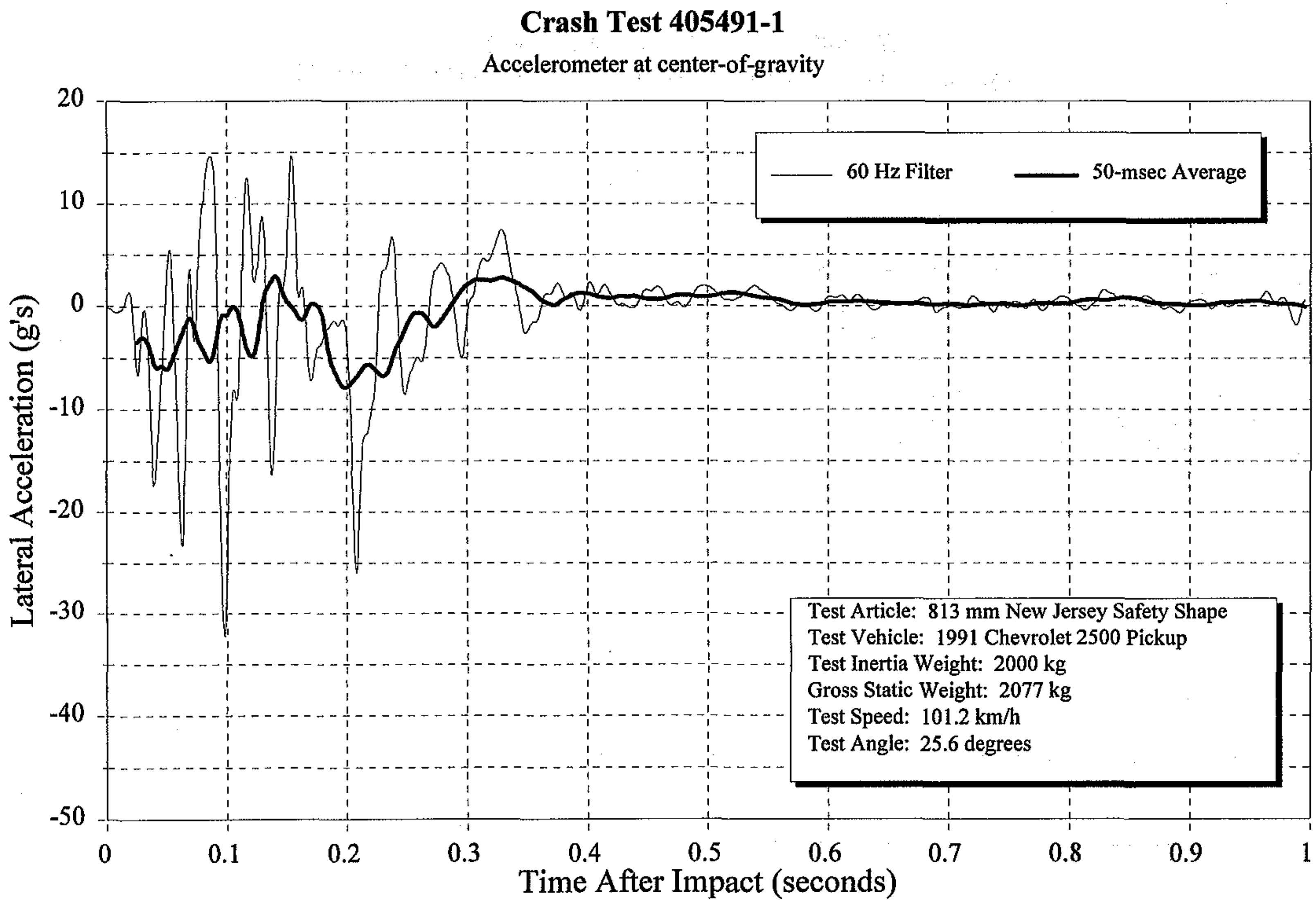


Figure 15. Vehicle lateral accelerometer trace for test 405491-1.
(accelerometer located at center-of-gravity)

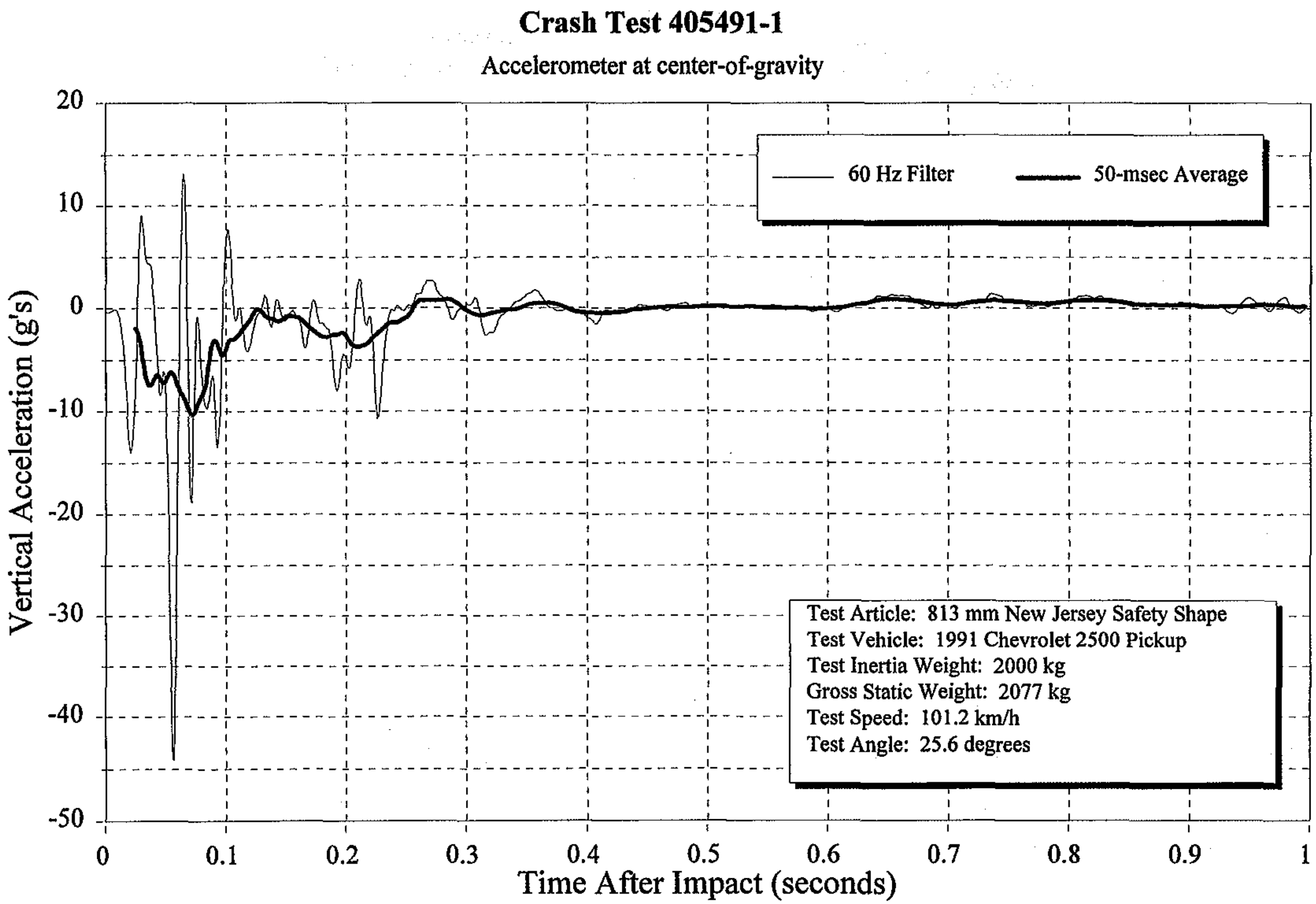


Figure 16. Vehicle vertical accelerometer trace for test 405491-1.
(accelerometer located at center-of-gravity)

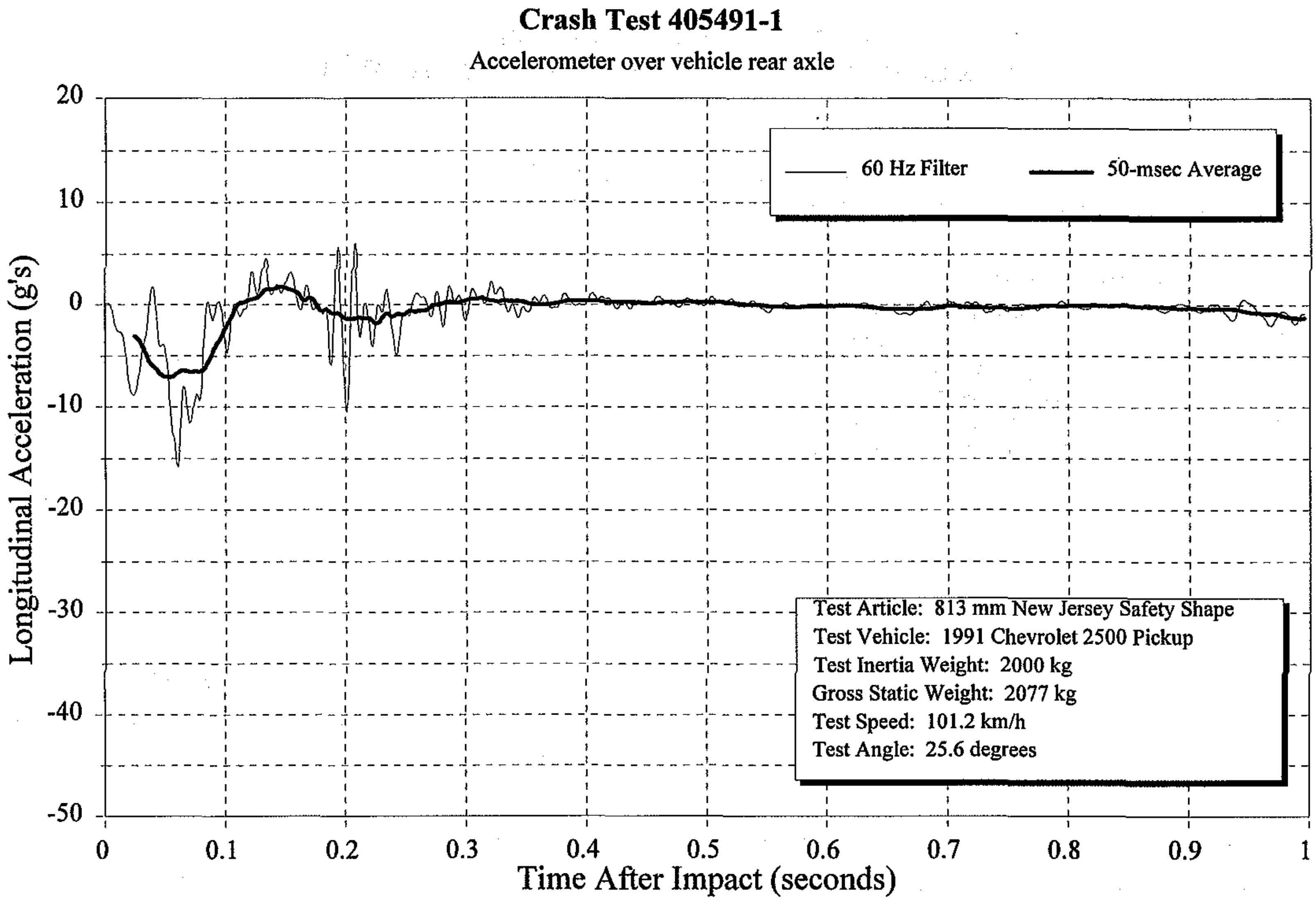


Figure 17. Vehicle longitudinal accelerometer trace for test 405491-1. (accelerometer located over vehicle rear axle)

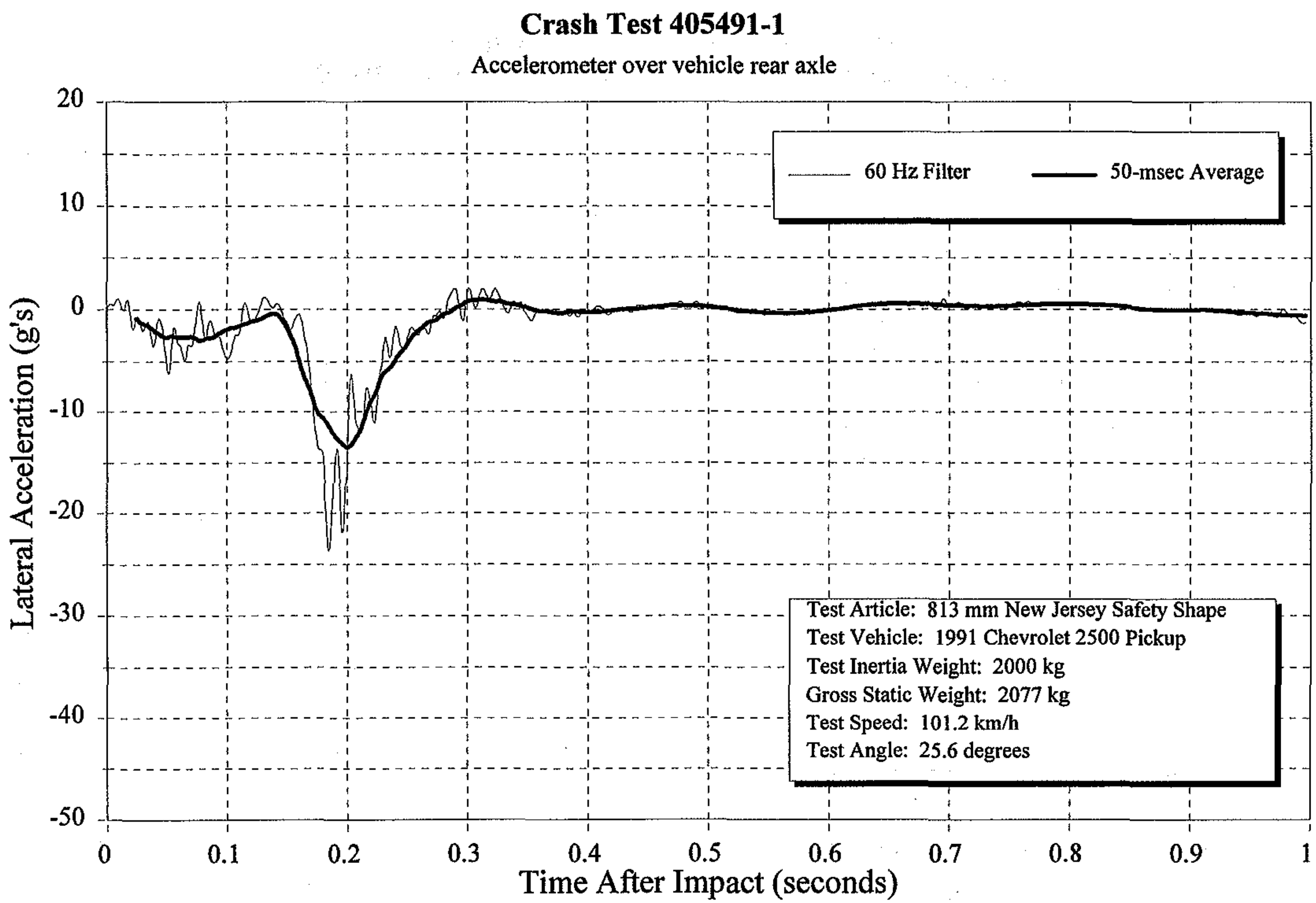


Figure 18. Vehicle lateral accelerometer trace for test 405491-1.
(accelerometer located over vehicle rear axle)

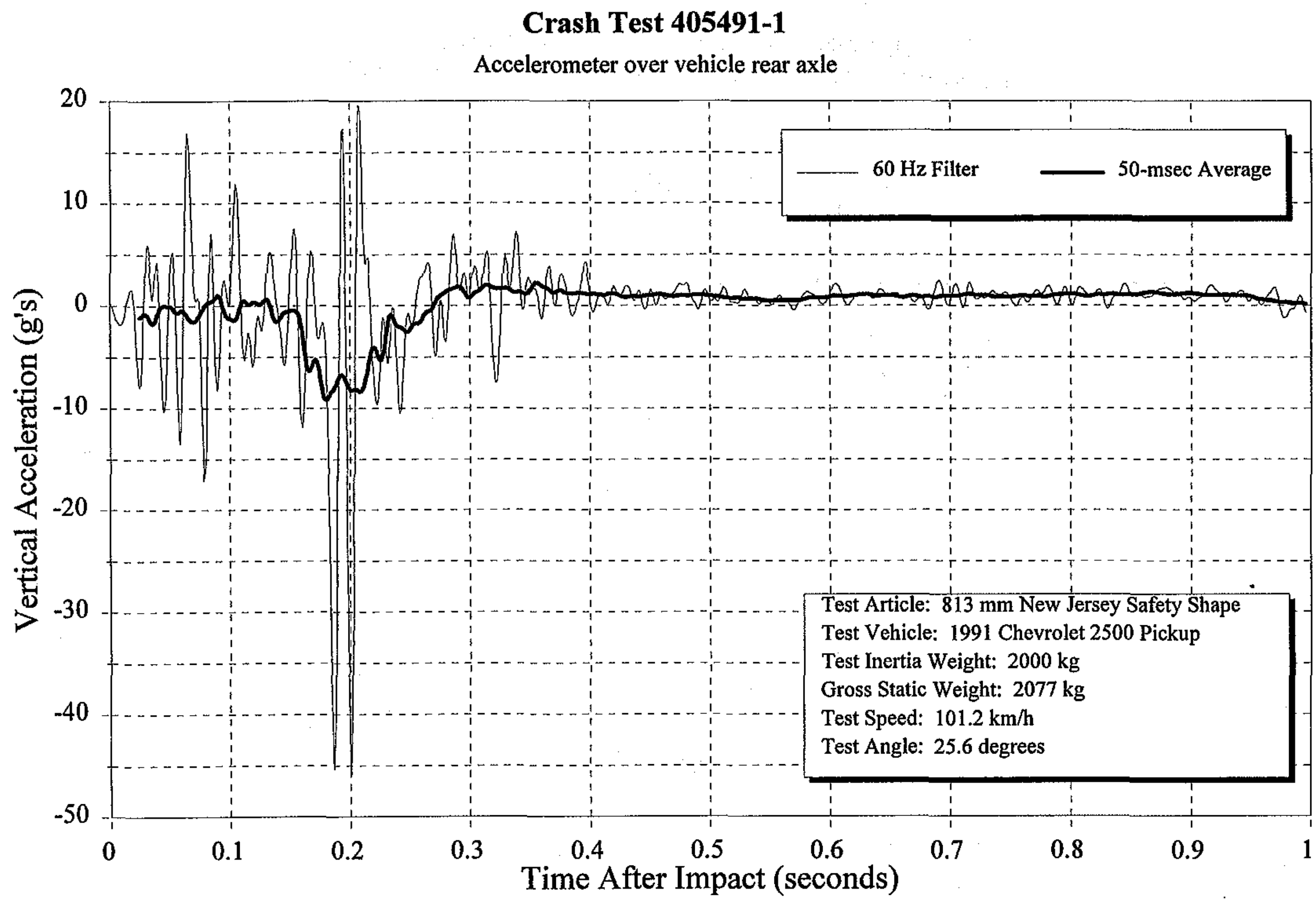


Figure 19. Vehicle vertical accelerometer trace for test 405491-1.
(accelerometer located over vehicle rear axle)

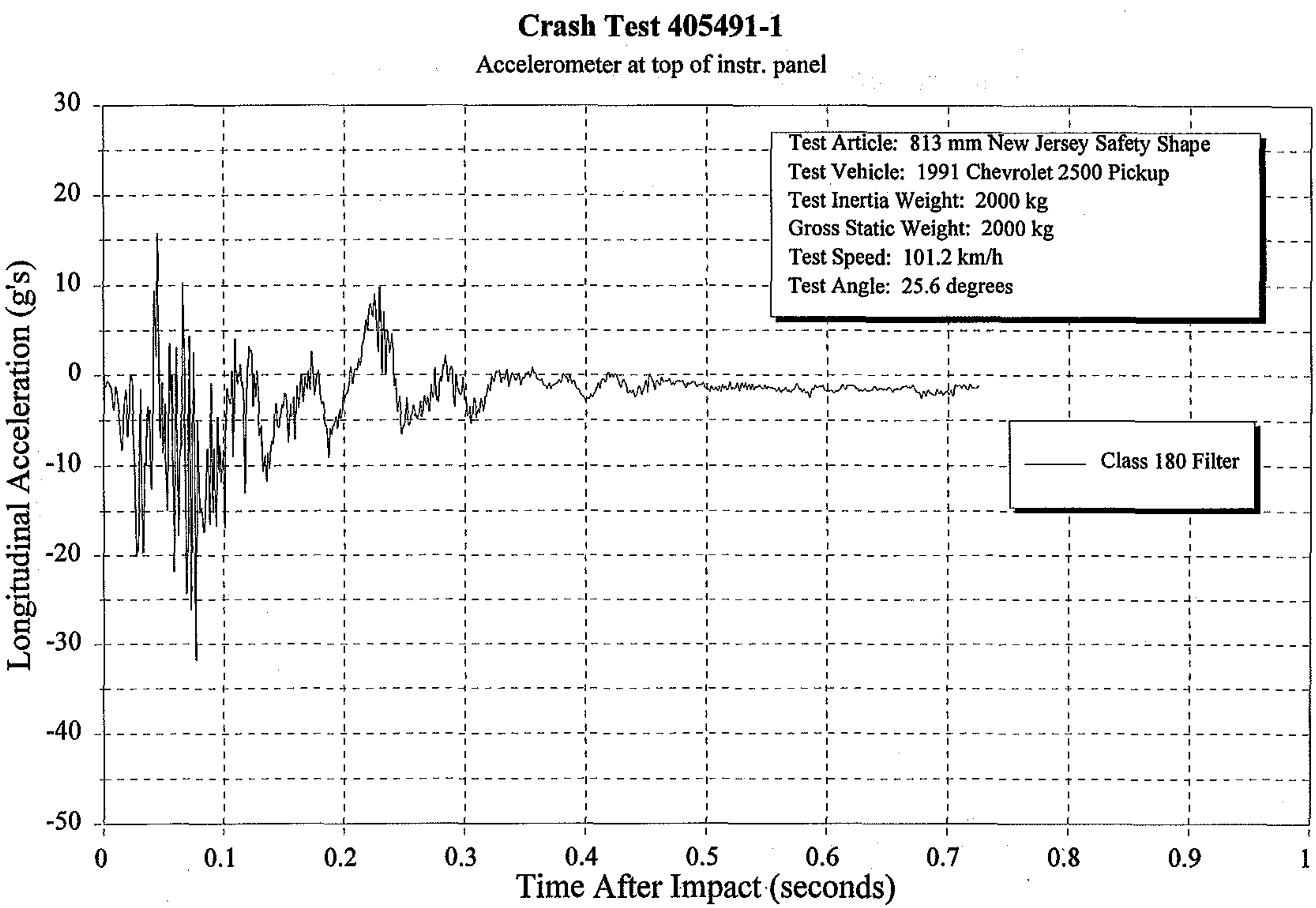


Figure 20. Vehicle longitudinal accelerometer trace for test 405491-1.
(accelerometer at top of instrument panel)

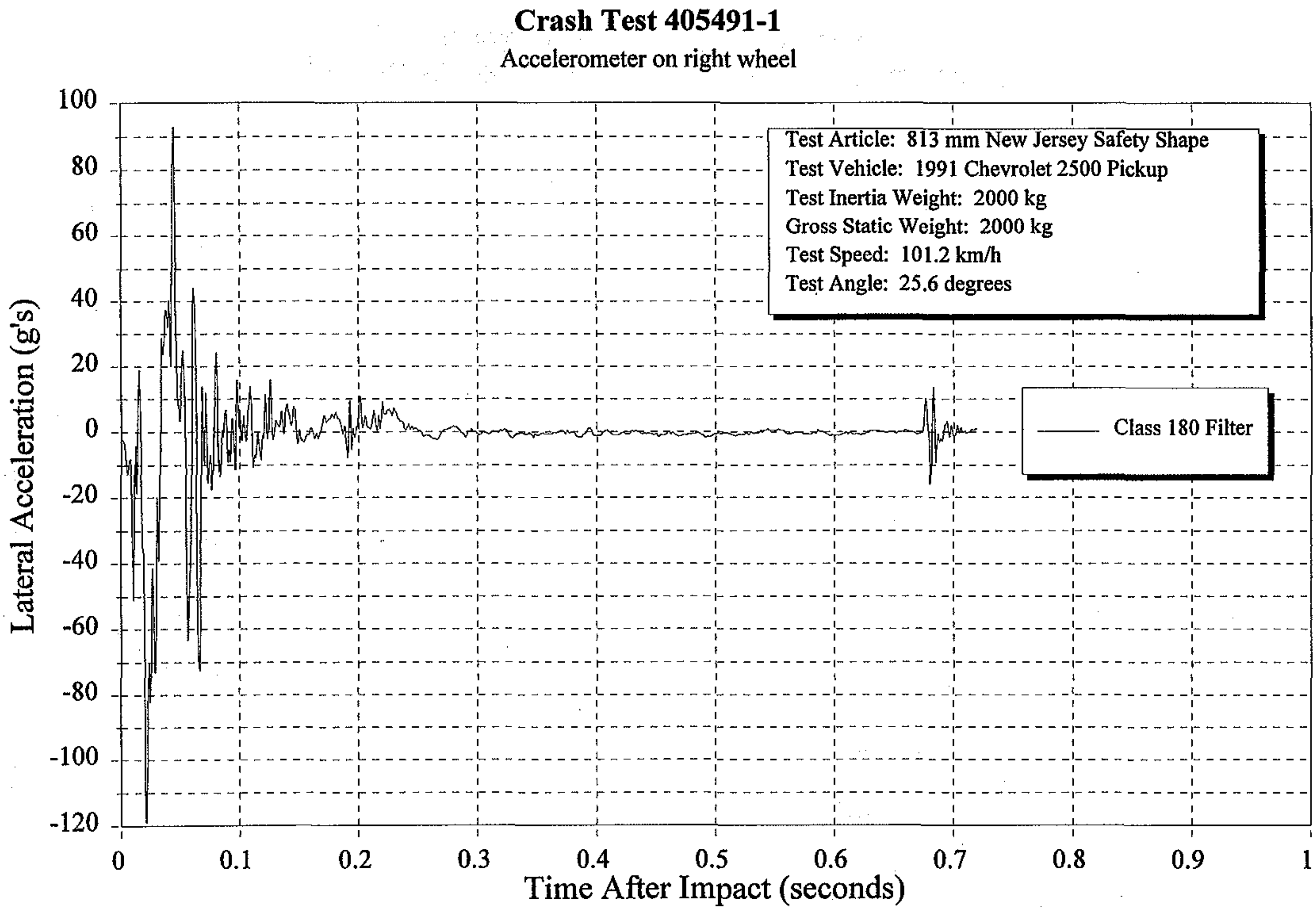


Figure 21. Vehicle lateral accelerometer trace for test 405491-1.
(accelerometer on right wheel)

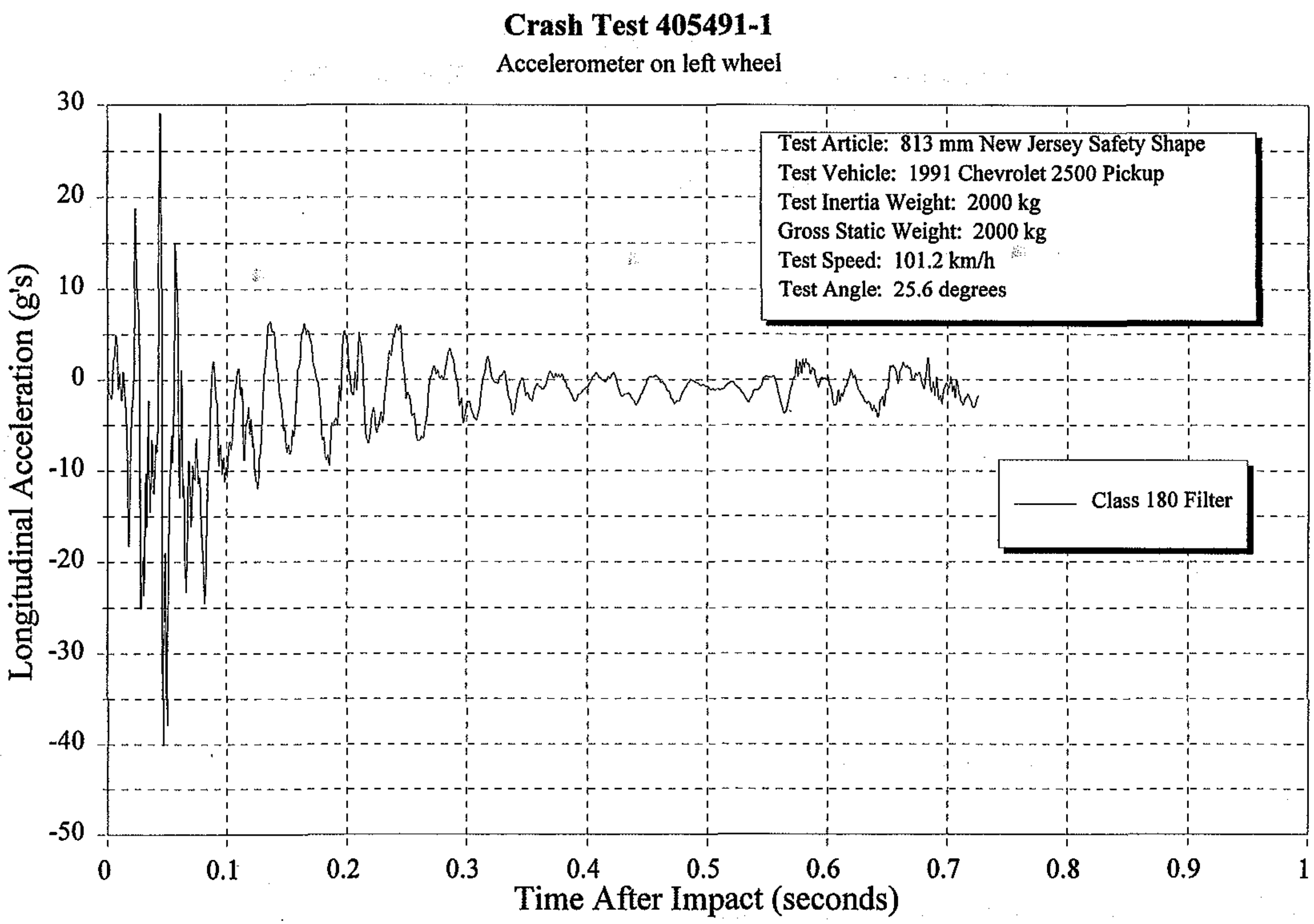


Figure 22. Vehicle longitudinal accelerometer trace for test 405491-1.
(accelerometer on left wheel)

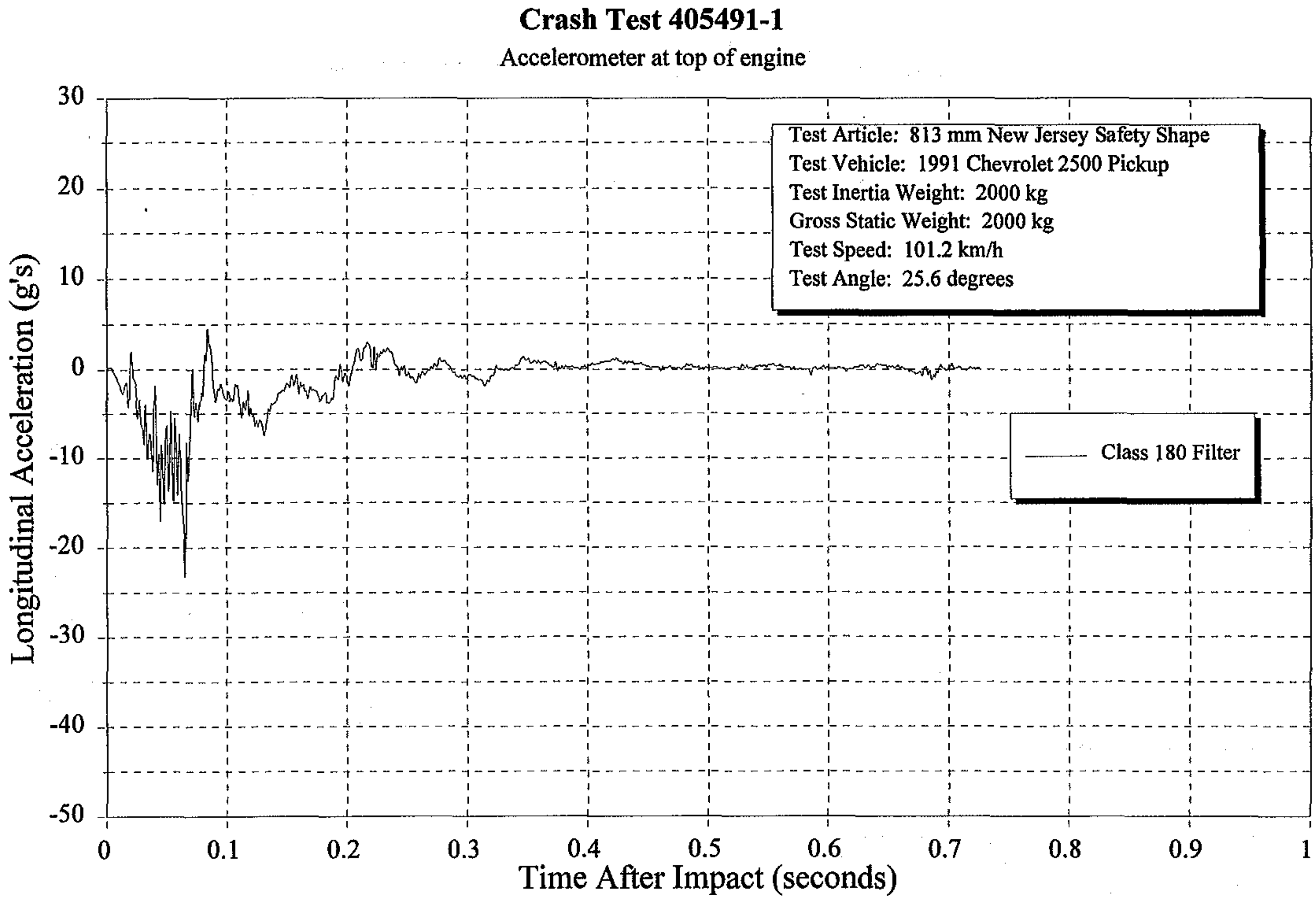


Figure 23. Vehicle longitudinal accelerometer trace for test 405491-1.
(accelerometer at top of engine)

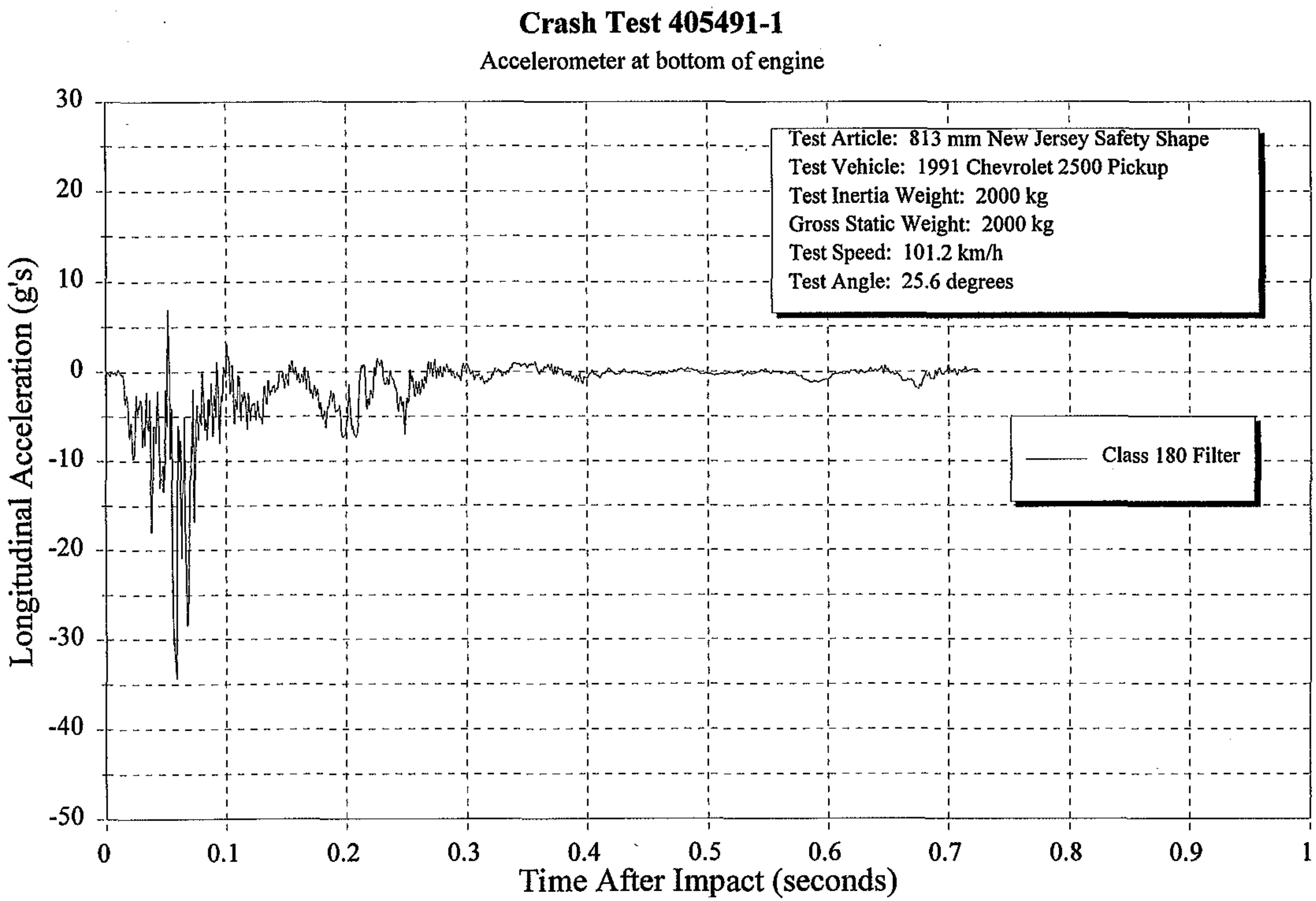


Figure 24. Vehicle longitudinal accelerometer trace for test 405491-1.
(accelerometer at bottom of engine)

IV. SUMMARY OF FINDINGS AND CONCLUSIONS

The New Jersey safety shaped barrier was judged to have met all evaluation criteria set forth in NCHRP Report 350. The barrier successfully contained and redirected the impacting vehicle without the vehicle penetrating or overriding the barrier. Tire marks from the vehicle reached the top of the front edge of the barrier, but did not extend across the top of the barrier. There were no detached elements or debris from the barrier that show potential for penetrating the occupant compartment or to present undue hazard to other traffic or people in the area. Maximum deformation of the occupant compartment was 84 mm at the center front firewall area, but the deformation was judged not to cause serious injuries. The vehicle remained upright and relatively stable during and after the collision period. Maximum roll of the vehicle was 34 degrees away from the barrier, i.e., toward the traffic side. The exit trajectory of the vehicle did not intrude into adjacent traffic lanes with an exit angle of 1.3 degrees. The occupant risk factors were well within the limits set forth by NCHRP 350.

In summary, the New Jersey safety shaped barrier is judged to have met all evaluation criteria set forth in NCHRP Report 350 for test designation 3-11.

Table 2. Assessment of results of test on New Jersey safety shaped barrier.

Test Agency: Texas Transportation Institute | Test No.: 405491-1 | Test Date: 09/06/95

Evaluation Criteria	Test Results	Assessment
Structural Adequacy		
A. Test article should contain and redirect the vehicle; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	The New Jersey safety shaped barrier contained and redirected the vehicle. The vehicle did not penetrate or override the installation.	Pass
Occupant Risk		
D. Detached elements, fragments or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment that could cause serious injuries should not be permitted.	There were no detached elements or debris from the barrier to show potential for penetrating the occupant compartment or present undue hazard to others in the area. Maximum deformation into the occupant compartment was 84 mm the center front firewall area, which was judged not to cause serious injury.	Pass
F. The vehicle should remain upright during and after collision although moderate roll, pitching and yawing are acceptable.	The vehicle remained upright and relatively stable throughout the collision and upon exiting the safety shape. Maximum roll attained by the vehicle was 34 degrees.	Pass
Vehicle Trajectory		
K. After collision it is preferable that the vehicle's trajectory not intrude into adjacent traffic lanes.	The vehicle did not intrude into adjacent traffic lanes.	Pass
L. The occupant impact velocity in the longitudinal direction should not exceed 12 m/s and the occupant ridedown acceleration in the longitudinal direction should not exceed 20 G's.	Longitudinal occupant impact velocity = 5.9 m/s Longitudinal occupant ridedown acceleration = -4.5 g	Pass
M. The exit angle from the test article preferably should be less than 60 percent of test impact angle, measured at time of vehicle loss of contact with test device.	The exit angle at loss of contact with the New Jersey safety shaped barrier was 1.3 degrees which was less than 60 percent of the impact angle.	Pass

REFERENCES

1. H. E. Ross, Jr., D. L. Sicking, R. A. Zimmer, and J. D. Michie, "Recommended Procedures for the Safety Performance Evaluation of Highway Features," NCHRP Report 350, Transportation Research Board, Washington, DC, 1993.

2. J. D. Michie, "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances," NCHRP Report 230, Transportation Research Board, Washington, DC, 1980.