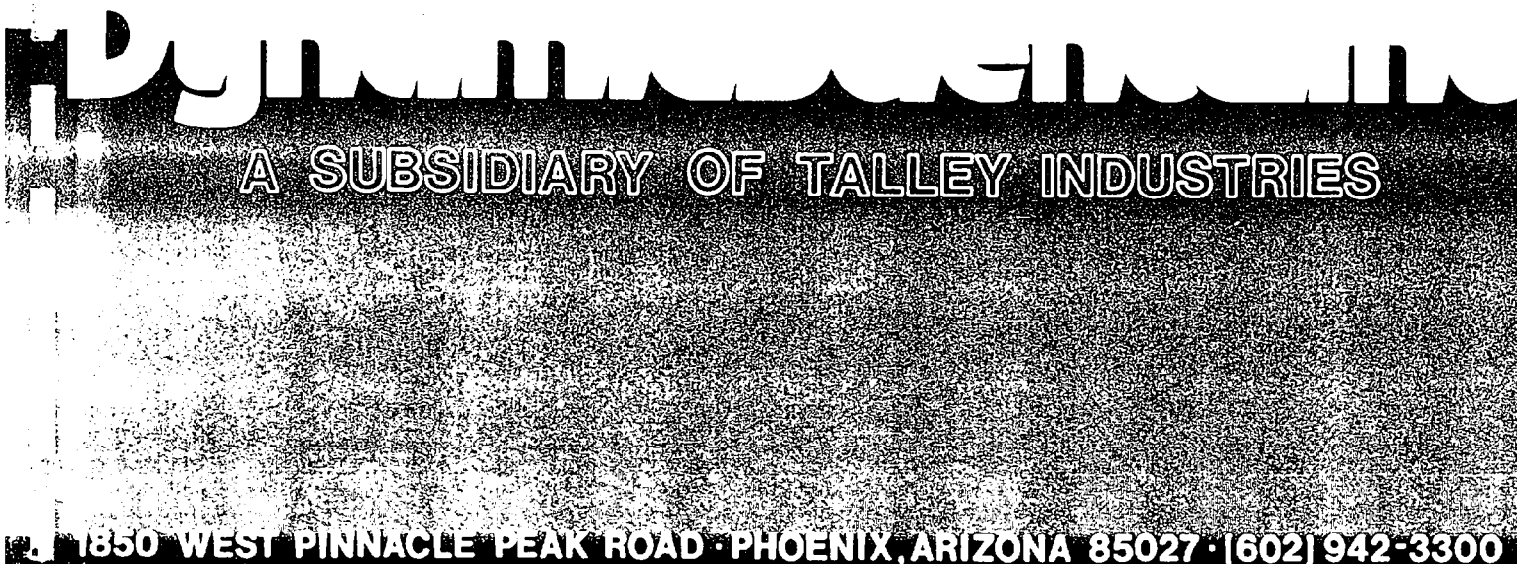
5.9- DØT0161

5.10- DØT0043

COPY



1850 WEST PINNACLE PEAK ROAD · PHOENIX, ARIZONA 85027 · (602) 942-3300

Report Number (to be assigned by NHTSA)

TASK 5 REPORT OF TESTS 5.9 AND 5.10 FOR DEVELOPMENT OF COMPLIANCE TEST FOR TRUCK REAR UNDERRIDE PROTECTION

R. Baczynski
S. Davis

TEST REPORT
June 1979

Document is available to the public through the
National Technical Information Service
Springfield, Virginia 22161

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

Prepared for the Department of Transportation, National Highway Traffic Safety Administration under Contract No. DOT-HS-8-01905. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

dsi DynamicScienceInc.
a TALLEY INDUSTRIES Company

8324

September 11, 1979

Mr. Gary Bell (NRD-12)
Contract Technical Manager
National Highway Traffic Safety
Administration
Trans Point Building
2100 Second Street, S.W.
Washington, D.C. 20590

Subject: Transmittal of Reproducible Report for Task 5, Tests 5.9 and 5.10

Reference: Contract DOT-HS-8-01905, "Development of Compliance Test for Truck Rear Underride Protection"

Dear Gary:

In accordance with the requirements of Task 5 of the referenced contract, enclosed are the reproducible and ten copies of the Report for Task 5, Tests 5.9 and 5.10.

Very truly yours,

Sol Davis

Sol Davis, Director
Research Operations

SD:krg

Enclosures

cc: Ms. Lauraline Clark (NAD-30)
D. Morrison (FHWA)
G. Buth (TTI)

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
TASK 5 REPORT OF TESTS 5.9 AND 5.10 FOR DEVELOPMENT OF COMPLIANCE TEST FOR TRUCK REAR UNDERRIDE PROTECTION	June 1979
	6. Performing Orgn Code
7. Author(s) Baczynski, R., Davis, S.	8. Performing Orgn Rpt No. 8319-79-96
9. Performing Organization Name and Address Dynamic Science, Inc. A Talley Industries Company 1850 West Pinnacle Peak Road Phoenix, Arizona 85027	10. Work Unit No.
	11. Contract or Grant No. DOT-HS-8-01905
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590	13. Type of Report and Period Covered TEST REPORT June 1979
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents the results of two of ten passenger car-to-rear underride crash tests conducted in accordance with the requirements of Task 5 of the "Development of Compliance Test for Truck Rear Underride Protection" program. The test vehicles selected for these tests were 1978 Chevrolet Impalas. These vehicles were impacted into bolt-on, rigid, cantilevered guards mounted to a truck/trailer body simulator at selected heights above ground level. The trailer body simulator used for the tests is a modified, 1977 Fruehauf, 40-foot, heavy duty platform trailer with Select-A-Point tandem rear wheels. For these two tests, two instrumented 50th percentile Part 572 anthropomorphic dummies were placed in the driver and front passenger positions in the car. The occupants were restrained with the vehicle's restraint system. The seat tracks were welded in the midposition to prevent breakaway and/or rotation.

17. Key Words	18. Distribution Statement
Underride Guard, Crash Tests Chevrolet Impala	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. Pages	22. Price
Unclassified	Unclassified	122	

Form DOT F 1700.7 (8-69)

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
	VOLUME			
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	degrees Fahrenheit	5 9 (after subtracting 32)	degrees Celsius	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10 000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1000 kg)	1.1	short tons	
	VOLUME			
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	degrees Celsius	9/5 (then add 32)	degrees Fahrenheit	°F

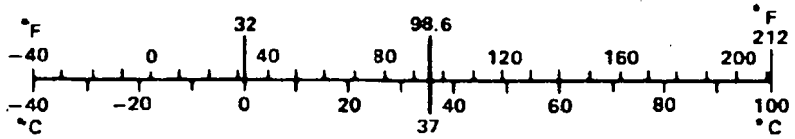


TABLE OF CONTENTS

TABLE OF CONTENTS (CONTD)

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

This report presents the results of the two full-size passenger car-to-rear truck underride guard crash tests conducted in accordance with the requirements of Task 5 of the "Development of Compliance Test for Truck Rear Underride Protection" program. This program is conducted for the Department of Transportation, National Highway Traffic Safety Administration, under Contract No. DOT-HS-8-01905. The test vehicles for the tests (5.9 and 5.10) were 1978 Chevrolet Impala four-door sedans. These vehicles were impacted into a bolt-on, rigid, cantilevered underride guard mounted to a truck/trailer body simulator. In Test 5.9, the vehicle was impacted into the trailer body simulator in a symmetric mode, and in Test 5.10, in an offset mode. For the offset condition, the centerline of the car was aligned six inches inboard of the outer edge of the trailer body simulator. The test matrix and summary of the test conditions for the tests in Task 5 are summarized in Table 1-1. The truck body simulator used for these tests is a modified, 1977 Fruehauf, 40-foot, heavy duty platform with Select-A-Point tandem rear wheels.

For these tests, two Part 572 instrumented dummies (GFE) were positioned in the left and right front occupant positions in the car. Each occupant was properly restrained with the vehicle's restraint system. The seat tracks were welded in their midposition to prevent breakaway and/or rotation.

Starting with Test 5.3, an underride guard (designated T-1 steel guard) was designed by Dynamic Science to provide a rigid

TABLE 1-1. TASK 5 CRASH TEST MATRIX

Test No.	Test Date	Struck Object	Bullet Vehicle	Impact Velocity (mph)	Engagement With Guard
5.1	9/07/78	Guard B 24" Height*	1978 Volkswagen Rabbit 4-door Sedan	40.43	Symmetric
5.2	10/03/78	Guard B 22" Height*	1978 Ford Fiesta 2-door Sedan	40.64	Symmetric
5.3	10/26/78	DSI T-1 (A) Guard 20" Height**	1978 Volkswagen Rabbit 4-door Sedan	40.44	Symmetric
5.4	11/22/78	DSI T-1 (B) Guard 24" Height	1978 Chevrolet Impala 4-door Sedan	40.40	Symmetric
5.5	12/28/78	DSI T-1 (B) Guard 24" Height	1978 Chevrolet Impala 4-door Sedan	40.03	Offset
5.6	11/27/78	DSI T-1 (B) Guard 22" Height	1978 Chevrolet Impala 4-door Sedan	40.58	Symmetric
5.7	1/26/78	DSI T-1 (C) Guard 22" Height	1978 Chevrolet Impala 4-door Sedan	38.94	Offset
5.8	1/22/79	DSI T-1 (C) Guard 22" Height	1978 Volkswagen Rabbit 4-door Sedan	40.09	Offset
5.9	4/03/79	DSI T-1 (C) Guard 22" Height	1978 Chevrolet Impala 4-door Sedan	35.06	Symmetric
5.10	4/04/79	DSI T-1 (C) Guard 22" Height	1978 Chevrolet Impala 4-door Sedan	30.26	Offset

*Guard B is the Fruehauf Guard, used for Task 3 and Task 4, modified to provide greater rigidity and proper height.
**Dynamic Science T-1 steel guard progressively strengthened, as required (Versions A, B, and C).

May 25, 1979

cantilevered design adequate to sustain loads as required to obtain data with the small and large passenger cars as defined in the Task 5 test matrix. Three progressively strengthened versions of this design (A, B, and C) were used for the tests in Task 5. It should be noted that these guards were not optimized for weight reduction since Dynamic Science's charter is to develop test procedures, not optimize underride guards.

The basic design of this guard utilized two vertical I-beams and a horizontal channel section (see Figure 1-1). Because the high strength T-1 steel used for the guard (100 ksi yield strength) is available in flat plate only, the structural sections were fabricated by sawcutting plates to size and welding the sections together with high-strength (103 ksi) welding wire.

T-1 steel guard Design B collapsed during the offset impact test with the Chevrolet Impala at 40 mph (24-in. guard ground clearance) because the load reached 94,000 pounds, exceeding the guard design load. The T-1 steel guard was modified (Design C) to sustain an ultimate load of 140 klb in the offset mode, and was first used for Test 5.7 and for the succeeding tests in Task 5. Additional support plates of 36 ksi yield were added to the flanges of the I-beams and channel section. The I-beams were also boxed in at the sides to prevent separation of the I-beam flanges. This Guard C weight was 395 pounds. It should be noted that this weight would have been much less if T-1 steel had been used for structural reinforcement instead of the lower strength 36 ksi steel.

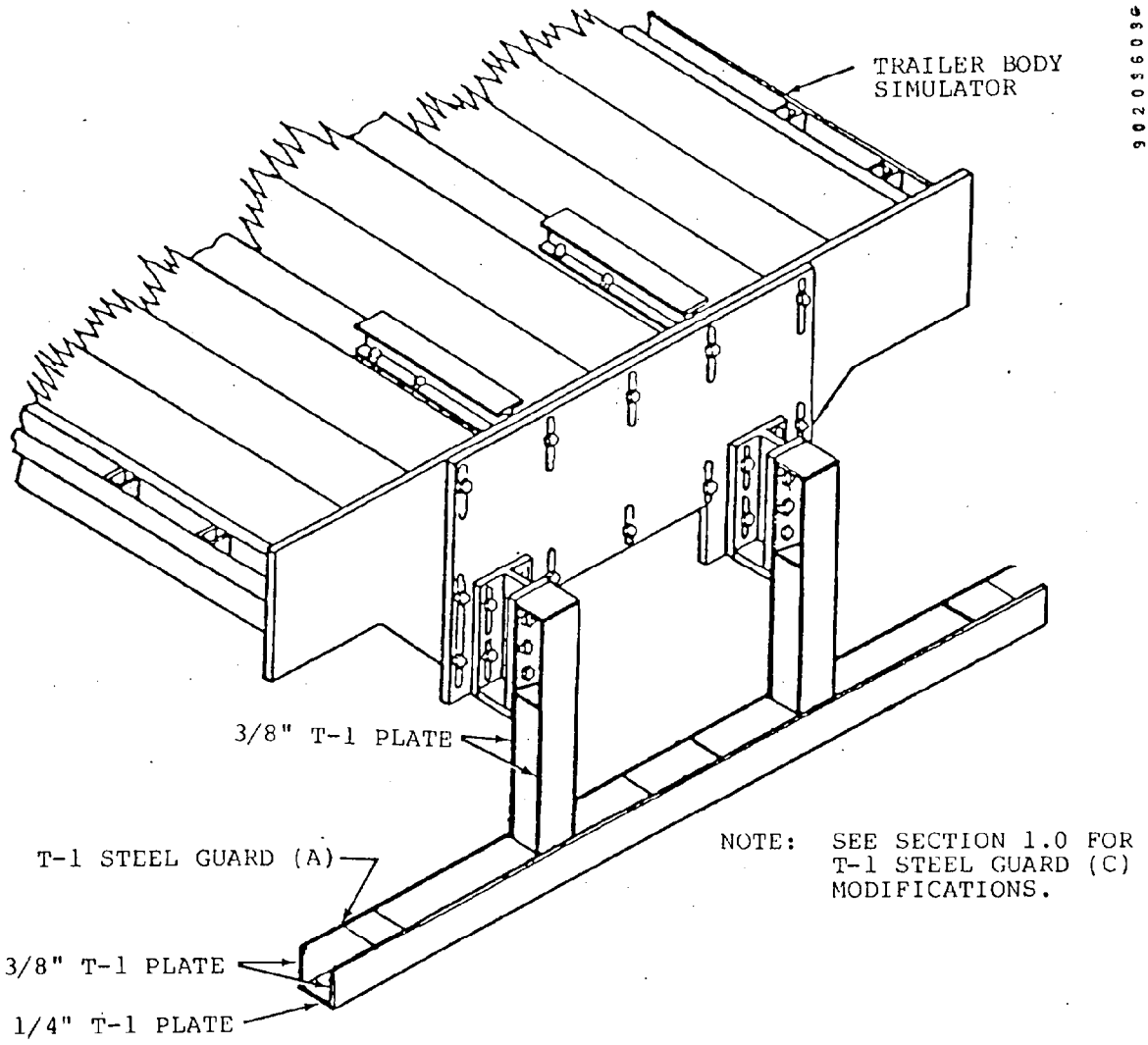


Figure 1-1. Dynamic Science Cantilevered T-1 Steel Guard (A).

1.1 TEST OBJECTIVES

The object of these tests was to obtain the necessary data for establishing appropriate criteria for development of compliance test parameters and procedures for truck-trailer rear underride protection. The specific object in Task 5 was to test selected new guard designs as to their effectiveness in rear underride collisions with current production full- and small-size passenger cars, and to provide a basis for selecting the best underride guard with regard to critical parameters (geometric design, strength, energy-absorbing capabilities, economic and environmental factors). The primary objectives of Tests 5.9 and 5.10 were to determine the effects of reduced impact speeds on guard loads, on occupant injury criteria, and underride distance for a large passenger car.

2.0 TEST METHODOLOGY

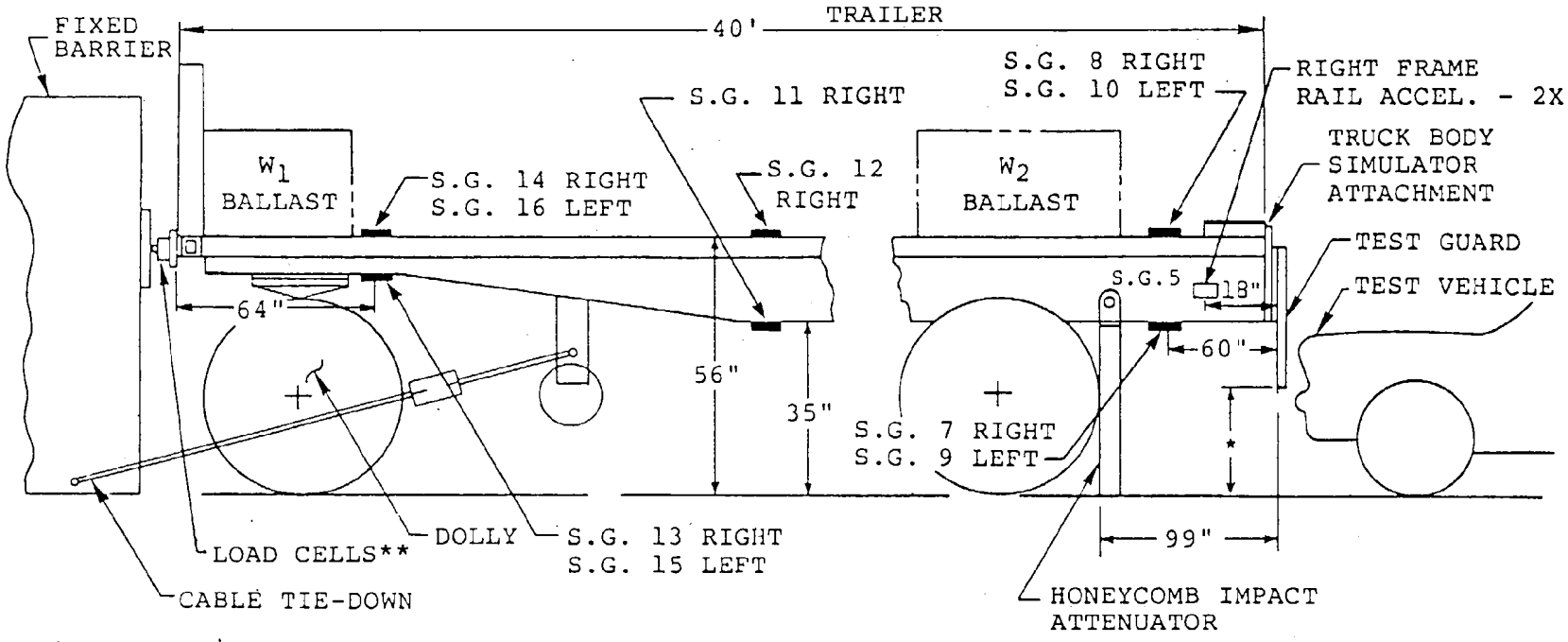
Two car-to-truck rear underride guard tests were conducted at the barrier impact facility. The truck body simulator developed in Task 3 was utilized for mounting of the selected underride guard in these tests (see Figure 1-1). For all tests, the selected test underride guard was mounted to the trailer body simulator. The test site layout of the test vehicle and trailer simulator arrangement for these tests is shown in Figure 2-1.

Test 5.9 was conducted with symmetric engagement between the vehicle and guard, i.e., with the trailer and vehicle longitudinal centerlines coincident (see Figure 2-2).

Test 5.10 was conducted in an offset engagement mode. The centerlines of the cars were aligned 6 inches inboard of the outer edge of the trailer body simulator (42 inches off-center) (see Figure 2-3).

To prevent damage to the trailer undercarriage in the event of excessive underride by the test vehicle, a steel plate was mounted just aft of the rear wheels, supported on pivot pins from the trailer main I-beams. The plate was backed up by the tandem wheel tires. The face of the impact plate was covered with honeycomb material to absorb the energy of the vehicle impact.

The vehicle impact velocity (see Table 1-1) was controlled to within ±1 mph. The test vehicle was prepared in accordance with the requirements of the test plan. It was then placed at the head



*See Table 1-1, Test Matrix.
**Four 100 Klb - Test 5.9 and 5.10.
NOTE: STRAIN GAUGES 7 THRU 16 MOUNTED ON UPPER AND LOWER FLANGES OF TRAILER SIMULATOR FRAME RAILS.

Figure 2-1. Tests 5.9 and 5.10 Truck Body Simulator Test Site Layout.

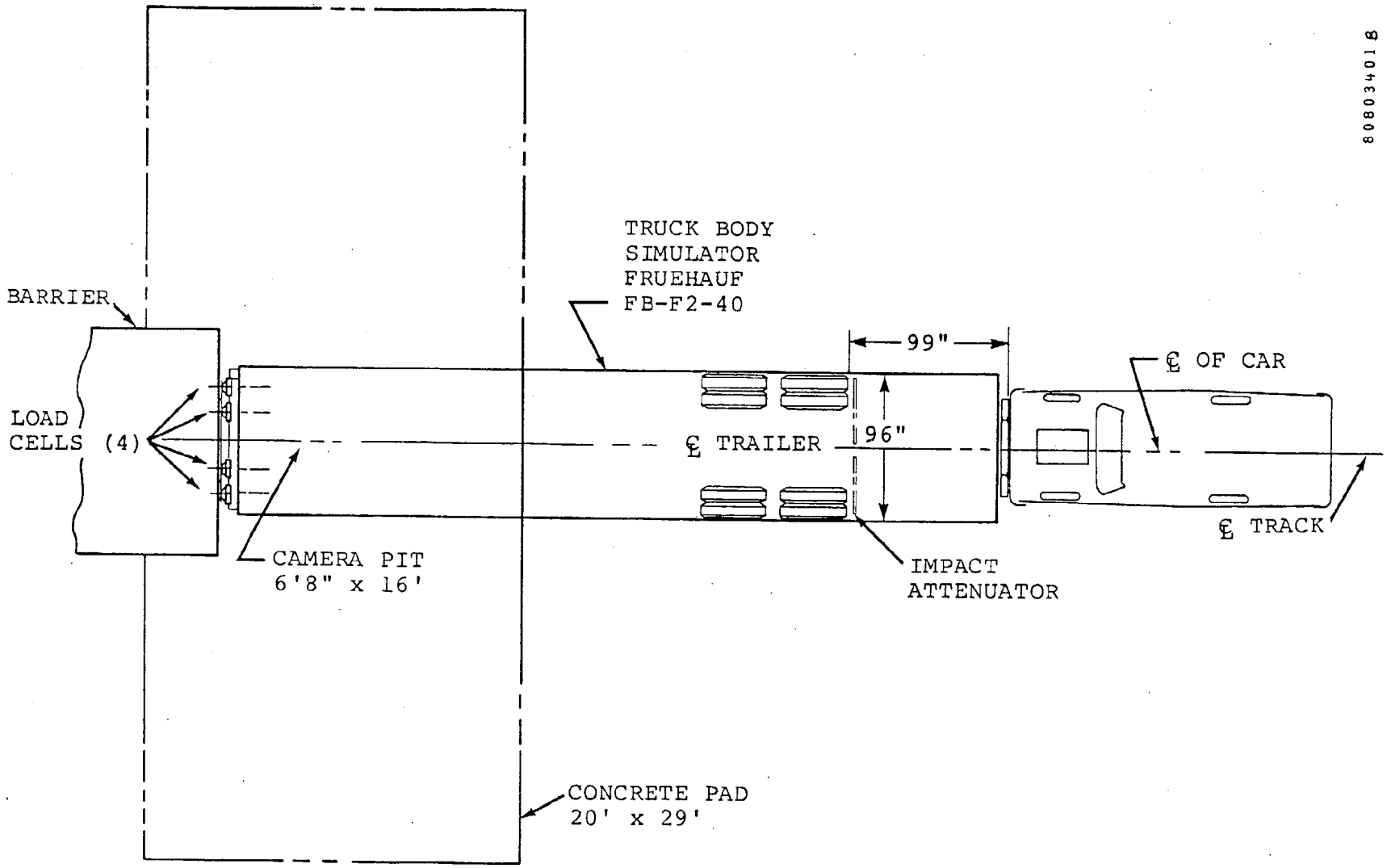


Figure 2-2. Symmetric Underride Guard Test Site.

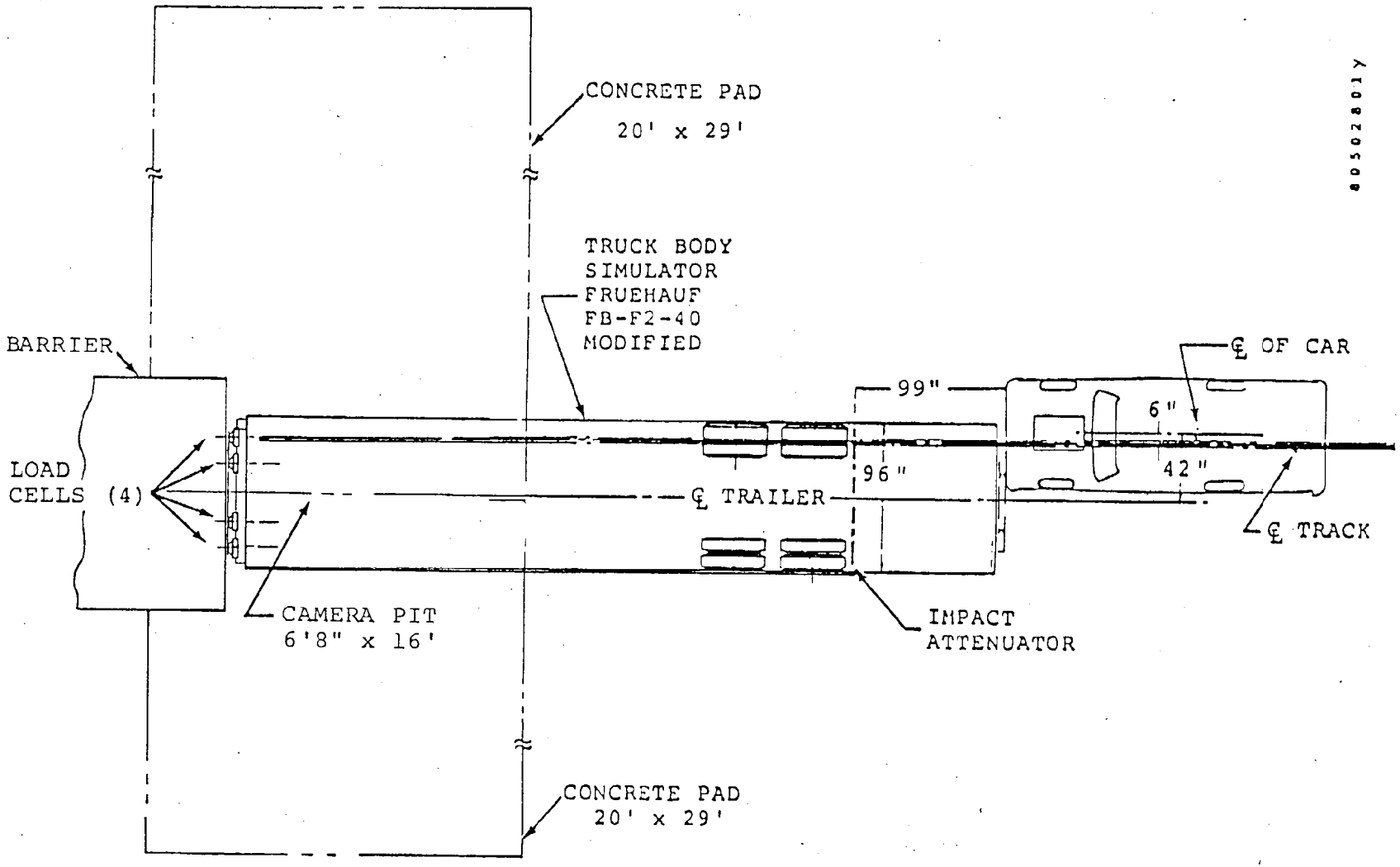


Figure 2-3. Task 5 Offset Underride Guard Test Site.

of the test track facing the barrier where it was attached to the tow and guidance system. The trailer body simulator was prepared in accordance with the requirements of the test plan. Upon completion of the pre-crash checkout of the instrumentation, the vehicle was towed to the specified test speed and released from the tow system just prior to impact. The data from the test vehicle was transmitted to the data acquisition center via umbilical cable with telemetry as a backup. The data from the truck body simulator was transmitted by umbilical cable only (see Figure 2-4).

2.1 DATA ACQUISITION METHODS

The overall plan for obtaining the necessary data is outlined in Table 2-1. The table defines the test parameter, measurement method, and recording method used during conduct of these tests.

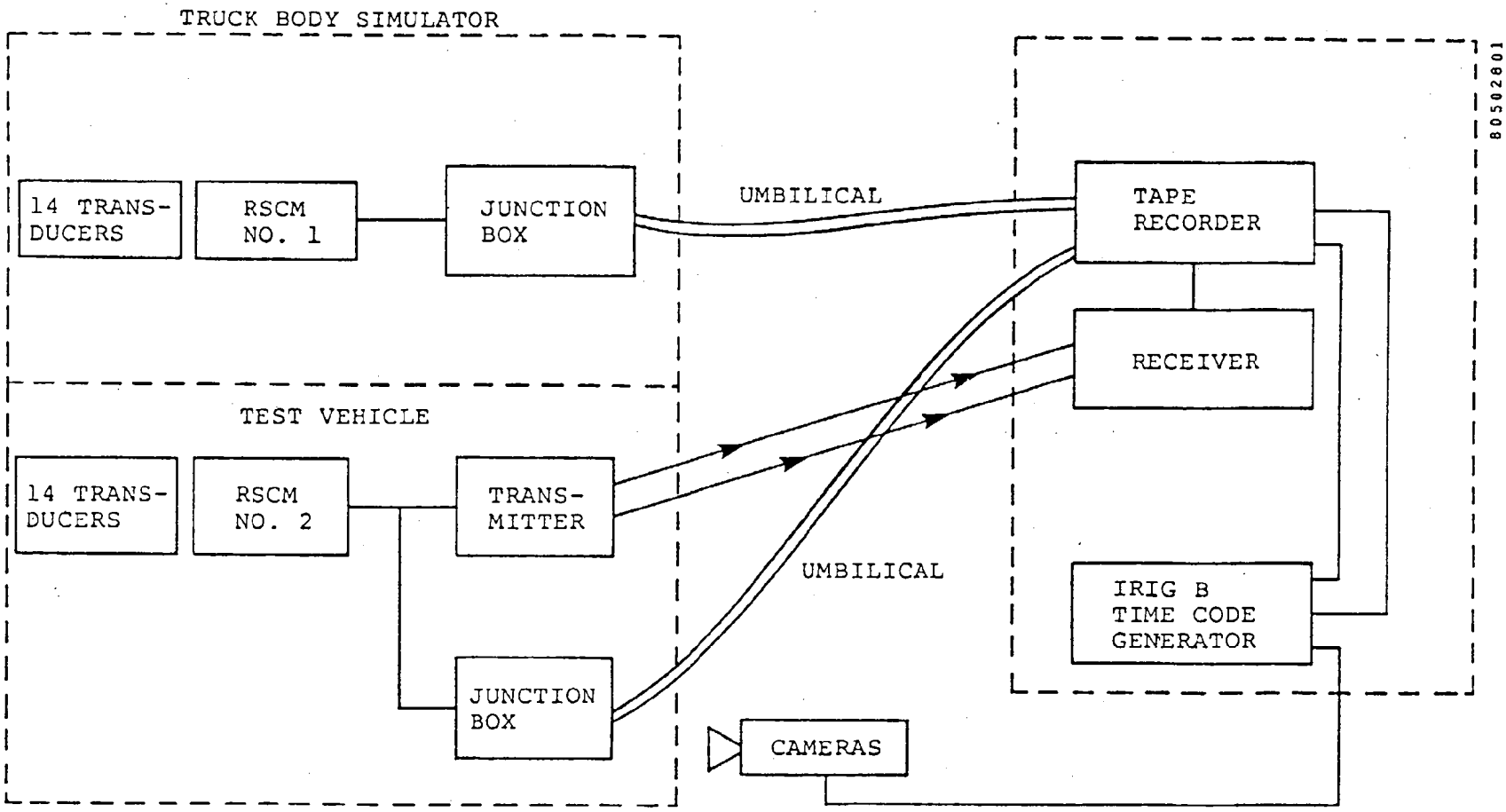


Figure 2-4. Data Acquisition - Vehicle-to-Truck Underride Simulator.

TABLE 2-1. DATA REQUIREMENTS

Test Parameter	Measurement Method	Magnetic Tape	Written Log	Photographic Analysis
Impact Time	Contact switch signal impressed on millisecond time base	X		
Approach Velocity	Tow cable velocity sensor	X		
Impact Velocity	Speed trap entrance and exit signals from speed trap	X*		
Rebound Velocity	Calculated from high-speed film analysis	X		X
Vehicle Acceleration Measurements	Accelerometers, unbound strain gauge type	X		
Underride Guard Structural Deformation	String potentiometer and direct linear measurement	X	X	
Stress in Underride Guard	Strain gauges	X		
Forces on Truck Body Simulator - Fixed Barrier Interface	Load cells	X		
Vehicle Structural Deformation	Direct linear measurement		X	
Vehicle Static Crush	Direct linear measurements		X	
Vehicle Dynamic Crush	Film analysis			X
Vehicle Underride Distance	Direct linear measurement and high-speed film analysis		X	X
Occupant Compartment Intrusion	Direct linear measurement and high-speed film analysis		X	X
Occupant Dynamic Displacement	High-speed film analysis			X
Vehicle Weight by Wheel	Direct pre-test measurement using balance scales		X	
Ballast Weight	Balance scale		X	

*Velocity is also measured by electronic counter.

3.0 DATA ACQUISITION

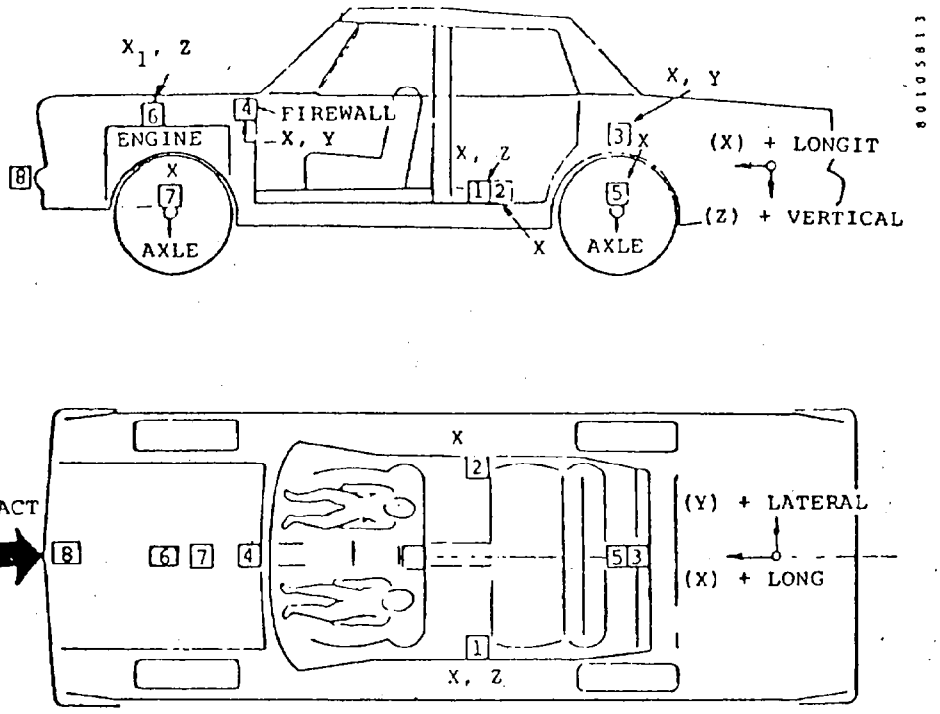
3.1 INSTRUMENTATION

3.1.1 Test Vehicle Instrumentation

The test vehicle had a 50th percentile restrained instrumented dummy positioned in the driver and front passenger locations. Twelve structural accelerometers were installed on the vehicle and consisted of the following (see Figure 3-1):

1. A biaxial (X, Y) mount located on the left rocker panel near the B-pillar to measure accelerations of the occupant compartment.
2. A single (X) mount similar to No. 1, but on the right side of the vehicle.
3. A biaxial mount (X, Y) located on the rear floor structure over the rear axle.
4. A biaxial mount (X, Y) located on the upper centerline of the firewall in the engine compartment to measure acceleration of the forward section of the passenger compartment.
5. A single mount (X) located on the centerline of the rear axle to measure acceleration of the rear drive train and rear suspension assembly.
6. A biaxial mount (X, Z) located on the top of the engine block in a protective case to measure acceleration of the engine.
7. A single mount (X) located on the front frame crossmember in a protective case to measure axial acceleration of the front frame.
8. Two tape switches were mounted on the initial contact point of the car to record impact. The tape switches were installed in parallel, to provide redundancy of data.

The instrumentation requirements for the test vehicle are given in Figure 3-1.



VEHICLE ACCELEROMETER LOCATIONS AND PHYSICAL COORDINATES					MAXIMUM EXPECTED READINGS		
No.	Description of Location	X**	Y**	Z**	LONG*	LAT*	VERT*
1	Rocker panel near B-pillar behind driver's seat	111	-24	0	50	50	
2	Rocker panel near B-pillar behind passenger's seat	111	24	0	50		
3	℄ of rear deck above rear axle	153	0	28	50	50	
4	℄ of firewall at A-pillar inside passenger compartment	60	18	6	100	100	
5	℄ of rear axle	156	0	7	100		
6	Engine block (Top ℄) - longitudinal and vertical accelerometers	45	0	17	200		200
7	Front crossmember	30	19	15	200		
8	Two impact switches						

*G
**Reference points:
X - Direction - Centerline of front bumper
Y - Direction - Centerline of vehicle
Z - Direction - Top of driver rocker sill.

Figure 3-1. 1978 Chevrolet Impala Accelerometer Locations.

3.1.2 Truck Body Simulator Instrumentation

The instrumentation on the truck body simulator was the same for the two tests except for strain gauge locations on the guard. Figures 2-1 and 3-2 show the location of the instrumentation on the truck body simulator and on the guard for the two engagements of the underride guards. The instrumentation purposes and locations were as follows:

1. Three strain gauges on Tests 5.9 and 5.10 were mounted on selected points of interest of the underride guard to measure strains developed in the structure due to the impact forces (see Figures 3-2 and 3-3).
2. Three string potentiometer displacement transducers mounted on the truck simulator structure to measure relative displacement of the lower section of the underride guard.
3. Four load cells mounted on the front face of the trailer platform in contact with the face of the fixed barrier to measure dynamic impact forces of the test.
4. One longitudinal accelerometer mounted on the web of the right main frame I-beams of the trailer to measure acceleration of the trailer.
5. On Tests 5.9 and 5.10, eight strain gauges were mounted on the upper and lower flanges of both main frame rails of the tailer to measure strains at various points in the truck body simulator during the crash (Figure 2-1).
6. Two tape contact switches, each mounted on the guard and car grille at the initial contact points of the impact. The switches were connected in parallel to provide redundancy of data.

3.2 PHOTOINSTRUMENTATION AND PHOTOGRAPHY REQUIREMENTS

3.2.1 Vehicle-to-Truck Body Simulator Test Photography

Six high-speed cameras (four 1000 fps and two 400 fps) and one panning (24 fps) camera were used, as shown in Table 3-1, for

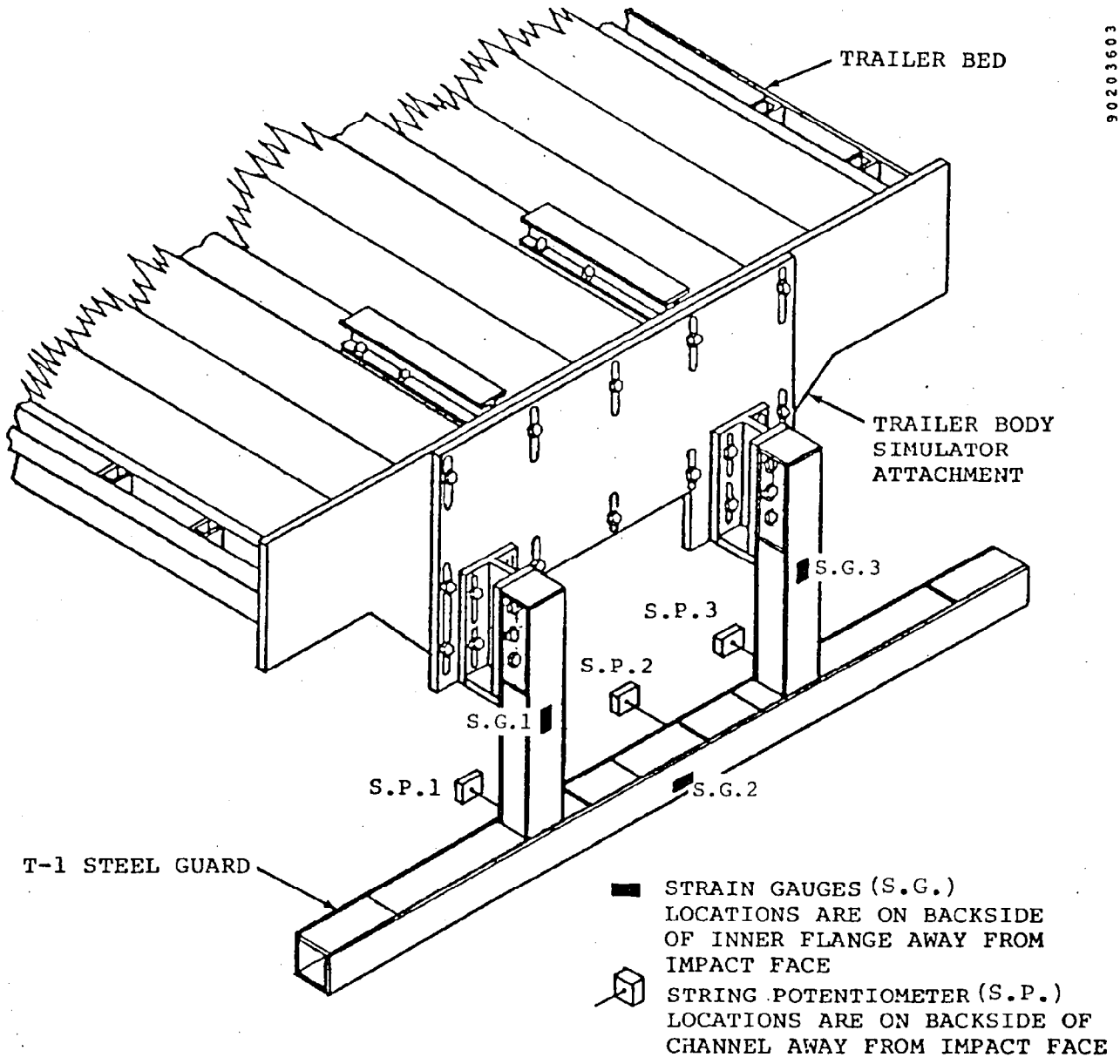


Figure 3-2. Test No. 5.9 Symmetric Underride Guard Instrumentation.

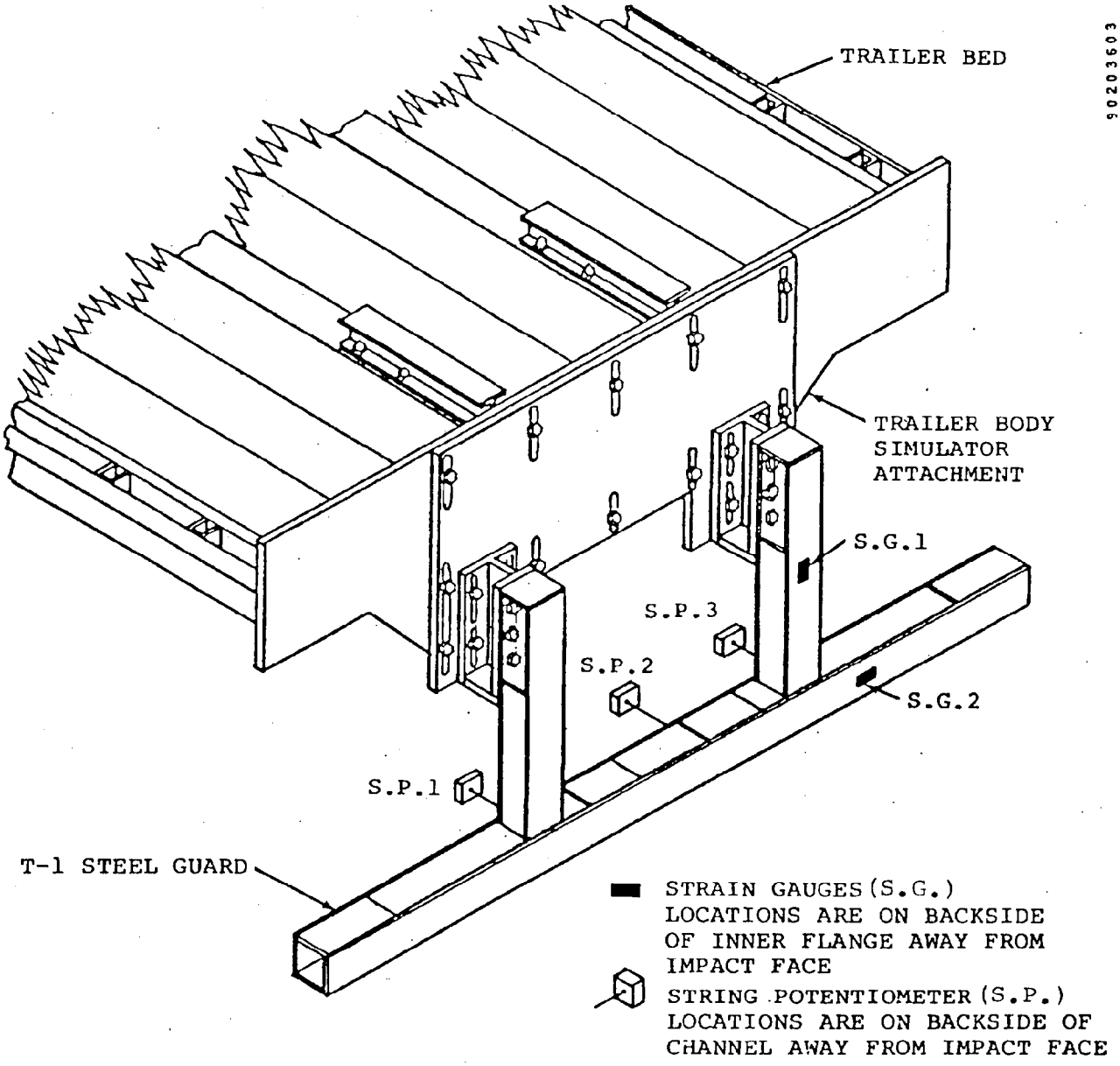


Figure 3-3. Test No. 5.10 Offset Underride Guard Instrumentation.

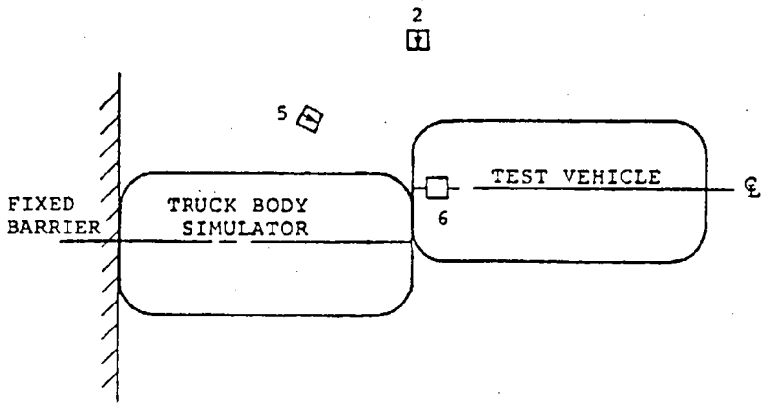
TABLE 3-1. CAMERA LOCATIONS

8319 5.1
Test No: through 5.10 Test Date: _____

Test Type: Car-to-Stationary Truck Body Simulator

Vehicle A (Away):	1978 Chevrolet 1978 VW Rabbit	
Vehicle B (Barrier):		

Comments: Camera locations are approximate and may be moved at the discretion of the test engineer.



NOTE: Vehicle Position Shown For Offset Engagement.

CAMERA	YES
STILLS	✓
SLIDES	✓
MOVIE	✓
POLAROID	
VIDEO	

CAMERA SYMBOLS

- ⊙ PIT
- ↑ GROUND
- △ BARRIER
- ⊠ OVERHEAD
- □ ON-BOARD

FRAME RATE

1. 1000 fr/sec
2. 200 fr/sec
3. Other 24 fr/sec
4. 400 fr/sec
5. 500 fr/sec

TIMING LIGHT SPEED

1. 100 Hz (10 msec/light)
2. 200 Hz (5 msec/light)
3. Other _____

Loc. No.	Location	Field of View	Lens Size	Frm Rate	Tmng Spd	Ser No	Impact Dist-X	C.L. Dist-Y	CAM Hght-Z
1	Left Side	Overall of vehicle and truck body	25mm	4	1				
2	Right Side	2/3 of vehicle to rear wheel of truck body	25mm	4	1				
3	Left Side	2/3 of vehicle to rear wheel of truck body	50mm	1	1				
4	Left Side	Close-up - front wheel of vehicle to rear wheel of truck body	25mm	1	1				
5	Left Side	Angled close-up of impact area	13mm	1	1				
6	Rear of truck body	Overhead view of impact area	13mm	1	1				
7	Left Side	Panning test and overall results	Zoom	3					

the vehicle-to-truck underride guard tests. Table 3-2 describes the still camera (B/W and color) photographic fields of view.

The panning camera documented the instrumentation, pre-test and post-test vehicle configurations, pre-test and post-test dummy positions, and the underride guard and test vehicle crush profiles.

3.3 VEHICLE STRUCTURAL DEFORMATION DATA

3.3.1 Data Acquisition

Pre-test and post-test measurements of the test vehicle and underride guard were made under the direction of the Test Engineer and were taken at the appropriate stage of vehicle testing.

TABLE 3-2. CAR-TO-TRUCK BODY SIMULATOR TESTS PHOTOGRAPHIC REQUIREMENTS AND CHECKLIST

Color Negatives (6cm x 7cm)	Color Slides (35mm)	Black and White	Field of View	Pre-test	Post-test
	X	X	Front View of Car	____	____
		X	Left Front Three-quarter View of Car	____	____
	X	X	Left Side View of Car	____	____
		X	Right Front Three-quarter View of Car	____	____
	X	X	Right Side View of Car	____	____
	X	X	Front View of Underride Guard	____	____
X	X	X	Overall View of Car and Truck Body Interface - Left Side	____	____
X		X	Overall View of Car and Truck Body Interface - Right Side	____	____
	X	X	Document Photos (2) of Truck Body Simulator	____	____
	X	X	Closeup of Bumper/ Underride Guard Matchup	____	____
		X	Closeup of Dummy Contact Points	____	____
		X	Overall Forward Occupant Compartment With Dummy	____	____
		X	Document Photos (3) of Truck Body/Fixed Barrier Interface	____	____
X			Time of Structural Collapse (100 ms)	____	____

4.0 SUMMARY OF TEST RESULTS

This section of the report presents the discussion of the test conditions and test results of the two Task 5 vehicle-to-underride guard symmetric and offset impacts (Tests 5.9 and 5.10). The data summary tables and data plots, along with photographs of the pre- and post-test documentation for Tests 5.9 and 5.10 are provided in Appendices A and B, respectively.

The test conditions and test results for Test 5.9 are presented in Section 4.1. The test conditions and test results for Test 5.10 are presented in Section 4.2.

A summary and discussion comparing pertinent crash data of these two tests with those of high speed Chevrolet tests (Tests 5.6 and 5.7) previously conducted in Task 5 is presented.

4.1 TEST 5.9 - SYMMETRIC IMPACT

4.1.1 Test Conditions - Test 5.9

The test vehicle longitudinal centerline was aligned with the longitudinal centerline of the trailer body simulator. The impacting vehicle test weight was a summation of the curb weight with all fluids removed except for water in the radiator, plus the weight of the on-board instrumentation and the instrumented dummies in the driver and front passenger positions. The dummies were restrained with the vehicle restraint system.

The truck body simulator was ballasted with concrete blocks totaling 9,250 pounds over the front dolly wheel centerline and 9,250 pounds over the rear tandem wheel centerline. The front ballast was added to prevent lifting of the front of the trailer during impact and maintain continuous contact of the load cells with the fixed barrier. The rear ballast was used to level the trailer fore and aft for proper orientation of the underride guard prior to the test. Through angled cable tiedown of the forward section of the trailer, the load cells were pre-loaded to approximately 2,000 pounds each. This pre-load was electrically set to zero during calibration setup to provide zero reference impact loads during the test.

The modified DSI T-1 steel guard (C) was used for this test (see Section 1.0). The guard width was 84 inches. The guard height from the ground was set at 22.0 inches. Ground level was established from the contact points of the test vehicle front tires. The car bumper was lowered approximately 2 inches to ensure that the underride guard would not impact the bumper during the crash. A switch bracket was installed on the front face of the car bumper for the time zero indication switch.

4.1.2 Test Results - Test 5.9

In Test 5.9, the 1978 Chevrolet Impala, weighing 4157 pounds, impacted the underride guard at 35.06 mph. The underride guard overrode the car bumper by 0.9 inch. The maximum dynamic vehicle underride measured from the forward face of the front bumper, obtained from high-speed film analysis, was 45.5 inches (see Figure A-1 in Appendix A); vehicle rebound was 6 inches on the left and

2.5 inches on the right side of the vehicle. The post-test measured static collapse of both sides of the vehicle was 42.5 inches. There was no measurable deformation of the underride guard.

The horizontal beam of the underride guard struck the vehicle at the bottom of the grille, pushing the radiator and air conditioning condenser into the engine block, in turn, contacting the engine block between the water pump and the crankshaft drive pulley. The entire engine, components and the body forward sheet metal were pushed back to just forward of the front axle centerline. At the drive tunnel, the firewall intrusion was 9.8 inches. The left front tire was punctured.

The driver dummy head struck the upper rim of the steering wheel. Its chest impacted the steering column hub. The passenger dummy head struck the top of the upper dash. Both dummies' knees impacted the lower dash panel.

Static deformation of the pertinent areas of the vehicle (including steering wheel movement) and photographs of the pre- and post-crash damage documentation are shown in Appendix A.

4.2 TEST 5.10 - OFFSET IMPACT

4.2.1 Test Conditions - Test 5.10

The test vehicle longitudinal centerline was offset 42 inches to the right of the trailer body centerline. This was accomplished by moving the trailer body centerline 36 inches to the left of the track centerline, and moving the test vehicle centerline six inches right. The test vehicle was a 1978 Chevrolet Impala four-door sedan. The Chevrolet Impala test weight was a summation of the curb weight with all fluids removed, except engine coolant, plus the weight of the on-board instrumentation and the instrumented dummies in the driver and right front passenger positions. The dummies were restrained with the vehicle restraint systems.

The trailer body simulator was ballasted as it was in Test 5.9.

The same T-1 Guard (C) used in Test 5.9 was utilized in Test 5.10. The guard height from ground level was set at 22 inches. A time zero contact switch was mounted at the front face of the bumper.

4.2.2 Test Results - Test 5.10

In Test 5.10, the 1978 Chevrolet Impala, weighing 4186 pounds, impacted the underride guard in the offset mode at 30.26 mph. The underride guard overrode the car bumper by 0.2 inch. The maximum dynamic vehicle underride (Figure A-1) on the left

side of the vehicle was 46.5 inches (obtained from high-speed film analysis). The vehicle rotated 8 degrees counterclockwise. There was no visible guard damage.

The horizontal beam of the underride guard pushed the engine backward into the firewall, rupturing the firewall sheet metal on the passenger side.

The driver dummy head impacted the upper rim of the steering wheel; its chest struck the steering wheel hub. There were no visible areas of contact between the passenger head or chest with the vehicle interior. The knees of both dummies contacted the lower part of the dash panel.

4.3 TEST RESULTS SUMMARY

This section summarizes the pertinent data for Tests 5.9 and 5.10. To provide a comparison of these two tests with previous tests at impact speeds of 40 mph (Symmetric Test 5.6 and Offset Test 5.7), the following tables and figures include corresponding data from those tests. Table 4-1 includes the vehicle description, test conditions, vehicle underride, and maximum loads. Table 4-2 provides the critical parameters for defining occupant injury criteria. Figures 4-1 and 4-2 are point-to-point graphs of areas of the occupant compartment deformation and intrusion. The complete list of car frontal and compartment static deformation data are listed in Tables A-9 and B-9 in their respective Appendices.

TABLE 4-1. SUMMARY OF UNDERRIDE GUARD TEST RESULTS

Parameter	Test 5.6	Test 5.9	Test 5.7	Test 5.10
Test Vehicle	1978 Chevrolet Impala	1978 Chevrolet Impala	1978 Chevrolet Impala	1978 Chevrolet Impala
Test Weight (lb)	4181	4157	4264	4186
Guard Height (in.)	22.0	22.0	22.0	22.0
Impact Velocity (mph)	40.58	35.06	38.94	30.26
Configuration	Symmetric	Symmetric	Offset	Offset
Maximum Truck Underride (in.)*	53.1 (65.4)**	45.5 (65.4)**	54.9 (65.4)**	46.5 (65.4)**
Maximum Force Load (lb)***	191,825	161,656	120,373	86,476

*Based on high-speed film analysis.
**Front bumper to centerline of windshield at hood level.
***Sum of four or five load cells on time basis.

TABLE 4-2. SUMMARY OF UNDERRIDE TEST OCCUPANT RESPONSE DATA

Parameter	Test 5.6	Test 5.9	Test 5.7	Test 5.10
Driver HIC	1499*	1117*	1380*	807
Driver Head SI/G**	2135*/94	1760*/86	2096*/109	1074*/78
Passenger HIC	1840*	1171*	189	649
Passenger Head SI/G**	2711*/104	1569*/91	247/40	980/72
Driver Chest SI/G**	895/68*	588/58	623/60*	309/49
Passenger Chest SI/G**	789/52	513/45	348/38	139/23
Driver Left Femur	-1001	518	-1358	-1758
Driver Right Femur	-1779	-1557	-2788*	-610
Passenger Left Femur	-427	-2082	-1179	-732
Passenger Right Femur	-707	-361	-860	-1315

*Exceeds Injury Criteria defined in FMVSS 208.
**G level defined as value for cumulative duration of at least 3 msec.

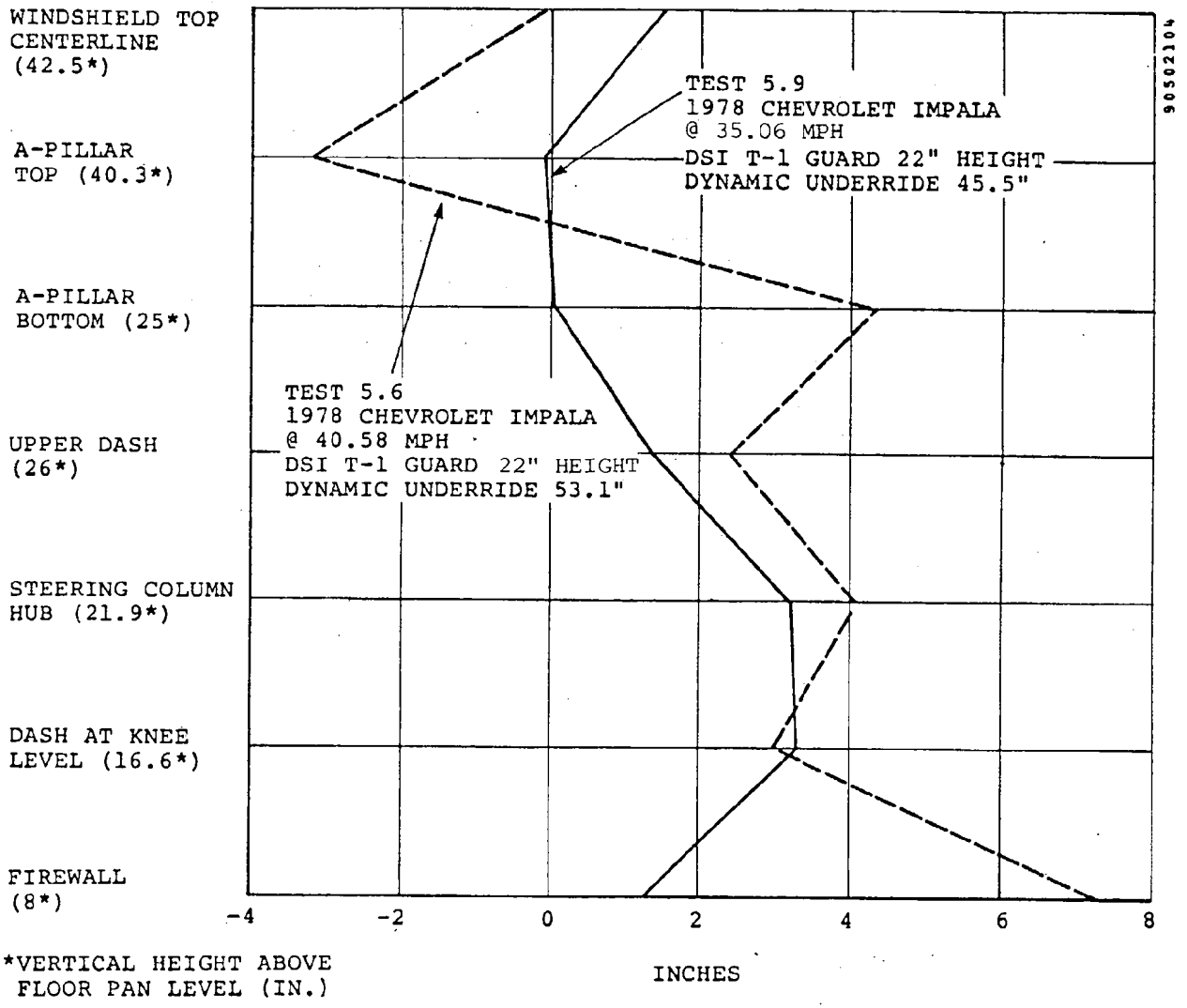


Figure 4-1. Post-test Static Driver Side Compartment Intrusion - Symmetric Tests 5.6 and 5.9.

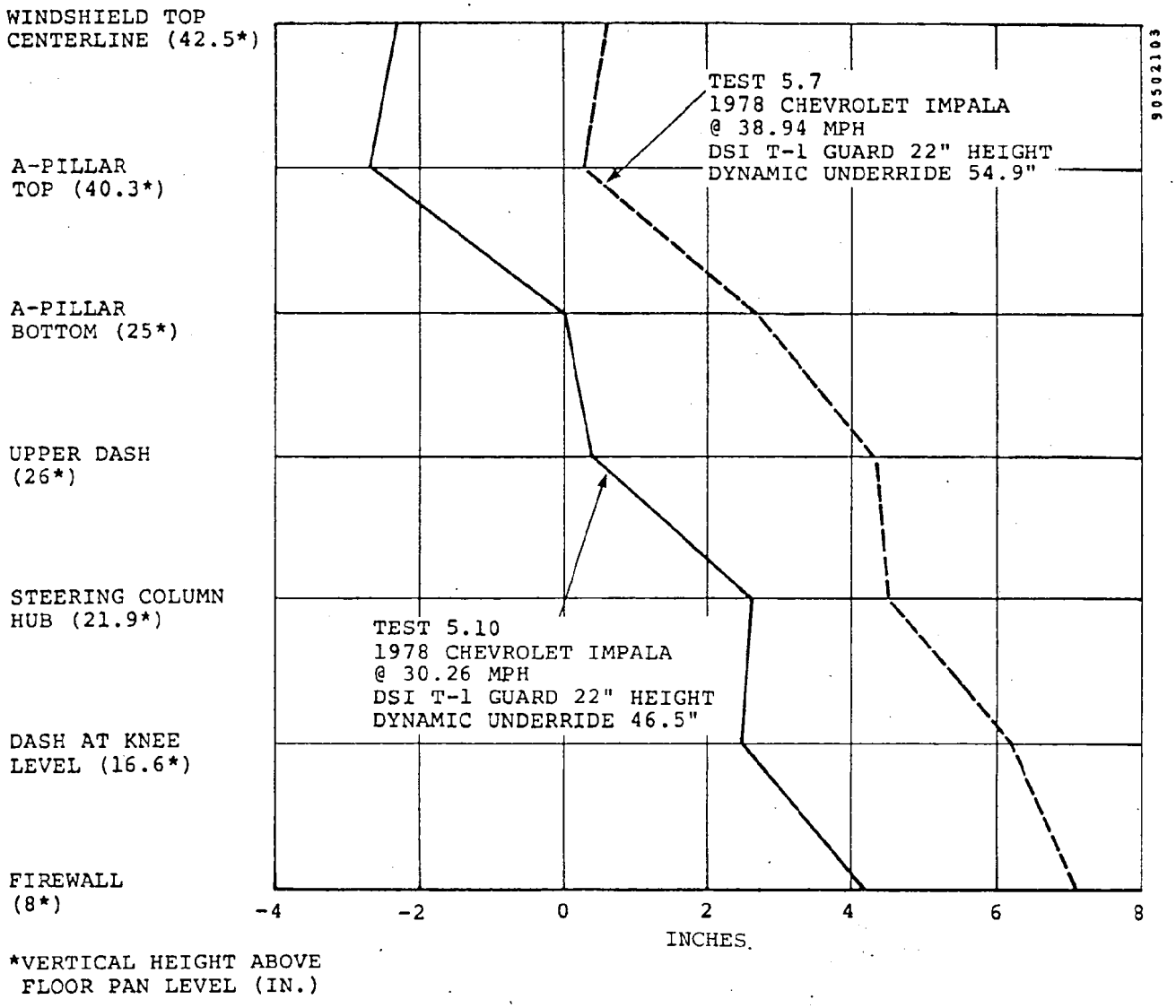


Figure 4-2. Post-test Static Driver Side Compartment Intrusion - Offset Tests 5.7 and 5.10.

5.0 TEST FACILITIES AND EQUIPMENT

5.1 GENERAL

The impact tests in this program were conducted at the Monorail Impact Facility, shown in Figure 5-1. The fixed barrier impact site was used for the vehicle-to-trailer body simulator tests.

Table 5-1 describes the test equipment and its function as it applies to the test parameters.

5.2 FACILITY AND EQUIPMENT DESCRIPTION

The following paragraphs briefly describe the track facility and equipment, their function, and mode of operation.

5.2.1 Test Track and Guidance System

The test track consists of 1,200 feet of asphalt pavement (SN = 75 ±5), 14 feet in width. The length allows sufficient acceleration distance to accommodate impact speeds in excess of 60 mph with sufficient distance remaining to abort the test if necessary. Guidance for the test vehicle is provided by a sliding shoe attached to the vehicle. The sliding shoe rides on the monorail embedded in the test track. Prior to impact, the shoe is mechanically released from the test vehicle.

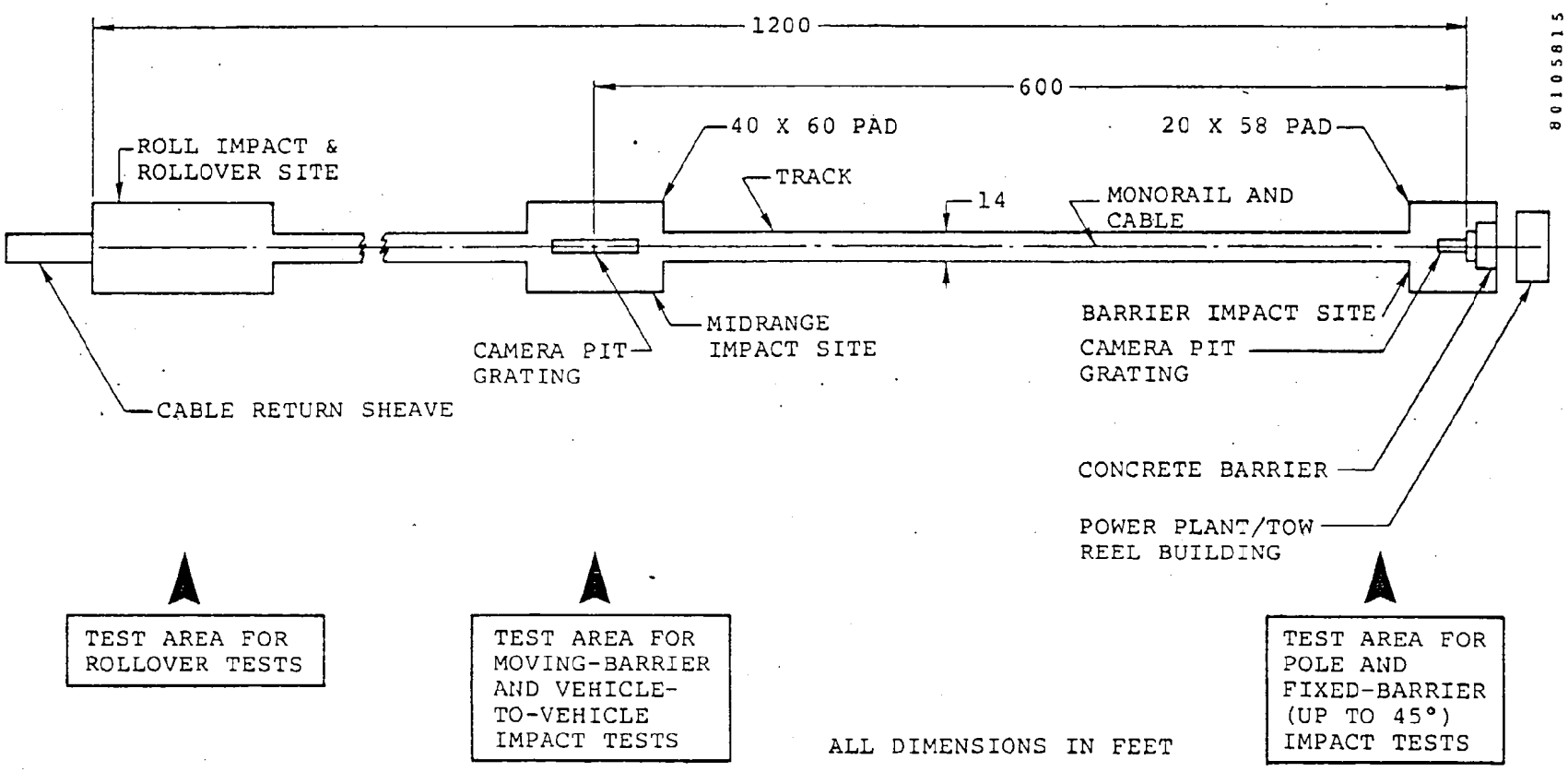


Figure 5-1. Monorail Impact Facility.

TABLE 5-1. TEST EQUIPMENT LIST AND FUNCTION

Item	Manufacturer	Model	Purpose
Timing Trap	Dynamic Science	None	Determine impact speed by furnishing a start and stop signal to recording oscillograph.
Oscillograph	Bell and Howell	5-134	Records timing start and stop signals from timing traps, cable drum drive rpm, and impact switch.
Speed Control	Dynamic Science	None	Precision control of cable drive drum rpm.
Beam Scales	Western	WP2000	Used to determine vehicle test weights.
High-speed Motion Picture Cameras	Photosonic, Milliken, Fairchild	16-1B DBM-5A HS-100	Used for side, overhead, and on-board film coverage as required.
Motion Picture Camera	Bolex	H-16	Panning and documentation.
Still Camera	Kowa	6	Documentary photo coverage.
100 and 1000 Hz Time Code Generators	Dynamic Science	None	Furnish timing signal for high-speed cameras and a 1-millisecond timing for velocity determination.
Calibrated Steel Rule	Starret	48 in.	Precision measurement of velocity trap spacing.
Anthropomorphic Dummies	Alderson	Part 572	To ballast the vehicle and to observe occupant dynamic movement.
Vehicle Accelerometers	Statham	A69TC-200	Measures acceleration.
Strain Gauges	BLH	FAE-25-35-P	Measure underride guard component strain.
String Potentiometers	Celesco	PT-101-30	Measures displacement.
100 Klb Load Cells	Interface	1330AF	Force on truck body simulator-fixed barrier interface.
Tape Recorder	Sangamo	Sabre III	Records instrumentation signals.
Oscillograph	Bell and Howell	5-134	Records real-time quick-look data.
Signal Conditioner	Ectron	M140	Conditions instrument output signal for recording.

5.2.2 Tow System and Velocity Control

The tow system consists of a drum-driven endless cable powered by a pair of 390-cubic-inch engines driven in tandem driving a modified three-speed C-6 automatic truck transmission. The tow system can propel a 6,000-pound vehicle into the fixed barrier at 75 mph or two 4,000-pound vehicles into each other at a closing speed of 90 mph. Velocity control is achieved through a manually controlled throttle system. A visual readout of speed versus distance is provided and compared with the "ideal curve." Velocity control of ±0.5 mph is realizable down to 20 mph and ±2.0 percent down to zero mph.

5.2.3 Abort System

Automatic abort capability is provided through the vehicle service brakes which are actuated by releasing high-pressure air into the hydraulic system. Abort criteria consist of vehicle speed, data acquisition and instrumentation system readiness, and stability of the vehicle on the test track. The first two criteria are automatically monitored by the test control system while the third criterion is visually monitored by the test conductor. Manual abort provisions are available to the test conductor. Upon verifying vehicle speed, the test control system automatically deactivates the abort system to preclude an inadvertent test abort immediately prior to impact.

5.2.4 Master Control System

The master control system used for impact tests controls and monitors all primary system functions that must operate throughout a predetermined interval during a test. This includes the starting and stopping of the tape recorder, high-speed cameras, and oscillograph, and the control of the power winch which propels the test vehicle. The operation of the various devices is confirmed, including vehicle velocity and tape recorder speed synchronization, before it passes through a "commit" window. When the vehicle is committed, the abort system is disarmed, preventing an accidental abort after the point of no return is reached.

Any system malfunction, including improper vehicle velocity up to the commit window, generates an abort. The control system uses the pulse output from the IRIG time base generator as a clock with a manual push button defining time zero. The logic circuits compare pulse counts from time zero to preset values dialed in at the control panel. As each control circuit gets an equal comparison, that circuit is turned on. If the self-test circuit does not verify, the abort system is automatically activated. After a successful vehicle test, the last control circuit shuts the entire system down. The manual backup control system provides the test conductor with the option of manually aborting the test if the need arises.

5.2.5 High-Speed Photography

Six high-speed (four 1000 and two 400 fps) motion 16 mm cameras with 100 Hz timing marks were used for photographic test documentation. Precise field of view monitoring is accomplished by bore sighting with the vehicle at the impact site prior to the test.

APPENDIX A

SUMMARY TABLES, DATA PLOTS, AND PHOTOGRAPHS

TEST 8319-5.9

SYMMETRIC IMPACT @ 35.06 MPH

TABLE A-1. RECEIVING INSPECTION OF VEHICLE - TEST 5.9

Contractor: Dynamic Science, Inc. Contract No.: DOT-HS-8-01905

VIN NO.: 1L69V8S151168 Make: Chevrolet

NHTSA No.: R&D

Year: 1978 Color: Blue Model: Impala 4-door Sedan

Auto Trans:	yes [X]	no [ ]	Pwr Steering:	yes [X]	no [ ]	Seats: (front)	Bench: X
Pwr Brakes:	yes [X]	no [ ]	Auto Speed Cont:	yes [ ]	no [X]		Bucket:
Pwr Seats:	yes [ ]	no [X]	Anti Skid Brake:	yes [ ]	no [X]		Split Bench:
Pwr Windows:	yes [ ]	no [X]	Air Conditioning:	yes [X]	no [ ]		
Tinted Glass:	yes [X]	no [ ]	Rear Window Def.:	yes [ ]	no [X]		Split Back Bench:
Radio:	yes [X]	no [ ]	Brakes: drum: R	disc: F			
Clock:	yes [ ]	no [X]					

Tire Size: FR78-15 Ply Rating: 4 Mfg. & Line: Firestone

Bias Ply: ___ Steel Belted: X Radial X /Eng.Type: V-8 Cylinders: 8 Total Displ: 305 CID

Trans, # Fwd. Speeds: 3 Shipping Weight: 4157 Odometer: 21762.5

Dealer (name, address, and phone number)
Courtesy Chevrolet (602) 279-3232
1233 East Camelback Road
Phoenix, Arizona

Remarks (list additional accessories not listed above)

Date of Manufacture: 10/77 Dynamic Science No.: 791 Date Received: 11-27-78

Tilting Steering Wheel: yes [ ] no [X] Telescoping Steering Wheel: yes [ ] no [X]

Fuel Capacity: _____ (from owner's manual) "Space Saver" Spare Tire yes [ ] no [X]

Restraint System: 3 Pt. Belt w/ELR

1. Is the vehicle stock throughout? Describe: Yes, new production vehicle.

2. Does vehicle show evidence of prior accident history? Describe: None

3. Does vehicle show any significant corrosion? Describe: None

4. Check condition of the front bumper and frame: Satisfactory

TABLE A-2. SUMMARY OF PRE-TEST VEHICLE ENGINE/BUMPER/FIREWALL CHARACTERISTICS

Test No. 8319-5.9 Type Symmetric

Car Model 1978 Chevrolet Impala Dynamic Science No. 791

	Pre-test
Engine Size	305 CID
Engine Height/width (in.)	29.5/21
Bumper to Engine (in.)	31.5
Engine Length (in.)	25
Engine to Firewall (in.)	4
Bumper to Firewall (in.)	60.5
Bumper to "Hard Point" (Engine) (in.)	31.5
Initial Impact Point to Front Bumper (in.)	5
Height From Top of Front Bumper to Lowest Point of Underride Guard (in.)	0.9
Horizontal Dimension From Centerline of Vehicle to Extreme Left Edge of Guard (in.)	42
Horizontal Dimension From Centerline of Vehicle to Extreme Right Edge of Guard (in.)	42

TABLE A-3. SUMMARY OF CAR ACCELEROMETER DATA

Accel. No.	Plot No.	Maximum Acceleration A (G)	Maximum Acceleration Time (msec)	Minimum Velocity V (mph)	Minimum Velocity Time (msec)	Maximum Displacement S (in.)	Maximum Displacement Time (msec)
1X	101	-46.4	67	-5.3	161	46.9	115
1Y	101	13.9	72	1.9	80	1.0	126
2X	102	-43.7	78	-2.4	166	48.7	126
3X	103	-41.8	71	-4.6	152	49.7	120
3Y	103	18.8	77	2.2	79	4.2	250
4X	104	-98.9	71	5.4	160	62.5	250
4Y	104	-54.1	65	-9.4	250	-24.0	250
5X	105	-66.1	60	22.3	63	128.3	250
6X	106	-114.1	57	-5.0	66	35.5	250
6Z	106	38.0	61	7.5	78	4.6	122
7X	107	-80.6	68	-2.1	166	41.5	122

TABLE A-4. SUMMARY OF TRAILER ACCELEROMETER DATA

Accelerometer Number	Plot Location Number	Maximum Acceleration A (G)	Maximum Acceleration Time (msec)
2X	202	-8.5	66

TABLE A-5. SUMMARY OF COMPARTMENT AND ENGINE ACCELEROMETER DATA

Accelerometer Number	Plot Location Number	Maximum Acceleration A (G)	Maximum Acceleration Time (msec)
Average of 1X and 2X	412	-40.0	68
6X	106	-114.1	57

TABLE A-6. SUMMARY OF UNDERRIDE GUARD STRING POTENTIOMETER DATA

Displacement Potentiometer		Plot Location	Maximum Dynamic Displacement	
Number	Location	Number	D (in.)	Time (msec)
SP1	Left	4300	-.2	59
SP2	Center	4301	-.3	90
SP3	Right	4302	-.3	49

TABLE A-7. COMPARISON OF TOTAL INTERFACE FORCE FROM LOAD CELL AND ACCELEROMETER DATA

Parameter	Trailer Force Data*	Car Acceleration Data**
Force (lb)	161,656	173,410
Time (msec)	66	60

*Sum of 4 load cells.
**Average of car accelerometers 1 and 2 x (vehicle minus engine weight) + engine acceleration x (engine weight of 675 lb).

TABLE A-8. SUMMARY OF UNDERRIDE GUARD AND TRAILER STRAIN GAUGE DATA

Strain Gauge		Maximum Strain*	Maximum Time
Number	Plot Location Number**	(μin./in.)	(msec)
SG1	4201	216.9	57
SG2	4201	-1172.9	58
SG3	4201	236.4	155
SG11	4202	211.8	67
SG12	4202	236.1	64

*STRESS = STRAIN (μin./in.) x E(30×10^6 lb/in. for steel)
Tensile strain and stress are negative.
**For location of strain gauges 1-3, see Figure 3-2; for location of strain gauges 7-16, see Figure 2-2.

TABLE A-9. SUMMARY OF PRE-TEST AND POST-TEST VEHICLE STATIC MEASUREMENTS

TEST NO. 8319-5.9 VEHICLE 1978 Chevrolet Impala

Location	Dimension* Pre	Post	Reference	Difference*
Front edge of water pump casting	161.6	147.5	Target 192"	14.1
Bottom of A-pillar (left)	119.3	118.6	Target 192"	0.7
Bottom of A-pillar (right)	119.2	118.5	Target 192"	0.7
Rear top edge of panel (left)	109.8	108.4	Target 192"	1.4
Rear top edge of panel (right)	110.0	108.5	Target 192"	1.5
Steering column hub (horizontal)	105.7	102.5	Target 192"	3.2
Steering column lower rim (horizontal)	103.2	101.9	Target 192"	1.3
Steering column hub (vertical)	21.9	23.6	Rocker Sill	-1.7
Steering column lower rim (vertical)	15.6	17.1	Rocker Sill	-1.5
Centerline windshield opening (top)	105.5	104.0	Target 192"	1.5

*Dimensions are in inches.

TABLE A-9. SUMMARY OF PRE-TEST AND POST-TEST VEHICLE STATIC MEASUREMENTS (CONTD)

TEST NO. 8319-5.9 VEHICLE 1978 Chevrolet Impala

Location	Dimension* Pre	Post	Reference	Difference*
Top of A-pillar (left)	100.6	100.7	Target 192"	-0.1
Top of A-pillar (right)	100.3	100.2	Target 192"	0.1
Dash panel at knee height (left)	120.1	116.8	Target 192"	3.3
Dash panel at knee height (right)	119.9	119.6	Target 192"	0.3
Firewall driver centerline	134.3	133.0	Target 192"	1.3
Firewall passenger centerline	131.9	128.0	Target 192"	3.9
Firewall vehicle centerline	132.1	122.3	Target 192"	9.8

*Dimensions are in inches.

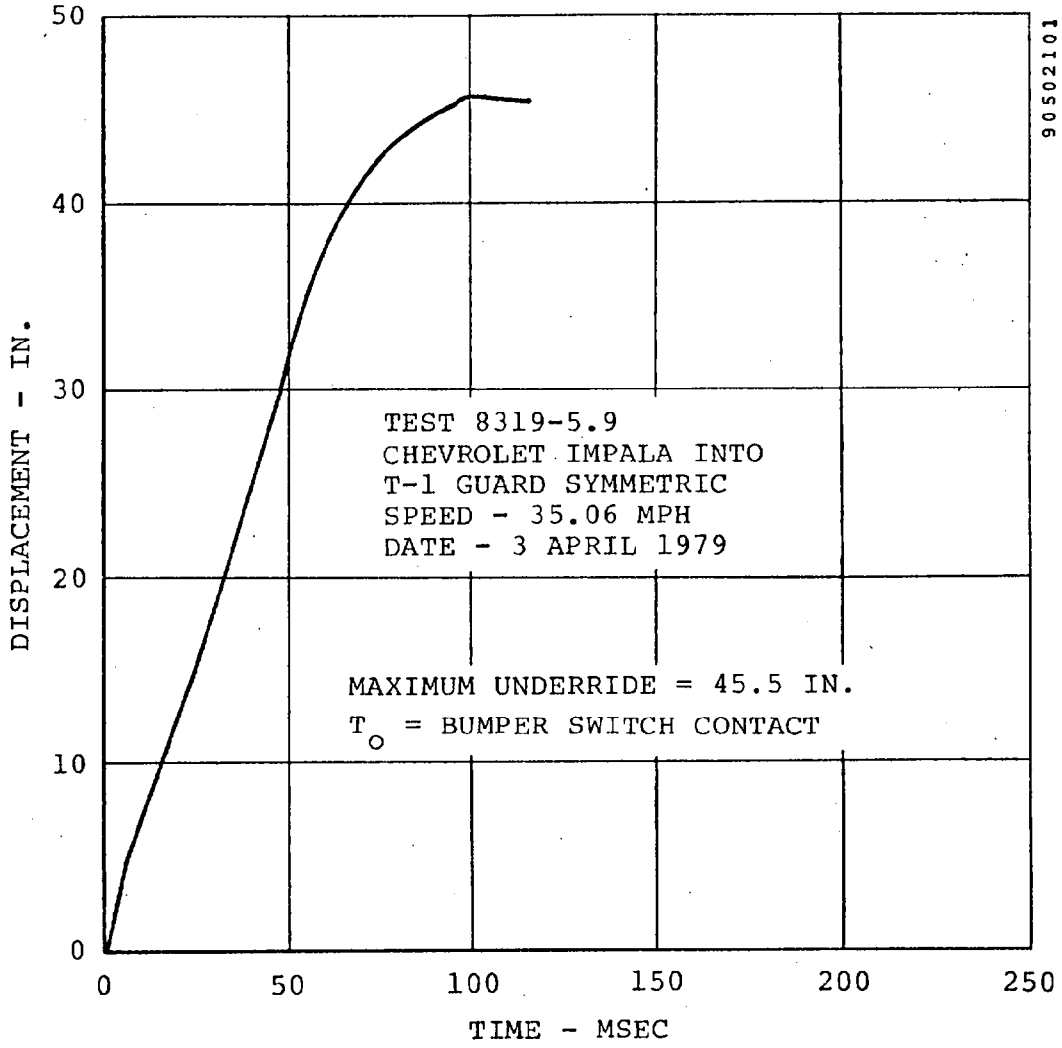


Figure A-10. Vehicle Underride Versus Time, Driver Side - Test 5.9.

TABLE A-10. SUMMARY OF PRE-TEST DUMMY POSITION DATA CHARACTERISTICS

TEST NO. 8319-5.9 TYPE Underride, Symmetric

CAR MODEL 1978 Chevrolet Impala DYNAMIC SCIENCE NO. 791

	Left Front Occupant	Right Front Occupant
Seat Range (in.)	6.2	6.0
Seat Position* (in.)	3.1	3.0
Front Seat to Firewall (in.)	26.6	24.6
Forehead to Windshield (in.)	20.4	20.9
Torso to Steering Wheel** (in.)	12.3	21.5
Left/Right Knee to Dash Panel (in.)	7.5/7.6	7.6/7.9

Dummy Type Alderson Part 572

Locations: Left Front Occupant - No. A03

Right Front Occupant - No. A04

Restraint Type: LF Std. 3-pt. belts w/emergency locking retractor

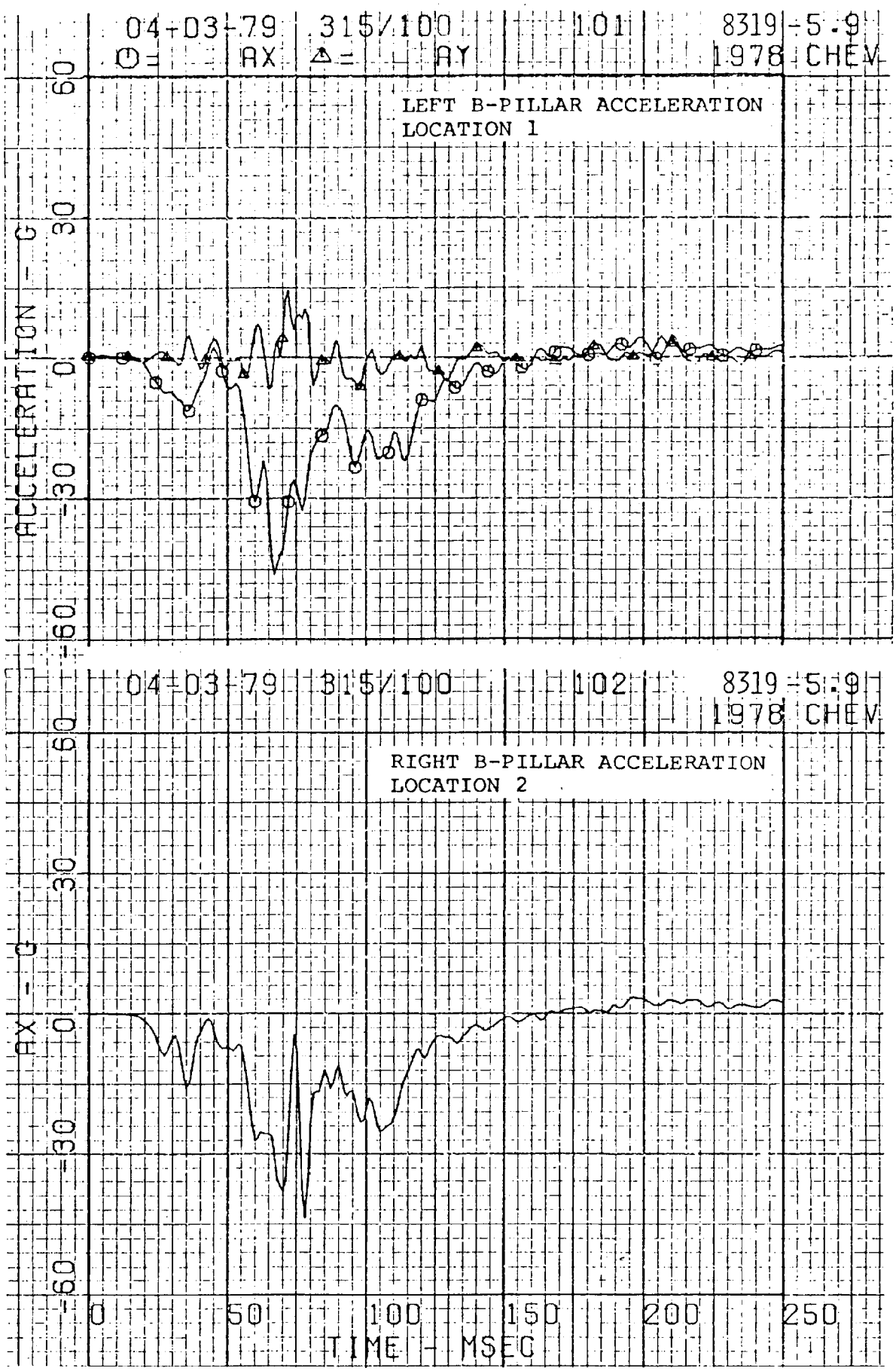
RF Std. 3-pt. belts w/emergency locking retractor

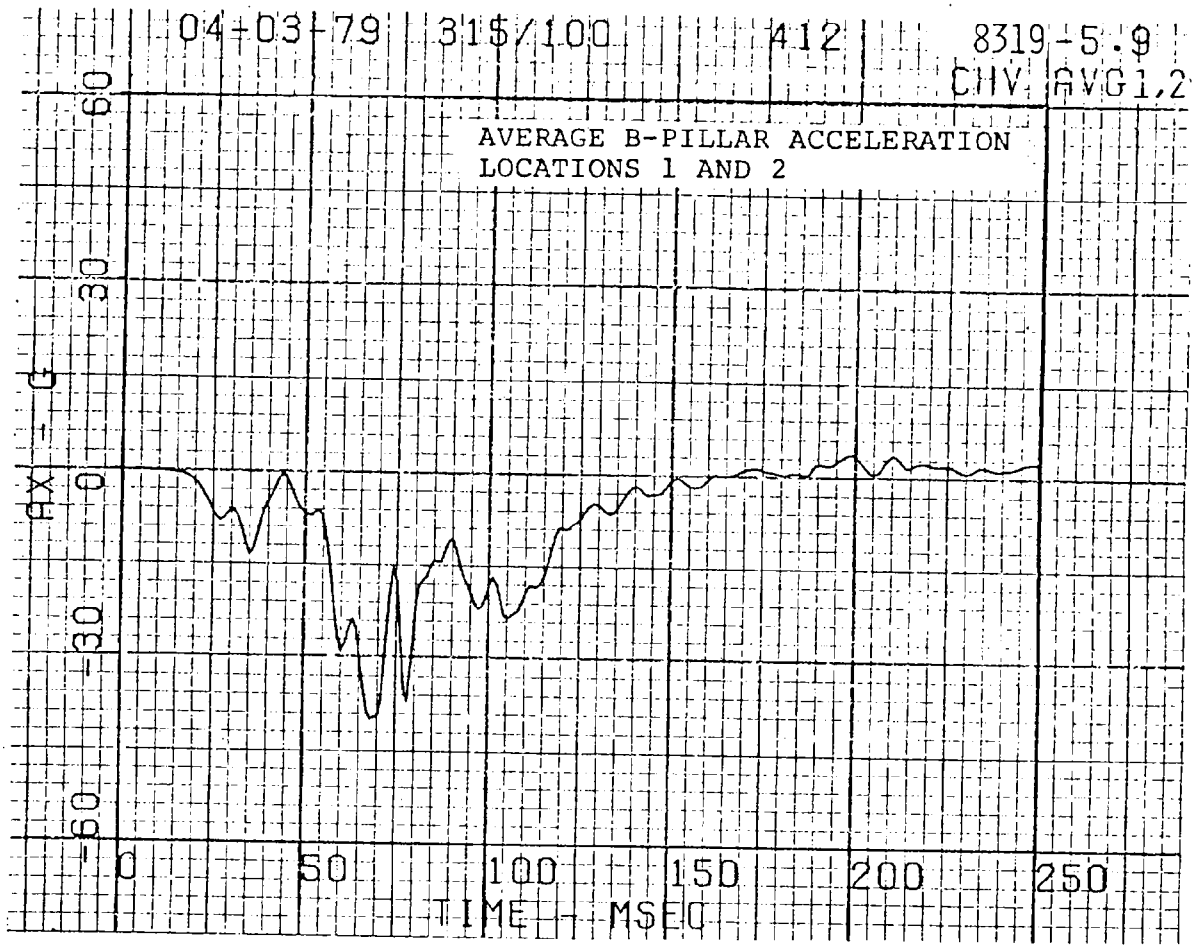
*From rearmost position to midpoint seat position.
**To dash panel for right front occupant.

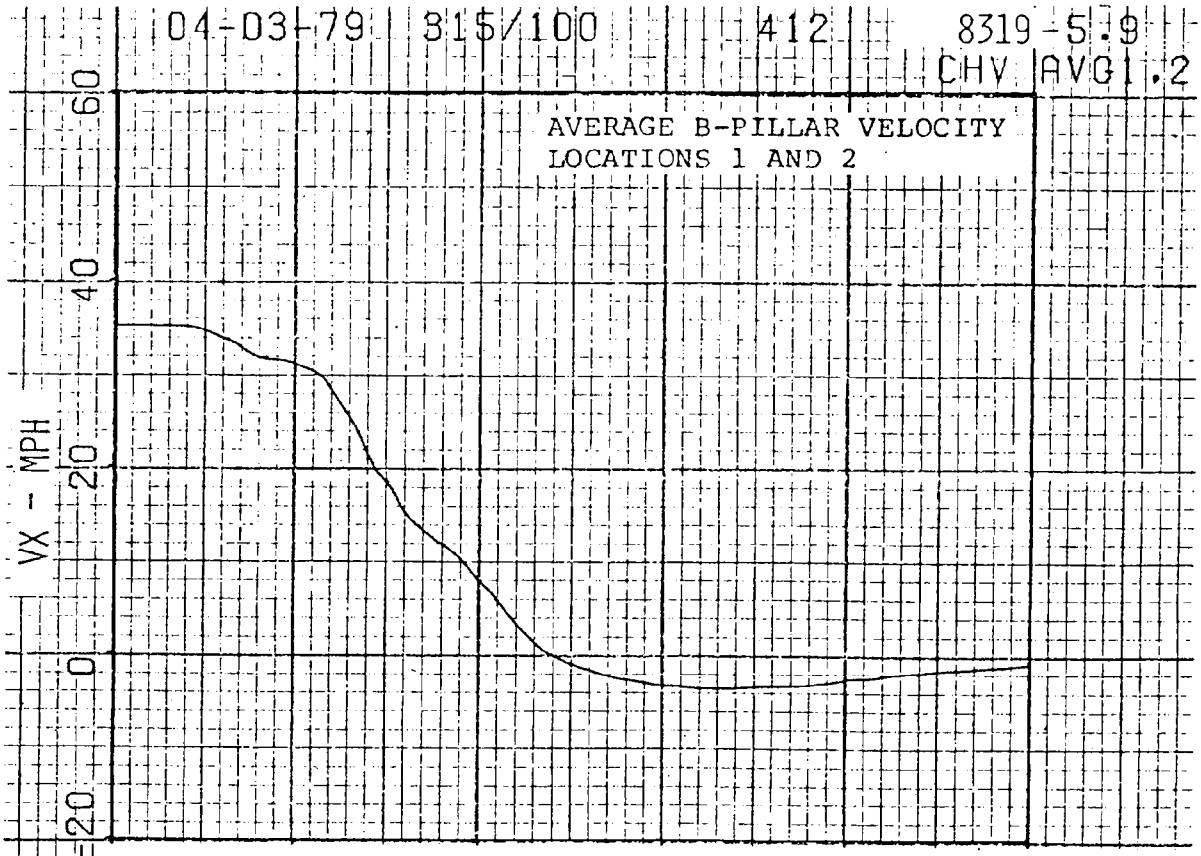
TABLE A-11. SUMMARY OF OCCUPANT RESPONSE DATA FOR TEST 5.9

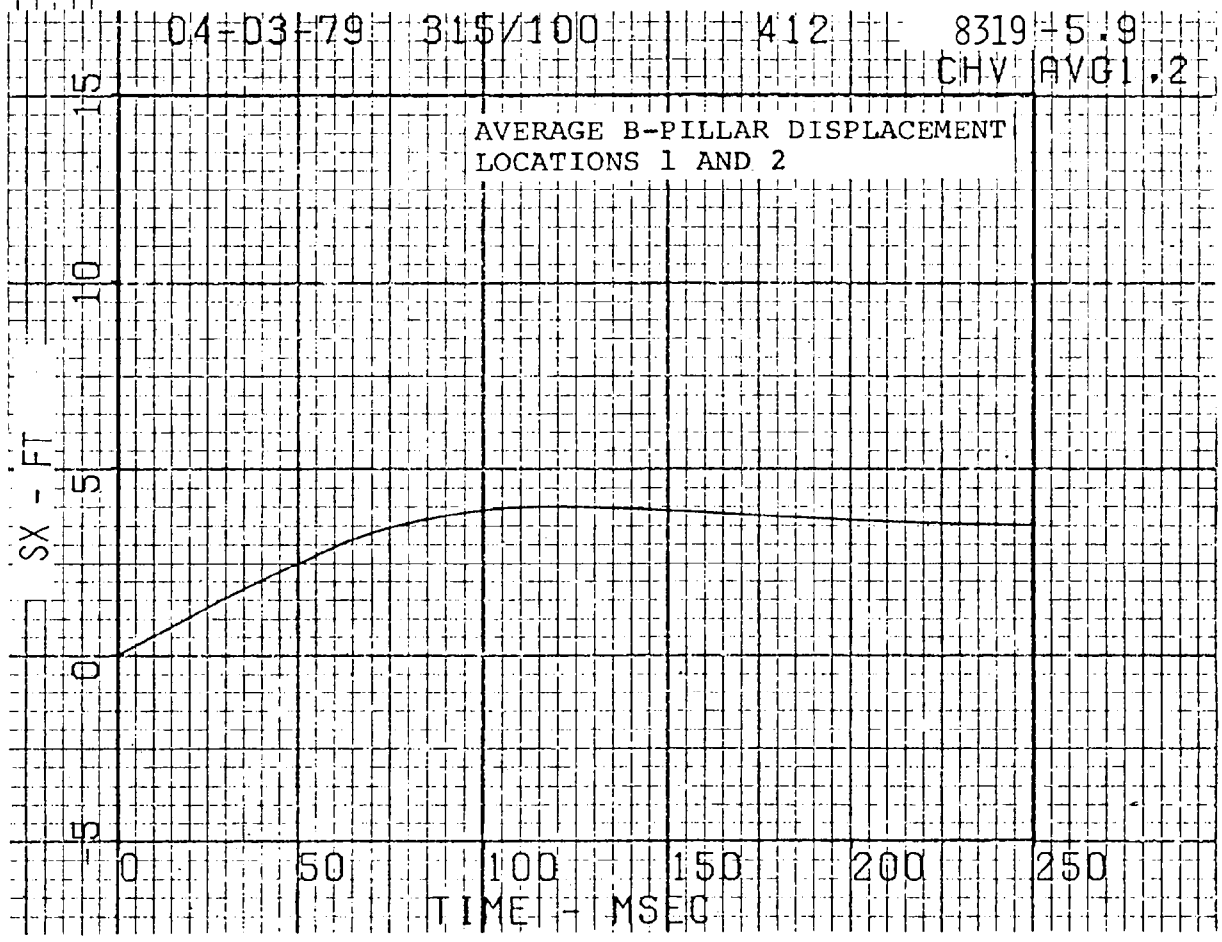
Response Parameter		Filter (Hz)	Left Front Dummy (Driver Maximum Value A (G)	Left Front Dummy (Driver Maximum Value T (msec)	Right Front Dummy (Passenger Maximum Value A (G)	Right Front Dummy (Passenger Maximum Value T (msec)
Head	X	1600	-137	111	-84	121
	Y	1600	-39	111	34	129
	Z	1600	72	99	70	114
	R	1600	153	99	106	114
SI/Time			1760	200	1569	200
HIC/Time			1117	92/128	1171	94/141
Head Acceleration	R*	1600	86		91	
Chest	X	315	-55	93	-39	113
	Y	315	-26	106	32	131
	Z	315	24	92	23	72
	R	315	60	106	46	129
SI/Time			588	200	513	200
Chest Acceleration	R*	315	58		45	
Left Femur Load**		1000	-518	104	-2082	68
Right Femur Load**		1000	-1557	101	-361	66

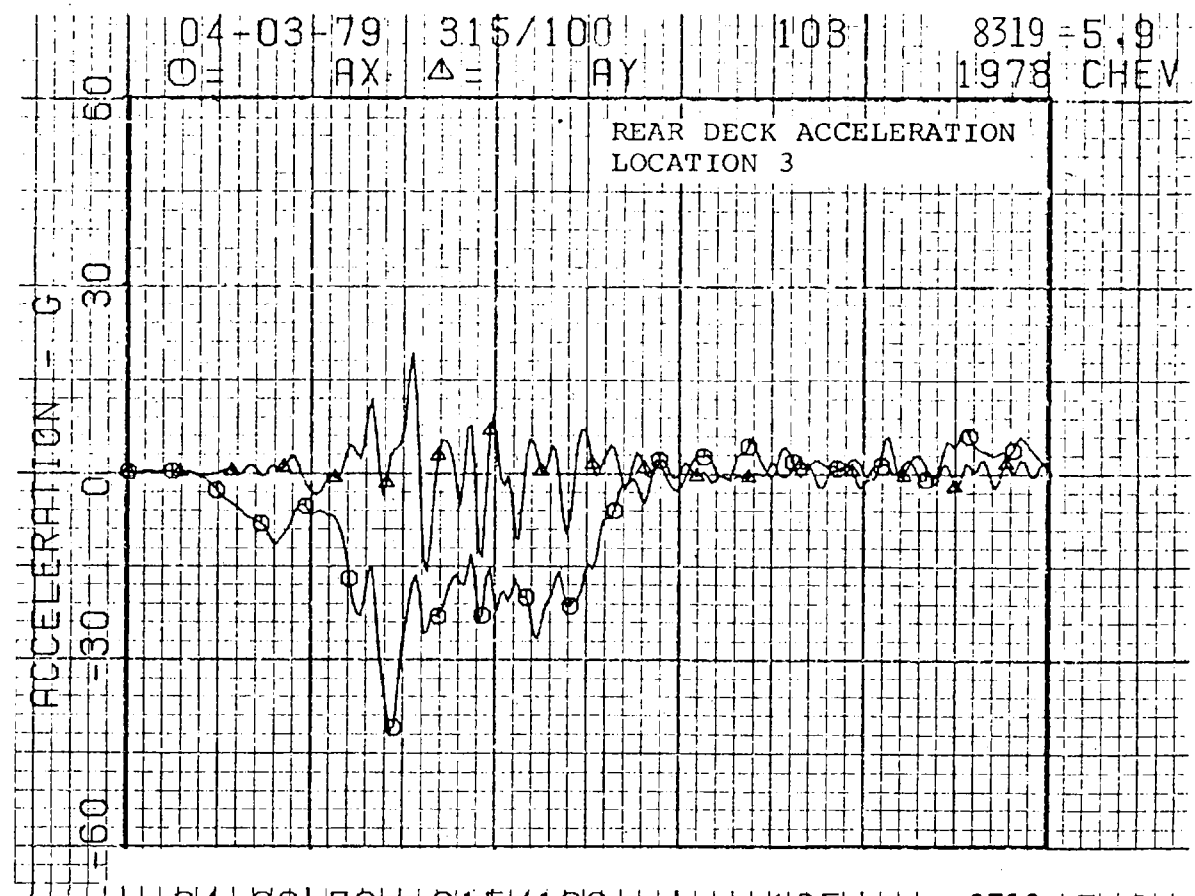
*G values defined as value exceeding a cumulative duration of 3 msec.
**Negative loads are compression; positive loads are tension.

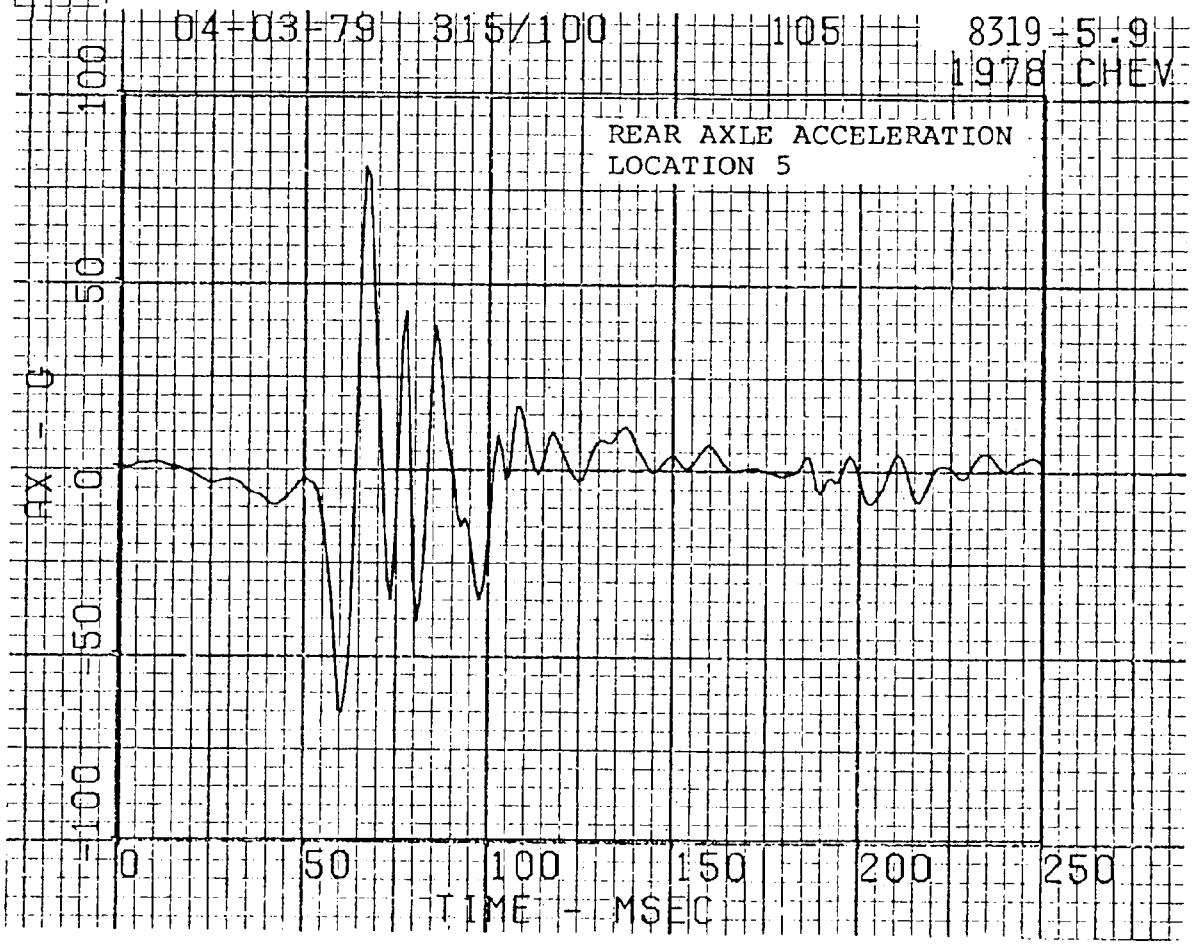

04-03-79 315/100 101 8319-5.9
○= AX △= AY 1978 CHEV
LEFT B-PILLAR ACCELERATION
LOCATION 1
ACCELERATION - G
60
30
0
-30
-60
04-03-79 315/100 102 8319-5.9
1978 CHEV
RIGHT B-PILLAR ACCELERATION
LOCATION 2
AX - G
60
30
0
-30
-60
0
50
100
150
200
250
TIME - MSEC

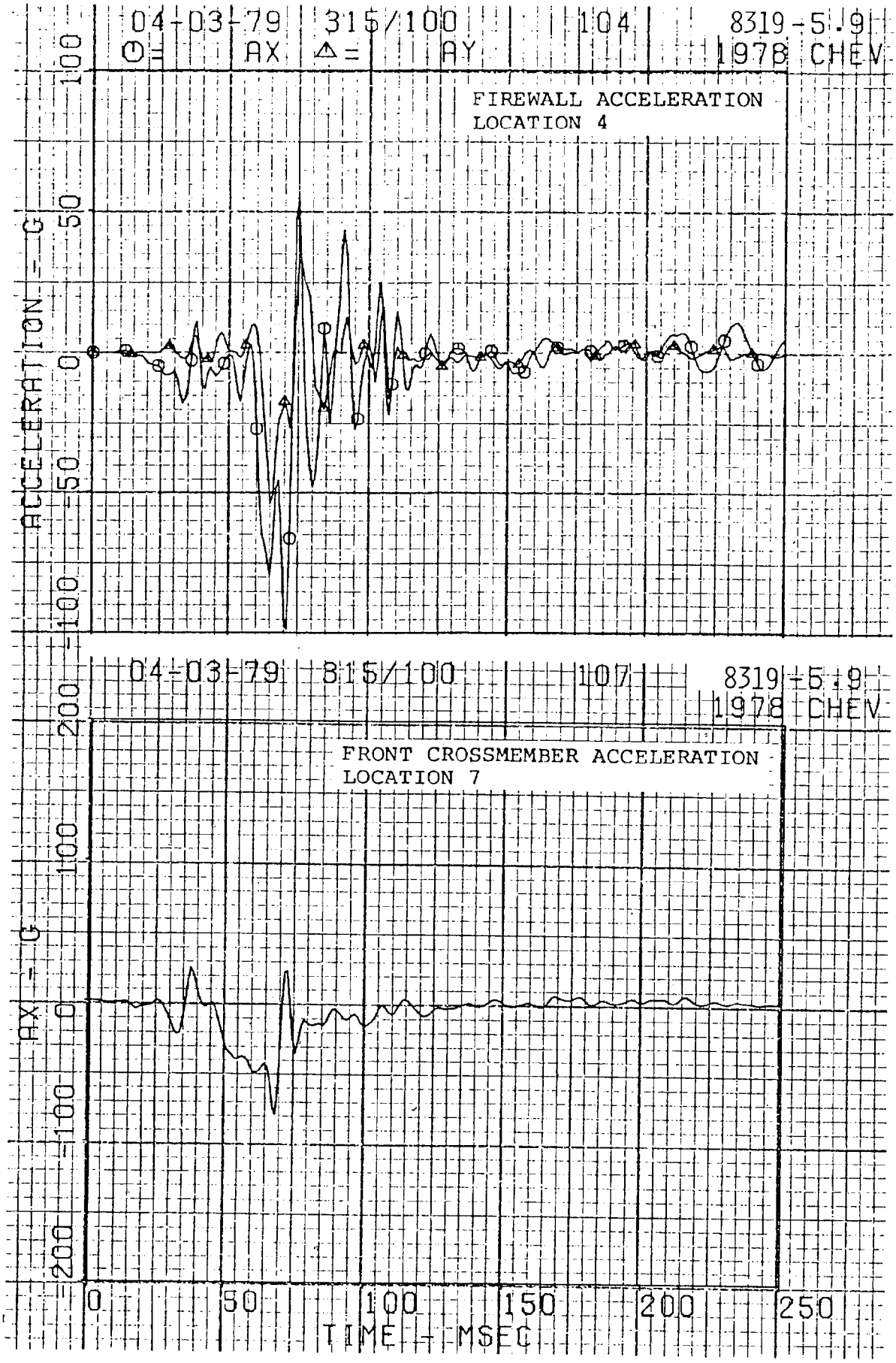

04-03-79 315/100 412 8319-5.9
CHV AVG1,2
AVERAGE B-PILLAR ACCELERATION
LOCATIONS 1 AND 2
AX - G
60
30
0
-30
-60
0
50
100
150
200
250
TIME - MSEC

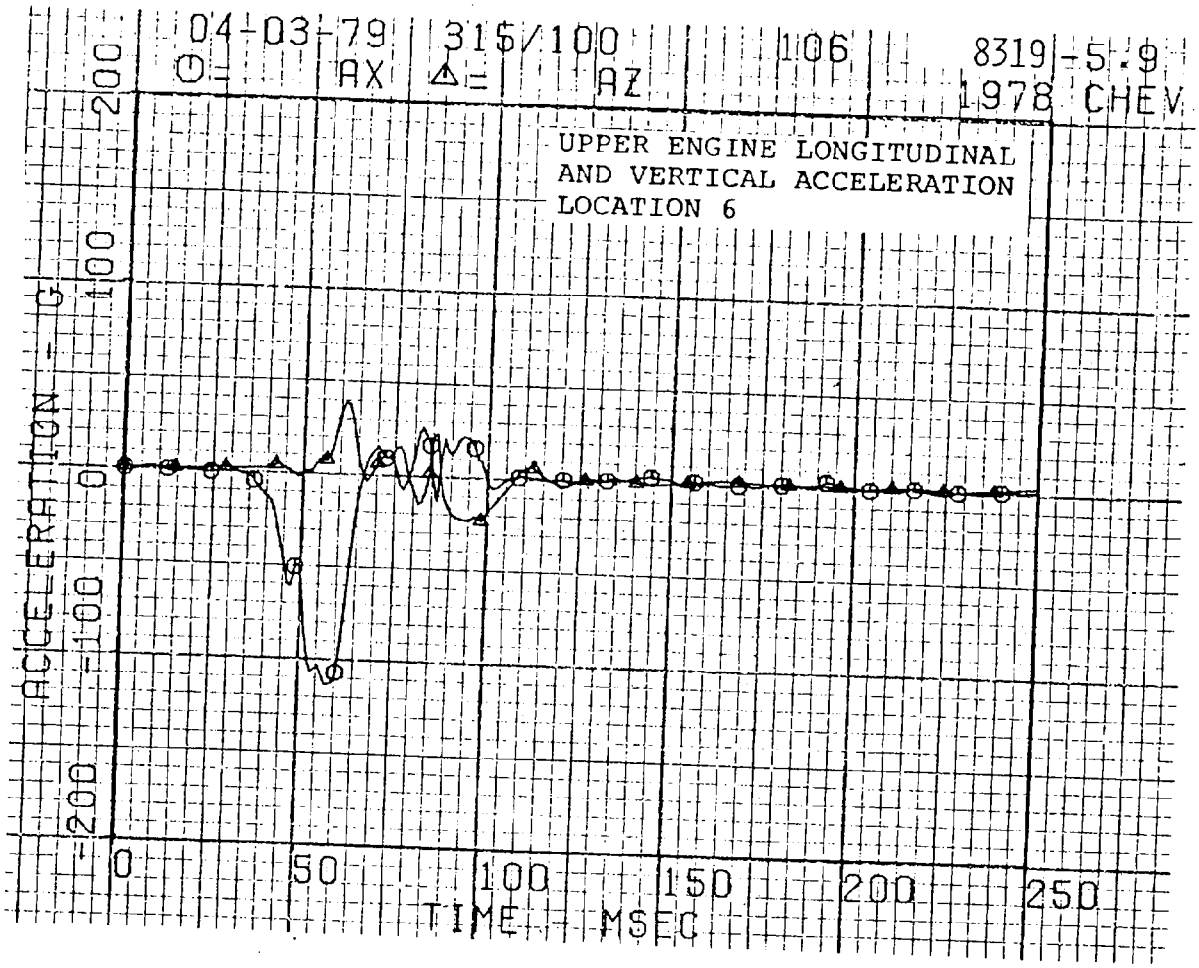

04-03-79 315/100 412 8319-5.9
CHV AVG1.2
AVERAGE B-PILLAR VELOCITY
LOCATIONS 1 AND 2
VX - MPH
60
40
20
0
-20

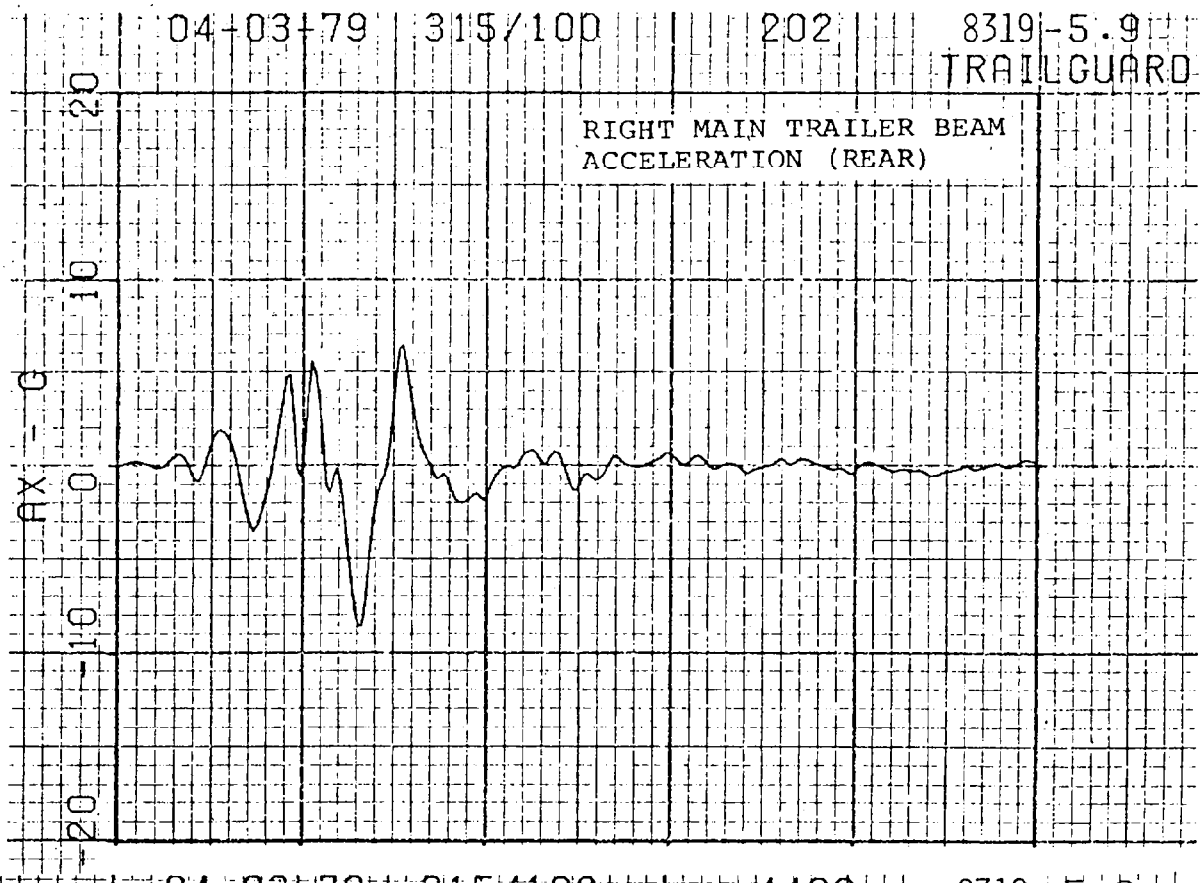

04-03-79 315/100 412 8319-5.9
CHV AVG1.2
AVERAGE B-PILLAR DISPLACEMENT
LOCATIONS 1 AND 2
SX - FT
15
10
5
0
-5
0
50
100
150
200
250
TIME - MSEC

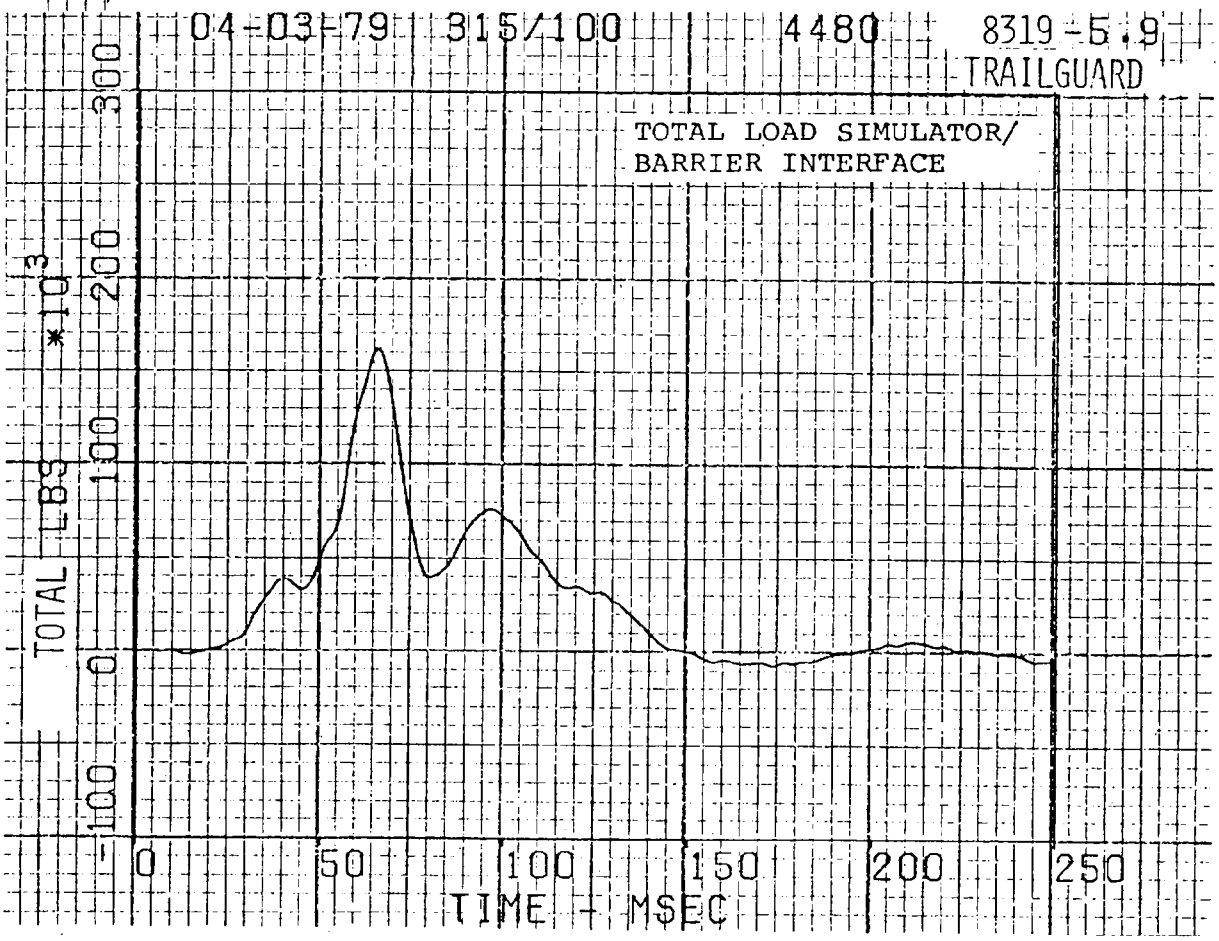

04-03-79 315/100 103 8319-5.9
1978 CHEV
REAR DECK ACCELERATION
LOCATION 3
ACCELERATION - G
60
30
0
-30
-60

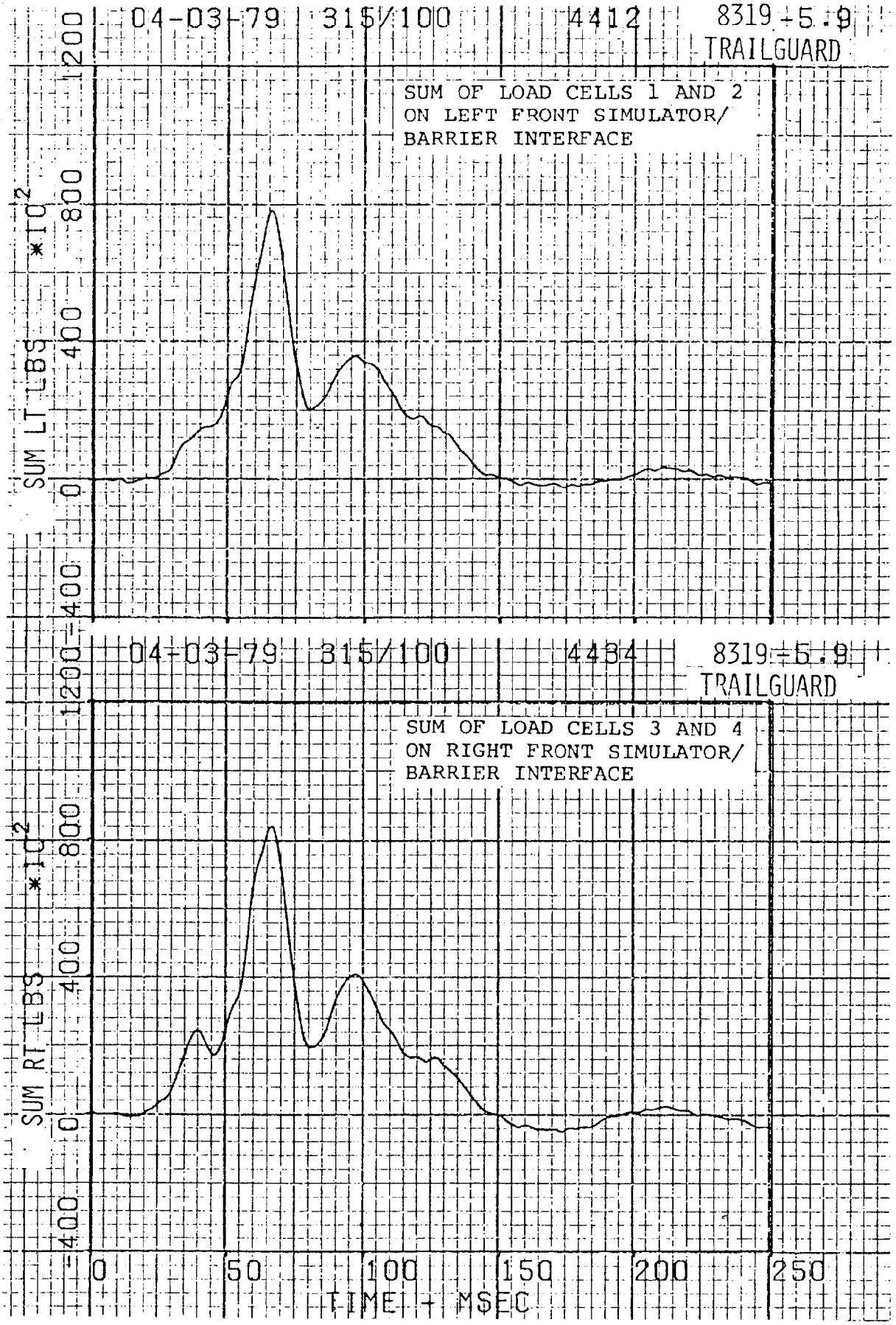

04-03-79 315/100 105 8319-5.9
1978 CHEV
REAR AXLE ACCELERATION
LOCATION 5
AX - G
100
50
0
-50
-100
0
50
100
150
200
250
TIME - MSEC

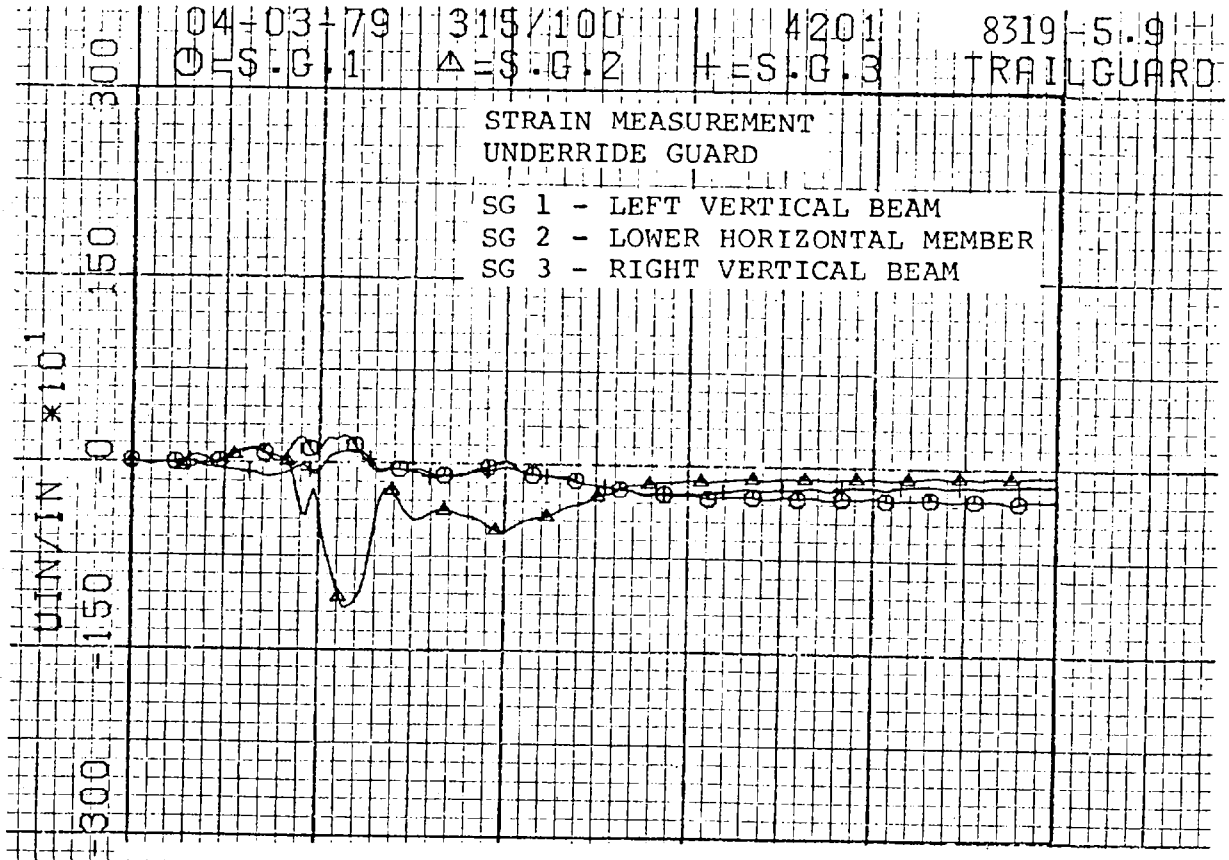

04-03-79 315/100 104 8319-5.9
○= AX △= AY 1978 CHEV
FIREWALL ACCELERATION
LOCATION 4
ACCELERATION = G
100
50
0
-50
-100
04-03-79 815/100 107 8319-5.9
1978 CHEV
FRONT CROSSMEMBER ACCELERATION
LOCATION 7
AX = G
200
100
0
-100
-200
0
50
100
150
200
250
TIME - MSEC

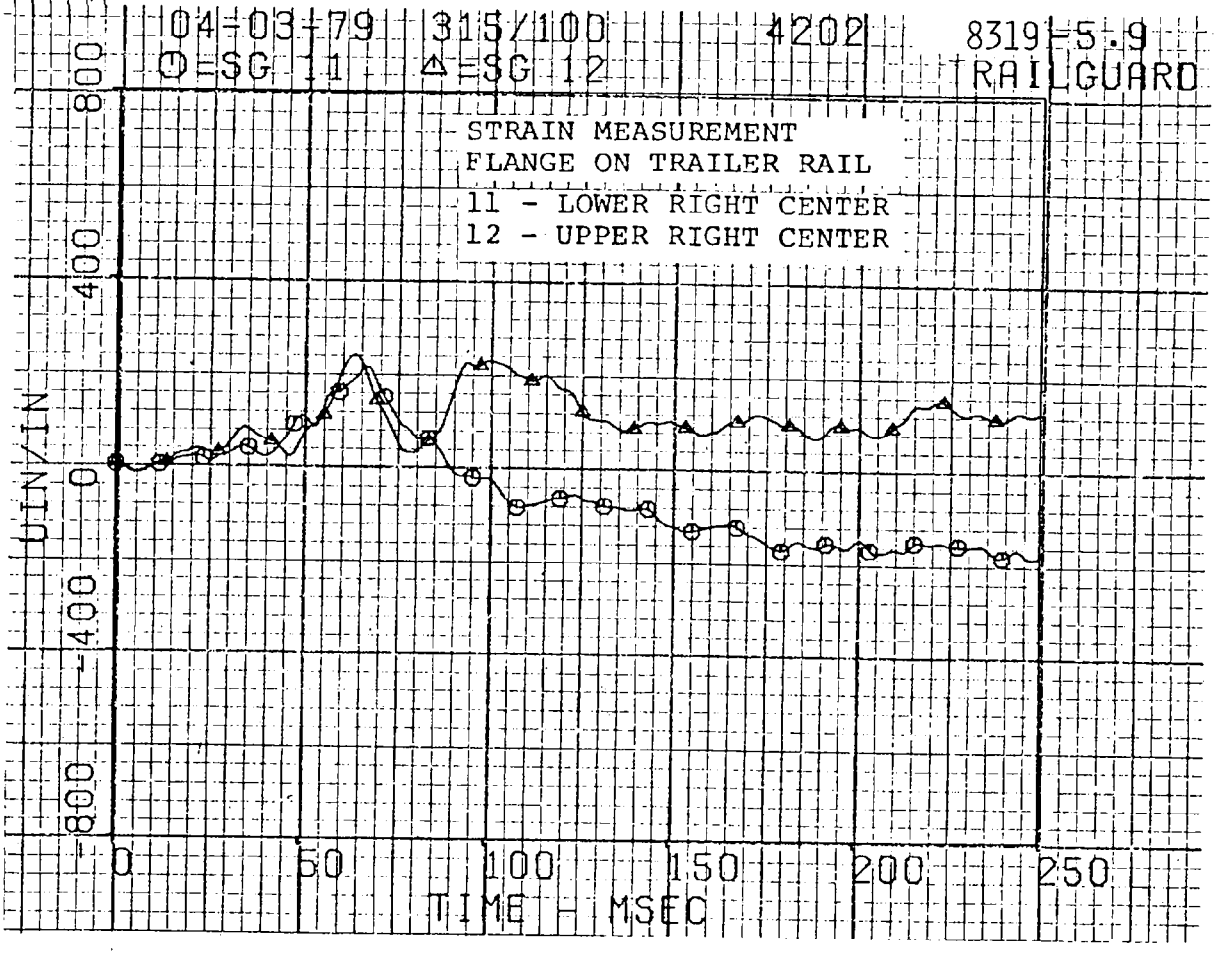

04-03-79
AX
AZ
106
8319-5.9
1978 CHEV
UPPER ENGINE LONGITUDINAL
AND VERTICAL ACCELERATION
LOCATION 6
ACCELERATION - G
200
100
0
-100
-200
0
50
100
150
200
250
TIME - MSEC

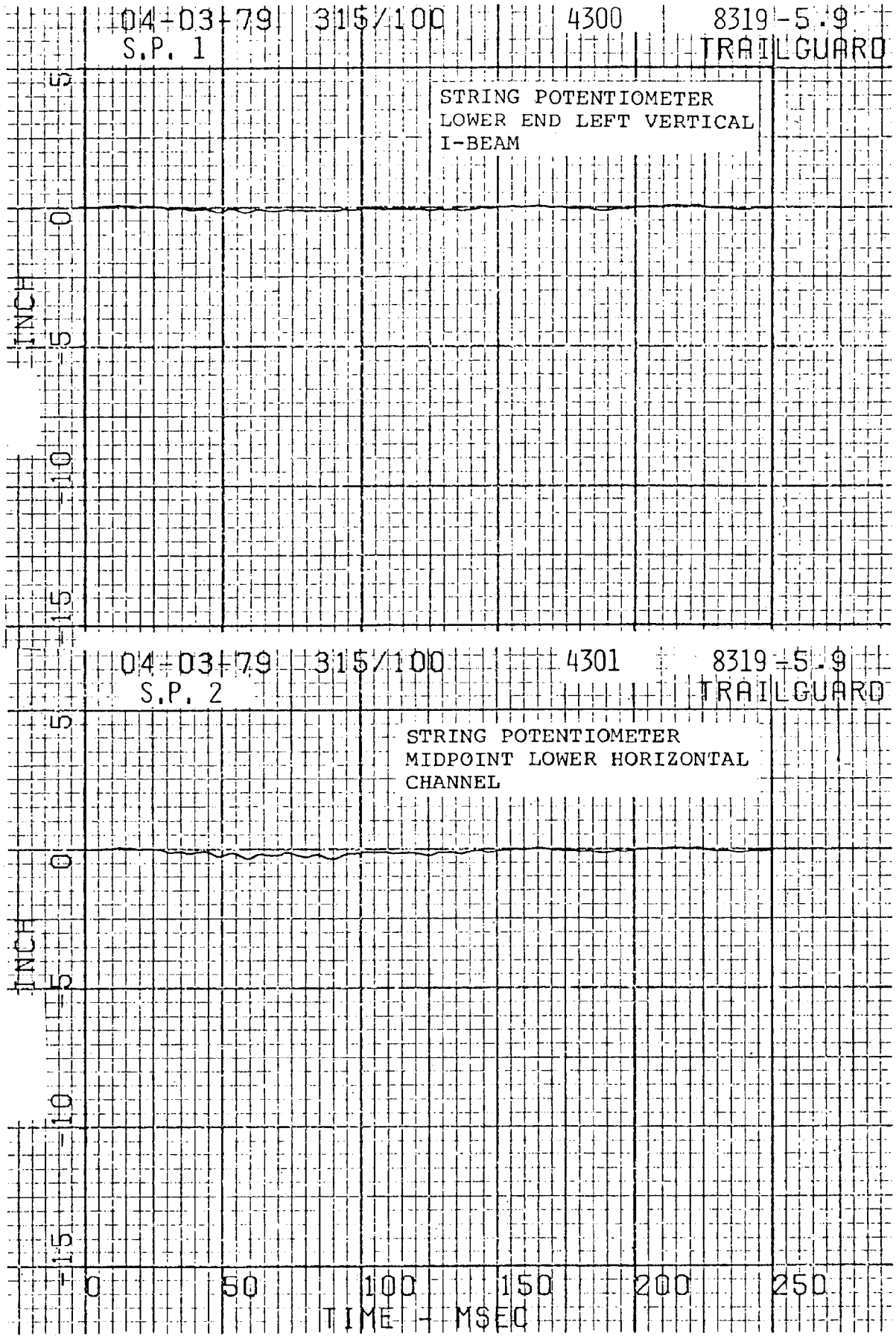

04-03-79 315/100 202 8319-5.9
TRAILGUARD
RIGHT MAIN TRAILER BEAM
ACCELERATION (REAR)
AX - G
20
10
0
-10
-20

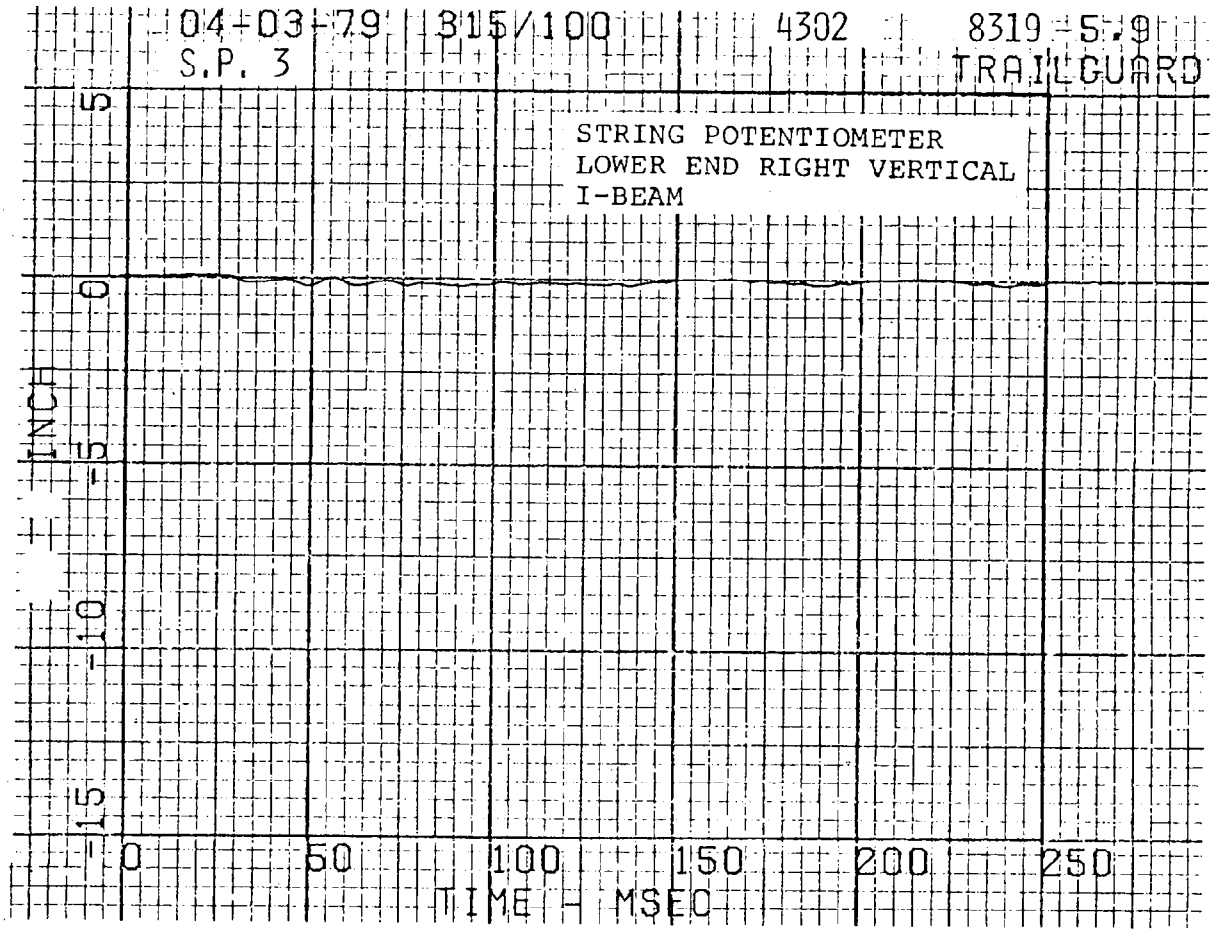

04-03-79 315/100 4480 8319-5.9
TRAILGUARD
TOTAL LOAD SIMULATOR/
BARRIER INTERFACE
TOTAL LBS *10^3
300
200
100
0
-100
0
50
100
150
200
250
TIME - MSEC

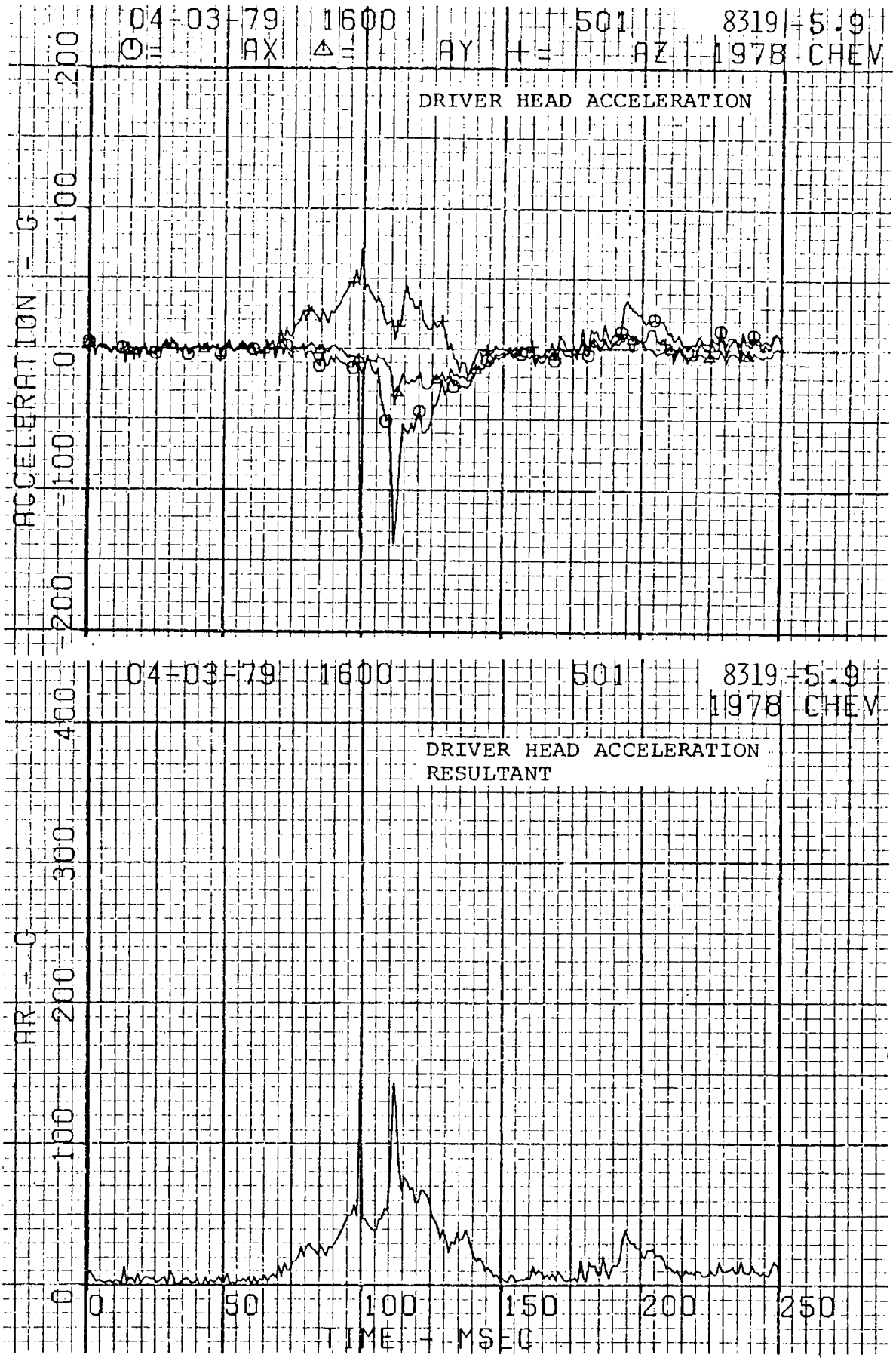

04-03-79 315/100 4412 8319 +5.9
TRAILGUARD
SUM OF LOAD CELLS 1 AND 2
ON LEFT FRONT SIMULATOR/
BARRIER INTERFACE
SUM LT LBS *10^2
1200
800
400
0
-400
04-03-79 315/100 4434 8319 +5.9
TRAILGUARD
SUM OF LOAD CELLS 3 AND 4
ON RIGHT FRONT SIMULATOR/
BARRIER INTERFACE
SUM RT LBS *10^2
1200
800
400
0
-400
0
50
100
150
200
250
TIME - MSEC

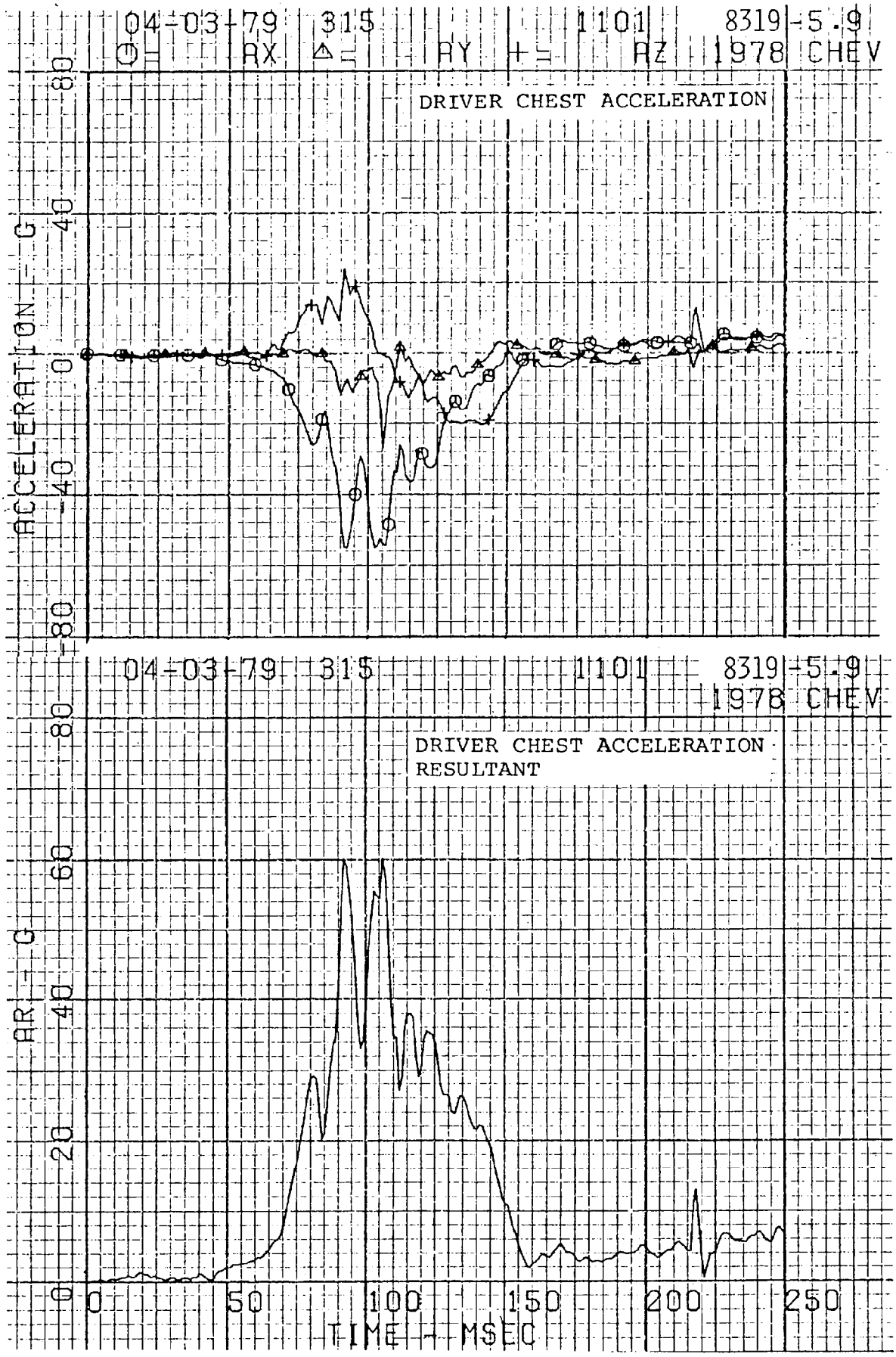

04-03-79 315/100 4201 8319-5.9
⊖=S.G.1 △=S.G.2 +=S.G.3 TRAILGUARD
STRAIN MEASUREMENT
UNDERRIDE GUARD
SG 1 - LEFT VERTICAL BEAM
SG 2 - LOWER HORIZONTAL MEMBER
SG 3 - RIGHT VERTICAL BEAM
UIN/IN *10^1
300
150
0
-150
-300

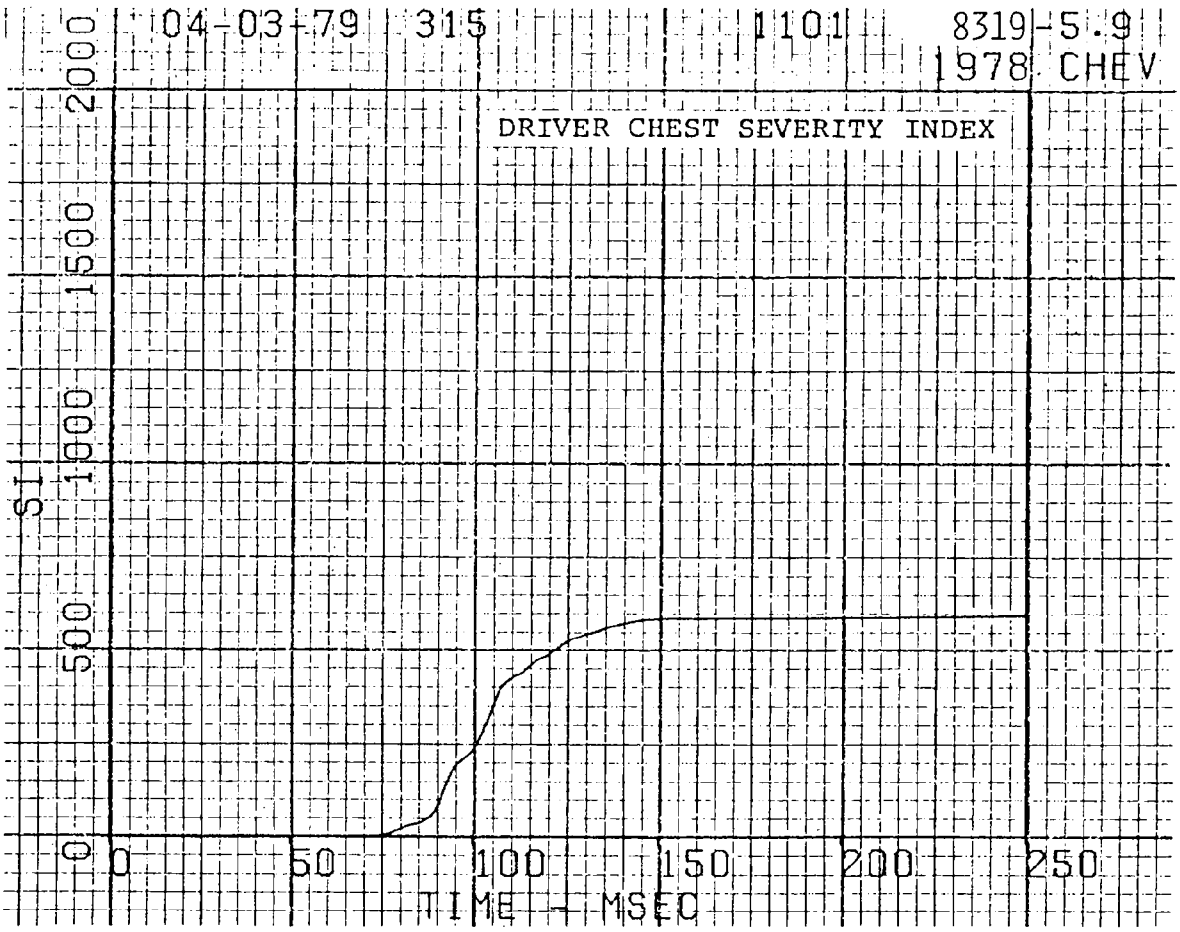

04-03-79 315/100 4202 8319-5.9
⊖=SG 11 △=SG 12 TRAILGUARD
STRAIN MEASUREMENT
FLANGE ON TRAILER RAIL
11 - LOWER RIGHT CENTER
12 - UPPER RIGHT CENTER
UIN/IN
-800
-400
0
0
50
100
150
200
250
TIME - MSEC

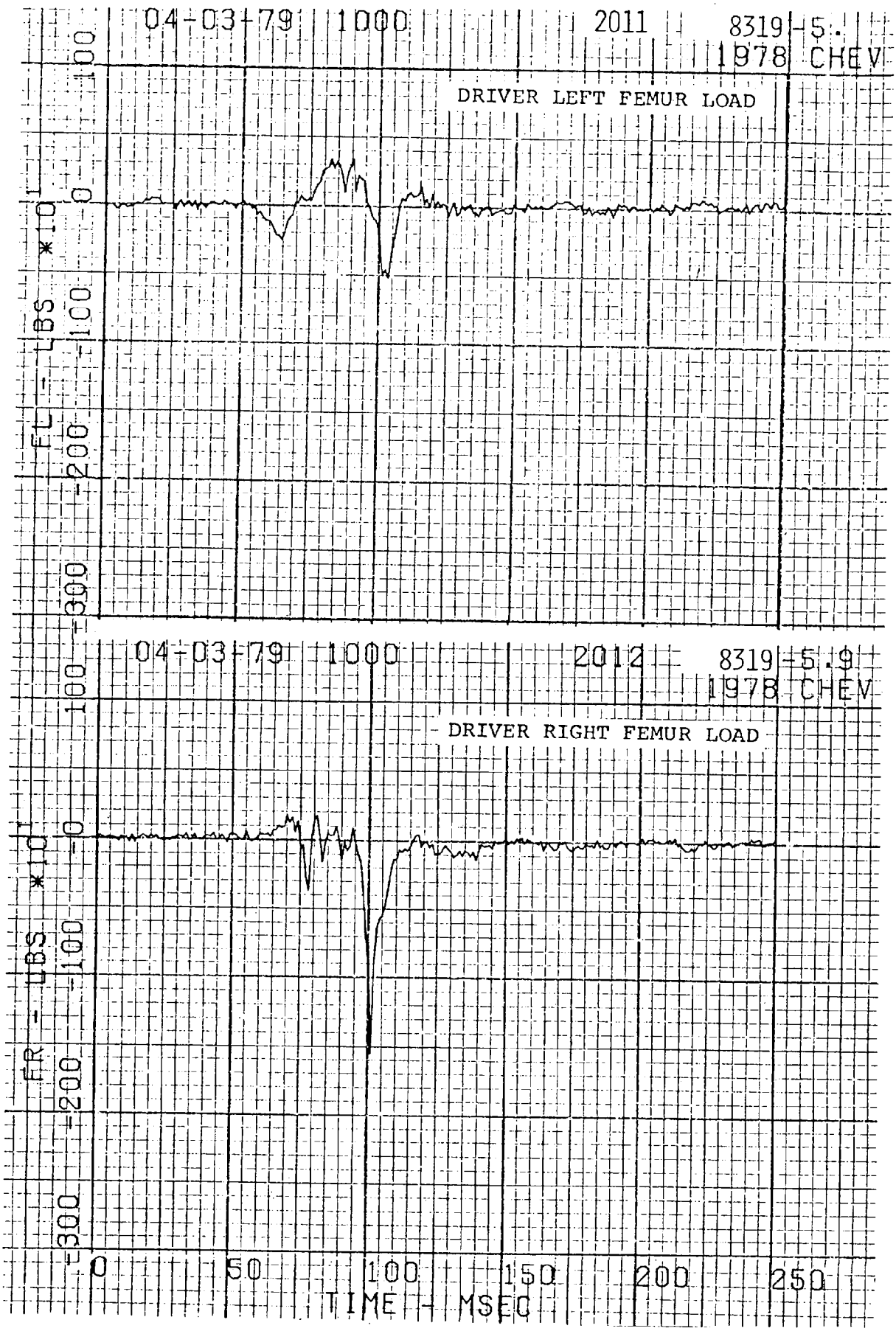

04-03-79 315/100 4300 8319-5.9
S.P. 1
TRAILGUARD
STRING POTENTIOMETER
LOWER END LEFT VERTICAL
I-BEAM
INCH
5
0
-5
-10
-15
04-03-79 315/100 4301 8319-5.9
S.P. 2
TRAILGUARD
STRING POTENTIOMETER
MIDPOINT LOWER HORIZONTAL
CHANNEL
INCH
5
0
-5
-10
-15
0
50
100
150
200
250
TIME - MSEC

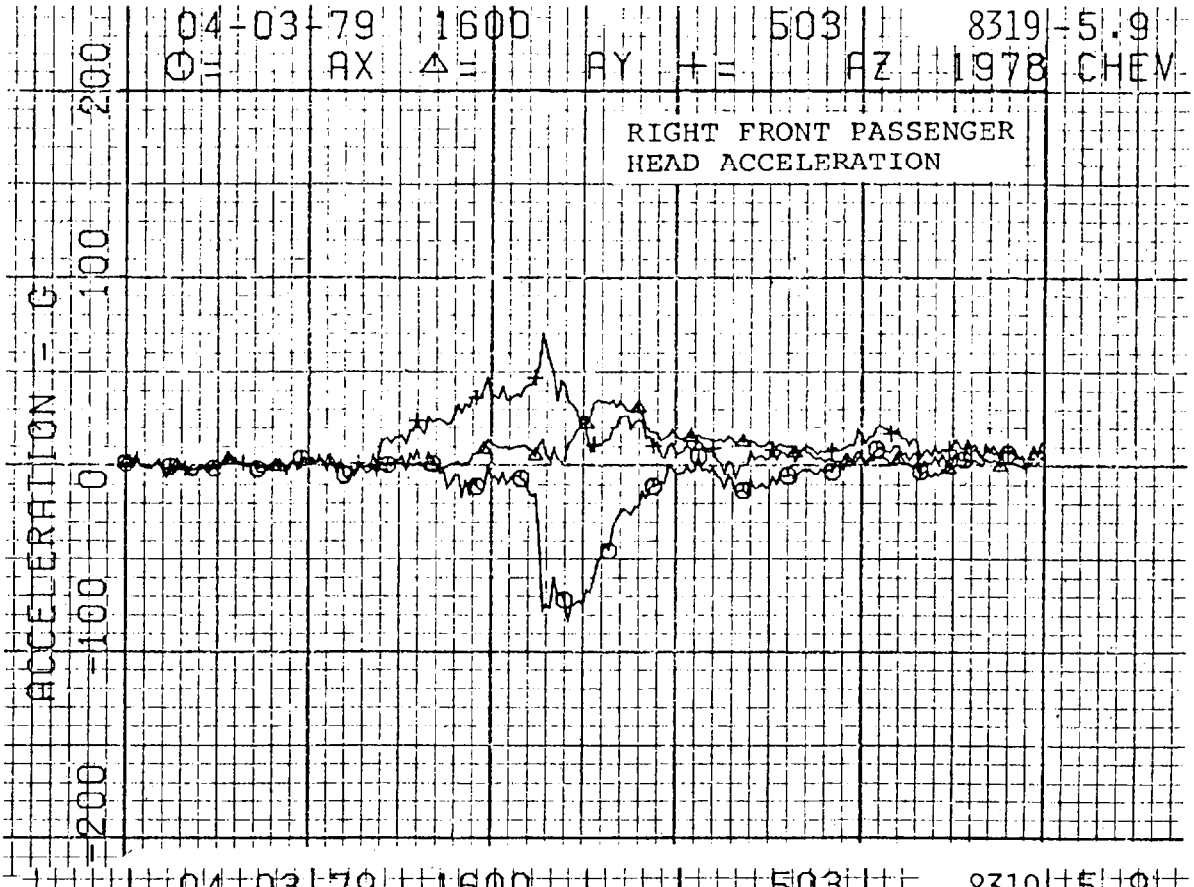

04+03-79 315/100 4302 8319-5-9
S.P. 3
TRAILGUARD
STRING POTENTIOMETER
LOWER END RIGHT VERTICAL
I-BEAM
INCH
5
0
-5
-10
-15
0
50
100
150
200
250
TIME - MSEC

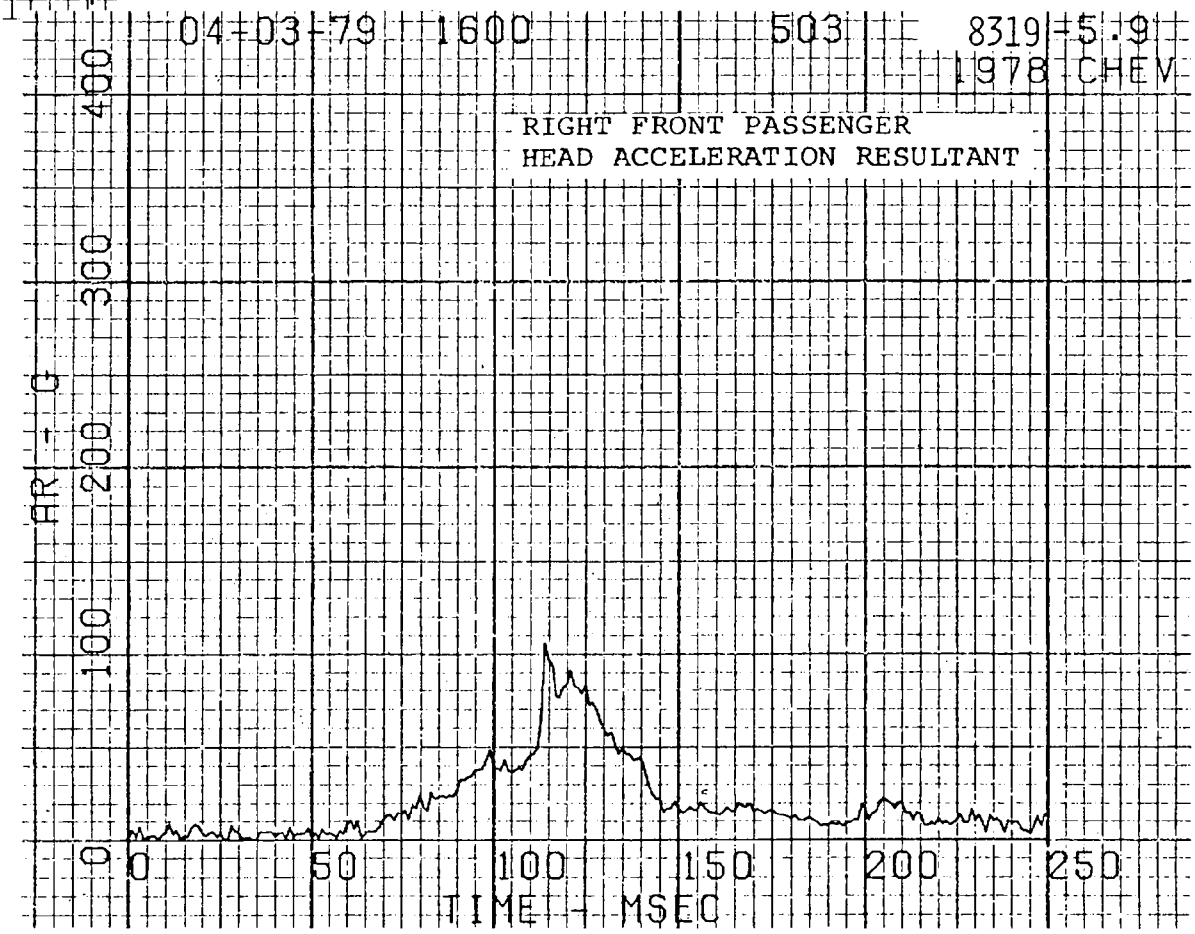

04-03-79 1600 501 8319-5-9
AX AY AZ 1978 CHEV
DRIVER HEAD ACCELERATION
ACCELERATION - G
200
100
0
-100
-200
04-03-79 1600 501 8319-5-9
1978 CHEV
DRIVER HEAD ACCELERATION
RESULTANT
AR - G
400
300
200
100
0
0
50
100
150
200
250
TIME - MSEC

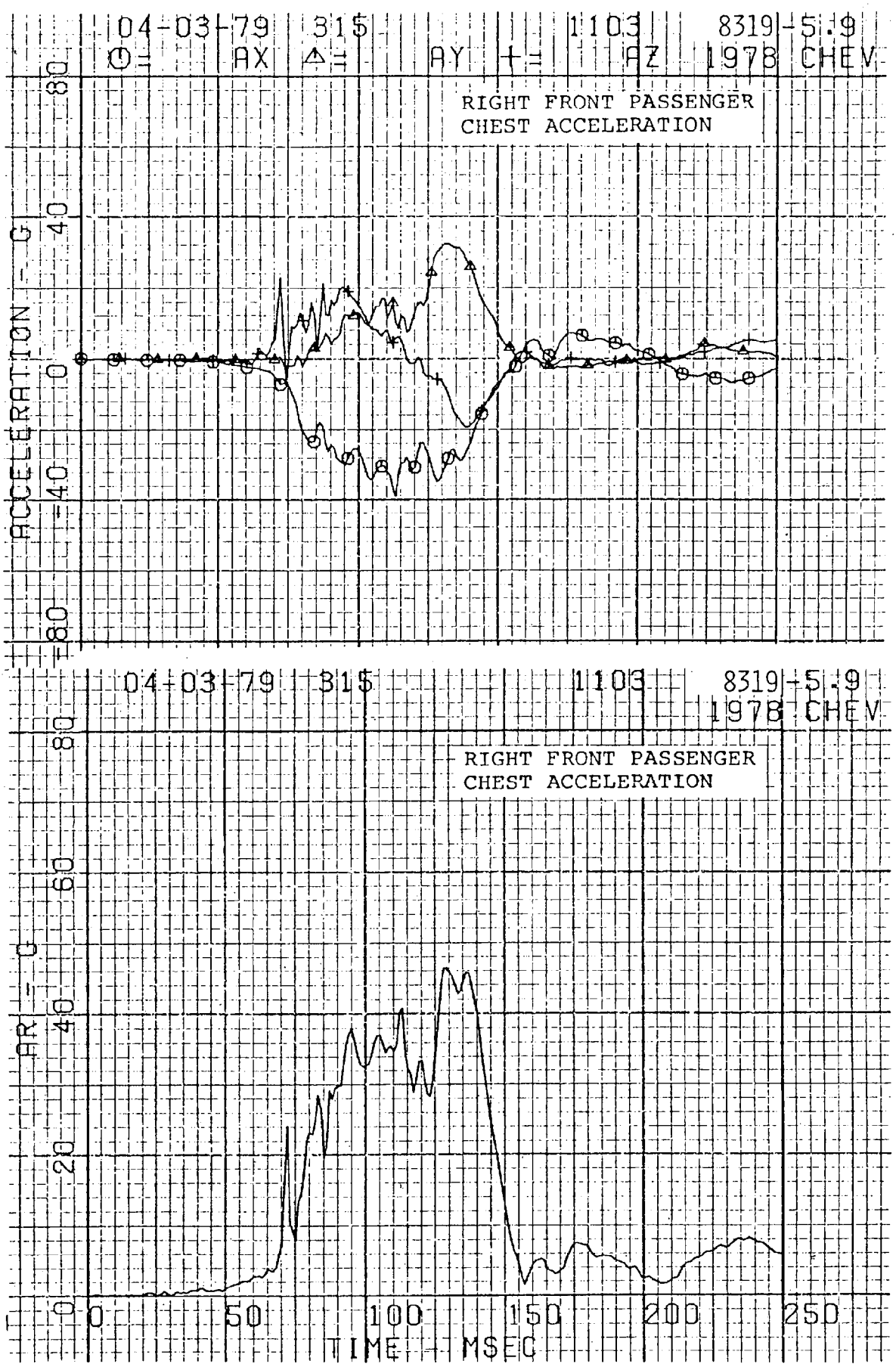

04-03-79 315 1101 8319-5-9
AX AY AZ 1978 CHEV
DRIVER CHEST ACCELERATION
ACCELERATION - G
80
40
0
-40
-80
04-03-79 315 1101 8319-5-9
1978 CHEV
DRIVER CHEST ACCELERATION
RESULTANT
AR - G
80
60
40
20
0
0
50
100
150
200
250
TIME - MSEC

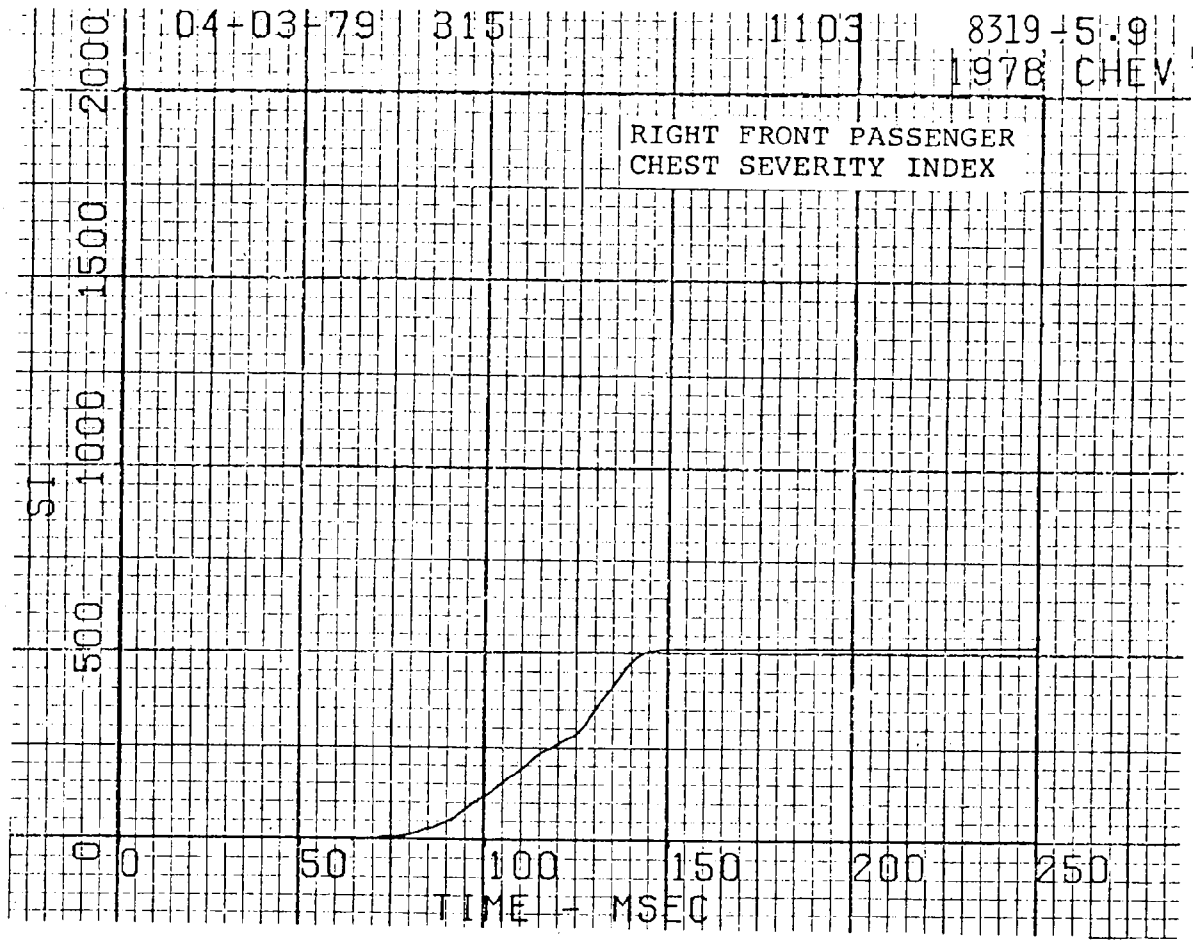

04-03-79 315 1101 8319 -5.9
1978 CHEV
DRIVER CHEST SEVERITY INDEX
SI
2000
1500
1000
500
0
0
50
100
150
200
250
TIME - MSEC

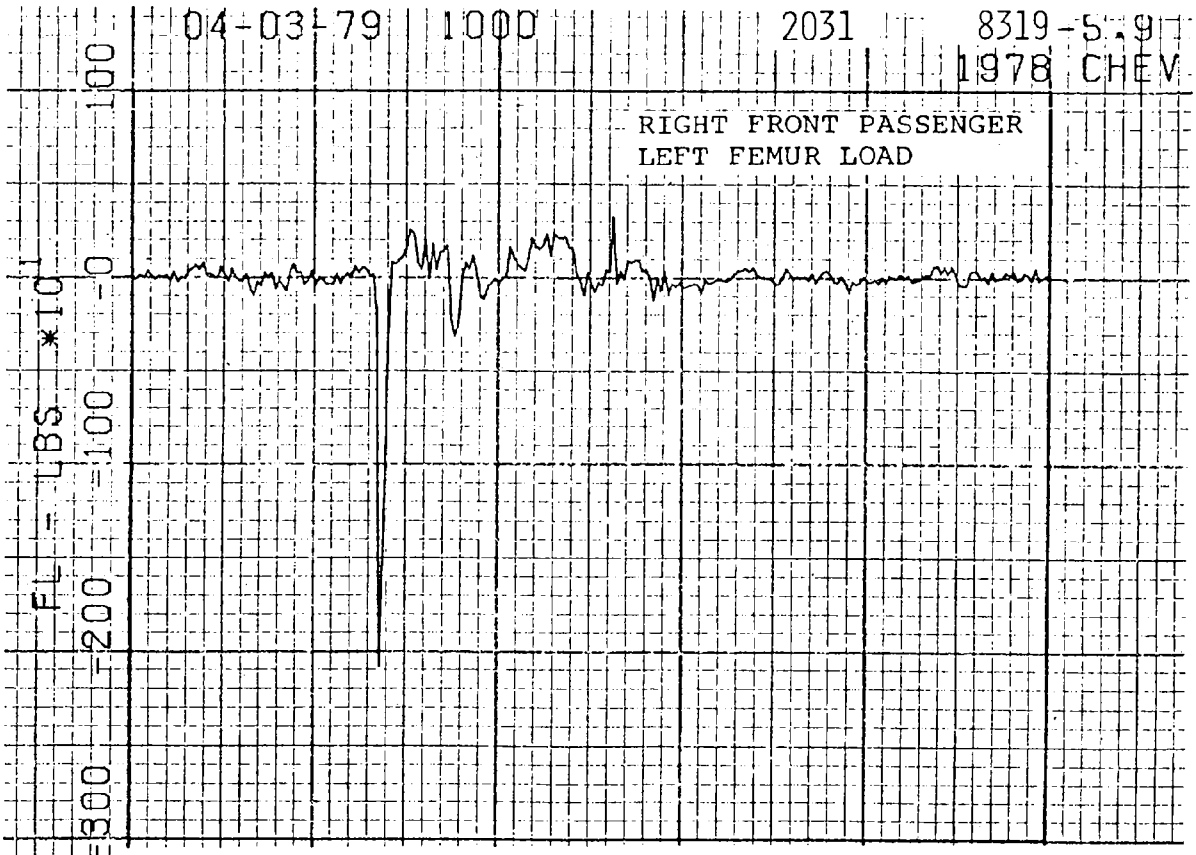

04-03-79 1000 2011 8319-5.
1978 CHEV
DRIVER LEFT FEMUR LOAD
FL - LBS *10
100
0
-100
-200
-300
04-03-79 1000 2012 8319-5.9
1978 CHEV
DRIVER RIGHT FEMUR LOAD
FR - LBS *10
100
0
-100
-200
-300
0
50
100
150
200
250
TIME - MSEC

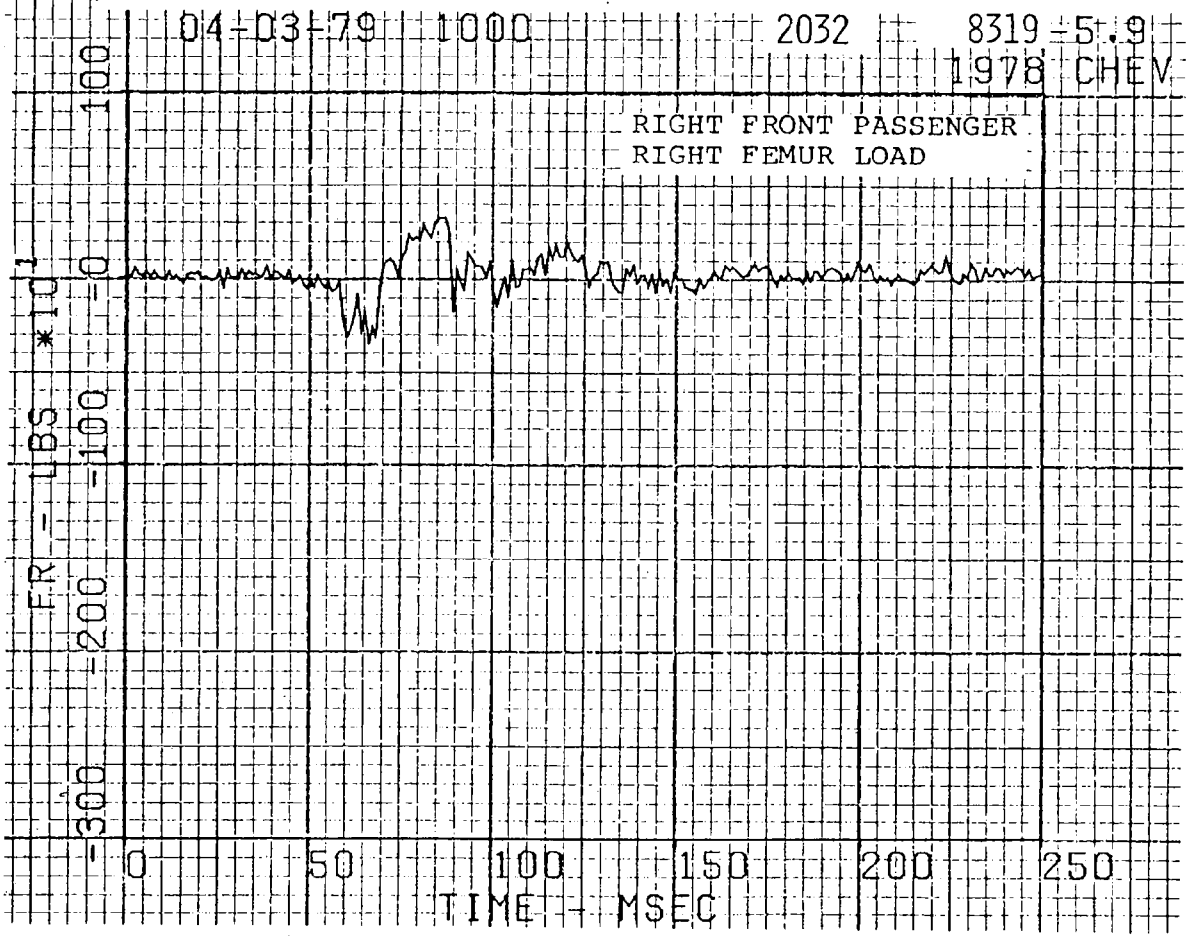

04-03-79 1600 503 8319-5.9
Θ= AX Δ= AY + = AZ 1978 CHEV
RIGHT FRONT PASSENGER
HEAD ACCELERATION
ACCELERATION = G
200
100
0
-100
-200

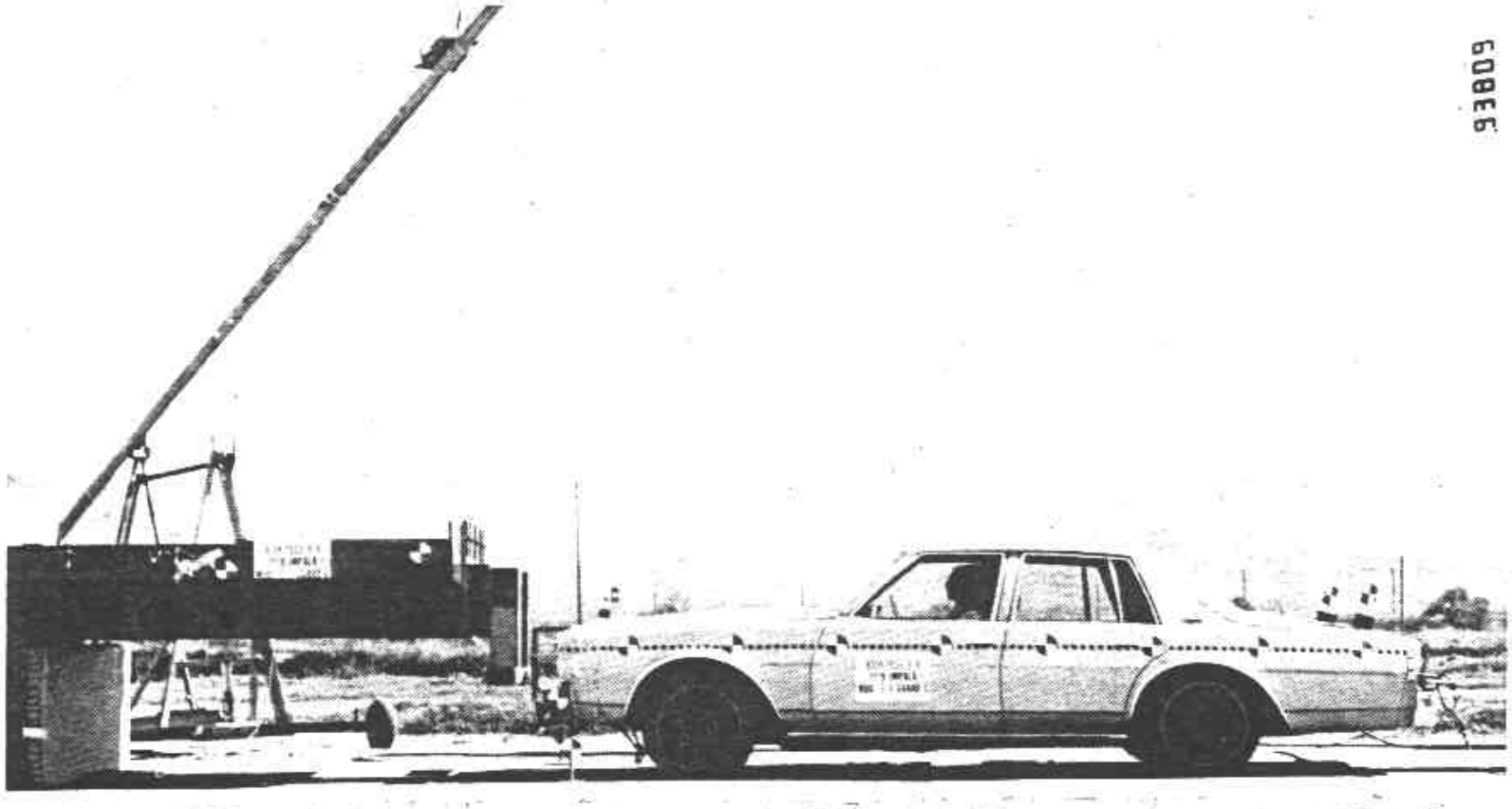

04-03-79 1600 503 8319-5.9
1978 CHEV
RIGHT FRONT PASSENGER
HEAD ACCELERATION RESULTANT
AR = G
400
300
200
100
0
0
50
100
150
200
250
TIME - MSEC


04-03-79 315 1103 8319-5.9
AX AY AZ 1978 CHEV
RIGHT FRONT PASSENGER
CHEST ACCELERATION
ACCELERATION - G
80
40
0
-40
-80
04-03-79 315 1103 8319-5.9
1978 CHEV
RIGHT FRONT PASSENGER
CHEST ACCELERATION
AR - G
80
60
40
20
0
0 50 100 150 200 250
TIME - MSEC

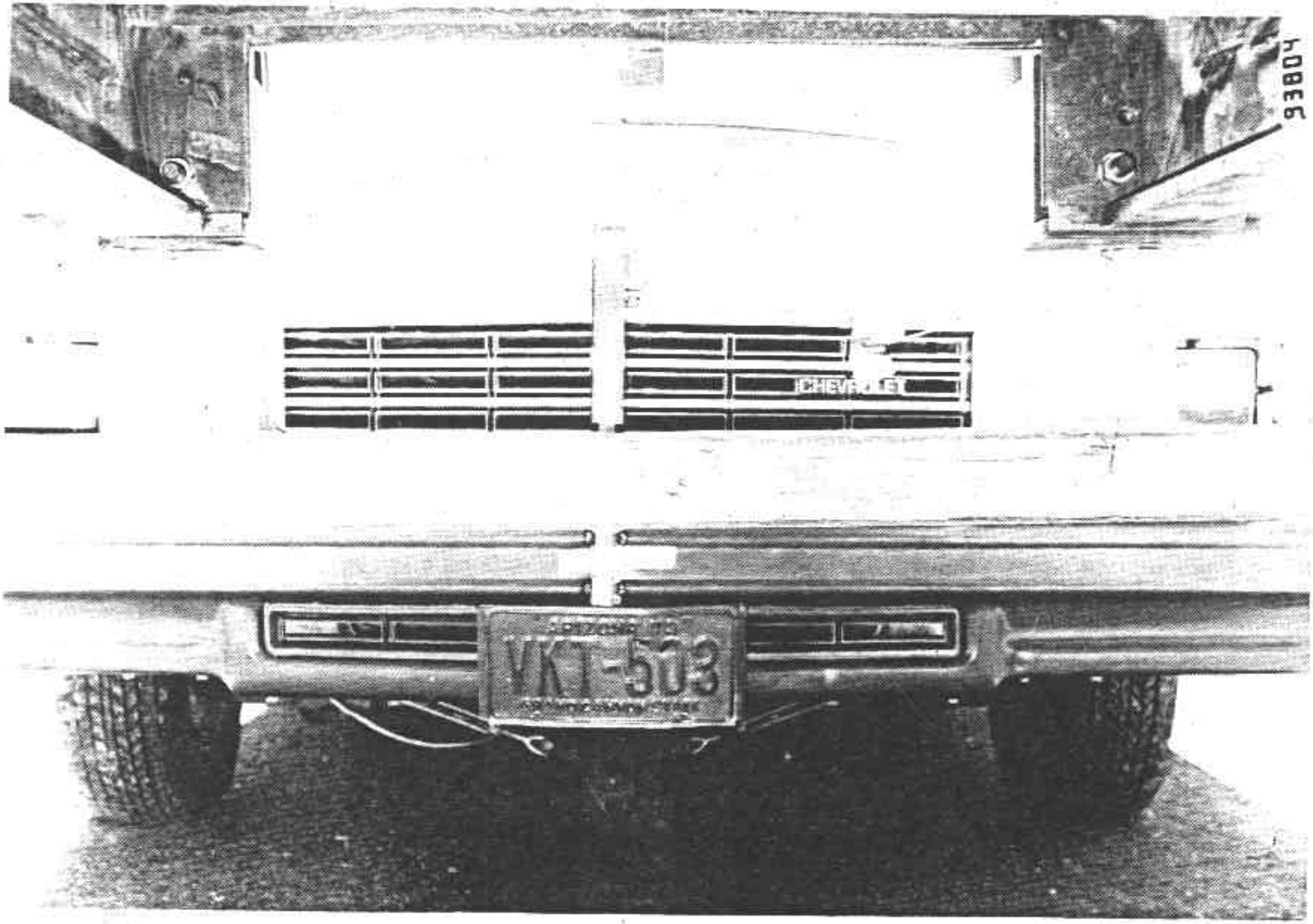

04-03-79 315 1103 8319-5-9
1978 CHEV
RIGHT FRONT PASSENGER
CHEST SEVERITY INDEX
SI
2000
1500
1000
500
0
0
50
100
150
200
250
TIME - MSEC


04-03-79 1000 2031 8319-5.9
1978 CHEV
RIGHT FRONT PASSENGER
LEFT FEMUR LOAD
FL = LBS *10
100
0
-100
-200
-300

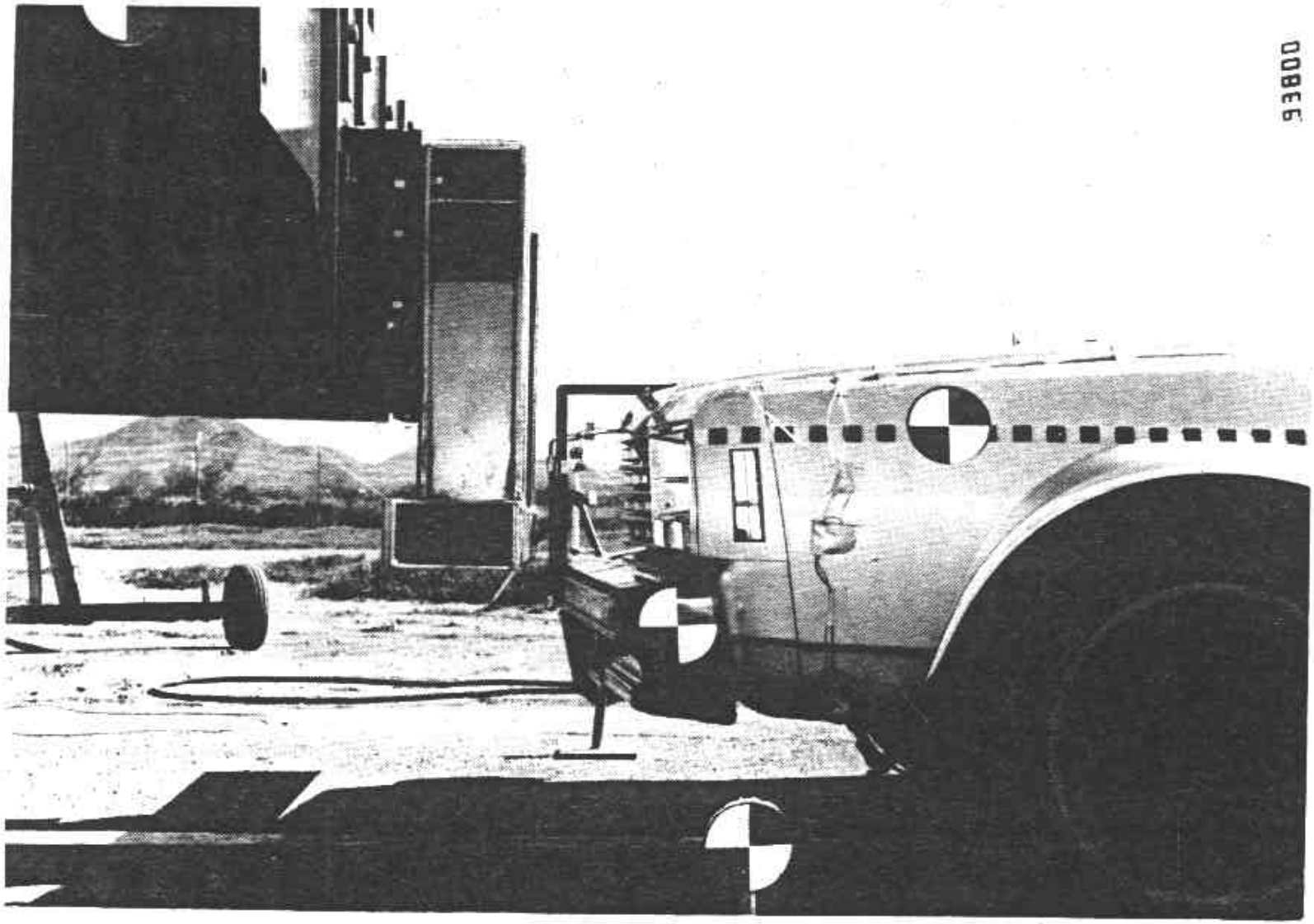

04-03-79 1000 2032 8319-5.9
1978 CHEV
RIGHT FRONT PASSENGER
RIGHT FEMUR LOAD
FR = LBS *10
100
0
-100
-200
-300
0
50
100
150
200
250
TIME - MSEC



Test 5.9 Pre-test Overall View of 1978 Chevrolet Impala/22-inch High T-1 Guard.

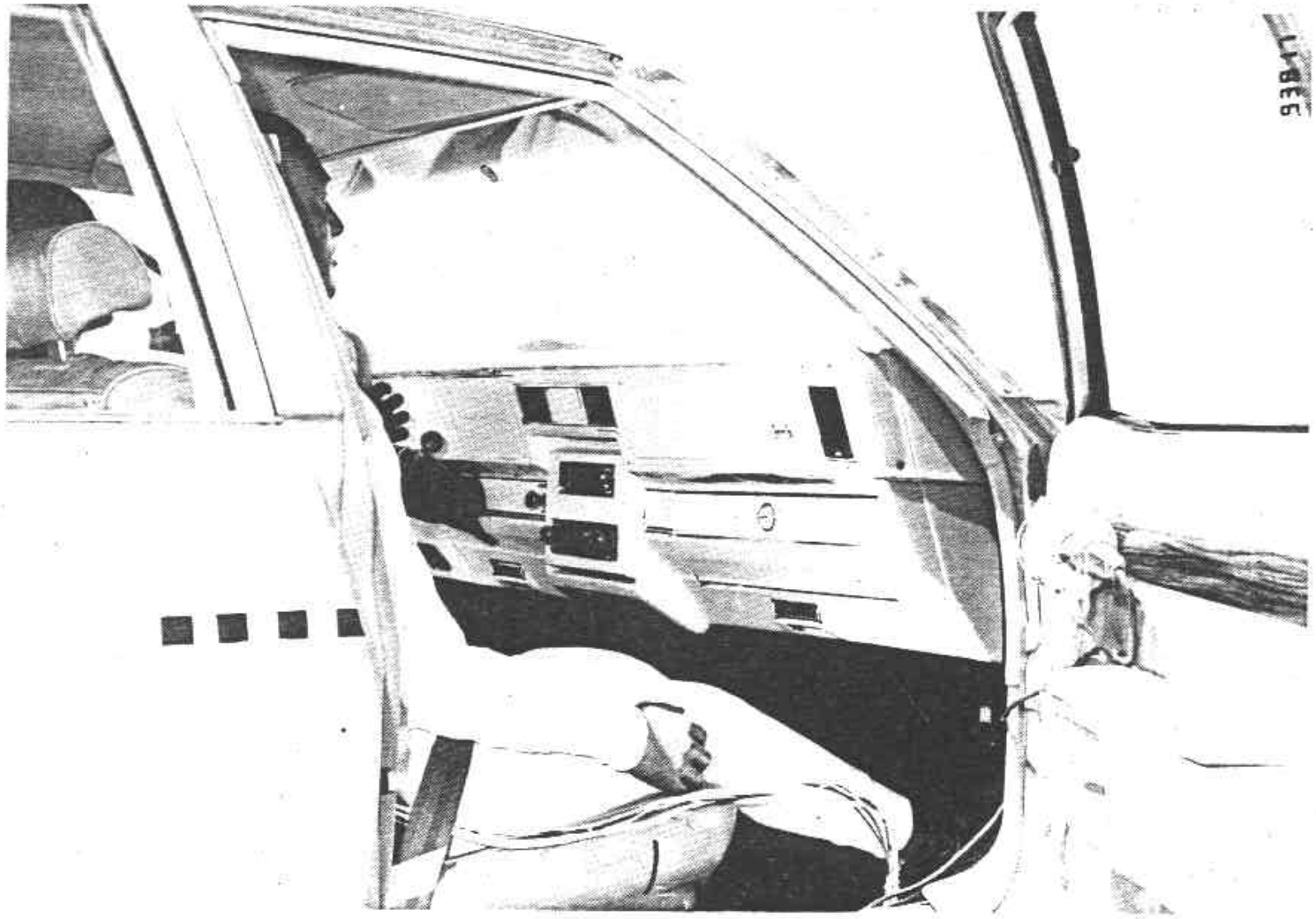


Test 5.9 Pre-test Front View of Test Vehicle and Guard.

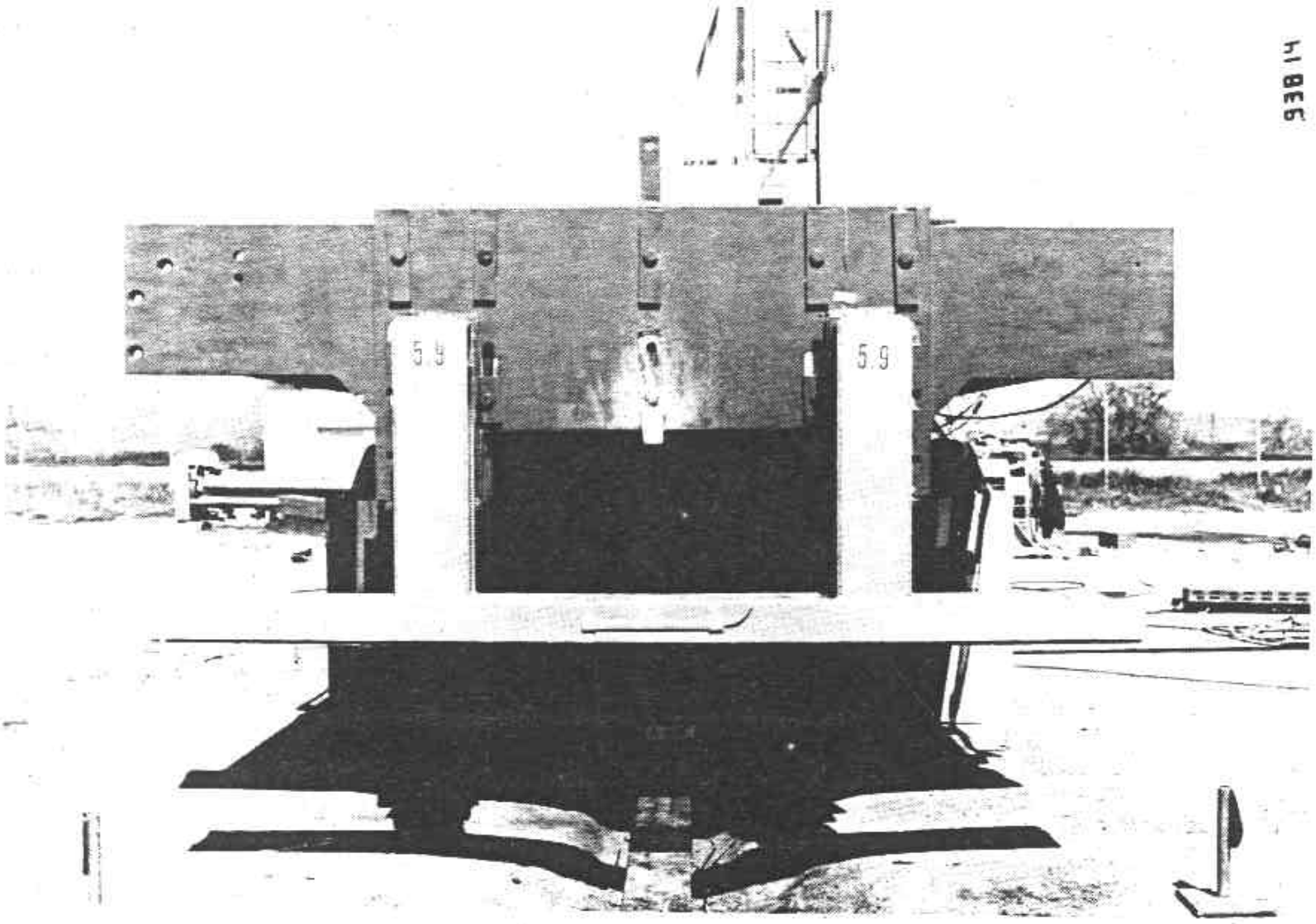


Test 5.9 Pre-test Side View of Test Vehicle and Guard Vertical Alignment.

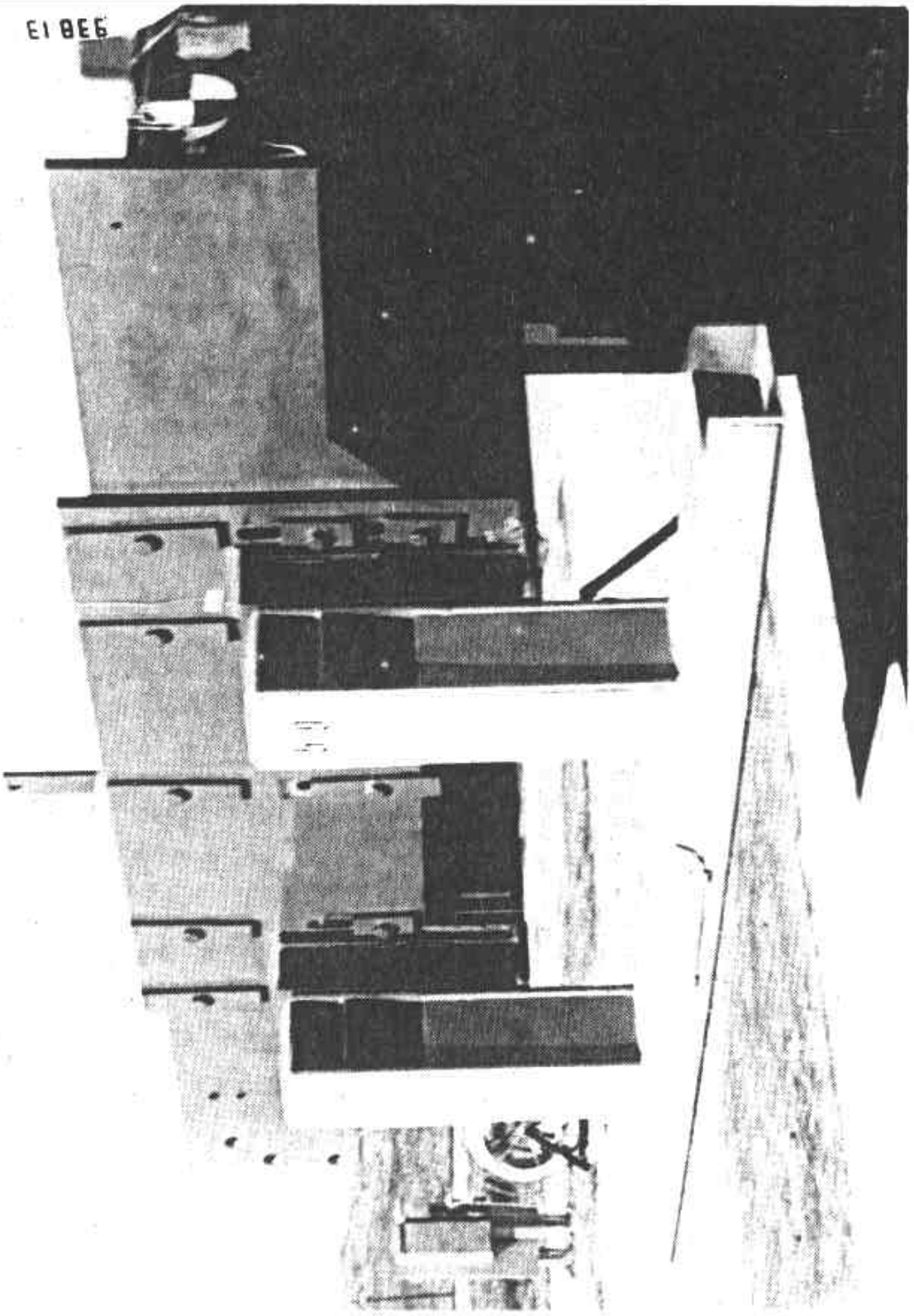
Test 5.9 Pre-test View of Driver Dummy.



Test 5.9 Pre-test View of Passenger Dummy.

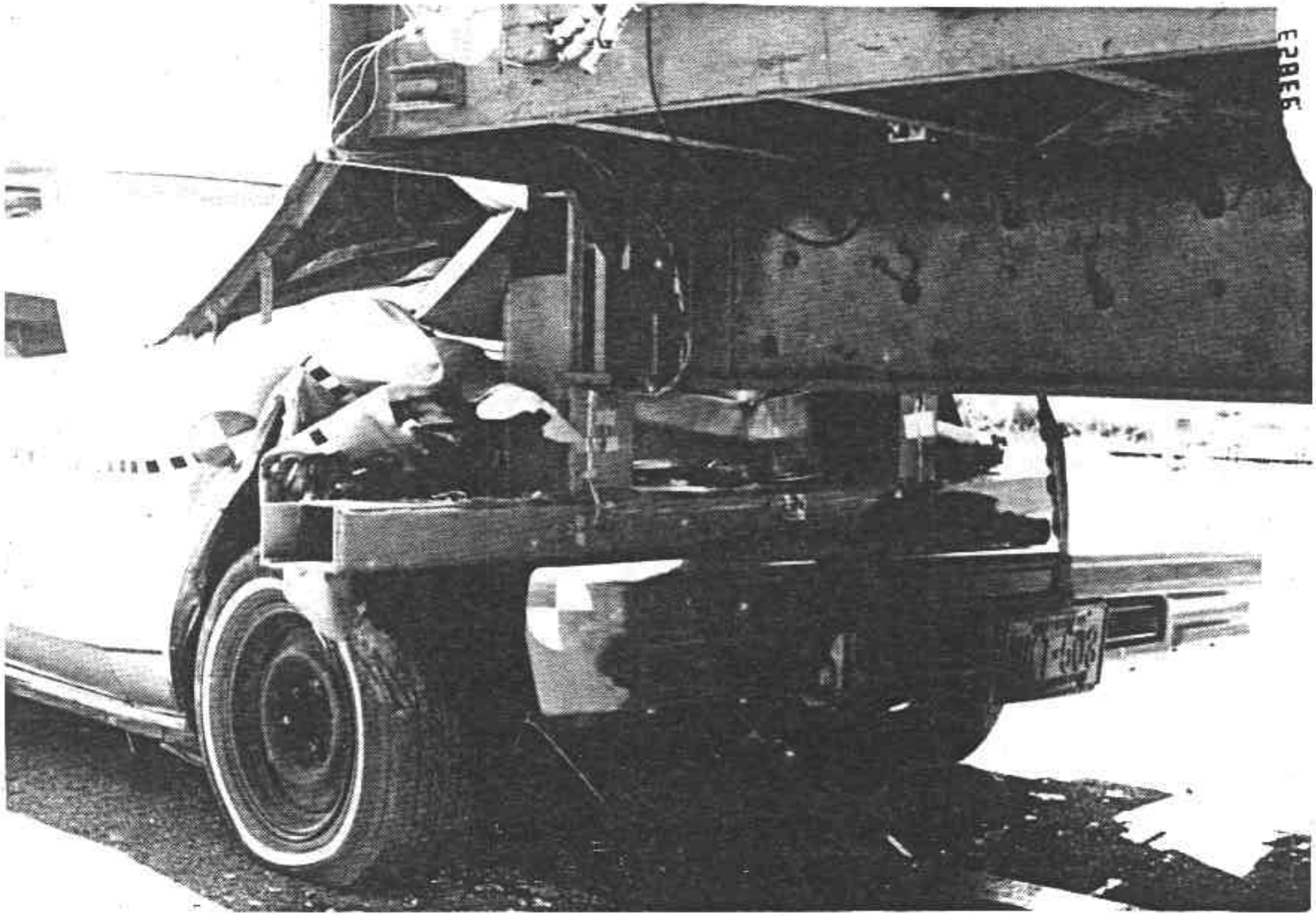


Test 5.9 Pre-test Overall View of Underride Guard.



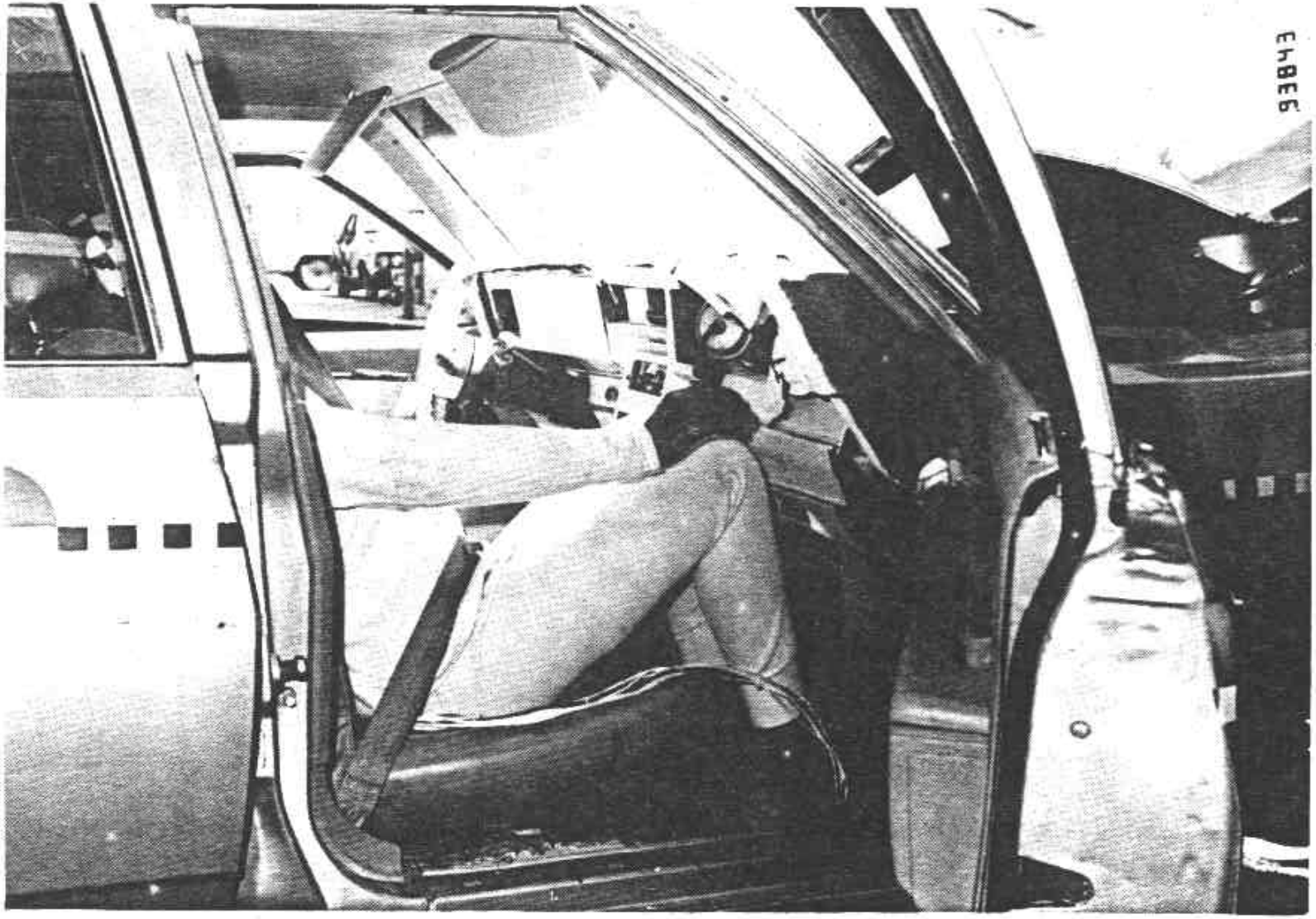
Test 5.9 Pre-test Three-quarter View of Underride Guard.

Test 5.9 Post-test Overall View of Chevrolet Impala/22-inch High T-1 Guard.



Test 5.9 Post-test Three-quarter Closeup View of Vehicle Underride.

Test 5.9 Post-test View of Driver Compartment and Dummy.



Test 5.9 Post-test View of Passenger Compartment and Dummy.

APPENDIX B

SUMMARY TABLES, DATA PLOTS, AND PHOTOGRAPHS

TEST 8319-5.10

RIGHT OFFSET IMPACT @ 30.26 MPH

TABLE B-1. RECEIVING INSPECTION OF VEHICLE - TEST 5.10

Contractor: Dynamic Science, Inc. Contract No.: DOT-HS-8-01905

VIN NO.: 1N69L8S132131 Make: Chevrolet

NHTSA No.: R&D

Year: 1978 Color: White Model: Impala 4-door Sedan

Auto Trans:	yes [X]	no [ ]	Pwr Steering:	yes [X]	no [ ]	Seats: (front)	Bench: X
Pwr Brakes:	yes [X]	no [ ]	Auto Speed Cont:	yes [X]	no [ ]		Bucket:
Pwr Seats:	yes [ ]	no [X]	Anti Skid Brake:	yes [ ]	no [X]		Split Bench:
Pwr Windows:	yes [X]	no [ ]	Air Conditioning:	yes [X]	no [ ]		
Tinted Glass:	yes [X]	no [ ]	Rear Window Def.:	yes [ ]	no [X]		Split Back Bench:
Radio:	yes [ ]	no [X]	Brakes: drum: R	disc: F			
Clock:	yes [X]	no [ ]					

Tire Size: FR 78-14 Ply Rating: 4 Mfg. & Line: Firestone

Bias Ply: ___ ___ Belted: X Radial X /Eng.Type: V-8 Cylinders: 8 Total Displ: 350 CID

Trans, # Fwd. Speeds: _____ Shipping Weight: _____ Odometer: _____

Dealer (name, address, and phone number)
Courtesy Chevrolet (602) 279-3232
1233 East Camelback Road
Phoenix, Arizona

Remarks (list additional accessories not listed above)

Date of Manufacture: 10-77 Dynamic Science No.: 603 Date Received: 1-26-78

Tilting Steering Wheel: yes [X] no [ ] Telescoping Steering Wheel: yes [ ] no [X]

Fuel Capacity: _____ (from owner's manual) "Space Saver" Spare Tire yes [ ] no [X]

Restraint System: Belt ELR System

1. Is the vehicle stock throughout? Describe: No, vehicle has been crashed twice before and had the front end repaired with parts from a 1978 Chevrolet Impala. Front fenders, hood, trim, bumper and grille replaced. The previous crash tests conducted with this vehicle were an FMVSS 301 rear impact and DSI Test No. 3051-8.

2. Does vehicle show evidence of prior accident history? Describe: Yes. Damage to vehicle rear; LR and RR fenders, rear seat panel severe buckling; LR and RR doors won't latch, doors wedged firmly in place; minor dents in all doors, fenders, and roof top; rear fender wells have holes cut in them to allow clearance for rear wheels.

3. Does vehicle show any significant corrosion? Describe: No.

4. Check condition of the front bumper and frame: Ok, no bumper guards.

TABLE B-2. SUMMARY OF PRE-TEST VEHICLE ENGINE/BUMPER/FIREWALL CHARACTERISTICS

Test No. 8319-5.10 Type Right Offset

Car Model 1978 Chevrolet Impala Dynamic Science No. 603

	Pre-test
Engine Size	350 CID
Engine Height/width (in.)	29.5/21
Bumper to Engine (in.)	31.5
Engine Length (in.)	25
Engine to Firewall (in.)	4
Bumper to Firewall (in.)	60.5
Bumper to "Hard Point" (Engine) (in.)	31.5
Initial Impact Point to Front Bumper (in.)	5
Height From Top of Front Bumper to Lowest Point of Underride Guard (in.)	0.2
Horizontal Dimension From Centerline of Vehicle to Extreme Left Edge of Guard (in.)	84
Horizontal Dimension From Centerline of Vehicle to Extreme Right Edge of Guard (in.)	0.0

TABLE B-3. SUMMARY OF CAR ACCELEROMETER DATA

Accel. No.	Plot No.	Maximum Acceleration A (G)	Maximum Acceleration Time (msec)	Minimum Velocity V (mph)	Minimum Velocity Time (msec)	Maximum Displacement S (in.)	Maximum Displacement Time (msec)
1X	101	-33.5	89	-5.6	203	46.0	134
1Y	101	-14.3	95	4.0	243	6.8	250
2X	102	-26.1	89	-4.4	203	52.9	155
3X	103	-26.1	72	4.9	210	54.4	154
3Y	103	14.	83	6.4	201	14.2	250
4X	104	-87.3	78	-4.5	112	40.4	173
4Y	104	47.2	77	7.6	138	19.8	250
5X	105	-31.7	68	-4.6	200	50.6	149
6X	106	-90.6	53	-5.3	82	31.1	70
6Z	106	-91.1	116	4.7	80	0.2	100
7X	107	-31.6	81	-5.9	238	51.0	150

TABLE B-4. SUMMARY OF TRAILER ACCELEROMETER DATA

Accelerometer Number	Plot Location Number	Maximum Acceleration A (G)	Maximum Acceleration Time (msec)
2X	202	13.3	61

TABLE B-5. SUMMARY OF COMPARTMENT AND ENGINE ACCELEROMETER DATA

Accelerometer Number	Plot Location Number	Maximum Acceleration A (G)	Maximum Acceleration Time (msec)
Average of 1X and 2X	412	-29.8	89
6X	106	-91	53

TABLE B-6. SUMMARY OF UNDERRIDE GUARD STRING POTENTIOMETER DATA

Displacement Potentiometer		Plot Location	Maximum Dynamic Displacement	
Number	Location	Number	D (in.)	Time (msec)
SP1	Left	4300	.4	71
SP2	Center	4301	-.3	93
SP3	Right	4302	-.5	77

TABLE B-7. COMPARISON OF TOTAL INTERFACE FORCE FROM LOAD CELL AND ACCELEROMETER DATA

Parameter	Trailer Force Data*	Car Acceleration Data**
Force (lb)	86,476	108,595
Time (msec)	78	75

*Sum of 4 load cells.
**Average of car accelerometers 1 and 2 x (vehicle minus engine weight) + engine acceleration x (engine weight of 675 lb).

TABLE B-8. SUMMARY OF UNDERRIDE GUARD AND TRAILER STRAIN GAUGE DATA

Strain Gauge		Maximum Strain*	Maximum Time
Number	Plot Location Number**	(μin./in.)	(msec)
SG2	4201	739.4	54
SG3	4201	244.0	74
SG4	4201	1594.0	71
SG11	4202	250.6	83
SG12	4202	317.3	75

*STRESS = STRAIN (μin./in.) x E(30×10^6 lb/in. for steel)
Tensile strain and stress are negative.
**For location of strain gauges 1-3, see Figure 3-2, for location of strain gauges 7-16, see Figure 2-2.

TABLE B-9. SUMMARY OF PRE-TEST AND POST-TEST VEHICLE STATIC MEASUREMENTS

TEST NO. 8319-5.10 VEHICLE 1978 Chevrolet Impala

Location	Dimension* Pre	Post	Reference	Difference*
Front edge of water pump casting	89.6	72.9	Target 120"	16.7
Bottom of A-pillar (left)	47.3	47.3	Target 120"	0.0
Bottom of A-pillar (right)	47.2	47.5	Target 120"	-0.3
Rear top edge of panel (left)	37.8	37.4	Target 120"	0.4
Rear top edge of panel (right)	38.0	37.7	Target 120"	0.3
Steering column hub (horizontal)	33.7	31.1	Target 120"	2.6
Steering column lower rim (horizontal)	31.2	31.8	Target 120"	-0.6
Steering column hub (vertical)	21.9	27.5	Rocker Sill	-5.6
Steering column lower rim (vertical)	15.6	17.3	Rocker Sill	-1.7
Centerline windshield opening (top)	33.5	35.8	Target 120"	-2.3

*Dimensions are in inches.

TABLE B-9. SUMMARY OF PRE-TEST AND POST-TEST VEHICLE STATIC MEASUREMENTS (CONTD)

TEST NO. 8319-5.10 VEHICLE 1978 Chevrolet Impala

Location	Dimension* Pre	Post	Reference	Difference*
Top of A-pillar (left)	28.6	31.3	Target 120"	-2.7
Top of A-pillar (right)	28.3	30.2	Target 120"	-1.9
Dash panel at knee height (left)	48.1	45.6	Target 120"	2.5
Dash panel at knee height (right)	47.9	41.7	Target 120"	6.2
Firewall driver centerline	62.3	58.1	Target 120"	4.2
Firewall passenger centerline	59.9	47.6	Target 120"	12.3
Firewall vehicle centerline	60.1	46.6	Target 120"	13.5

*Dimensions are in inches.

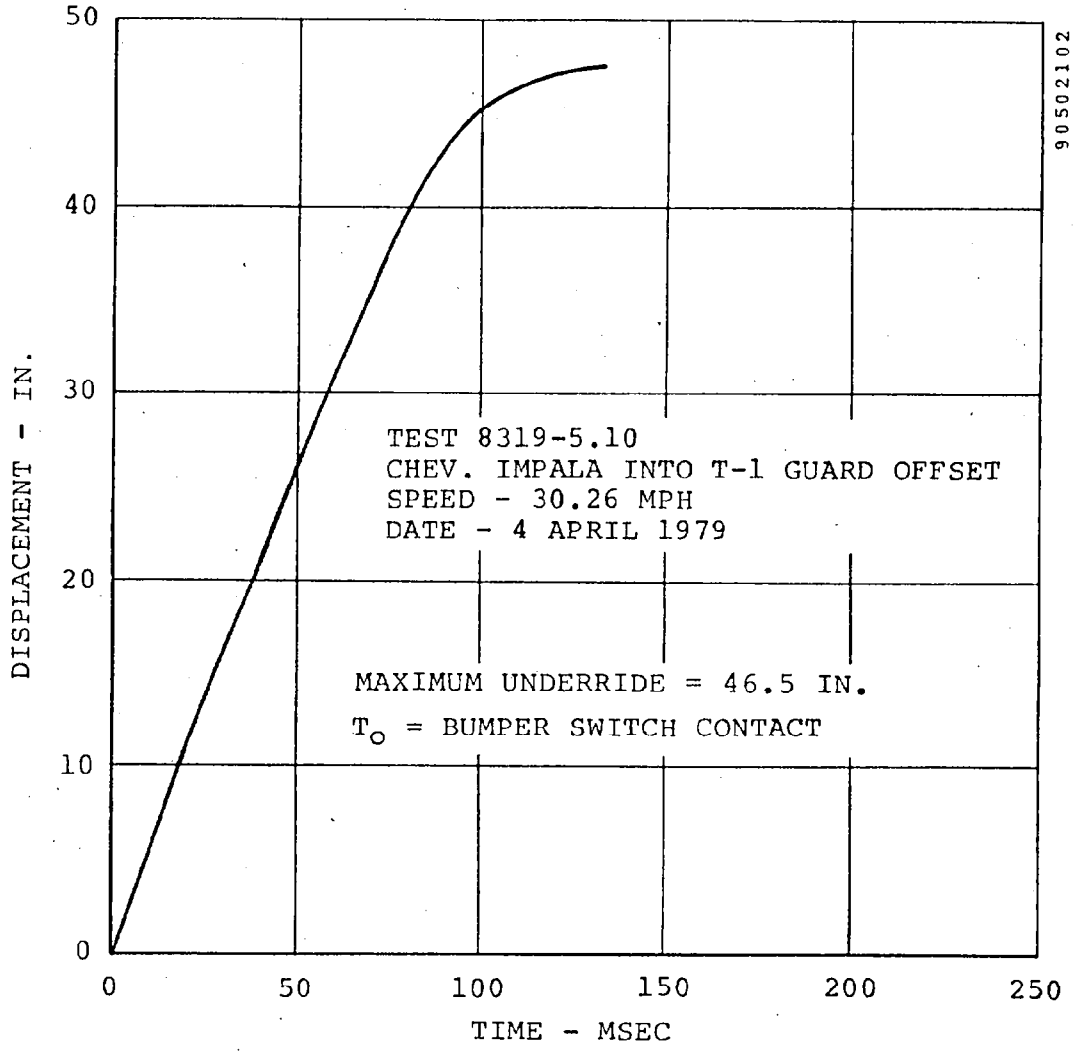


Figure B-1. Vehicle Underride Versus Time, Driver Side - Test 5.10.

TABLE B-10. SUMMARY OF PRE-TEST DUMMY POSITION DATA CHARACTERISTICS

TEST NO. 8319-5.10 TYPE Right Offset

CAR MODEL 1978 Chevrolet Impala DYNAMIC SCIENCE NO. 791

	Left Front Occupant	Right Front Occupant
Seat Range (in.)	6.1	6.1
Seat Position* (in.)	3.0	3.0
Front Seat to Firewall (in.)	26.6	24.9
Forehead to Windshield (in.)	21.8	22.0
Torso to Steering Wheel** (in.)	12.4	21.6
Left/Right Knee to Dash Panel (in.)	7.5/7.7	8.0/8.2

Dummy Type Alderson Part 572

Locations: Left Front Occupant - No. A03

Right Front Occupant - No. 759

Restraint Type: LF Std. 3-pt. belts w/emergency locking retractor

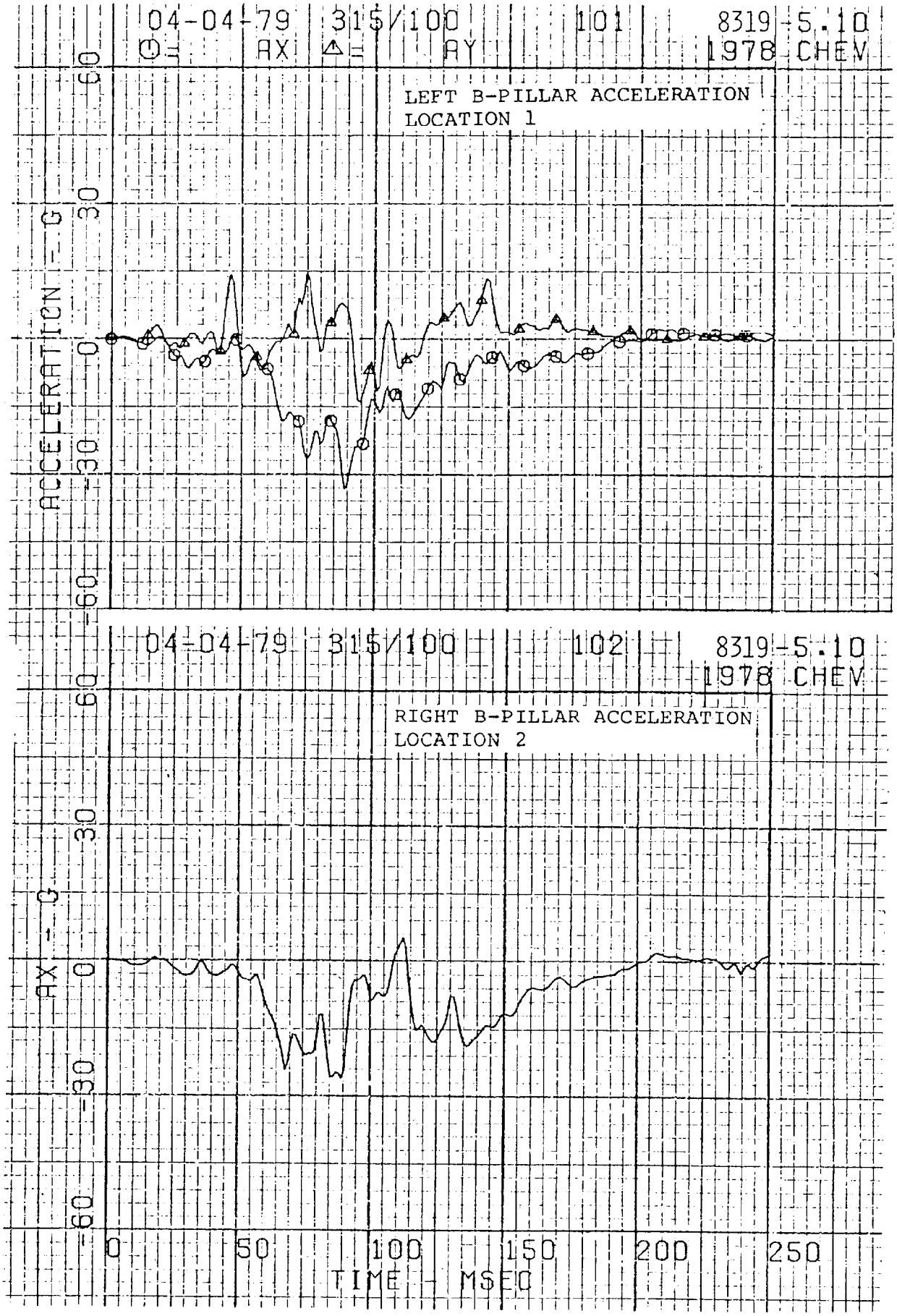
RF Std. 3-pt. belts w/emergency locking retractor

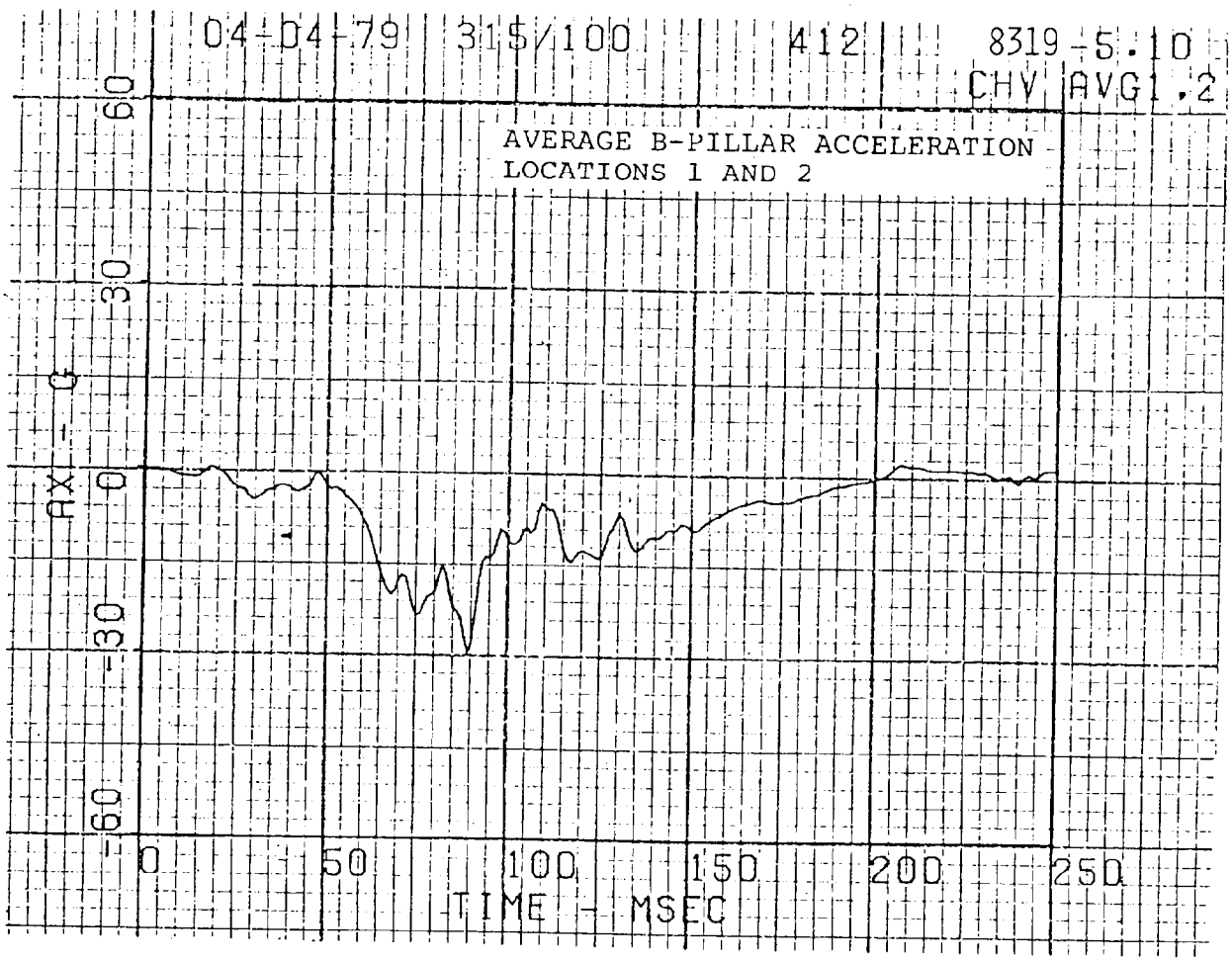
*From rearmost position to midpoint seat position.
**To dash panel for right front occupant.

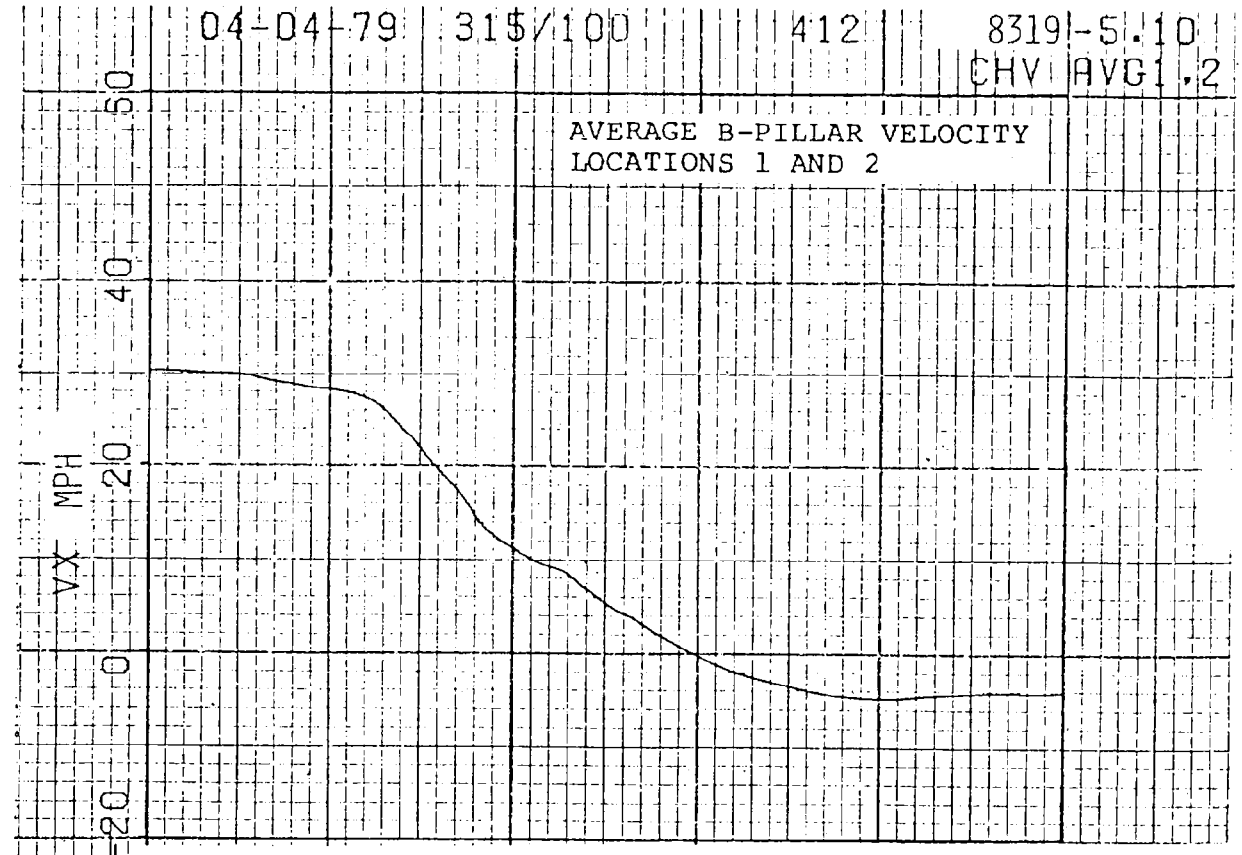
TABLE B-11. SUMMARY OF OCCUPANT RESPONSE DATA FOR TEST 5.10

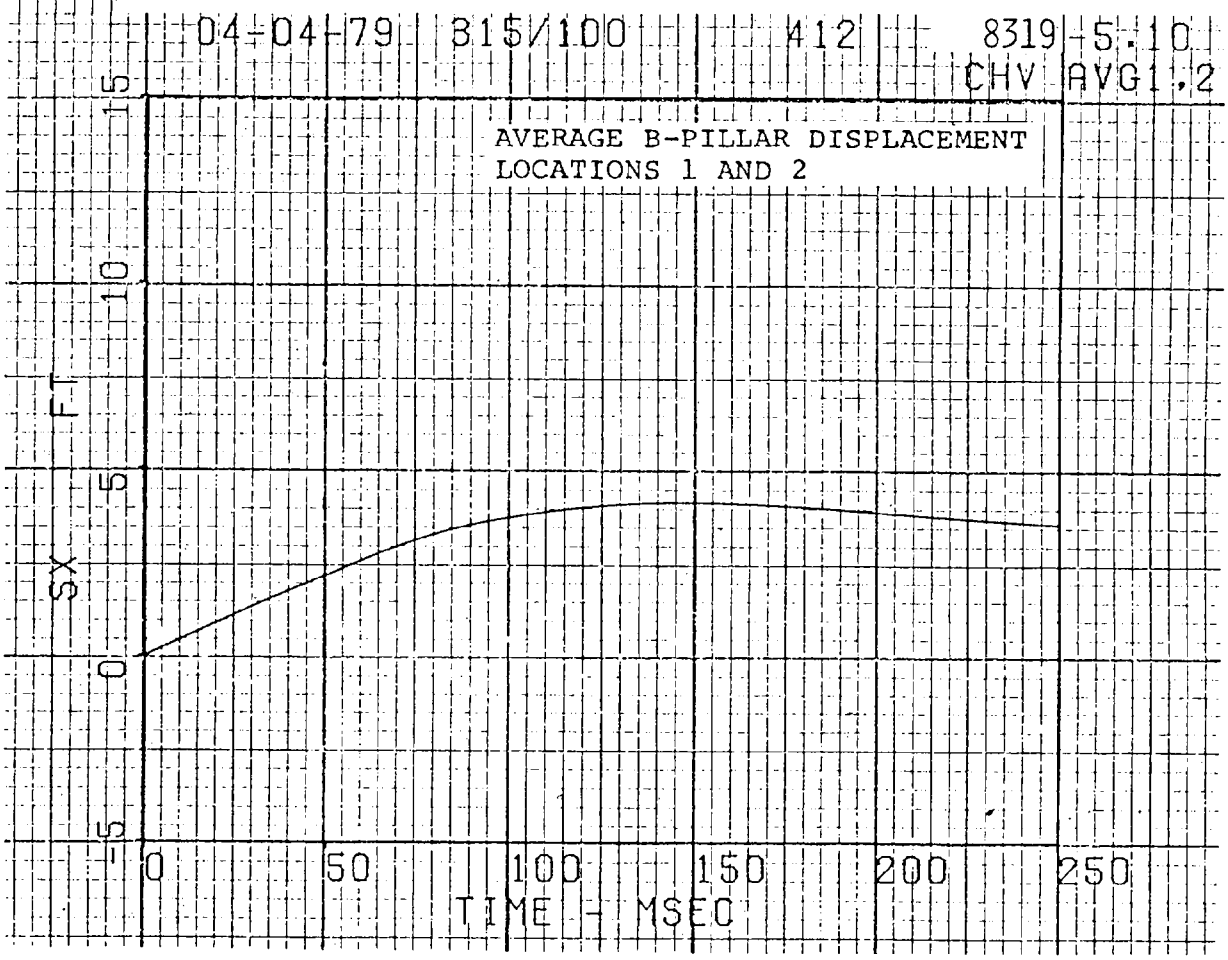
Response Parameter		Filter (Hz)	Left Front Dummy (Driver) Maximum Value A (G)	Left Front Dummy (Driver) Maximum Value T (msec)	Right Front Dummy (Passenger) Maximum Value A (G)	Right Front Dummy (Passenger) Maximum Value T (msec)
Head	X	1600	-108	113	-42*	153
	Y	1600	-33	113	16	166
	Z	1600	43	136	66	152
	R	1600	118	113	79*	153
SI/Time			1074	200	980	200
HIC/Time			807	108/143	649	108/177
Head Acceleration	R**	1600	78		72	
Chest	X	315	-51	131	-25	157
	Y	315	-15	132	7	138
	Z	315	16	105	15	79
	R	315	55	131	25	157
SI/Time			309	200	139	200
Chest Acceleration	R**		49		23	
Left Femur Load***		1000	-1758	75	-732	112
Right Femur Load***		1000	-610	82	-1315	116

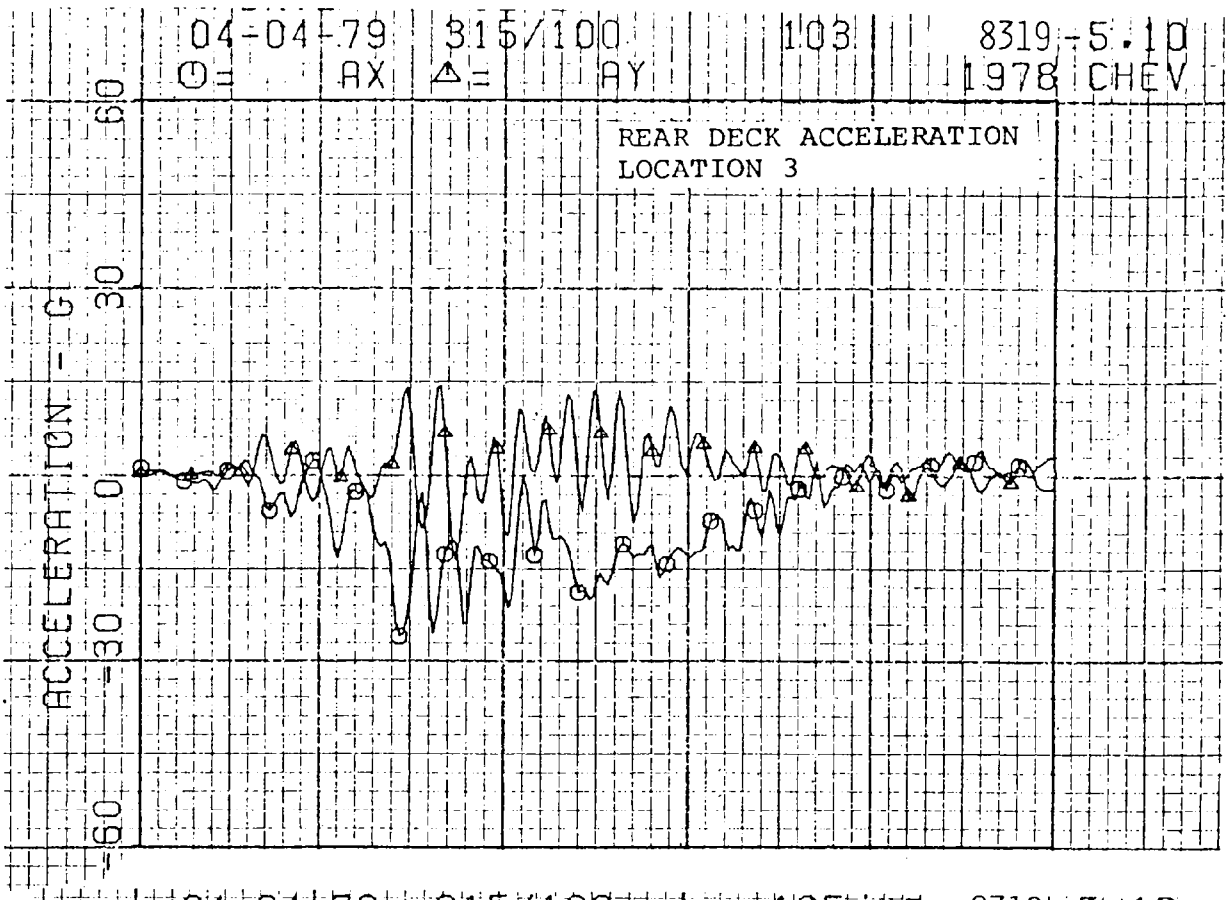
*See plots of Right Front Head Accelerometer Data (Appendix B) - data spikes questionable.
**G values defined as value exceeding a cumulative duration of 3 msec.
***Negative loads are compression; positive loads are tension.

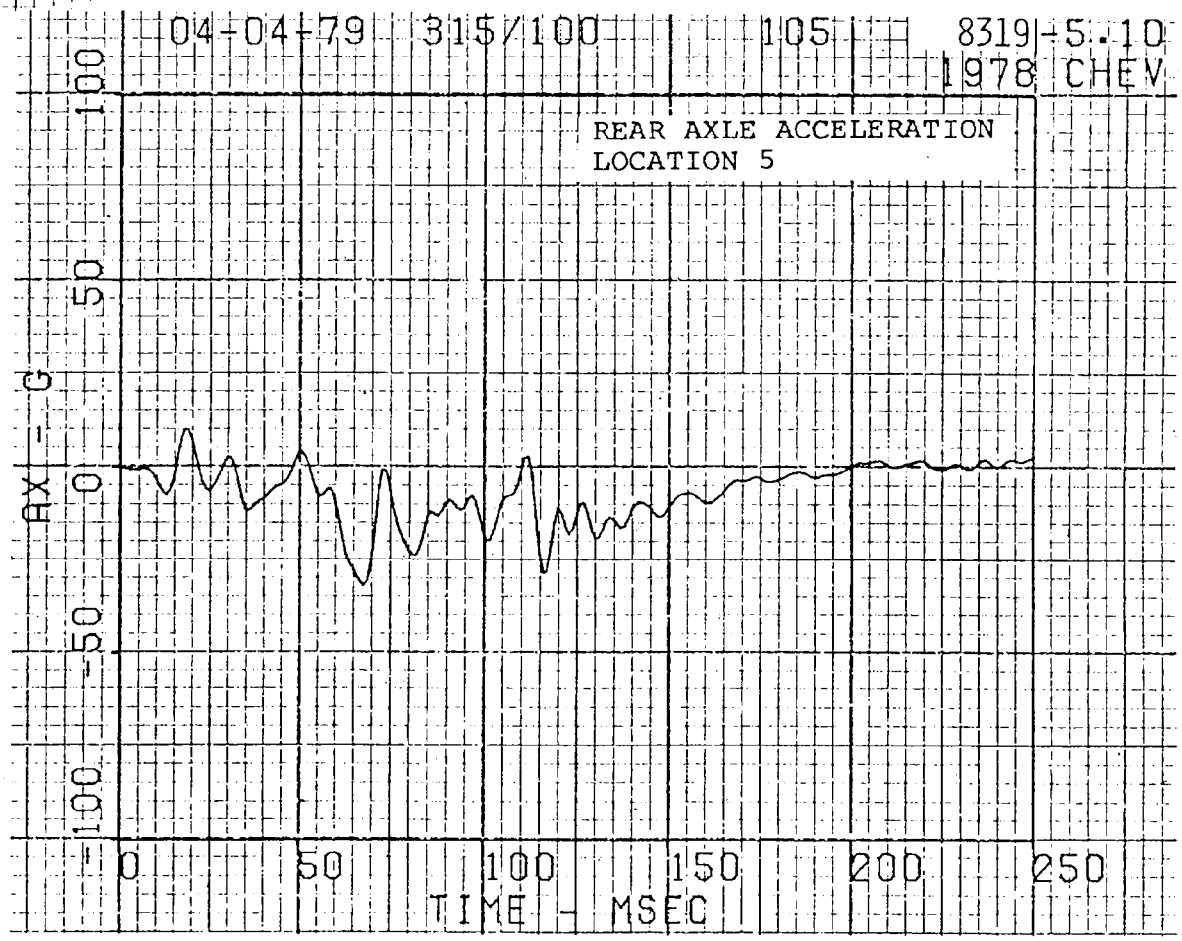

04-04-79 315/100 101 8319-5.10
O= AX Δ= AY 1978 CHEV
LEFT B-PILLAR ACCELERATION
LOCATION 1
ACCELERATION -G
60
30
0
-30
-60
04-04-79 315/100 102 8319-5.10
1978 CHEV
RIGHT B-PILLAR ACCELERATION
LOCATION 2
AX - G
60
30
0
-30
-60
0
50
100
150
200
250
TIME - MSEC

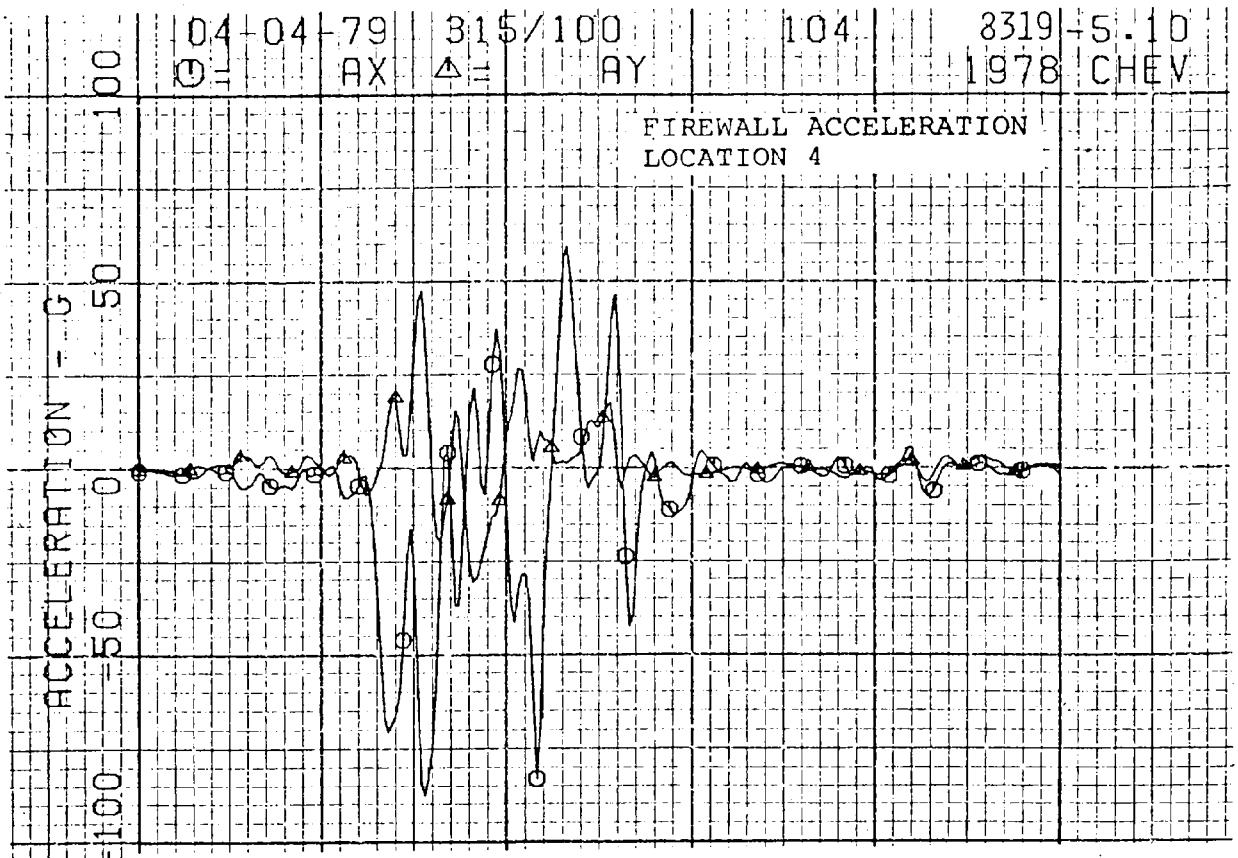

04-04-79 315/100 412 8319-5.10
CHV AVG1 .2
AVERAGE B-PILLAR ACCELERATION
LOCATIONS 1 AND 2
AX - G
60
30
0
-30
-60
0
50
100
150
200
250
TIME - MSEC

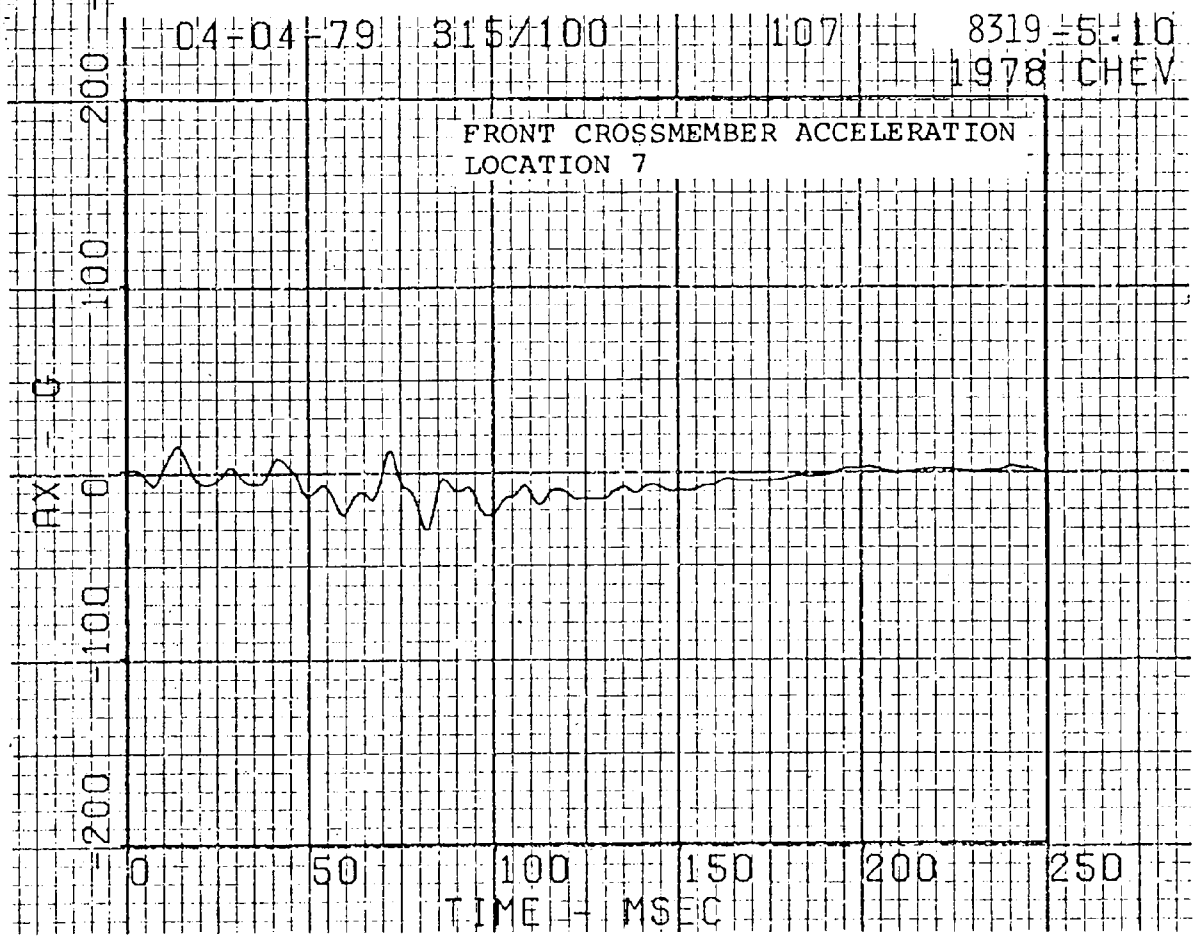

04-04-79 315/100 412 8319-5.10
CHV AVG1,2
AVERAGE B-PILLAR VELOCITY
LOCATIONS 1 AND 2
VX MPH
50
40
20
0
-20

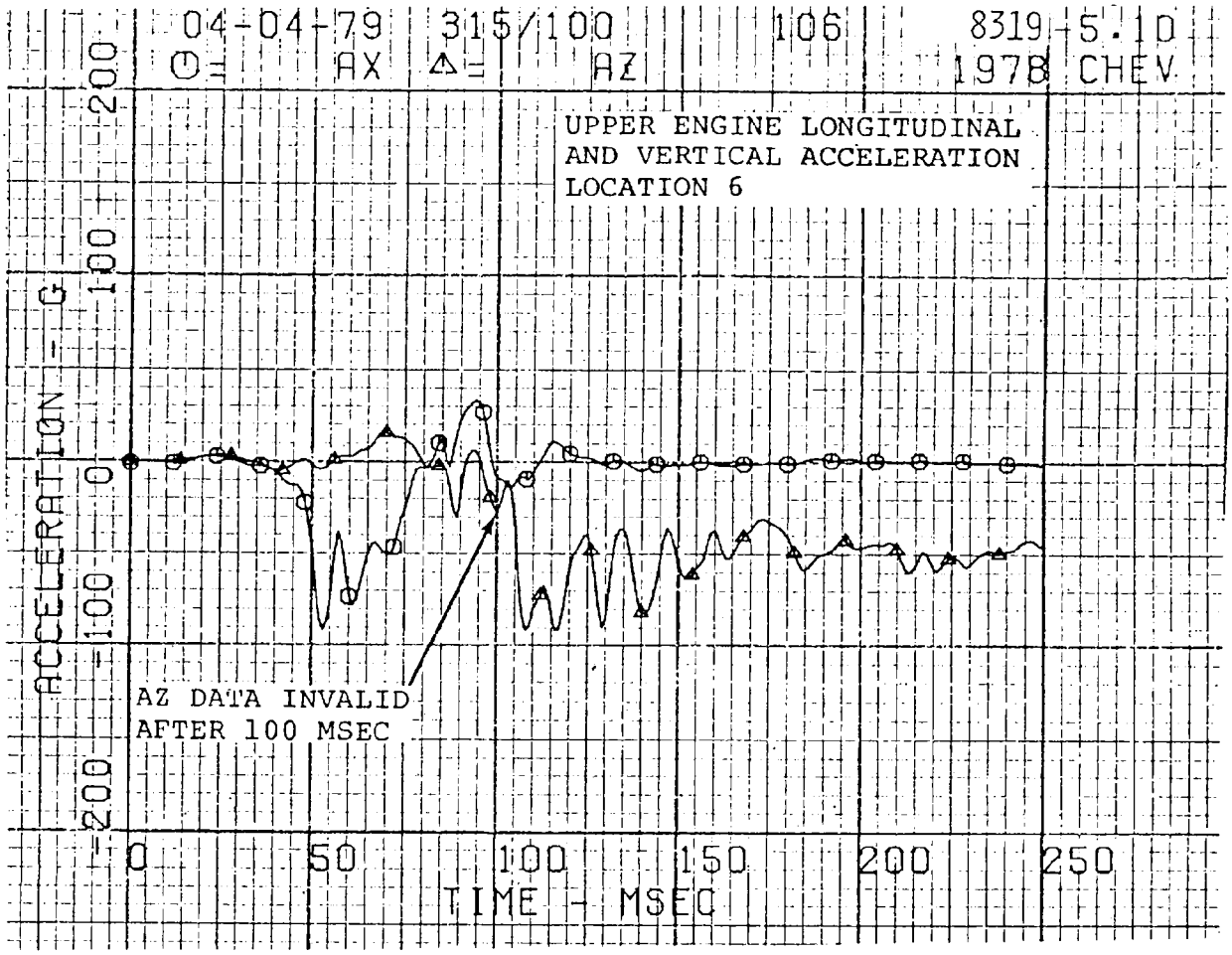

04-04-79 315/100 412 8319-5.10
CHV AVG1,2
AVERAGE B-PILLAR DISPLACEMENT
LOCATIONS 1 AND 2
SX FT
15
10
5
0
-5
0
50
100
150
200
250
TIME - MSEC

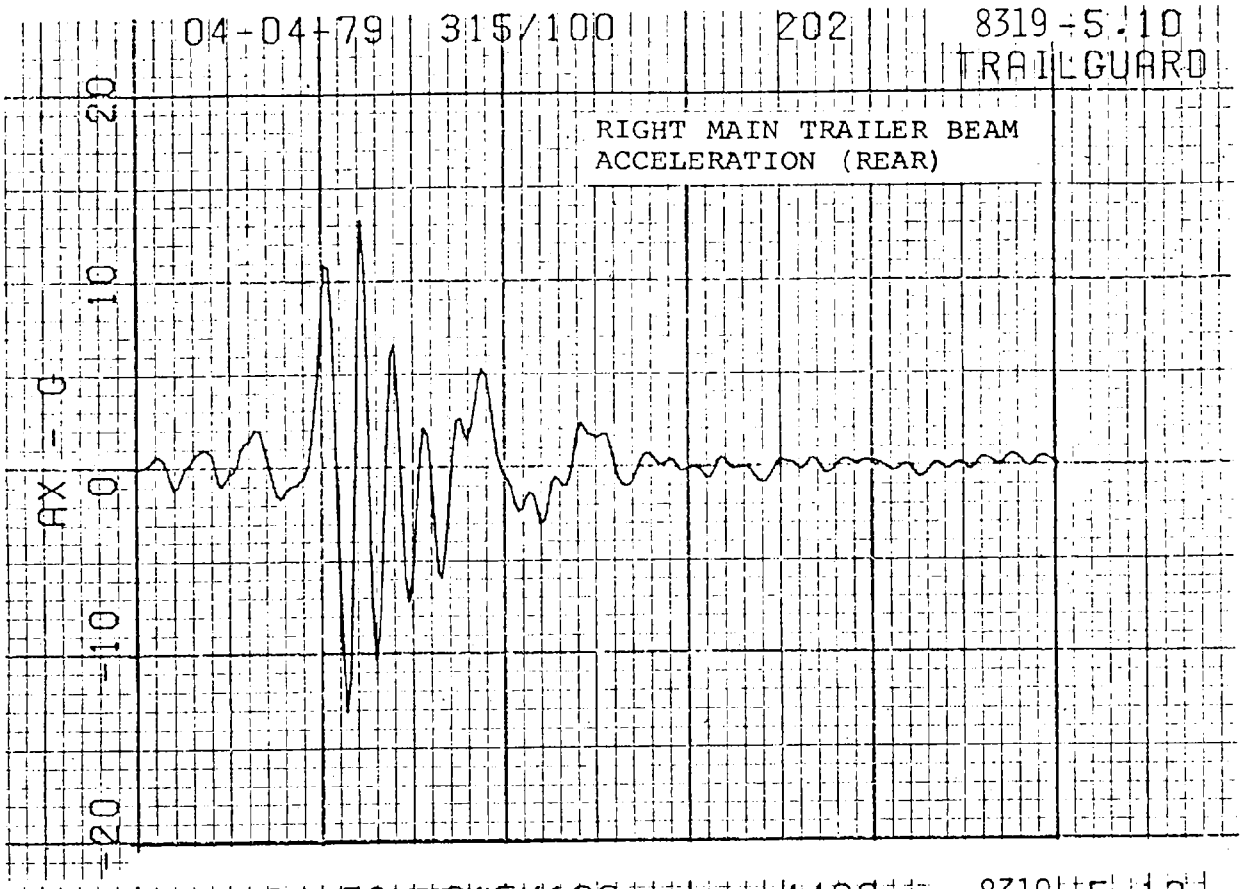

04-04-79 315/100 103 8319-5.10
○= AX △= AY 1978 CHEV
REAR DECK ACCELERATION
LOCATION 3
ACCELERATION - G
60
30
0
-30
-60

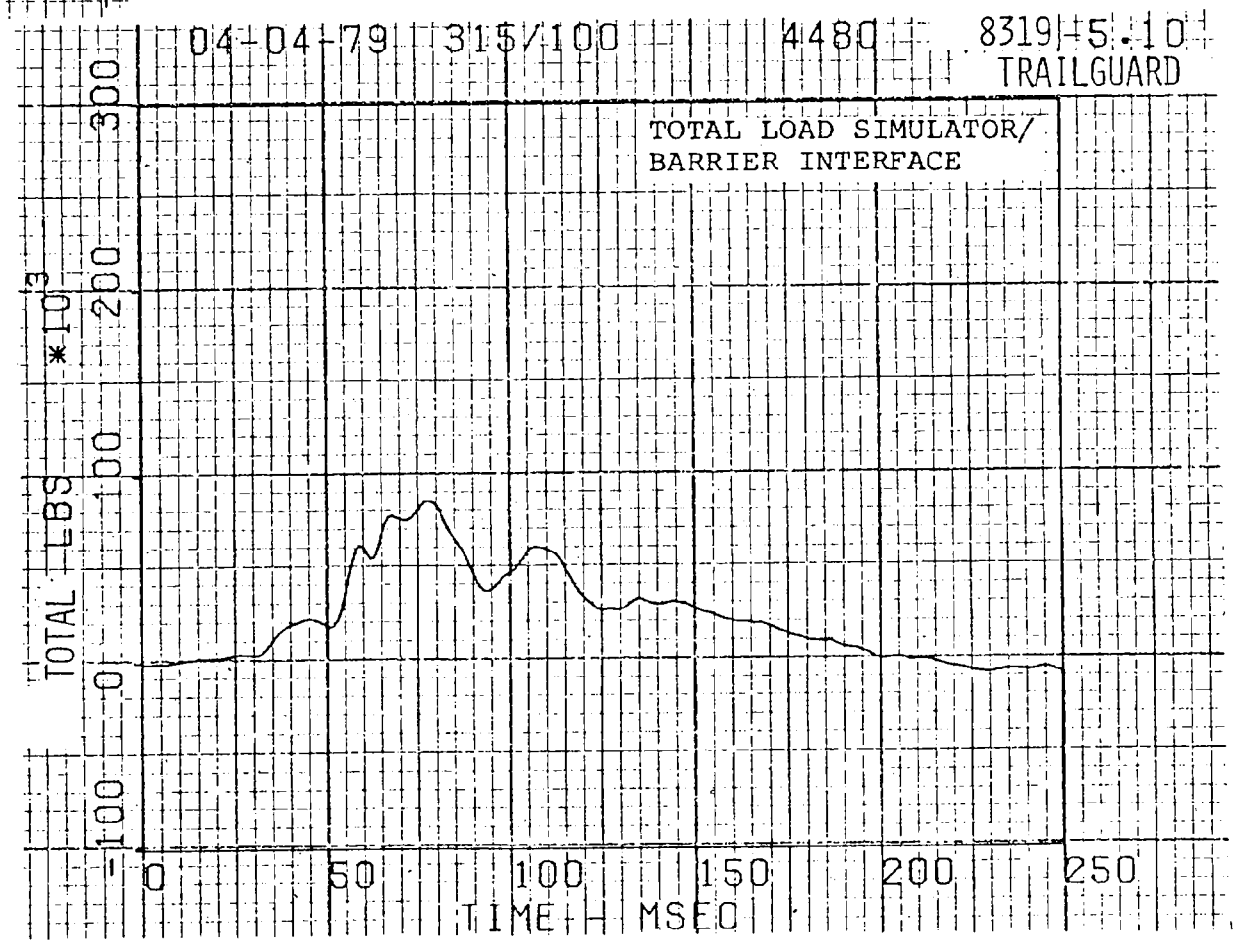

04-04-79 315/100 105 8319-5.10
1978 CHEV
REAR AXLE ACCELERATION
LOCATION 5
AX - G
100
50
0
-50
-100
0
50
100
150
200
250
TIME - MSEC

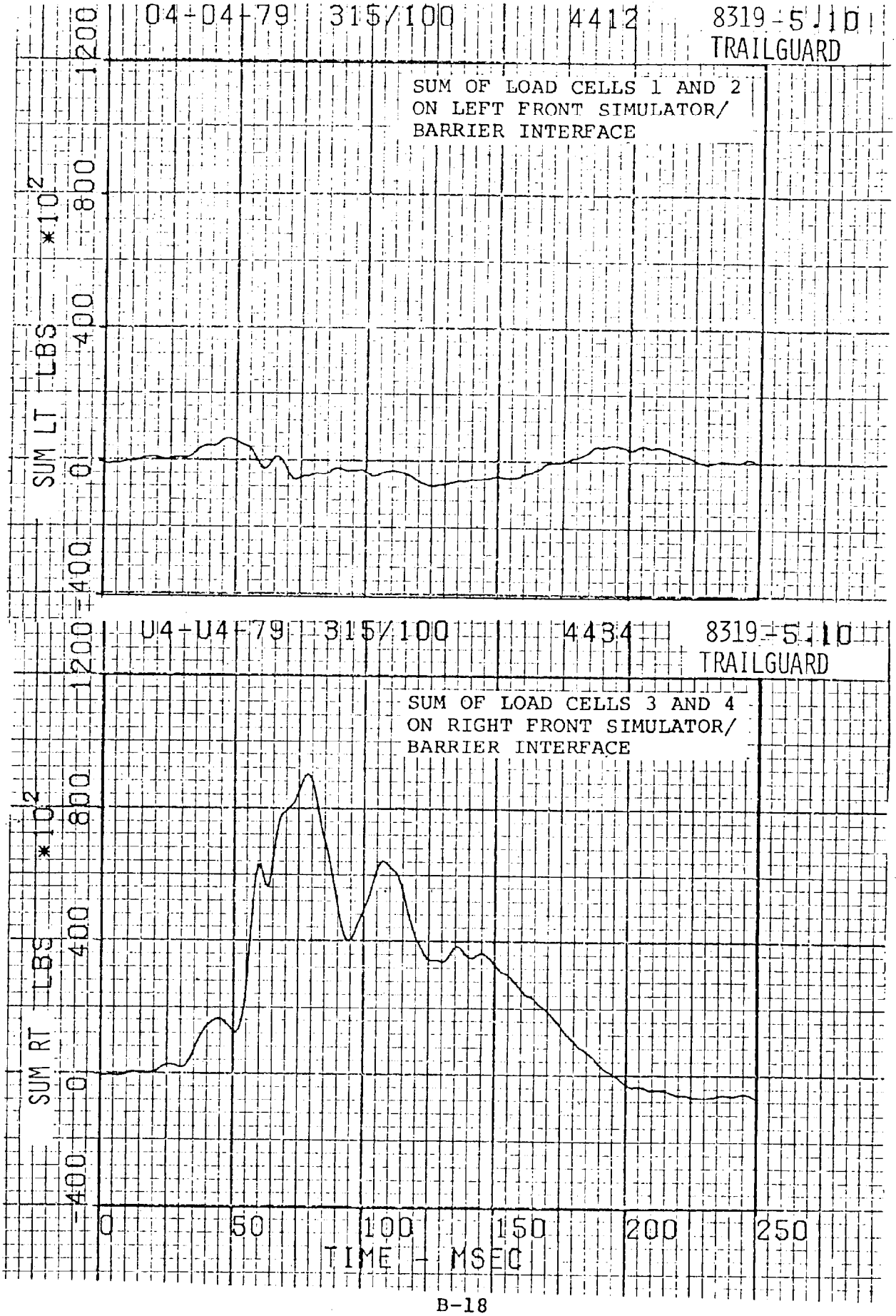

04-04-79 315/100 104 8319-5.10
AX AY 1978 CHEV
FIREWALL ACCELERATION
LOCATION 4
ACCELERATION - G
100
50
0
-50
-100

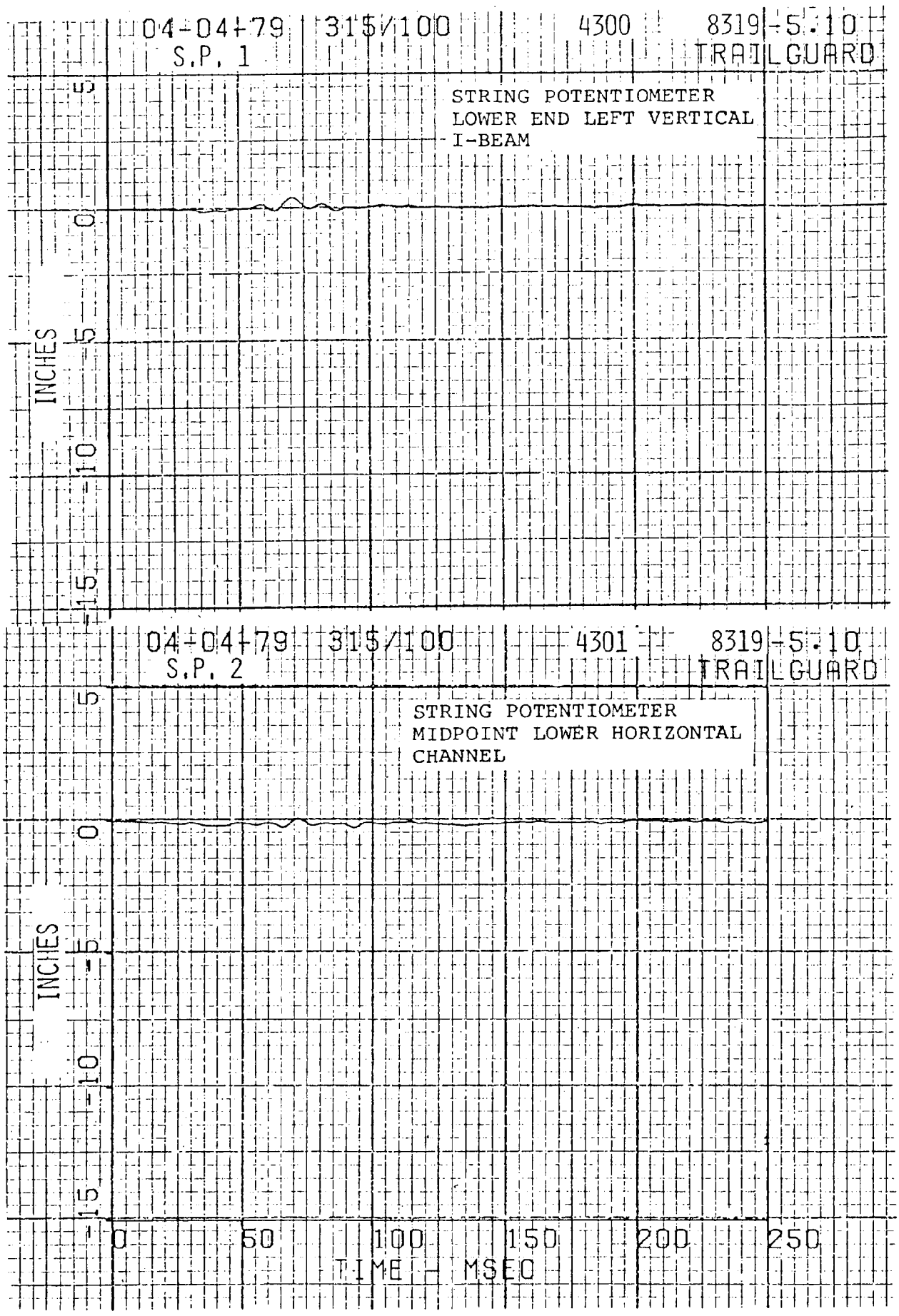

04-04-79 315/100 107 8319-5.10
1978 CHEV
FRONT CROSSMEMBER ACCELERATION
LOCATION 7
AX - G
200
100
0
-100
-200
0
50
100
150
200
250
TIME - MSEC

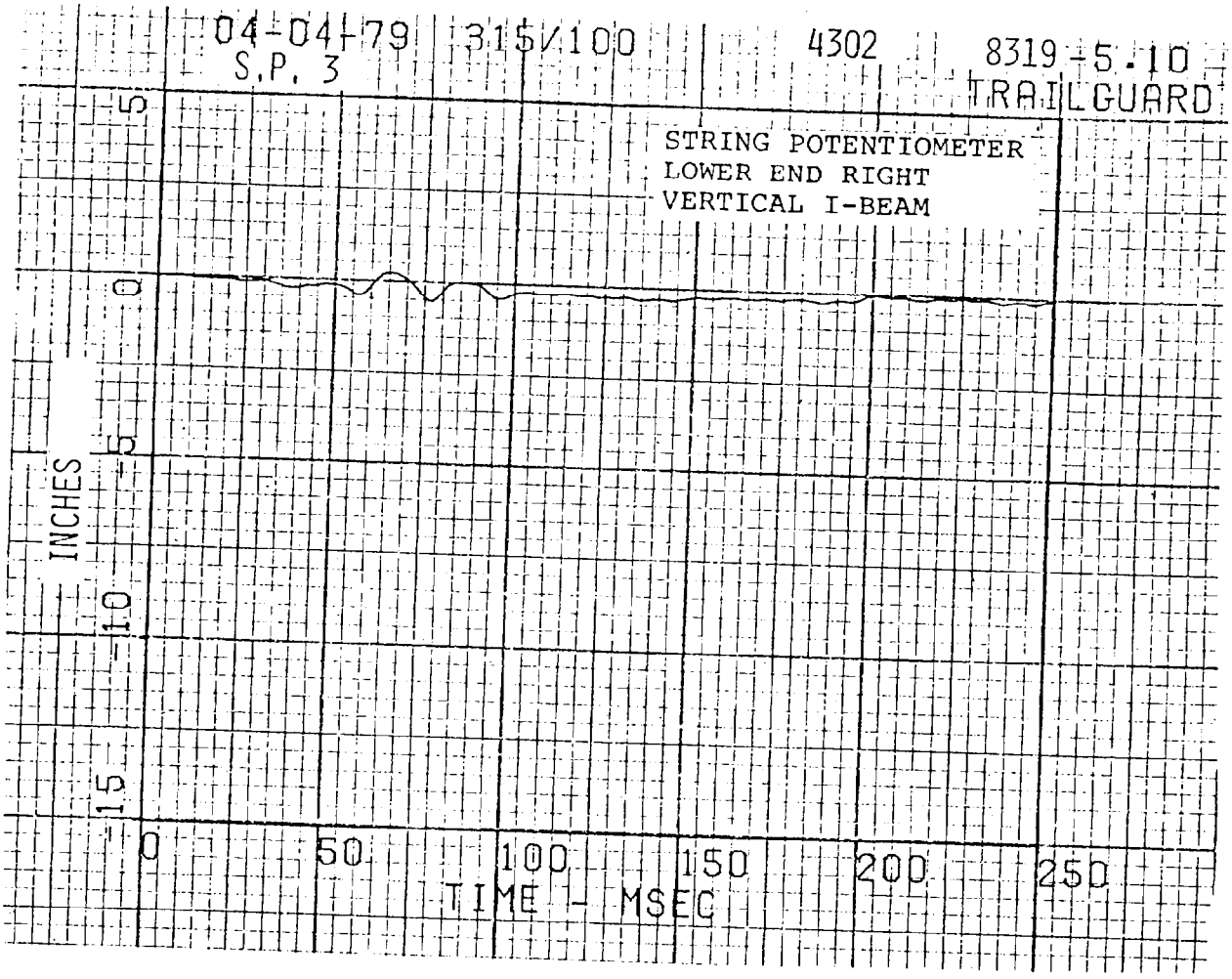

04-04-79 315/100 106 8319 5.10
AX AZ 1978 CHEV
UPPER ENGINE LONGITUDINAL
AND VERTICAL ACCELERATION
LOCATION 6
ACCELERATION - G
200
100
0
-100
-200
AZ DATA INVALID
AFTER 100 MSEC
0
50
100
150
200
250
TIME - MSEC

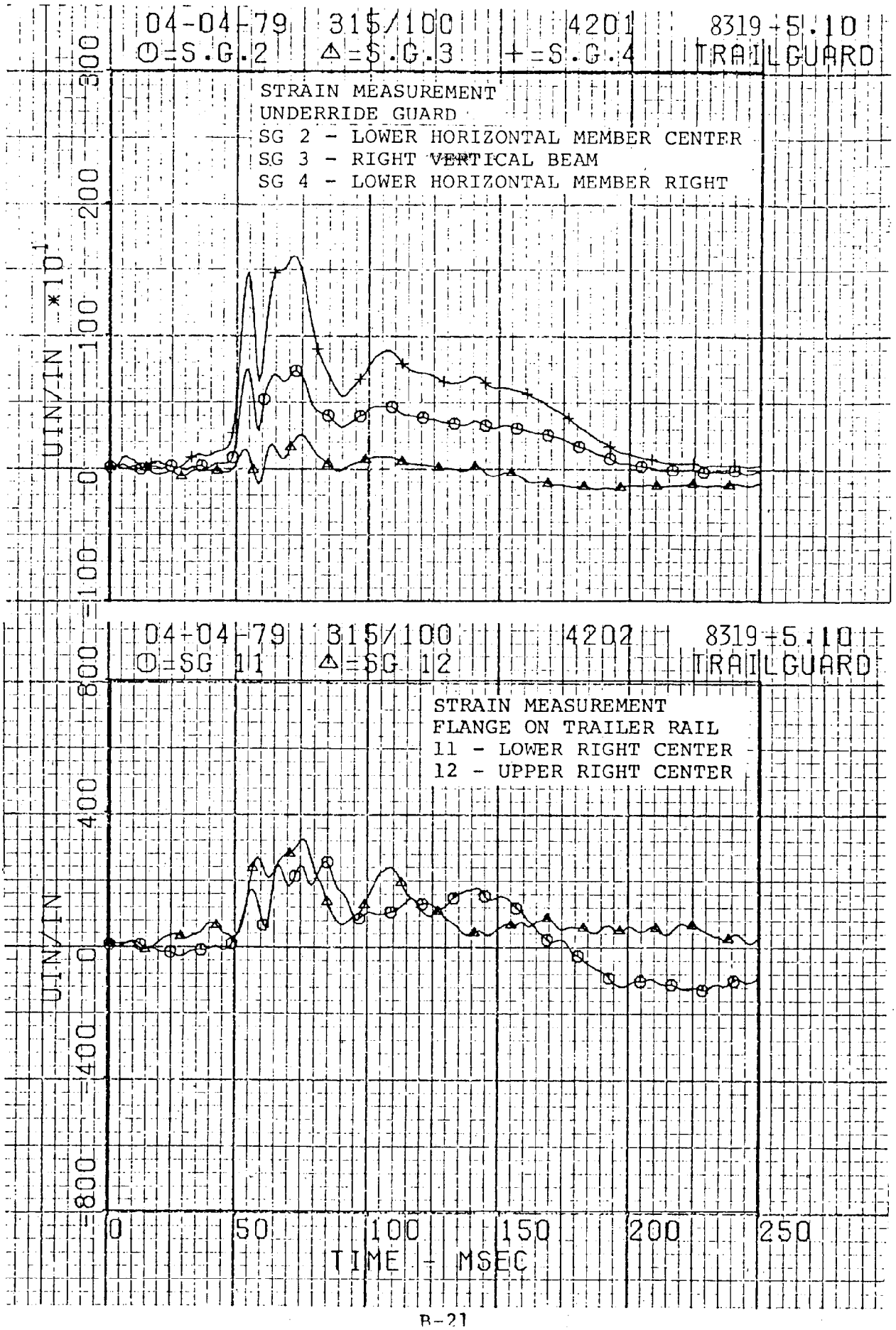

04-04-79 315/100 202 8319-5.10
TRAILGUARD
RIGHT MAIN TRAILER BEAM
ACCELERATION (REAR)
AX - G
20
10
0
-10
-20

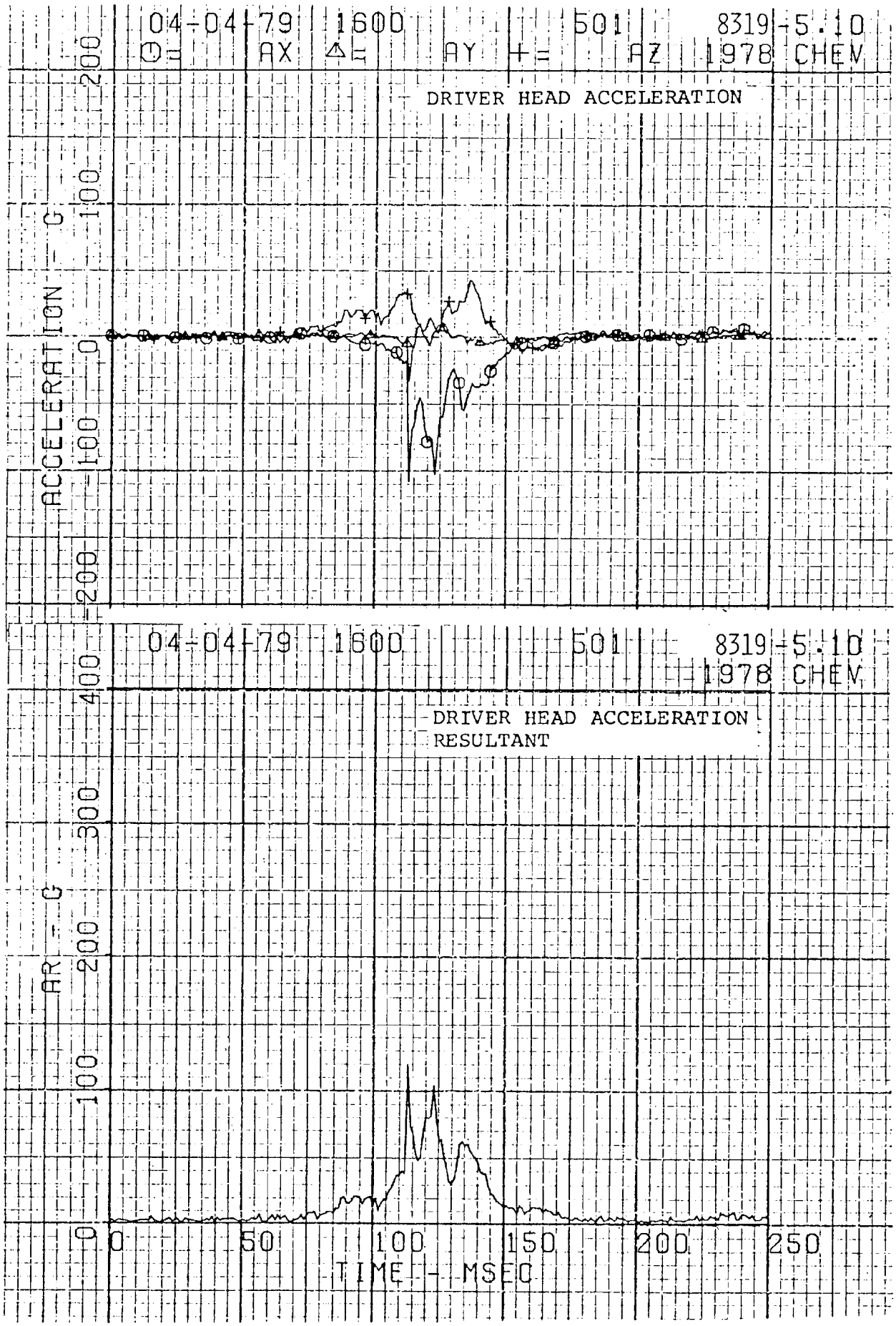

04-04-79 315/100 4480 8319-5.10
TRAILGUARD
TOTAL LOAD SIMULATOR/
BARRIER INTERFACE
TOTAL LBS *10^3
300
200
100
0
-100
0
50
100
150
200
250
TIME - MSEC

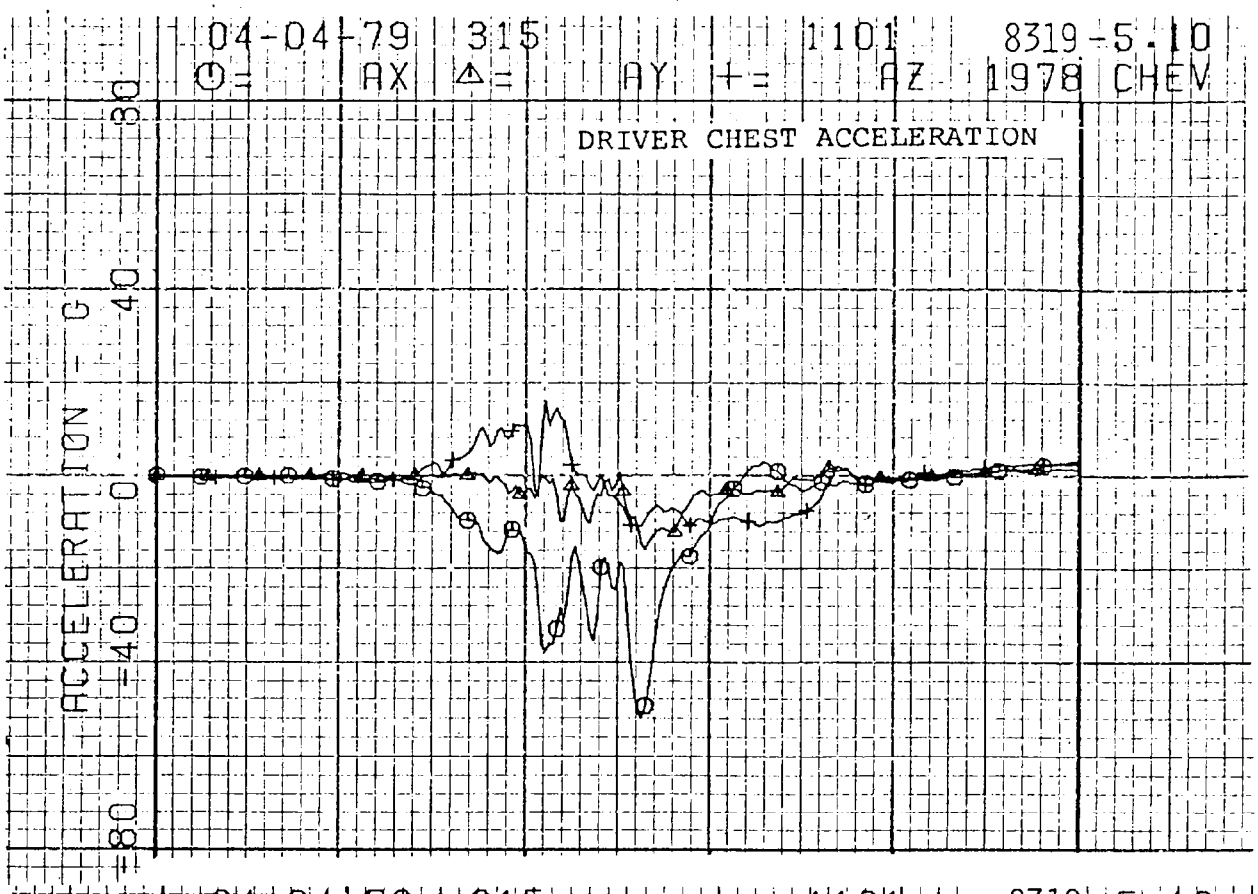

04-04-79 315/100 4412 8319-5.10
TRAILGUARD
SUM OF LOAD CELLS 1 AND 2
ON LEFT FRONT SIMULATOR/
BARRIER INTERFACE
SUM LT LBS *10^2
1200
800
400
0
-400
04-04-79 315/100 4434 8319-5.10
TRAILGUARD
SUM OF LOAD CELLS 3 AND 4
ON RIGHT FRONT SIMULATOR/
BARRIER INTERFACE
SUM RT LBS *10^2
1200
800
400
0
-400
0
50
100
150
200
250
TIME - MSEC

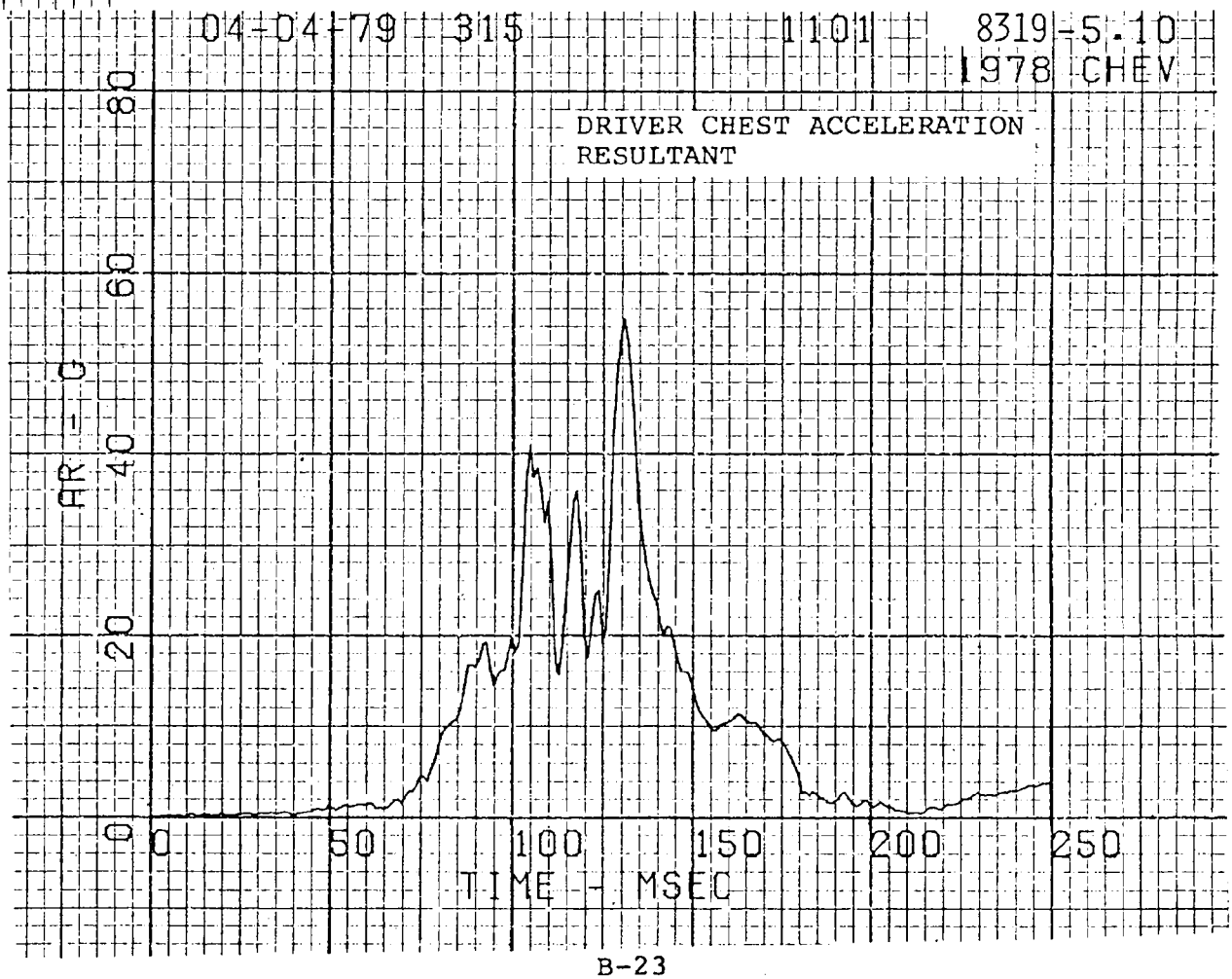

04-04-79 315/100 4300 8319-5.10
S.P. 1
TRAILGUARD
STRING POTENTIOMETER
LOWER END LEFT VERTICAL
I-BEAM
INCHES
5
0
-5
-10
-15
04-04-79 315/100 4301 8319-5.10
S.P. 2
TRAILGUARD
STRING POTENTIOMETER
MIDPOINT LOWER HORIZONTAL
CHANNEL
INCHES
5
0
-5
-10
-15
0
50
100
150
200
250
TIME - MSEC

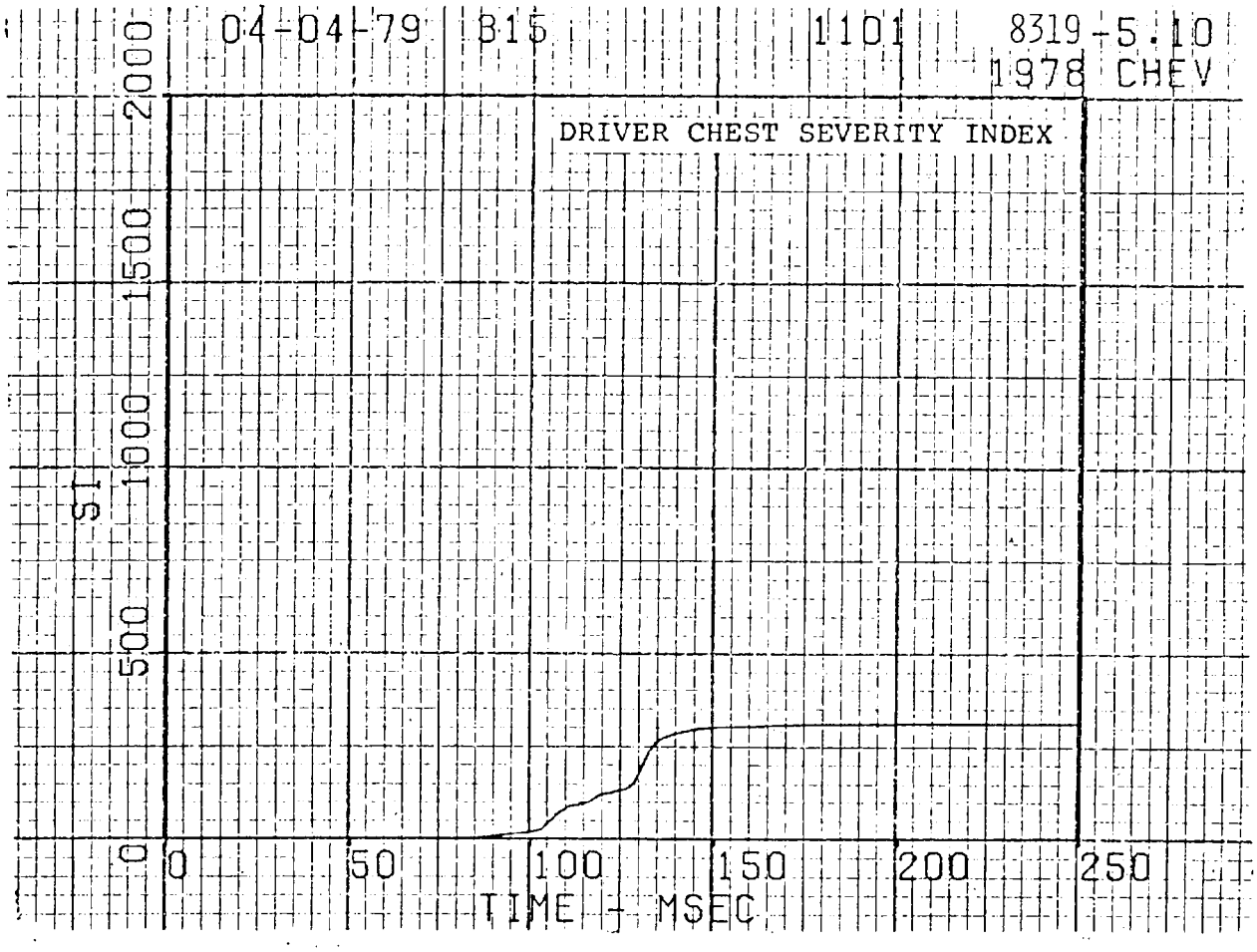

04-04-79 315/100 4302 8319-5.10
S.P. 3
TRAILGUARD
STRING POTENTIOMETER
LOWER END RIGHT
VERTICAL I-BEAM
INCHES
5
0
-5
-10
-15
0
50
100
150
200
250
TIME - MSEC

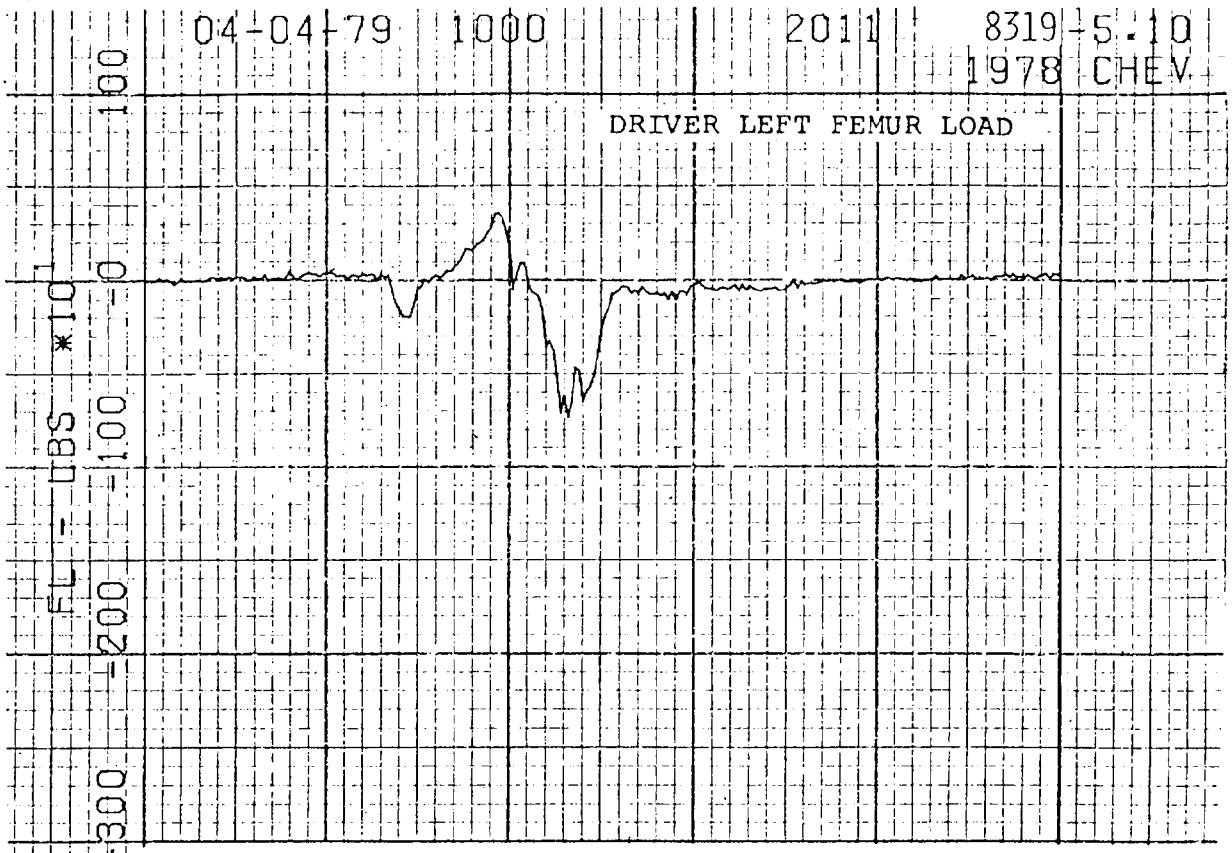

04-04-79 315/100 4201 8319+5.10
○=S.G.2 △=S.G.3 +=S.G.4 TRAILGUARD
STRAIN MEASUREMENT
UNDERRIDE GUARD
SG 2 - LOWER HORIZONTAL MEMBER CENTER
SG 3 - RIGHT VERTICAL BEAM
SG 4 - LOWER HORIZONTAL MEMBER RIGHT
UIN/IN *10⁻⁴
300
200
100
0
=100
04-04-79 315/100 4202 8319+5.10
○=SG 11 △=SG 12 TRAILGUARD
STRAIN MEASUREMENT
FLANGE ON TRAILER RAIL
11 - LOWER RIGHT CENTER
12 - UPPER RIGHT CENTER
UIN/IN
800
400
0
=400
=800
0
50
100
150
200
250
TIME - MSEC

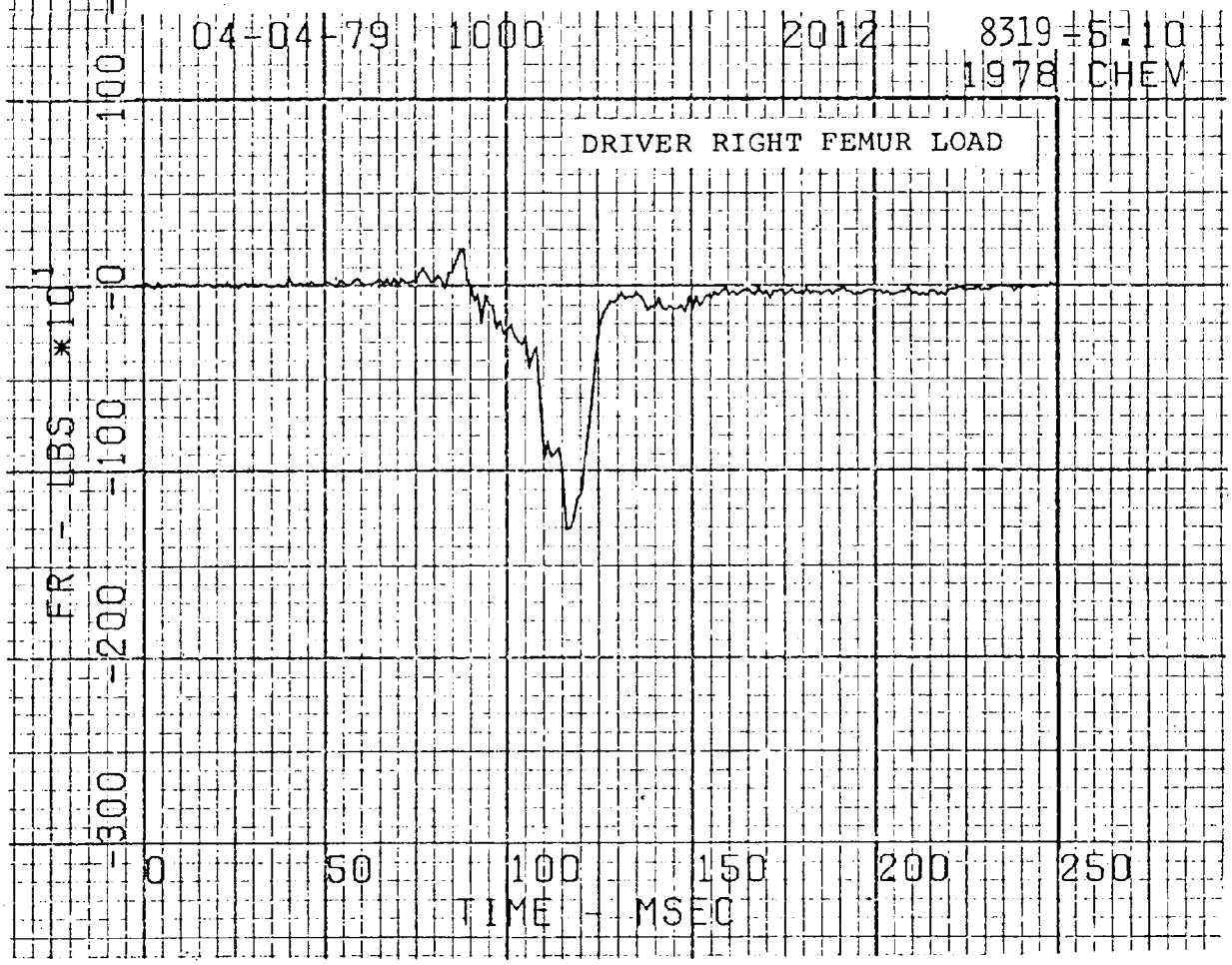

04-04-79 1600 501 8319-5.10
AX AY AZ 1978 CHEV
DRIVER HEAD ACCELERATION
ACCELERATION - G
200
100
0
-100
-200
04-04-79 1600 501 8319-5.10
1978 CHEV
DRIVER HEAD ACCELERATION
RESULTANT
AR - G
400
300
200
100
0
0
50
100
150
200
250
TIME - MSEC

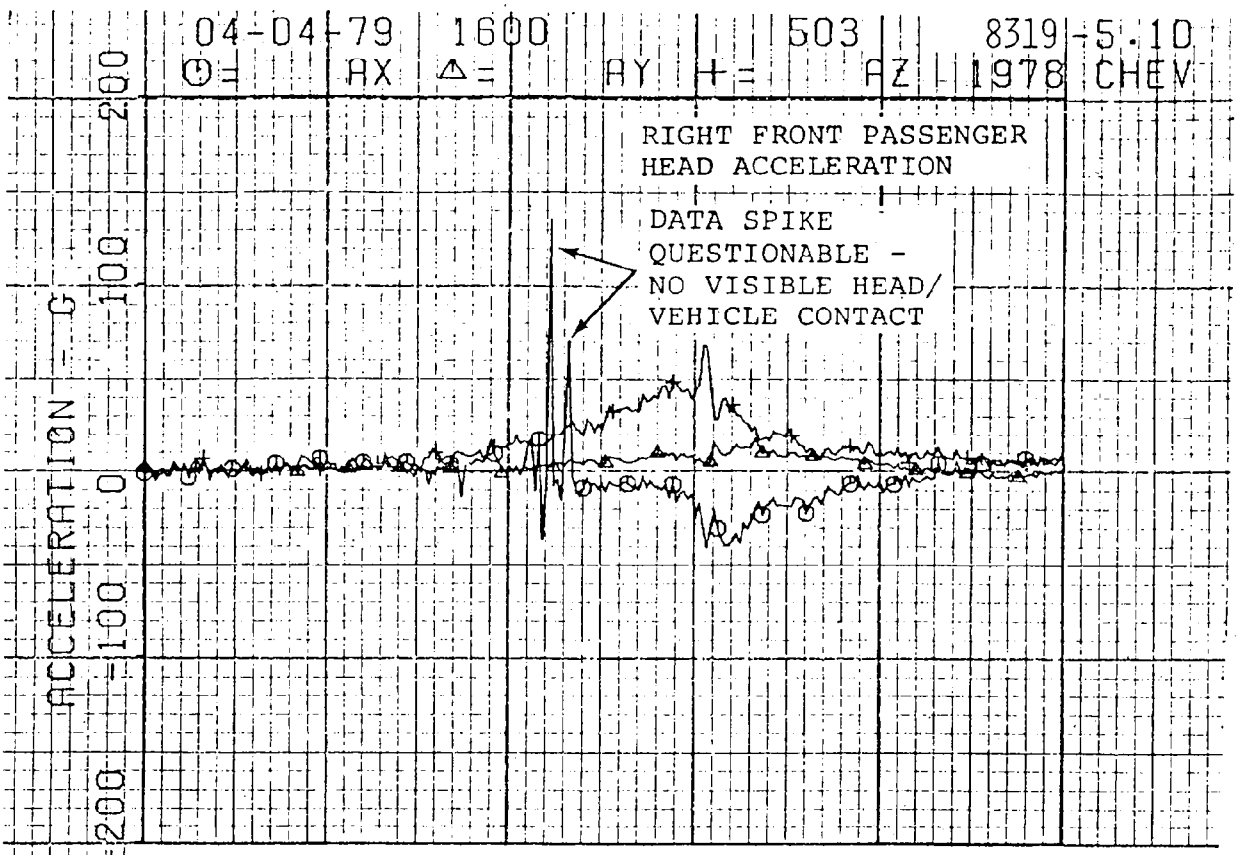

04-04-79 315 1101 8319-5.10
O= AX Δ= AY += AZ 1978 CHEV
DRIVER CHEST ACCELERATION
ACCELERATION - G
30
40
0
-40
-80

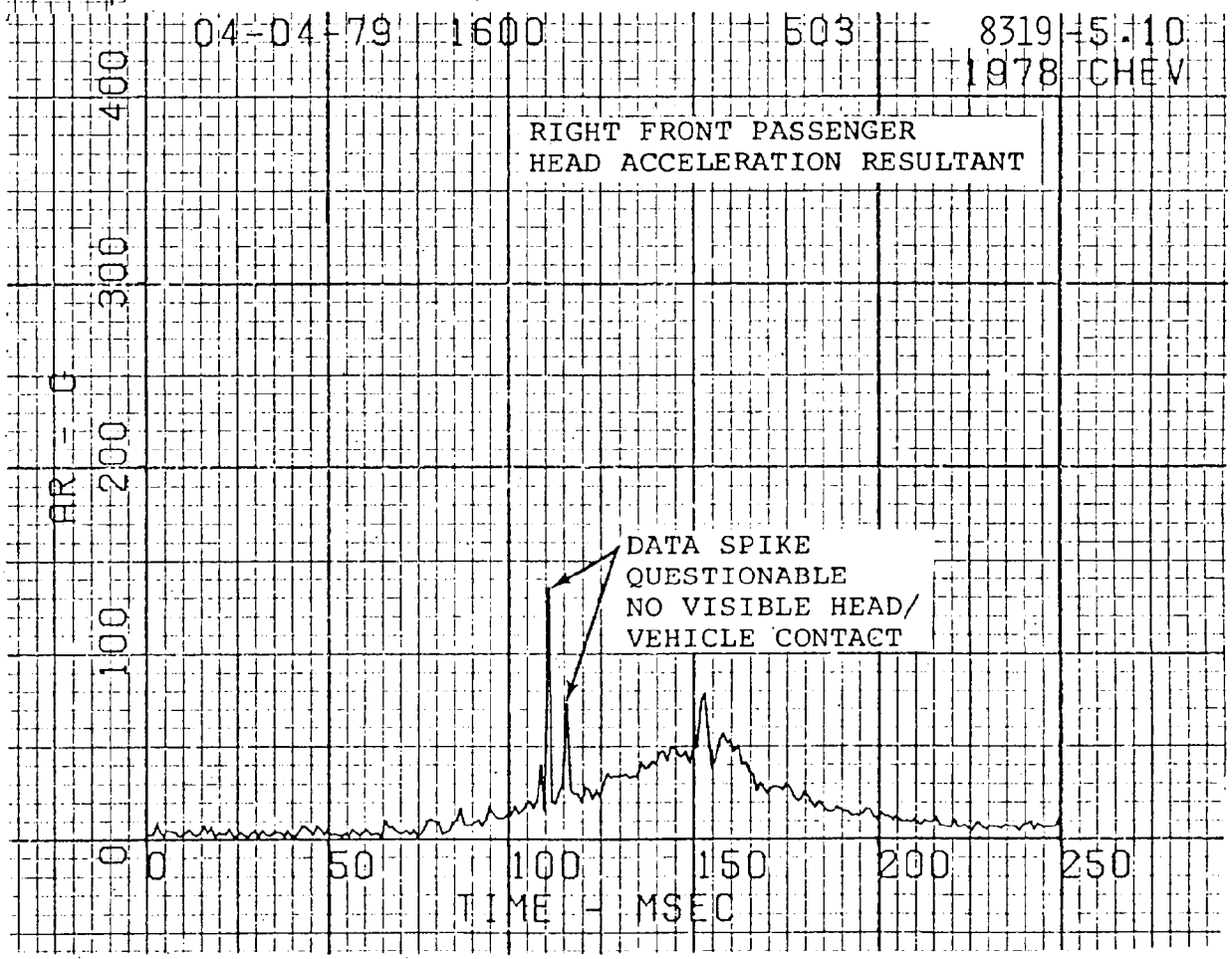

04-04-79 315 1101 8319-5.10
1978 CHEV
DRIVER CHEST ACCELERATION
RESULTANT
AR - G
80
60
40
20
0
0
50
100
150
200
250
TIME - MSEC

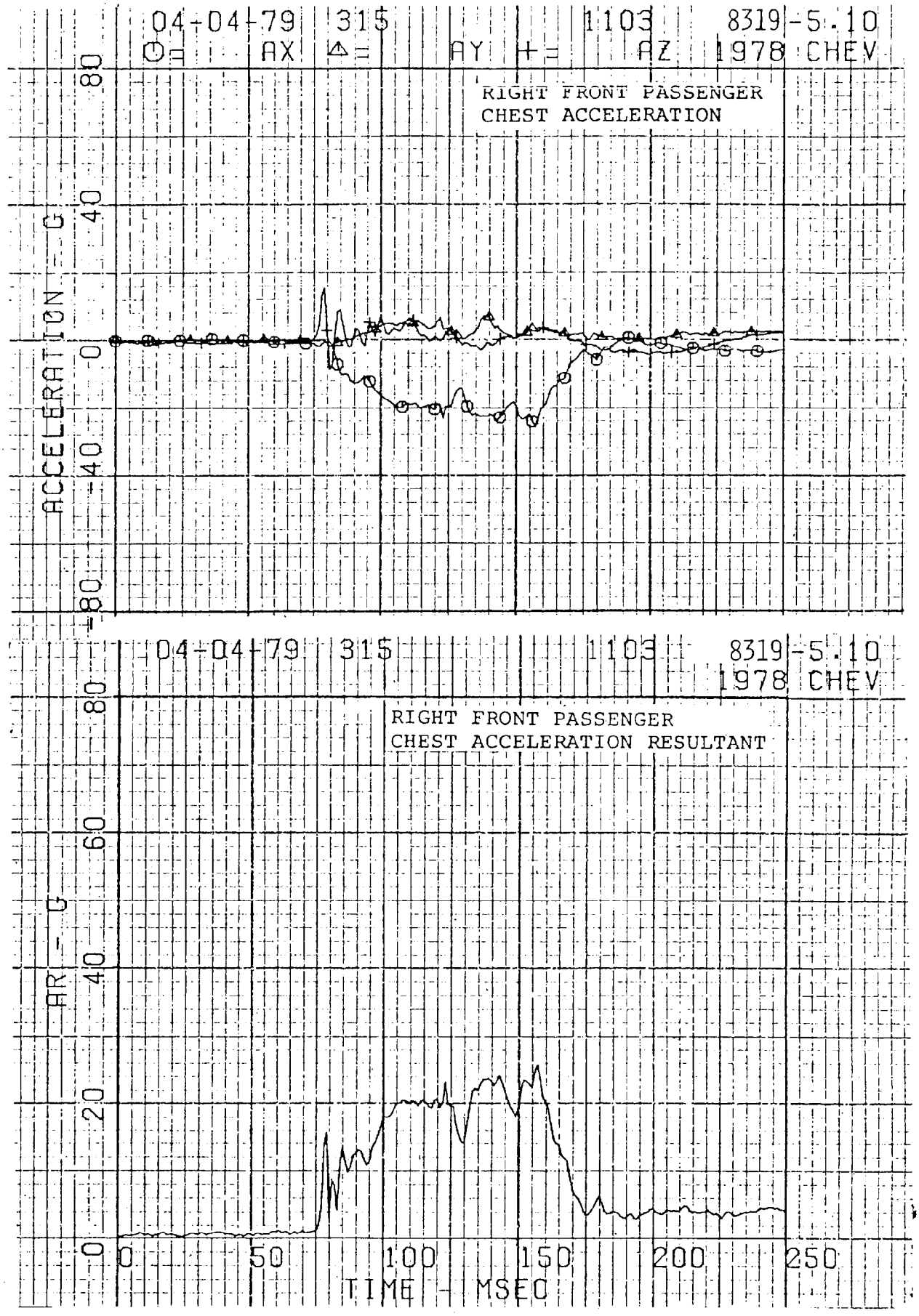

04-04-79 815 1101 8319-5.10
1978 CHEV
DRIVER CHEST SEVERITY INDEX
SI
2000
1500
1000
500
0
0
50
100
150
200
250
TIME - MSEC

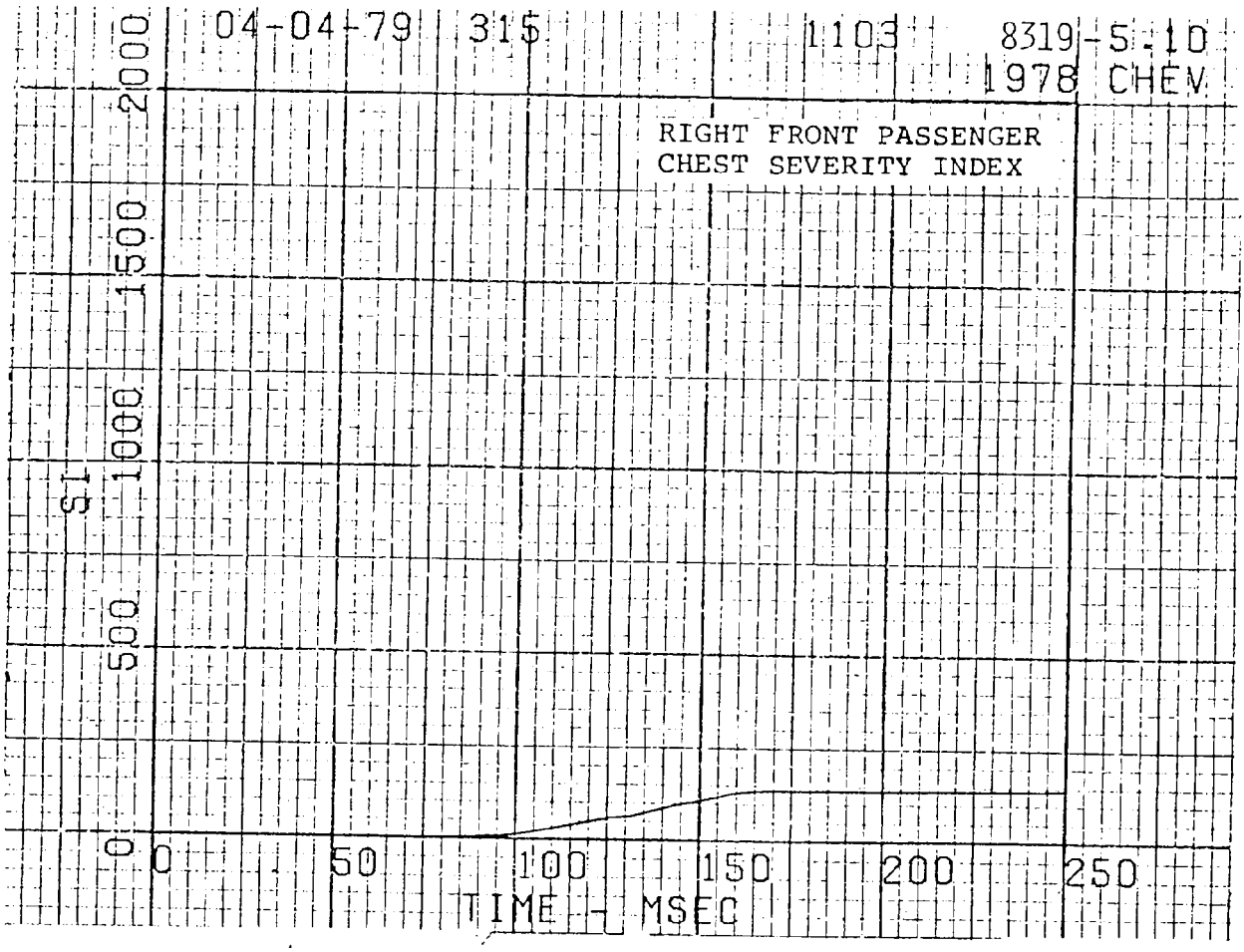

04-04-79 1000 2011 8319-5.10
1978 CHEV.
DRIVER LEFT FEMUR LOAD
FL - LBS *10
100
0
-100
-200
-300

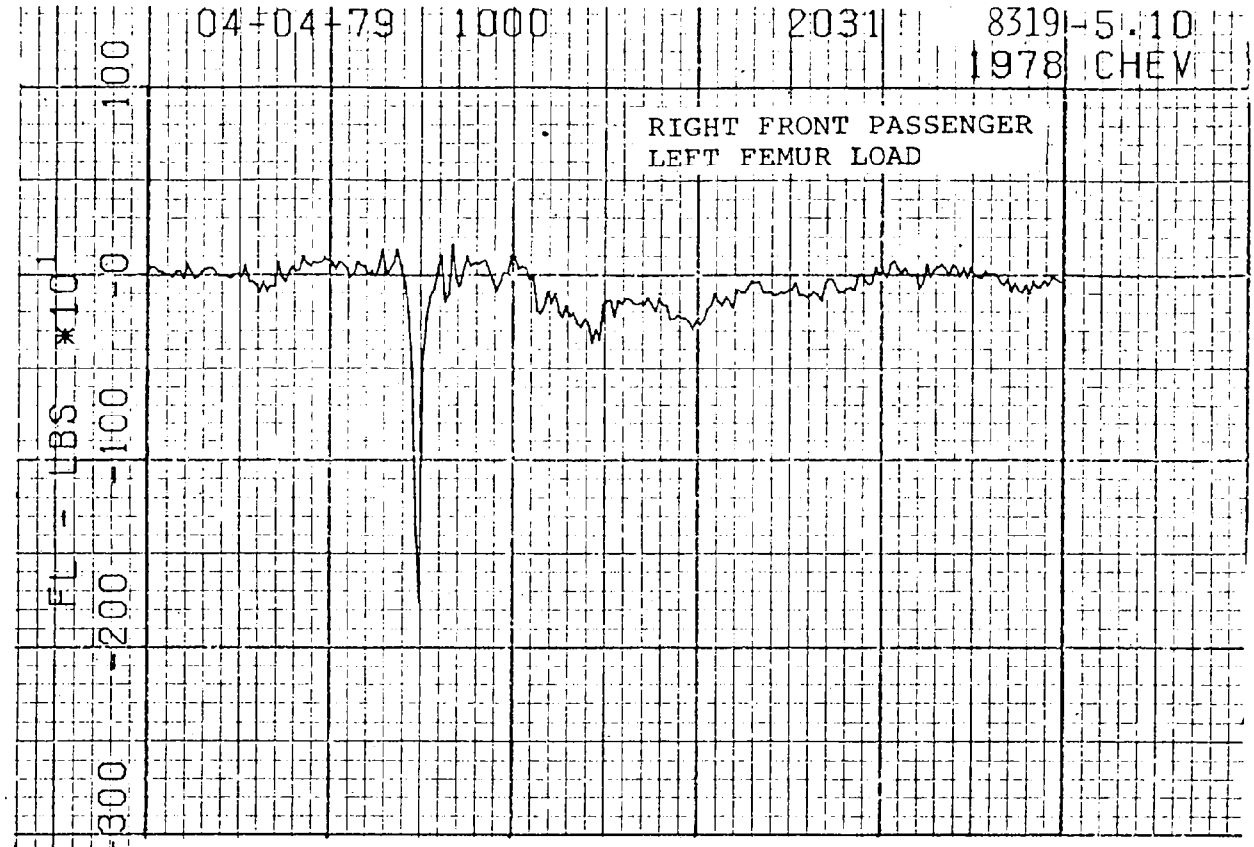

04-04-79 1000 2012 8319-5.10
1978 CHEV.
DRIVER RIGHT FEMUR LOAD
FR - LBS *10
100
0
-100
-200
-300
0
50
100
150
200
250
TIME - MSEC

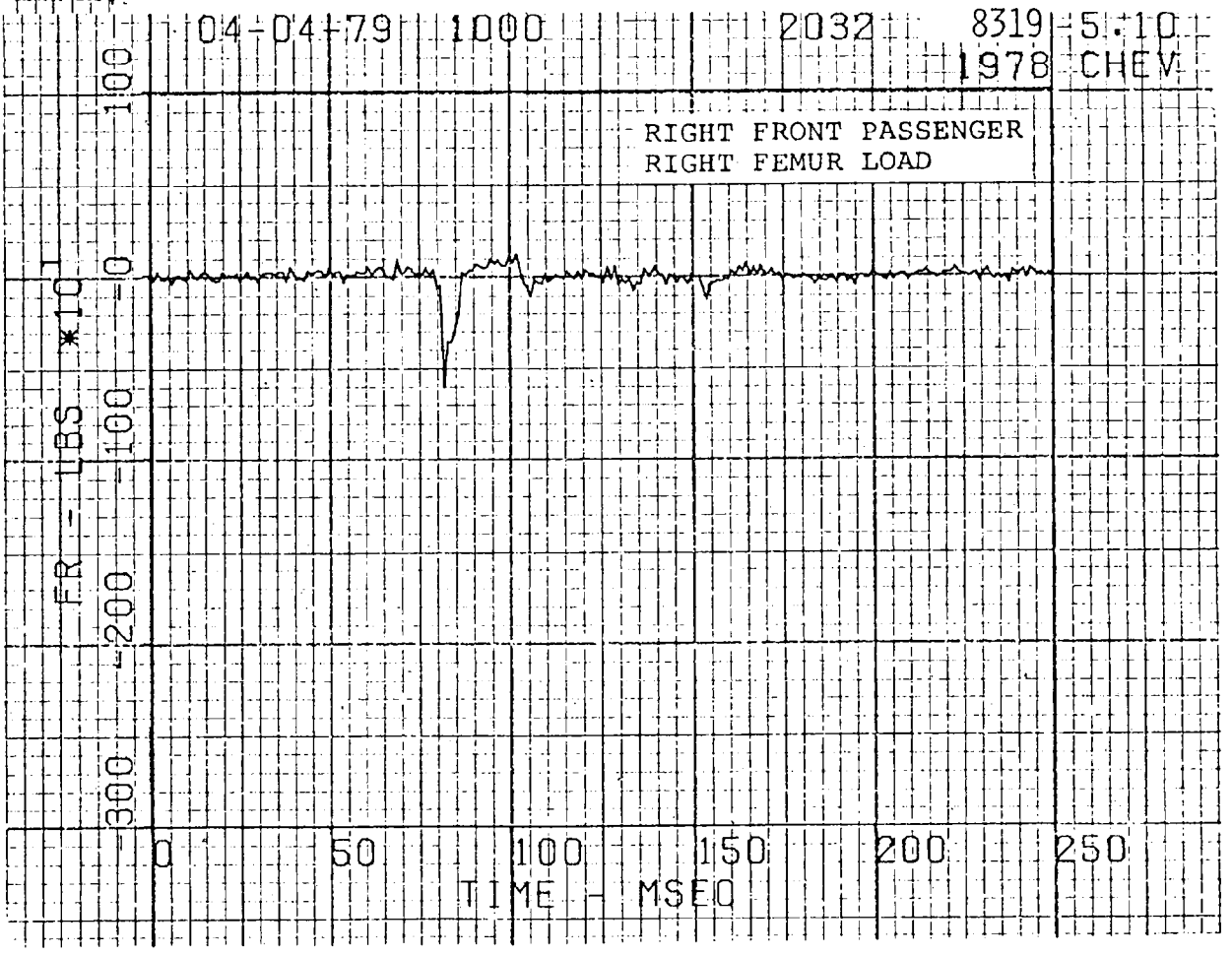

04-04-79 1600 503 8319-5.10
⊙= AX △= AY += AZ 1978 CHEV
RIGHT FRONT PASSENGER
HEAD ACCELERATION
DATA SPIKE
QUESTIONABLE -
NO VISIBLE HEAD/
VEHICLE CONTACT
ACCELERATION = G
200
100
0
-100
-200

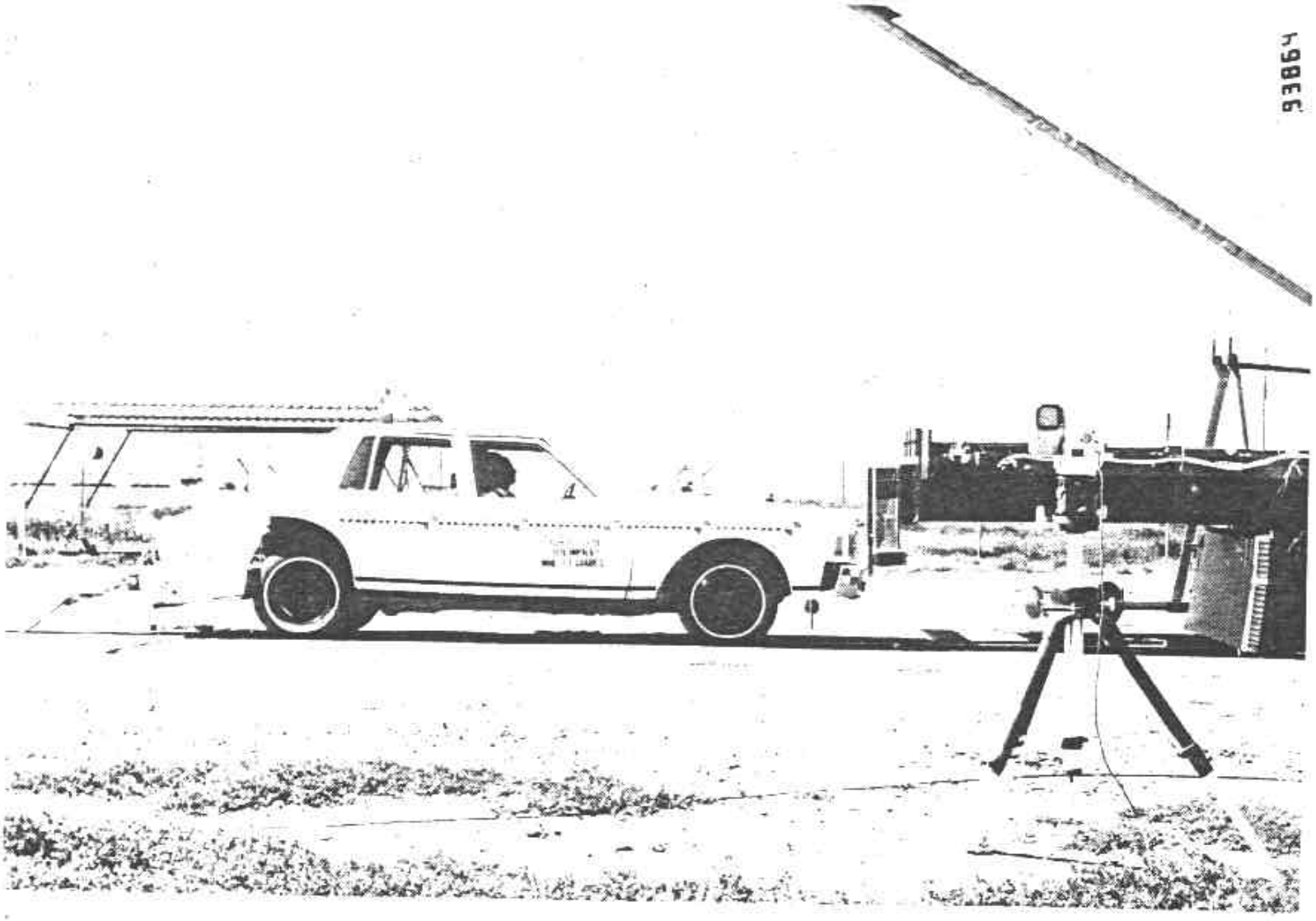

04-04-79 1600 503 8319-5.10
1978 CHEV
RIGHT FRONT PASSENGER
HEAD ACCELERATION RESULTANT
DATA SPIKE
QUESTIONABLE
NO VISIBLE HEAD/
VEHICLE CONTACT
AR = G
400
300
200
100
0
0
50
100
150
200
250
TIME - MSEC


04-04-79 315 1103 8319-5.10
AX AY AZ 1978 CHEV
RIGHT FRONT PASSENGER
CHEST ACCELERATION
ACCELERATION - G
80
40
0
-40
-80
04-04-79 315 1103 8319-5.10
1978 CHEV
RIGHT FRONT PASSENGER
CHEST ACCELERATION RESULTANT
AR - G
80
60
40
20
0
0
50
100
150
200
250
TIME - MSEC

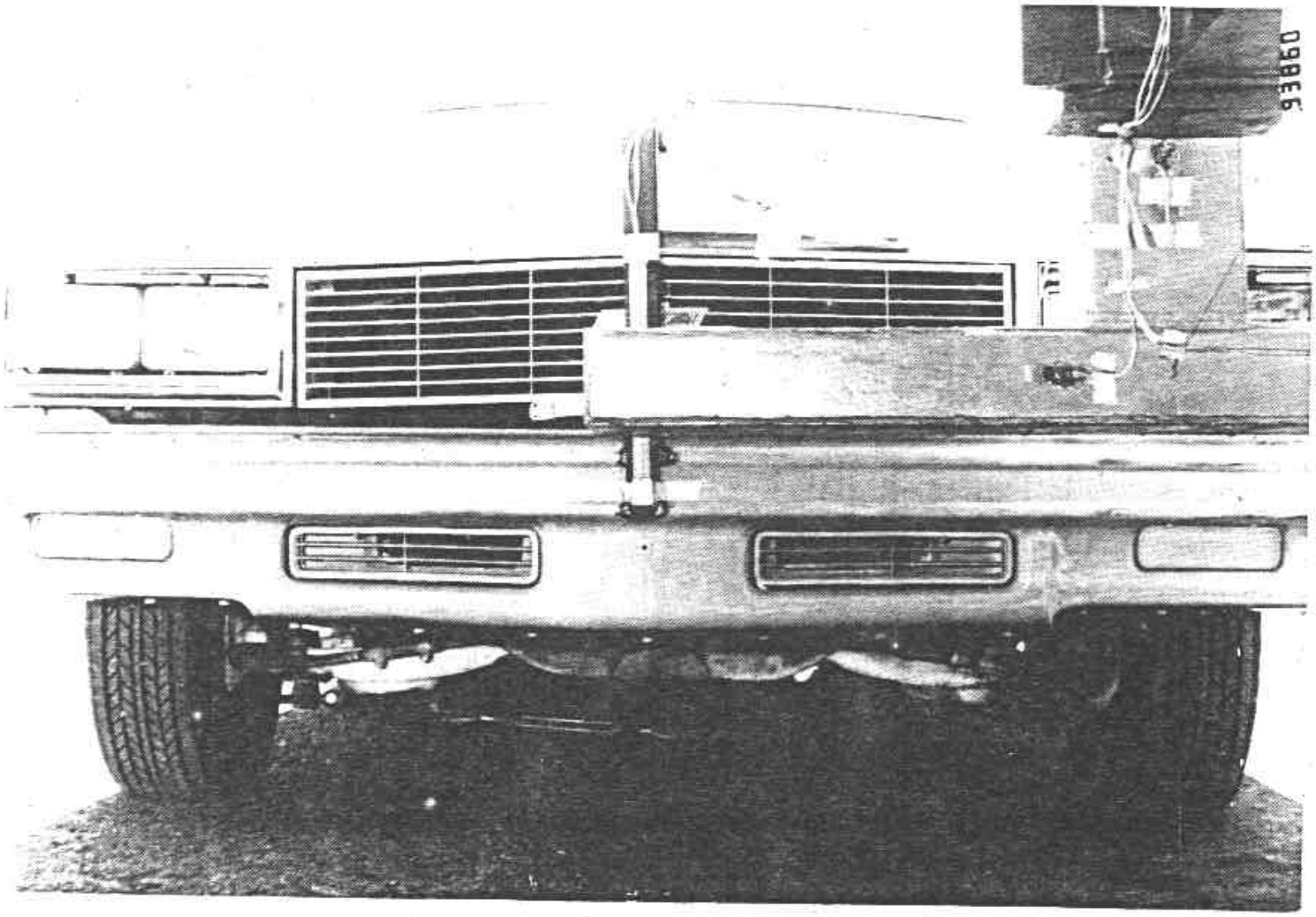

04-04-79 315
1103
8319-5-10
1978 CHEV
RIGHT FRONT PASSENGER
CHEST SEVERITY INDEX
SI
2000
1500
1000
500
0
0
50
100
150
200
250
TIME - MSEC


04-04-79 1000 2031 8319-5.10
1978 CHEV
RIGHT FRONT PASSENGER
LEFT FEMUR LOAD
FL - LBS *10
100
0
-100
-200
-300

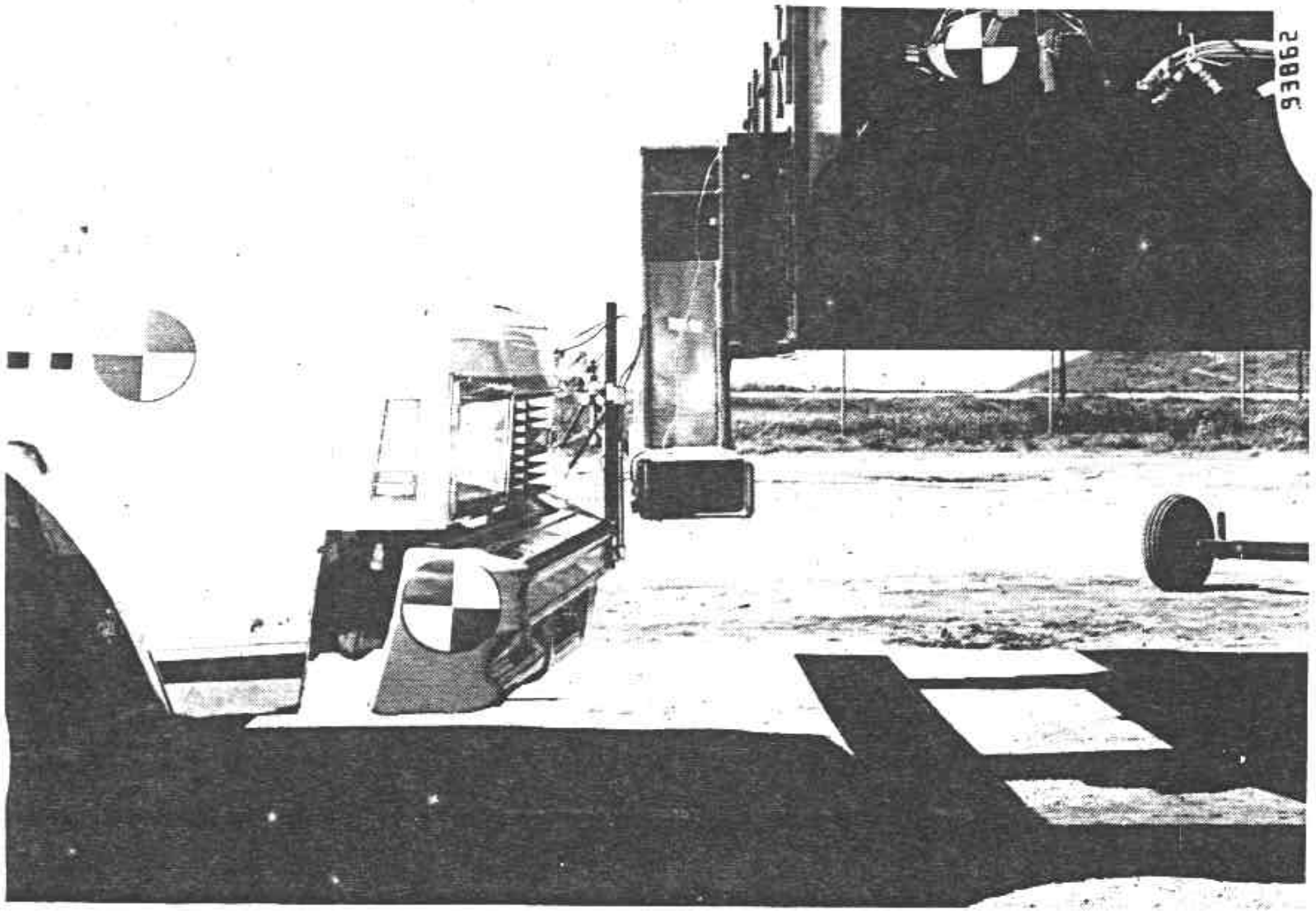

04-04-79 1000 2032 8319-5.10
1978 CHEV
RIGHT FRONT PASSENGER
RIGHT FEMUR LOAD
FR - LBS *10
100
0
-100
-200
-300
0
50
100
150
200
250
TIME - MSEC



Test 5.10 Pre-test Overall View of 1979 Chevrolet Impala/22-inch High T-1 Guard 42-inch Right Offset Crash.

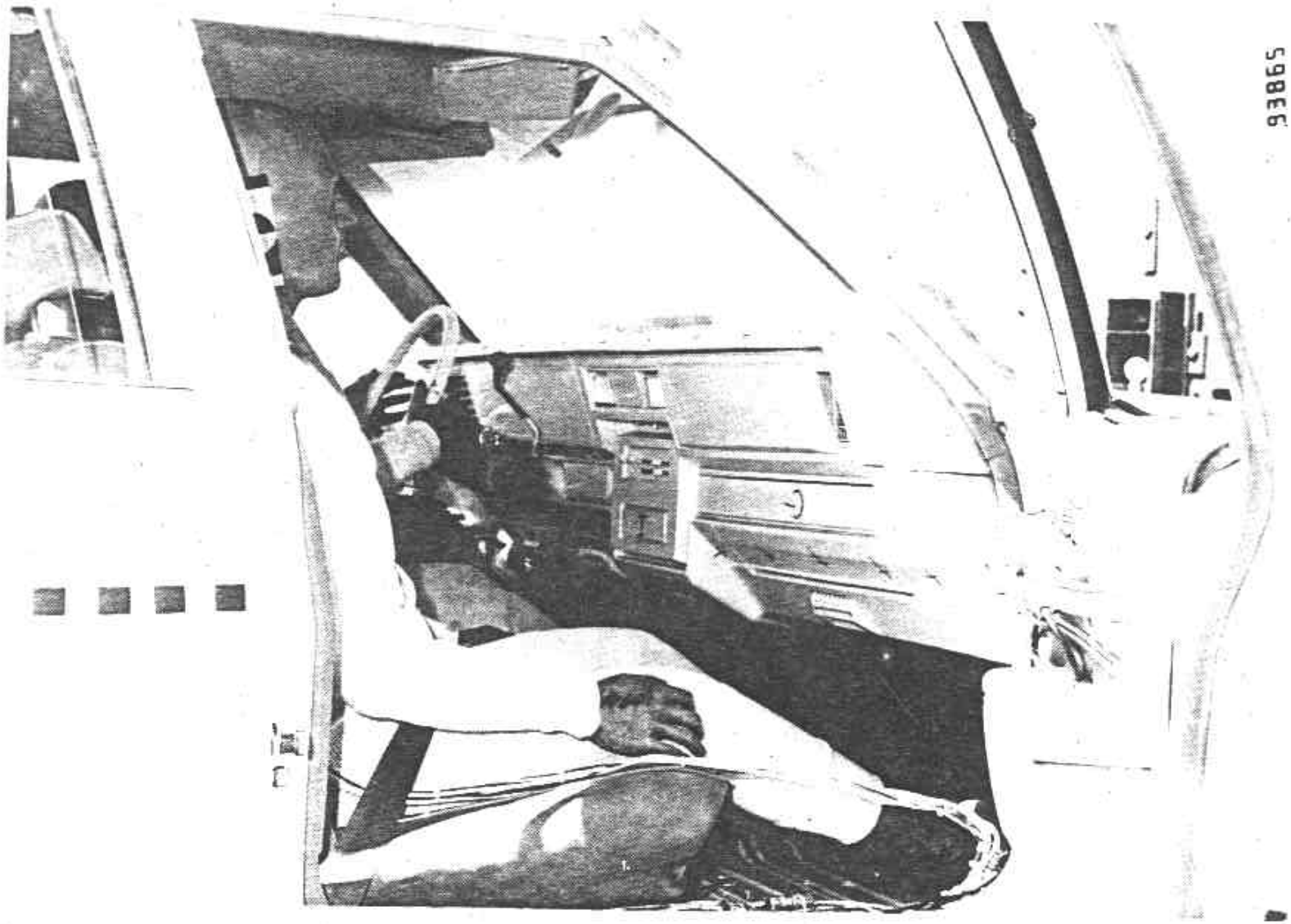


Test 5.10 Pre-test Front View of Test Vehicle and Guard.

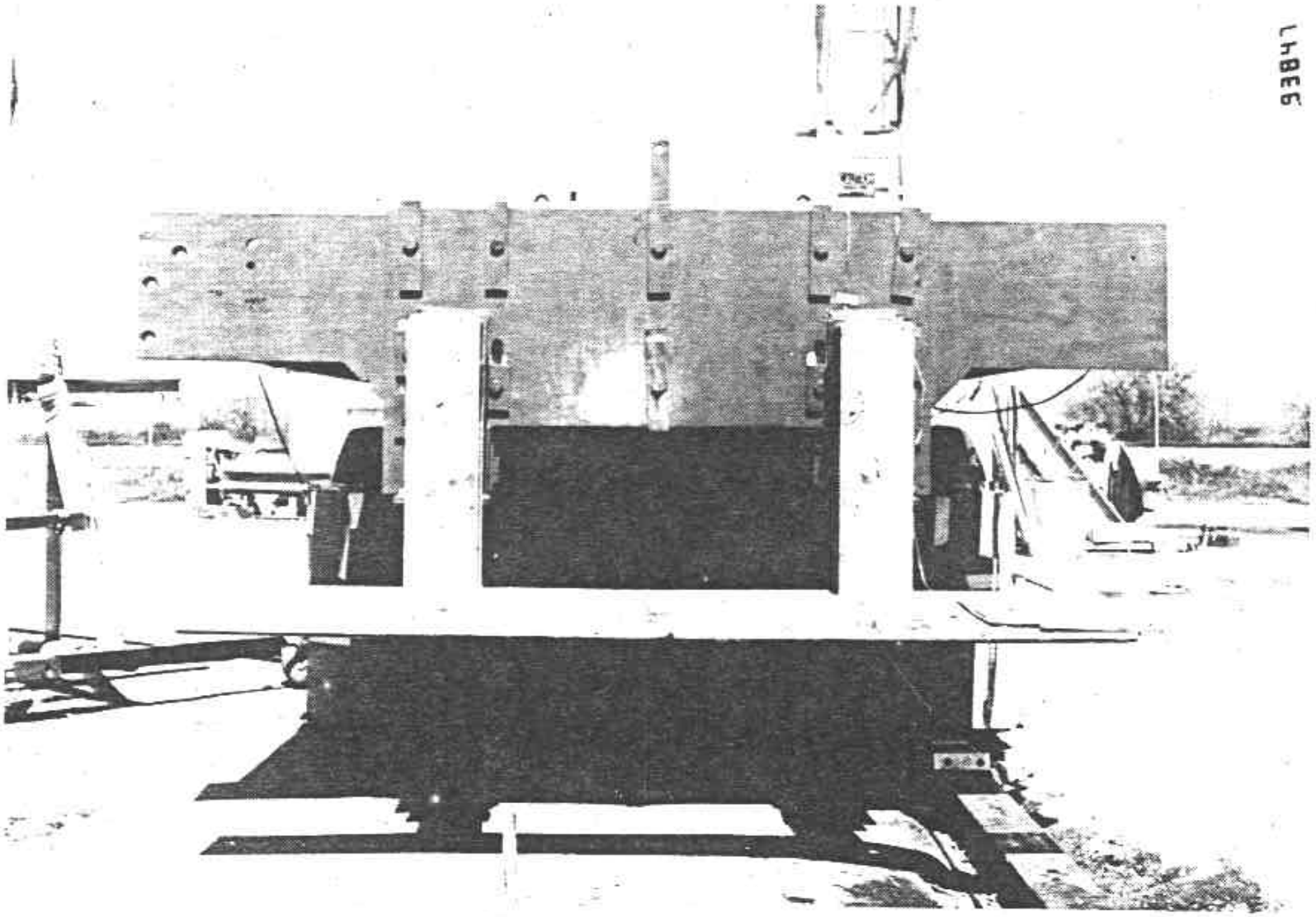


Test 5.10 Pre-test Side View of Test Vehicle/Guard Vertical Alignment.

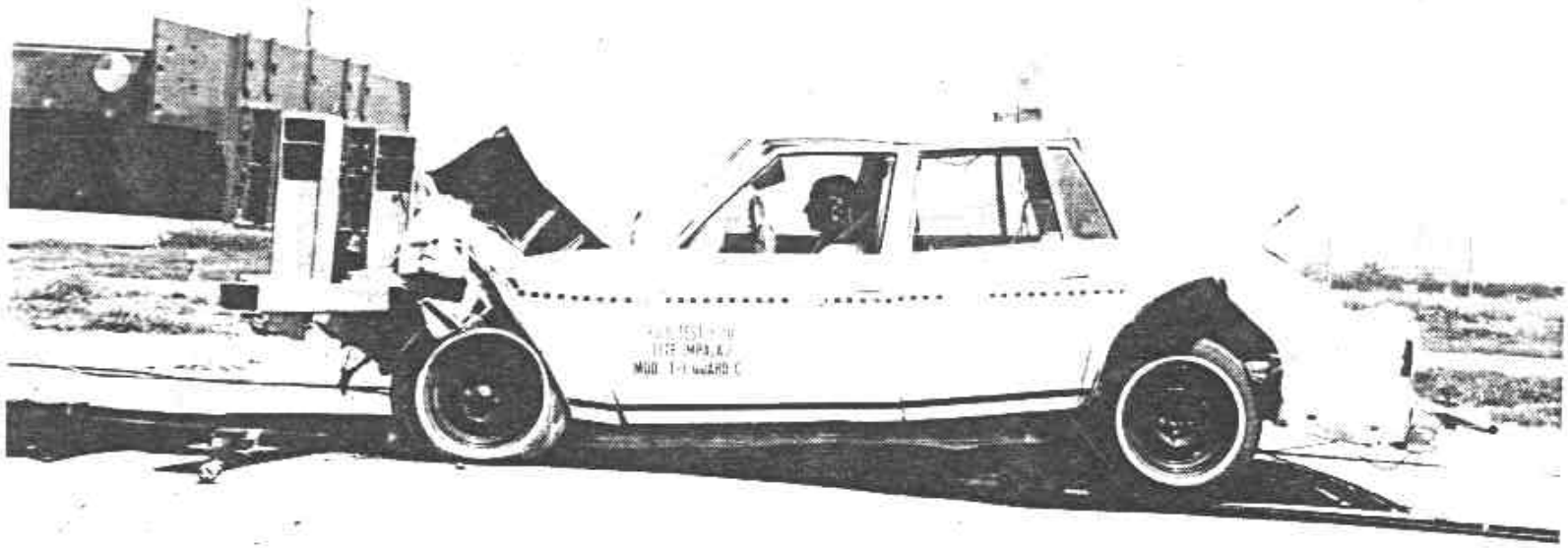
Test 5.10 Pre-test View of Driver Compartment and Dummy.



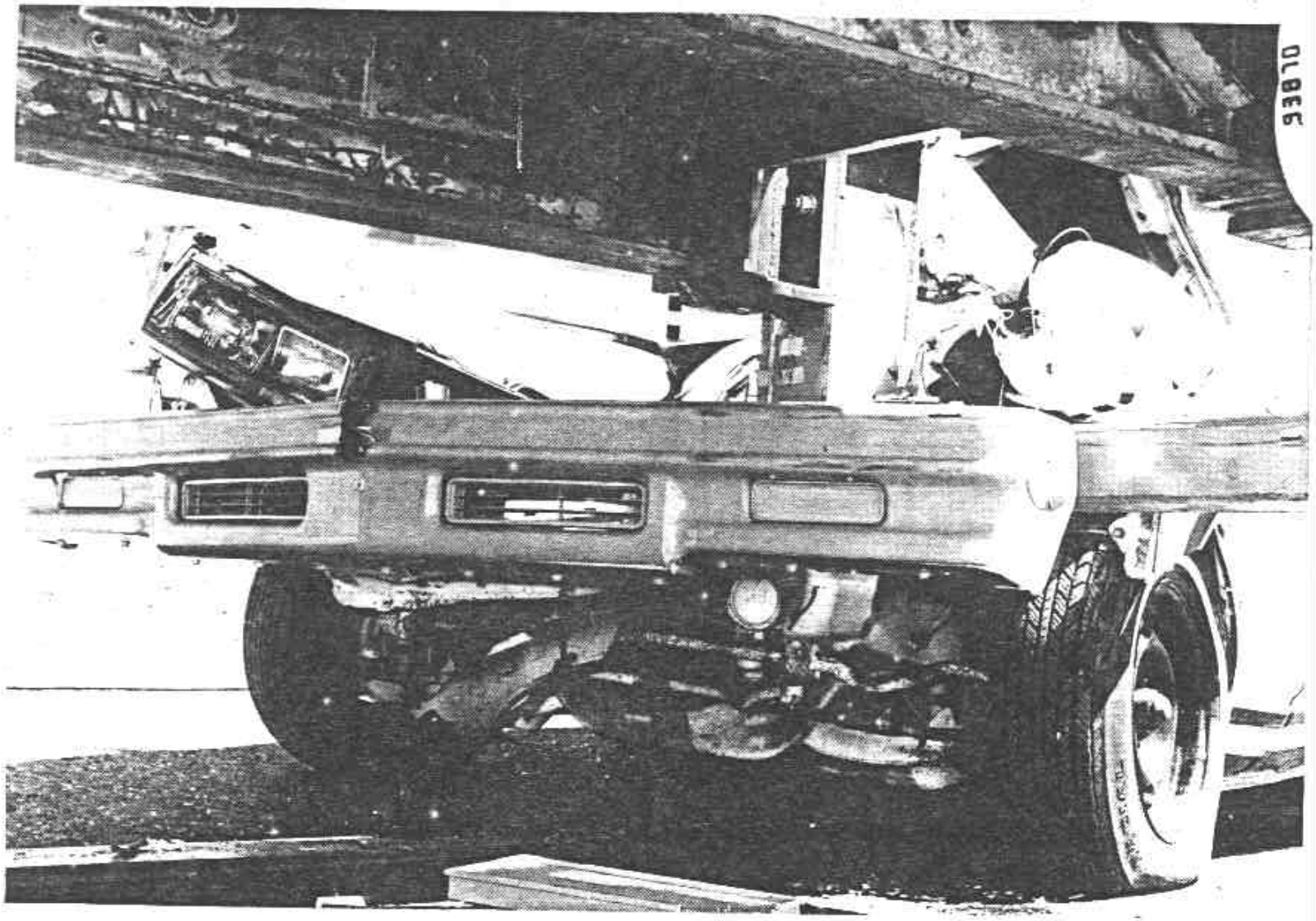
Test 5.10 Pre-test View of Passenger Compartment and Dummy.



Test 5.10 Pre-test Overall View of Underride Guard.

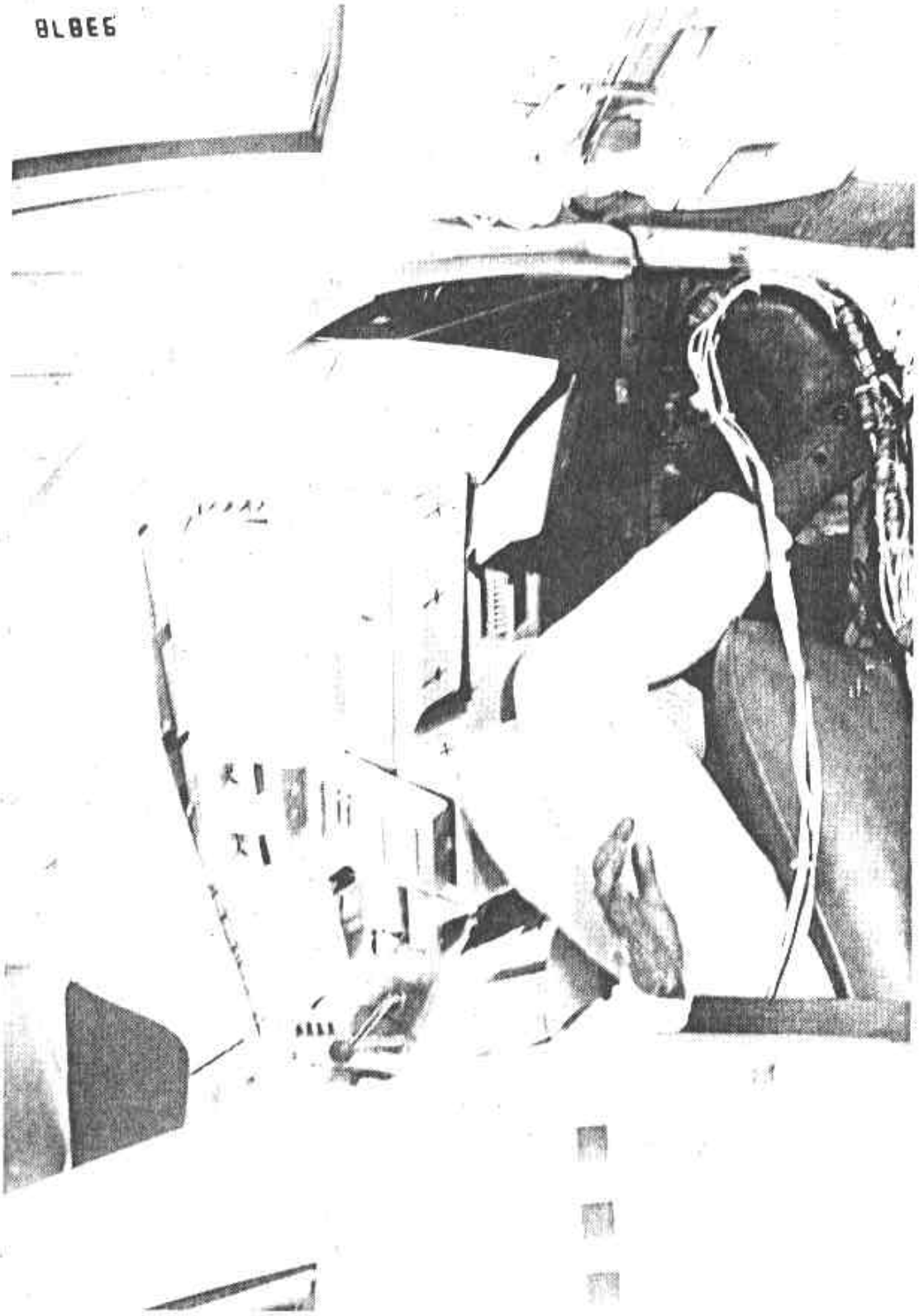


Test 5.10 Post-test Overall View of 1978 Chevrolet Impala/22-inch High T-1 Guard 42-inch Right Offset Crash.

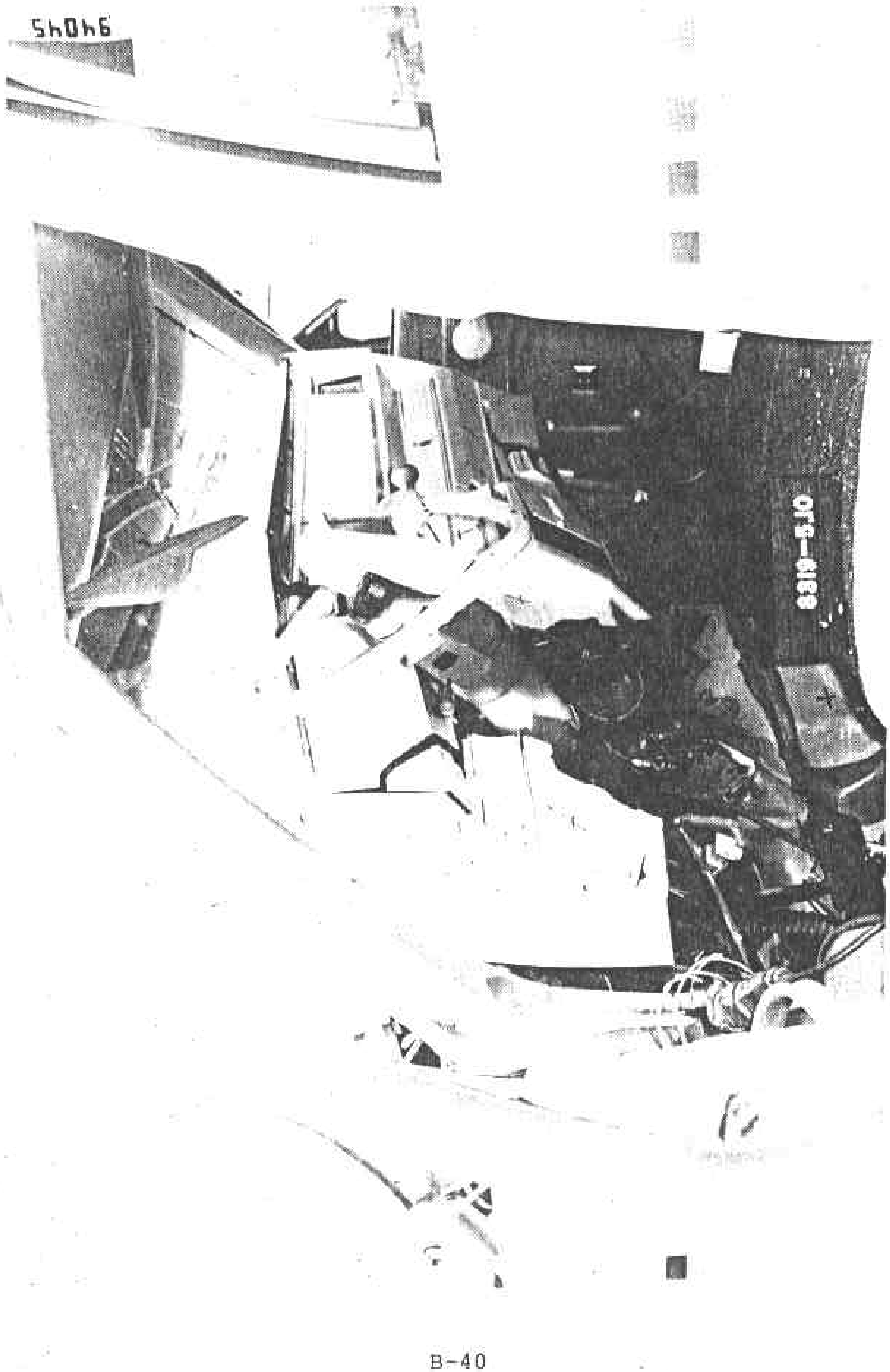


Test 5.10 Post-test Closeup View of Vehicle/Guard (Front - Driver Side).

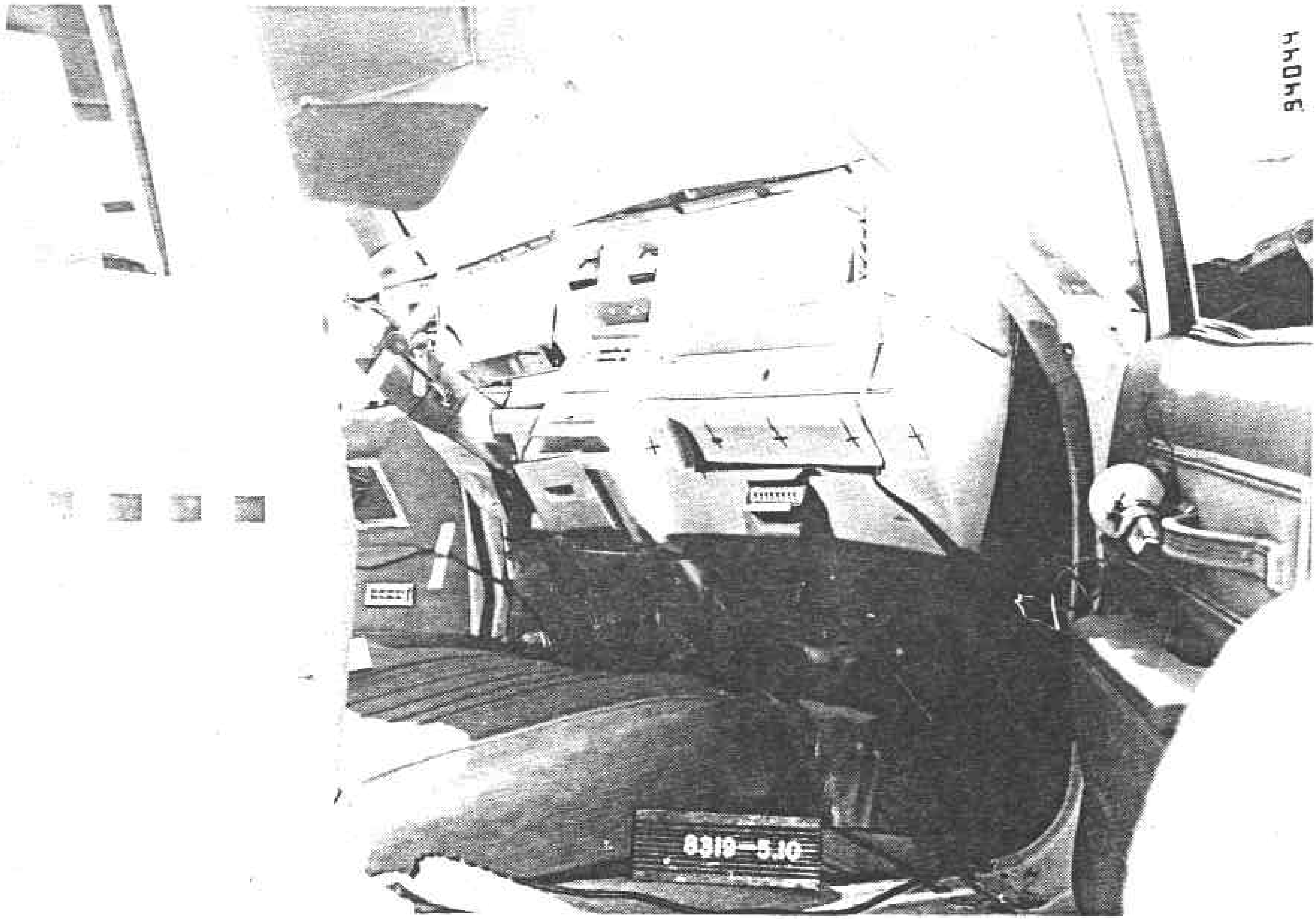
Test 5.10 Post-test View of Driver Dummy.



Test 5.10 Post-test View of Passenger Dummy.



Test 5.10 Post-test View of Driver Compartment.



Test 5.10 Post-test View of Passenger Compartment.