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PARATRANSIT VEHICLE TEST AND EVALUATION
Volume II: Acceleration and Interior Measurement Tests

L. Wesson
C. Culley
R.L. Anderson

Dynamic Science, Inc.
1850 West Pinnacle Peak Road
Phoenix AZ 85047

JUNE 1978

FINAL REPORT

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16. Abstract

The vehicles presently available for paratransit service do not cover the full spectrum of required characteristics necessary for public transportation. Therefore, specifications were developed by the U.S. Government for a vehicle specifically for use in paratransit service. Prototype vehicles were manufactured for the Government by two different manufacturers (ASL Engineering and Dutcher Industries). Dynamic Science, Inc., conducted an independent series of tests and evaluations of the two prototype vehicles. The program was structured to provide performance data on the prototypes compared to a baseline vehicle that will be used to upgrade future redesigns. The program consisted of five separate test series: 1) Ride Comfort and Quality; 2) Acceleration and Interior Measurement; 3) Handling; 4) Fuel Economy; and 5) Noise. The results of the program are documented in a five-volume technical report, and each volume corresponds to one of the individual test series.

This volume (Volume II) presents the test procedure and results of the acceleration and interior measurement test series. The tests determined the acceleration characteristics of the vehicles, the effects of vehicle acceleration/deceleration on vehicle passengers, the effectiveness of wheelchair restraint systems, and the available interior space for the driver and passengers. Performance data of the prototypes are compared with those of two baseline test vehicles.

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PREFACE

This final report, Volume II, summarizes the acceleration and interior measurement tests on the Paratransit Evaluation and Testing Contract. The program was structured to provide performance data on the prototypes compared to a baseline vehicle that will be used to upgrade future redesigns.

The program was conducted by Dynamic Science, Inc. under Contract DOT-TSC-1241 with the Transportation Systems Center (TSC) of Cambridge, Massachusetts for the Urban Mass Transportation Administration. The contract was technically managed by Mr. Jim Kakatsakis and Mr. Joe Picardi of TSC.

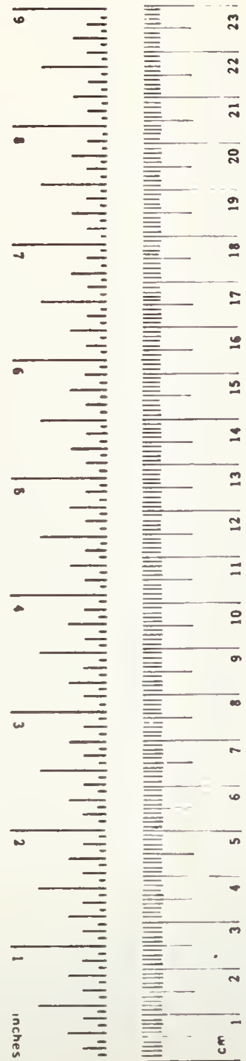
The opinions and findings expressed in this publication are those of the authors and not necessarily those of the Government.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

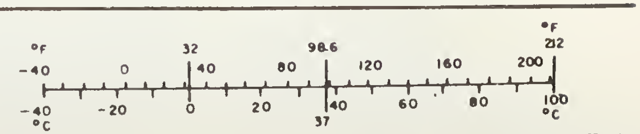
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	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	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



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)	2.6	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
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	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

The paratransit mode of transportation provides an alternative between transit in privately owned and operated vehicles and scheduled mass transit systems. Paratransit includes such systems as dial-a-ride, taxi, and jitney service. It is of vital importance to people without individual cars or ready access to regular mass transit and to people of limited mobility. The vehicles presently available for paratransit service, however, do not cover the full spectrum of required characteristics. They are slightly modified versions of vehicles designed for different purposes. As such, they are not as efficient in their operation nor as easy to enter and exit as is desirable in this type of transportation.

Therefore, the Urban Mass Transportation Administration (UMTA), working through the Transportation Systems Center (TSC), developed specifications for a vehicle specifically for use in paratransit, which combines a number of desirable features without compromising important performance parameters. Prototype vehicles were manufactured for UMTA by two different manufacturers (ASL Engineering and Dutcher Industries) according to these specifications. The primary features of the vehicles are a low pollution, quiet, efficient propulsion system combined with a body designed for the comfort and convenience of both the passengers and driver. The vehicles include provisions for easy ingress and egress for the general public as well as the elderly and handicapped, including the easy ingress/egress and accommodation of a wheelchair passenger.

Dynamic Science, Inc. was selected by UMTA to conduct an independent series of tests and evaluations of the two prototype paratransit vehicles (PTV). These tests were designed to provide additional information on the ride quality and comfort, fuel economy, performance and handling charactersitics of the two vehicles. A compact passenger car (Chevrolet Nova) was utilized as a baseline test vehicle throughout the test series to furnish comparative data for the evaluations.

The paratransit vehicle testing and evaluation program consisted of six major tasks. The first task consisted of initial vehicle inspection, test preparation, and driver familiarization efforts conducted upon delivery of the vehicles to the Dynamic Science test facility. The remaining five tasks consisted of conducting and evaluating the results of five separate test series. These series were:

- Ride Comfort and Quality Test Series which measured the ride characteristics of the test vehicles to determine if, and how well they satisfy accepted standards of ride quality.
- Acceleration and Interior Measurement Test Series which determined the acceleration characteristics and available interior space of the vehicles in order to evaluate their suitability for urban paratransit use.
- Handling Test Series which determined the steering and handling characteristics of the PTVs and allowed their characteristics to be compared with those of the baseline test vehicle.
- Fuel Economy Test Series which obtained fuel economy data for the PTVs under actual road conditions with various driving cycles.
- Noise Test Series which measured the acoustic noise generated by the vehicles and the noise environment inside the passenger and driver compartments.

The Paratransit Test and Evaluation Program is documented in five separate volumes as follows:

Volume 1 - Ride Comfort and Quality Tests

Volume 2 - Acceleration and Interior Measurement Tests

Volume 3 - Handling Tests

Volume 4 - Fuel Economy Tests

Volume 5 - Noise Tests.

This volume (Volume 2) presents the test procedures and results of the acceleration and interior measurement tests conducted on the two PTV prototypes and the baseline test vehicle.

2.0 TEST DESCRIPTION

2.1 TEST OBJECTIVES

The objectives of the acceleration and interior measurement test series were to provide the following information:

- Define PTV acceleration characteristics and compare them with the acceleration characteristics of the baseline passenger car.
- Define the upper limit of safe passenger deceleration characteristics with the current seat designs in the two PTVs, and compare these limits with those of a current production taxicab.
- Provide information on wheelchair occupant movement and restraint system effectiveness in the PTVs during longitudinal and lateral vehicle acceleration.
- Describe PTV interior dimensions along with a baseline taxi so as to be able to compare the available interior space in the passenger, driver, and luggage compartments.

2.2 TEST DESIGN

The testing consisted of four different series of tests as outlined in Table 1.

The first series (vehicle acceleration) measured the time required for the vehicles to accelerate from rest to 55 mph or the maximum speed attainable (whichever was less). The vehicle acceleration tests were run on the PTVs and baseline passenger car for three throttle positions (maximum acceleration position, one-half of maximum acceleration position, and one-quarter of maximum acceleration position), with the loading conditions listed in Table 2. An instrumented 50th percentile male dummy was seated in the wheelchair (rear seat of Nova) during the 650-pound load tests so that passenger accelerations could be measured.

TABLE 1. SUMMARY OF ACCELERATION AND INTERIOR MEASUREMENT TESTS

Test Type	Vehicles Tested	Test Procedures	Test Objectives
Vehicle Acceleration	ASL PTV Dutcher PTV Nova (baseline	Accelerate from rest to 55 mph at specified throttle positions	1. Determine vehicle acceleration characteristics 2. Determine acceleration levels transmitted to wheelchair occupant
Passenger Deceleration	ASL PTV Dutcher PTV Taxicab	Decelerate from 40 mph at specified deceleration levels	Determine vehicle deceleration level which causes rear seat passengers to lift off seat
Wheelchair Deceleration	ASL PTV Dutcher PTV	1. Decelerate from 40 mph at specified deceleration levels 2. Drive at 40 mph through turn radii which will yield specified lateral acceleration levels	Determine motions of wheelchair passenger resulting from longitudinal/lateral accelerations
Interior Measurement	ASL PTV Dutcher PTV Taxicab	Measure interior dimensions and luggage compartment space	Determine available space for driver, passengers, and luggage

TABLE 2. LOADING CONDITIONS FOR VEHICLE ACCELERATION TESTS

Total Load (lb)	Remarks
300	Loaded to simulate one wheelchair passenger (prototype) or one rear passenger (baseline) in addition to driver.
650	Loaded to simulate two rear and one wheelchair passenger (prototype) or three rear passengers (baseline) in addition to driver.
900	Loaded to simulate squeeze load of five passengers (prototype) or three rear and two front seat passengers (baseline) in addition to driver.

The second series of the tests consisted of passenger deceleration testing on the PTVs and the baseline taxicab. The tests were run at six longitudinal deceleration levels (0.3, 0.4, 0.5, 0.6, 0.7, and 0.8G or more until dislodging of a passenger was reached) from a steady velocity of 40 mph. The loading condition consisted of the driver, instrumentation, and two rear passengers (one 50th percentile male dummy and one 5th percentile female dummy).

The third series of tests consisted of wheelchair deceleration testing, run on the PTVs for three vehicle longitudinal deceleration levels (0.6, 0.4, and 0.2G) from 40 mph, and five vehicle lateral acceleration levels (0.5, 0.4, 0.3, 0.2, and 0.1G) with a steady velocity of 40 mph. A 5th percentile female dummy occupied the wheelchair position. The tests were conducted for the restraint conditions listed in Table 3.

TABLE 3. RESTRAINT CONDITIONS FOR WHEELCHAIR DECELERATION TESTS

Vehicle	Test	Wheelchair Restraint/ Restraint Bar	Body Restraint	Wheelchair Brake
ASL	1	On	On	On
	2	On	Off	On
	3	Off	Off	On
Dutcher	1	On	N/A	On
	2	Off	N/A	On

N/A - not applicable (no body restraint on the Dutcher).

The last series of tests measured the interior dimensions and luggage compartment space of the two PTVs and the baseline taxicab. The dimensions measured and the techniques used corresponded to those set forth in SAE J1100a, "Motor Vehicle Dimensions," and SAE J826b, "Devices for Use in Defining and Measuring Vehicle Seating Accommodation."

2.3 SCOPE OF TEST SERIES

The acceleration testing was composed of the three test series (vehicle, passenger, and wheelchair) listed in Table 4. The vehicle acceleration testing consisted of 90 tests on each of the PTV prototypes and the baseline passenger car. The passenger deceleration testing was composed of 30 tests on each of the PTV prototypes and the baseline taxicab. The wheelchair deceleration testing consisted of an average of 100 tests (37 longitudinal deceleration tests and 63 lateral deceleration tests) on each PTV prototype.

The interior measurement test series is summarized in Table 5. This test series consisted of 11 driver compartment measurements, 8 passenger compartment measurements, and 2 luggage compartment measurements on each PTV prototype and the baseline taxicab.

TABLE 4. ACCELERATION TEST SERIES

Test Type	Vehicle	Test Condition per Setup	Test Direction	Number of Repeat Runs	Setup Conditions	Number of Tests/Vehicle
Vehicle Acceleration	PTV, passenger car	3 throttle positions	2	5	3 loading conditions	90
Passenger Deceleration	PTV, taxi	6 deceleration levels	1	5	1 setup	30
Wheelchair Deceleration						
• Longitudinal	PTV	3 deceleration levels	1	5	3 ASL restraint conditions 2 Dutcher restraint conditions	37 average
• Lateral	PTV	5 deceleration levels	1	5	3 ASL restraint conditions 2 Dutcher restraint conditions	63 average

TABLE 5. INTERIOR MEASUREMENT TEST SERIES

Compartment Region to be Measured	Parameters to be Measured				Number of Measurements/ Vehicle
	Length Dimension	Height Dimension	Width Dimension	Volume Dimension	
Driver	4	5	2	-	11
Passenger	2	4	2	-	8
Luggage	-	1	-	1	2

3.0 TEST VEHICLES

The test vehicles consisted of two prototype paratransit vehicles (one manufactured by ASL Engineering and the other by Dutcher Industries) and two baseline vehicles (Chevrolet Nova and Checker Taxicab).

3.1 ASL PARATRANSIT VEHICLE

The ASL PTV (Figure 1) is a front engine, front drive vehicle which can accommodate a maximum of five seated passengers or three seated passengers plus a wheelchair. Ingress/egress is accomplished through remotely operated sliding doors on each side of the vehicle. An electrically powered loading ramp may be extended on the right side of the vehicle to permit unassisted ingress and egress for wheelchair passengers.

The driver's compartment is separated from the passenger compartment by a bullet-resistant partition. An intercom system is provided for communication between the two compartments. All seating positions are equipped with belt restraints, and a restraint system is also provided to fasten the wheelchair securely to the vehicle.

3.2 DUTCHER PARATRANSIT VEHICLE

The Dutcher PTV (Figure 2) is a rear engine, rear drive vehicle which also accommodates five seated passengers or four seated passengers plus a wheelchair. Hydraulically actuated bifold doors on each side of the vehicle permit passenger ingress and egress. An electrically powered loading ramp extending on the right side of the vehicle allows wheelchair ingress and egress.

Figure 1. ASL Paratransit Vehicle.

Figure 2. Dutcher Paratransit Vehicle.

As in the ASL PTV, the Dutcher PTV contains a driver compartment which is completely separated from the passenger compartment by a transparent partition. Communication between passengers and driver is accomplished through an intercom system. Restraints are provided for all seating positions and for the wheelchair.

3.3 BASELINE TEST VEHICLES

3.3.1 Baseline Passenger Car

The baseline test vehicle which was used for most of the comparative evaluation of the PTV test results was a 1977 Chevrolet Nova 6, shown in Figure 3. However, it was used in this test series for the vehicle acceleration tests only.

The criteria for the selection of the baseline vehicle were:

- Compact Size
- 4-Door Passenger Car
- 6-Cylinder Engine
- Automatic Transmission
- Air Conditioning System
- Radial Tires
- Weight, Width, and Length Comparable to the Paratransit Vehicle
- Mileage Less Than 5000 Miles.

The Nova was selected because it fulfills all of the above requirements and, in addition, is more prevalent and more commonly known than any of the other vehicles which met the criteria.

3.3.2 Baseline Taxicab

The passenger deceleration tests and interior measurement tests were conducted using a standard production taxicab as the

Figure 3. Baseline Nova Passenger Car.

baseline vehicle for comparison with the two PTV prototypes. A 1977 Checker Taxicab, Model A-11 (shown in Figure 4) was selected as the baseline taxi since it is typical of the majority of the taxicab fleet. In addition, the seats in this vehicle were covered with a vinyl similar to that found in both PTV prototypes, thus enabling valid comparisons to be made between all three vehicles.

3.4 COMPARISON OF BASIC VEHICLE CHARACTERISTICS

The basic test vehicle characteristics are listed in Table 6. The characteristics of the two PTV vehicles are similar in most instances. The major differences between the two vehicles lie in the engine location/drive configuration and in the front-to-rear weight ratio (1.59 for the ASL and 0.60 for the Dutcher).

Figure 4. Baseline Checker Taxicab.

TABLE 6. BASIC TEST VEHICLE CHARACTERISTICS

Vehicle Parameter	ASL PTV	Dutcher PTV	Nova (Base-line)	Checker Taxicab
1. Dimensions				
Height (in.)	70.8	80.1	55.1	64
Width (in.)	72.5	72.8	73	73.5
Length (in.)	184	172.5	197.1	206.5
Wheelbase (in.)	108.3	106.8	111.4	120
Track				
- Front (in.)	63.4	63.5	61	65
- Rear (in.)	63.2	61.9	59.3	63.1
2. Weight				
Curb Weight (lb)	3510	3021	3450	3984
- Front/Rear Ratio	1.59	0.60	1.23	1.18
3. Minimum Turning				
Diameter (ft)	37.5	33.8	40.2	--
4. Engine				
Location	Front	Rear	Front	Front
No. of Cylinders	4	4	6	6
Displacement ($in.^3$)	114.5	120.3	250	250
Horsepower	95	86	110	110
Compression Ratio	8:1	7.6:1	8.25:1	8.25:1
5. Transmission				
Automatic/Manual	Automatic	Automatic	Automatic	Automatic
No. of Forward Speeds	3	3	3	3
6. Brakes				
Power/Manual	Power	Manual	Power	Manual
Front	Disc	Disc	Disc	Disc
Rear	Drum	Drum	Drum	Drum
7. Tire Size	ER78-14	Front BR78-13 Rear ER78-14	FR78-14	G78-15
8. Steering				
Power/Manual	Power	Manual	Power	Manual
Type	Rack & Pinion	Rack & Pinion	Standard	Standard
9. Drive				
Front/Rear	Front	Rear	Rear	Rear
Ratio	4.11	4.57	2.73	--
10. Fuel Capacity (gal)	15	15	21	--

4.0 TEST FACILITIES

All testing was performed at the Dynamic Science test facility (see Figure 5) on the south straightaway of the two-mile oval (for longitudinal acceleration/deceleration tests), the skid pad (for lateral acceleration tests), and in the garage (for the interior measurement tests).

The two-mile oval is a minimum of two lanes wide (fourteen feet each) throughout. The entire surface of the oval, with the exception of specially coated braking lanes on part of the north straightaway, is made of asphaltic concrete. There are no perceptible bumps or dips due to overlapping paving strips. In the straightaways, the pavement slope is maintained at ±1 percent, and the grade is less than 1 percent. Banked curves are provided which allow vehicle speeds of 50 mph with no lateral acceleration and top speeds in excess of 60 mph.

The skid pad (Item 18 of Figure 5) is a large flat (runout less than 0.25 inches in ten feet) asphaltic concrete area adjoining the south straightaway of the two-mile oval. The skid pad covers ten acres and has a maximum width and length of 600 feet each.

Skid numbers are monitored periodically by a skid trailer which meets the ASTM-274 requirements. The skid numbers obtained just prior to the acceleration testing were:

- Skid Pad = 74.0
- South Straightaway = 77.0

1. ENGINEERING/ADMINISTRATION CENTER
2. MECHANICAL/INSTRUMENTATION SHOPS
3. DUMMY CALIBRATION LABORATORY
4. GARAGE/MAINTENANCE SHOP
5. ENVIRONMENTAL CHAMBER
6. STATIC CRUSH FACILITY
7. TWO-MILE OVAL
8. TURNAROUND (TYPICAL OF TWO)
9. BARRIER IMPACT FACILITY
10. DROP TOWER/SLED TEST FACILITY
11. CENTRAL DATA ACQUISITION AND CONTROL STATION
12. PENDULUM FACILITY
13. NONMETALLICS LABORATORY
14. TEST SERVICE FACILITY
15. VEHICLE-TO-VEHICLE TEST FACILITY
16. ROLLOVER TEST FACILITY
17. RIDE QUALITY COURSE
18. SKID PAD
19. HIGH AND LOW SKID NUMBER BRAKING LANES
20. SALT WATER TROUGH
21. BELGIAN BLOCK
22. PARKING BRAKE TEST RAMP
23. PULL-OFF AREA (TYPICAL OF THIRTEEN)
24. BALLISTIC TEST RANGE

Figure 5. Aerial View of Dynamic Science Deer Valley Facility.

5.0 TEST PROCEDURES

5.1 TEST INSTRUMENTATION/EQUIPMENT

5.1.1 Required Measurements

The primary variables measured during the acceleration testing were:

1. Velocity (all tests)
2. Longitudinal acceleration (all tests)
3. Throttle position (vehicle acceleration tests)
4. Wheelchair occupant chest acceleration (vehicle acceleration tests)
5. Passenger lift-off (passenger deceleration tests)
6. Lateral acceleration (wheelchair deceleration tests)
7. Passenger motion (wheelchair deceleration tests).

The primary variables measured during the interior measurement testing were:

1. Driver compartment dimensions
2. Passenger compartment dimensions
3. Luggage compartment capacity.

5.1.2 Instrumentation/Equipment Specifications

5.1.2.1 Acceleration Testing

The instrumentation used in the acceleration testing is listed in Table 7.

TABLE 7. ACCELERATION INSTRUMENTATION LIST

Measurand	Type Transducer	Manufacturer and Model	Full-Scale Range	Full-Scale Transducer Accuracy	Quantity	Remarks
Vehicle Velocity	Fifth Wheel	Labeco TT481 with DD-1.1 readout	100 mph	0.5%	1	
Longitudinal Acceleration	Accelerometer	Bell & Howell 4-205	±1G	.75%	1	
Lateral Acceleration	Accelerometer	Bell & Howell 4-205	±1G	.75%	1	
Throttle* Position	Displacement	Celesco PT 101-15C	15 inch	.1%	1	
Dummy Accelera-tion*	Strain Gauge Accelerometer	Bell & Howell 4-302-0001	5G	.75%	3	1 dummy
Passenger Lift-off**	Round Wafer Switch	Tapeswitch T4-026	20 oz.	N/A	8	2 occupant
Dummy Movement***	Movie Camera	Milliken DBM5	N/A	N/A	1	2 attachement positions

*Vehicle acceleration testing only.
**Passenger deceleration testing only.
***Wheelchair deceleration testing only.

A Labeco fifth wheel was used to measure vehicle velocity. The output of the fifth wheel was inputted into a Labeco DD1.1 speedometer for visual display of velocity at the driver's location. Vehicle dynamics were measured by accelerometers mounted near the vehicle center of gravity in the longitudinal and lateral directions.

The throttle position during vehicle acceleration tests was measured by a displacement transducer attached to the accelerator linkage system. The Alderson VIP-50 anthropomorphic dummy used in the vehicle acceleration testing was instrumented with three orthogonal accelerometers mounted in its chest cavity to measure dummy referenced vertical, lateral, and longitudinal accelerations.

Two anthropomorphic dummies (one 50th percentile male and one 5th percentile female) were fitted with denim trousers and installed in the vehicles for the passenger deceleration tests. An array of four tapeswitch contact switches was used to determine passenger lift-off for each dummy during the tests. The approximate positioning of the switches is shown in Figure 6.

Dummy motion during the wheelchair deceleration testing was documented using a movie camera attached to the vehicle and operated at 64 frames per second. The longitudinal acceleration tests were photographed from the side of the wheelchair while the lateral acceleration tests were photographed with a forward view facing the wheelchair. The field of view of the camera covered the pelvis to the head of the dummy. Two-inch circular targets on the dummy and background were used to provide a reference system for analysis.

Additional instrumentation in the vehicles included an event marker switch triggered by the driver upon starting the test to provide an impulse signal on the recording system. A U-tube manometer was mounted in the driver's compartment to assist the

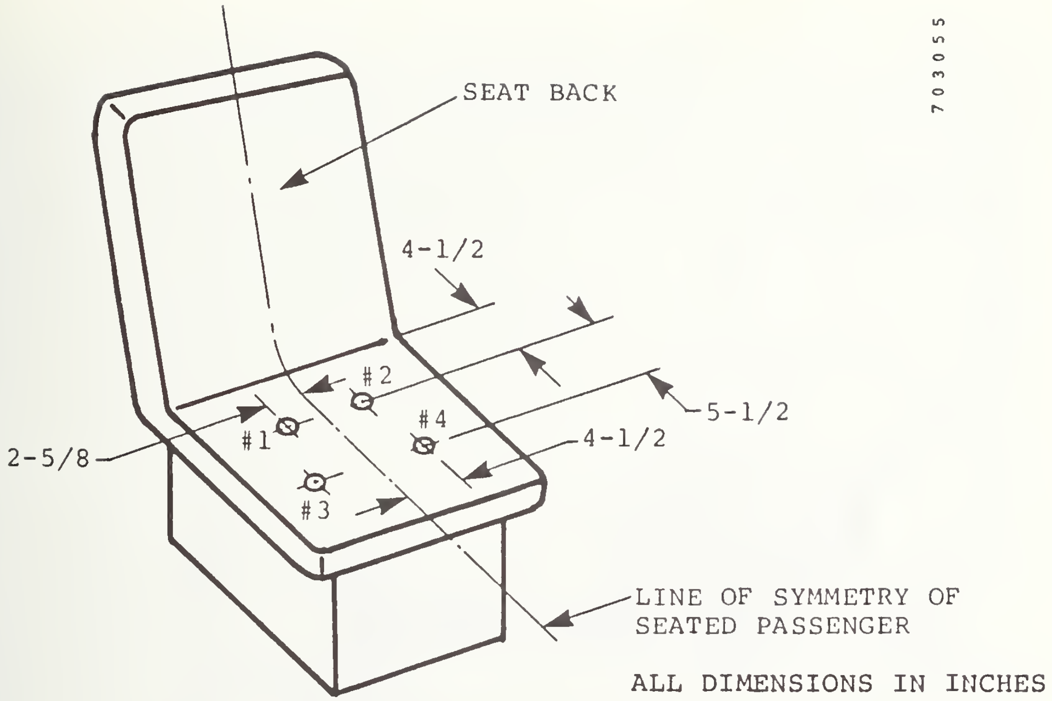


Figure 6. Switch Configuration for Determining Passenger Lift-off.

driver in maintaining the controlled longitudinal accelerations. An automatic steering machine installed in the vehicle was used to attain the required lateral accelerations during the wheelchair acceleration testing.

5.1.2.2 Interior Measurement Testing

The equipment used for the interior measurement testing consisted of a three-dimensional H-point machine (Figure 7) and the set of standard luggage specified in Table 8.

5.1.3 Data Acquisition System

The data acquisition system for the acceleration testing is shown schematically in Figure 8. The signal conditioning equipment was mounted on board the vehicle in a location which did

Figure 7. Three-Dimensional H-Point Machine (SAE J826b).

TABLE 8. STANDARD LUGGAGE SET

Luggage (with Coventional Handles)	Box Size (in.)	Identification Letter	No.	Volume/ Piece (ft^3)
Men's 2-suiter	9 x 19 x 24	A	4	2.375
Ladies overnight	6.5 x 13 x 18	B	4	0.880
Ladies pullman	9 x 16 x 26	C	2	2.167
Ladies wardrobe	8.5 x 18 x 21	D	2	1.859
Ladies train case	8 x 9 x 15	E	2	0.625
Men's overnight	7 x 14 x 21	F	2	1.191
Golf bag containing:				
2 woods, 4 irons,	--	-	1	1.500
1 putter, 10 1/2 shoes,				
3 golf balls				
H boxes	6 x 4.5 x 12.8	H	20	0.200
Total			37	

not interfere with the testing procedures. All data were transmitted to the Central Data Acquisition Control Station (CDACS) via a telemetry system. At the CDACS, the data were recorded on a tape recorder for a permanent record of the test as well as for access at a future date. The data were also discriminated and displayed on a recording oscillograph for the purpose of obtaining quick-look evaluation data. The quick-look data provided a check as to whether test conditions had been achieved and also provided a view of the critical test parameters to ensure that good data were obtained during each test run.

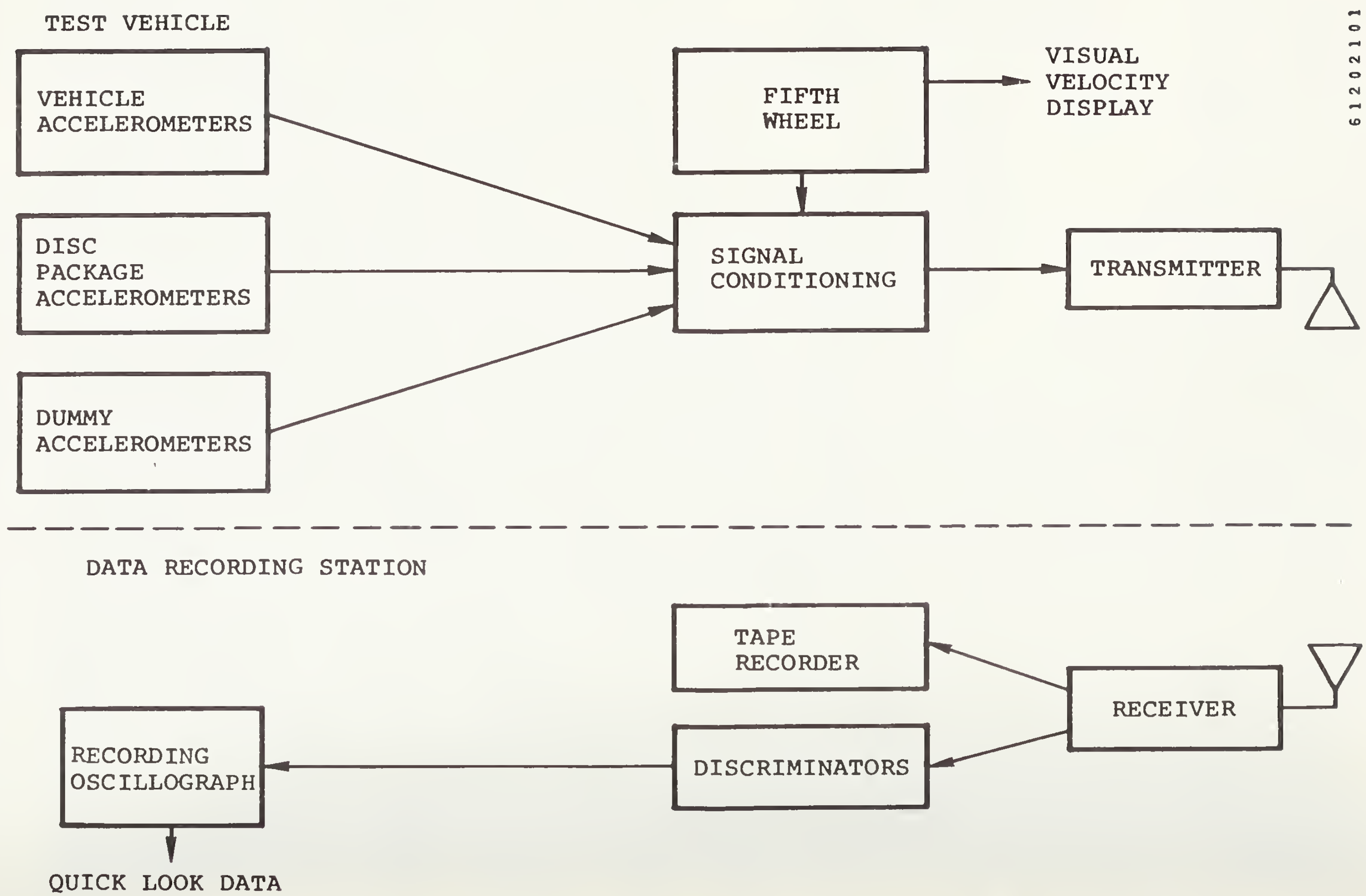


Figure 8. Data Acquisition System Schematic.

The data recording started at least five seconds prior to starting the test and continued until at least ten seconds after completing the test. The driver notified the CDACS when to start and stop the recorder and oscillograph.

All data from the interior measurement testing were recorded by hand on Test Data Log Sheets.

5.1.4 Calibration Procedures

Pre- and post-test electrical calibrations of the instrumentation/data acquisition system were obtained for each set of test runs. In addition, the following physical tests were performed on a daily basis to check the calibration of the instruments:

- The fifth wheel was spun up using a calibration motor. Tire pressure was adjusted to yield the desired calibration value.
- The vehicle was decelerated at a moderate and constant level and the average longitudinal acceleration determined by dividing the velocity change (ΔV) by the corresponding change in time (Δt).
- Velocity and lateral acceleration were correlated with each other by driving the vehicle around a 100-foot radius circle at constant speed. The correlation equation is:

$$A_y = V^2/R$$

where A_y = lateral acceleration

V = vehicle velocity

R = radius of circle (100 feet)

5.2 VEHICLE PREPARATION

The vehicles were prepared for the acceleration tests by installing the instrumentation listed in Section 5.1.2.1 and by ballasting the vehicles to the prescribed loading conditions when necessary. No instrumentation was necessary for the interior measurement testing.

5.2.1 Instrumentation Installation

The Labeco fifth wheel was mounted to the rear bumper of the vehicle as shown in Figure 9. The visual displays from the fifth wheel and the U-tube manometer were mounted in the driver's field of view as illustrated in Figure 10. The longitudinal and lateral accelerometers were mounted near the vehicle's center of gravity as shown in Figure 11.

The throttle position instrumentation as installed is illustrated in Figure 12. Physical blocking of the accelerator pedal prevented the driver from exceeding the specified throttle position. To ensure accurate throttle conditions, pedal travel was measured by a linear displacement transducer attached to the accelerator pedal.

The wafer switches used to record passenger lift-off during the passenger deceleration tests were taped to the seat cushions as shown in Figures 13 and 14.

The steering machine installation for the lateral wheelchair tests is shown in Figure 15. Figure 16 shows a typical installation of the signal conditioning equipment.

Figure 9. Fifth Wheel Installed on Taxicab.

Figure 10. Typical Mounting of Visual Displays.

Figure 11. Typical Accelerometer Installation.

Figure 12. Throttle Position Instrumentation as Installed in Dutcher Prototype.

Figure 13. Passenger Lift-off Switches in ASL Prototype.

Figure 14. Passenger Lift-off Switches in Dutcher Prototype.

Figure 15. Steering Machine Installed in Dutcher Prototype.

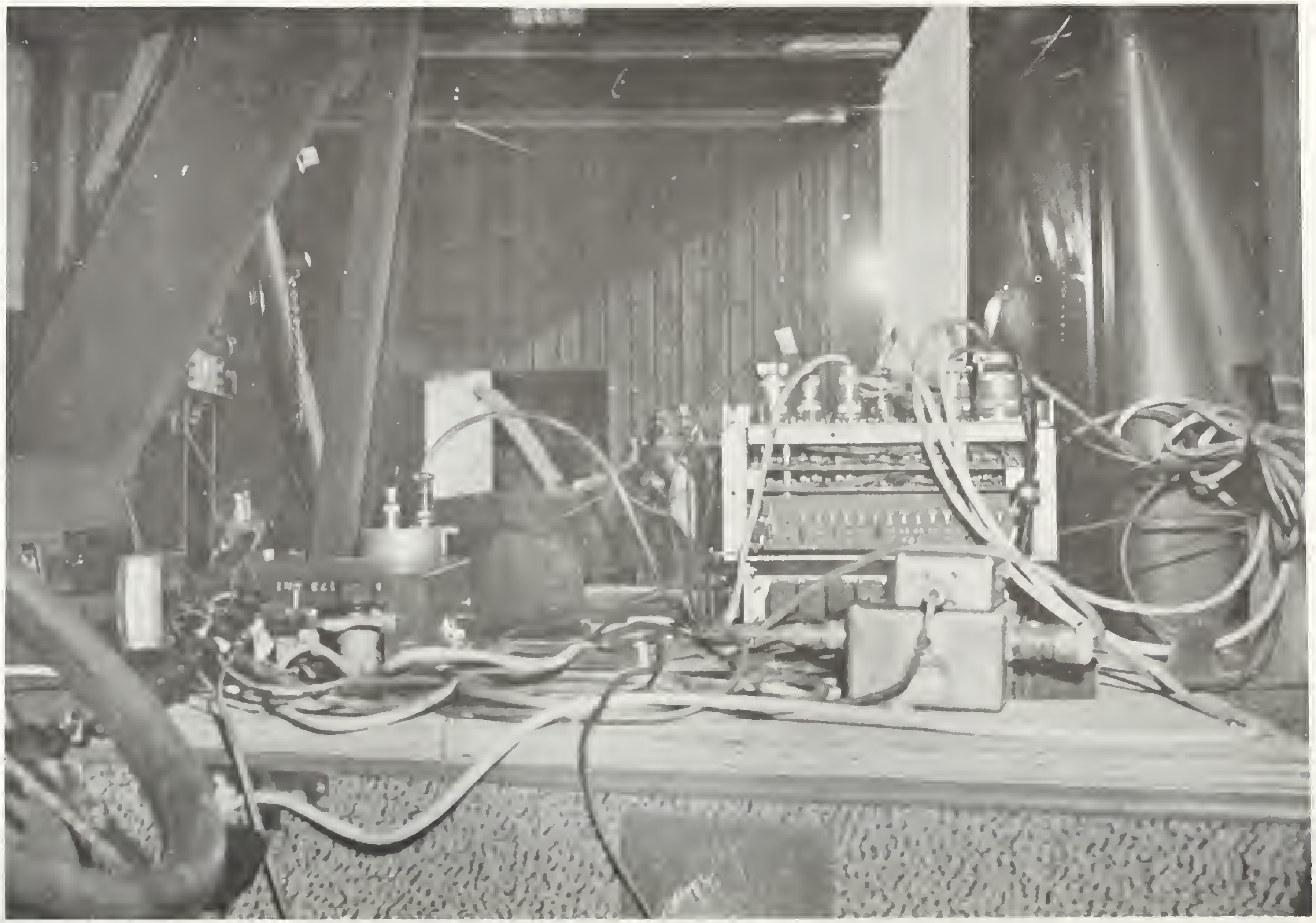


Figure 16. Typical Installation of Signal Conditioning Equipment.

5.2.2 Vehicle Loading

The vehicle acceleration testing was the only test series in which the vehicle loading conditions were specified by weight. Three different loading conditions were specified for this test series (300, 650, and 900 pounds). The vehicle loads included the driver and instrumentation.

An instrumented 50th percentile anthropomorphic test dummy was placed in the wheelchair during the testing at the 650-pound load condition to obtain passenger acceleration levels. The additional weight necessary to reach 650-and 900-pound loads was provided by sandbags placed in the passenger compartment.

One minor exception to the above loading procedure occurred with the Dutcher prototype. During the handling tests conducted earlier with the Dutcher PTV, it was noted that the inside front wheel lifted from the surface during turning maneuvers. The manufacturer adjusted the suspension and added ballast to the front of the vehicle to alleviate this problem. This ballast remained in the vehicle during the acceleration testing and made up part of the entire ballast load. Thus, not all of the Dutcher's ballast was contained in the passenger compartment.

The vehicle test weights for the vehicle acceleration test series are listed in Table 9.

5.3 ACCELERATION TEST PROCEDURES

5.3.1 General Test Procedures

The three acceleration test series utilized the same pretest procedures and operated under the same limit conditions.

TABLE 9. VEHICLE TEST WEIGHTS FOR VEHICLE ACCELERATION TEST SERIES

Specified Test Load (lb)	Vehicle Test Weight (lb)		
	Nova (Baseline)	ASL Prototype	Dutcher Prototype
300	3759	3997	3321
650	4108	4163	3675
900	4360	4397	3918

The pre-test procedures common to all the acceleration tests were as follows:

1. Warm up vehicle and stabilize electronics by completing two laps of the track at 30-40 mph.
2. Park vehicle on calibration line and obtain electrical pre-test calibration.
3. Perform physical calibration procedure appropriate for tests to be conducted.

Limit conditions for testing included wind speed and test specifications. Testing was suspended if the steady wind speed exceeded 10 mph or if gusts exceeded 15 mph. A test was repeated if the longitudinal and lateral acceleration/deceleration was not within 0.05G of that specified or if the initial velocity was not within ±2 mph of the specified velocity.

5.3.2 Vehicle Acceleration Tests

The vehicle acceleration tests were conducted according to the schedule presented in Table 10. The tests were run alternately in each direction for each throttle position and load condition.

TABLE 10. VEHICLE ACCELERATION TESTING SCHEDULE

Test Parameters (Throttle Position/ Direction)	Number of Test Runs		
	Condition 1	Condition 2	Condition 3
Maximum acceleration/east	5 @ light load	5 @ medium load	5 @ heavy load
Maximum acceleration west	5@ light load	5 @ medium load	5 @ heavy load
1/2 maximum acceleration/east	5 @ light load	5 @ medium load	5 @ heavy load
1/2 maximum acceleration/west	5 @ light load	5 @ medium load	5 @ heavy load
1/4 maximum acceleration/east	5 @ light load	5 @ medium load	5 @ heavy load
1/4 maximum acceleration/west	5 @ light load	5 @ medium load	5 @ heavy load

The event switch was engaged by the driver, and the vehicle was accelerated to 55 mph (or the maximum attainable speed, whichever was less). The speed was maintained for at least five seconds before bringing the vehicle to a complete stop.

5.3.3 Passenger Deceleration Tests

The passenger deceleration tests were conducted according to the schedule in Table 11. The driver approached the test initiation point at a speed of 40 mph. At the test initiation point, the driver applied the vehicle brakes and stopped the vehicle at the designated deceleration level. It was not necessary to test at levels higher than 0.8G since passenger lift-off was attained in all three vehicles before that point.

TABLE 11. PASSENGER DECELERATION TESTING SCHEDULE

Deceleration Level (G)	Number of Test Runs
0.3	5
0.4	5
0.5	5
0.6	5
0.7	5
0.8	5
Higher level if required to obtain lift-off	5 each level

The passenger restraint systems were utilized to retain the test dummies in their seats during the testing. However, the lap belts in the ASL prototype were adjusted loosely to permit the dummies to lift-off or slide off the seat to the extent that at least one of the contact switches would be activated. The restraint bar in the Dutcher prototype needed no adjustment to meet the above criteria. The dummy configurations in the ASL and Dutcher vehicles are shown in Figures 17 and 18, respectively.

5.3.4 Wheelchair Deceleration Tests

The wheelchair deceleration tests were conducted according to the schedule shown in Table 12. Two different test procedures were used for the tests - one for longitudinal deceleration and one for lateral acceleration.

The longitudinal deceleration tests were similar to the passenger deceleration tests described previously. The driver approached the test initiation point at a speed of 40 mph. At the

Figure 17. Passenger Deceleration Test Dummies in ASL Prototype.

Figure 18. Passenger Deceleration Test Dummies in Dutcher Prototype.

TABLE 12. WHEELCHAIR DECELERATION TESTING SCHEDULE

Deceleration Level (G)	Number of Test Runs		
	Condition 1*	Condition 2	Condition 3**
Longitudinal			
0.6	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
0.4	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
0.2	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
Lateral			
0.5	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
0.4	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
0.3	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
0.2	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3
0.1	5 @ Restraint 1	5 @ Restraint 2	5 @ Restraint 3

*Refer to Table 3 (page 9) for description of restraint conditions.
**ASL prototype only.

test initiation point, the driver applied the brakes so as to stop the vehicle at the designated deceleration levels.

The lateral acceleration tests were conducted on the skid pad. The steering machine in the vehicle was set prior to the test run for the steering wheel angle that would yield a right turn at the designated lateral acceleration. The driver approached the skid pad from the east at 40 mph. At the test initiation point, he engaged the steering machine and maintained the vehicle speed at 40 mph during the turn. After five seconds, the steering machine was disengaged and the vehicle was controlled manually while bringing it to a stop.

The on-board cameras used to record the dummy motions during all of the tests were turned on at least five seconds before the start of each test and allowed to run at least three seconds after the vehicle had been brought to a complete stop. Figures 19 and 20 show the two prototype vehicles as they were configured for the longitudinal deceleration testing.

5.4 PROBLEMS ENCOUNTERED DURING ACCELERATION TESTING

The wheelchair in the Dutcher prototype would not remain upright during the higher lateral acceleration tests conducted without the wheelchair restraint bar in place. Thus, the 0.4G and 0.5G lateral tests with no wheelchair restraint were not conducted on the Dutcher PTV. This problem was not encountered in the ASL prototype because the wheelchair in the ASL is partially recessed in the vehicle interior structure, thus providing some lateral restraint even though the wheelchair restraint belts are not used. The differences in the wheelchair configurations of the two vehicles can be seen in Figures 19 and 20.

5.5 INTERIOR MEASUREMENT TEST PROCEDURES

The three-dimensional reference system used for the interior measurement tests is shown in Figure 21. The zero "X" plane was taken through the centerline of the front axle for all three vehicles to facilitate direct comparisons of H-point positions. (ASL Engineering defined the zero "X" plane of their prototype through the front axle centerline while Dutcher Industries defined theirs as 30 inches forward of the front axle.) The zero "Y" plane passes through the longitudinal centerline of the vehicle. The zero "Z" plane corresponds to the lowest point on the top surface of the front floor pan but was not used in any of the measurements. However, the vehicles were ballasted for the measurements to bring the vehicle fiducial marks to the manufacturers' specifications for above-ground height.

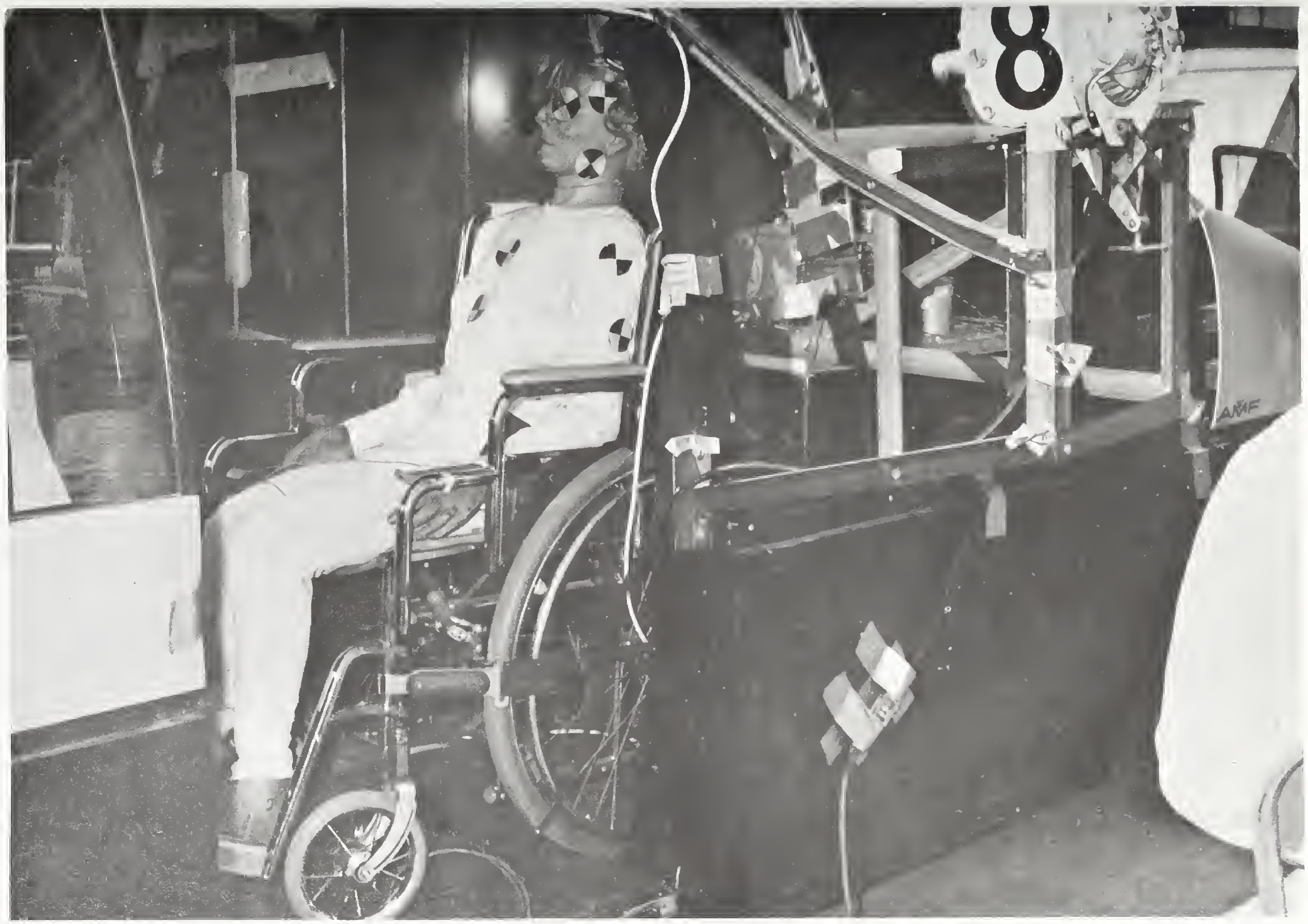


Figure 19. ASL Prototype Configured for Longitudinal Deceleration Testing.

Figure 20. Dutcher Prototype Configured for Longitudinal Deceleration Testing.

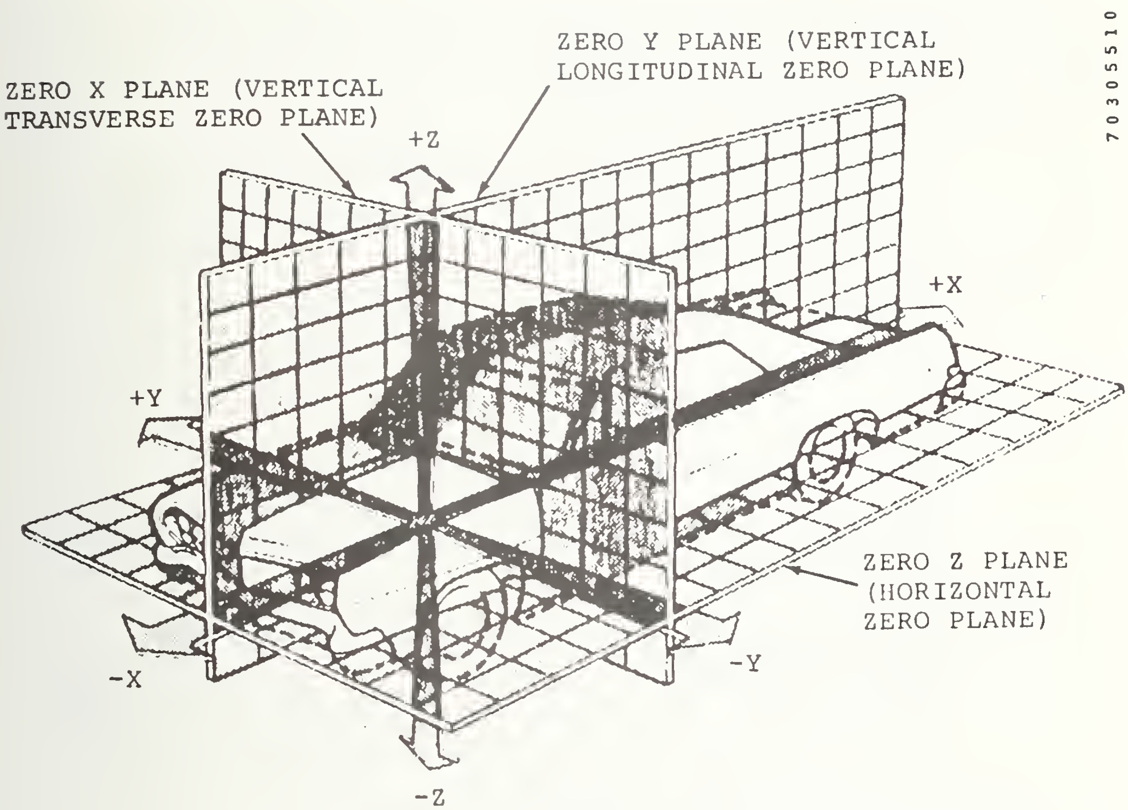


Figure 21. Three-Dimensional Reference System for Interior Measurement Tests.

The three-dimensional H-point machine used in the tests was positioned in the vehicle according to the procedures in SAE J826b. The relationship between the H-point of the testing device and the vehicle seating reference point is defined by the following terms:

- H-point

  The H-point is the pivot center of the torso and thigh on the three-dimensional device.

- Seating Reference Point (SgRP)

  The SgRP is the H-point for the rearmost normal design driving or riding position of a designated seating position which includes consideration of all modes of adjustment, horizontal, vertical, and tilt, in the vehicle.

The dimensions measured during the testing and their definitions (from SAE J1100a) are listed below:

Driver Compartment Dimensions

- L31 - H-point to Vertical Zero Line - Front

  The longitudinal ("X" coordinate) distance between the SgRP-front and the zero "X" plane.

- H30 - H-point to Heel Point - Front

  The vertical distance between the SgRP-front and the accelerator heel point.

- H61 - Effective Head Room - Front

  The distance measured along a line 8 degrees rear of vertical from the SgRP-front to the headlining, plus 4.0 inches (102mm).

- L34 - Maximum Effective Leg Room - Accelerator

  The distance along a line from the right ankle pivot center to the SgRP-front, plus 10.0 inches (254 mm). Measured with right foot on the accelerator pedal.

- L40 - Back Angle - Front

  The angle measured between a vertical line through the SgRP-front and the torso line.

- L17 - H-point Travel

  The horizontal distance between the device's H-point in the foremost seat track position and the "X" plane through the SgRP-front.

- H50 - Upper Body Opening to Ground - Front

  The vertical distance from the underside of the upper part of the trimmed body opening to the ground in the "X" plane through the SgRP-front.

- W3 - Shoulder Room - Front

  The minimum lateral distance between the trimmed surfaces on an "X" plane within the space defined longitudinally by the seat back and 8.0 inches (203 mm) in front of the seat, vertically by the upper limit of the trimmed surface and 10.0 inches (254 mm) above the

SgRP-front. On the PTV prototypes, the trimmed surfaces included the shielding between the driver and passengers and any luggage or storage compartment in the front seat area of the vehicles.

- W5 - Hip Room - Front

  The minimum lateral distance between the trimmed surfaces on an "X" plane within the space defined longitudinally by 3.0 inches (76 mm) fore and aft of the SgRP-front, vertically by 1.0 inch (25 mm) below and 3.0 inches (76 mm) above the SgRP-front.

- H18 - Steering Wheel Angle - Vertical

  The angle measured from a vertical to the surface plane of the steering wheel.

Passenger Compartment Dimensions

- H31 - H-point to Heel Point - Second

  The vertical distance between the SgRP-second and the heel point on the depressed floor covering.

- H63 - Effective Head Room - Second

  The distance measured along a line 8 degrees rear of vertical from the SgRP-second to the headlining, plus 4.0 inches (102 mm).

- L51 - Minimum Effective Leg Room - Second

  The distance along a line from the right ankle pivot center to the SgRP-second, plus 10.0 inches (254 mm).

- H51 - Upper Body Opening to Ground - Second

  The vertical distance from the underside of the upper part of the trimmed body opening to the ground in the "X" plane that is 13.0 inches (330 mm) forward of the "X" plane through the SgRP-second.

- W4 - Shoulder Room - Second

  The minimum lateral distance between the trimmed surfaces on an "X" plane through the SgRP second and within 10.0 inches (254 mm) and 16.0 inches (406 mm) above the SgRP-second.

- W6 - Hip Room - Second

  The minimum lateral distance between the trimmed surfaces on an "X" plane within the space defined longitudinally by 3.0 inches (76 mm) fore and aft of the SgRP-second, vertically by 1.0 inch (25 mm) below and 3.0 inches (76 mm) above the SgRP-second.

- L3 - Compartment Room - Second

  The horizontal distance between the back of the front seat and the front of the rear seat back at a height tangent to the top of the rear seat cushion.

Luggage Compartment Dimensions

- H195 - Lift Over Height

  The vertical dimension from the lower opening of the luggage compartment at the zero "Y" plane to the ground.

- V1 - Luggage Capacity - Usable

  The total of volumes of individual pieces of the standard luggage set plus H-boxes that can be stowed in the luggage compartment.

All of the interior measurement tests were conducted according to the procedures specified in SAE J1100a, "Motor Vehicle Dimensions," and SAE J826b, "Devices for Use in Defining and Measuring Vehicle Seating Accomodation." Figures 22 and 23 show the H-point machine positioned in the ASL and Dutcher prototypes, respectively.

The loading of the luggage compartment to determine its capacity proceeds by placing pieces from the standard luggage set into the compartment in random order. To ensure that the maximum capacity of each vehicle was determined, the loading was done by five to six different individuals and the highest load capacity taken as the usable luggage capacity. There was no spare tire or jack in the baseline taxicab during loading since neither of the PTVs contain provisions for a spare tire.

Figure 22. H-point Machine Installed in Driver's Seat of ASL Prototype.

Figure 23. H-point Machine Installed in Passenger Seat of Dutcher Prototype.

5.6 PROBLEMS ENCOUNTERED DURING INTERIOR MEASUREMENT TESTS

Two problems were encountered in positioning the H-point machine in the driver's seat of the ASL prototype. When the H-point machine was installed in the seat, it was necessary to position the left lower leg assembly 2.5 inches closer to the center of the knee joint T-bar than the right leg in order to keep the T-bar parallel to the ground. This occurred because the shape of the toe pan would not permit the left foot to rest any further toward the outside of the vehicle without tilting the H-point machine (see Figure 22).

When measuring the H-point travel of the ASL driver's seat, the H-point machine contacted the steering column before the entire available seat track movement had been utilized. In the foreward seat position, the length of the 95th percentile leg segments forced the front of the H-point seat pan upward from the seat (see Figure 24). The H-point machine also contacted the steering column in the baseline taxicab before the full amount of forward seat travel had been used.

Figure 24. H-point Machine in ASL Driver's Seat Forward Position.

6.0 TEST RESULTS

6.1 VEHICLE ACCELERATION TESTS

6.1.1 Vehicle Data

The acceleration performances of the Nova, ASL, and Dutcher prototypes are summarized in Tables 13, 14, and 15, respectively. The data in these tables were obtained by averaging all ten repeatability runs for each test condition.

The ASL prototype could attain a velocity of 40 mph or more in only half of the test runs at one-quarter throttle (see Table 14). Its average acceleration at this throttle setting was approximately half that of the other two vehicles. This lack of acceleration in the ASL could be partly due to the characteristics of its transmission. The times of transmission shifts for the three vehicles are given in Table 16. This table shows that the ASL consistently shifted from Low 2 to Drive in a shorter time at one-quarter throttle than at the other throttle conditions. It also shifted significantly faster at one-quarter throttle than did the Dutcher prototype.

It is also possible that some characteristic of the throttle linkage in the ASL prototype resulted in a lower than anticipated flow of fuel to the engine at one-quarter throttle, thus reducing engine power more than anticipated. The marginal power at this throttle position is evidenced by the 50 percent of the individual test runs in which the ASL did reach 40 mph. The majority of these runs were in a westerly direction and thus on a very slight downgrade (less than 1 percent).

The times for all three vehicles to reach intermediate speeds are given in Table 17. These data are shown graphically as velocity-time plots in Figures 25 through 33. (Velocity-time plots

TABLE 13. SUMMARY OF VEHICLE ACCELERATION PERFORMANCE FOR THE NOVA (BASELINE PASSENGER CAR)

Throttle Position	Test Load (lb)	Average Longitudinal Acceleration (G)	Time of Shifts (sec)				Time to Reach Intermediate Speeds (sec)									
			1st Shift		2nd Shift		20 mph		30 mph		40 mph		45 mph		50 mph	
			Avg*	S.D.**	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.
Full	300	.09	6.85	.34	14.06	.48	3.12	.13	5.45	.21	7.94	.38	9.94	.39	11.94	.50
Half	300	.09	5.95	.31	10.26	.53	3.40	.17	5.78	.21	9.56	.37	12.05	.41	15.25	.77
Quarter	300	.09	4.85	.12	10.63	.34	3.72	.07	7.31	.28	12.84	.57	16.68	.88	21.44	1.14
Full	650	.15	7.30	.66	None	None	3.50	.23	5.89	.36	9.50	.53	11.70	.58	14.00	.71
Half	650	.12	6.36	.14	11.21	.24	3.58	.18	6.16	.16	10.34	.29	13.33	.35	17.2	.75
Quarter	650	.11	5.45	.22	11.92	.59	4.60	.12	9.15	.36	16.49	1.34	21.66	2.36	28.26	3.63
Full	900	.13	7.62	2.01	None	None	3.96	.68	6.75	.79	10.32	.91	12.80	1.06	15.50	1.14
Half	900	.13	6.99	.21	12.24	.42	3.85	.15	6.60	.28	11.05	.44	14.08	.37	18.46	.69
Quarter	900	.12	5.70	.21	12.59	.70	4.64	.27	9.34	.53	16.79	1.20	22.73	2.10	27.07	.29

*Avg = average value
**S.D. = standard deviation.

TABLE 14. SUMMARY OF VEHICLE ACCELERATION PERFORMANCE FOR THE ASL PROTOTYPE

Throttle Position	Test Load (lb)	Average Longitudinal Deceleration (G)	Time of Shifts (sec)				Time to Reach Intermediate Speeds (sec)									
			1st Shift		2nd Shift		20 mph		30 mph		40 mph		45 mph		50 mph	
			Avg*	S.D.**	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.
Full	300	.089	6.44	.28	23.76	1.93	5.09	.43	8.83	.73	13.52	.86	16.41	1.17	19.77	1.45
Half	300	.084	6.84	.34	22.67	1.89	6.75	.58	13.11	1.21	21.68	2.36	28.69	1.98	44.77	6.30
Quarter	300	.05	7.10	.47	14.43	1.08	12.16	1.06	29.29	5.22	(1)	-	-	-	-	-
Full	650	.10	7.00	.25	24.38	1.66	5.99	.22	9.97	.42	15.77	.99	18.61	1.21	22.25	1.62
Half	650	.11	7.15	.31	23.69	1.73	7.02	.32	13.78	.73	22.67	1.50	31.22	1.99	43.10	3.30
Quarter	650	.05	7.50	.40	14.99	1.34	12.47	1.00	31.03	6.11	(2)	-	-	-	-	-
Full	900	.07	6.83	.33	25.56	1.90	5.86	.20	9.90	.53	15.80	1.08	18.99	1.23	22.69	1.76
Half	900	.10	7.28	.22	25.29	2.37	7.07	.27	14.20	1.19	22.70	2.23	29.54	3.72	41.21	7.36
Quarter	900	.05	8.09	.54	16.68	1.25	13.97	1.54	43.16	16.03	(3)	-	-	-	-	-

*Avg = average value
**S.D. = standard deviation
(1) maximum speed of 3 runs < 40 mph
(2) maximum speed of 6 runs < 40 mph
(3) maximum speed of 5 runs < 40 mph

TABLE 15. SUMMARY OF VEHICLE ACCELERATION PERFORMANCE FOR THE DUTCHER PROTOTYPE

Throttle Position	Test Load (lb)	Average Longitudinal Acceleration (G)	Time of Shifts (sec)				Time to Reach Intermediate Speeds (sec)									
			1st Shift		2nd Shift		20 mph		30 mph		40 mph		45 mph		50 mph	
			Avg*	S.D.**	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.	Avg	S.D.
Full	300	.14	7.47	.18	17.78	.87	4.31	.15	6.72	.25	10.45	.37	13.18	.53	15.56	.76
Half	300	.15	4.57	.66	15.95	1.13	4.37	.23	8.31	.87	13.70	1.02	17.03	1.29	22.66	2.07
Quarter	300	.13	4.30	.13	20.67	1.19	4.70	.15	9.87	.51	17.96	1.15	23.88	1.91	35.29	4.57
Full	650	.13	7.97	.32	19.87	.91	4.55	.12	7.31	.15	11.99	.44	14.73	.59	18.00	.87
Half	650	.13	4.93	.91	17.49	2.02	4.61	.30	9.18	1.10	15.79	1.89	20.12	2.68	27.89	3.74
Quarter	650	.09	4.80	.25	24.29	3.88	5.42	.45	11.75	1.34	21.78	3.60	30.29	6.06	45.69	12.16
Full	900	.12	8.58	.44	22.46	1.57	4.94	.20	7.82	.51	13.37	.77	16.58	.96	20.76	1.42
Half	900	.10	5.09	.71	19.99	2.35	4.79	.35	9.98	1.20	16.87	1.99	21.10	2.18	35.46	8.68
Quarter	900	.10	4.84	.24	27.37	3.61	5.53	.35	12.04	1.17	21.66	3.26	32.30	5.77	(1)	-

*Avg = average value
**S.D. = standard deviation
(1) maximum speed of 6 runs < 50 mph

TABLE 16. COMPARISON OF TIME OF SHIFTS FOR VEHICLE ACCELERATION TESTING

		Time of Shift (sec)					
		First Shift			Second Shift		
Throttle Position	Test Load (lb)	Nova (Base-line)	ASL Proto-type	Dutcher Proto-type	Nova (Base-line)	ASL Proto-type	Dutcher Proto-type
Full	300	6.85	6.44	7.47	14.06	23.76	17.78
Half	300	5.95	6.84	4.57	10.26	22.67	15.95
Quarter	300	4.85	7.10	4.30	10.63	14.43	20.67
Full	650	7.30	7.00	7.97	None	24.38	19.87
Half	650	6.36	7.15	4.93	11.21	23.69	17.49
Quarter	650	5.45	7.50	4.80	11.92	14.99	24.29
Full	900	7.62	6.83	8.58	None	25.56	22.46
Half	900	6.99	7.28	5.09	12.24	25.29	19.99
Quarter	900	5.70	8.09	4.84	12.59	16.68	27.37

showing standard deviations for the individual vehicles are contained in Appendix A.)

The plots in Figures 25 through 33 show that the Nova exhibited the best acceleration characteristics during all test conditions, followed by the Dutcher prototype. The ASL PTV had the slowest acceleration of the three vehicles under every condition. The larger engine of the Nova undoubtedly accounted for its better acceleration characteristics as compared to the prototype vehicles with their smaller engines. The reasons for the marked delay in acceleration rates of the ASL at one-quarter throttle have been discussed above.

TABLE 17. COMPARISON OF TIME TO REACH INTERMEDIATE SPEED FOR THE VEHICLE ACCELERATION TESTING

		Time of Intermediate Speeds (sec)														
		20 mph			30 mph			40 mph			45 mph			50 mph		
Throttle Position	Test Load (lb)	Nova (Baseline)	ASL Prototype	Dutcher Prototype	Nova (Baseline)	ASL Prototype	Dutcher Prototype	Nova (Baseline)	ASL Prototype	Dutcher Prototype	Nova (Baseline)	ASL Prototype	Dutcher Prototype	Nova (Baseline)	ASL Prototype	Dutcher Prototype
Full	300	3.12	5.09	4.31	5.45	8.83	6.72	7.94	13.52	10.45	9.94	16.41	13.18	11.94	19.77	15.56
Half	300	3.40	6.75	4.37	5.78	13.11	8.31	9.56	21.68	13.70	12.05	28.69	17.03	15.25	44.77	22.66
Quarter	300	3.72	12.16	4.70	7.31	29.29	9.87	12.84	-	17.96	16.68	-	23.88	21.44	-	35.29
Full	650	3.50	5.99	4.55	5.89	9.97	7.31	9.50	15.77	11.99	11.70	18.61	14.73	14.00	22.25	18.00
Half	650	3.58	7.02	4.61	6.16	13.78	9.18	10.34	22.67	15.79	13.33	31.22	20.12	17.20	43.10	27.89
Quarter	650	4.60	12.47	5.42	9.15	31.03	11.75	16.49	-	21.78	21.66	-	30.29	28.26	-	45.69
Full	900	3.96	5.86	4.94	6.75	9.90	7.82	10.32	15.80	13.37	12.80	18.99	16.58	15.50	22.69	20.76
Half	900	3.85	7.07	4.79	6.60	14.20	9.98	11.05	22.70	16.87	14.08	29.54	21.10	18.46	41.21	35.46
Quarter	900	4.64	13.97	5.53	9.34	43.16	12.04	16.79	-	21.66	22.73	-	32.30	27.07	-	-

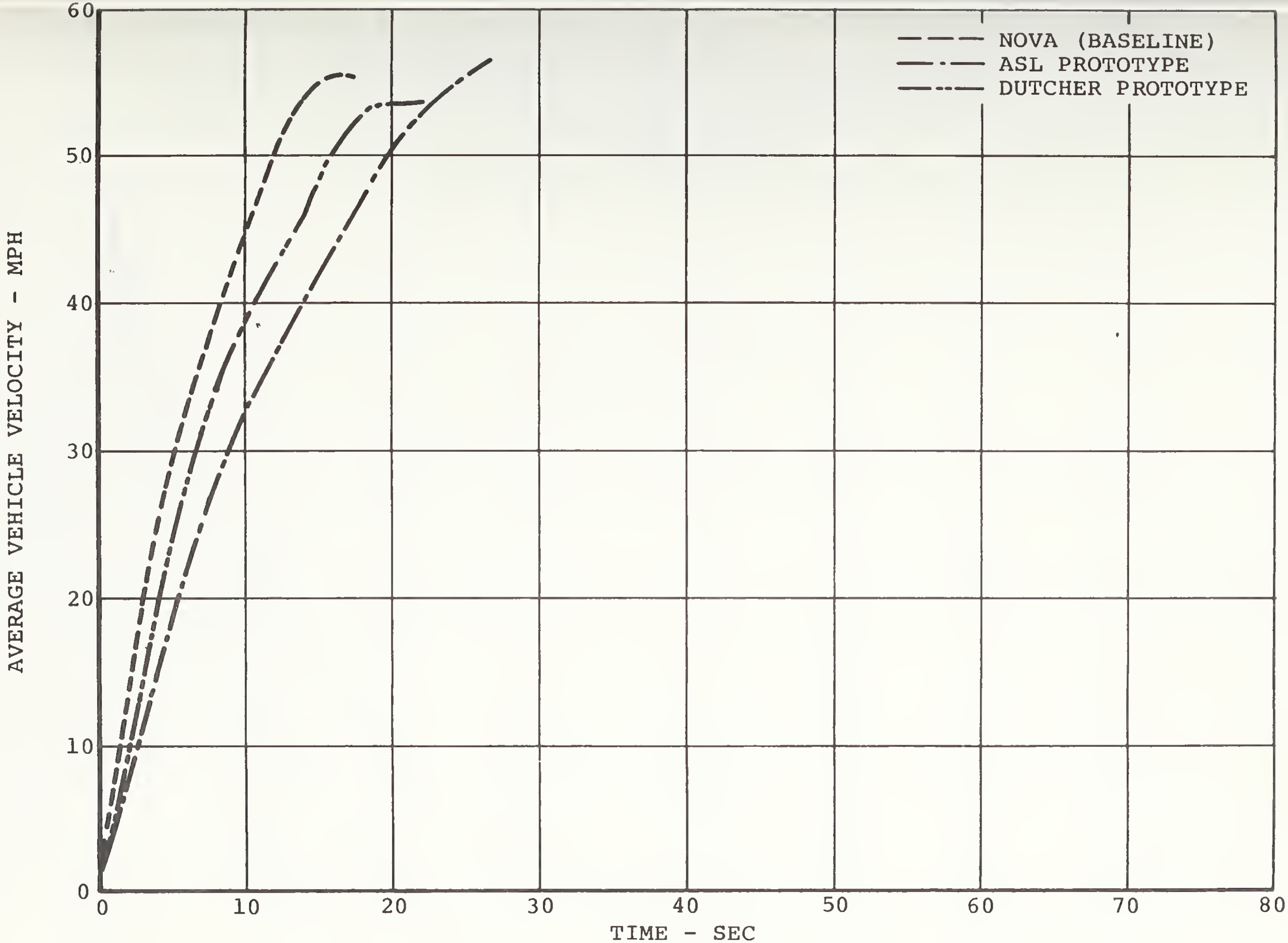


Figure 25. Vehicle Velocities During Acceleration Testing, Full Throttle, 300-pound Load.

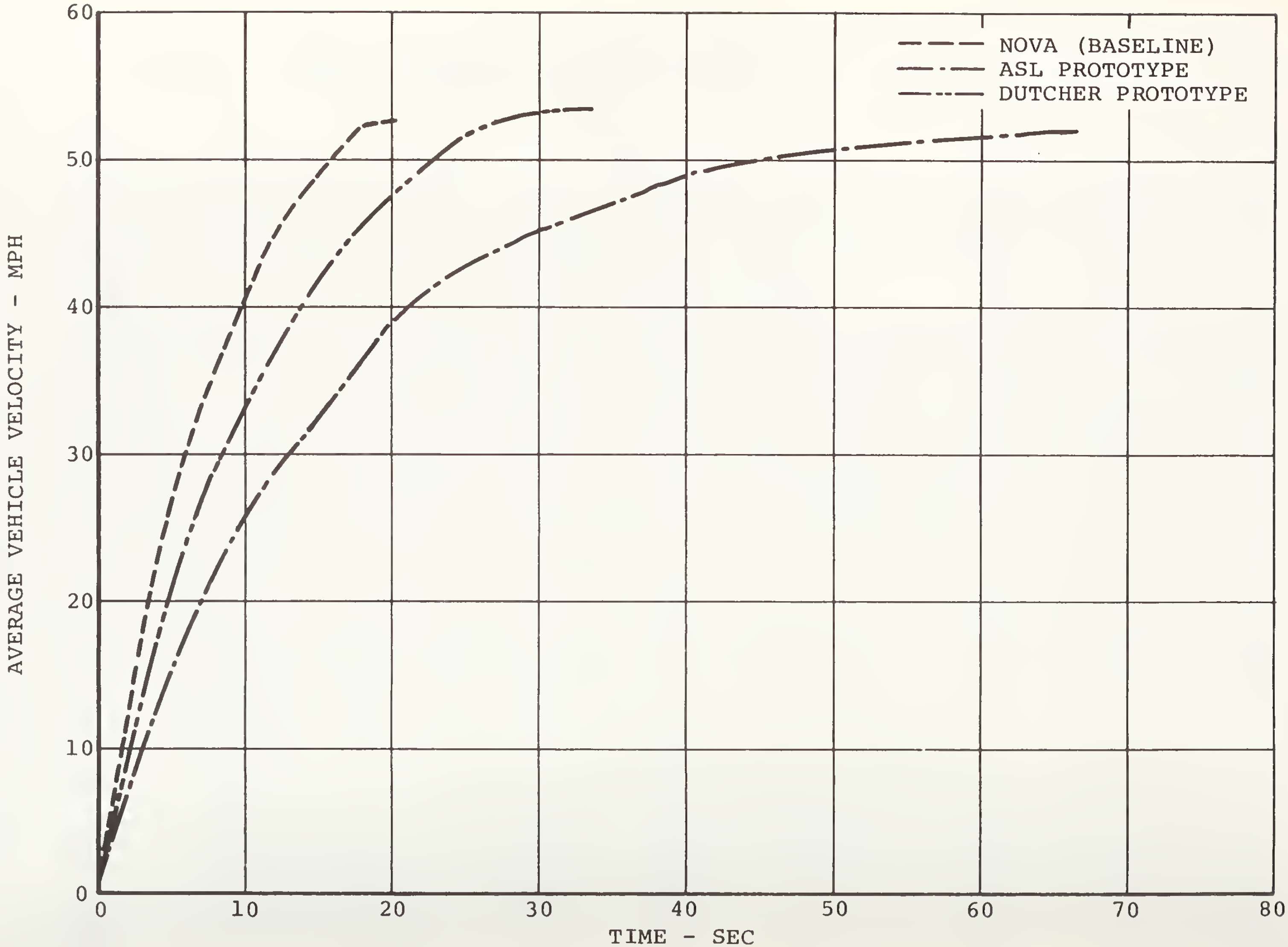


Figure 26. Vehicle Velocities During Acceleration Testing, 1/2 Throttle, 300-pound Load.

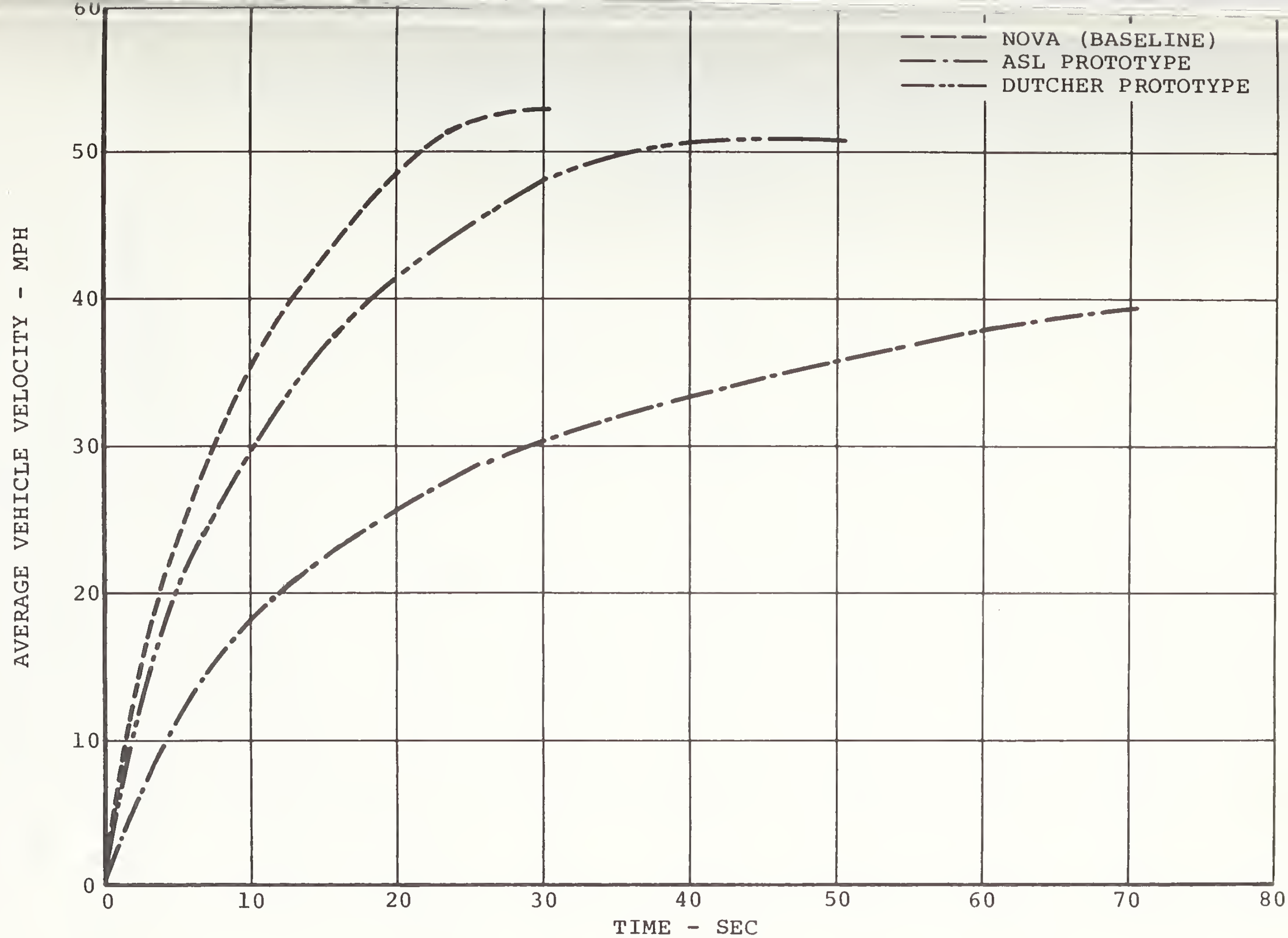


Figure 27. Vehicle Velocities During Acceleration Testing, 1/4 Throttle, 300-pound Load.

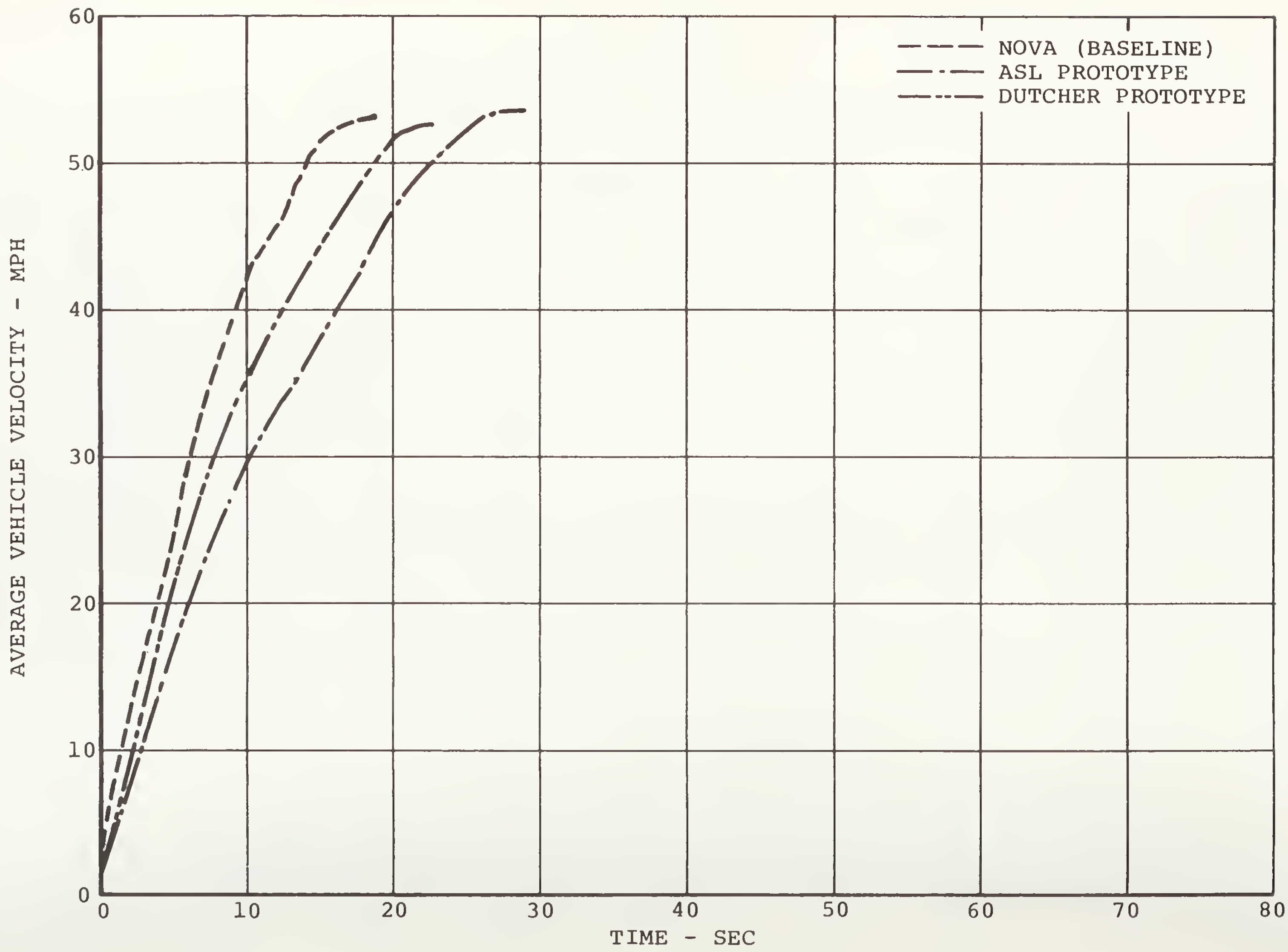


Figure 28. Vehicle Velocities During Acceleration Testing, Full Throttle, 650-pound Load.

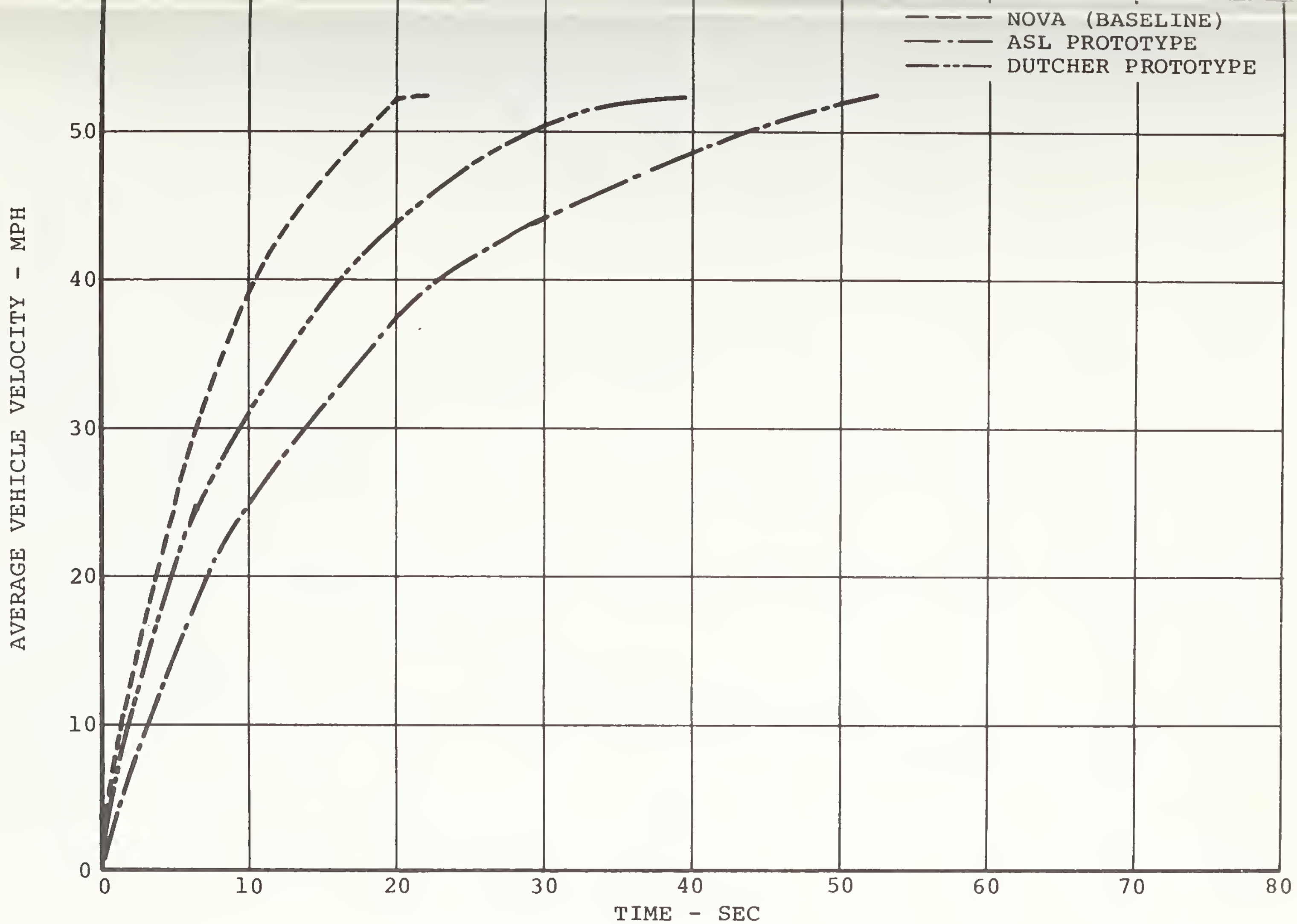


Figure 29. Vehicle Velocities During Acceleration Testing, 1/2 Throttle, 650-pound Load.

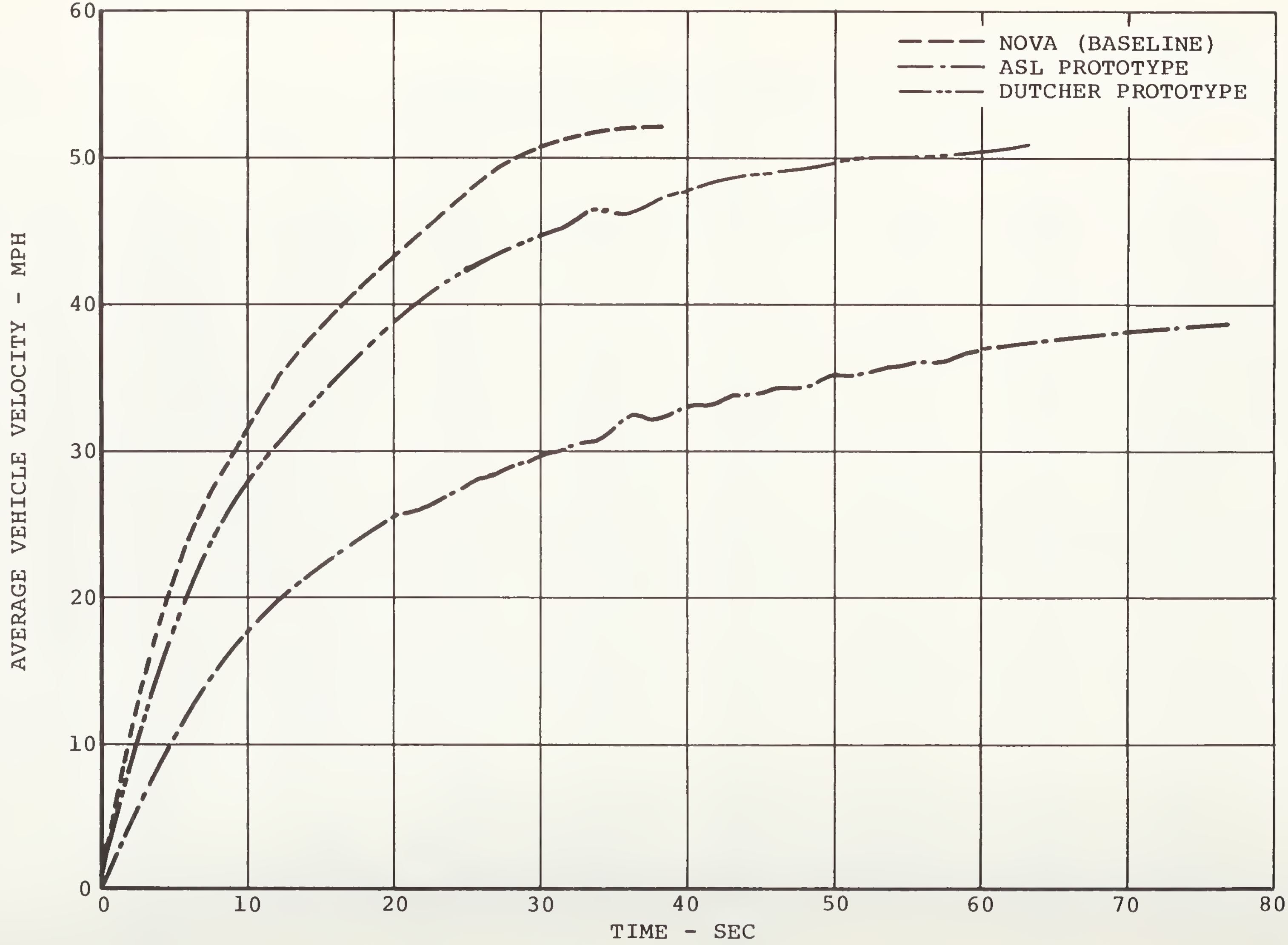


Figure 30. Vehicle Velocities During Acceleration Testing, 1/4 Throttle, 650-pound Load.

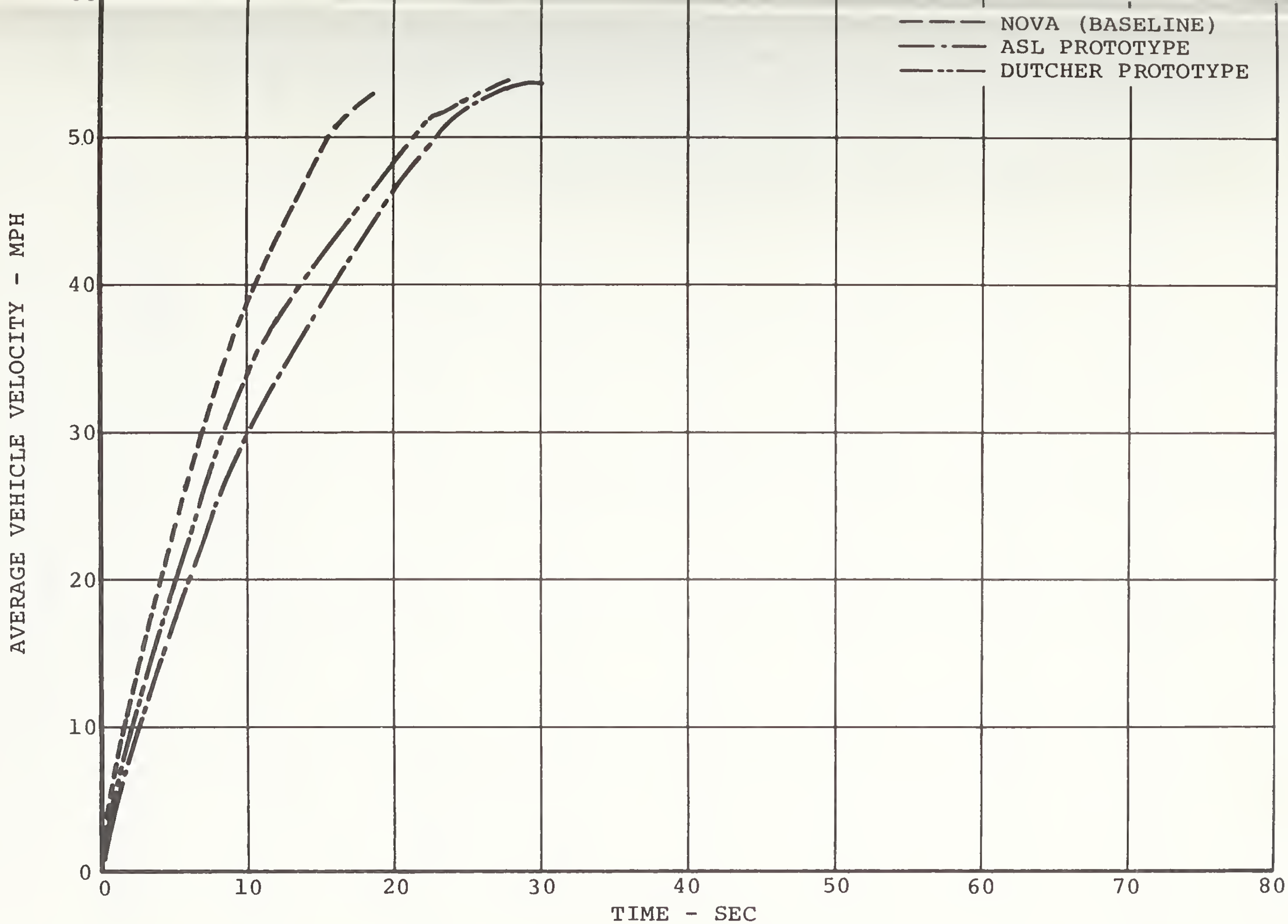


Figure 31. Vehicle Velocities During Acceleration Testing, Full Throttle, 900-pound Load.

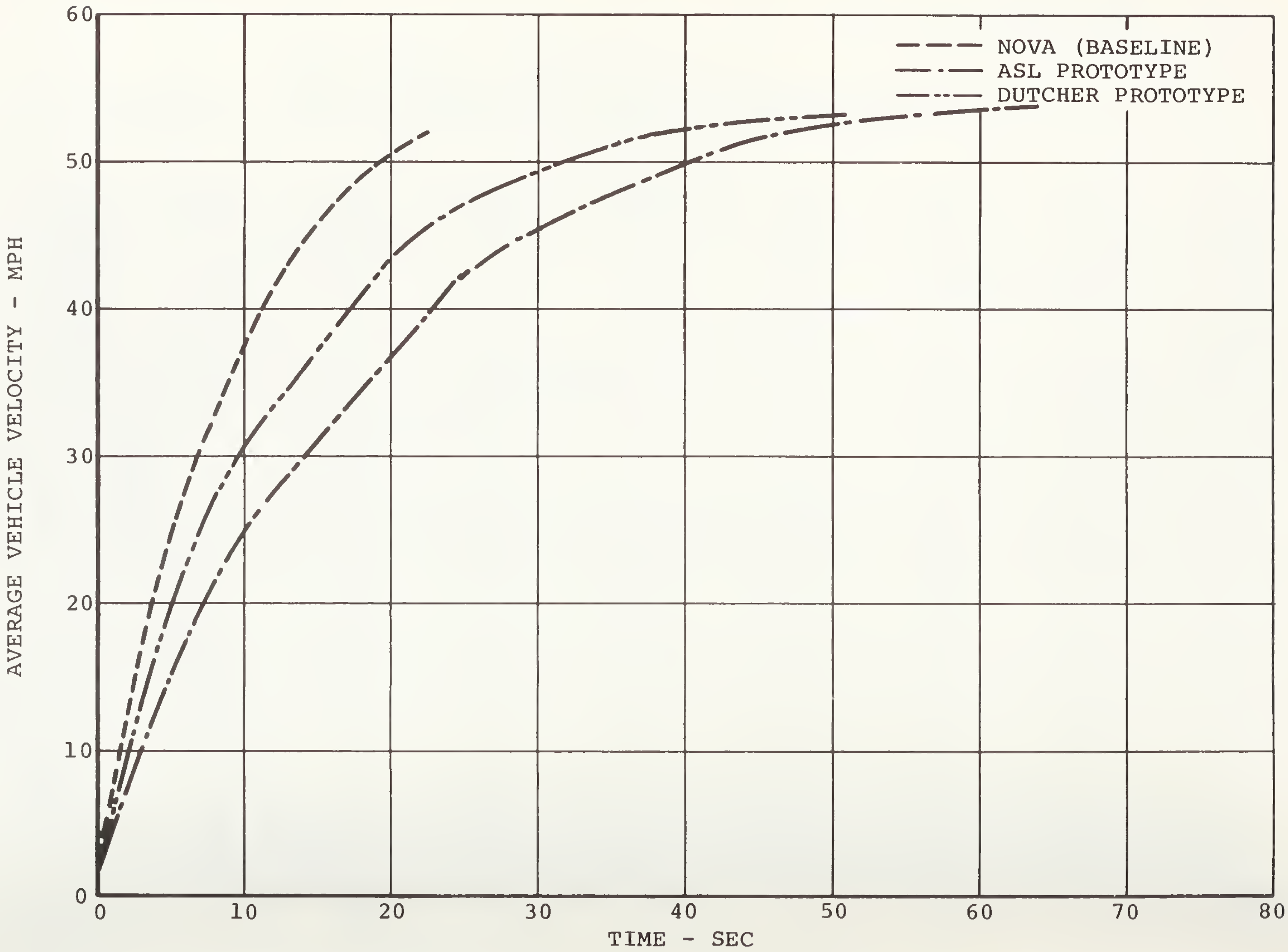


Figure 32. Vehicle Velocities During Acceleration Testing, 1/2 Throttle, 900-pound Load.

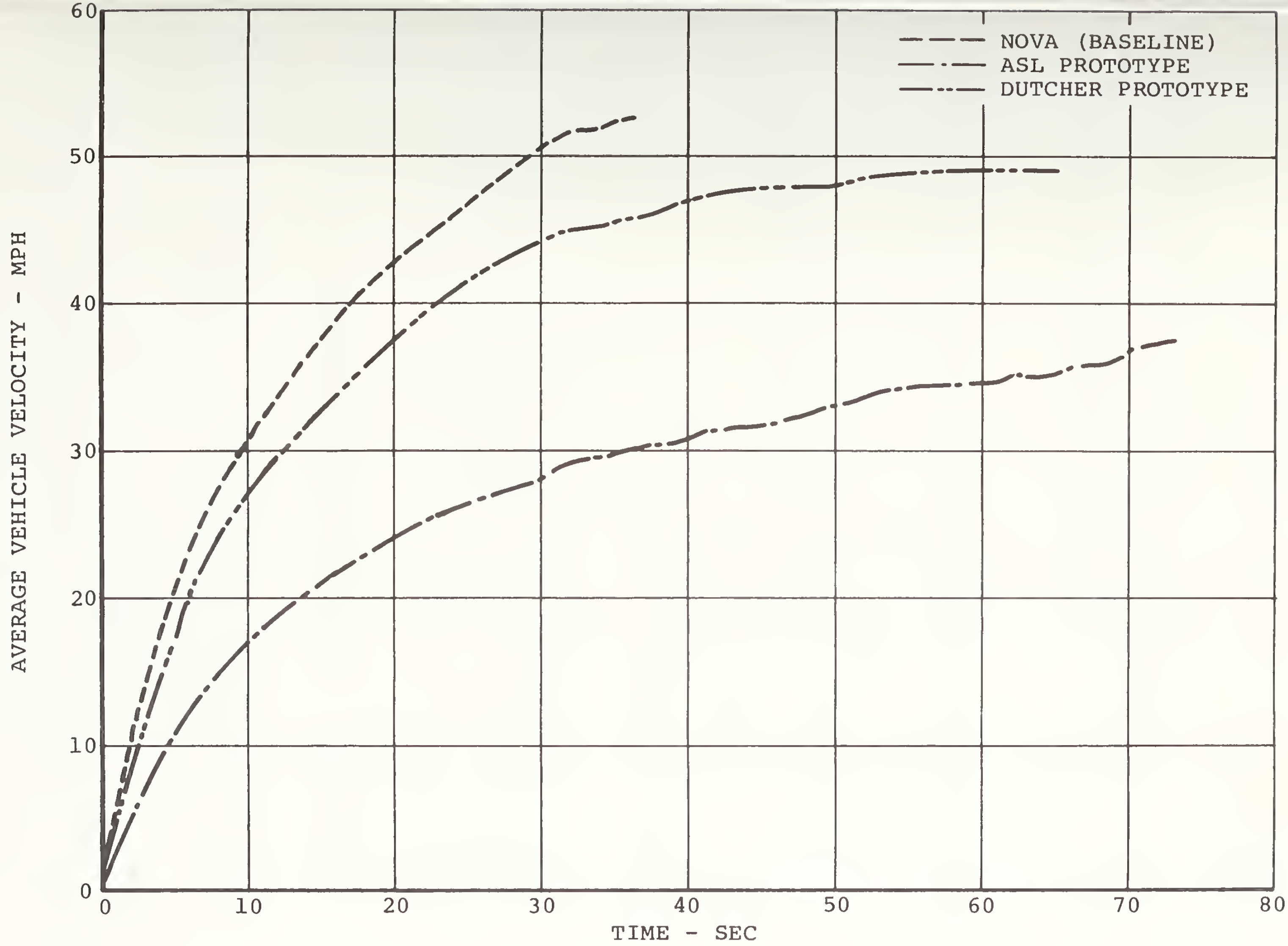


Figure 33. Vehicle Velocities During Acceleration Testing, 1/4 Throttle, 900-pound Load.

6.1.2 Dummy Data

The average longitudinal accelerations of the vehicle dummies monitored during the 650-pound load tests are shown in Figures 34 through 36. Individual acceleration plots showing standard deviations are contained in Appendix B.

The peak dummy accelerations in both the Nova and Dutcher prototype were nearly identical under all three throttle conditions, ranging from 0.23 to 0.25G. The peak accelerations in the ASL dummy were somewhat lower, ranging from 0.14 to 0.20G. The acceleration curves are consistent with the vehicles' acceleration performances and there seems to be no significant differences between the dummy in the wheelchairs of the PTVs and in the rear seat of the Nova.

6.2 PASSENGER DECELERATION TESTS

Lift-off for each dummy during the passenger deceleration tests was monitored by the four contact switches on the seat. Lift-off was considered to have happened if any of the four switches opened. The test data were translated into dislodgement percentage, calculated from the following equation:

$$\text{Dislodgement Percentage} = \frac{\text{Number of Lift-offs}}{\text{Number of Deceleration Runs}} \times 100$$

The average vehicle deceleration and dislodgement percentage for the baseline taxicab, ASL, and Dutcher prototypes are presented in Tables 18 through 20 and Figures 37 through 39. These data show that the female dummy was dislodged at a lower deceleration than the male dummy in both paratransit vehicles, while the opposite was true for the taxicab. The male dummy in the taxi registered lift-off sooner than the female dummy because the male dummy slid on the seat while the female dummy rotated on the seat.

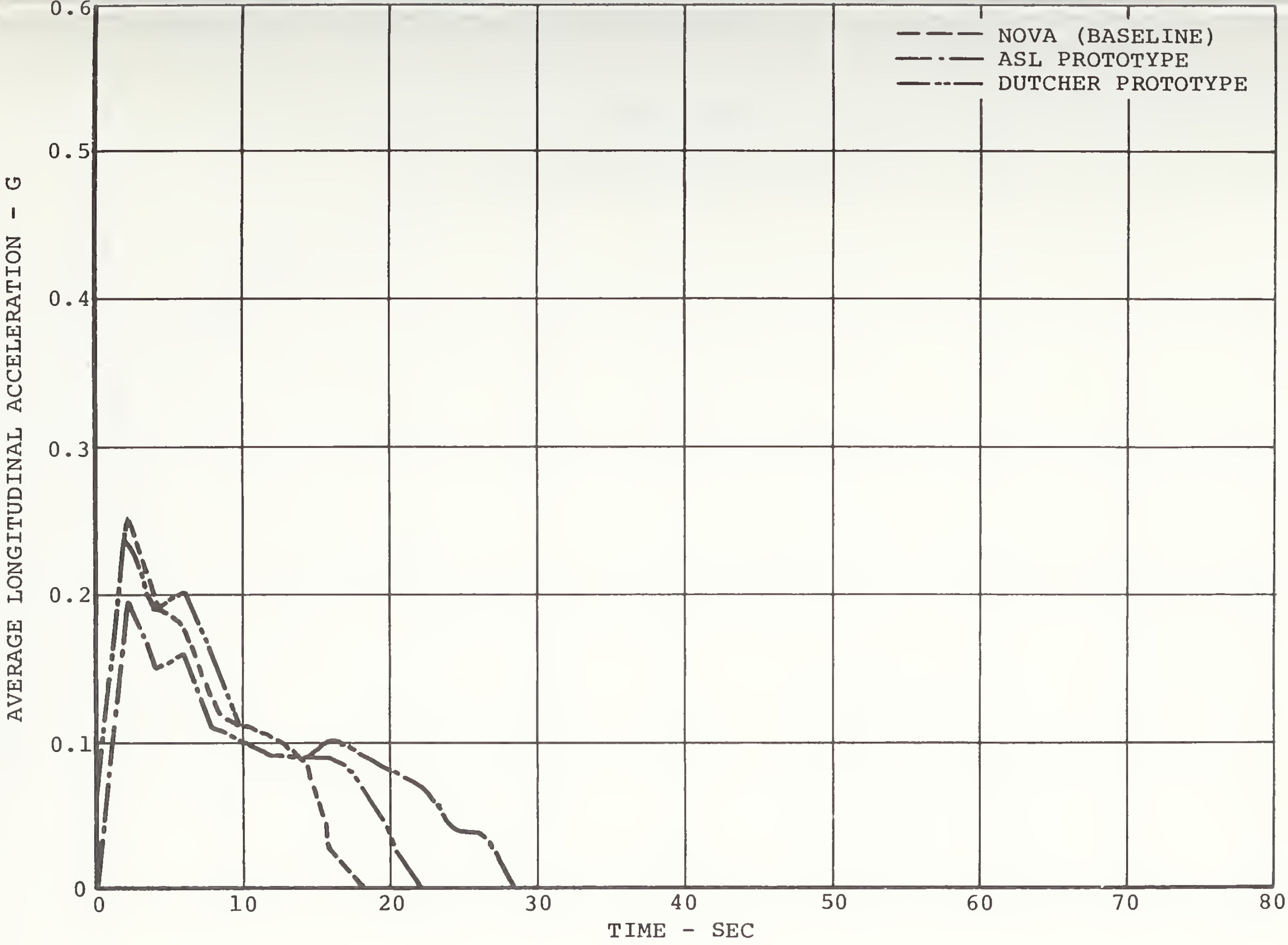


Figure 34. Dummy Accelerations During Vehicle Acceleration Testing, Full Throttle, 650-pound Load.

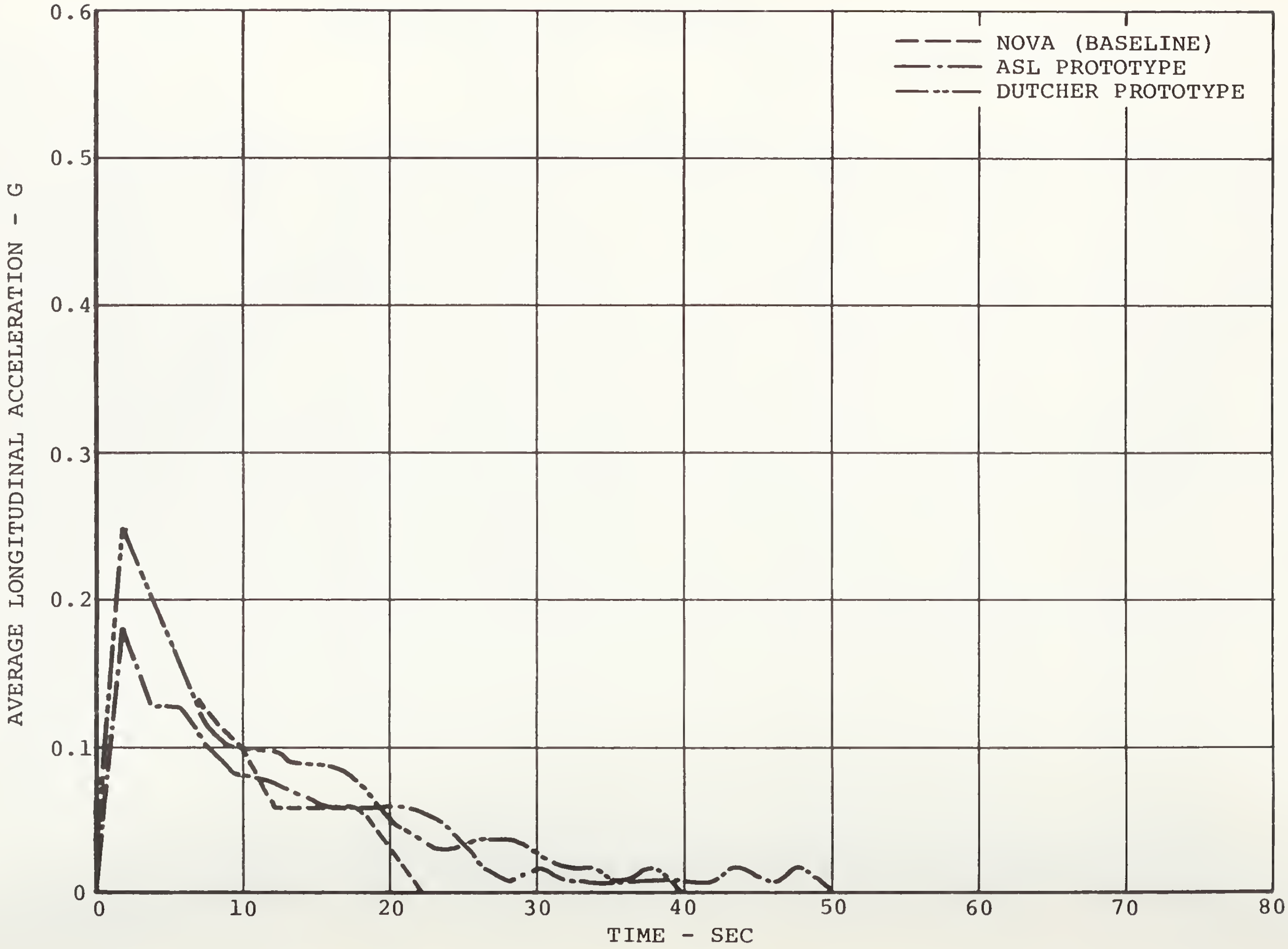


Figure 35. Dummy Accelerations During Vehicle Acceleration Testing, 1/2 Throttle, 650-pound Load.

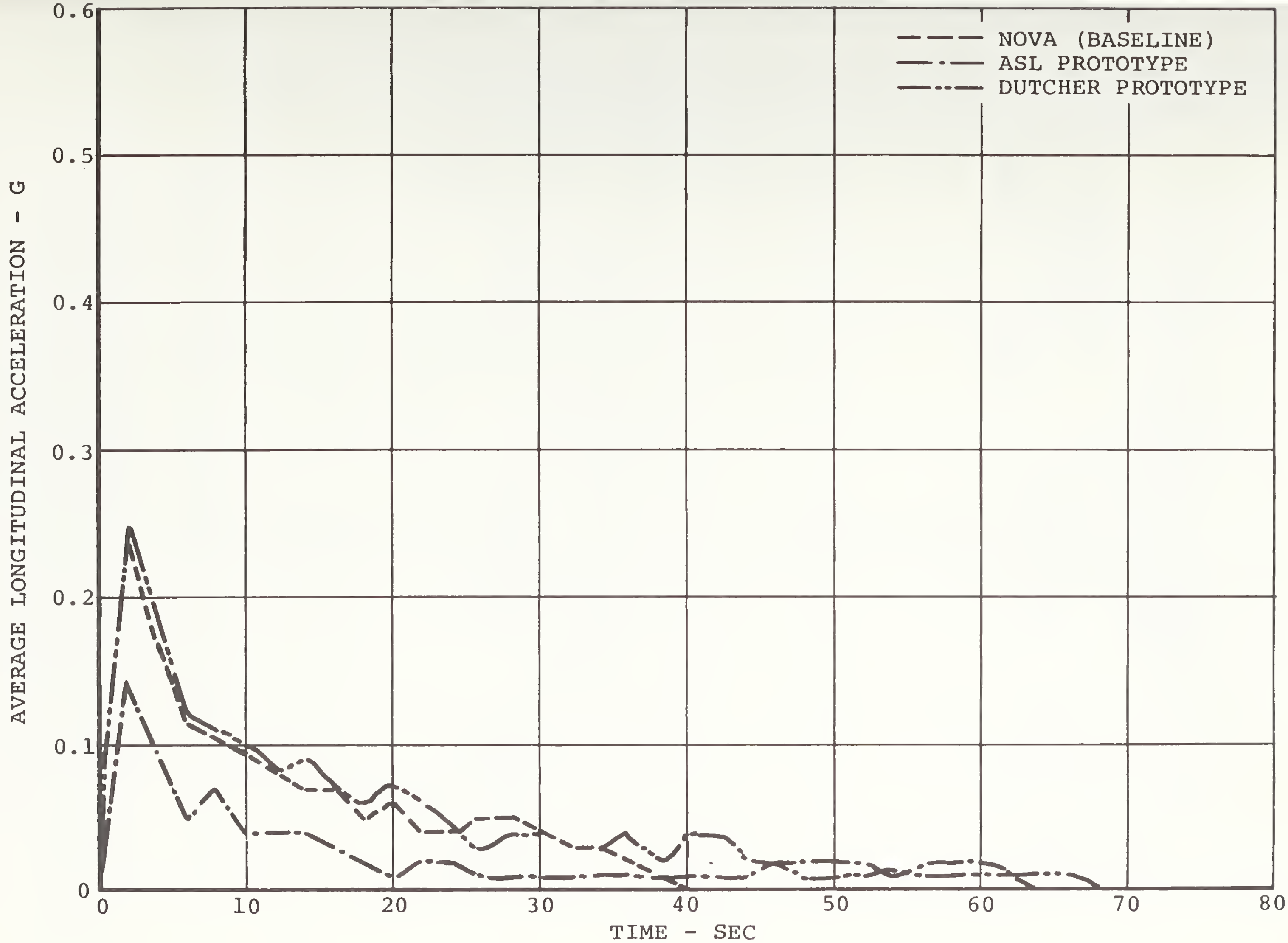


Figure 36. Dummy Accelerations During Vehicle Acceleration Testing, 1/4 Throttle, 650-pound Load.

TABLE 18. SUMMARY OF PASSENGER DECELERATION TESTING FOR THE CHECKER CAB (BASELINE TAXICAB)

Nominal Longitudinal Deceleration (G)	Average Longitudinal Deceleration (G)	Dislodgement Percentage	
		Female Dummy	Male Dummy
0.3	.298	0	0
0.4	.369	0	0
0.5	.489	0	0
0.6	.592	0	80
0.7	.678	100	100

TABLE 19. SUMMARY OF PASSENGER DECELERATION TESTING FOR THE ASL PROTOTYPE

Nominal Longitudinal Deceleration (G)	Average Longitudinal Deceleration (G)	Dislodgement Percentage	
		Female Dummy	Male Dummy
0.3	.356	0	0
0.4	.395	100	0
0.5	.498	100	0
0.6	.630	100	0
0.7	.644	100	100

TABLE 20. SUMMARY OF PASSENGER DECELERATION TESTING FOR THE DUTCHER PROTOTYPE

Nominal Longitudinal Deceleration (G)	Average Longitudinal Deceleration (G)	Dislodgement Percentage	
		Female Dummy	Male Dummy
0.3	.298	0	0
0.4	.382	60	0
0.5	.480	100	0
0.6	.540*	100	100

*Maximum achievable steady deceleration.

Comparative plots of dummy dislodgement in the three vehicles are presented in Figures 40 and 41. Figure 40 shows that the baseline taxi had the best passenger deceleration performance for the female dummy. The best performance for the male dummy was attained by the ASL prototype, as shown in Figure 41. The taxicab had the best overall performance when considering both dummies together.

6.3 WHEELCHAIR DECELERATION TESTS

The following parameters were determined for each test condition (deceleration level and restraint system) by averaging the repeatability runs:

- Vehicle test deceleration (longitudinal/lateral) versus time.
- Displacement in a plane parallel to the test acceleration for the dummy's head and upper throrax (i.e., longitudinal and vertical displacement for longitudinal deceleration; lateral and vertical displacement for lateral deceleration) versus time.

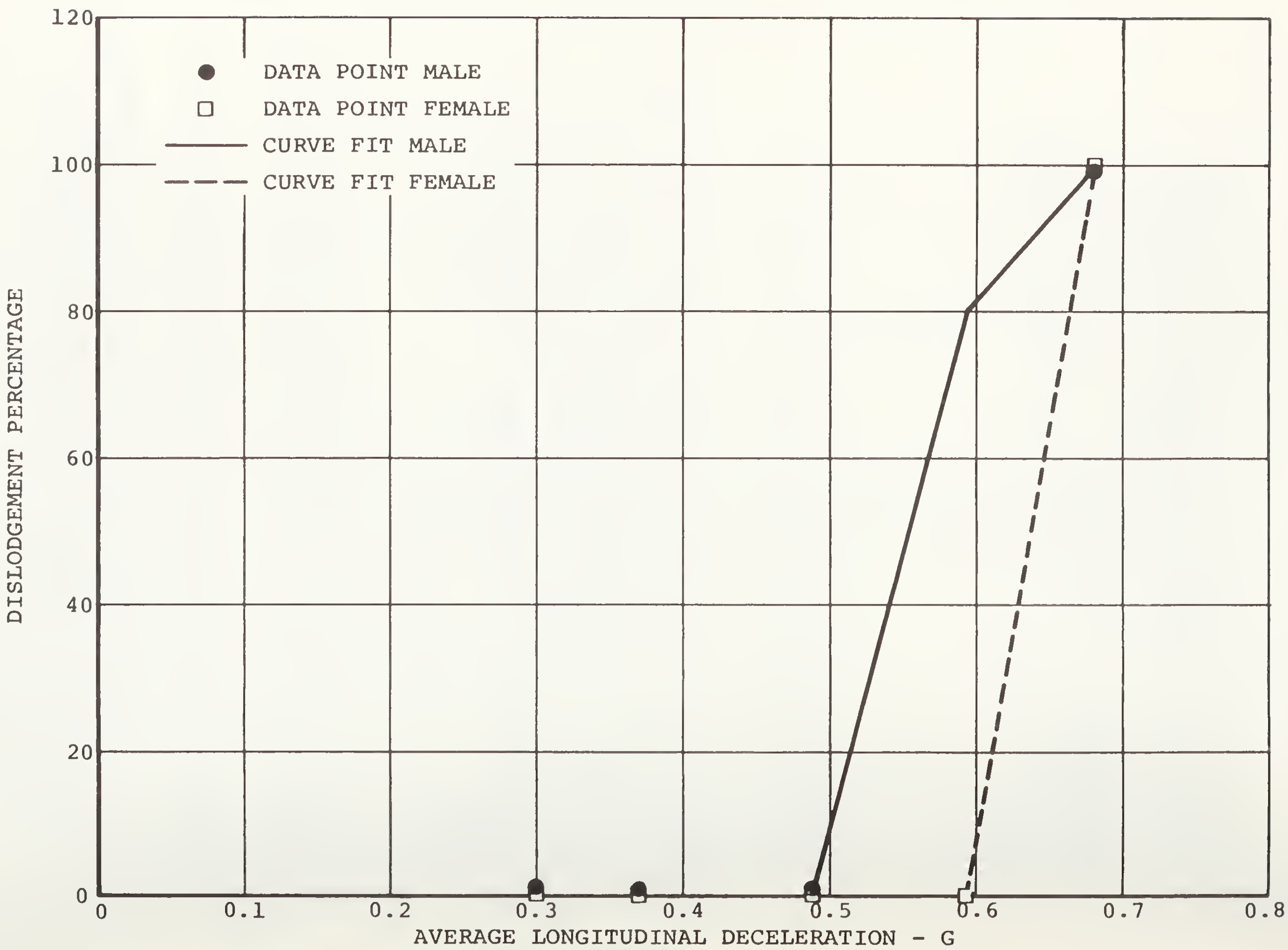


Figure 37. Dummy Dislodgement During Vehicle Deceleration of Checker Taxicab.

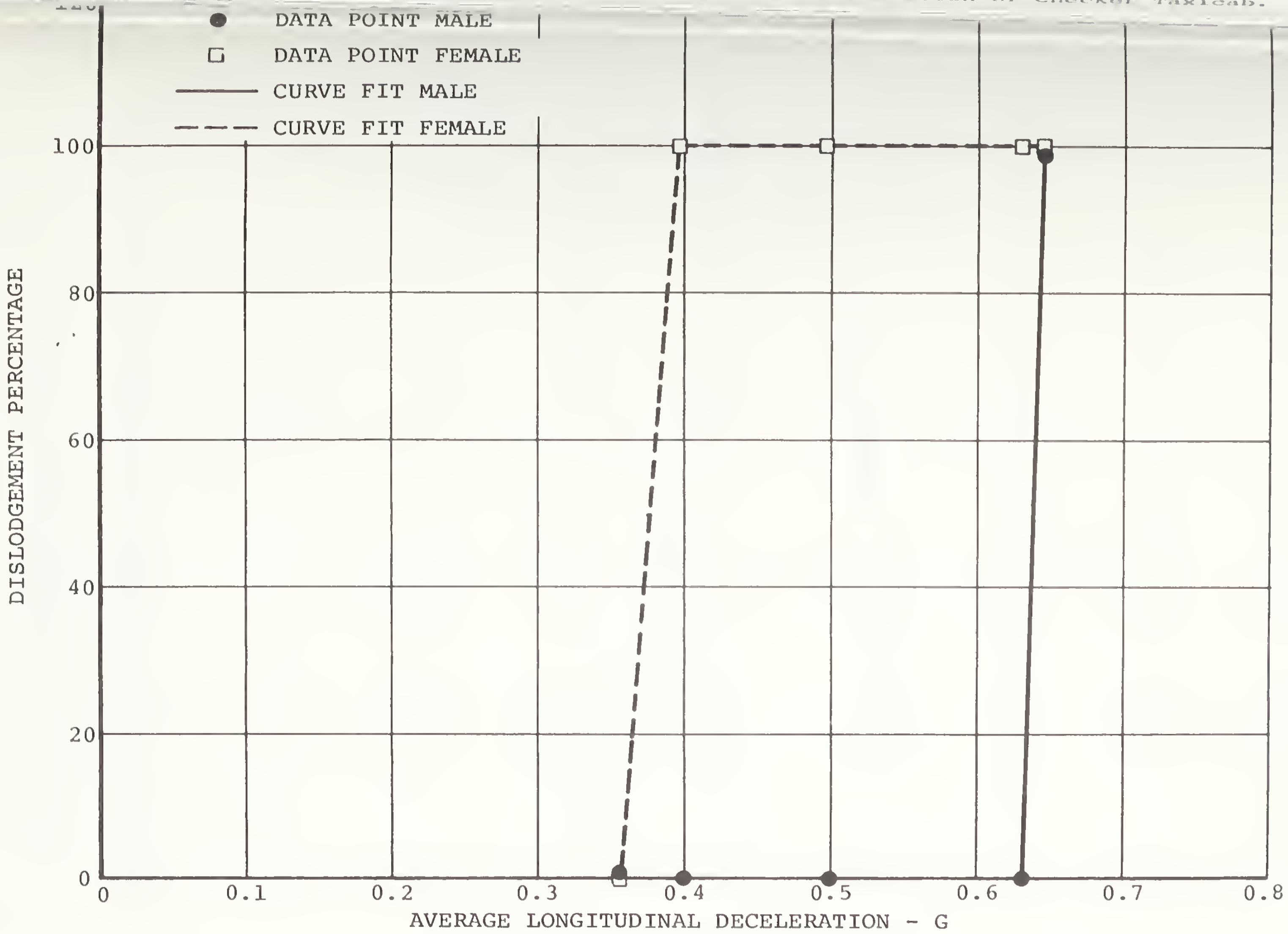


Figure 38. Dummy Dislodgement During Vehicle Deceleration of ASL Prototype.

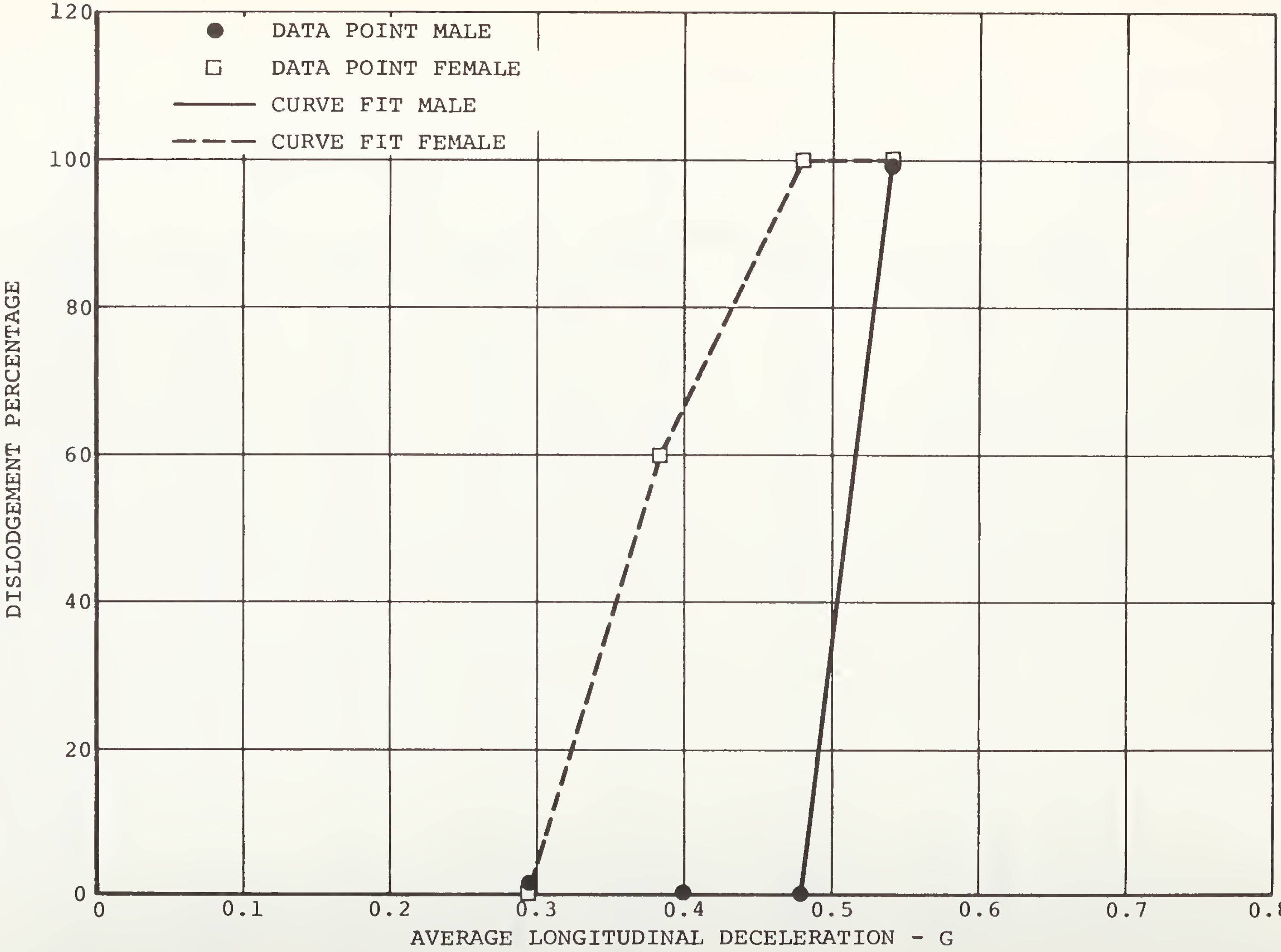


Figure 39. Dummy Dislodgement During Vehicle Deceleration of Dutcher Prototype.

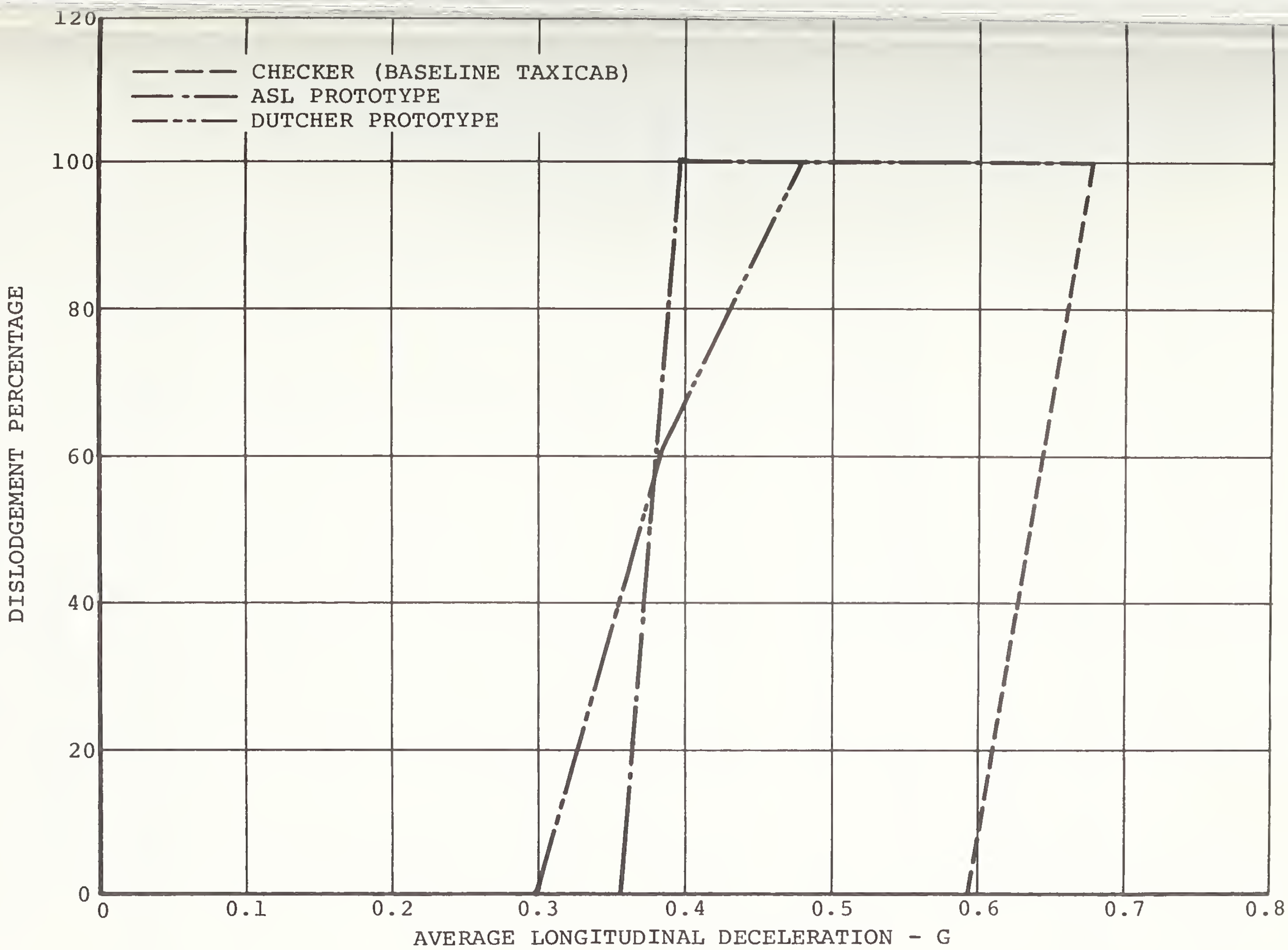


Figure 40. Dislodgement of Female Dummy During Passenger Deceleration Tests.

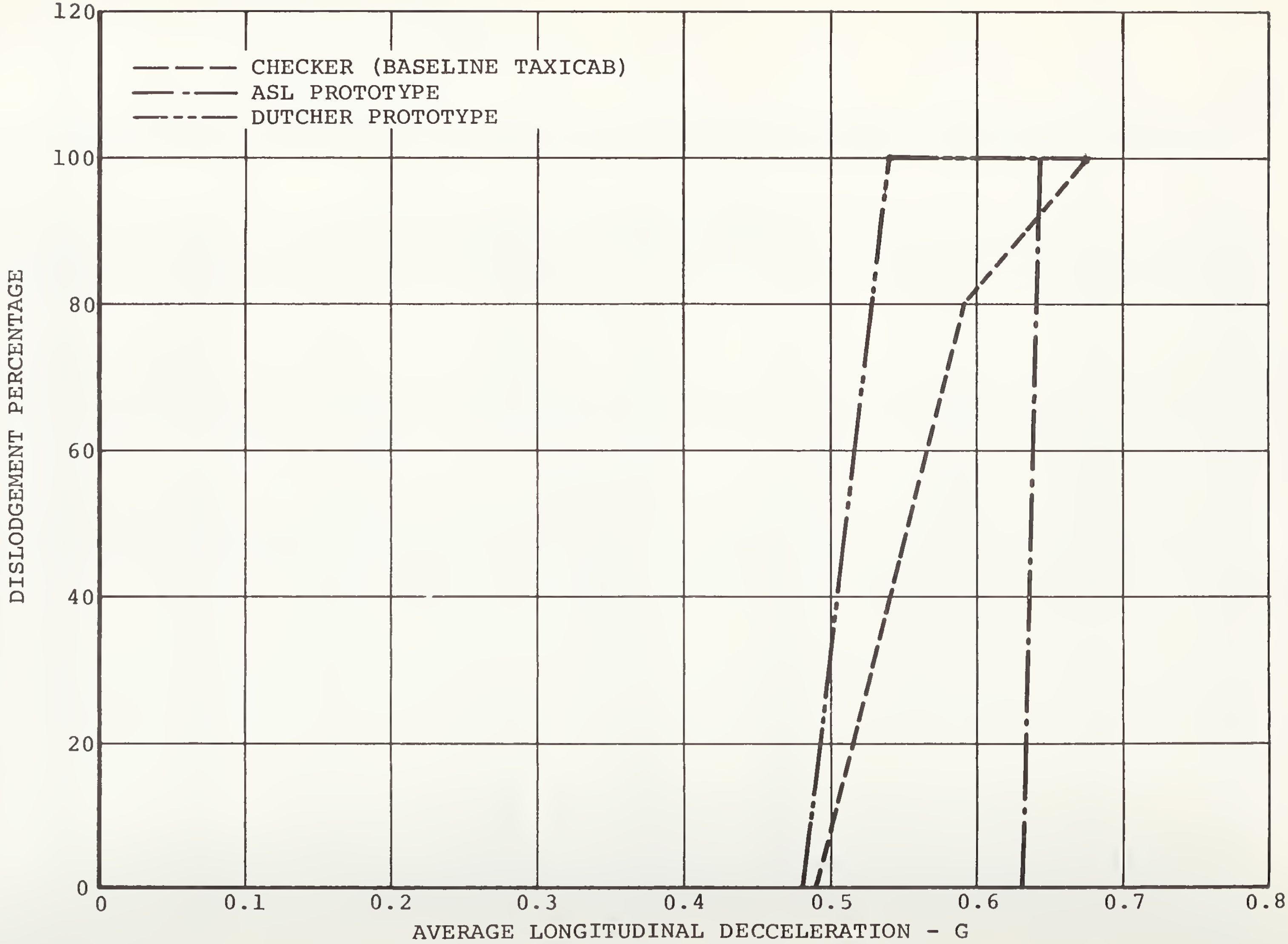


Figure 41. Dislodgement of Male Dummy During Passenger Deceleration Tests.

- Rotation in a plane parallel to the test acceleration for the dummy's head and upper thorax (i.e., pitch rotation for longitudinal deceleration; roll rotation for lateral deceleration) versus time.

Graphs of the longitudinal deceleration data are contained in Appendix C and graphs of the lateral acceleration data are contained in Appendix D. The results of both series of tests are summarized in the following two sections.

6.3.1 Longitudinal Deceleration Tests

The average maximum dummy motions measured during the longitudinal deceleration tests are presented in Table 21.

Head and thorax displacements during the 0.2 and 0.4G tests were small (1.0 inch or less) in both prototypes. The 0.6G tests produced some significant head motions in the unrestrained condition for the ASL and the wheelchair restrained conditions for the Dutcher (2.6 inches and 1.7 inches, respectively). These displacements should not cause a passenger too much discomfort, however, because the dummy as a whole was displaced against the back of the wheelchair and head rotation was negligible.

6.3.2 Lateral Acceleration Tests

The average maximum dummy motions during the lateral acceleration tests are summarized in Table 22.

Dummy displacements were significantly greater for most of the lateral tests above 0.2G than for the corresponding acceleration levels in the longitudinal tests. This reflects the lack of lateral support for the wheelchair occupants.

TABLE 21. AVERAGE MAXIMUM DUMMY MOTIONS DURING WHEELCHAIR LONGITUDINAL DECELERATION TESTS

Measurement	ASL Restraint Condition*			Dutcher Restraint Condition**	
	1	2	3	1	1
Head Displacement (in.)					
0.2G	0.4	0.4	0.5	0.5	0.7
0.4G	0.6	0.8	1.0	0.7	1.0
0.6G	1.0	1.3	2.6	1.7	0.9
Thorax Displacement (in.)					
0.2G	0.2	0.2	0.5	0.6	0.4
0.4G	0.3	0.5	0.7	0.5	0.7
0.6G	0.6	0.8	1.3	0.9	0.6
Head Rotation (deg)					
0.2G	1.1	1.7	1.5	1.0	1.5
0.4G	1.5	2.4	2.1	1.5	2.3
0.6G	2.5	2.4	1.5	2.2	2.8
Thorax Rotation (deg)					
0.2G	1.0	0.9	1.3	0.6	0.7
0.4G	1.7	0.8	1.2	0.5	0.8
0.6G	1.6	1.6	1.6	0.9	1.3

*1 = wheelchair + dummy restraint
2 = wheelchair restraint
3 = no restraint
**1 = wheelchair restraint
2 = no restraint

TABLE 22. AVERAGE MAXIMUM DUMMY MOTIONS DURING WHEELCHAIR LATERAL ACCELERATION TESTS

Measurement	ASL Restraint Condition*			Dutcher Restraint Condition**	
	1	2	3	1	2
Head Displacement (in.)					
0.1G	0.2	0.2	0.3	0.3	0.5
0.2G	0.4	0.5	1.0	1.2	1.3
0.3G	1.1	1.1	2.2	1.8	1.9
0.4G	1.8	1.5	---	1.9	---
0.5G	3.3	2.8	7.1	2.1	---
Thorax Displacement (in.)					
0.1G	0.1	0.1	0.3	0.2	0.6
0.2G	0.3	0.4	0.7	1.1	0.9
0.3G	0.6	0.7	1.8	1.4	2.5
0.4G	1.3	1.0	---	1.4	---
0.5G	2.3	1.9	7.2	1.7	---
Head Rotation (deg)					
0.1G	0.2	0.0	0.4	0.6	0.6
0.2G	0.4	0.2	1.4	1.6	1.7
0.3G	2.7	0.4	3.6	2.1	3.9
0.4G	4.0	1.8	---	2.8	---
0.5G	6.1	5.3	8.2	2.1	---
Thorax Rotation (deg)					
0.1G	0.0	0.4	0.4	0.5	0.3
0.2G	0.2	0.6	0.6	1.2	1.3
0.3G	1.4	1.6	2.1	1.2	2.3
0.4G	2.0	0.2	---	1.1	---
0.5G	3.9	2.4	8.0	1.2	---

*1 = wheelchair + dummy restraint
2 = wheelchair restraint
3 = no restraint
**1 = wheelchair restraint
2 = no restraint

Notes: 1. Data lost for ASL Restraint Condition 3 at 0.4G
2. 0.4G and 0.5G tests not conducted with Dutcher due to instability of wheelchair.

In the ASL prototype, the lateral displacement and rotation data for the wheelchair-plus-occupant restraint and wheelchair-only restraint conditions were not significantly different. The data for the unrestrained wheelchair and occupant tests showed considerably more dummy motion than in the other two test configurations, especially at the 0.5G acceleration level. Head and chest displacements at this level measured 7.1 and 7.2 inches, respectively. Head and chest rotations were 8.2 and 8.0 degrees. This degree of motion would be difficult to tolerate if the handicapped person lacked sufficient muscle control to compensate.

The dummy motions for the wheelchair restrained tests in the Dutcher prototype were comparable to those obtained in the ASL for the same restraint condition. However, the 0.4 and 0.5G tests in the Dutcher with no wheelchair restraint could not be run because the wheelchair would not remain upright at these acceleration levels. The difference in the performance of the Dutcher and ASL prototypes with no wheelchair restraint was due to the interior structure of the ASL restraining the wheelchair while no comparable restraint was present in the Dutcher (refer to Figures 19 and 20).

6.4 INTERIOR MEASUREMENT TESTS

The results of the interior measurement tests are presented in Table 23. The reduced shoulder and hip room in the front seat of the prototypes as compared to the taxicab is the result of enclosing the driver. The taxicab possessed considerably more luggage capacity than the prototypes, while the prototypes themselves were about equal in luggage capacity. Passenger ingress and egress from the prototypes should be considerably easier than from the taxicab because of the greater height of the prototypes' door openings.

TABLE 23. INTERIOR MEASUREMENT TEST RESULTS

Dimension*	Description	Measurement		
		ASL	Dutcher	Baseline Taxicab
Driver Compartment				
L17 (in.)	H-point travel	4.88	4.25	2.75
L31 (in.)	H-point to vertical zero line - front	45.56	64.94	55.56
L34 (in.)	Maximum effective leg room-accelerator	42.63	42.38	38.94
L40 (deg)	Back angle - front	11.5	14.5	17.0
H18 (deg)	Steering wheel angle - vertical	29.5	52.0	32.7
H30 (in.)	H-point to heel point - front	13.81	13.38	10.56
H50 (in.)	Upper body opening to ground - front	63.50	72.94	58.63
H61 (in.)	Effective head room - front	43.10	43.20	40.00
W3 (in.)	Shoulder room - front	28.50	33.16	60.63
W5 (in.)	Hip room - front	25.31	34.94	64.00
Passenger Compartment				
L3 (in.)	Compartment room - second	52.25	68.50	34.94
L51 (in.)	Minimum effective leg room - second	42.25	42.94	41.88
H31 (in.)	H-point to heel point - second	18.13	17.63	12.50
H51 (in.)	Upper body opening to ground - second	67.75	73.00	58.50
H63 (in.)	Effective head room - second	42.40	40.80	38.75
W4 (in.)	Shoulder room - second	69.63	62.12	58.94
W6 (in.)	Hip room - second	41.75	20.44	61.44
Luggage Compartment				
H195 (in.)	Liftover - height	32.75	13.13	32.50
V1 (ft^3)	Luggage capacity - usable	9.29	9.99	18.23

*from SAE J1100a.

APPENDIX A

VELOCITY VERSUS TIME DATA FOR
VEHICLE ACCELERATION TESTS

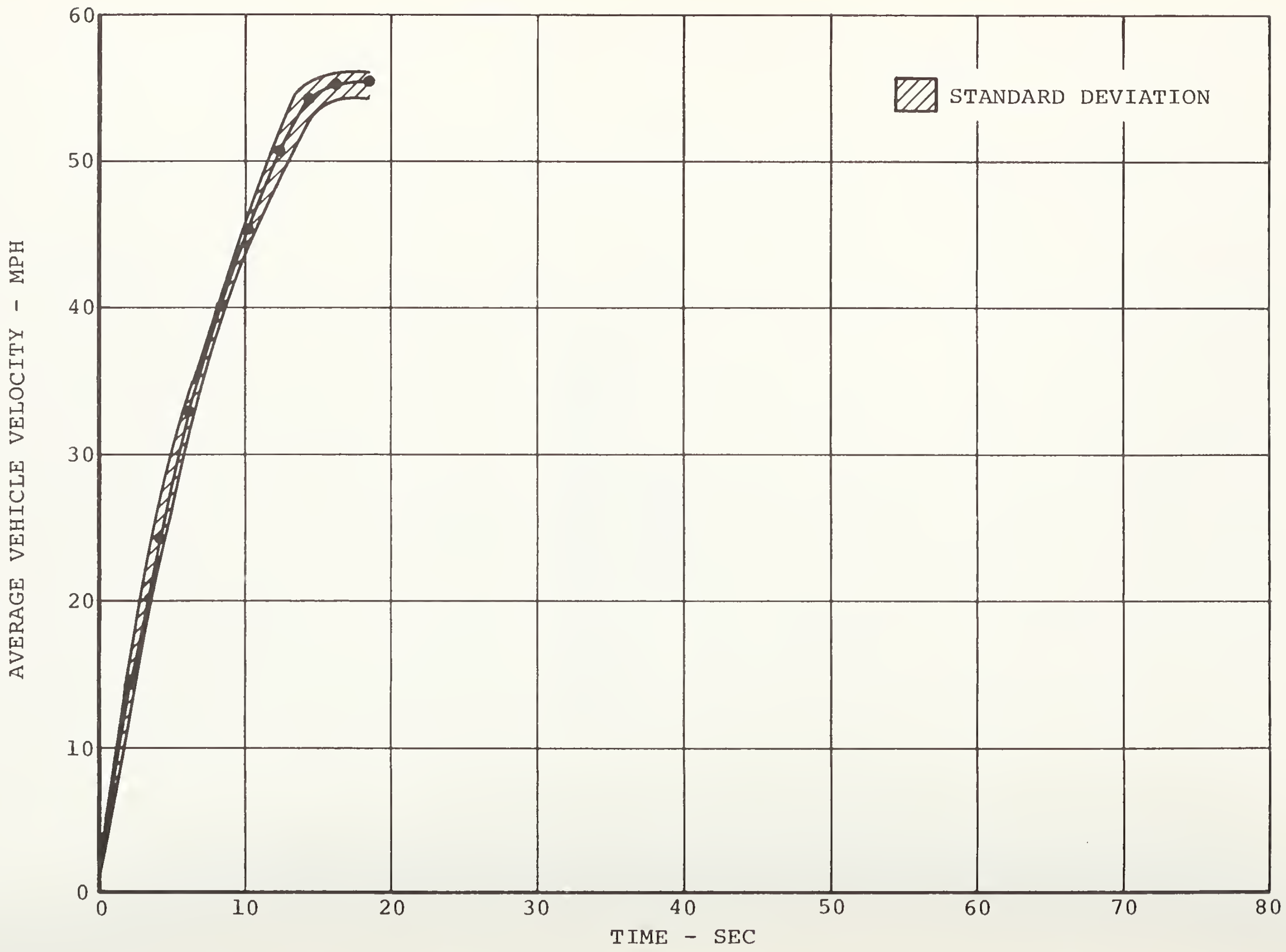


Figure A-1. Velocity of Nova During Vehicle Acceleration Tests, Full Throttle, 300-pound Load.

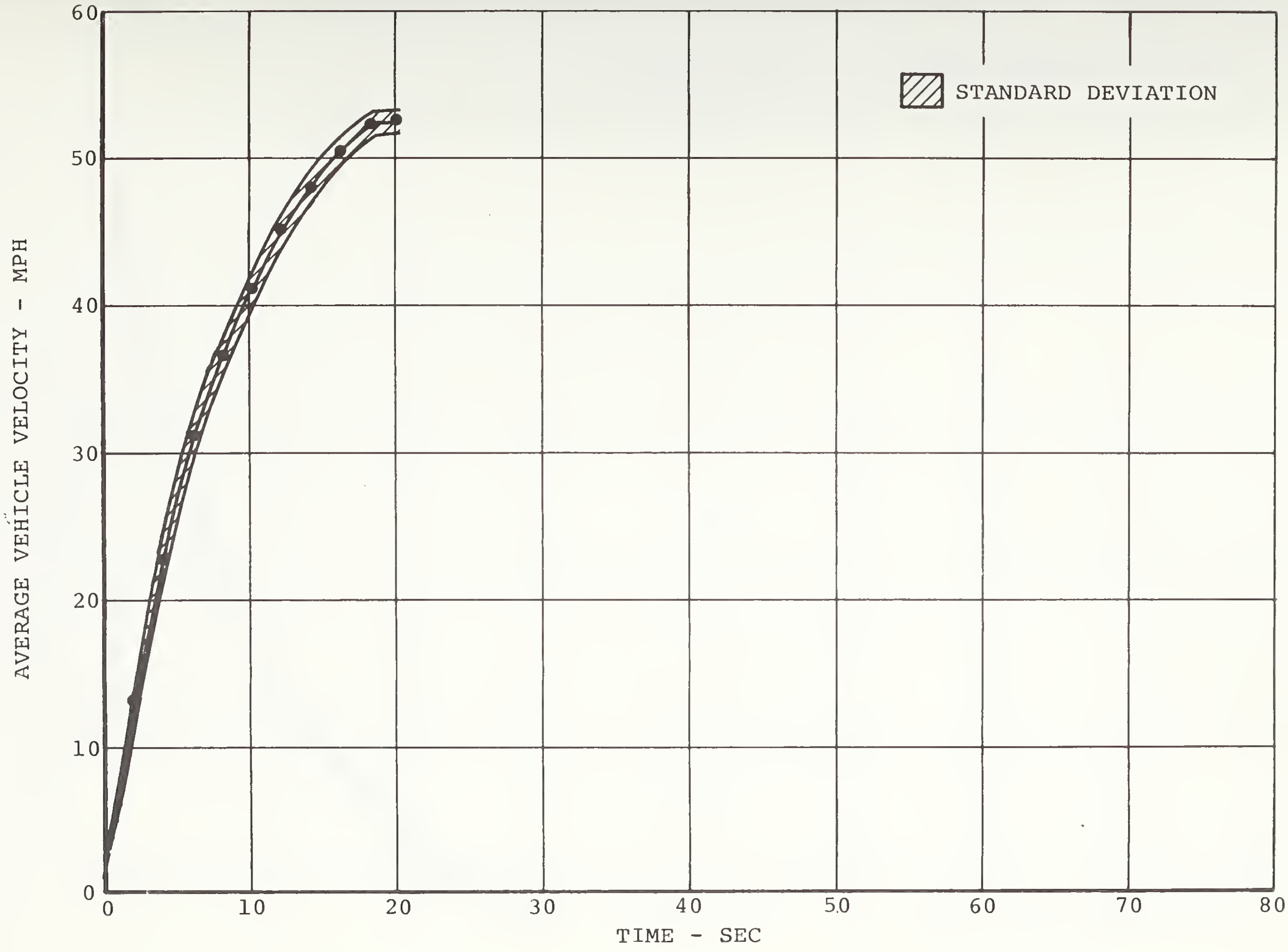


Figure A-2. Velocity of Nova During Vehicle Acceleration Tests, 1/2 Throttle, 300-pound Load.

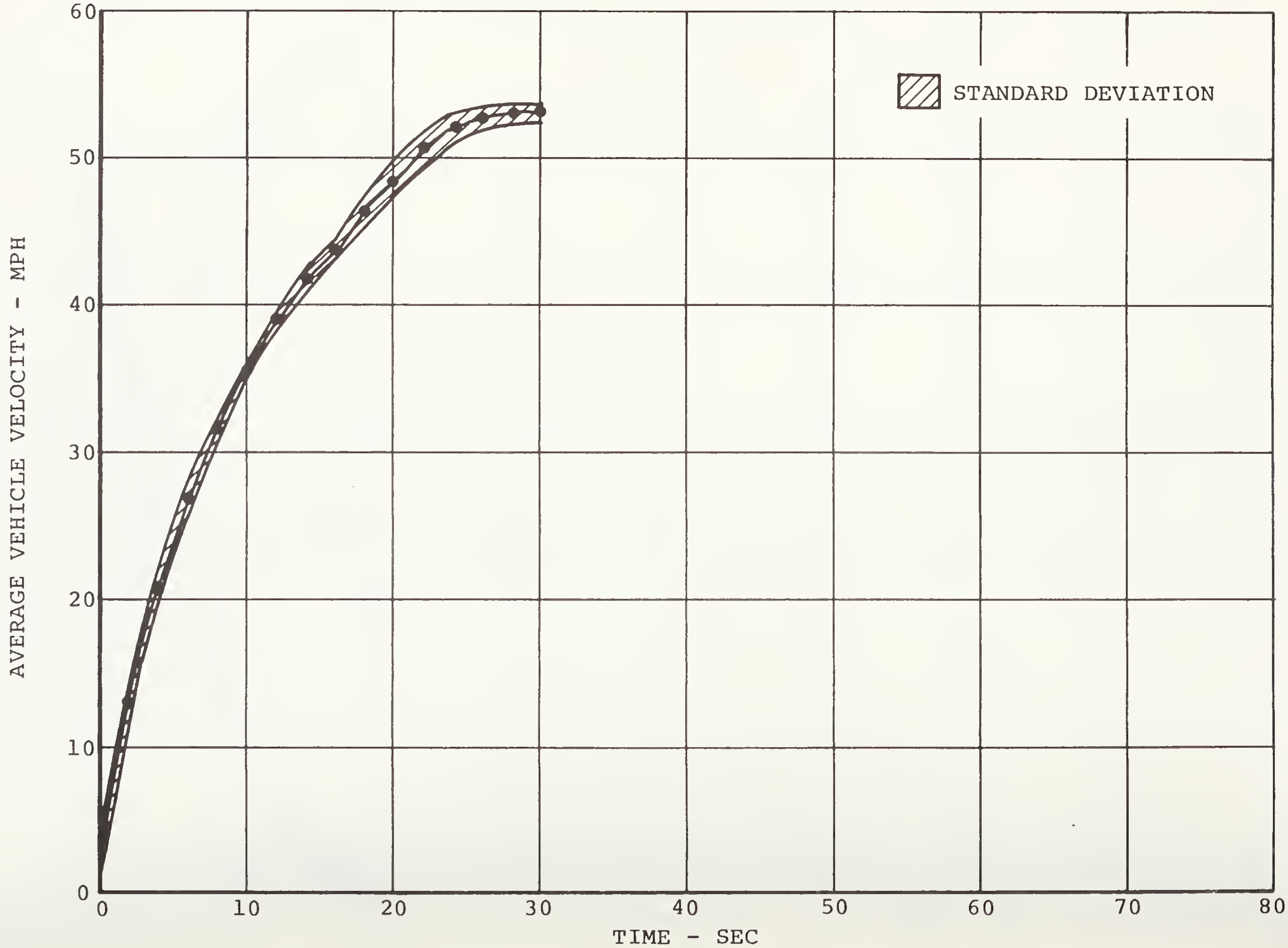


Figure A-3. Velocity of Nova During Vehicle Acceleration Tests, 1/4 Throttle, 300-pound Load.

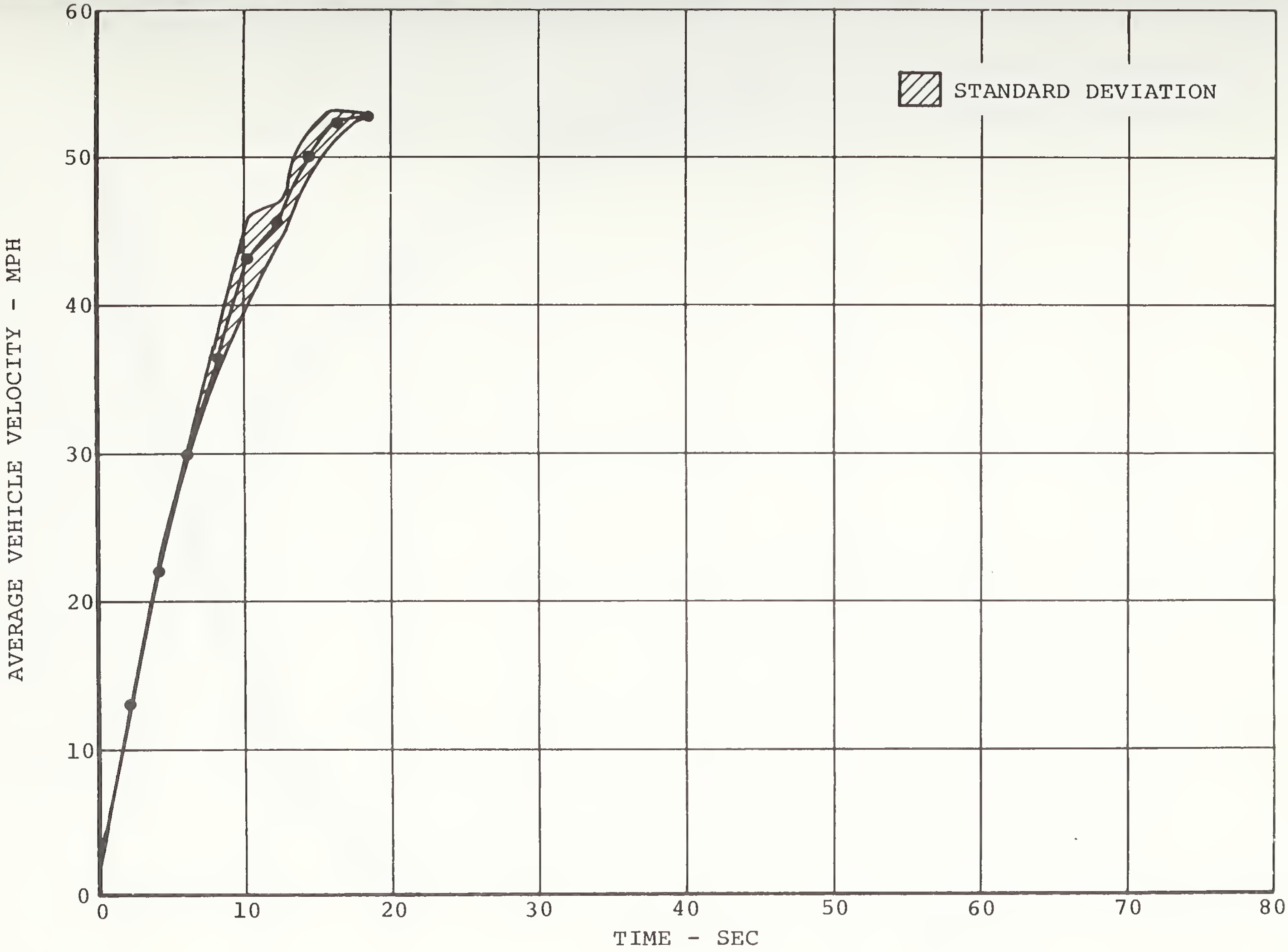


Figure A-4. Velocity of Nova During Vehicle Acceleration Tests, Full Throttle, 650-pound Load.

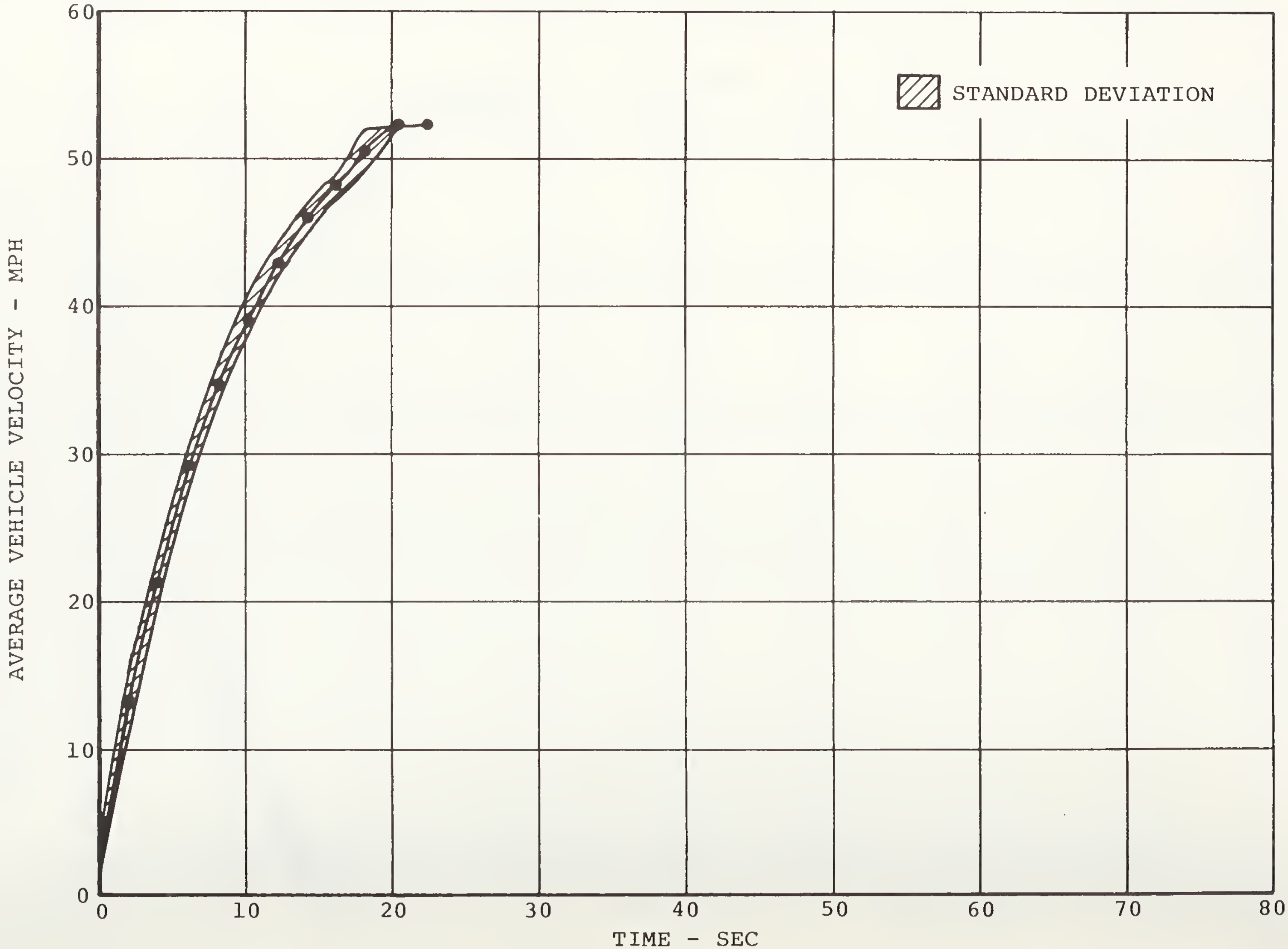


Figure A-5. Velocity of Nova During Vehicle Acceleration Tests, 1/2 Throttle, 650-pound Load.

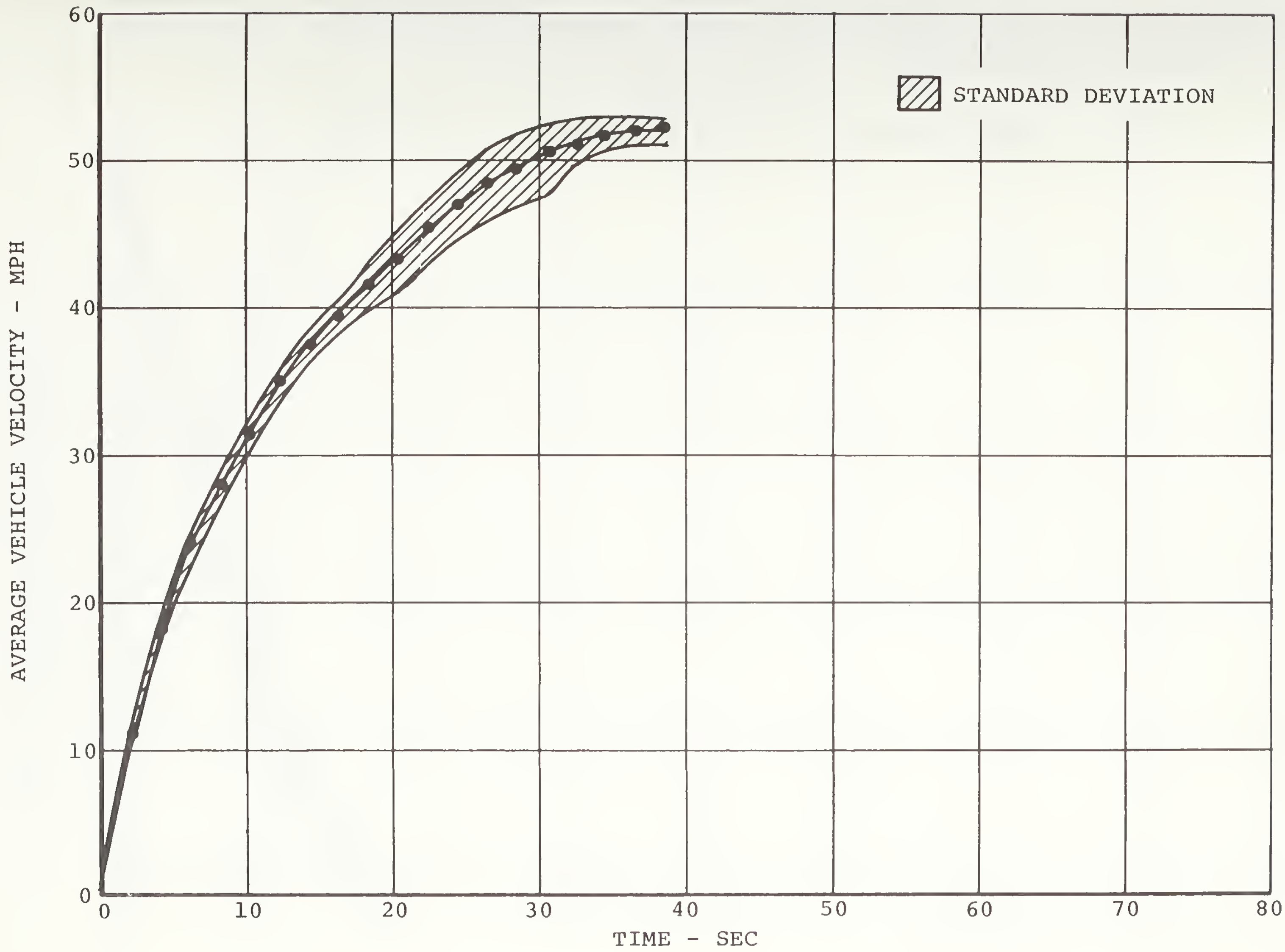


Figure A-6. Velocity of Nova During Vehicle Acceleration Tests, 1/4 Throttle, 650-pound Load.

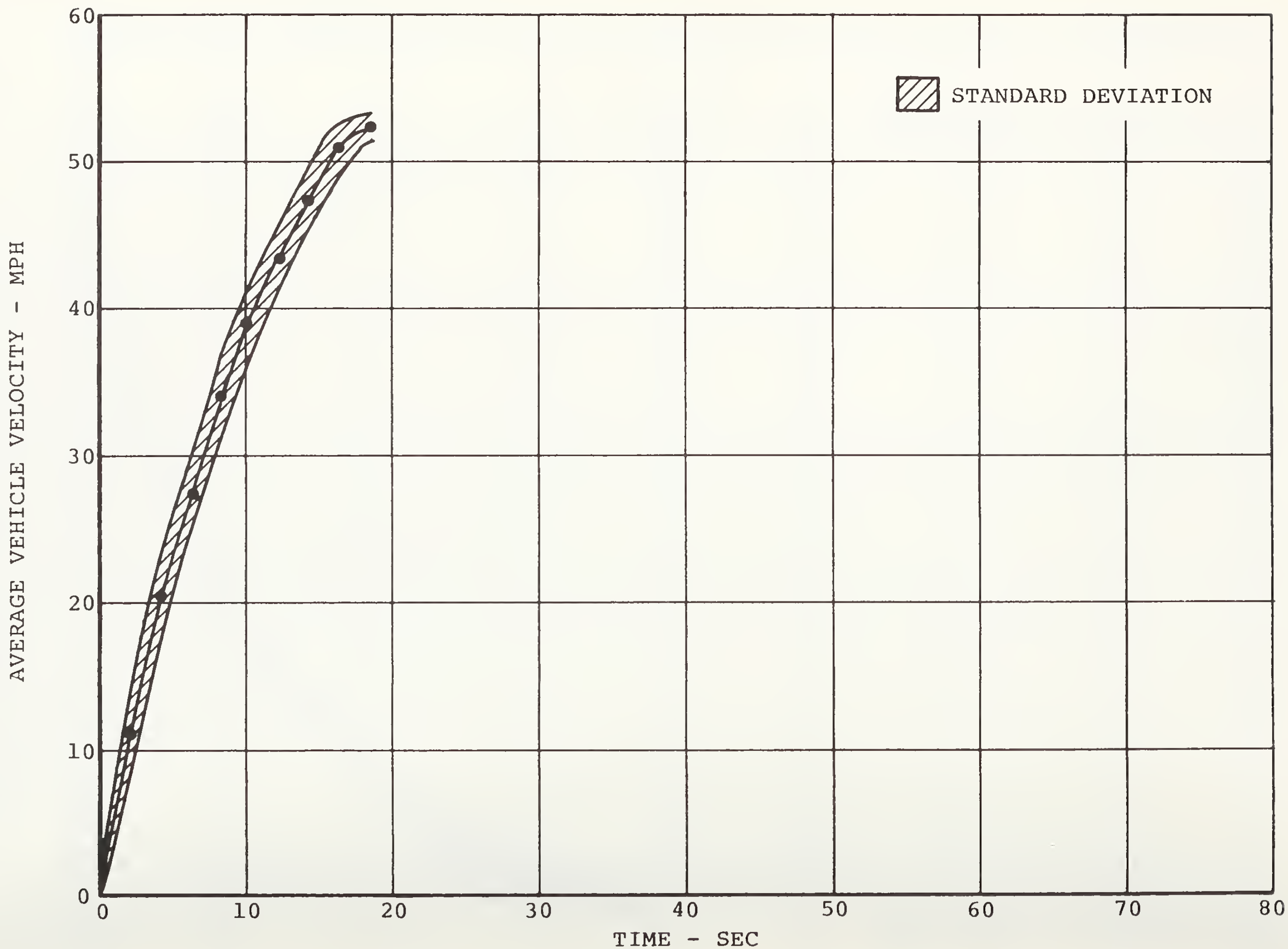


Figure A-7. Velocity of Nova During Vehicle Acceleration Tests, Full Throttle, 900-pound Load.

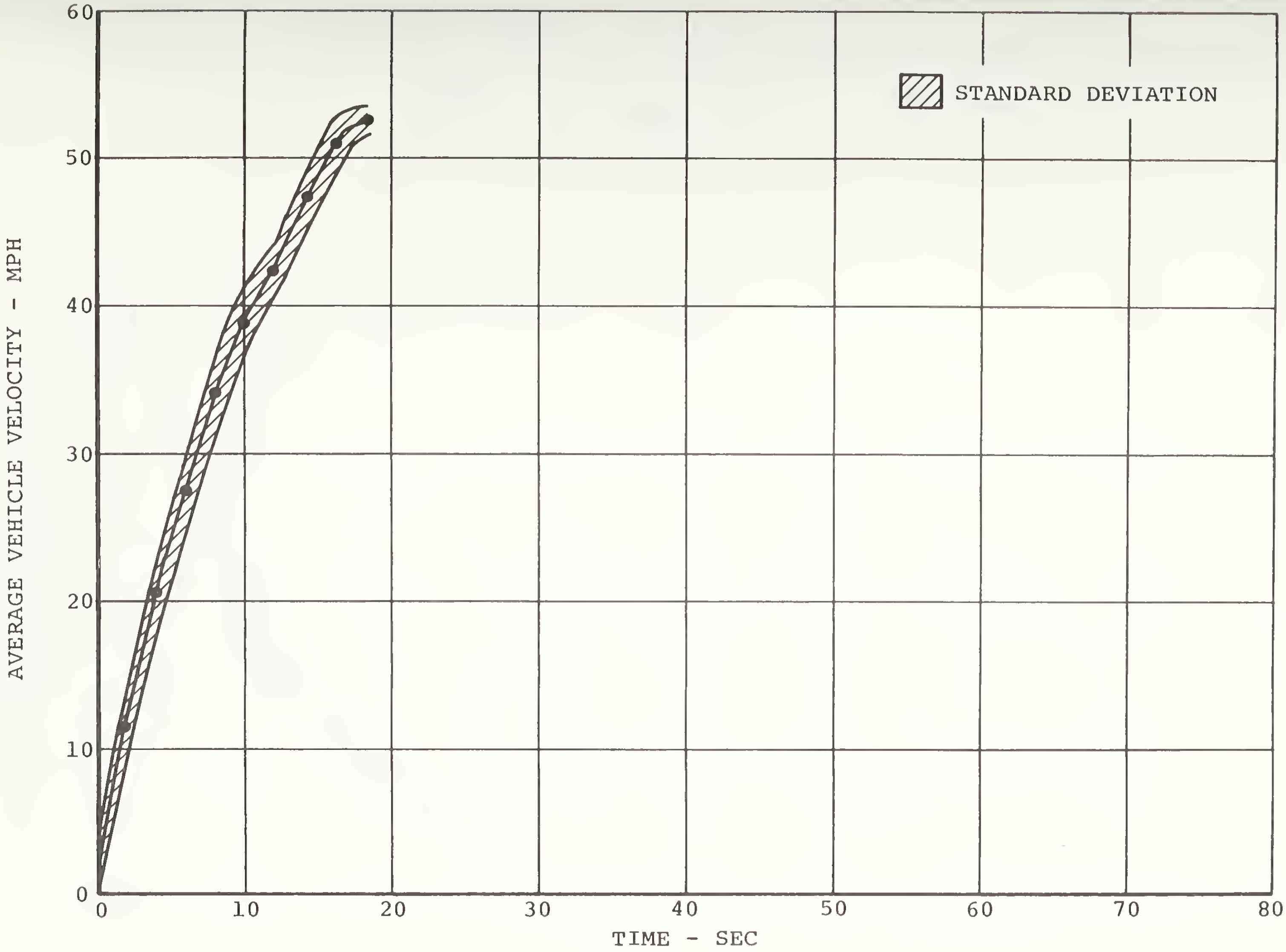


Figure A-8. Velocity of Nova During Vehicle Acceleration Tests, 1/2 Throttle, 900-pound Load.

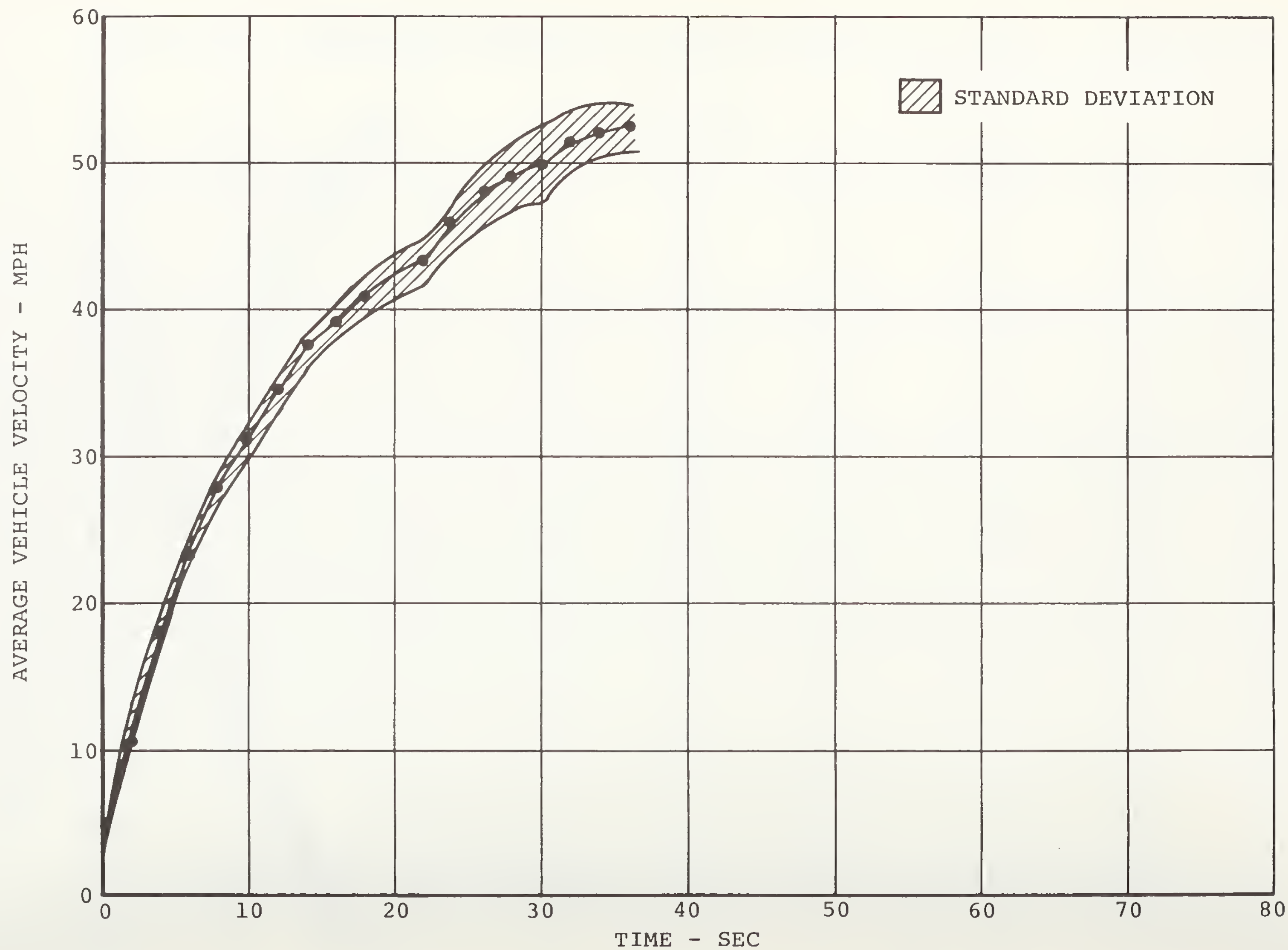


Figure A-9. Velocity of Nova During Vehicle Acceleration Tests, 1/4 Throttle, 900-pound Load.

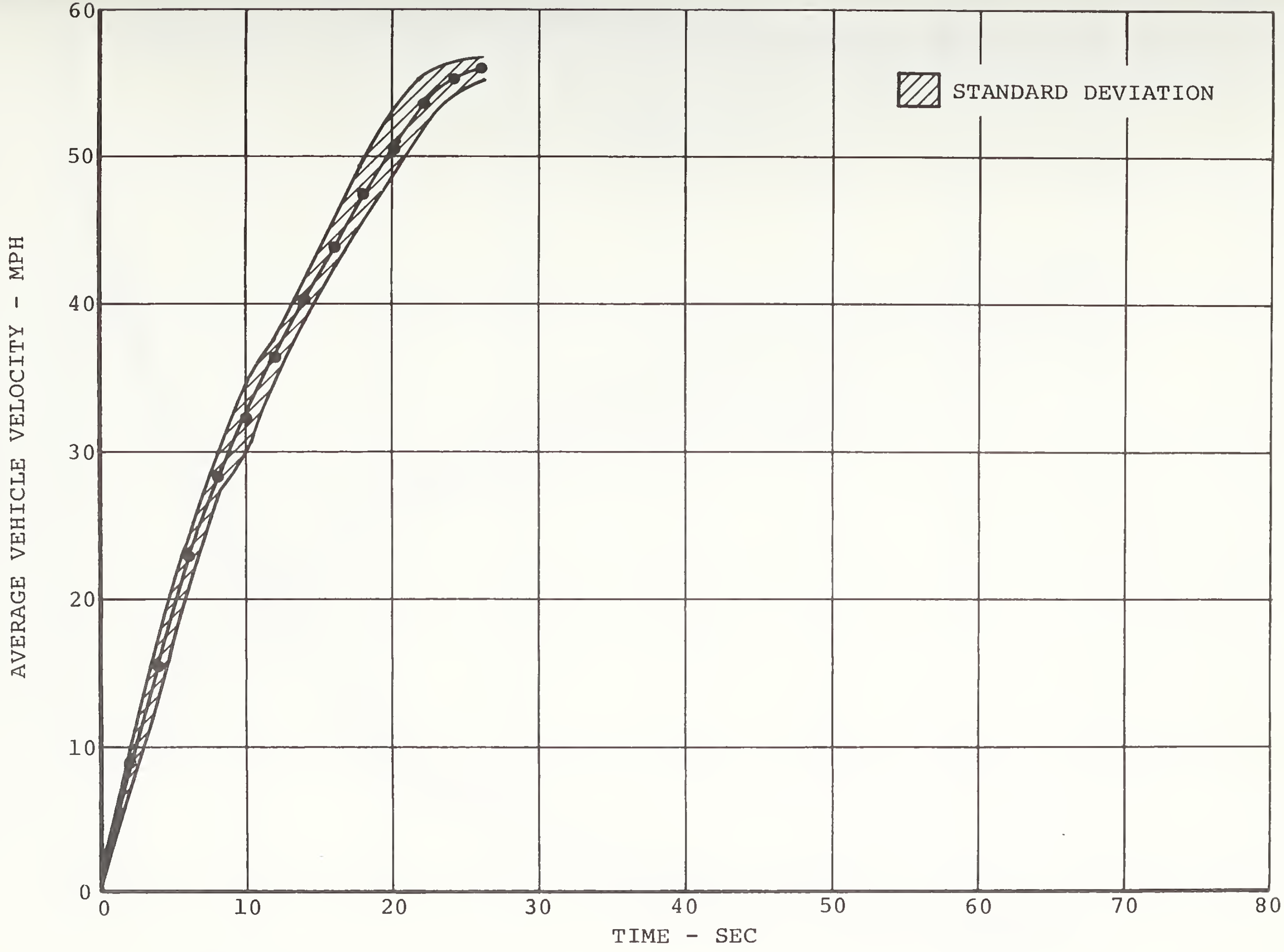


Figure A-10. Velocity of ASL Prototype During Vehicle Acceleration Tests, Full Throttle, 300-pound Load.

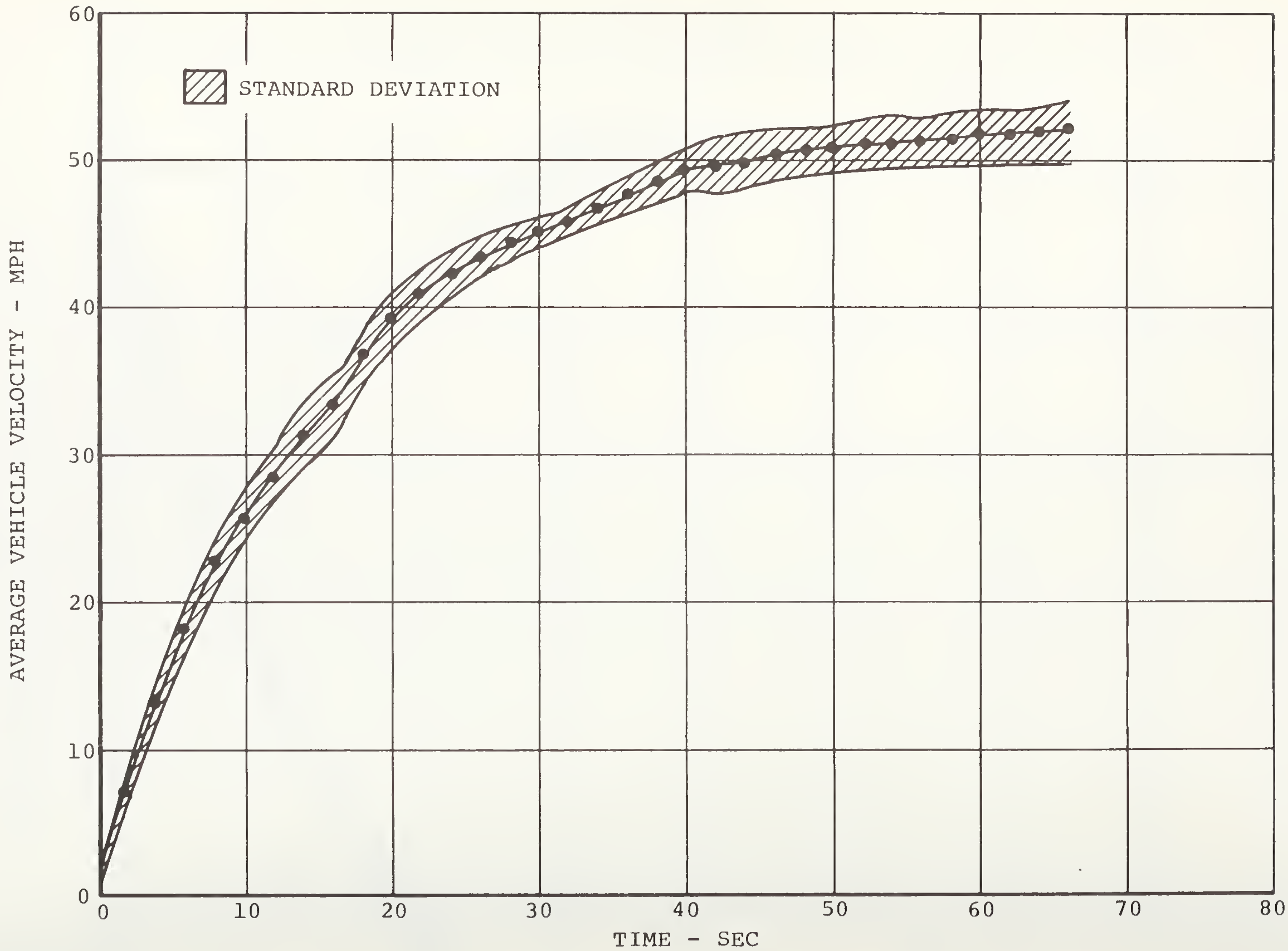


Figure A-11. Velocity of ASL Prototype During Vehicle Acceleration Tests, 1/2 Throttle, 300-pound Load.

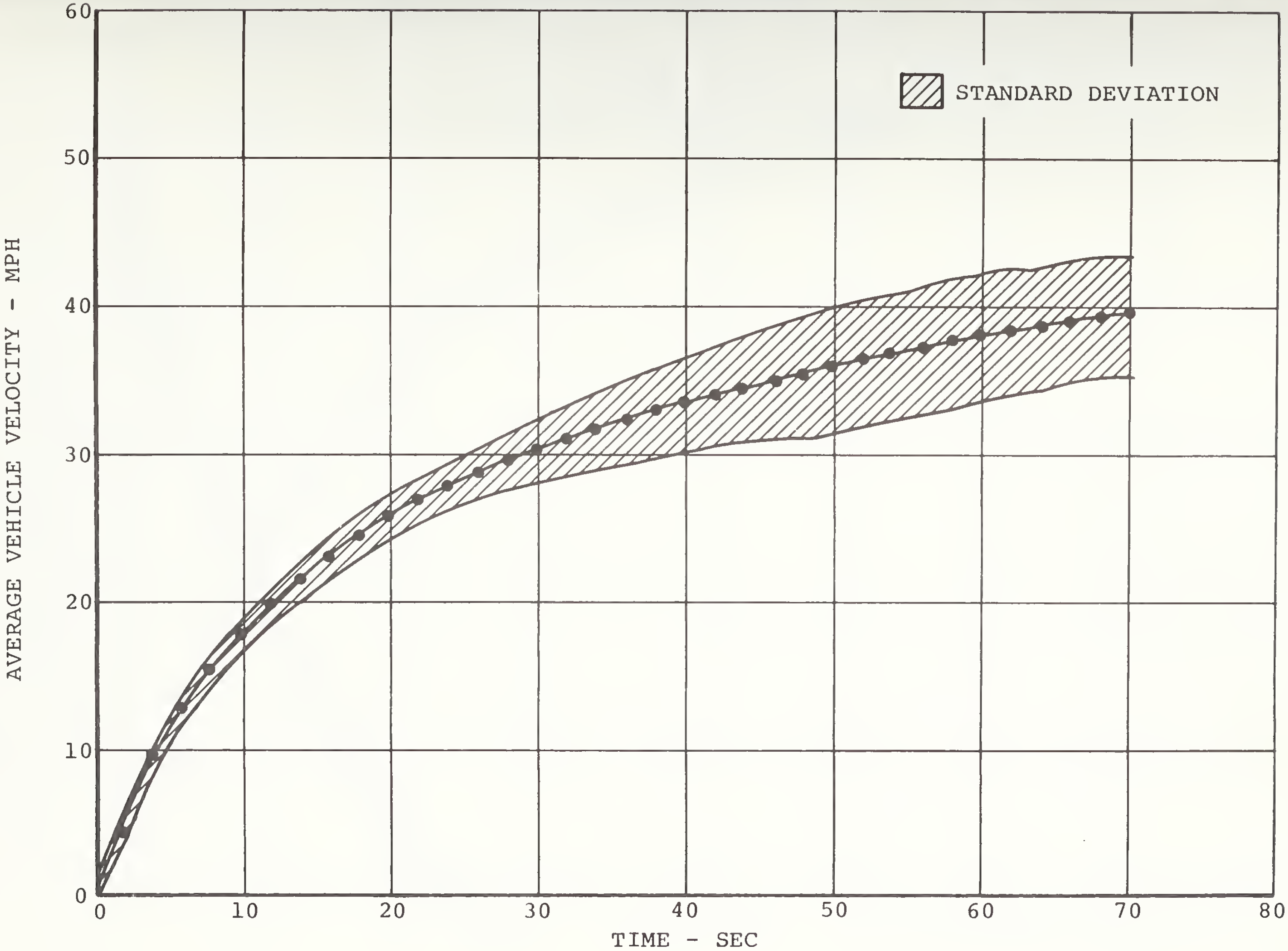


Figure A-12. Velocity of ASL Prototype During Vehicle Acceleration Tests, 1/4 Throttle, 300-pound Load.

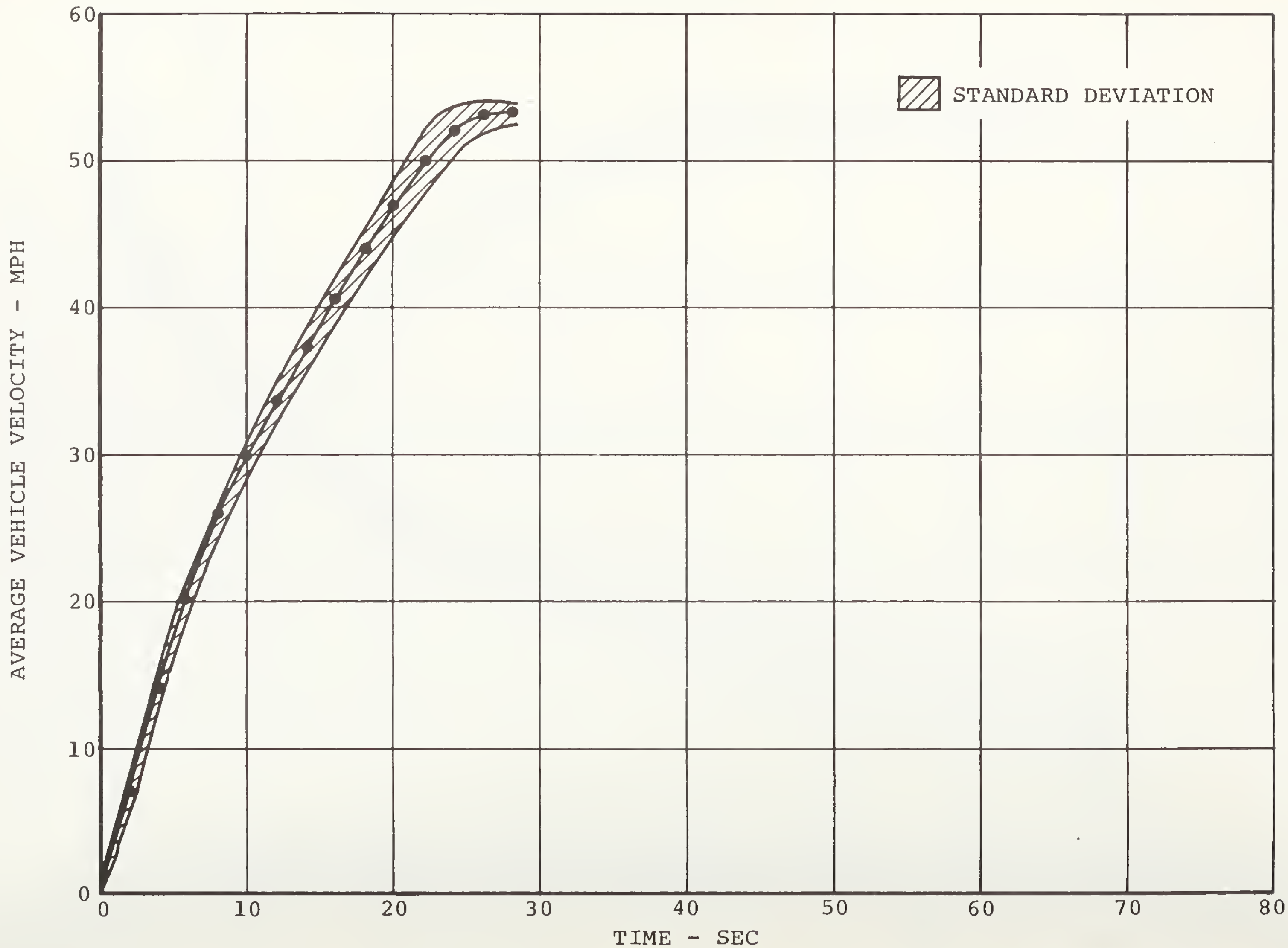


Figure A-13. Velocity of ASL Prototype During Vehicle Acceleration Tests, Full Throttle, 650-pound Load.

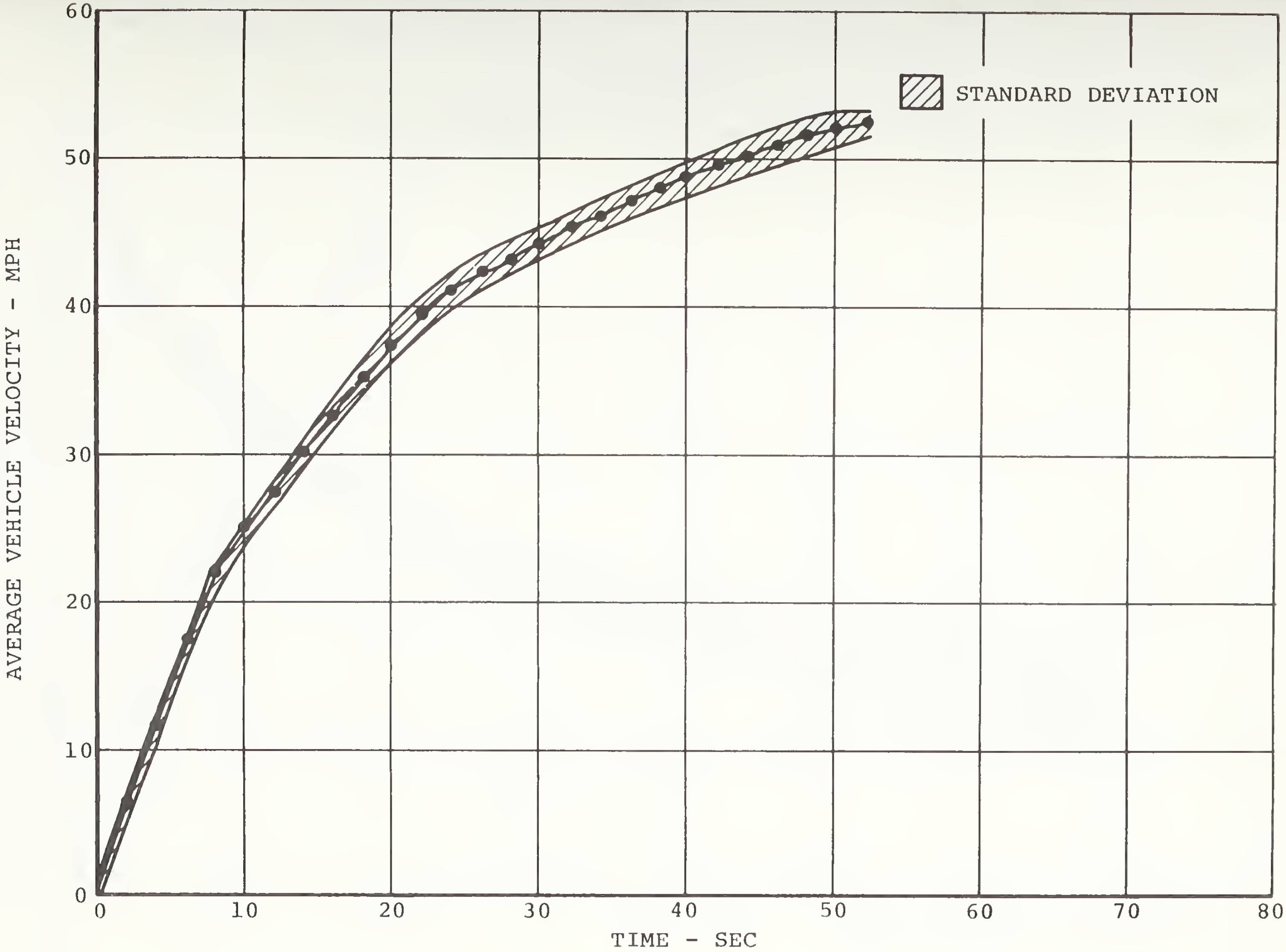


Figure A-14. Velocity of ASL Prototype During Vehicle Acceleration Tests, 1/2 Throttle, 650-pound Load.

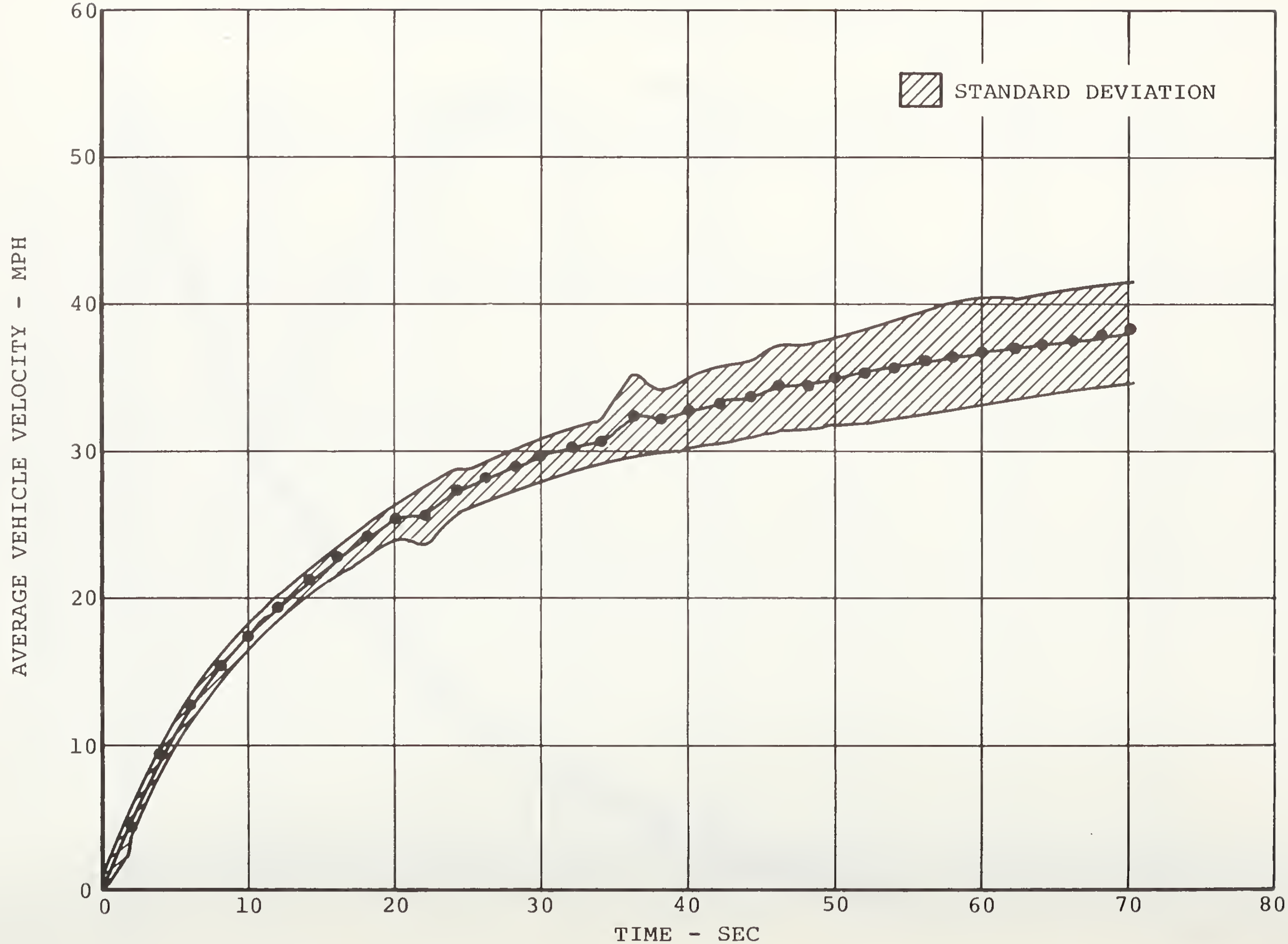
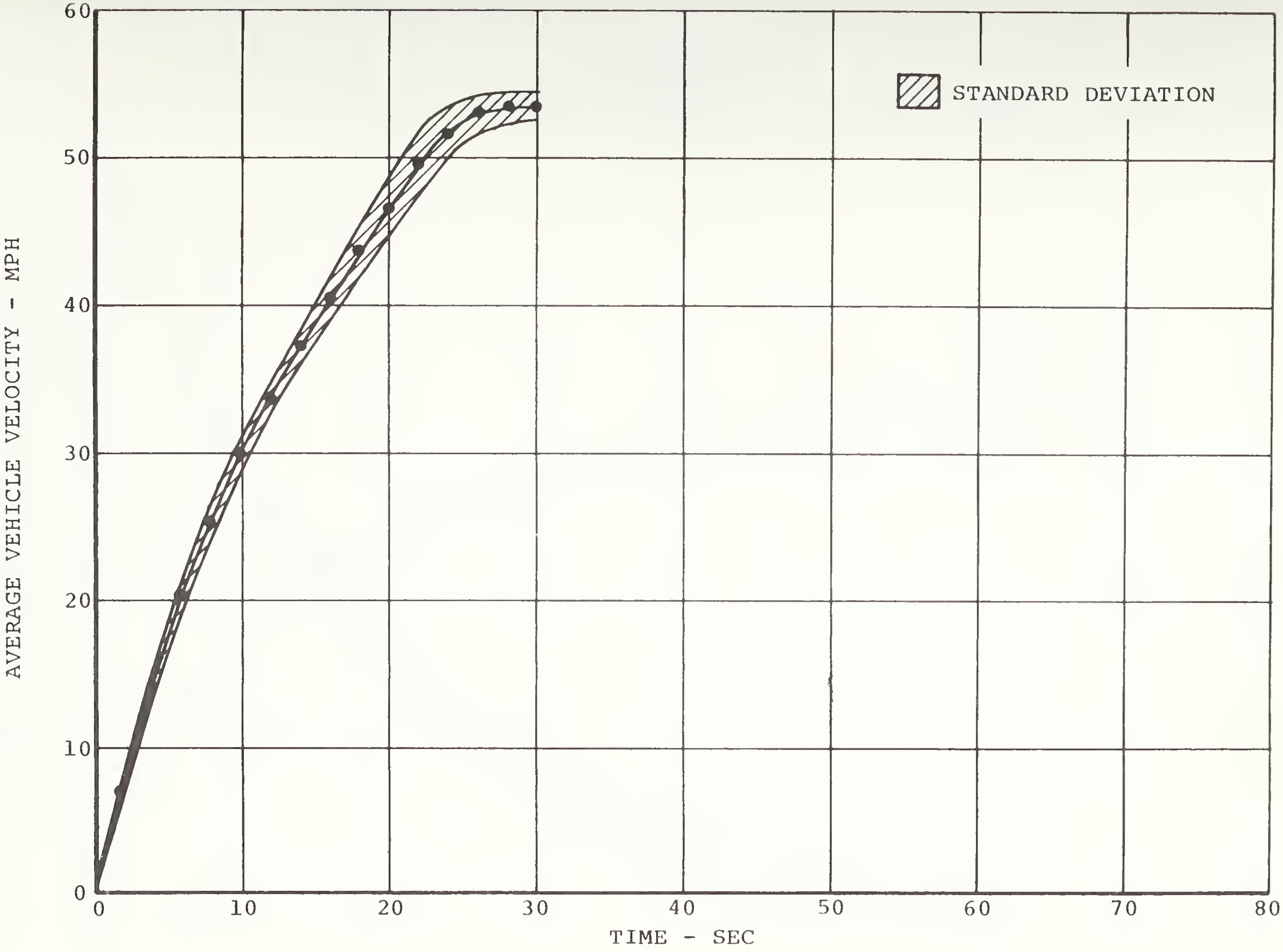


Figure A-15. Velocity of ASL Prototype During Vehicle Acceleration Tests, 1/4 Throttle, 650-pound Load.



A-16. Velocity of ASL Prototype During Vehicle Acceleration Tests, Full Throttle, 900-pound Load.

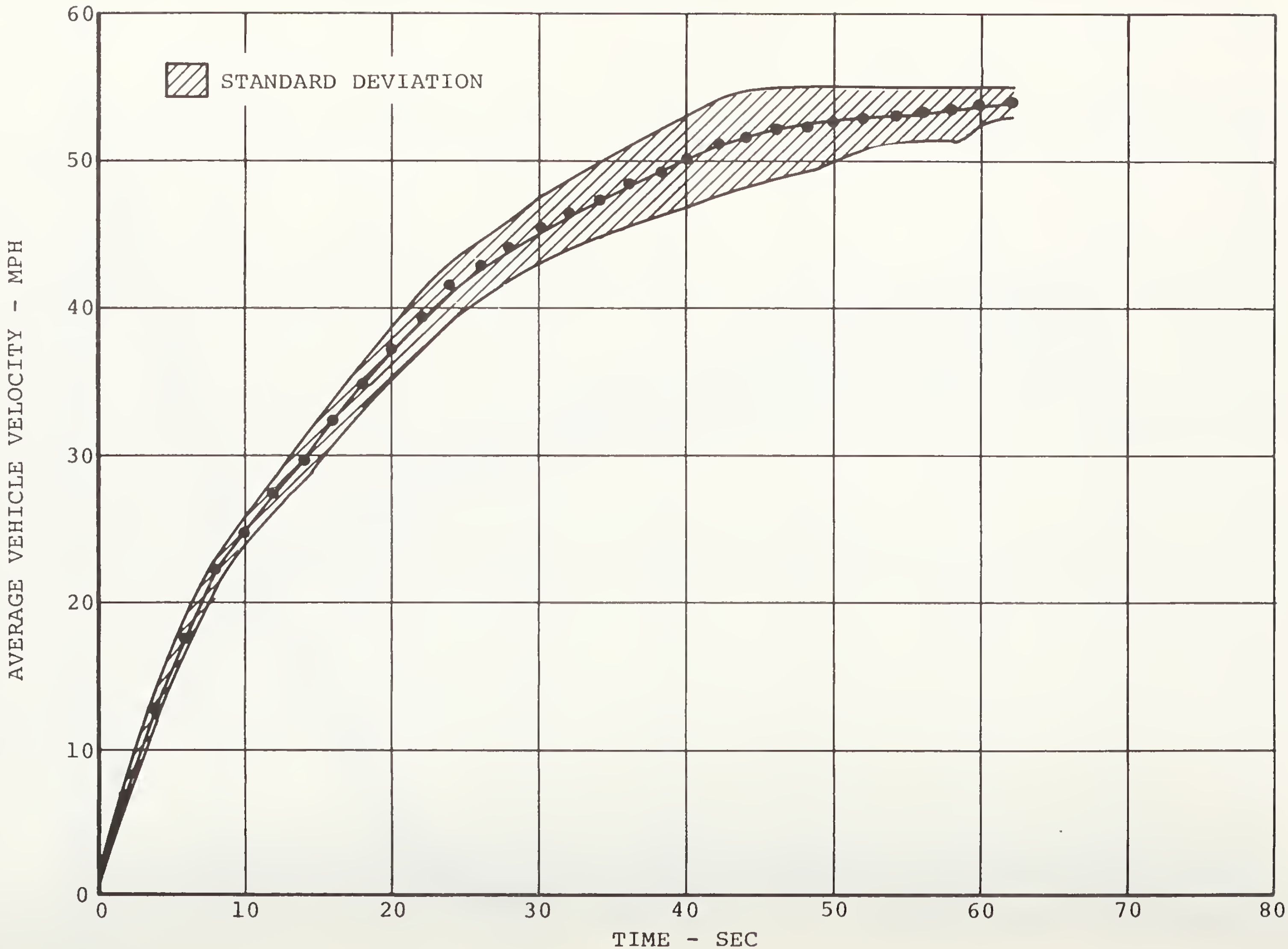


Figure A-17. Velocity of ASL Prototype During Vehicle Acceleration Tests, 1/2 Throttle, 900-pound Load.

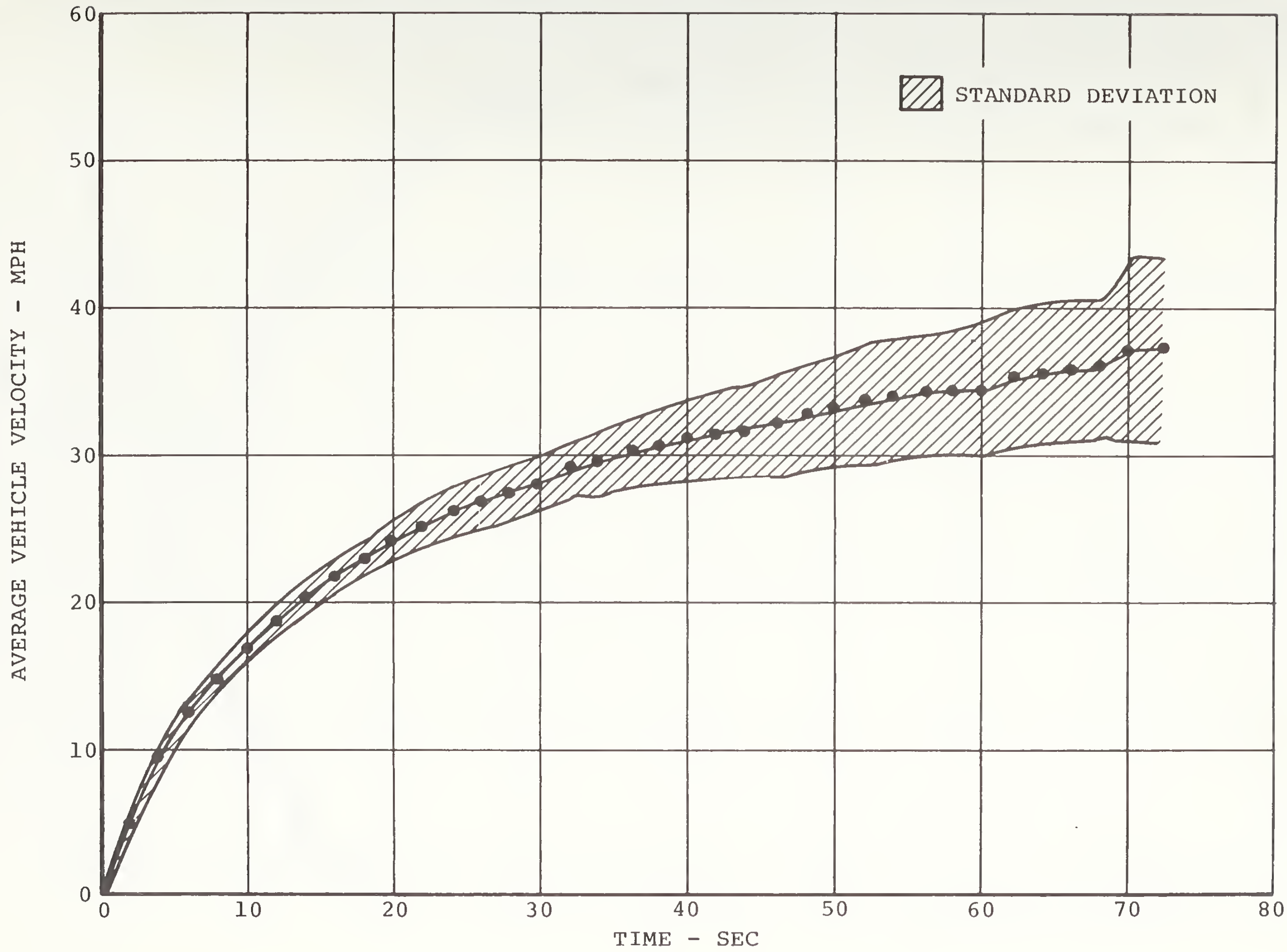


Figure A-18. Velocity of ASL Prototype During Vehicle Acceleration Tests, 1/4 Throttle, 900-pound Load.

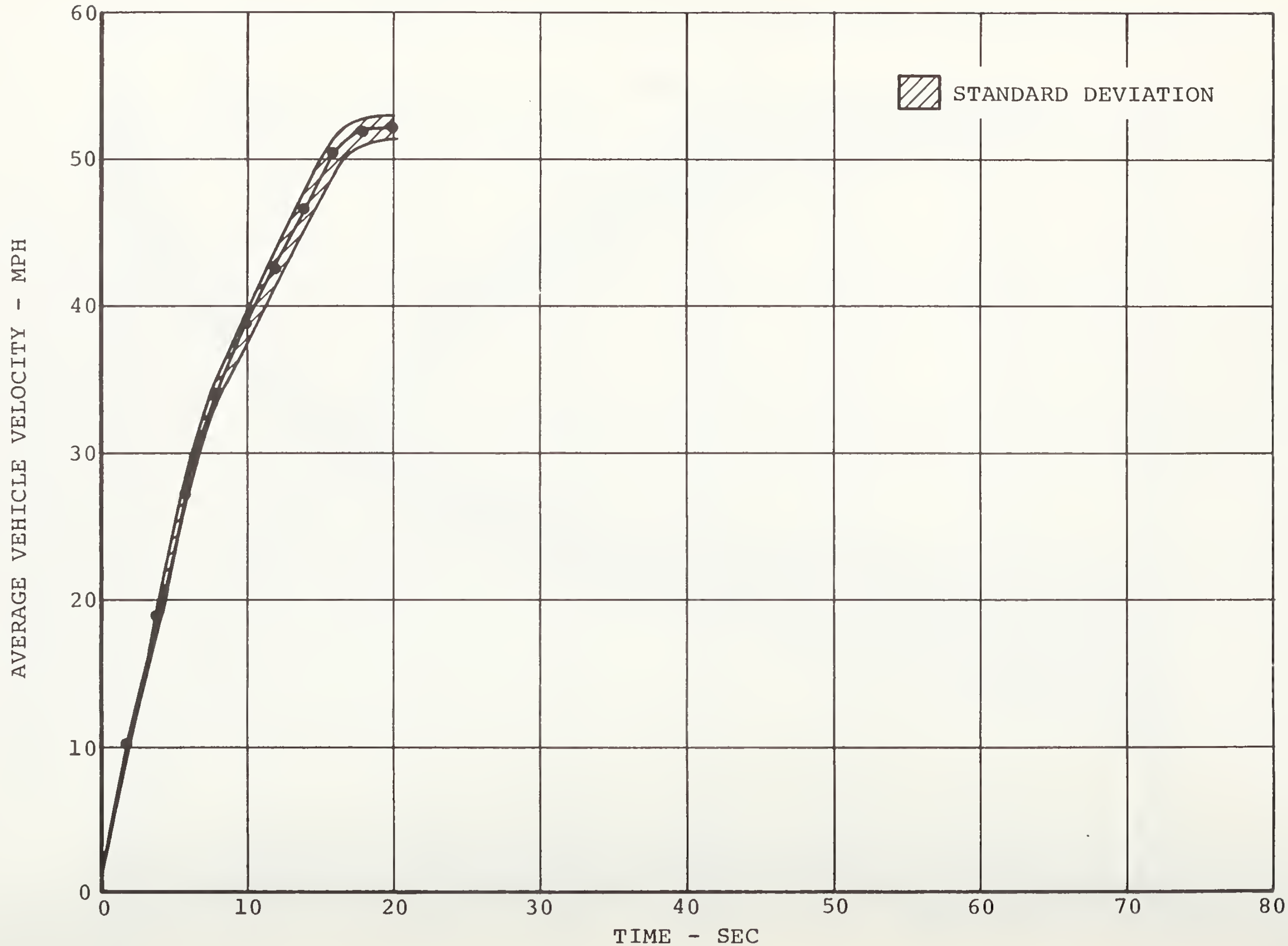


Figure A-19. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, Full Throttle, 300-pound Load.

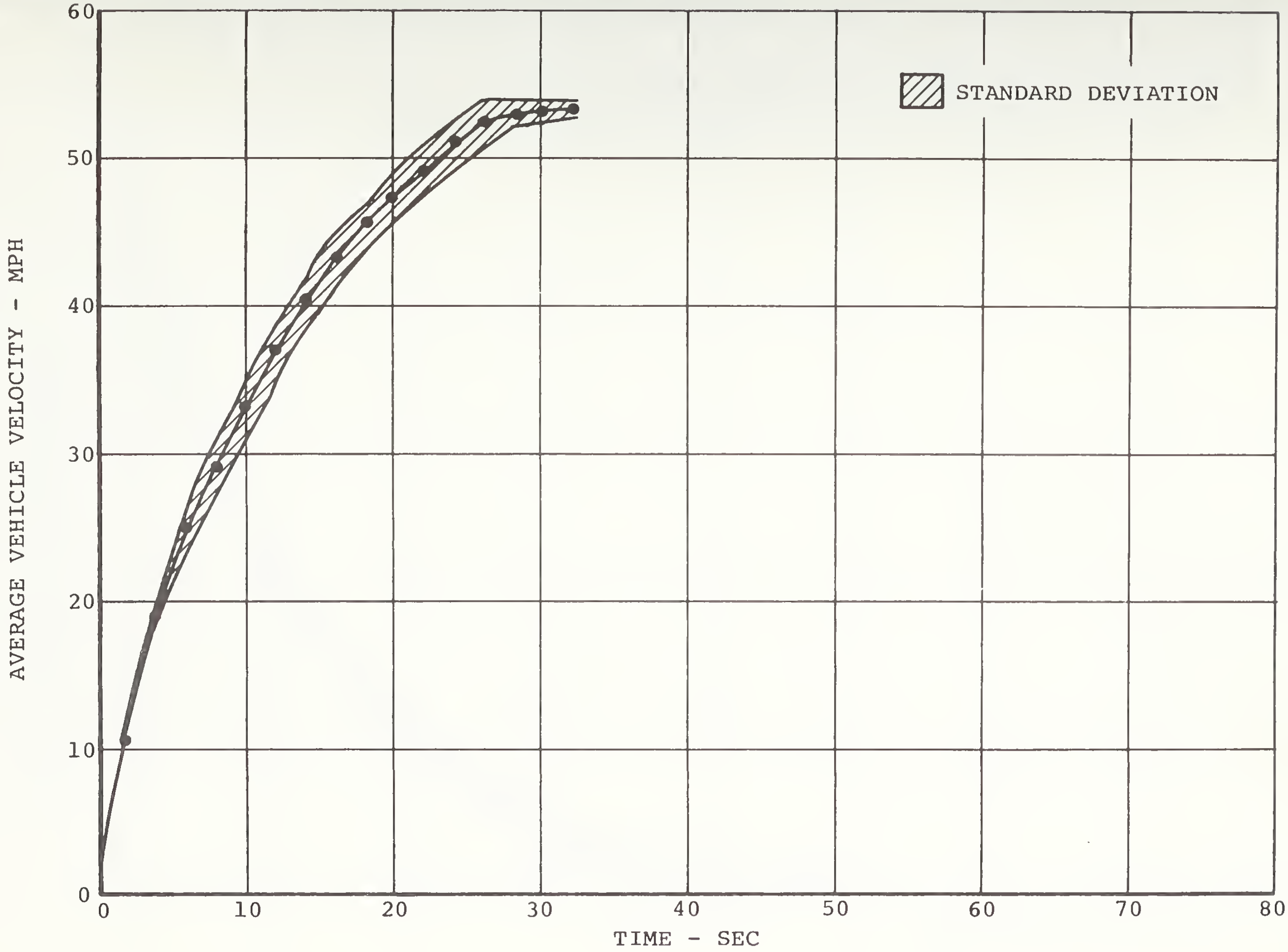


Figure A-20. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, 1/2 Throttle, 300-pound Load.

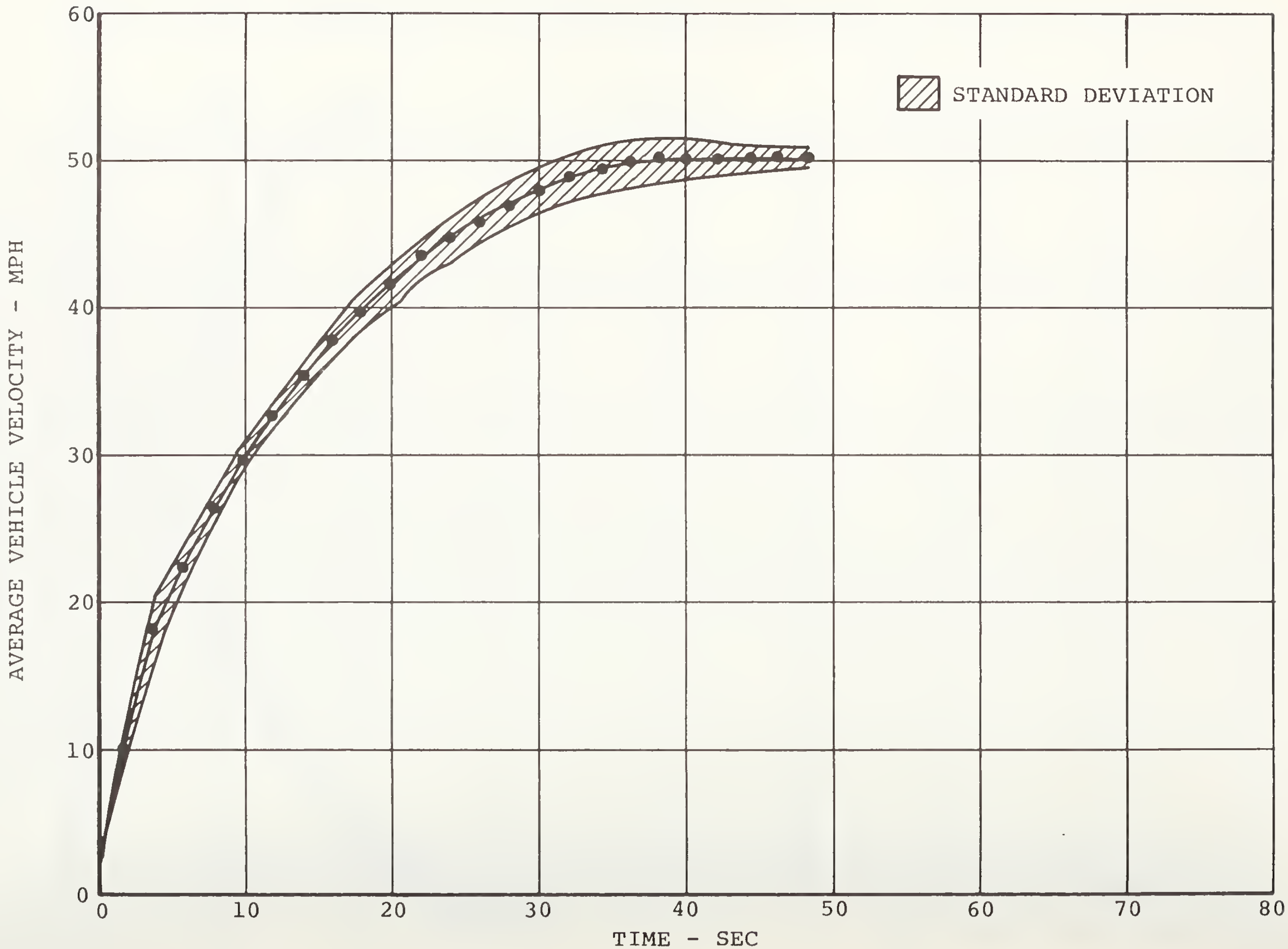


Figure A-21. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, 1/4 Throttle, 300-pound Load.

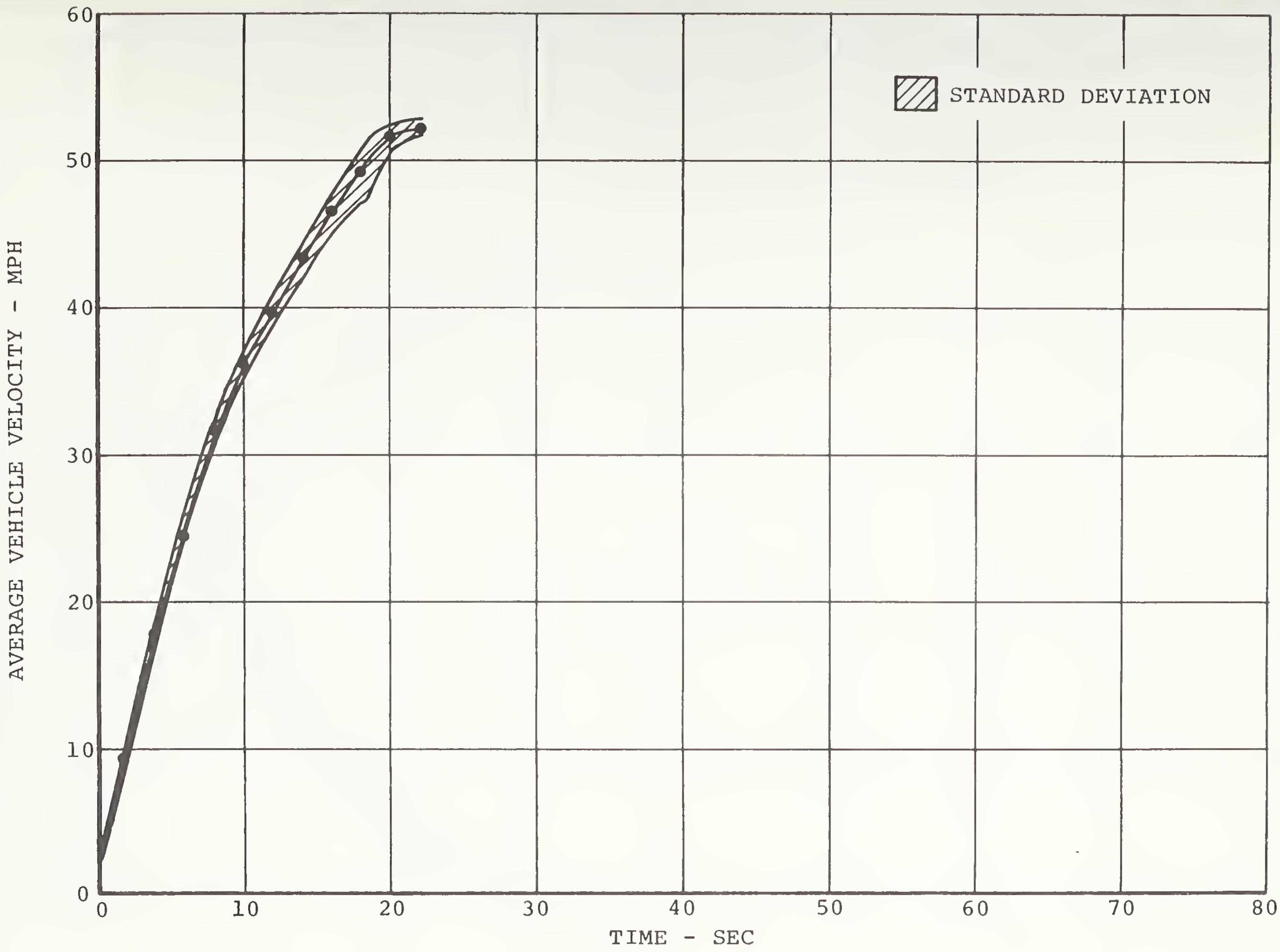


Figure A-22. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, Full Throttle, 650-pound Load.

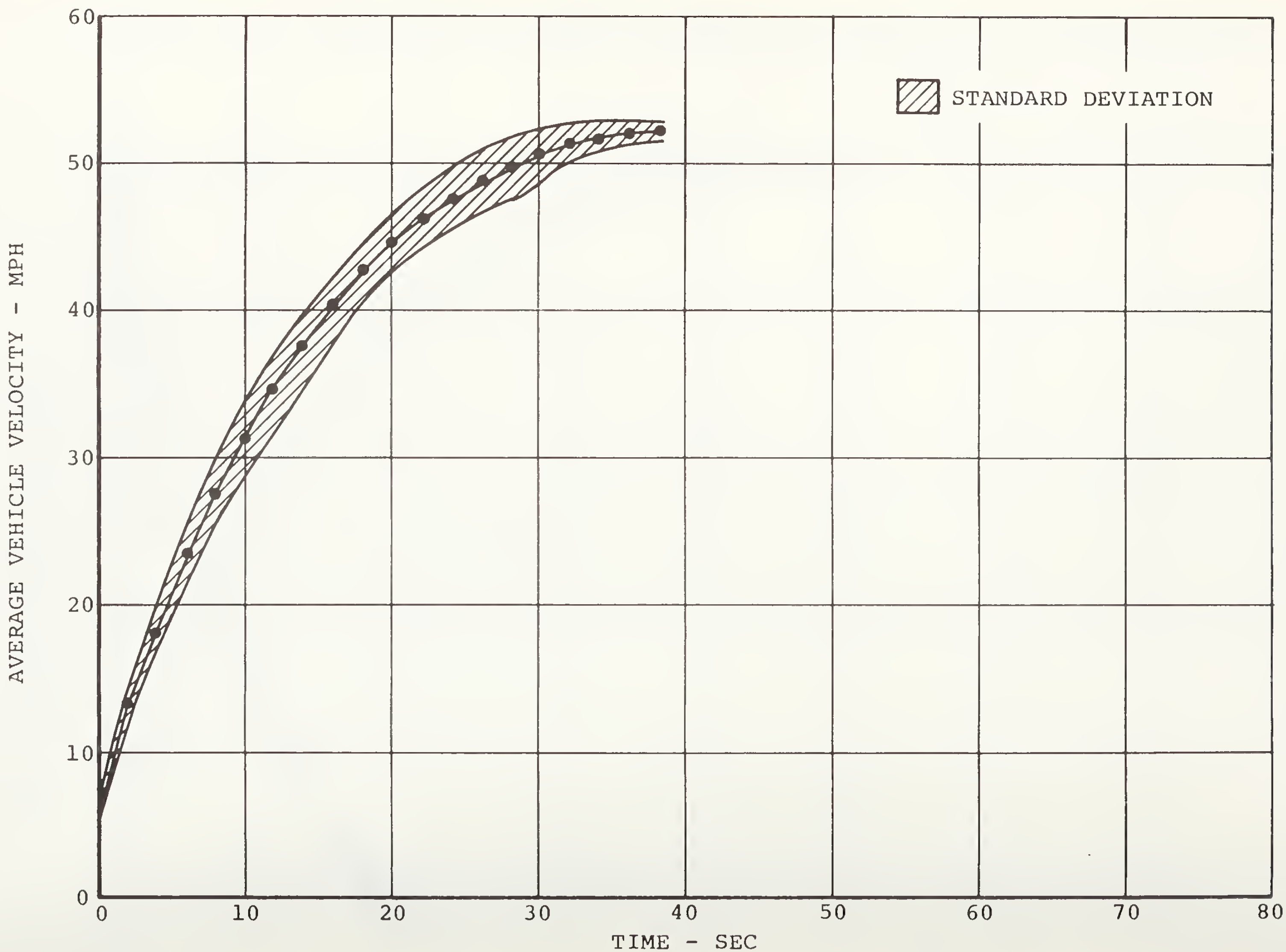


Figure A-23. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, 1/2 Throttle, 650-pound Load.

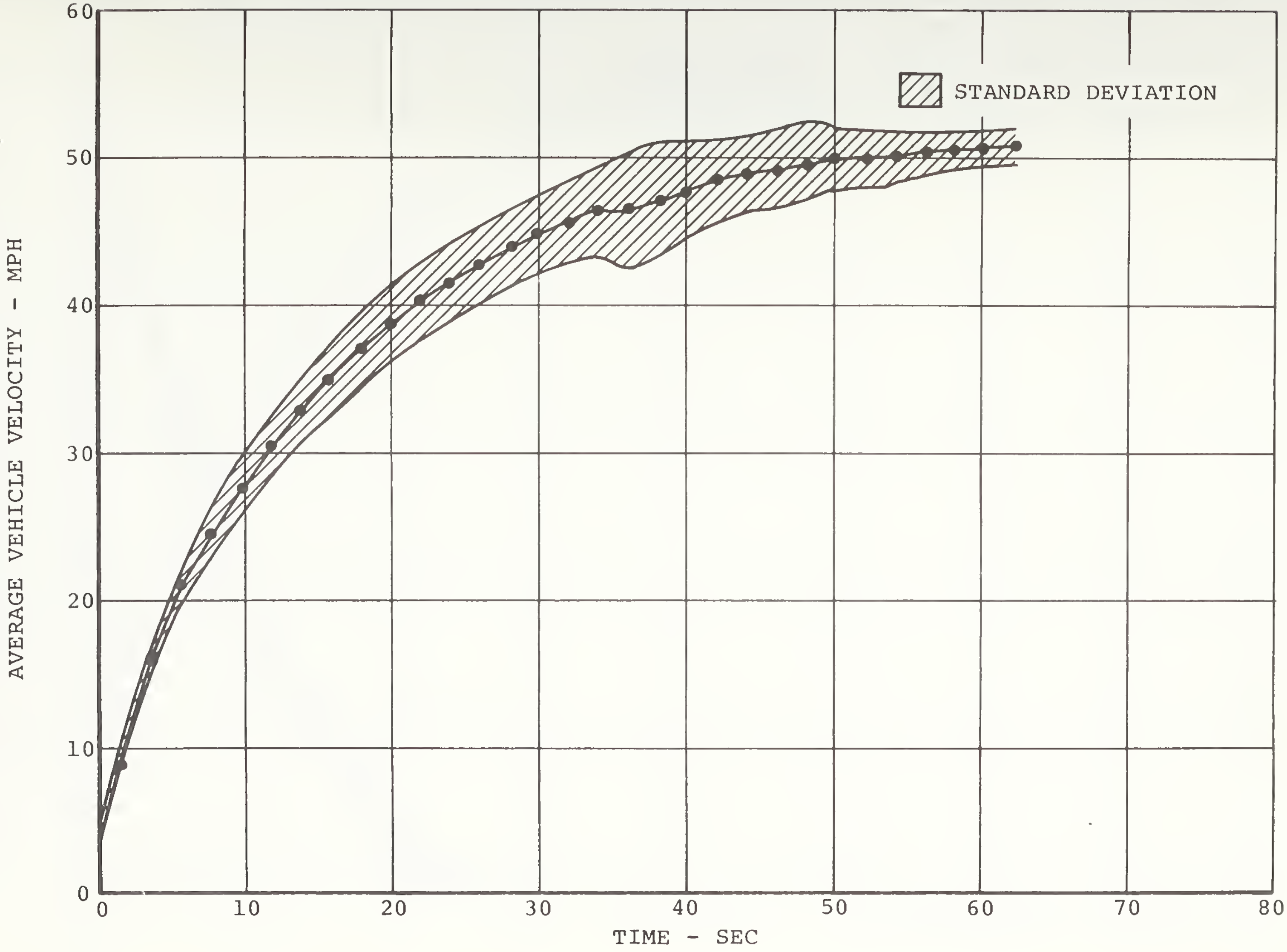


Figure A-24. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, 1/4 Throttle, 650-pound Load.

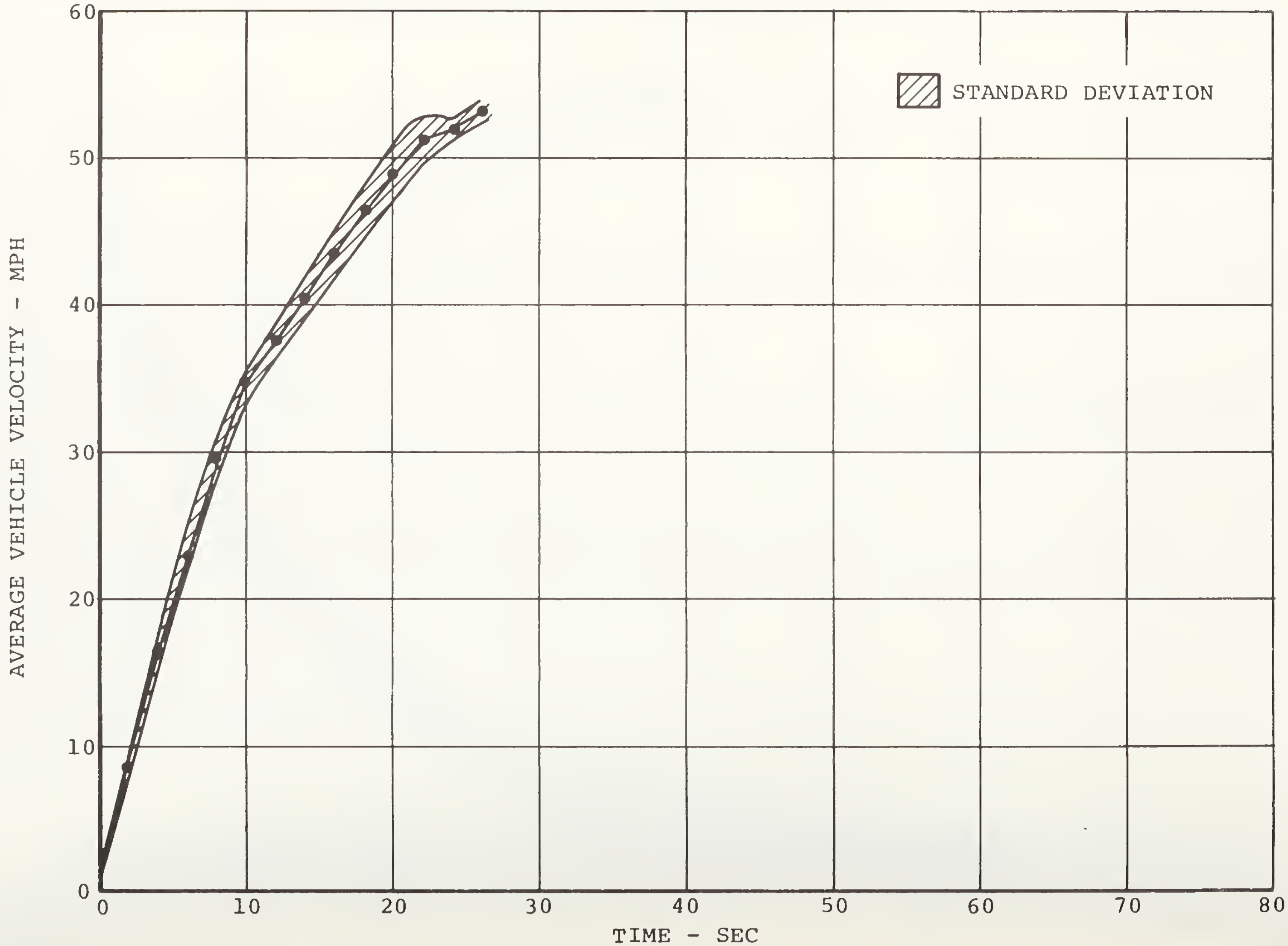


Figure A-25. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, Full Throttle, 900-pound Load.

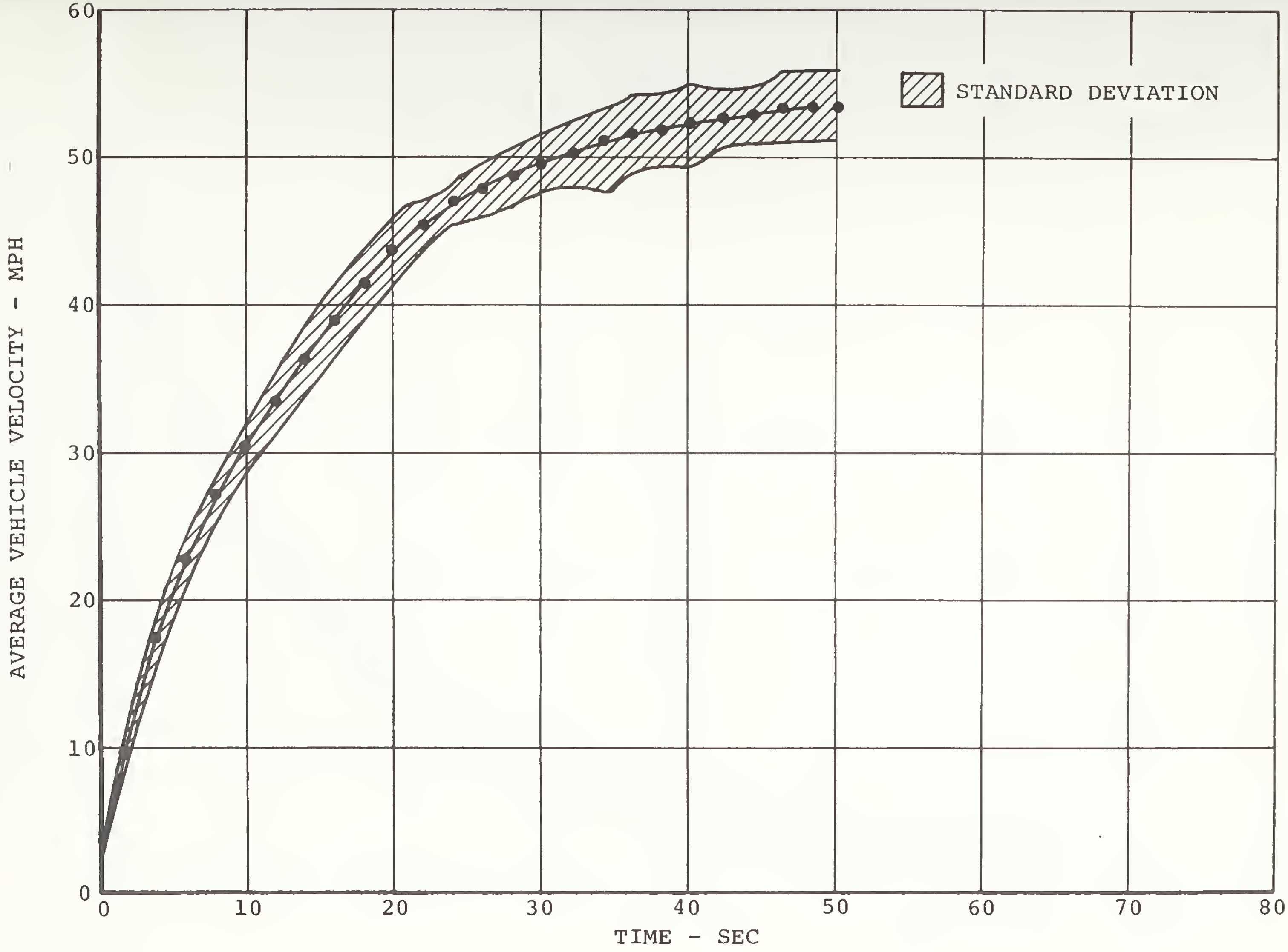


Figure A-26. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, 1/2 Throttle, 900-pound Load.

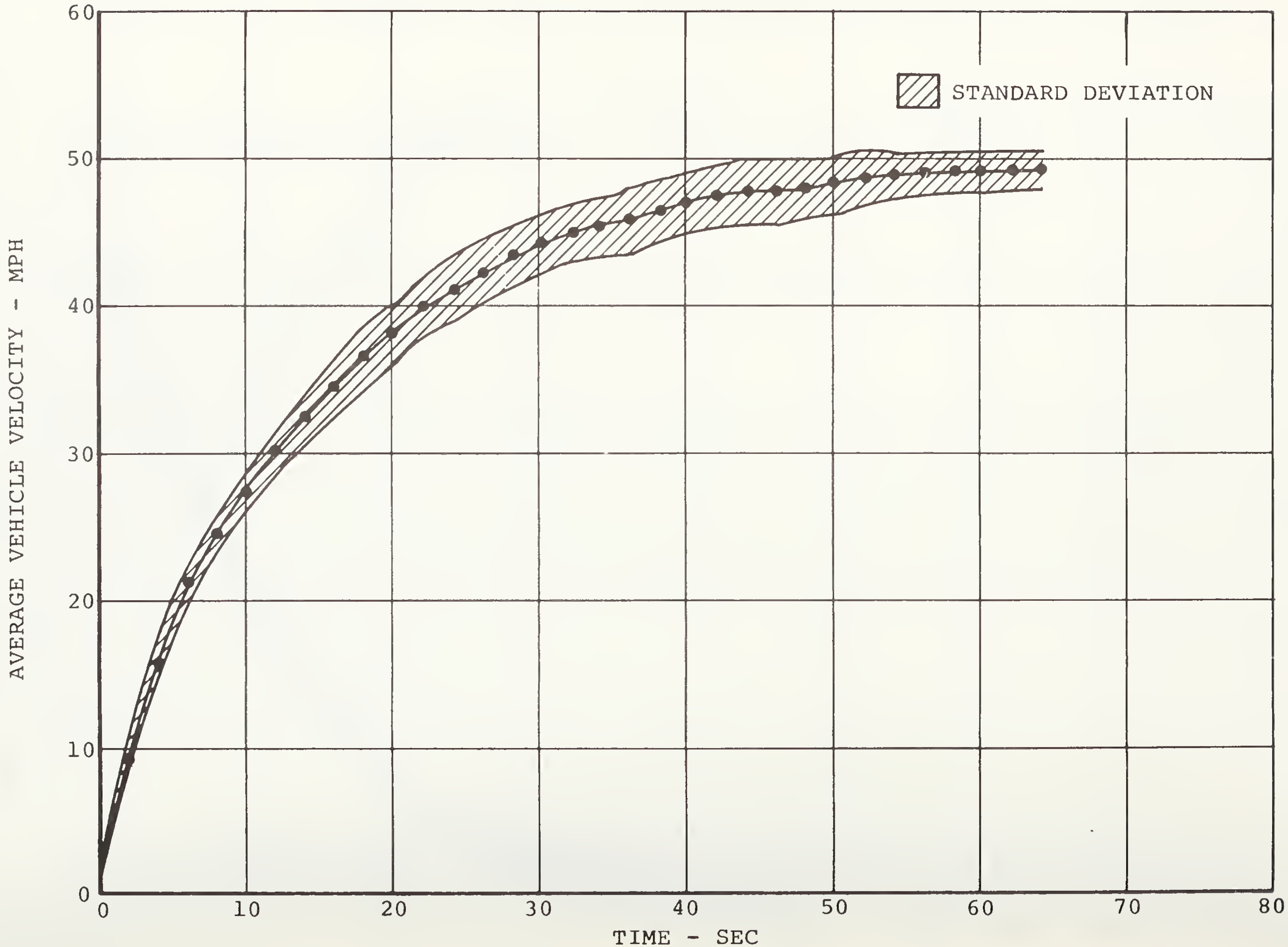


Figure A-27. Velocity of Dutcher Prototype During Vehicle Acceleration Tests, 1/4 Throttle, 900-pound Load.

APPENDIX B

WHEELCHAIR DUMMY ACCELERATION VERSUS TIME DATA FOR VEHICLE ACCELERATION TESTS

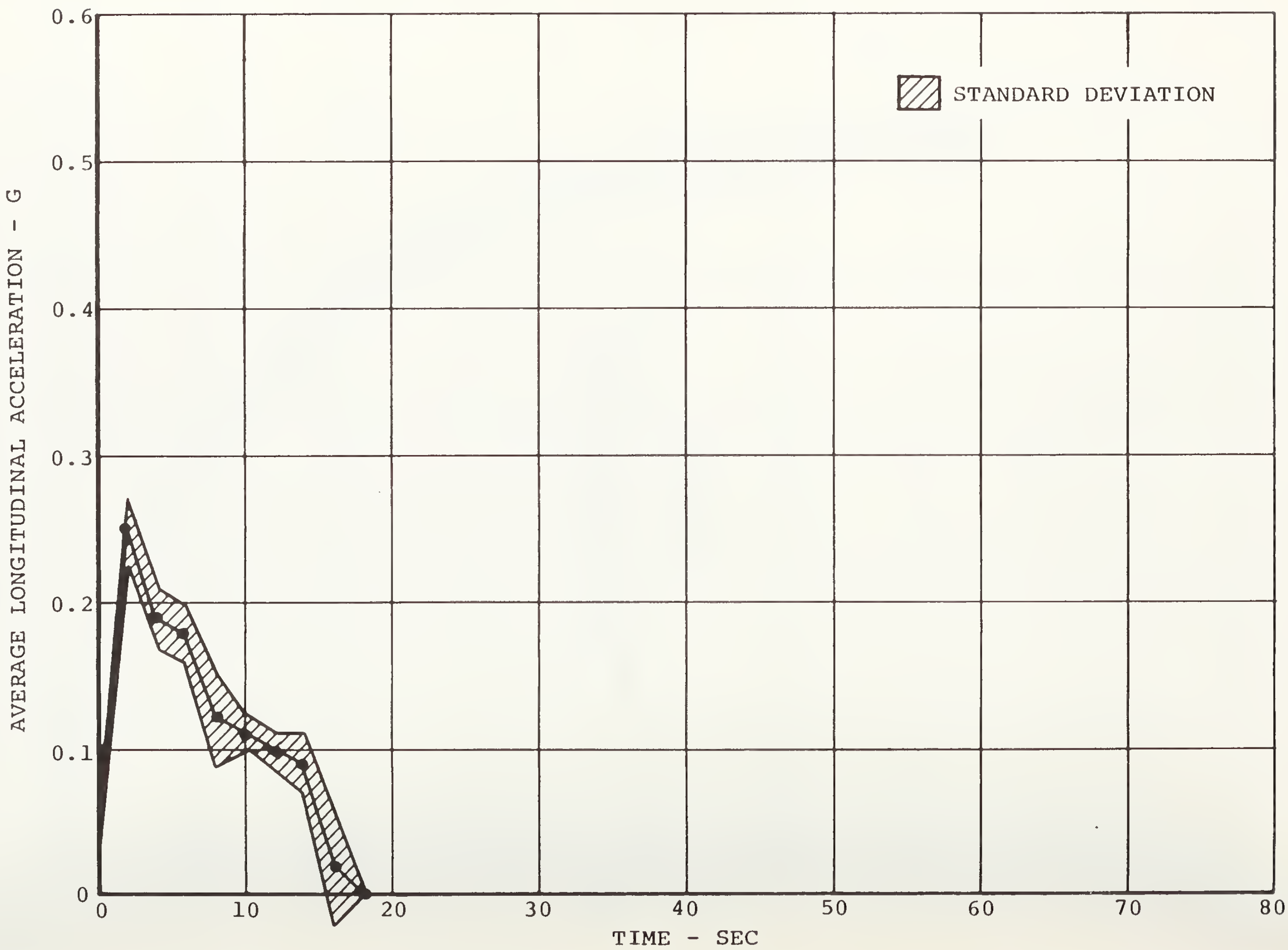


Figure B-1. Wheelchair Dummy Acceleration During Nova Acceleration Tests, Full Throttle, 650-pound Load.

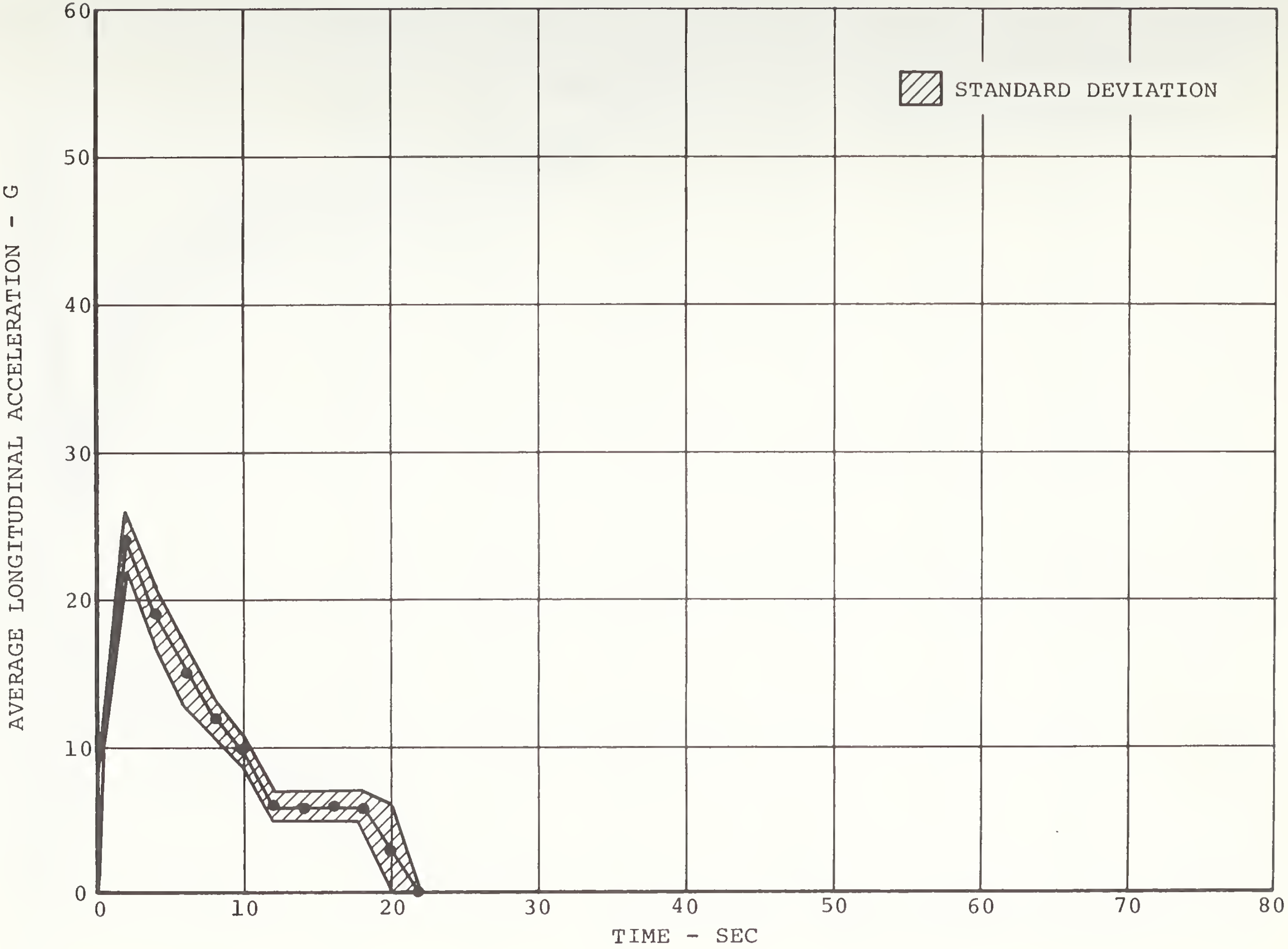


Figure B-2. Wheelchair Dummy Acceleration During Nova Acceleration Tests, 1/2 Throttle, 650-pound Load.

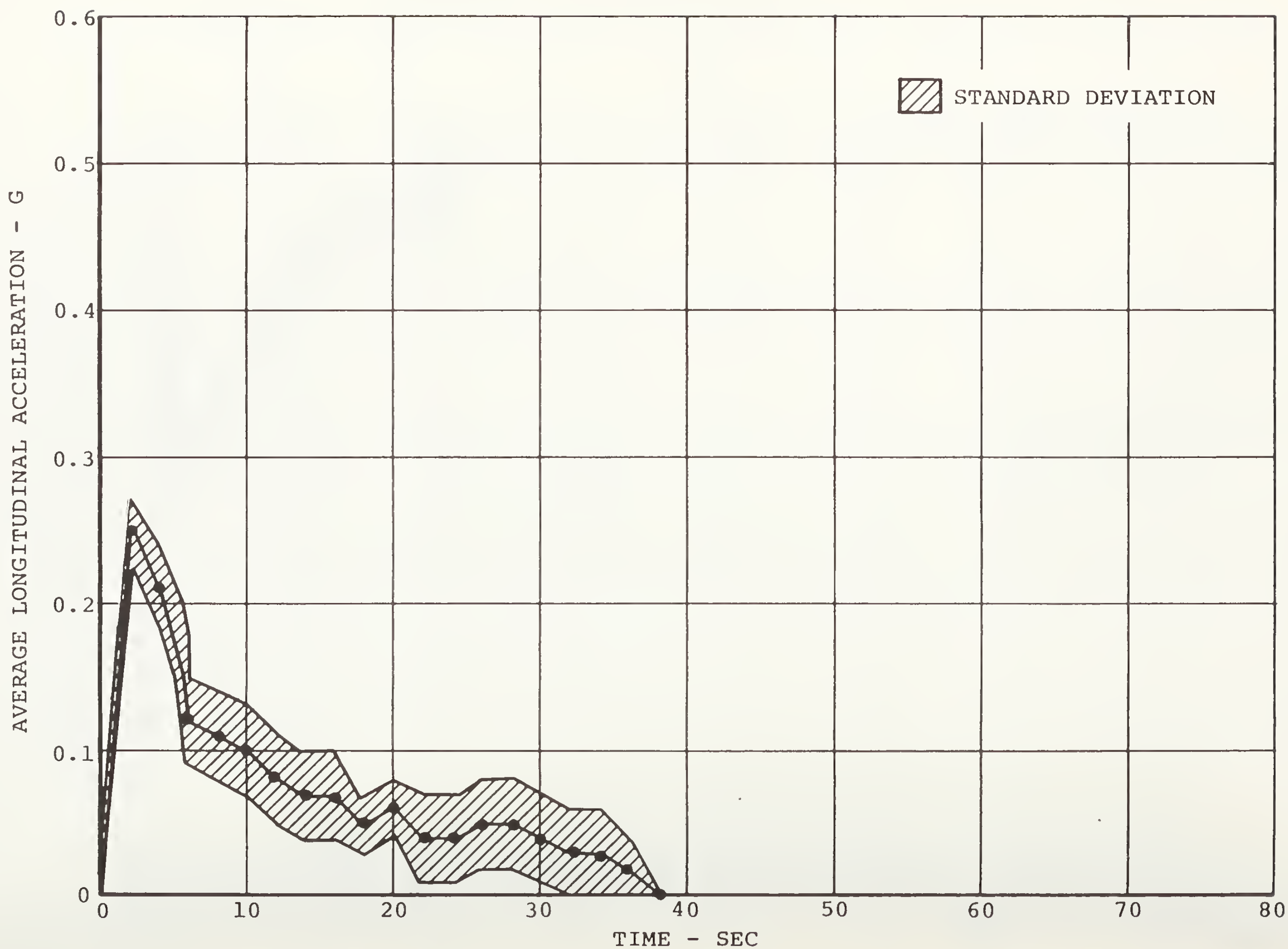


Figure B-3. Wheelchair Dummy Acceleration During Nova Acceleration Tests, 1/4 Throttle, 650-pound Load.

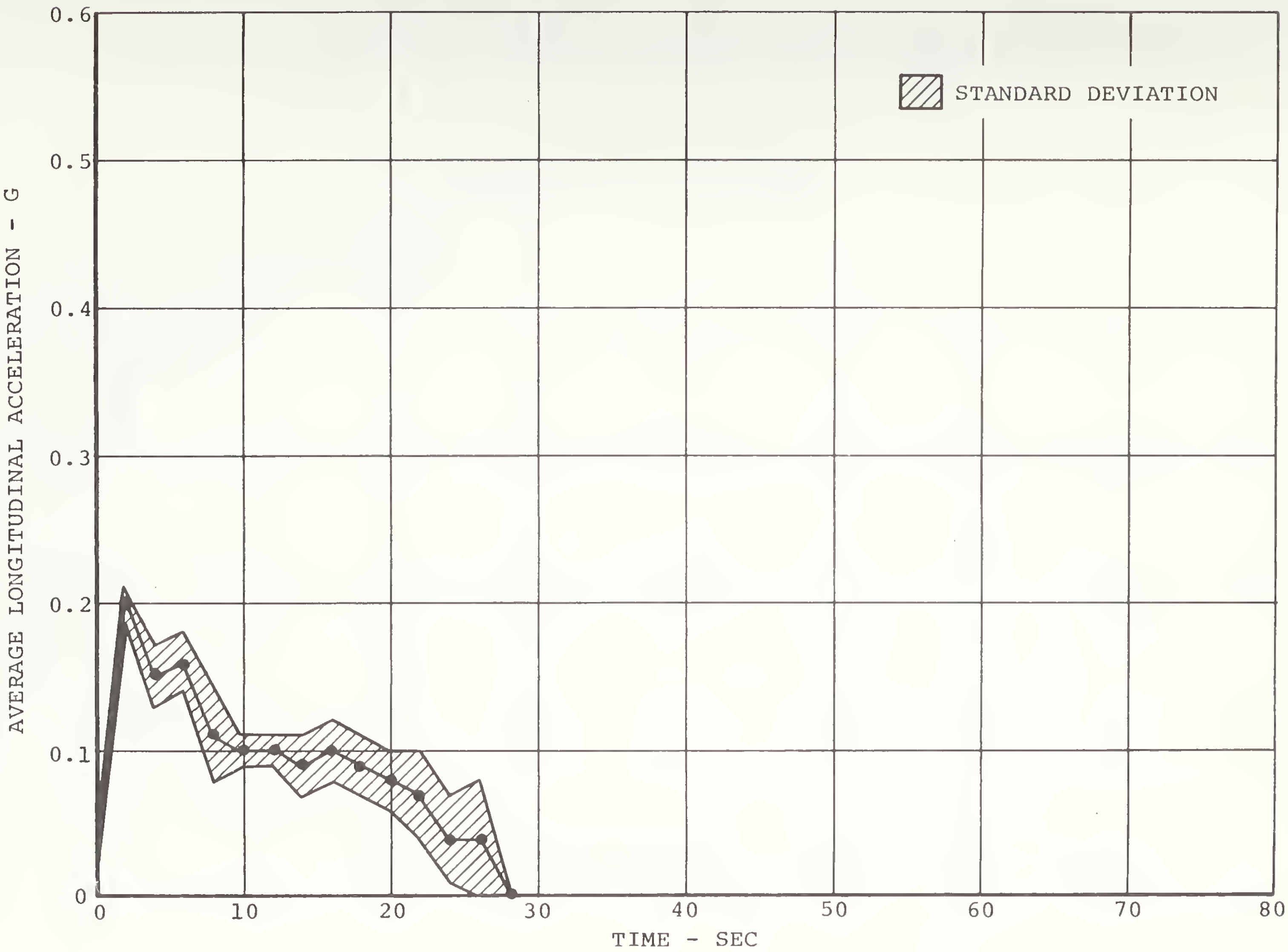


Figure B-4. Wheelchair Dummy Acceleration During ASL Acceleration Tests, Full Throttle, 650-pound Load.

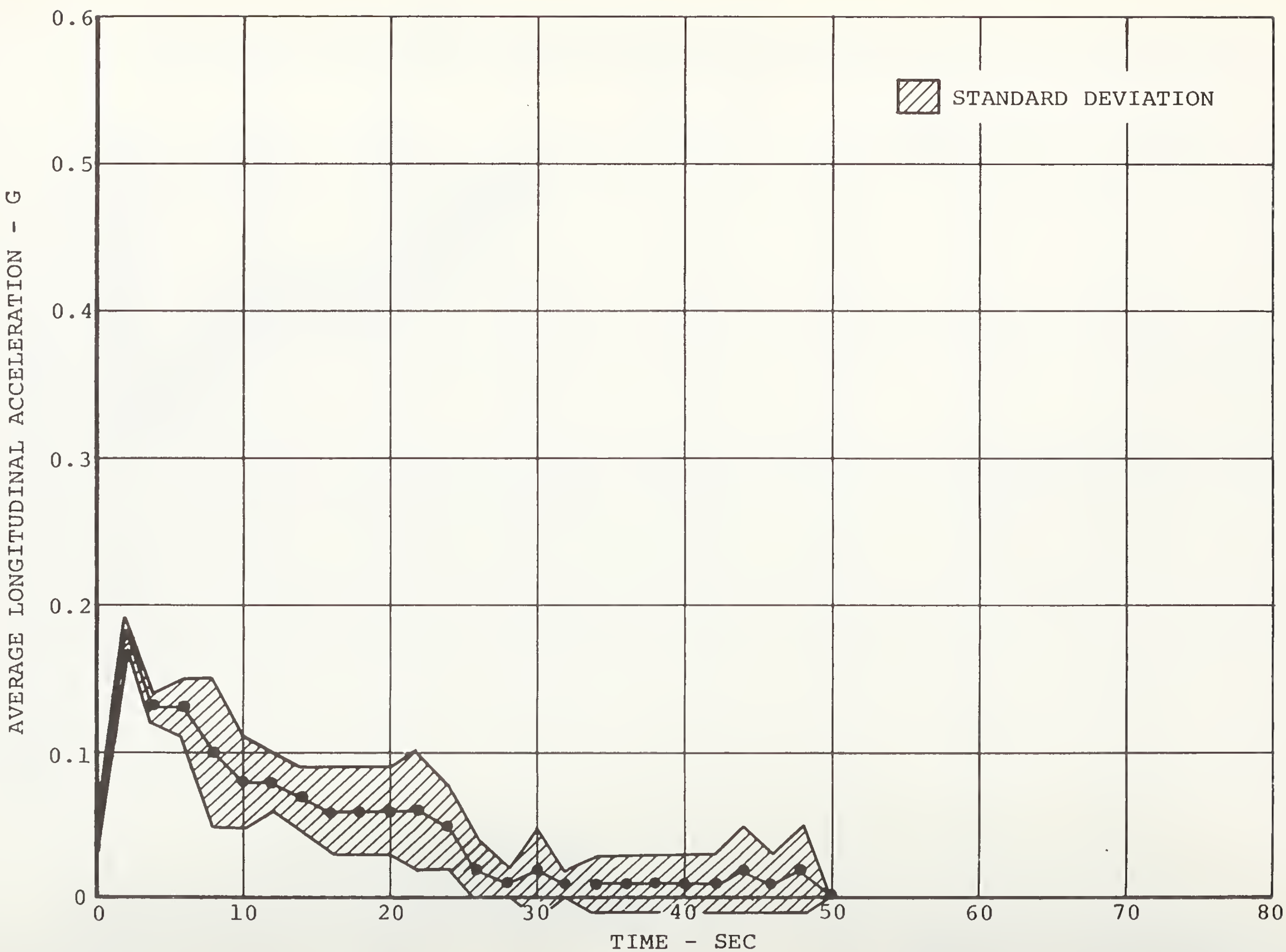


Figure B-5. Wheelchair Dummy Acceleration During ASL Acceleration Tests, 1/2 Throttle, 650-pound Load.

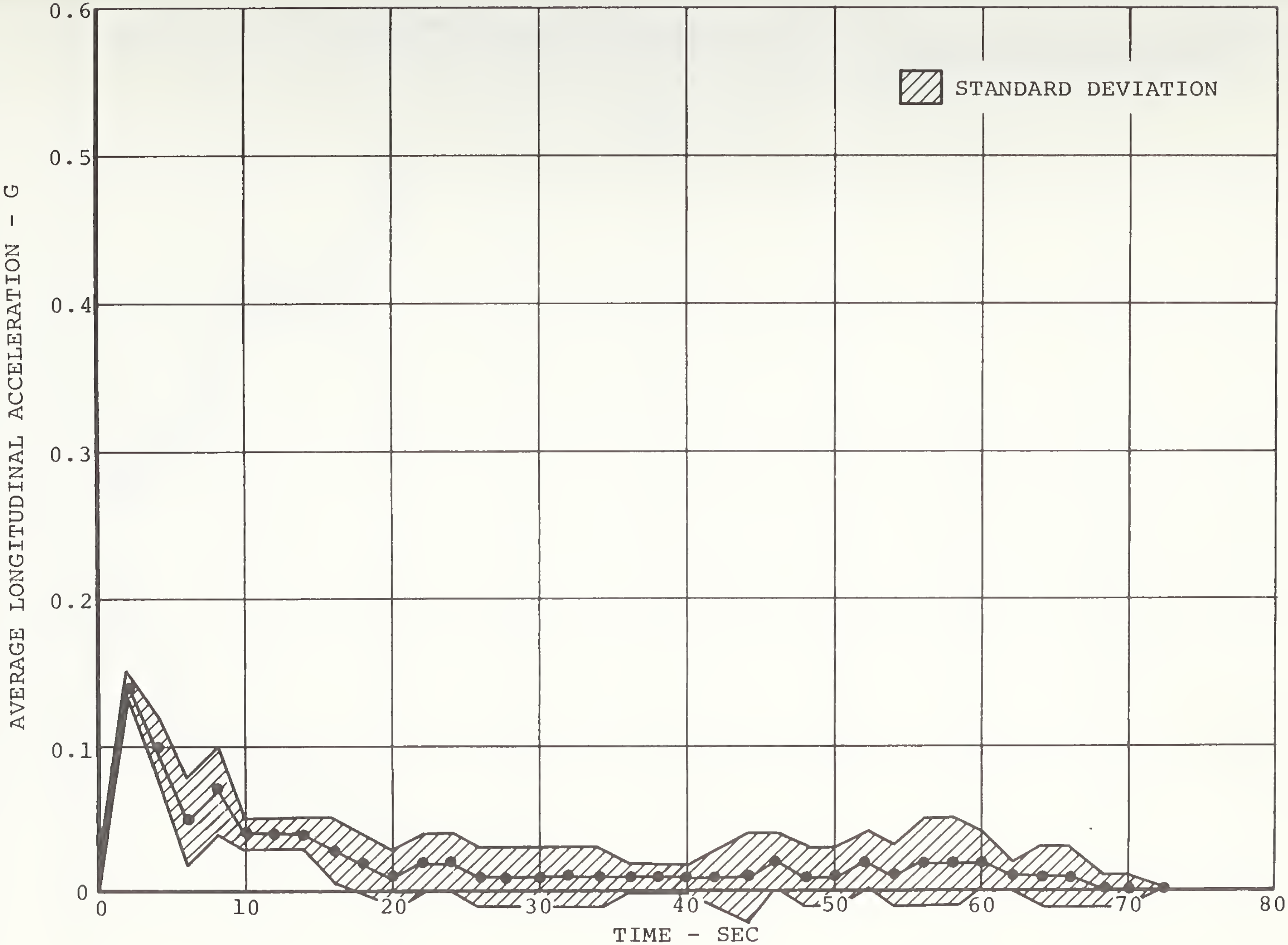


Figure B-6. Wheelchair Dummy Acceleration During ASL Acceleration Tests, 1/4 Throttle, 650-pound Load.

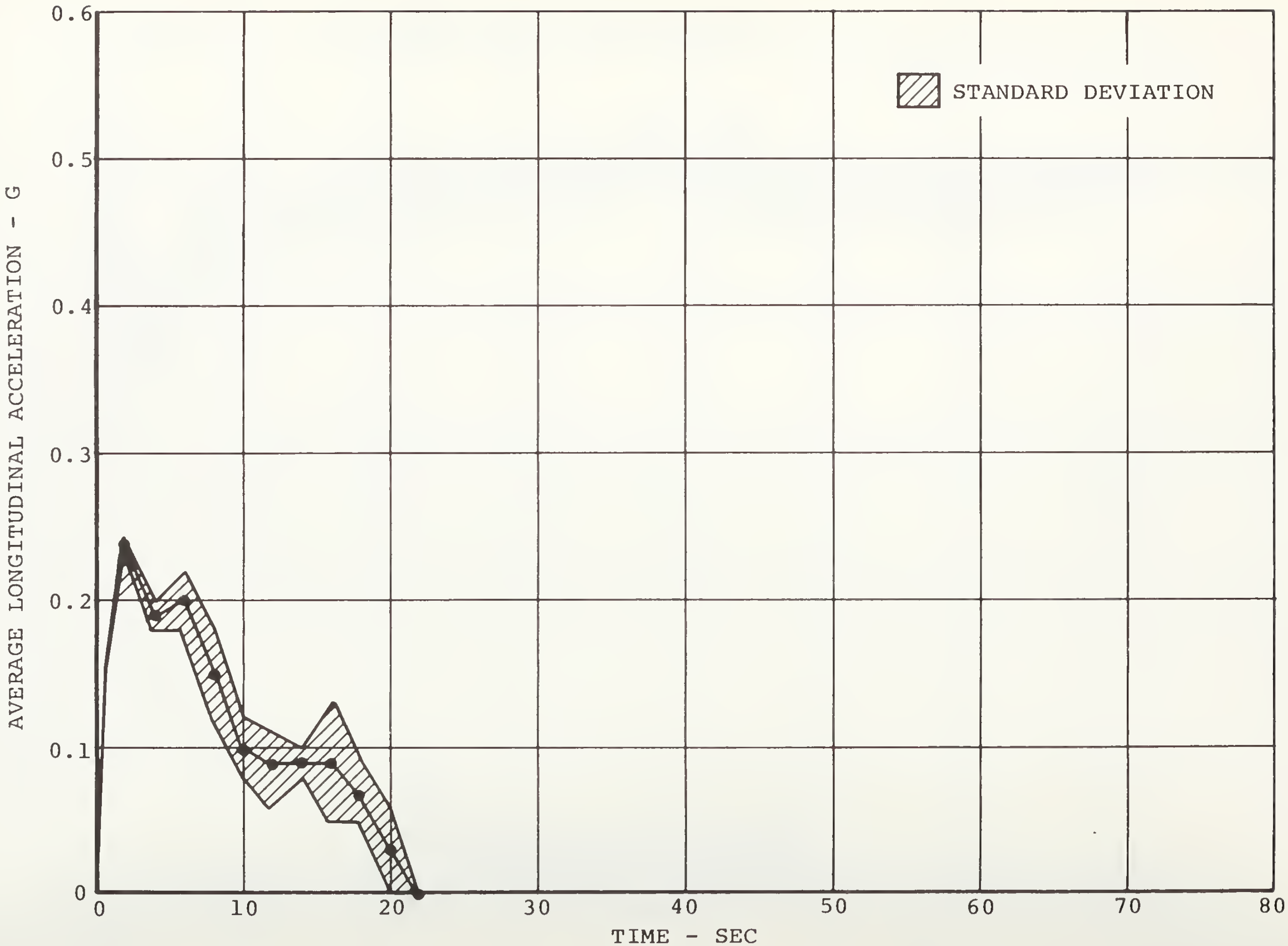


Figure B-7. Wheelchair Dummy Acceleration During Dutcher Acceleration Tests, Full Throttle, 650-pound Load.

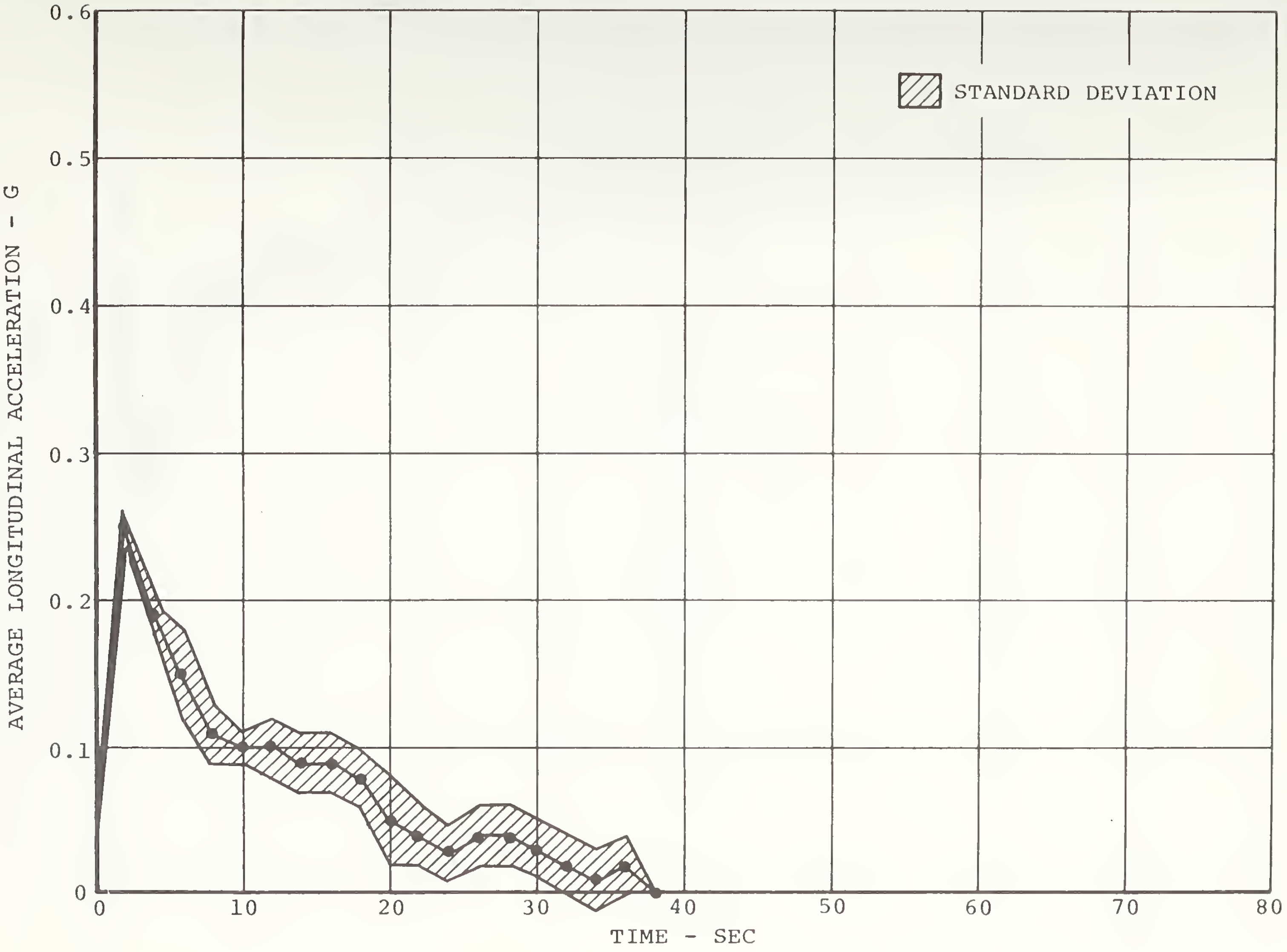


Figure B-8. Wheelchair Dummy Acceleration During Dutcher Acceleration Tests, 1/2 Throttle, 650-pound Load.

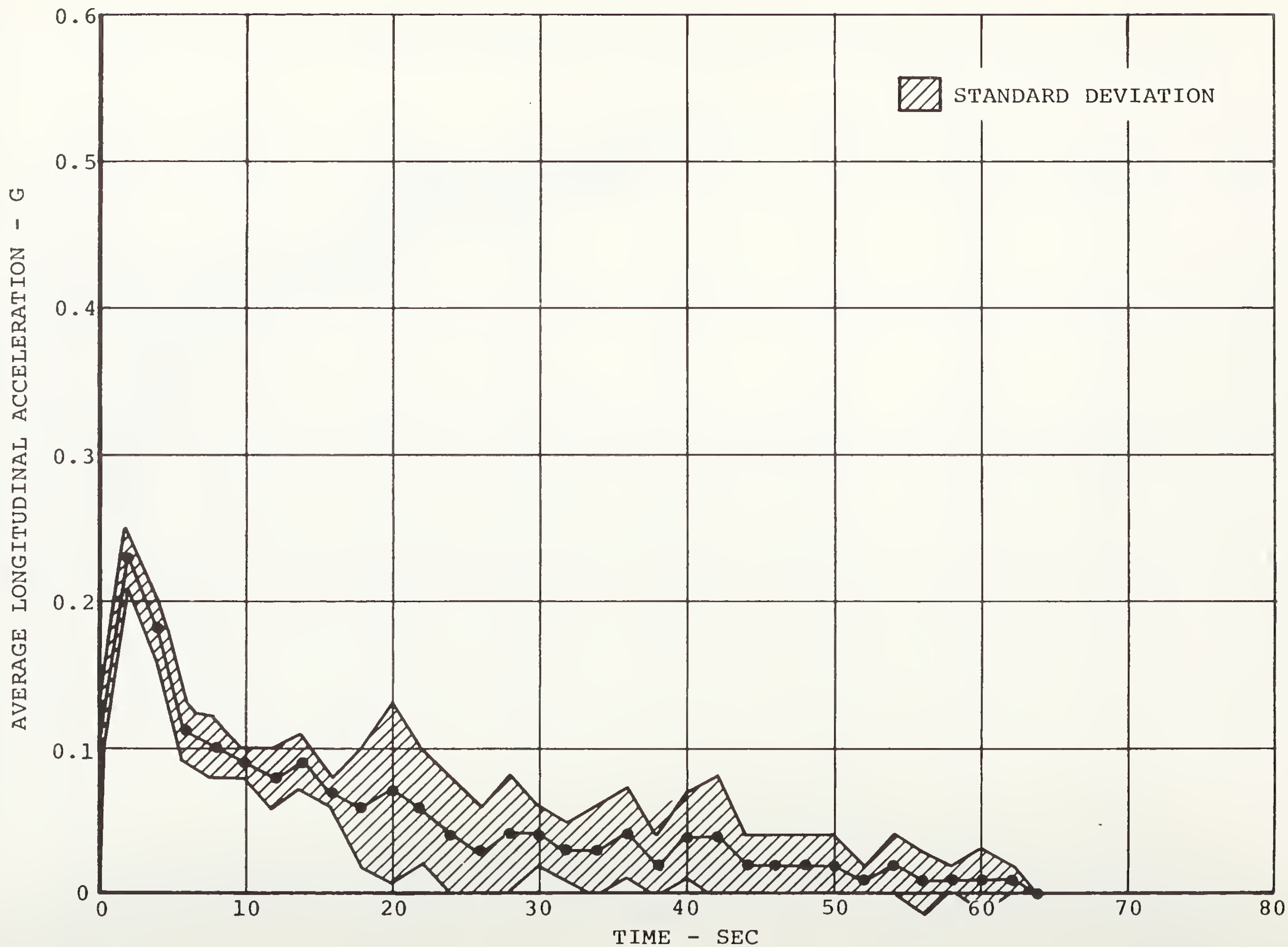


Figure B-9. Wheelchair Dummy Acceleration During Dutcher Acceleration Tests, 1/4 Throttle, 650-pound Load.

APPENDIX C

DUMMY MOTIONS VERSUS
TIME FOR WHEELCHAIR LONGITUDINAL
DECELERATION TESTS

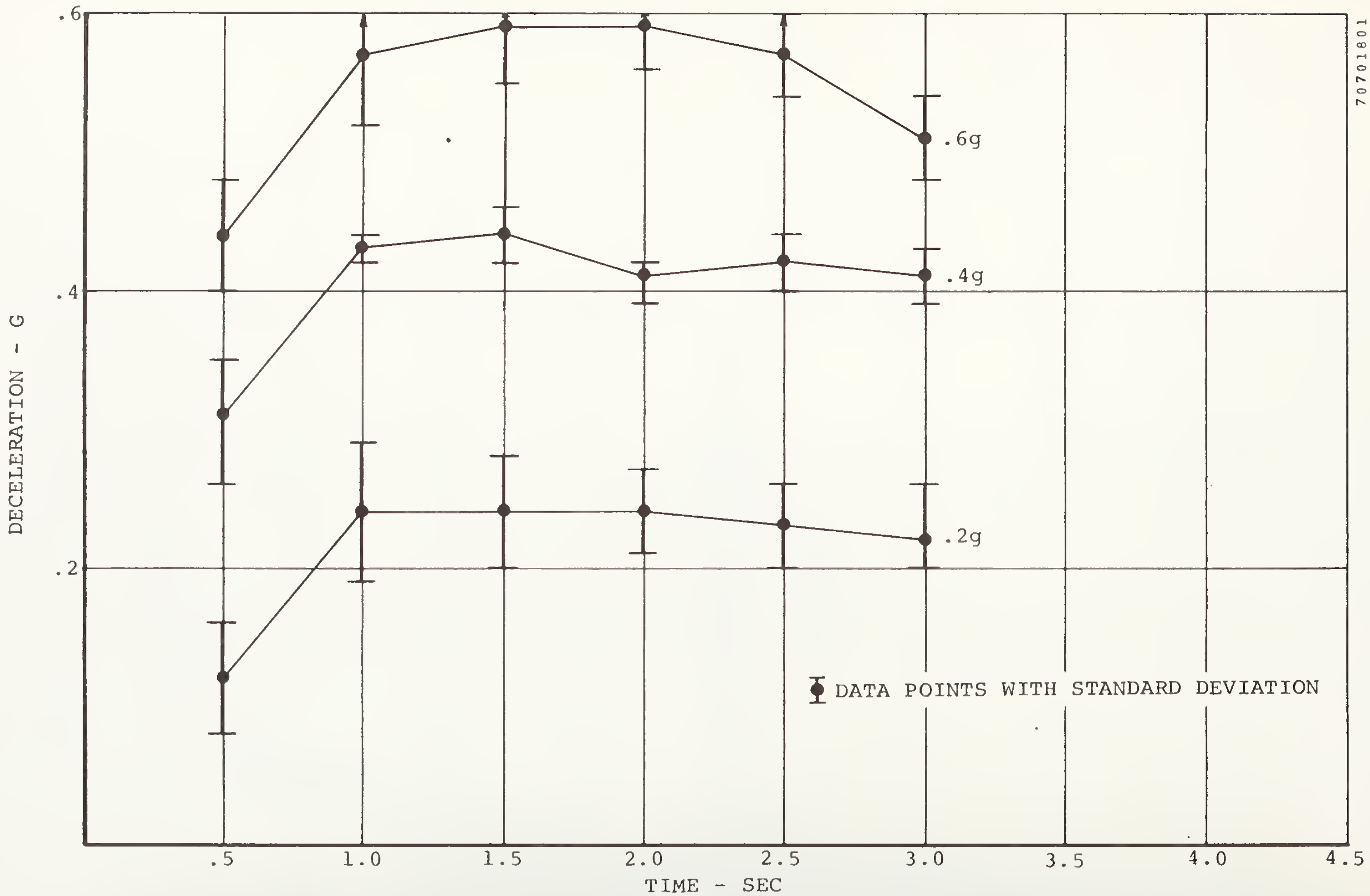


Figure C-1. Vehicle Longitudinal Deceleration, ASL Wheelchair Deceleration Tests, Wheelchair and Dummy Restrained.

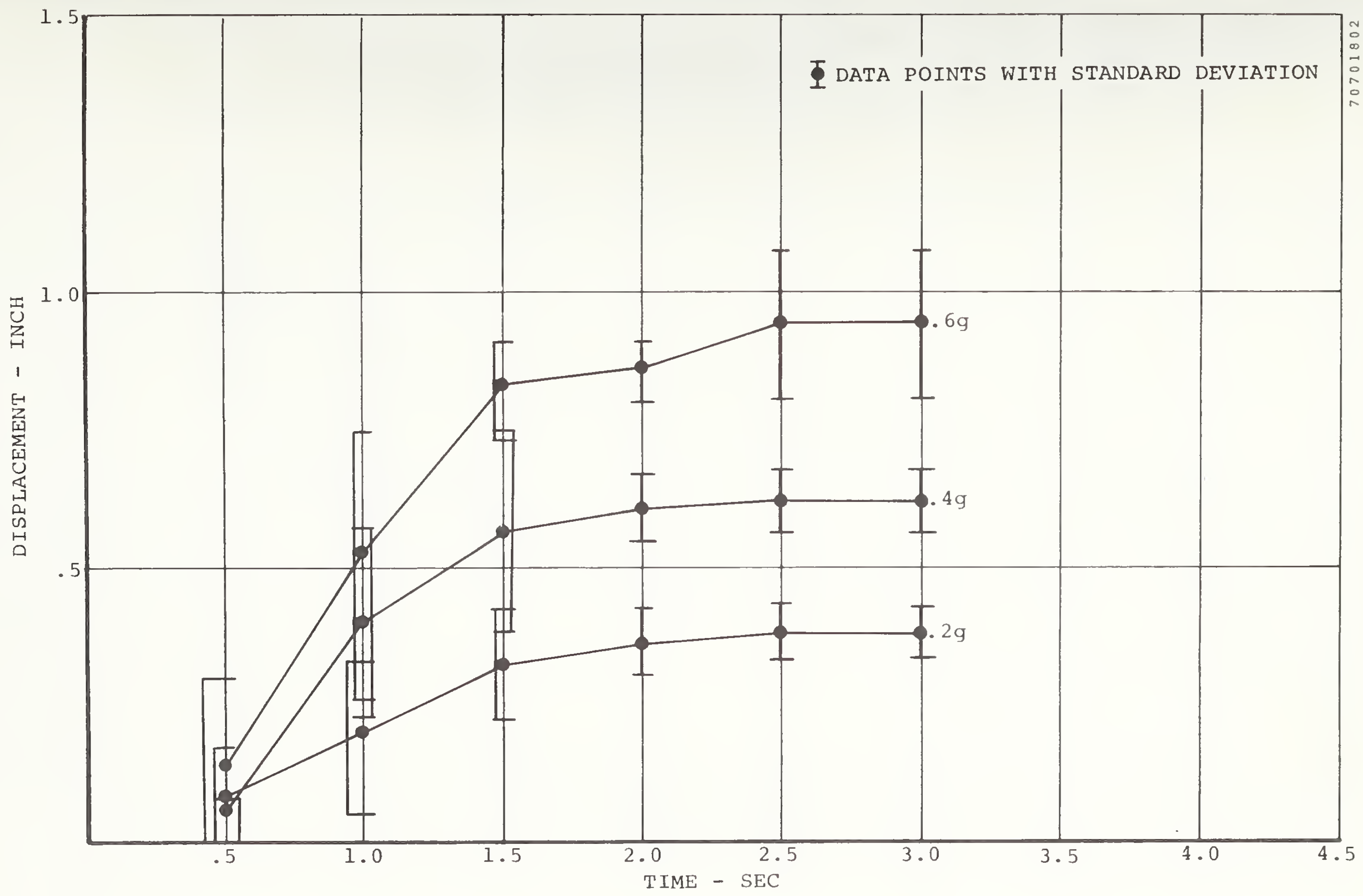


Figure C-2. ASL Dummy Head Displacement, Longitudinal Deceleration, Wheelchair and Dummy Restrained.

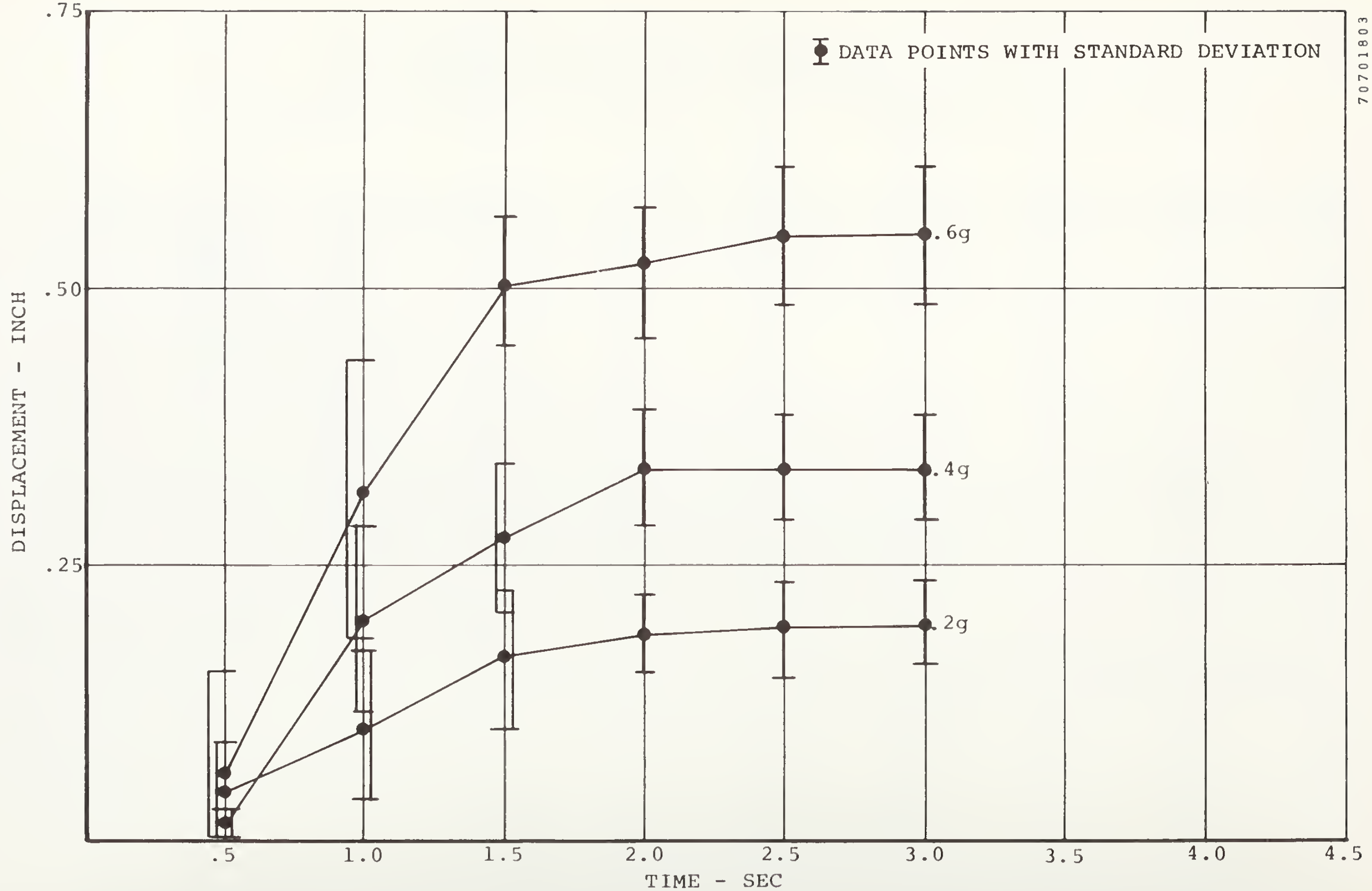


Figure C-3. ASL Dummy Thorax Displacement, Longitudinal Deceleration, Wheelchair and Dummy Restrained.

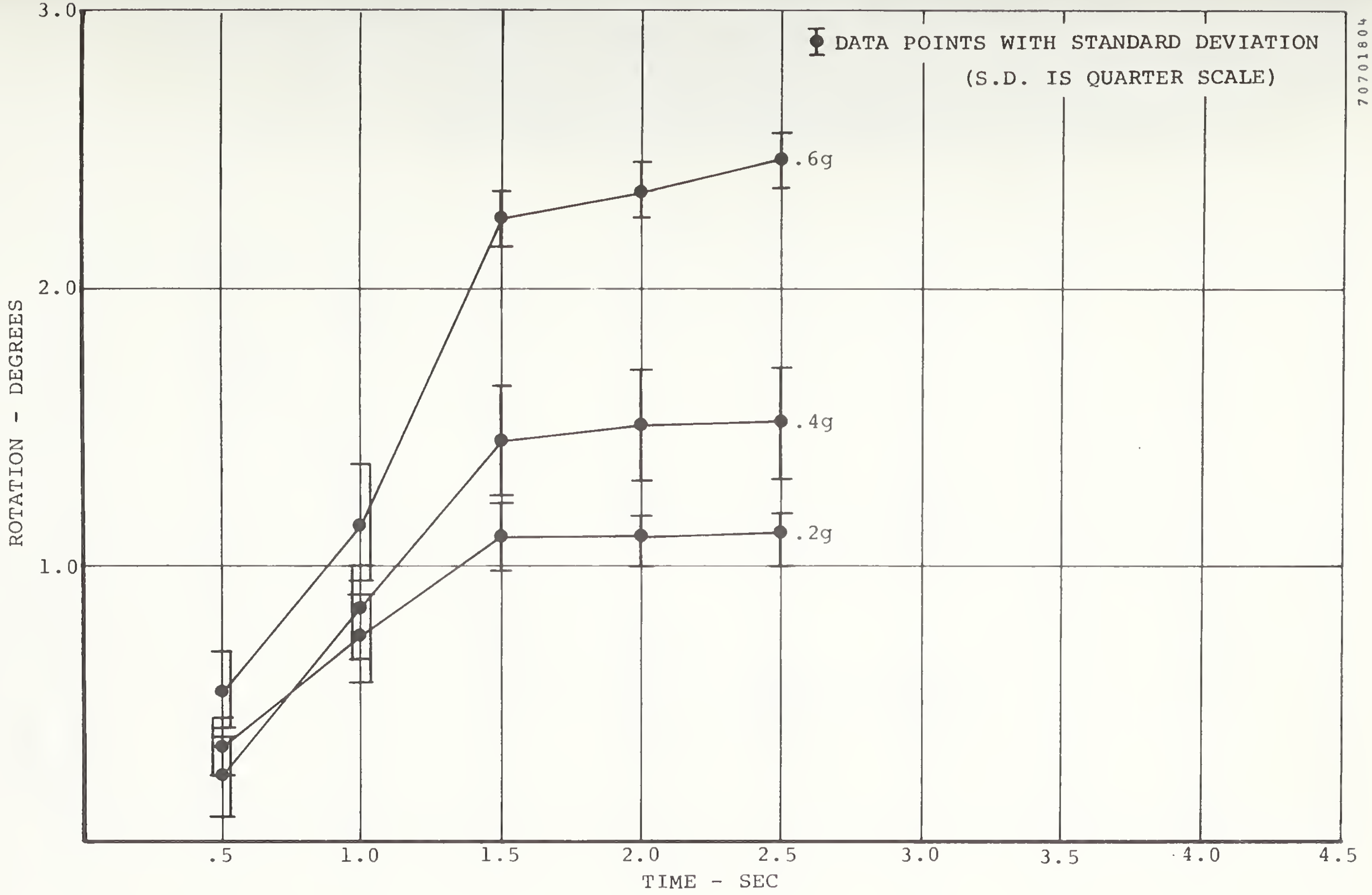


Figure C-4. ASL Dummy Head Rotation, Longitudinal Deceleration, Wheelchair and Dummy Restrained.

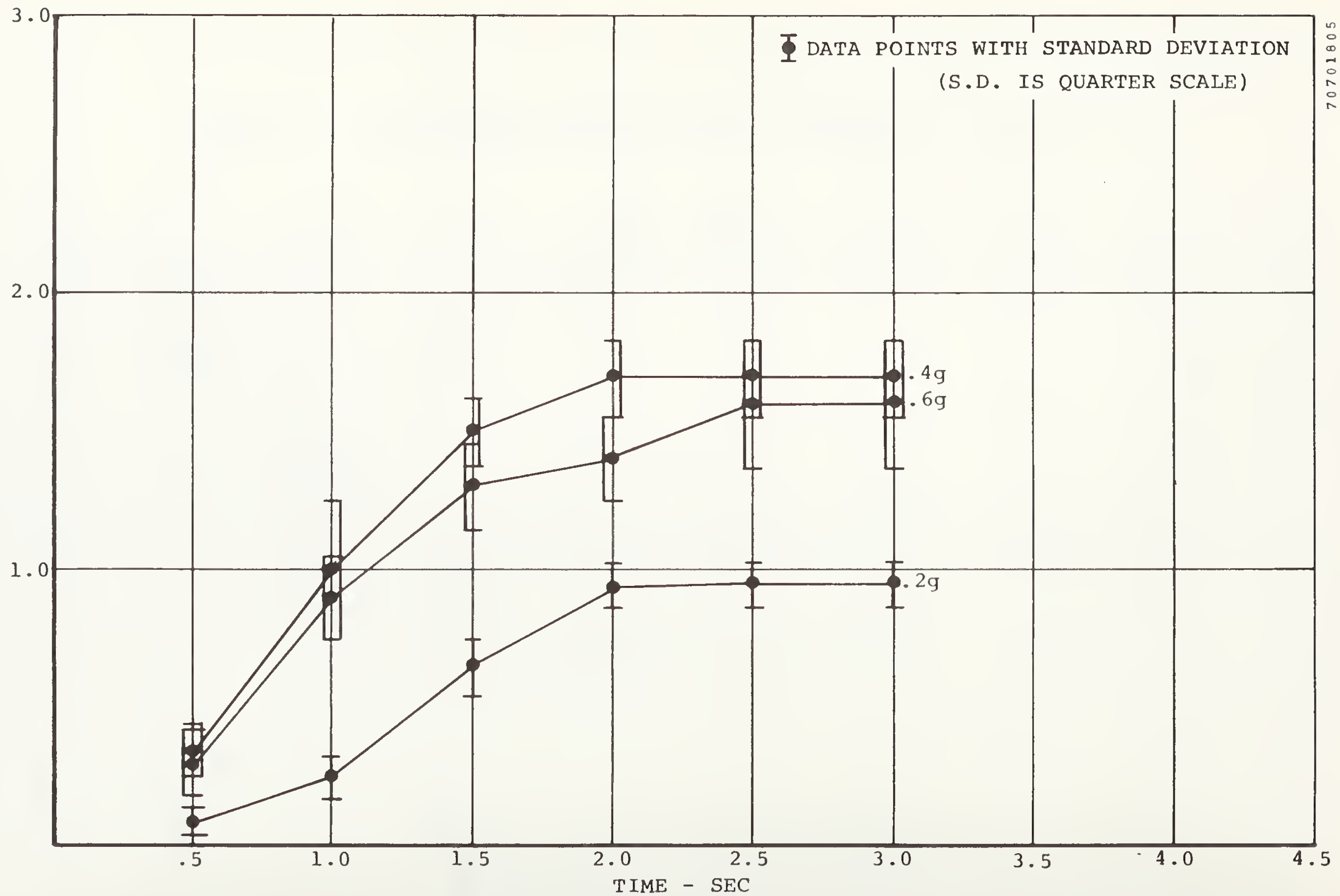


Figure C-5. ASL Dummy Thorax Rotation, Longitudinal Deceleration, Wheelchair and Dummy Restrained.

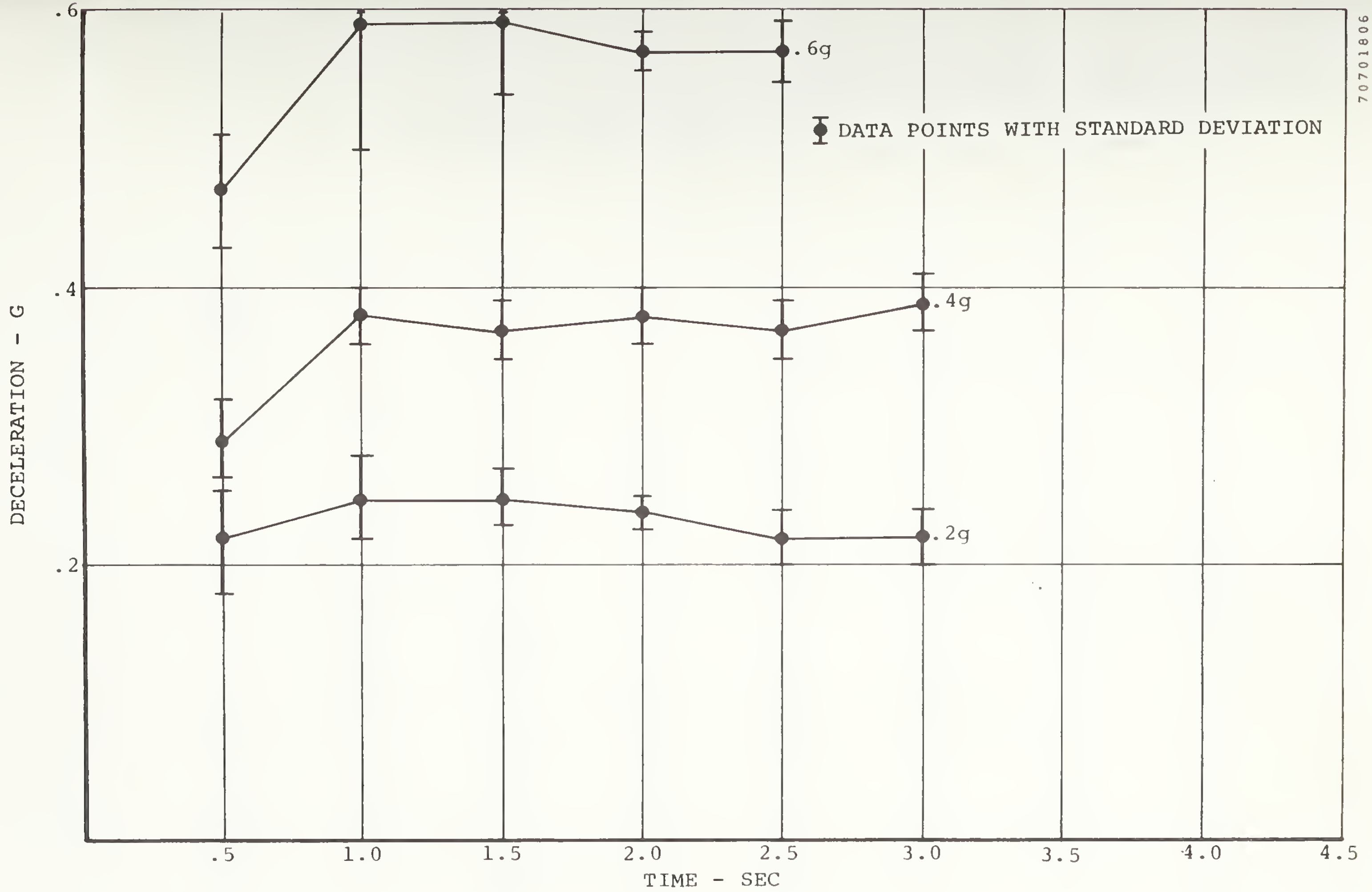


Figure C-6. Vehicle Longitudinal Deceleration, ASL Wheelchair Deceleration Tests, Wheelchair Restrained.

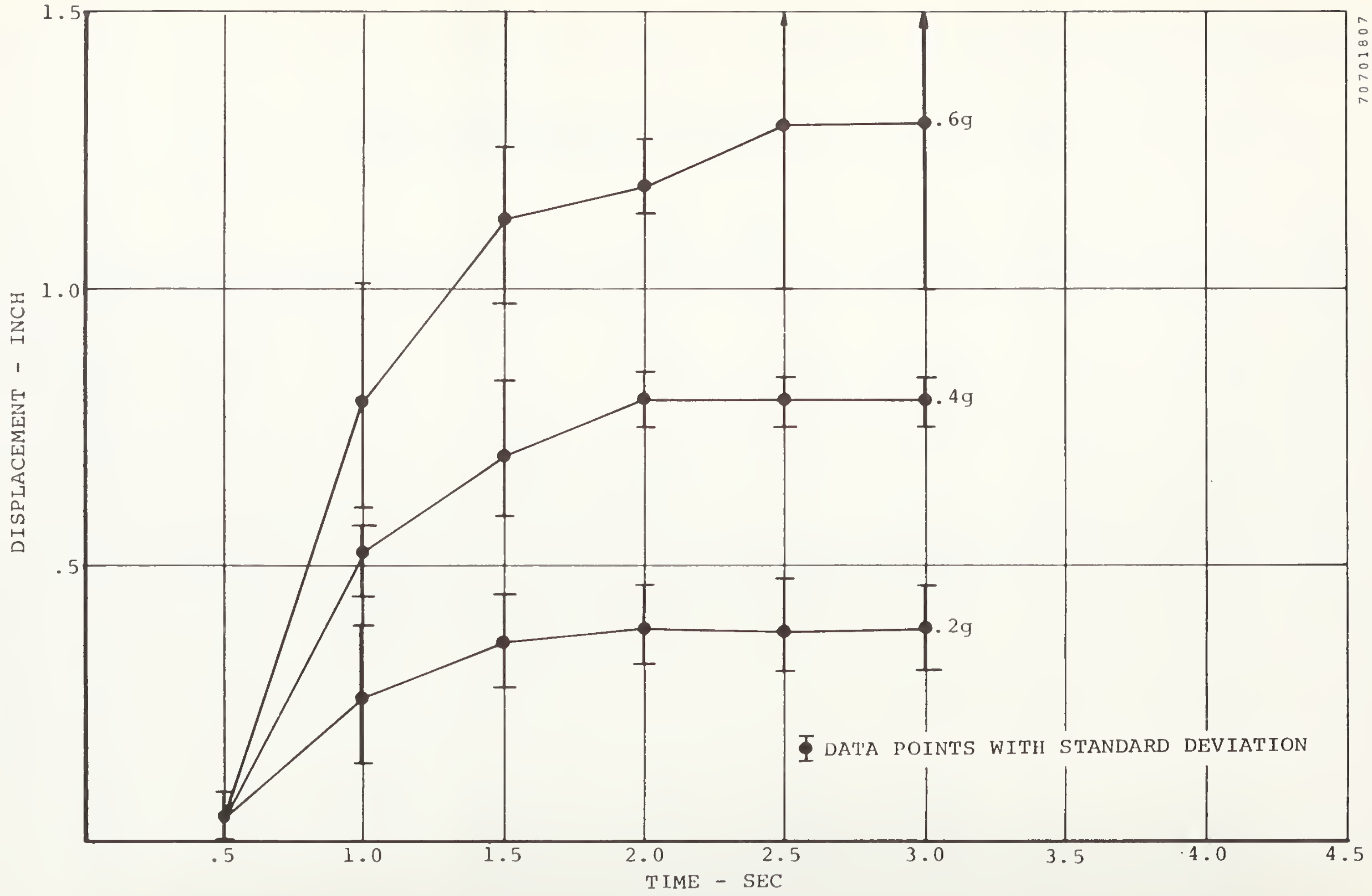


Figure C-7. ASL Dummy Head Displacement, Longitudinal Deceleration, Wheelchair Restrained.

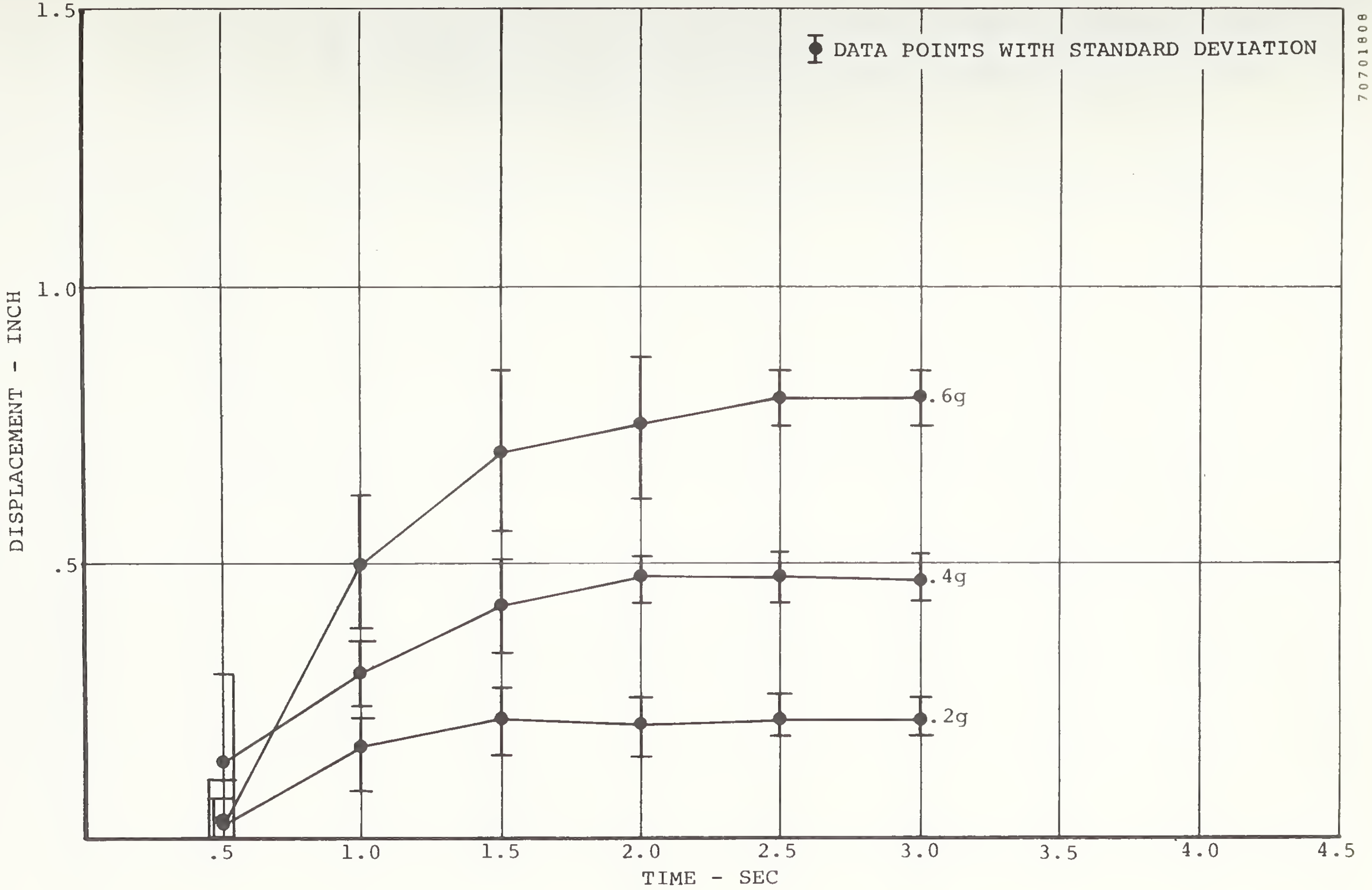
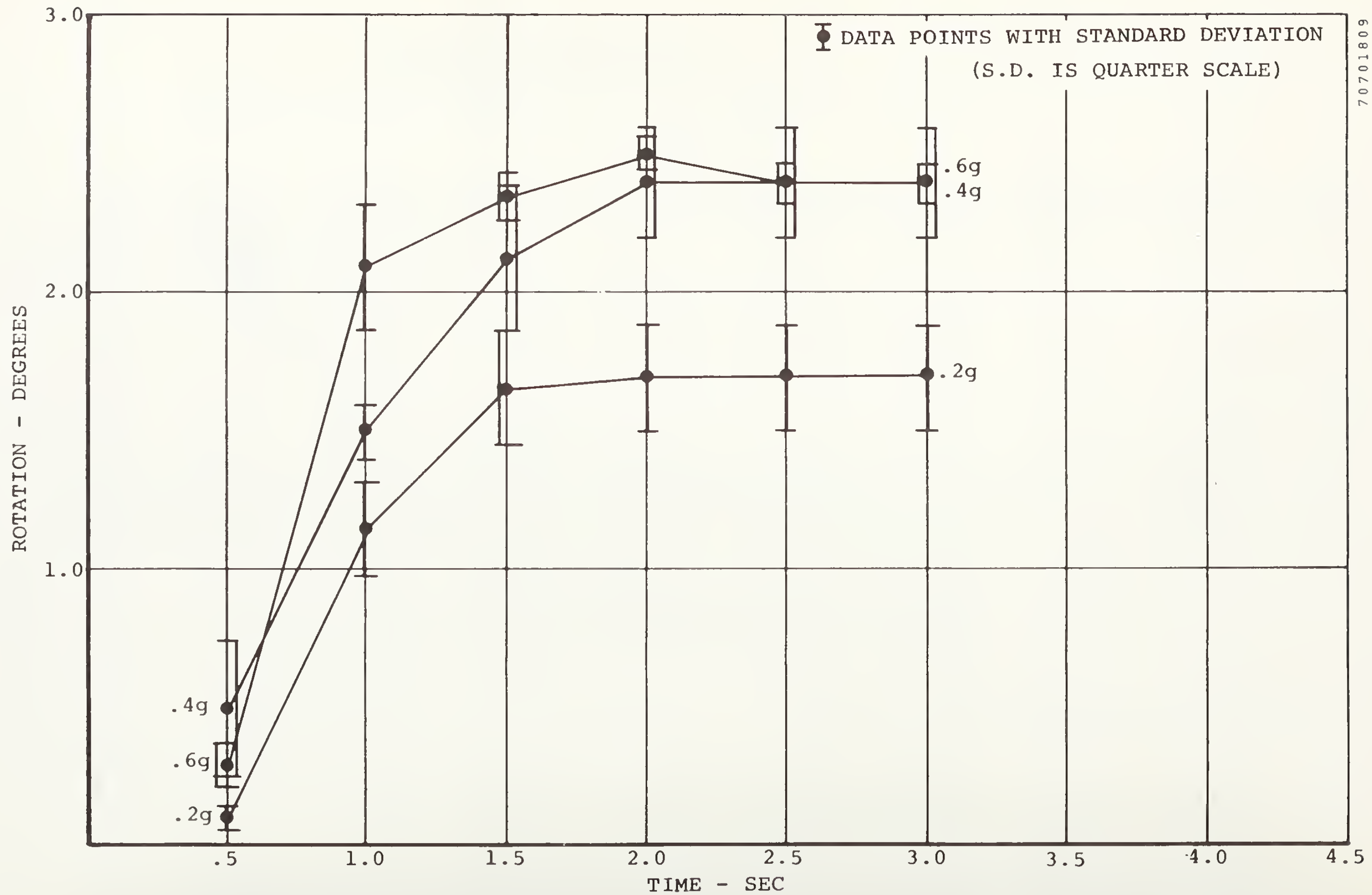


Figure C-8. ASL Dummy Thorax Displacement, Longitudinal Deceleration, Wheelchair Restrained.



'igure C-9. ASL Dummy Head Rotation, Longitudinal Deceleration, Wheelchair Restrained.

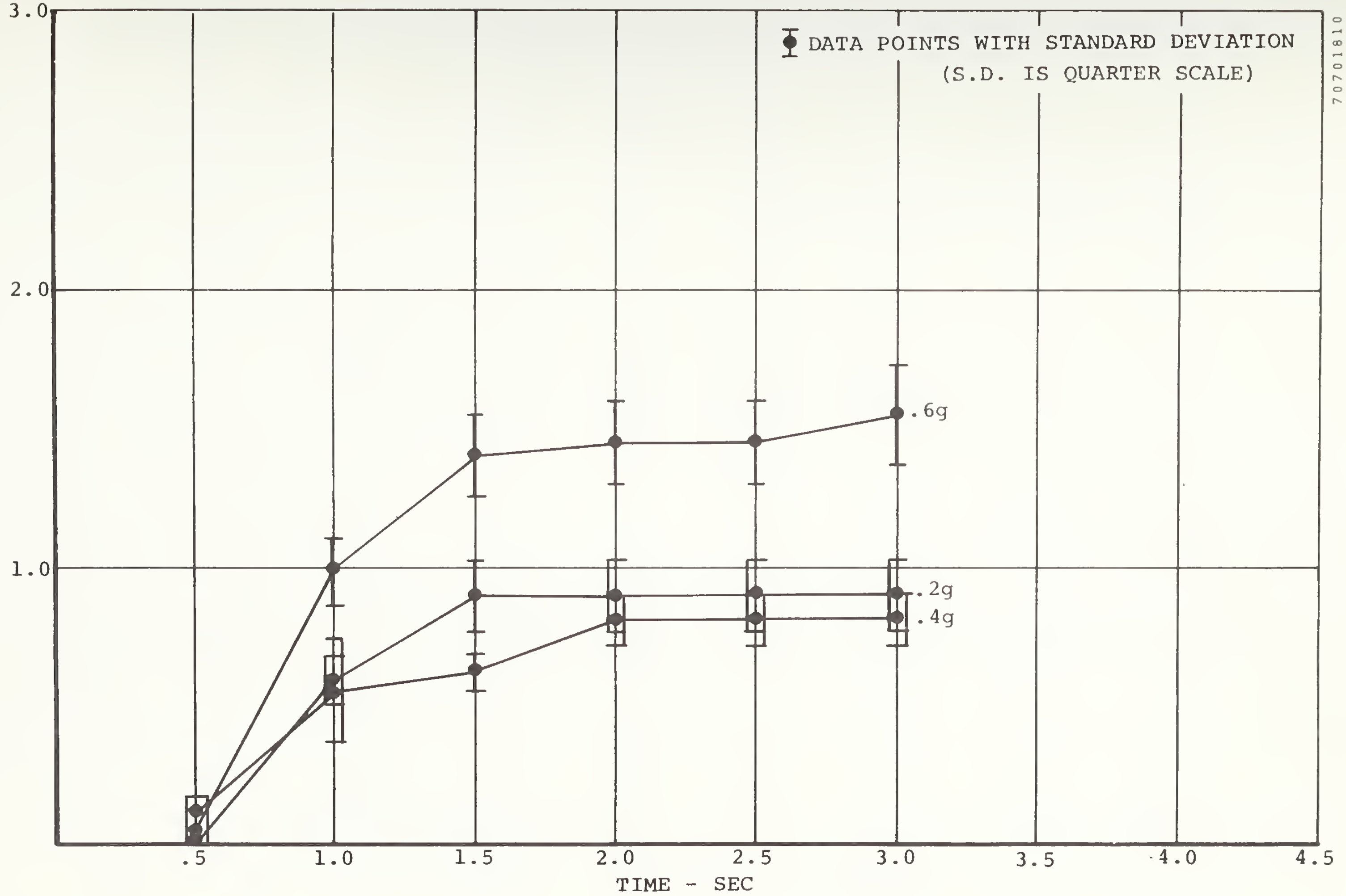


Figure C-10. ASL Dummy Thorax Rotation, Longitudinal Deceleration, Wheelchair Restrained.

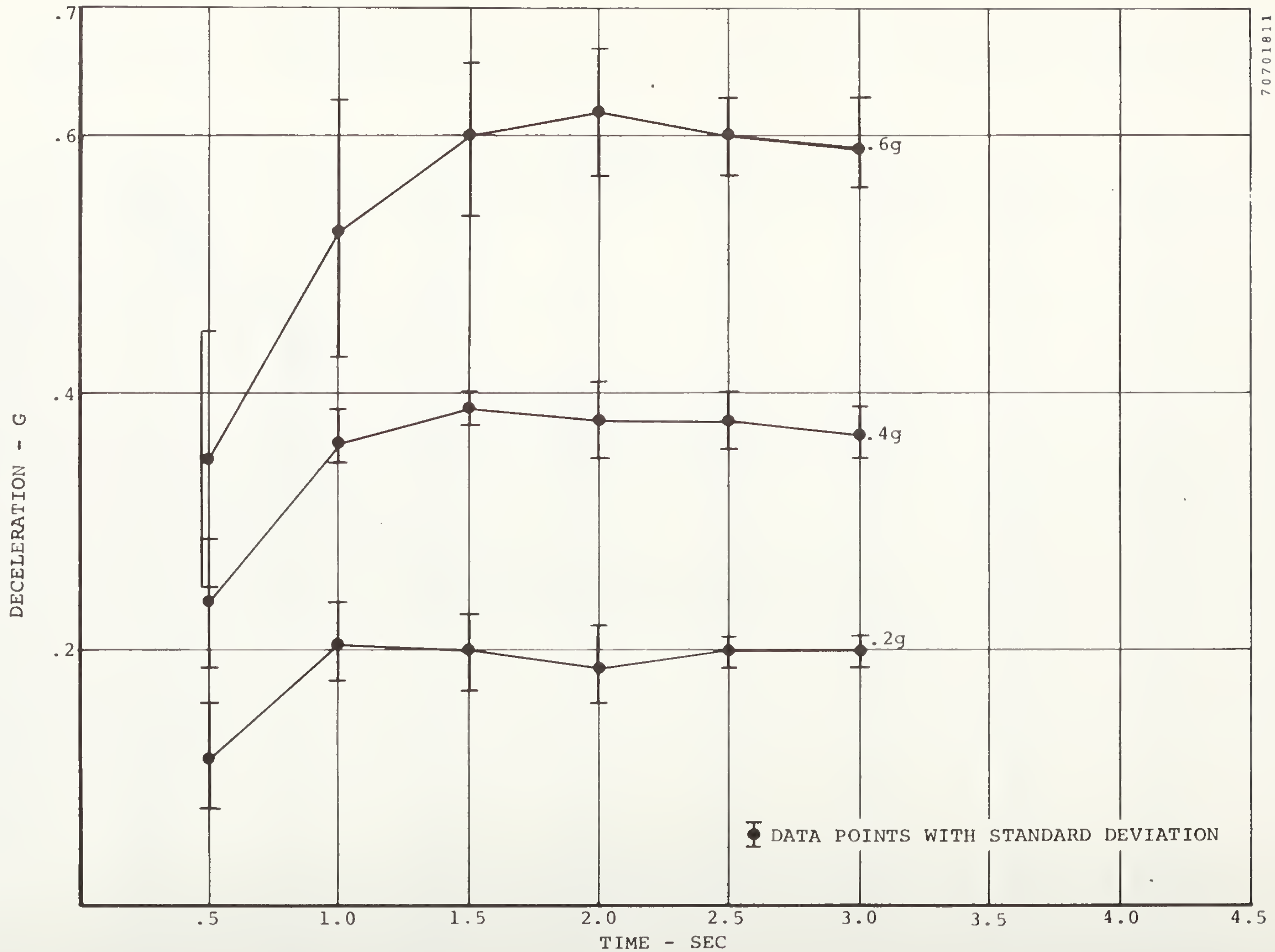


Figure C-11. Vehicle Longitudinal Deceleration, ASL Wheelchair Deceleration Tests, No Restraint.

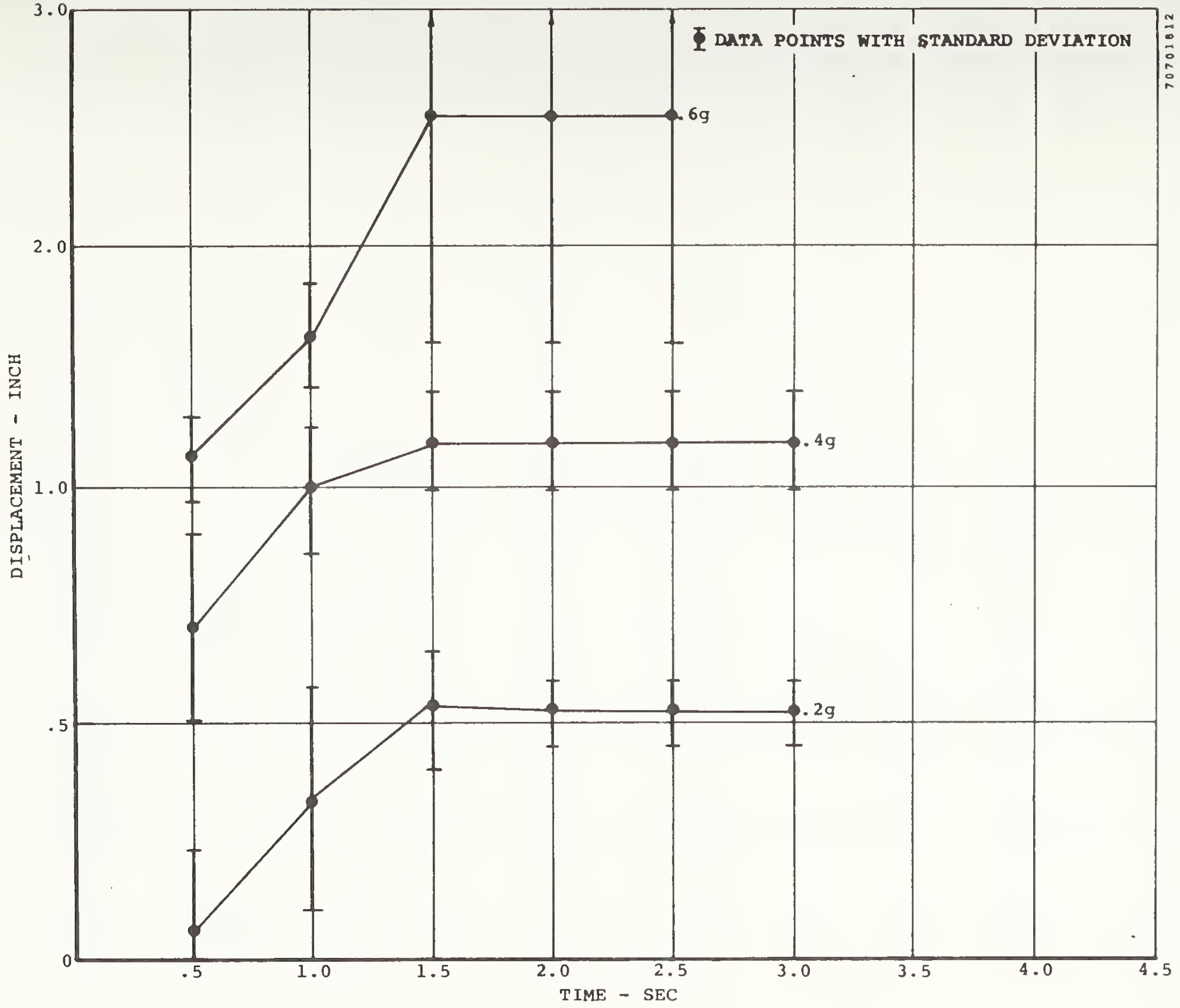


Figure C-12. ASL Dummy Head Displacement, Longitudinal Deceleration, No Restraint.

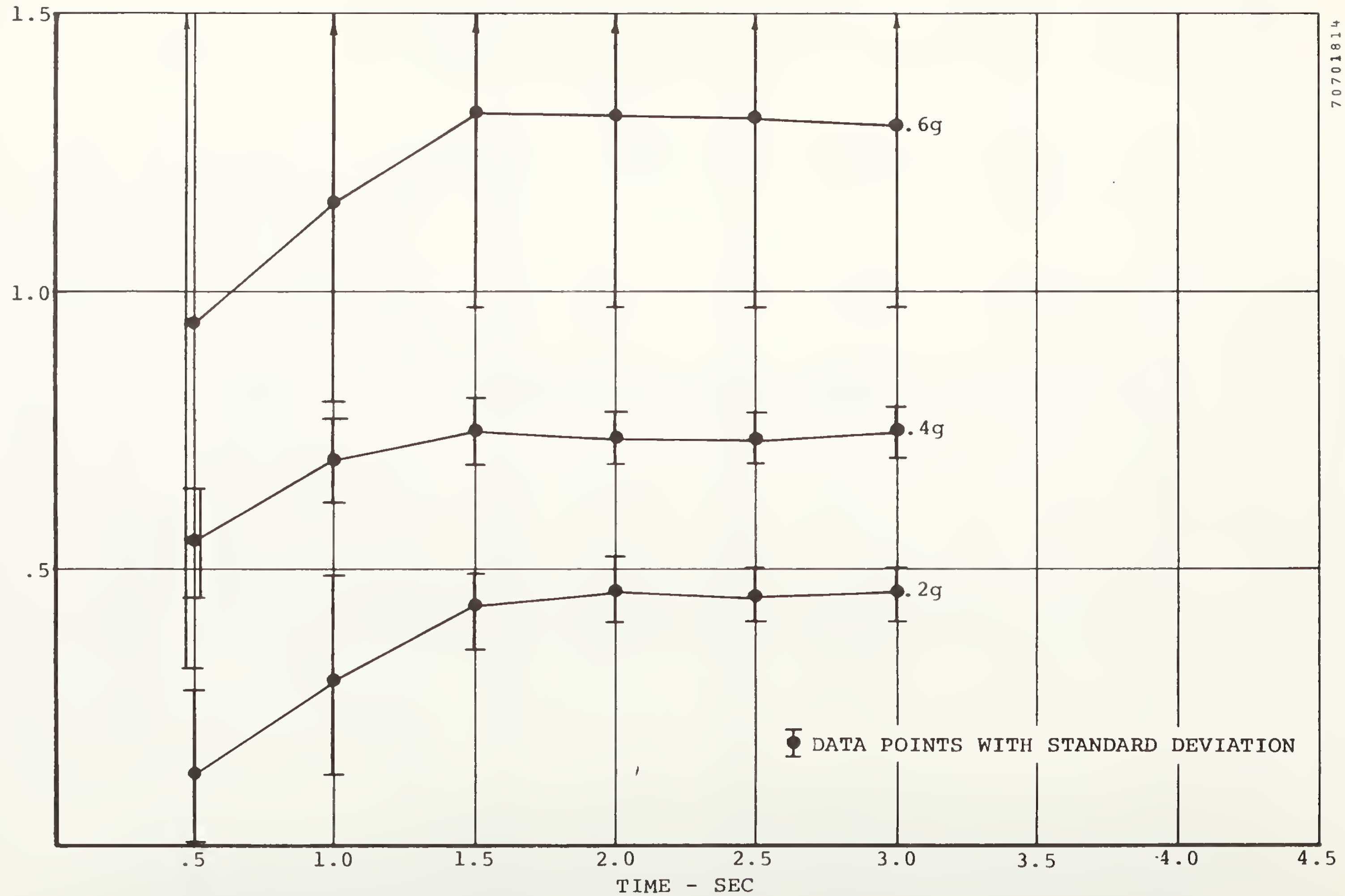


Figure C-13. ASL Dummy Thorax Displacement, Longitudinal Deceleration, No Restraint.

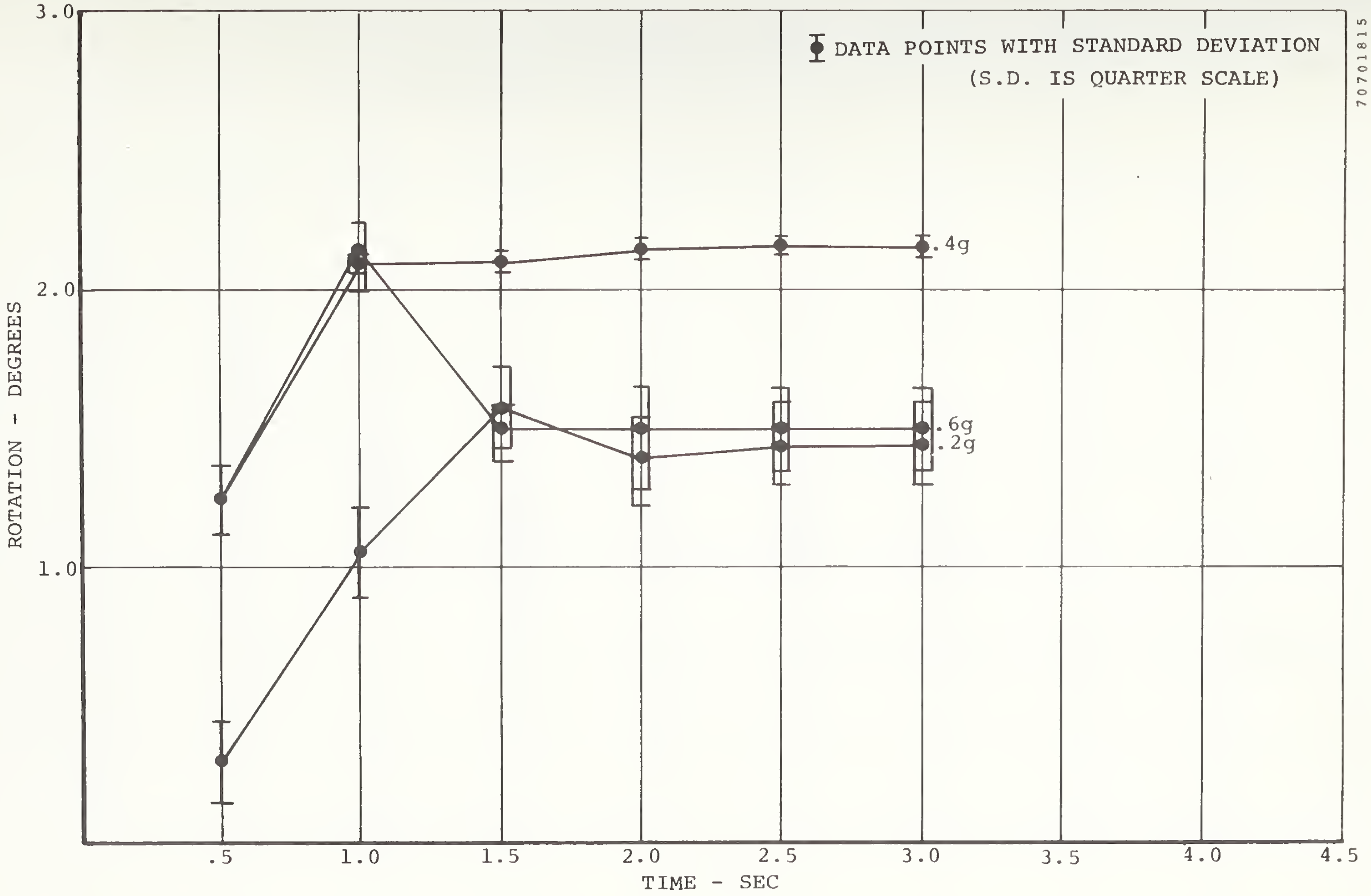


Figure C-14. ASL Dummy Head Rotation, Longitudinal Deceleration, No Restraint.

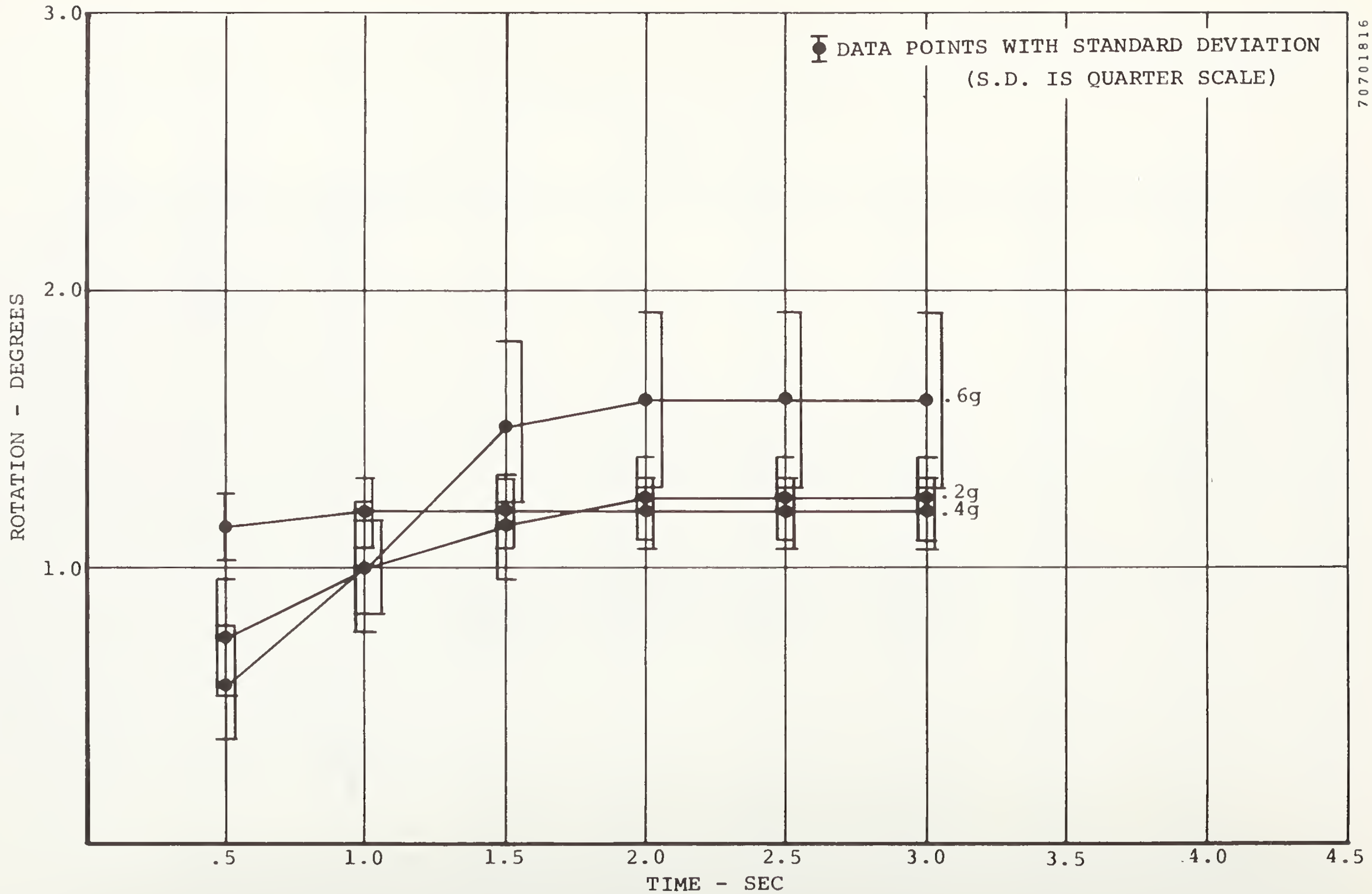


Figure C-15. ASL Dummy Thorax Rotation, Longitudinal Deceleration, No Restraint.

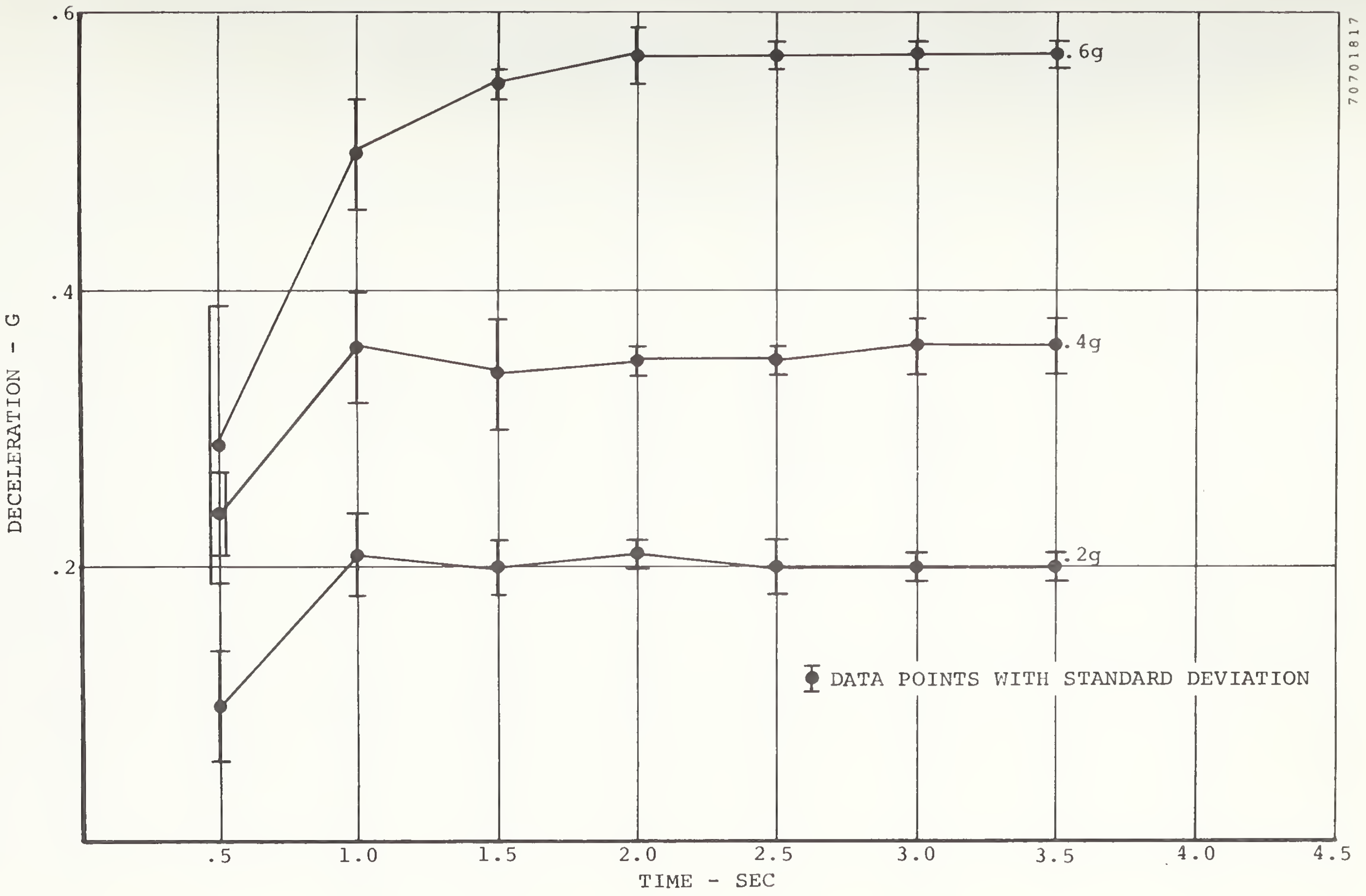


Figure C-16. Vehicle Longitudinal Deceleration, Dutcher Wheelchair Deceleration Tests, Wheelchair Restrained.

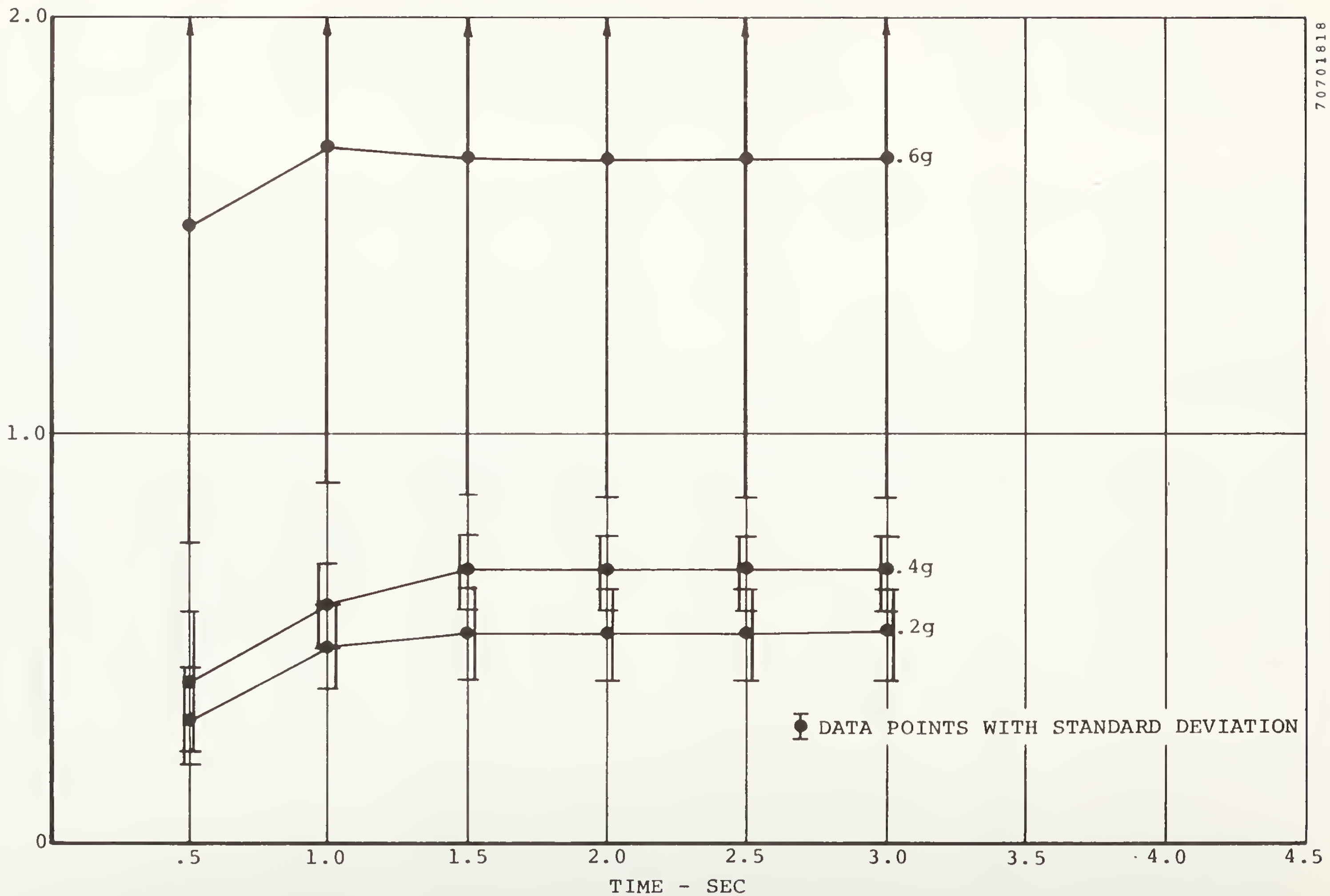


Figure C-17. Dutcher Dummy Head Displacement, Longitudinal Deceleration, Wheelchair Restrained.

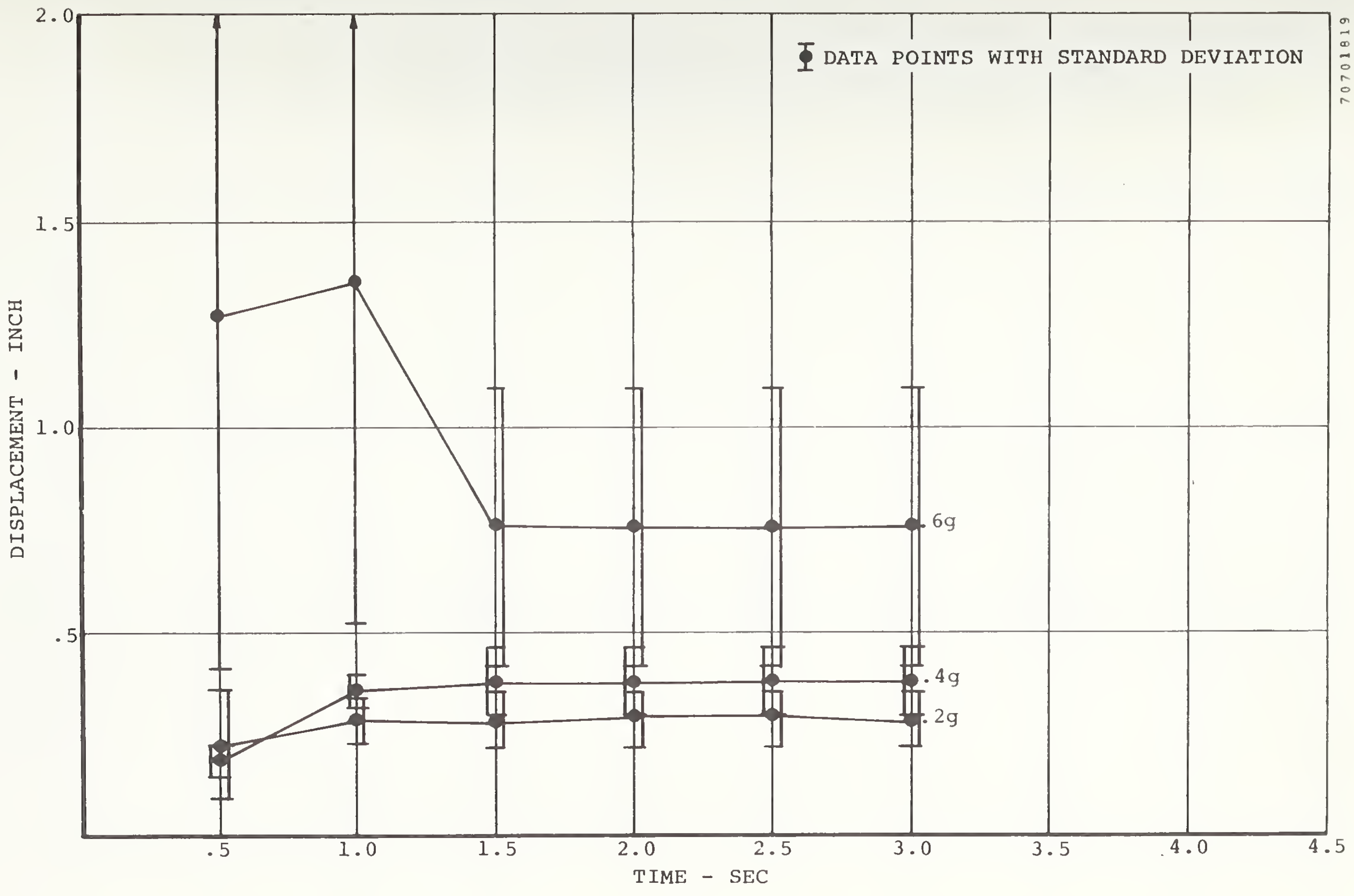


Figure C-18. Dutcher Dummy Thorax Displacement, Longitudinal Deceleration, Wheelchair Restrained.

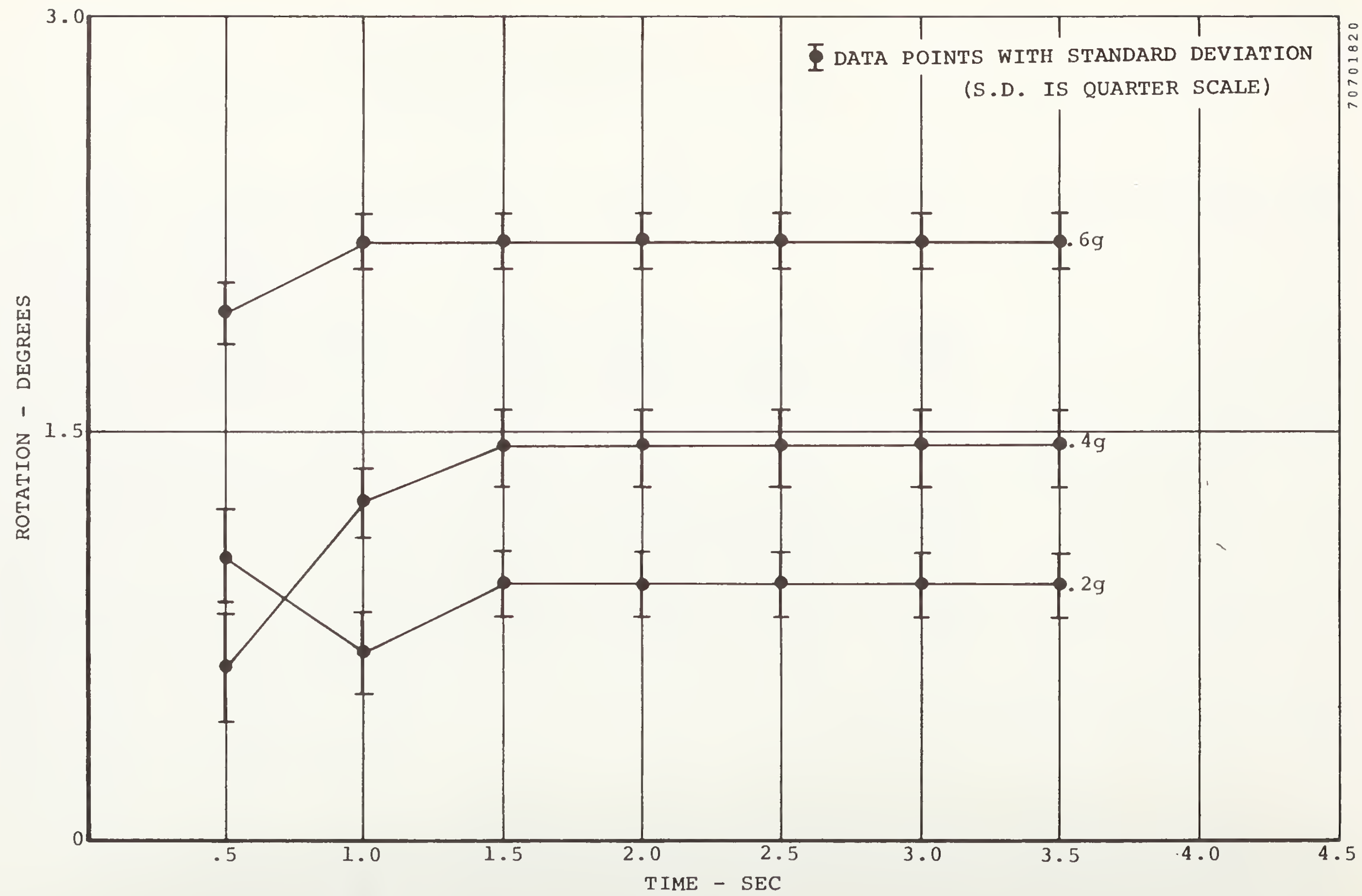


Figure C-19. Dutcher Dummy Head Rotation, Longitudinal Deceleration, Wheelchair Restrained.

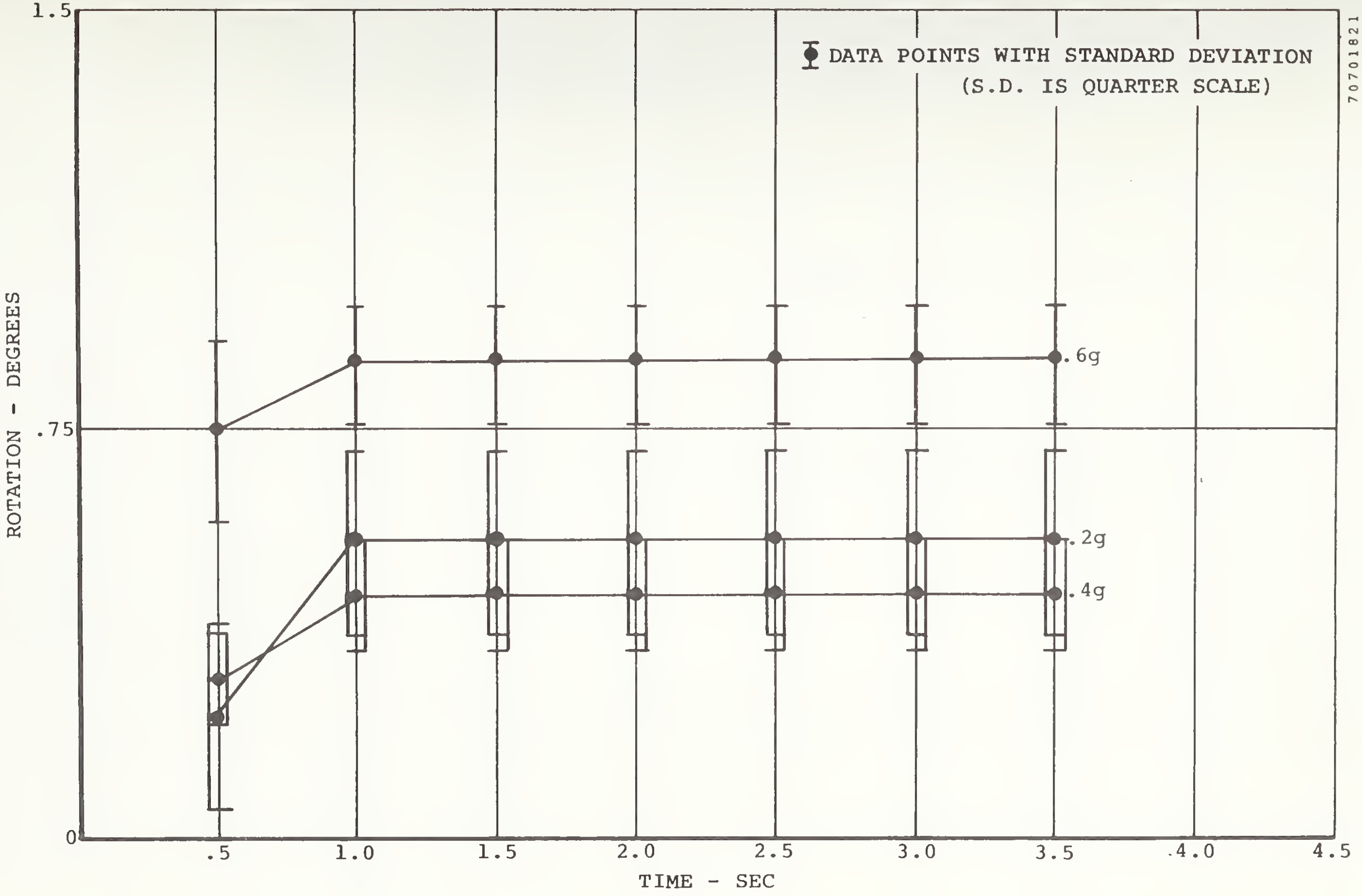


Figure C-20. Dutcher Dummy Thorax Rotation, Longitudinal Deceleration, Wheelchair Restrained.

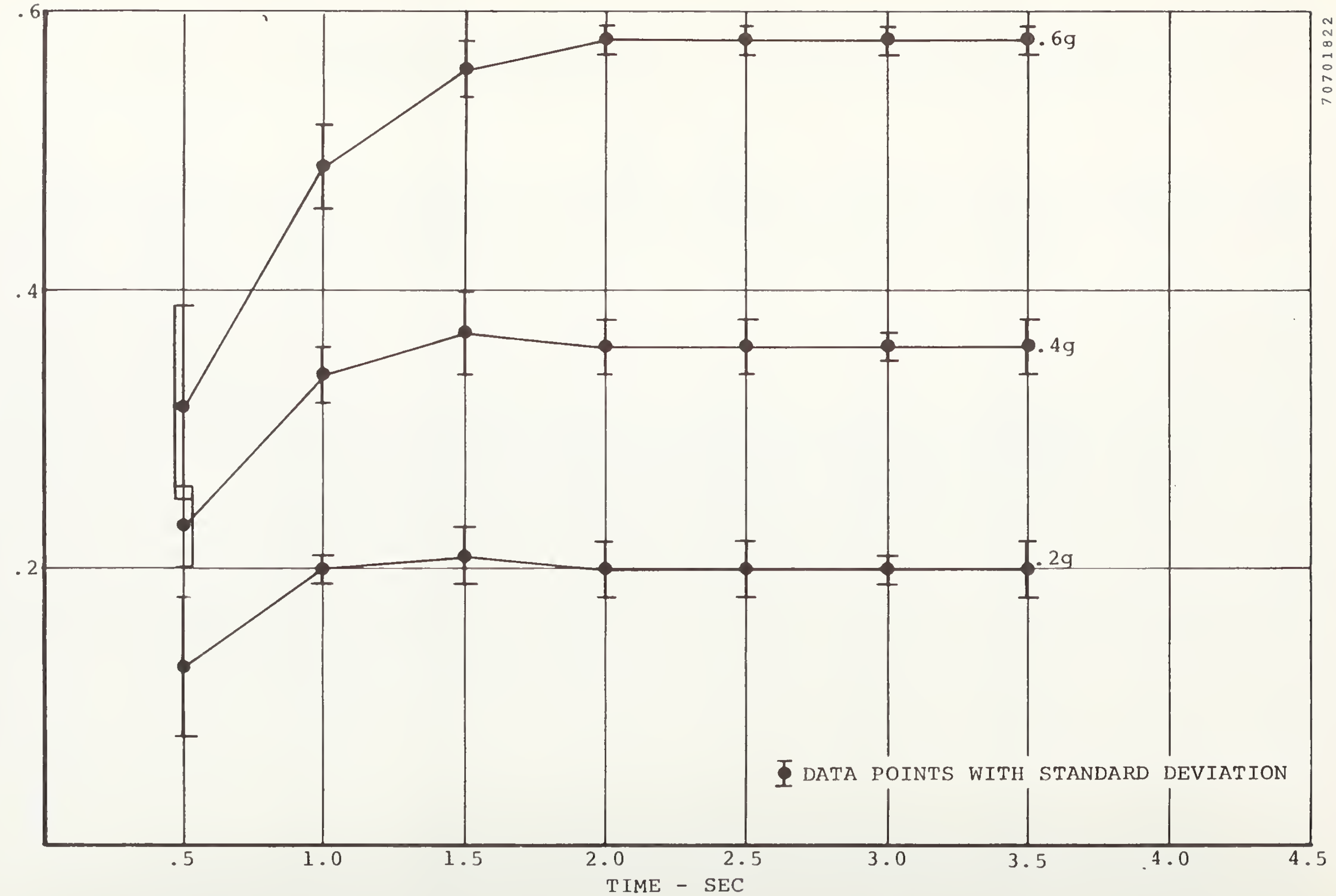


Figure C-21. Vehicle Longitudinal Deceleration, Dutcher Wheelchair Deceleration Tests, No Restraint.

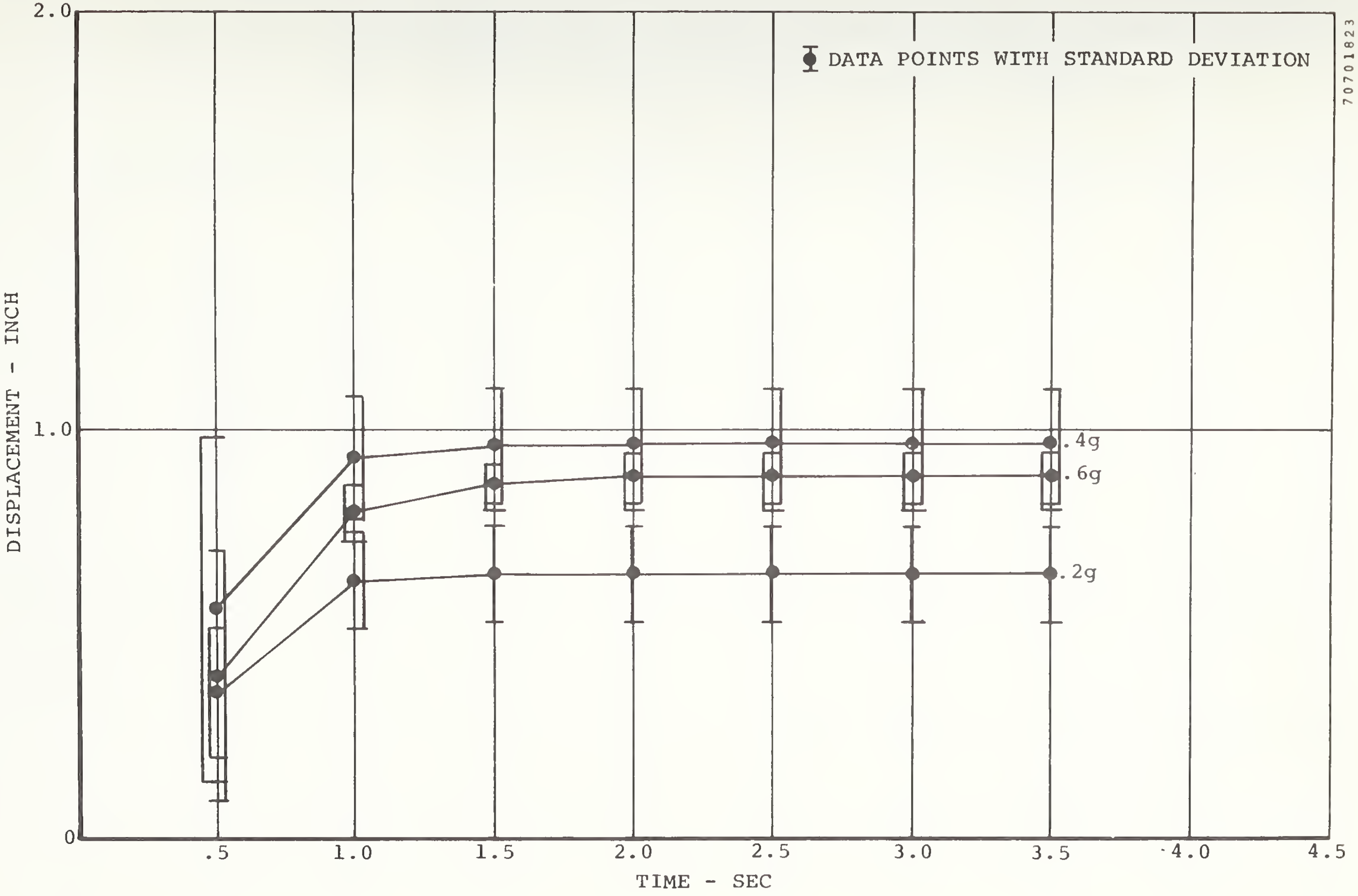


Figure C-22. Dutcher Dummy Head Displacement, Longitudinal Deceleration, No Restraint.

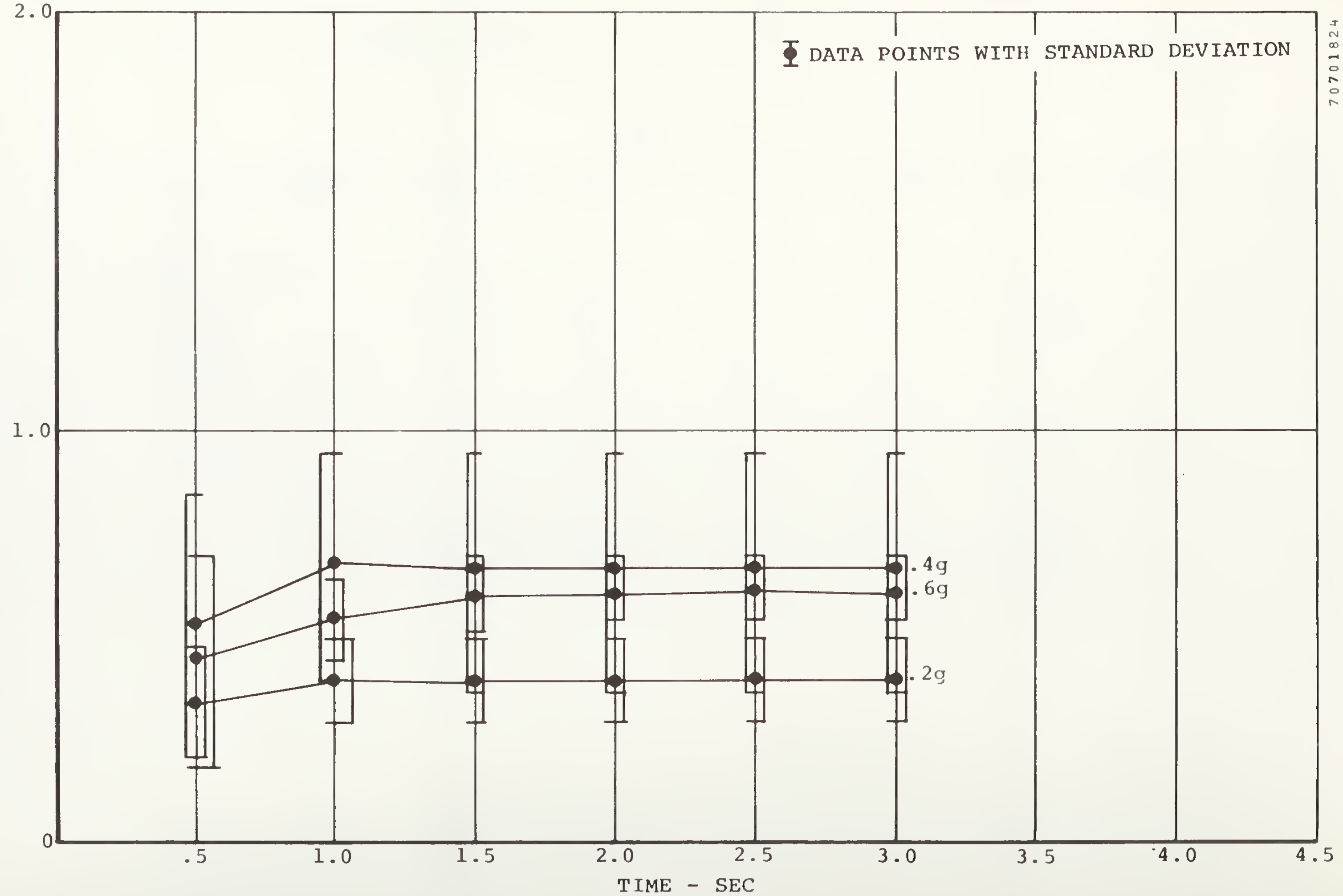


Figure C-23. Dutcher Dummy Thorax Displacement, Longitudinal Deceleration, No Restraint.

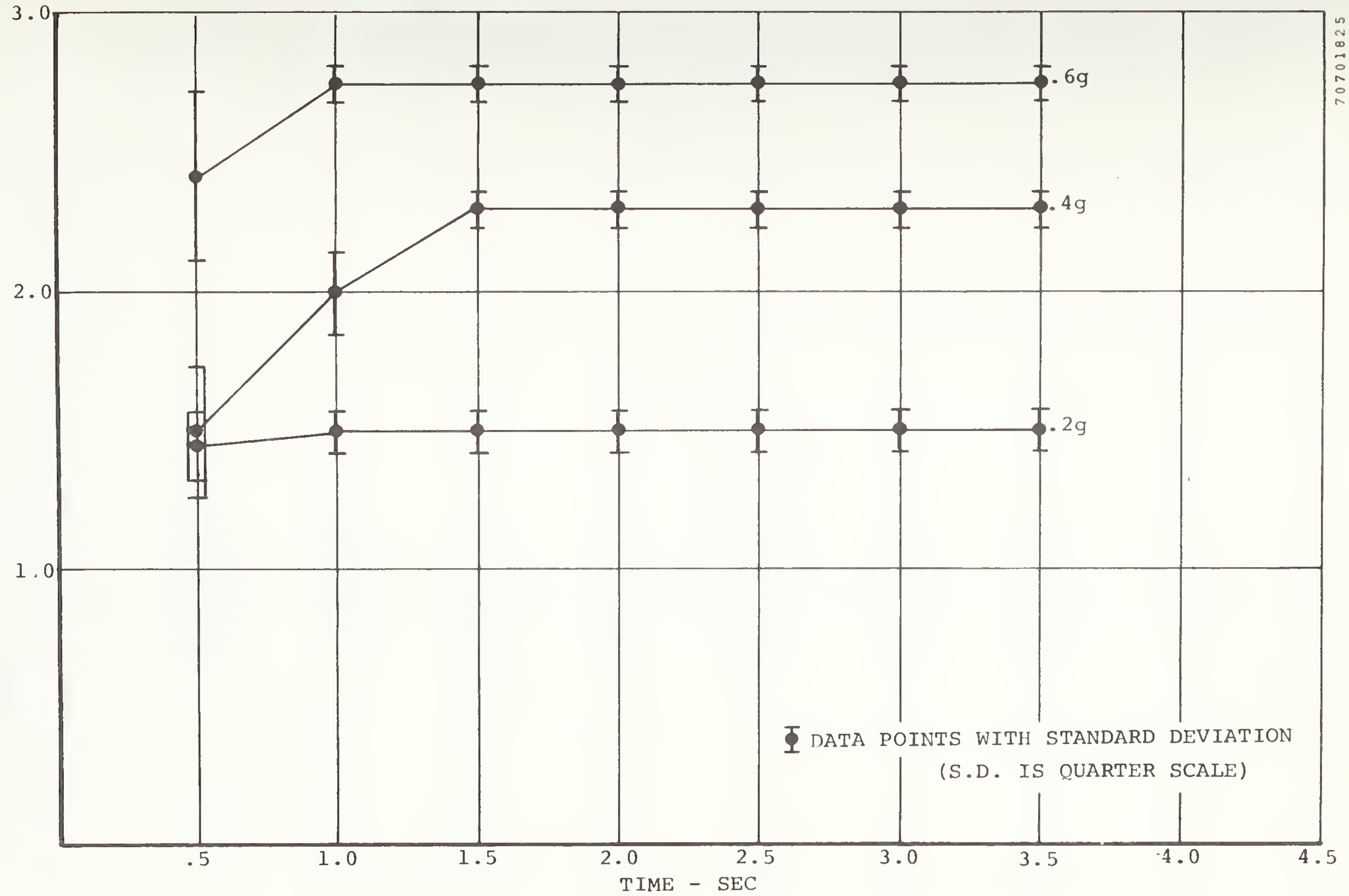


Figure C-24. Dutcher Dummy Head Rotation, Longitudinal Deceleration, No Restraint.

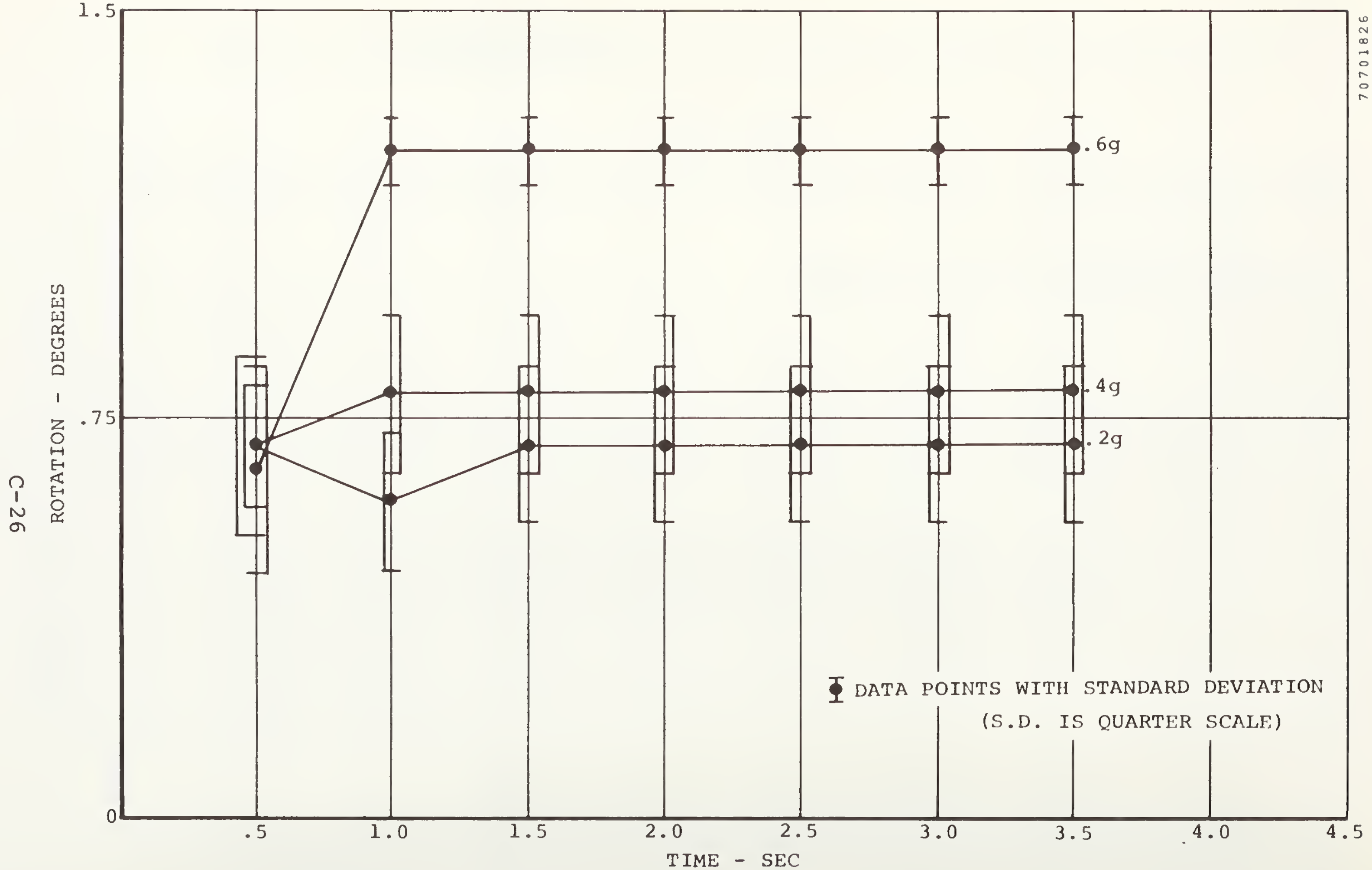


Figure C-25. Dutcher Dummy Thorax Rotation, Longitudinal Deceleration, No Restraint.

APPENDIX D

DUMMY MOTIONS VERSUS TIME
FOR WHEELCHAIR LATERAL
ACCELERATION TESTS

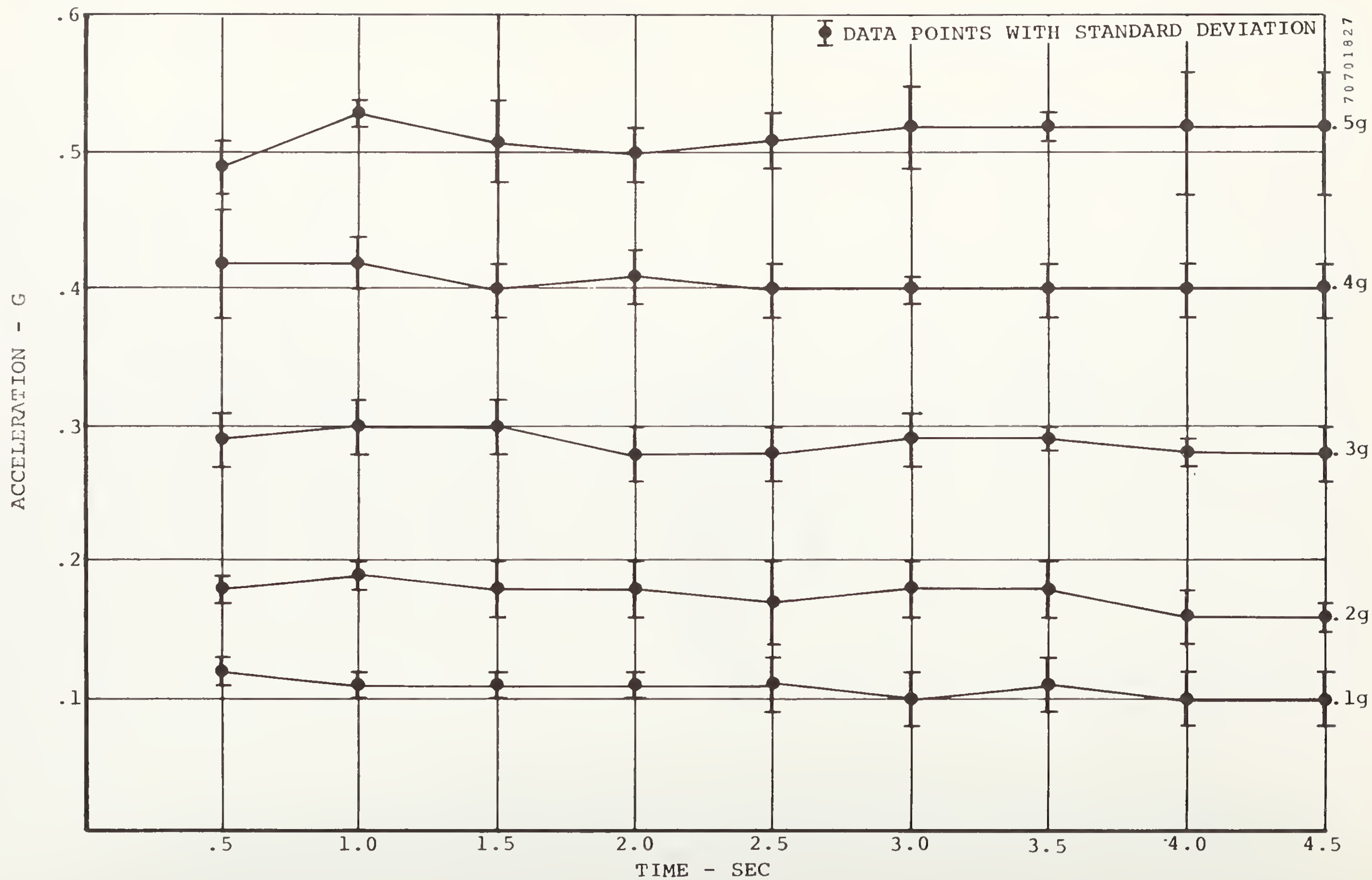


Figure D-1. Vehicle Lateral Acceleration, ASL Wheelchair Acceleration Tests, Wheelchair and Dummy Restrained.

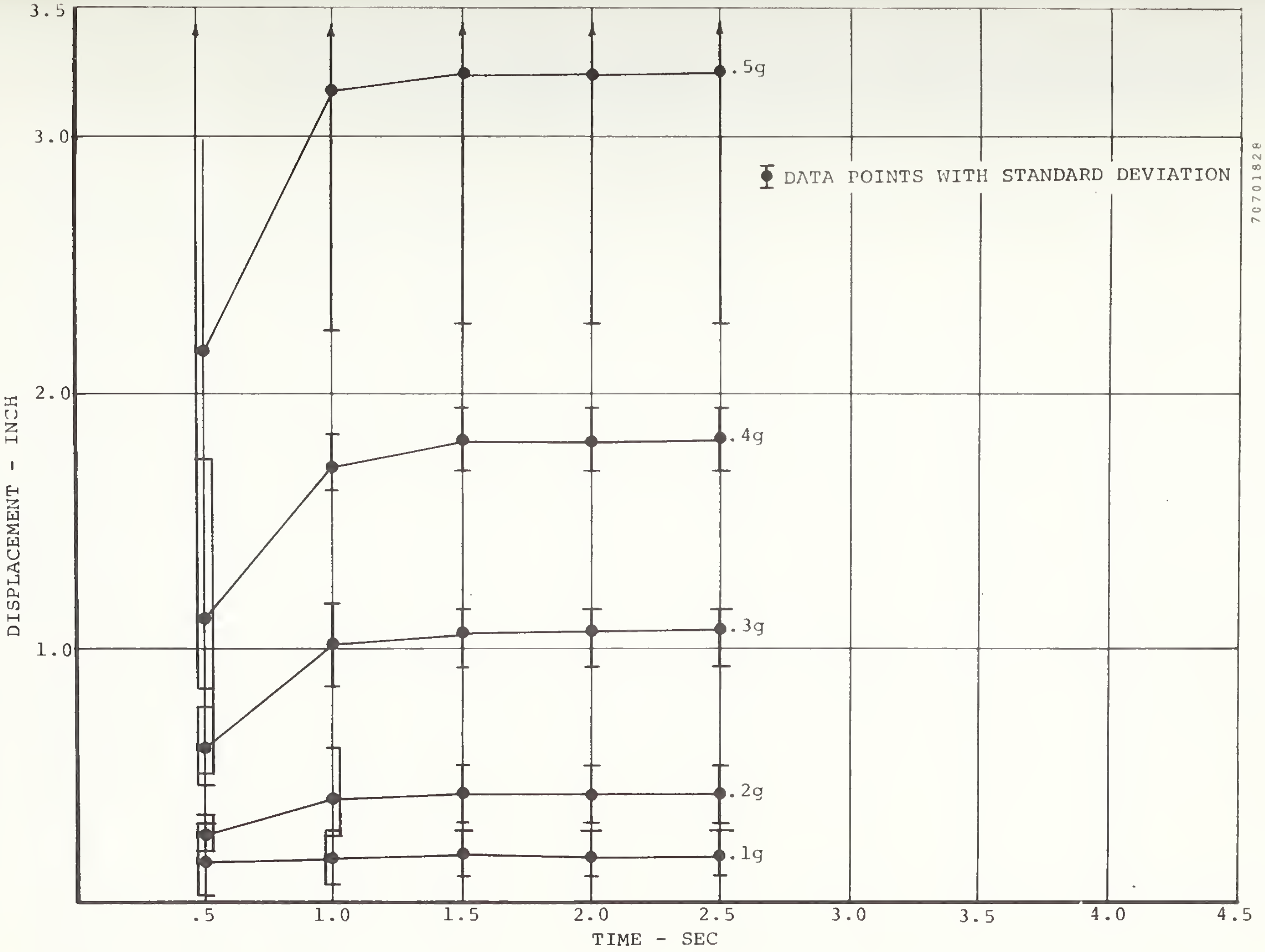


Figure D-2. ASL Dummy Head Displacement, Lateral Acceleration, Wheelchair and Dummy Restrained.

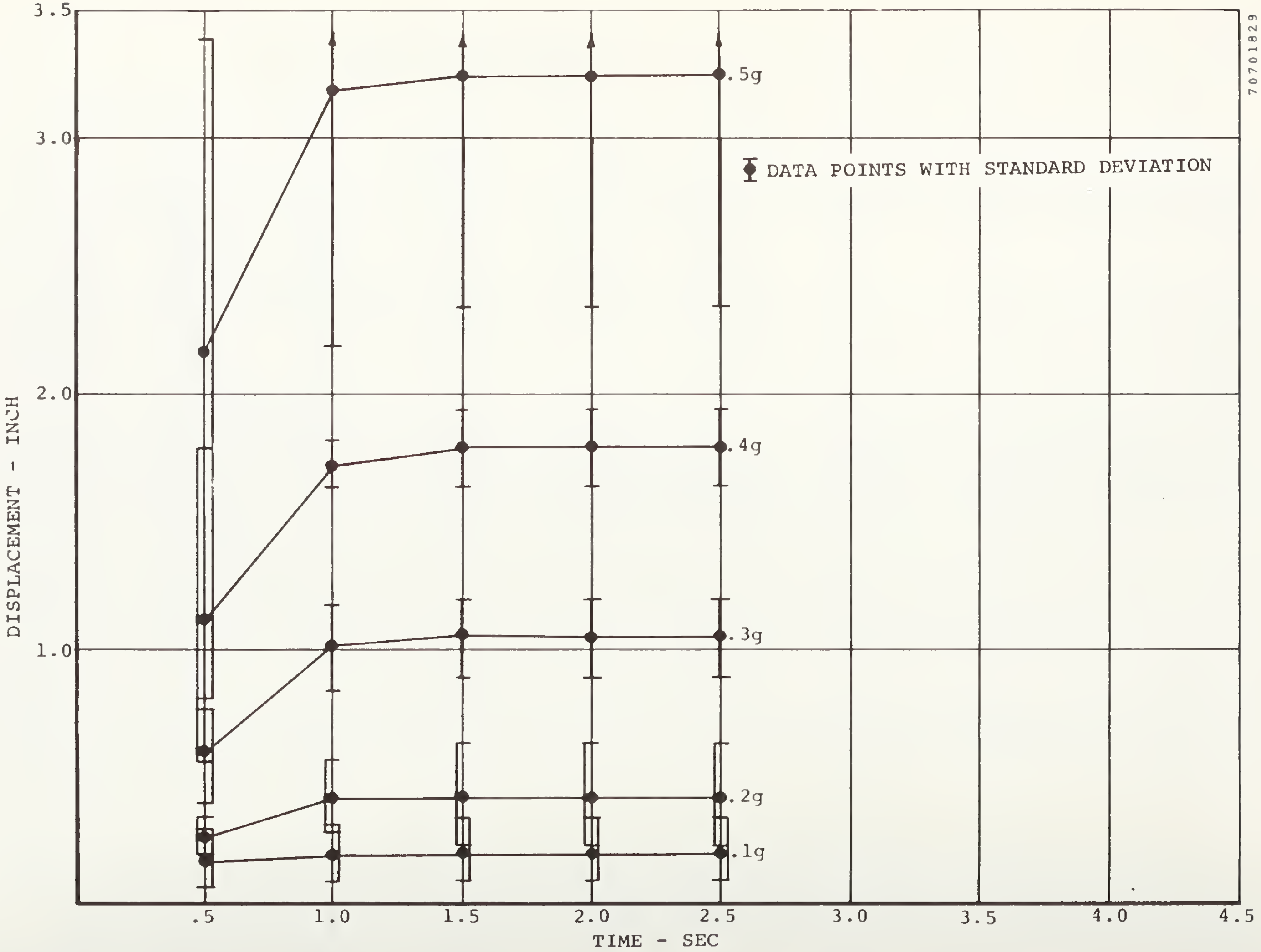


Figure D-3. ASL Dummy Thorax Displacement, Lateral Acceleration, Wheelchair and Dummy Restrained.

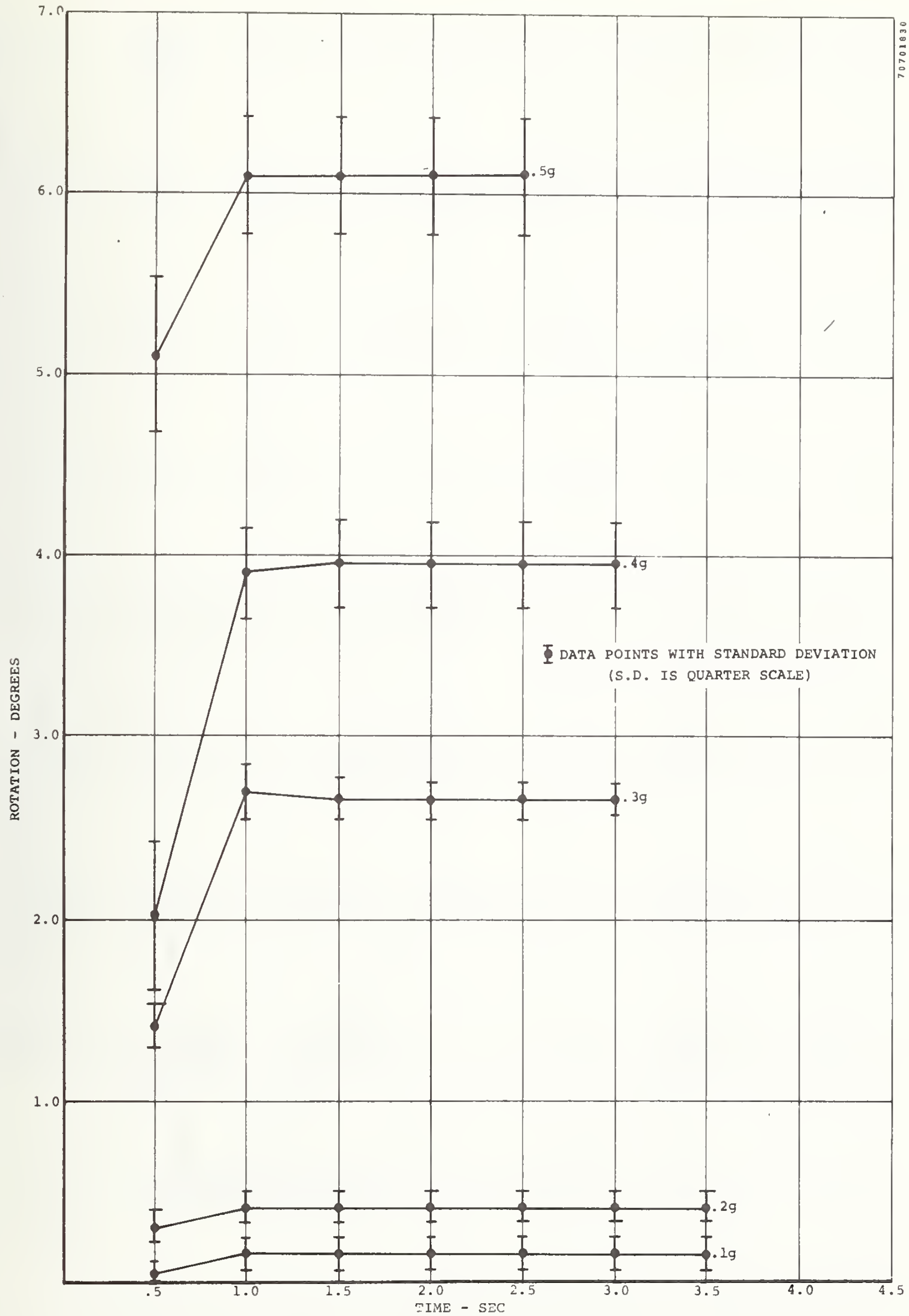


Figure D-4. ASL Dummy Head Rotation, Lateral Acceleration, Wheelchair and Dummy Restrained.

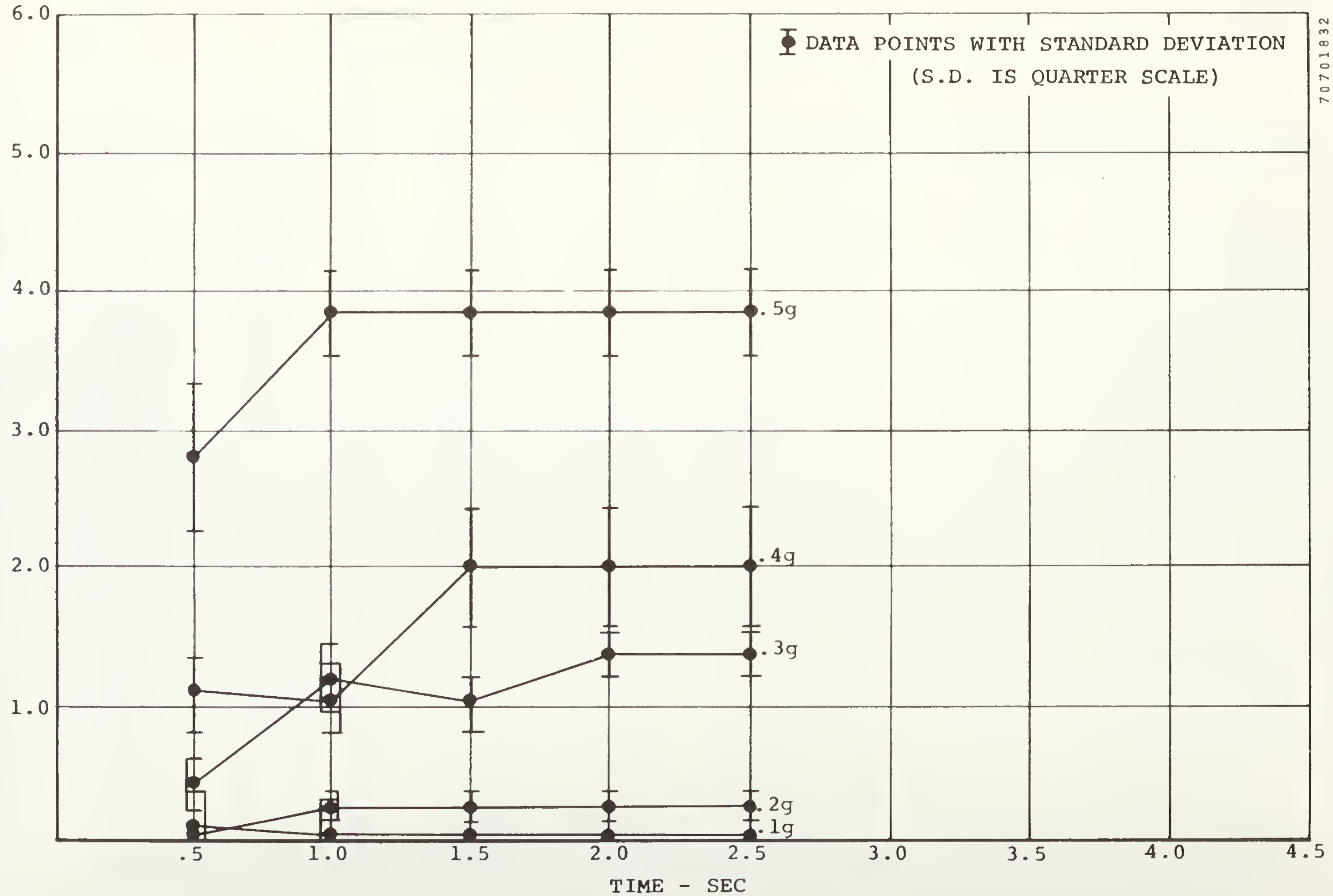


Figure D-5. ASL Dummy Thorax Rotation, Lateral Acceleration, Wheelchair and Dummy Restrained.

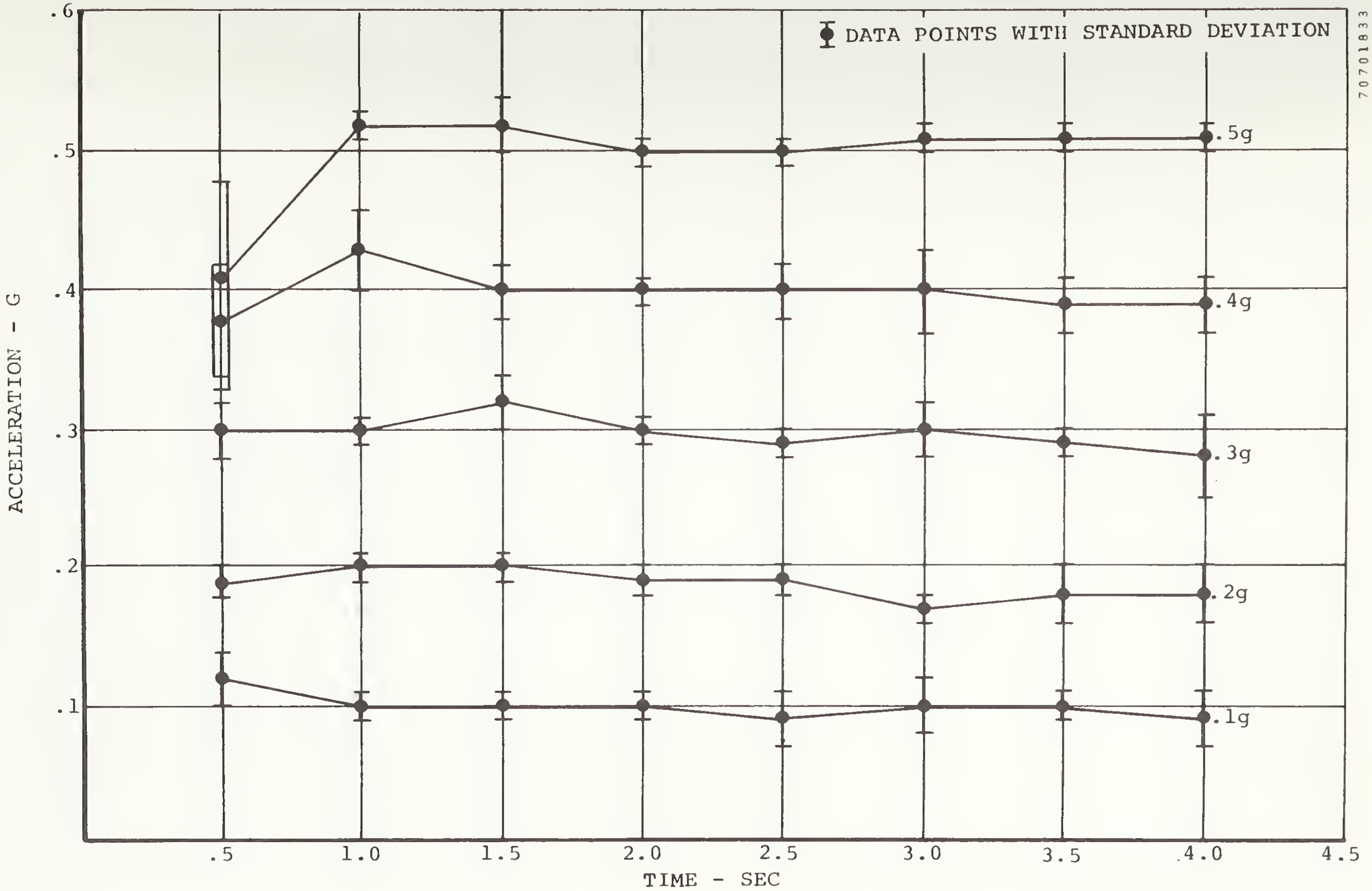


Figure D-6. Vehicle Lateral Acceleration, ASL Wheelchair Acceleration Tests, Wheelchair Restrained.

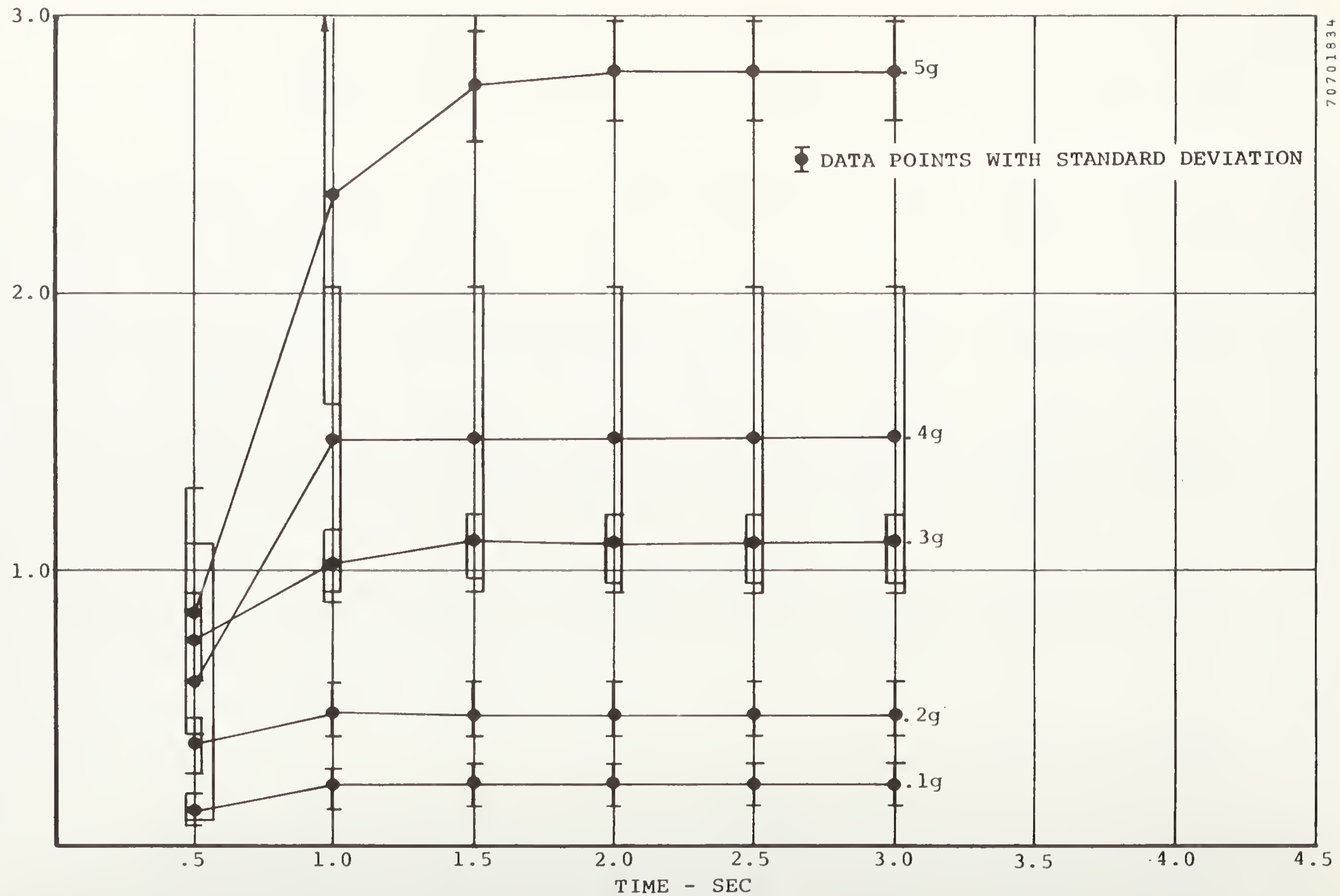


Figure D-7. ASL Dummy Head Displacement, Lateral Acceleration, Wheelchair Restrained.

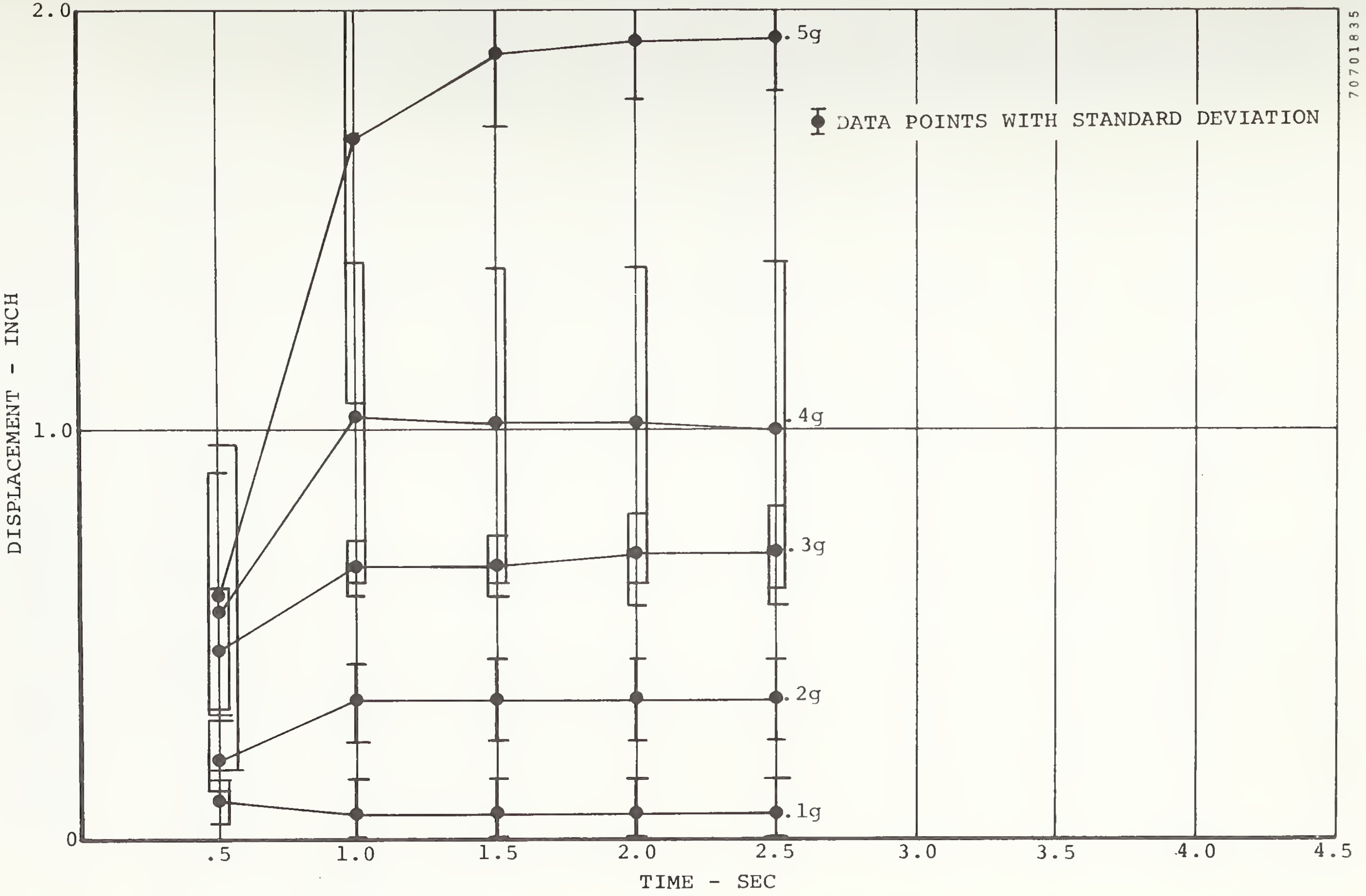


Figure D-8. ASL Dummy Thorax Displacement, Lateral Acceleration, Wheelchair Restrained.

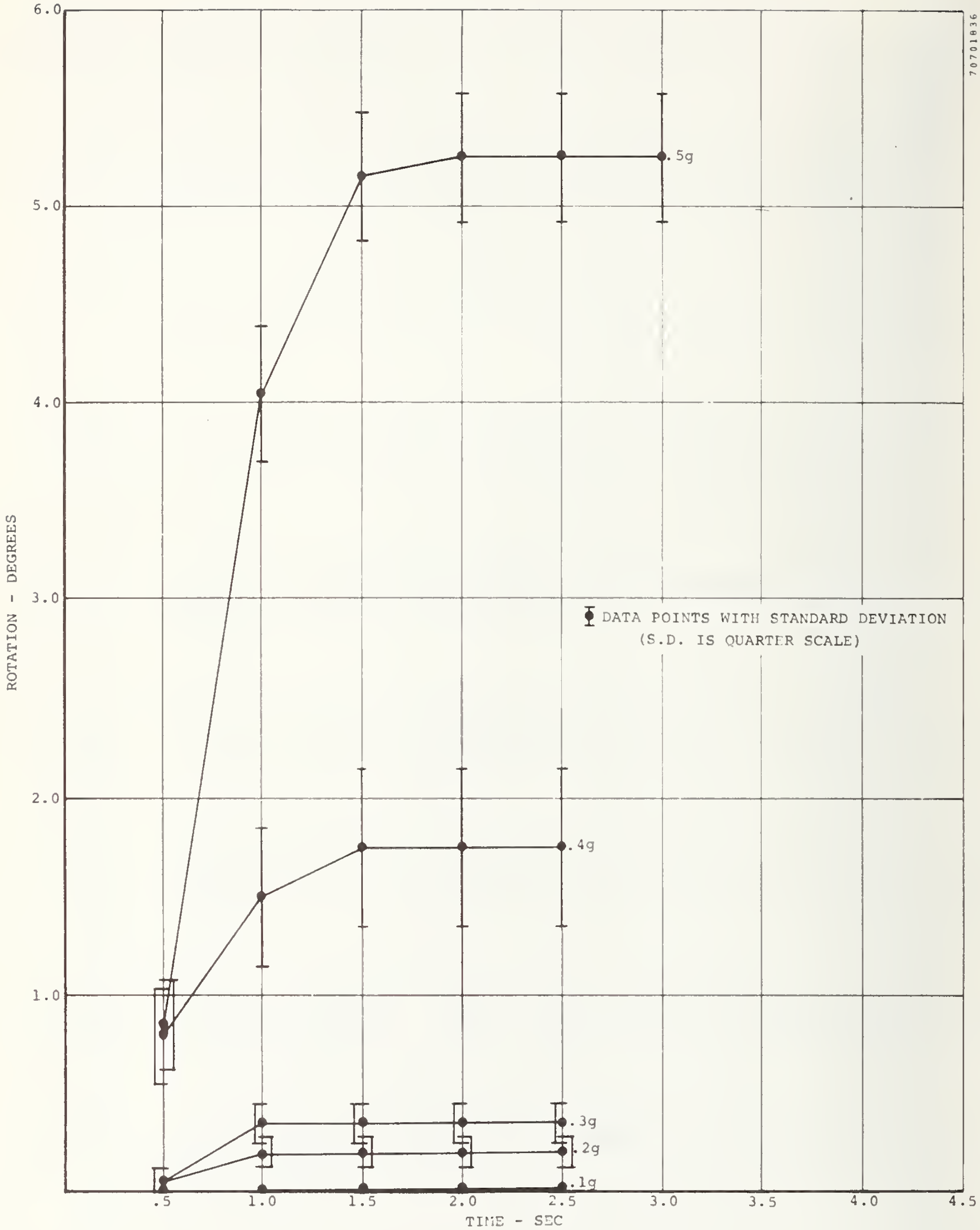


Figure D-9. ASL Dummy Head Rotation, Lateral Acceleration, Wheelchair Restrained.

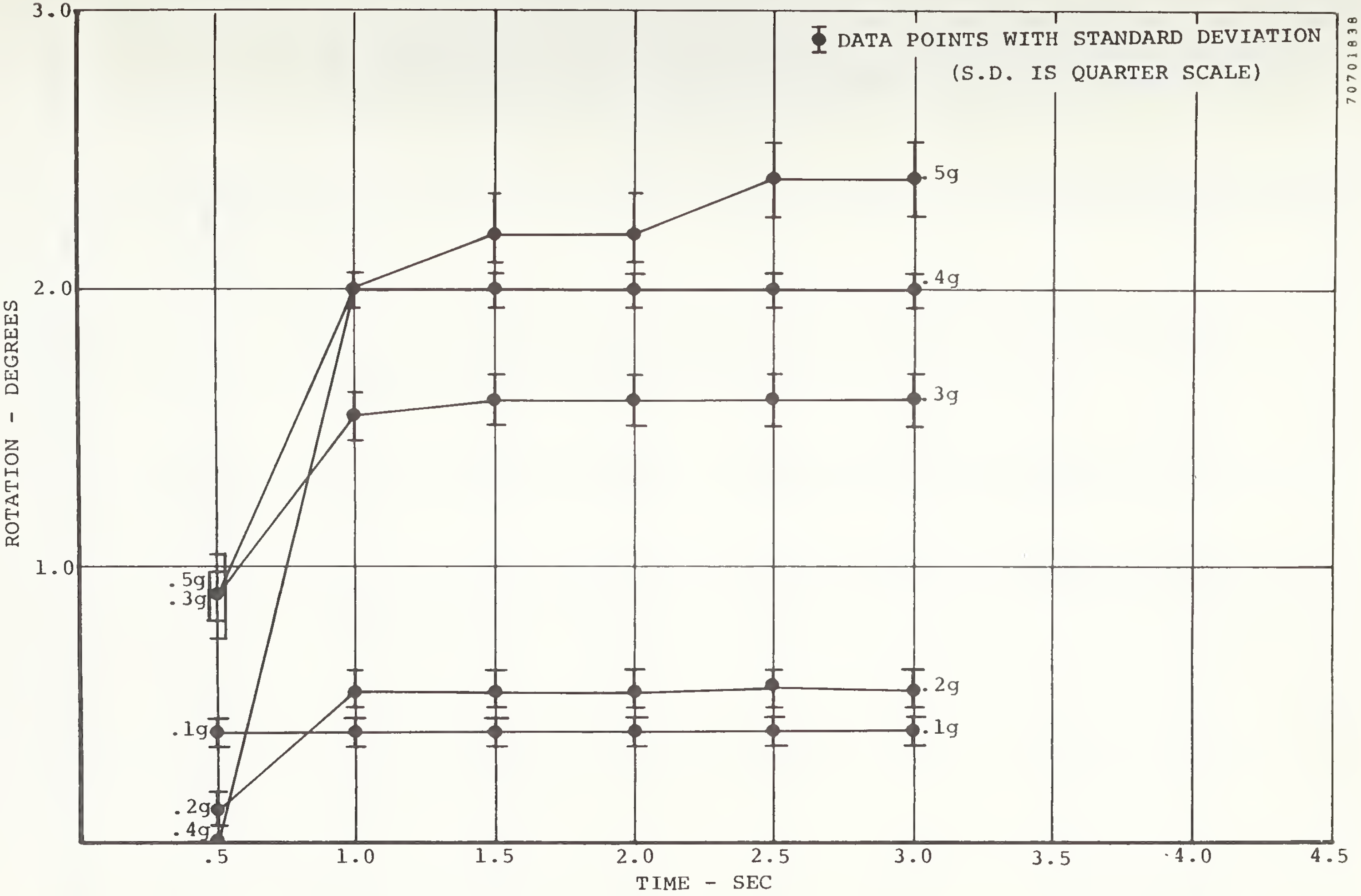


Figure D-10. ASL Dummy Thorax Rotation, Lateral Acceleration Tests, Wheelchair Restrained.

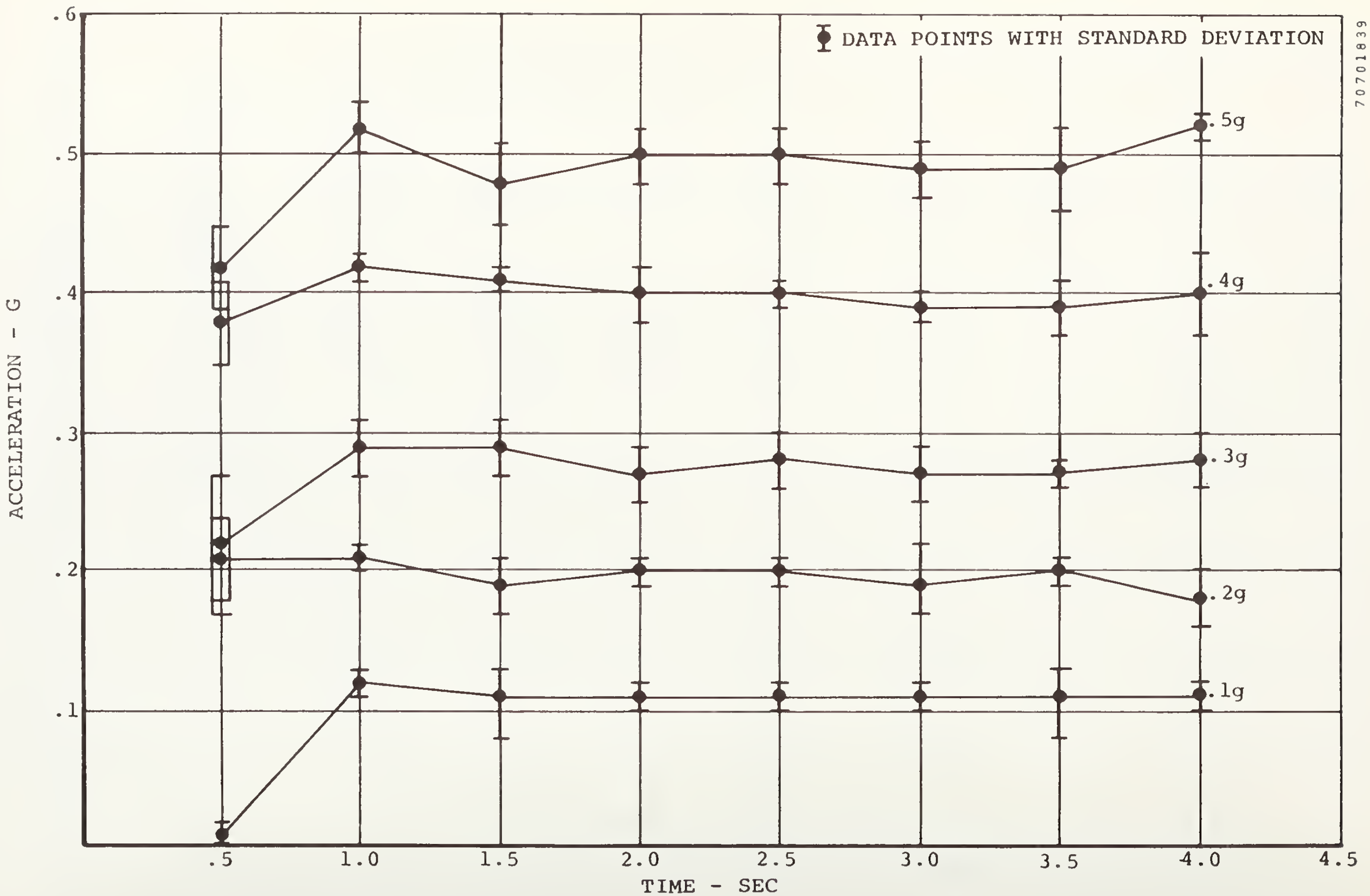


Figure D-11. Vehicle Lateral Acceleration, ASL Wheelchair Acceleration Tests, No Restraint.

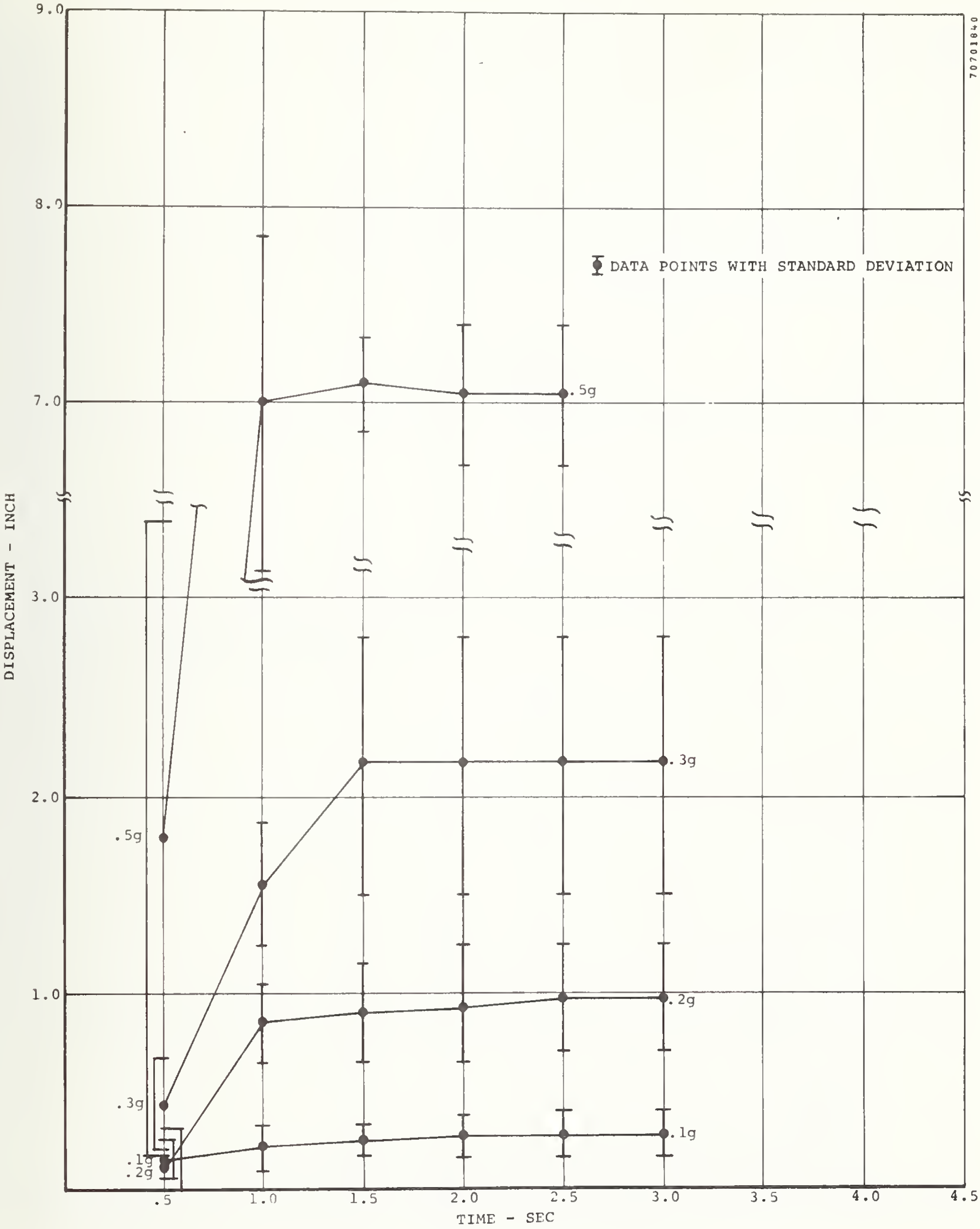


Figure D-12. ASL Dummy Head Displacement, Lateral Acceleration, No Restraint.

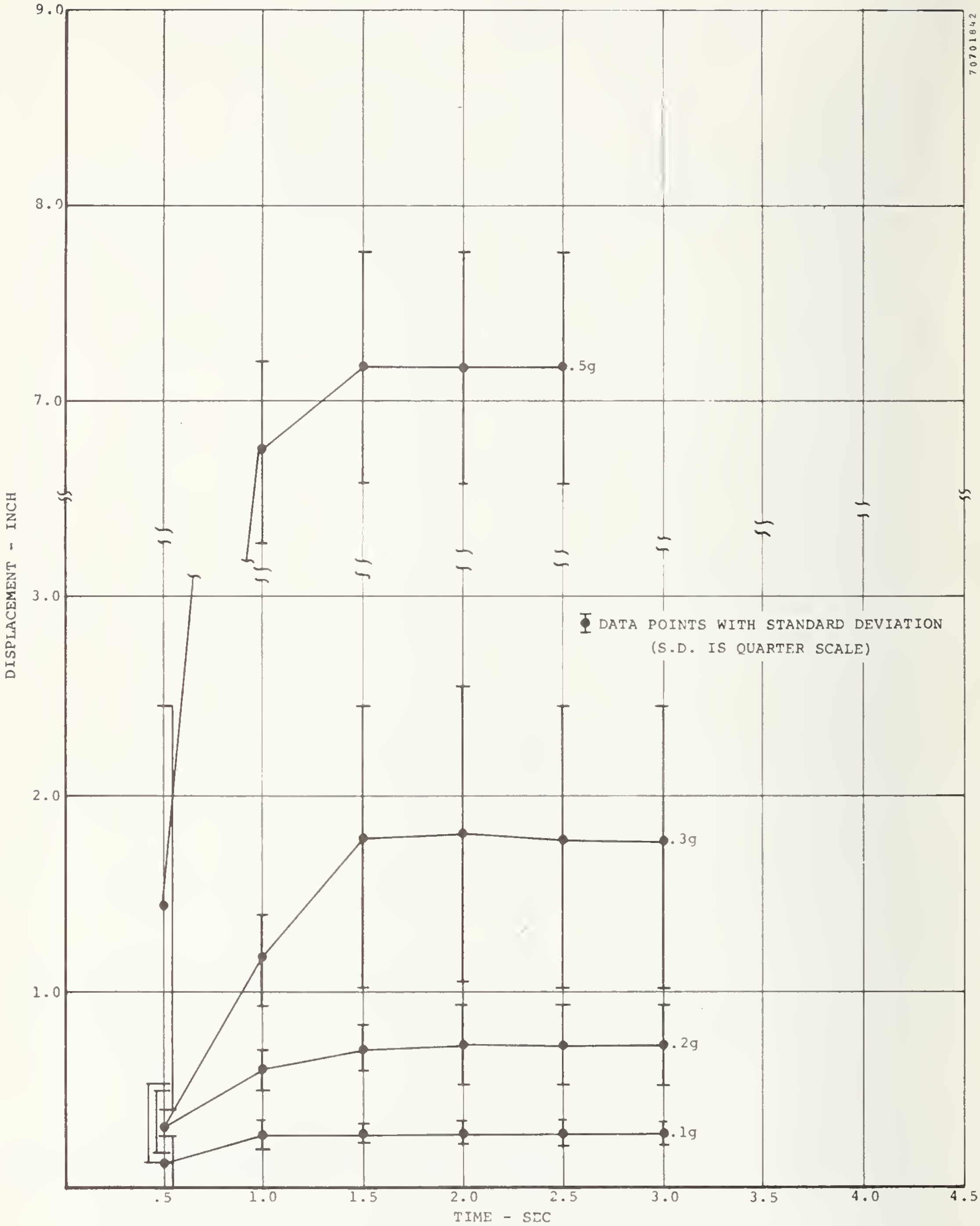


Figure D-13. ASL Dummy Thorax Displacement, Lateral Acceleration, No Restraint.

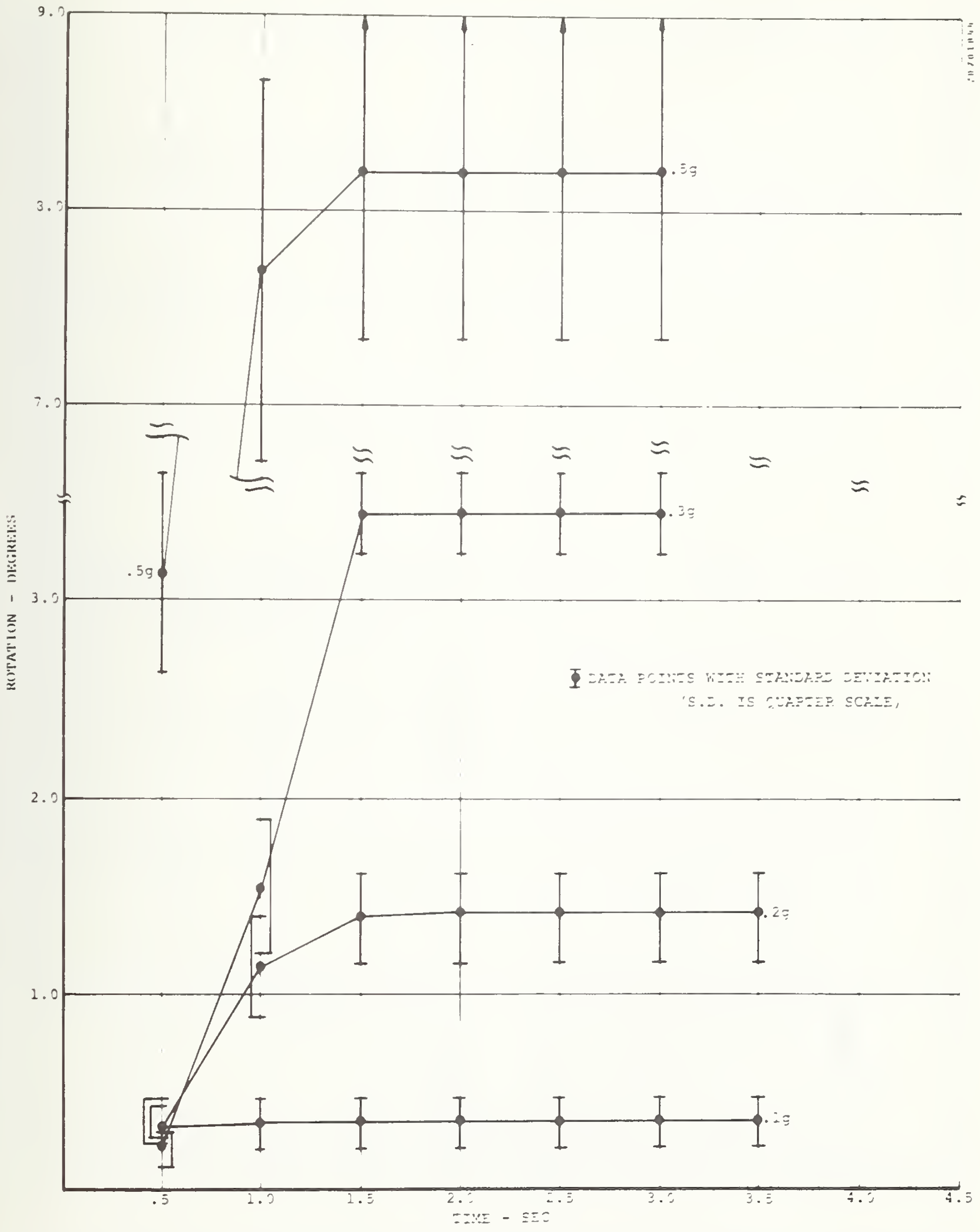


Figure D-14. ASL Dummy Head Rotation, Lateral Acceleration, No Restraint.

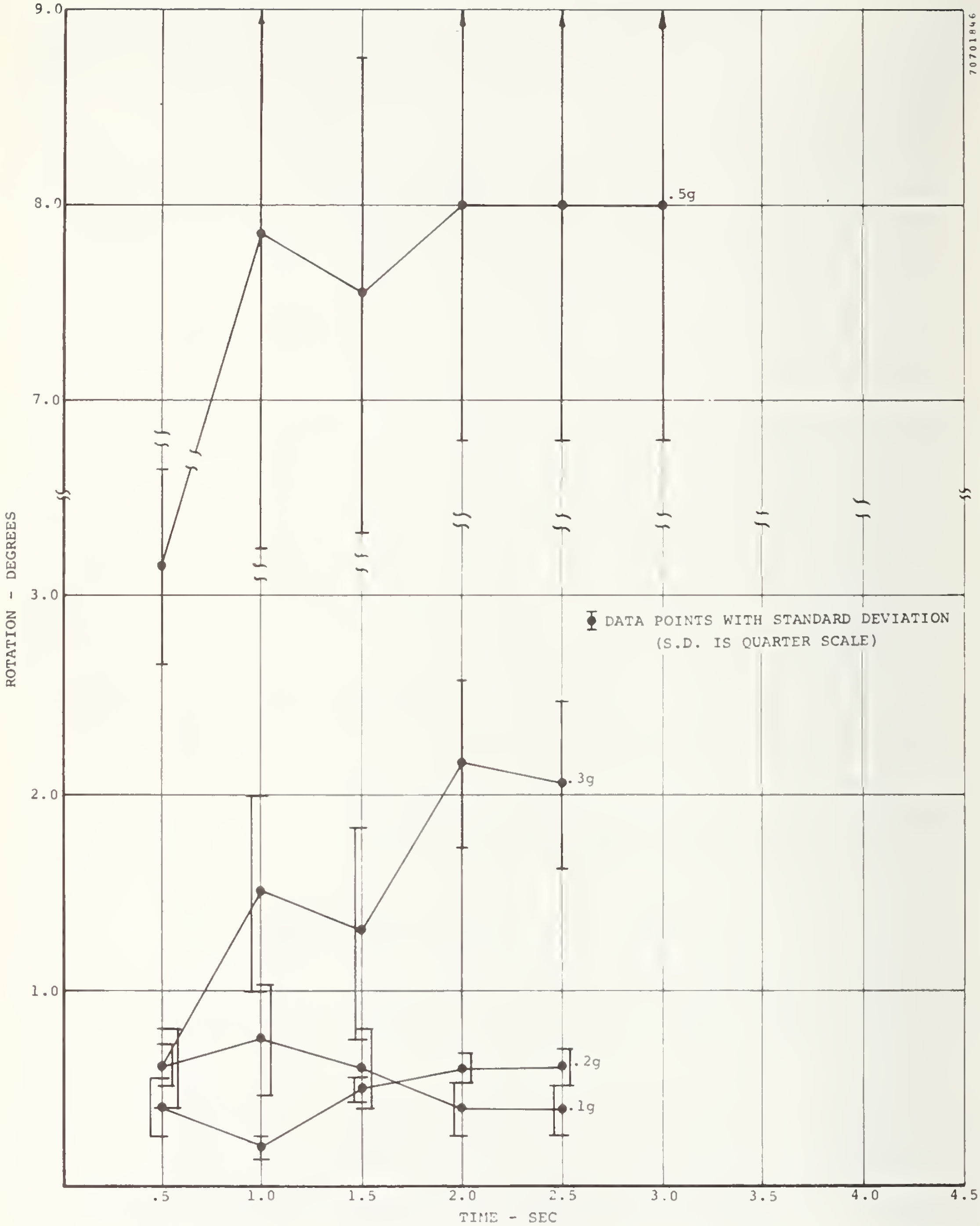


Figure D-15. ASL Dummy Thorax Rotation, Lateral Acceleration, No Restraint.

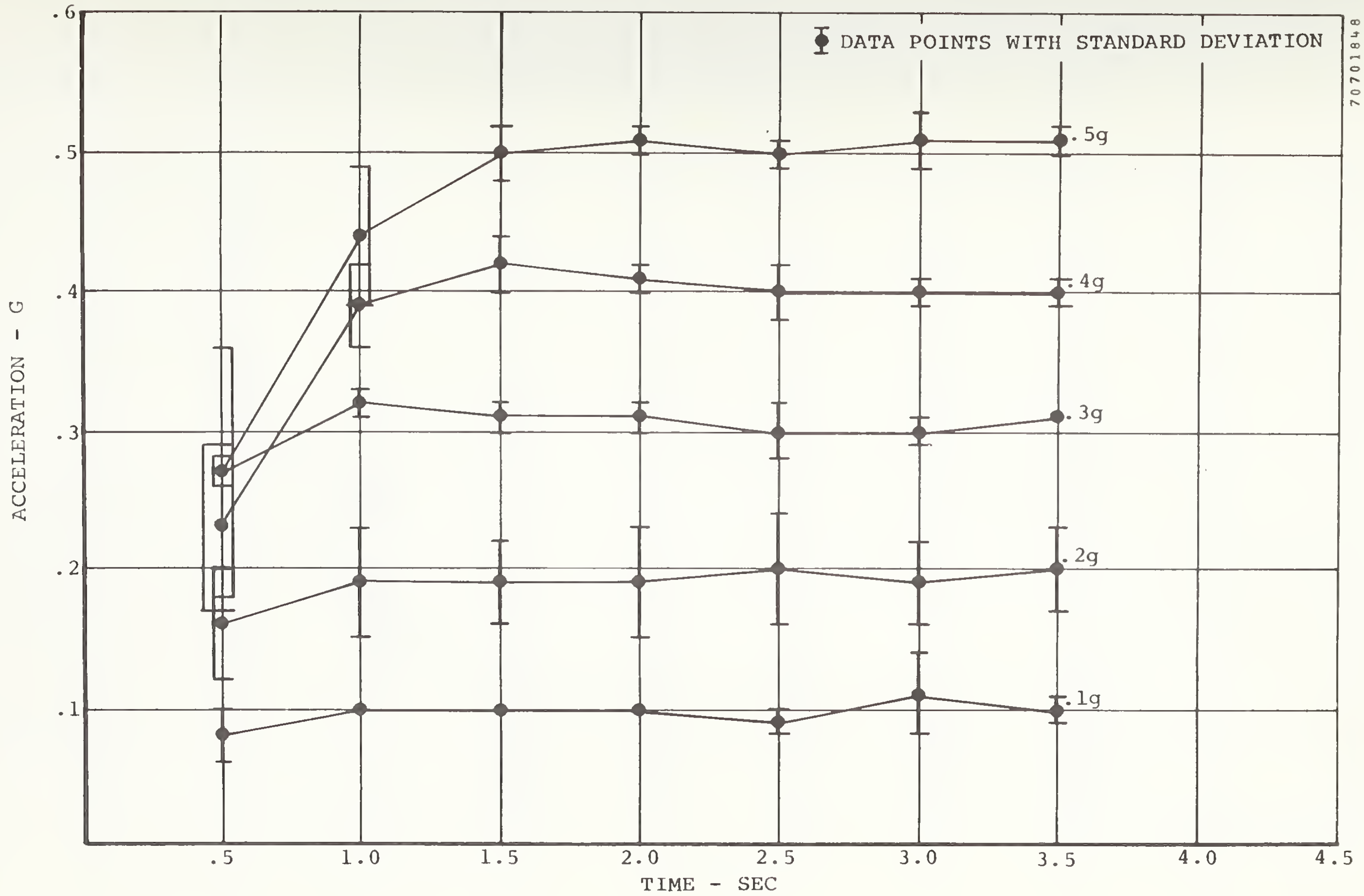


Figure D-16. Vehicle Lateral Acceleration, Dutcher Wheelchair Acceleration Tests, Wheelchair Restrained.

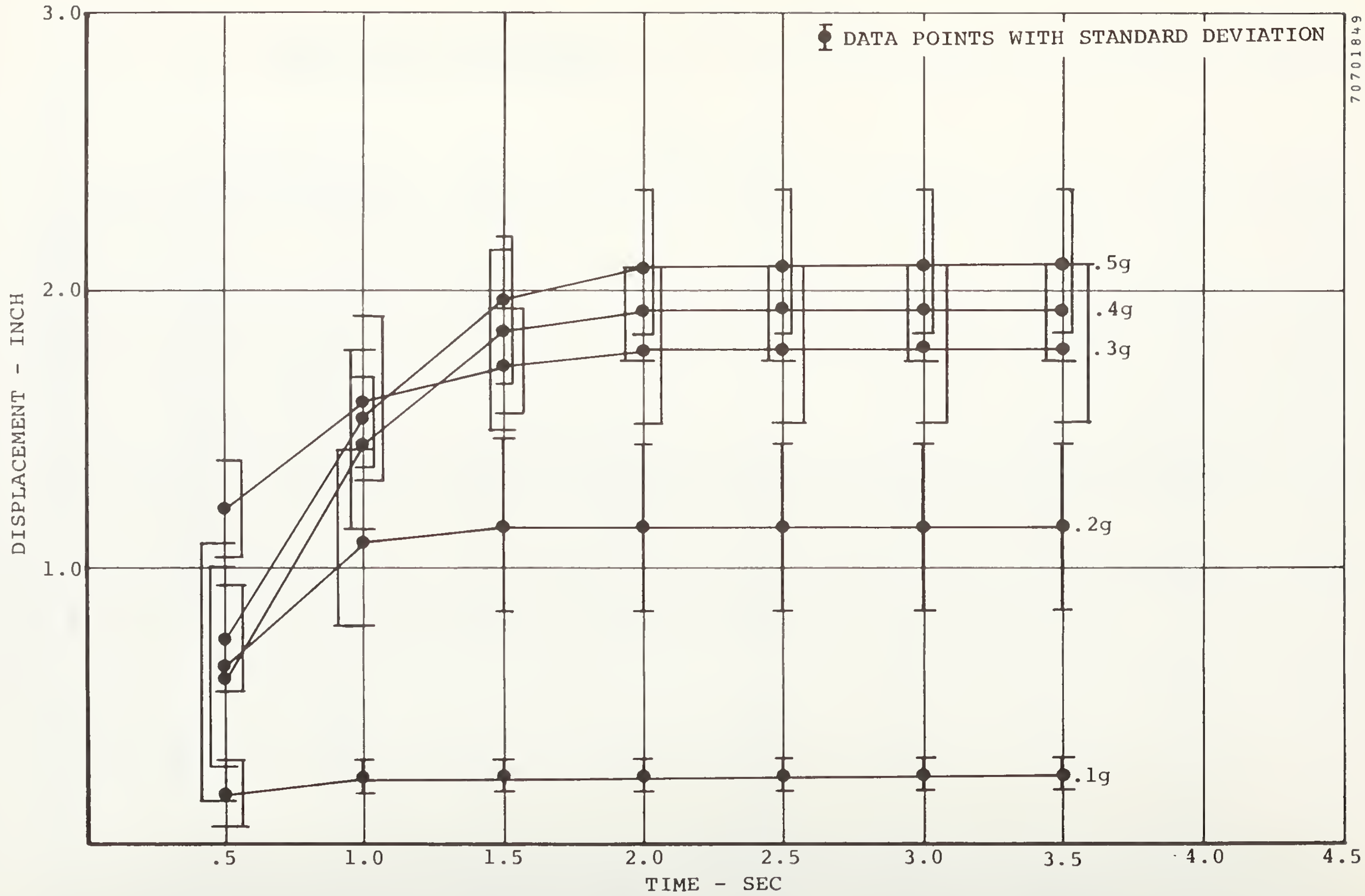


Figure D-17. Dutcher Dummy Head Displacement, Lateral Acceleration, Wheelchair Restrained.

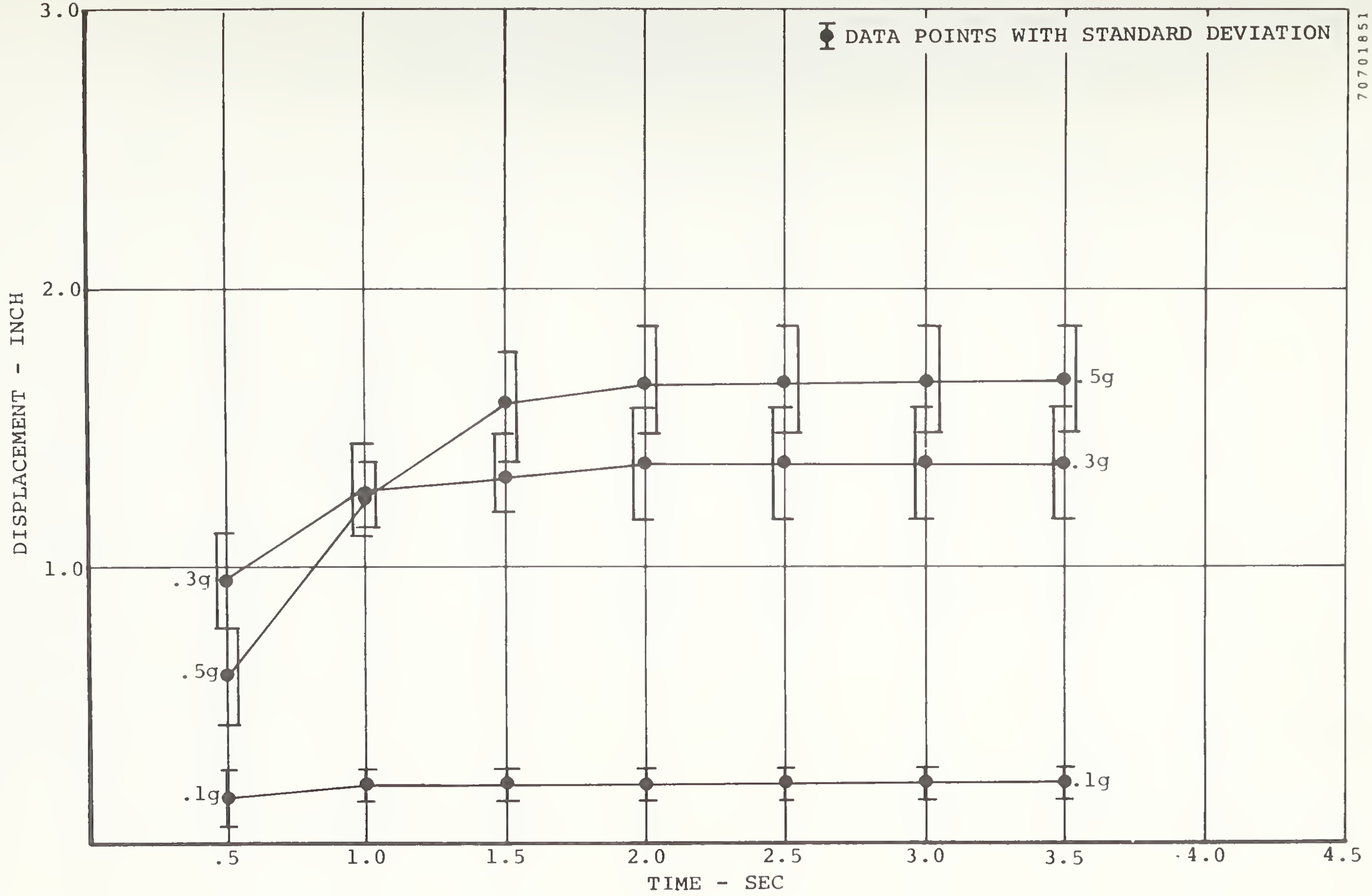


Figure D-18a. Dutcher Dummy Thorax Displacement, Lateral Acceleration, Wheelchair Restrained.

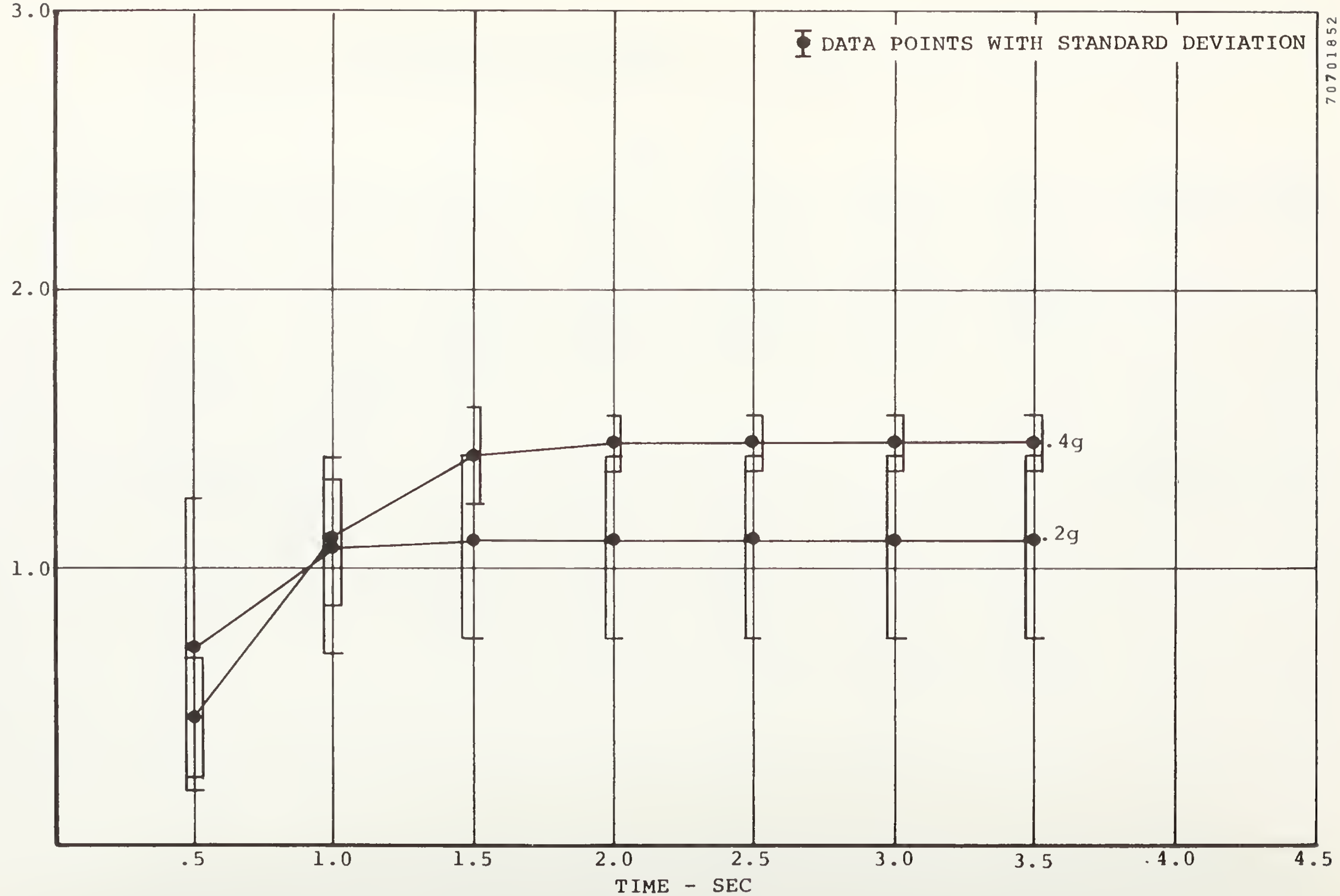


Figure D-18b. Dutcher Dummy Thorax Displacement, Lateral Acceleration, Wheelchair Restrained.

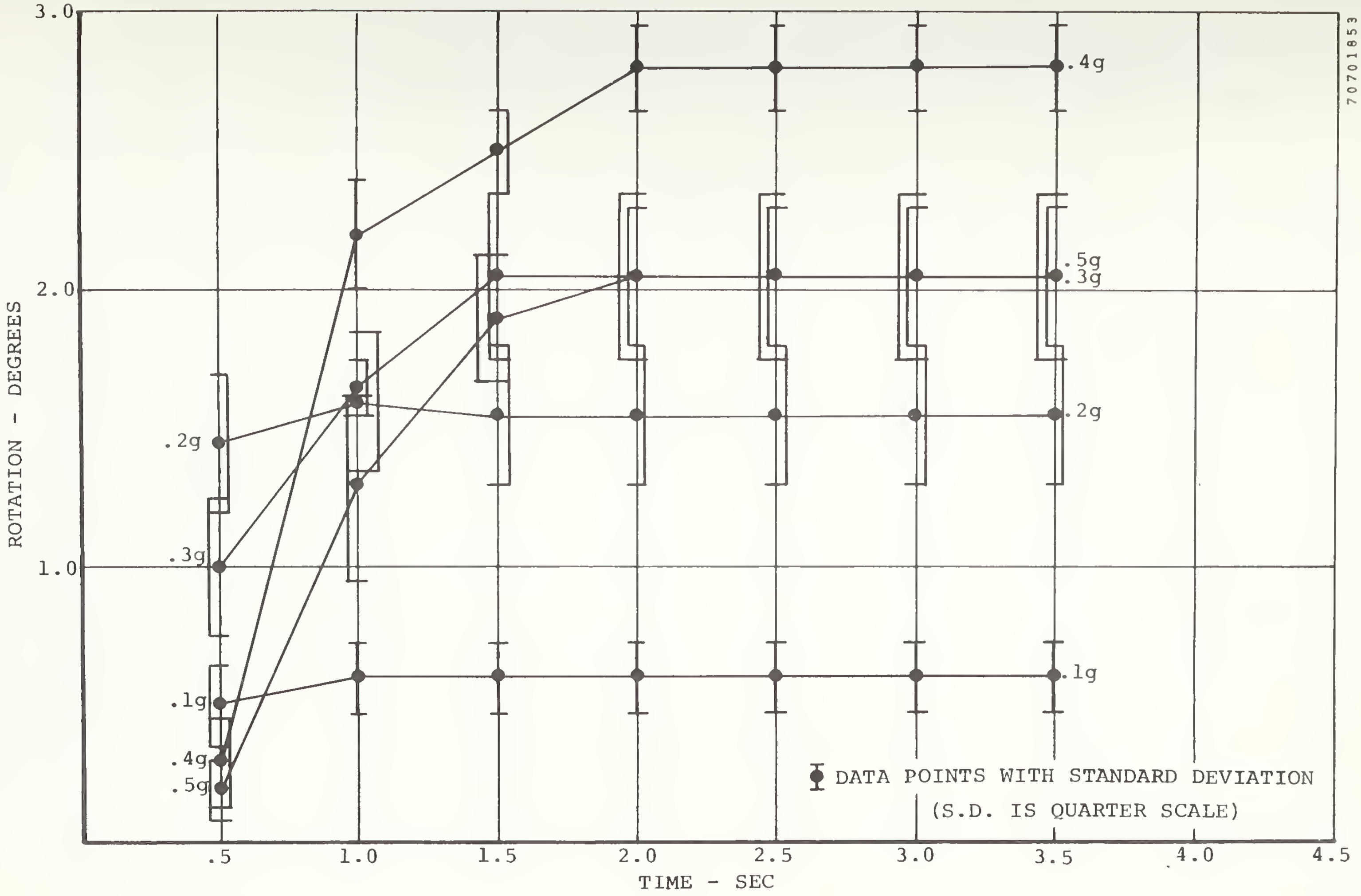


Figure D-19. Dutcher Dummy Head Rotation, Lateral Acceleration, Wheelchair Restrained.

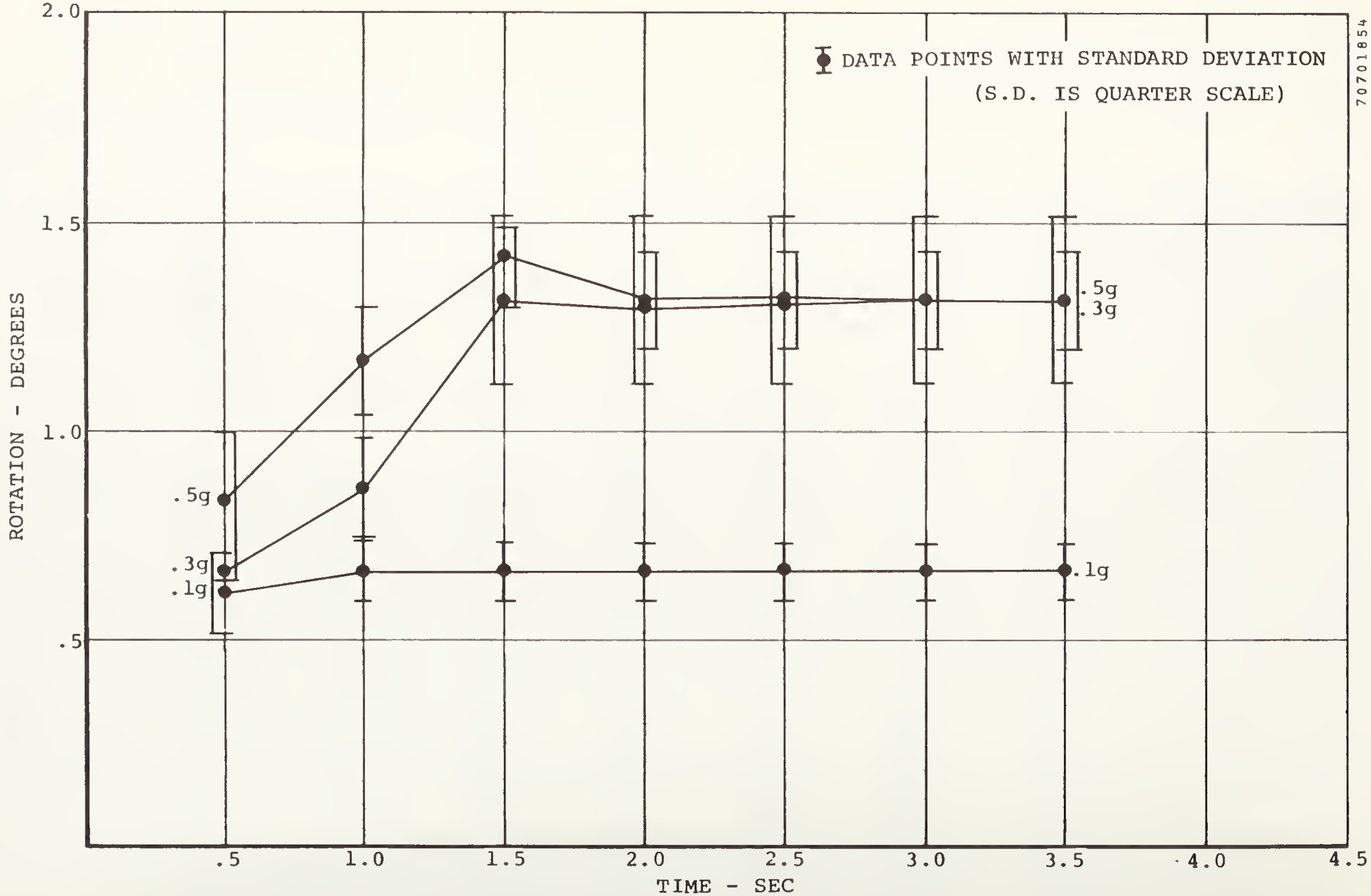


Figure D-20a. Dutcher Dummy Thorax Rotation, Lateral Acceleration, Wheelchair Restrained.

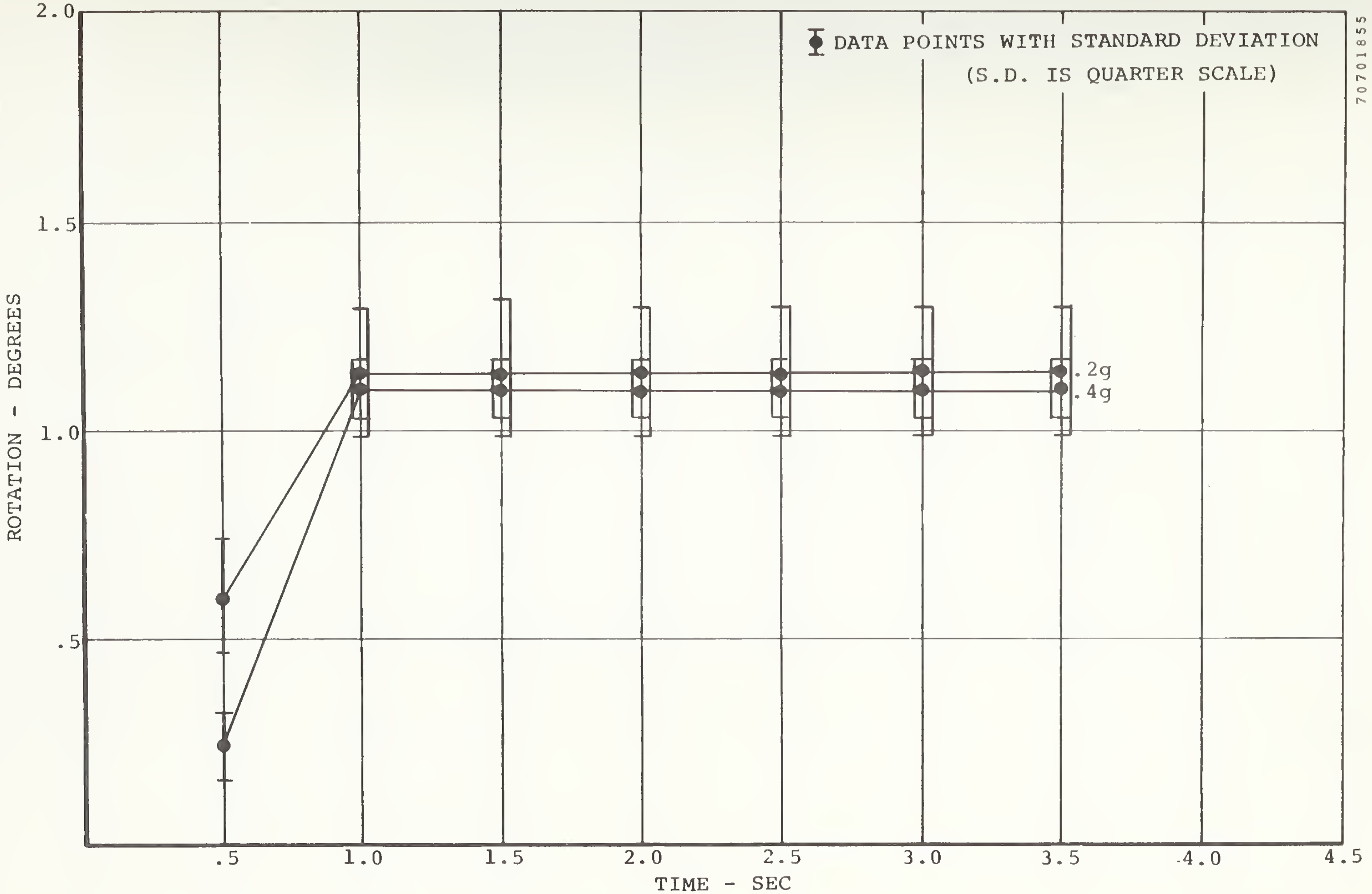


Figure D-20b. Dutcher Dummy Thorax Rotation, Lateral Acceleration, Wheelchair Restrained.

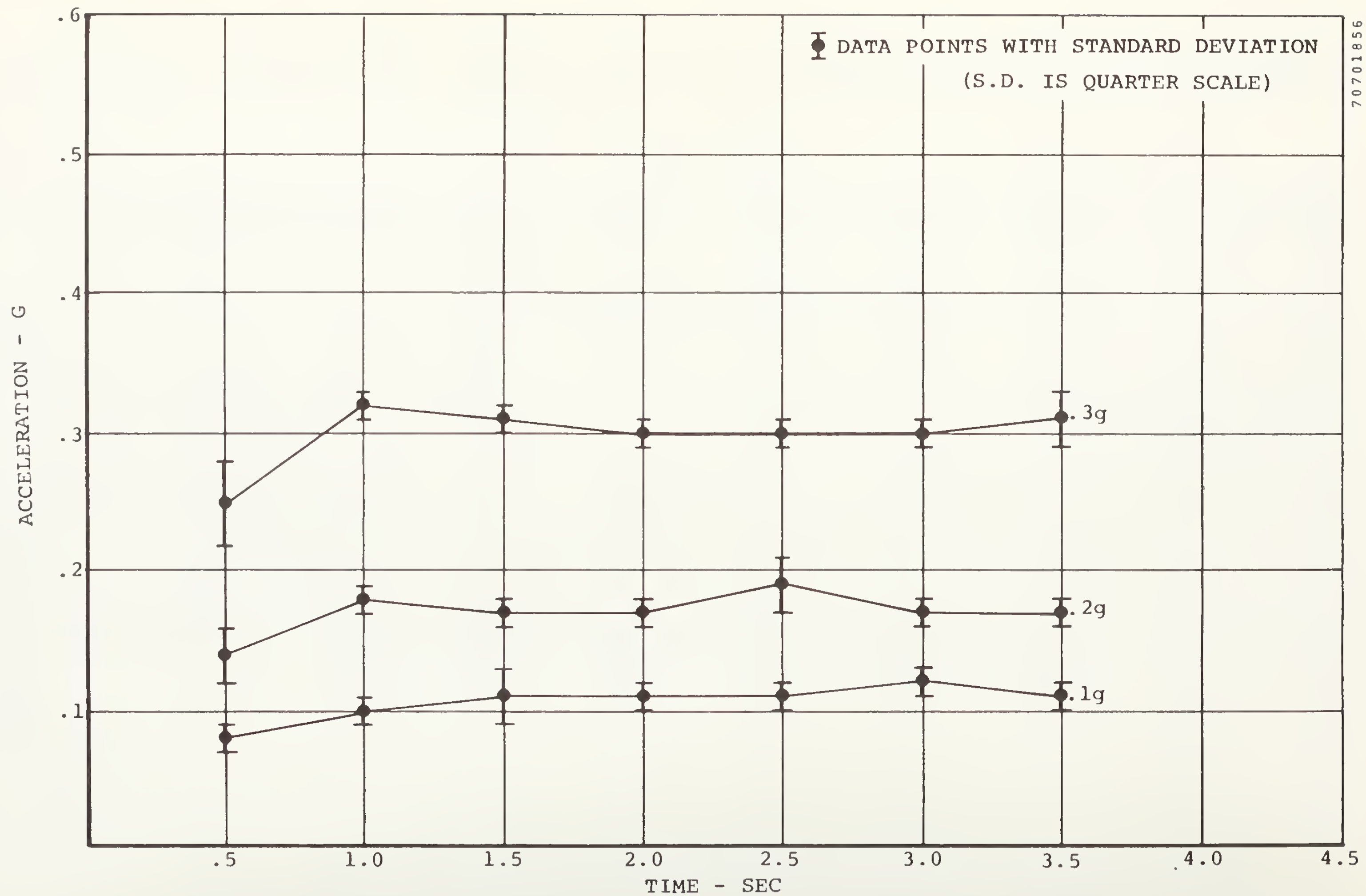


Figure 21. Vehicle Lateral Acceleration, Dutcher Wheelchair Acceleration Tests, No Restraint.

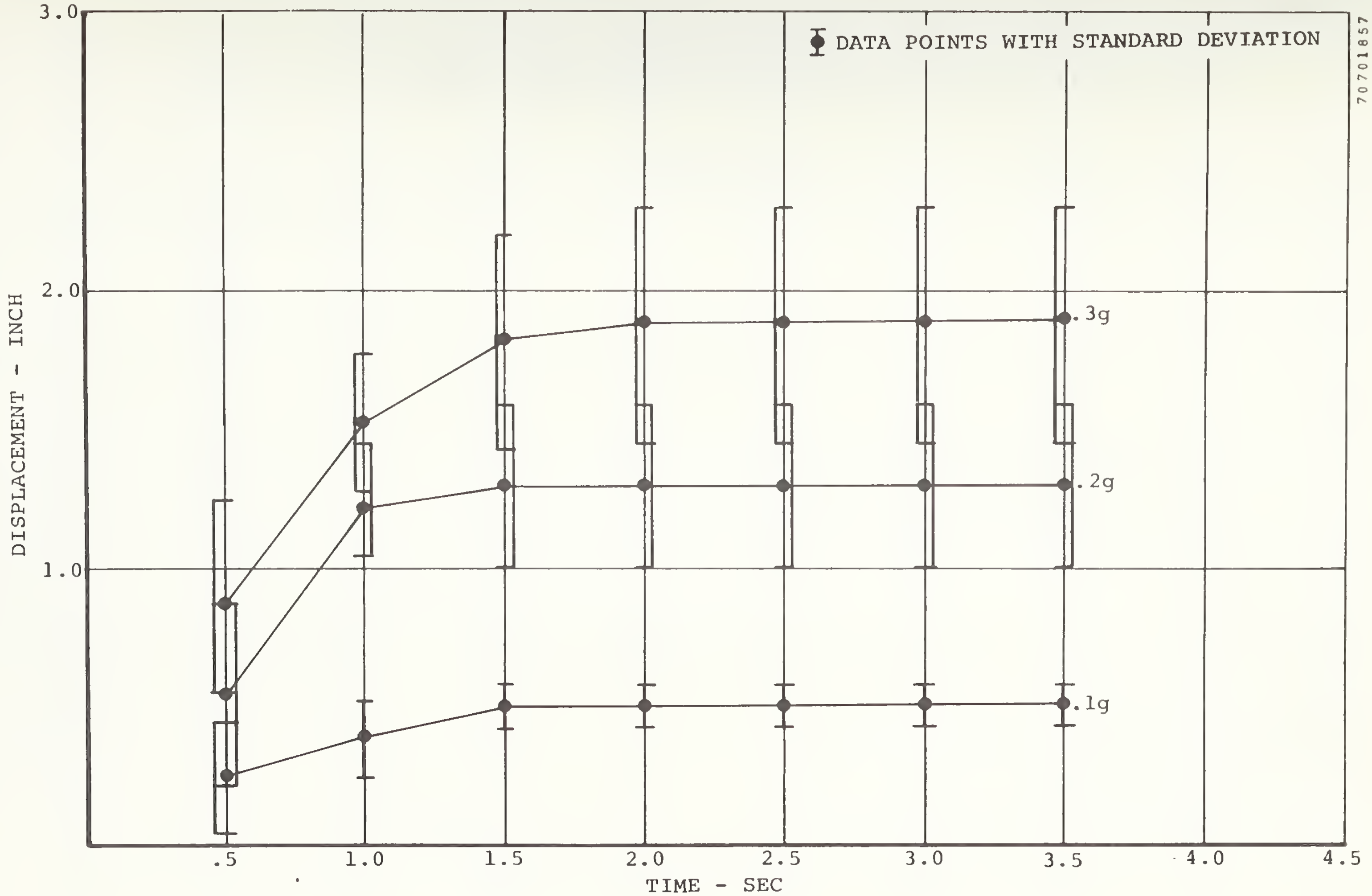


Figure D-22. Dutcher Dummy Head Displacement, Lateral Acceleration, No Restraint.

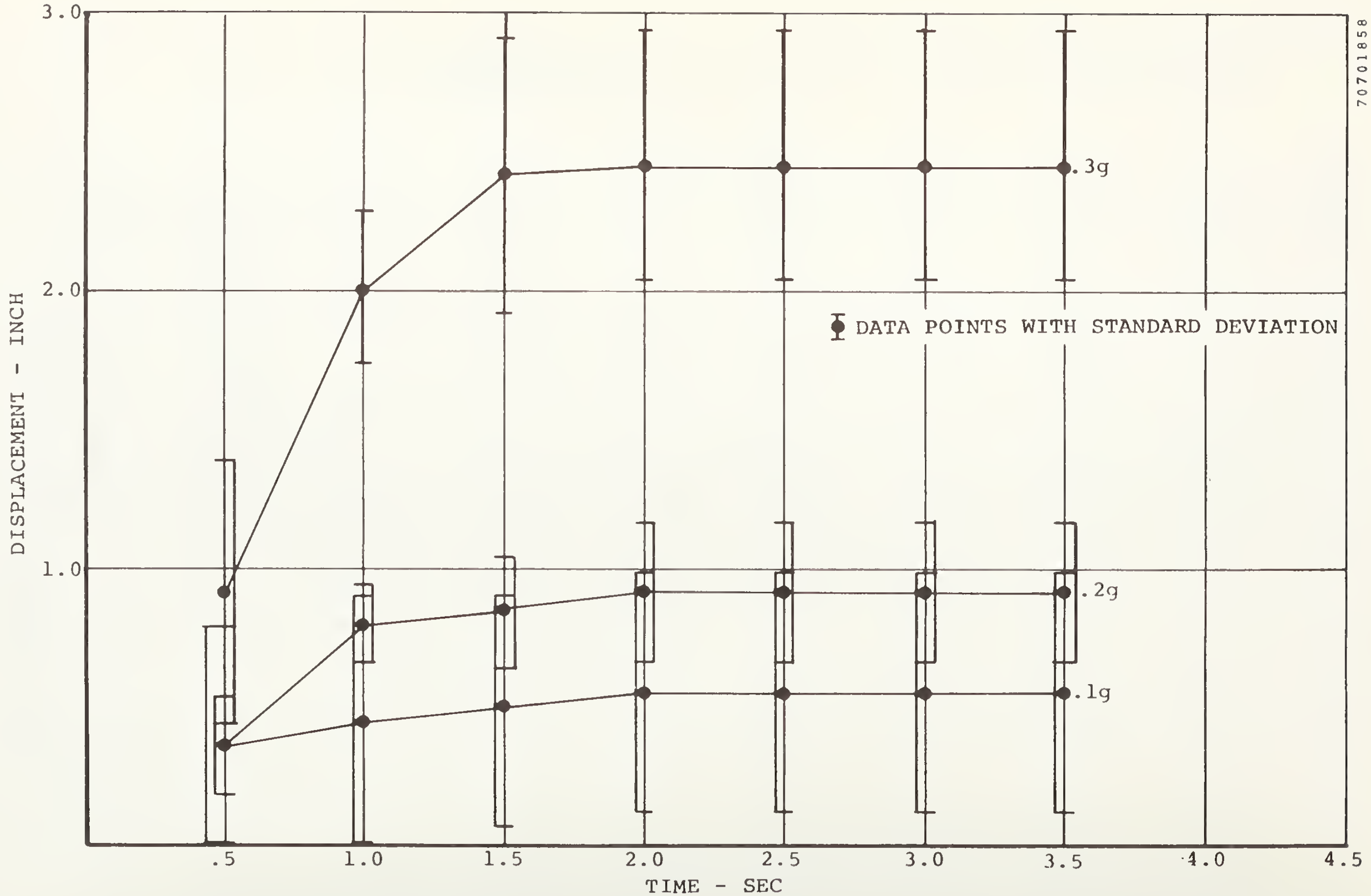


Figure D-23. Dutcher Dummy Thorax Displacement, Lateral Acceleration, No Restraint.

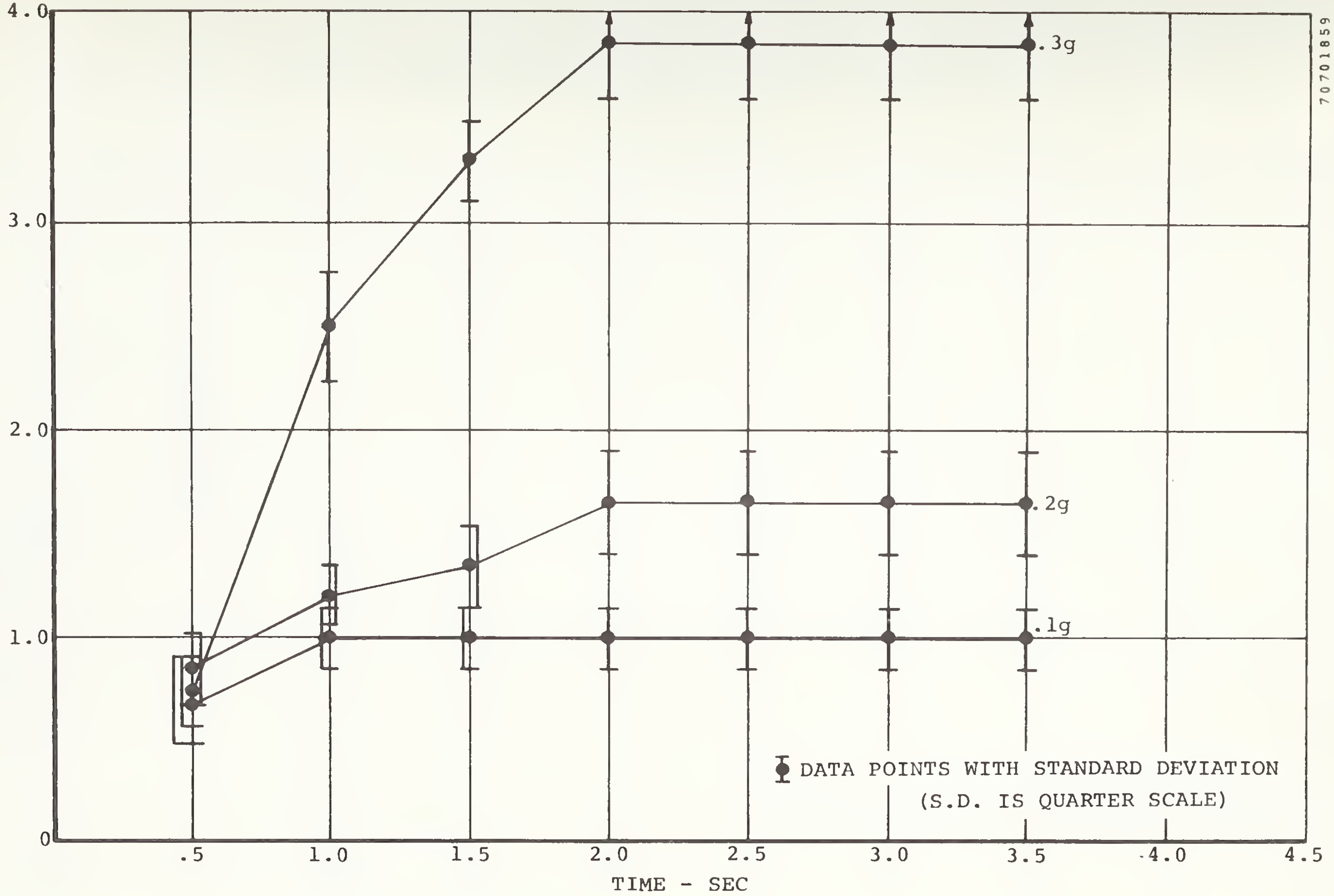


Figure D-24. Dutcher Dummy Head Rotation, Lateral Acceleration, No Restraint.

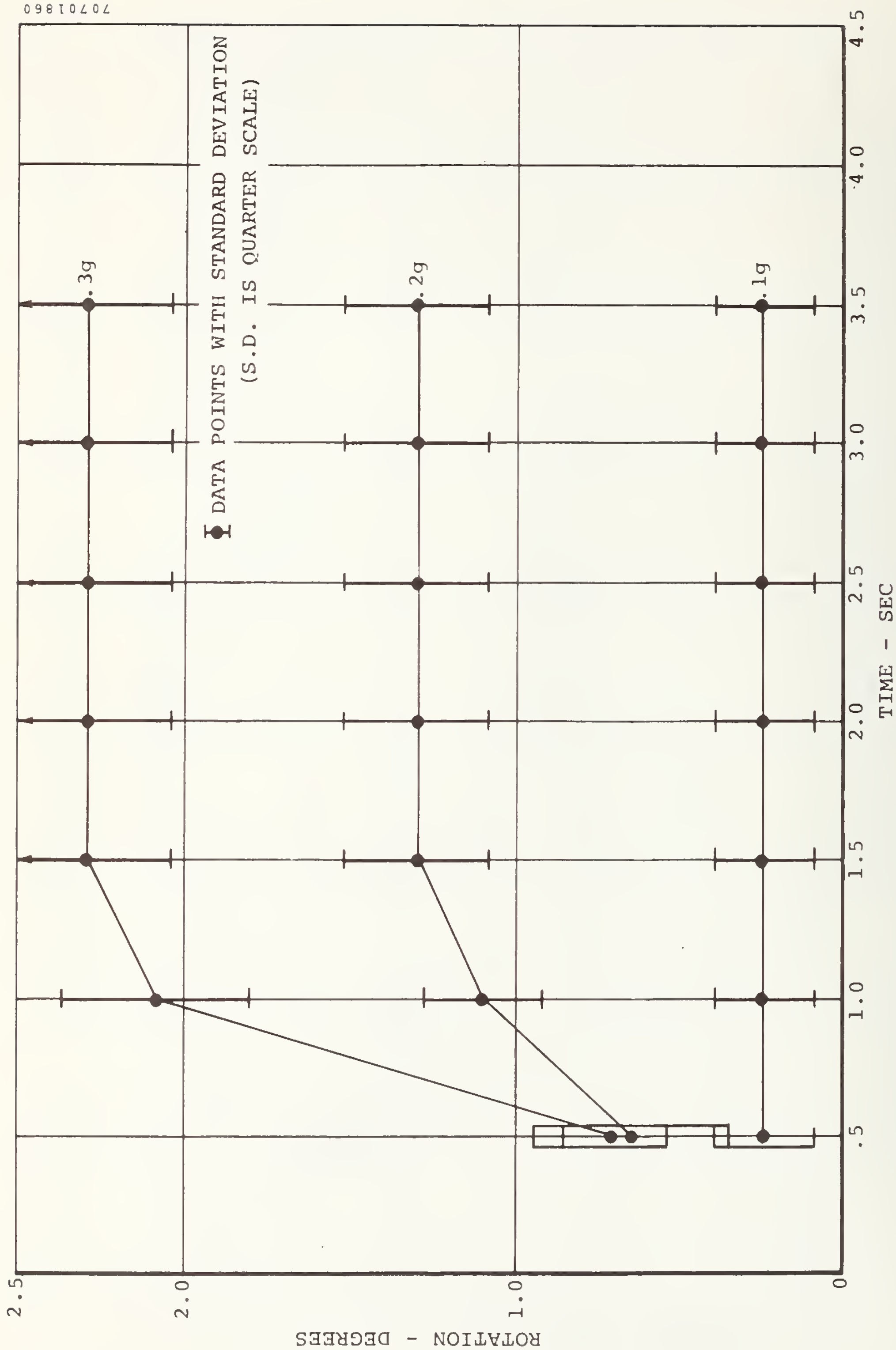


Figure D-25. Dutcher Dummy Thorax Rotation, Lateral Acceleration, No Restraint.

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