

OST 75-55

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VEHICLE TEST PROCEDURE DRIVING SCHEDULES

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FINAL REPORT

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16. Abstract The results of a study conducted to analyze the status of vehicle test procedure driving schedules are presented. Twenty-two driving schedules were identified and analyzed. Four categories of driving schedules were used: urban, suburban, highway/interstate, and other. Two types of driving schedules were included: "nonstylized," typified by the Environmental Protection Agency's Federal Test Procedure driving schedule, and "stylized," typified by the Society of Automotive Engineers' driving schedules. Parametric evaluators are presented for each driving schedule analyzed and discussed.					
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PREFACE

This report presents a study of test procedure driving schedules used in determining a motor vehicle's fuel economy, and identifies, analyzes, and evaluates the characteristics of the schedules. The study was conducted as part of the Test and Evaluation Subproject of the Automotive Energy Efficiency Project (OS 514) at the Transportation Systems Center and sponsored by the Office of the Secretary of Transportation.

This report discusses the salient characteristics of driving schedules which are currently being used to determine automotive fuel economy, exhaust emissions, and component characteristics. The analyses discussed and the results reported highlight the major features of the various driving schedules and serve as a basis for future discussion and development of improved or alternative driving schedules.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures		Approximate Conversions from Metric Measures						
Symbol	When You Know	Multiply by	To Find	Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH								
in	inches	2.5	centimeters	cm	millimeters	0.04	inches	in
ft	feet	30	centimeters	cm	inches	0.4	inches	in
yd	yards	0.9	meters	m	feet	3.3	feet	ft
mi	miles	1.6	kilometers	km	yards	1.1	yards	yd
					miles	0.6	miles	mi
AREA								
m ²	square meters	6.5	square centimeters	cm ²	square centimeters	0.16	square inches	in ²
ft ²	square feet	0.09	square meters	m ²	square meters	1.2	square yards	yd ²
yd ²	square yards	0.8	square meters	m ²	square kilometers	0.4	square miles	mi ²
mi ²	square miles	2.6	square kilometers	km ²	hectares (10,000 m ²)	2.5	acres	ac
	acres	0.4	hectares	ha				
MASS (weight)								
oz	ounces	28	grams	g	grams	0.005	ounces	oz
lb	pounds	0.45	kilograms	kg	kilograms	2.2	pounds	lb
	short tons (2000 lb)	0.9	tonnes	t	tonnes (1000 kg)	1.1	short tons	st
VOLUME								
teaspoon	teaspoons	5	milliliters	ml	milliliters	0.03	fluid ounces	fl oz
Tablespoon	tablespoons	15	milliliters	ml	liters	2.1	pints	pt
fl oz	fluid ounces	30	milliliters	ml	liters	1.06	quarts	qt
c	cups	0.24	liters	l	liters	0.26	gallons	gal
pt	pints	0.47	liters	l	cubic meters	36	cubic feet	ft ³
qt	quarts	0.95	liters	l	cubic meters	1.3	cubic yards	yd ³
gal	gallons	3.8	cubic meters	m ³				
ft ³	cubic feet	0.03	cubic meters	m ³				
yd ³	cubic yards	0.76						
TEMPERATURE (exact)								
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

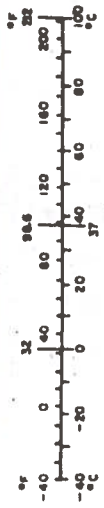
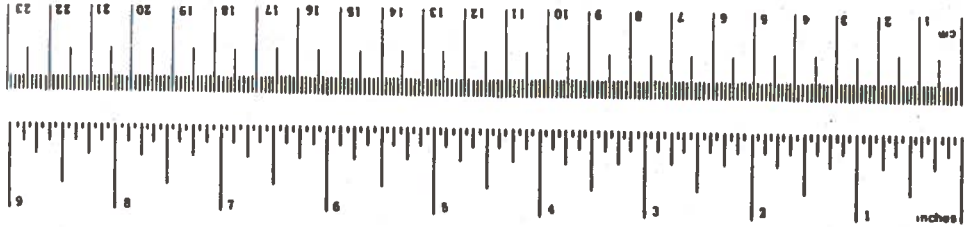


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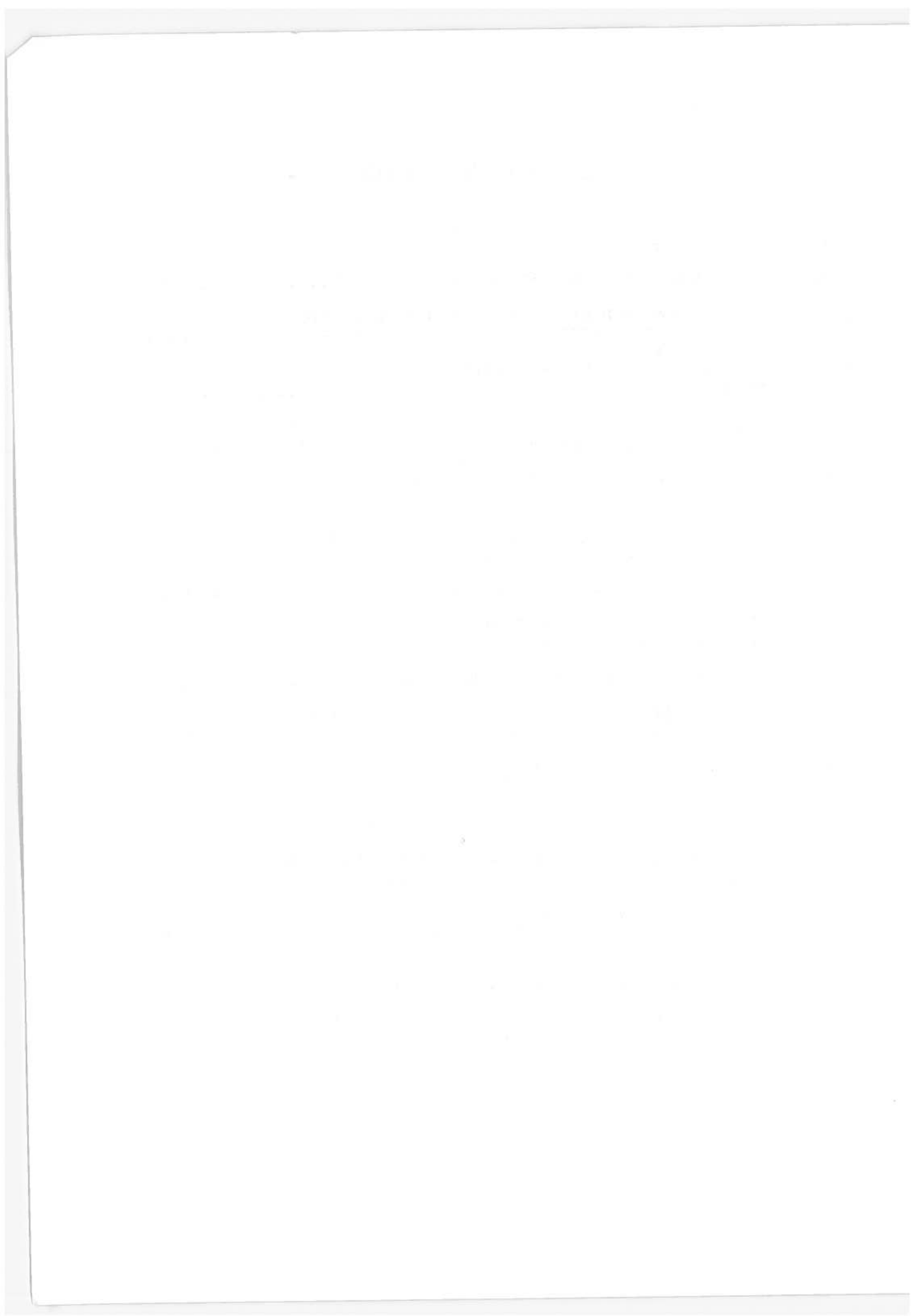
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1. SUMMARY

The driving cycle and the driving schedule are essential elements of every automotive test procedure. The relationship of the driving cycle and schedule to actual vehicle operation conditions is a major prerequisite of any automobile fuel economy test procedure.

Twenty-one automobile test procedure driving schedules were obtained and analyzed. Specifically, schedule distance, time, mean speed, maximum speed, number of idles, number of stops, stops per mile, and percent time and distance in cruise, acceleration, deceleration, and idle were calculated and tabulated. Table 1-1 includes a summary of these driving schedules and is intended to serve as a quick reference of the features and characteristics of the driving schedules discussed in this report.

The driving schedules are categorized according to the driving conditions or patterns that they represent.

Three major groups of driving schedules were analyzed: urban, suburban, and highway/interstate. These groups are based on a mixture of demographic location and road type, with suburban being an undefined term.

From the completed analyses, no one particular parametric evaluator appears to adequately describe the driving schedule. Thus, any future effort in driving schedule development must describe vehicle operation in terms of mean speed, maximum speed, schedule length, percent time and distance in mode, etc.

TABLE 1-1 DRIVING SCHEDULE SUMMARY

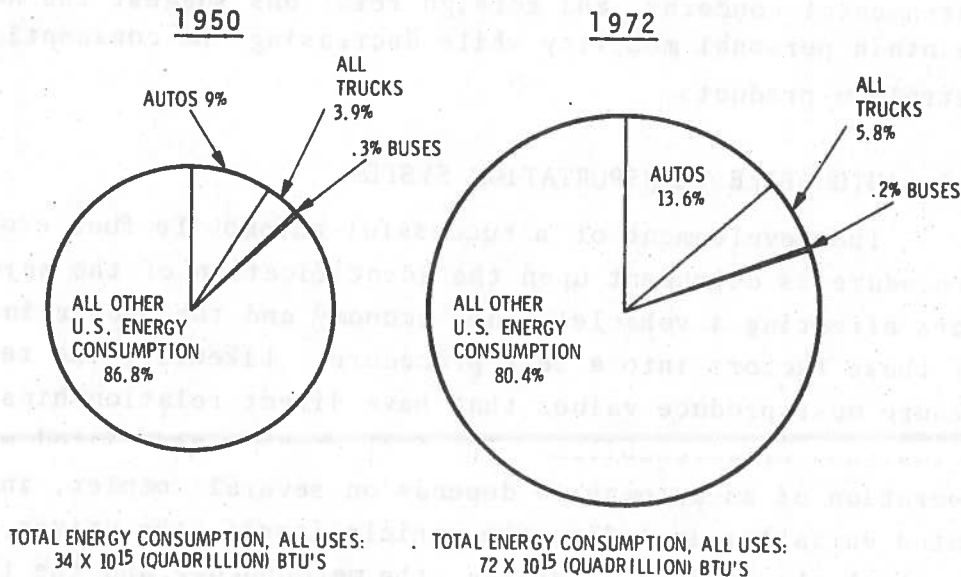
Schedule	Schedule		Distance Miles	Time Seconds	Speed MPH		Number of		Stops Per Mile	Percent Time in				Percent Distance in		
	Source	Type			Mean	Maximum	Idles	Stops		Idle	Cruise	Acceleration	Deceleration	Cruise	Acceleration	Deceleration
City	EPA FTP	Non- Stylized	7.5	137	19.3	36.7	15	1	2.3	17.9	7.9	11.9	46.6	41.5		
	SAE-J1082	Stylized	2.0	462	15.6	30.0	4	8	4.0	15.0	56.2	75.2	10.2	14.5		
	GM-CBD	Stylized	2.0	432	19.1	30.0	4	8	5.9	13.5	63.8	81.5	8.5	10.0		
	Ford-City	Stylized	3.0	739	15.3	30.0	6	20	5.5	18.8	55.1	76.3	13.7	10.0		
	AMC City	Stylized	4.0	1019	16.4	35.0	23	24	5.2	15.8	34.2	58.1	26.2	13.7		
Suburban	Chrysler Urban	Stylized	4.0	122	16.2	35.0	24	24	5.2	16.4	34.5	59.3	25.5	13.5		
	GM-ARB	Stylized	0.5	137	21.2	35.0	1	1	1.2	14.6	24.7	23.6	39.5	36.2		
Suburban	SAE-J1082	Stylized	5.2	455	41.2	60.0	2	2	0.4	3.1	75.2	83.2	9.3	7.5		
	Ford-Sub	Stylized	5.2	438	42.7	60.0	2	2	0.4	1.4	81.6	86.6	9.3	4.1		
	AMC-Sub	Stylized	5.2	434	42.4	60.0	2	3	0.6	1.4	83.5	86.1	9.2	4.7		
	GM-Sub	Stylized	3.7	564	23.9	40.0	5	6	1.6	13.5	39.2	77.9	8.1	14.1		
Highway	EPA-Highway	Non- Stylized	10.2	765	48.0	39.9	0	1	0.1	0.0	16.0	18.0	45.2	35.8		
	SAE-J1082-55	Stylized	4.7	508	35.0	60.0	0	0	0.0	0.0	91.5	61.9	19.1	10.1		
	SAE-J1082-70	Stylized	4.7	542	30.0	55.0	0	0	0.0	0.0	51.5	51.5	24.5	24.5		
	GM-Highway	Stylized	15.0	1158	48.6	70.0	3	4	0.5	2.1	13.1	68.4	14.6	17.1		
	GM-Inter- state	Stylized	15.0	77	30.4	54.0	0	1	0.1	0.0	85.1	85.8	5.0	8.2		
	Chrysler- Interstate	Stylized	18.7	1154	38.3	54.0	0	0	0.0	0.0	87.3	58.2	20.9	20.9		
City	Chrysler Const. Speed	Stylized	32.7	2984	40.5	30.0	0	0	0.0	100.0	0.0	100.0	0.0	0.0		
	EPA-25 MPH	Semi- Stylized	9.3	1377	24.4	60.0	15	14	1.5	15.8	57.8	56.7	24.7	18.6		
	EPA-35 MPH	Semi- Stylized	15.2	1572	34.0	60.0	9	8	0.5	7.4	54.4	70.8	16.4	12.8		
	EPA-45 MPH	Semi- Stylized	19.9	1389	45.1	60.0	6	5	0.3	5.7	67.8	77.5	11.9	10.8		

2. BACKGROUND

2.1 GENERAL

Recent events have focused national attention on the amount of resources consumed in the United States every year. Historically, this statistic has had minor impact upon national policy decisions due to the philosophical viewpoint that the U.S. possessed unlimited resources. However, this viewpoint is changing. Because of the intensification of interest regarding our depleting limited resources, the need has arisen to analyze the amount of resources available, their allocation, and their utilization.

One major outgrowth of this increased interest is greater attention to our petroleum resources, particularly those resources directed into automotive-related activities. The amount of energy consumed by motor vehicles each year in the U.S. has grown from about 13 percent in 1950 to nearly 20 percent in 1972.^{1,2} Figure 2-1 shows motor vehicle energy consumption for passenger cars,



Source: Reference 2

Figure 2-1 Share of U.S. Energy Consumed by Motor Vehicles in 1950 and 1972

buses, and trucks, and indicates that the total use has more than tripled since 1950. (Motor vehicle consumption in 1972 was 14.1×10^{15} BTU's, while in 1950 it was 4.5×10^{15} BTU's.)²

Automotive fuel use is important for a variety of reasons:

- 1) World oil reserves are limited. One estimate shows that 90% of the world oil supply will have been consumed by about 2025.
- 2) Imports account for a substantial - and rising - share of the U.S. petroleum budget. In 1972, imports accounted for 29 percent of domestic oil use, compared with less than 18 percent in 1960. Dependence on foreign oil raises serious national security, foreign relations, and balance-of-payments problems.
- 3) Exploration, production, transportation, refining, and use of petroleum present serious environmental problems.¹

The combined effects of these and other factors will apply increasing pressure on the market structure for gasoline and automobiles. Thus, private economics, plus resource scarcities, environmental concerns, and foreign relations suggest the need to maintain personal mobility while decreasing the consumption of petroleum products.

2.2 AUTOMOBILE TRANSPORTATION SYSTEM

The development of a successful automobile fuel economy test procedure is dependent upon the identification of the major factors affecting a vehicle's fuel economy and the proper integration of these factors into a test procedure. Likewise, the test procedure must produce values that have direct relationships to the actual use of automobiles. The fuel economy associated with the operation of an automobile depends on several complex, interrelated variables including the vehicle itself, the driver, the road on which the vehicle is driven, the meteorology, and the traffic. These variables are discussed below.

2.2.1 Vehicle

The basic vehicle design determines the range of potential fuel economy. The design engineer, with consideration for the

consumer preference, selects the engine size and type, the transmission type, differential ratio, accessories (e.g., air conditioning, power steering, etc.), and the size and shape of the body. These decisions determine the vehicle weight and internal and external energy consumption, and thus influence vehicle fuel economy. The type of tires and their inflation pressure, coupled with the weight of the vehicle, are the principal determinants of vehicle rolling resistance. The state of the engine tune affects fuel economy and emissions.

2.2.2 Driver

The vehicle driver influences fuel economy and exhaust emissions by the manner in which he operates the vehicle and by the route which he selects for a particular trip (i.e., the path from origin to destination). Vehicle operation is reflected by the speeds, accelerations, decelerations and the percentage of time and distance in mode (i.e., idle, cruise, acceleration, and deceleration). The time interval between trips determines if the engine starts hot or cold.

2.2.3 Road

For a particular trip, the roads that compose the route from origin to destination are fundamental in influencing driver behavior. By the physical design and condition, a road may be the constraining factor on speed and speed change. For example, central business district streets limit speed by their design and traffic control systems, whereas, interstate roads are specifically designed not to be a controlling factor. The road surface and condition impacts vehicle rolling resistance and thus fuel economy and exhaust emissions.³

2.2.4 Meteorology/Topography

The ambient meteorological conditions influence vehicle fuel economy. Ambient temperature affects the viscosity of lubricating fluids and thus internal frictional losses. Ambient temperature also motivates the driver to utilize certain accessories (e.g.,

air conditioners). Ambient pressure and temperature determine the air density which influences aerodynamic drag and the air to fuel ratio to the engine. Wind is also a factor in determining aerodynamic drag. Snow, ice, and rain affect rolling resistance, and at times can dramatically influence driver behavior.

The topography and regional location determine elevation and thus the average barometric pressure. Likewise, regional topography (e.g., level, hilly, or mountainous) and population interact to determine the ratios of the various road types and the road grades encountered.

2.2.5 Traffic

Of the factors affecting fuel economy, traffic conditions can be the most dynamic with time. For the urban environment, traffic congestion has achieved a certain level of "acceptance" and is readily identified as to location, time of day, and day of week. Peak hour congestion is usually associated with the morning home-to-work trip and the afternoon work-to-home trip. As traffic volumes increase significantly, congestion increases producing longer travel times, reduced peak and average speeds, and increased idle times. Fuel economy is a nonlinear function with speed;⁴ thus, the impact on traffic on fuel economy is dependent upon the individual magnitudes of each factor in the aggregate.

2.3 AUTOMOBILE TRAVEL

2.3.1 Trips

Automobile use is composed of individual discrete events called trips. Each trip is undertaken for a specific purpose and has associated with it, a specific origin-destination and travel route. Every time we enter our automobile and begin a trip, we have made a number of conscious and unconscious decisions pertaining to trip purpose, starting time, travel route, and destination. (Obviously, all trip origins have been previous trip destinations.) Major trip purposes commonly used in transportation studies include: 1) Earning a living, 2) Family business,

3) Educational, civic, and religious, and 4) Social and recreational.⁵ Trip length, origin, destination, time of day, day of week, season of year, etc., are all associated with trip purpose.

A specific trip profile is associated with each trip. This profile is a function of the vehicle, the driver, the roadways, ambient conditions of weather and traffic and other traffic. The trip profile is characterized by the starting temperature of the engine, the amount of engine idle, cruise times, cruise speed, acceleration and deceleration magnitudes and durations, travel time, and travel distance. These factors determine the fuel consumed by the vehicle during a trip and the fuel economy of the vehicle; i.e., $\frac{\text{Distance Traveled}}{\text{Gallons Consumed}}$.

A driving pattern develops when a sufficient number of individuals have similar vehicle usage (i.e., trips). A driving pattern is described in terms of a day's sequence of trips all starting approximately the same time of day and having the same trip segment string (i.e., have identical roadway class usage). The sequence of trips is described by a scenario of driver behavior.⁶ Familiar driving patterns are associated with the urban work trip and occur five days a week in the morning and late afternoon. Other urban driving patterns are associated with various urban trip purposes: business, shopping, social/recreation, etc.

A traffic pattern is distinguished from a driving pattern in that a traffic pattern is associated with a functional roadway class, and possibly in a specific location and time of day. Traffic patterns are readily recognizable for high-speed highways and interstates, residential streets, and central business district streets.

2.3.2 Trip Aggregations

Automobile use is described by two general characteristics: travel and trips. Travel is generally considered as an aggregate descriptor of vehicle use: e.g., total annual nationwide vehicle-miles traveled (VMT), fuel consumed, number of motor vehicles registered, etc.

The U.S. DOT/Federal Highway Administration (FHWA) is the principal highway agency of the Federal Government; as such, it is the principal agency for collecting, tabulating and analyzing highway related travel statistics. The Highway Statistics series has been published annually since 1945 with the most recent issue being the 1972 Highway Statistics.⁷ This publication is prepared by the Highway Statistics Division, Office of Highway Planning, Federal Highway Administration, relating to three major areas of highway transportation: (1) highway use - the ownership and operation of motor vehicles; (2) highway finance - the receipts and expenditures for highways by public agencies; and (3) the highway plant - the extent and changing characteristics of the mileage of public highways, roads, and streets in the nation.

The FHWA estimates roadway usage as vehicle-miles traveled by state, region, and nationwide. Table 2-1 is a presentation of VMT by demographic location (i.e., urban and rural), functional, and Federal funding classifications. It should be noted that the relationships between functional classification and Federal funding classifications in Table 2-1 are based upon the author's judgement. Urban VMT has increased at a more rapid rate than rural VMT since 1970 as shown in Table 2-2. Automobiles are approximately 82% of all registered motor vehicles in this country and are responsible for about 80% of total VMT. Total highway fuel consumption in 1972 was estimated to be 105,062 million gallons by 118,505,863 motor vehicles.

The fuel economy value obtained from a test must bear some relationship to the actual vehicle fuel economy experienced in "normal" driving. The formulation of a fuel economy test procedure for an automobile that bears some relationship to actual vehicle use is the task presented. This task reduces to a problem of aggregation and disaggregation descriptions of vehicle use. Characteristics of discrete trips must be aggregated to a level that is meaningful and manageable; vehicle travel statistics must be disaggregated to a comparable level.

TABLE 2-1 NATIONWIDE ANNUAL VEHICLE MILES TRAVELED - 1972 (FHWA - 1972 HIGHWAY STATISTICS)
ALL VEHICLES

Functional Classification		Federal Funding-Related Classification	VMT (millions)	VMT by Location (%)	VMT by Total (%)
R	Interstate	Interstate	98,392	16.7	7.7
U	Principal & Minor Arterials	Primary	19,565*	3.3	1.5
R	Major Collectors	Secondary	209,702	35.5	16.7
A	Other	- NONE -	153,291	26.0	12.1
L			109,277**	18.5	8.6
RURAL SUBTOTAL			590,227	100.0	46.6
U	Interstate	Interstate	100,433	14.8	7.9
R	Urban Extensions of Rural Principal & Minor Arterials	Primary	21,702*	3.2	1.7
B	Other Urban Principal & Minor Arterial Systems; Collector Streets	Secondary	159,053	23.4	12.5
A		FAU	69,099	10.2	5.4
N		- NONE -	55,514	8.2	4.4
			272,314**	40.2	21.5
URBAN SUBTOTAL			678,115	100.0	53.4
TOTAL			1,268,342		100.0

*Traveled-Way

**State and Local

TABLE 2-2 URBAN AND RURAL VEHICLE MILES TRAVELED (1967-1972)
 FHWA HIGHWAY STATISTICS 1967-1974
 ALL VEHICLES

YEAR	VMT (millions)			% VMT	
	URBAN	RURAL	TOTAL	URBAN	RURAL
1967	485,493	476,060	961,553	50.5	49.5
1968	513,289	502,360	1,015,649	50.5	49.5
1969	544,547	526,028	1,070,575	50.9	49.0
1970	557,373	543,332	1,100,705	51.5	48.5
1971	612,975	573,314	1,186,289	51.6	48.4
1972	678,115	590,227	1,268,342	53.3	46.7

Source: References 7 and 8.

3. FUEL ECONOMY TEST PROCEDURES

3.1 AUTOMOTIVE FUEL ECONOMY TEST

Automotive fuel economy tests may be performed to satisfy a variety of needs, such as basic research and development, consumer information, or governmental regulation. An automotive fuel economy test is structured similar to any engineering test, as illustrated in Figure 3-1. The Test Requirement is a statement of general need and/or policy; e.g., provide consumer information. The Test Specification states the specific objective of the test; e.g., provide consumer information in the form of a vehicle fuel economy label (window sticker); it also specifies the format, accuracy, and precision of the measurement, and possibly the approach in selecting the vehicles for test. The Test Procedure accordingly specifies the laboratory test conditions and procedures, test equipment, data reduction, and data presentation. A major part of the Test Procedure is the vehicle's driving cycle and driving schedule.

3.2 TEST PROCEDURE DRIVING CYCLE

The test procedure driving cycle is a specification of values for pertinent parameters of the test procedure. These parameters include: the physical environment of the test (e.g., ambient temperature, pressure, humidity); the preparation of the vehicle; mileage accumulation, state of engine tune, and temperature (hot or cold start condition); and the test procedure driving schedule (the speed-time sequence that exercises the vehicle during the test). The values for these factors are determined from the trip and travel statistics addressed in Section 2.3 and are the major factors in determining a vehicle's relative fuel economy (relative to "best" and "worst" possible fuel economy).

3.3 TEST PROCEDURE DRIVING SCHEDULE

An essential element of any vehicle test procedure is the driving schedule. The driving schedule is a series of exercises

General Outline

TEST PROGRAM

Example

AUTOMOTIVE FUEL
ECONOMY TEST

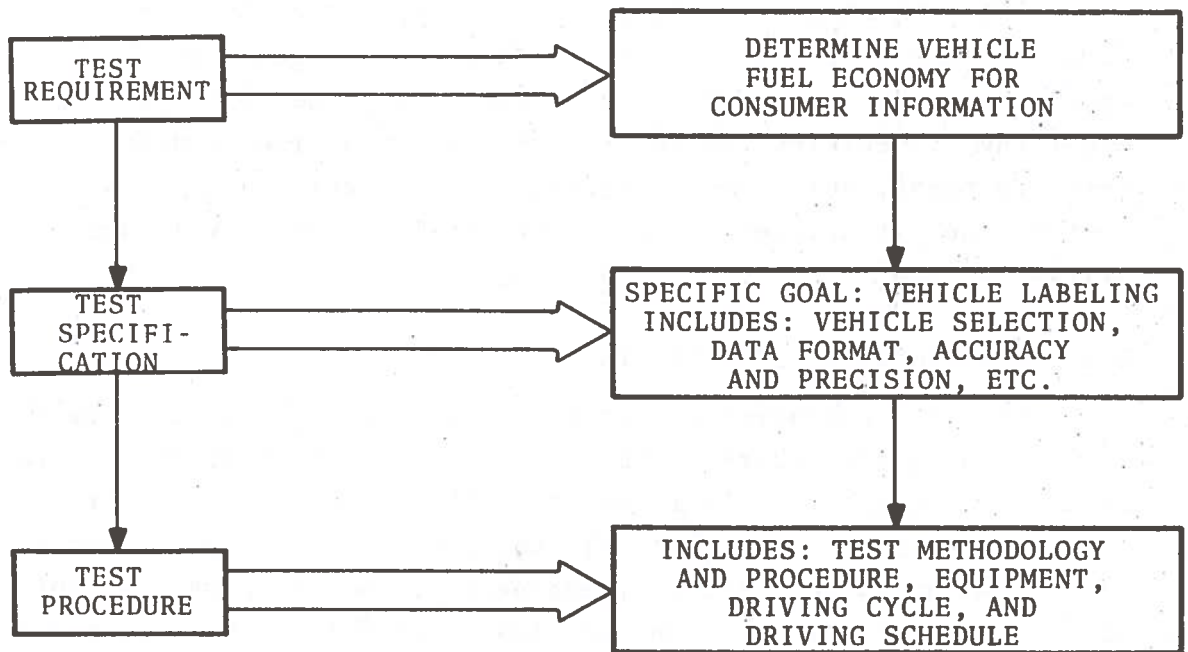


Figure 3-1 Structure of an Automotive Fuel Economy Test

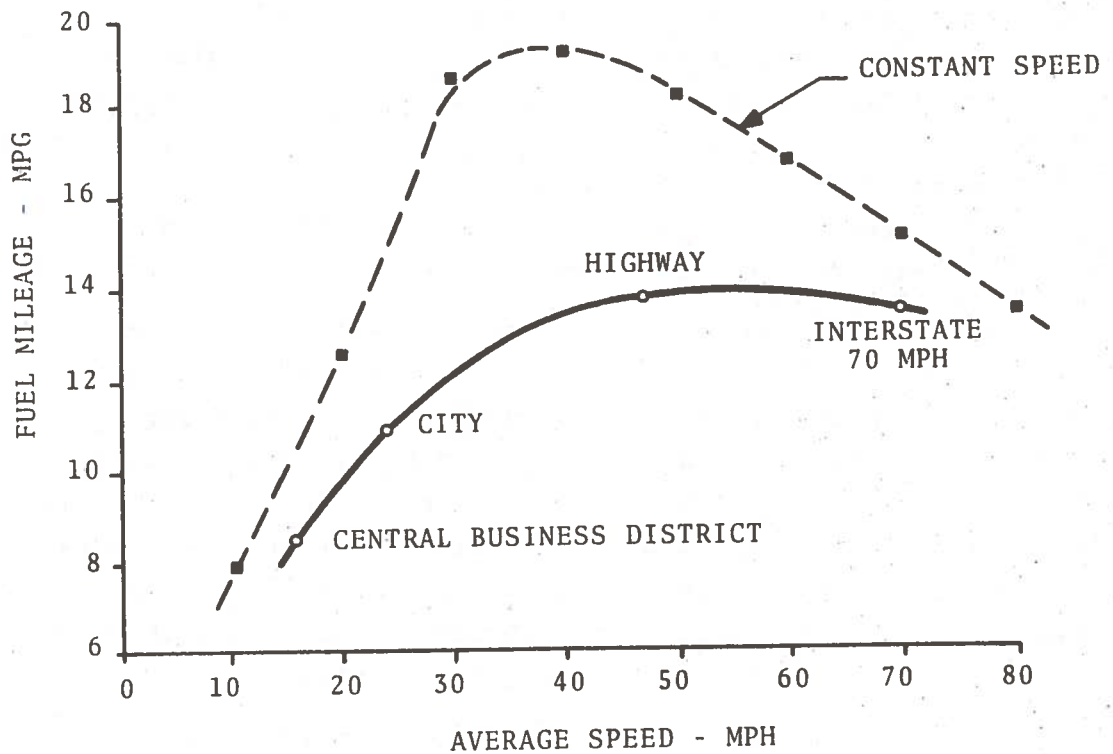
to be performed by the vehicle during the test (e.g., idles, acceleration, cruises, and decelerations). In this report, driving schedules have been classified according to their structure:

1) those that specify the vehicle speed on a second-by-second basis referred to as nonstylized (EPA Type); and 2) those that specify maneuvers at a certain distance or time referred to as stylized (SAE Type). Several of the driving schedules which were reviewed based their simulation on driving conditions encountered in a specific demographic location; e.g., urban, suburban, or central business district. Other driving schedules which were reviewed attempted to simulate the conditions encountered while driving on a specific road type; e.g., rural highways or interstates. The central business district driving schedules display low speeds, many stops, and substantial periods of engine idle. Urban driving schedules generally have lower speed than rural driving schedules, with less time and distance in the cruise mode and more in the acceleration, deceleration, and idle modes.

Actual driving exhibits a continued variation in vehicle speed with time.⁹ The auto industry has found that by straightening certain portions of the driving schedule (stylizing) the tests can be conducted on a test track rather than in a laboratory. The speed time profile of stylized driving schedule is broken into segments according to the mode of vehicle operation (i.e., acceleration, deceleration, cruise or idle). The result is a number of straight lines for the speed-time profile approximating the continuously changing "real life" speed-time trace.

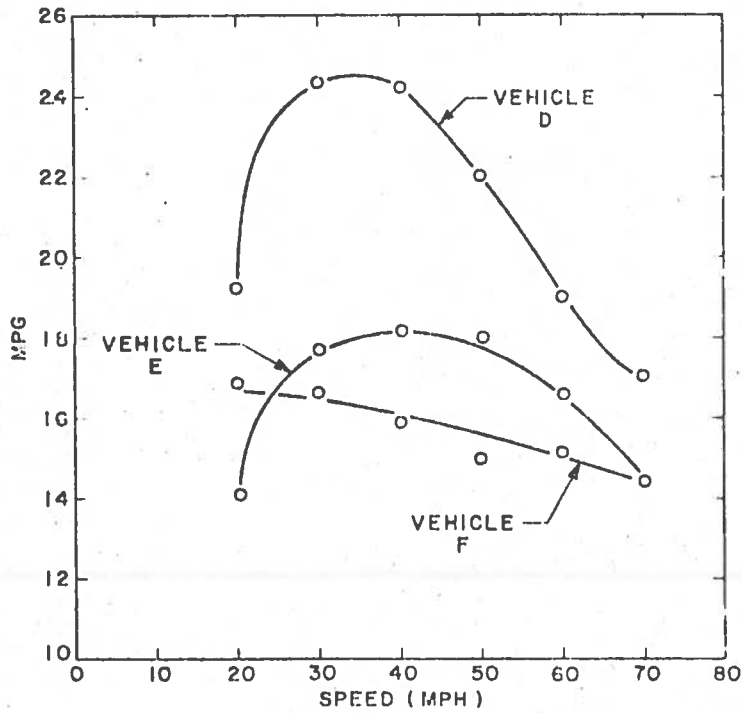
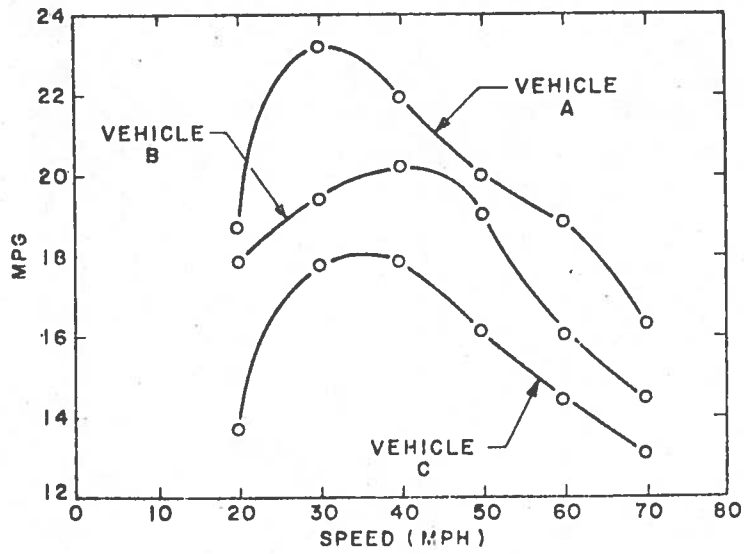
A significant difference in fuel economy exists between a steady or constant-speed fuel economy and the fuel economy experience by a vehicle performing a driving schedule with the same average speed. Figure 3-2 is an illustration of this difference obtained by the General Motors Corp. on a 1973 full size car. (The Central Business District, City, Highway and Interstate driving schedules are discussed in Section 4.) Not only is the fuel economy over the various driving schedules different, individual vehicles have unique speed-fuel economy relationships.

Figure 3-3 presents constant speed fuel economy for six different vehicles and illustrates the variability of constant speed fuel economy between various vehicles.



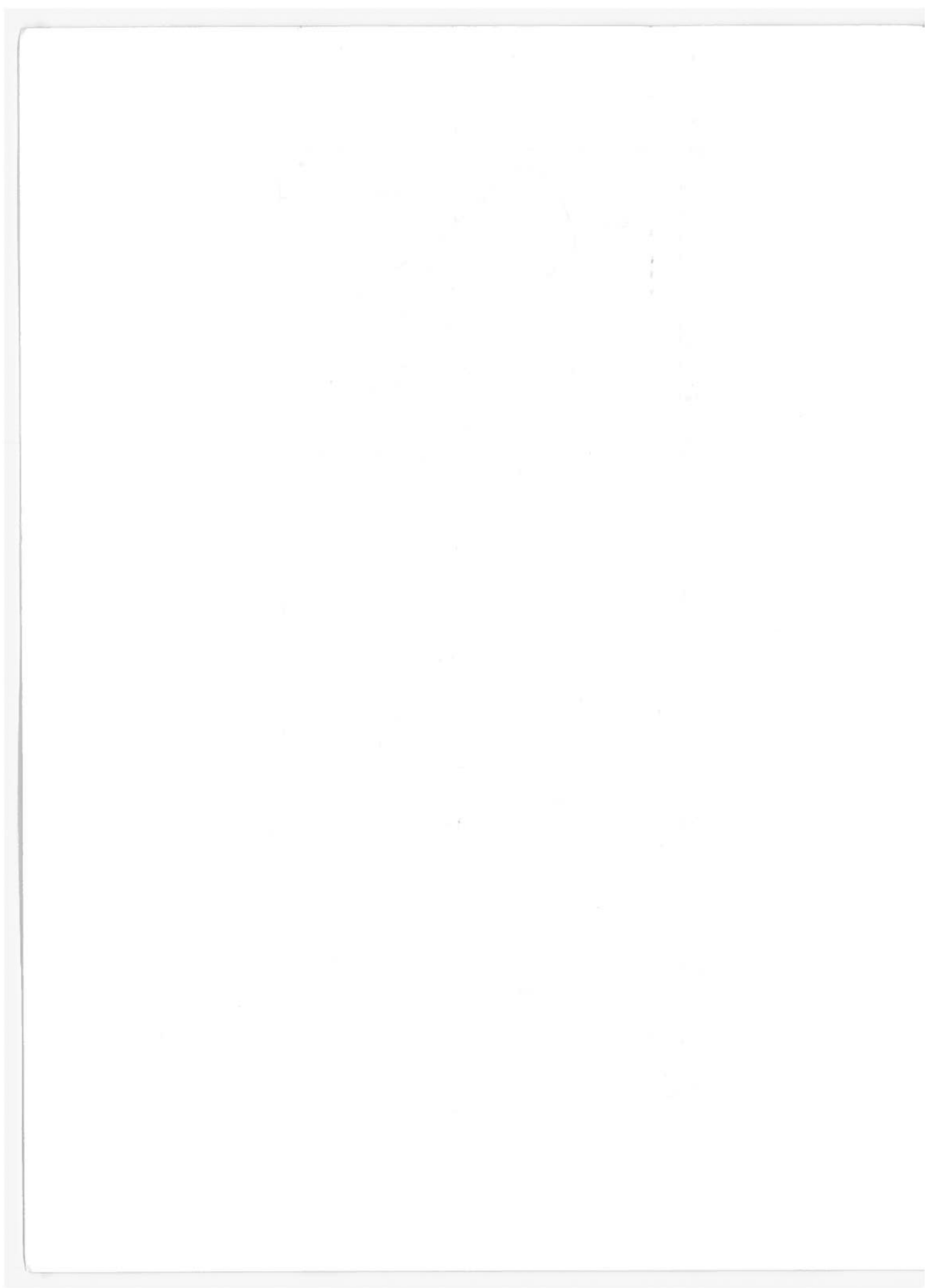
Source: Reference 10

Figure 3-2 Typical Fuel Economy Results - 1973 GM Full Sized Car Constant Speed versus Driving Schedule Average Speed



Source: Reference 4

Figure 3-3 Constant Speed Fuel Economy for Six Different Automobiles



4. DRIVING SCHEDULE ANALYSIS

4.1 ANALYSIS APPROACH AND PARAMETER EVALUATORS

The analysis of automotive test procedure driving schedules was initiated by identifying known test procedures and obtaining copies of the relevant portions. Upon visual inspection of the driving schedules obtained, two distinct schedule types were evident: 1) a nonstylized second-by-second specification of vehicle speed; e.g., EPA Federal Test Procedure (FTP); and 2) a stylized specification of maneuver of time-speed variations, as typified by the Society of Automotive Engineers (SAE) driving schedules. Figures 4-1 and 4-2 illustrate nonstylized and stylized driving schedules. Appropriate computer software was written to permit computer simulation of the drive schedules with analysis and plotting subroutines. Specific parametric evaluators include:

1. Distance - Total schedule distance in miles.
2. Time - Overall elapsed time in seconds of the schedule.
3. Mean Speed - Speed obtained by dividing the total schedule distance by the total elapsed time.
4. Maximum Speed - Maximum speed specified during the schedule.
5. Number of Stops - Total number of times the vehicle comes to rest (0 MPH) from a speed greater than zero (0 MPH).
6. Stops/Miles - Average number of times a vehicle comes to a rest in traveling one mile. (Total number of stops divided by total schedule distance).
7. Number of Idles - Total number of times the vehicle remains at rest (0 MPH) for more than one second.
8. Mode - Vehicle kinematic condition; acceleration, deceleration, cruise, and idle.

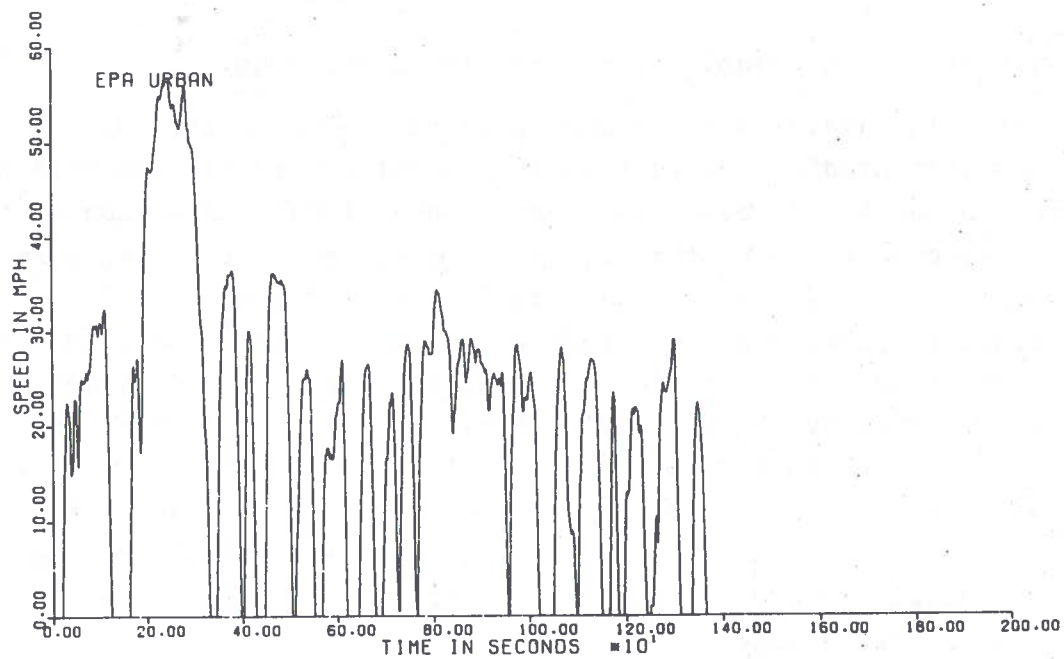


Figure 4-1 Non-Stylized Driving Schedule - EPA-Federal Test Procedure; Speed-Time

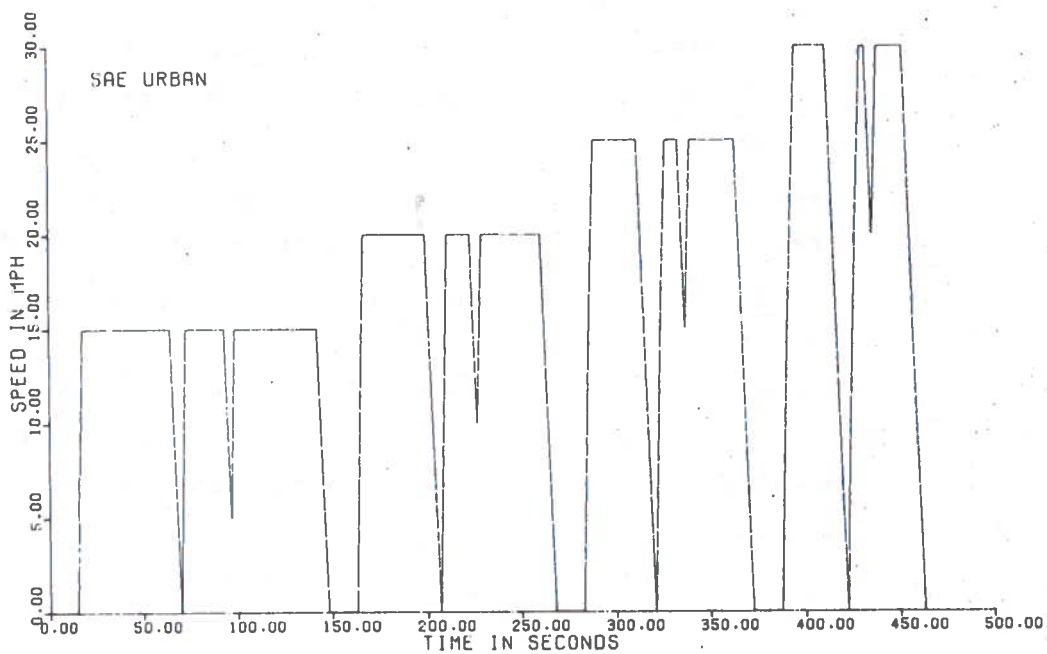


Figure 4-2 Stylized Driving Schedule - SAE Urban J1082; Speed-Time

9. Percent Time - Ratio of the amount of time the vehicle spends while in a specific mode to the total elapsed time of the schedule. The ratio is multiplied by 100 to give the percentage.
10. Percent Distance Traveled - Ratio of the amount of distance the vehicle travels while in a specific mode to the total distance. The ratio is multiplied by 100 to give a percentage figure.

Seven different plots of each driving schedule were obtained (see the appendixes): 1) vehicle speed versus time, 2) vehicle acceleration versus time, 3) vehicle speed versus accumulated distance, 4) vehicle various speed intervals, 5) percent distance in various speed intervals, and 6) vehicle acceleration versus instantaneous vehicle speed.

The values and plots obtained for the various parameters describe the aspects of vehicle operation on the driving schedule but give little hint as to the energy expended or fuel used by a vehicle executing the schedule. To obtain information of this type, a vehicle simulation model must be employed. Although these vehicle simulation models may be a worthy endeavor, it is beyond the scope of this work to evaluate the expected fuel consumption of a vehicle driving these various schedules.

4.2 ANALYSES RESULTS

The driving schedules obtained and analyzed in this work are divided into four categories by travel or schedule characteristics:

1. Urban
2. Suburban
3. Highway/Interstate
4. Other

4.2.1 Urban Driving Schedules

An urban driving schedule attempts to simulate driving conditions encountered by trip in an urban or metropolitan area. The Federal Government employs the term "urban" for cities whose population exceeds 5,000 and urbanized for cities with population greater than 50,000.¹¹ Within a city, especially our larger metropolitan centers, several distinct areas can be readily identified and defined. The Central Business District (CBD) is defined as the high-density commercial and business core of the city, and the Central City (CC) is the area within the incorporated limits of the city other than the CBD.¹² Urban driving is generally characterized by short trip length and low average speeds with frequent stops and substantial periods of engine idle. Urban driving represents the most dynamic change in travel characteristics relative to the time of day (peak period versus off-peak period). Urban interstate driving may be free-flowing in off-peak hours, but approach CBD street characteristics as roadways become congested in peak period.

Seven urban driving schedules were analyzed; six are stylized maneuver-by-maneuver driving schedules, and one, the EPA-FTP is a continuous, second-by-second speed-time sequence. Table 4-1 is a summary of characteristics of these driving schedules.

As shown in Table 4-1, the average schedule distance is 3.5 miles with a range from 0.8 miles to 7.5 miles for the urban driving schedules. The mean speed range is from 15.6 to 21.2 MPH with a mean of means equal to 17.3 MPH. The stops per mile range from 1.2 to 5.5 with a mean of 3.9. These values represent, in a general sense, the description of urban travel; namely, low average speed with several stops, substantial periods of engine idle, and short trip distances.

Four of the driving schedules in Table 4-1 are taken from the test procedures of the major U.S. auto manufacturers. These test procedures are utilized in vehicle tests conducted by the manufacturers. The Society of Automotive Engineers (SAE) formulated their test procedure (J1082) specifically for fuel economy

TABLE 4-1 CHARACTERISTICS OF VARIOUS URBAN DRIVING SCHEDULES

Parameter	Schedule							Mean or Mean of Means for All Urban Driving Schedules
	EPA FTP	SAE Urban	GM Business District	Ford City	AMC City	Chrysler Urban	California ARB 7-Mode	
Distance (mile)	7.5	2.0	2.0	3.6	4.6	4.6	0.8	3.5
Time (sec)	1372	462	452	799	1019	1027	157	753
Mean Speed (MPH)	19.5	15.6	16.1	16.3	16.4	16.2	21.2	17.3
Max. Speed (MPH)	56.7	30.0	30.0	30.0	35.0	35.0	50.0	38.1
Number Of:								
Idles	15	4	4	6	23	24	1	11
Stops	17	8	8	20	24	24	1	14.6
Stops/Mile	2.3	4.0	3.9	5.5	5.2	5.2	1.2	3.9
Percent Time In:								
Idle	17.8	13.0	13.3	18.8	15.8	16.4	14.6	15.7
Cruise	7.9	58.2	63.8	50.1	34.2	34.8	22.3	38.8
Acceleration	39.6	11.4	10.6	18.8	31.2	30.5	31.1	24.7
Deceleration	34.7	17.4	12.3	12.3	18.7	18.3	32.1	20.8
Percent Distance In:								
Cruise	11.9	75.2	81.5	76.3	58.1	59.3	23.6	55.1
Acceleration	46.6	10.2	8.5	13.7	26.2	25.5	39.5	24.3
Deceleration	41.5	14.5	10.0	10.0	15.7	15.3	36.9	20.6

tests based upon the "best" technical judgment of the industry. The EPA-Federal Test Procedure (FTP) driving schedule is used in the exhaust emission certification of new motor vehicles and is based upon field work performed in Los Angeles.⁹ Recently, (1974 and 1975 model years) EPA has used the FTP driving schedule in determining the fuel economy of vehicles undergoing emission certification. Appendix A presents a detailed discussion of each urban driving schedule.

4.2.2 Suburban Driving Schedules

A suburban driving schedule attempts to simulate driving conditions encountered in a trip in a "suburban" environment. A difficulty arises from the fact that the Federal Government does not recognize the term suburban, and hence does not obtain or tabulate any information on locations defined as suburban. A suburban driving schedule has been described as a particular form of drive schedule having a prescribed set of stops, starts, accelerations, and decelerations used in the automotive testing practice and not explicitly defined.¹³ Suburban driving schedules appear to be an intermediary step between urban schedules (characterized by low speed, many stops per mile) and highway/interstate schedules (characterized by high speed, few if any stops per mile). Table 4-2 is a summary presentation of the characteristics of the four suburban drive schedules analyzed.

The SAE, Ford, and AMC suburban driving schedules are similar. The GM suburban driving schedule has an average speed of about 18 MPH less than the others (42 MPH versus 24 MPH) and a stop per mile figure of 1.6 versus approximately 0.5. Appendix B presents a complete discussion on each of the suburban driving schedules.

4.2.3 Highway/Interstate Driving Schedule

A highway/interstate driving schedule attempts to approximate the conditions encountered in driving on a highway. It is important to note that this category of driving schedule is defined for

TABLE 4-2 CHARACTERISTICS OF VARIOUS SUBURBAN DRIVING SCHEDULES

Parameter	Schedule				Mean or Mean of Means for All Suburban Driving Schedules
	SAE Suburban	Ford Suburban	AMC Suburban	GM Suburban	
Distance (mile)	5.2	5.2	5.2	3.7	4.8
Time (sec)	455	438	444	564	475
Mean Speed (MPH)	41.2	42.7	42.4	23.9	37.5
Max. Speed (MPH)	60.0	60.0	60.0	40.0	55.0
Number of:					
Idles	2	2	2	3	2.2
Stops	2	2	3	6	3.2
Stops/Mile	0.4	0.4	0.6	1.6	0.7
Percent Time In:					
Idle	3.1	1.4	1.4	13.3	4.8
Cruise	75.2	81.6	80.5	59.9	74.3
Acceleration	11.3	11.7	11.5	10.6	11.3
Deceleration	10.5	5.4	6.6	16.2	9.7
Percent Distance In:					
Cruise	83.2	86.6	86.1	77.9	83.4
Acceleration	9.3	9.3	9.2	8.1	9.0
Deceleration	7.5	4.1	4.7	14.1	7.6

a specific type of roadway, whereas urban and suburban are defined by demographic location. A highway is defined as a public way whose purpose is vehicular travel connecting major population centers and/or traffic generators.¹⁴ An interstate roadway has a similar definition, but is considered to be the highest functional class of roadway with full access control in both the rural and urban locations.

Driving on a highway or interstate is characterized by moderate to high speed, little or no idling, and few, if any, stops. Usually most of the driving is for intercity trip purposes, and the objective is to cover the given distance in the shortest time period feasible.

The six highway/interstate driving schedules analyzed can be classified into two distinct sub-categories: those with an average speed of about 50 MPH and those with an average speed of 70 mph. Table 4-3 is a summary presentation of the characteristics of the highway/interstate driving schedules. The mean speed range is from 48 MPH to 70 MPH with a mean of means equal to 58 MPH. The stops per mile range from 0.0 to 0.3 with a mean of 0.1 stops per mile. The percent time in cruise for the stylized drive schedules ranges from 51.5 to 83.1 percent, whereas with the nonstylized drive schedule (EPA Highway), 16.6 percent of the time is in a cruise mode. Appendix C presents a complete discussion of the highway/interstate driving schedules. It should be noted that the EPA Highway Schedule and the SAE Interstate 55 MPH Schedule were devised in response to the imposition of the nationwide 55 MPH maximum speed limit in the winter of 1974.

4.2.4 Other Driving Schedules

Four additional driving schedules could not be categorized with any of the previous schedules. These driving schedules maintain a specific uniqueness that requires a separate category. This category termed "other" includes the following:

1. Chrysler Constant Speed/Road Load Driving Schedule
2. EPA 25 MPH Average Speed Driving Schedule

TABLE 4-3 CHARACTERISTICS OF VARIOUS HIGHWAY/INTERSTATE DRIVING SCHEDULES

Parameter	Schedule						Mean or Means of Means For All Highway/ Interstate Driving Schedules
	EPA Highway	SAE Interstate 55 MPH	SAE Interstate 70 MPH	GM Highway	GM Interstate	Chrysler Interstate	
Distance (Miles)	10.2	4.7	4.7	15.0	15.0	18.7	11.4
Time (sec)	759	308	242	1108	767	1154	723
Mean Speed (MPH)	48.6	55.0	70.0	48.6	70.4	58.3	58.5
Max. Speed (MPH)	59.9	60.0	75.0	70.0	75.0	75.0	69.2
Number of:							
Idles	0	0	0	3	0	0	0.5
Stops	1	0	0	4	1	0	1.0
Stops/Mile	0.1	0.0	0.0	0.3	0.1	0.0	0.1
Percent Time In:							
Idle	0.0	0.0	0.0	2.7	0.0	0.0	0.4
Cruise	16.6	61.9	51.5	58.1	83.1	59.3	55.1
Acceleration	44.3	19.1	24.3	19.0	6.4	20.3	22.2
Deceleration	39.0	19.1	24.3	20.2	10.6	20.3	22.3
Percent Distance In:							
Cruise	18.0	61.9	51.5	68.4	85.8	58.2	57.3
Acceleration	43.2	19.1	24.3	14.6	5.0	20.9	21.2
Deceleration	38.8	19.1	24.3	17.1	9.2	20.9	21.6

3. EPA 35 MPH Average Speed Driving Schedule

4. EPA 45 MPH Average Speed Driving Schedule

The Chrysler Constant Speed driving schedule is a cruise mode driving schedule used for measuring fuel economy at various cruise speeds. The fuel consumed for each cruise speed from 20 MPH to 80 MPH is recorded. Further investigation is required to determine the usefulness of using a variety of cruise speeds in conjunction with weighting factors to depict the fuel economy of a vehicle under any driving condition.

The remaining three schedules are semistylized driving schedules developed for the EPA by Scott Research Laboratories.¹⁵ The intent of the work was to update curves that are used to estimate the changes in emissions for light-duty vehicles as the average route speeds vary. Appendix D presents further information concerning these driving schedules. Table 4-4 is a summary presentation of the characteristics of the "other" driving schedules.

TABLE 4-4 CHARACTERISTICS OF VARIOUS "OTHER" DRIVING SCHEDULES

Parameter	Schedule			
	Chrysler Constant Speed	EPA 25 MPH	EPA 35 MPH	EPA 45 MPH
Distance (mile)	32.7	9.3	15.2	19.9
Time (sec)	2884	1377	1572	1589
Mean Speed (MPH)	40.8	24.4	34.9	45.1
Max. Speed (MPH)	80.0	60.0	60.0	60.0
Number of:				
Idles	0	15	9	6
Stops	0	14	8	5
Stops/Mile	0.0	1.5	0.5	0.3
Percent Time in:				
Idle	0.0	15.8	7.4	3.7
Cruise	100.0	37.8	54.4	67.8
Acceleration	0.0	26.6	21.9	15.3
Deceleration	0.0	20.7	16.8	13.5
Percent Distance in:				
Cruise	100.0	56.7	70.8	77.3
Acceleration	0.0	24.7	16.4	11.9
Deceleration	0.0	18.6	12.8	10.8



Scale 1/4" = 1'-0"



Scale 1/4" = 1'-0"



Scale 1/4" = 1'-0"

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Essential elements of any automotive test procedure are the driving cycle and the driving schedule. A major prerequisite of any automobile fuel economy test procedure is the relationship which the driving cycle and driving schedule have to actual conditions and operations in normal or typical vehicle use and operations. Individual, discrete trips and aggregate travel statistics are a measure of vehicle use that can be utilized in driving cycle and driving schedule evaluation and development. The three major groupings of driving schedules which were evaluated, urban, suburban, and highway/interstate, are based on demographic location and road type, with suburban being an undefined term. The major difference between a stylized and a nonstylized driving schedule appears to be in the test procedure itself, whether it is a track test or a dynamometer test. The nonstylized driving schedule is extremely difficult to perform on a track, whereas the stylized driving schedule may be utilized in either test. From the evaluation completed, no single parametric evaluator appears to describe adequately the entire driving schedule. Thus, any future driving schedule development will be required to use multiple descriptors of actual vehicle operation. It is concluded that most of the driving schedules analyzed had little or no direct correlation with field data of vehicle operation. The exceptions are the EPA-FTP and Highway Schedules, which do have supporting material available in the open literature.* The driving schedules used by the auto manufactures seem to be based on engineering judgment since no supporting documentation could be identified. This aspect does not necessarily reduce the usefulness of these driving schedules for individual vehicle test that the manufactures perform, but this fact does severely limit the applicability of these test results to national scale policy decision.

*Since the time of this work, the General Motors Corporation has published the results of their field study on vehicle use and operation.¹⁶

5.2 RECOMMENDATIONS

The principal recommendation is that driving schedules that may be developed in the future be directly correlated to actual vehicle operation and use. If the results of individual vehicle tests are to be of significance on a national scale, this correlation is mandatory. It is recommended that driving schedules be based on: 1) a total trip concept; e.g., typical urban trip, or 2) specific road type; e.g., rural interstates. It is recommended that "Suburban" driving schedules not be used.

For the development of advanced automobile test procedures, it is clearly evident that a concerted effort must be undertaken to better define vehicle use and operation in the United States. This can be approached by aggregating information on individual, discrete trips to a level where specific trip characteristics are readily discernable. Likewise, nationwide aggregate travel statistics must be disaggregated to a level compatible with the trip statistics. These two tasks are closely related and must be undertaken simultaneously. The goal of this effort would be the "fleshing out" of the driving schedule tree shown in Figure 5-1. Test procedures require, at a minimum, driving schedules for the urban trip, rural trip, and, possibly, specific road types. Since traffic conditions and vehicle design attributes are long-term dynamic entities, occasional updating of driving schedule data bases must occur.

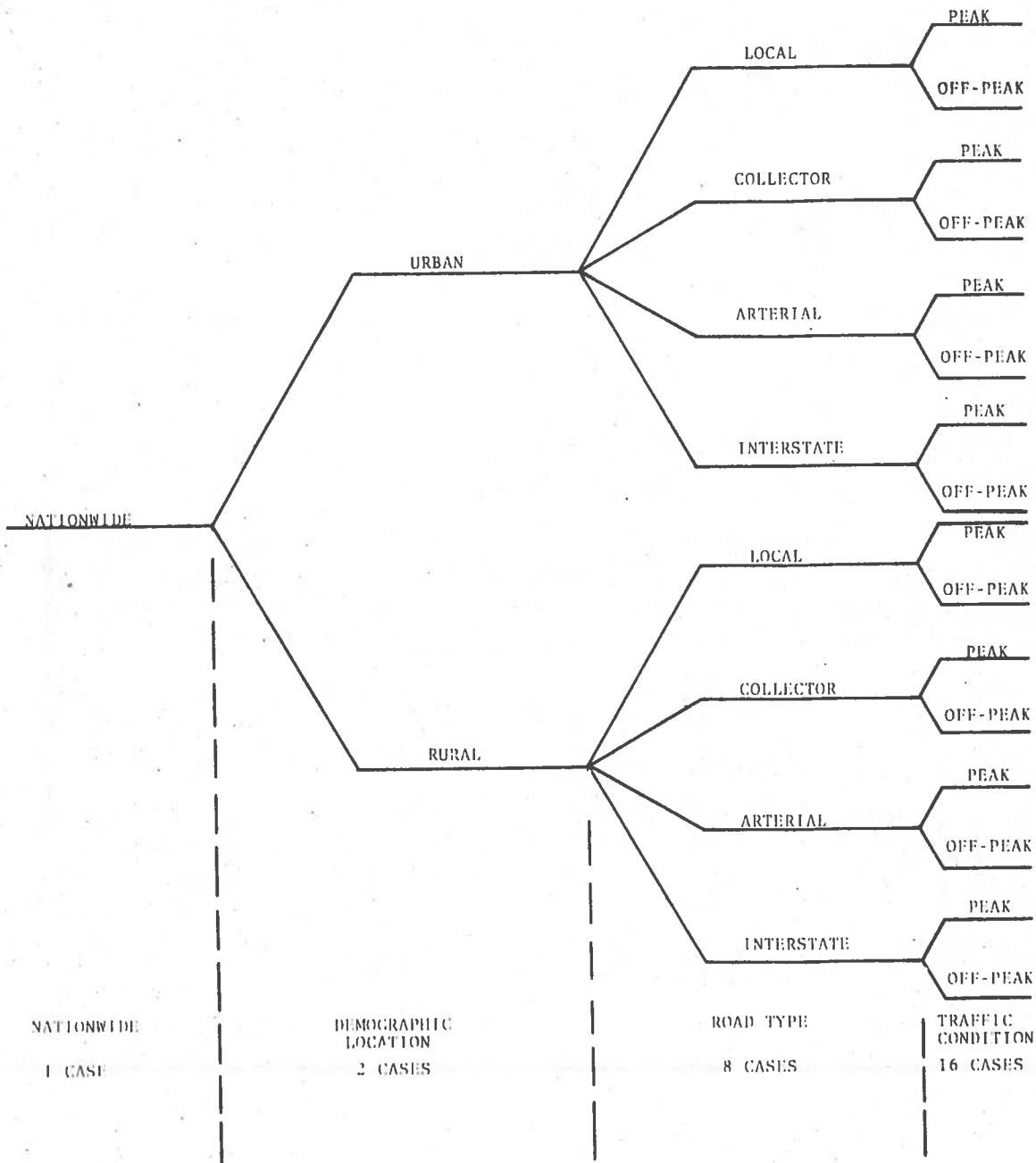
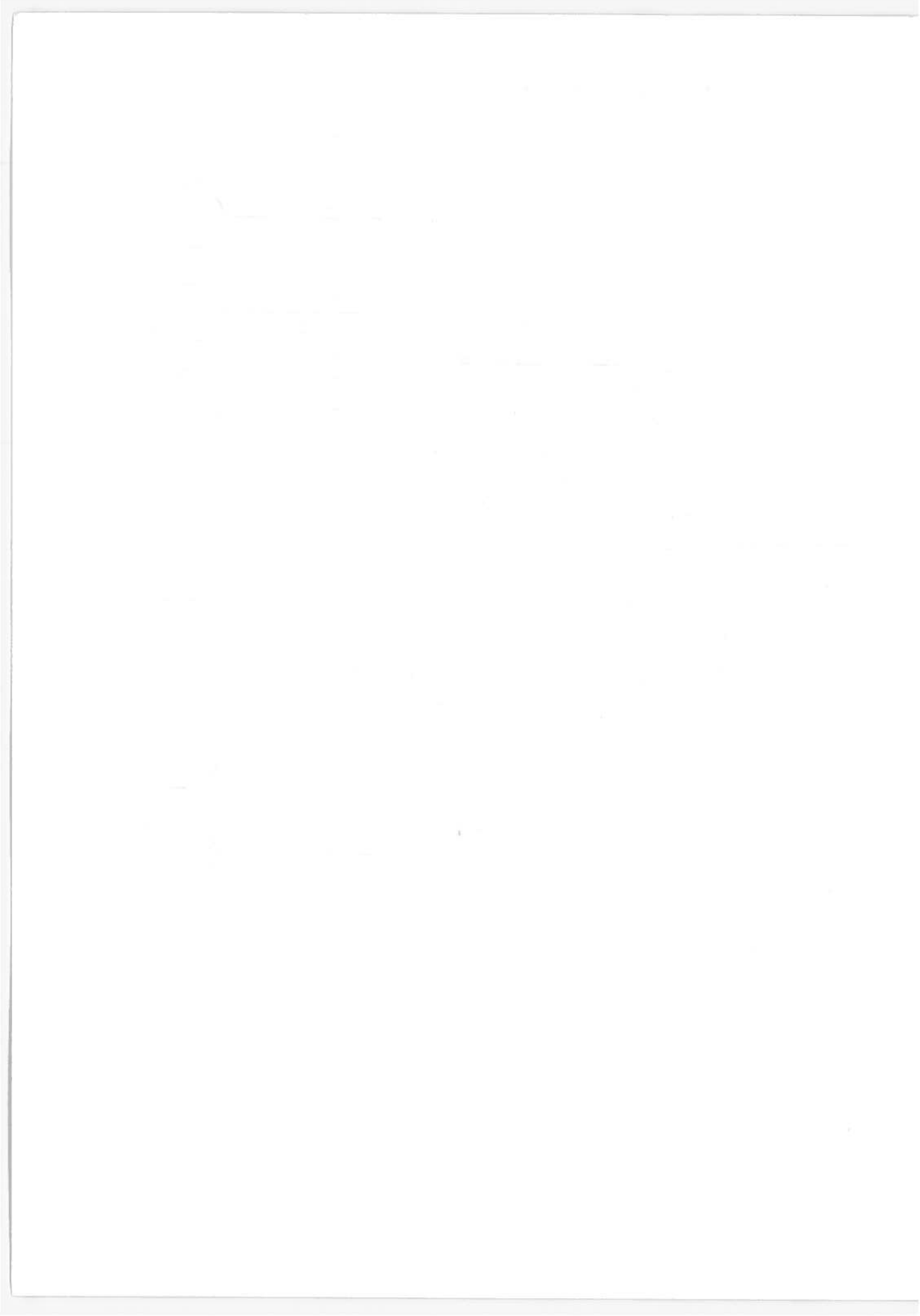


Figure 5-1 Suggested Levels for Test Procedure Driving Schedule Development



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Dear Sir,

I have the honor to acknowledge the receipt of your letter of the 14th inst.

and in reply to inform you that the same has been forwarded to the proper authorities.

I am, Sir, very respectfully,
Yours truly,
J. H. [Name]

[Address]

[Address]

[Address]

[Address]

[Address]

APPENDIX A

URBAN DRIVING SCHEDULES

An urban driving schedule attempts to approximate the driving condition within a large city. The DOT/FHWA study¹¹ defines an urban environment based on population level (as compared to density level). FHWA maintains that an urban environment exists if the population level exceeds 5000.

The driving schedule for an urban area is characterized by low average speeds, frequent stops, and several idling periods (see Table A-1). There is little, if any, highway type driving associated with the urban driving schedule, and the maximum speed that the vehicle attains is low, in most cases less than 35 MPH. The driving schedule can be either a continuous speed-time trace or a stylized schedule. In either case, the vehicle changes speed frequently.

The urban driving schedules analyzed are summarized in Table A-1 and include the following:

1. Environmental Protection Agency's FTP Urban Driving Schedule.
2. Society of Automotive Engineers Urban Driving Schedule - J1082.
3. General Motors Corporation's Central Business District Driving Schedule.
4. Ford Motor Company's Ford City Economy Driving Schedule.
5. Chrysler Corporation's Urban/Hot Start Driving Schedule.
6. American Motors Corporation City Driving Schedule.
7. California ARB 7-Mode Driving Schedule.

TABLE A-1 CHARACTERISTICS OF VARIOUS URBAN DRIVING SCHEDULES

Parameter	Schedule							Mean or Mean of Means for All Urban Driving Schedules
	EPA FTP	SAE Urban	GM Business District	Ford City	AMC City	Chrysler Urban	California ARB 7-Mode	
Distance (mile)	7.5	2.0	2.0	3.6	4.6	4.6	0.8	3.5
Time (sec)	1372	462	452	799	1019	1027	137	753
Mean Speed (MPH)	19.5	15.6	16.1	16.3	16.4	16.2	21.2	17.3
Max. Speed (MPH)	56.7	30.0	30.0	30.0	35.0	35.0	50.0	38.1
Number Of:								
Idles	15	4	4	6	23	24	1	11
Stops	17	8	8	20	24	24	1	14.6
Stops/Mile	2.3	4.0	3.9	5.5	5.2	5.2	1.2	3.9
Percent Time In:								
Idle	17.8	13.0	13.3	18.8	15.8	16.4	14.6	15.7
Cruise	7.9	58.2	63.8	50.1	34.2	34.8	22.3	58.8
Acceleration	39.6	11.4	10.6	18.8	31.2	50.5	31.1	24.7
Deceleration	34.7	17.4	12.3	12.3	18.7	18.3	32.1	20.8
Percent Distance In:								
Cruise	11.9	75.2	81.5	76.3	58.1	59.3	23.6	55.1
Acceleration	46.6	10.2	8.5	13.7	26.2	25.5	59.5	24.3
Deceleration	41.5	14.5	10.0	10.0	15.7	15.5	36.9	20.6

Characteristics of each schedule are displayed by seven plots: Speed versus Time, Acceleration versus Time, Speed versus Distance, Acceleration versus Distance, Percent Time by Speed Interval, Percent Distance by Speed Interval, and Acceleration versus Instantaneous Speed.

A.1 ENVIRONMENTAL PROTECTION AGENCY URBAN (FTP) DRIVING SCHEDULE

A.1.1 Description

The EPA urban driving schedule was developed from the accumulated field data obtained within a 12-mile radius of downtown Los Angeles. It is the result of more than 15 years of effort by various groups to translate the Los Angeles driving patterns to a driving schedule for vehicle dynamometer tests. The objective of these studies was to produce a driving schedule (representative of Los Angeles driving conditions) to evaluate motor vehicle exhaust emissions. The schedule consists of 1372 data points, plotted to give a continuous, speed-time profile. This nonstylized drive schedule is intended to be run with vehicles in a cold-start as well in a hot-start condition. Also, this schedule is used in the Federal Test Procedure (FTP) for certification of all new cars for exhaust emissions.¹⁷

The initial development of this schedule began with a 1956-1957 AMA-California traffic survey to determine how vehicles were driven in the greater Los Angeles area. There was a parallel study to determine baseline emissions and the amount of exhaust gas generated in each of the operating modes for each vehicle in service. The traffic survey established the 11 most important driving modes for exhaust emissions. The field survey determined the engine air consumption (exhaust flow) in each mode, and baseline vehicle emissions.¹⁸

The results of this work were calculated composite average emissions for highway vehicles in Los Angeles. The contributions from all modes were added to give the final number, and the contribution from each mode was equal to the measured concentration multiplied by a correction factor. The resultant quantity of emissions was then multiplied by a weighting factor representative of the percent of exhaust gas generated in that mode during

normal driving. The correction factor related the unburned hydrocarbons or carbon monoxide concentration to the carbon concentration in the exhaust gases. At a fixed flow rate, the concentration of emissions represents the quantity of emissions per unit time; the total carbon represents the rate of fuel use per unit time.

In February of 1964, the 11-mode schedule was simplified to the 7-mode schedule in order to establish a test schedule with more normal vehicle average speeds to provide for more normal thermal loading on exhaust treating systems.

Because the 7-mode driving schedule was not a schedule that an average driver ever used on the streets, a new test driving schedule was developed for use starting with the 1972 model year. This new test procedure involved not only a change in driving schedule, but also a change in measurement procedure from exhaust concentration to constant volume sampling measurement of true exhaust mass. The new driving schedule for constant volume sampling (CVS) was generated from the LA-4 route (see Figure A-1) put together from the L.A. County Highway Department traffic count survey of 1962-63.

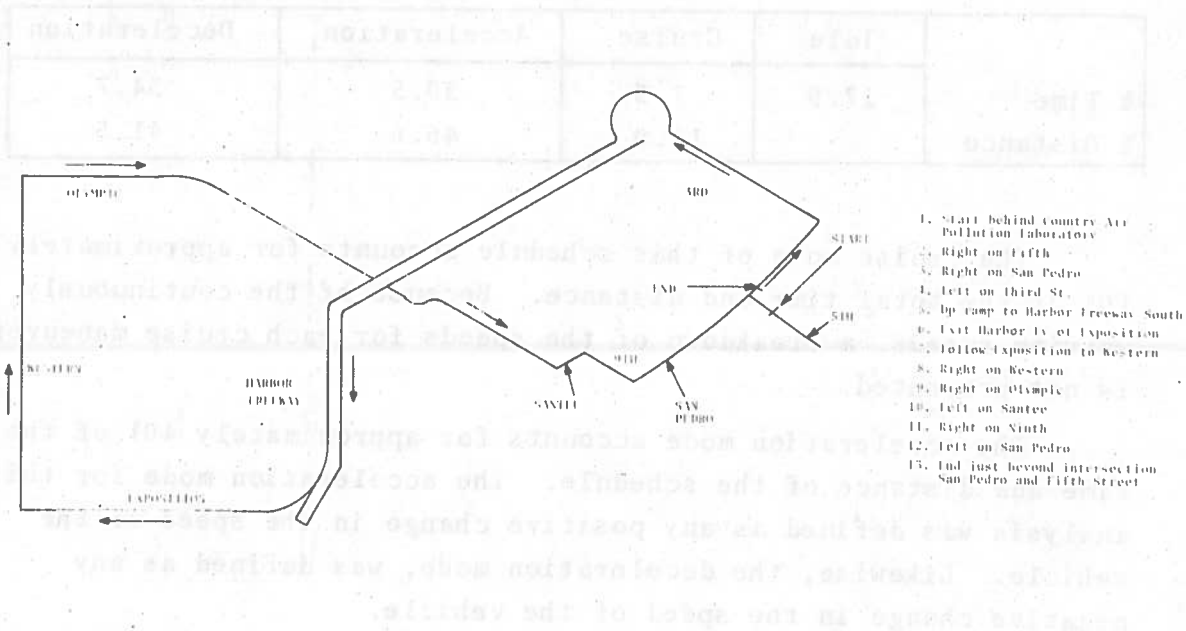


Figure A-1 Description of LA-4 Road Route

The LA-4 route with which EPA started was only a speed/time trace, so it was not possible to determine engine loads, grades, braking, etc., from the trace. The original route of about 12 miles was proportionately shortened to 7.5 miles (1,372 seconds) with some accelerations and decelerations modified in order to be within the capabilities of the Clayton Dynamometers being used for emissions testing. Although this schedule contains idle, freeway, arterial, and central business district driving, it is heavily weighted towards peak-period or rush hour driving, where admittedly emissions problems are greatest.

The FTP schedule has an average speed of 19.5 MPH, with a maximum speed of 56.7 MPH. The route is 7.5 miles long and takes 1372 seconds to complete. It has 16 idles and 17 stops, giving a figure of 2.3 stops per mile. The percent time and distance modes are shown in Table A-2.

TABLE A-2 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE EPA URBAN (FTP) DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	17.9	7.9	39.5	34.7
% Distance	-	11.9	46.6	41.5

The cruise mode of this schedule accounts for approximately 10% of the total time and distance. Because of the continuously varying speeds, a breakdown of the speeds for each cruise maneuver is not presented.

The acceleration mode accounts for approximately 40% of the time and distance of the schedule. The acceleration mode for this analysis was defined as any positive change in the speed of the vehicle. Likewise, the deceleration mode, was defined as any negative change in the speed of the vehicle.

A.1.2 Discussion

The EPA driving schedule was compiled from field data and is representative of rush hour conditions within the Los Angeles urbanized area for the route and period data were collected. The main aspect of the schedule is the speed variability. However, because of its constantly changing speed, it is thought to be only a useful schedule for dynamometer testing. With the dynamometer, a driver's aid is required for successful completion of the schedule. A modified schedule could be incorporated into a track test procedure. Modification, such as stylizing by straight-line curve fitting, may make the schedule usable in a track procedure. However, further sensitivity analyses are needed before any conclusions can be drawn.

A.1.3 EPA-FTP Urban Driving Schedule Instructions¹⁷

The instructions for the EPA-FTP Urban Driving Schedule are listed in Table A-3, and corresponding characteristics and profiles are shown in Figures A-2 through A-8.

TABLE A-3 EPA-FTP URBAN DRIVING SCHEDULE INSTRUCTIONS

Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)
0	0.0	49	22.7	98	29.5	147	0.0	196	36.2	245	56.5	294	50.1		
1	0.0	50	22.6	99	29.8	148	0.0	197	37.5	246	56.5	295	50.0		
2	0.0	51	21.5	100	30.3	149	0.0	198	39.5	247	56.5	296	49.6		
3	0.0	52	19.0	101	30.7	150	0.0	199	40.5	248	56.4	297	49.5		
4	0.0	53	17.1	102	30.9	151	0.0	200	42.1	249	56.1	298	49.5		
5	0.0	54	15.8	103	31.0	152	0.0	201	43.5	250	55.8	299	49.5		
6	0.0	55	15.8	104	30.9	153	0.0	202	45.1	251	55.1	300	49.1		
7	0.0	56	17.7	105	30.4	154	0.0	203	46.0	252	54.6	301	48.6		
8	0.0	57	19.8	106	29.8	155	0.0	204	46.8	253	54.2	302	48.1		
9	0.0	58	21.6	107	29.9	156	0.0	205	47.5	254	54.0	303	47.2		
10	0.0	59	23.2	108	30.2	157	0.0	206	47.5	255	53.7	304	46.1		
11	0.0	60	24.2	109	30.7	158	0.0	207	47.3	256	53.6	305	45.0		
12	0.0	61	24.6	110	31.2	159	0.0	208	47.2	257	53.6	306	43.8		
13	0.0	62	25.0	111	31.8	160	0.0	209	47.0	258	54.0	307	42.6		
14	0.0	63	24.6	112	32.4	161	0.0	210	47.0	259	54.1	308	41.5		
15	0.0	64	24.5	113	32.2	162	0.0	211	47.0	260	54.1	309	40.5		
16	0.0	65	24.5	114	32.2	163	0.0	212	47.0	261	53.8	310	38.5		
17	0.0	66	24.7	115	31.7	164	5.5	213	47.0	262	53.4	311	37.0		
18	0.0	67	24.8	116	28.6	165	9.9	214	47.2	263	53.0	312	35.2		
19	0.0	68	24.7	117	25.3	166	9.9	215	47.4	264	52.6	313	33.8		
20	0.0	69	24.6	118	22.0	167	13.2	216	47.9	265	52.1	314	32.5		
21	3.0	70	24.6	119	18.7	168	16.5	217	48.6	266	52.4	315	31.5		
22	5.9	71	25.1	120	15.4	169	19.8	218	49.1	267	52.0	316	30.6		
23	8.6	72	25.6	121	12.1	170	22.2	219	49.5	268	51.9	317	30.5		
24	11.5	73	25.7	122	8.8	171	24.5	220	50.0	269	51.7	318	30.0		
25	14.3	74	25.4	123	5.5	172	25.8	221	05.6	270	51.5	319	29.0		
26	16.9	75	24.9	124	2.2	173	26.4	222	51.0	271	51.6	320	27.5		
27	17.5	76	25.0	125	0.0	174	25.7	223	51.5	272	51.8	321	26.8		
28	18.1	77	25.4	126	0.0	175	25.1	224	52.1	273	52.1	322	25.5		
29	20.7	78	26.0	127	0.0	176	24.7	225	55.2	274	52.5	323	20.1		
30	22.4	79	26.0	128	0.0	177	25.0	226	54.1	275	53.0	324	19.1		
31	22.5	80	25.7	129	0.0	178	25.2	227	54.6	276	53.5	325	18.5		
32	22.5	81	26.1	130	0.0	179	25.4	228	54.9	277	54.0	326	17.0		
33	21.5	82	26.7	131	0.0	180	25.8	229	55.0	278	54.9	327	15.5		
34	20.9	83	27.5	132	0.0	181	25.8	230	54.9	279	55.4	328	12.5		
35	20.4	84	28.6	133	0.0	182	26.5	231	54.6	280	55.6	329	10.8		
36	19.8	85	29.5	134	0.0	183	24.0	232	54.8	281	56.0	330	8.0		
37	19.8	86	29.8	135	0.0	184	22.7	233	55.1	282	55.8	331	4.7		
38	14.9	87	30.1	136	0.0	185	19.4	234	55.5	283	55.2	332	1.4		
39	14.9	88	30.4	137	0.0	186	17.7	235	55.7	284	55.4	333	0.0		
40	15.2	89	30.7	138	0.0	187	17.2	236	55.7	285	55.6	334	0.0		
41	15.5	90	30.5	139	0.0	188	18.1	237	56.1	286	55.6	335	0.0		
42	15.5	91	30.7	140	0.0	189	18.6	238	56.5	287	55.6	336	0.0		
43	16.0	92	30.4	141	0.0	190	20.0	239	56.0	288	55.5	337	0.0		
44	17.1	93	30.3	142	0.0	191	22.2	240	56.7	289	55.7	338	0.0		
45	19.1	94	30.4	143	0.0	192	24.5	241	56.5	290	55.5	339	0.0		
46	21.1	95	30.8	144	0.0	193	27.5	242	56.5	291	55.5	340	0.0		
47	22.1	96	30.4	145	0.0	194	30.4	243	56.5	292	55.1	341	0.0		
48	22.9	97	29.9	146	0.0	195	35.5	244	56.5	293	50.0	342	0.0		

TABLE A-3 ETA-FTP URBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)
543	0.0	592	14.5	441	0.0	480	34.6	559	35.6	588	16.6	637	0.0
544	0.0	595	12.0	442	0.0	491	34.5	540	35.2	589	16.5	638	0.0
545	0.0	594	8.7	443	0.0	492	35.5	541	35.0	590	16.5	639	0.0
546	0.0	595	5.4	444	0.0	495	32.0	542	35.0	591	16.6	640	0.0
547	1.0	596	2.1	445	0.0	494	30.1	545	35.0	592	17.0	641	0.0
548	4.5	597	0.0	446	0.0	495	28.0	544	34.4	595	17.6	642	0.0
549	7.6	598	0.0	447	0.0	496	25.5	545	35.1	594	18.5	643	0.0
550	10.9	599	0.0	448	3.5	497	22.5	546	35.1	595	19.2	644	0.0
551	14.2	400	0.0	449	6.6	498	19.8	547	16.5	596	20.2	645	0.0
552	17.5	401	0.0	450	9.9	499	16.5	548	15.2	597	21.0	646	0.0
553	20.8	402	0.0	451	13.2	500	15.2	549	9.9	598	21.1	647	0.0
554	24.1	403	0.0	452	16.5	501	10.5	550	6.6	599	21.2	648	0.0
555	27.4	404	5.9	453	19.8	502	7.2	551	5.5	600	21.6	649	0.0
556	30.7	405	9.2	454	23.1	503	4.0	552	0.0	601	22.0	650	0.0
557	34.0	406	12.5	455	26.4	504	1.0	553	0.0	602	22.5	651	0.0
558	37.3	407	15.8	456	29.7	505	0.0	554	0.0	603	22.5	652	0.0
559	40.6	408	19.1	457	33.0	506	0.0	555	0.0	604	22.5	653	0.0
560	43.9	409	22.4	458	36.3	507	0.0	556	0.0	605	22.5	654	0.0
561	47.2	410	25.7	459	39.6	508	0.0	557	0.0	606	22.7	655	0.0
562	50.5	411	29.0	460	42.9	509	0.0	558	0.0	607	23.7	656	0.0
563	53.8	412	32.3	461	46.2	510	0.0	559	0.0	608	25.1	657	0.0
564	57.1	413	35.6	462	49.5	511	1.2	560	0.0	609	26.0	658	0.0
565	60.4	414	38.9	463	52.8	512	3.5	561	0.0	610	26.5	659	0.0
566	63.7	415	42.2	464	56.1	513	5.5	562	0.0	611	27.0	660	0.0
567	67.0	416	45.5	465	59.4	514	6.5	563	0.0	612	27.0	661	0.0
568	70.3	417	48.8	466	62.7	515	8.5	564	0.0	613	22.8	662	0.0
569	73.6	418	52.1	467	66.0	516	9.0	565	0.0	614	19.5	663	0.0
570	76.9	419	55.4	468	69.3	517	10.5	566	0.0	615	16.2	664	0.0
571	80.2	420	58.7	469	72.6	518	11.9	567	0.0	616	12.9	665	0.0
572	83.5	421	62.0	470	75.9	519	14.0	568	0.0	617	9.6	666	0.0
573	86.8	422	65.3	471	79.2	520	16.0	569	5.5	618	6.5	667	0.0
574	90.1	423	68.6	472	82.5	521	17.7	570	6.6	619	5.0	668	0.0
575	93.4	424	71.9	473	85.8	522	19.0	571	9.9	620	0.0	669	0.0
576	96.7	425	75.2	474	89.1	523	20.1	572	13.0	621	0.0	670	0.0
577	100.0	426	78.5	475	92.4	524	21.0	573	14.6	622	0.0	671	0.0
578	103.3	427	81.8	476	95.7	525	22.0	574	16.0	623	0.0	672	0.0
579	106.6	428	85.1	477	99.0	526	23.0	575	17.0	624	0.0	673	0.0
580	109.9	429	88.4	478	102.3	527	23.8	576	17.0	625	0.0	674	0.0
581	113.2	430	91.7	479	105.6	528	24.5	577	17.0	626	0.0	675	0.0
582	116.5	431	95.0	480	108.9	529	24.9	578	17.5	627	0.0	676	0.0
583	119.8	432	98.3	481	112.2	530	25.0	579	17.5	628	0.0	677	0.0
584	123.1	433	101.6	482	115.5	531	25.0	580	17.5	629	0.0	678	0.0
585	126.4	434	104.9	483	118.8	532	25.0	581	17.5	630	0.0	679	0.0
586	129.7	435	108.2	484	122.1	533	25.0	582	16.9	631	0.0	680	0.0
587	133.0	436	111.5	485	125.4	534	25.0	583	16.6	632	0.0	681	0.0
588	136.3	437	114.8	486	128.7	535	25.0	584	16.6	633	0.0	682	0.0
589	139.6	438	118.1	487	132.0	536	25.6	585	16.1	634	0.0	683	0.0
590	142.9	439	121.4	488	135.3	537	25.6	586	16.0	635	0.0	684	0.0
591	146.2	440	124.7	489	138.6	538	26.0	587	16.0	636	0.0	685	0.0

TABLE A-3 EPA-FTP URBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)
686	0.0	732	12.5	778	25.0	824	29.9	870	25.1	916	22.2	962	8.6		
687	0.0	733	14.0	779	26.5	825	29.9	871	25.5	917	21.6	963	11.9		
688	0.0	734	16.0	780	27.5	826	29.9	872	25.7	918	21.6	964	15.2		
689	0.0	735	18.0	781	28.0	827	29.9	873	26.2	919	21.7	965	17.5		
690	0.0	736	19.6	782	28.5	828	29.6	874	26.9	920	22.6	966	18.6		
691	0.0	737	21.5	785	28.9	829	29.5	875	27.5	921	23.4	967	20.0		
692	0.0	738	23.1	784	28.9	830	29.5	876	27.8	922	24.0	968	21.1		
693	0.0	739	24.5	785	28.8	831	29.5	877	28.4	923	24.2	969	22.0		
694	1.4	740	25.5	786	28.8	832	28.9	878	29.0	924	24.4	970	23.0		
695	3.5	741	26.5	787	28.5	833	28.2	879	29.2	925	24.9	971	24.5		
696	4.4	742	27.1	788	28.5	834	27.7	880	29.1	926	25.1	972	26.3		
697	6.5	743	27.6	789	28.5	835	27.0	881	29.0	927	25.2	973	27.5		
698	9.2	744	27.9	790	28.5	836	25.5	882	28.9	928	25.3	974	28.1		
699	11.3	745	28.5	791	28.5	837	23.7	883	28.5	929	25.5	975	28.4		
700	13.5	746	28.6	792	27.6	838	22.0	884	28.1	930	25.7	976	28.5		
701	14.6	747	28.6	793	27.5	839	20.5	885	28.0	931	25.0	977	28.5		
702	16.4	748	28.3	794	27.5	840	19.2	886	28.0	932	25.0	978	28.5		
703	16.7	749	28.2	795	27.5	841	19.2	887	27.6	933	25.0	979	27.7		
704	16.5	750	28.10	796	27.5	842	20.1	888	27.2	934	24.7	980	27.5		
705	16.5	751	27.5	797	27.5	843	20.9	889	26.6	935	24.5	981	27.2		
706	18.2	752	26.8	798	27.5	844	21.4	890	26.8	936	24.5	982	26.8		
707	19.2	753	25.5	799	27.5	845	22.0	891	27.5	937	24.5	983	26.5		
708	20.1	754	23.5	800	28.0	846	22.6	892	27.8	938	24.5	984	26.0		
709	21.5	755	21.5	801	28.5	847	24.0	893	28.0	939	25.0	985	25.2		
710	22.5	756	19.0	802	30.0	848	24.0	894	27.8	940	25.0	986	24.0		
711	22.5	757	16.5	803	31.0	849	25.0	895	28.0	941	24.6	987	24.0		
712	22.7	758	14.9	804	32.0	850	26.0	896	28.0	942	24.6	988	22.0		
713	22.7	759	12.5	805	33.0	851	26.0	897	28.0	943	24.1	989	21.5		
714	23.3	760	9.4	806	33.0	852	26.6	898	27.4	944	24.5	990	21.5		
715	23.5	761	6.2	807	33.6	853	26.8	899	27.4	945	24.5	991	21.8		
716	22.5	762	3.0	808	34.0	854	27.0	900	26.9	946	23.6	992	22.5		
717	21.6	763	15.0	809	34.5	855	27.2	901	26.6	947	23.1	993	23.0		
718	20.5	764	15.0	810	34.2	856	27.8	902	26.6	948	23.0	994	22.8		
719	18.0	765	0.5	811	34.0	857	28.1	903	26.5	949	22.0	995	22.8		
720	15.0	766	0.0	812	34.0	858	28.8	904	26.5	950	20.1	996	23.0		
721	12.0	767	3.0	813	33.9	859	28.9	905	26.5	951	16.9	997	22.7		
722	9.0	768	6.3	814	33.6	860	29.0	906	26.2	952	15.6	998	22.7		
723	6.2	769	9.6	815	33.1	861	29.1	907	26.2	953	10.5	999	22.7		
724	4.5	770	12.9	816	33.0	862	29.0	908	25.9	954	0	1,000	22.5		
725	3.0	771	15.8	817	32.5	863	28.1	909	25.6	955	0	1,001	24.0		
726	0.5	772	17.5	818	32.0	864	27.5	910	25.6	956	0.4	1,002	24.6		
727	0.5	773	18.4	819	31.9	865	27.0	911	25.6	957	0.4	1,003	24.8		
728	0.5	774	19.5	820	31.6	866	25.8	912	25.8	958	0.0	1,004	25.1		
729	3.2	775	20.7	821	31.5	867	25.0	913	25.5	959	0.0	1,005	25.5		
730	6.5	776	22.0	822	30.6	868	24.5	914	24.6	960	0	1,006	25.6		
731	9.6	777	23.2	823	30.0	869	24.8	915	25.5	961	0	1,007	25.5		

TABLE A-3 EPA-FTP URBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)
1,008	25.0	1,049	0.0	1,091	9.0	1,133	27.0	1,175	21.1	1,217	31.8	1,259	4.0
1,009	24.1	1,050	0.0	1,092	8.7	1,134	27.0	1,176	23.0	1,218	21.5	1,260	5.0
1,010	23.2	1,051	0.0	1,093	8.6	1,135	26.9	1,177	23.5	1,219	21.5	1,261	6.3
1,011	22.9	1,052	0.0	1,094	8.0	1,136	26.8	1,178	25.0	1,220	21.5	1,262	8.0
1,012	22.5	1,053	1.2	1,095	7.0	1,137	26.8	1,179	22.5	1,221	21.8	1,263	10.0
1,013	22.0	1,054	4.0	1,096	5.0	1,138	26.5	1,180	20.0	1,222	22.0	1,264	10.5
1,014	21.6	1,055	7.3	1,097	4.2	1,139	26.4	1,181	16.7	1,223	21.9	1,265	9.5
1,015	21.5	1,056	10.6	1,098	2.6	1,140	26.0	1,182	13.4	1,224	21.7	1,266	8.5
1,016	17.5	1,057	13.9	1,099	1.0	1,141	25.5	1,183	10.1	1,225	21.5	1,267	7.6
1,017	14.2	1,058	17.0	1,100	0.0	1,142	24.6	1,184	6.8	1,226	21.5	1,268	8.8
1,018	10.9	1,059	18.5	1,101	0.1	1,143	23.5	1,185	3.5	1,227	21.4	1,269	11.0
1,020	7.6	1,060	20.0	1,102	0.6	1,144	21.5	1,186	0.2	1,228	20.1	1,270	14.0
1,021	4.5	1,062	21.8	1,105	1.6	1,145	20.0	1,187	0.0	1,229	19.5	1,271	17.0
1,022	1.0	1,063	23.0	1,106	3.6	1,146	17.5	1,188	0.0	1,230	19.2	1,272	19.5
1,023	0.0	1,064	24.8	1,105	6.9	1,147	16.0	1,189	0.0	1,231	19.6	1,273	21.0
1,024	0.0	1,065	25.6	1,107	10.0	1,148	14.0	1,190	0.0	1,232	19.8	1,274	21.8
1,025	0.0	1,066	26.4	1,108	14.0	1,149	10.7	1,191	0.0	1,233	20.0	1,275	22.2
1,026	0.0	1,067	26.8	1,109	14.5	1,150	7.4	1,192	0.0	1,234	19.5	1,276	23.0
1,027	0.0	1,068	27.4	1,110	16.0	1,151	4.1	1,193	0.0	1,235	17.5	1,277	23.6
1,028	0.0	1,069	27.9	1,111	18.1	1,152	0.8	1,194	0.0	1,236	15.5	1,278	24.1
1,029	0.0	1,070	28.3	1,112	20.0	1,153	0.0	1,195	0.0	1,237	15.0	1,279	24.5
1,030	0.0	1,071	28.0	1,113	21.0	1,154	0.0	1,196	0.0	1,238	10.0	1,280	24.5
1,031	0.0	1,072	27.5	1,114	21.2	1,155	0.0	1,197	0.2	1,239	8.0	1,281	24.0
1,032	0.0	1,073	27.0	1,115	21.5	1,156	0.0	1,198	1.5	1,240	6.0	1,282	23.5
1,033	0.0	1,074	27.0	1,116	21.4	1,157	0.0	1,199	3.5	1,241	4.0	1,283	23.5
1,034	0.0	1,075	26.3	1,117	21.7	1,158	0.0	1,200	6.5	1,242	2.5	1,284	23.5
1,035	0.0	1,076	24.5	1,118	22.5	1,159	0.0	1,201	9.8	1,243	0.7	1,285	23.5
1,036	0.0	1,077	22.5	1,119	25.0	1,160	0.0	1,202	12.0	1,244	0.0	1,286	23.5
1,037	0.0	1,078	21.5	1,120	25.8	1,161	0.0	1,203	12.9	1,245	0.0	1,287	23.5
1,038	0.0	1,079	20.6	1,121	24.5	1,162	0.0	1,204	13.0	1,246	0.0	1,288	24.1
1,039	0.0	1,080	18.0	1,122	24.9	1,163	0.0	1,205	12.6	1,247	0.0	1,289	24.1
1,040	0.0	1,081	15.0	1,123	24.8	1,164	0.0	1,206	12.8	1,248	0.0	1,290	24.5
1,041	0.0	1,082	12.3	1,124	24.9	1,165	0.0	1,207	15.1	1,249	0.0	1,291	24.7
1,042	0.0	1,083	11.1	1,125	24.8	1,166	0.0	1,208	15.1	1,250	0.0	1,292	25.0
1,043	0.0	1,084	10.6	1,126	24.8	1,167	0.0	1,209	14.0	1,251	0.0	1,293	25.4
1,044	0.0	1,085	10.0	1,127	25.4	1,168	0.0	1,210	15.5	1,252	1.0	1,294	25.6
1,045	0.0	1,086	9.5	1,128	25.8	1,169	2.1	1,211	17.0	1,253	1.0	1,295	25.7
1,046	0.0	1,087	9.1	1,129	26.4	1,170	5.4	1,212	18.6	1,254	1.0	1,296	26.0
1,047	0.0	1,088	8.7	1,130	26.4	1,171	8.7	1,213	19.7	1,255	1.0	1,297	26.2
1,048	0.0	1,089	8.6	1,131	26.6	1,172	12.0	1,214	21.0	1,256	1.0	1,298	27.0
1,048	0.0	1,090	8.8	1,132	26.9	1,173	15.3	1,215	21.5	1,257	1.6	1,299	27.8
				1,132	27.0	1,174	18.6	1,216	21.8	1,258	3.0	1,300	28.3

TABLE A-3 EPA-FTP URBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)	Time (sec.)	Speed (m.p.h.)
1,501	29.0	1,546	19.5										
1,502	29.1	1,547	20.5										
1,503	29.0	1,548	21.3										
1,504	28.0	1,549	21.9										
1,505	24.7	1,550	22.1										
1,506	21.4	1,551	22.4										
1,507	18.1	1,552	22.0										
1,508	14.8	1,553	21.6										
1,509	11.5	1,554	21.1										
1,510	8.2	1,555	20.5										
1,511	4.9	1,556	20.0										
1,512	1.6	1,557	19.6										
1,513	0.0	1,558	18.5										
1,514	0.0	1,559	17.5										
1,515	0.0	1,560	16.5										
1,516	0.0	1,561	15.5										
1,517	0.0	1,562	14.0										
1,518	0.0	1,563	11.0										
1,519	0.0	1,564	8.0										
1,520	0.0	1,565	5.2										
1,521	0.0	1,566	2.5										
1,522	0.0	1,567	0.0										
1,523	0.0	1,568	0.0										
1,524	0.0	1,569	0.0										
1,525	0.0	1,570	0.0										
1,526	0.0	1,571	0.0										
1,527	0.0	1,572	0.0										
1,528	0.0												
1,529	0.0												
1,530	0.0												
1,531	0.0												
1,532	0.0												
1,533	0.0												
1,534	0.0												
1,535	0.0												
1,536	0.0												
1,537	0.0												
1,538	1.5												
1,539	4.8												
1,540	8.1												
1,541	11.4												
1,542	15.2												
1,543	15.1												
1,544	16.8												
1,545	18.5												

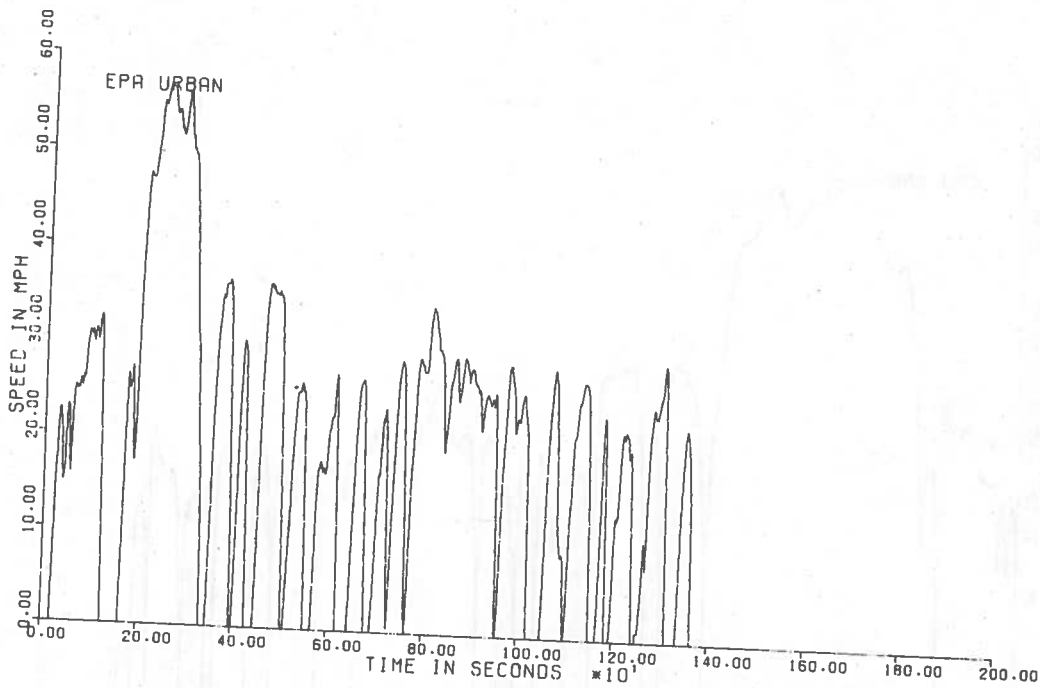


Figure A-2 Speed-Time Profile of the EPA-FTP Driving Schedule

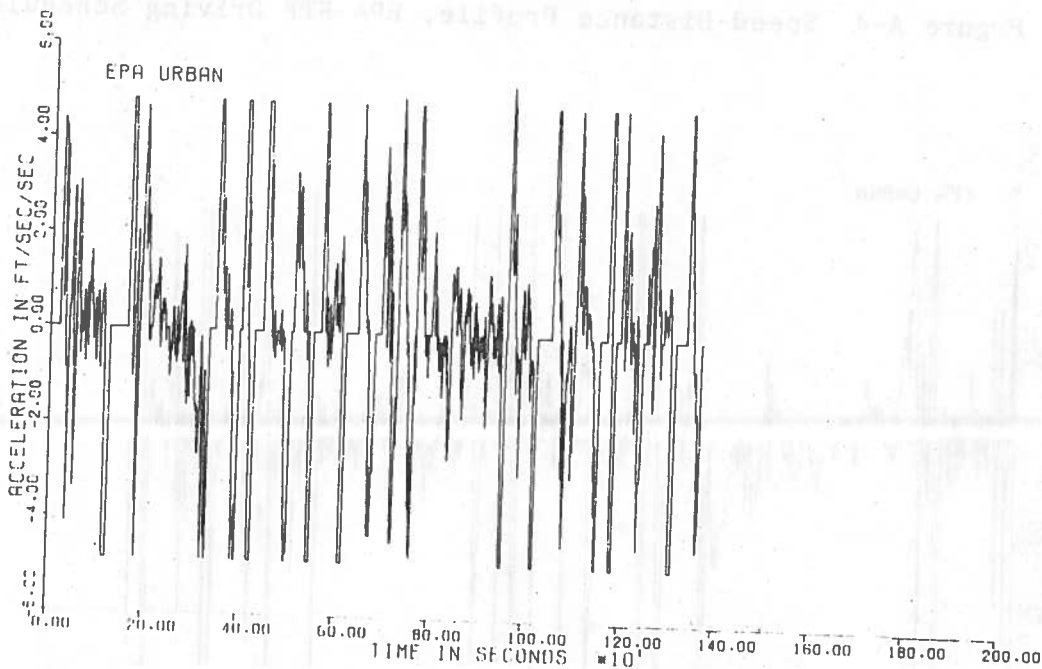


Figure A-3 Acceleration-Time Profile of the EPA-FTP Driving Schedule

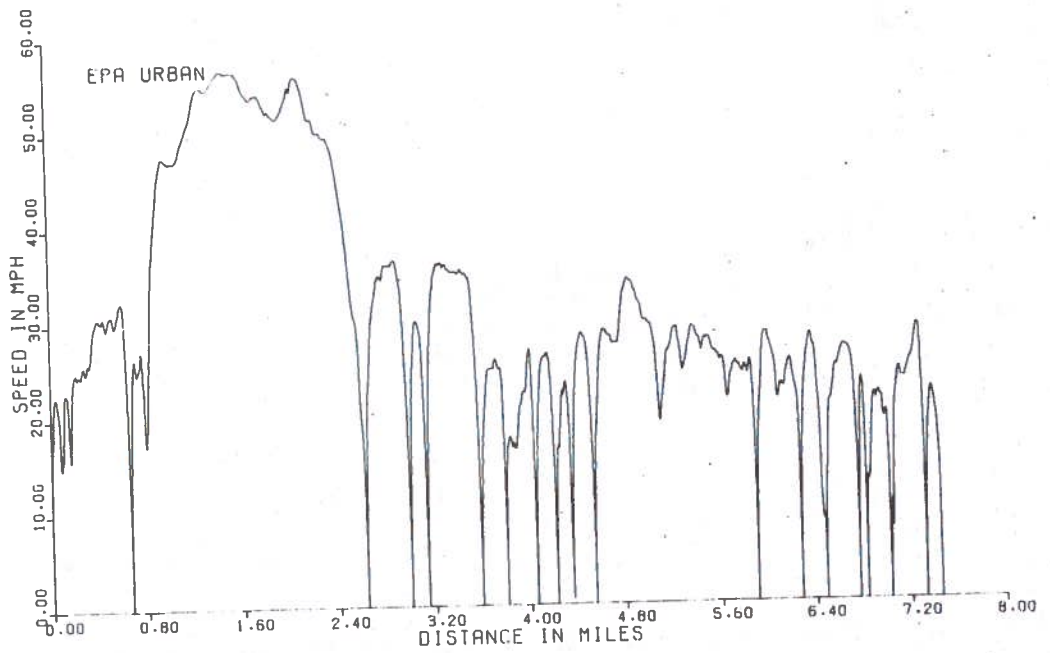


Figure A-4 Speed-Distance Profile, EPA-FTP Driving Schedule

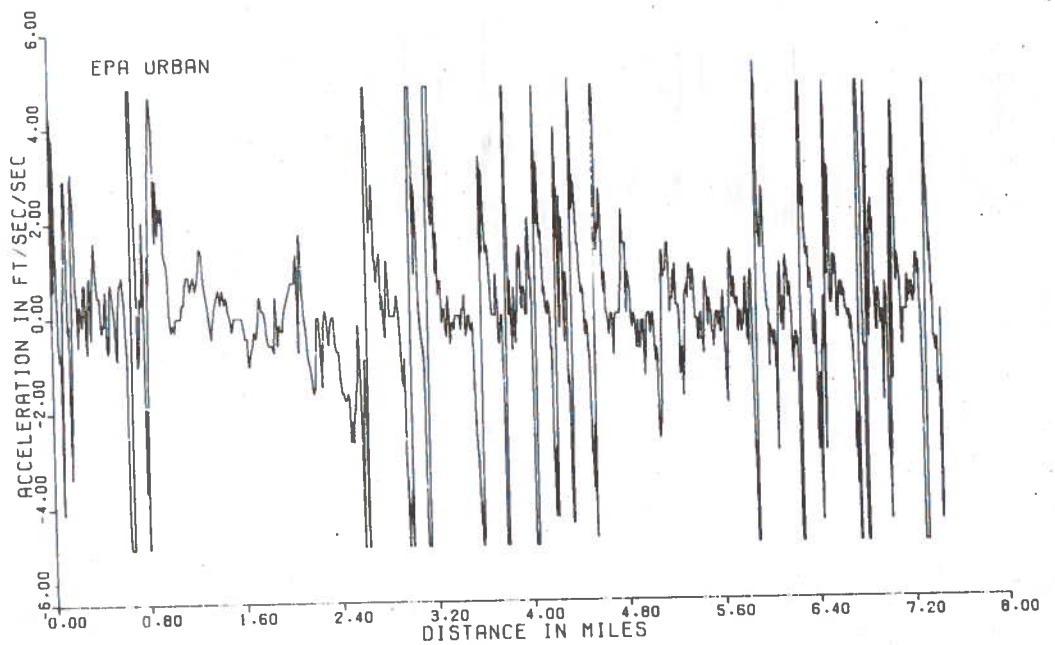


Figure A-5 Acceleration-Distance Profile, EPA-FTP Driving Schedule

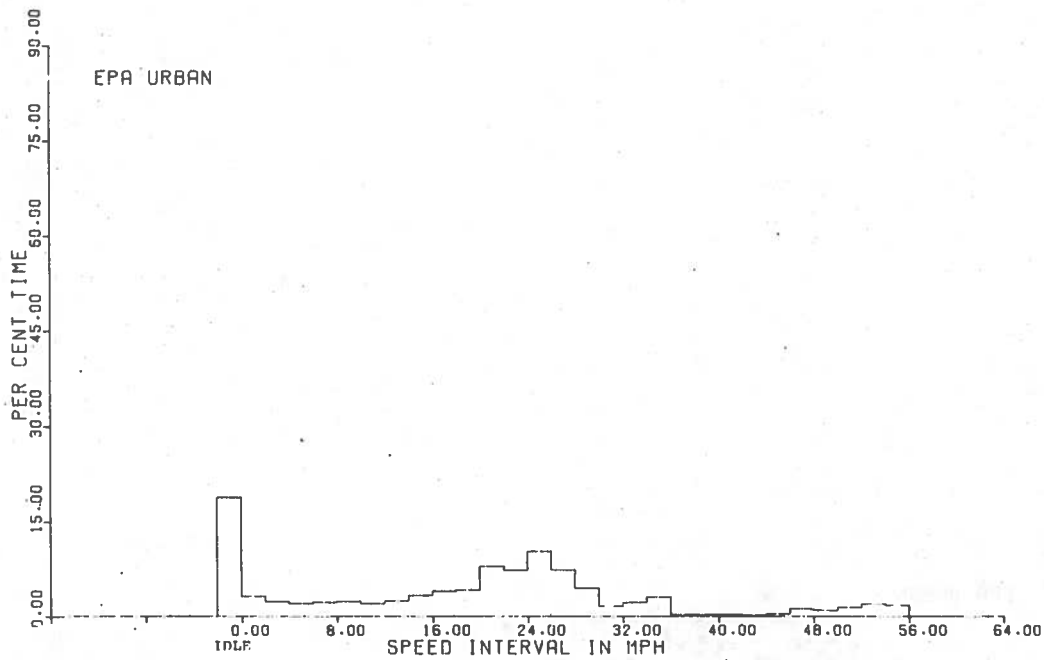


Figure A-6 EPA-FTP Driving Schedule, Percent Time-Speed Interval Profile

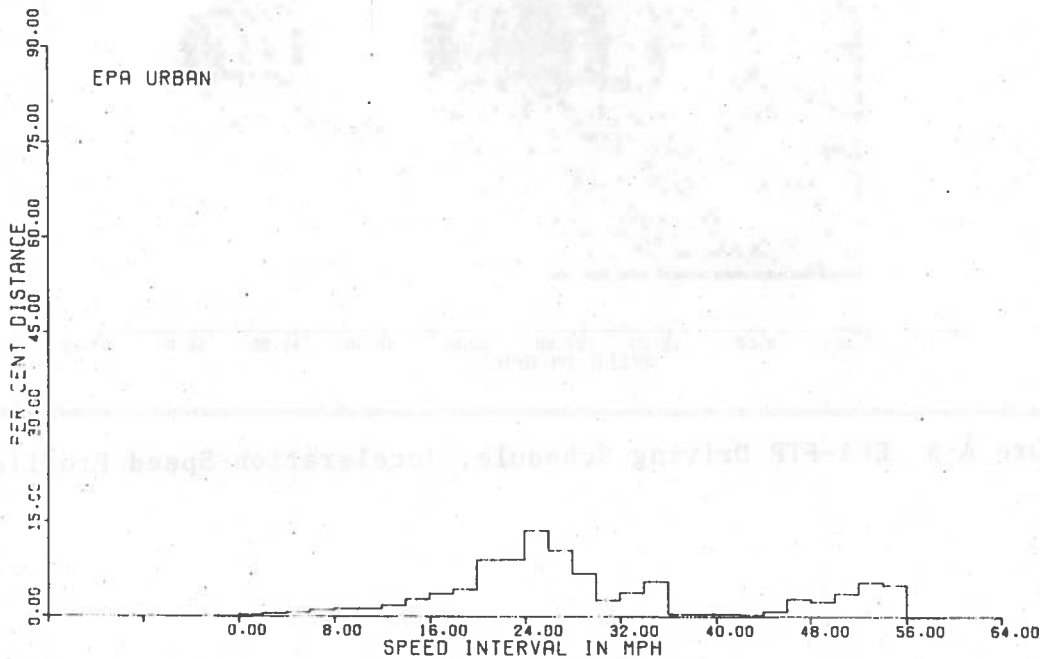


Figure A-7 EPA-FTP Driving Schedule, Percent Distance-Speed Interval Profile

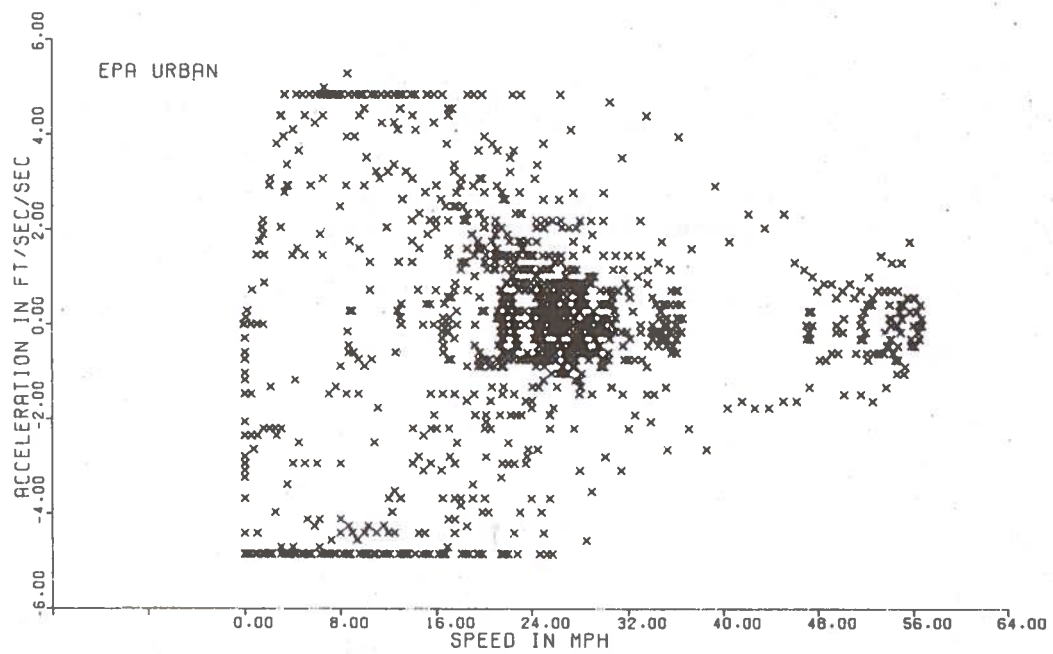


Figure A-8 EPA-FTP Driving Schedule, Acceleration-Speed Profile

A.2 SOCIETY OF AUTOMOTIVE ENGINEERS' URBAN DRIVING SCHEDULE - J1082¹⁹

A.2.1 Description

The SAE Urban Driving Schedule (J-1082) was developed by engineers and scientists associated with SAE who were concerned with formulating test procedures for determining automotive fuel economy. The objective was to develop a test procedure, including the driving schedule, which would relate to typical conditions encountered in urban driving and could be used as a standard throughout industry for measuring vehicle fuel economy. The schedule adopted by the SAE Fuel Economy Task Force is a stylized driving schedule to be executed on a test track. The vehicle's fuel economy is determined with the vehicle in a fully warmed up condition.

The driving schedule was evaluated by computer simulation of the maneuvers. Table A-4 lists the evaluated driving schedule parameters. The schedule has an average speed of 15.6 MPH, and reaches a maximum speed of 30.0 MPH. It is 2.0 miles long, has an elapsed time of 462 seconds, and contains 4 idles and 8 stops per mile.

TABLE A-4 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE SAE URBAN DRIVING SCHEDULE (J1082)

	Idle	Cruise	Acceleration	Deceleration
% Time	13.0	58.2	11.4	17.4
% Distance		75.2	10.2	14.5

As shown in Table A-4, greater than 50% of the time and greater than 75% of the distance are spent in the cruise mode. Cruises are performed at speeds of 15 MPH, 20 MPH, 25 MPH, and 30 MPH. There are three cruises performed at each of the respective speeds. The acceleration mode has seven accelerations at a rate of $+5.0 \text{ ft/sec}^2$ and nine accelerations at a rate of $+7.0 \text{ ft/sec}^2$. The deceleration mode has 12 decelerations, all performed

at a rate of -4 ft/sec^2 . The idle mode accounts for 13% of the schedule's time. The schedule incorporates four 15-second idle periods.

A.2.2 Discussion

The driver of a test vehicle performing this schedule would find the instructions readable, but some confusion may arise on the last maneuver. The last instruction is vague as to where to begin braking. Without some driver aid such as a marker to show the location where brake application is to begin, there is some probability for error. Also, the instructions for the locations of a stop should be included in the previous instruction. This would allow for better continuity of information flow.

The deceleration rate is the same throughout the schedule. The sensitivity of the fuel economy of a vehicle to the deceleration rate has not yet been determined and further investigation of this parameter is required. The statistical correlation of this stylized schedule to a typical drive in an urban reas has not been determined.

A.2.3 SAE Urban Driving Schedule Instructions¹⁹

The instructions for the SAE Urban Driving Schedule - J1082 are listed in Table A-5 and correspond to Figures A-9 through A-15.

TABLE A-5 SAE URBAN DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (km)	Operation
0.0 (0.0)	Start fuel meter and timing device, idle 15 seconds, accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 15 MPH (24.1 km/h) to the 0.2 miles (0.32 km) marker.
0.2 (0.32)	Stop at 4 ft/s^2 (1.2 m/s^2), accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 15 MPH (24.1 km/h) to the 0.3 mile (0.48 km) marker.

TABLE A-5 SAE URBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Distance Miles (km)	Operation
0.3 (0.48)	Decelerate to 5 MPH (8.0 km/h) at 4 ft/s^2 (1.2 m/s^2), accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 15 MPH (24.1 km/h) to the 0.5 mile (0.80 km) marker.
0.5 (0.80)	Stop at 4 ft/s^2 (1.2 m/s^2), idle 15 seconds, accelerate to 20 MPH (32.2 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 20 MPH (32.2 km/h) to the 0.7 mile (1.13 km) marker.
0.7 (1.13)	Stop at 4 ft/s^2 (1.2 m/s^2), accelerate to 20 MPH (32.2 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 20 MPH (32.2 km/h) to the 0.8 mile (1.29 km) marker.
0.8 (1.29)	Decelerate to 10 MPH (16.1 km/h) at 4 ft/s^2 (1.2 m/s^2), accelerate to 20 MPH (32.2 km/h) at 5 ft/s^2 (1.5 m/s^2). Proceed at 20 MPH (32.2 km/h) to the 1.0 mile (1.61 km) marker.
1.0 (1.61)	Stop at 4 ft/s^2 (1.2 m/s^2), idle 15 seconds, accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2), then to 25 MPH (40.2 km/h) at 5 ft/s^2 (1.5 m/s^2). Proceed at 25 MPH (40.2 km/h) to the 1.2 mile (1.93 km) marker.
1.2 (1.93)	Stop at 4 ft/s^2 (1.2 m/s^2), accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2), then to 24 MPH (40.2 km/h) at 5 ft/s^2 (1.5 m/s^2). Proceed at 25 MPH (40.2 km/h) to the 1.3 mile (2.09 km) marker.
1.3 (2.09)	Decelerate to 15 MPH (24.1 km/h) at 4 ft/s^2 (1.2 m/s^2), accelerate to 25 MPH (40.2 km/h) at 5 ft/s^2 (1.5 m/s^2). Proceed at 24 MPH (40.2 km/h) to the 1.5 mile (2.41 km) marker.

TABLE A-5 SAE URBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Distance Miles (km)	Operation
1.5 (2.41)	Stop at 4 ft/s ² (1.2 m/s ²), idle 15 seconds, accelerate to 15 MPH (24.1 km/h) at 7 ft/s ² , then to 30 MPH (48.3 km/h) at 5 ft/s ² (1.5 m/s ²). Proceed at 30 MPH (48.3 km/h) to the 1.7 mile (2.74 km) marker.
1.7 (2.74)	Stop at 4 ft/s ² (1.2 m/s ²), accelerate to 15 MPH (24.1 km/h) at 7 ft/s ² (2.1 m/s ²) and then to 30 MPH (48.3 km/h) at 5 ft/s ² (1.5 m/s ²). Proceed at 30 MPH (48.3 km/h) to the 1.8 mile (2.90 km) marker.
1.8 (2.90)	Decelerate to 20 MPH (32.2 km/h) at 4 ft/s ² (1.2 m/s ²), accelerate to 30 MPH (48.3 km/h) at 5 ft/s ² (1.5 m/s ²). Proceed at 30 MPH (48.3 km/h).
2.0 (3.22)	Begin braking at 4 ft/s ² (1.2 m/s ²) to arrive at stop at 2.0 mile (3.22 km) marker. Stop fuel meter and timing device at stop, record fuel consumed, elapsed time and fuel temperature.

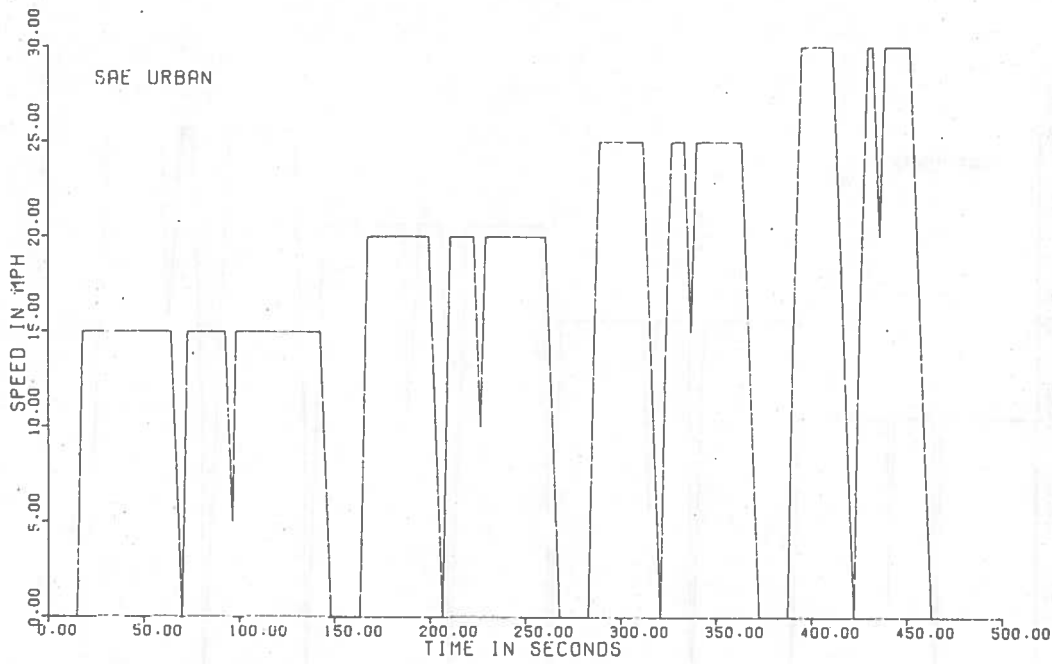


Figure A-9 SAE Urban Driving Schedule - J1082, Speed-Time Profile

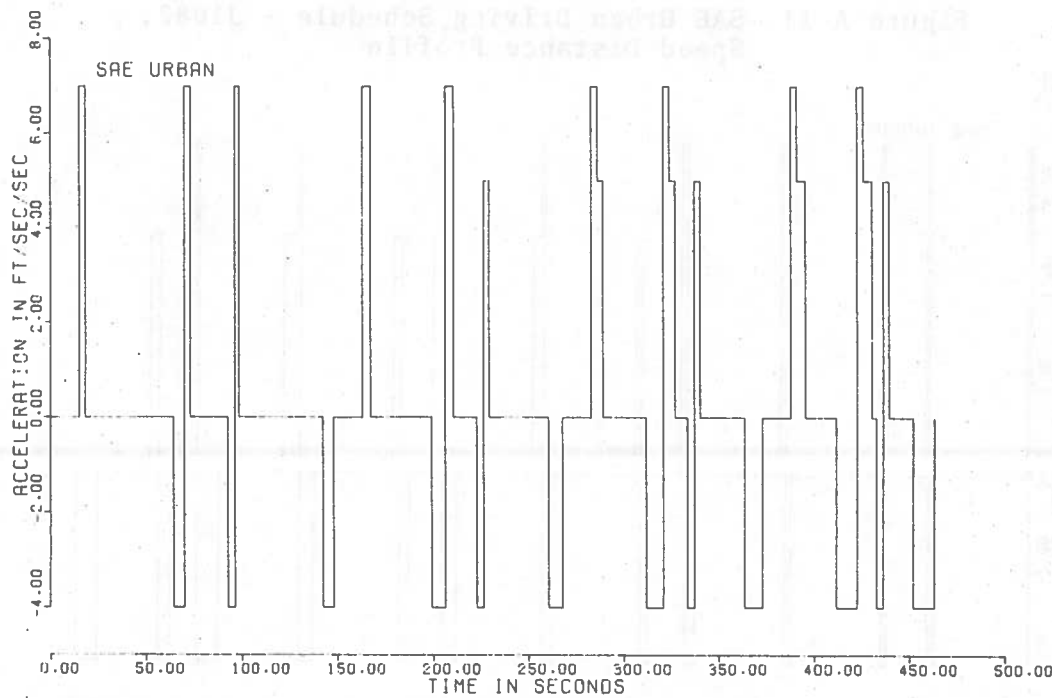


Figure A-10 SAE Urban Driving Schedule - J1082, Acceleration-Time Profile

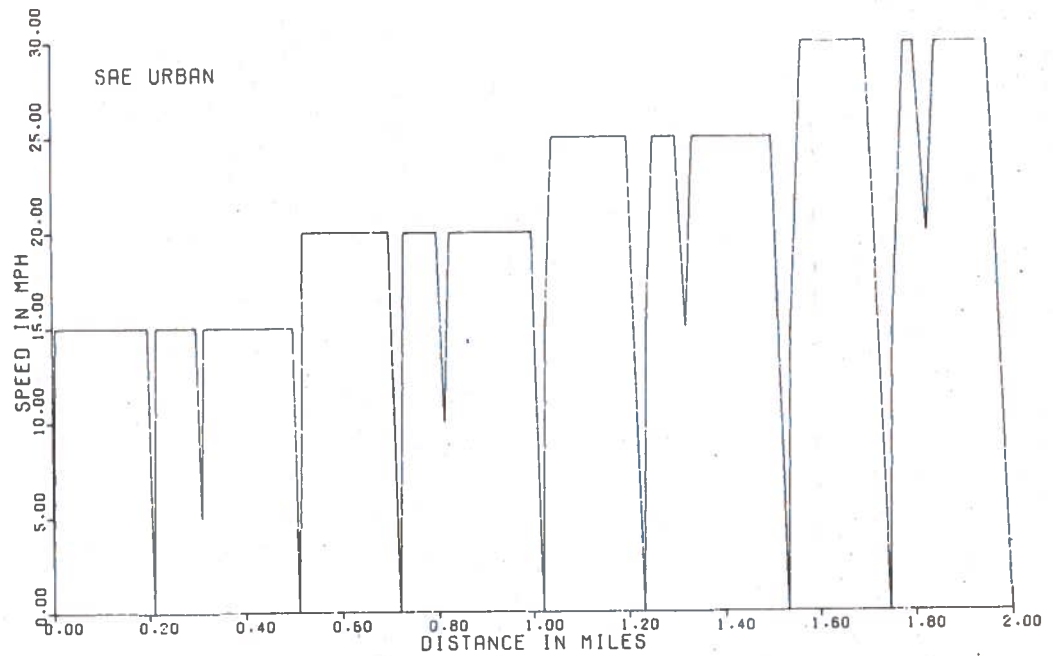


Figure A-11 SAE Urban Driving Schedule - J1082,
Speed-Distance Profile

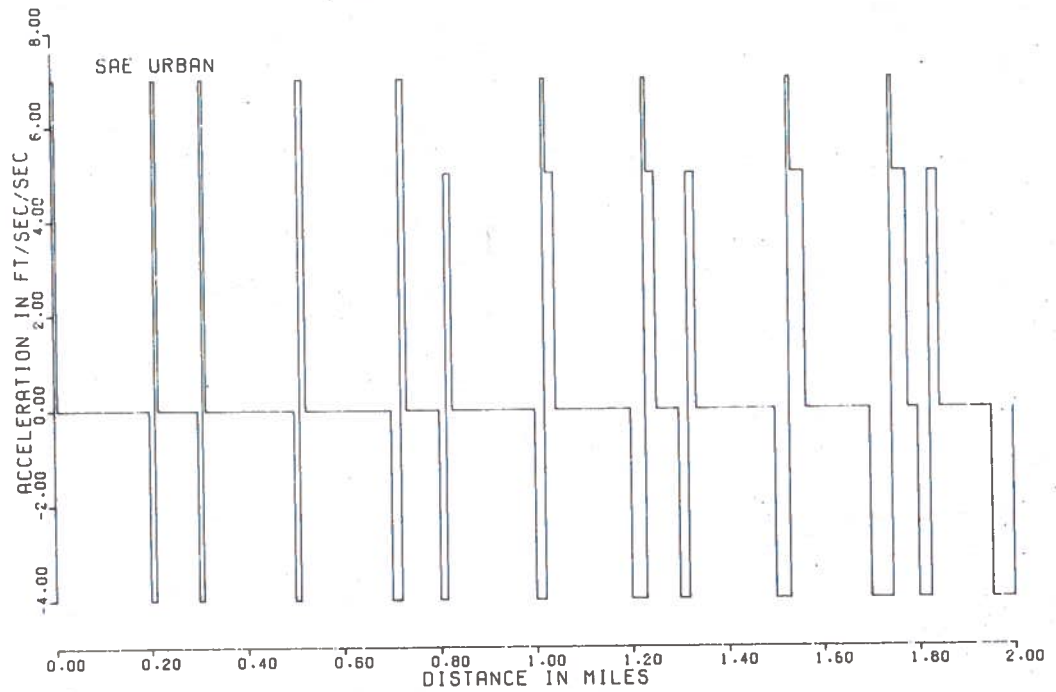


Figure A-12 SAE Urban Driving Schedule - J1082,
Acceleration-Distance Profile

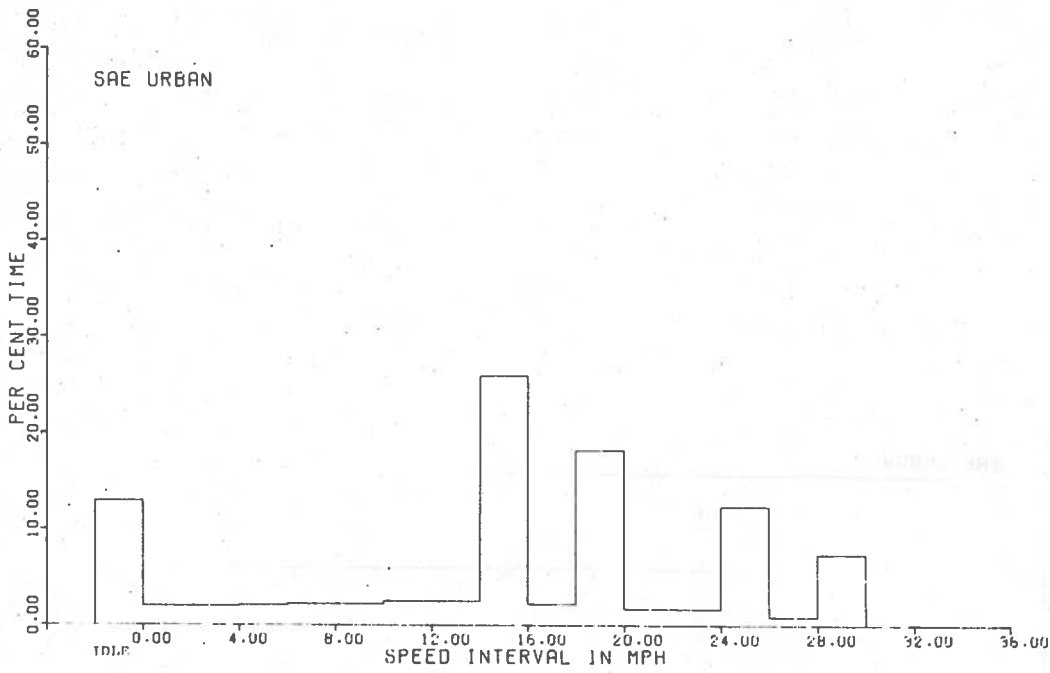


Figure A-13 SAE Urban Driving Schedule - J1082, Percent Time-Speed Interval Profile

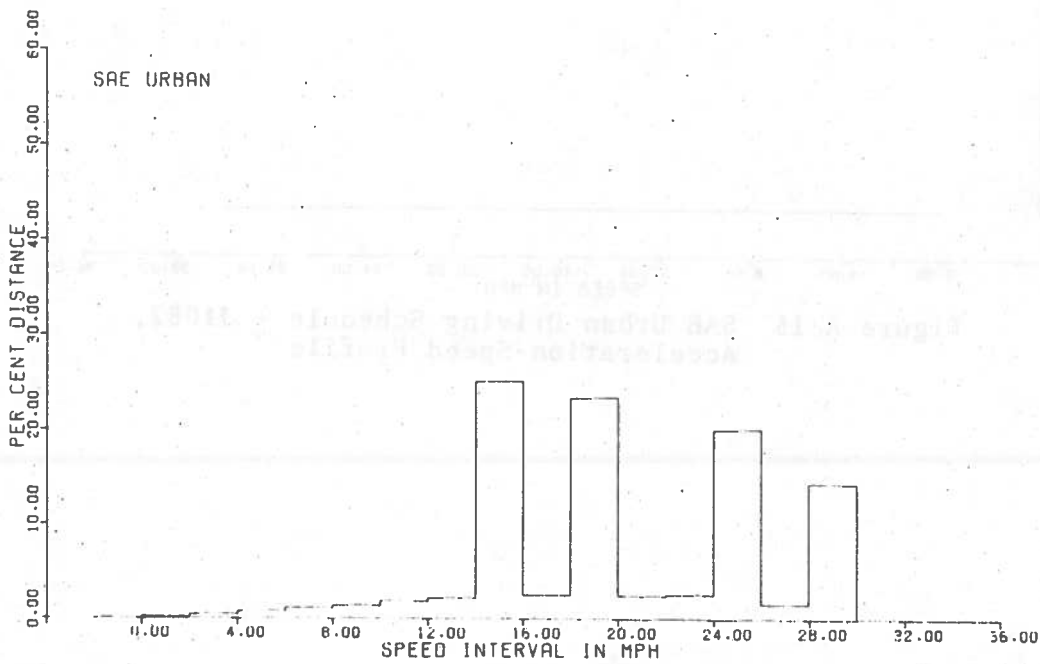


Figure A-14 SAE Urban Driving Schedule - J1082, Percent Distance-Speed Interval Profile

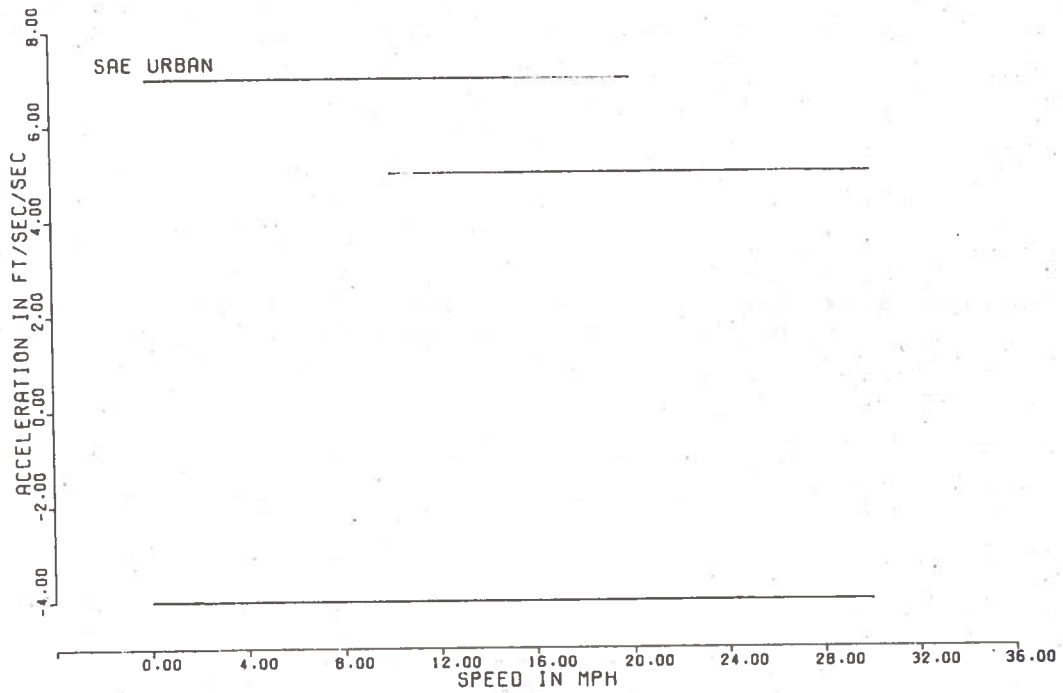


Figure A-15 SAE Urban Driving Schedule - J1082, Acceleration-Speed Profile

A.3 GENERAL MOTORS CENTRAL BUSINESS DISTRICT DRIVING SCHEDULE

A.3.1 Description

General Motors Corporation conducts extensive testing of their vehicles. One such test, developed by their engineers, is a fuel economy test simulating a drive through a central business district (CBD) of a city. The fuel economy test is performed on a test track, and incorporates a stylized driving schedule. The test evaluates the fuel economy of the vehicle under steady-state warmed-up conditions.

The driving schedule was analyzed by computer simulation of the maneuvers, and parameters were evaluated. The schedule has an average speed of 16.1 MPH, and reaches a maximum speed of 30.0 MPH. It is 2.0 miles long, has an elapsed time of 452 seconds; and contains 4 idles and 8 stops. The schedule incorporates 3.9 stops per mile. The percent time and distance modes are shown in Table A-6.

TABLE A-6 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE GM CENTRAL BUSINESS DISTRICT DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	13.3	63.8	10.6	12.3
% Distance		81.5	8.5	10.0

The cruise mode accounts for greater than 60 percent of the time and greater than 80% of the distance traveled. The speeds of the cruises are 15 MPH, 20 MPH, 25 MPH, and 30 MPH. There are three cruises performed at each of the respective speeds. The acceleration mode has twelve accelerations; six at a rate of 5 ft/sec² and six at a rate of 8 ft/sec². There are 12 decelerations; eight decelerations occurring at a rate of -6.0 ft/sec² and four decelerations at a rate of -5.0 ft/sec². The idle mode uses 13.3% of the schedule's time. There are four 15-second idle periods.

A.3.2 Discussion

The instructions to the GM driving schedule are clear, and the test driver should not find any difficulty in performing the necessary maneuvers. A problem area that might arise with some test vehicles is the 8 ft/sec² acceleration rate. This acceleration rate may be beyond the capability of certain vehicles.

Another point of interest is that this driving schedule was the main source reference used for the development of the SAE urban driving schedule. They are similar, as noted by the values of their respective parameters and their accompanying plots.

A.3.3 General Motors Central Business District Driving Schedule Instructions

Instructions for the General Motors Central Business District Driving Schedule are listed in Table A-7, and corresponding profiles are shown in Figures A-16 through A-22.

TABLE A-7 GENERAL MOTORS CENTRAL BUSINESS DISTRICT DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (km)	Operation
0.0 (0.0)	Start fuel meter, idle 15 sec., accel. to 15 MPH (24.1) at 5 fps ² (1.52)
0.2 (0.32)	Stop at 6 fps ² (1.83), accel. to 15 MPH (24.1) at 5 fps ² (1.52)
0.3 (0.48)	Decel. to 5 MPH (8.0) at 5 fps ² (1.42), accel. to 15 MPH (24.1) at 5 fps ² (1.52)
0.5 (0.80)	Stop at 6 fps ² (1.83), idle 15 sec., accel. to 20 MPH (32.2) at 8 fps ² (2.44)
0.7 (1.13)	Stop at 6 fps ² (1.83), accel. to 20 MPH (32.2) at 8 fps ² (2.44)
0.8 (1.29)	Decel. to 10 MPH (16.1) at 5 fps ² (1.52), accel. to 20 MPH (32.2) at 5 fps ² (1.52)

TABLE A-7 GENERAL MOTORS CENTRAL BUSINESS DISTRICT DRIVING
SCHEDULE INSTRUCTIONS (CONTINUED)

Distance Miles (km)	Operation
1.0 (1.61)	Stop at 6 fps ² (1.83), idle 15 sec., accel. to 25 MPH (40.2) at 8 fps ² (2.44)
1.2 (1.93)	Stop at 6 fps ² (1.83), accel. to 25 MPH (40.2) at 8 fps ² (2.44)
1.3 (2.09)	Decel. to 15 MPH (24.1) at 5 fps ² (1.52), accel. to 25 MPH (40.2) at 5 fps ² (1.52)
1.5 (2.41)	Stop at 6 fps ² (1.83), idle 15 sec., accel. to 30 MPH (48.3) at 8 fps ² (2.44)
1.7 (2.74)	Stop at 6 fps ² (1.83), accel. to 30 MPH (48.3) at 8 fps ² (2.44)
1.8 (2.90)	Decel. to 20 MPH (32.2) at 5 fps ² (1.52), accel. to 30 MPH (48.3) at 5 fps ² (1.52)
2.0 (3.22)	Stop at fps ² (1.83) and stop fuel meter, record fuel consumed, elapsed time and fuel temperature
0.0 (0.0)	Run recheck cycle

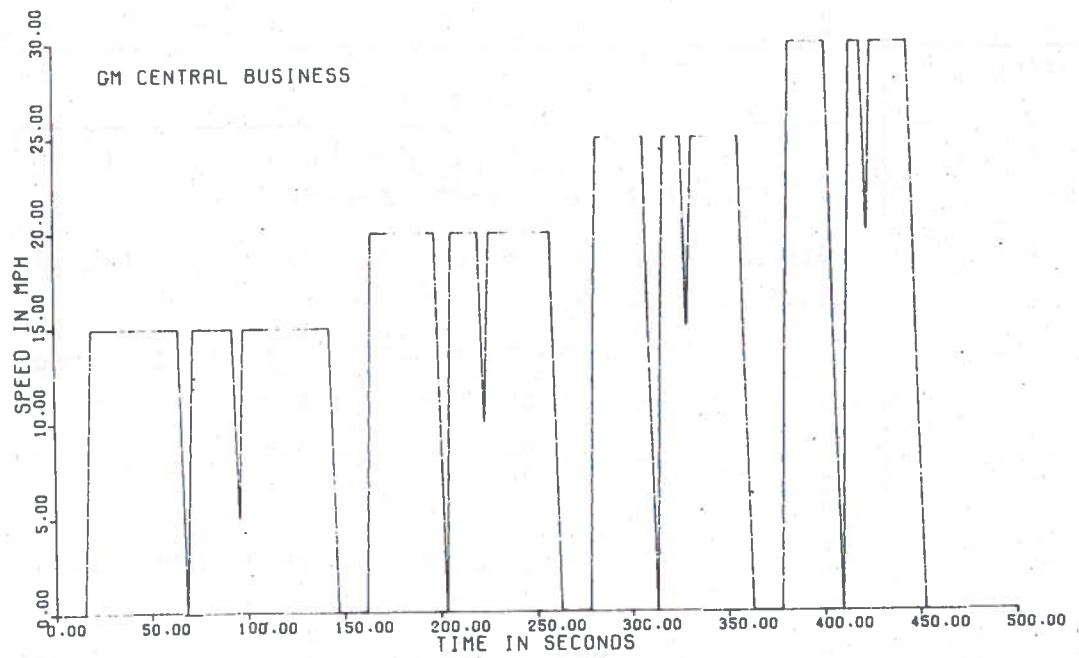


Figure A-16 GM Central Business District Driving Schedule, Speed-Time Profile

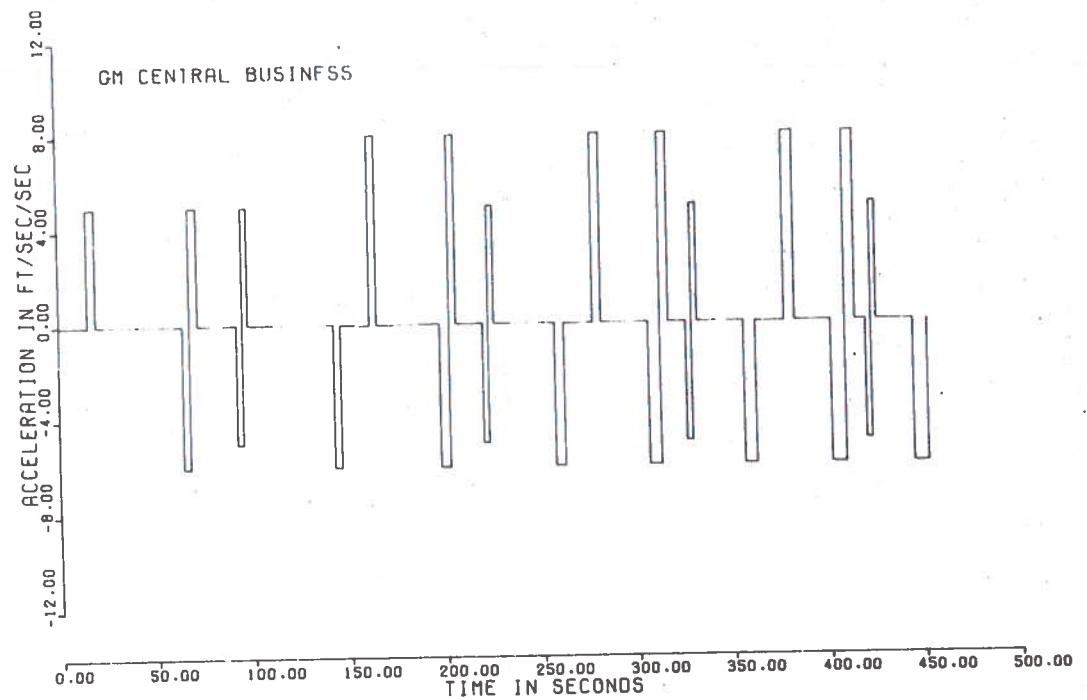


Figure A-17 GM Central Business District Driving Schedule, Acceleration-Time Profile

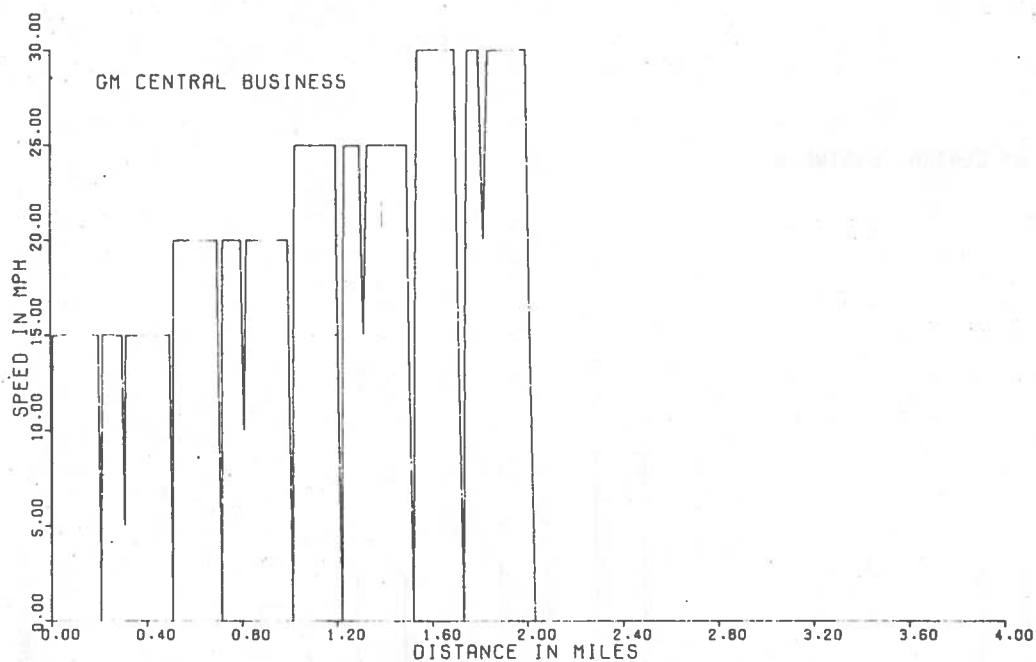


Figure A-18 GM Central Business District Driving Schedule, Speed-Distance Profile

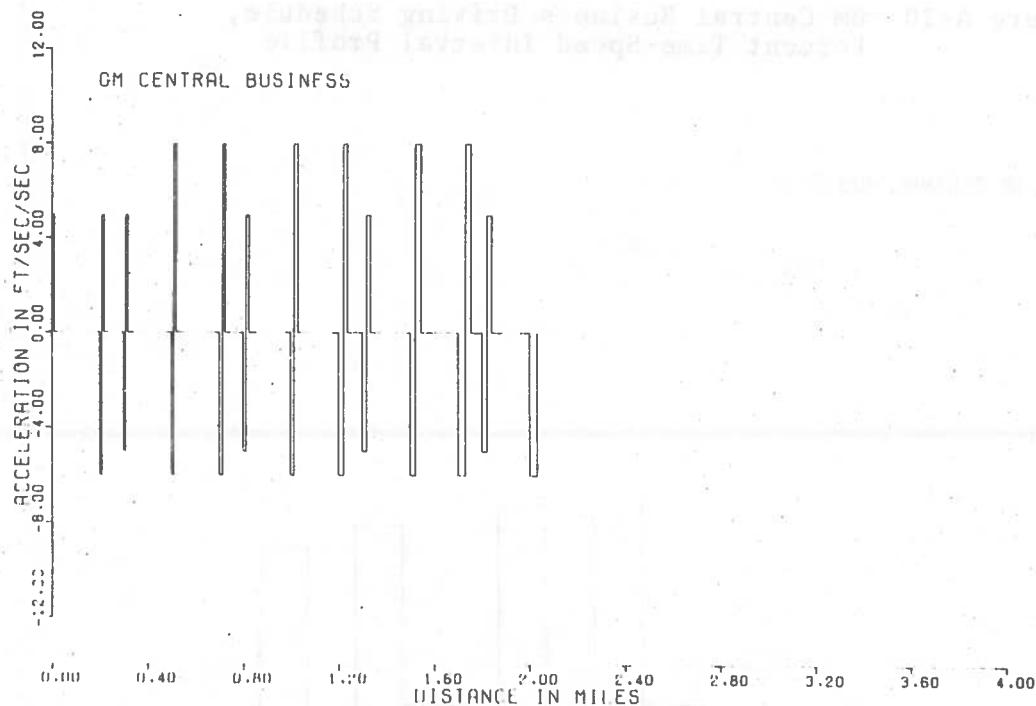


Figure A-19 GM Central Business District Driving Schedule, Acceleration-Distance Profile

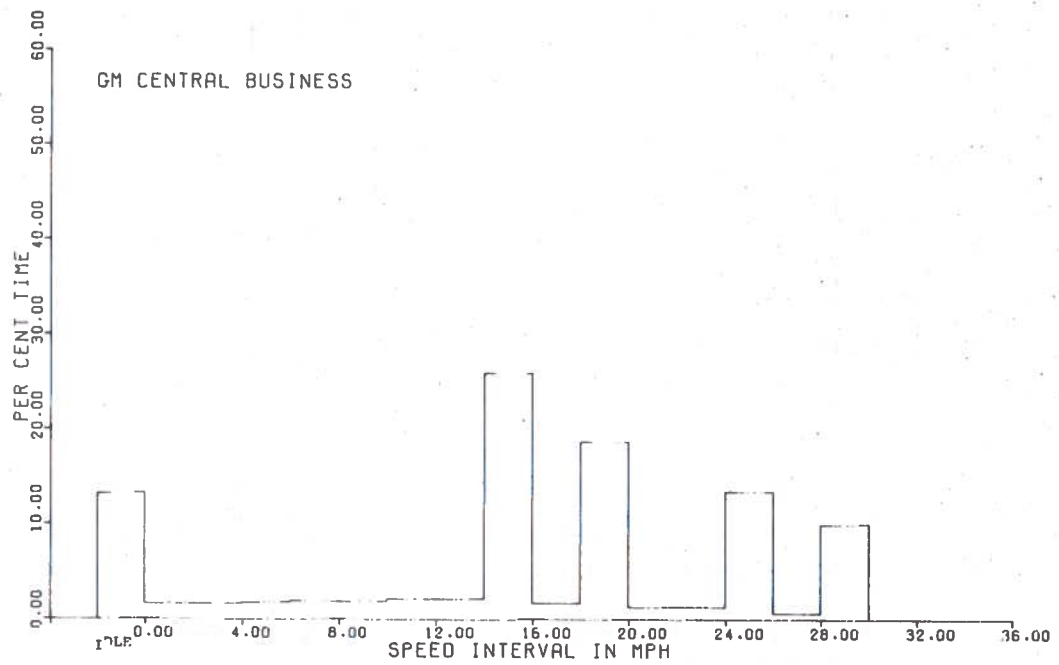


Figure A-20 GM Central Business Driving Schedule, Percent Time-Speed Interval Profile

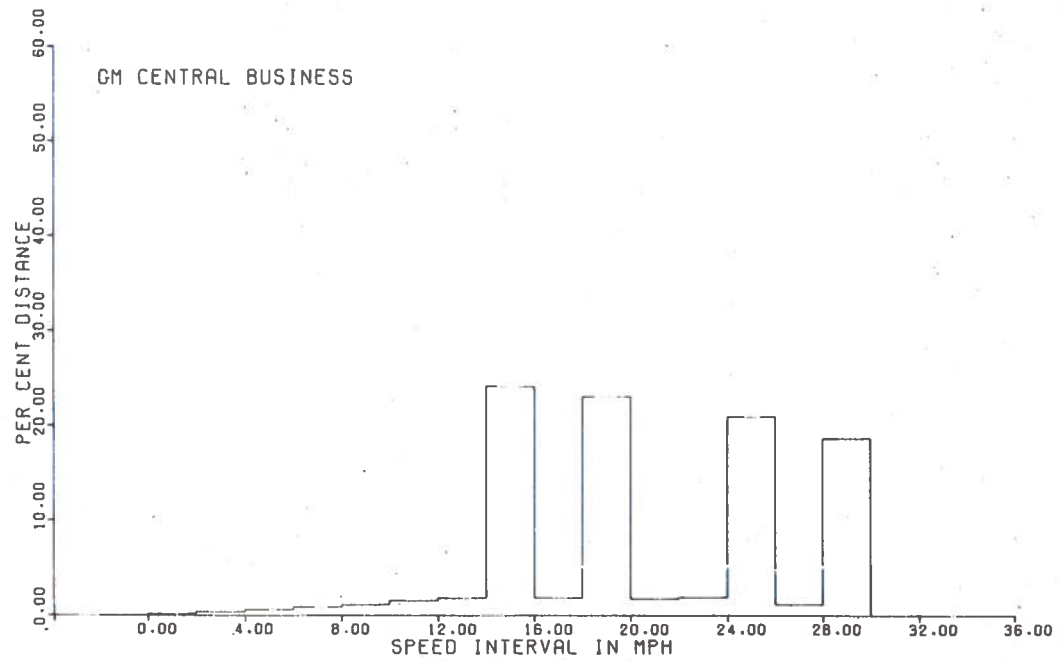


Figure A-21 GM Central Business District Driving Schedule, Percent-Distance Speed Interval Profile

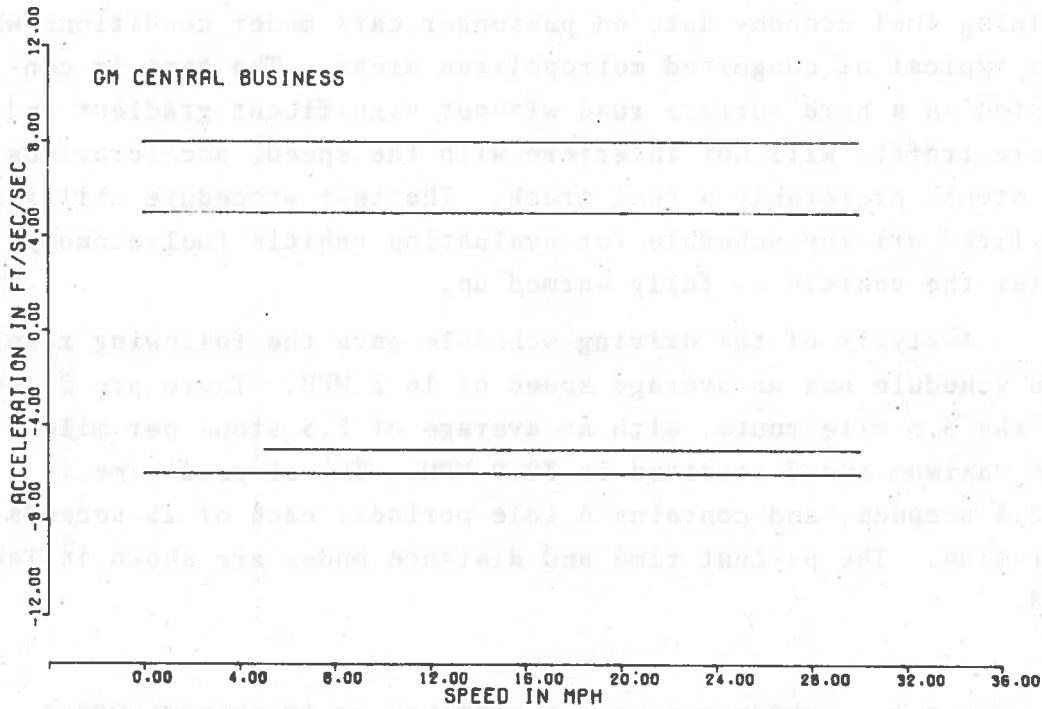


Figure A-22 GM Central Business District Driving Schedule, Acceleration-Speed Profile

A.4 FORD CITY ECONOMY DRIVING SCHEDULE

A.4.1 Description

Ford Motor Company has developed test procedures descriptive of city-type driving. This procedure describes a method for obtaining fuel economy data on passenger cars under conditions which are typical of congested metropolitan areas. The test is conducted on a hard surface road without significant gradient and where traffic will not interfere with the speed, accelerations, or stops—preferably a test track. The test procedure utilizes a stylized driving schedule for evaluating vehicle fuel economy after the vehicle is fully warmed up.

Analysis of the driving schedule gave the following results. The schedule has an average speed of 16.3 MPH. There are 20 stops in the 3.6 mile route, with an average of 5.5 stops per mile. The maximum speed attained is 30.0 MPH. The elapsed time is 798.8 seconds, and contains 6 idle periods, each of 25 seconds duration. The percent time and distance modes are shown in Table A-8.

TABLE A-8 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE FORD CITY ECONOMY DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	18.8	50.1	18.8	12.3
% Distance		76.3	13.7	10.0

The cruise mode utilizes greater than 50% of the schedule's time and greater than 75% of the distance traveled. There are a total of 20 cruises: 4 cruises performed at a speed of 6.99 MPH,* 8 cruises at 25 MPH, and eight cruises at 30 MPH. The

*The 6.99 MPH cruise is an assumed value necessary to analyze the schedule.

acceleration mode uses slightly greater than 18% and 13% of the schedule's time and distance, respectively. The schedule contains 36 accelerations: 4 at a rate of $+0.99 \text{ ft/sec}^2$,** 16 accelerations at a $+5 \text{ ft/sec}^2$ rate, and 16 at a $+7 \text{ ft/sec}^2$ acceleration rate. The deceleration mode, accounting for about 10% of the schedule's time and its distance has only one deceleration rate, -7 ft/sec^2 . There is a total of 20 decelerations performed during this schedule.

A.4.2 Discussion

The instructions to this schedule were unclear, lacking detail, and containing ambiguity. One such example involves the U-turn maneuvers. No acceleration rate was given: the only instruction was that the turn was to be completed in 25 seconds. There is difficulty in interpreting whether the mileage accumulated during the turn was 0.05 miles, or some fraction thereof.

Since the schedule had the time limitation requirement of 820-826 seconds, it was impossible to meet the 25 second elapsed time requirement during the U-turn maneuver. The assumed acceleration rate during this segment of the maneuver was $+0.99 \text{ ft/sec}^2$, with a maximum assumed speed of 6.99 MPH. The simulation then assumed a cruise at 6.99 MPH to the location where brake application was initiated. The instructions then regained clarity. The vehicle was to stop at the 0.05 mile marker at a rate of -7 ft/sec^2 , thus completing the maneuver.

Another difficulty found was in the presentation of information. The instructions do not allow for continuous information flow. The vehicle is to come to rest at the mileage marker. However, the instructions to perform this maneuver were not included in the previous statement. The driver on an actual test would not know to stop the vehicle at a particular marker until he reads the instructions for that marker. Performing in this fashion, he would reach the marker at a certain speed, read the next instruction to be performed between this new marker and the proceeding

**The acceleration rate of 0.99 ft/sec^2 is an assumed value necessary to analyze the schedule.

one, and find out that he should be at a stop. This could become a source of error.

The nonvarying deceleration rate incorporated within this driving schedule is a limitation. Whether this is a good approximation of typical urban driving or whether it significantly affects fuel economy measurements has not been ascertained.

A unique feature of this schedule is the U-turn. Since no field data are yet available, it is impossible to predict the effect this maneuver has on fuel consumption. Future investigations into this area may prove to be fruitful.

A.4.3 Ford City Economy Driving Schedule Instructions

Instructions for the Ford City Economy Driving Schedule are listed in Table A-9, and corresponding profiles are shown in Figures A-23 through A-29.

TABLE A-9 FORD CITY ECONOMY DRIVING SCHEDULE INSTRUCTIONS

Step	Miles	Operation
(a)		Warm up vehicle by operating 1.80 miles in accordance with the route in steps (b) through (k). Do not use fuel burette during warm-up.
(b)	.00	<u>Start a U-turn from the first marker.</u> Simultaneously start fuel burette and stop watch. <u>Complete turn in 25 seconds.</u>
(c)	.05	Stop at second marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to third marker at 30 MPH.
(d)	.31	Stop at third marker at 7 ft/sec/sec. Idle engine for 25 seconds. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to fourth marker at 30 MPH.

TABLE A-9 FORD CITY ECONOMY DRIVING SCHEDULE
INSTRUCTIONS (CONTINUED)

Step	Miles	Operation
(e)	.49	Stop at fourth marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to fifth marker at 30 MPH.
(f)	.68	Stop at fifth marker at 7 ft/sec/sec. Idle engine for 25 seconds. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to sixth marker at 30 MPH.
(g)	.90	Stop at sixth marker at 7 ft/sec/sec. Make a U-turn (opposite directions to first turn); elapsed time to turn, 25 seconds.
(h)	.95	Stop at seventh marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to eighth marker at 30 MPH.
(i)	1.17	Stop at eighth marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to ninth marker at 30 MPH.
(j)	1.35	Stop at ninth marker at 7 ft/sec/sec. Idle for 25 seconds. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to tenth marker at 30 MPH.
(k)	1.54	Stop at tenth marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 30 MPH at 5 ft/sec/sec. Proceed to 11th marker at 30 MPH.
(l)	1.80	Stop at 11th marker at 7 ft/sec/sec. Make a U-turn (same as first turn); elapsed time for turn, 25 seconds.

TABLE A-9 FORD CITY ECONOMY DRIVING SCHEDULE
INSTRUCTIONS (CONTINUED)

Step	Miles	Operation
(m)	1.85	Stop at 12th marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 13th marker at 25 MPH.
(n)	2.11	Stop at 13th marker at 7 ft/sec/sec. Idle for 25 seconds. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 14th marker.
(o)	2.29	Stop at 14th marker 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec.
(p)	2.48	Stop at 15th marker at 7 ft/sec/sec. Idle for 25 seconds. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 16th marker at 25 MPH.
(q)	2.70	Stop at 16th marker at 7 ft/sec/sec. Make a U-turn (opposite to first turn); elapsed time for turn, 25 seconds.
(r)	2.75	Stop at 17th marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 18th marker at 25 MPH.
(s)	2.97	Stop at 18th marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 19th marker at 25 MPH.
(t)	3.15	Stop at 19th marker at 7 ft/sec/sec. Idle engine for 25 seconds. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 20th marker at 25 MPH.

TABLE A-9 FORD CITY ECONOMY DRIVING SCHEDULE
INSTRUCTIONS (CONTINUED)

Step	Miles	Operation
(u)	3.34	Stop at 20th marker at 7 ft/sec/sec. Accelerate from 0 to 15 MPH at 7 ft/sec/sec; continue accelerating to 25 MPH at 5 ft/sec/sec. Proceed to 21st marker at 25 MPH.
(v)	3.60	Stop at 21st marker at 7 ft/sec/sec. Shut off fuel burette and stop watch, and record elapsed time, fuel consumed, and operating temperature.
(w)		Immediately repeat above steps from (b) through (v).

Source: Reference 21.

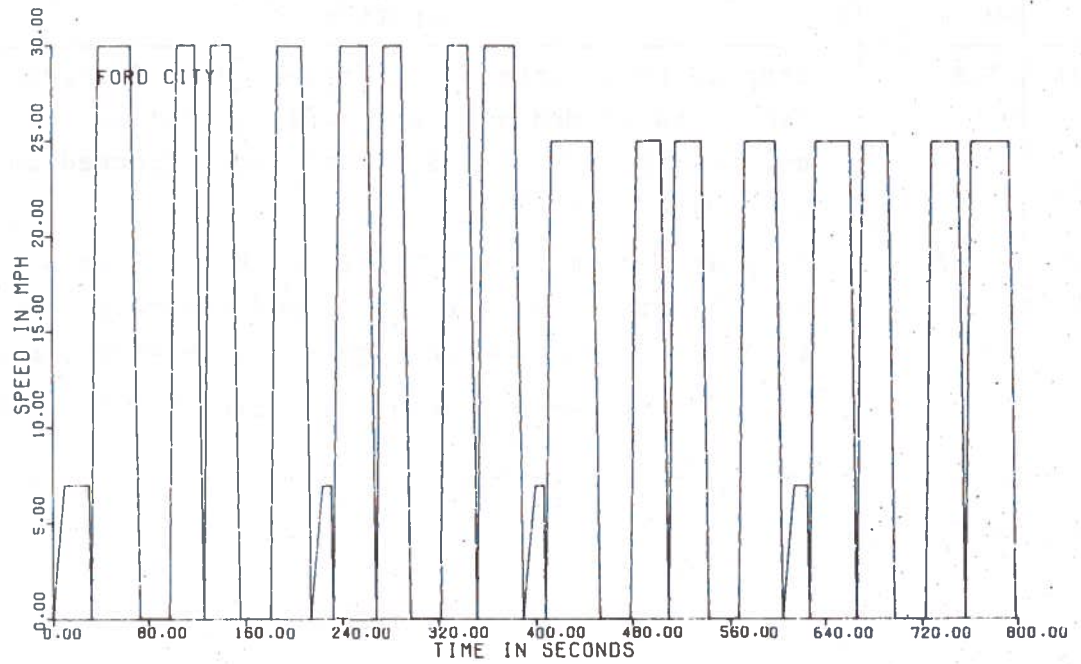


Figure A-23 Ford City Economy Driving Schedule, Speed-Time Profile

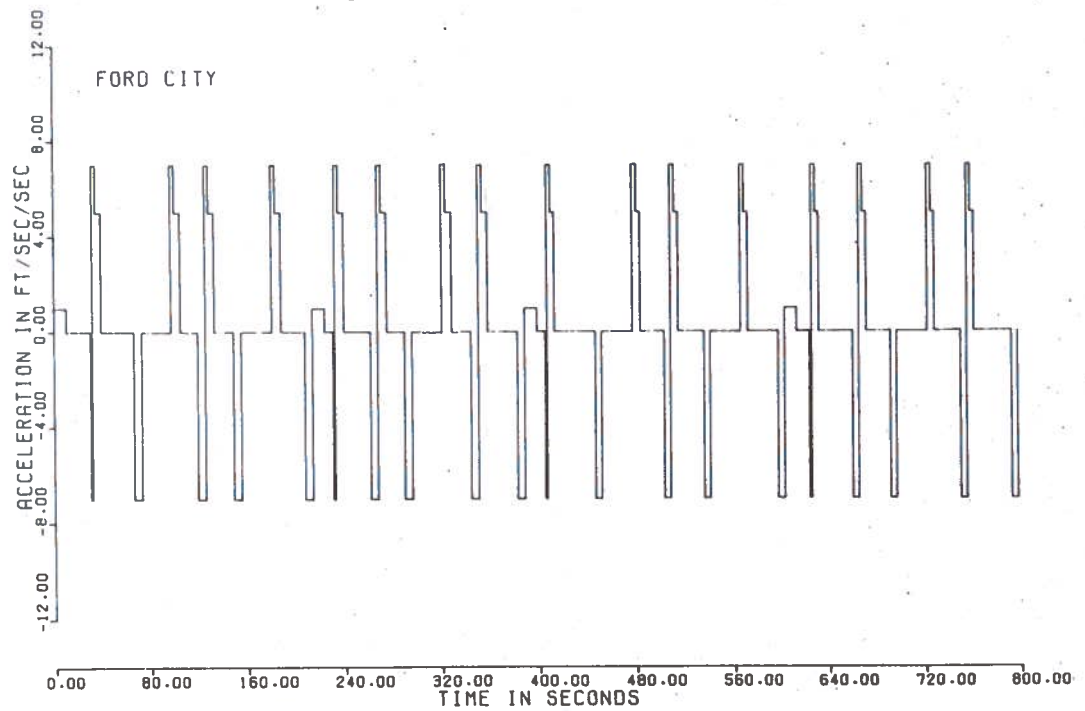


Figure A-24 Ford City Economy Driving Schedule, Acceleration-Time Profile

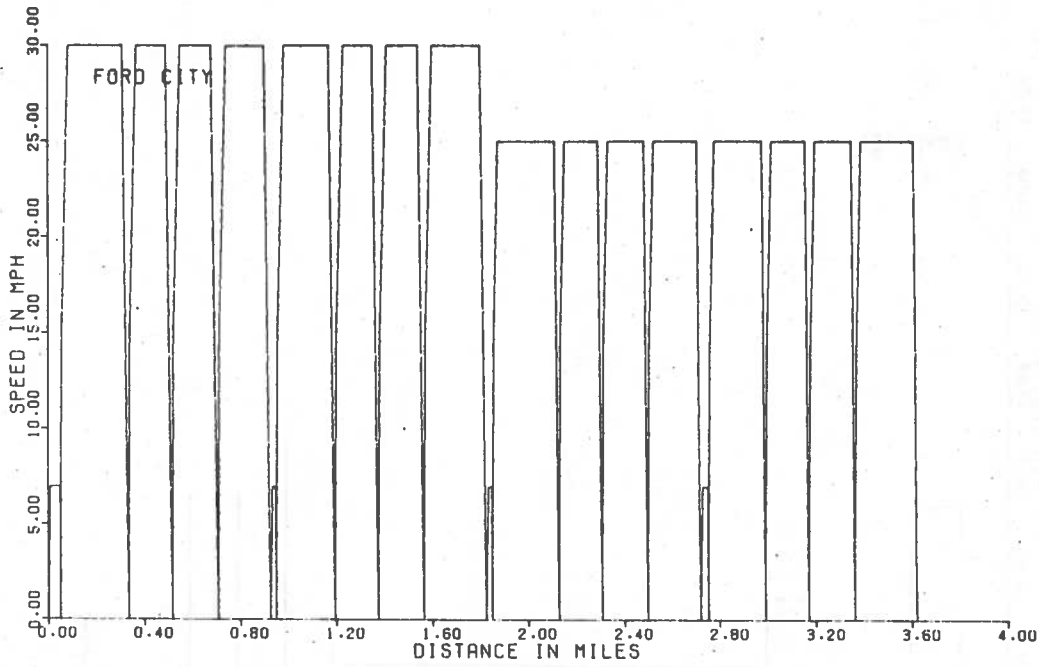


Figure A-25 Ford City Economy Driving Schedule, Speed-Distance Profile

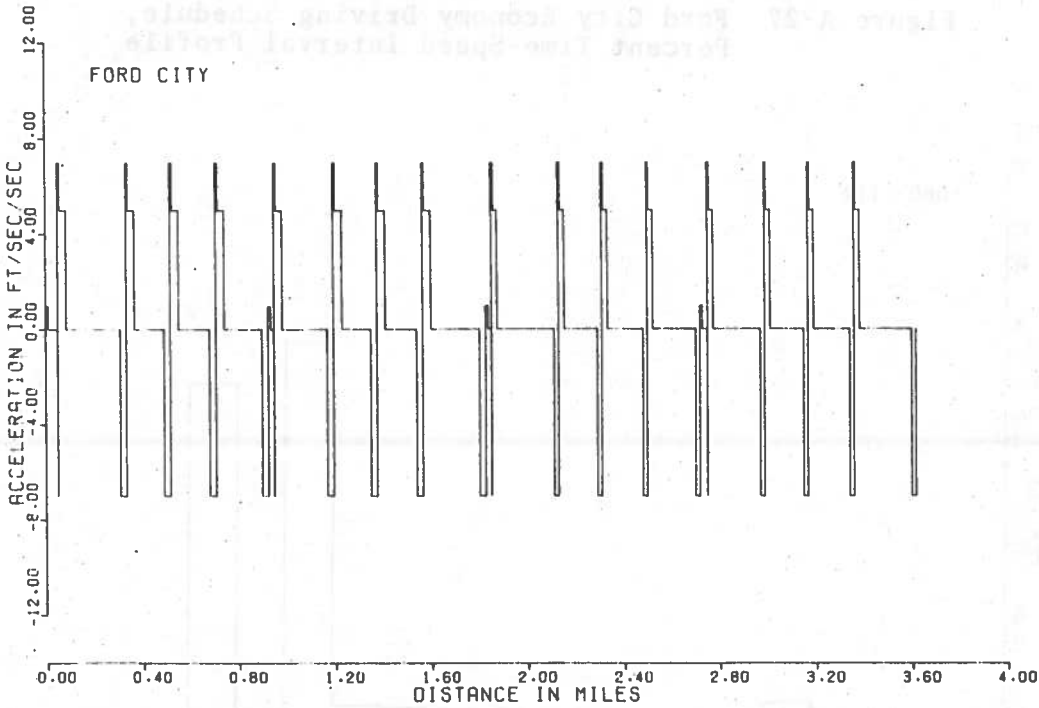


Figure A-26 Ford City Economy Driving Schedule, Acceleration-Distance Profile

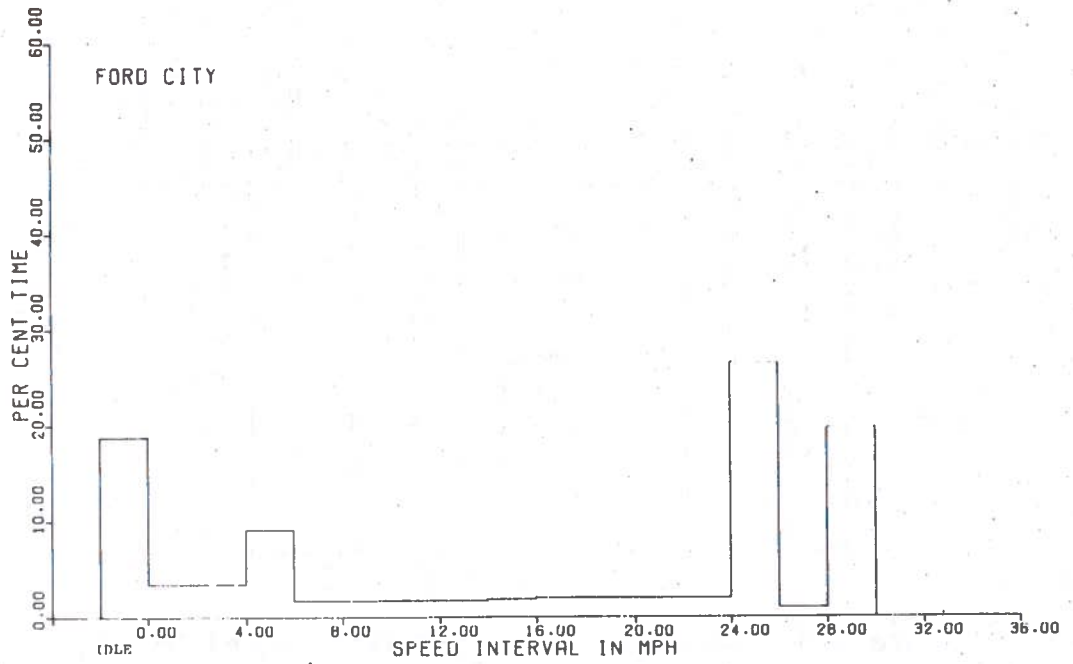


Figure A-27 Ford City Economy Driving Schedule, Percent Time-Speed Interval Profile

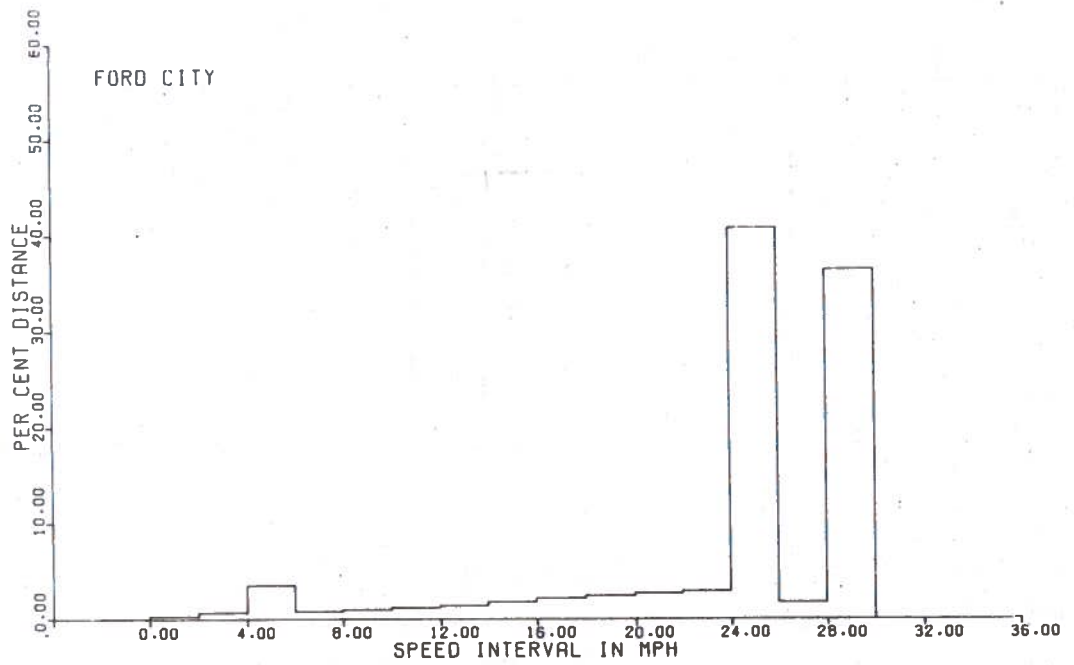


Figure A-28 Ford City Economy Driving Schedule, Percent Distance-Speed Interval Profile

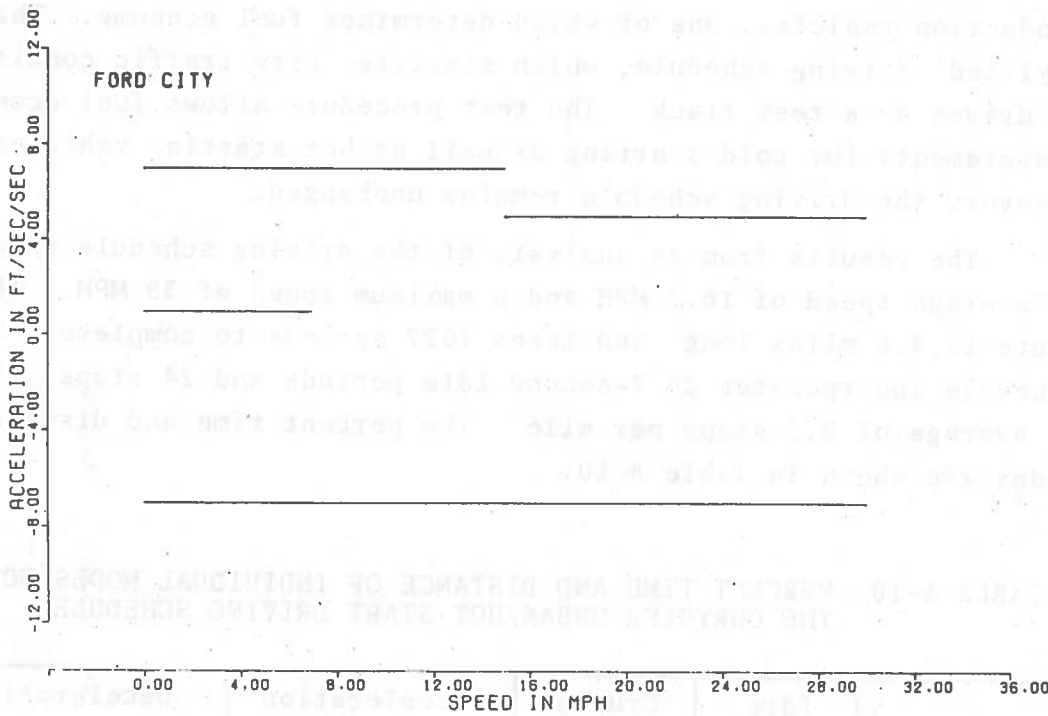


Figure A-29 Ford City Economy Driving Schedule, Acceleration-Speed Profile

A.5 CHRYSLER URBAN/HOT START DRIVING SCHEDULE

A.5.1 Description

Chrysler Corporation performs a number of tests on their production vehicles, one of which determines fuel economy. This stylized driving schedule, which simulates city traffic conditions, is driven on a test track. The test procedure allows fuel economy measurements for cold-starting as well as hot-starting vehicles; however, the driving schedule remains unchanged.

The results from an analysis of the driving schedule show an average speed of 16.2 MPH and a maximum speed of 35 MPH. The route is 4.6 miles long and takes 1027 seconds to complete. The schedule incorporates 24 7-second idle periods and 24 stops, with an average of 5.2 stops per mile. The percent time and distance modes are shown in Table A-10.

TABLE A-10 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE CHRYSLER URBAN/HOT START DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	16.4	34.8	30.5	18.3
% Distance		59.3	25.5	15.3

As is shown in Table A-10 greater than 30% of the elapsed time and greater than 55% of the total distance traveled is in the cruise mode. There are 24 cruise maneuvers performed during this schedule; 22 cruises at 26 MPH and two cruises at 35 MPH. The acceleration mode has one acceleration rate, $+3 \text{ ft/sec}^2$. This is performed 24 times and accounts for slightly greater than 30% and 25% of the schedule's time and distance, respectively. The deceleration mode also has only one rate, -5 ft/sec^2 . This maneuver is performed 24 times and accounts for 18.3% of the schedule's time and 15.3% of the schedule's distance.

A.5.2 Discussion

The instructions to this schedule are clear, except for the points where the deceleration maneuvers are initiated. The location where braking is first applied should either be computed beforehand, or clearly marked on the test track as a driver aid.

Certain maneuvers are repeated 21 times. Unless a checklist is employed by test personnel, the repetition may become a source of error.

Since the schedule has nonvarying acceleration and deceleration rates, use of it as a simulation of typical urban driving conditions is questioned. Also, two cruise speeds are utilized during the schedule, 26 and 35 MPH; whether this fact is important to fuel economy measurement is undetermined at this time.

A.5.3 Chrysler Urban/Hot Start Driving Schedule Instructions

Instructions for the Chrysler Urban/Hot Start Driving Schedule²² are indicated in Table A-11, and corresponding profiles are shown in Figures A-30 through A-36.

TABLE A-11 CHRYSLER URBAN/HOT START DRIVING SCHEDULE INSTRUCTIONS

Step	Operation
a.	Accelerate at 3 ft/sec/sec. to 26 MPH.
b.	Upon attaining 26 MPH, continue at road load (at that speed). Limit distance traveled (from start of acceleration to stop) to about <u>0.17</u> mile. Begin stopping at the paint stripe on track, and brake car at a deceleration rate of 5 ft/sec/sec.
c.	Idle engine normally for 7 seconds (in gear).
d.	Accelerate at 3 ft/sec/sec. to 35 MPH.

TABLE A-11 CHRYSLER URBAN/HOT START DRIVING SCHEDULE
INSTRUCTIONS (CONTINUED)

Step	Operation
e.	Upon attaining 35 MPH, continue at road load (at that speed). Limit distance traveled (from start of acceleration to stop) to about <u>0.46</u> mile. Begin stopping at paint stripe on the track, and brake car at a deceleration rate of 5 ft/sec/sec.
f.	Idle engine normally for 7 seconds (in gear).
g.	Repeat steps 1-3 21 more times limiting distance traveled (from start of acceleration to stop) to .17 mile.
h.	Complete one lap by repeating steps 4-6 limiting distance traveled (from start of acceleration to stop) to .42 miles. Laps should end at Pritchard Road. There will be a total of 24 stops per lap with the second and last ones being from 35 MPH, and all others from 26 MPH.

Source: Reference 22.

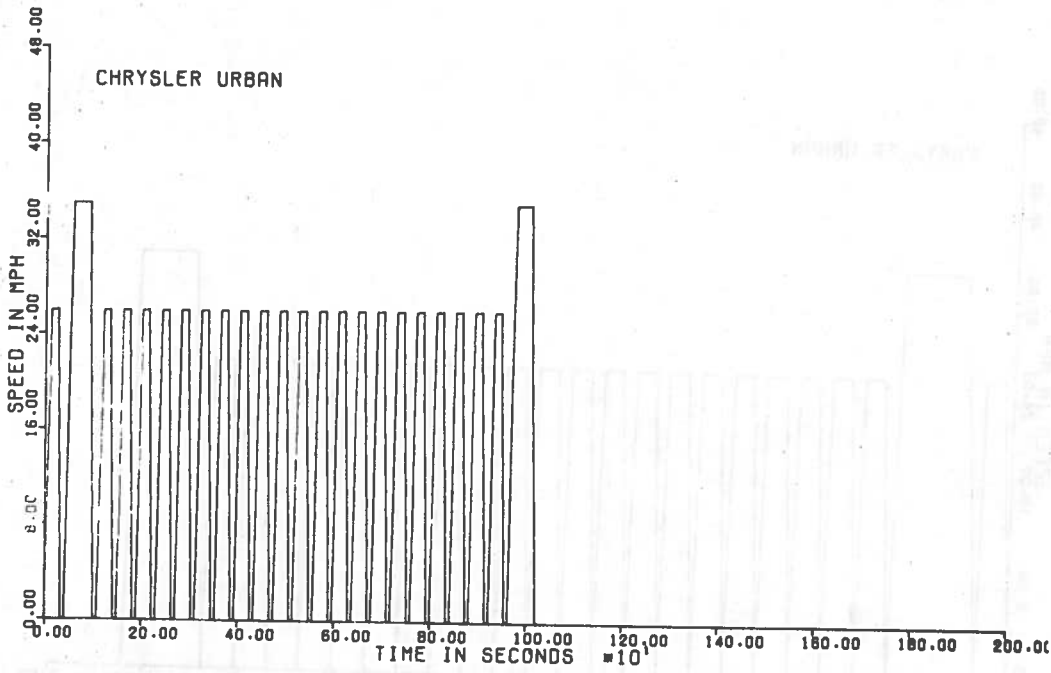


Figure A-30 Chrysler Urban Traffic Driving Schedule, Speed-Time Profile

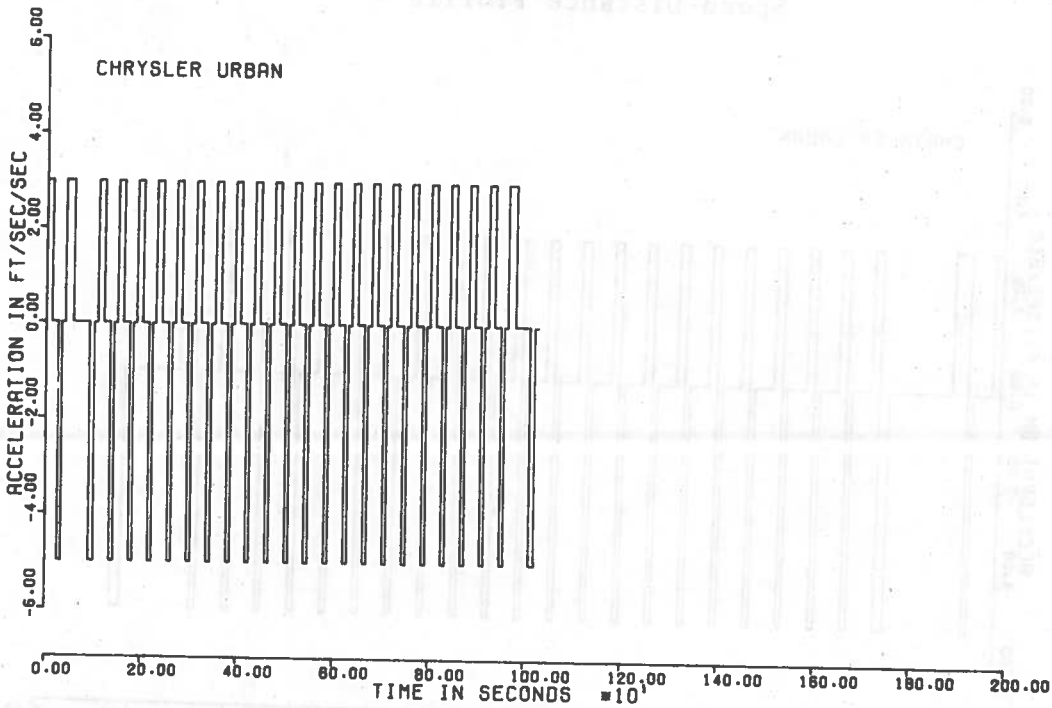


Figure A-31 Chrysler Urban Traffic Driving Schedule, Acceleration-Time Profile

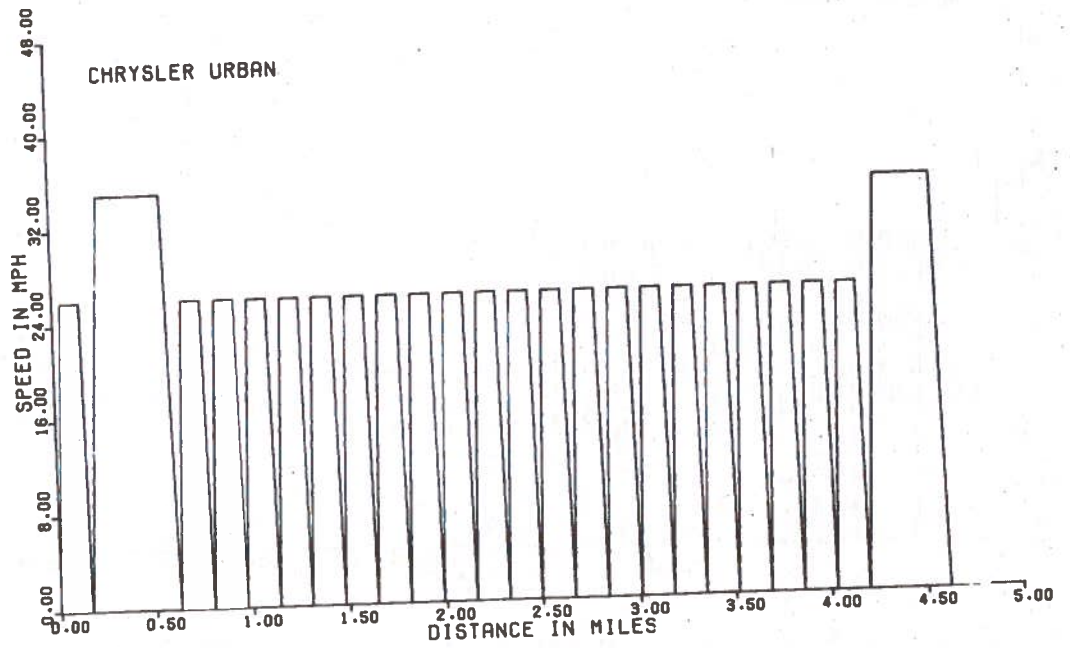


Figure A-32 Chrysler Urban Traffic Driving Schedule, Speed-Distance Profile

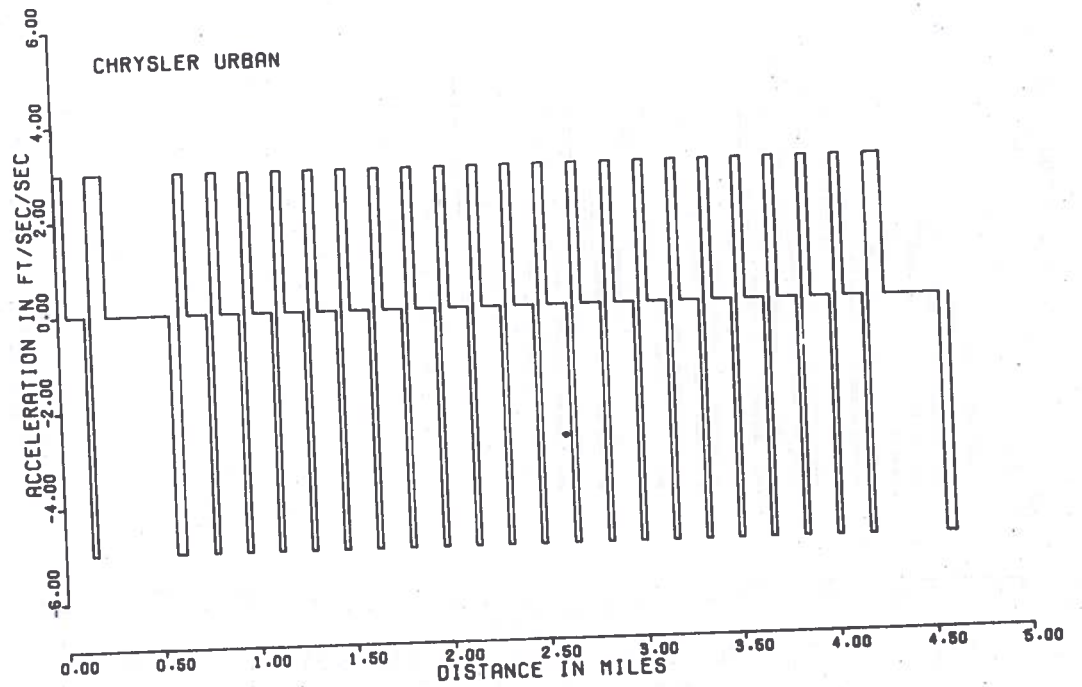


Figure A-33 Chrysler Urban Traffic Driving Schedule, Acceleration-Distance Profile

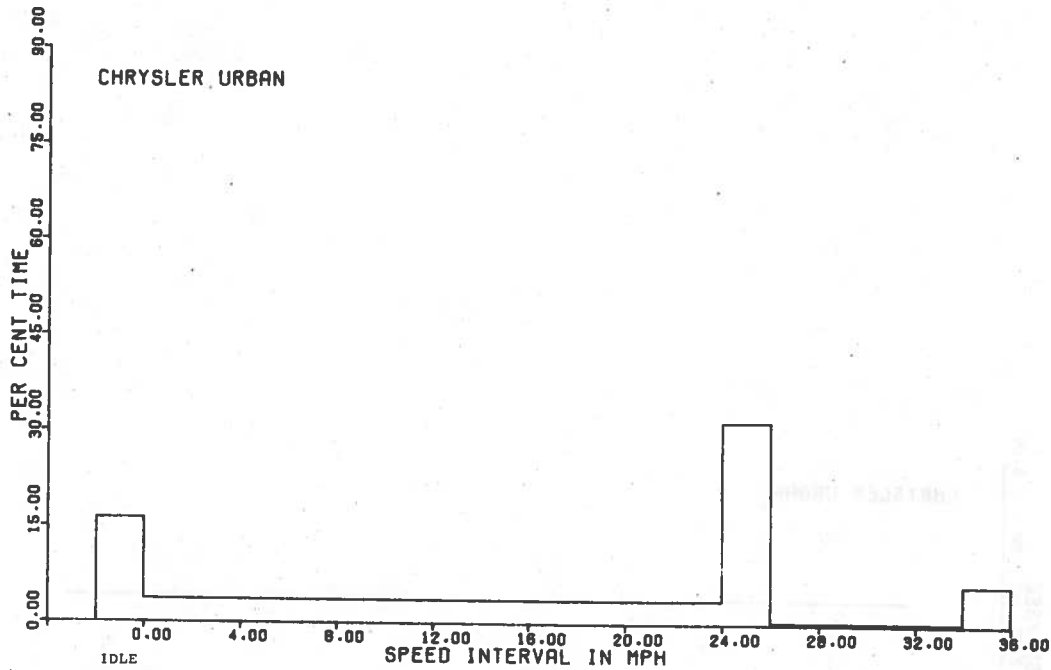


Figure A-34 Chrysler Urban Traffic Driving Schedule, Percent Time-Speed Interval Profile

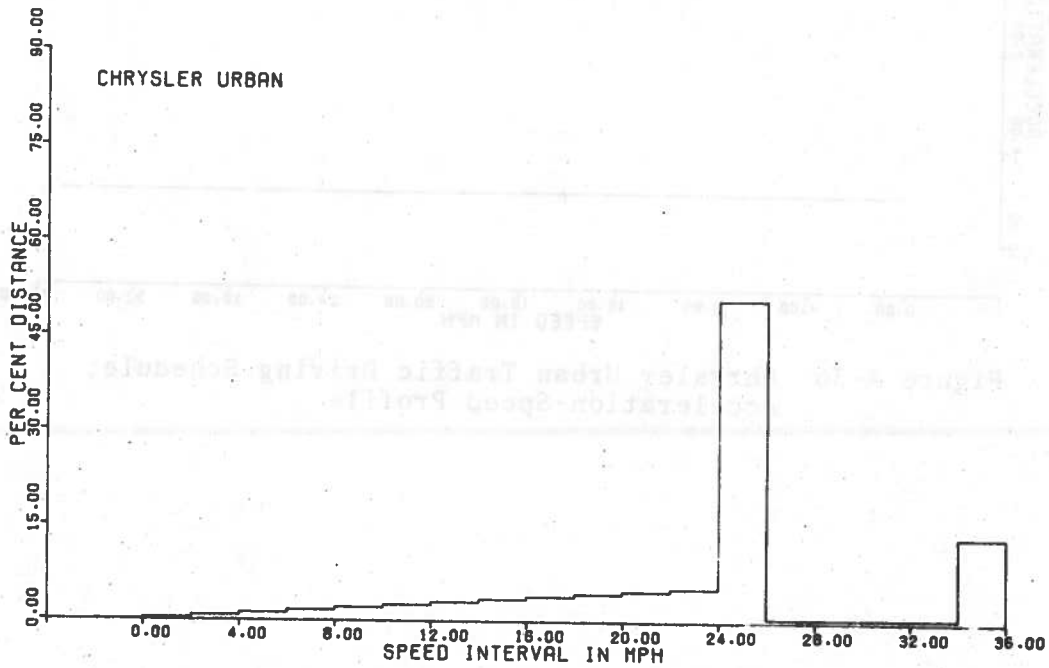


Figure A-35 Chrysler Urban Traffic Driving Schedule, Percent Distance-Speed Interval Profile

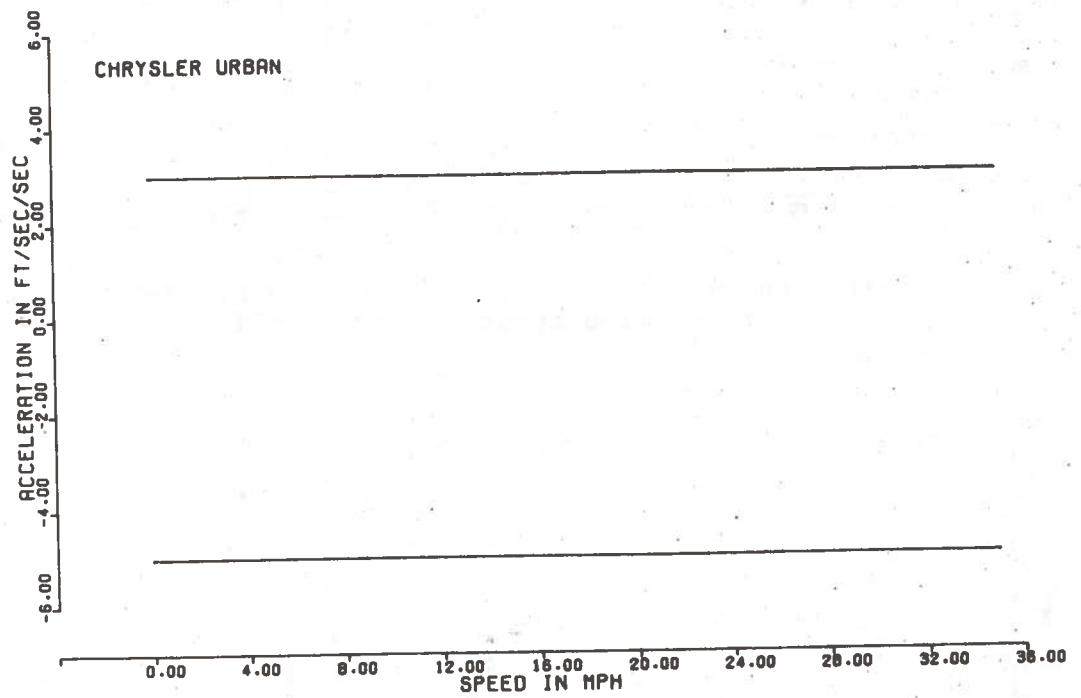


Figure A-36 Chrysler Urban Traffic Driving Schedule, Acceleration-Speed Profile

A.6 AMERICAN MOTORS CORPORATION CITY DRIVING SCHEDULE

A.6.1 Description

American Motors Corporation conducts numerous tests on their vehicles. One such test, which simulates a city traffic route, is used as a method for obtaining vehicle fuel economy. The test, which is conducted on a track, measures the fuel economy of the vehicle when it is thoroughly warmed up. The driving schedule is a stylized version of urban driving conditions.

The results obtained from the computer simulation indicated that the driving schedule has an average speed of 16.4 MPH, and a maximum speed of 35 MPH. The 4.6 mile route requires 1019 seconds to complete. The schedule also incorporates 23 7-second idle periods and 24 stops, giving a figure of 5.2 stops per mile. The percent time and distance modes are shown in Table A-12.

TABLE A-12 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE AMC CITY DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	15.8	34.2	31.2	18.7
% Distance		58.1	26.2	15.7

The schedule has 24 cruises accounting for approximately 34% of the time and 58% of the distance. There are 21 cruises at 26.0 MPH and three at 35 MPH. The acceleration mode has only one rate, $+3 \text{ ft/sec}^2$. There are 24 times when this mode is used, accounting for approximately 31% of the schedule's time and about 26% of its distance. The deceleration mode accounts for nearly 19% and 16% of the schedule's time and distance, respectively. There is only 1 rate of deceleration, -5 ft/sec^2 , and it is used 24 times throughout the schedule.

A.6.2 Discussion

The major criticism of the schedule is the lack of continuous information flow. The instructions for deceleration to a stop are given in the statement where the vehicle is to have stopped. If the statement preceded the marker location where the stop is to be performed, the probability for error would be reduced. Also, the location for application of the braking maneuver is not given and must be either computed beforehand or marked on the test track as a driver aid.

The schedule also lacks variable acceleration and deceleration rates, and is limited to two cruise speeds. Additional data are required to understand the significance of these factors on fuel economy.

This schedule is based upon the Chrysler Urban/Hot Start Driving Schedule. They both contain many similarities, as noted by the analysis of their respective parameters and their accompanying plots.

A.6.3 American Motors Corporation City Driving Schedule Instructions

Instructions for the American Motors Corporation City Driving Schedule are indicated in Table A-13, and corresponding profiles are shown in Figure A-37 through A-43.

TABLE A-13 AMC CITY DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (ft.)	Operation
0.0 (00.0)	Start fuel meter and stopwatch, accelerate to 26 MPH at 3 fps ² .
.17 (898)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
.34 (1795.2)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .

TABLE A-13 AMC CITY DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Distance Mile (ft.)	Operation
.51 (2692.8)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
.68 (3590)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
85 (4488)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
1.02 (5386)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
1.19 (6283)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
1.36 (7181)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
1.53 (8078)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 35 MPH at 3 fps ² .
1.97 (10,402) (1 lap)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 35 MPH at 3 fps ² .
2.15 (11,326)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
2.32 (12,250)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
2.49 (13,147)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
2.66 (14,045)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
2.83 (14,942)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .

TABLE A-13 AMC CITY DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Distance Miles (ft.)	Operation
3.0 (15,840)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
3.17 (16,738)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
3.34 (17, 635)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
3.51 (18,533)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 35 MPH at 3 fps ² .
3.95 (20,856) (2 laps)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
4.12 (21, 754)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
4.29 (22,651)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
4.46 (23,549)	Stop at 5 fps ² , idle 7 seconds (in gear), then accelerate to 26 MPH at 3 fps ² .
4.63 (24,446)	Stop at 5 fps ² , stop fuel meter, record fuel consumed and elapsed time.

Source: Reference 22.

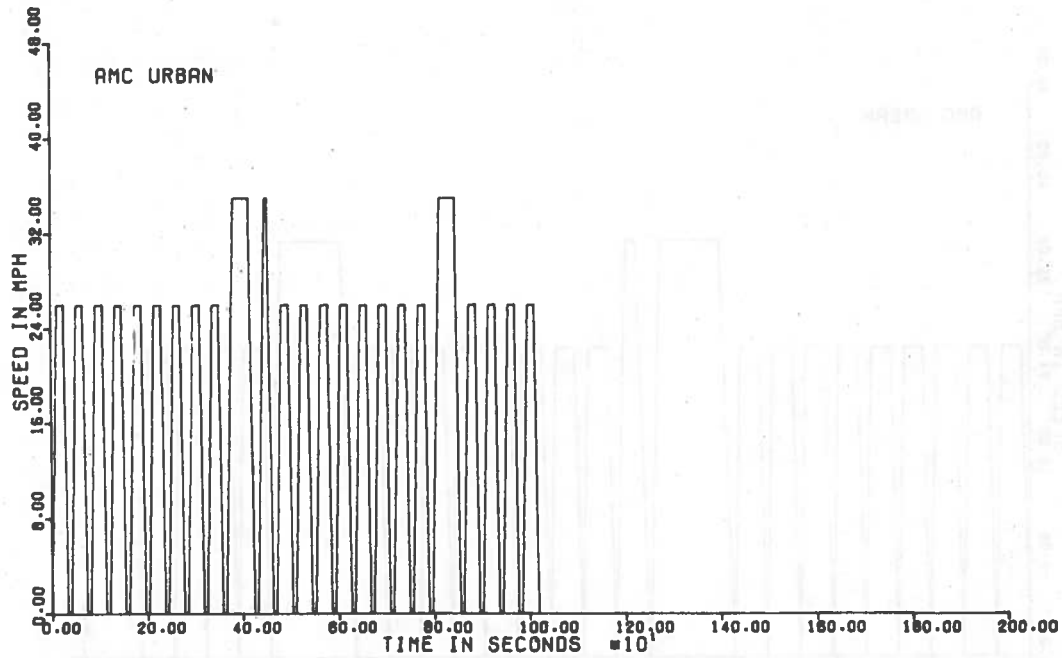


Figure A-37 AMC City Driving Schedule, Speed-Time Profile

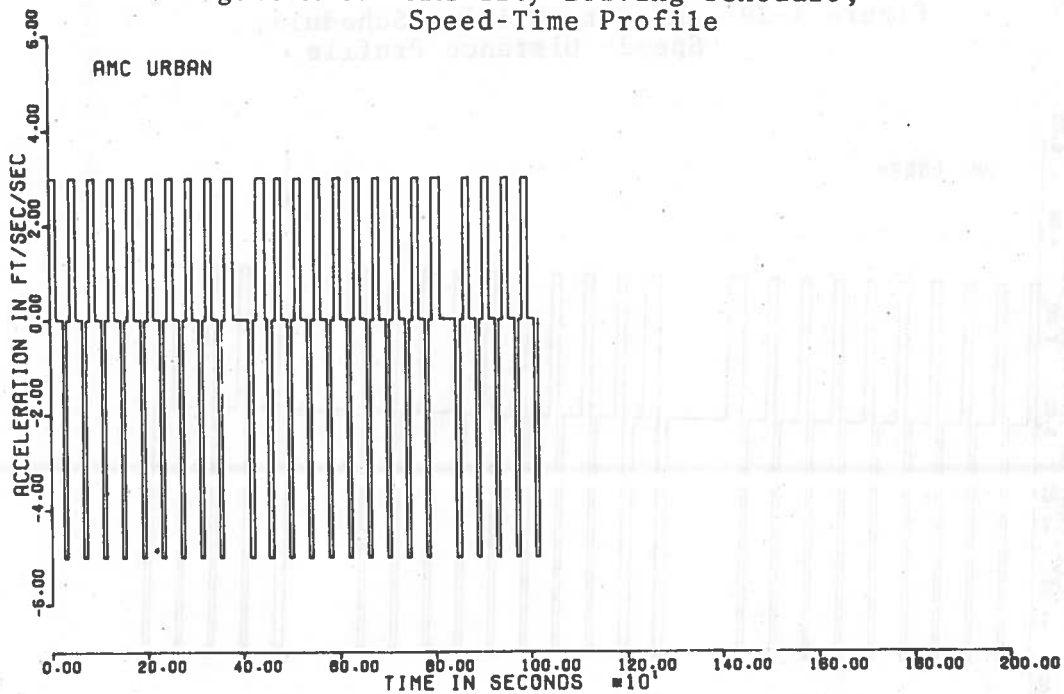


Figure A-38 AMC City Driving Schedule, Acceleration-Time Profile

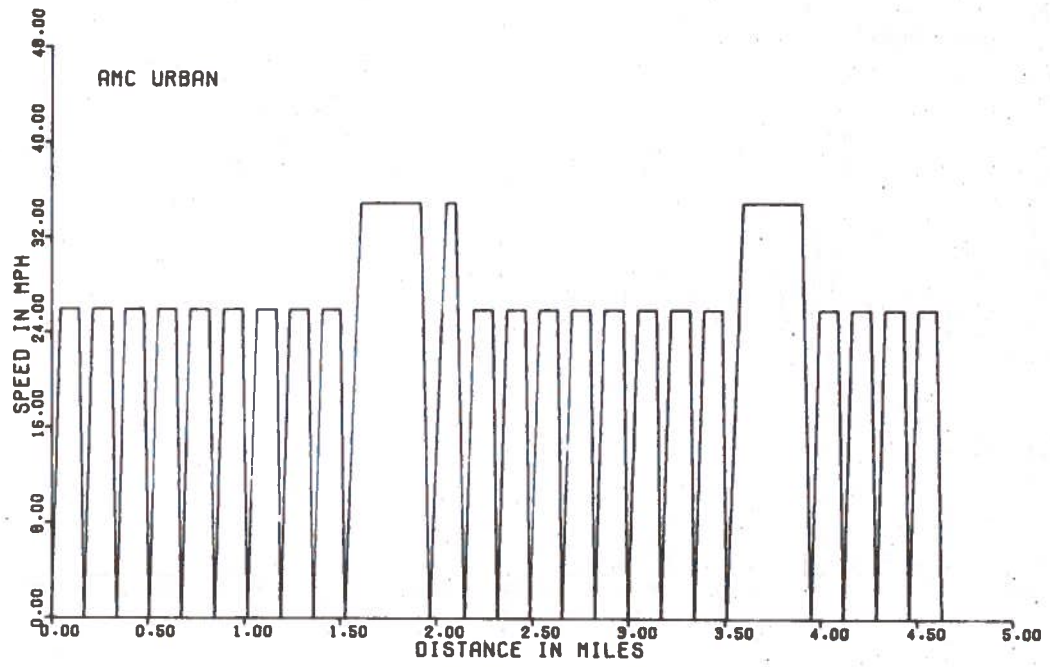


Figure A-39 AMC City Driving Schedule,
Speed- Distance Profile

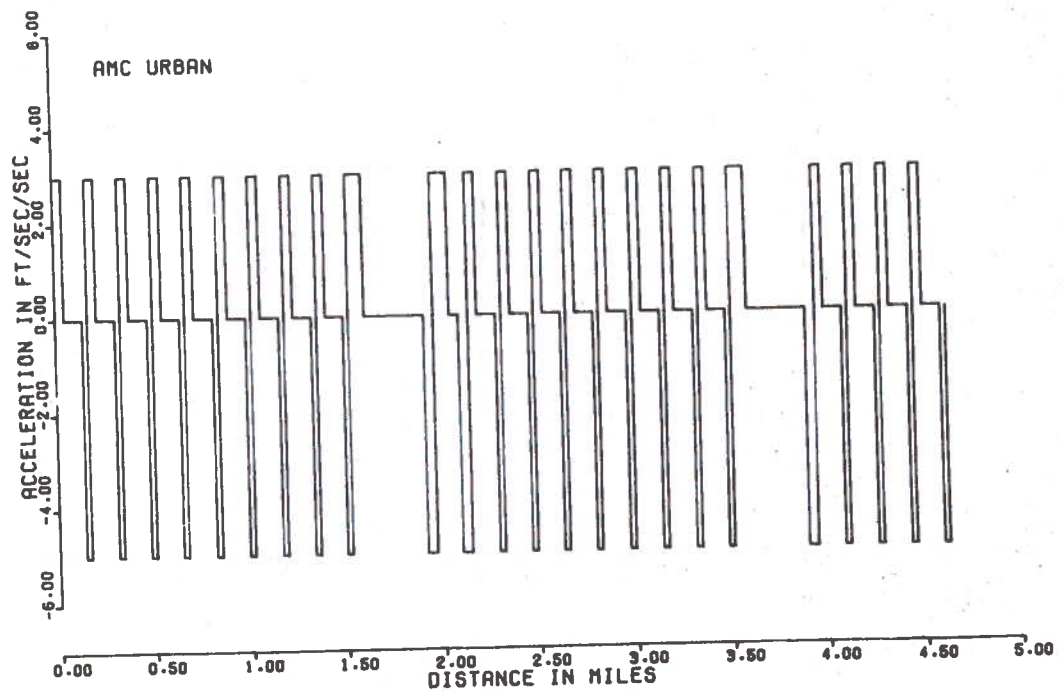


Figure A-40 AMC City Driving Schedule,
Acceleration-Distance Profile

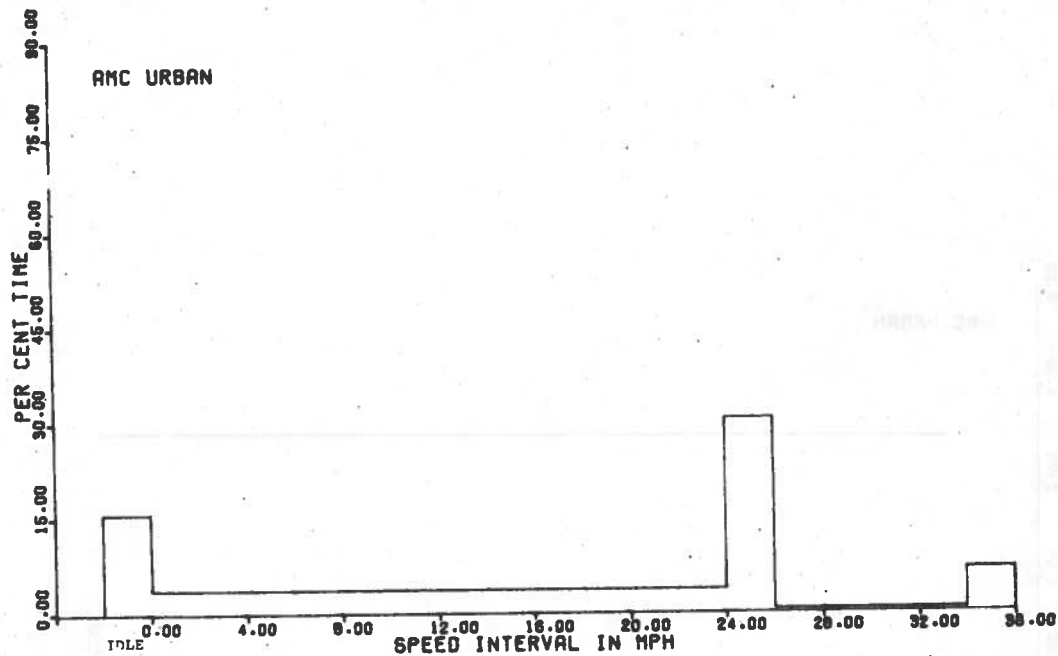


Figure A-41 AMC City Driving Schedule, Percent Time-Speed Interval Profile

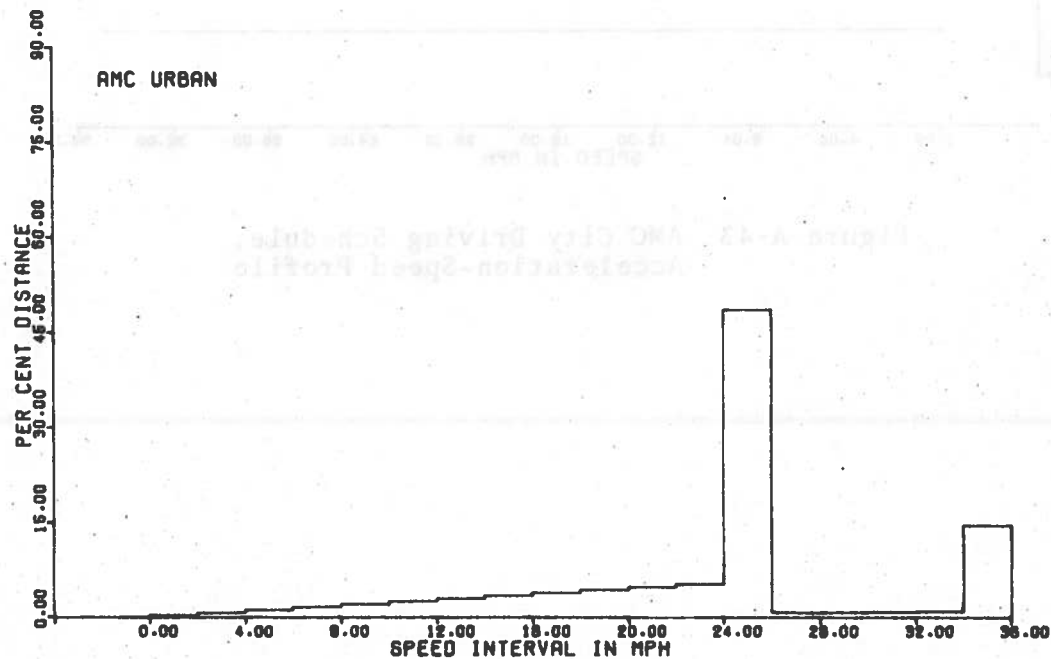


Figure A-42 AMC City Driving Schedule, Percent Distance-Speed Interval Profile

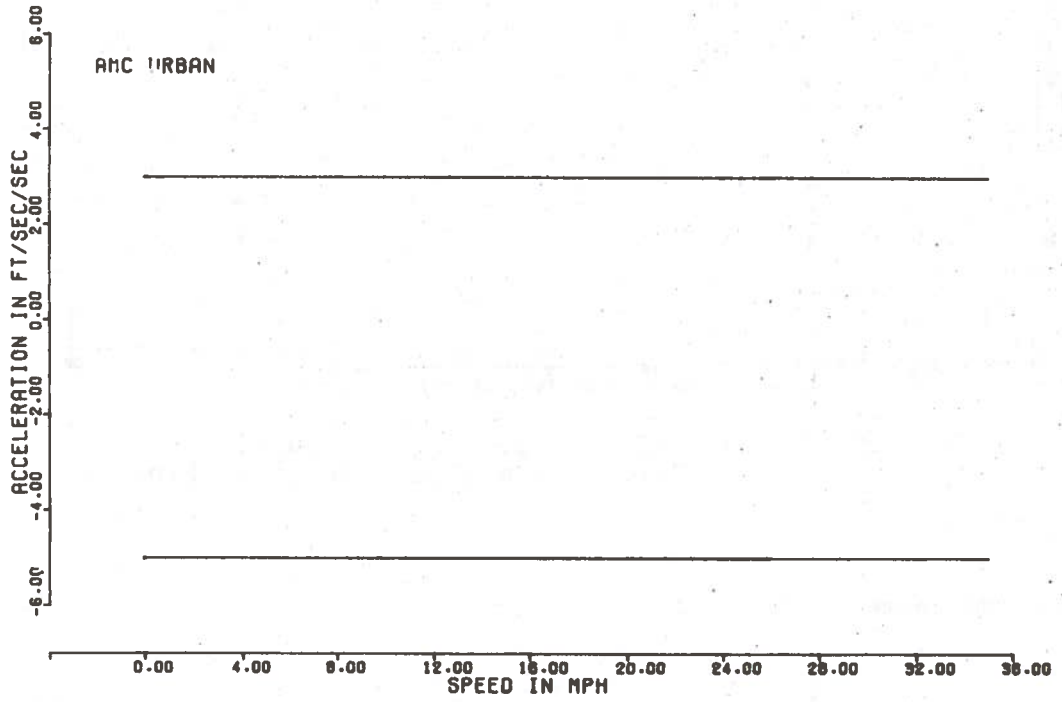


Figure A-43 AMC City Driving Schedule, Acceleration-Speed Profile

A-7 CALIFORNIA RESOURCES BOARD (ARB) 7 MODE DRIVING SCHEDULE

A.7.1 Description

The California Air Resources Board (ARB) 7 mode driving schedule originated from a 1956-1957 AMA-California traffic survey^{18,23,24}. The traffic survey was initiated to identify how vehicles were driven (i.e., the vehicle driving patterns) in the region within a 12-mile radius of downtown Los Angeles. The survey results indicated an average trip length of 7 miles, requiring 20.3 minutes to complete. In addition, the average route speed was determined to be 21 MPH. The survey also identified the 11 most important operating modes for determining compliance to exhaust standards and the percent time in each mode.

Complimenting this study was a field survey. This survey determined the amount of exhaust gas generated in each of the operating modes established by the traffic survey. In addition, the field survey determined the baseline emission measurements on vehicles in service.

The results reported were the calculated composite average emissions. The contributions from all modes were added to give the final number, and the contribution from each mode equal to the measured concentration multiplied by a correction factor. The resultant quantity of emissions was then multiplied by a weighting factor representative of the percent of exhaust gas generated in that mode during normal driving. The correction factor related the unburned hydrocarbons or carbon monoxide concentration to the carbon concentration in the exhaust gases. At a fixed flow rate, the concentration of emissions represents quantity of emissions per unit time, the total carbon represents rate of fuel use per unit time.

In February 1964, the 11-mode schedule was simplified to the present 7-mode schedule in order to establish a test schedule with more normal vehicle average speed to provide for more normal thermal loading on exhaust treating system.

The 7-mode schedule is used for emission measurements. It is a stylized driving schedule, and can be performed on a test track or dynamometer. It also measures the emissions of a vehicle when it is either in a cold-start or hot start condition. The schedule has an average speed of 21.2 MPH, and a maximum speed of 50.0 MPH. It is .81 miles long * and has an elapsed time of 137 seconds. It incorporates one 20-second idle and one stop, giving a stops per mile figure of 1.2. The percent time and distance modes are shown in Table A-14.

TABLE A-14 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE CALIFORNIA ARB 7-MODE DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	14.6	22.3	31.1	32.1
% Distance		23.6	39.5	36.9

The schedule has two cruises; one at 15 MPH and one at 30 MPH, accounting for slightly greater than 20% of the schedule's time and distance. Slightly greater than 30% of the schedule's time and almost 40% of the distance traveled is performed in the acceleration mode. There is a total of two accelerations, one at 3.23 ft/sec² and one at 1.76 ft/sec². The deceleration mode accounts for 32.3% of the time and 37% of the distance traveled throughout the schedule. The schedule has two deceleration maneuvers; one at a rate of -2.05 ft/sec² and one at -2.20 ft/sec².

A.7.2 Discussion

The California ARB 7-Mode driving schedule was developed to evaluate auto emissions, not vehicle fuel economy. It has received general acceptance as a driving schedule, and was utilized

*There is a discrepancy with this figure. The computer simulation gave .81 miles distance, but the ARB gives a value of .86 miles distance.

in the development of the Environmental Protection Agency's Federal Test Procedure driving schedule (see Section A.1).

The information is easily interpreted and should not be a source for any errors. One main problem that could be a source of error is the brevity of the schedule. The schedule distance is so short that even small deviations from the schedule's maneuvers may result in large errors. Modification of the schedule to extend the distance traveled and the cumulative time would help alleviate this problem.

A.7.3 California ARB 7-Mode Driving Schedule Instructions

Instructions for the California ARB 7-Mode Driving Schedule are indicated in Table A-15, and corresponding profiles are shown in Figures A-44 through A-50.

TABLE A-15 CALIFORNIA ARB 7-MODE DRIVING SCHEDULE INSTRUCTIONS

Sequence No.	Mode MPH	Acceleration MPH in Secs.	Elapsed Time Seconds	Cumulative Time Seconds
1	Idle	-	20	20
2	0 to 30	2.2	14	34
3	30	-	15	49
4	30 to 15	-1.4	11	60
5	15	-	15	75
6	15 to 50	1.2	29	104
7	50 to 0	-1.5	33	137

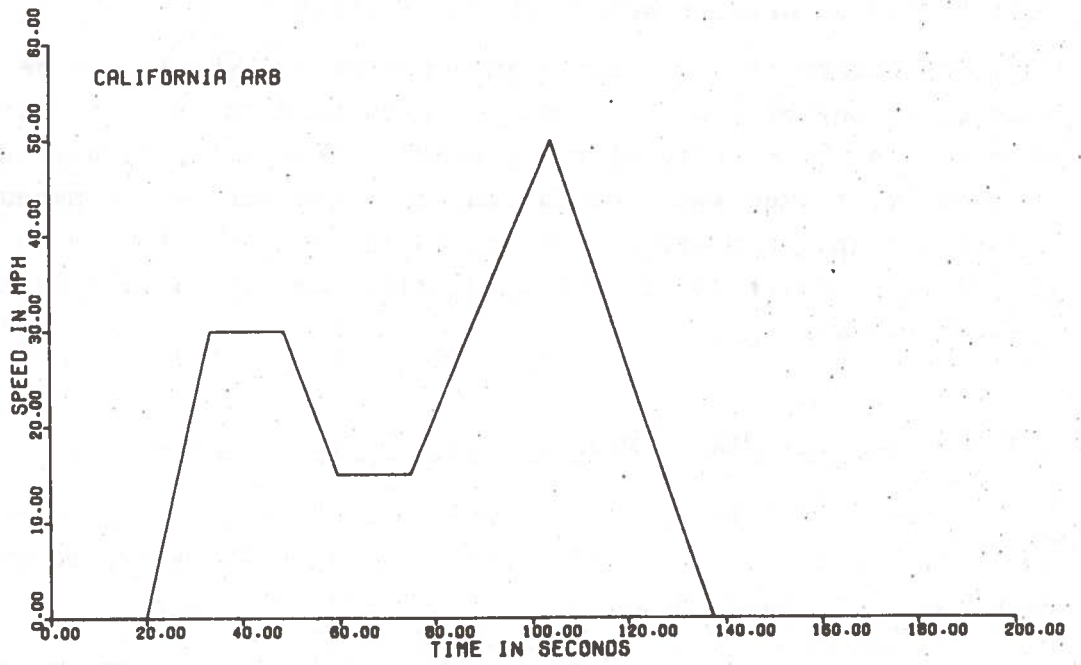


Figure A-44 CA ARB 7-Mode Driving Schedule, Speed-Time Profile

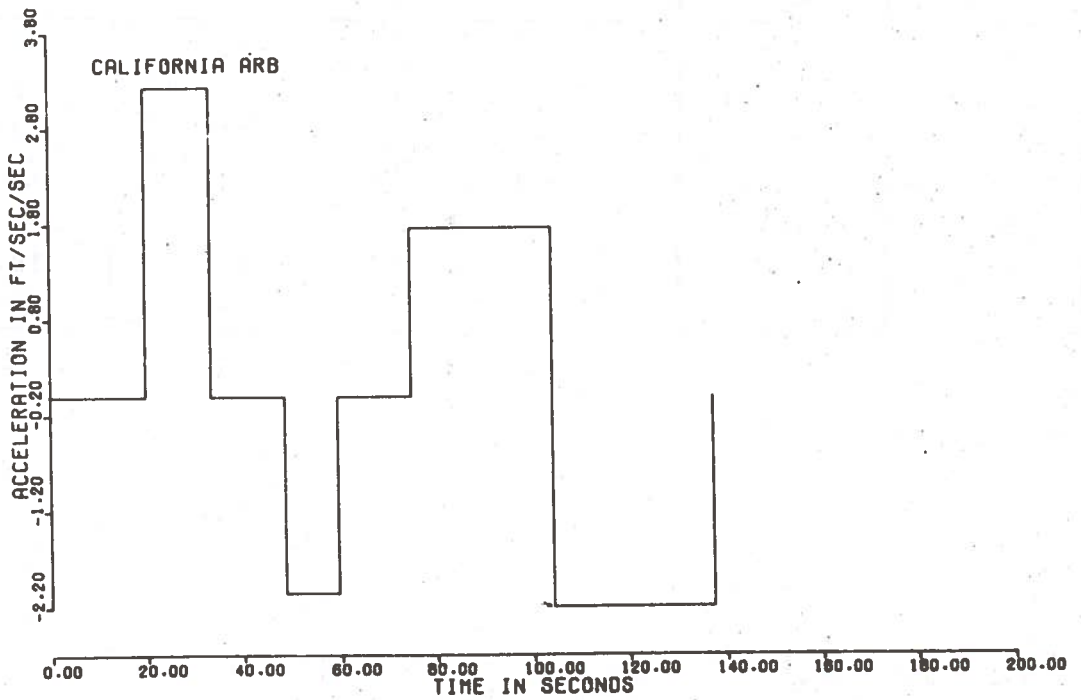


Figure A-45 CA ARB 7-Mode Driving Schedule, Acceleration-Time Profile

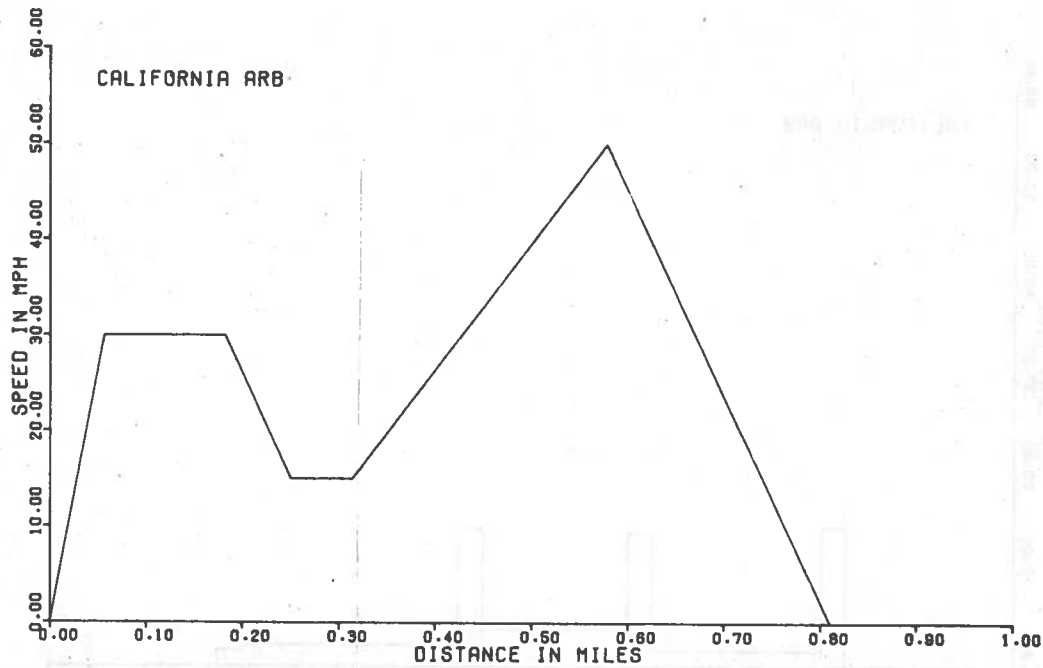


Figure A-46 CA ARB 7-Mode Driving Schedule, Speed-Distance Profile

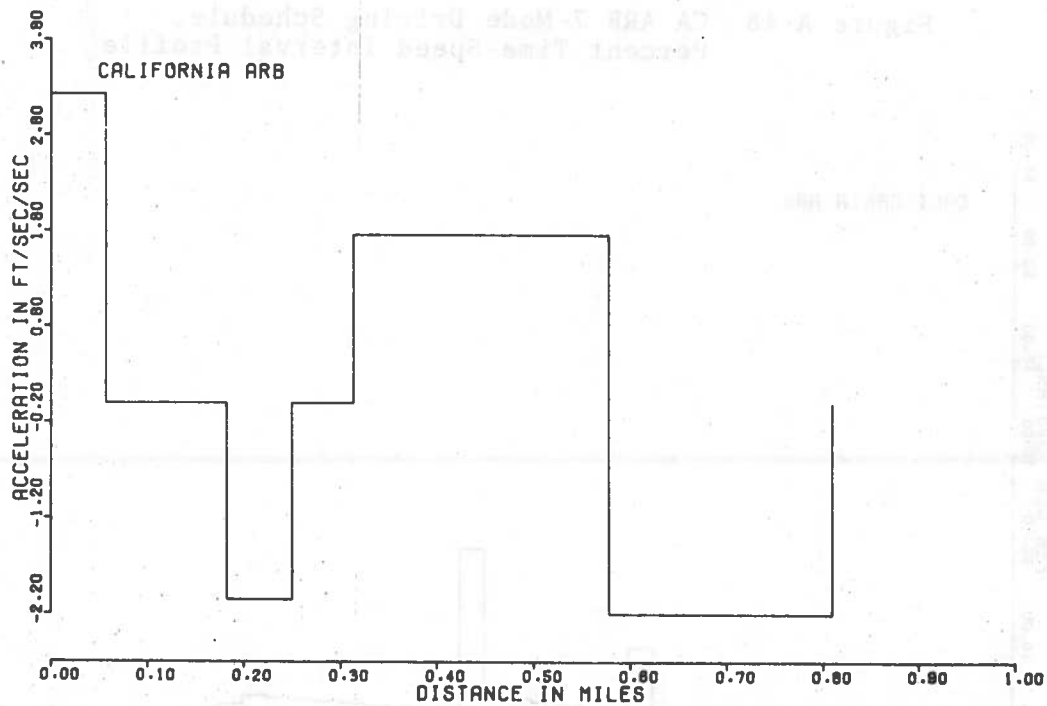


Figure A-47 CA ARB 7-Mode Driving Schedule, Acceleration-Distance Profile

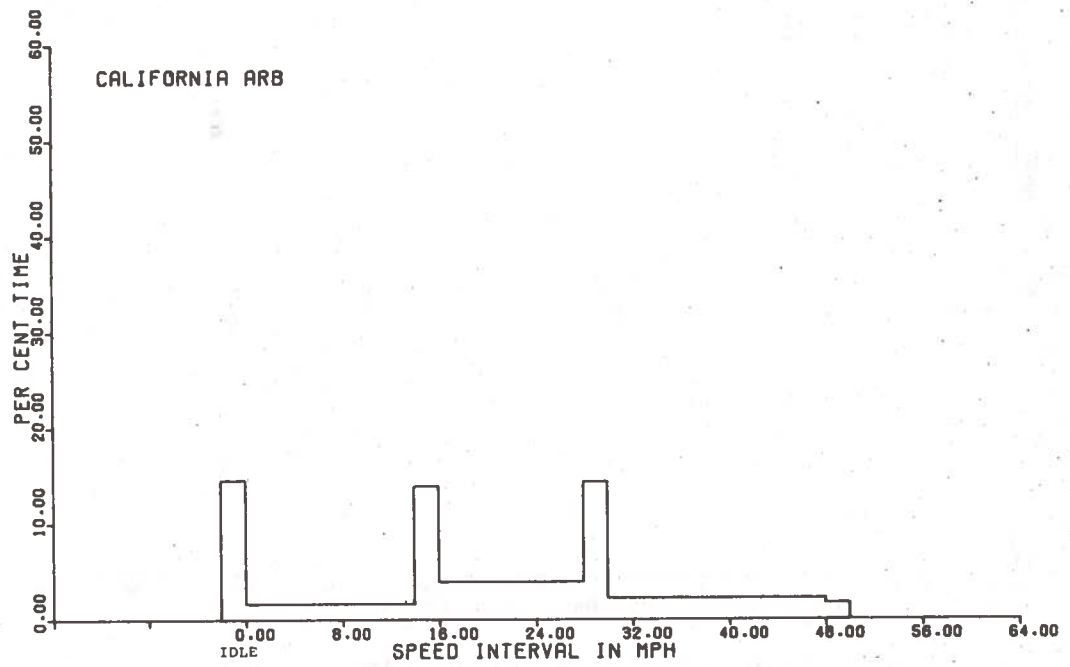


Figure A-48 CA ARB 7-Mode Driving Schedule, Percent Time-Speed Interval Profile

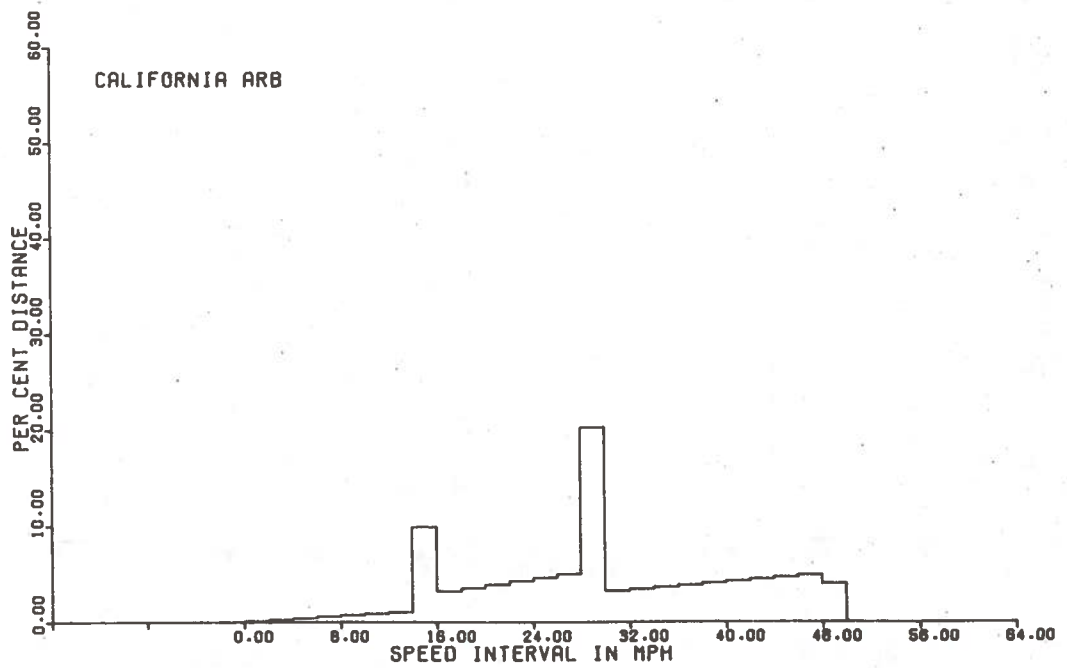


Figure A-49 CA ARB 7-Mode Driving Schedule, Percent Distance-Speed Interval Profile

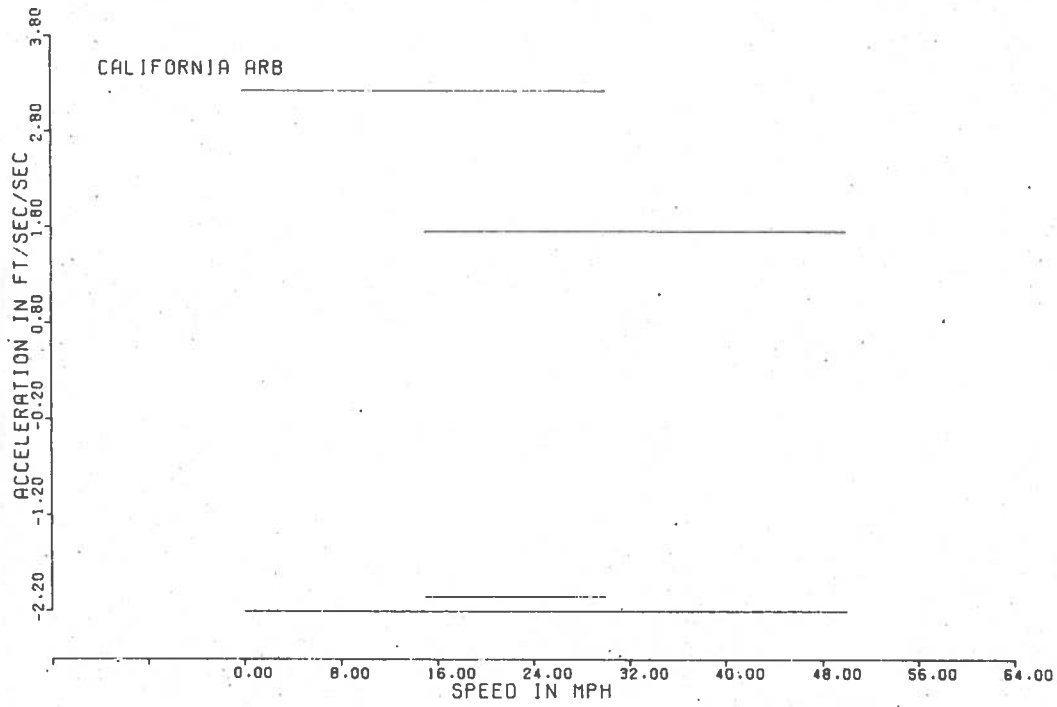


Figure A-50 CA ARB 7-Mode Driving Schedule, Acceleration-Speed Profile



APPENDIX B
SUBURBAN DRIVING SCHEDULES

A suburban driving schedule attempts to approximate those conditions that would be encountered while driving through a suburban area. The difficulty arises from the fact that no clear definition of "suburban" exists. Hence, the driving schedules classified as suburban schedules are actually intermediate schedules between the low speed urban driving schedules and the high speed highway/interstate driving schedules.

Some generalizations have been made. The suburban driving schedule incorporates some stops and some idling periods as indicated in Table B-1. The schedule has low to moderate speeds, and usually incorporates a segment of highway type driving. The maximum speed attained during the schedule is usually high (around 60 MPH).

The suburban driving schedule can be either continuous speed-time trace or a stylized schedule. However, all the schedules analyzed within this section are stylized driving schedules. Those analyzed include the following:

- 1) SAE Suburban Driving Schedule - J-1082
- 2) Ford Suburban Driving Schedule
- 3) AMC Suburban Driving Schedule
- 4) General Motors Suburban Driving Schedule

The seven characteristic plots of each schedule are included.

TABLE B-1 CHARACTERISTICS OF VARIOUS SUBURBAN DRIVING SCHEDULES

Parameter	Schedule				Mean or Mean of Means for All Suburban Driving Schedules
	SAE Suburban	Ford Suburban	AMC Suburban	GM Suburban	
Distance (mile)	5.2	5.2	5.2	3.7	4.8
Time (sec)	455	438	444	564	475
Mean Speed (MPH)	41.2	42.7	42.4	23.9	37.5
Max. Speed (MPH)	60.0	60.0	60.0	40.0	55.0
Number of:					
Idles	2	2	2	3	2.2
Stops	2	2	3	6	3.2
Stops/Mile	0.4	0.4	0.6	1.6	0.7
Percent Time In:					
Idle	3.1	1.4	1.4	13.3	4.8
Cruise	75.2	81.6	80.5	59.9	74.3
Acceleration	11.3	11.7	11.5	10.6	11.3
Deceleration	10.5	5.4	6.6	16.2	9.7
Percent Distance In:					
Cruise	83.2	86.6	86.1	77.9	83.4
Acceleration	9.3	9.3	9.2	8.1	9.0
Deceleration	7.5	4.1	4.7	14.1	7.6

B.1 SOCIETY OF AUTOMOTIVE ENGINEERS SUBURBAN DRIVING SCHEDULE -
J-1082

B.1.1 Description

The SAE Economy Task Force developed fuel economy test procedures from conditions other than urban driving. One test procedure simulates suburban driving. This procedure utilizes a stylized driving schedule with the test conducted on a test track. The vehicle's fuel economy is determined after it attains a steady-state warmed-up operating condition. This is to reduce the number of variables associated with cold start tests. The purpose for the development of this schedule, as with their other schedules, was to standardize a test procedure for measuring fuel economy of vehicles operating under conditions typical of suburban driving.

The results of the computer simulation showed an average speed of 41.2 MPH, and a maximum speed of 60.0 MPH. The route is 5.2 miles long, taking 455 seconds to complete. The schedule incorporates two idle periods and two stops, and therefore has 0.38 stops per mile. The percent time and distance modes are shown in Table B-2.

TABLE B-2 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE SAE SUBURBAN DRIVING SCHEDULE J1082

	Idle	Cruise	Acceleration	Deceleration
% Time	3.1	75.2	11.3	10.5
% Distance	-	83.2	9.3	7.5

As shown in Table B-2, more than 75% of the time and 80% of the distance is spent in the cruise mode. There is a total of five cruise maneuvers: two at 40 MPH, two at 50 MPH, and one at 60 MPH. The acceleration mode accounts for approximately 10% of the schedule's time and distance traveled, respectively. There are five accelerations at a rate of $+3.0 \text{ ft/sec}^2$; two accelerations at a rate of $+5.0 \text{ ft/sec}^2$, and two accelerations at $+7.0 \text{ ft/sec}^2$ rate. The deceleration mode also accounts for approximately 10% of the schedule's time and distance traveled. There are three deceleration maneuvers performed during the schedule, each at a rate of -4 ft/sec^2 . The remaining 3% of the schedule's time is spent in the idle mode.

B.1.2 Discussion

The driving cycle is clear, and the test driver should have no difficulty in following it on the test track. The computer simulation, however, does deviate on some values from statistics published by the SAE. The SAE evaluation gives a 41.9 MPH average speed with a running time of 447 seconds. The difference between the two evaluations is 1.6% on the running time and 1.7% on the average speed.

The deceleration mode lacks variability, having only one rate of deceleration. As stated by the SAE Task Force further analysis is needed to compare the sensitivity of vehicle fuel economy to nonuniform deceleration rates. Also it must be determined, through further investigation, if the average route speed is too high to be representative of suburban driving.

B.1.3 SAE Suburban Driving Schedule Instructions (19)

The instructions for the SAE Suburban Driving Schedule are listed in Table B-3, and the corresponding profiles are shown in Figures B-1 through B-3.

TABLE B-3 SAE SUBURBAN DRIVING SCHEDULE INSTRUCTIONS J1082

Distance Miles (km)	Operation
0.0 (0.0)	Approach starting line at 40 MPH (64.4 km/h). At line, start fuel measuring and timing devices, accelerate to 60 MPH (96.5 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 60 MPH (96.5 km/h) to the 0.7 mile (1.13 km) marker.
0.7 (1.13)	Decelerate to 30 MPH (48.3 km/h) at 4 ft/s^2 (1.2 m/s^2). Accelerate to 50 MPH (80.5 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 50 MPH (80.5 km/h) to the 2.0 mile (3.22 km) marker.
2.00 (3.22)	Stop at 4 ft/s^2 (1.2 m/s^2), idle 7 seconds, accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2). Continue accelerating to 25 MPH (40.2 km/h) at 5 ft/s^2 (1.5 m/s^2). Continue accelerating to 40 MPH (64.4 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 40 MPH (64.4 km/h) to the 2.6 mile (4.18 km) marker.
2.60 (4.18)	Accelerate to 50 MPH (80.5 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 50 MPH (80.5 km/h) to the 3.3 (5.31 km) marker.
3.30 (5.31)	Stop at 4 ft/s^2 (1.2 m/s^2), idle 7 seconds, accelerate to 15 MPH (24.1 km/h) at 7 ft/s^2 (2.1 m/s^2). Continue accelerating to 25 MPH (40.2 km/h) at 5 ft/s^2 (1.5 m/s^2). Continue accelerating to 40 MPH (64.4 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 40 MPH (64.4 km/h) to the 5.2 mile (8.37 km). Record fuel consumed, elapsed time, and fuel temperature.
0.0 (0.0)	Run recheck cycle.

Source: Reference 19.

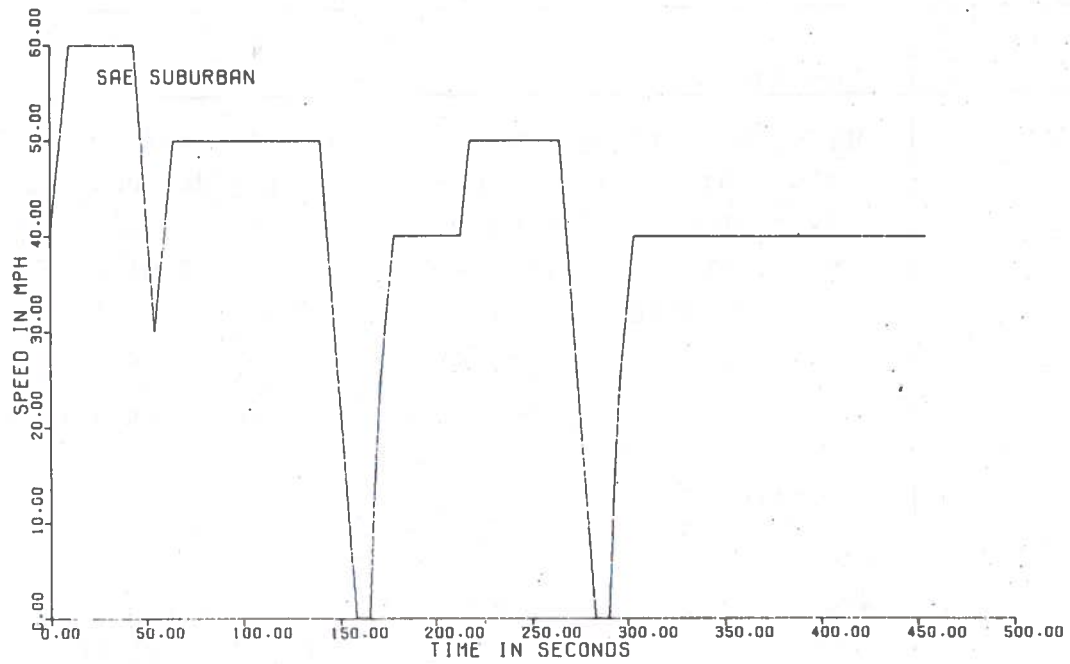


Figure B-1 SAE Suburban Driving Schedule - J1082, Speed-Time Profile

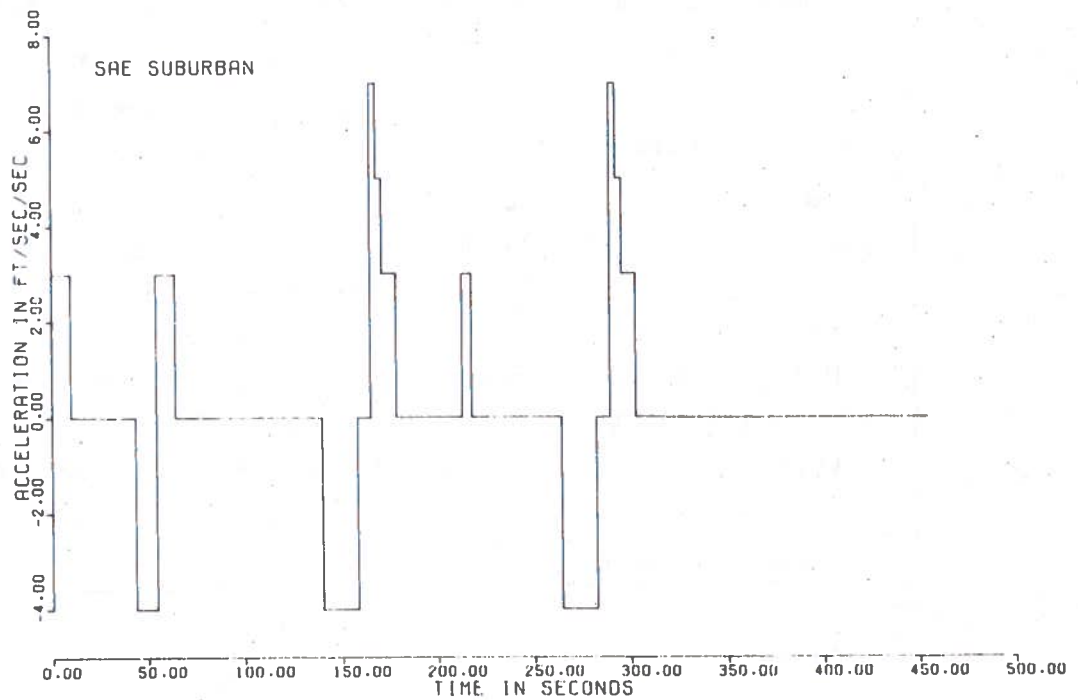


Figure B-2 SAE Suburban Driving Schedule - J1082, Acceleration-Time Profile

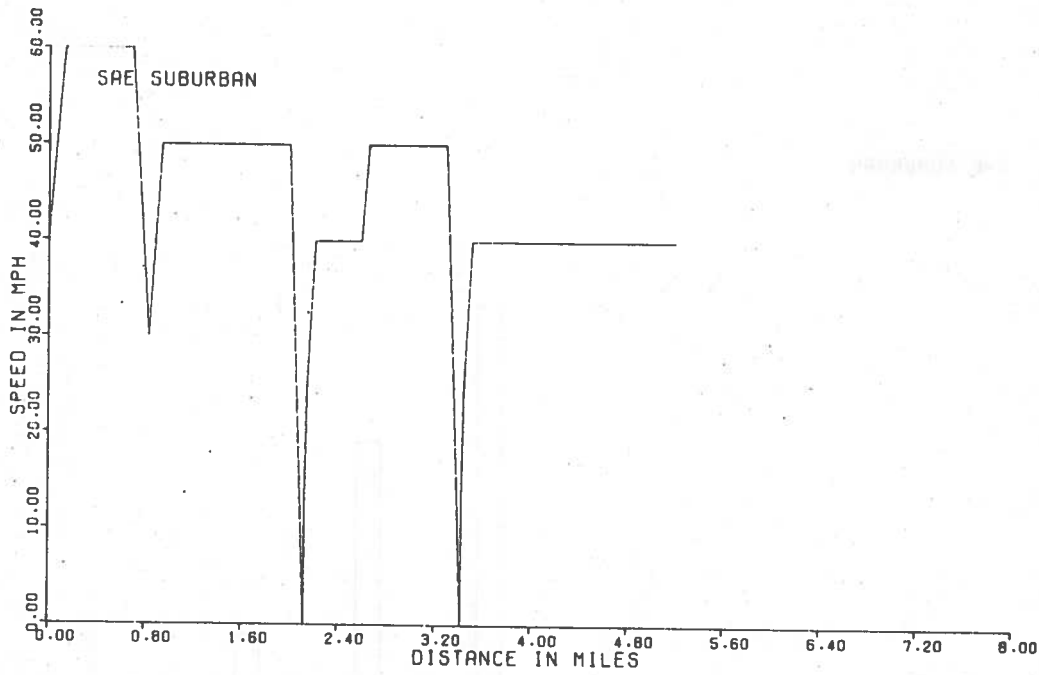


Figure B-3 SAE Suburban Driving Schedule - J1082, Speed-Distance Profile

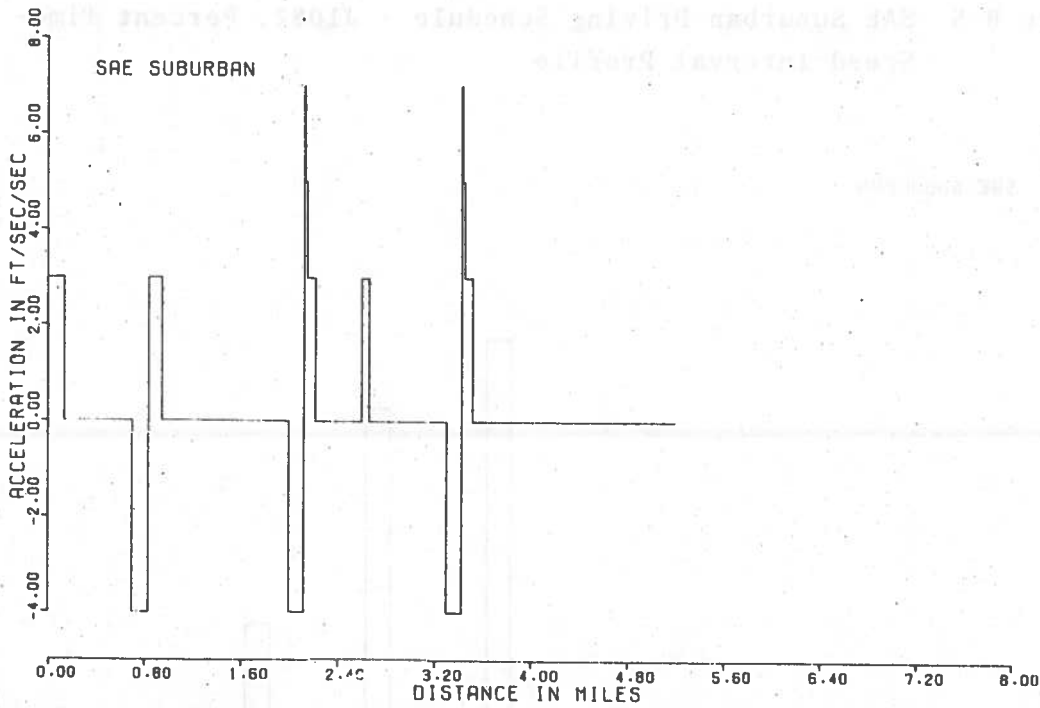


Figure B-4 SAE Suburban Driving Schedule - J1082, Acceleration-Distance Profile

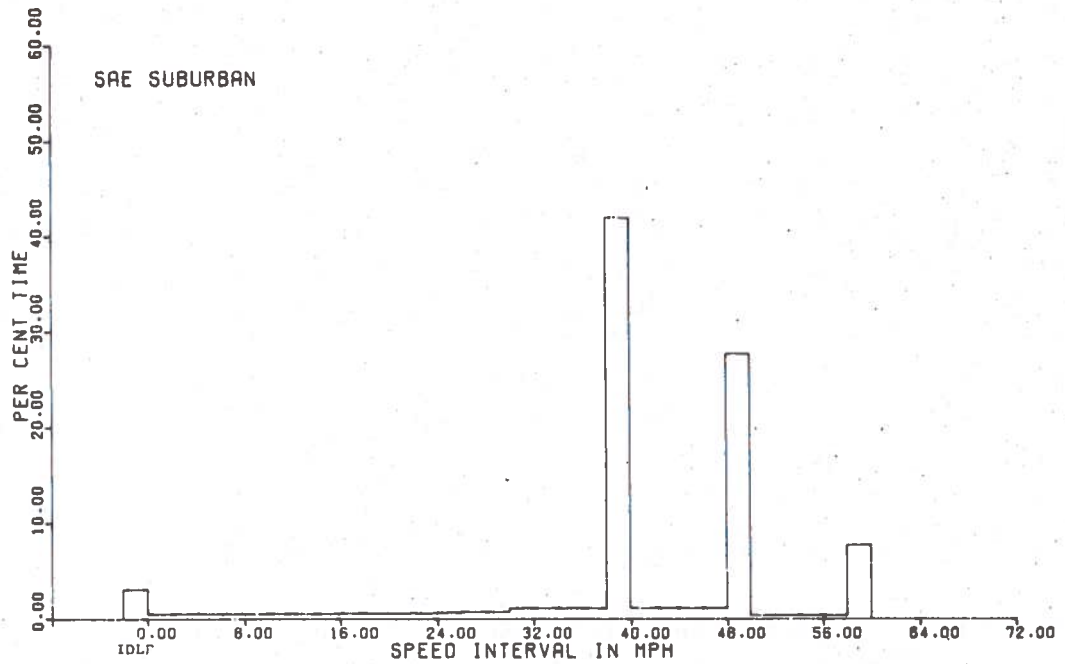


Figure B-5 SAE Suburban Driving Schedule - J1082, Percent Time-Speed Interval Profile

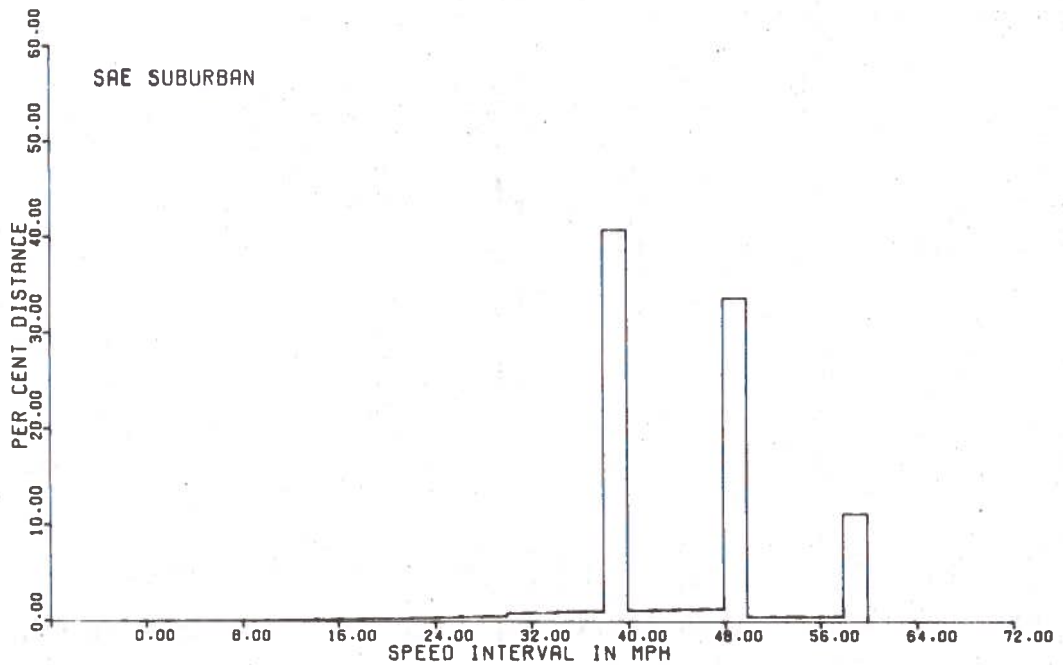


Figure B-6 SAE Suburban Driving Schedule - J1082, Percent Distance-Speed Interval Profile

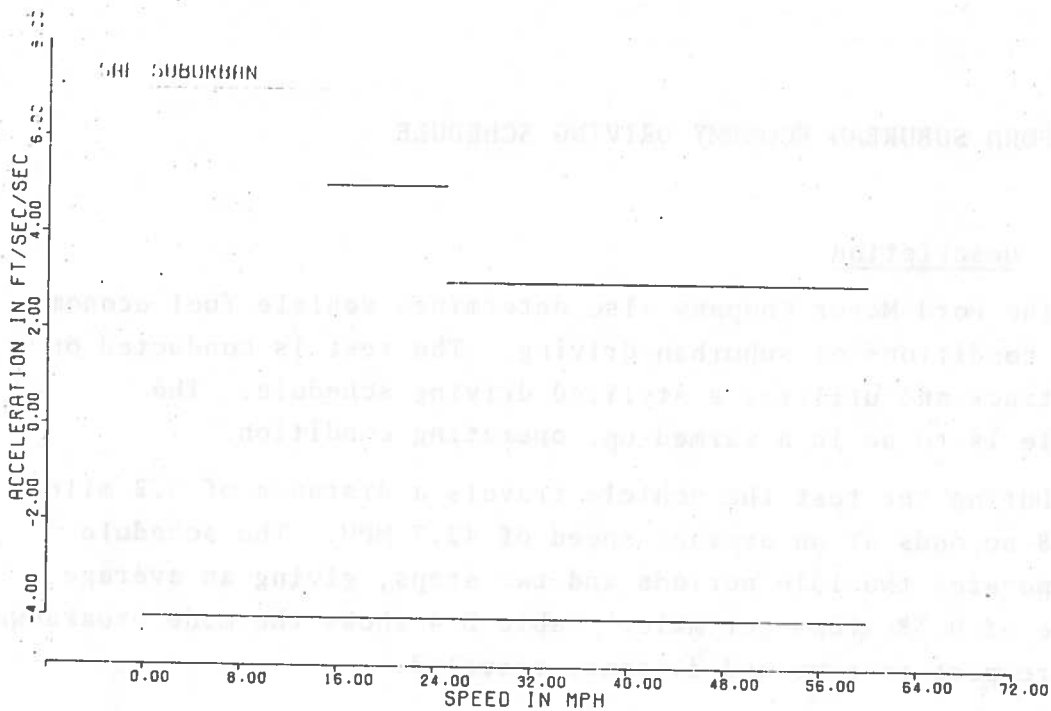


Figure B-7 SAE Suburban Driving Schedule - J1082, Acceleration-Speed Profile

Speed (MPH)	Acceleration (ft/sec/sec)	Time (sec)	Distance (ft)
0.00	4.50	0.00	0.00
16.00	4.50	3.56	28.50
16.00	3.50	3.56	28.50
56.00	3.50	39.11	1050.00
56.00	0.50	39.11	1050.00
72.00	0.50	42.67	1280.00

B.2 FORD SUBURBAN ECONOMY DRIVING SCHEDULE

B.2.1 Description

The Ford Motor Company also determines vehicle fuel economy under conditions of suburban driving. The test is conducted on a test track and utilizes a stylized driving schedule. The vehicle is to be in a warmed-up, operating condition.

During the test the vehicle travels a distance of 5.2 miles in 438 seconds at an average speed of 42.7 MPH. The schedule incorporates two idle periods and two stops, giving an average figure of 0.38 stops per mile. Table B-4 shows the mode breakdown with respect to time and distance traveled.

TABLE B-4 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE FORD SUBURBAN ECONOMY DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	1.4	81.6	11.7	5.4
% Distance	-	86.6	9.3	4.1

The cruise mode accounts for the majority of the schedule's time and distance, 81.6% and 86.6% respectively. The five cruise maneuvers incorporated within the schedule are further subdivided into: two cruises at 40 MPH, two cruises at 50 MPH, and one cruise at 60 MPH. The acceleration mode has five accelerations performed at a $+3.0 \text{ ft/sec}^2$ rate, two accelerations at $+5.0 \text{ ft/sec}^2$, and two accelerations at a rate of $+7.0 \text{ ft/sec}^2$, totaling nine acceleration maneuvers. These accelerations use 11.7% of the schedule's time and 9.3% of its distance. The idle periods make up 1.4% of the time. The remaining time and distance are used in the deceleration mode (5.4% of the time and 4.1% of the distance). The one deceleration maneuver occurs at a rate of -5 ft/sec^2 , and two deceleration maneuvers occur at a rate of -10 ft/sec^2 .

B.2.2 Discussion

The presentation of the instructions for this driving schedule could be a source of probable error. The instructions for a deceleration and stop maneuvers are given in the section where the vehicle should already be stopped. The instruction should be given in the preceding step to enhance continuous information flow. Also the location where this maneuver is to begin is not given and should be indicated by either a driver aid such as a location marker or computation beforehand, so that the test can be performed accurately.

Comparison of parameters between the computer simulation and Ford show good agreement for the running time. Ford's requirement that the schedule run between 441 and 445 seconds (computer simulation ran 438 seconds) could not be reproduced.

Another point of interest is that this schedule was the principal reference for the development of the SAE urban drive schedule. They both contain many similarities, as noted by analysis of their respective parameters and their accompanying plots.

B.2.3 Ford Suburban Economy Driving Schedule Instructions (21)

Instructions for the Ford Suburban Economy Driving Schedule are indicated in Table B-5, and corresponding profiles are shown in Figures B-8 through B-14.

TABLE B-5 FORD SUBURBAN ECONOMY DRIVING SCHEDULE INSTRUCTIONS

Miles	Operation
(a)	Warm up vehicle by operating a distance of approximately 10 miles at 60 MPH; include 2 brake stops at 10 ft/sec/sec during the last 5 miles. Approach starting (first) marker at 40 MPH.
(b) .00	Start burette and stop watch when passing the starting marker. Accelerate from 40 to 60 MPH at 3 ft/sec/sec.

TABLE B-5 FORD SUBURBAN ECONOMY SCHEDULE INSTRUCTIONS (CONTINUED)

Miles	Operation
(c) .70	At second marker decelerate from 60 to 30 MPH at 5 ft/sec/sec and then accelerate from 30 to 50 MPH at 3 ft/sec/sec. Proceed to third marker at 50 MPH.
(d) 2.00	Stop at 10 ft/sec/sec at third marker. Idle for 3 seconds. Accelerate from a standing start to 15 MPH at 7 ft/sec/sec; continue accelerating at 5 ft/sec/sec from 15 to 25 MPH, and at 3 ft/sec/sec from 25 to 40 MPH.
(e) 2.60	At fourth marker accelerate from 40 to 50 MPH at 3 ft/sec/sec. Proceed to next marker at 50 MPH.
(f) 3.30	Stop at 10 ft/sec/sec at fifth marker. Idle for 3 seconds. Accelerate from a standing start to 15 MPH at 7 ft/sec/sec; continue accelerating at 5 ft/sec/sec from 15 to 25 MPH, and at 3 ft/sec/sec from 25 to 40 MPH. Proceed to sixth marker at 40 MPH.
(g) 5.20	Stop the burette and stopwatch when passing the sixth marker. Stop and record fuel consumed, elapsed time, and operating temperature.
(h)	Restablize vehicle warmup by operating a distance of approximately 5 miles at 60 MPH; include 2 brake stops at 10 ft/sec/sec. Approach starting (first) marker at 40 MPH.
(i)	Repeat above steps (b) through (g).

Source: Reference 21.

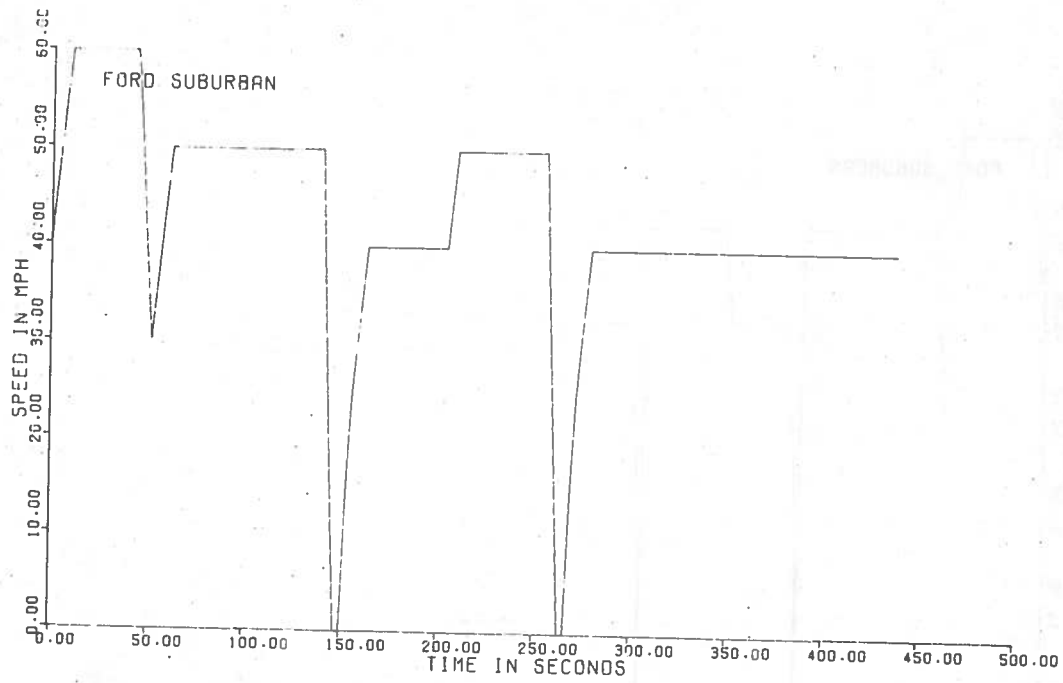


Figure B-8 Ford Suburban Economy Driving Schedule, Speed-Time Profile

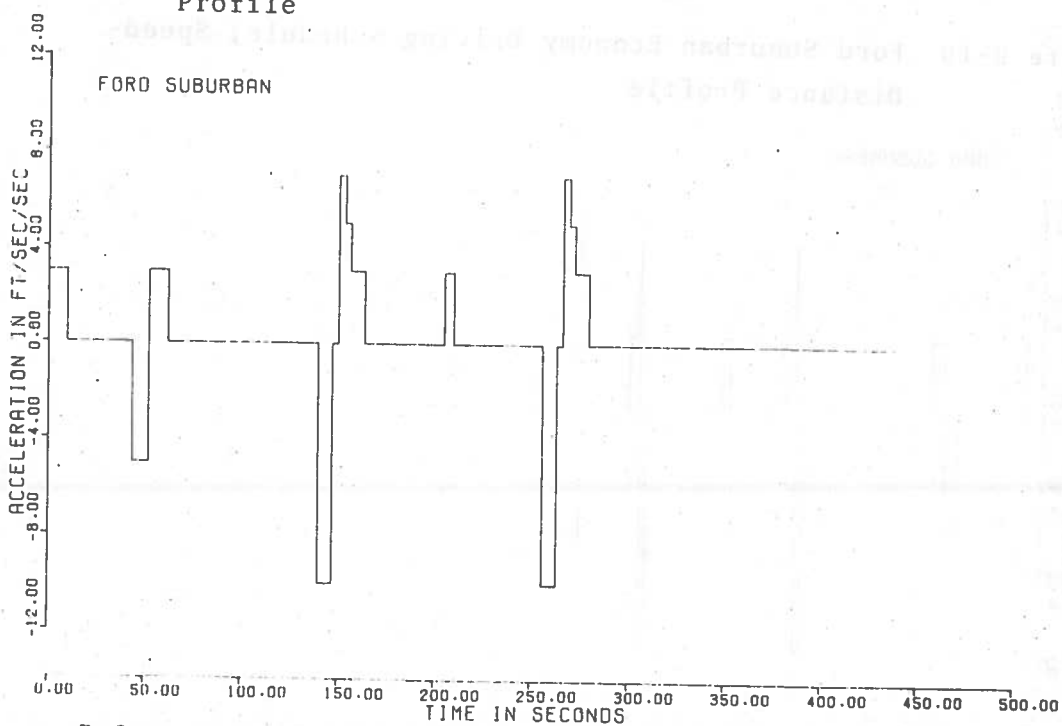


Figure B-9 Ford Suburban Economy Driving Schedule, Acceleration-Time Profile

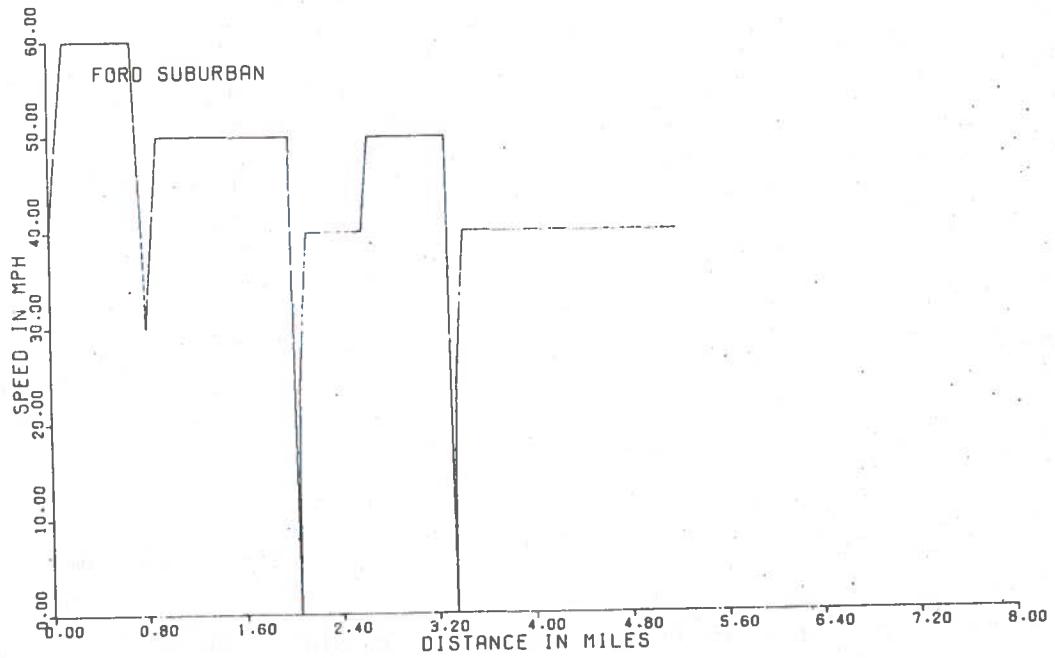


Figure B-10 Ford Suburban Economy Driving Schedule, Speed-Distance Profile

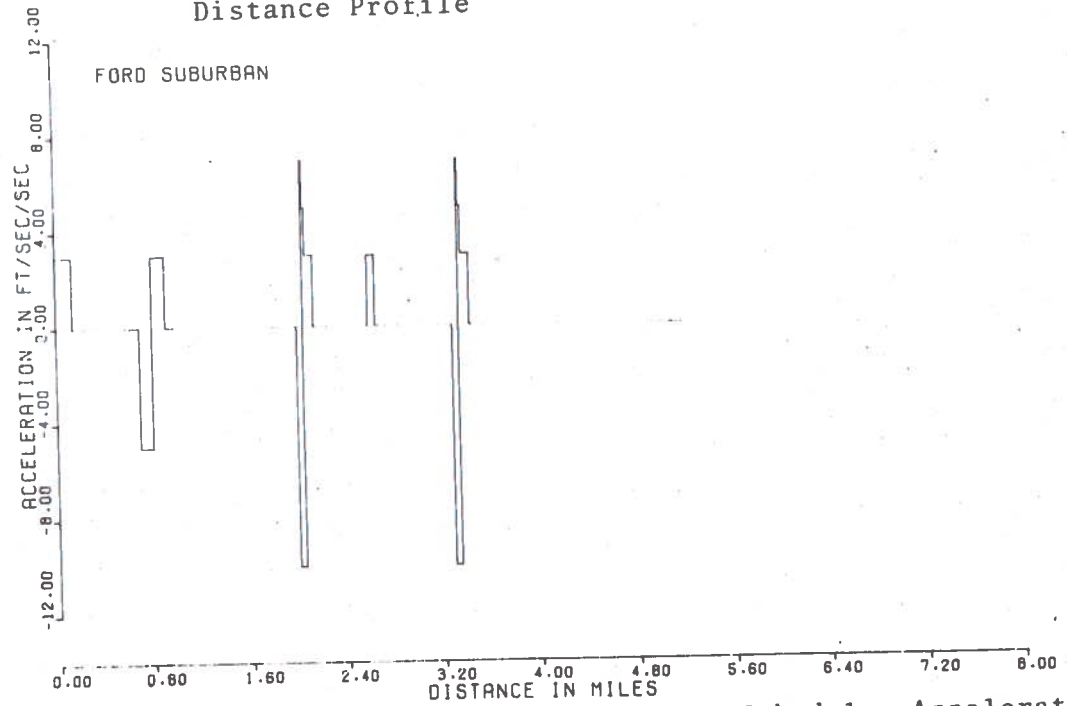


Figure B-11 Ford Suburban Economy Driving Schedule, Acceleration-Distance Profile

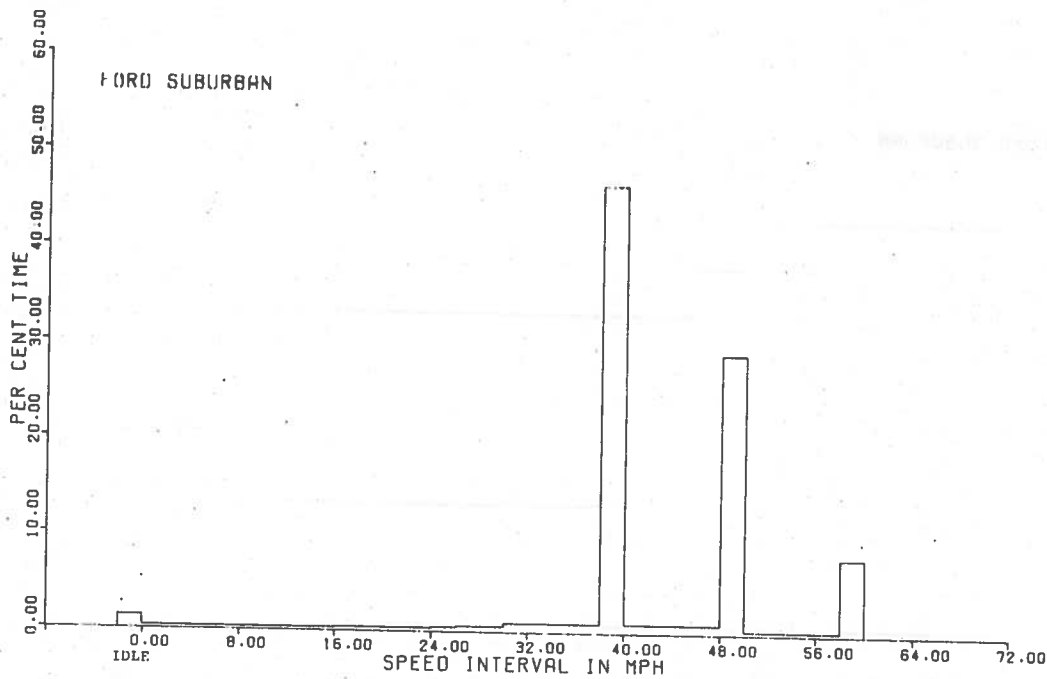


Figure B-12 Ford Suburban Economy Schedule, Percent Time-Speed Interval Profile

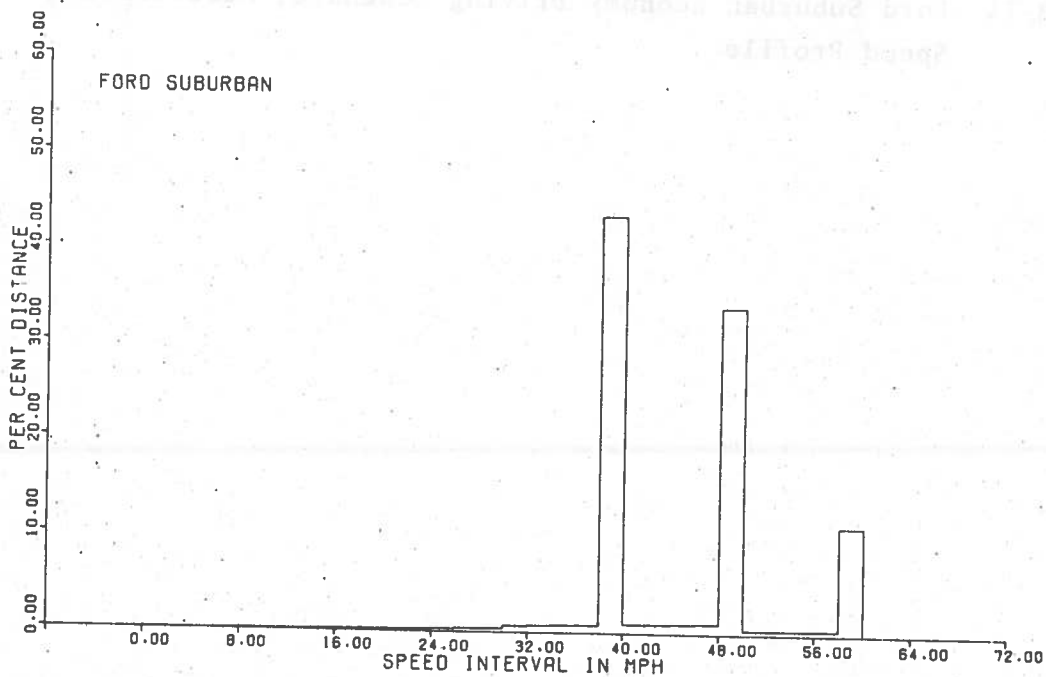


Figure B-13 Ford Suburban Economy Driving Schedule, Percent Distance-Speed Interval Profile

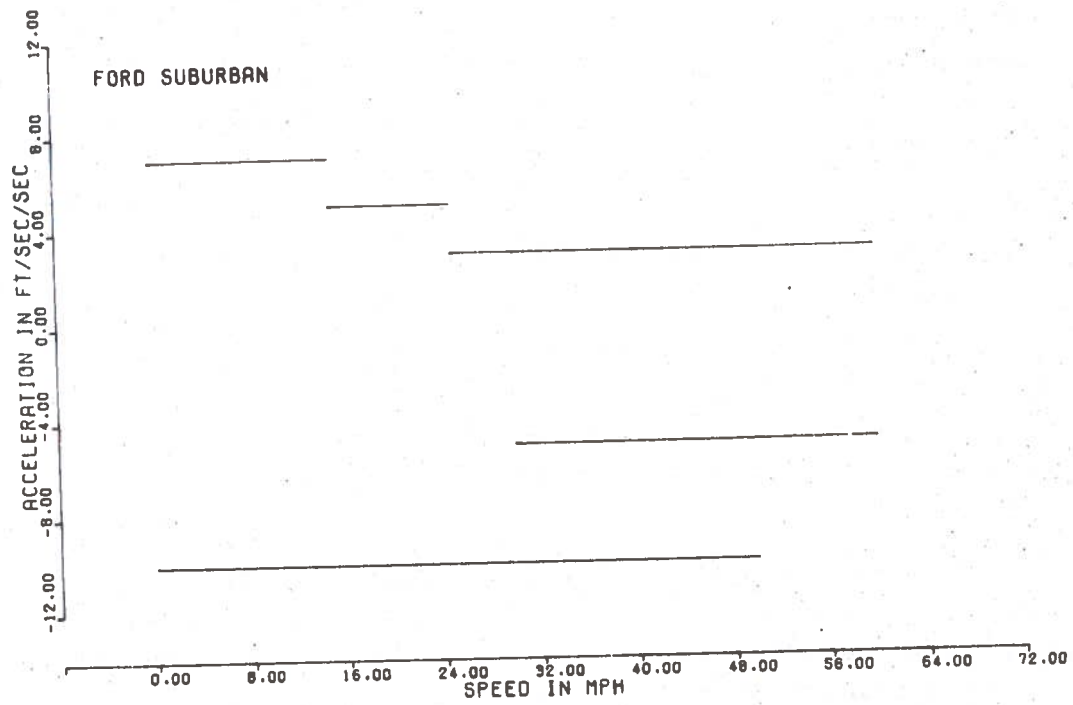


Figure B-14 Ford Suburban Economy Driving Schedule, Acceleration-Speed Profile

B.3 AMERICAN MOTORS CORPORATION SUBURBAN DRIVING SCHEDULE

B 3.1 Description

Another test procedure employed by the AMC simulates suburban driving. The test procedure is used as a method for obtaining vehicle fuel economy. The test is conducted on a test track with the vehicle following a stylized driving schedule. The data obtained represent the fuel economy of a vehicle after it attains a steady-state warmed-up mode of operation.

The results of a computer simulation show that the vehicle travels at an average speed of 42.4 MPH. The maximum speed obtained throughout the 5.23 mile long route is 60 MPH. The overall time required to perform this test is 444 seconds. The schedule incorporates two idles, three stops, and has a stops per mile figure of 0.57. Table B-6 shows the mode breakdown with respect to time and distance.

TABLE B-6 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE AMC SUBURBAN DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	1.4	80.5	11.5	6.6
% Distance	-	86.1	9.2	4.7

As shown in Table B-6, greater than 80% of the time and distance of this schedule is spent in the cruise mode. There are five cruises performed; two cruises at 40 MPH, two at 50 MPH, and one at 60 MPH. The acceleration mode accounts for approximately 10% of the schedule's time and distance traveled. There are five accelerations at $+3.0 \text{ ft/sec}^2$, two accelerations at $+5.0 \text{ ft/sec}^2$, and two at a rate of $+7.0 \text{ ft/sec}^2$. There are four decelerations. One maneuver is performed at -5 ft/sec^2 ; the remaining three

are performed at -10 ft/sec^2 . The idle mode utilizes a small percentage of the schedule's time, 1.4%.

B.3.2 Discussion

The instructions are simple and clear, leaving the test driver with more time to concentrate on accurately reproducing the schedule on the test track. A possible area for further investigation is the idle periods. There are two within this schedule, each one of three seconds duration. Whether it accurately depicts typical suburban driving conditions and its impact on fuel economy has not been determined.

Another point of interest is that this schedule is similar to the Ford Suburban Driving Schedule. They both contain many similarities, as noted by the analysis of their respective parameters and their accompanying plots. This leads to the conclusion that the schedules are interrelated; i.e. one is based upon the other.

B.3.3 American Motors Corporation Suburban Driving Schedule Instructions (22)

Instructions for the American Motors Corporation Suburban Driving Schedule are listed in Table B-7, and corresponding profiles are shown in Figure B-15 through B-21.

TABLE B-7 AMC SUBURBAN DRIVING SCHEDULE INSTRUCTIONS
 (Note: Approach starting point at 40 MPH.)

Distance Miles (ft.)	Operation
0.00 (00.0)	Start burette and stopwatch when passing starting point. Accelerate from 40-60 MPH at 3 fps ² .
0.7 (3696)	Decelerate from 60 to 30 MPH at 5 fps ² than accelerate to 50 MPH at 3 fps ² .
2.0 (10,560)	Stop at 10 fps ² , idle for 3 seconds, accelerate to 15 MPH at 7 fps ² , then to 25 MPH at 5 fps ² , then to 40 MPH at 3 fps ² .
2.6 (13,728)	Accelerate to 50 MPH at 3 fps ² .
3.3 (17,424)	Stop at 10 fps ² , idle 3 seconds, accelerate to 15 MPH at 7 fps ² , then to 25 MPH at 5 fps ² , then to 40 MPH at 3 fps ² .
5.2 (27,456)	Stop at 10 fps ² , stop fuel meter, record fuel consumed and elapsed time.

Source: Reference 22.

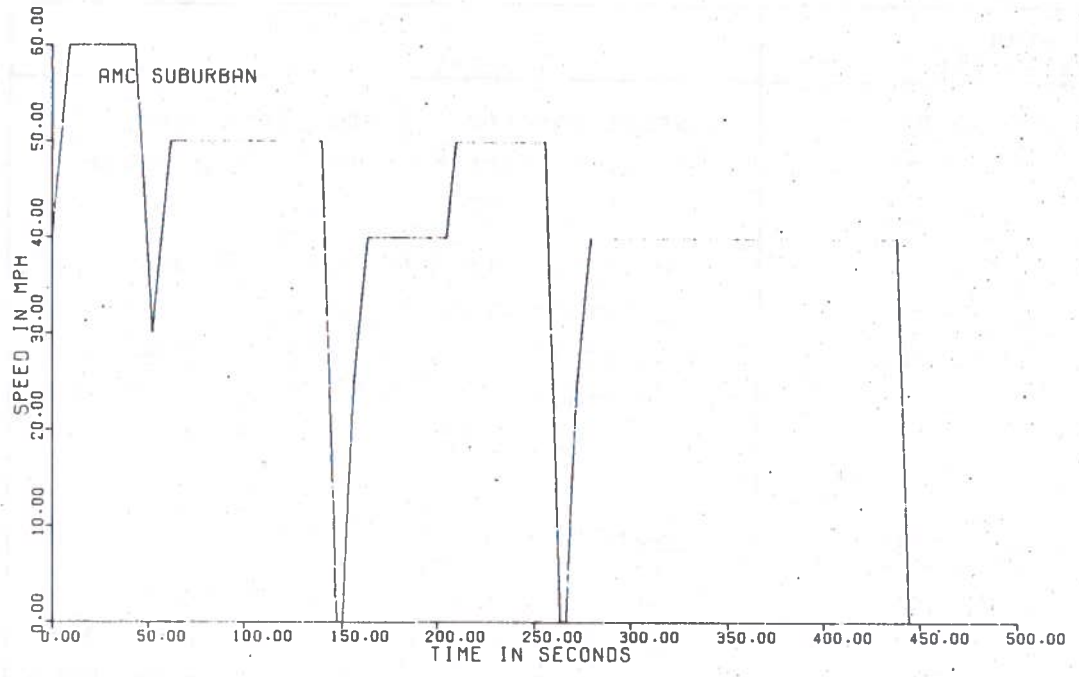


Figure B-15 AMC Suburban Driving Schedule, Speed-Time Profile

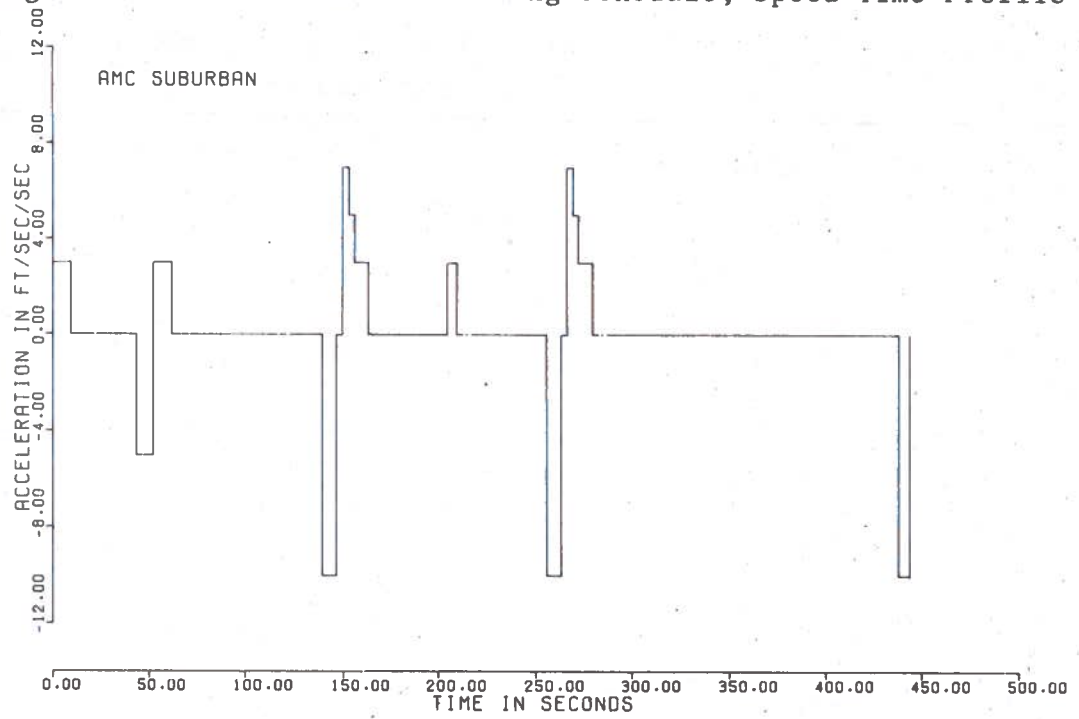


Figure B-16 AMC Suburban Driving Schedule, Acceleration-Time Profile

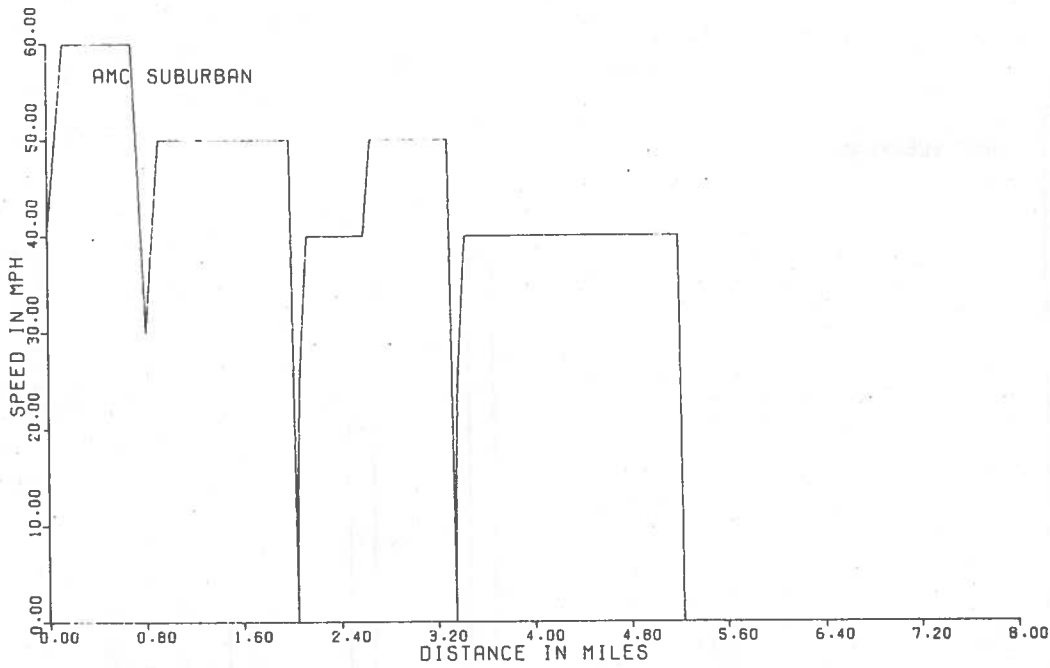


Figure B-17 AMC Suburban Driving Schedule, Speed-Distance Profile

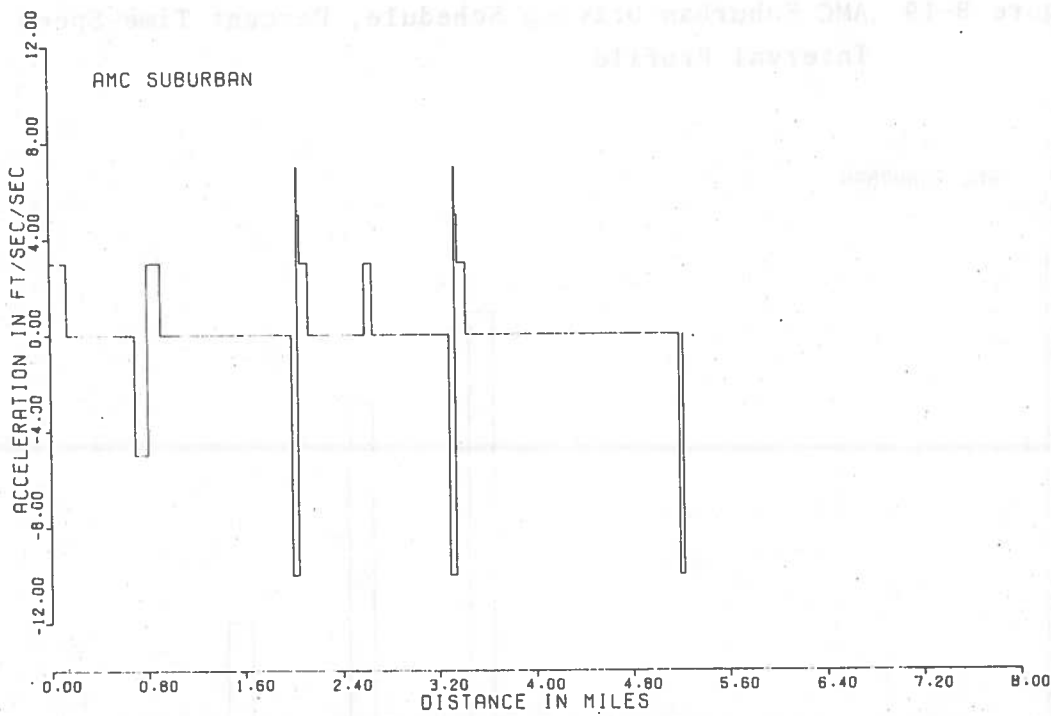


Figure B-18 AMC Suburban Driving Schedule, Acceleration-Distance Profile

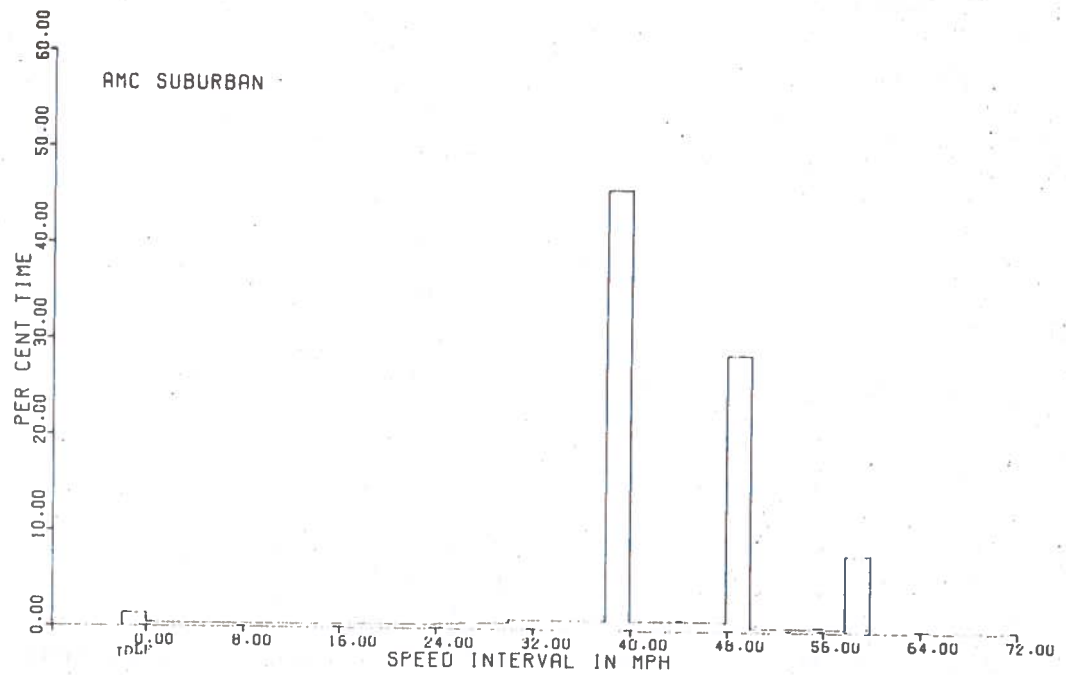


Figure B-19 AMC Suburban Driving Schedule, Percent Time-Speed Interval Profile

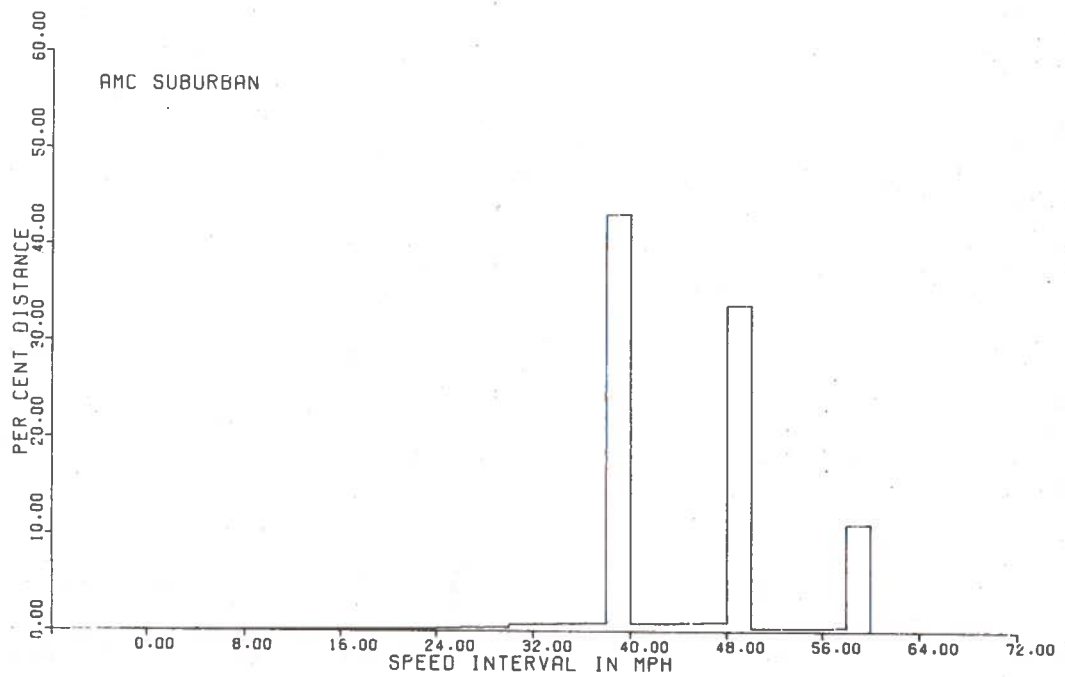


Figure B-20 AMC Suburban Driving Schedule, Percent Distance-Speed Interval Profile

B.4.1 Description

General Motors Corporation determines vehicle fuel economy associated with urban driving. The test procedure incorporates a stated driving schedule, and is performed on a test track. The test is performed in a fully warmed-up condition.

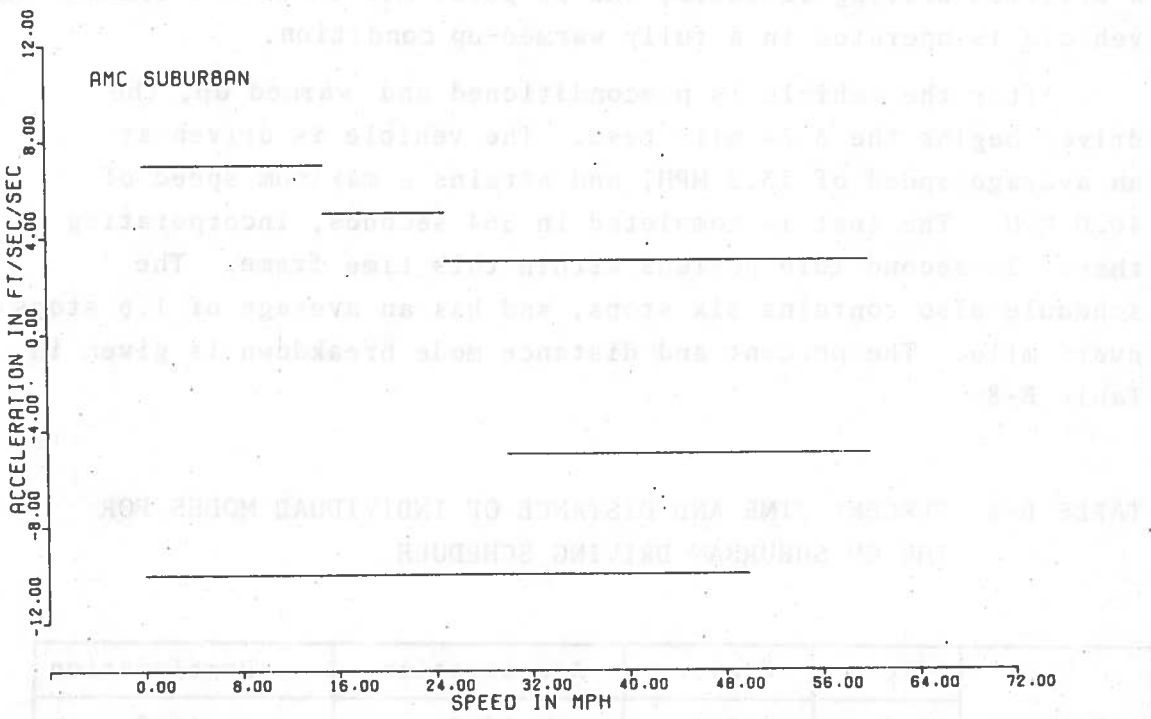


Figure B-21 AMC Suburban Driving Schedule, Acceleration-Speed Profile

B.4 GENERAL MOTORS SUBURBAN DRIVING SCHEDULE

B.4.1 Description

General Motors Corporation determines vehicle fuel economy associated with suburban driving. The test procedure incorporates a stylized driving schedule, and is performed on a test track. The vehicle is operated in a fully warmed-up condition.

After the vehicle is preconditioned and warmed up, the driver begins the 3.74 mile test. The vehicle is driven at an average speed of 23.9 MPH, and attains a maximum speed of 40.0 MPH. The test is completed in 564 seconds, incorporating three 25-second idle periods within this time frame. The schedule also contains six stops, and has an average of 1.6 stops every mile. The percent and distance mode breakdown is given in Table B-8.

TABLE B-8 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE GM SUBURBAN DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	13.3	59.9	10.6	16.2
% Distance	-	77.9	8.1	14.1

As is shown in Table B-8 59.9% of the time and about 78% of the distance traveled is spent in the cruise mode. There are a total of eleven cruise maneuvers performed in this schedule. The acceleration mode has 11 accelerations, accounting for about 8% of the schedule's distance and about 11% of its time. There are three acceleration rates of $+3.0 \text{ ft/sec}^2$, one at 8.20 ft/sec^{2*} , six accelerations at $+6.0 \text{ ft/sec}^2$, and one acceleration at a rate of $+8.0 \text{ ft/sec}^2$.

*This is an assumed value for wide-open throttle (WOT).

The 10 deceleration maneuvers account for 16.2% of the schedule's time and 14.1% of the distance traveled. The rates are as follows: Two decelerations occur at a rate of $-0.69 \text{ ft/sec}^{2*}$, two decelerations at -4.0 ft/sec^2 , and six decelerations at a rate of -6.0 ft/sec^2 . The idle mode accounts for 13.3% of the time.

B.4.2 Discussion

The instructions are clear and the driver performing this test should have no difficulty in interpreting the maneuvers. However, there are two areas that are not rigorously (numerically) defined. These involve decelerating at closed throttle and accelerating at wide-open throttle. Although a test driver can perform these maneuvers, the analyst would not be able to interpret what values actually occurred during a test. The only alternatives are either to assume specific values (for a typical vehicle) or specify for each vehicle a particular value. For the computer simulation acceleration values of -0.69 ft/sec^2 and 8.20 ft/sec^2 were assumed for closed throttle and wide-open throttle, respectively.

B.4.3 General Motors Suburban Driving Schedule Instructions (20)

Instructions for the General Motor Suburban Driving Schedule are listed in Table B-9, and corresponding profiles are shown in Figures B-22 through B-28.

TABLE B-9 GM SUBURBAN DRIVING SCHEDULE INSTRUCTIONS

Distance, Miles (km)	Operation	Fuel Temp
0.0 (0.0)	Start fuel meter, accel. to 20 MPH (32.2) at 6 fps^2 (1.83)	
0.1 (0.16)	Accel. to 25 MPH (40.2) at 3 fps^2 (0.91)	

*This is an assumed value for closed throttle (CT).

TABLE B-9 GM SUBURBAN DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Distance, Mile (km)	Operation	Fuel Temp
0.3 (0.48)	Stop at 6 fps ² (1.83), accel. to 25 MPH (40.2) at 6 fps ² (1.83)	
0.5 (0.80)	Decel. to 10 MPH (16.1) at 4 fps ² (1.22), accel. to 30 MPH (48.3) at 6 fps ² (1.83)	
1.3 (2.09)	Stop at 6 fps ² (1.83), idle 25 sec., accel. to 30 MPH (48.3) at 6 fps ² (1.83)	(1)
1.5 (2.41)	Decel. to 25 MPH (40.2) at closed throttle, accel. to 35 MPH (56.3) at 3 fps ² (0.91)	
2.0 (3.22)	Stop at 6 fps ² (1.83), accel. to 40 MPH (64.4) at W.O.T.	
2.8 (4.51)	Stop at 6 fps ² (1.83), idle 25 sec., accel. to 25 MPH (40.2) at 6 fps ² (1.83)	(2)
3.0 (4.83)	Decel. to 5 MPH (8.0) at 4 fps ² (1.22), accel. to 25 MPH (40.2) at 6 fps ² (1.83)	
3.2 (5.15)	Stop at 6 fps ² (1.83), idle 25 sec., accel. to 35 MPH (56.3) at 8 fps ² (2.44)	(3)
3.4 (5.47)	Decel. to 25 MPH (40.2) at closed throttle, accel. to 35 MPH (56.3) at 3 fps ² (0.91)	
3.7 (5.95)	Stop at 6 fps ² and stop fuel meter, record fuel consumed, elapsed time and fuel temperature	(4)
0.0 (0.0)	Run recheck cycle	

Source: Reference 20.

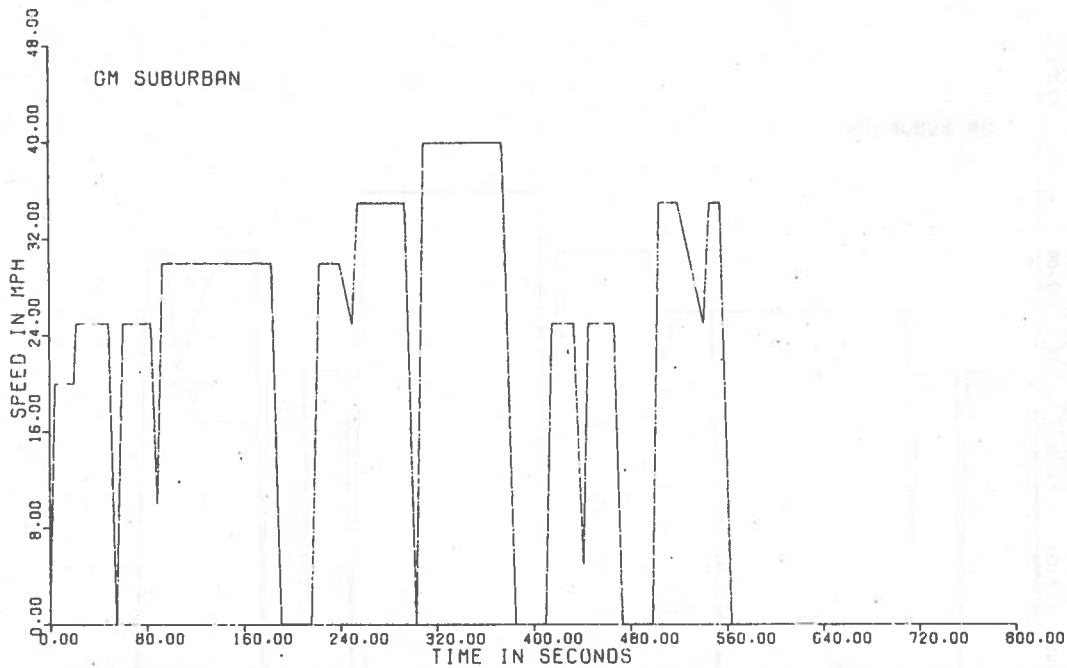


Figure B-22 GM Suburban Driving Schedule, Speed-Time Profile

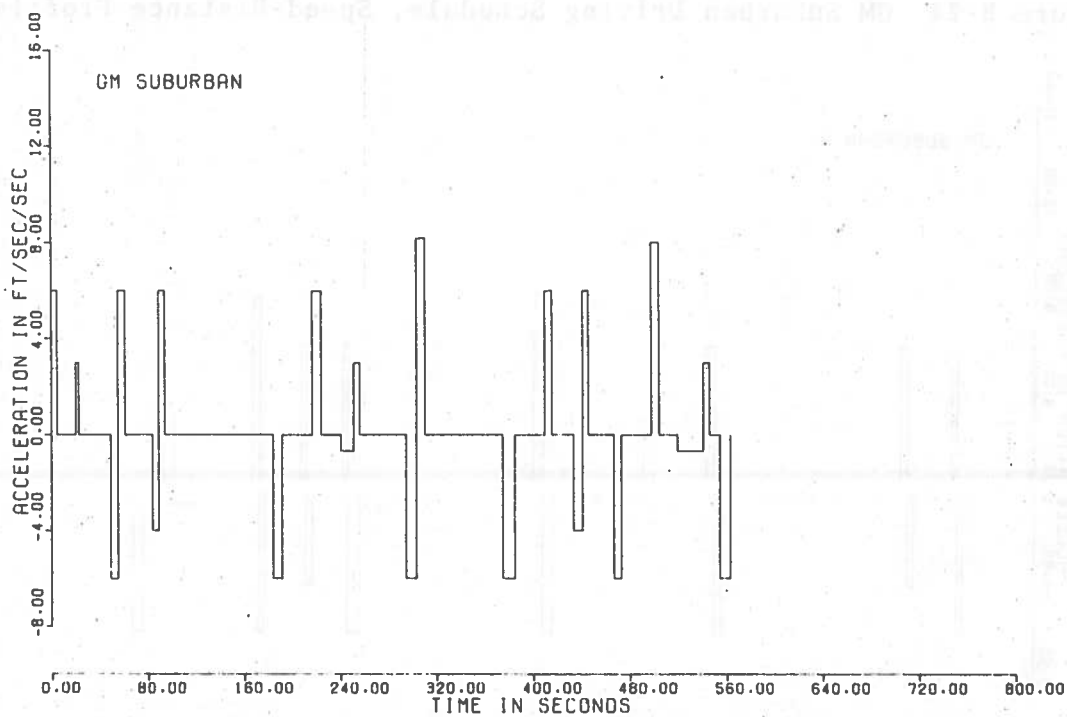


Figure B-23 GM Suburban Driving Schedule, Acceleration-Time Profile

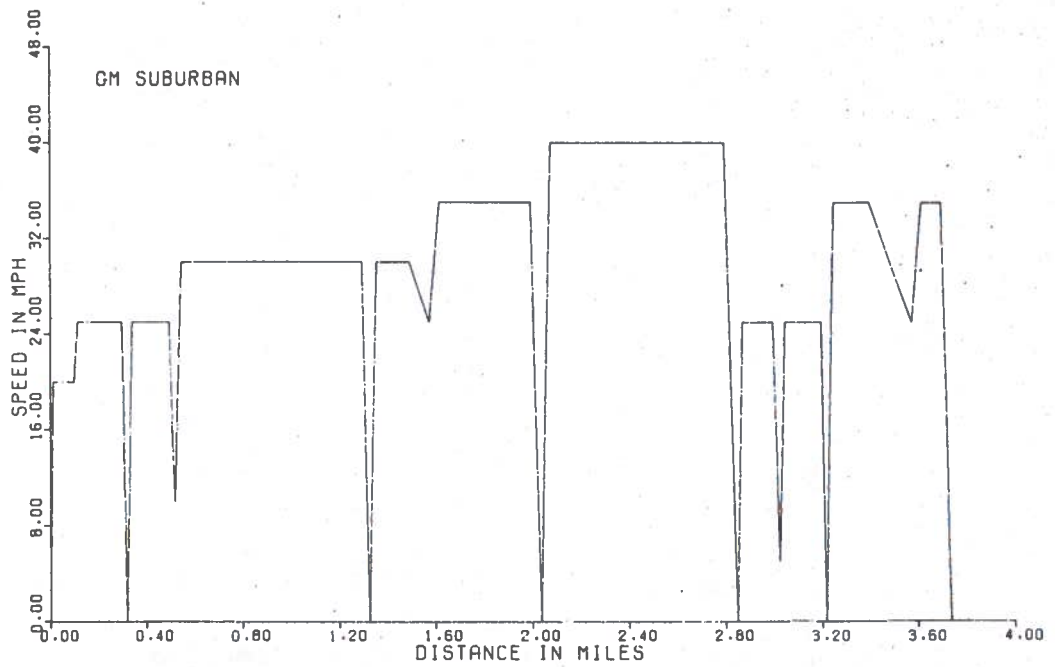


Figure B-24 GM Suburban Driving Schedule, Speed-Distance Profile

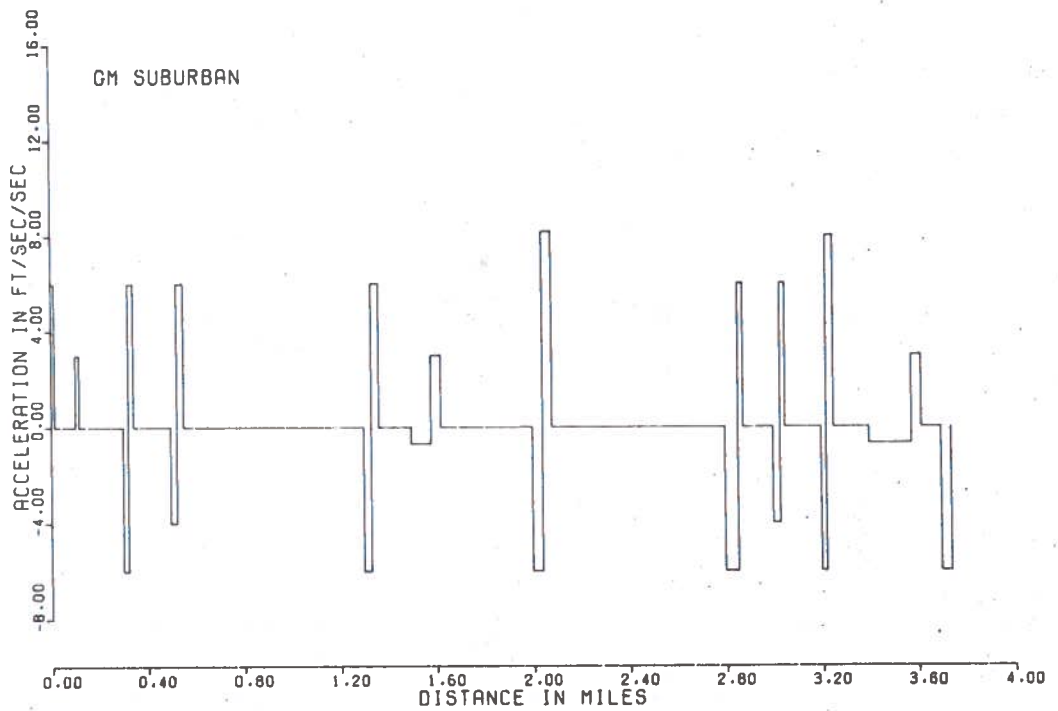


Figure B-25 GM Suburban Driving Schedule, Acceleration-Distance Profile

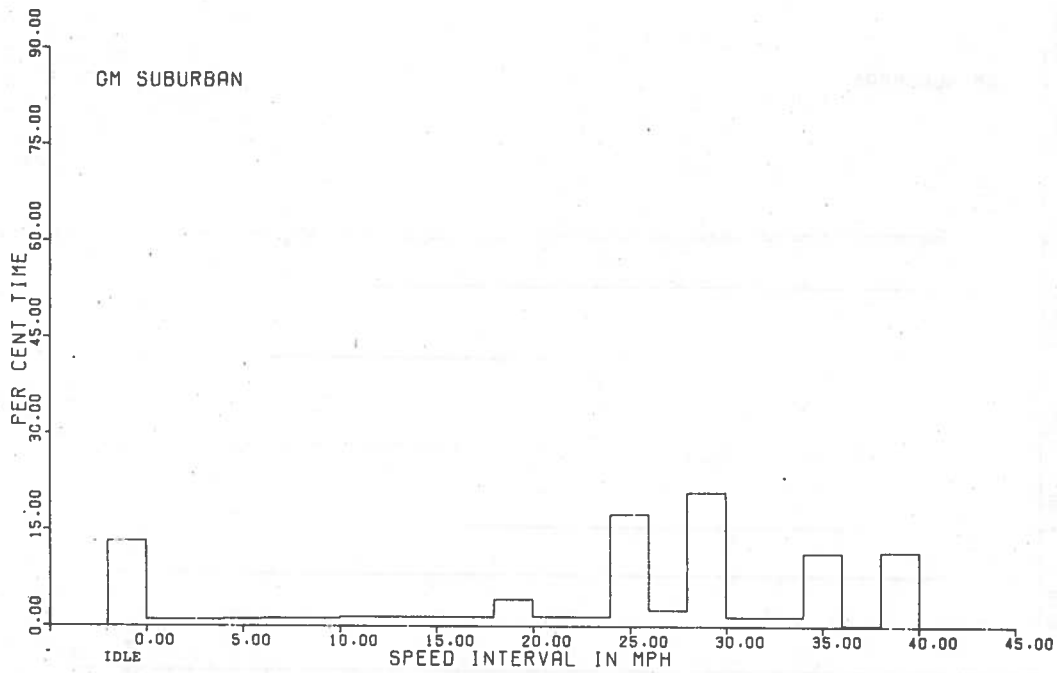


Figure B-26 GM Suburban Driving Schedule, Percent Time-Speed Interval Profile

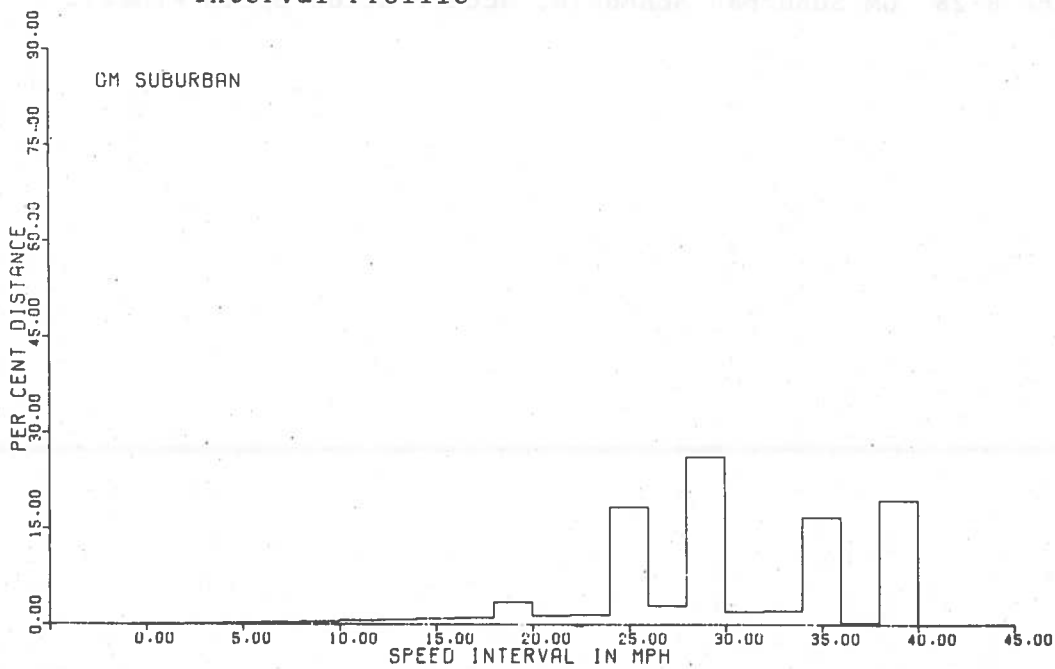


Figure B-27 GM Suburban Driving Schedule, Percent Distance-Speed Interval Profile

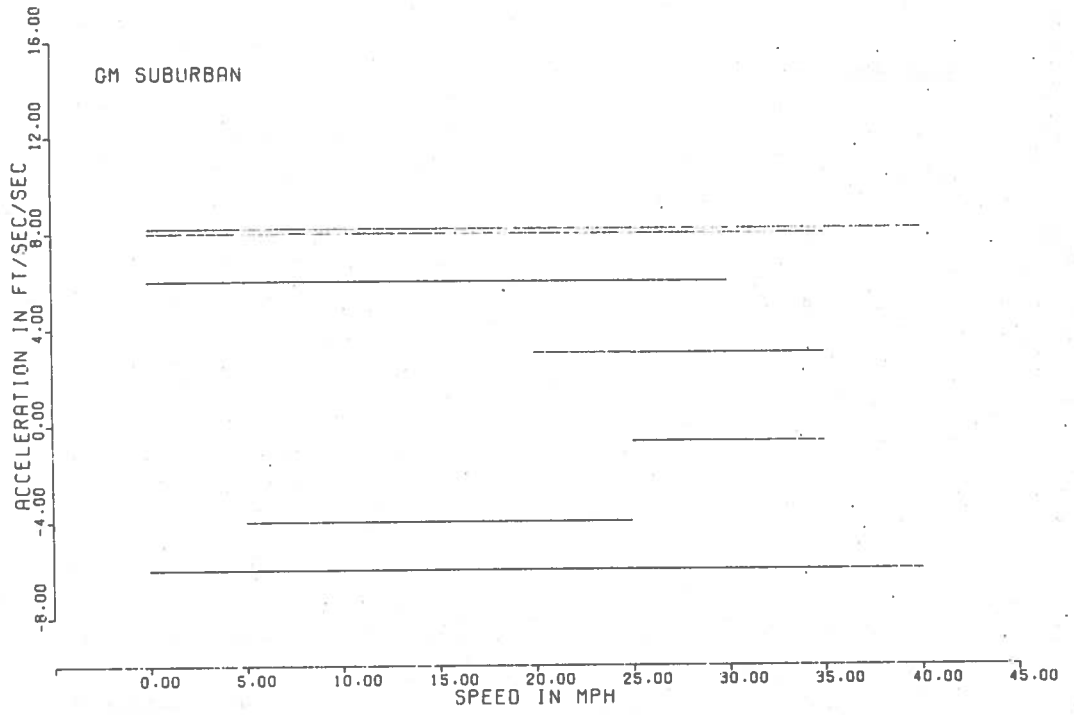


Figure B-28 GM Suburban Schedule, Acceleration-Speed Profile

APPENDIX C
HIGHWAY/INTERSTATE DRIVING SCHEDULES

A Highway/Interstate driving schedule approximates the conditions one would encounter while driving on the open road at nearly constant-speed cruise conditions. A highway, as defined by the Highway Capacity Manual,¹⁴ denotes a public way whose purpose is vehicular travel, and includes the entire area within the right-of-way or in rural areas. In urban areas where there is comparatively little access and egress, a highway connects major population centers and/or traffic generators. An interstate highway is the highest functional class of roadway. It is a nationwide system receiving Federal/State funding allotment on a 90/10 ratio basis. Interstate roadways generally connect major centers of population density and have become a major transportation network for automotive and truck use.

The highway/interstate driving patterns are the easiest to reproduce under simulation, because they are not dependent on region or trip purpose as are suburban schedules. This is partially due to the fact that the definition is based upon functional classification and therefore leads to a stricter definition.

The driving schedule for a highway/interstate system is characterized by moderate to high average speeds, little or no idling, and few, if any stops. Usually most of the driving is done at high speeds, at times exceeding 70 MPH. The driving schedules analyzed were both stylized and nonstylized, and are summarized in Table C-1.

From the highway/interstate schedules analyzed, it was found that they can be classified into two categories:

- 1) Those schedules have an average speed of about 50 MPH. These include:
 - a) SAE Interstate 55 MPH Driving Schedule - J-1082
 - b) General Motors Highway Driving Schedule

TABLE C-1 CHARACTERISTICS OF VARIOUS HIGHWAY/INTERSTATE DRIVING SCHEDULES

Parameter	Schedule						Mean or Means of Means For All Highway/ Interstate Driving Schedules
	EPA Highway	SAE Interstate 55 MPH	SAE Interstate 70 MPH	GM Highway	GM Interstate	Chrysler Interstate	
Distance (Miles)	10.2	4.7	4.7	15.0	15.0	18.7	11.4
Time (sec)	765	308	242	1108	767	1154	724
Mean Speed (MPH)	48.6	55.0	70.0	48.6	70.4	58.3	58.5
Max. Speed (MPH)	59.9	60.0	75.0	70.0	75.0	75.0	69.2
Number of:							
Idles	0	0	0	3	0	0	0.5
Stops	1	0	0	4	1	0	1.0
Stops/Mile	0.1	0.0	0.0	0.5	0.1	0.0	0.1
Percent Time In:							
Idle	0.0	0.0	0.0	2.7	0.0	0.0	0.4
Cruise	16.6	61.9	51.5	58.1	83.1	59.3	55.1
Acceleration	44.3	19.1	24.3	19.0	6.4	20.3	22.2
Deceleration	39.0	19.1	24.3	20.2	10.6	20.3	22.3
Percent Distance In:							
Cruise	18.0	61.9	51.5	68.4	85.8	58.2	57.3
Acceleration	43.2	19.1	24.3	14.6	5.0	20.9	21.2
Deceleration	38.8	19.1	24.3	17.1	9.2	20.9	21.6

c) Chrysler Interstate Driving Schedule

d) EPA Highway Driving Schedule

2) Those schedules having an average speed of about 70 MPH.

These include:

a) SAE Interstate 70 MPH Driving Schedule - J-1082.

b) General Motors Interstate Driving Schedule

The EPA Highway Driving Schedule contains a nonstylized speed-time profile, and the remaining five schedules have stylized speed-time traces.

TABLE C-1 PERCENT TOTAL HIGHWAY VEHICLE MILES TRAVEL TO THE 5 MILES PER HOUR CLASSIFICATION

Type of Highway	Percent of Highway Vehicle Miles
A. Single-lane, two-way	59.2
B. Single-lane, one-way	15.4
C. Collector	17.9
D. Local	19.1

C.1 ENVIRONMENTAL PROTECTION AGENCY'S HIGHWAY DRIVING SCHEDULE

C.1.1 Description

The EPA Highway driving schedule was developed from measurements of "road speed versus time profiles of vehicle operation on all types of highways and non-urban roads." These profiles were then reduced to characteristic parameters which were used to develop a composite driving schedule. The objective of this study "was to produce a driving schedule which could be used to measure vehicle fuel economy under typical highway operation as simulated on a chassis dynamometer."²⁵ This nonstylized schedule can be used to measure the fuel economy of a vehicle while in either a cold-start or hot-start condition.

The EPA highway driving schedule development was initiated after a road classification scheme was calculated, breaking down roads by function and percent usage as shown in Table C-2.

TABLE C-2 PERCENT TOTAL HIGHWAY VEHICLE MILES TRAVELED FOR A RURAL SYSTEMS ROAD CLASSIFICATION

Type of Highway	Percent of Highway Vehicle Miles Traveled
A. Principal Arterials	39.5
B. Minor Arterials	22.4
C. Collectors	23.9
D. Locals	<u>14.2</u>
	100.0%

Source: Reference 25.

Since highway operation represents 40 to 50% of total vehicle miles traveled, a value which continually decreases as urbanization increases, the above percentages became the basis for the construction of a composite highway driving schedule to simulate all types of highway operation.

For the study, five routes were selected, incorporating each road type to be traveled during the characterization. The first route that was driven was primarily a type B (minor arterial) route with 61% type B roads, 28% type A (major arterial) roads, and 11% type C (collector) roads. The second route was a type A route with 100% type A roads. The third route incorporated 44% type C roads, 22% type D (local) roads, 17% type A roads, and 17% type B roads. The fourth route consisted of 47% type D roads, 43% type C roads, and 10% of type A roads. The fifth route, an Ohio Freeway subject to a 55 MPH speed limit, consisted of 100% type A roads. The data collection consisted of a driver operating the vehicle in a normal manner over a route. The drivers were told to stay within posted speed limits and drive the vehicle as they normally would. Also they were told to pass as many cars that pass the instrumented test car. The data collection represented an accumulation of 1050 miles of roads over 23 hours duration. During all travel, an observer accompanies the driver to make notes about the trip and to log pertinent data.

The 460 feet of recorder chart gathered during the experiment were reviewed and identified as to route segments (according to type of road, A through D). Segments which represented urban (population greater than 5,000) driving were deleted. Data reduction consisted of tabulating route speeds at 15 second intervals to determine the maximum, minimum and average segment speeds. Total segment time, distance, number of stops, and number of major speed deviations per mile for each segment were calculated. A speed deviation was defined as an excursion greater than ± 5 MPH from a line connecting end-point velocities on 1.5 minutes of the entire segment.

The data were compiled from all the charts for each road type, the average characteristics were determined for each road type, and the composite highway trip characteristics were determined. A driving schedule committee reviewed the data, decided that a nominal 10 mile highway route would be optimum for laboratory testing, and agreed on a method for obtaining the route. The committee analyzed the information and constructed a composite

route that was thought to represent an accurate approximation of real world conditions.

During the construction of this schedule, the committee decided to use actual on-road traces to represent each segment. This decision placed two restrictions on the end-points of the segments; the slopes and speeds had to be continuous at the segment junctions. Furthermore, the committee thought the most realistic sequence of road segments would be DCAB. The schedule would start from an idle, contain four speed deviations (one each in B and D, two in C) and end with a deceleration to a stop and idle.

The average speed of the schedule is 48.6 MPH with a maximum speed attained of 59.9 MPH. The time to travel the 10.25 miles distance is 765 seconds. There is one stop incorporated in the schedule, giving a figure of 0.1 stops per mile. The percent time and distance modes of the schedule are shown in Table C-3.

TABLE C-3 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR EPA HIGHWAY DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	0.1	16.6	44.3	39.0
% Distance	-	18.0	43.2	38.8

The majority of time and distance of this schedule is spent in the acceleration mode, 44.3% and 43.2%, respectively. The next major usage of the schedule's time and distance is in the deceleration mode. It accounts for almost 40% of the time and distance, respectively. The cruise mode accounts for 16.6% of the schedule's time and 18% of the schedule's distance.

C.1.2 Discussion

One consideration of this schedule is that, at this time, it is necessary to run the schedule on the dynamometer. It appears that, as with the EPA-FTP driving schedule, it would be difficult

to adopt these schedules to a track test. The probability of a source or error occurring under test track conditions becomes large unless driver aides are provided.

The data represent highway driving patterns, with variable speeds, accelerations, and decelerations occurring at one second intervals. The deceleration mode (for purposes of computer analysis) was defined in a literal sense. That is, any negative decrease in the speed over a one-second time interval was considered a deceleration. Likewise, any positive increment in the speed over that same time period was considered an acceleration.

C.1.3 EPA Highway Driving Schedule Instructions²⁵

The instructions for the EPA Highway Driving Schedule are indicated in Table C-4, and corresponding profiles are shown in Figure C-1 through C-7.

TABLE C-4 EPA HIGHWAY DRIVING SCHEDULE INSTRUCTIONS

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***** EPA HIGHWAY FUEL ECONOMY DRIVING CYCLE *****
 *** SPEED (MPH) VS TIME (SEC) ***

SEC	MPH	SEC	MPH	SFC	MPH	SEC	MPH	SFC	MPH	SEC	MPH	SEC	MPH	SEC	MPH	SEC	MPH
0	SAMPLE ON	50	38.6	100	44.5	200	43.4	150	44.1	250	48.0	300	33.4	350	59.0		
1	0.0	51	39.3	101	44.8	201	43.2	151	44.3	251	48.0	301	35.6	351	58.9		
2	0.0	52	40.0	102	49.1	202	43.2	152	44.4	252	48.0	302	37.5	352	58.8		
3	2.0	53	40.7	103	49.2	203	43.1	153	44.6	253	48.1	303	39.1	353	58.5		
4	4.9	54	41.4	104	49.1	204	43.0	154	44.7	254	48.2	304	40.2	354	58.4		
5	8.1	55	42.2	105	49.1	205	43.0	155	44.9	255	48.2	305	41.1	355	58.2		
6	11.3	56	42.9	106	49.0	206	43.1	156	45.2	256	48.1	306	41.8	356	58.1		
7	14.5	57	43.5	107	49.0	207	43.4	157	45.7	257	48.6	307	42.4	357	58.0		
8	17.3	58	44.0	108	49.1	208	43.4	158	45.9	258	48.9	308	42.8	358	57.9		
9	19.6	59	44.3	109	49.2	209	43.4	159	46.3	259	49.1	309	43.3	359	57.5		
10	21.8	60	44.5	110	49.3	210	43.5	160	46.8	260	49.1	310	43.8	360	57.4		
11	24.0	61	44.8	111	49.4	211	42.6	161	46.9	261	49.1	311	44.3	361	57.2		
12	27.8	62	44.9	112	49.5	212	41.5	162	47.0	262	49.1	312	44.7	362	57.1		
13	27.1	63	45.0	113	49.5	213	40.7	163	47.1	263	49.1	313	45.0	363	57.0		
14	28.0	64	45.1	114	49.5	214	40.0	164	47.0	264	49.0	314	45.2	364	57.0		
15	30.0	65	45.4	115	49.4	215	40.0	165	47.9	265	49.4	315	45.4	365	56.9		
16	30.7	66	45.7	116	49.1	216	40.3	166	48.0	266	47.7	316	45.5	366	56.9		
17	31.5	67	46.0	117	48.9	217	41.0	167	48.0	267	47.5	317	45.8	367	56.9		
18	32.2	68	46.3	118	48.6	218	42.0	168	47.9	268	47.2	318	46.0	368	57.0		
19	32.9	69	46.5	119	48.4	219	42.7	169	47.8	269	46.7	319	46.1	369	57.0		
20	34.1	70	46.8	120	48.1	220	43.1	170	47.8	270	46.7	320	46.5	370	57.0		
21	34.6	71	46.9	121	47.7	221	43.2	171	48.7	271	46.2	321	46.8	371	57.0		
22	34.9	72	47.1	122	47.4	222	43.4	172	48.2	272	46.2	322	47.1	372	57.0		
23	35.1	73	47.1	123	47.3	223	43.9	173	48.2	273	45.8	323	47.7	373	57.0		
24	35.7	74	47.2	124	47.5	224	44.3	174	48.7	274	45.6	324	48.3	374	57.0		
25	35.9	75	47.3	125	47.8	225	44.7	175	48.5	275	45.4	325	49.0	375	57.0		
26	36.1	76	47.3	126	47.9	226	45.1	176	48.4	276	45.2	326	49.7	376	57.0		
27	36.2	77	47.1	127	48.0	227	45.4	177	48.3	277	45.0	327	50.3	377	56.9		
28	36.3	78	47.0	128	47.9	228	45.8	178	48.0	278	44.7	328	50.8	378	56.8		
29	36.4	79	46.9	129	47.9	229	46.5	179	48.0	279	44.5	329	51.7	379	56.5		
30	36.5	80	46.9	130	47.9	230	46.9	180	48.0	280	44.2	330	52.4	380	56.2		
31	36.6	81	46.9	131	48.0	231	47.2	181	48.1	281	43.5	331	53.1	381	56.0		
32	36.8	82	47.0	132	48.0	232	47.4	182	48.1	282	42.8	332	53.8	382	56.0		
33	36.8	83	47.1	133	47.9	233	47.3	183	48.1	283	42.0	333	54.5	383	56.0		
34	36.8	84	47.1	134	47.9	234	47.3	184	48.1	284	40.1	334	55.2	384	56.1		
35	36.9	85	47.1	135	47.9	235	47.2	185	48.1	285	38.6	335	55.8	385	56.4		
36	36.9	86	47.1	136	48.0	236	47.2	186	48.1	286	37.5	336	56.4	386	56.7		
37	36.9	87	47.0	137	48.0	237	47.2	187	48.1	287	35.8	337	56.9	387	56.9		
38	36.9	88	46.9	138	48.0	238	47.1	188	48.1	288	34.7	338	57.0	388	57.1		
39	36.9	89	46.8	139	48.0	239	47.0	189	48.0	289	34.0	339	57.1	389	57.3		
40	36.9	90	46.8	140	48.0	240	47.0	190	48.0	290	33.3	340	57.3	390	57.4		
41	37.0	91	46.8	141	48.0	241	46.9	191	48.0	291	32.5	341	57.6	391	57.4		
42	37.0	92	46.8	142	48.0	242	46.8	192	48.0	292	31.7	342	57.8	392	57.0		
43	37.0	93	46.8	143	48.0	243	46.9	193	48.0	293	30.6	343	58.0	393	56.9		
44	37.0	94	46.9	144	48.0	244	47.0	194	48.0	294	29.6	344	58.1	394	56.9		
45	37.0	95	47.1	145	48.0	245	47.2	195	48.0	295	28.8	345	58.4	395	56.6		
46	37.0	96	47.1	146	48.0	246	47.5	196	48.0	296	28.4	346	58.7	396	56.3		
47	37.1	97	47.7	147	48.0	247	47.9	197	48.0	297	28.6	347	58.8	397	56.1		
48	37.3	98	48.0	148	48.0	248	48.0	198	48.0	298	29.5	348	58.9	398	56.4		
49	37.8	99	48.2	149	48.0	249	48.0	199	48.0	299	31.4	349	59.0	399	56.7		

TABLE C-4 EPA HIGHWAY DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

SEC	MPH	SEC	MPH	SEC	MPH	SEC	MPH	SEC	MPH	SEC	MPH	SEC	MPH	SEC	MPH
400	57.1	450	58.2	500	54.7	550	55.8	600	44.3	650	50.2	700	54.2	750	26.8
401	57.5	451	58.1	501	54.6	551	55.6	601	48.0	651	50.7	701	54.5	751	24.5
402	57.8	452	58.0	502	54.4	552	55.4	602	47.9	652	51.1	702	54.8	752	21.5
403	58.0	453	58.0	503	54.3	553	55.2	603	47.8	653	51.7	703	55.0	753	19.5
404	58.0	454	58.0	504	54.3	554	55.1	604	47.7	654	52.2	704	55.5	754	17.4
405	58.0	455	58.0	505	54.2	555	55.0	605	47.9	655	52.5	705	55.9	755	15.1
406	58.0	456	58.0	506	54.1	556	54.9	606	48.3	656	52.1	706	56.1	756	12.4
407	58.0	457	58.0	507	54.1	557	54.6	607	48.0	657	51.6	707	56.3	757	9.7
408	58.0	458	57.9	508	54.4	558	54.4	608	49.1	658	51.1	708	56.4	758	7.0
409	57.9	459	57.9	509	54.0	559	54.2	609	49.0	659	51.0	709	56.5	759	5.0
410	57.8	460	58.0	510	54.0	560	54.1	610	48.9	660	51.0	710	56.7	760	3.3
411	57.7	461	58.1	511	54.0	561	53.9	611	48.0	661	51.1	711	56.9	761	2.0
412	57.8	462	58.1	512	54.0	562	53.4	612	47.1	662	51.4	712	57.0	762	0.7
413	57.9	463	58.2	513	54.0	563	53.3	613	46.1	663	52.0	713	57.3	763	0.0
414	57.9	464	58.3	514	54.0	564	53.1	614	46.1	664	52.2	714	57.7	764	0.0
415	58.0	465	58.3	515	54.0	565	52.9	615	46.1	665	52.2	715	58.2	765	SAMPLE OFF
416	58.1	466	58.3	516	54.0	566	52.6	616	45.2	666	52.5	716	58.8		
417	58.4	467	58.2	517	54.1	567	52.4	617	46.9	667	52.8	717	59.1		
418	58.9	468	58.1	518	54.2	568	52.2	618	47.8	668	52.7	718	59.2		
419	59.1	469	58.0	519	54.5	569	52.1	619	49.0	669	52.6	719	59.1		
420	59.4	470	57.8	520	54.8	570	52.0	620	49.7	670	52.3	720	58.8		
421	59.8	471	57.5	521	54.9	571	52.0	621	50.6	671	52.3	721	58.5		
422	59.9	472	57.1	522	55.0	572	52.0	622	51.5	672	52.4	722	58.1		
423	59.9	473	57.0	523	55.1	573	52.0	623	52.2	673	52.5	723	57.7		
424	59.8	474	56.6	524	55.2	574	52.1	624	52.7	674	52.7	724	57.3		
425	59.6	475	56.1	525	55.3	575	52.0	625	53.0	675	52.7	725	57.1		
426	59.4	476	56.0	526	55.3	576	52.0	626	53.6	676	52.4	726	56.8		
427	59.2	477	55.8	527	55.4	577	51.9	627	54.0	677	52.1	727	56.5		
428	59.1	478	55.5	528	55.5	578	51.6	628	54.1	678	51.7	728	56.2		
429	59.0	479	55.2	529	55.6	579	51.4	629	54.4	679	51.1	729	55.5		
430	58.9	480	55.1	530	55.7	580	51.1	630	54.7	680	50.5	730	54.6		
431	58.7	481	55.0	531	55.8	581	50.7	631	55.1	681	50.1	731	54.1		
432	58.6	482	54.9	532	55.9	582	50.3	632	55.4	682	49.8	732	53.7		
433	58.5	483	54.9	533	56.0	583	49.4	633	55.4	683	49.7	733	53.2		
434	58.4	484	54.9	534	56.0	584	49.3	634	55.0	684	49.6	734	52.9		
435	58.4	485	54.9	535	56.0	585	49.7	635	54.5	685	49.5	735	52.5		
436	58.3	486	54.9	536	56.0	586	49.2	636	54.6	686	49.5	736	52.0		
437	58.2	487	54.9	537	56.0	587	49.1	637	52.5	687	49.7	737	51.3		
438	58.1	488	55.0	538	56.0	588	49.0	638	50.2	688	50.0	738	50.5		
439	58.0	489	55.0	539	56.0	589	49.0	639	48.2	689	50.2	739	49.5		
440	57.9	490	55.0	540	56.0	590	48.1	640	46.5	690	50.6	740	48.5		
441	57.9	491	55.0	541	56.0	591	48.4	641	46.2	691	51.1	741	47.6		
442	57.9	492	55.0	542	56.0	592	48.9	642	46.0	692	51.6	742	46.8		
443	57.9	493	55.0	543	56.0	593	49.0	643	46.0	693	51.9	743	45.6		
444	57.9	494	55.1	544	56.0	594	49.1	644	46.3	694	52.0	744	44.2		
445	58.0	495	55.1	545	56.0	595	49.1	645	46.8	695	52.1	745	42.5		
446	58.1	496	55.0	546	56.0	596	49.0	646	47.5	696	52.4	746	39.2		
447	58.1	497	54.9	547	56.0	597	48.9	647	48.2	697	52.9	747	35.9		
448	58.2	498	54.9	548	55.9	598	48.9	648	48.8	698	53.3	748	32.6		
449	58.2	499	54.8	549	55.9	599	48.6	649	49.5	699	53.7	749	29.3		

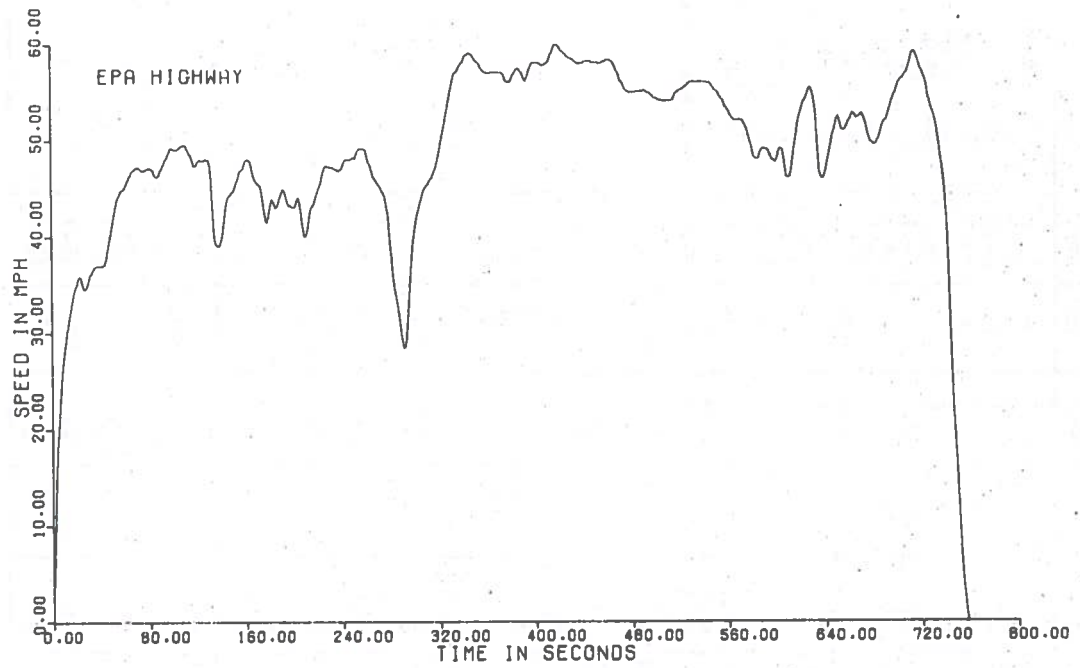


Figure C-1 EPA Highway Driving Schedule, Speed-Time Profile

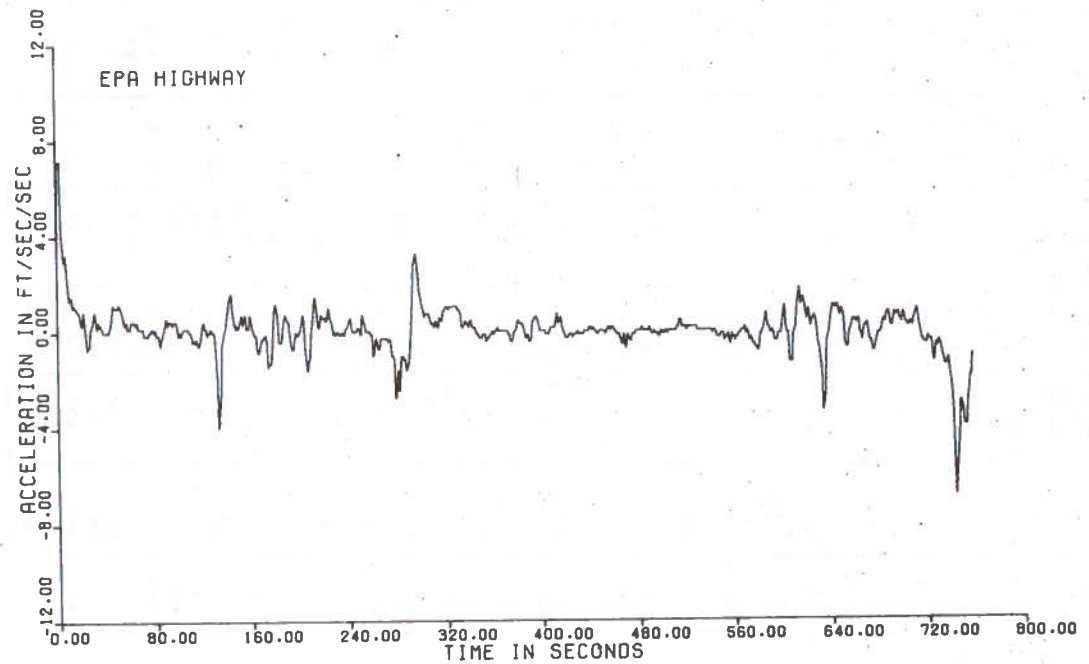


Figure C-2 EPA Highway Driving Schedule, Acceleration-Time Profile

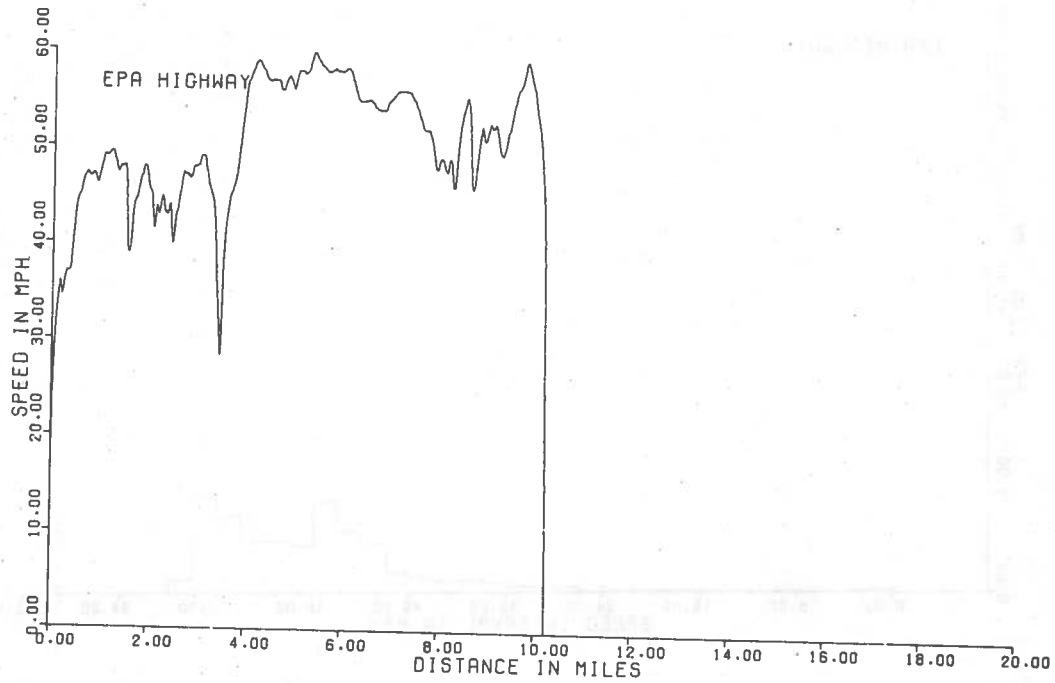


Figure C-3 EPA Highway Driving Schedule, Speed-Distance Profile

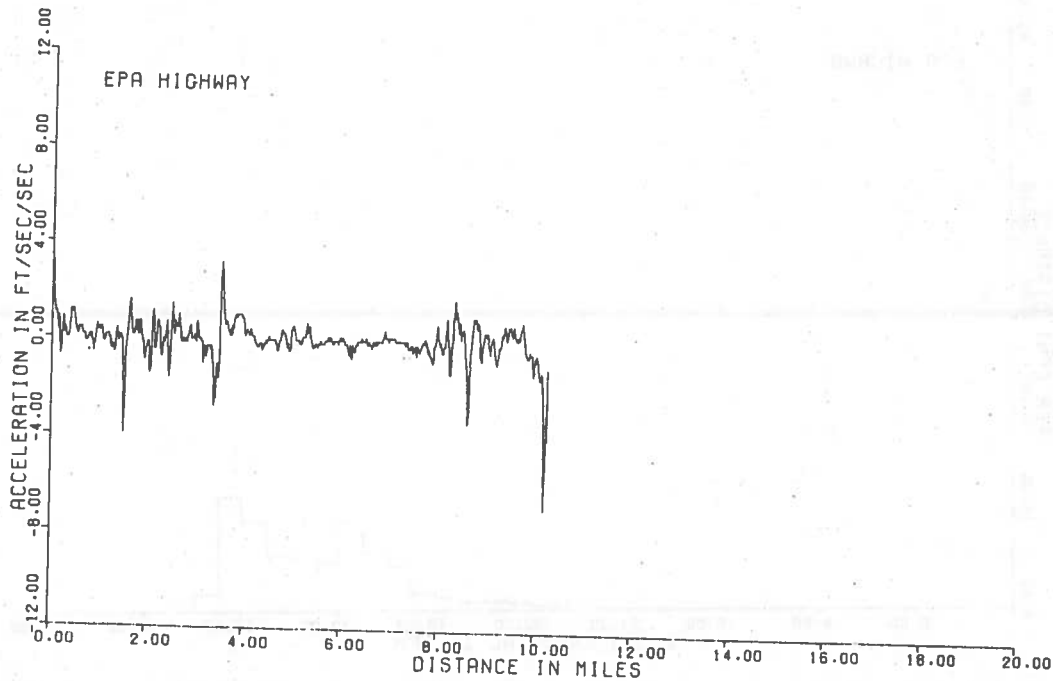


Figure C-4 EPA Highway Driving Schedule, Acceleration-Distance Profile

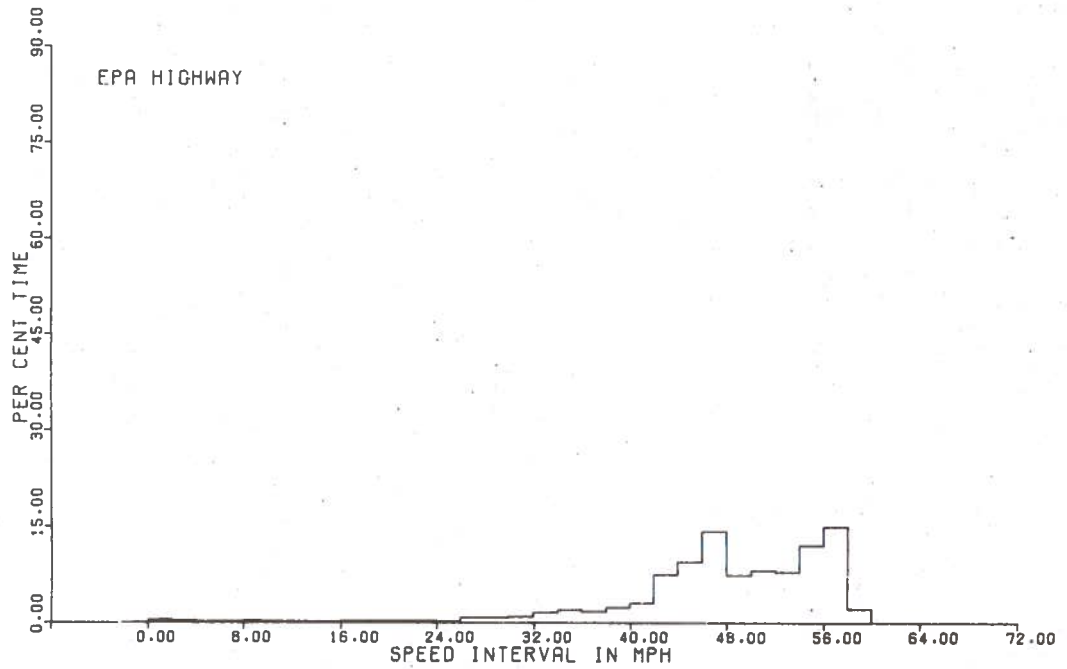


Figure C-5 EPA Highway Driving Schedule, Percent Time-Speed Interval Profile

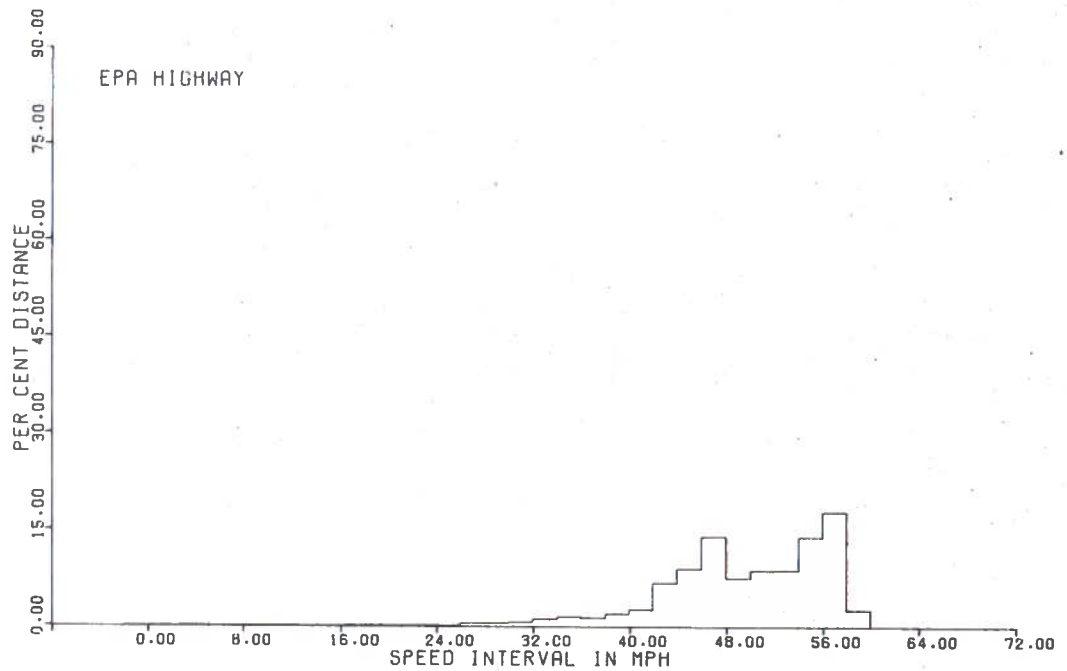


Figure C-6 EPA Highway Driving Schedule, Percent Distance-Speed Interval Profile

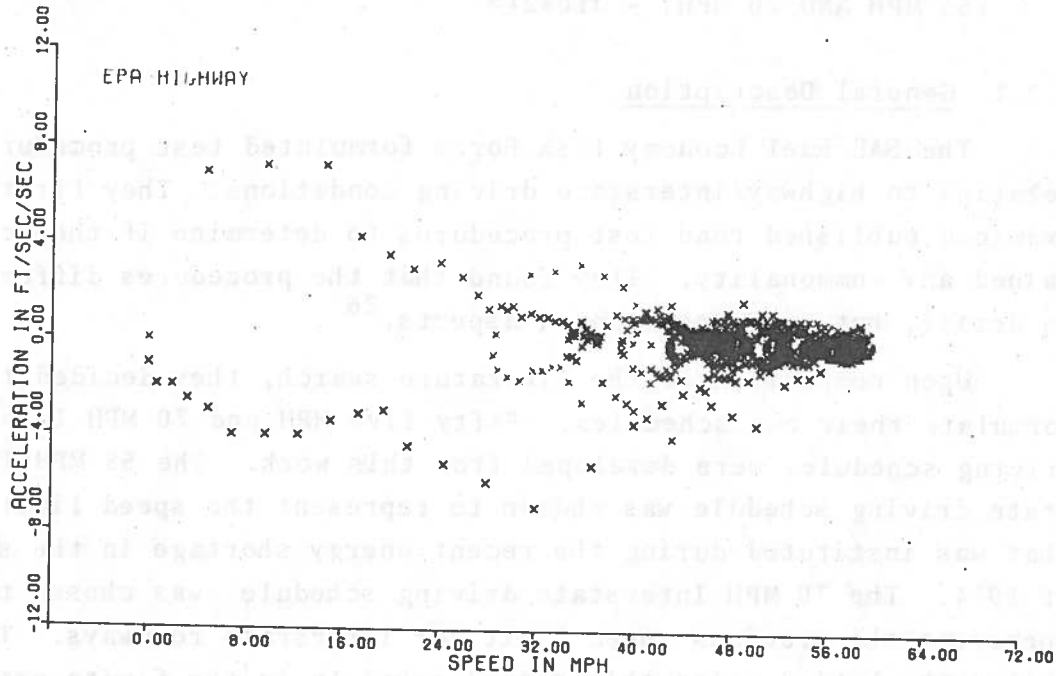


Figure C-7 EPA Highway Driving Schedule, Acceleration-Speed Profile

C.2 SOCIETY OF AUTOMOTIVE ENGINEERS INTERSTATE DRIVING SCHEDULES (55 MPH AND 70 MPH) - J1082¹⁹

C.2.1 General Description

The SAE Fuel Economy Task Force formulated test procedures relating to highway/interstate driving conditions. They first examined published road test procedures to determine if they contained any commonality. They found that the procedures differed in detail, but contained common aspects.²⁶

Upon completion of the literature search, they decided to formulate their own schedules. Fifty-five MPH and 70 MPH Interstate driving schedules were developed from this work. The 55 MPH Interstate driving schedule was chosen to represent the speed limit that was instituted during the recent energy shortage in the spring of 1974. The 70 MPH Interstate driving schedule was chosen to represent the previous speed limit for interstate roadways. The philosophy behind using this second schedule is the finite probability that the recently imposed 55 MPH speed limit may be changed back to the original 70 MPH speed limit. The main difference between the two schedules is the average speeds. They were developed to be used in determining a vehicle's fuel economy experienced in typical highway driving. Both schedules are conducted on a test track, with each following a stylized speed-time trace. The vehicle's fuel economy is measured after it attains a steady-state warmed-up condition; this is to reduce the variables that are associated with cold-starting conditions.

C.2.2 SAE Interstate (55 MPH) Driving Schedule

C.2.2.1 Description - In this driving schedule, the vehicle travels at an average speed of 55 MPH, reaching a maximum speed of 60 MPH. The schedule requires 308 seconds to complete. There are no stops or idle periods incorporated within the schedule. The percent time and distance modes are shown in Table C-5.

TABLE C-5 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE SAE 55 MPH INTERSTATE DRIVING SCHEDULE J1082

	Idle	Cruise	Acceleration	Deceleration
% Time	0	61.9	19.1	19.1
% Distance	-	61.9	19.1	19.1

The table shows that more than 60% of the time and distance traveled, respectively, is done in the cruise mode. There are five cruise maneuvers performed during the schedule, each at a speed of 55 MPH. The acceleration mode has eight maneuvers performed at a rate of $+1.0 \text{ ft/sec}^2$. These maneuvers take almost 20% of the schedule's time and distance, respectively. The deceleration mode also utilizes 20% of the schedule's time and distance. There are four deceleration maneuvers performed, each at a rate of -1.0 ft/sec^2 .

C.2.2.2 Discussion - The test driver of a vehicle performing this test should find the instructions clear; however, the presentation could be improved by a change in the format. The wording should be changed from "repeat accelerations and decelerations as at 0.20 miles" to specifically wording the maneuvers.

The rate of the accelerations and decelerations does not vary. Whether this is a significant factor in affecting the vehicles fuel economy is unknown at this time.

C.2.2.3 SAE Interstate (55 MPH) Driving Schedule Instructions¹⁹ - Instructions for the SAE Interstate (55 MPH) Driving Schedule are indicated in Table C-6, and corresponding profiles are shown in Figures C-8 through C-14.

TABLE C-6 SAE INTERSTATE (55 MPH) DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (km)	Operation
0.0 (0.0)	Approach the starting line at 55 MPH (88.5 km/h). At line, start fuel measuring and timing devices. Proceed at 55 MPH (88.5 km/h) to the 0.2 mile (0.32 km) marker.
0.20 (0.32)	Accelerate to 60 MPH (96.6 km/h) at 1 ft/s ² (0.3 m/s ²). Immediately decelerate to 50 MPH (80.5 km/h) at 1 ft/s ² (0.3 m/s ²). Immediately accelerate to 55 MPH (88.5 km/h) at 1 ft/s ² (0.3 m/s ²). Proceed at 55 MPH (88.5 km/h) to the 1.2 mile (1.93 km) marker.
1.2 (1.93)	Repeat accelerations and decelerations as at 0.20 miles (0.32 km). Proceed to the 2.2 mile (3.54 km) marker.
2.2 (3.54)	Repeat accelerations and decelerations as at 0.20 miles (0.32 km). Proceed to the 3.2 mile (5.15 km) marker.
3.2 (5.15)	Repeat accelerations and decelerations as at 0.20 miles (0.32 km). Proceed to the 4.7 mile (7.56 km) marker.
4.7 (7.56)	Stop fuel measuring and timing device while driving at 55 MPH (88.5 km/h) at 4.7 miles (7.56 km). Record fuel consumed, elapsed time, and operating temperature.
0.0 (0.0)	Run recheck cycle.

Source: Reference 19.

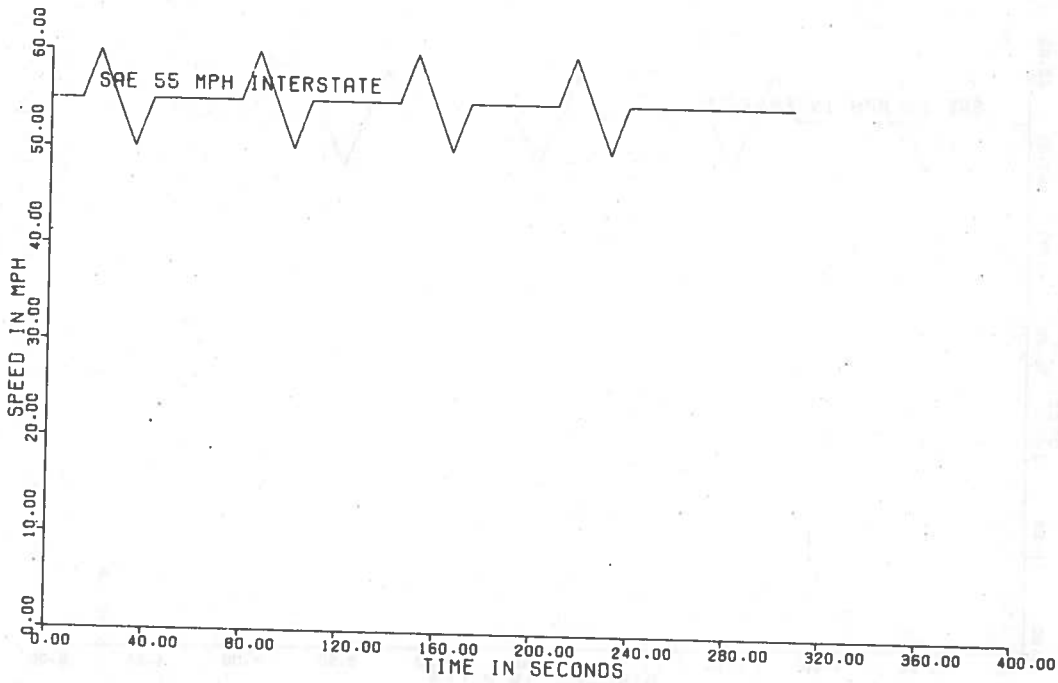


Figure C-8 SAE Interstate (55 MPH) Driving Schedule - J1082, Speed-Time Profile

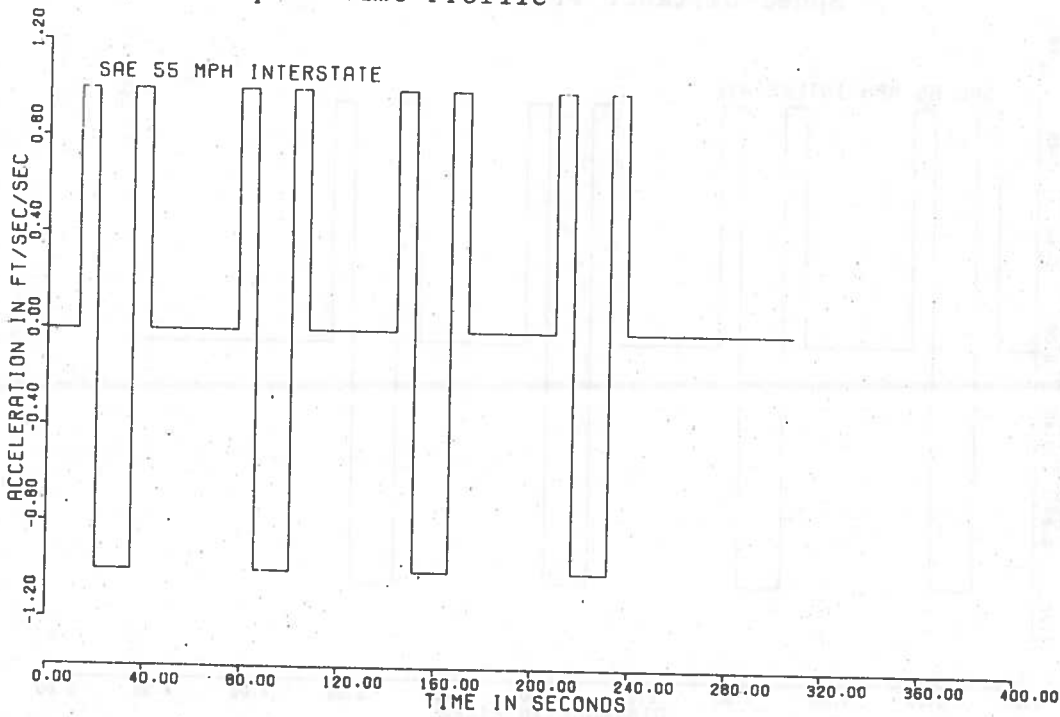


Figure C-9 SAE Interstate (55 MPH) Driving Schedule - J1082, Acceleration-Time Profile

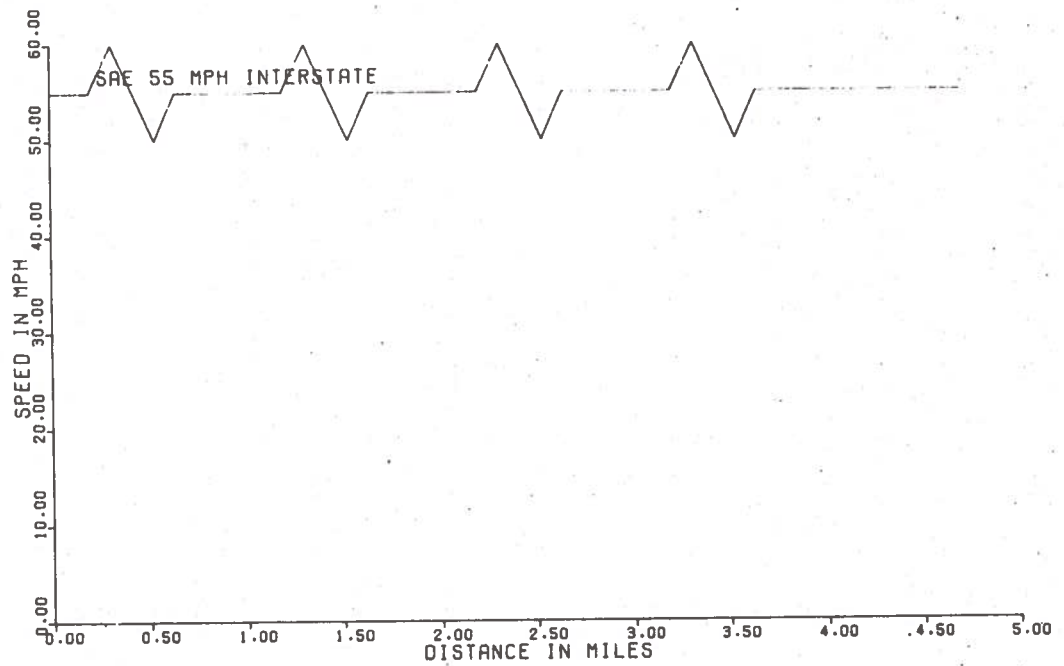


Figure C-10 SAE Interstate (55 MPH) Driving Schedule - J1082, Speed-Distance Profile

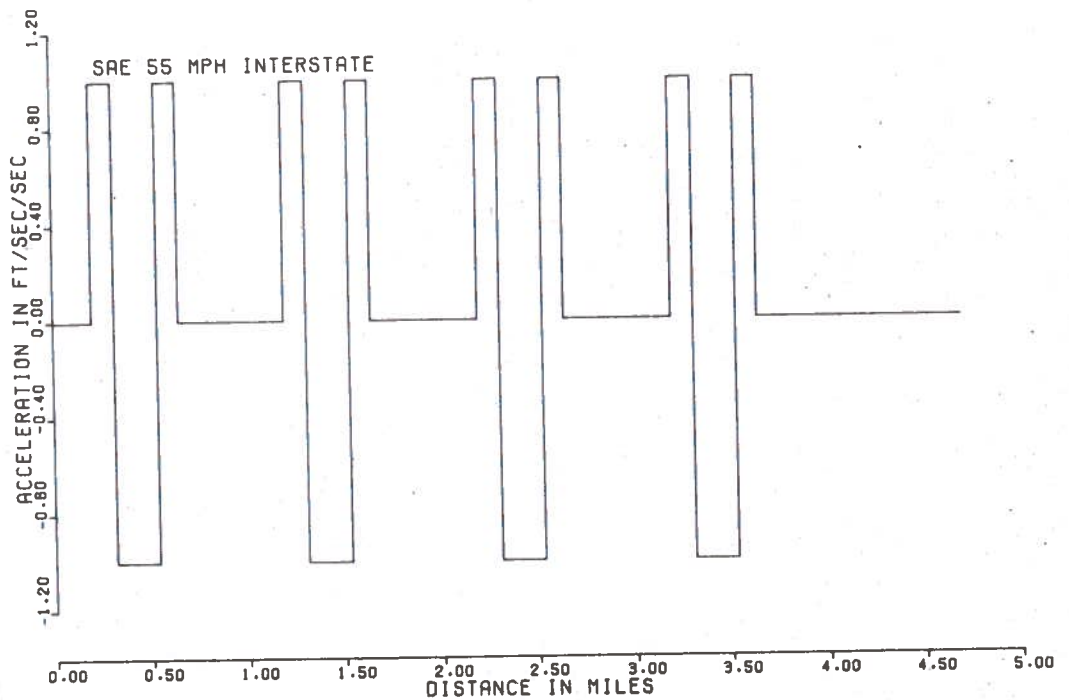


Figure C-11 SAE Interstate (55 MPH) Driving Schedule - J1082, Acceleration-Distance Profile

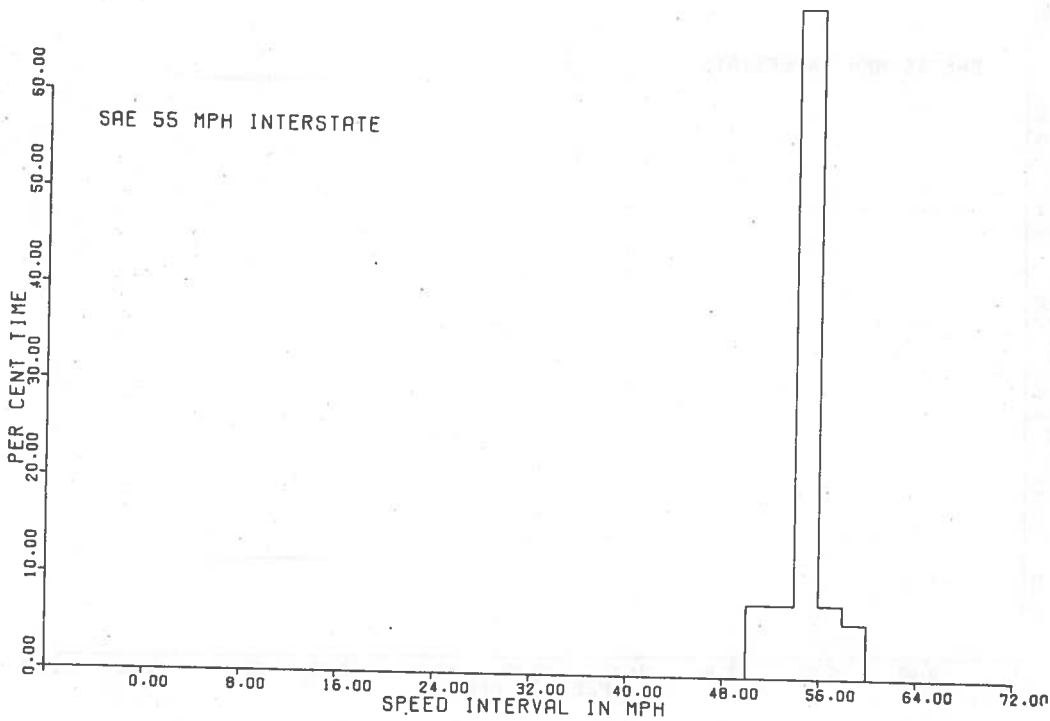


Figure C-12 SAE Interstate (55 MPH) Driving Schedule, Percent Time-Speed Interval Profile

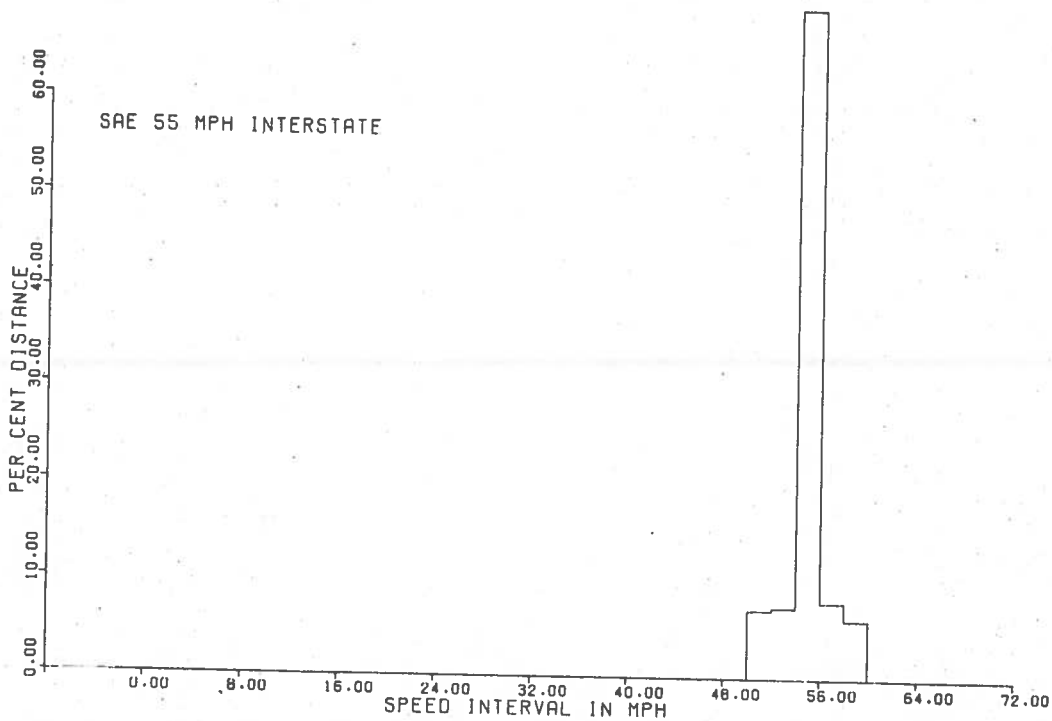


Figure C-13 SAE Interstate (55 MPH) Driving Schedule, Percent Distance-Speed Interval

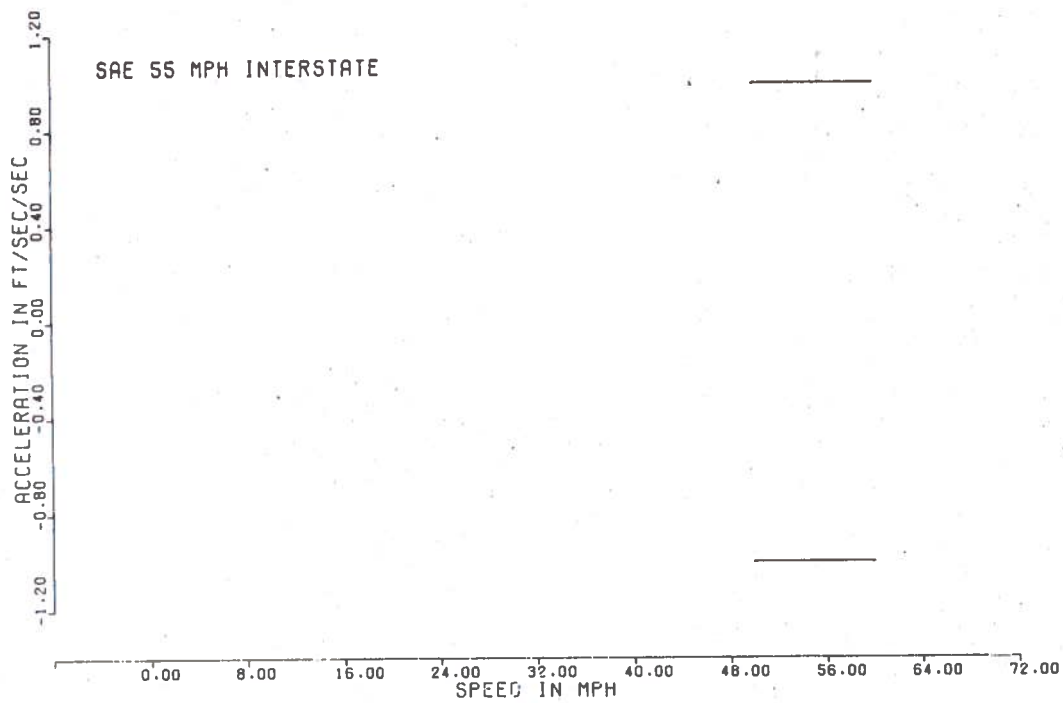


Figure C-14 SAE Interstate (55 MPH) Driving Schedule, Acceleration-Speed Profile

C.2.3 SAE Interstate (70 MPH) Driving Schedule - J1082¹⁹

C.2.3.1 Description - This driving schedule has an average speed of 70 MPH and a maximum speed of 75 MPH. The 4.7 mile route is traveled in 242 seconds. The schedule does not include any idle periods or stops. The percent time and distance modes are shown in Table C-7.

TABLE C-7 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE SAE 70 MPH INTERSTATE DRIVING SCHEDULE J1082

	Idle	Cruise	Acceleration	Deceleration
% Time	0	51.5	24.3	24.3
% Distance	0	51.5	24.3	24.3

Table C-7 presents results attained from a simulation of this schedule. As seen, the cruise mode accounts for more than half of the travel time and distance. This mode is composed of five cruise maneuvers, each at 70 MPH. The acceleration mode which accounts for almost a quarter of the schedule's time and travel distance is composed of eight maneuvers, each at an acceleration rate of $+1.0 \text{ ft/sec}^2$. The deceleration mode which also utilizes almost a quarter of time and distance is composed of four maneuvers each at a rate of -1.0 ft/sec^2 .

C.2.3.2 Discussion - The instructions are written without ambiguity, and the test driver should not have any problems in interpreting the maneuvers. As with the SAE schedule in Section C.2.2, the presentation could be better written if specific terminology for each maneuver is spelled out instead of "repeat maneuvers as at 0.20 miles." Again the acceleration and deceleration rates are nonvarying.

C.2.3.3 SAE Interstate (70 MPH) Driving Schedule Instructions - Instructions for the SAE Interstate (70 MPH) Driving Schedule are indicated in Table C-8, and corresponding profiles are shown in Figures C-15 through C-21.

TABLE C-8 SAE INTERSTATE (70 MPH) DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (km)	Operation
0.0 (0.0)	Approach the starting line at 70 MPH (112.6 km/h). At line, start fuel measuring and timing devices. Proceed at 70 MPH (112.6 km/h) to the 0.2 mile (0.32 km) marker.
0.20 (0.32)	Accelerate to 75 MPH (120.7 km/h) at 1 ft/s ² (0.3 m/s ²). Immediately decelerate to 65 MPH (104.6 km/h) at 1 ft/s ² . Immediately accelerate to 70 MPH (112.6 km/h) at 1 ft/s ² . Proceed at 70 MPH (112.6 km/h) to the 1.2 mile (1.93 km) marker.
1.2 (1.93)	Repeat accelerations and decelerations as at 0.20 miles (0.32 km). Proceed to the 2.2 mile (3.54 km) marker.
2.2 (3.54)	Repeat accelerations and decelerations as at 0.20 miles (0.32 km). Proceed to the 3.2 mile (5.15 km) marker.
3.2 (5.15)	Repeat accelerations and decelerations as at 0.20 miles (0.32 km). Proceed to the 4.7 mile (7.56 km) marker.
4.7 (7.56)	Stop fuel measuring and timing device while driving at 70 MPH (112.6 km/h) at 4.7 miles (7.56 km). Record fuel consumed, elapsed time, and operating temperature.
0.0 (0.0)	Run recheck cycle.

Source: Reference 19.

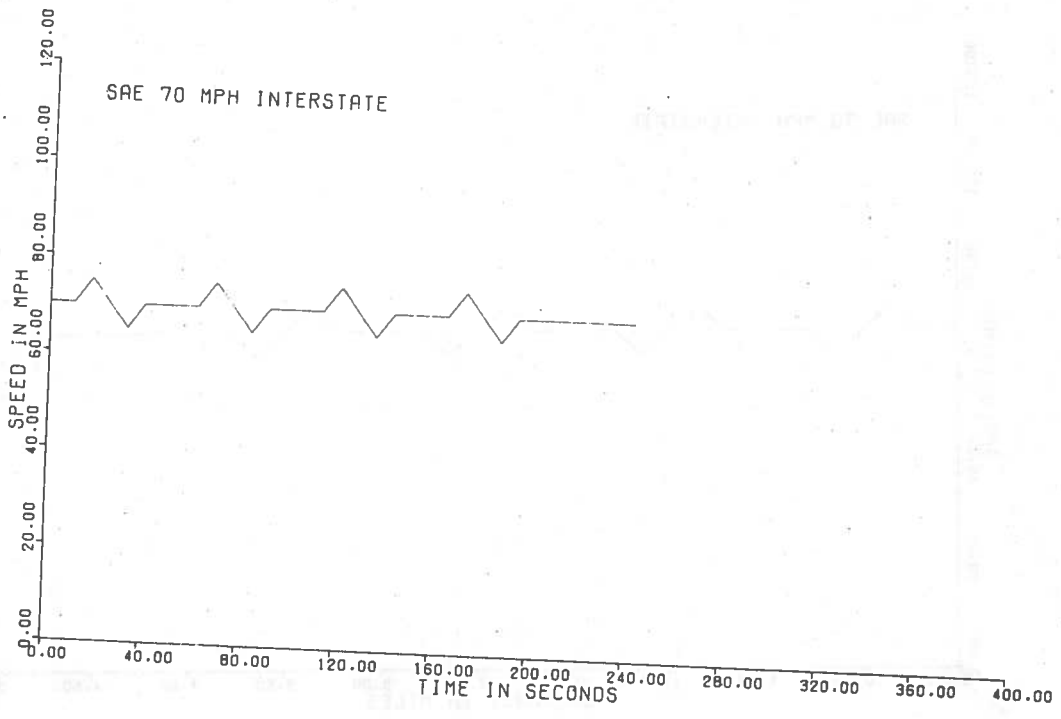


Figure C-15 SAE Interstate (70 MPH) Driving Schedule - J1082, Speed-Time Profile

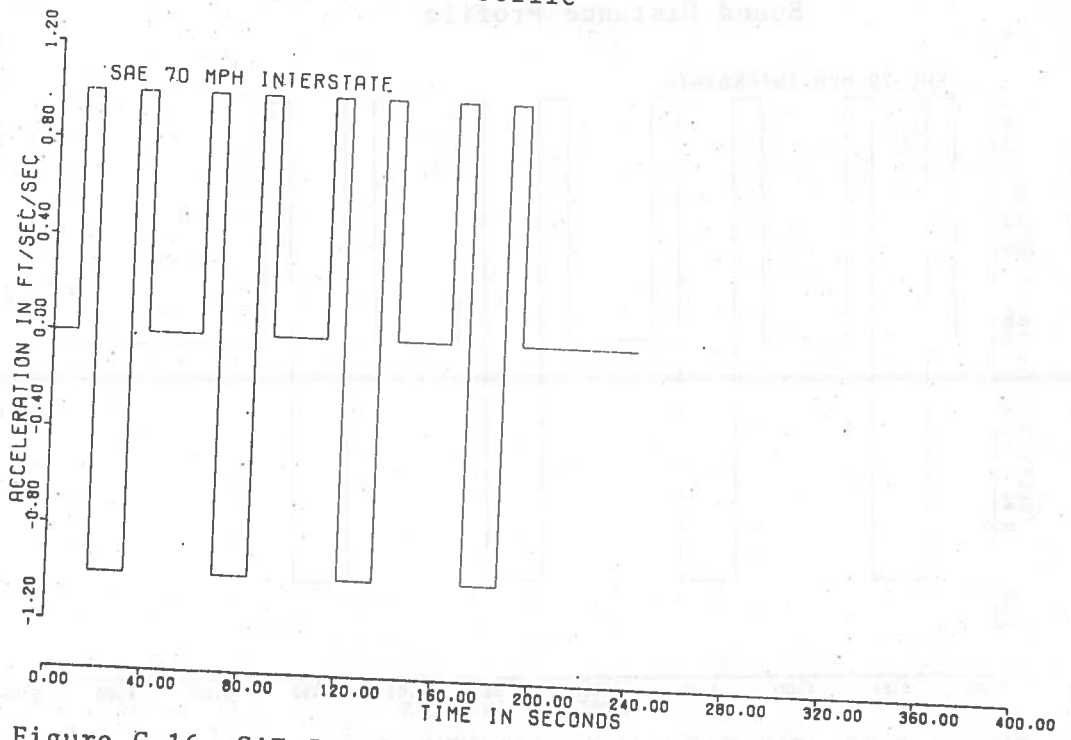


Figure C-16 SAE Interstate (70 MPH) Driving Schedule - J1082, Acceleration-Time Profile

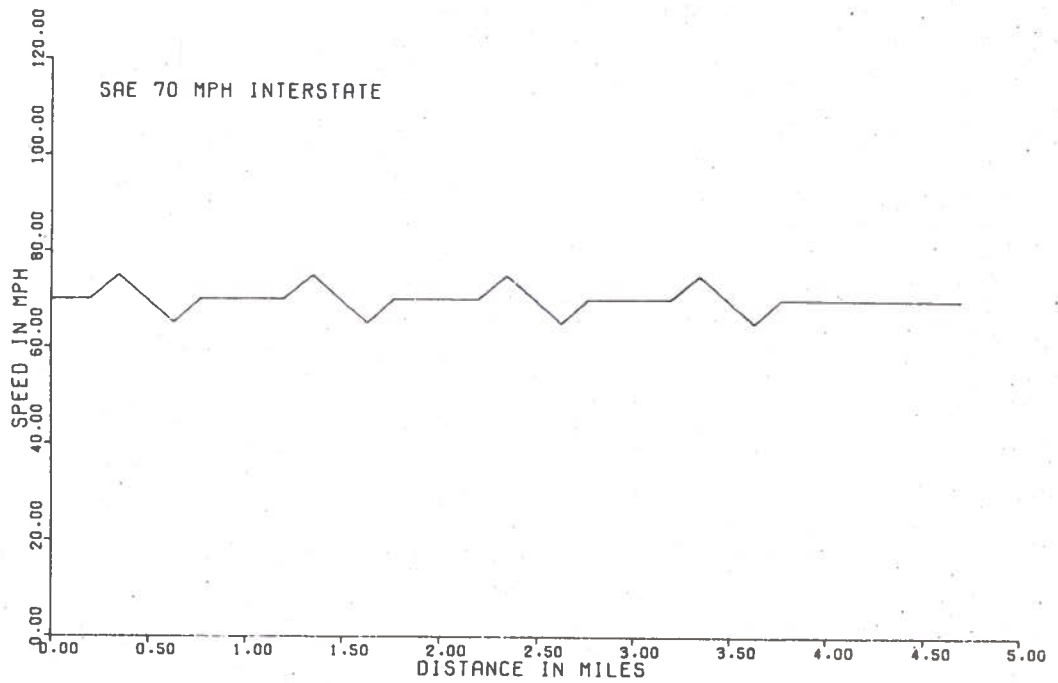


Figure C-17 SAE Interstate (70 MPH) Driving Schedule - J1082, Speed-Distance Profile

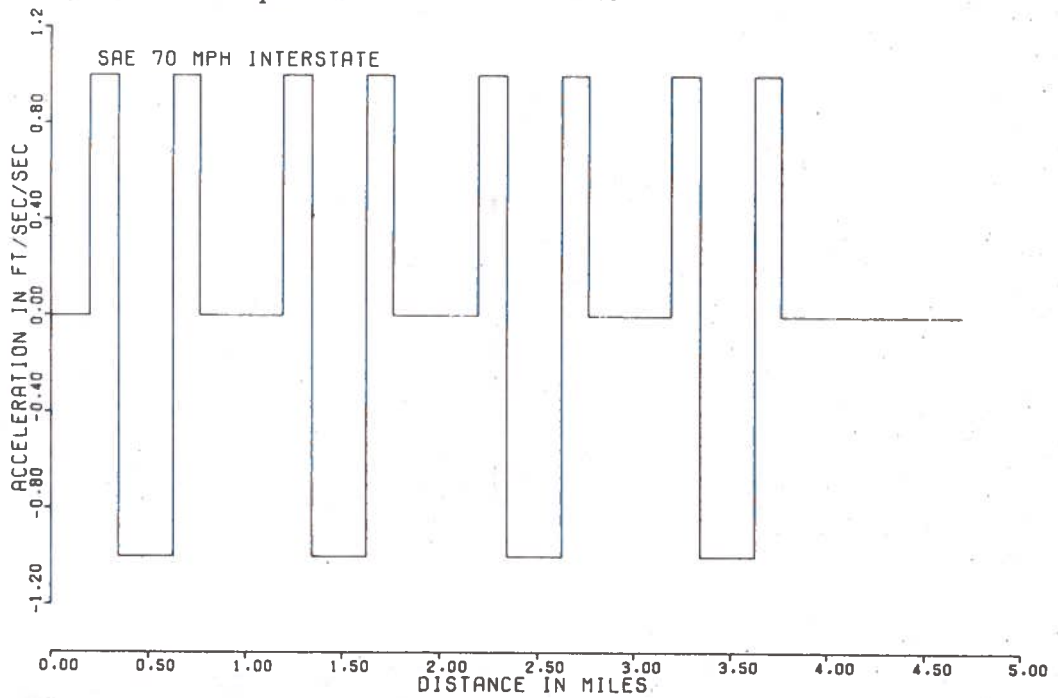


Figure C-18 SAE Interstate (70 MPH) Driving Schedule - J1082, Acceleration-Distance Profile

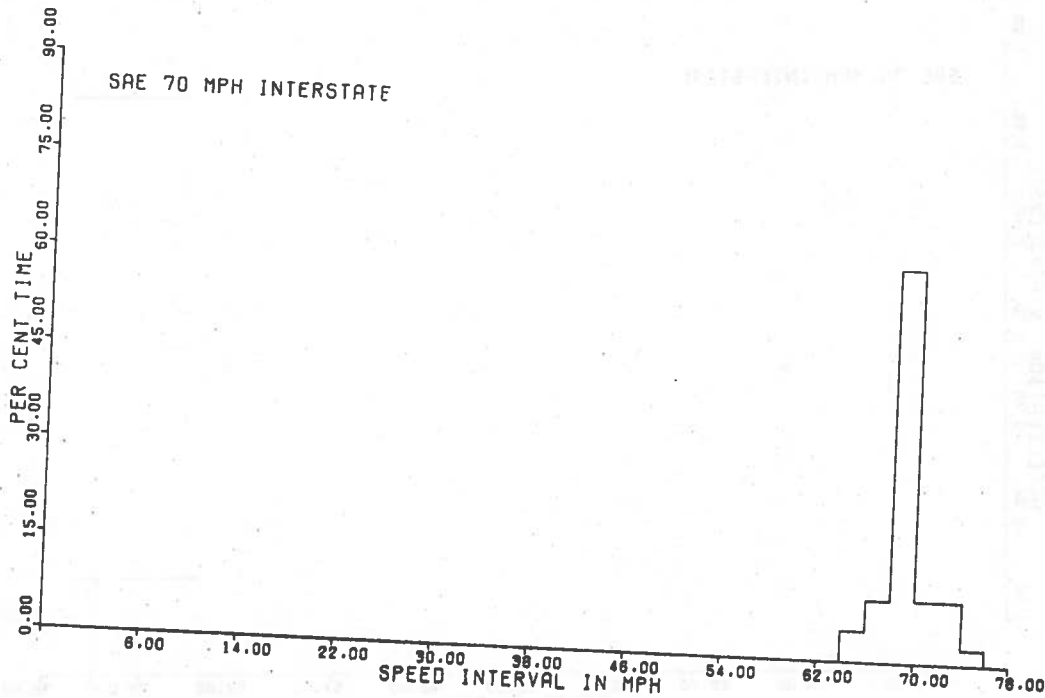


Figure C-19 SAE Interstate (70 MPH) Driving Schedule - J1082, Percent Time-Speed Interval Profile

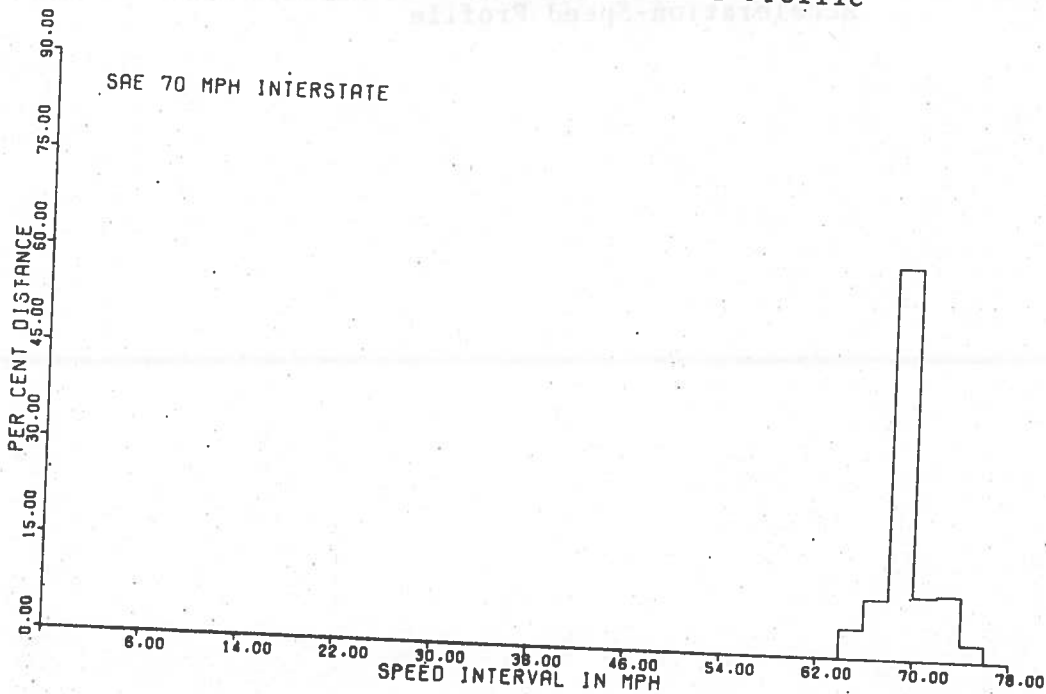


Figure C-20 SAE Interstate (70 MPH) Driving Schedule - J1082, Percent Distance-Speed Interval Profile

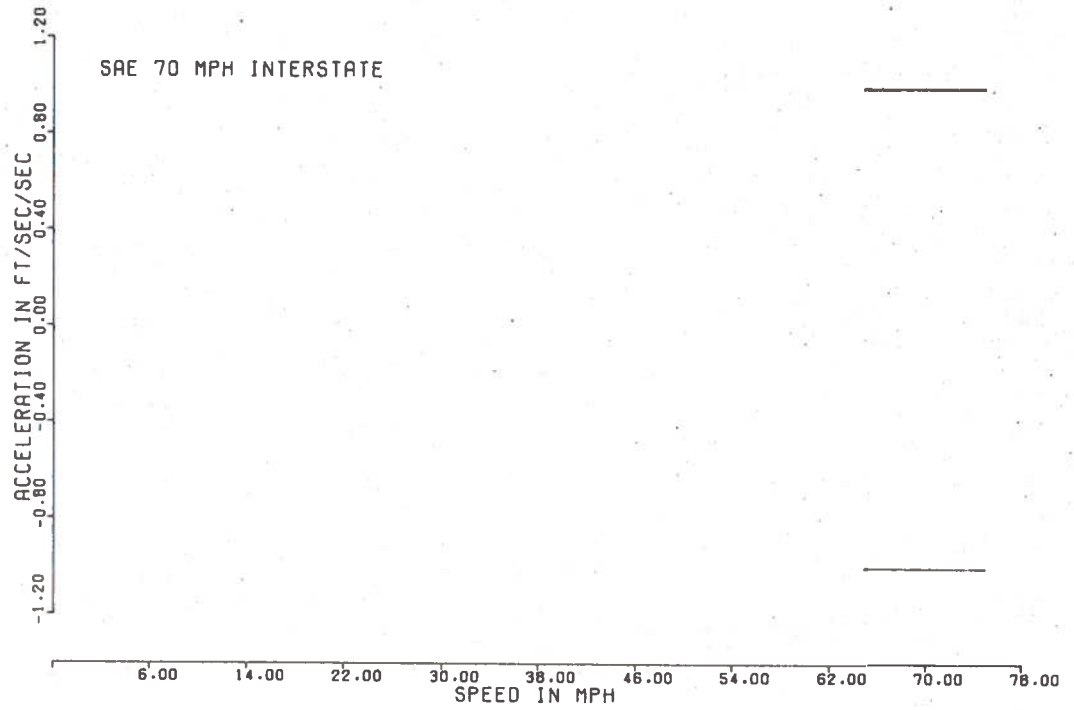


Figure C-21 SAE Interstate (70 MPH) Driving Schedule - J1082, Acceleration-Speed Profile

C.3 GENERAL MOTORS HIGHWAY AND INTERSTATE DRIVING SCHEDULES

C.3.1 General Description

General Motors Corporation has developed two driving schedules simulating travel on highway and interstate roadways for measuring vehicle fuel economy. The GM highway driving schedule, attempts to simulate those conditions typical of highway driving and includes vehicle stops and idles, and therefore simulates a roadway with partial access control. The GM interstate driving schedule attempts to simulate driving conditions on a limited access roadway, i.e., an interstate. Both schedules are used to measure vehicle fuel economy for a warmed-up operating condition and are performed on a test track.

C.3.2 GM Highway Driving Schedule

C.3.2.1 Description - The schedule distance is 15.0 miles at an average speed of 48.6 MPH, attaining a maximum speed of 70 MPH. The schedule takes 1108 seconds to complete, incorporating three idle periods within this time frame. In addition, the schedule has four stops, giving an average of 0.27 stops per mile. The percent time and distance modes are shown in Table C-9.

TABLE C-9 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE GM HIGHWAY DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	2.7	58.1	19.0	20.2
% Distance		68.4	14.6	17.1

The cruise mode uses almost 60% of the schedule's time and almost 70% of its distance. There are eleven cruises throughout the schedule. Three cruises at 30 MPH, two at 50 MPH, two at 55 MPH, two at 60 MPH, and two at 70 MPH. The acceleration mode composes almost 20% of the time and almost 15% of the distance

traveled in the schedule. There are 12 maneuvers associated with this mode. Seven accelerations are performed at a rate of $+2.0 \text{ ft/sec}^2$, four at a $+5.0 \text{ ft/sec}^2$ rate, and one at a rate of 3.90 ft/sec^2 .* The deceleration mode, which accounts for nearly 20% of the schedule's time and nearly 17% of its traveled distance, has 11 maneuvers associated with it. Six maneuvers are performed at an assumed rate,** one at a rate of -4.0 ft/sec^2 , and four at a -6.0 ft/sec^2 rate.

C.3.2.2 Discussion - The test driver of the vehicle should have no trouble in adhering to the requirements of this schedule, since the instructions are clearly presented. The maneuvers to decelerate at closed throttle (CT) or accelerate at wide-open-throttle (WOT) should be easy to perform. The difficulty arises in interpreting the CT and WOT values. Values for CT and WOT conditions of a full size vehicle were assumed for the computer simulation. Since individual vehicles differ with respect to these two conditions, no set value can be applied.

C.3.2.3 General Motors Highway Driving Schedule Instructions²⁰ - Instructions for the GM Highway Driving Schedules are indicated in Table C-10, and corresponding profiles are shown in Figures C-22 through C-28.

*An assumed value for wide-open throttle from 45 MPH to 70 MPH.

**Assumed values for closed throttle; 0.87 ft/sec^2 from 55 MPH to 30 MPH, 1.06 ft/sec^2 from 55 MPH to 45 MPH, 1.10 ft/sec^2 from 60 MPH to 30 MPH, and 1.27 ft/sec^2 from 60 MPH to 42 MPH.

TABLE C-10 GM HIGHWAY DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (km)	Operation	Fuel Temp
0.0 (0.0)	Start fuel meter, accel. to 15 MPH (24.1) at 5 fps ² (1.52), then to 50 MPH *80.4) at 2 fps ² (0.61)	
1.5 (2.41)	Decel. to 30 MPH (48.3) at CT*	
2.0 (3.22)	Accel. to 50 MPH (80.4) at 2 fps ² (0.61)	
3.5 (5.63)	Decel. at CT	
3.7 (5.95)	Stop at 6 fps ² (1.83), idle sec., accel. to 15 MPH (24.1) at 5 fps ² (1.52), then to 55 MPH (88.5) at 2 fps ² (0.61)	(1)
5.3 (8.53)	Decel. to 30 MPH (48.3) at CT	
5.8 (9.33)	Accel. to 55 MPH (88.5) at 2 fps ² (0.61)	
7.3 (11.75)	Decel. at CT	
7.5 (12.07)	Stop at 6 fps ² (1.83), idle 10 sec., accel. to 15 MPH (24.1) at 5 fps ² (1.52), then to 60 MPH (96.5) at 2 fps ² (0.61)	(2)
9.0 (14.48)	Decel. to 30 MPH (48.3) at CT	
9.5 (15.29)	Accel. to 60 MPH (96.5) 2 fps ² (0.61)	
11.0 (17.70)	Decel. at CT	
11.3 (18.18)	Stop at 6 fps ² (1.83), idle 10 sec., stop fuel meter and record fuel consumed, elapsed time and fuel temperature, start fuel meter and accel. to 15 MPH (24.1) at 5 fps ² (1.52), then to 70 MPH (112.6) at 2 fps (0.61)	(3)
12.8 (20.60)	Decel. to 45 MPH (72.4) at fps ² (1.22), accel. to 70 MPH (112.6) at WOT.**	
14.8 (23.81)	Stop at 6 fps ² (1.83) and stop fuel meter, record fuel consumed, elapsed time, and fuel temperature.	(4)
11.3 (18.18)	Run recheck lap	

Source: Reference 20.

*Closed Throttle
 **Wide-open Throttle

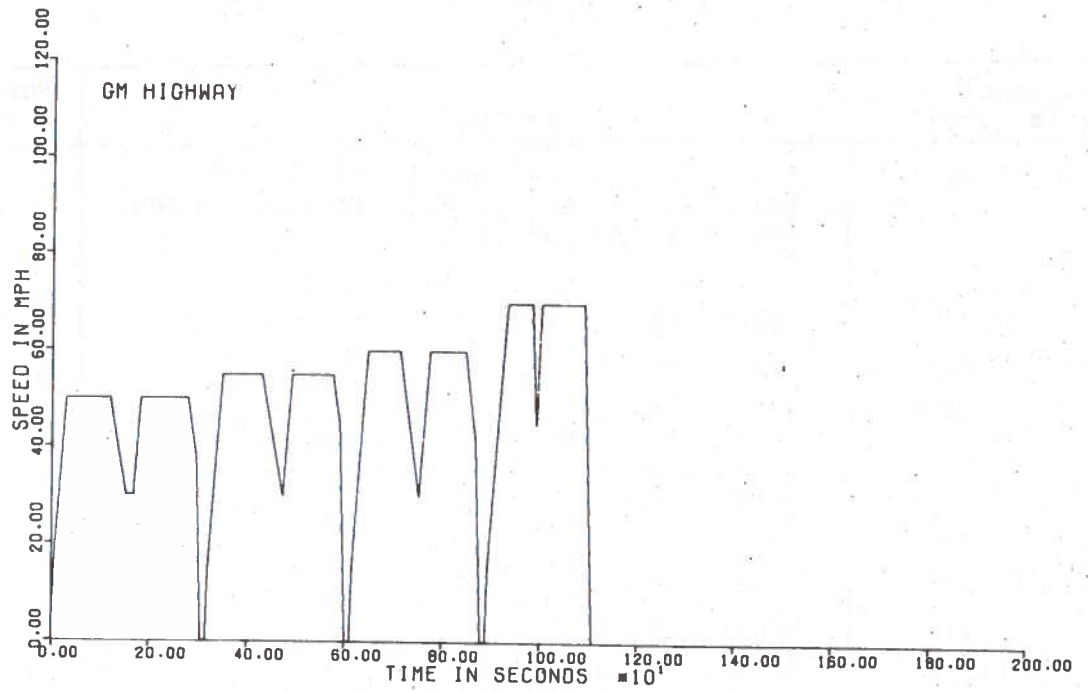


Figure C-22 GM Highway Driving Schedule, Speed-Time Profile

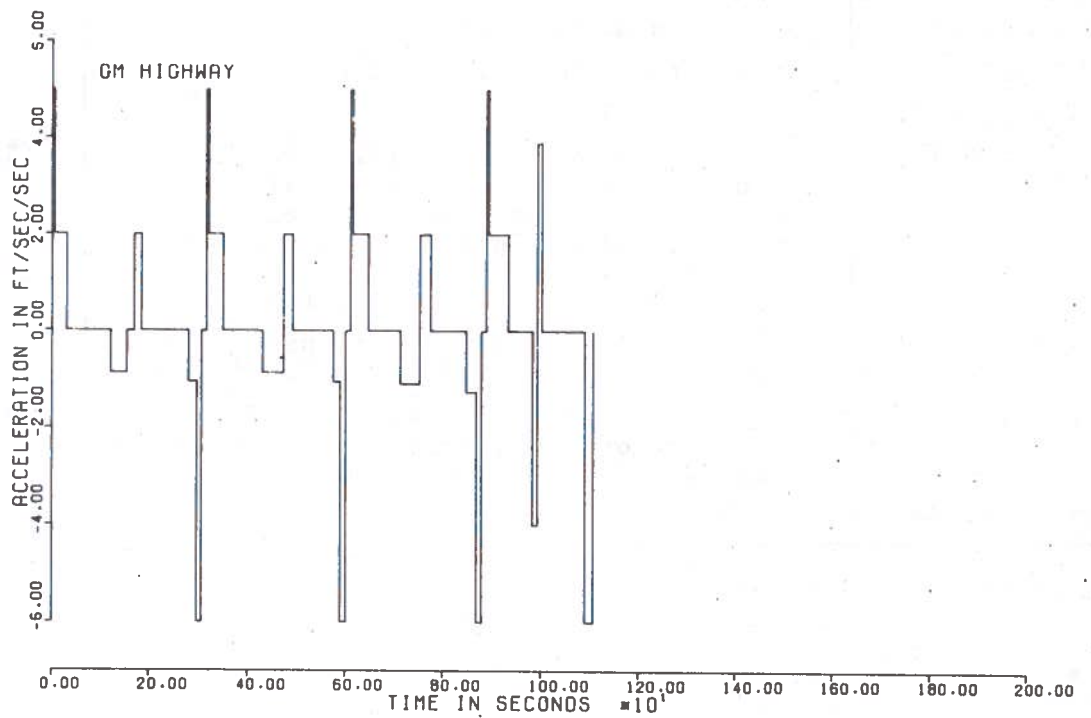


Figure C-23 GM Highway Driving Schedule, Acceleration-Time Profile

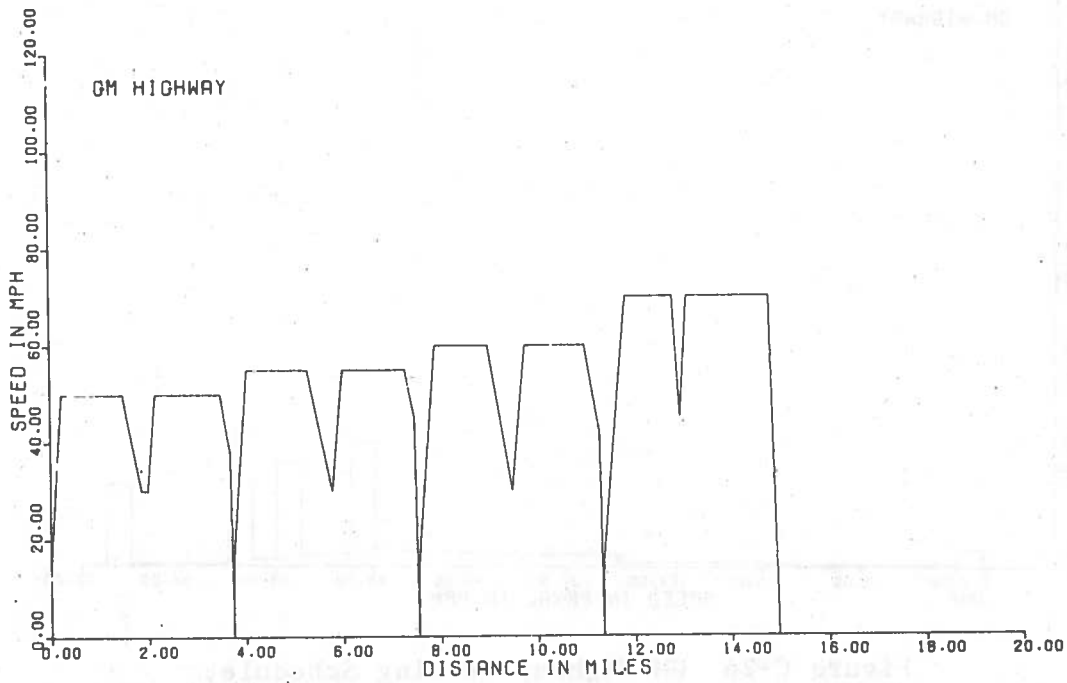


Figure C-24 GM Highway Driving Schedule, Speed-Distance Profile

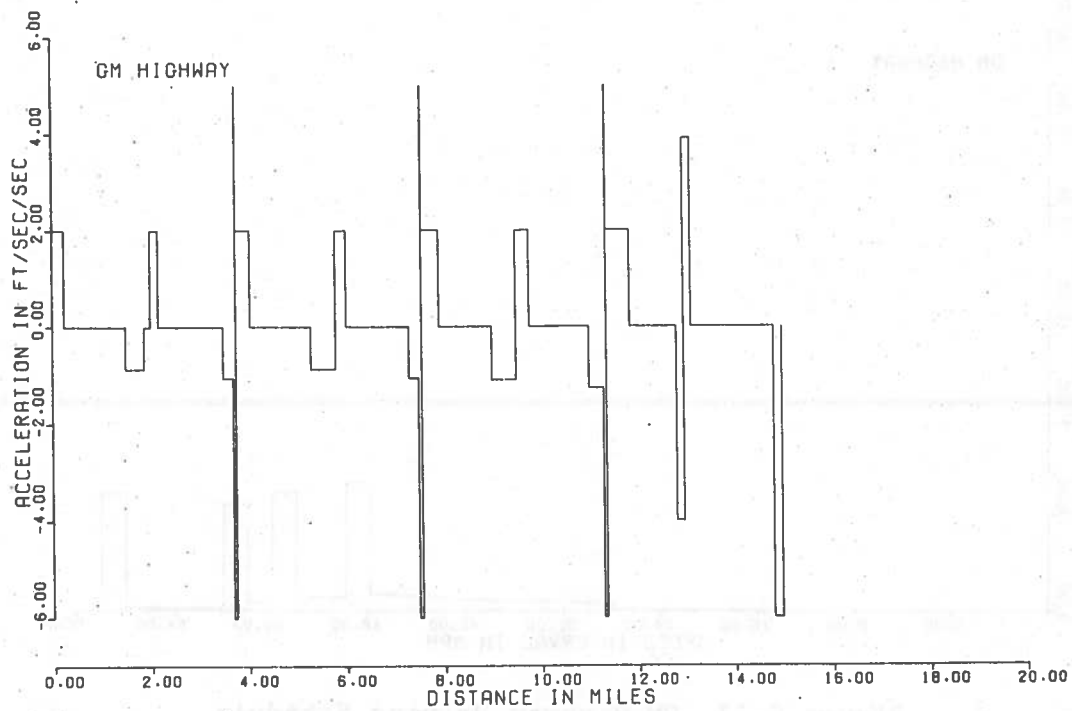


Figure C-25 GM Highway Driving Schedule, Acceleration-Distance Profile

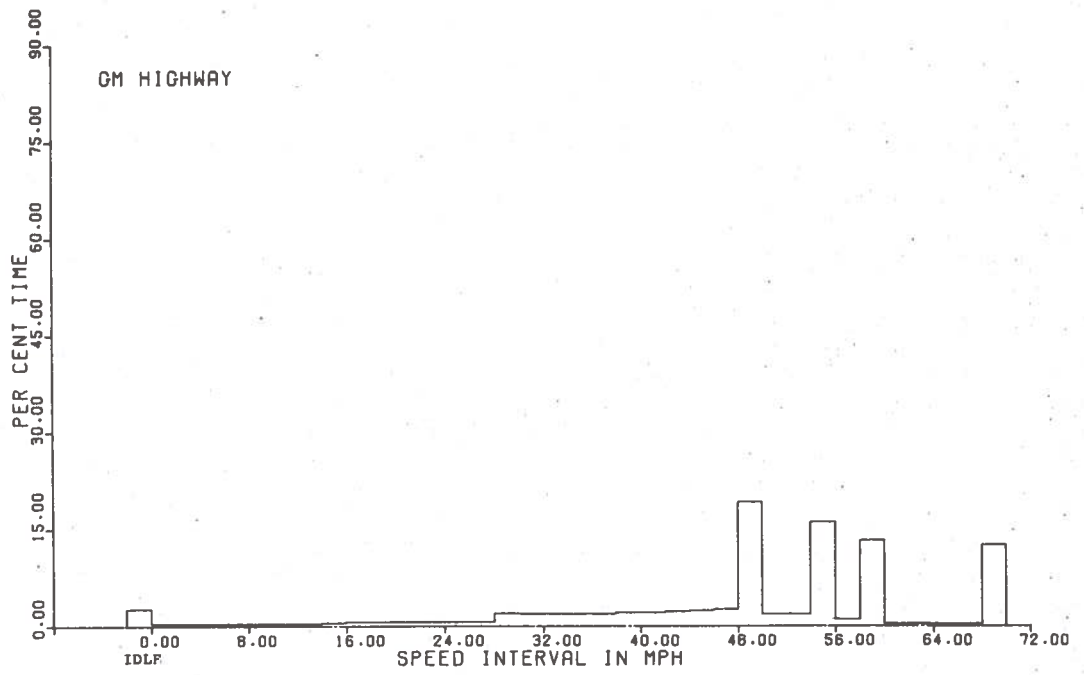


Figure C-26 GM Highway Driving Schedule, Percent Time-Speed Interval Profile

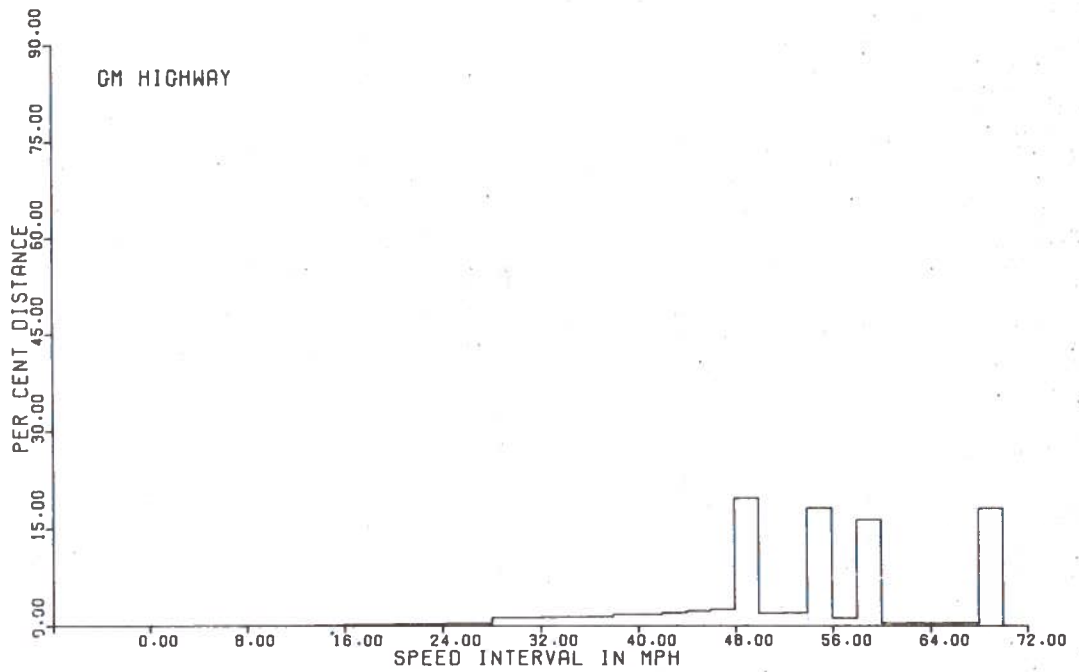


Figure C-27 GM Highway Driving Schedule, Percent Distance-Speed Interval Profile

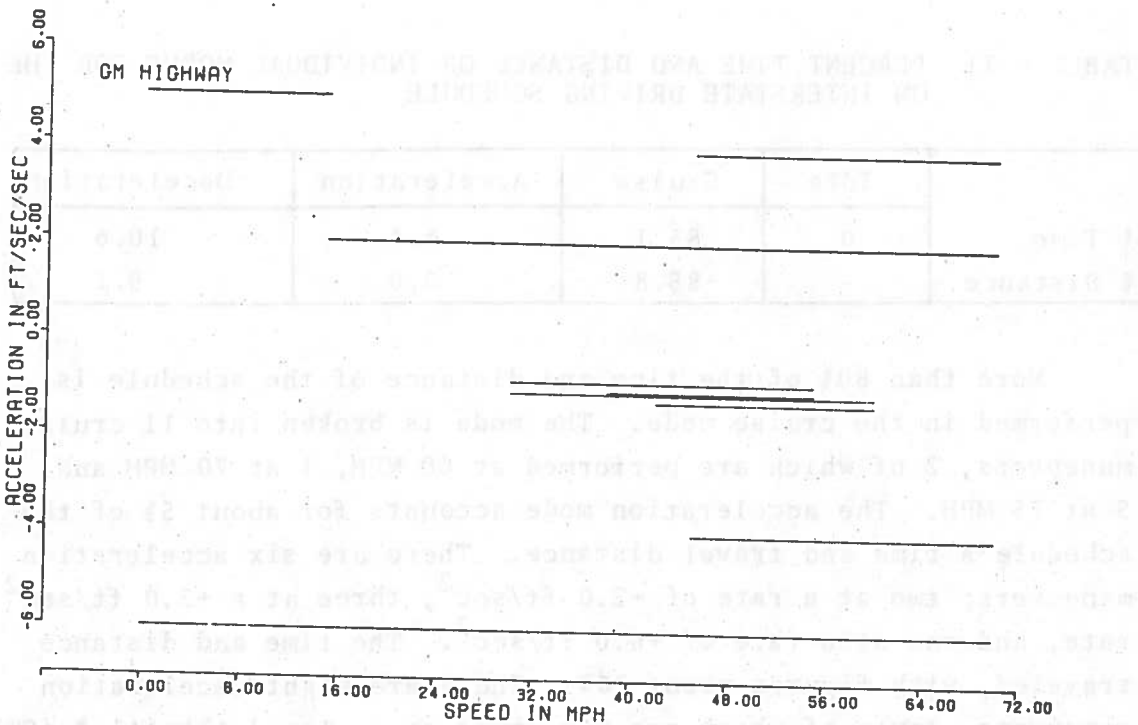


Figure C-28 GM Highway Driving Schedule, Acceleration-Speed Profile

C.3.3 GM Interstate Driving Schedule

C.3.3.1 Description - The GM Interstate driving schedule has a higher average speed (70.5 MPH) than the GM highway driving schedule (48.6 MPH). The maximum speed that the vehicle attains for this schedule is 75 MPH. The test route is 15.0 miles long, and is driven in 767 seconds. The schedule contains no idle periods and only one stop, giving an average figure of 0.067 stops per mile. The percent time and distance modes are shown in table C-11.

TABLE C-11 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE GM INTERSTATE DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	0	83.1	6.4	10.6
% Distance	-	85.8	5.0	9.2

More than 80% of the time and distance of the schedule is performed in the cruise mode. The mode is broken into 11 cruise maneuvers, 2 of which are performed at 60 MPH, 4 at 70 MPH and 5 at 75 MPH. The acceleration mode accounts for about 5% of the schedule's time and travel distance. There are six acceleration maneuvers; two at a rate of $+2.0 \text{ ft/sec}^2$, three at a $+3.0 \text{ ft/sec}^2$ rate, and one at a rate of $+6.0 \text{ ft/sec}^2$. The time and distance traveled, with figures about 10%. There are eight deceleration maneuvers, seven of which are performed at a closed throttle* (CT) rate and one at a rate of -6.00 ft/sec^2 .

C.3.3.2 Discussion - The test driver should have no difficulty in maneuvering the vehicle to adhere to the instructions. The presentation of the instructions is orderly, resulting in a continuous flow of information. The main difficulty in this schedule is the deceleration maneuvers that are performed at closed throttle. A value of -1.27 ft/sec^2 was assumed for this maneuver. The difficulty would arise only in the analysis, since no specific figure is given.

*Values for closed throttle were assumed to be -1.27 ft/sec^2 .

TABLE C-12 GM INTERSTATE DRIVING SCHEDULE INSTRUCTIONS

Distance Miles (km)	Operation	Fuel Temp
0.0 (0.0)	Record fuel temperature, start fuel meter, accel. to 40 MPH (64.4) at 6 fps ² (1.83), then to 75 MPH (120.7) at 3 fps ² (.91).	(1)
2.0 (3.22)	Decel. to 70 MPH (112.6) at CT	
3.0 (4.83)	Accel. to 75 MPH (120.7) at 2 fps ² (.61)	
5.0 (8.04)	Decel. to 70 MPH (112.6) at CT	(2)
6.0 (9.65)	Decel. to 60 MPH (96.5) at CT	
6.5 (10.46)	Accel. to 75 MPH (120.7) at 3 fps ³ (.91)	
9.0 (14.48)	Decel. to 70 MPH (112.6) at CT	
10.0 (16.09)	Accel. to 75 MPH (120.7) at 2 fps ² (.61)	(3)
12.0 (19.31)	Decel. to 70 MPH (112.6) at CT	
13.0 (20.92)	Decel. to 60 MPH (96.5) at CT	
13.5 (21.72)	Accel. to 75 MPH (120.7) at 3 fps ² (.91)	
14.5 (23.33)	Decel. at CT	
14.9 (23.97)	Stop at 6 fps ² (1.83), record fuel consumed, elapsed time and fuel temperature	(4)
0.0 (0.0)	Run recheck cycle	

Source: Reference 20.

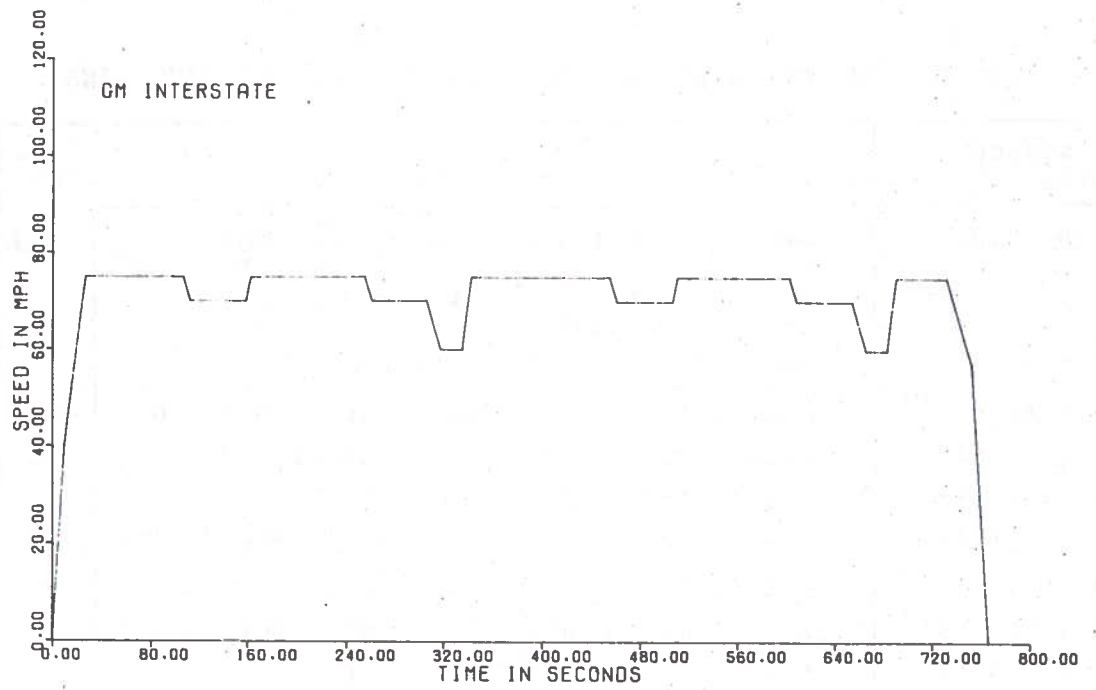


Figure C-29 Illustration of the Speed-Time Profile of the GM Interstate Driving Schedule

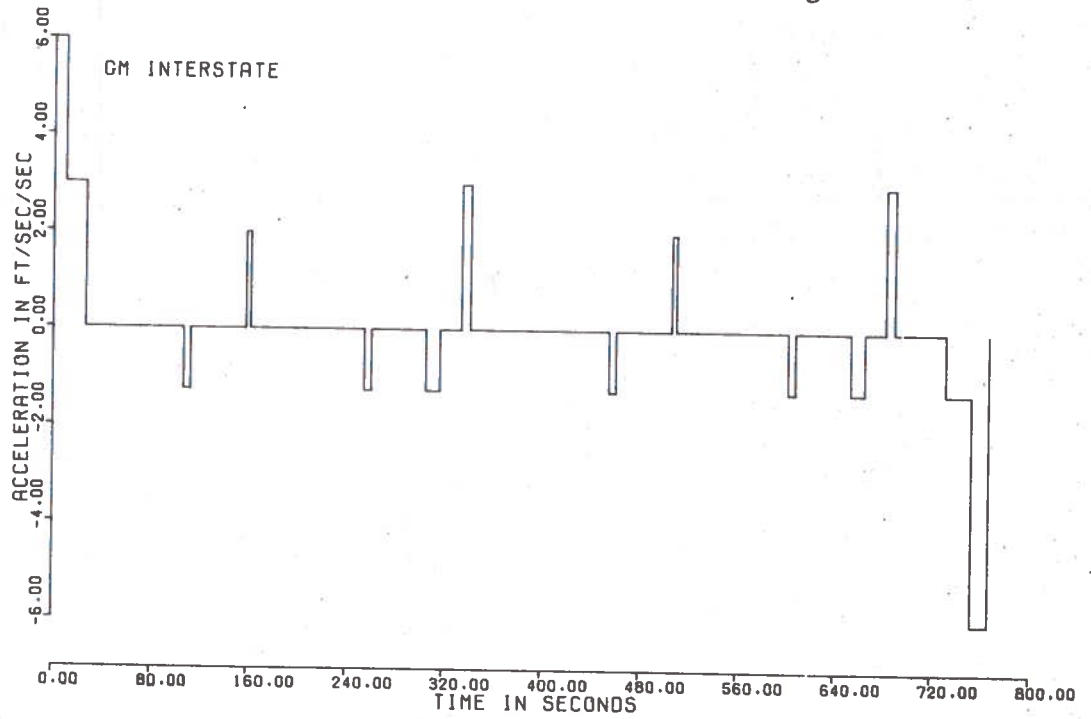


Figure C-30 Illustration of the Acceleration-Time Profile of the GM Interstate Driving Schedule

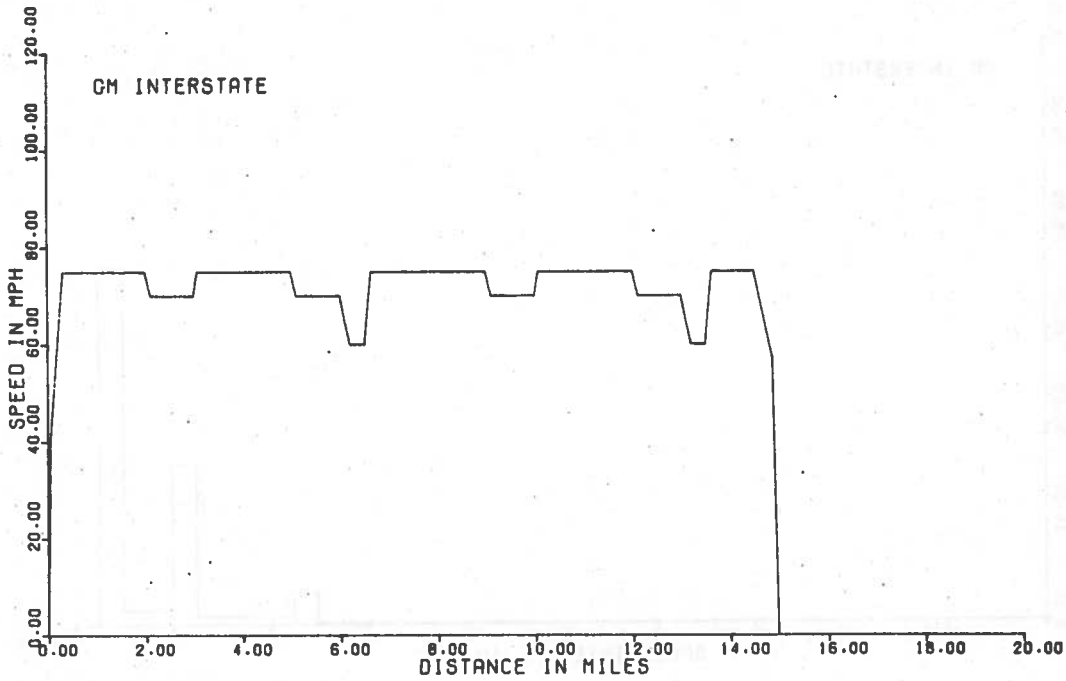


Figure C-31 Illustration of the Acceleration-Distance Profile of the GM Interstate Driving Schedule

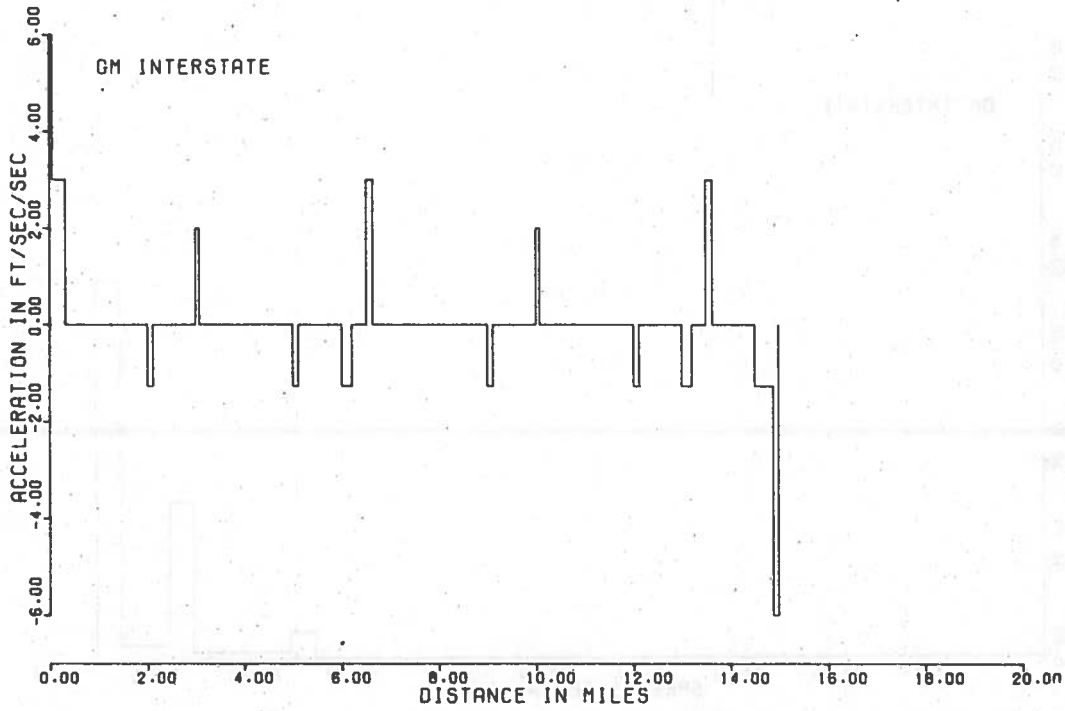


Figure C-32 Illustration of the Acceleration-Distance Profile of the GM Interstate Driving Schedule

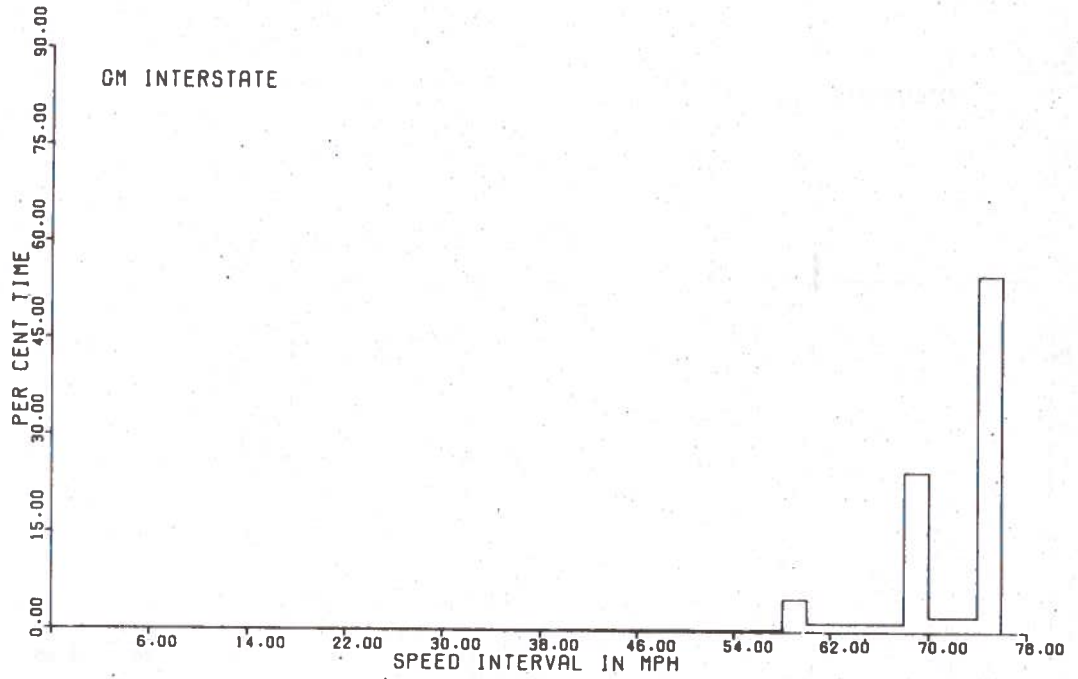


Figure C-33 Illustration of the Percent Time-Speed Interval Profile of the GM Interstate Driving Schedule

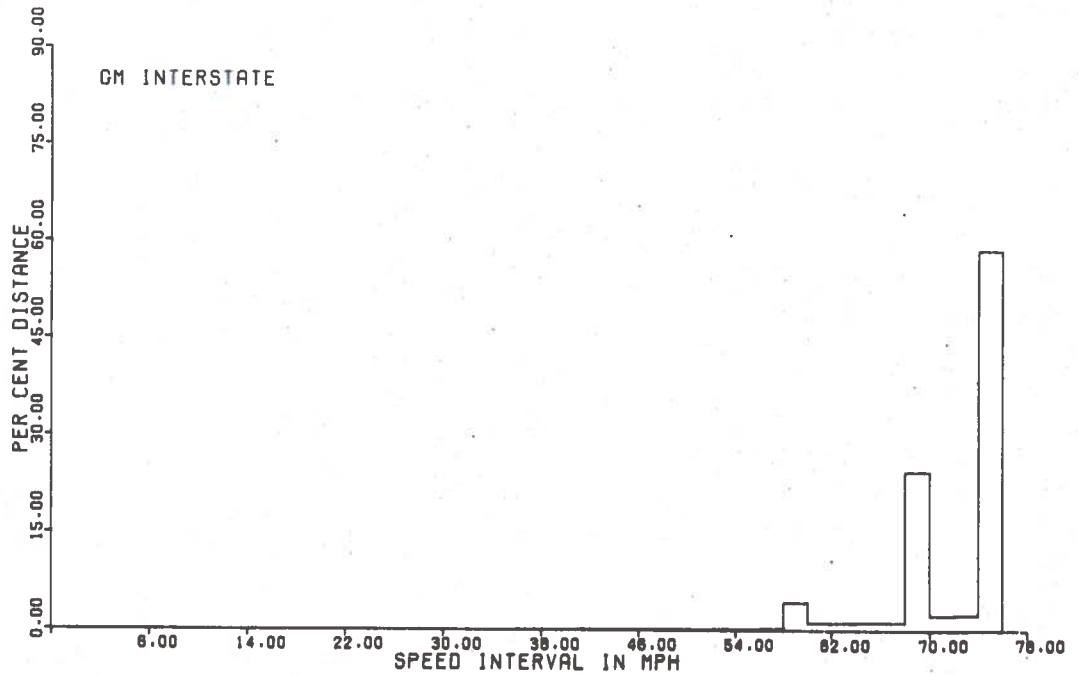


Figure C-34 Illustration of the Percent Distance-Speed Interval Profile of the GM Interstate Driving Schedule

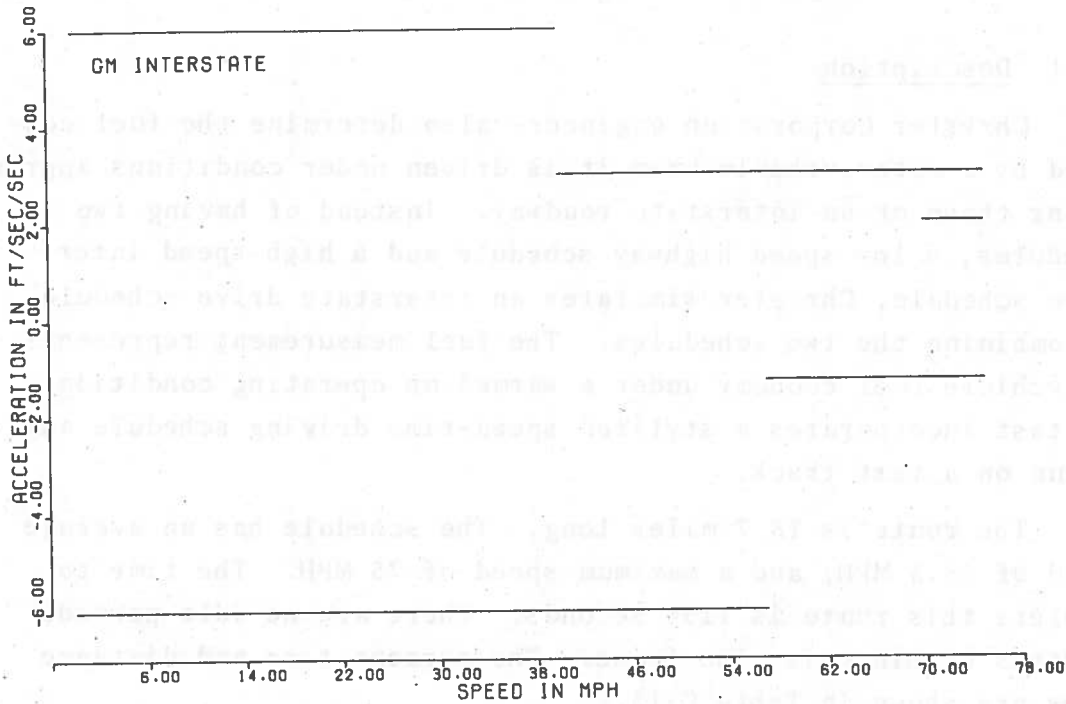


Figure C-35 Illustration of the Acceleration-Speed Profile of the GM Interstate Driving Schedule

Acceleration	Speed	Time	Distance
5.5	30.0	1.8	135.0
2.5	54.0	1.8	135.0
-5.5	78.0	1.8	135.0

C.4 CHRYSLER CORPORATION INTERSTATE DRIVING SCHEDULE

C.4.1 Description

Chrysler Corporation engineers also determine the fuel consumed by a motor vehicle when it is driven under conditions approximating those of an interstate roadway. Instead of having two schedules, a low speed highway schedule and a high speed interstate schedule, Chrysler simulates an interstate drive schedule by combining the two schedules. The fuel measurement represents the vehicle fuel economy under a warmed-up operating condition. The test incorporates a stylized speed-time driving schedule and is run on a test track.

The route is 18.7 miles long. The schedule has an average speed of 58.3 MPH, and a maximum speed of 75 MPH. The time to complete this route is 1154 seconds. There are no idle periods or stops within this time frame. The percent time and distance modes are shown in Table C-13.

TABLE C-13 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE CHRYSLER INTERSTATE DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	0	59.3	20.3	20.3
% Distance	-	58.2	20.9	20.9

Table C-13 shows that almost 60% of the driving schedule time and distance is in the cruise mode. There are eight cruise maneuvers incorporated within this schedule; four at a speed of 50 MPH and four at 70 MPH. The deceleration and acceleration modes each require approximately 20% for the time and distance modes. There are 16 acceleration maneuvers performed, each at the same rate of $+1.0 \text{ ft/sec}^2$. The deceleration mode has 8 maneuvers, each at a rate of -1.0 ft/sec^2 .

C.4.2 Discussion

The instructions for this schedule require driver aides (markers) to be placed on the test track. The schedule is specifically designed for the Chrysler Test Track, see Figure C-36. The maneuvers are understandable to the test driver, but may present difficulty to anyone attempting to analyze the test. The test procedures could be more descriptive by noting the distance between the markers as well as the distance for each lane used. Greater detail should be noted between the two test segments (the only data given is that one lap should be run at 50 MPH average speed and one lap at a 70 MPH average speed.) Also, the presentation would be less subject to error if a point-by-point description for each maneuver were incorporated in the test instead of "repeat the above."

C.4.3 Chrysler Corporation Interstate Driving Schedule Instructions

Instructions for the Chrysler Corporation Interstate Driving Schedule are included in Table C-14 and are referenced to Figure C-36. Corresponding profiles are shown in Figures C-37 to C-43.

TABLE C-14 CHRYSLER CORPORATION INTERSTATE DRIVING SCHEDULE INSTRUCTIONS

Step	Operation
A.	Run 2 laps at each speed noting fuel counts and time per lap. 1. 50 MPH average speed (50-55-45-50) in Lane 3. 2. 70 MPH average speed (70-75-65-70) in Lane 4.
B.	Run as follows, using the AMA cycle reflector marks on the oval (red or blue) as noted in Figure C-36.
C.	The test is to be run as follows: Road Load to marker ① Start instrumentation

TABLE C-14 CHRYSLER CORPORATION INTERSTATE DRIVING SCHEDULE INSTRUCTIONS (CONTINUED)

Step	Operation
C. cont.	Accelerate at 1 ft/sec^2 to road load speed plus 5 MPH Decelerate at 1 ft/sec^2 to road load speed minus 5 MPH Accelerate at 1 ft/sec^2 to road load speed Hold road load till marker (2) At marker (2) repeat accel.-decel.-accel.-R.L. Repeat at markers (3) and (4) Shut off instrumentation at marker (1)
D.	When two or more test conditions are requested they should run back to back at the low speed before proceeding to the high speed portion of the test.

Source: Reference 22

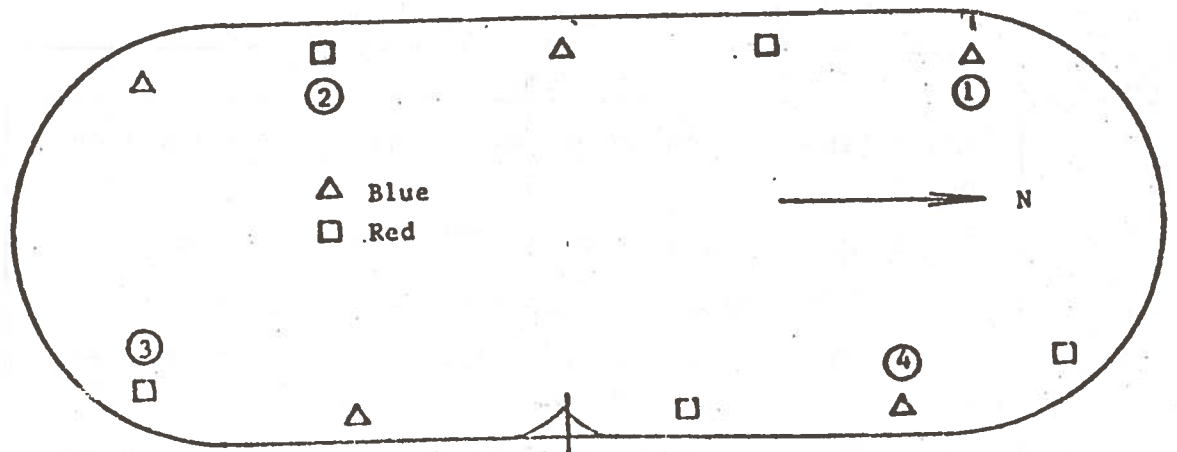


Figure C-36 Chrysler Test Track

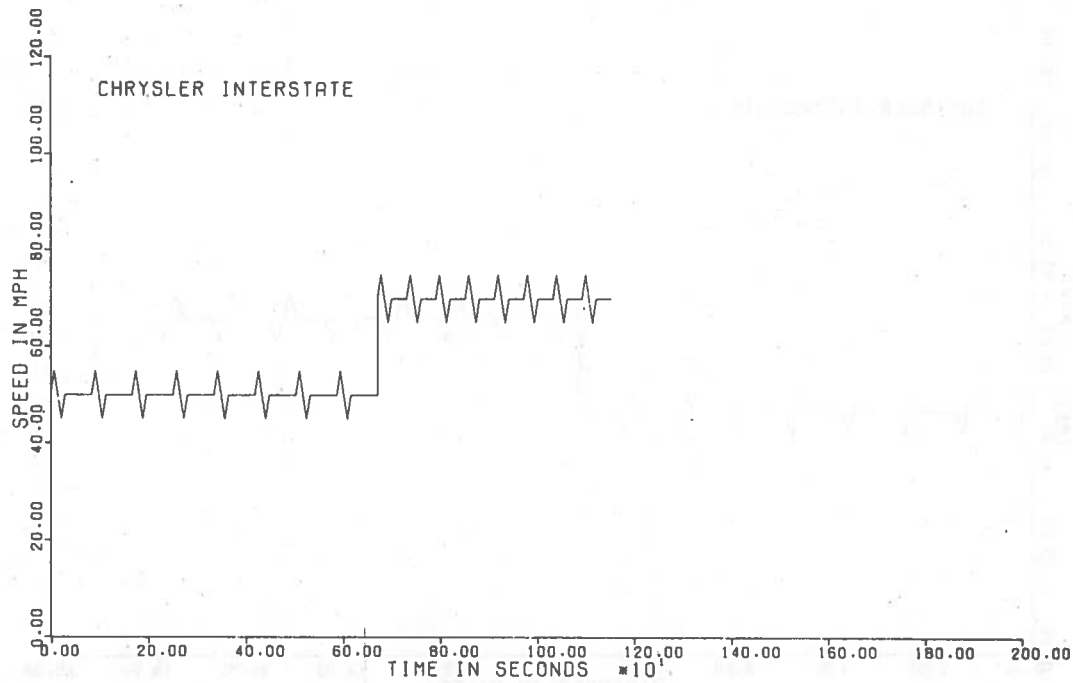


Figure C-37 Chrysler Interstate Driving Schedule, Speed-Time Profile

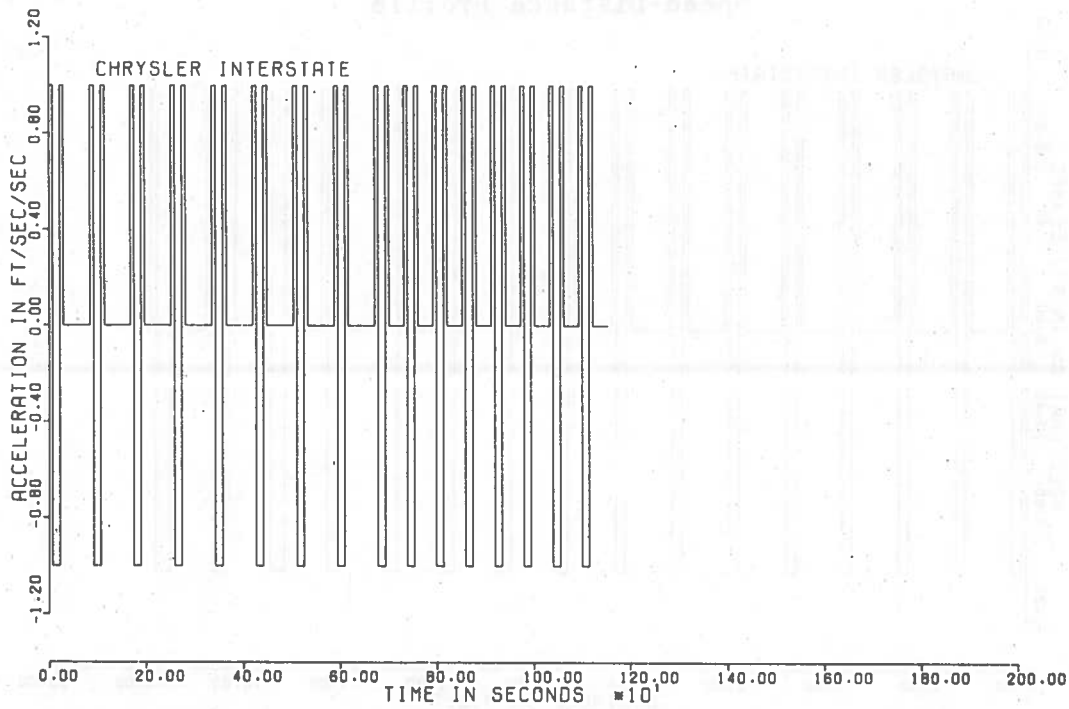


Figure C-38 Chrysler Interstate Driving Schedule, Acceleration-Time Profile

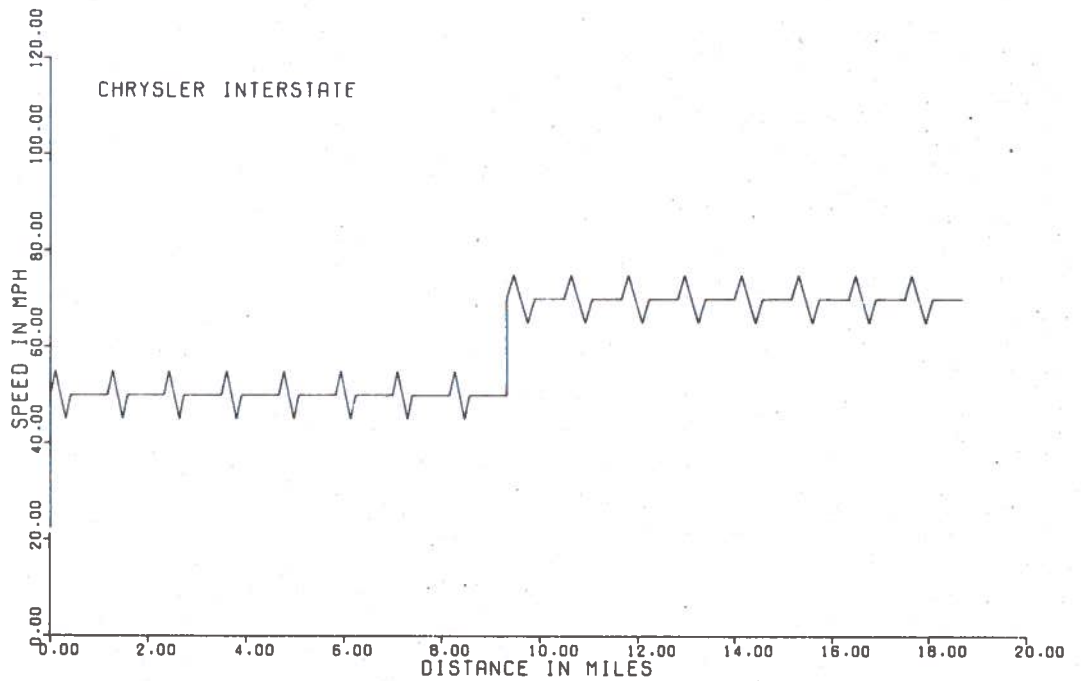


Figure C-39 Chrysler Interstate Driving Schedule, Speed-Distance Profile

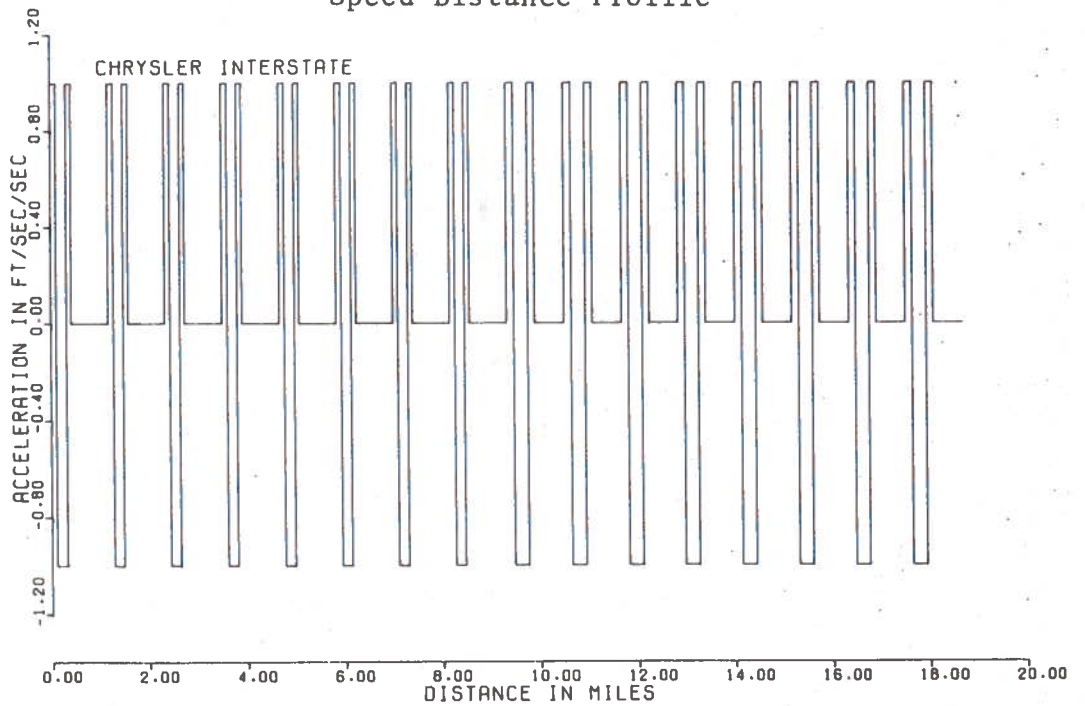


Figure C-40 Chrysler Interstate Driving Schedule, Acceleration-Distance Profile

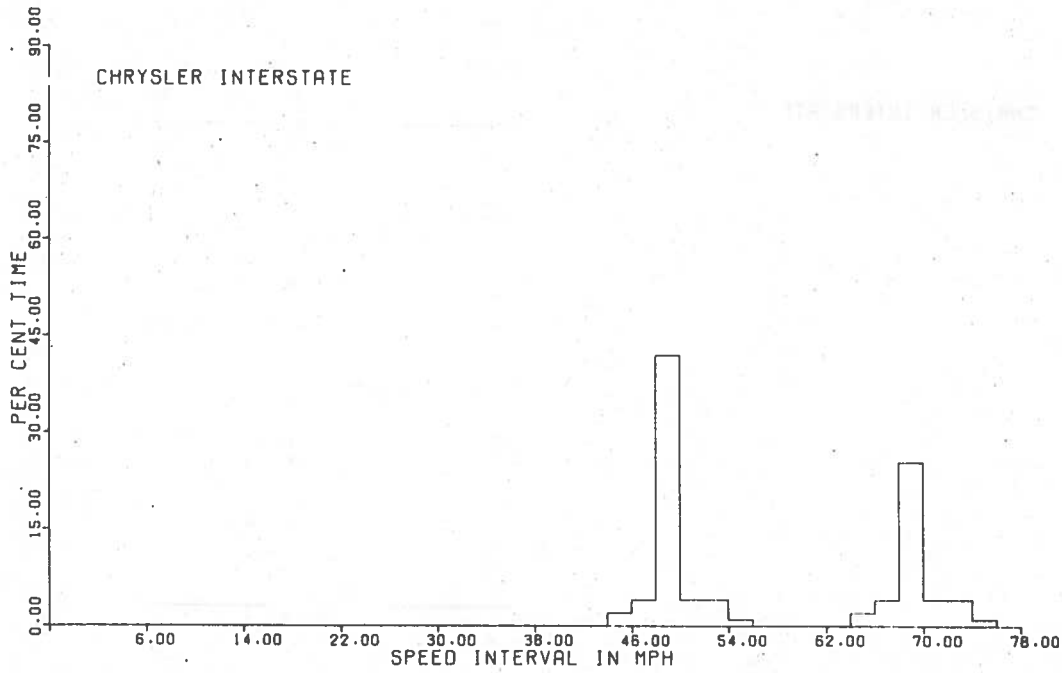


Figure C-41 Chrysler Interstate Driving Schedule, Percent Time-Speed Interval Profile

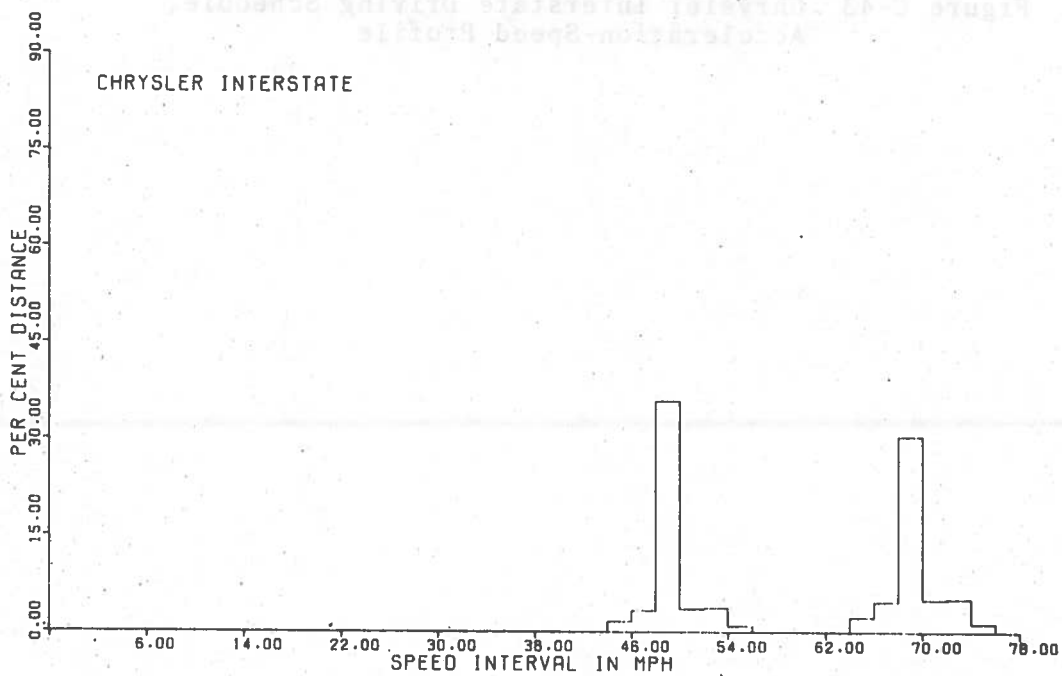


Figure C-42 Chrysler Interstate Driving Schedule, Percent Distance-Speed Interval Profile

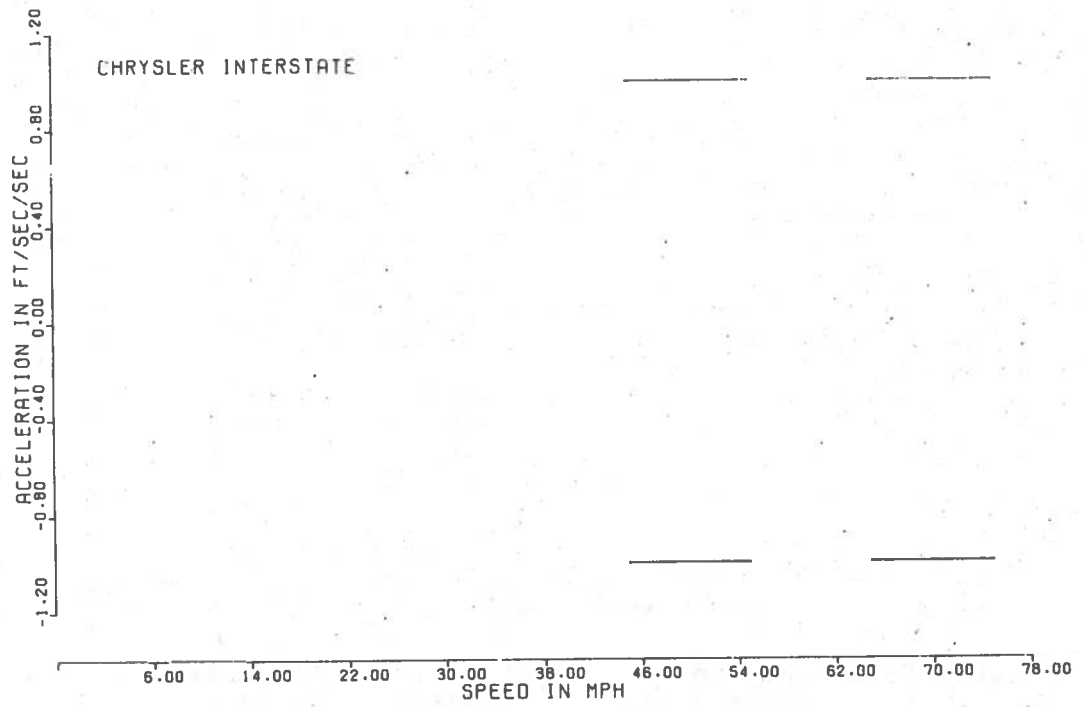


Figure C-43 Chrysler Interstate Driving Schedule, Acceleration-Speed Profile

APPENDIX D
"OTHER" DRIVING SCHEDULES

The driving schedules analyzed herein could not be placed into the urban, suburban or highway/interstate categories. These driving schedules maintain a specific uniqueness that requires that they be treated separately. The schedules herein described include the following:

1. Chrysler Constant Speed/Road Load Driving Schedule
2. EPA 25 MPH Average Seep Driving Schedule
3. EPA 35 MPH Average Speed Driving Schedule
4. EPA 45 MPH Average Speed Driving Schedule

Table D-1 is a presentation of the characteristics of the "Other" Driving Schedules.

TABLE D-1 CHARACTERISTICS OF VARIOUS "OTHER" SCHEDULES.

Parameter	Schedule			
	Chrysler Constant Speed	EPA 25 MPH	EPA 35 MPH	EPA 45 MPH
Distance (mile)	32.7	9.3	15.2	19.9
Time (sec)	2884	1377	1572	1589
Mean Speed (MPH)	40.8	24.4	34.9	45.1
Max. Speed (MPH)	80.0	60.0	60.0	60.0
Number of:				
Idles	0	15	9	6
Stops	0	14	8	5
Stops/Mile	0.0	1.5	0.5	0.3
Percent Time in:				
Idle	0.0	15.8	7.4	3.7
Cruise	100.0	37.8	54.4	67.8
Acceleration	0.0	26.6	21.9	15.3
Deceleration	0.0	20.7	16.8	13.5
Percent Distance in:				
Cruise	100.0	56.7	70.8	77.3
Acceleration	0.0	24.7	16.4	11.9
Deceleration	0.0	18.6	12.8	10.8

D-1 CHRYSLER CORPORATION CONSTANT SPEED/ROAD LOAD DRIVING SCHEDULE

D.1.1 Description

Chrysler Corporation, in addition to the test procedures for urban and interstate type driving, has developed test procedures for other types of driving conditions. This test attempts to determine the fuel economy of a vehicle under constant road load conditions. The test determines the fuel economy when the vehicle is traveling at speeds from 20 MPH to 80 MPH. The fuel economy figures represent those obtained when a vehicle is in a warmed-up operating condition. The schedule is run on a test track and has a stylized speed-time trace.

The driving schedule takes 2884 seconds to complete on a route that is 32.7 miles long. In a general sense the schedule has an average speed of 40.8 MPH and a maximum speed of 80 MPH. The schedule has no idles or stops, and incorporates cruise maneuvers exclusively. The cruise speeds are as follows:

- | | |
|--------------------|--------------------|
| a. 1 lap at 20 MPH | e. 1 lap at 60 MPH |
| b. 1 lap at 30 MPH | f. 1 lap at 70 MPH |
| c. 1 lap at 40 MPH | g. 1 lap at 80 MPH |
| d. 1 lap at 50 MPH | |

Since the vehicles are tested at Chrysler Oval Test Track, the test procedure instructions use lane designations. Lane one was used for cruises of 20 and 30 MPH; lane two for the 40 MPH cruise; lane three for the 50 MPH cruise; lane 4 for the 60 and 70 MPH cruises; and lane 5 for the 80 MPH cruise.

D.1.2 Discussion

The manner in which the instructions are presented is such that the test driver could only perform this schedule at the Chrysler Oval Test Track. The distance for each lane were not

given in this particular driving schedule, nor were the elapsed times for each speed. Further, they assumed no accelerations. Instead the test driver was allowed to segment the test, attaining the next desired cruise speed by including an unrecorded lap. This schedule therefore assumes a step increase in speed.

The schedule cannot be viewed as typical of any driving patterns per se. It is basically a series of cruises at different speeds. The average speed was only computed to show a mean cruise speed.

D.1.3 Chrysler Constant Speed/Road Load Driving Schedule Instructions

Instructions for the Chrysler Constant Speed/Road Load Driving Schedule are indicated in Table D-2. No driving schedule profiles are included.

TABLE D-2 CHRYSLER CONSTANT SPEED/ROAD LOAD DRIVING SCHEDULE INSTRUCTIONS

Step	Operation																
A.	Operate vehicle at constant speed.																
B.	Start at the lowest test speed and run the highest speed last.																
C.	<p>Record fuel used in thousandths of a gallon and lap times for the warm-up and one additional lap at each test speed requested. Do not run a third lap unless the economy difference between the warm-up lap and warmed-up lap exceeds 0.003 of a gallon. Run each speed in designated lane as follows:</p> <table data-bbox="251 1732 1055 1837"> <tr> <td>MPH</td> <td>20</td> <td>30</td> <td>40</td> <td>50</td> <td>60</td> <td>70</td> <td>80</td> </tr> <tr> <td>Lane</td> <td>1</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>4</td> <td>5</td> </tr> </table>	MPH	20	30	40	50	60	70	80	Lane	1	1	2	3	4	4	5
MPH	20	30	40	50	60	70	80										
Lane	1	1	2	3	4	4	5										
D.	Stabilize at the next speed for a minimum of 1/2 lap.																

TABLE D-2 CHRYSLER CONSTANT SPEED/ROAD LOAD DRIVING SCHEDULE
INSTRUCTIONS (CONTINUED)

Stop	Operation
E.	<p>Observe and record the following items on Form No. 800-140 for 20, 30, 40, 50, 60, 70 and 80 MPH speeds.</p> <ol style="list-style-type: none"> 1. Fuel economy 2. Manifold vacuum in north and south straightaways 3. Distributor vacuum in north and south straightaways 4. Driveability 5. Ambient air temperature 6. Lap time
F.	<p>Observe and record air temperature, barometer, humidity (except below 20°F) and wind at the beginning and end of test.</p>

Source: Reference 22.

D.2 ENVIRONMENTAL PROTECTION AGENCY 25 MPH, 35 MPH, AND 45 MPH AVERAGE DRIVING SCHEDULES

D.2.1 General Description

Scott Research Laboratories, under contract to EPA, performed a study for the purpose of updating curves used to estimate the changes in emissions for light-duty vehicles as the average vehicle speed changes.¹⁵ The program objective was accomplished by performing four major tasks as follows:

1. Urban driving pattern data collected during the CAPE-10 Vehicle Operations Survey, conducted in 1971 under the joint sponsorship of EPA and CRC, were processed by city and time of day into freeway, nonfreeway, and composite speed-mode matrices.
2. Weighted combinations of freeway and nonfreeway matrices, representing average route speeds ranging from about 21 to 47 MPH, were then used to generate representative driving patterns at speeds ranging from approximately 15 to 45 MPH. Eighty-eight driving patterns were selected as most representative out of a total sample of about 150,000 computer-generated driving patterns.
3. Second-by-second schedules of the 88 driving patterns were then input to an EPA-supplied computer program for the estimation of HC, CO, and NO_x emissions over each driving pattern for each 11 vehicle groups defined by model year and altitude (low altitude vs. high altitude). The EPA-supplied computer program is based on the results of several emissions testing programs conducted by the EPA.
4. A regression analysis was then conducted to relate estimated emissions to average route speed for each of the 11 vehicle groups.

As stated, the data used as input to this study were obtained from the CRC/APRAC-CAPE-10-68 program conducted by Scott and referred to as the Vehicle Operations Survey (VOS) program. The primary objective of the VOS program was to collect and evaluate information on urban driving patterns as characterized by detailed vehicle modal operating characteristics. A complete description of the VOS is found in reference 27. Likewise, reference 15 describes the techniques of driving schedule generations. From this work came the development of 88 selected patterns, of which three were selected for presentation here. These are the 25 MPH, 35 MPH, and 45 MPH average speed driving schedules obtained from EPA-Ann Arbor.

D.2.2 The EPA 25 MPH Average Speed Driving Schedule

D.2.2.1 Description - The EPA 25 MPH driving schedule is a semistylized drive schedule that can be used for dynamometer testing. It is used on vehicles that are tested from a cold-start as well as a hot-start operating condition.

The schedule has an average of 24.4 MPH and attains a maximum speed of 60.0 MPH. It is 9.3 miles long and has an elapsed time of 1377 seconds. There are 14 stops and 15 idle periods. It incorporates 1.5 stops per mile. The percent time and distance modes are shown in Table D-3.

TABLE D-3 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE EPA 25 MPH AVERAGE DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	14.9	37.8	26.6	20.7
% Distance	-	56.7	24.7	18.6

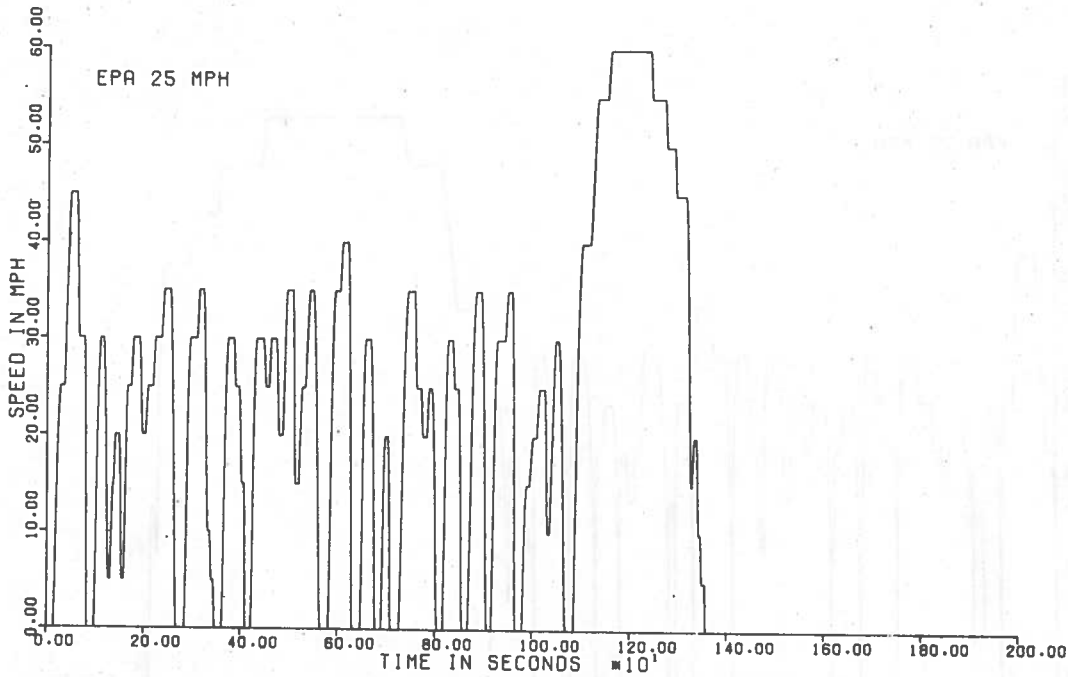


Figure D-1 EPA 25 MPH Average Speed Driving Schedule, Speed-Time Profile

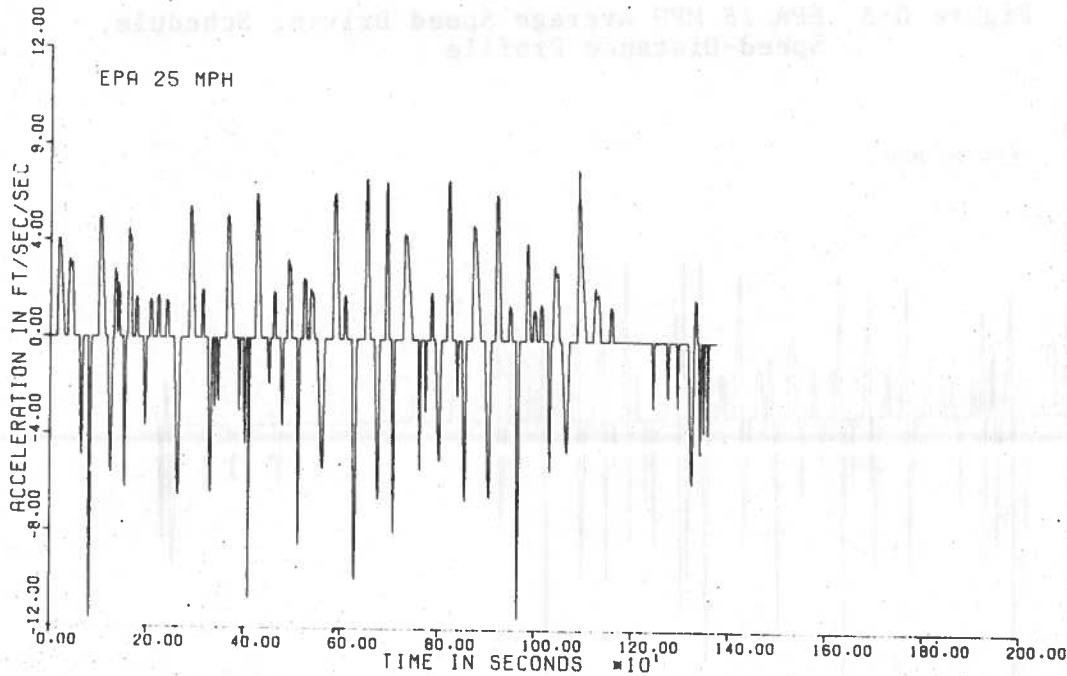


Figure D-2 EPA 25 MPH Average Speed Driving Schedule, Acceleration-Time Profile

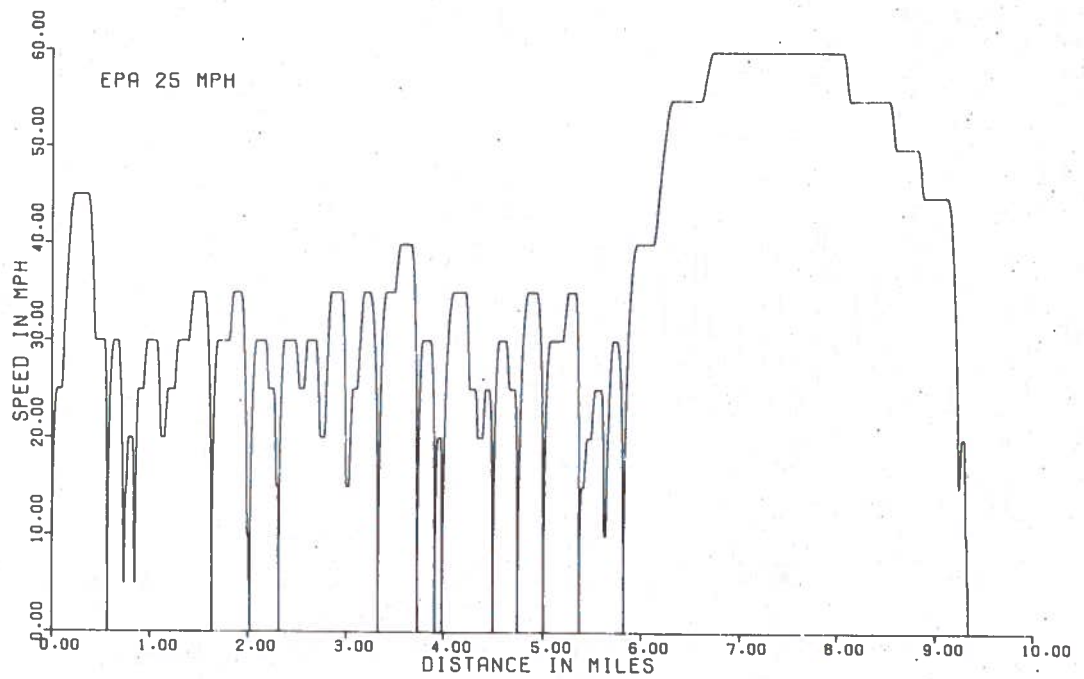


Figure D-3 EPA 25 MPH Average Speed Driving Schedule, Speed-Distance Profile

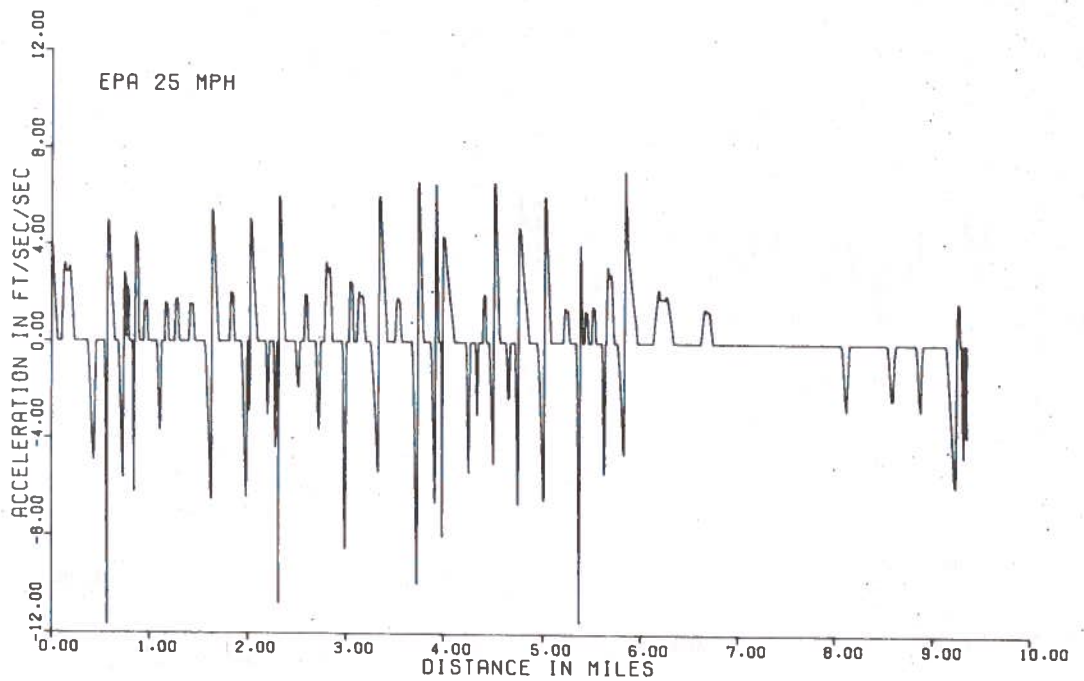


Figure D-4 EPA 25 MPH Average Speed Driving Schedule, Acceleration-Distance Profile

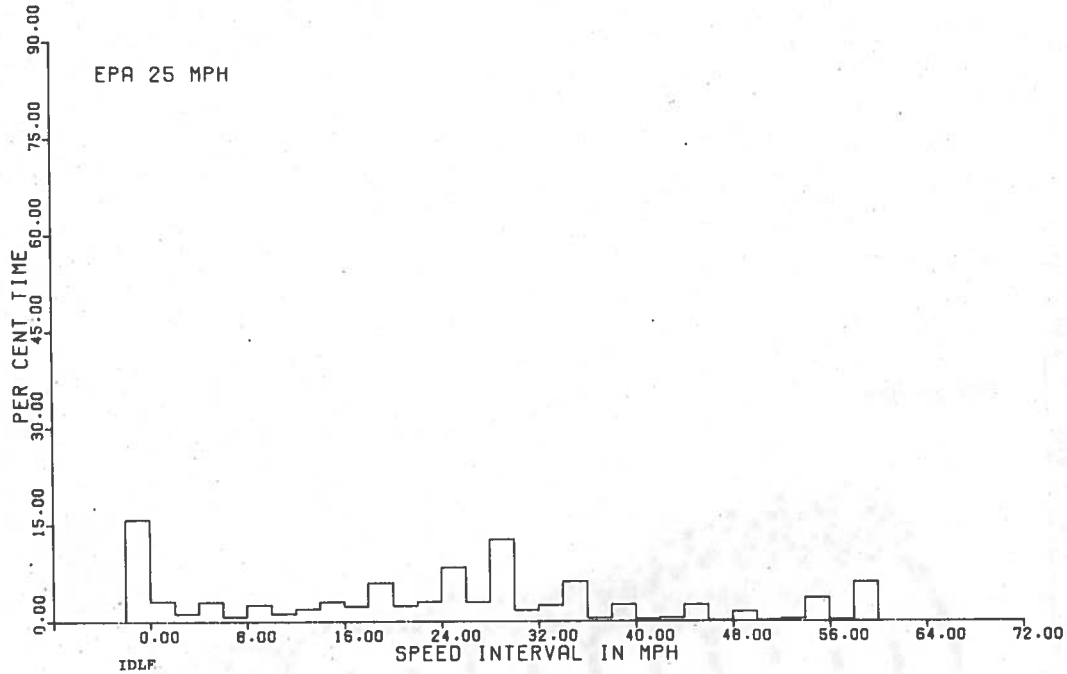


Figure D-5 EPA 25 MPH Average Speed Driving Schedule, Percent Time-Speed Interval Profile

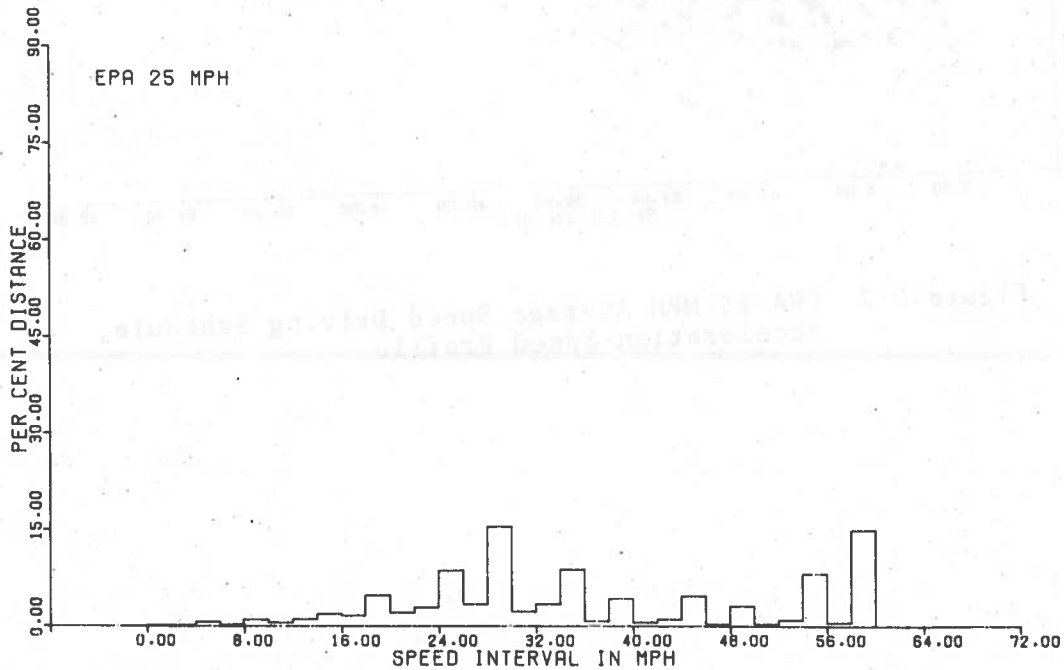


Figure D-6 EPA 25 MPH Average Speed Driving Schedule, Percent Distance-Speed Interval Profile

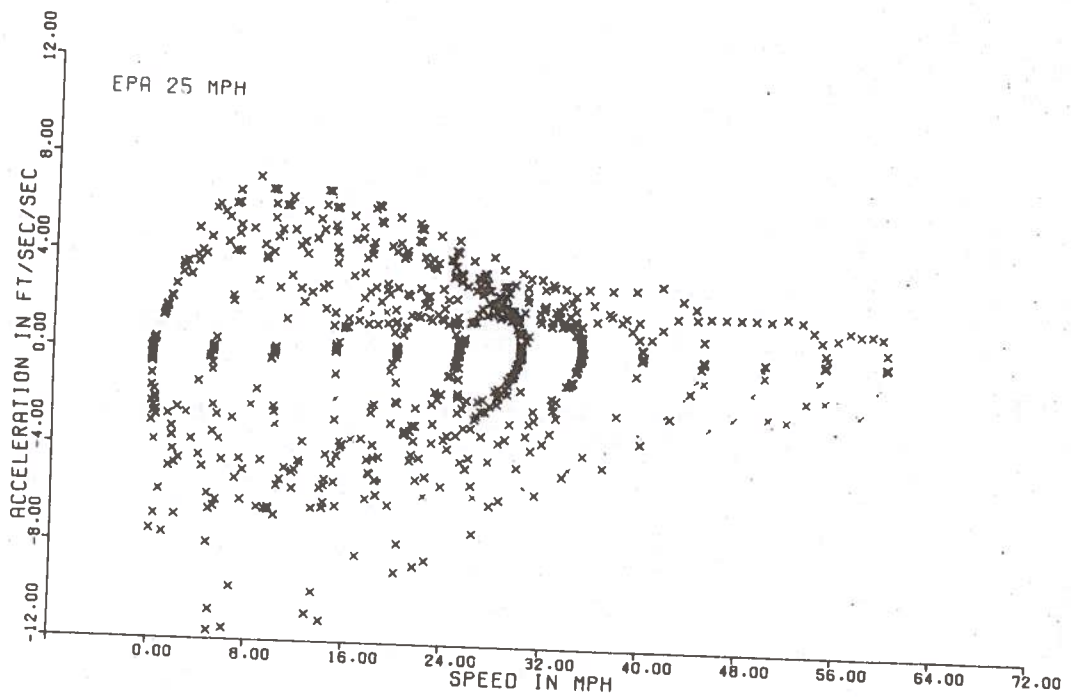


Figure D-7 EPA 25 MPH Average Speed Driving Schedule, Acceleration-Speed Profile

D.2.2.2 Discussion - This schedule incorporates a semistylized speed-time trace. The manner of presentation is similar to the EPA urban and highway driving schedules. That is, for each time interval there is a corresponding speed. This presentation therefore leads to better reproducibility on the dynamometer as opposed to track testing. However, the probability of error (if track tested) would be less than the continuously-varying, speed profiles of the EPA urban or highway schedules. Characteristic profiles for the EPA 25 MPH average Speed Driving Schedule are shown in Figures D-1 through D-7.

D.2.3 The EPA 35 MPH Average Driving Schedule

D.2.3.1 Description - The EPA 35 MPH average driving schedule is also a semistylized drive schedule that can be used for testing a vehicle on a dynamometer. It is used on vehicles that are tested for a cold-start condition as well as a hot-start condition.

The schedule has an average speed of 34.9 MPH and a maximum speed of 60.0 MPH. It has an elapsed time of 1574 seconds with the vehicle traveling a distance of 15.2 miles. It has a total of eight idle periods and eight stops, with 0.5 stops per mile. The percent time and distance modes are presented in Table D-4.

TABLE D-4 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE EPA 35 MPH AVERAGE SPEED DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	6.9	54.4	21.9	16.8
% Distance		70.8	16.4	12.8

D.2.3.2 Discussion - As with the schedule discussed in Section D.2.2, this driving schedule also approximates a suburban drive

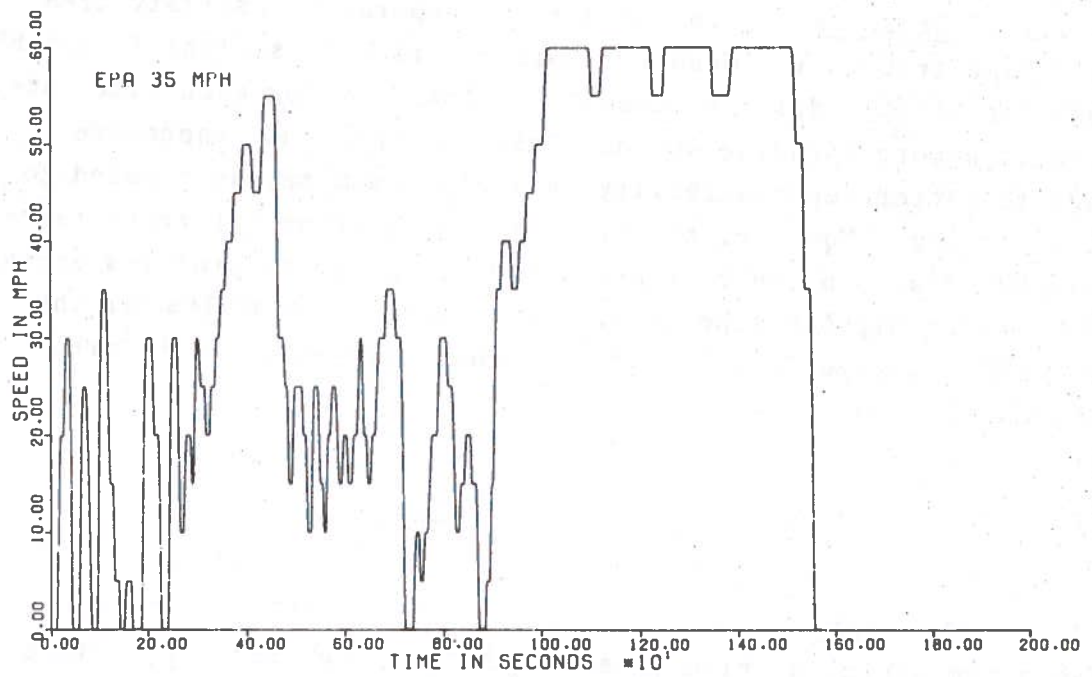


Figure D-8 EPA 35 MPH Average Speed Driving Schedule, Speed-Time Profile

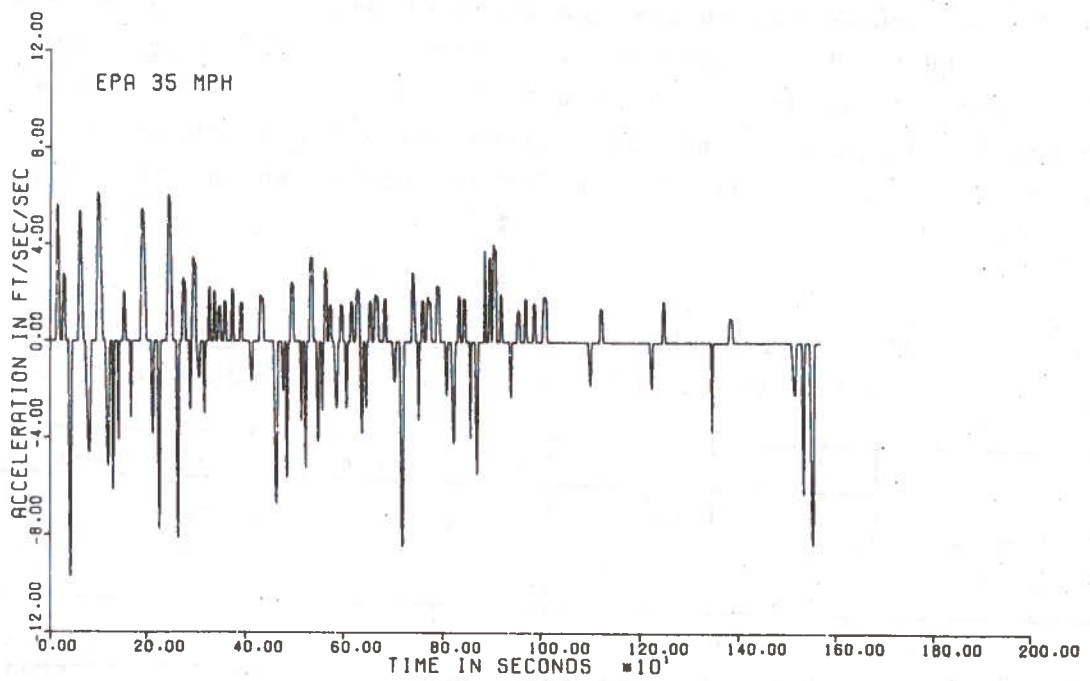


Figure D-9 EPA 35 MPH Average Speed Driving Schedule, Acceleration-Time Profile

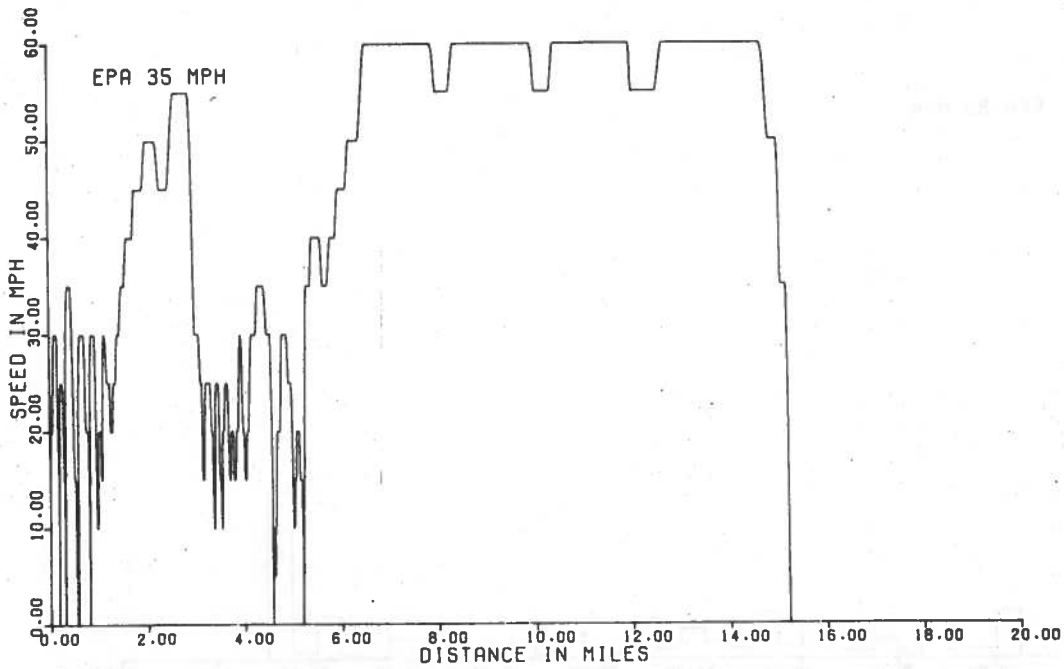


Figure D-10 EPA 35 MPH Average Speed Driving Schedule, Speed-Distance Profile

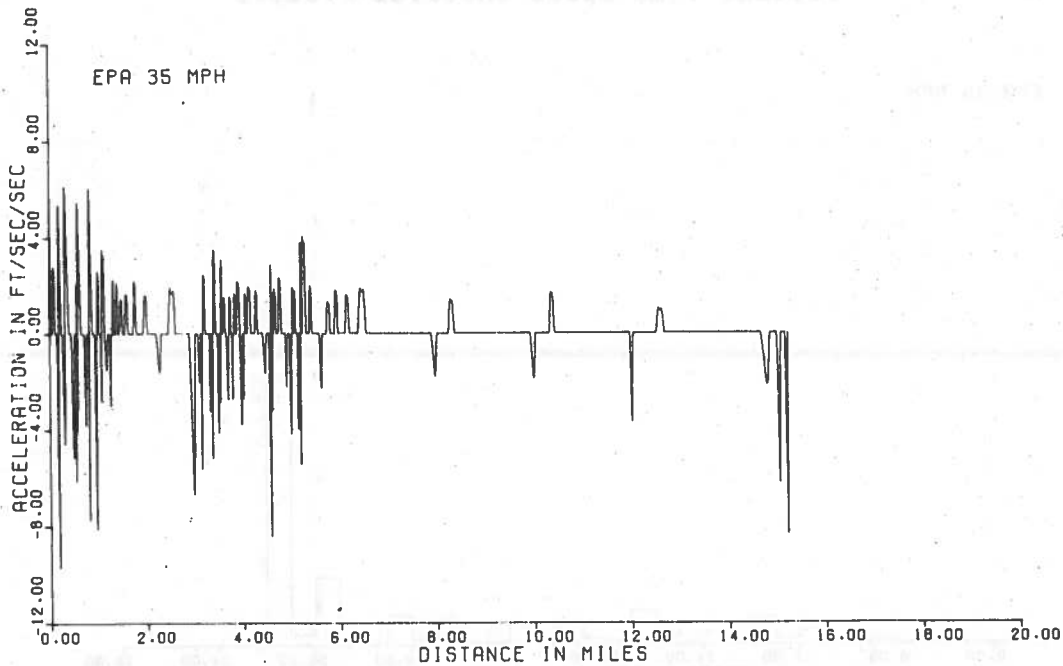


Figure D-11 EPA 35 MPH Average Speed Driving Schedule, Acceleration-Distance Profile

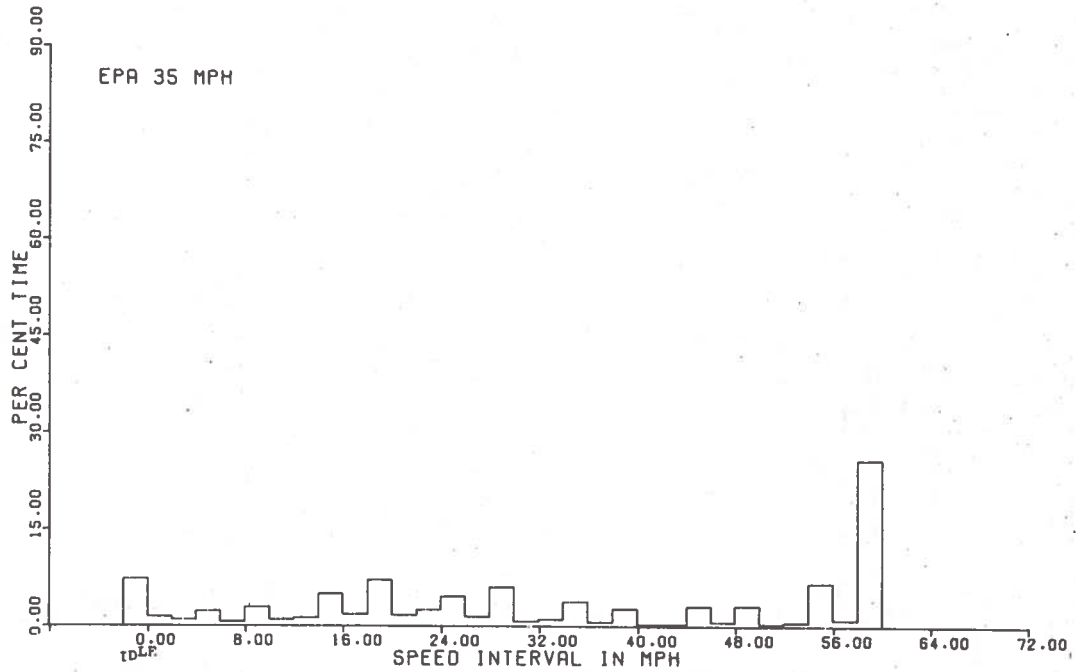


Figure D-12 EPA 35 MPH Average Speed Driving Schedule, Percent Time-Speed Interval Profile

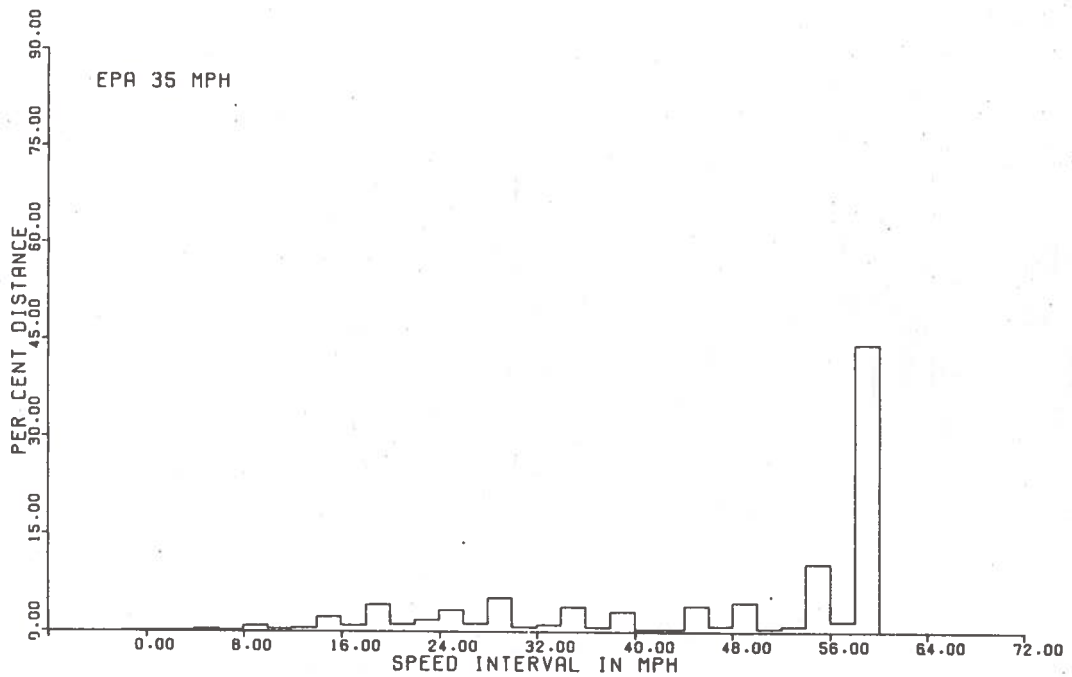


Figure D-13 EPA 35 MPH Average Speed Driving Schedule, Percent Distance-Speed Interval Profile

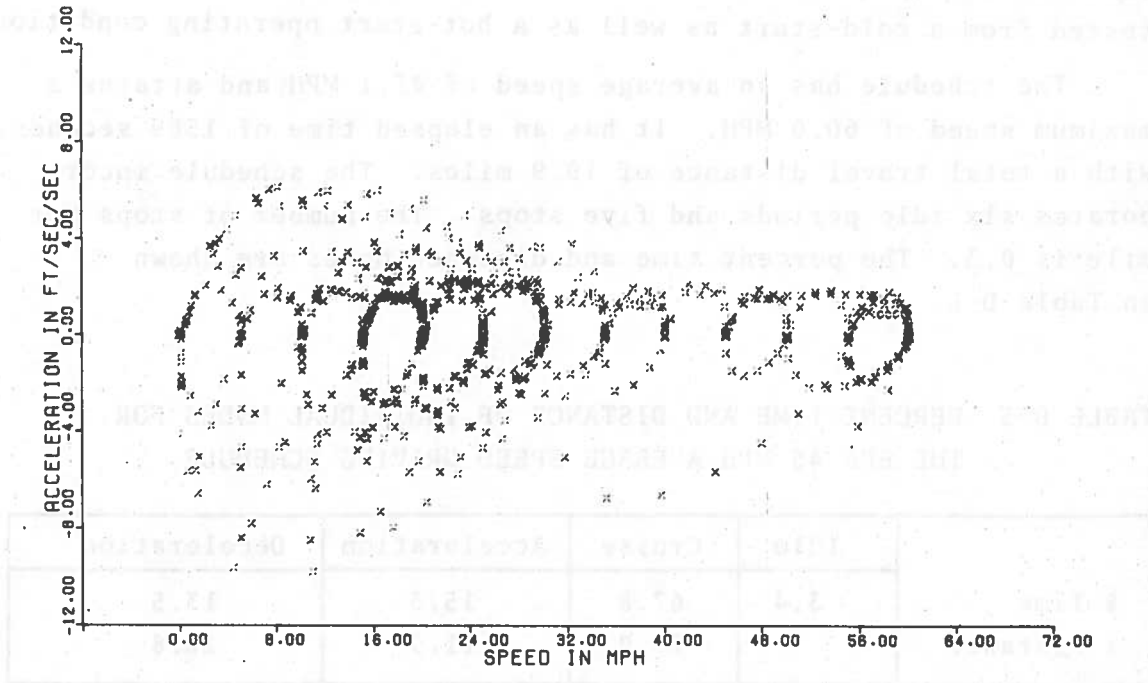


Figure D-14 EPA 35 MPH Average Speed Driving Schedule, Acceleration-Speed Profile

schedule. Characteristic profiles for the EPA 35 MPH Average Speed Driving Schedules are shown in Figures D-8 through D-14.

D.2.4 The EPA 45 MPH Average Speed Driving Schedule

D.2.4.1 Description - The EPA 45 MPH average speed driving schedule is a semistylized schedule that can be for testing a vehicle on a dynamometer. It is used on vehicles that are tested from a cold-start as well as a hot-start operating condition.

The schedule has an average speed of 45.1 MPH and attains a maximum speed of 60.0 MPH. It has an elapsed time of 1589 seconds, with a total travel distance of 19.9 miles. The schedule incorporates six idle periods and five stops. The number of stops per mile is 0.3. The percent time and distance modes are shown in Table D-5.

TABLE D-5 PERCENT TIME AND DISTANCE OF INDIVIDUAL MODES FOR THE EPA 45 MPH AVERAGE SPEED DRIVING SCHEDULE

	Idle	Cruise	Acceleration	Deceleration
% Time	3.4	67.8	15.3	13.5
% Distance		77.9	11.9	10.8

D.2.4.2 Discussion - This schedule is between a suburban and a highway/interstate driving schedule. It was not determined whether this schedule is representative of an identifiable driving pattern. Characteristic profiles for this schedule are shown in Figures D-15 through D-21.

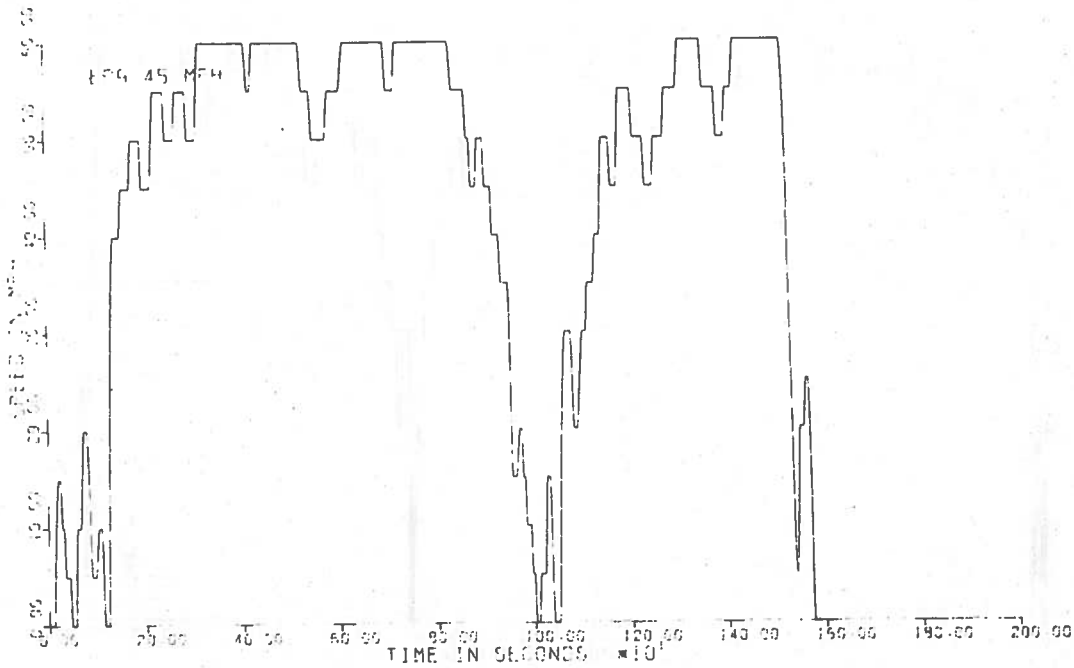


Figure D-15 EPA 45 MPH Average Speed Driving Schedule, Speed-Time Profile

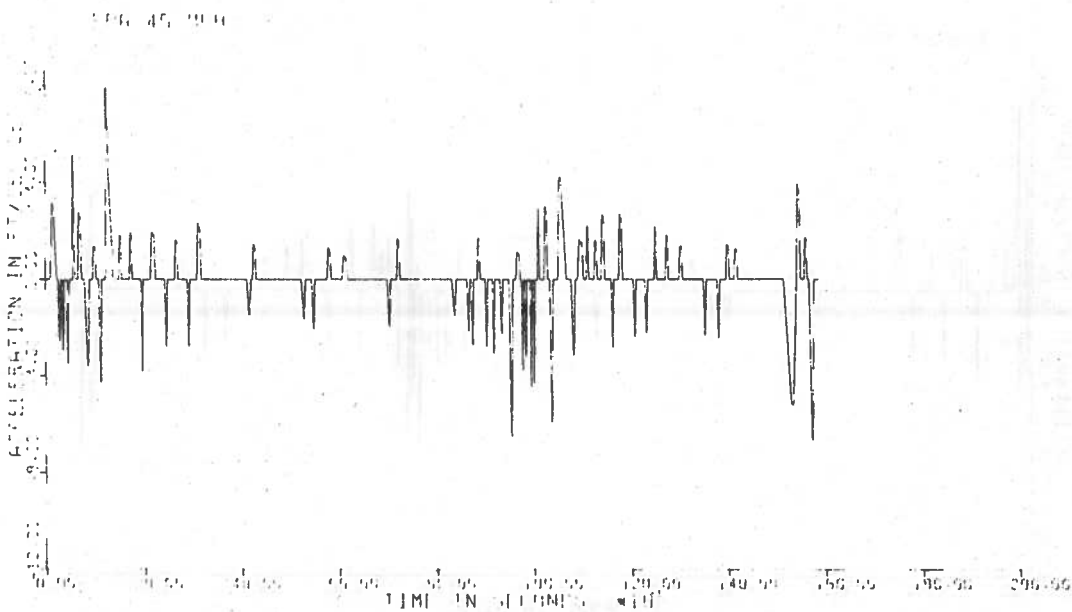


Figure D-16 EPA 45 MPH Average Speed Driving Schedule, Acceleration-Time Profile

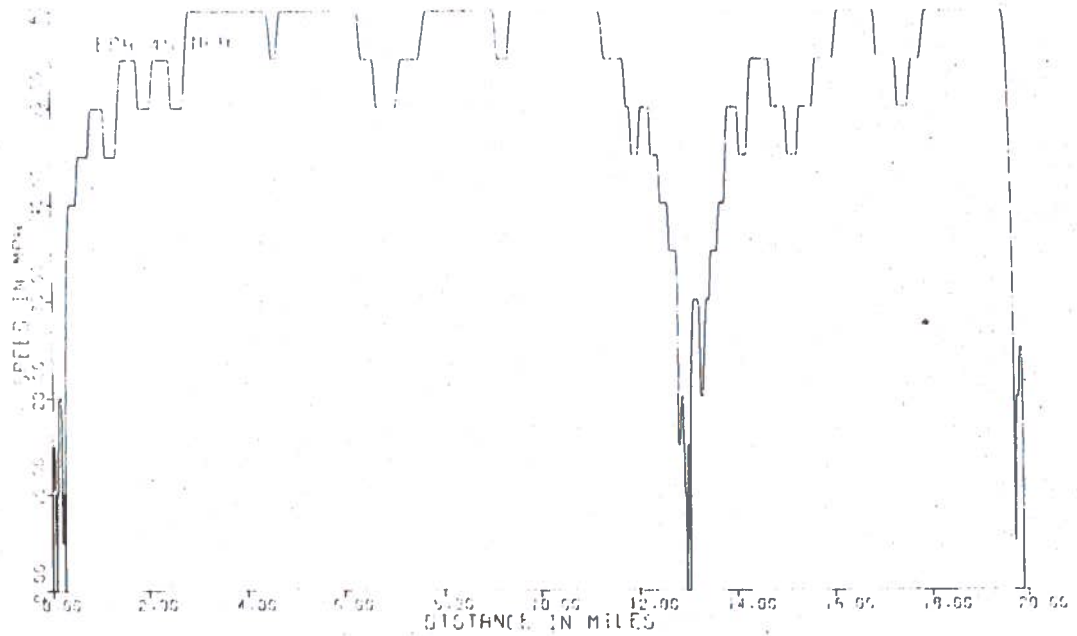


Figure D-17 EPA 45 MPH Average Speed Driving Schedule, Speed-Distance Profile

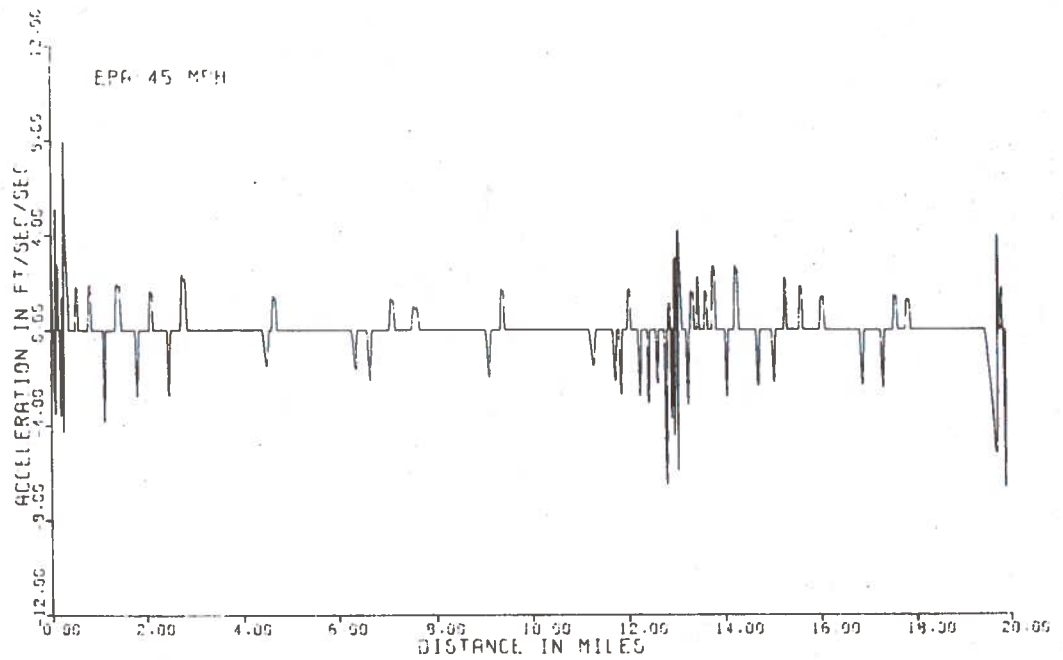


Figure D-18 EPA 45 MPH Average Speed Driving Schedule, Acceleration-Distance Profile

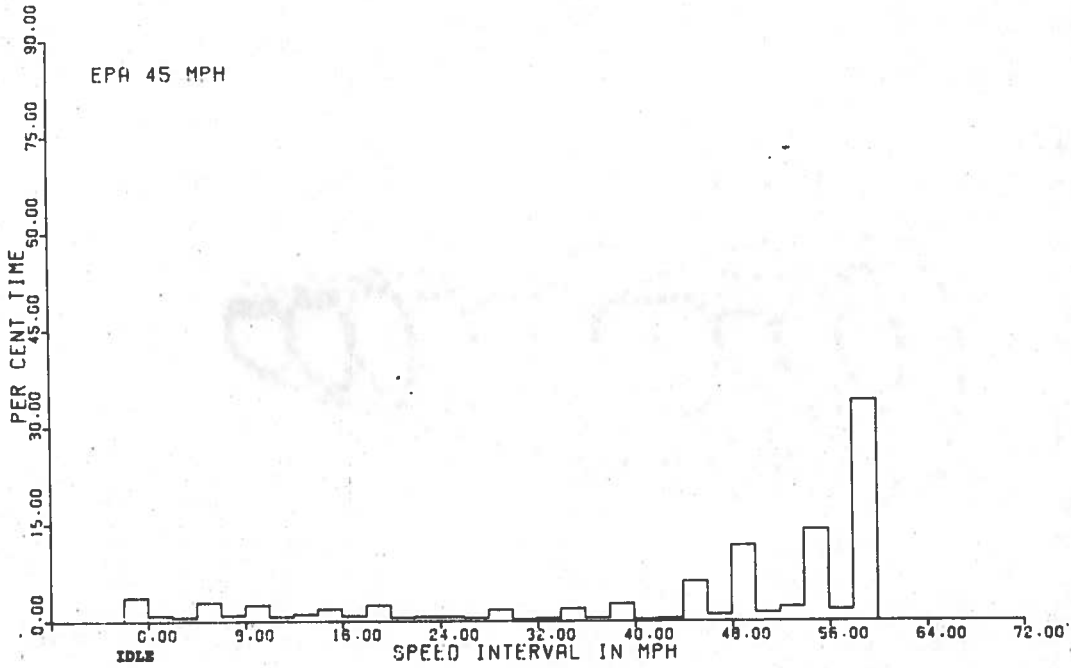


Figure D-19 EPA 45 MPH Average Speed Driving Schedule, Percent Time-Speed Interval Profile

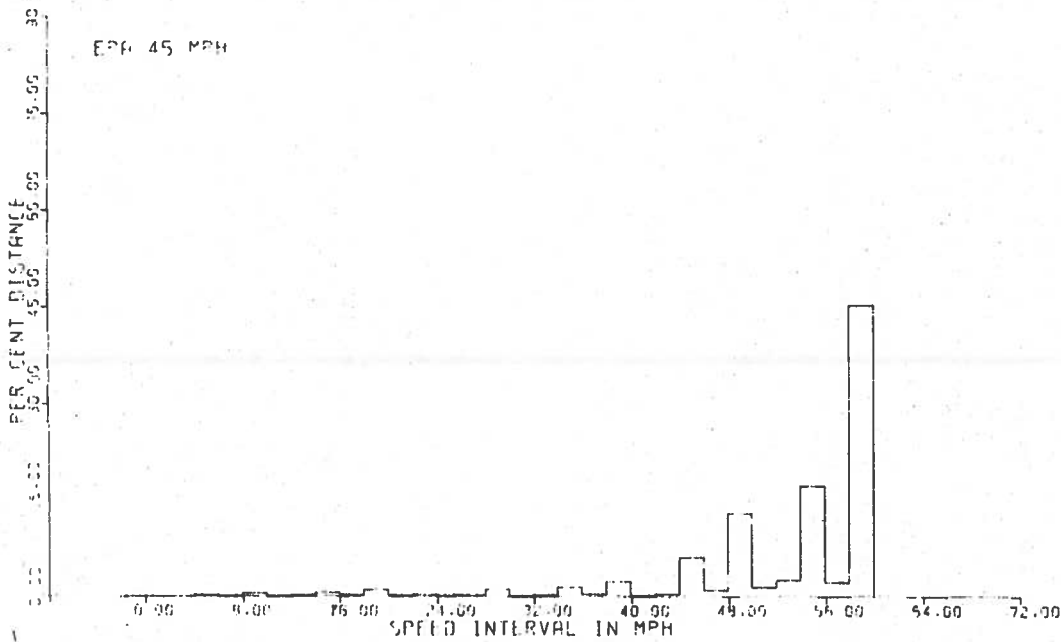


Figure D-20 EPA 45 MPH Average Speed Driving Schedule, Percent Distance-Speed Interval Profile

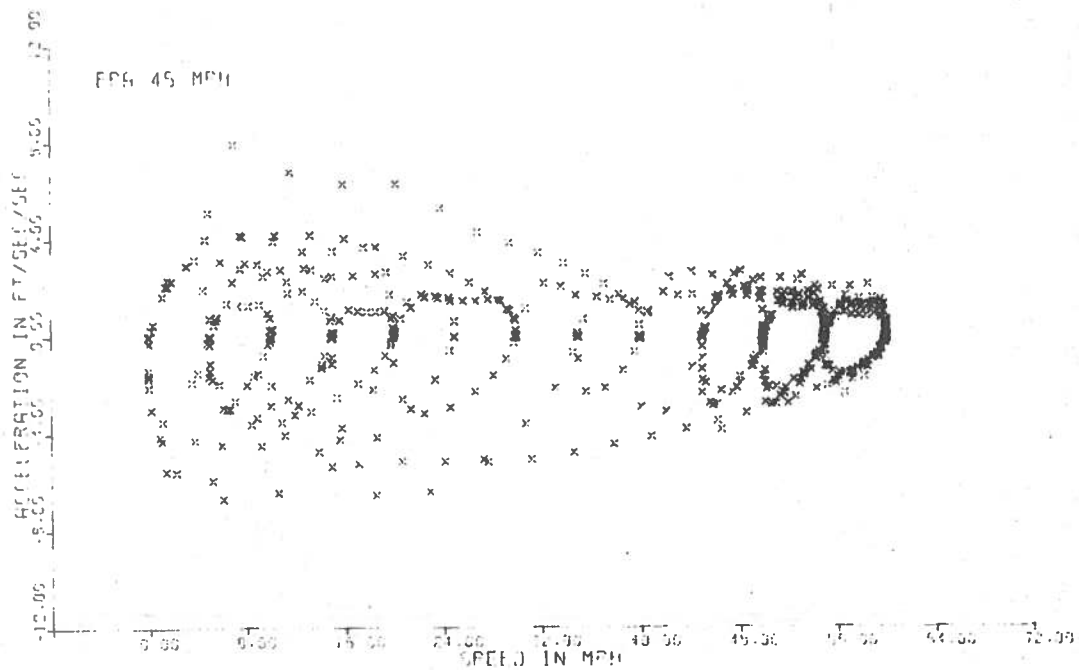


Figure D-21 EPA 45 MPH Average Speed Driving Schedule, Acceleration-Speed Profile

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