EPA-460/3-77-011
August 1977

DEVELOPMENT OF REVISED LIGHT-DUTY-VEHICLE EMISSION - AVERAGE SPEED RELATIONSHIPS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

EPA-460/3-77-011

DEVELOPMENT OF REVISED LIGHT-DUTY-VEHICLE EMISSION - AVERAGE SPEED RELATIONSHIPS

by

Malcolm Smith and Tom Aldrich

Olson Laboratories, Inc.
421 East Cerritos Ave.
Anaheim, California 92805

Contract No. 68-03-2222

EPA Project Officer: Ronald E. Kruse

Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

August 1977

This report was furnished to the Environmental Protection Agency by Olson Laboratories, Inc., 421 East Cerritos Ave., Anaheim, California 92805, in fulfillment of Contract No. 68-03-2222. The contents of this report are reproduced herein as received from Olson Laboratories, Inc. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency. Mention of company or product names is not to be considered as an endorsement by the Environmental Protection Agency.

Publication No. EPA-460/3-77-011

Foreword

Development of emission factors for use in environmental impact analysis and evaluation of emission control system performance in the in-use vehicle population depends on the ability to estimate accurately the effect of speed on vehicle emissions and fuel economy. The primary purpose of this contract was to analyze emission and fuel economy data and to establish the dependence of emission levels and fuel economy on average speed.

ABSTRACT

This report presents the results of Contract No. 68-03-2222, entitled "Development of Revised Light-Duty Vehicle Emission Average Speed Relationships." The two-fold purpose of the program was (1) to perform a statistical analysis of the GM chase-car data, and (2) to establish regressions of fuel economy and emissions on average speed over driving cycles generated from combined GM and CAPE-10 data.

Ten cycles were selected at each of 11 nominal speeds ranging from 5 mph to 55 mph. Hot-start estimates of HC, CO, NO_x (all in units of grams per mile), and fuel economy (in units of miles per gallon) over each of the cycles were obtained for each of 18 model-year groups. The emissions and fuel economy estimates were regressed on average speed to yield the desired emission-average speed relationship for each model-year group. The equations were then normalized to 19.6 mph, the average speed over the FTP cycle, to yield correction-factor equations. Groups were combined to give composite correction-factor equations for the 1975 vehicle population in low-altitude cities and for the 1974 vehicle population in high-altitude cities.

CONTENTS

FIGURES

TABLES

Section 1

SUMMARY

This report presents the results of Contract No. 68-03-2222, entitled "Development of Revised Light-Duty Vehicle Emission Average Speed Relationships." The two-fold purpose of the program was (1) to perform a statistical analysis of the GM chase-car data, and (2) to establish regressions of fuel economy and emissions on average speed over driving cycles generated from combined GM and CAPE-10 data.

The GM data were collected by following randomly-selected light-duty vehicles on a trip basis. This is, each vehicle was followed from an initial or starting point to a destination. Each such trip is called a "follow."

The CAPE-10 data were collected by Scott Research Laboratories, Inc. by driving on prescribed routes whose designs were based on vehicle-usage-pattern data obtained by Systems Development Corporation during the first phase of the CAPE-10 program. A randomly-selected vehicle was followed for approximately 2 minutes, whereupon the chase vehicle would switch to another lane, as feasible, and follow another vehicle.

An analysis of data collected by GM over Federal Highway Administration (FHWA) routes in St. Louis revealed that the 13 GM-defined road types could not be reclassified directly into the five FHWA-defined road types. A classification system was developed, however, which converted each GM road-type into one of three combined FHWA road-type classifications: Freeway, Major/Minor Arterial, and Collector/Local.

After reclassification, the GM data were edited and a statistical analysis was conducted. The data for each city were then weighted so that the percentage of miles on each road-type corresponded to the nationwide percentage of miles on each road-type as determined by the FHWA. The data were further weighted for each city to reflect 1) each city's proportion of the daily vehicle miles traveled in the 12 GM cities, as determined by the FHWA, and 2) each city's proportion of the daily vehicle miles traveled in the 12 GM cities, as determined by the EPA using a different methodology. Three representative urban driving schedules were generated from each of the two weighted data sets.

The CAPE-10 data were originally weighted by traffic density and initial-speed-versus-final-speed data matrices for each city were weighted by vehicle registration to create the composite matrices. Composite matrices suitable for the development of driving schedules were available for freeway and nonfreeway operation, but no further break out of road type was possible without reprocessing the CAPE-10 data. The existing matrices were used, so the CAPE-10 data were not weighted by road-type.

The EPA-weighted GM data were then combined with the CAPE-10 data and used to generate driving cycles with average speeds ranging from approximately

5 mph to 55 mph in increments of 5 mph. Statistical filtering of cycle statistics was used to select ten cycles at each of the 11 nominal speeds. Hot-start estimates of HC, CO, NO_x (all in units of grams per mile), and fuel economy (in units of miles per gallon) over each of the cycles were obtained with an EPA-supplied program for each of 18 model-year groups. The emissions and fuel economy estimates were regressed on average speed to yield the desired emission-average speed relationship for each model-year group. The equations were then normalized to 19.6 mph, the average speed over the FTP cycle, to yield correction-factor equations. After normalization, the groups were combined to give a composite correction-factor equation for the 1975 vehicle population in low-altitude cities and a composite correction-factor equation for the 1974 vehicle population in high-altitude cities.

The regression analysis resulted in best expressing the natural logarithm of HC (and CO) as a fifth-order polynomial of average speed. The NO_x and fuel economy data, however, were best fit with ordinary fourth-order polynomials of average speed. In all cases, the standard error of the estimate was small, indicating excellent fits.

The objectives of the program were thus successfully satisfied with a valid methodology which provided reliable relationships between emissions and fuel economy and average speed. The development of these emission factors provides a useful tool for those analyzing the environmental impact of various mixes of light-duty vehicles.

Section 2

INTRODUCTION

This section states the objectives of the Emissions-Average Speed project, relates some of the background information pertinent to the project, and presents the basic scope of operations.

2.1 PROGRAM OBJECTIVES

The two-fold objective of the Emissions-Average Speed project was: 1) to analyze the GM chase-car data, and 2) to determine coefficients for computing emissions and fuel economy as a function of average speed, using combined CAPE-10 and GM chase-car data. The following tasks were implemented to meet this objective:

1. GM road types were reclassified into FHWA road types.

2. GM data were statistically analyzed to determine the percentages of miles on combined FHWA road types.

   Some of the other statistics included in the analysis were as follows:

   - Percentage of miles and time in each GM-defined traffic density.
   - Percentage of miles and time on each FHWA combined road type.
   - Average speed in each GM-defined traffic density.
   - Average speed on each FHWA combined road type.
   - Stops per mile on each FHWA combined road type.
   - Average number of trips on each FHWA combined road type.

   Those statistics were collected for each of the 12 GM cities in addition to overall urban data, rural data, and other data samples of interest. Additional summary statistics such as average trip length, average trip duration, and average speed were determined for each of the 12 GM cities as well as for the other data samples of interest.

3. Using the results of the statistical analysis and actual nationwide mileage on FHWA road types, the data were weighted by road type.

4. Weighted GM data matrices of initial speed versus final speed were combined with the CAPE-10 data matrices of initial speed versus final speed to generate driving cycles. Warmed-up emissions and fuel economy were estimated over the cycles.

5. Hot-start emissions and fuel economy estimates were regressed on average speed to yield coefficients for each model-year group. These were normalized to 19.6 mph, the average speed over the FTP cycle.

6. Composite equations relating emissions and fuel economy, normalized to 19.6 mph, were derived for low-altitude and for high-altitude cities.

2.2 BACKGROUND INFORMATION

The GM chase-car survey included data from the 12 cities below:

San Francisco
Los Angeles
San Diego
Phoenix
Salt Lake City
Denver
St. Louis
Chicago
Detroit
Atlanta
Washington
Newark/New York

It was required that the GM data reflect the same percentage of miles on a given road type in a given city as that determined by the FHWA. To determine the percentage of the GM data on each of the FHWA-defined road routes, a means of reclassifying the GM-defined road types into FHWA-defined road types was required.

A basis for accomplishing the reclassification was provided when GM sent a chase-car to St. Louis to drive on routes designed by the FHWA. The road-type data were recorded using the GM system of identification. Maps were provided by the EPA on which each section of road for each route was identified by its FHWA-defined road type. It was thus possible to compare how GM and the FHWA classified each section of road. A road-type reclassification scheme was developed from the comparison analysis.

The CAPE-10 data were collected on preselected road routes. The selection of these road routes was based upon data collected in the first phase of the CAPE-10 program. The first phase was conducted by the System Development Corporation. They performed surveys in the urban areas of Los Angeles, Houston, Cincinnati, Chicago, New York, and Minneapolis-St. Paul, to determine vehicle-usage patterns. These data were used in the second phase of the program, conducted by Scott Research Laboratories, Inc. (SRL), to design driving survey routes and to collect data in Houston, Cincinnati, Chicago, New York, and Los Angeles.

The chase-car technique employed by SRL involved emulating the driving behavior of vehicles on each route by following a car for about 2 minutes and switching to another car in a different lane when possible. The data collected within each city in this manner were weighted by traffic density. Mode-frequency and time-in-mode matrices in an initial-speed-versus-final-speed format were developed for each city. Composite data matrices were obtained from the city matrices by weighting each according to the number of vehicles registered in that urban area.

Using combined GM and CAPE-10 data matrices, a large number of cycles was generated over a range of average speeds. Warmed-up emissions and fuel economy were estimated for each of the 110 best cycles for each of 18 vehicle groups. The emission-estimating program was supplied by the EPA. Equations utilized to generate emissions were determined by the Calspan Corporation. The emissions, in grams/mile, estimated by the program are not current; they are based on data up to 4 years old. This does not prevent their use, however, as inputs to a normalizing process or for comparative purposes.

2.3 SCOPE OF EFFORT

The three phases of the Emissions-Average Speed program were:

Phase I Special statistical tasks.
Phase II Statistical processing and weighting of GM data.
Phase III Generation of revised emission-average speed relationships.

The first phase was comprised of the following topics of special interest during the performance of the contract.

1. Additional analysis of the FHWA road routes in St. Louis to determine usefulness of speed limit and number of lanes in the reclassification of GM road types.

2. An error analysis to determine the nature and extent of errors on the GM tapes requiring editing.

3. Statistical analysis of the Federal Highway Cycle.

4. Determination of trip-length distribution for the full trips in the GM chase-car data set.

The second-phase tasks were:

1. Analysis of the Federal urban test cycle.

2. Editing of the GM chase-car data set.

3. Statistical analysis of the GM chase-car data set and FHWA road routes.

4. Weighting the GM chase-car data set.

5. Statistical analysis of the weighted GM chase-car data.

6. Generation of driving cycles from the weighted GM chase-car data.

7. Statistical analysis of the rural data collected in GM's chase-car study.

8. Generation of rural cycles from the GM rural data.

The third-phase tasks were:

1. Combining the weighted GM data with the CAPE-10 data.

2. Generation of cycles over a range of average speeds.

3. Estimation of emissions and fuel economy over these cycles.

4. Determination of the relationships between emissions and fuel economy and average speed.

5. Plotting regressions to determine adequacy of fit.

6. Normalization of regressions to obtain speed correction factor equations yielding the value 1.0 at 19.6 mph.

7. Combining group results to yield composite normalized equations for low-altitude, calendar year 1975, and high-altitude, calendar year 1974, cities.

Section 3

DESCRIPTION OF GM CHASE-CAR DATA ANALYSIS

This section describes the methodology utilized for GM data editing, GM data analysis, and cycle generation.

3.1 GM CHASE-CAR DATA DESCRIPTION

A complete list of the 35 data variables of interest to GM in the conduct of their chase-car data collection effort is shown in Table 3-1. Each such set of variables collected at an instant of time appears on the data tapes as one record. The data were collected at a sampling rate of one record per second. The position within the record occupied by a given variable is called a field.

Various fields monitored by GM were of interest in the statistical analysis of the chase-car data set. Time fields were utilized in the analysis of FHWA routes driven by GM in St. Louis and in the statistical computations. Speed limit and number of lanes were incorporated into the analysis of FHWA routes in St. Louis. Road type, traffic density, and location were key variables in the statistical analysis. The bit codes used by GM are shown in Table 3-2.

3.2 EDITING

As road-type, traffic density, location, time, and speed were of key significance in the analysis of the GM data, it was imperative that the recorded values be correct. The data editing consisted of first determining the nature and extent of errors, and second, determining the optimum means of correcting the errors.

3.2.1 Nature and Extent of Data Errors

The initial task in the generation of record-by-record statistics was the reclassification of each GM road type on tape to an FHWA road type. Road-type occurrences* of only a few seconds duration were usually noted when the road type changed. That resulted from the time required to reset thumbwheel switches. To remove these intermediate and false road types, all road-type occurrences that did not last for five or more records were converted to the next road type unless that road type was either out of range (an inadmissible value) or a new follow was encountered. When a road type was found to be out of range, the next ten records were searched for a new road type. When a new road type was found, the out-of-range values were converted to the new value. If a new follow were encountered before a new road type was found, the out-of-range

*A road-type occurrence consists of the sequence of records when one road-type changes to the next road-type.

Table 3-1. CHASE FILTER LIST
AND VARIABLE LIST

NUMBER	NAME
1	Day
2	Hour
3	Minute
4	Second
5	Speed
6	Temperature
7	Fuel Rate
8	Turn Signal
9	Brake Lights
10	Vehicle Type
11	Traffic Density
12	Sex
13	Traffic Location
14	Speed Limit
15	Weather
16	Night/Day
17	Test Vehicle Identification
18	Test Vehicle Driver
19	Number of People in Car
20	Follow Mode
21	Terrain
22	General Location
23	Road Type
24	Population Density
25	Number of Lanes
26	Operate/Stand By
27	Acceleration
28	Selection Bias
29	Spare
30	High/Low Power
31	Age
32	Hill/No Hill
33	Up Hill/Down Hill
34	GM/Non-GM
35	Follow Number

Table 3-2. BIT CODES

Vehicle Type: 3 bits	
Subcompact	0
Compact	1
Sports Car	2
Intermediate	3
Standard	4
Luxury	5
Vans	6
Trucks	7
Position in Traffic: 2 bits	
Leading	0
Surrounded - Moving w/Traffic	1
Surrounded - Aggressive	2
Trailing	3
Speed Limit: 4 bits	
15 mph	0
20 mph	1
25 mph	2
30 mph	3
35 mph	4
40 mph	5
45 mph	6
50 mph	7
55 mph	8
60 mph	9
65 mph	10
70 mph	11
55/60 mph	12
55/65 mph	13
55/70 mph	14
55/75 mph	15
Weather (Road Condition): 3 bits	
Wet	0
Dry	1
Raining - Light	2
Raining - Heavy	3
Snowing - Light	4
Snowing - Heavy	5
Foggy	6
Icy	7

Table 3-2. BIT CODES (Continued)

Test Vehicle ID: 2 bits	
1	0
2	1
3	2
4	3
Driver Code: 3 bits	
1	0
2	1
3	2
4	3
5	4
6	5
7	6
8	7
Number of People in Car: 3 bits	
1	0
2	1
3	2
4	3
5	4
6	5
7	6
8 or more	7
Follow Mode: 2 bits	
Void	0
Flow with Traffic	1
Full Trip	2
Partial Trip	3
Terrain: 3 bits	
Level	0
Rolling	1
Hilly	2
Mountainous	3
Road Type: 4 bits	
Unpaved - Rural	0
Unpaved - Suburban	1

Table 3-2. BIT CODES (Continued)

Road Type: 4 bits (Continued)	
Rural Highway	2
Suburban - No Curb	3
Suburban - Curb	4
Suburban - Shopping Center	5
Suburban - Artery	6
Urban	7
Urban - Artery	8
Central Business District - Parking	9
Central Business District - No Parking	10
Strip - Commercialism	11
Expressway - Business Route	12
Expressway	13
Population Density: 3 bits	
Urban - Heavy	0
Urban - Light	1
Industrial Vicinity	2
Suburban - Heavy	3
Suburban - Light	4
Rural	5
Boonies	6
Number of Lanes: 3 bits	
1	0
1.5	1
2	2
2.5	3
3	4
4	5
5	6
6 or more	7
Spare Toggles: 8 bits	
Bit No.	
0	1 GM
	0 Non-GM
1	1 Up Hill
	0 Down Hill
2	1 No Hill
	0 Hill
3	00 0-24
	01 24-34
4	10 35-54
	11 55 & over

Table 3-2. BIT CODES (Continued)

Spare Toggles: 8 bits (Continued)	
Bit No.	
5	0 High power 1 Normal
6	1 Biased 0 Nonbiased
7	Spare
Traffic Density: 3 bits	
None	0
Light - Not Influenced	1
Light - Influenced	2
Medium - Not Influenced	3
Medium - Influenced	4
Heavy - Not Influenced	5
Heavy - Influenced	6
Heavy - Stop and Go	7
Sex	
Male	0
Female	1
Operate/Standby	
Standby	0
Operate	1
Night or Day	
Night	0
Day	1
Turn Signals	
Not Used	0
Right	1
Left	2
Straight	3
Brake Lights	
On	0
Off	1

values were converted to the previous road type. If a road-type occurrence of less than five records finished a follow, then the road type for those records was converted to the previous road type value. Traffic density exhibited intermediate and out-of-range traffic densities in the same manner as the road type. GM location codes also exhibited intermediate values. Since location was a key parameter in the statistical analysis, intermediate location values were edited.

Time problems were noted as well, arising from:

1) A value of 99 (placed by GM to indicate an error) noted in the fields of hours, minutes, or seconds.

2) Spurious values of day lasting for only a few records.

3) A reversal in a time field; i.e., a time value being less than the previous time value.

In addition, nonnumeric characters were found in the fields not of interest. Because of the potential impact of errors in the key variables, it was decided to map these errors to determine their nature, location, and extent. An assembler program was written to map the location, extent, and nature of the time reversals, intermediate location values, and records where special characters appeared. Fields with invalid characters were changed to -9. The number of records with errors in fields of interest and the number of errors in fields not of interest were counted. This was required because the extent of the editing effort would depend not only on the number of invalid characters, but also the number of records with invalid characters. In addition, the time reversals, the day errors, and the location errors were mapped. The time reversals distort computations of mileage, average speed, stops per mile, and average trip length. The intermediate location errors would result in premature follow termination.

Fortunately, no invalid characters occurred in the fields of interest. The number of time reversals and day changes within a follow (71 time reversals and 46 changes) led to a decision to edit the time fields. The number of intermediate location errors (61), and their effect on the program logic which terminated a follow when the location changed, necessitated editing the location values. Editing was accomplished, then, for the time fields, location, road type, and traffic density.

3.2.2 Editing Procedures

The editing procedures are summarized below for each field:

1) Day - Follows that contained a day change were reclassified, but the data were not included in the statistical analysis.

2) Time (Hours, Minutes, Seconds) - The hours, minutes, and seconds fields were used to calculate the time in seconds for each record. This time in seconds was compared to the previous record's time in seconds to determine if a time reversal had occurred; i.e., if the previous record's time were greater than the current record's time. If a time reversal had occurred on the current record, then the

current record's time, in seconds, was changed to the previous record's time, in seconds, plus one. The occurrence of a time reversal also put the program into a time-generating mode. Each succeeding record's time was set to the previous record's time plus one. The time-generating process continued until the generated time for a given record coincided with the time read from tape for the record. When GM found an error, a 99 was written in the corresponding field. Where a 99 was encountered during editing, it was changed to a time consistent with the preceding and following record times.

The example shown in Table 3-3 shows a 99 in the seconds field of the third record. This 99 is thus converted to a 32, corresponding to the previous record time, plus 1. On the fourth record, a time reversal occurs; i.e., 28 is less than 32. The fourth record's time is thus set to the third record's time plus one.

Table 3-3. ORIGINAL AND EDITED TIME FIELDS

	ORIGINAL			EDITED		
RECORD	Hrs.	Min.	Sec.	Hrs.	Min.	Sec.
1	10	15	30	10	15	30
2	10	15	31	10	15	31
3	10	15	99	10	15	32
4	10	15	28	10	15	33
5	10	15	29	10	15	34
6	10	15	30	10	15	35
7	10	15	36	10	15	36

This time generation continues until the seventh record, where the generated time coincides with the time appearing on tape.

3) Road Type - All road types not lasting for five or more records were converted to the next road type, unless that road type was out of range or a new follow was encountered. If a new follow were encountered, the intermediate road type was converted to the previous road type.

   Out-of-range road types were converted to the next road type, unless a new follow was encountered in the next ten records. In that event, the follow was reclassified, but the data were not included in the statistical analysis.

4) Traffic Density - This was handled in the same way as road type.

5) Location - Whenever a location value lasted for less than 10 seconds, it was converted to the next location.

All follows were checked to see if they were biased (duplicate data), as flagged on tape by GM. Biased data were skipped in the processing. They were not statistically analyzed nor were they reclassified.

The follow mode was determined from the first record of every follow. The follow mode was indicated by GM in subsequent processing as void, flowing with traffic, full, or partial. Follows that were indicated as void or as flowing with traffic were not included in the statistical analysis. They were, however, reclassified. Follows that were full or partial were reclassified and included in the statistical analysis. Follows were checked to see if they started in a shopping center. If no other road type were encountered, the follow was reclassified but not included in the statistical analysis.

Since much of the statistical analysis was follow-dependent, it was necessary to calculate statistics on a provisional basis while reading the follow. Once the follow was read and its type determined, the statistics would either be added into the appropriate location's statistical accumulators or zeroed out. For example, when the follow remained in a shopping center, the statistics were deleted.

Since the statistics were accumulated on the basis of location, whenever the location changed, say from a city to the rural environs, the follow was terminated. The statistics for the follow were then added into the appropriate location. The rest of the follow was treated as another follow to be added to the new location.

For full trips only, as indicated by the follow-mode switch, trip-length distributions were determined for each of the 12 GM cities for both urban and urban-rural follows. In addition, trip-length distributions outside the 12 GM cities were determined for rural follows, urban follows, and urban-rural follows.

3.3 FHWA ROUTE ANALYSIS

The data base for generation of driving cycles was to consist of GM data matrices combined with CAPE-10 data matrices. As GM data were to be weighted by road type prior to combination with the CAPE-10 data, road type assumed pivitol importance in the statistical analysis. Data had been collected by the FHWA on the percentage of daily vehicle miles traveled on each of the FHWA road types in each of the 12 GM cities. To utilize these weighting factors, however, a procedure was required to reclassify the GM road types into the following FHWA road types.

- Freeway
- Major arterial
- Minor arterial
- Collector
- Local

GM drove preselected FHWA road routes in St. Louis, measuring the same driving parameters as measured in their chase-car study. These data, along with trip logs and route maps, were utilized to prepare a contingency, or frequency of occurrence, table of GM road types versus FHWA road types.

3.3.1 Initial Contingency Table

Trips logs of the FHWA routes contained length, in miles, of each street segment on each route and could thus be used to determine how far each street

segment was from the start of the route. The FHWA road type for each street segment was determined from maps of the road routes. Figure 3-1 shows a section of one such map. Roads that did not appear on the map would be classified as local. Table 3-4 shows a trip log with mileages for the initial segments of St. Louis Route 7, Table 3-5 shows a trip log with the clock times noted for various segments of Route 7, and Table 3-6 shows a dump of the GM data collected on the initial segment of Route 7, with the clock time which appeared on the tape and the cumulative mileage from trip start.

The mileage computed from the FHWA road route data was determined as follows:

$$M_i = M_{i-1} + \frac{(S_i + S_{i-1})(t_i - t_{i-1})}{72000^*},$$

*Speed on tape was in tenths of miles per hour.

where:

M_i : Cumulative miles traveled from trip start for current record.

M_{i-1}: Cumulative miles traveled from trip start for previous record.

S_i : Speed for current record.

S_{i-1}: Speed for previous record.

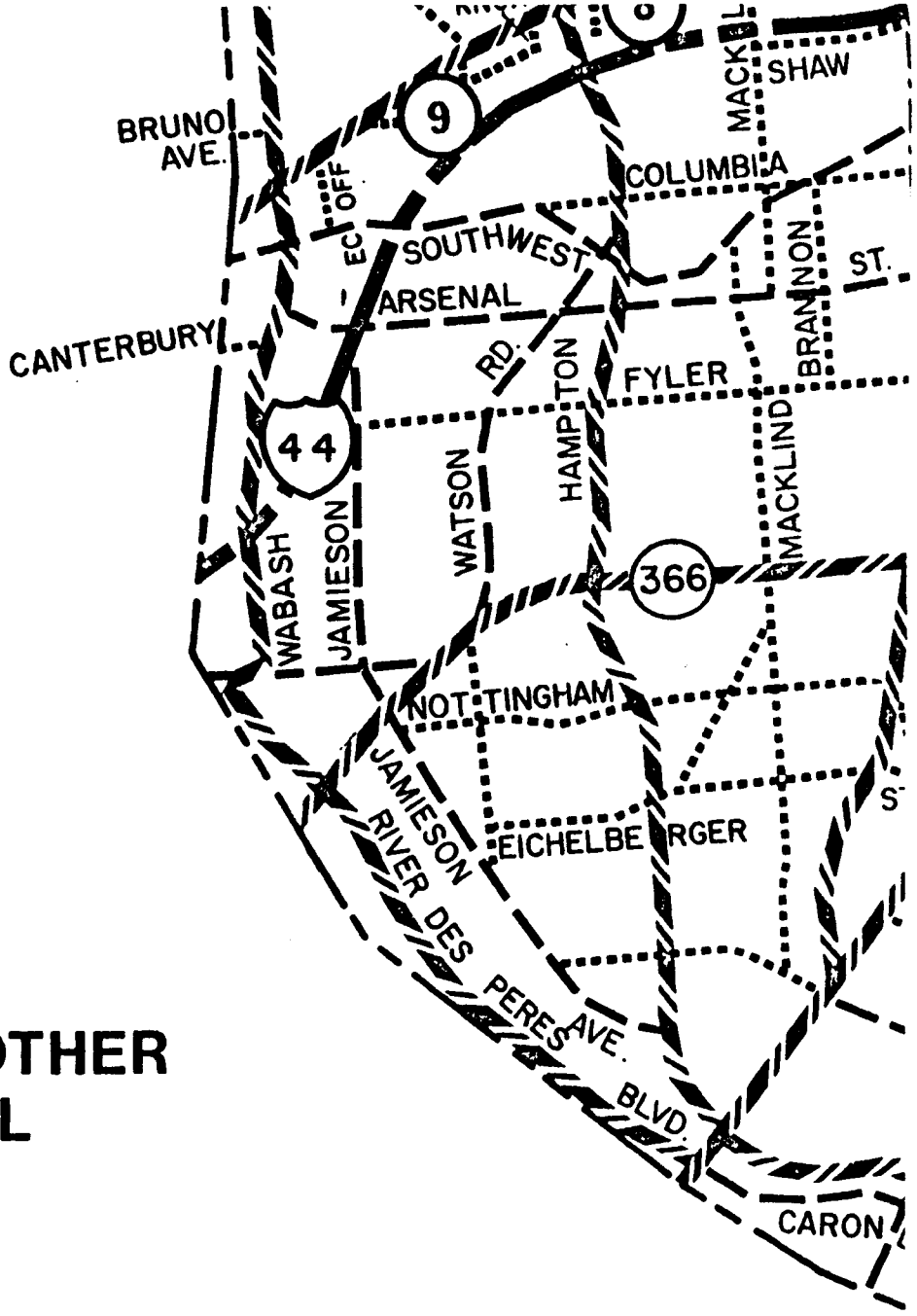
t_i : Time in seconds for current record.

t_{i-1}: Time in seconds for previous record.

The trip logs of the FHWA routes were used to establish how far each street segment was from the start of the route and to determine the clock time for the start of each street segment. The maps were used to determine the FHWA road type for each street segment. Dumps of the GM data were used to determine the length of each street segment, the distance of each segment from the start of the route, the clock time for the start of each segment, and the GM road type for each segment. In the case where the length of a given road segment appearing in the log did not match the length determined from the tape, and where clock time did not appear on the log, drops in vehicle speed were utilized to determine where the vehicle turned from one road segment to another.

For each street segment, the GM-defined road type and the FHWA-defined road type provided an entry into the appropriate cell of a contingency table. This initial contingency table, Table 3-7 (where each entry is a frequency of occurrence), did not provide an adequate basis for reclassification due to error rates as high as 54 percent (GM Road Type 9).

Figure 3-1. SECTION OF ST. LOUIS MAP



LEGEND

- FREEWAY
- EXPRESSWAY AND OTHER PRINCIPAL ARTERIAL
- MINOR ARTERIAL
- COLLECTOR

Table 3-4. SPEED CHARACTERISTICS STUDY TRIP LOG
(Route-Trip Number 7)

SEGMENT-SECTION NUMBER	STREET/ROAD NUMBER/ TURN INSTRUCTIONS	LENGTH MILES	TERMINAL DESCRIPTION
010	I-55		Gravios Avenue
011	I-55	5.50	Germania Avenue
012	I-55	.40	Weber Road Exit
020	I-55	2.40	Exit to Reavis Barracks Road
030	Exit ramp & left turn	.10	Reavis Barracks Road
031	Reavis Barracks Road	.10	Union Road
040	Right turn	.05	Union Road
041	Union Road	.35	Green Park Road
042	Union Road	.20	Senator Court
050	Union Road	1.40	Lindbergh (U.S. 61)
060	Right turn	.05	Lindbergh (U.S. 61)
061	Lindbergh (U.S. 61)	1.25	Mueller Road
062	Lindbergh (U.S. 61)	.30	Lin-Ferry Road
070	Lindbergh (U.S. 61)	.10	Tesson-Ferry Road
080	Left Turn	.05	Tesson-Ferry Road
081	Tesson-Ferry Road	.65	E. Concord Road
082	Tesson-Ferry Road	.30	Carolynne Drive

Table 3-5. TRIP LOG BY SEGMENT

TIME	SEGMENT	COMMENTS
0954:49	010	INITIATE I-55SB at Gravois
0958:49		Bates Street
1002:58	020	Exit I-55 for Reavis Bks.
1003:13		Enter Reavis Bks. Road
1003:33	040	Right turn to Union
1006:40	060	Right turn to Lindberg
1010:35		Stop light before turn to Tesson Ferry
1011:18	090	Enter Tesson Ferry Road
1013:12	100	I-244NB Entrance Ramp
1013:33	110	Enter I-244 NB
1015:04	120	Exit Ramp from I-244
1016:20	130	MO 30
1018:56		Merimac River
1020:55		Jefferson County Line
1023:11	150	New Sugar Creek Road
1026:00	160	Enter Hawkins
1026:47		Flagman Stopping traffic
1027:39	170	Vandover
1030:00		Cross I-44
1031:06		Valley Park City Limits/ Merimac River
1032:00		1st road sign of MO-141
1034:38		Big Bend Boulevard (slow farm vehicle with 5 or 6 cars behind)
1036:57		Manchester city limits
1038:33		Manchester Road
1042:20		Clayton Road/H H Stop sign
1044:30	190	US-40 EB Entrance Ramp
1044:50	200	US-40 EB
1046:00		Following Porsche 911- Targa
1049:04		Frontenac city limits
1053:35		Richmond city limits
1055:21	210	Hanley Road North Exit
1100:09		Right turn to Forsyth
1101:05		Leather Bottle
1101:23		Walter Mitty's
1106:06		Left turn to Skinker
1106:48		Enter Forest Park Parkway
1109:07		Pass Union Street Exit
1110:11		Pass Kings Highway
1110:30		Traffic Counter #65
1111:11		***STOP TO CHANGE TAPE STOP***
1112:16		***RE-START CONTINUE ROUTE RE-START***
1114:17		Vandeventer
1116:03	900	END-FOREST Park Parkway and Grand

Table 3-6. DUMP OF GM DATA FOR ROUTE 7

FOLLOW 98, DAY 113

RECORD NUMBER	MILES FROM START	ROAD TYPE	TIME	SPEED	TRAFFIC DENSITY	SPEED LIMIT	NUMBER OF LANES	FOLLOW NUMBER	FOLLOW CHANGE
87366	0.0	12	9:54:49	519	3	8	2	98	1
87367	0.014	12	9:54:50	514	3	8	2	98	0
87368	0.029	12	9:54:51	510	3	8	2	98	0
87369	0.043	12	9:54:52	514	3	8	2	98	0
87370	0.057	12	9:54:53	519	3	8	2	98	0
87371	0.072	12	9:54:54	528	3	8	2	98	0
87372	0.087	12	9:54:55	541	3	8	2	98	0
87373	0.102	12	9:54:56	554	3	8	2	98	0
87374	0.117	12	9:54:57	567	3	8	2	98	0
87375	0.133	12	9:54:58	580	3	8	2	98	0
87376	0.149	12	9:54:59	589	3	8	2	98	0
87377	0.166	12	9:55: 0	598	3	8	2	98	0
87378	0.183	12	9:55: 1	602	3	8	2	98	0
87379	0.199	12	9:55: 2	611	3	8	2	98	0
87380	0.217	12	9:55: 3	616	3	8	2	98	0
87381	0.234	12	9:55: 4	624	4	8	2	98	0
87382	0.251	12	9:55: 5	629	4	8	2	98	0
87383	0.269	12	9:55: 6	624	4	8	2	98	0
87384	0.286	12	9:55: 7	629	4	8	2	98	0
87385	0.303	12	9:55: 8	633	4	8	2	98	0
87386	0.321	12	9:55: 9	629	4	8	2	98	0
87387	0.338	12	9:55:10	620	4	8	4	98	0
87388	0.356	12	9:55:11	616	4	8	4	98	0
87389	0.372	12	9:55:12	607	4	8	4	98	0
87390	0.389	12	9:55:13	602	4	8	4	98	0
87391	0.406	12	9:55:14	594	4	8	4	98	0
87392	0.422	12	9:55:15	585	4	8	4	98	0
87393	0.438	12	9:55:16	576	4	8	4	98	0
87394	0.454	12	9:55:17	572	4	8	4	98	0
87395	0.470	12	9:55:18	576	4	8	4	98	0
87396	0.486	12	9:55:19	585	4	8	4	98	0
87397	0.503	12	9:55:20	594	4	8	4	98	0
87398	0.519	12	9:55:21	602	4	8	4	98	0
87399	0.536	12	9:55:22	611	4	8	4	98	0

Table 3-7. INITIAL ROAD TYPE CONTINGENCY TABLE

GM ROAD TYPES	FHWA ROAD TYPES				
	Freeway (Type 1)	Major Arterial (Type 2)	Minor Arterial (Type 3)	Collector (Type 4)	Local (Type 5)
1					
2		8	10	1	2
3					3
4					
5					
6		36	25	4	
7			1	1	10
8		71	23	9	10
9		8	11	2	3
10		8	6	1	3
11		64	14	3	
12	17				
13	10				

An error rate here is defined as the number of segments incorrectly classified divided by the total number of segments.

3.3.2 Reclassification Utilizing Speed Limit

To provide further information for reclassifying GM road types into FHWA road types, speed limit and number of lanes were incorporated into the analysis. For each street segment with an associated GM road type and an associated FHWA road type, segments with different speed limits were identified.

For example, suppose a given road segment was defined by GM to be Type 6. One might find the first part of the segment to be FHWA Type 2 (or major arterial as one can see from Table 3-7), and the rest of the segment to be FHWA Type 3. Further, the speed limit could be 30 mph on the first part and 25 mph on the remainder. For this example, two entries would be made in a contingency table of FHWA road type versus speed limit for GM Road Type 6. (Such a contingency table was made for each GM road type of interest.) The entries for the example would be made in the cells corresponding to FHWA Road Type 2 and 30 mph, and to FHWA Road Type 3 and 25 mph. The contingency table actually obtained for GM Road Type 6 is shown in Table 3-8.

Table 3-8. SPEED LIMIT VERSUS FHWA ROAD TYPE
(GM Road Type 6)

SPEED LIMIT (mph)	FHWA ROAD TYPES*		
	Major Arterial (Type 2)	Minor Arterial (Type 3)	Collector (Type 4)
15			
20	1	1	2
25		1	
30	4	5	3
35	12	7	1
40	18	8	
45	9	2	
50	1		
55	2		
60			
65			
70			

*No occurrences of GM Road Type 6 on FHWA freeway or local road types were observed.

From each such contingency table the percentage of road sections that would be successfully reclassified was determined.

Taking GM Road Type 6, for example, one could reclassify those segments with a 20-mph speed limit as FHWA Type 4. The data in Table 3-8 indicate successful reclassification two times out of four, for an error rate of 50 percent. Those segments with a 30-mph speed limit could be reclassified as FHWA Type 3 with an error rate of 58 percent (7/12). Those segments with speed limits of 35 mph or greater could be reclassified as FHWA Type 2 with an error rate of 30 percent (18/60).

With an error rate as high as 58 percent (a correct reclassification percentage of 42 percent), speed limit alone did not provide a sufficiently good means of reclassifying GM road types. The reclassification method using speed limit would give an overall error rate of 34 percent (26/77) compared with an error rate of 45 percent in the original table. Although an improvement, it was still not adequate for Road Type 6. The results for the road types of interest are as follows:

GM ROAD TYPE	INITIAL ERROR	ERROR, WITH SPEED LIMIT
2	52%	28%
6	45%	34%
7	17%	23%
8	37%	35%
9	54%	45%
10	56%	45%
11	21%	18%

3.3.3 Reclassification Utilizing Number of Lanes

A contingency table of number of lanes versus FHWA road type was then prepared for each GM road type. The contingency table for GM Road Type 6 is shown in Table 3-9.

Table 3-9. NUMBER OF LANES VERSUS FHWA ROAD TYPES FOR GM ROAD TYPE 6

NUMBER OF LANES	FHWA ROAD TYPES		
	Major Arterial (Type 2)	Minor Arterial (Type 3)	Collector (Type 4)
1	5	17	4
1.5	1	4	
2	34	15	
2.5	24	3	
3	1		
4			
5			
6			

From the data in Table 3-9, one can reclassify GM Road Type 6 with one lane in each direction as FHWA Type 3 with an error of 35 percent. GM Road Type 6 segments with 1.5 lanes can be reclassified as FHWA Type 3 with a 20-percent error, those with two lanes can be reclassified as FHWA Type 2 with a 31-percent error, and those with 2.5 lanes and above can be reclassified as FHWA Type 2 with an 11-percent error.

Overall, there would be a 26-percent error (28/108) when incorporating number of lanes into the analysis of GM Road Type 6. The error rates using number of lanes were lower than the error rates utilizing speed limit for four GM road types and higher for three GM road types. While providing a slightly better reclassification scheme than did speed limit, the number of lanes still was not deemed to provide an adequate reclassification scheme as indicated below:

GM ROAD TYPE	INITIAL ERROR	ERROR, WITH NUMBER OF LANES
2	52%	35%
6	45%	26%
7	17%	38%
8	37%	33%
9	54%	48%
10	56%	33%
11	21%	14%

3.3.4 Reclassification with Number of Lanes and Speed Limit

Since number of lanes and speed limit each provided improvement in the reclassification error rates, it was natural to consider a contingency table

in which both parameters were tallied against FHWA road type for each GM road type. To illustrate, suppose a GM Type 6 segment was FHWA Type 2 over the first part and FHWA Type 3 over the remainder. Furthermore, suppose the number of lanes to change from three to four and the speed limit to change from 35 to 40 mph. (It should be noted that lane and speed-limit changes need not correspond to FHWA-road-type changes.) Table 3-10 shows the contingency table for GM Road Type 6 utilizing both speed limit and number of lanes.

From Table 3-10, GM Road Type 6 would be reclassified as FHWA Road Type 2 at speed limits of 45 mph and above. At a 40-mph limit, GM-defined Type 6 would be FHWA Type 3 when the number of lanes was one or 1.5 and would be FHWA Type 2 with two or 2.5 lanes. For a 35-mph limit, GM Type 6 would be reclassified as FHWA Type 3 when the number of lanes was one or 1.5 and as FHWA Type 2 when the number of lanes was two or 2.5. For 30-mph and 25-mph speed limits, GM Type 6 would be reclassified as FHWA Type 3. For a 20-mph speed limit, GM Type 6 would be reclassified as FHWA Type 4.

Of the 120 total segments in the table, 27 would be incorrectly reclassified with this method, for an error of 23 percent. This combined reclassification scheme for the GM road types of interest yields the reclassification errors given below:

GM ROAD TYPE	ERROR
2	20%
6	23%
7	15%
8	26%
9	43%
10	36%
11	13%

With error rates as high as 43 percent, this method of reclassification was still unacceptable. It was concluded that the GM road types could not be accurately reclassified into the full set of five FHWA road types.

The contingency tables broken down by the five FHWA road types indicated, however, that most GM road types tended to fall into three combined FHWA road-types:

a) Freeway/expressway.
b) Major and minor arterials.
c) Local and collector streets.

The data were thus re-analyzed with major and minor arterials combined as arterial, and local and collector combined as local-collector.

The resultant two-variable contingency table, Table 3-11, offered an accurate reclassification from the GM road types into three combined FHWA categories.

Table 3-10. SPEED LIMIT VERSUS FHWA ROAD TYPES BROKEN DOWN BY NUMBER OF LANES FOR GM ROAD TYPE 6

SPEED LIMIT	NUMBER OF LANES	FHWA ROAD TYPE		
		Major Arterial (Type 2)	Minor Arterial (Type 3)	Collector (Type 4)
20	1	1	1	2
	1.5			
	2			
	2.5 and up			
25	1	1		
	1.5			
	2			
	2.5 and up			
30	1	2	6	3
	1.5		1	
	2	2	5	
	2.5 and up			
35	1		3	1
	1.5			
	2	11	4	
	2.5 and up	7	2	
40	1	3	8	
	1.5		3	
	2	15	5	
	2.5 and up	7	2	
45	1	3	1	
	1.5	1		
	2	10	1	
	2.5 and up	7		
50	1			
	1.5			
	2	1		
	2.5 and up			
55	1			
	1.5			
	2	1		
	2.5 and up	1		

Table 3-11. CONTINGENCY TABLE OF GM ROAD TYPES VERSUS COMBINED FHWA TYPES

GM ROAD TYPE	COMBINED FHWA ROAD TYPE		
	Freeway	Arterial	Local/Collector
2		18	3
3			3
4			
5			
6		61	4
7		1	11
8		94	19
9		19	5
10		14	4
11		78	3
12	17		
13	10		

Little additional information was provided by incorporating number of lanes or speed limit into the contingency table. The two-variable table yielded the reclassification shown in Table 3-12.

Table 3-12. RECLASSIFICATION OF GM ROAD TYPES

GM ROAD TYPE	COMBINED FHWA ROAD TYPE
Unpaved rural	Rural local
Unpaved surburan	Rural local
Rural highway	Rural artery
Suburban-no curb	Rural local
Suburban-curb	Urban local
Suburban-shopping center	Urban local
Suburban-artery	Urban artery
Urban	Urban local
Urban artery	Urban artery
Central business district*	Urban artery
Central business district**	Urban artery
Commercial strip	Urban artery
Express-business route	Urban freeway
Expressway	Rural freeway

*Parking
**Nonparking

The contingency table did not provide the desired 5-percent or less error rate for reclassifying all road types. This could have arisen from such considerations as:

1. Overlapping of definitions of the road-types; i.e., what GM calls central business district can sometimes be called local or collector or artery by the FHWA.

2. Mileage discrepancies between the distances noted by FHWA in their route descriptions and the distances computed from the data on tape.

To give an indication of the influence of the first possibility, it should be noted that the number of times that the GM road type changed while the FHWA road type remained constant was 198, while the number of times that the FHWA road type changed while the GM road type remained constant was 51. This high occurrence of changing FHWA road types when the GM road type remained constant leads to a given GM road type being associated with a range of FHWA road types.

3.4 STATISTICAL PROCESSING

Statistics calculated during Phase II included record-by-record statistics, such as time or frequency in speed bands, and modal statistics, such as total time in each mode.

Four types of follows were noted on tape: follows with urban road types only in an urban location, follows with urban and rural road types in an urban location, follows with urban and rural road types in a rural location, and follows with rural road types only in a rural location. Since the characteristics of an urban road type in an urban location might differ from the characteristics of that same urban road type in a rural location, statistics were calculated separately for each case. Three types of data samples were thus considered, corresponding to follows in urban location with urban road types, follows in rural locations with rural road types, and follows with both urban and rural road types. Statistics were calculated both within and without the 12 GM cities. Urban data from urban-rural follows were combined with the data from urban follows to yield urban data for all follows. Rural data from urban-rural follows were combined with the data from rural follows to yield rural data for all follows. The resulting data samples of interest appear in Table 3-13.

Table 3-13. DATA SAMPLES OF INTEREST

A. Individual GM cities, urban follows only
B. Individual GM cities, urban-rural follows only
C. Individual GM cities, all follows
D. Other urban data outside GM cities, urban follows only
E. Other urban data outside GM cities, all follows
F. Other urban data outside GM cities, urban-rural follows only
G. Rural data, rural follows only
H. Rural data, all follows
I. Urban data, urban follows only
J. Urban data, urban-rural follows only
K. Urban data, all follows
L. Total data sample
M. Individual FHWA routes

For full trips only, as indicated by the follow-mode switch, trip-length distributions were determined for each of the 12 GM cities, for both urban and urban-rural follows. In addition, trip-length distributions outside the 12 GM cities were determined for rural follows, urban follows, and urban-rural follows.

Speed bands were established for speeds identically zero, those greater than zero and less than 2.5 mph, and in 5-mph increments to 62.5 mph. A final category included all speeds greater than or equal to 62.5 mph. After determining the speed band into which a given record's speed fell, the frequency accumulated for that band was incremented by one. As the time difference from record to record was 1 second, this was equivalent to adding 1 second to the time in that speed band. Therefore, the frequency of speed-band occurrence was also the time in the speed band, in seconds.

Speed-band frequencies were computed for each road type for later weighting. Percentages were based on the total frequency for all road types combined. Percentages of time in acceleration/deceleration bands were computed for the two Federal test cycles and for each road type in each data sample of interest. Acceleration/deceleration bands were established for each road type in 1-mph/sec increments from -9.5 mph/sec to +9.5 mph/sec. After the magnitude of the acceleration or deceleration was calculated, the frequency accumulated for that band was incremented by one. Again, this was equivalent to adding 1 second to the time accumulated in the speed band. The acceleration/deceleration percentages were based on the total frequency for road types combined.

The percentages of time spent accelerating, decelerating, and in cruise for each road type were computed from the frequencies in the acceleration/deceleration bands. The sum of the frequencies in the deceleration bands yielded the frequency of deceleration. Similarly, the sum of the frequencies in the acceleration bands yielded the frequency of acceleration. Idle frequency, broken down by road type, was incremented during data processing each time an identically-zero speed occurred and when the previous record's speed was identically zero. When the data for road types were combined, the total idle frequency was subtracted from the ±0.5-mph/sec cruise band to yield the cruise frequency at nonzero speed.

The miles and time for each traffic density for each road type were computed for each data sample of interest. Miles traveled was computed using the average speed from the previous record's speed and the current record's speed. For the first record of a follow, of course, no mileage was accumulated.

Matrices of traffic density by road type, both in miles and time, were summed across traffic density to yield the miles and time on each road type. These totals were then used to compute the percentages of miles and time in a given traffic density and road type based on the total for that road type. The matrices were summed across road type as well, to yield miles and time in traffic densities, as well as on road types. Percentages of miles and time in traffic densities and on road types were computed using the total miles and time computed from all road types.

Average speed for each traffic density on each road type was computed from the mileage and time in hours for that traffic density on that road type. The average speed for each road type was similarly computed. Overall average

speeds were computed from the sum of the mileages and times over all road types.

Stops per mile were computed for each road type in each data sample of interest. After discussing the problems inherent in defining different types of stops with the project officer, a simple definition of a stop was chosen. A stop for each road type was tallied whenever the current speed was identically zero and the previous speed was not identically zero. Stops per mile were computed for each road type in each data sample of interest.

For each road type in each data sample of interest, the number of follows containing one or more occurrences of that road type was computed. Additionally, the total number of occurrences of a road type was incremented whenever the road type changed. When divided by the total number of trips that contained one or more occurrences of that road type, this yielded the average number of occurrences per trip for trips with that road type.

Summing the frequency of occurrence of each road type yielded the total number of road-type occurrences for each data sample of interest. This, divided by the total number of trips for that city, yielded the average number of different road types per trip. Dividing the mileage and time in each city by the number of trips yielded the average length and duration, respectively, of the follows in that city.

The above-described statistics for various unweighted data samples of interest are given in Appendix A.

3.5 WEIGHTING OF DATA

Weighting factors reflecting road-type usage within each city were computed from the statistics calculated during GM data processing and from FHWA road-usage statistics. Weighting factors reflecting each GM city's proportion of overall national urban operation were computed by both the FHWA and the EPA. The GM data within each city were weighted with respect to road-type usage within that city and then with respect to that city's proportion of overall national urban operation.

3.5.1 Calculation of Within-City Road-Type Weighting Factors

The data were weighted by road type for each city so that the percentage of miles on that road type reflected the percentage of daily vehicles miles traveled (DVMT) as determined by the FHWA. The percentages computed from the data tapes and the percentages determined by the FHWA for each city are shown in the first two columns of Table 3-14.

For each road type in each city, the weighting factor was determined by dividing the percentage of DVMT for the road type in that city, as determined by the FHWA, by the percentage of miles on that road type in that city, as indicated by the GM data. For example, the percent of DVMT on freeways in the City of Detroit was 15.2 percent. The percent of DVMT on freeways in Detroit, as determined during processing of the GM data, was 3.07 percent. The weighting factor for freeways in the City of Detroit is thus 15.2 divided by 3.07, or 4.9511. The weighting factors so computed are given in the last column of Table 3-14.

Table 3-14. PERCENTAGES OF DAILY VEHICLE MILES TRAVELED IN EACH ROAD TYPE FOR EACH GM CITY

CITY	ROAD TYPE	% DAILY VEHICLE MILES TRAVELED	% AS INDICATED IN DATA	WEIGHTING FACTOR
Detroit	Freeway	15.23	3.07	4.96
	Arterial	68.80	84.13	.82
	Local	15.97	12.80	1.25
New York	Freeway	10.18	17.84	.57
	Arterial	63.24	72.75	.87
	Local	26.58	9.41	2.82
Washington, D.C.	Freeway	19.30	-	-
	Arterial	59.20	89.55	.66
	Local	21.50	10.43	2.06
Atlanta	Freeway	28.23	10.28	2.75
	Arterial	35.56	88.59	.40
	Local	36.21	1.13	32.04
Los Angeles	Freeway	24.52	27.07	.91
	Arterial	59.08	66.56	.89
	Local	16.40	6.37	2.57
San Francisco	Freeway	10.63	16.38	.65
	Arterial	69.68	75.65	.92
	Local	19.68	7.97	2.47
Phoenix	Freeway	10.07	2.13	4.73
	Arterial	76.74	93.06	.82
	Local	13.68	4.81	2.74
San Diego	Freeway	33.05	13.95	2.37
	Arterial	52.97	76.84	.69
	Local	13.98	9.21	1.52
Denver	Freeway	18.75	5.53	3.39
	Arterial	68.93	85.51	.81
	Local	12.32	8.96	1.38
Salt Lake City	Freeway	18.86	-	-
	Arterial	47.74	92.87	.51
	Local	33.40	7.13	4.27
Chicago	Freeway	21.27	18.88	1.13
	Arterial	47.01	73.30	.64
	Local	31.72	7.82	4.06
St. Louis	Freeway	19.16	18.04	1.06
	Arterial	60.24	70.85	.85
	Local	20.60	11.11	1.85

3.5.2 Calculation of City Weighting Factors

The initial step in the determination of weighting factors for each GM city was the calculation of the percentage of DVMT in each GM city with respect to overall national urban operation. This calculation was accomplished in two different ways.

The first method of calculating the percentage of DVMT in each GM city was based directly on the fraction of DVMT on each road type in each of the 12 GM cities as determined by the FHWA. These data appear in Table 3-15. Summing these percentages across road type for each city yielded each city's percentage of DVMT with respect to the other GM cities, as shown in Table 3-16 in the column labeled "FHWA."

The second method of calculating percentage of DVMT in each GM city was based on an analysis conducted by the EPA. Only the fractions of DVMT by road type within an urban area were utilized to categorize U.S. cities. For each of the several urban functional road type classifications employed by the FHWA, five ranges of fractional DVMT were established to group the DVMT statistics of all U.S. cities. A computer program was written by the EPA to group each U.S. urban area into the appropriate range for each of the road-type classifications considered. The span limits for each road type were set so that, where possible, at least one GM-sampled city fell within every range. The DVMT on a given road type accumulated for all cities grouped within each fraction span of that particular road type, were also calculated by the computer program. For each separate road type, the percentage DVMT represented by the urban areas grouped in a GM city's respective range was calculated. All of these percentages of DVMT for a given road type were multiplied by the proportion of DVMT for that road type with respect to the total DVMT for all urban road types. Then, the percentages for all road types of a single GM city were summed to provide the percentage of DVMT for each of the 12 GM-sampled cities.

For example, the five DVMT-fraction ranges established for the functional road classification labeled Interstate were 0-0.007, 0.008-0.014, 0.015-0.021, 0.022-0.028, 0.029-1.000. Grouping each U.S. urban area into the appropriate category according to the fraction of DVMT accumulated on Interstates within that city resulted in the following:

	INTERSTATE		
Range	No. of Cities	DVMT Accumulated (Thousands of miles)	Fraction of DMVT Accumulated
1 (0-0.007)	115	3,668	0.0202
2 (0.008-0.014)	52	42,540	0.2341
3 (0.015-0.021)	54	59,897	0.3295
4 (0.022-0.028)	18	60,121	0.3308
5 (0.029-1.000)	5	15,528	0.0854
Total	284	181,754	1.0000

The 12 GM cities were fit into 4 of the 5 ranges and, in this scheme, are representative of 98.0 percent of all urban Interstate driving.

Table 3-15. SUMMARIES OF DAILY VEHICLE-MILES OF TRAVEL BY FUNCTIONAL CLASS

URBANIZED AREA	PRINCIPAL ARTERIAL						MINOR ARTERIAL		COLLECTOR		LOCAL		TOTAL	
	Freeway and Expressway				Other Principal Arterial									
	Interstate		Other Freeway & Expressway											
	Miles	Fract.	Miles	Fract.	Miles	Fract.	Miles	Fract.	Miles	Fract.	Miles	Fract.	Miles	Fract.
New York City	15,672	.102	30,103	.196	32,557	.212	34,680	.225	9,757	.063	31,158	.202	153,927	.297
Washington, D.C.	4,933	.193	2,658	.104	7,803	.305	4,675	.183	1,851	.072	3,646	.143	25,566	.049
Detroit	7,666	.152	3,742	.074	17,527	.348	13,349	.265	3,950	.078	4,085	.081	50,319	.097
Chicago	15,070	.213	1,741	.025	16,987	.240	14,579	.206	3,913	.055	18,565	.062	70,855	.137
St. Louis	3,953	.192	1,044	.051	7,887	.382	3,500	.170	1,589	.077	2,662	.129	20,635	.040
Atlanta	4,816	.282	160	.009	2,110	.124	3,797	.223	1,073	.063	5,106	.299	17,062	.033
Phoenix	791	.101	-0-	-0-	5,283	.673	745	.095	702	.089	334	.043	7,855	.015
Denver	1,945	.188	620	.060	4,290	.414	2,239	.216	428	.041	850	.082	10,372	.020
Salt Lake City	842	.189	-0-	-0-	1,530	.343	601	.135	763	.171	728	.163	4,464	.009
Los Angeles	24,569	.245	14,082	.141	34,566	.345	10,549	.105	5,851	.058	10,580	.106	100,197	.194
San Diego	3,787	.330	1,177	.103	1,556	.136	3,339	.291	554	.048	1,048	.091	11,461	.022
San Francisco	4,783	.106	12,235	.272	9,141	.203	9,970	.222	3,207	.071	5,647	.126	44,983	.087
Total	88,827	.172	67,562	.131	141,237	.273	102,023	.197	33,638	.065	84,409	.163	517,696	1.000

Table 3-16. PERCENTAGE OF MILES TRAVELED IN EACH GM CITY

CITY	PERCENT MILES TRAVELED		
	As Indicated By Data	FHWA	EPA
Detroit	15.99	9.7	10.4
Newark/New York	13.20	29.7	10.2
Washington, D.C.	3.14	4.9	8.2
Atlanta	2.70	3.3	5.6
Los Angeles	30.24	19.4	9.3
San Francisco	6.31	8.7	8.7
Phoenix	4.18	1.5	6.4
San Diego	1.36	2.2	6.9
Denver	6.00	2.0	8.0
Salt Lake City	4.88	.9	7.4
Chicago	8.50	13.7	10.7
St. Louis	3.50	4.0	8.2

Range	GM Cities
1	--
2	New York City, Phoenix, San Francisco
3	Washington, D.C., Detroit, St. Louis, Denver, Salt Lake City
4	Chicago, Los Angeles
5	Atlanta, San Diego

Therefore, New York City, Phoenix, and San Francisco together must reflect 23.4 percent of all urban Interstate driving nationally; individually, each represents 7.8 percent. The remainder of the urban Interstate DVMT was proportioned among the other nine GM cities according to the interval in which each was placed. This same procedure was repeated for the other four FHWA urban road classifications - Expressway and Other Principal Arterial, Minor Arterial, Collector, and Local.

The fractions of total urban DVMT reflected by each of the five categories with respect to all urban driving are:

Road Classification	Fraction of Total Urban DVMT
Interstate	0.145
Expressway and Other Principal Arterial	0.405
Minor Arterial	0.203
Collector	0.077
Local	0.170
Total	1.000

To determine the contribution of each road category on each GM city's weighting factor, the fraction of urban Interstate DVMT attributed to each GM city was then multiplied by 0.145 (e.g., for New York City one has: 0.078 x 0.145 = 0.011). Correspondingly, the fractions of DVMT reflected by the GM cities within each of the other four road classifications were also multiplied by the appropriate DVMT fraction for that road type category - 0.203 for Minor Arterial, etc.

The composite percentages of DVMT were then derived for each of the 12 GM cities separately by summing the values computed for each of the 5 road type classifications. These values appear in the last column of Table 3-16. Data for each road type in each city were multiplied by the weighting factor for that road type in that city. Percentages were then recomputed on the basis of the new resulting totals.

The FHWA-based and EPA-based weighting factors required for the two weightings of the data are derived from Table 3-16 by dividing the FHWA and EPA percent miles traveled, respectively, by the percent miles traveled from the GM data. For example, in Detroit the FHWA value of 9.7 is divided by 15.99 to yield 0.60663. The weighting factors so derived are given in Table 3-17.

Table 3-17. WEIGHTING FACTORS FOR EACH GM CITY

CITIES	FHWA-BASED	EPA-BASED
Detroit	0.607	0.650
Newark/New York	2.250	0.773
Washington, D.C.	1.561	2.611
Atlanta	1.222	2.074
Los Angeles	0.642	0.308
San Francisco	1.379	1.379
Phoenix	0.359	1.531
San Diego	1.618	5.074
Denver	0.333	1.333
Salt Lake City	0.184	1.516
Chicago	1.612	1.259
St. Louis	1.143	2.343

Once weighted by road type, the data for a city were multiplied by the city's weighting factor for both weightings and then recombined with urban data, to form a new urban data base, and with rural data, to form revised statistics for the total data sample. Percentages were again recomputed on the basis of the new resulting totals.

3.6 PROCESSING GM DATA FOR CYCLE GENERATION

The matrices used to describe and develop driving patterns, formatted as shown in Figure 3-2, are defined as follows (see References 1 and 2):

Total-Time-in-Mode Matrix - The time spent in executing each mode was accumulated to yield the two-dimensional total-time-in-mode matrix.

Mode-Frequency-of-Occurrence Matrix - This two-dimensional matrix was derived from the distribution-of-time-in-mode matrix by simply tallying the number of times each mode occurred.

Average-Time-in-Mode Matrix - This matrix is generated by dividing each element in the total-time-in-mode matrix by the corresponding element in the mode-frequency-of-occurrence matrix.

Transition-Probability Matrix - This matrix is obtained by row normalization of the mode-frequency-of-occurrence matrix; i.e., the nondiagonal elements in each row of the mode-frequency-of-occurrence matrix are first summed, and each nondiagonal row element is then divided by the row total. The off-diagonal entries in any row are, therefore, the conditional probabilities of making transitions from the row's cruise mode (diagonal element) to those acceleration or deceleration modes. The diagonal elements in the transition probability matrix remain undefined, of course, since no transition occurs while cruising.

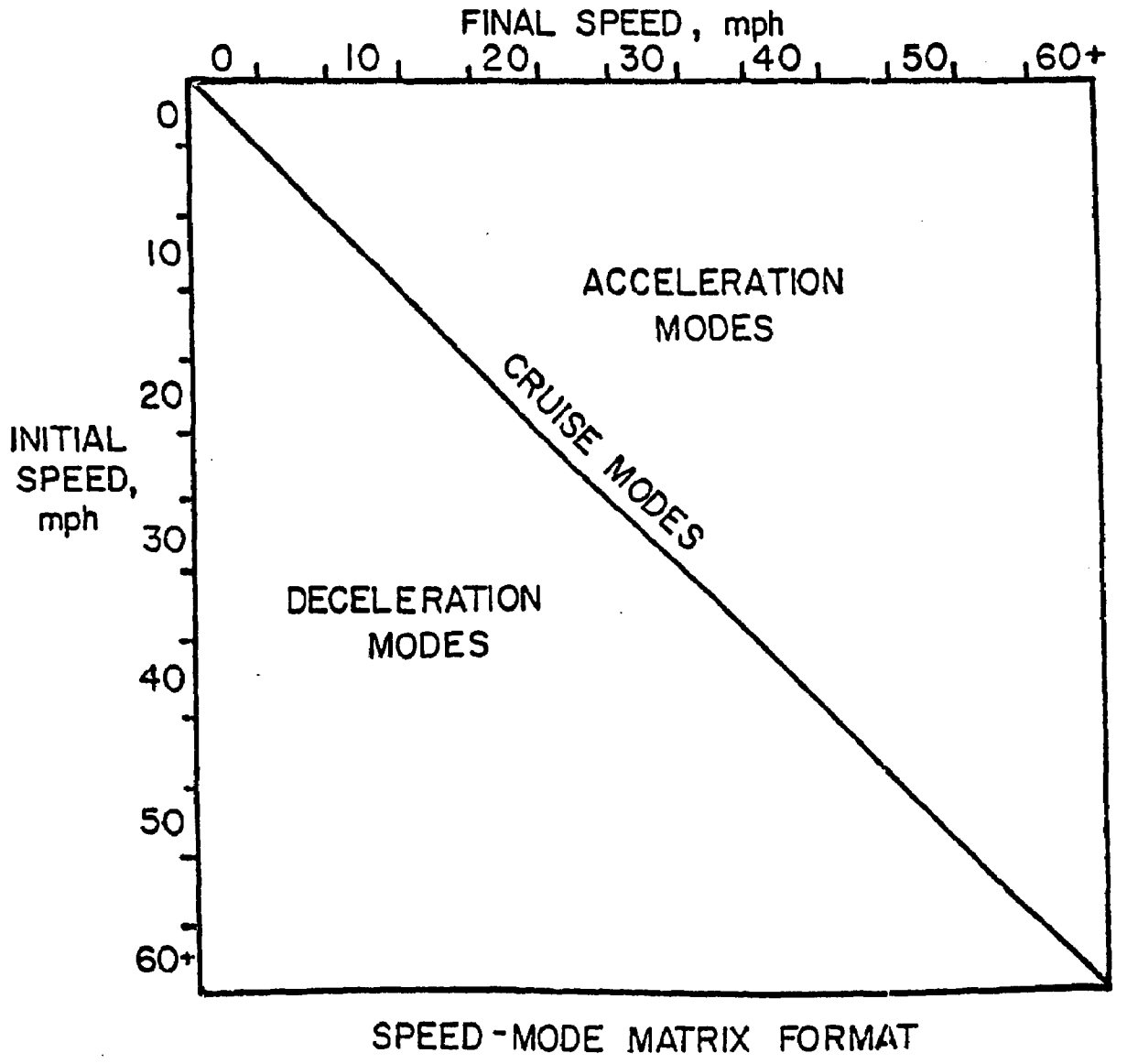

FINAL SPEED, mph
0
10
20
30
40
50
60+
INITIAL SPEED, mph
ACCELERATION MODES
CRUISE MODES
DECELERATION MODES
SPEED-MODE MATRIX FORMAT

Figure 3-2.

3.7 ANALYSIS OF ROAD TYPE VERSUS SPEED

To determine if average speed could be used as an indication of road type, the average speed for each of the combined FHWA urban road types over each St. Louis route was computed from the GM data. Those average speeds are tabulated by route and combined road type in Table 3-18.

Table 3-18. AVERAGE SPEEDS BY COMBINED FHWA ROAD TYPE FOR EACH FHWA ROUTE IN ST. LOUIS

	URBAN			RURAL		
ROUTE	Local	Arterial	Freeway	Local	Arterial	Freeway
1		18.80				
2	15.58	20.69				
3	20.33	16.83	49.32			
4		24.10	54.32			49.08
6		26.13	56.93	29.61	34.96	53.37
7		27.11	53.09		42.79	58.55
8	18.23	24.65	54.56		49.65	52.89
9		24.26			34.12	
10		26.08	57.25			44.30
11		26.34	55.39		44.43	
12		40.03	56.82	55.07	52.66	58.27
13		36.06	56.89		50.59	57.01
14		31.65	44.76		42.92	
15	32.11	30.54	53.86		48.93	59.70

Since the amount of missing data in Table 3-18 precluded an analysis of variance based on all the road routes, it was necessary to use a combination of routes which minimized the number of missing observations.

The only routes with occurrences of the urban-local road type were Routes 2, 3, 8, and 15. Those routes were, therefore, selected for the analysis of variance. The missing average speed for freeway on Route 2 is estimated from:

$$\text{average speed} = \frac{aT + bB - S}{(a-1)\ (b-1)},$$

where

a = number of treatments (road types)
b = number of blocks (routes)
T = sum of average speeds with same treatment as missing average speed
B = sum of average speeds in same block as missing average speed
S = sum of all observed average speeds.

Thus, from the data in Table 3-18, the missing average speed was estimated to be:

$$\text{average speed} = \frac{3(157.74) + 4(36.27) - 336.70}{(3 - 1)(4 - 1)}$$

$$= 46.93 \text{ mph}$$

Table 3-19 gives the speed totals, mean speeds, and sums of squares over both routes and road types from which the analysis of variance table, Table 3-20, is constructed.

Table 3-19. AVERAGE SPEEDS BY COMBINED FHWA ROAD TYPE FOR SELECTED FHWA ROUTES WITH ESTIMATED DATA

ROUTE NUMBER	URBAN			TOTAL	MEAN	S.S.
	Local	Arterial	Freeway			
2	15.58	20.69	46.93	83.20	27.73	2,873.24
3	20.33	16.83	49.32	86.32	28.83	3,129.02
8	18.23	24.65	54.56	97.44	32.48	3,916.75
15	32.11	30.54	53.86	116.51	38.84	4,864.64
Total	86.25	92.71	204.67	383.63		
Mean	21.56	23.18	51.17			
S.S.	2,019.43	2,251.64	10,512.58			14,783.65

Table 3-20. ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
Road Types	2	2,216.67	1,108.34
Routes	3	216.51	72.17
Error	6	86.14	14.36
Total	11	2,519.32	

Average speed can be used as an indication of road type if there is a significant average-speed difference between each pair of road types at a preassigned probability level. To determine the existence of significant differences, the least significant difference (lsd), a quantity based on the student-t distribution, was calculated. The lsd, which in this case is the lsd between two average speeds, is given by:

$$\text{lsd} = t_{\alpha,n}\left(\frac{2s_e^2}{a}\right)^{\frac{1}{2}},$$

where

$t_{\alpha,n}$ = Student-t value at probability level α for n degrees of freedom

s_e^2 = error sum of squares

a = number of treatments.

However, since there was a missing average-speed value which was estimated, that estimated value is correlated with the other values used for the estimation. The error sum of squares is thus biased and must be corrected to the quantity:

$$s_e^2 \left(\frac{2}{a} + \frac{b}{a(a-1)(b-1)} \right),$$

where a and b are the number of treatments (road types) and blocks (routes), respectively. In addition, the error degrees of freedom must be reduced by one.

Since the error sum of squares has 5 degrees of freedom, and selecting the usual .05 probability level, the lsd is:

$$\text{lsd} = t_{.05,5} \left[\frac{2s_e^2}{a} \left(\frac{2}{a} + \frac{b}{a(a-1)(b-1)} \right) \right]^{\frac{1}{2}}$$

$$= 2.571 \left[\frac{2(86.14)}{3} \left(\frac{2}{3} + \frac{4}{3(3-1)(4-1)} \right) \right]^{\frac{1}{2}}$$

$$= 18.37 \text{ mph.}$$

The differences in average speed between road types are:

Comparison	Average Speed Difference (mph)
Local versus Artery	1.62
Local versus Freeway	29.61
Artery versus Freeway	27.99

The average-speed difference between local and arterial roads is much less than the lsd and thus average speed cannot be used as an indication of those road types. The average-speed differences between freeway and the other two road types are both considerably larger than the lsd. Average speed, then, can be used only to indicate freeway versus nonfreeway road types. This conclusion, of course, is based on the data for just four St. Louis road routes.

Section 4

RESULTS OF GM CHASE-CAR ANALYSIS

This section describes the parameters for which statistics were generated and presents the results of the GM chase-car statistical analysis.

The 1,728 trips, or follows, contained in the GM data for all 12 GM cities combined (urban follows only), had an average trip length of 1.96 miles and an average duration of 5.03 minutes. As shown in Table 4-1, the number of follows ranged from 28 in Atlanta to 450 in Los Angeles. The average trip length ranged from 1.24 miles in San Francisco to 3.27 miles in Atlanta. The average trip duration ranged from 3.83 minutes in San Francisco to 7.33 minutes in Atlanta.

Table 4-1. URBAN-FOLLOW STATISTICS FOR THE 12 GM CITIES

LOCATION	NUMBER OF FOLLOWS	AVERAGE LENGTH (Miles)	AVERAGE DURATION (Minutes)
Detroit	287	1.89	4.78
Newark/New York City	255	1.75	5.73
Washington, D.C.	67	1.59	5.43
Atlanta	28	3.27	7.33
Los Angeles	450	2.28	4.93
San Francisco	172	1.24	3.83
Phoenix	61	2.32	5.34
San Diego	29	1.58	4.03
Denver	121	1.68	4.51
Salt Lake City	86	1.92	4.59
Chicago	107	2.69	6.95
St. Louis	65	1.83	4.36

4.1 TRAFFIC DENSITY BY ROAD TYPE IN MILES AND TIME

Percentages of miles and time were computed for each traffic density on each road type for each data sample of interest. These percentages were computed for unweighted data, for data weighted with respect to all 12 GM cities, and for data weighted with respect to overall urban operation. The results for selected data samples of interest appear in Appendices A, B, and C. To yield a more compact set of statistics, the traffic densities indicated by GM were combined into the following traffic densities:

- Light or average traffic
- Medium traffic
- Heavy and stop-and-go traffic.

The results for the 12-city total, urban follows only, appear in Table 4-2.

Table 4-2. ROAD TYPE VERSUS TRAFFIC DENSITY FOR 12-CITY TOTAL IN PERCENTAGE OF MILES

ROAD TYPE TRAFFIC DENSITY	UNWEIGHTED	FHWA-WEIGHTED	EPA-WEIGHTED
Local/Collector			
Light or no traffic	85.66	81.99	84.31
Medium traffic	13.34	17.50	15.16
Heavy and stop-and-go traffic	1.00	.52	.53
Artery			
Light or no traffic	39.13	32.93	39.00
Medium traffic	56.33	59.39	55.93
Heavy and stop-and-go traffic	4.54	7.69	5.07
Freeway			
Light or no traffic	5.00	5.34	7.00
Medium traffic	70.38	73.56	74.77
Heavy and stop-and-go traffic	24.61	21.10	18.24

4.2 AVERAGE SPEED

The average speeds for unweighted and road-type-weighted data appear in Table 4-3 for each of the 12 GM cities.

Table 4-3. AVERAGE SPEEDS FOR EACH GM CITY

CITY	UNWEIGHTED	ROAD TYPE
Detroit	23.68	24.40
Newark/New York City	18.36	17.18
Washington, D.C.	17.54	17.24
Atlanta	26.77	19.34
Los Angeles	27.70	26.24
San Francisco	19.49	18.35
Phoenix	26.05	26.30
San Diego	23.56	25.19
Denver	22.38	23.53
Salt Lake City	25.11	22.88
Chicago	23.21	22.12
St. Louis	25.14	24.06

The differences between the weighted values and unweighted values for a given GM city are attributable to the weighting by road type for that city. The overall average speeds for unweighted and weighted data are:

GM unweighted data	23.39 mph
GM data weighted by FHWA statistics	20.66 mph
GM data weighted by EPA statistics	21.72 mph

4.3 OPERATIONAL MODE STATISTICS

A comparison of the percent of time in idle, cruise, acceleration, and deceleration for each of the 12 GM cities for unweighted and road-type-weighted data is presented in Tables 4-4 through 4-7.

Table 4-4. PERCENT OF TIME AT IDLE FOR EACH GM CITY

CITY	UNWEIGHTED	WEIGHTED
Detroit	7.50	6.98
Newark/New York	16.83	15.75
Washington, D.C.	17.20	15.91
Atlanta	11.30	7.76
Los Angeles	6.19	5.63
San Francisco	10.05	9.33
Phoenix	6.71	6.11
San Diego	8.70	7.29
Denver	10.35	9.06
Salt Lake City	9.24	5.45
Chicago	10.94	8.30
St. Louis	8.32	7.52

Table 4-5. PERCENT OF TIME IN CRUISE FOR EACH GM CITY

CITY	UNWEIGHTED	WEIGHTED
Detroit	40.32	41.25
Newark/New York	32.52	31.50
Washington, D.C.	32.13	32.19
Atlanta	36.95	31.39
Los Angeles	41.65	40.40
San Francisco	34.29	32.97
Phoenix	42.87	42.93
San Diego	38.30	38.02
Denver	40.83	41.18
Salt Lake City	39.55	38.38
Chicago	38.90	37.85
St. Louis	36.48	36.03

Table 4-6. PERCENT OF TIME IN ACCELERATION FOR EACH GM CITY

CITY	UNWEIGHTED	WEIGHTED
Detroit	29.33	29.23
Newark/New York	28.06	28.78
Washington, D.C.	28.01	28.55
Atlanta	28.70	30.63
Los Angeles	30.30	30.91
San Francisco	31.46	32.35
Phoenix	29.93	29.92
San Diego	29.30	30.00
Denver	27.70	28.09
Salt Lake City	29.72	31.25
Chicago	28.97	31.06
St. Louis	30.12	30.17

Table 4-7. PERCENT OF TIME IN DECELERATION IN EACH GM CITY

CITY	UNWEIGHTED	WEIGHTED
Detroit	22.85	22.55
Newark/New York	22.59	23.97
Washington, D.C.	22.66	23.35
Atlanta	23.05	30.22
Los Angeles	21.86	23.05
San Francisco	24.20	25.35
Phoenix	20.49	21.04
San Diego	23.69	24.69
Denver	21.12	21.67
Salt Lake City	32.49	24.92
Chicago	21.19	22.79
St. Louis	25.09	26.27

The percent of time in idle, cruise, acceleration and deceleration appear below for weighted and unweighted data overall, and for the current FTP driving schedule.

	% Idle	% Cruise	% Accel	% Decel
GM unweighted data	10.00	38.28	29.39	22.34
GM data weighted by FHWA statistics	10.85	35.31	29.94	23.91
GM data weighted by EPA statistics	9.34	36.54	30.05	24.07
Federal Test Procedure	17.86	36.01	26.60	19.53

4.4 STOPS PER MILE

A comparison of the stops per mile for each of the 12 GM cities for unweighted and road-type-weighted data is presented in Table 4-8.

Table 4-8. STOPS PER MILE FOR EACH GM CITY

CITY	STOPS PER MILE	
	Unweighted	Weighted
Detroit	1.17	1.08
Newark/New York City	2.01	2.06
Washington, D.C.	2.47	2.36
Atlanta	.84	1.71
Los Angeles	.76	.78
San Francisco	1.63	1.70
Phoenix	.83	.74
San Diego	1.05	.99
Denver	1.18	1.00
Salt Lake City	.90	.66
Chicago	1.21	1.06
St. Louis	.95	.96

The stops per mile for the overall GM data, along with the stops per mile on the Federal cycle, are presented below:

GM unweighted data	1.19
GM data weighted by FHWA statistics	1.42
GM data weighted by EPA statistics	1.26
Federal Test Procedure	2.13

4.5 ROAD-TYPE STATISTICS

The percentage of miles on each road type for weighted and unweighted data and for FHWA statistics appears in Table 4-9.

Table 4-9. PERCENTAGE OF MILES ON COMBINED URBAN ROAD TYPES

DATA SOURCE	LOCAL/ COLLECTOR	ARTERIAL	FREEWAY
GM unweighted data	8.34	76.47	15.19
GM data weighted by FHWA statistics	23.03	60.74	16.23
GM data weighted by EPA statistics	22.39	61.45	16.16
FHWA statistics	22.80	60.00	17.20

Significantly more mileage in urban arteries is indicated in the GM data than in the FHWA report, and significantly less in the urban local types than in the FHWA report. An examination of the cities individually bears out these conclusions:

1. The percentage of urban arteries as indicated in the data exceeds the percentage of urban arteries as indicated by FHWA statistics in all 12 GM cities.

2. The percentage of urban freeways as indicated in the GM data is less than the percentage of urban freeways as indicated by FHWA statistics in the GM cities except New York, Los Angeles, and San Francisco.

3. The percentage of urban local/collector as indicated in the GM data is less than the percentage of urban local/collector as indicated by FHWA statistics in all 12 GM cities.

The following points are relevant with respect to the discrepancies:

1. Those GM road types from the FHWA routes in St. Louis which were classified as arterials had 11.8 percent of their occurrences along the routes on FHWA local/collector. Those GM road types from the FHWA routes in St. Louis which were classified as local/collector had 6.6 percent of their occurrences along the routes on FHWA arterials.

2. The percentage of rural freeways in the data for the 12 GM cities, urban-rural follows only, is 41.68.

Average speeds for the GM data for all 12 GM cities combined, urban follows only, are given in Table 4-10 for each combined road type.

Table 4-10. AVERAGE SPEEDS (MPH) ON COMBINED URBAN ROAD TYPES

DATA SOURCE	LOCAL/ COLLECTOR	ARTERIAL	FREEWAY
GM unweighted data	16.69	22.25	44.70
GM data weighted by FHWA statistics	15.85	20.15	43.48
GM data weighted by EPA statistics	15.98	21.67	43.85

Stops per mile for the GM data from all 12 GM cities combined, urban follows only, are shown in Table 4-11 for each combined road type.

Table 4-11. STOPS PER MILE FOR COMBINED URBAN ROAD TYPES

DATA SOURCE	LOCAL/ COLLECTOR	ARTERIAL	FREEWAY
GM unweighted data	1.43	1.37	.12
GM data weighted by FHWA statistics	1.60	1.70	.12
GM data weighted by EPA statistics	1.56	1.45	.11

4.6 COMPARISON OF URBAN-RURAL FOLLOWS WITH URBAN FOLLOWS AND RURAL FOLLOWS

A look at average speeds for different road types affords an interesting comparison of the types of follows, as shown in Table 4-12.

Table 4-12. AVERAGE SPEED (MPH)

ROAD TYPE	URBAN FOLLOWS	URBAN-RURAL FOLLOWS	RURAL FOLLOWS
Urban Local	16.66	18.09	
Urban Artery	22.26	27.05	
Urban Freeway	44.74	50.60	
Rural Local		20.82	35.53
Rural Artery		44.31	43.54
Rural Freeway		55.27	57.10

Section 5

DEVELOPMENT OF EMISSIONS/FUEL ECONOMY/AVERAGE SPEED RELATIONSHIPS

The purpose of this task was to develop equations expressing emissions and fuel economy as a function of average speed. Driving cycles at average speeds ranging from about 5 mph to 55 mph were first computer-generated with a Monte Carlo model. HC, CO, and NO_x emissions, together with fuel consumption (FC) in units of miles per gallon, were estimated over these cycles for each of 18 vehicle groups utilizing an EPA-supplied computer program. Each of the dependent variables (HC, CO, NO_x, and FC) was regressed on average speed for each vehicle group. Then each of the resulting equations was normalized to obtain a correction-factor equation yielding a value of 1.0 at 19.6 mph, the average speed of the LA-4 cycle. Finally, weighting factors based on vehicle population distributions were used to develop a 1975 composite correction-factor equation for low-altitude cities and a 1974 composite correction-factor equation for high-altitude cities.

5.1 CYCLE GENERATION

The procedures used to obtain the mode-frequency and time-in-mode matrices which are the basis for the computer generation of cycles are described in References 1 and 2. The Monte Carlo technique of modal-cycle generation is described in References 3 and 4. Wherever possible, just those cycles passing through a statistical filter to ensure representativeness were selected. It should be noted that the statistical filter used for the present study was based on the Kolmogorov-Smirnov test (a comparison of two distribution functions), whereas Reference 5 discusses the G-test which was used for that study of the relationships between emissions and average speed.

To obtain an adequate sample for the development of the required regression equations, ten cycles were selected at each average speed from 5 mph to 55 mph at a 5-mph increment. The set of input matrices included the GM modal matrices, broken down by road type, the CAPE-10 matrices, broken down by freeway/nonfreeway, and combined GM and CAPE-10 matrices. Since none of these matrix sets (i.e., mode-frequency and time-in-mode matrices) represents an average speed of less than 20 mph, it was necessary to use truncated matrices to yield average speeds of 5, 10, and 15 mph.

The combined GM/CAPE-10 nonfreeway matrix set was first truncated to 3 x 3 matrices; i.e., to initial/final speeds of just 0, 5, and 10 mph. A sample of 500 test cycles was then generated. These cycles had average speeds of about 3 mph, however, when cycles within 1 mph of 5 mph were desired. The input matrices were then truncated to 4 x 4 matrices with initial/final speeds of 0, 5, 10, and 15 mph. Cycles based on these matrices had the desired average speed and the ten best cycles were selected.

Similarly, the input matrices were truncated to 6 x 6 matrices (0 to 25 mph) to yield 10-mph cycles and truncated to 8 x 8 matrices (0 to 35 mph) to obtain 15-mph cycles.

The GM/CAPE-10 nonfreeway matrix set yielded 20-mph cycles, so no special procedures were required to obtain ten representative cycles. The GM/CAPE-10 combined freeway and nonfreeway matrix set yielded 25-mph cycles; so again, no special procedures were required to obtain ten representative cycles.

None of the available matrix sets yielded 30-mph or 35-mph cycles. Hence, it was necessary to weight the freeway and nonfreeway matrix sets to obtain matrices which would provide cycles with the proper average speeds. Since the average nonfreeway speed was 20.1 mph and the average freeway speed was 42.2 mph for the combined GM/CAPE-10 data, multiplication of the freeway matrices by a weighting factor greater than unity and then adding the corresponding nonfreeway matrices yields a resulting matrix set with a speed somewhere between 20.1 mph and 42.2 mph. The weighting factor to yield the desired average speed was computed from:

$$W = \frac{T_{NF}\ (S_D - S_{NF})}{T_F\ (S_F - S_D)},$$

where

W = weighting factor
T_{NF} = total nonfreeway time
T_F = total freeway time
S_D = desired average speed
S_{NF} = average nonfreeway speed
S_F = average freeway speed.

For example, the weighting factor for a desired average speed of 30 mph was computed as follows:

S_{NF} = 20.1 mph
S_F = 42.2 mph
S_D = 30.0 mph
T_{NF} = 1574.19 hours
T_F = 384.76 hours

$$W = \frac{1574.19\ (30.0-20.1)}{384.76\ (42.2-30.0)}$$

$$= 3.32$$

The weighting factors for desired speeds of 30 mph and 35 mph were 3.32 and 8.455, respectively, Thus, the freeway matrices were multiplied by the appropriate weighting factor and added to the nonfreeway matrices to yield a matrix set with which cycles at the desired average speed could be generated. This procedure yielded ten good cycles at each average speed of 30 mph and 35 mph.

The GM/CAPE-10 freeway matrix set yielded good cycles at 40 mph, so no special procedures were required to obtain the ten-cycle sample. That same matrix set also yielded three cycles at 45 mph which satisfied the statistical filter. These three cycles were augmented with seven cycles obtained from the GM rural data matrix set.

To obtain cycles with average speeds of 50 mph and 55 mph, the truncation technique was again employed. Now, however, the lower speeds were deleted. The ten 50-mph cycles were obtained from a matrix set with initial/final speeds of 0, 40, 45, 50, 55, and 60 mph. A matrix set with initial/final speeds of 0, 50, 55, and 60 mph was used to generate the sample of 55-mph cycles. The matrices used for each average speed are summarized in Table 5-1, where NF is nonfreeway, F is freeway, and WF is weighted freeway.

Table 5-1. SUMMARY OF MATRICES BY AVERAGE SPEED

AVERAGE SPEED	MATRIX SIZE	SPEED RANGE	MATRIX TYPE
5 mph	4 x 4	0-15	NF
10 mph	6 x 6	0-25	NF
15 mph	8 x 8	0-35	NF
20 mph	13 x 13	0-60	NF
25 mph	13 x 13	0-60	F + NF
30 mph	13 x 13	0-60	WF + NF
35 mph	13 x 13	0-60	WF + NF
40 mph	13 x 13	0-60	F
45 mph	13 x 13	0-60	F, Rural
50 mph	6 x 6	0, 40-60	F
55 mph	4 x 4	0, 50-60	F

A total sample of 110 cycles, 10 each at speeds of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, and 55 mph was thus generated for input to the emissions and fuel economy estimating program.

Summary statistics for the cycle averages at each nominal average speed are shown in Table 5-2 and the statistics for each individual cycle are given in Appendix D. The percentage parameter data in Table 5-2 are plotted against average speed in Figures 5-1 and 5-2.

5.2 ESTIMATION OF EMISSIONS AND FUEL ECONOMY

EPA-supplied software (Reference 6) was used to estimate HC, CO, and NO_x emissions (in units of grams per mile), and to estimate fuel economy (in units of miles per gallon), using the carbon-balance method, over each of the 10 cycles at each of the 11 average speeds. These computations were based on regression coefficients developed from EPA surveillance programs for each of the 18 model-year groups listed in Table 5-3.

Table 5-2. SUMMARY CYCLE STATISTICS

CYCLE NOMINAL AVERAGE SPEED		% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
5 mph	Mean	48.42	15.17	18.98	17.41	3.97
	Std. Dev.	1.35	1.07	0.50	0.95	0.21
10 mph	Mean	31.84	22.66	25.11	20.39	10.45
	Std. Dev.	1.29	0.89	1.29	0.88	0.21
15 mph	Mean	24.12	27.79	26.42	21.66	15.89
	Std. Dev.	0.52	1.19	0.63	0.69	0.10
20 mph	Mean	16.94	35.17	26.33	21.57	20.75
	Std. Dev.	0.48	0.82	0.89	1.27	0.24
25 mph	Mean	13.44	42.28	24.78	19.51	25.28
	Std. Dev.	0.57	1.29	1.35	1.40	0.35
30 mph	Mean	10.12	49.05	22.25	18.58	30.38
	Std. Dev.	0.39	1.83	1.02	1.05	0.58
35 mph	Mean	6.75	57.04	19.67	16.53	35.35
	Std. Dev.	0.61	1.70	1.31	1.01	0.27
40 mph	Mean	3.10	64.82	17.36	14.72	40.66
	Std. Dev.	0.51	1.27	0.80	0.77	0.19
45 mph	Mean	2.36	69.95	15.03	12.67	45.25
	Std. Dev.	0.37	2.05	1.80	0.87	1.26
50 mph	Mean	2.45	72.82	13.41	11.32	50.83
	Std. Dev.	0.14	1.44	0.84	0.79	0.15
55 mph	Mean	2.03	79.21	9.82	8.94	54.65
	Std. Dev.	0.27	1.39	0.62	0.72	0.34

FIGURE 5-1

% IDLE AND % CRUISE VS. SPEED

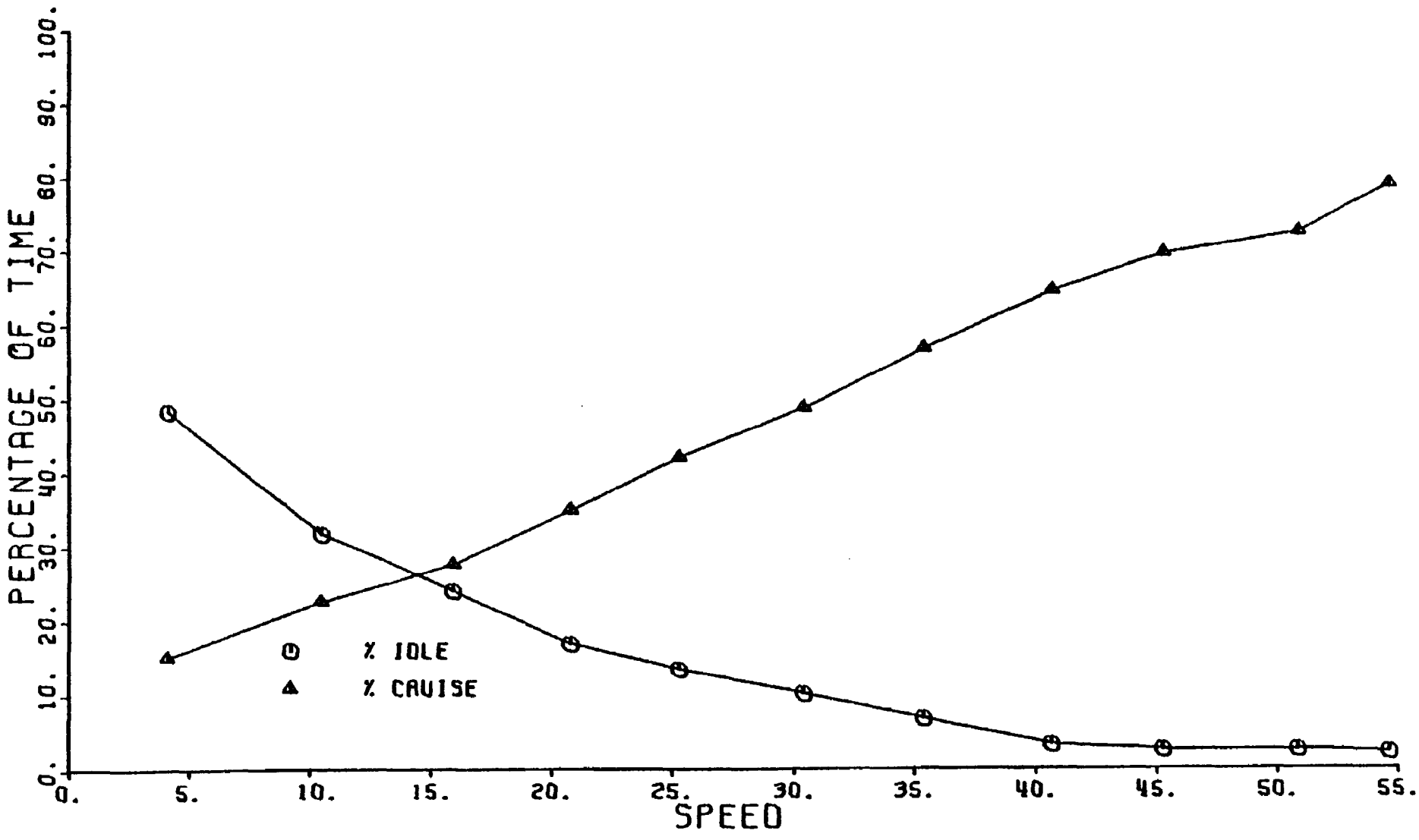


FIGURE 5-2

% ACCELERATION AND % DECELERATION VS. SPEED

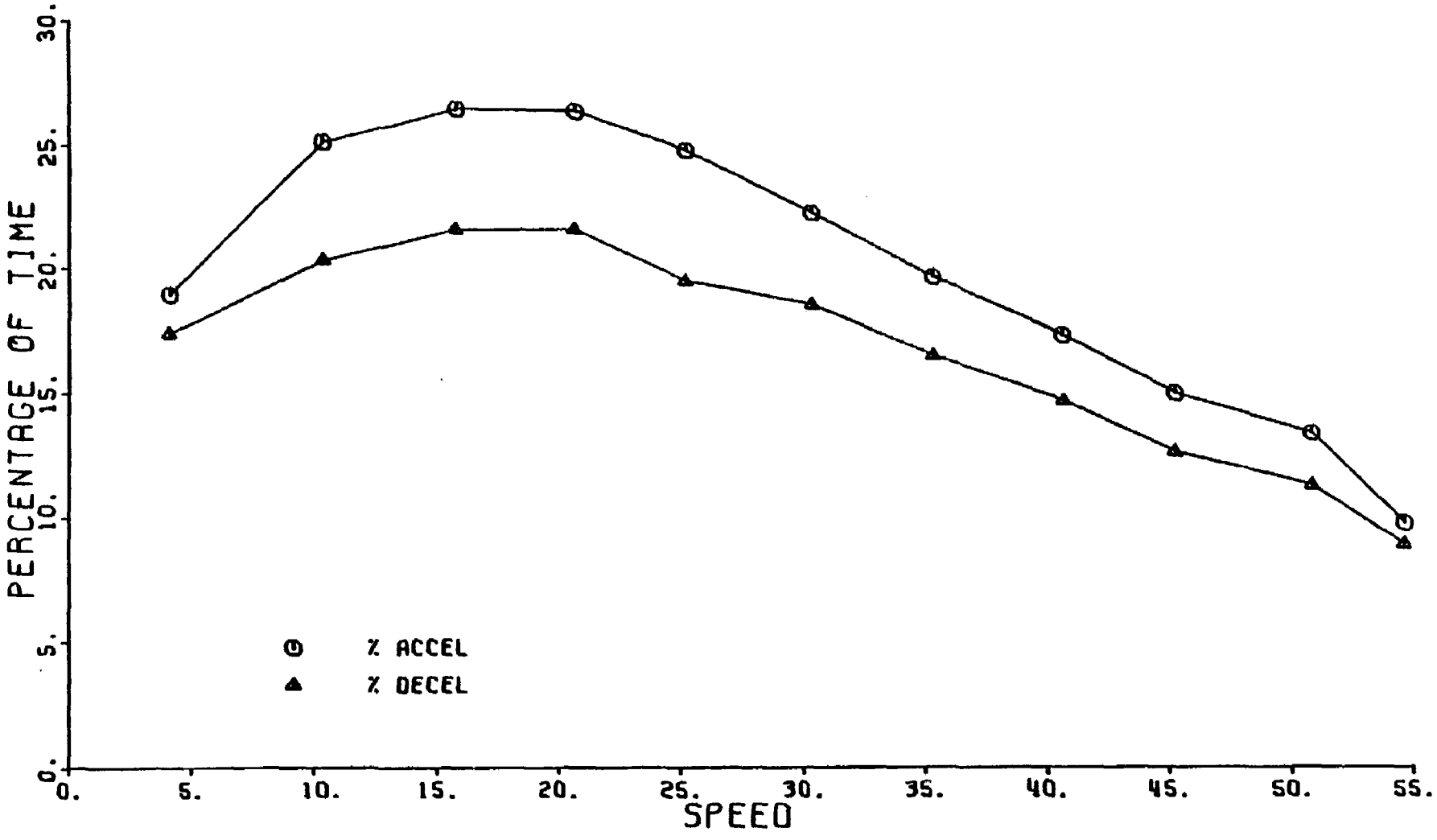


Table 5-3. MODEL-YEAR GROUPS

Group 1:	1957 - 1967 (Denver)
Group 2:	1957 - 1967 (Low altitude, No 1966, 1967 California)
Group 3:	1966 - 1967 (California)
Group 4:	1968 (Low altitude)
Group 5:	1969 (Low altitude)
Group 6:	1970 (Low altitude)
Group 7:	1971 (Low altitude)
Group 8:	1968 (Denver)
Group 9:	1969 (Denver)
Group 10:	1970 (Denver)
Group 11:	1971 (Denver)
Group 12:	1972 (Denver)
Group 13:	1972 (Los Angeles)
Group 14:	1972 (Low altitude)
Group 15:	1973 - 1974 (Denver)
Group 16:	1973 - 1974 (Los Angeles)
Group 17:	1973 - 1974 (Low altitude)
Group 18:	1975 (Low altitude)

The emissions and fuel economy data, together with average speed and group number, were computer-punched on cards to yield a comprehensive data deck for performance of the regression analysis necessary for development of the desired relationships.

5.3 REGRESSION ANALYSIS

In a study conducted in 1973 (Reference 5), HC, CO, and NO_x emissions were regressed on average speeds ranging from about 15 mph to 45 mph for Model-Year Groups 1 through 11. At that time it was found that the best curve fits were obtained when the natural logarithm of HC (and CO) was regressed on a second-order polynomial function of average speed and when NO_x emissions were expressed as a linear function of average speed. Fuel economy was not estimated for that study.

For purposes of the present study, each of the dependent variables (HC, CO, NO_x, and FE), as well as the natural logarithm of each, was regressed on polynomial functions of average speed up to sixth-order. Analysis of the two sets of output showed the regressions using the natural logarithm of HC and CO to provide the best fit to the data for these emissions. The fuel economy and NO_x data, however, were best fit with ordinary polynomial functions of average speed. Further, the HC and CO fits were optimized when a fifth-order polynomial was utilized; and the NO_x and fuel economy fits were best accomplished with fourth-order polynomials. The regression equations for each of the 18 model-year groups are given in Appendix E. Those equations yield emissions and fuel economy estimates in units of grams per mile and miles per gallon, respectively. Appendix F gives plots of the second-order through fifth-order regressions for HC and CO and the second-order through fourth-order regressions for NO_x and fuel economy for Model-Year Group 4.

5.4 NORMALIZATION OF RELATIONSHIPS

Normalization of the regression equations to yield correction-factor equations whose computed values would be 1.0 at 19.6 mph was accomplished for the two different functional forms.

In the case of HC and CO, the emission as a function of speed, E(S), is given by:

$$E(S) = e^{f(S)},$$

where f(S) is the polynomial

$$f(S) = A_0 + A_1S + A_2S^2 + A_3S^3 + A_4S^4 + A_5S^5,$$

and A_0 through A_5 are the regression coefficients. The normalized value of E, $E_N(S)$, is thus given by:

$$E_N(S) = \frac{e^{f(S)}}{E(19.6)}$$

$$= \exp\,(A_0 - \ln E(19.6) + A_1S + ... + A_5S^5).$$

That is, the regression coefficient A_0 is replaced by the new coefficient $A_0 = A_0 - \ln E(19.6)$, and all other coefficients remain the same.

Since NO_x and fuel economy were nonlogarithmic functions of a fourth-order polynomial of speed, each of them was normalized simply by computing the value at 19.6 mph and then dividing each regression coefficient by that value. For example, the normalized fuel economy equations are of the form:

$$FE_N(S) = A_0' + A_1'S + A_2'S^2 + A_3'S^3 + A_4'S^4,$$

where $A_i' = A_i/FE(19.6)$, $i = 0,....,4$, and the A_i are the original regression coefficients.

The normalized regression equations for each of the 18 model-year groups are given in Appendix G. The standard error of the estimate for each normalized equation, in correction-factor units, was obtained by dividing the standard error of the estimate for the nonnormalized equation by the normalizing factor. Plots of those equations revealed the HC curves to have essentially the same shape for all 18 groups. This was also true of the CO and fuel economy curves. Appendix F shows the typical curve shapes for HC, CO, and fuel economy. The data values have also been plotted in the figures of Appendix F to illustrate the rather small amount of variability in the HC, CO, and fuel economy data at each speed. The NO_x curves, however, showed a wide variation in shape, particularly below 20 mph. Appendix H shows the NO_x-speed relationship for each group. The reasons for the NO_x curve-shape differences, particularly below 20 mph, have not been identified at this point in time, but EPA surveillance data appear to support the findings.

5.5 COMPOSITE EQUATIONS

The final task in the development of emissions/average speed relationships was the production of a single composite equation for each of low-altitude and

high-altitude cities. EPA-supplied weighting factors for the distribution of vehicles in the national population as of the time of the study are given in Table 5-4.

Table 5-4. WEIGHTING FACTORS BY VEHICLE AGE

AGE, YEARS	MODEL YEAR	WEIGHT
0	1976	0.0
1	1975	0.112
2	1974	0.143
3	1973	0.130
4	1972	0.121
5	1971	0.108
6	1970	0.094
7	1969	0.079
8	1968	0.063
9	1967	0.047
10	1966	0.032
11	1965	0.019
12	1964	0.013
13	1963 and earlier	0.039

The Denver groups comprised the high-altitude data base and the low-altitude data base consisted of the remaining groups with the exception of Group 3.

It should be noted here that Automotive Testing Laboratories (ATL) found that the national weightings were not very accurate in the case of Denver where the DVMT for older cars was higher than for the rest of the country. For location-specific computations, then, it is recommended that the methodology used herein be utilized with ATL weighting factors.

Since the groups do not correspond on a one-to-one basis with model year, it was necessary to revise the weighting factors in order to obtain the composite equations. It was assumed that both high-altitude and low-altitude vehicles were distributed in accordance with the data of Table 5-4. Since no 1975 Denver data were available, the weighting factors for the high-altitude composite were renormalized as shown in Table 5-5.

Table 5-5. HIGH-ALTITUDE WEIGHTING FACTORS

GROUP	ORIGINAL WEIGHT	RECOMPUTED WEIGHT
1	0.150	0.1689
8	0.063	0.0709
9	0.079	0.0890
10	0.094	0.1059
11	0.108	0.1216
12	0.121	0.1363
15	0.273	0.3076
	0.088	1.0000

The weighting factors for the low-altitude composite are given in Table 5-6.

Table 5-6. LOW-ALTITUDE WEIGHTING FACTORS

GROUP	WEIGHT
2	0.1500
4	0.0630
5	0.0790
6	0.0940
7	0.1080
13	0.0605
14	0.0605
16	0.1365
17	0.1365
18	0.1120

In both tables, the weights for groups with more than one model-year are the sum of the weights for the constituent model years.

The development of the composite equations for NO_x and fuel economy was mathematically simple. For example, the normalized composite for fuel economy, FE_{NC}, is given by:

$$FE_{NC} = \sum W_i \, f_i(S),$$

where W_i is the weighting factor for the ith group and $f_i(S)$ is the polynomial function of speed for the ith group. This is equivalent, of course, to computing the coefficients directly from:

$$A'_k = \sum W_i \, A_{ik},$$

where A'_k is the kth coefficient of the composite equation, W_i is the weighting factor for the ith group, and A_{ik} is the kth coefficient of the normalized regression function for the ith group.

In the case of the normalized composite equations for HC and CO, mathematical complexity was avoided with a regression procedure. The equation for each group in the desired composite was used to compute a value for every 5 mph from 5 mph to 55 mph. The values for each group for each speed were then weighted by the group's weighting factor. That is, the composite value for each speed S is given by:

$$E_C(S) = \sum W_i \, E_i(S),$$

where W_i is the weight for the ith group and $E_i(S)$ is the normalized value computed from the equation for the ith group. The resulting set of 11 points was then fit by an exponential fifth-order function of speed to yield the desired composite. It should be noted that this procedure, in each case, yielded a fit to the 11 points with a standard error of the estimate of essentially zero.

The normalized composite equations are given in Tables 5-7 and 5-8 for the high-altitude and low-altitude cases, respectively. Plots of the composite equations are shown in Figures 5-3 through 5-10. The standard errors of the estimate shown in Figures 5-3 through 5-10 are given in correction-factor units and were computed as the rms values of the normalized standard errors of the estimate of the constituent groups. Recapitulating, the equations in Tables 5-7 and 5-8 and in Appendices E and G have the following forms:

$$\ln HC = A_0 + A_1 S + A_2 S^2 + A_3 S^3 + A_4 S^4 + A_5 S^5$$

$$\ln CO = A_0 + A_1 S + A_2 S^2 + A_3 S^3 + A_4 S^4 + A_5 S^5$$

$$NO_x = A_0 + A_1 S + A_2 S^2 + A_3 S^3 + A_4 S^4$$

$$FE = A_0 + A_1 S + A_2 S^2 + A_3 S^3 + A_4 S^4$$

Since these regression equations are based on speeds ranging from 5 mph to 55 mph, extrapolations to speeds outside that range should not be made. Examination of the figures for the HC and CO plots, for example, shows an accelerating reduction for speeds greater than 55 mph. That reduction is, of course, an artifact of the chosen polynomial which is not data-constrained beyond the range of the input data.

Table 5-7. HIGH-ALTITUDE COMPOSITE

VARIABLE	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E
ln HC	2.15405E00	-2.86990E-01	1.60889E-02	-4.85447E-04	7.21563E-06	-4.12845E-08	.0252
ln CO	2.04796E00	-3.04407E-01	1.91346E-02	-6.26621E-04	9.86736E-06	-5.89447E-08	.0373
NO_x	1.76943E00	-1.54423E-01	9.10244E-03	-1.92134E-04	1.40357E-06	0.0	.0244
FE	6.18918E-03	9.83255E-02	-3.44293E-03	6.00301E-05	-4.10472E-07	0.0	.0125

Table 5-8. LOW-ALTITUDE COMPOSITE

VARIABLE	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E
ln HC	2.34303E00	-3.06961E-01	1.74062E-02	-5.46045E-04	8.40516E-06	-4.95135E-08	.0350
ln CO	2.62736E00	-3.41296E-01	1.94581E-02	-6.21813E-04	9.73974E-06	-5.82392E-08	.0304
NO_x	1.02978E00	-2.73922E-02	2.15752E-03	-5.06867E-05	4.05999E-07	0.0	.0263
FE	3.48926E-02	8.55822E-02	-2.56869E-03	4.20651E-05	-2.86277E-07	0.0	.0135

FIGURE 5-3

HIGH-ALTITUDE COMPOSITE: NORMALIZED HC VS SPEED

(S.E.E.=.0252)

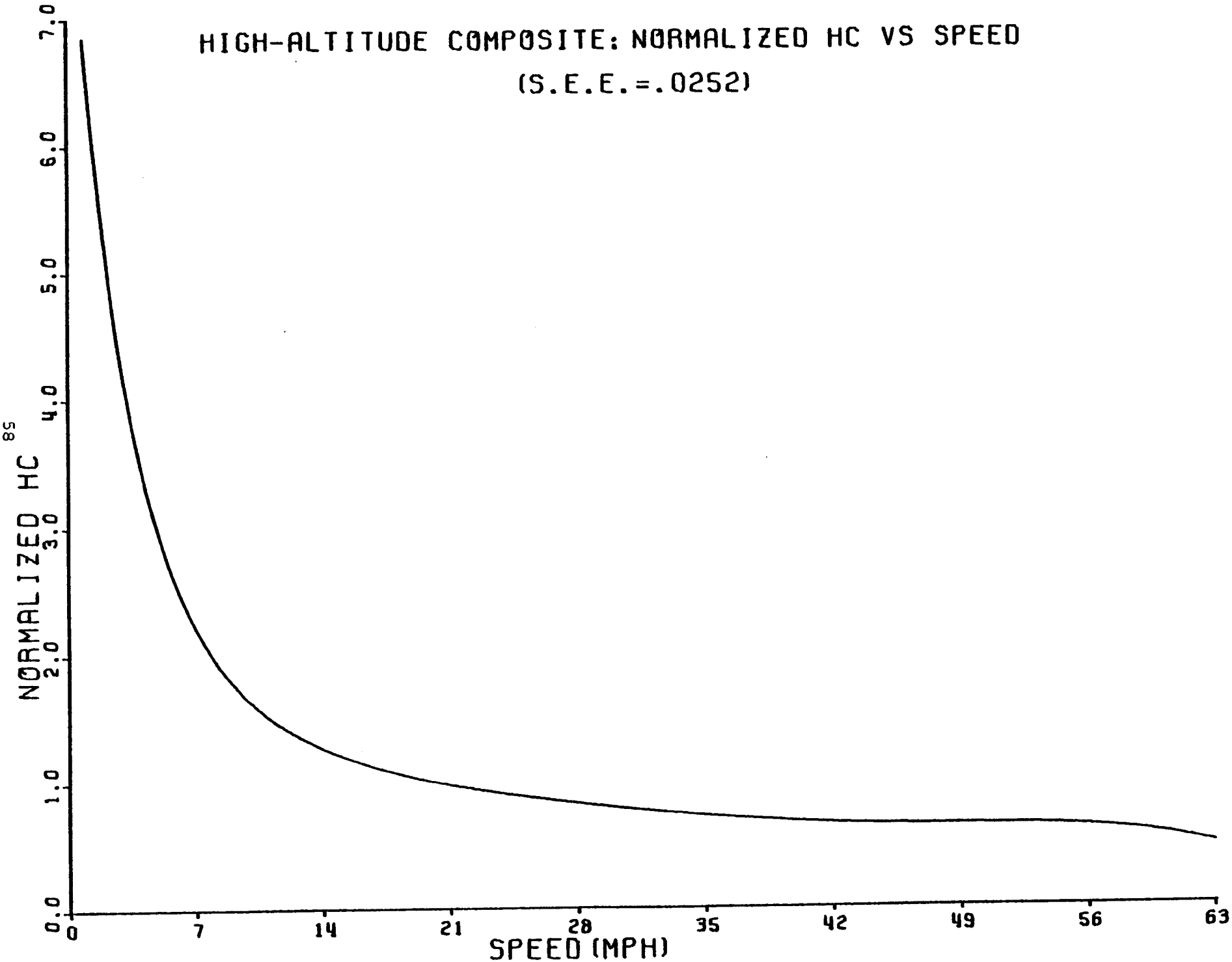


FIGURE 5-4

HIGH-ALTITUDE COMPOSITE: NORMALIZED CO VS SPEED

(S.E.E.=.0373)

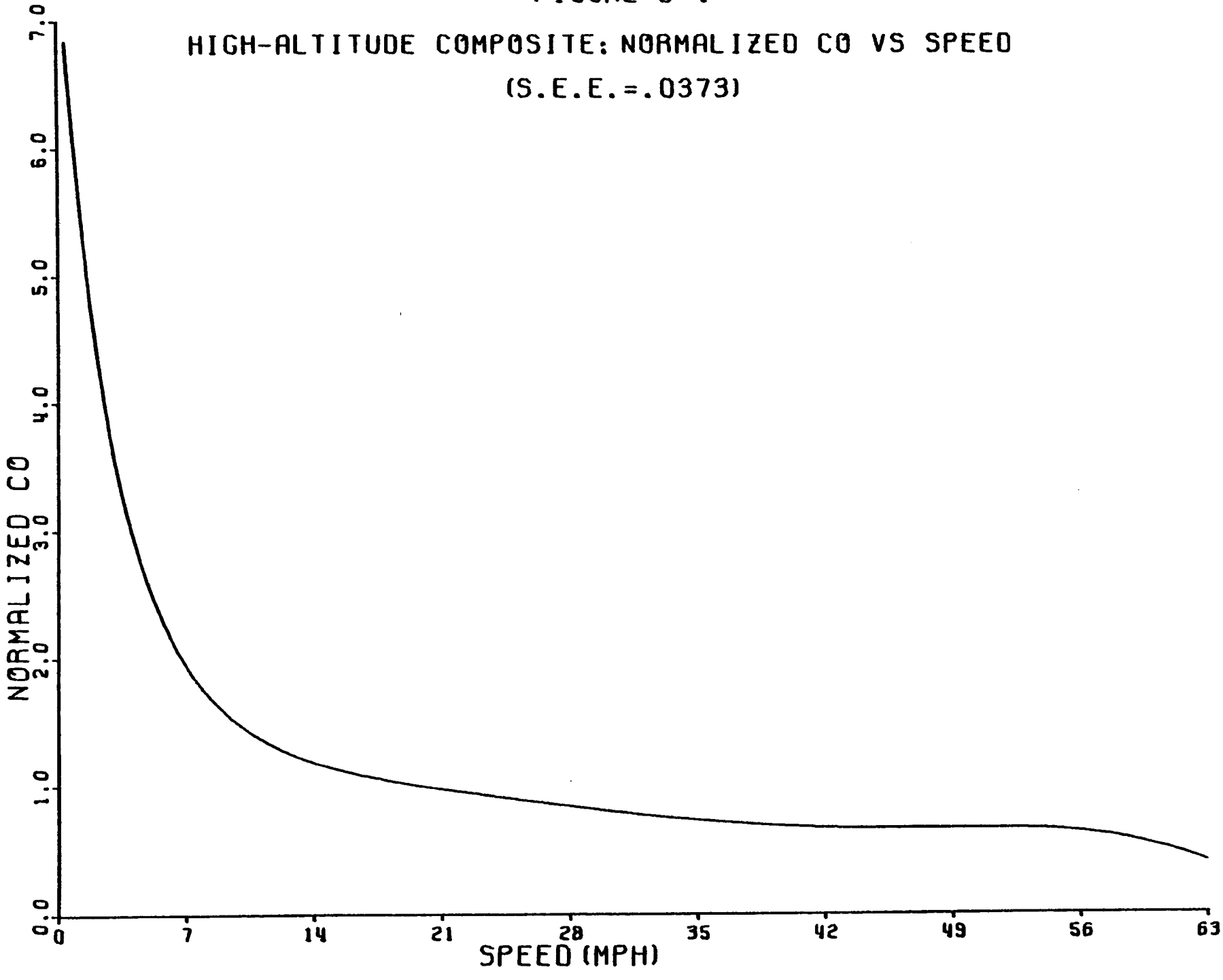


FIGURE 5-5

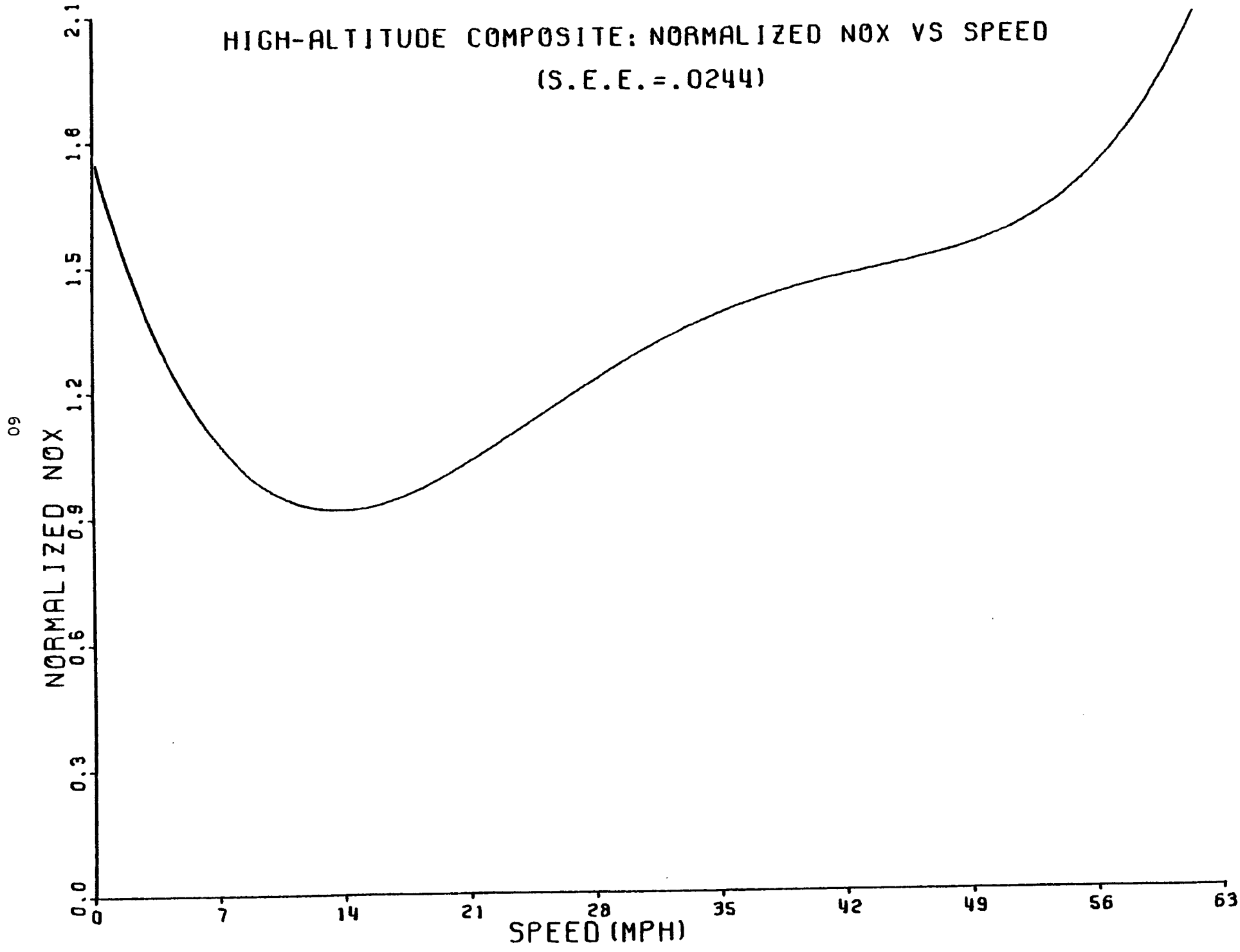

HIGH-ALTITUDE COMPOSITE: NORMALIZED NOX VS SPEED
(S.E.E.=.0244)
NORMALIZED NOX
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

FIGURE 5-6

HIGH-ALTITUDE COMPOSITE: NORMALIZED FE VS SPEED

(S.E.E.=.0125)

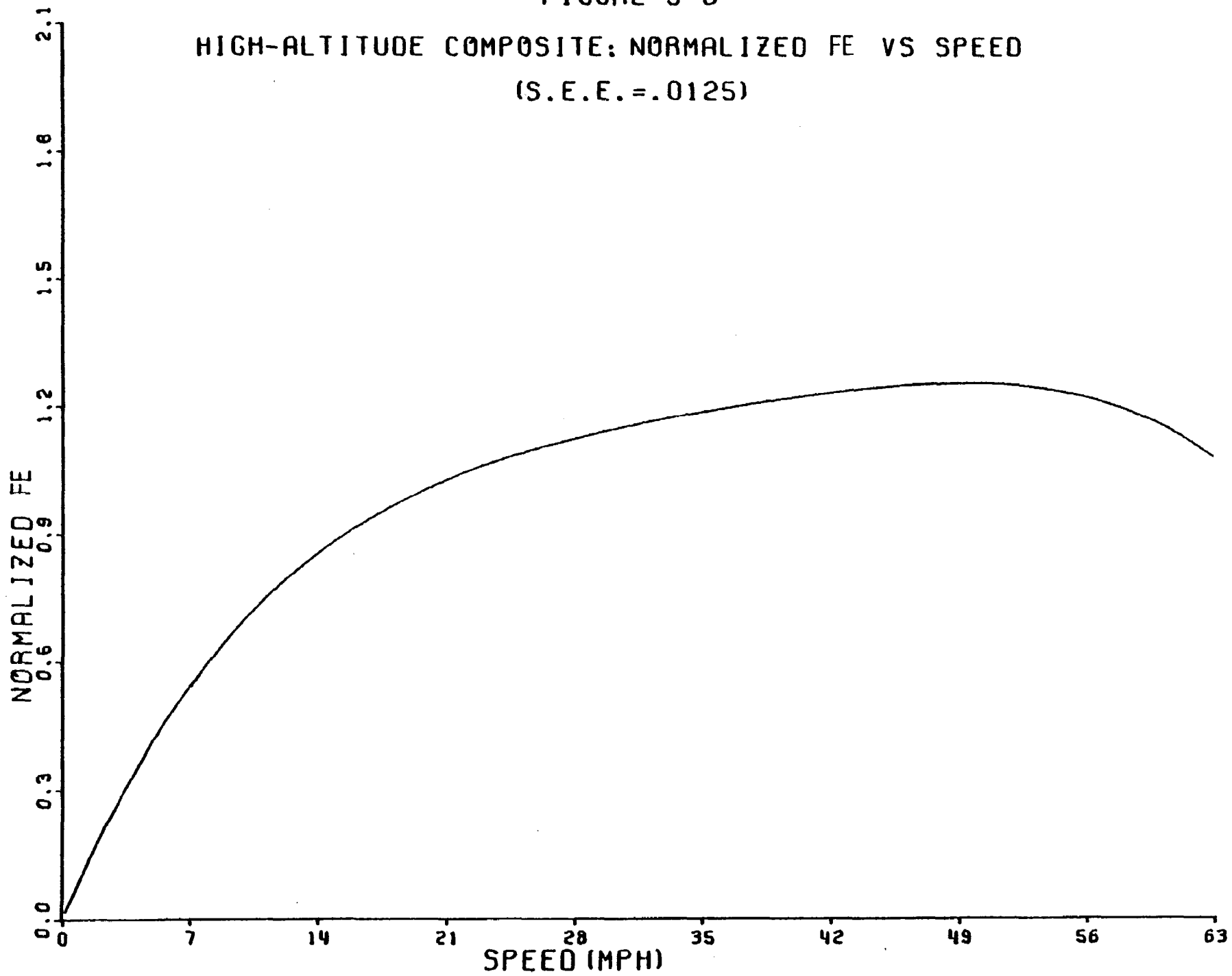


FIGURE 5-7

LOW-ALTITUDE COMPOSITE: NORMALIZED HC VS SPEED

(S.E.E.=.0350)

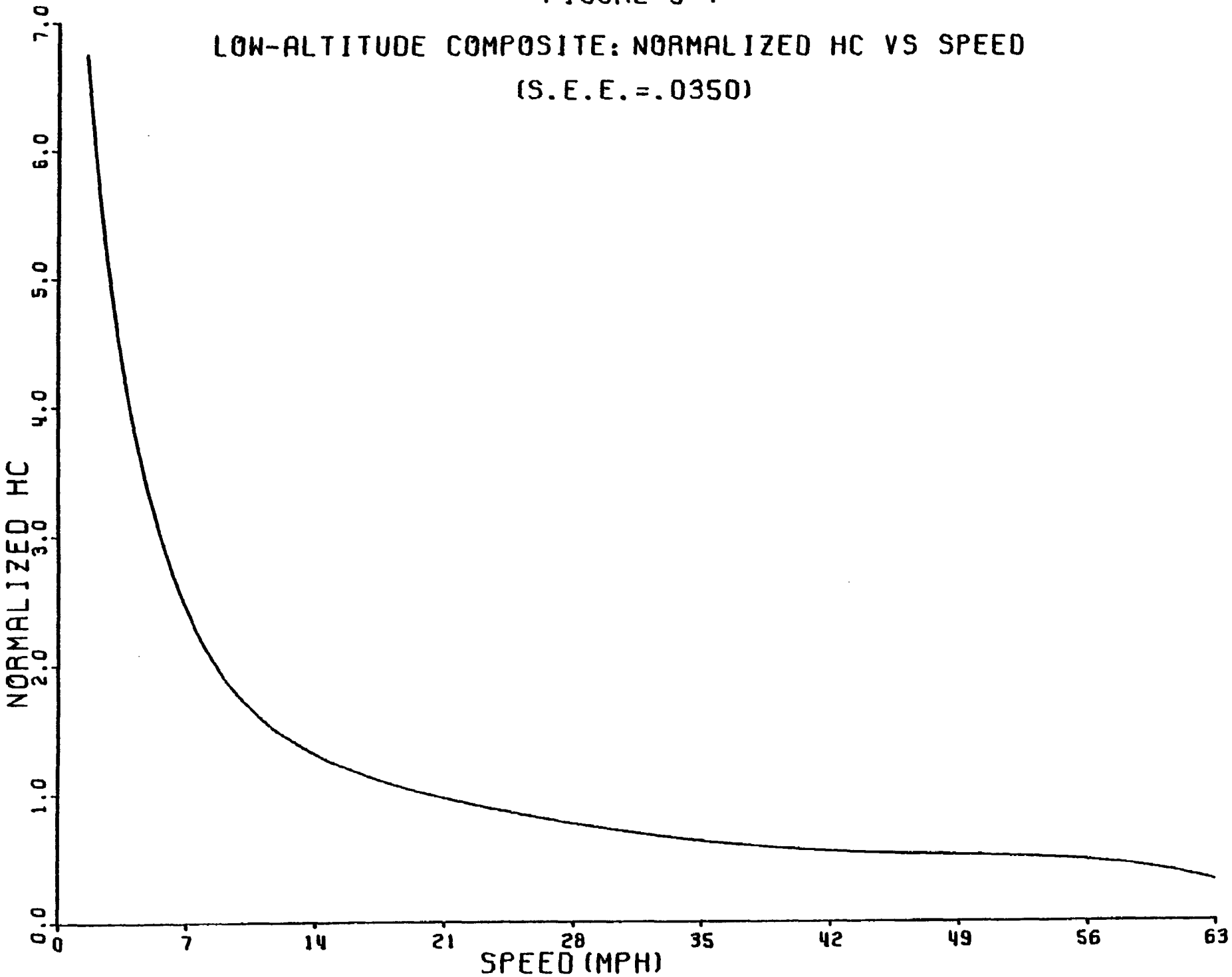


FIGURE 5-8

LOW-ALTITUDE COMPOSITE: NORMALIZED CO VS SPEED

(S.E.E.=.0304)

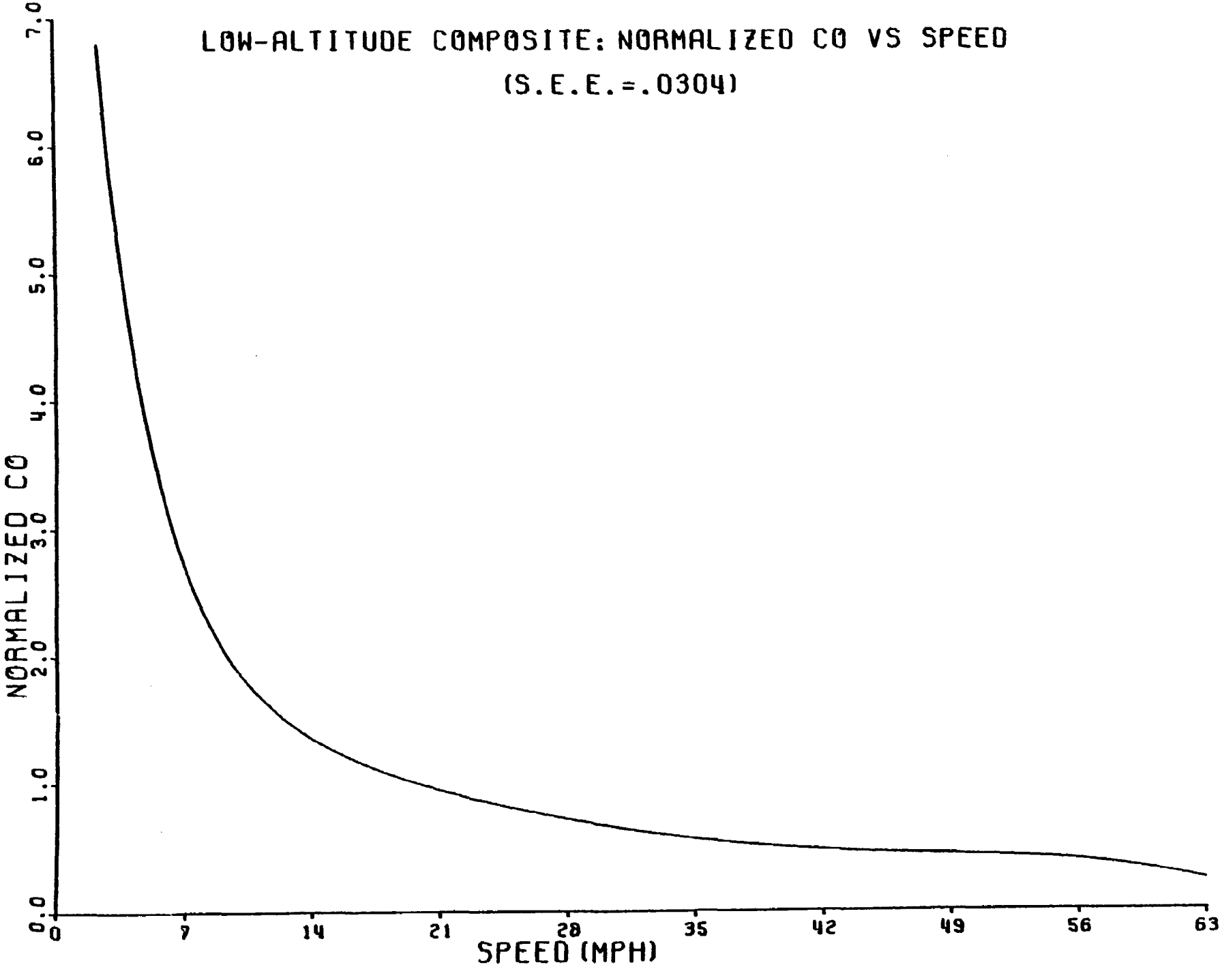


FIGURE 5-9

LOW-ALTITUDE COMPOSITE: NORMALIZED NOX VS SPEED

(S.E.E.=.0263)

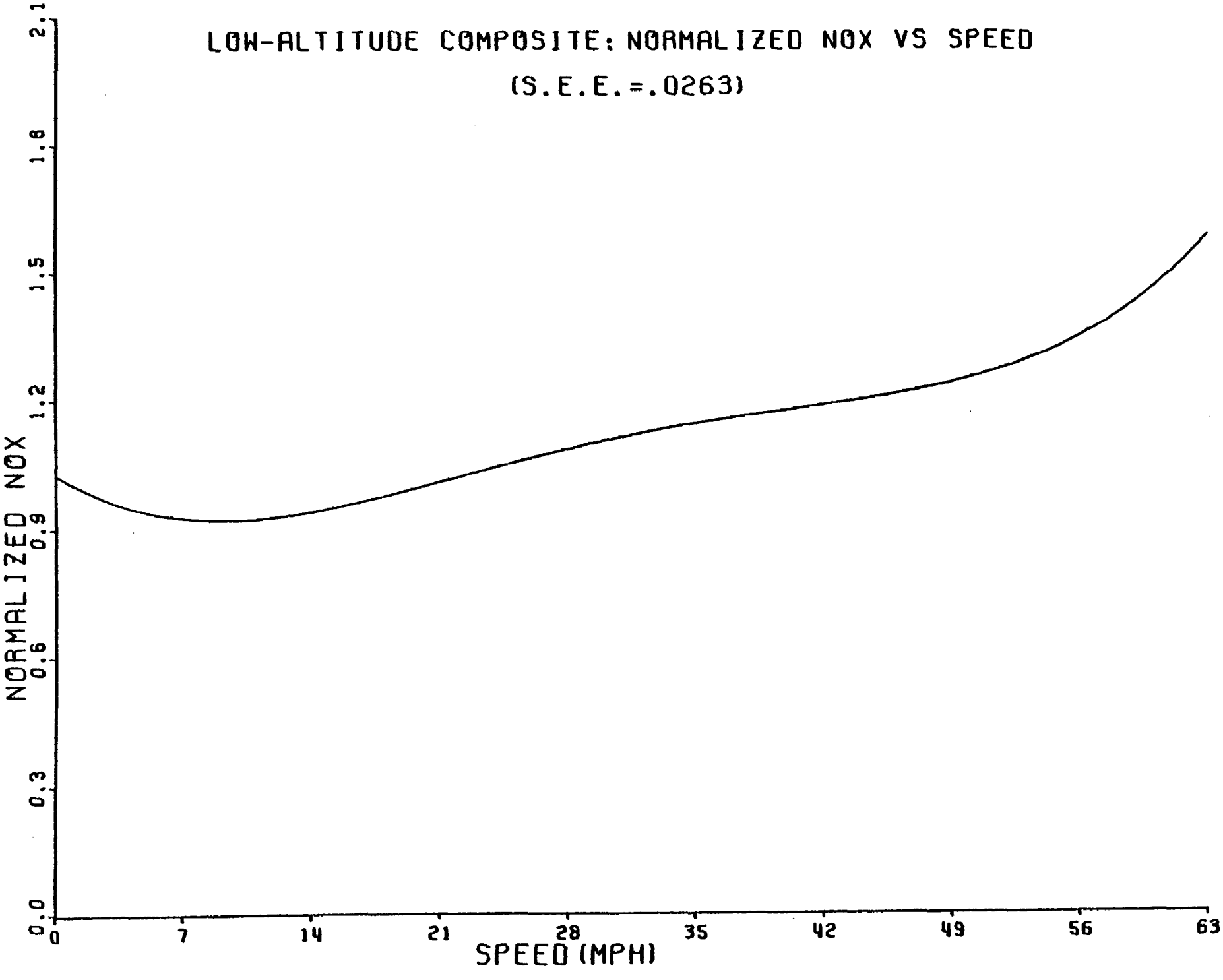
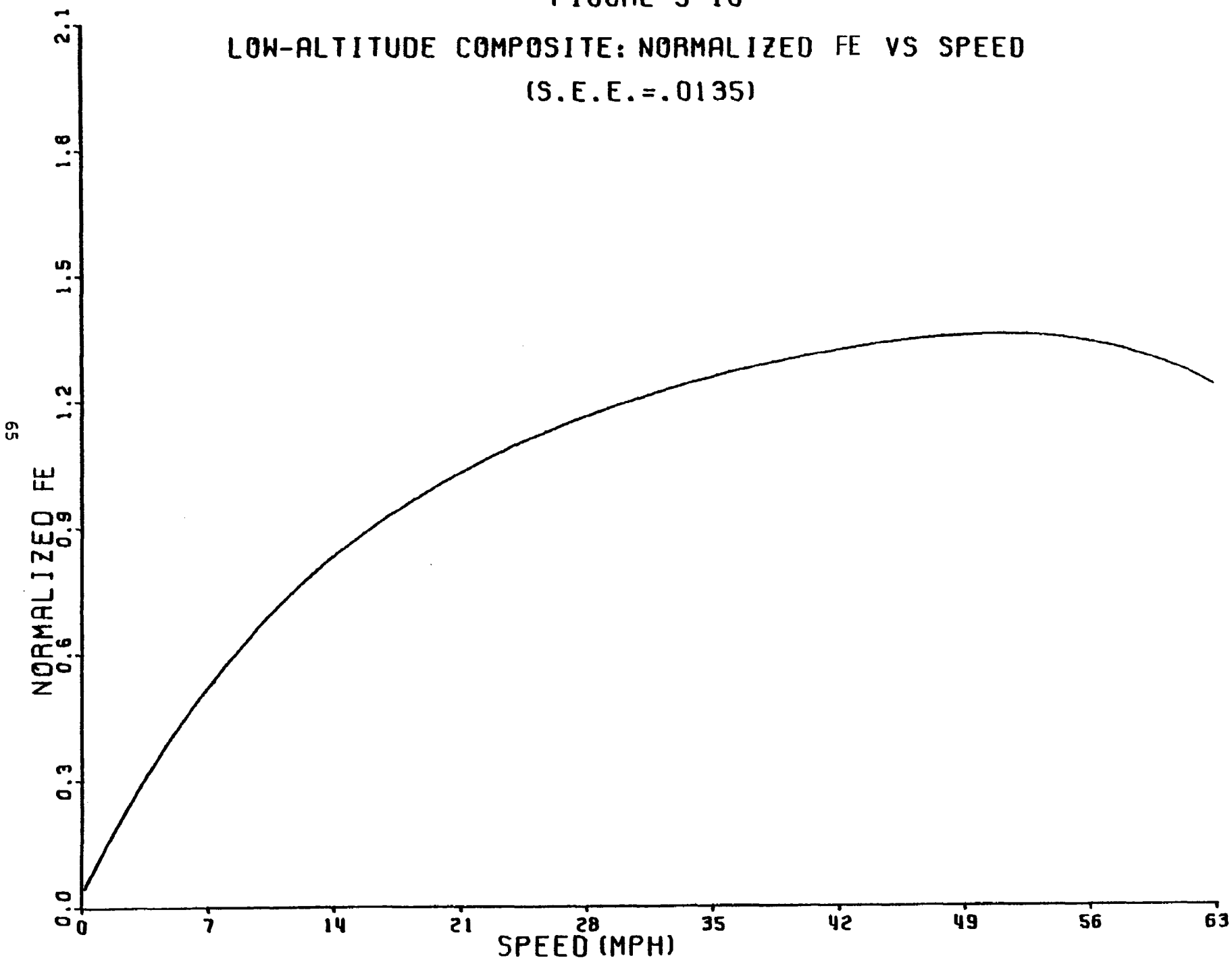


FIGURE 5-10

LOW-ALTITUDE COMPOSITE: NORMALIZED FE VS SPEED

(S.E.E.=.0135)



REFERENCES

1. "Vehicle Operations Survey," Volume 1, Final Report for CRC APRAC Project No. CAPE 10-68, Scott Research Laboratories, Inc., December 17, 1971.

2. Smith, Malcolm and Michael Manos, "Determination and Evaluation of Urban Vehicle Operating Patterns," paper No. 72-177 presented at the 65th Meeting of the Air Pollution Control Association, June 18-22, 1972.

3. Smith, Malcolm and David Weston, "A Technique for Generating Representative Driving Cycles," paper No. 72-165 presented at the 65th Meeting of the Air Pollution Control Association, June 18-22, 1972.

4. Smith, Malcolm and David Weston, "Construction of Chassis Dynamometer Test Cycles," Volume I, Final Report, Scott Research Laboratories, Inc., SRL Report No. 2948-06-0871, November 18, 1971.

5. Smith, Malcolm, "Development of Representative Driving Patterns at Various Average Route Speeds," Final Report, Scott Research Laboratories, Inc., SRL Report No. 2148-07-0274, February 11, 1974.

6. Kunselman, P. et al, "Automobile Exhaust Emission Modal Analysis Model," Report No. EPA 460/3-74-005, January 1974.

Appendix A

STATISTICS FOR UNWEIGHTED GM DATA

For the following data samples,

1. 12-city total, urban follows only
2. 12-city total, for all follows
3. Rural data, for rural follows only
4. Rural data, for all follows
5. Urban-rural follow data
6. Urban data, for urban follows only
7. Urban data, for all follows
8. Total data sample

the following statistics are contained in this appendix:

1. Road Type versus Traffic Density in miles, percentage of miles, time, and percentage of time.

2. Average speed for each road type and each traffic density.

3. Time percentage of time, miles, percentage of miles, and average speed, in each traffic density.

4. Time percentage of time, miles, percentage of miles, average speed, number of trips, and stops per mile on each road type, together with the average number of occurrence per trip for each road type.

5. Speed distribution frequency, percentage frequency, and cumulative percentage frequency.

6. Acceleration-deceleration distribution frequency, percentage frequency, and cumulative percentage frequency.

7. Frequency and percentage frequency in idle, cruise acceleration, and deceleration.

In addition, a summary of follow data is included.

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
12 CITY TOTAL
(MILES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	118.42 41.92	122.81 4.74	3.36 0.65
LIGHT UNINFLUENCED	95.90 33.95	679.93 26.25	17.43 3.39
LIGHT INFLUENCED	27.65 9.79	210.91 8.14	4.94 0.96
MEDIUM UNINFLUENCED	18.02 6.38	593.01 22.90	128.49 24.97
MEDIUM INFLUENCED	19.67 6.96	865.79 33.43	233.66 45.41
HEAVY UNINFLUENCED	0.15 0.05	18.30 0.71	22.47 4.37
HEAVY INFLUENCED	2.64 0.93	92.92 3.59	91.59 17.80
HEAVY STOP AND GO	0.07 0.02	6.23 0.24	12.57 2.44
TOTALS (%)	282.50 100.00	2589.91 100.00	514.50 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
12 CITY TOTAL
(MINUTES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	407.65 40.14	299.97 4.30	5.80 0.84
LIGHT UNINFLUENCED	337.68 33.25	1651.27 23.65	26.07 3.77
LIGHT INFLUENCED	98.50 9.70	524.27 7.51	6.70 0.97
MEDIUM UNINFLUENCED	75.85 7.47	1501.20 21.50	151.58 21.95
MEDIUM INFLUENCED	84.78 8.35	2431.07 34.82	285.38 41.33
HEAVY UNINFLUENCED	0.37 0.04	57.07 0.82	28.57 4.14
HEAVY INFLUENCED	10.32 1.02	434.12 6.22	144.75 20.96
HEAVY STOP AND GO	0.50 0.05	83.57 1.20	41.70 6.04
TOTALS (%)	1015.65 100.00	6982.52 100.00	690.55 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
12 CITY TOTAL
(AVERAGE SPEED)
(MPH)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	17.43	24.57	34.79
LIGHT UNINFLUENCED	17.04	24.71	40.11
LIGHT INFLUENCED	16.84	24.14	44.23
MEDIUM UNINFLUENCED	14.25	23.70	50.86
MEDIUM INFLUENCED	13.92	21.37	49.12
HEAVY UNINFLUENCED	23.78	19.24	47.19
HEAVY INFLUENCED	15.36	12.84	37.96
HEAVY STOP AND GO	7.80	4.47	18.08

TRAFFIC DENSITY SUMMARY FOR
12 CITY TOTAL
FOR URBAN FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	713.42	8.21	244.59	7.22	20.57
LIGHT UNINFLUENCED	2015.02	23.19	793.26	23.42	23.62
LIGHT INFLUENCED	629.47	7.24	243.50	7.19	23.21
MEDIUM UNINFLUENCED	1728.63	19.90	739.51	21.83	25.67
MEDIUM INFLUENCED	2801.23	32.24	1119.12	33.04	23.97
HEAVY UNINFLUENCED	86.00	0.99	40.92	1.21	28.55
HEAVY INFLUENCED	589.18	6.78	187.15	5.53	19.06
HEAVY STOP AND GO	125.77	1.45	18.86	0.56	9.00
TOTALS	8688.71	100.00	3386.91	100.00	23.39

ROAD TYPE SUMMARY
FOR
12 CITY TOTAL
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	TOTALS
TIME(MIN)	1015.65	6982.52	690.55	8688.71
TIME,%	11.69	80.36	7.95	100.00
MILES	282.50	2589.91	514.50	3386.91
MILES,%	8.34	76.47	15.19	100.00
AVERAGE SPEED (MPH)	16.69	22.25	44.70	23.39
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.26	1.14	1.03	1.18
NUMBER OF TRIPS	915	1649	138	2702
STOPS/MILE	1.43	1.37	0.12	1.19

SPEED DISTRIBUTION
FOR
12 CITY TOTAL
FOR URBAN FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	56097	10.78	10.78
0.1 - 2.5	19494	3.74	14.52
2.5 - 7.5	31136	5.98	20.50
7.5 - 12.5	37917	7.28	27.78
12.5 - 17.5	42840	8.23	36.01
17.5 - 22.5	50145	9.63	45.64
22.5 - 27.5	59433	11.42	57.06
27.5 - 32.5	68485	13.15	70.21
32.5 - 37.5	61182	11.75	81.97
37.5 - 42.5	37411	7.19	89.15
42.5 - 47.5	23158	4.45	93.60
47.5 - 52.5	15275	2.93	96.53
52.5 - 57.5	10830	2.08	98.61
57.5 - 62.5	5624	1.08	99.69
62.5 -100.0	1588	0.31	100.00

ACCEL/DECEL DISTRIBUTION
FOR
12 CITY TOTAL
FOR URBAN FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	88	0.02	0.02
-9.5 - -8.5	12	0.00	0.02
-8.5 - -7.5	57	0.01	0.03
-7.5 - -6.5	207	0.04	0.07
-6.5 - -5.5	645	0.12	0.19
-5.5 - -4.5	2290	0.44	0.64
-4.5 - -3.5	6503	1.25	1.89
-3.5 - -2.5	21987	4.24	6.13
-2.5 - -1.5	28695	5.53	11.66
-1.5 - -0.5	55343	10.67	22.34
-0.5 - 0.5	250343	48.28	70.61
0.5 - 1.5	98857	19.06	89.68
1.5 - 2.5	29212	5.63	95.31
2.5 - 3.5	15584	3.01	98.32
3.5 - 4.5	7329	1.41	99.73
4.5 - 5.5	1249	0.24	99.97
5.5 - 6.5	123	0.02	99.99
6.5 - 7.5	10	0.00	100.00
7.5 - 8.5	1	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	18	0.00	100.00

OPERATIONAL MODE SUMMARY
FOR
12 CITY TOTAL
FOR URBAN FOLLOWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	51832	10.00
CRUISE	198511	38.28
ACCELERATION	152383	29.39
DECELERATION	115827	22.34

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
12 CITY TOTAL
(MILES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	139.71 42.77	161.85 5.08	3.91 0.44
LIGHT UNINFLUENCED	107.46 32.90	845.25 26.52	30.85 3.46
LIGHT INFLUENCED	30.60 9.37	268.85 8.43	10.17 1.14
MEDIUM UNINFLUENCED	21.17 6.48	715.25 22.44	252.32 28.31
MEDIUM INFLUENCED	23.29 7.13	1046.28 32.82	413.88 46.43
HEAVY UNINFLUENCED	0.18 0.06	21.80 0.68	27.44 3.08
HEAVY INFLUENCED	4.21 1.29	121.59 3.81	139.58 15.66
HEAVY STOP AND GO	0.07 0.02	6.91 0.22	13.21 1.48
TOTALS (%)	326.68 100.00	3187.77 100.00	891.35 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
12 CITY TOTAL
(MINUTES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	474.78 40.81	381.43 4.58	6.80 0.60
LIGHT UNINFLUENCED	377.42 32.44	1994.42 23.93	42.93 3.76
LIGHT INFLUENCED	109.13 9.38	650.57 7.80	15.00 1.32
MEDIUM UNINFLUENCED	89.58 7.70	1787.12 21.44	290.00 25.54
MEDIUM INFLUENCED	97.08 8.34	2855.23 34.25	495.92 43.68
HEAVY UNINFLUENCED	0.42 0.04	69.62 0.84	34.33 3.02
HEAVY INFLUENCED	14.45 1.24	508.80 6.10	204.28 17.99
HEAVY STOP AND GO	0.52 0.04	88.32 1.06	46.10 4.06
TOTALS (%)	1163.38 100.00	8335.50 100.00	1135.37 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
12 CITY TOTAL
(AVERAGE SPEED)
(MPH)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	17.66	25.46	34.50
LIGHT UNINFLUENCED	17.08	25.43	43.12
LIGHT INFLUENCED	16.82	24.79	40.67
MEDIUM UNINFLUENCED	14.18	24.01	52.20
MEDIUM INFLUENCED	14.40	21.99	50.07
HEAVY UNINFLUENCED	26.06	18.79	47.95
HEAVY INFLUENCED	17.47	14.34	40.99
HEAVY STOP AND GO	7.55	4.69	17.19

TRAFFIC DENSITY SUMMARY FOR
12 CITY TOTAL
FOR ALL FOLLOWS

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	863.02	8.12	305.46	6.93	21.24
LIGHT UNINFLUENCED	2414.77	22.71	983.56	22.32	24.44
LIGHT INFLUENCED	774.70	7.28	309.61	7.03	23.98
MEDIUM UNINFLUENCED	2166.70	20.37	968.73	22.44	27.38
MEDIUM INFLUENCED	3448.23	32.43	1483.45	33.67	25.81
HEAVY UNINFLUENCED	104.37	0.98	49.42	1.12	28.41
HEAVY INFLUENCED	727.53	6.84	265.38	6.02	21.89
HEAVY STOP AND GO	134.93	1.27	20.18	0.46	8.98
TOTALS	10634.25	100.00	4405.80	100.00	24.86

ROAD TYPE SUMMARY
FOR
12 CITY TOTAL
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	TOTALS
TIME(MIN)	1163.38	8335.50	1135.37	10634.25
TIME,%	10.94	78.38	10.68	100.00
MILES	326.68	3187.77	891.35	4405.80
MILES,%	7.41	72.35	20.23	100.00
AVERAGE SPEED (MPH)	16.85	22.95	47.10	24.86
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.26	1.22	1.06	1.22
NUMBER OF TRIPS	1071	1919	216	3206
STOPS/MILE	1.39	1.28	0.09	1.05

SPEED DISTRIBUTION
FOR
12 CITY TOTAL
FOR ALL FOLLOWS

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY, %	CUMULATIVE FREQUENCY, %
ZERO	64540	11.27	11.27
0.1 - 2.5	22271	3.89	15.16
2.5 - 7.5	35379	6.18	21.34
7.5 - 12.5	43505	7.60	28.93
12.5 - 17.5	49221	8.59	37.53
17.5 - 22.5	57911	10.11	47.64
22.5 - 27.5	69213	12.09	59.72
27.5 - 32.5	80560	14.07	73.79
32.5 - 37.5	75914	13.26	87.04
37.5 - 42.5	48828	8.53	95.57
42.5 - 47.5	31704	5.54	101.11
47.5 - 52.5	23080	4.03	105.14
52.5 - 57.5	20029	3.50	108.63
57.5 - 62.5	11778	2.06	110.69
62.5 -100.0	3315	0.58	111.27

ACCEL/DECEL DISTRIBUTION
FOR
12 CITY TOTAL
FOR ALL FOLLOWS

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	96	0.02	0.02
-9.5 - -8.5	15	0.00	0.02
-8.5 - -7.5	66	0.01	0.03
-7.5 - -6.5	242	0.04	0.07
-6.5 - -5.5	780	0.12	0.19
-5.5 - -4.5	2739	0.43	0.62
-4.5 - -3.5	7645	1.20	1.82
-3.5 - -2.5	25801	4.06	5.89
-2.5 - -1.5	33810	5.33	11.21
-1.5 - -0.5	67671	10.66	21.87
-0.5 - 0.5	310885	48.96	70.83
0.5 - 1.5	121901	19.20	90.03
1.5 - 2.5	34482	5.43	95.46
2.5 - 3.5	18505	2.91	98.38
3.5 - 4.5	8636	1.36	99.74
4.5 - 5.5	1463	0.23	99.97
5.5 - 6.5	153	0.02	99.99
6.5 - 7.5	16	0.00	100.00
7.5 - 8.5	2	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	20	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
12 CITY TOTAL
FOR ALL FOLLOWS

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	59651	9.39
CRUISE	251234	39.57
ACCELERATION	185178	29.17
DECELERATION	138865	21.87

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
RURAL DATA
(MILES)
(%)
FOR RURAL FOLLOWS ONLY

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	58.64 97.90	70.95 56.27	1.13 0.59
LIGHT UNINFLUENCED	0.19 0.32	25.77 20.44	38.85 20.30
LIGHT INFLUENCED	0.96 1.60	19.66 15.59	2.86 1.49
MEDIUM UNINFLUENCED	0.11 0.18	4.64 3.68	80.20 41.91
MEDIUM INFLUENCED	0.0 0.0	5.06 4.01	57.22 29.90
HEAVY UNINFLUENCED	0.0 0.0	0.0 0.0	1.39 0.73
HEAVY INFLUENCED	0.0 0.0	0.0 0.0	9.64 5.04
HEAVY STOP AND GO	0.0 0.0	0.0 0.0	0.09 0.05
TOTALS (%)	59.89 100.00	126.08 100.00	191.38 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
RURAL DATA
(MINUTES)
(%)
FOR RURAL FOLLOWS ONLY

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	98.37	95.90	1.55
TRAFFIC	97.25	55.20	0.77
LIGHT	0.45	34.48	38.70
UNINFLUENCED	0.44	19.85	19.24
LIGHT	2.03	31.42	3.15
INFLUENCED	2.01	18.08	1.57
MEDIUM	0.30	6.35	83.02
UNINFLUENCED	0.30	3.66	41.28
MEDIUM	0.0	5.58	58.85
INFLUENCED	0.0	3.21	29.26
HEAVY	0.0	0.0	1.58
UNINFLUENCED	0.0	0.0	0.79
HEAVY	0.0	0.0	13.86
INFLUENCED	0.0	0.0	6.90
HEAVY	0.0	0.0	0.36
STOP AND GO	0.0	0.0	0.19
TOTALS	101.15	173.73	201.12
(%)	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
RURAL DATA
(AVERAGE SPEED)
(MPH)
FOR RURAL FOLLOWS ONLY

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	35.77	44.39	43.58
LIGHT UNINFLUENCED	25.76	44.84	60.24
LIGHT INFLUENCED	28.25	37.55	54.49
MEDIUM UNINFLUENCED	21.71	43.85	57.96
MEDIUM INFLUENCED	0.0	54.38	58.34
HEAVY UNINFLUENCED	0.0	0.0	52.72
HEAVY INFLUENCED	0.0	0.0	41.64
HEAVY STOP AND GO	0.0	0.0	14.35

TRAFFIC DENSITY SUMMARY FOR
RURAL DATA
FOR RURAL FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	195.82	41.14	130.71	34.64	40.05
LIGHT UNINFLUENCED	73.63	15.47	64.82	17.18	52.82
LIGHT INFLUENCED	36.60	7.69	23.48	6.22	38.49
MEDIUM UNINFLUENCED	89.67	18.84	84.95	22.51	56.84
MEDIUM INFLUENCED	64.43	13.54	62.28	16.50	58.00
HEAVY UNINFLUENCED	1.58	0.33	1.39	0.37	52.72
HEAVY INFLUENCED	13.88	2.92	9.64	2.55	41.64
HEAVY STOP AND GO	0.38	0.08	0.09	0.02	14.35
TOTALS	476.00	100.00	377.36	100.00	47.57

ROAD TYPE SUMMARY
FOR
RURAL DATA
FOR RURAL FOLLOWS ONLY

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	101.15	173.73	201.12	476.00
TIME,%	21.25	36.50	42.25	100.00
MILES	59.89	126.08	191.38	377.36
MILES,%	15.87	33.41	50.72	100.00
AVERAGE SPEED (MPH)	35.53	43.54	57.10	47.57
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.00	1.00	1.00	1.00
NUMBER OF TRIPS	11	37	23	71
STOPS/MILE	0.15	0.06	0.02	0.05

SPEED DISTRIBUTION
FOR
RURAL DATA
FOR RURAL FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	230	0.81	0.81
0.1 - 2.5	138	0.48	1.29
2.5 - 7.5	350	1.23	2.52
7.5 - 12.5	895	3.15	5.67
12.5 - 17.5	439	1.54	7.20
17.5 - 22.5	764	2.68	9.88
22.5 - 27.5	791	2.77	12.65
27.5 - 32.5	1073	3.76	16.41
32.5 - 37.5	2099	7.35	23.76
37.5 - 42.5	2283	8.00	31.76
42.5 - 47.5	2548	8.93	40.69
47.5 - 52.5	3955	13.86	54.55
52.5 - 57.5	4610	16.15	70.70
57.5 - 62.5	3193	11.19	81.89
62.5 -100.0	5170	18.11	100.00

ACCEL/DECEL DISTRIBUTION
FOR
RURAL DATA
FOR RURAL FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	9	0.03	0.03
-9.5 - -8.5	4	0.01	0.05
-8.5 - -7.5	9	0.03	0.08
-7.5 - -6.5	19	0.07	0.14
-6.5 - -5.5	25	0.09	0.23
-5.5 - -4.5	67	0.24	0.47
-4.5 - -3.5	134	0.47	0.94
-3.5 - -2.5	397	1.39	2.33
-2.5 - -1.5	587	2.06	4.39
-1.5 - -0.5	1912	6.72	11.11
-0.5 - 0.5	19463	68.36	79.46
0.5 - 1.5	4793	16.83	96.30
1.5 - 2.5	510	1.79	98.09
2.5 - 3.5	285	1.00	99.09
3.5 - 4.5	190	0.67	99.76
4.5 - 5.5	55	0.19	99.95
5.5 - 6.5	8	0.03	99.98
6.5 - 7.5	0	0.0	99.98
7.5 - 8.5	1	0.00	99.98
8.5 - 9.5	0	0.0	99.98
9.5 - 50.0	5	0.02	100.00

OPERATICNAL MODE SUMMARY
FOR
RURAL DATA
FOR RURAL FOLLCWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	208	0.73
CRUISE	19255	67.63
ACCELERATION	5847	20.54
DECELERATION	3163	11.11

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
RURAL DATA
(MILES)
(%)
FOR ALL FOLLOWS

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	76.07 84.57	152.78 31.92	17.48 1.45
LIGHT UNINFLUENCED	7.49 8.32	127.89 26.72	201.94 16.72
LIGHT INFLUENCED	3.55 3.94	81.24 16.97	15.30 1.27
MEDIUM UNINFLUENCED	1.83 2.04	36.37 7.60	435.45 36.06
MEDIUM INFLUENCED	0.99 1.10	79.79 16.67	388.90 32.21
HEAVY UNINFLUENCED	0.0 0.0	0.06 0.01	31.06 2.57
HEAVY INFLUENCED	0.01 0.01	0.55 0.12	115.20 9.54
HEAVY STOP AND GO	0.01 0.02	0.02 0.00	2.13 0.18
TOTALS (%)	89.95 100.00	478.71 100.00	1207.45 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
RURAL DATA
(MINUTES)
(%)
FOR ALL FOLLOWS

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	145.13	208.37	21.33
TRAFFIC	77.30	32.00	1.57
LIGHT	22.82	163.37	227.12
UNINFLUENCED	12.15	25.09	16.69
LIGHT	8.03	118.88	19.87
INFLUENCED	4.28	18.26	1.46
MEDIUM	8.43	47.83	466.68
UNINFLUENCED	4.49	7.35	34.30
MEDIUM	3.28	111.78	427.68
INFLUENCED	1.75	17.17	31.43
HEAVY	0.0	0.07	36.53
UNINFLUENCED	0.0	0.01	2.68
HEAVY	0.02	0.87	156.18
INFLUENCED	0.01	0.13	11.48
HEAVY	0.03	0.03	5.30
STOP AND GO	0.02	0.01	0.39
TOTALS	187.75	651.20	1360.70
(%)	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
RURAL DATA
(AVERAGE SPEED)
(MPH)
FOR ALL FOLLOWS

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	31.45	43.99	49.17
LIGHT UNINFLUENCED	19.69	46.97	53.35
LIGHT INFLUENCED	26.48	41.00	46.21
MEDIUM UNINFLUENCED	13.05	45.62	55.98
MEDIUM INFLUENCED	18.06	42.83	54.56
HEAVY UNINFLUENCED	0.0	50.22	51.01
HEAVY INFLUENCED	27.20	38.17	44.26
HEAVY STOP AND GO	24.55	42.02	24.09

TRAFFIC DENSITY SUMMARY FOR
RURAL DATA
FOR ALL FOLLOWS

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	374.83	17.04	246.33	13.87	39.43
LIGHT UNINFLUENCED	413.30	18.79	337.32	18.99	48.97
LIGHT INFLUENCED	146.78	6.67	100.09	5.64	40.91
MEDIUM UNINFLUENCED	522.95	23.77	473.65	26.67	54.34
MEDIUM INFLUENCED	542.75	24.67	469.68	26.44	51.92
HEAVY UNINFLUENCED	36.60	1.66	31.11	1.75	51.01
HEAVY INFLUENCED	157.07	7.14	115.76	6.52	44.22
HEAVY STOP AND GO	5.37	0.24	2.17	0.12	24.21
TOTALS	2199.65	100.00	1776.11	100.00	48.45

ROAD TYPE SUMMARY
FOR
RURAL DATA
FOR ALL FOLLOWS

	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	187.75	651.20	1360.70	2199.65
TIME,%	8.54	29.60	61.86	100.00
MILES	89.95	478.71	1207.45	1776.11
MILES,%	5.06	26.95	67.98	100.00
AVERAGE SPEED (MPH)	28.74	44.11	53.24	48.45
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.16	1.25	1.07	1.14
NUMBER OF TRIPS	111	123	212	446
STOPS/MILE	0.36	0.08	0.02	0.06

SPEED DISTRIBUTION
FOR
RURAL DATA
FOR ALL FOLLOWS

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	1064	0.81	0.81
0.1 - 2.5	578	0.44	1.24
2.5 - 7.5	1309	0.99	2.24
7.5 - 12.5	2133	1.62	3.85
12.5 - 17.5	1947	1.48	5.33
17.5 - 22.5	3096	2.35	7.68
22.5 - 27.5	3529	2.68	10.35
27.5 - 32.5	4852	3.68	14.03
32.5 - 37.5	6718	5.09	19.12
37.5 - 42.5	8825	6.69	25.82
42.5 - 47.5	12047	9.13	34.95
47.5 - 52.5	20384	15.45	50.40
52.5 - 57.5	27951	21.19	71.59
57.5 - 62.5	22298	16.91	88.50
62.5 -100.0	15170	11.50	100.00

ACCEL/DECEL DISTRIBUTION
FOR
RURAL DATA
FOR ALL FOLLOWS

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	16	0.01	0.01
-9.5 - -8.5	5	0.00	0.02
-8.5 - -7.5	11	0.01	0.02
-7.5 - -6.5	29	0.02	0.05
-6.5 - -5.5	51	0.04	0.09
-5.5 - -4.5	202	0.15	0.24
-4.5 - -3.5	483	0.37	0.61
-3.5 - -2.5	1738	1.32	1.92
-2.5 - -1.5	2641	2.01	3.93
-1.5 - -0.5	11224	8.52	12.45
-0.5 - 0.5	86592	65.74	78.19
0.5 - 1.5	24723	18.77	96.96
1.5 - 2.5	2357	1.79	98.75
2.5 - 3.5	968	0.73	99.49
3.5 - 4.5	540	0.41	99.90
4.5 - 5.5	100	0.08	99.97
5.5 - 6.5	16	0.01	99.99
6.5 - 7.5	7	0.01	99.99
7.5 - 8.5	3	0.00	99.99
8.5 - 9.5	0	0.0	99.99
9.5 - 50.0	9	0.01	100.00

OPERATICNAL MODE SUMMARY
FOR
RURAL DATA
FOR ALL FOLLOWS

OPERATIONAL MODE	FREQUENCY	FREQUENCY, %
IDLE	961	0.73
CRUISE	85631	65.01
ACCELERATION	28723	21.81
DECELERATION	16400	12.45

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(MILES)
(%)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	23.15	43.18	0.55	17.43	81.83	16.36
TRAFFIC	45.13	6.13	0.14	58.01	23.21	1.61
LIGHT	13.54	199.87	13.96	7.29	102.12	163.09
UNINFLUENCED	26.40	28.35	3.60	24.27	28.96	16.05
LIGHT	5.59	75.63	6.06	2.59	61.58	12.44
INFLUENCED	10.90	10.73	1.56	8.61	17.46	1.22
MEDIUM	3.25	134.64	127.42	1.73	31.73	355.25
UNINFLUENCED	6.34	19.10	32.87	5.74	9.00	34.96
MEDIUM	4.16	218.02	186.04	0.99	74.73	331.67
INFLUENCED	8.11	30.93	47.99	3.29	21.19	32.64
HEAVY	0.04	3.50	4.97	0.0	0.06	29.67
UNINFLUENCED	0.07	0.50	1.28	0.0	0.02	2.92
HEAVY	1.57	29.35	47.99	0.01	0.55	105.57
INFLUENCED	3.05	4.16	12.38	0.03	0.16	10.39
HEAVY	0.0	0.70	0.64	0.01	0.02	2.04
STOP AND GO	0.0	0.10	0.17	0.05	0.01	0.20
TOTALS	51.30	704.88	387.63	30.05	352.62	1016.07
(%)	100.00	100.00	100.00	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(MINUTES)
(%)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	72.45 42.57	88.27 5.64	1.00 0.22	46.77 54.00	112.47 23.55	19.78 1.71
LIGHT UNINFLUENCED	46.32 27.21	403.92 25.83	17.98 3.91	22.37 25.83	128.88 26.99	188.42 16.25
LIGHT INFLUENCED	18.70 10.99	161.68 10.34	9.28 2.02	6.00 6.93	87.47 18.32	16.72 1.44
MEDIUM UNINFLUENCED	14.55 8.55	312.22 19.97	142.62 31.03	8.13 9.39	41.48 8.69	383.67 33.09
MEDIUM INFLUENCED	13.98 8.22	502.63 32.14	219.02 47.65	3.28 3.79	106.20 22.24	368.83 31.81
HEAVY UNINFLUENCED	0.05 0.03	12.55 0.80	5.77 1.25	0.0 0.0	0.07 0.01	34.95 3.01
HEAVY INFLUENCED	4.13 2.43	77.62 4.96	59.53 12.95	0.02 0.02	0.87 0.18	142.30 12.27
HEAVY STOP AND GO	0.02 0.01	4.78 0.31	4.40 0.96	0.03 0.04	0.03 0.01	4.92 0.42
TOTALS (%)	170.20 100.00	1563.67 100.00	459.60 100.00	86.60 100.00	477.47 100.00	1159.58 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(AVERAGE SPEED)
(MPH)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	19.17	29.35	32.81	22.36	43.66	49.61
LIGHT UNINFLUENCED	17.55	29.69	46.59	19.57	47.54	51.93
LIGHT INFLUENCED	17.94	28.07	39.18	25.89	42.24	44.65
MEDIUM UNINFLUENCED	13.41	25.87	53.61	12.73	45.89	55.56
MEDIUM INFLUENCED	17.85	26.03	50.97	18.06	42.22	53.96
HEAVY UNINFLUENCED	42.72	16.75	51.70	0.0	50.22	50.93
HEAVY INFLUENCED	22.75	22.69	48.36	27.20	38.17	44.51
HEAVY STOP AND GO	0.0	8.73	8.75	24.55	42.02	24.85

TRAFFIC DENSITY SUMMARY FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	340.73	8.70	182.50	7.18	32.14
LIGHT UNINFLUENCED	807.88	20.62	499.88	19.66	37.13
LIGHT INFLUENCED	295.85	7.65	163.89	6.45	32.79
MEDIUM UNINFLUENCED	902.67	23.04	654.01	25.72	43.47
MEDIUM INFLUENCED	1213.55	30.99	815.62	32.08	40.31
HEAVY UNINFLUENCED	53.38	1.36	38.23	1.50	42.97
HEAVY INFLUENCED	284.47	7.26	185.03	7.28	39.03
HEAVY STOP AND GO	14.18	0.36	3.41	0.13	14.43
TOTALS	3917.12	100.00	2542.56	100.00	38.95

ROAD TYPE SUMMARY
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS CNLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	170.20	1563.67	459.60	86.60	477.47	1159.58	3917.12
TIME,%	4.35	39.92	11.73	2.21	12.19	29.60	100.00
MILES	51.30	704.88	387.63	30.05	352.62	1016.07	2542.56
MILES,%	2.02	27.72	15.25	1.18	13.87	39.96	100.00
AVERAGE SPEED (MPH)	18.09	27.05	50.60	20.82	44.31	52.57	38.95
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.30	1.63	1.10	1.18	1.36	1.07	1.34
NUMBER OF TRIPS	178	320	84	100	86	189	957
STOPS/MILE	1.21	0.82	0.06	0.77	0.09	0.02	0.29

SPEED DISTRIBUTION
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	10066	4.29	4.29
0.1 - 2.5	3539	1.51	5.79
2.5 - 7.5	5711	2.43	8.22
7.5 - 12.5	7514	3.20	11.42
12.5 - 17.5	8670	3.69	15.11
17.5 - 22.5	11208	4.77	19.89
22.5 - 27.5	13909	5.92	25.81
27.5 - 32.5	17853	7.60	33.41
32.5 - 37.5	21433	9.13	42.54
37.5 - 42.5	19896	8.47	51.01
42.5 - 47.5	19574	8.33	59.34
47.5 - 52.5	25190	10.73	70.07
52.5 - 57.5	32918	14.02	84.08
57.5 - 62.5	25482	10.85	94.93
62.5 -100.0	11903	5.07	100.00

ACCEL/DECEL DISTRIBUTION
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	15	0.01	0.01
-9.5 - -8.5	5	0.00	0.01
-8.5 - -7.5	13	0.01	0.01
-7.5 - -6.5	46	0.02	0.03
-6.5 - -5.5	172	0.07	0.11
-5.5 - -4.5	637	0.27	0.38
-4.5 - -3.5	1605	0.68	1.06
-3.5 - -2.5	5650	2.41	3.47
-2.5 - -1.5	7781	3.32	6.79
-1.5 - -0.5	23320	9.95	16.74
-0.5 - 0.5	135378	57.74	74.48
0.5 - 1.5	45926	19.59	94.07
1.5 - 2.5	7786	3.32	97.39
2.5 - 3.5	3924	1.67	99.06
3.5 - 4.5	1840	0.78	99.85
4.5 - 5.5	298	0.13	99.97
5.5 - 6.5	39	0.02	99.99
6.5 - 7.5	13	0.01	100.00
7.5 - 8.5	3	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	6	0.00	100.00

OPERATIONAL MODE SUMMARY
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	9288	3.96
CRUISE	126090	53.78
ACCELERATION	59835	25.52
DECELERATION	39244	16.74

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MILES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	119.60 41.72	124.98 4.75	3.36 0.65
LIGHT UNINFLUENCED	97.61 34.05	694.24 26.37	17.44 3.36
LIGHT INFLUENCED	27.93 9.74	217.28 8.25	4.94 0.95
MEDIUM UNINFLUENCED	18.03 6.29	595.66 22.78	130.34 25.09
MEDIUM INFLUENCED	20.64 7.20	878.27 33.36	236.76 45.58
HEAVY UNINFLUENCED	0.15 0.05	18.30 0.70	22.47 4.33
HEAVY INFLUENCED	2.64 0.92	93.43 3.55	91.59 17.63
HEAVY STOP AND GO	0.07 0.02	6.23 0.24	12.57 2.42
TOTALS (%)	286.66 100.00	2632.39 100.00	519.47 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MINUTES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	411.80 39.89	304.92 4.30	5.80 0.83
LIGHT UNINFLUENCED	343.90 33.31	1685.30 23.75	26.10 3.75
LIGHT INFLUENCED	100.38 9.72	538.18 7.58	6.70 0.96
MEDIUM UNINFLUENCED	75.88 7.35	1515.58 21.36	153.65 22.06
MEDIUM INFLUENCED	89.23 8.64	2475.08 34.88	289.32 41.53
HEAVY UNINFLUENCED	0.37 0.04	57.07 0.80	28.57 4.10
HEAVY INFLUENCED	10.32 1.00	437.08 6.16	144.75 20.78
HEAVY STOP AND GO	0.50 0.05	83.58 1.18	41.70 5.99
TOTALS (%)	1032.38 100.00	7096.80 100.00	696.58 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(AVERAGE SPEED)
(MPH)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	17.43	24.59	34.79
LIGHT UNINFLUENCED	17.03	24.72	40.10
LIGHT INFLUENCED	16.70	24.22	44.23
MEDIUM UNINFLUENCED	14.25	23.74	50.90
MEDIUM INFLUENCED	13.88	21.29	49.10
HEAVY UNINFLUENCED	23.78	19.24	47.19
HEAVY INFLUENCED	15.36	12.82	37.96
HEAVY STOP AND GO	7.80	4.47	18.08

TRAFFIC DENSITY SUMMARY FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	722.52	8.19	247.94	7.21	20.59
LIGHT UNINFLUENCED	2055.30	23.29	809.30	23.54	23.63
LIGHT INFLUENCED	645.27	7.31	250.15	7.27	23.26
MEDIUM UNINFLUENCED	1745.12	19.77	748.02	21.75	25.72
MEDIUM INFLUENCED	2853.63	32.33	1135.68	33.03	23.88
HEAVY UNINFLUENCED	86.00	0.97	40.92	1.19	28.55
HEAVY INFLUENCED	592.15	6.71	187.66	5.46	19.01
HEAVY STOP AND GO	125.78	1.43	18.86	0.55	9.00
TOTALS	8825.76	100.00	3438.53	100.00	23.38

ROAD TYPE SUMMARY
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	TOTALS
TIME(MIN)	1032.38	7096.80	696.58	8825.76
TIME,%	11.70	80.41	7.89	100.00
MILES	286.66	2632.39	519.47	3438.53
MILES,%	8.34	76.56	15.11	100.00
AVERAGE SPEED (MPH)	16.66	22.26	44.74	23.38
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.26	1.15	1.03	1.18
NUMBER OF TRIPS	932	1686	141	2759
STOPS/MILE	1.44	1.37	0.12	1.19

SPEED DISTRIBUTION
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	57136	10.80	10.80
0.1 - 2.5	19770	3.74	14.54
2.5 - 7.5	31669	5.99	20.53
7.5 - 12.5	38514	7.28	27.81
12.5 - 17.5	43560	8.24	36.05
17.5 - 22.5	50908	9.63	45.68
22.5 - 27.5	60363	11.41	57.09
27.5 - 32.5	69372	13.12	70.21
32.5 - 37.5	62099	11.74	81.95
37.5 - 42.5	38108	7.21	89.16
42.5 - 47.5	23625	4.47	93.62
47.5 - 52.5	15514	2.93	96.56
52.5 - 57.5	10912	2.06	98.62
57.5 - 62.5	5691	1.08	99.70
62.5 -100.0	1597	0.30	100.00

ACCEL/DECEL DISTRIBUTION
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	88	0.02	0.02
-9.5 - -8.5	13	0.00	0.02
-8.5 - -7.5	57	0.01	0.03
-7.5 - -6.5	207	0.04	0.07
-6.5 - -5.5	652	0.12	0.19
-5.5 - -4.5	2330	0.44	0.64
-4.5 - -3.5	6580	1.25	1.88
-3.5 - -2.5	22335	4.24	6.12
-2.5 - -1.5	29132	5.53	11.66
-1.5 - -0.5	56164	10.66	22.32
-0.5 - 0.5	254586	48.33	70.65
0.5 - 1.5	100341	19.05	89.70
1.5 - 2.5	29647	5.63	95.33
2.5 - 3.5	15796	3.00	98.33
3.5 - 4.5	7400	1.40	99.73
4.5 - 5.5	1259	0.24	99.97
5.5 - 6.5	123	0.02	99.99
6.5 - 7.5	10	0.00	100.00
7.5 - 8.5	1	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	18	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

OPERATICNAL MODE	FREQUENCY	FREQUENCY,%
IDLE	52810	10.03
CRUISE	201776	38.31
ACCELERATION	154595	29.35
DECELERATION	117558	22.32

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MILES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	142.75 42.24	168.16 5.04	3.91 0.43
LIGHT UNINFLUENCED	111.16 32.89	894.11 26.79	31.41 3.46
LIGHT INFLUENCED	33.52 9.92	292.91 8.78	11.00 1.21
MEDIUM UNINFLUENCED	21.28 6.30	734.29 22.00	257.76 28.42
MEDIUM INFLUENCED	24.80 7.34	1096.30 32.85	422.80 46.61
HEAVY UNINFLUENCED	0.18 0.05	21.80 0.65	27.44 3.02
HEAVY INFLUENCED	4.21 1.25	122.77 3.68	139.58 15.39
HEAVY STOP AND GO	0.07 0.02	6.93 0.21	13.21 1.46
TOTALS (%)	337.96 100.00	3337.27 100.00	907.10 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MINUTES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	484.25 40.27	393.18 4.54	6.80 0.59
LIGHT UNINFLUENCED	390.22 32.45	2089.22 24.12	44.08 3.81
LIGHT INFLUENCED	119.08 9.90	695.87 8.08	15.98 1.38
MEDIUM UNINFLUENCED	90.43 7.52	1827.80 21.11	296.27 25.62
MEDIUM INFLUENCED	103.22 8.58	2977.72 34.38	508.33 43.97
HEAVY UNINFLUENCED	0.42 0.03	69.62 0.80	34.33 2.97
HEAVY INFLUENCED	14.45 1.20	514.70 5.94	204.28 17.67
HEAVY STOP AND GO	0.52 0.04	88.37 1.02	46.10 3.99
TOTALS (%)	1202.58 100.00	8660.46 100.00	1156.16 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(AVERAGE SPEED)
(MPH)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	17.69	25.66	34.50
LIGHT UNINFLUENCED	17.09	25.68	42.75
LIGHT INFLUENCED	16.89	25.11	41.30
MEDIUM UNINFLUENCED	14.12	24.10	52.20
MEDIUM INFLUENCED	14.42	22.09	49.90
HEAVY UNINFLUENCED	26.06	18.79	47.95
HEAVY INFLUENCED	17.47	14.31	40.99
HEAVY STOP AND GO	7.55	4.70	17.19

TRAFFIC DENSITY SUMMARY FOR
URBAN DATA
FOR ALL FOLLOWS

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	884.23	8.02	314.82	6.87	21.36
LIGHT UNINFLUENCED	2523.52	22.90	1036.67	22.62	24.65
LIGHT INFLUENCED	834.93	7.58	337.43	7.36	24.25
MEDIUM UNINFLUENCED	2214.50	20.10	1013.33	22.11	27.46
MEDIUM INFLUENCED	3589.27	32.57	1543.90	33.69	25.81
HEAVY UNINFLUENCED	104.37	0.95	49.42	1.08	28.41
HEAVY INFLUENCED	733.43	6.66	266.56	5.82	21.81
HEAVY STOP AND GO	134.58	1.22	20.20	0.44	8.98
TOTALS	11019.23	100.00	4582.33	100.00	24.95

ROAD TYPE SUMMARY
FOR
URBAN DATA
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	TOTALS
TIME(MIN)	1202.58	8660.46	1156.18	11019.23
TIME,%	10.91	78.59	10.49	100.00
MILES	337.96	3337.27	907.10	4582.33
MILES,%	7.38	72.83	19.80	100.00
AVERAGE SPEED (MPH)	16.86	23.12	47.07	24.95
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.26	1.22	1.05	1.23
NUMBER OF TRIPS	1110	2006	225	3341
STOPS/MILE	1.41	1.25	0.09	1.04

SPEED DISTRIBUTION
FOR
URBAN DATA
FOR ALL FOLLOWS

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	66368	11.17	11.17
0.1 - 2.5	22869	3.85	15.02
2.5 - 7.5	36421	6.13	21.16
7.5 - 12.5	44794	7.54	28.70
12.5 - 17.5	50722	8.54	37.24
17.5 - 22.5	59784	10.07	47.30
22.5 - 27.5	71534	12.04	59.34
27.5 - 32.5	83446	14.05	73.39
32.5 - 37.5	78913	13.29	86.68
37.5 - 42.5	51462	8.66	95.34
42.5 - 47.5	33700	5.67	101.02
47.5 - 52.5	24275	4.09	105.10
52.5 - 57.5	20489	3.45	108.55
57.5 - 62.5	12068	2.03	110.58
62.5 -100.0	3500	0.59	111.17

ACCEL/DECEL DISTRIBUTION
FOR
URBAN DATA
FOR ALL FOLLOWS

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	96	0.01	0.01
-9.5 - -8.5	17	0.00	0.02
-8.5 - -7.5	68	0.01	0.03
-7.5 - -6.5	243	0.04	0.06
-6.5 - -5.5	798	0.12	0.19
-5.5 - -4.5	2832	0.43	0.62
-4.5 - -3.5	7836	1.19	1.81
-3.5 - -2.5	26644	4.05	5.86
-2.5 - -1.5	34859	5.30	11.15
-1.5 - -0.5	70172	10.67	21.82
-0.5 - 0.5	322835	49.07	70.89
0.5 - 1.5	126337	19.20	90.09
1.5 - 2.5	35586	5.41	95.50
2.5 - 3.5	19037	2.89	98.39
3.5 - 4.5	8850	1.35	99.74
4.5 - 5.5	1512	0.23	99.97
5.5 - 6.5	154	0.02	99.99
6.5 - 7.5	16	0.00	100.00
7.5 - 8.5	2	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	20	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
URBAN DATA
FOR ALL FOLLOWS

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	61345	9.32
CRUISE	261490	39.74
ACCELERATION	191554	29.11
DECELERATION	143565	21.82

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(MILES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWA
NO	142.75	168.16	3.91	76.07	152.78	17.48
TRAFFIC	42.24	5.04	0.43	84.57	31.92	1.45
LIGHT	111.16	894.11	31.41	7.49	127.89	201.94
UNINFLUENCED	32.89	26.79	3.46	8.32	26.72	16.72
LIGHT	33.52	292.91	11.00	3.55	81.24	15.30
INFLUENCED	9.92	8.78	1.21	3.94	16.97	1.27
MEDIUM	21.28	734.29	257.76	1.83	36.37	435.45
UNINFLUENCED	6.30	22.00	28.42	2.04	7.60	36.06
MEDIUM	24.80	1096.30	422.80	0.99	79.79	388.90
INFLUENCED	7.34	32.85	46.61	1.10	16.67	32.21
HEAVY	0.18	21.80	27.44	0.0	0.06	31.06
UNINFLUENCED	0.05	0.65	3.02	0.0	0.01	2.57
HEAVY	4.21	122.77	139.58	0.01	0.55	115.20
INFLUENCED	1.25	3.68	15.39	0.01	0.12	9.54
HEAVY	0.07	6.93	13.21	0.01	0.02	2.13
STOP AND GO	0.02	0.21	1.46	0.02	0.00	0.18
TOTALS	337.96	3337.27	907.10	89.95	478.71	1207.45
(%)	100.00	100.00	100.00	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(MINUTES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	484.25 40.27	393.18 4.54	6.80 0.59	145.13 77.30	208.37 32.00	21.33 1.57
LIGHT UNINFLUENCED	390.22 32.45	2089.22 24.12	44.08 3.81	22.82 12.15	163.37 25.09	227.12 16.69
LIGHT INFLUENCED	119.08 9.90	699.87 8.08	15.98 1.38	8.03 4.28	118.88 18.26	19.87 1.46
MEDIUM UNINFLUENCED	90.43 7.52	1827.80 21.11	296.27 25.62	8.43 4.49	47.83 7.35	466.68 34.30
MEDIUM INFLUENCED	103.22 8.58	2977.72 34.38	508.33 43.97	3.28 1.75	111.78 17.17	427.68 31.43
HEAVY UNINFLUENCED	0.42 0.03	69.62 0.80	34.33 2.97	0.0 0.0	0.07 0.01	36.53 2.68
HEAVY INFLUENCED	14.45 1.20	514.70 5.94	204.28 17.67	0.02 0.01	0.87 0.13	156.18 11.48
HEAVY STOP AND GO	0.52 0.04	88.37 1.02	46.10 3.99	0.03 0.02	0.03 0.01	5.30 0.39
TOTALS (%)	1202.58 100.00	8660.46 100.00	1156.18 100.00	187.75 100.00	651.20 100.00	1360.70 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(AVERAGE SPEED)
(MPH)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	17.69	25.66	34.50	31.45	43.99	49.17
LIGHT UNINFLUENCED	17.09	25.68	42.75	19.69	46.97	53.35
LIGHT INFLUENCED	16.89	25.11	41.30	26.48	41.00	46.21
MEDIUM UNINFLUENCED	14.12	24.10	52.20	13.05	45.62	55.98
MEDIUM INFLUENCED	14.42	22.09	49.90	18.06	42.83	54.56
HEAVY UNINFLUENCED	26.06	18.79	47.95	0.0	50.22	51.01
HEAVY INFLUENCED	17.47	14.31	40.99	27.20	38.17	44.26
HEAVY STOP AND GO	7.55	4.70	17.19	24.55	42.02	24.09

TRAFFIC DENSITY SUMMARY FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	1259.07	9.52	561.15	8.83	26.74
LIGHT UNINFLUENCED	2936.82	22.22	1373.99	21.61	28.07
LIGHT INFLUENCED	981.72	7.43	437.52	6.88	26.74
MEDIUM UNINFLUENCED	2737.45	20.71	1486.98	23.39	32.59
MEDIUM INFLUENCED	4132.02	31.26	2013.58	31.67	29.24
HEAVY UNINFLUENCED	140.57	1.07	80.54	1.27	34.28
HEAVY INFLUENCED	890.50	6.74	382.32	6.01	25.76
HEAVY STOP AND GO	140.35	1.06	22.37	0.35	9.56
TOTALS	13218.88	100.00	6358.44	100.00	28.86

ROAD TYPE SUMMARY
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	1202.58	8660.46	1156.18	187.75	651.20	1360.70	13218.88
TIME,%	9.10	65.52	8.75	1.42	4.93	10.29	100.00
MILES	337.96	3337.27	907.10	89.95	478.71	1207.45	6358.44
MILES,%	5.32	52.49	14.27	1.41	7.53	18.99	100.00
AVERAGE SPEED (MPH)	16.86	23.12	47.07	28.74	44.11	53.24	28.86
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.26	1.22	1.05	1.16	1.25	1.07	1.22
NUMBER OF TRIPS	1110	2006	225	111	123	212	3787
STOPS/MILE	1.41	1.25	0.09	0.36	0.08	0.02	0.76

SPEED DISTRIBUTION
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY, %	CUMULATIVE FREQUENCY, %
ZERO	67432	8.51	8.51
0.1 - 2.5	23447	2.96	11.47
2.5 - 7.5	37730	4.76	16.23
7.5 - 12.5	46927	5.92	22.16
12.5 - 17.5	52669	6.65	28.80
17.5 - 22.5	62880	7.94	36.74
22.5 - 27.5	75063	9.47	46.22
27.5 - 32.5	88298	11.15	57.36
32.5 - 37.5	85631	10.81	68.17
37.5 - 42.5	60287	7.61	75.78
42.5 - 47.5	45747	5.77	81.55
47.5 - 52.5	44659	5.64	87.19
52.5 - 57.5	48440	6.11	93.31
57.5 - 62.5	34366	4.34	97.64
62.5 -100.0	18670	2.36	100.00

ACCEL/DECEL DISTRIBUTION
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	112	0.01	0.01
-9.5 - -8.5	22	0.00	0.02
-8.5 - -7.5	79	0.01	0.03
-7.5 - -6.5	272	0.03	0.06
-6.5 - -5.5	849	0.11	0.17
-5.5 - -4.5	3034	0.38	0.55
-4.5 - -3.5	8319	1.05	1.61
-3.5 - -2.5	28382	3.59	5.20
-2.5 - -1.5	37500	4.75	9.95
-1.5 - -0.5	81396	10.31	20.26
-0.5 - 0.5	409427	51.85	72.11
0.5 - 1.5	151060	19.13	91.23
1.5 - 2.5	37943	4.80	96.04
2.5 - 3.5	20005	2.53	98.57
3.5 - 4.5	9430	1.19	99.77
4.5 - 5.5	1612	0.20	99.97
5.5 - 6.5	170	0.02	99.99
6.5 - 7.5	23	0.00	100.00
7.5 - 8.5	5	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	29	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	62306	7.89
CRUISE	347121	43.96
ACCELERATION	220277	27.89
DECELERATION	159965	20.26

SUMMARY OF FOLLOW DATA
FOR URBAN FOLLOWS ONLY

LOCATION	AVERAGE LENGTH (MILES)	AVERAGE DURATION (MINUTES)	AVERAGE SPEED (MPH)	STOPS/MILE	NUMBER OF FOLLOWS	AVERAGE NUMBER OF DIFFERENT ROAD TYPES PER TRIP
DETROIT	1.89	4.78	23.68	1.17	287	1.63
NEWARK/NEW YORK CITY	1.75	5.73	18.36	2.01	255	1.53
WASHINGTON, D.C.	1.59	5.43	17.54	2.47	67	1.43
ATLANTA	3.27	7.33	26.77	0.84	28	1.43
LOS ANGELES	2.28	4.93	27.70	0.76	450	1.62
SAN FRANCISCO	1.24	3.83	19.49	1.63	172	1.45
PHOENIX	2.32	5.34	26.05	0.83	61	1.51
SAN DIEGO	1.58	4.03	23.56	1.05	29	1.69
DENVER	1.68	4.51	22.38	1.18	121	1.57
SALT LAKE CITY	1.92	4.59	25.11	0.90	86	1.37
CHICAGO	2.69	6.95	23.21	1.21	107	1.51
ST. LOUIS	1.83	4.36	25.14	0.95	65	1.77

SUMMARY OF FOLLOW DATA
FOR URBAN-RURAL FOLLOWS ONLY

LOCATION	AVERAGE LENGTH (MILES)	AVERAGE DURATION (MINUTES)	AVERAGE SPEED (MPH)	STOPS/MILE	NUMBER OF FOLLOWS	AVERAGE NUMBER OF DIFFERENT ROAD TYPES PER TRIP
DETROIT	7.61	11.28	40.44	0.24	84	2.83
NEWARK/NEW YORK CITY	10.33	16.11	38.48	0.29	26	2.96
WASHINGTON, D.C.	8.32	13.72	36.41	0.45	4	3.00
ATLANTA	4.65	7.98	34.94	0.22	12	3.00
LOS ANGELES	8.73	12.74	41.13	0.28	43	2.86
SAN FRANCISCO	8.87	13.01	40.90	0.20	20	3.20
PHOENIX	0.0	0.0	0.0	0.0	0	0.0
SAN DIEGO	7.13	10.35	41.31	0.34	10	3.50
DENVER	4.08	8.46	28.92	0.81	24	2.67
SALT LAKE CITY	4.50	7.93	34.04	0.40	23	2.83
CHICAGO	12.21	21.57	33.97	0.57	8	3.00
ST. LOUIS	7.71	12.49	37.01	0.36	21	3.38

SUMMARY OF FOLLOW DATA
FOR ALL FOLLOWS

LOCATION	AVERAGE LENGTH (MILES)	AVERAGE DURATION (MINUTES)	AVERAGE SPEED (MPH)	STOPS/MILE	NUMBER OF FOLLOWS	AVERAGE NUMBER OF DIFFERENT ROAD TYPES PER TRIP
12 CITY TOTAL FOR URBAN FOLLOWS ONLY	1.96	5.03	23.39	1.19	1728	1.56
12 CITY TOTAL FOR ALL FOLLOWS	2.20	5.31	24.86	1.05	2003	1.60
URBAN DATA FOR URBAN FOLLOWS ONLY	1.95	5.00	23.38	1.19	1765	1.56
URBAN DATA FOR ALL FOLLOWS	2.19	5.25	24.95	1.04	2097	1.59
URBAN-RURAL DATA FOR URBAN-RURAL FOLLOWS ONLY	7.66	11.80	38.95	0.29	332	2.88
RURAL DATA FOR RURAL FOLLOWS ONLY	6.29	7.93	47.57	0.05	60	1.18
RURAL DATA FOR ALL FOLLOWS	4.53	5.61	48.45	0.06	392	1.14
TOTAL DATA SAMPLE FOR ALL FOLLOWS	2.95	6.13	28.86	0.76	2157	1.76

Appendix B

SELECTED STATISTICS FOR GM DATA UTILIZING FHWA WEIGHTINGS

This appendix contains FHWA-weighted data for the following data samples:

1. Urban data, for urban follows only
2. Urban-rural data
3. Total data sample

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MILES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	264.75 34.14	87.74 4.22	3.64 0.66
LIGHT UNINFLUENCED	297.58 38.37	460.86 22.19	21.58 3.93
LIGHT INFLUENCED	73.24 9.44	144.01 6.93	3.83 0.70
MEDIUM UNINFLUENCED	54.61 7.04	430.16 20.71	120.61 21.98
MEDIUM INFLUENCED	81.34 10.49	797.13 38.38	284.26 51.81
HEAVY UNINFLUENCED	0.27 0.04	17.06 0.82	16.55 3.02
HEAVY INFLUENCED	3.59 0.46	129.17 6.22	88.32 16.10
HEAVY STOP AND GO	0.15 0.02	10.57 0.51	9.83 1.79
TOTALS (%)	775.51 100.00	2076.70 100.00	548.62 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MINUTES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	949.83 32.34	227.48 3.69	7.58 1.00
LIGHT UNINFLUENCED	1096.67 37.35	1183.85 19.18	32.30 4.27
LIGHT INFLUENCED	263.67 8.98	376.42 6.10	5.08 0.67
MEDIUM UNINFLUENCED	213.00 7.25	1143.68 18.53	144.93 19.17
MEDIUM INFLUENCED	388.22 13.22	2406.37 38.98	354.95 46.94
HEAVY UNINFLUENCED	0.83 0.03	58.47 0.95	21.45 2.84
HEAVY INFLUENCED	23.50 0.80	628.48 10.18	148.33 19.62
HEAVY STOP AND GO	0.92 0.03	147.82 2.39	41.55 5.49
TOTALS (%)	2936.83 100.00	6172.57 100.00	756.18 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(AVERAGE SPEED)
(MPH)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	16.72	23.14	28.83
LIGHT UNINFLUENCED	16.28	23.36	40.10
LIGHT INFLUENCED	16.67	22.95	45.21
MEDIUM UNINFLUENCED	15.38	22.57	49.93
MEDIUM INFLUENCED	12.57	19.88	48.05
HEAVY UNINFLUENCED	19.62	17.51	46.28
HEAVY INFLUENCED	9.16	12.33	35.72
HEAVY STOP AND GO	9.80	4.29	14.20

TRAFFIC DENSITY SUMMARY FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	1184.90	12.01	356.14	10.47	18.03
LIGHT UNINFLUENCED	2313.02	23.45	780.02	22.94	20.23
LIGHT INFLUENCED	645.17	6.54	221.08	6.50	20.56
MEDIUM UNINFLUENCED	1501.62	15.22	605.37	17.80	24.19
MEDIUM INFLUENCED	3149.53	31.92	1162.72	34.19	22.15
HEAVY UNINFLUENCED	80.75	0.82	33.88	1.00	25.18
HEAVY INFLUENCED	800.32	8.11	221.08	6.50	16.57
HEAVY STOP AND GO	190.28	1.93	20.56	0.60	6.48
TOTALS	9865.58	100.00	3400.83	100.00	20.68

ROAD TYPE SUMMARY
FOR
URBAN CATA
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	TOTALS
TIME(MIN)	2936.83	6172.57	756.18	9865.58
TIME,%	29.77	62.57	7.66	100.00
MILES	775.51	2076.70	548.62	3400.83
MILES,%	22.80	61.06	16.13	100.00
AVERAGE SPEED (MPH)	15.84	20.19	43.53	20.68
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.24	1.16	1.03	1.20
NUMBER OF TRIPS	2701	1426	166	4293
STOPS/MILE	1.61	1.69	0.12	1.42

SPEED DISTRIBUTION
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY, %	CUMULATIVE FREQUENCY, %
ZERO	69175	11.70	11.70
0.1 - 2.5	24482	4.14	15.84
2.5 - 7.5	45045	7.62	23.46
7.5 - 12.5	57502	9.72	33.18
12.5 - 17.5	62603	10.59	43.77
17.5 - 22.5	69660	11.78	55.55
22.5 - 27.5	69635	11.78	67.33
27.5 - 32.5	64140	10.85	78.17
32.5 - 37.5	48742	8.24	86.42
37.5 - 42.5	28915	4.89	91.31
42.5 - 47.5	20093	3.40	94.70
47.5 - 52.5	14554	2.46	97.17
52.5 - 57.5	9959	1.68	98.85
57.5 - 62.5	5211	0.88	99.73
62.5 -100.0	1589	0.27	100.00

ACCEL/DECEL DISTRIBUTION
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY, %	CUMULATIVE FREQUENCY, %
-50.0 - -9.5	86	0.01	0.01
-9.5 - -8.5	7	0.00	0.02
-8.5 - -7.5	38	0.01	0.02
-7.5 - -6.5	182	0.03	0.05
-6.5 - -5.5	710	0.12	0.17
-5.5 - -4.5	2425	0.41	0.59
-4.5 - -3.5	6966	1.18	1.77
-3.5 - -2.5	26449	4.49	6.26
-2.5 - -1.5	36108	6.13	12.39
-1.5 - -0.5	67536	11.47	23.86
-0.5 - 0.5	272319	46.25	70.11
0.5 - 1.5	113685	19.31	89.41
1.5 - 2.5	34615	5.88	95.29
2.5 - 3.5	17893	3.04	98.33
3.5 - 4.5	8267	1.40	99.74
4.5 - 5.5	1393	0.24	99.97
5.5 - 6.5	143	0.02	100.00
6.5 - 7.5	10	0.00	100.00
7.5 - 8.5	0	0.0	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	10	0.00	100.00

OPERATIONAL MODE SUMMARY
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY, %
IDLE	63973	10.86
CRUISE	208328	35.37
ACCELERATION	176087	29.90
DECELERATION	140603	23.87

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(MILES)
(%)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	73.64	31.56	0.84	17.43	81.83	16.36
TRAFFIC	43.64	5.77	0.18	58.01	23.21	1.61
LIGHT	46.58	145.89	15.67	7.29	102.12	163.09
UNINFLUENCED	27.60	26.66	3.37	24.27	28.96	16.05
LIGHT	30.04	56.61	6.51	2.59	61.58	12.44
INFLUENCED	17.80	10.35	1.40	8.61	17.46	1.22
MEDIUM	6.13	89.00	161.84	1.73	31.73	355.25
UNINFLUENCED	3.63	16.27	34.80	5.74	9.00	34.96
MEDIUM	11.16	189.32	227.14	0.99	74.73	331.67
INFLUENCED	6.61	34.60	48.84	3.29	21.19	32.64
HEAVY	0.03	1.72	6.20	0.0	0.06	29.67
UNINFLUENCED	0.02	0.31	1.33	0.0	0.02	2.92
HEAVY	1.18	31.84	46.04	0.01	0.55	105.57
INFLUENCED	0.70	5.82	9.90	0.03	0.16	10.39
HEAVY	0.0	1.23	0.80	0.01	0.02	2.04
STOP AND GO	0.0	0.23	0.17	0.05	0.01	0.20
TOTALS	168.75	547.18	465.05	30.05	352.62	1016.07
(%)	100.00	100.00	100.00	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(MINUTES)
(%)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	240.30	68.93	1.55	46.77	112.47	19.78
TRAFFIC	40.31	5.62	0.28	54.00	23.55	1.71
LIGHT	185.02	293.52	21.87	22.37	128.88	188.42
UNINFLUENCED	31.04	23.95	3.89	25.83	26.99	16.25
LIGHT	96.25	120.55	10.17	6.00	87.47	16.72
INFLUENCED	16.15	9.84	1.81	6.93	18.32	1.44
MEDIUM	28.70	208.83	180.40	8.13	41.48	383.67
UNINFLUENCED	4.81	17.04	32.13	9.39	8.69	33.09
MEDIUM	42.73	445.60	274.80	3.28	106.20	368.83
INFLUENCED	7.17	36.36	48.95	3.79	22.24	31.81
HEAVY	0.03	7.15	7.22	0.0	0.07	34.95
UNINFLUENCED	0.01	0.58	1.29	0.0	0.01	3.01
HEAVY	3.10	72.73	59.80	0.02	0.87	142.30
INFLUENCED	0.52	5.93	10.65	0.02	0.18	12.27
HEAVY	0.0	8.18	5.63	0.03	0.03	4.92
STOP AND GO	0.0	0.67	1.00	0.04	0.01	0.42
TOTALS	596.13	1225.50	561.43	86.60	477.47	1159.58
(%)	100.00	100.00	100.00	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(AVERAGE SPEED)
(MPH)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	18.39	27.47	32.48	22.36	43.66	49.61
LIGHT UNINFLUENCED	15.11	29.82	43.01	19.57	47.54	51.93
LIGHT INFLUENCED	18.73	28.18	38.42	25.89	42.24	44.65
MEDIUM UNINFLUENCED	12.81	25.57	53.83	12.73	45.89	55.56
MEDIUM INFLUENCED	15.67	25.49	49.59	18.06	42.22	53.96
HEAVY UNINFLUENCED	48.28	14.44	51.58	0.0	50.22	50.93
HEAVY INFLUENCED	22.86	26.27	46.20	27.20	38.17	44.51
HEAVY STOP AND GO	0.0	9.03	8.54	24.55	42.02	24.85

TRAFFIC DENSITY SUMMARY FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	489.80	11.93	221.66	8.59	27.15
LIGHT UNINFLUENCED	840.07	20.46	480.65	18.63	34.33
LIGHT INFLUENCED	337.15	8.21	169.77	6.58	30.21
MEDIUM UNINFLUENCED	851.22	20.73	645.67	25.03	45.51
MEDIUM INFLUENCED	1241.45	30.23	835.01	32.37	40.36
HEAVY UNINFLUENCED	49.42	1.20	37.67	1.46	45.74
HEAVY INFLUENCED	278.82	6.79	185.19	7.18	39.85
HEAVY STOP AND GO	18.80	0.46	4.11	0.16	13.11
TOTALS	4106.71	100.00	2579.73	100.00	37.69

ROAD TYPE SUMMARY
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS CNLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	596.13	1225.50	561.43	86.60	477.47	1159.58	4106.71
TIME,%	14.52	29.84	13.67	2.11	11.63	28.24	100.00
MILES	168.75	547.18	465.05	30.05	352.62	1016.07	2579.73
MILES,%	6.54	21.21	18.03	1.16	13.67	39.39	100.00
AVERAGE SPEED (MPH)	16.98	26.75	49.70	20.82	44.31	52.57	37.69
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.28	1.69	1.07	1.18	1.36	1.07	1.30
NUMBER OF TRIPS	622	243	129	100	86	189	1369
STOPS/MILE	0.89	0.81	0.06	0.77	0.09	0.02	0.27

SPEED DISTRIBUTION
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	9507	3.86	3.86
0.1 - 2.5	3989	1.62	5.48
2.5 - 7.5	7791	3.16	8.65
7.5 - 12.5	12594	5.12	13.76
12.5 - 17.5	11656	4.73	18.50
17.5 - 22.5	13802	5.61	24.11
22.5 - 27.5	15957	6.48	30.59
27.5 - 32.5	17186	6.98	37.57
32.5 - 37.5	18881	7.67	45.24
37.5 - 42.5	17584	7.14	52.38
42.5 - 47.5	18986	7.71	60.09
47.5 - 52.5	26473	10.75	70.85
52.5 - 57.5	33632	13.66	84.51
57.5 - 62.5	25877	10.51	95.02
62.5 -100.0	12253	4.98	100.00

ACCEL/DECEL DISTRIBUTION
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY, %	CUMULATIVE FREQUENCY, %
-50.0 - -9.5	18	0.01	0.01
-9.5 - -8.5	3	0.00	0.01
-8.5 - -7.5	10	0.00	0.01
-7.5 - -6.5	39	0.02	0.03
-6.5 - -5.5	172	0.07	0.10
-5.5 - -4.5	645	0.26	0.36
-4.5 - -3.5	1875	0.76	1.12
-3.5 - -2.5	6498	2.64	3.77
-2.5 - -1.5	9050	3.68	7.45
-1.5 - -0.5	25397	10.34	17.79
-0.5 - 0.5	138196	56.25	74.04
0.5 - 1.5	48904	19.90	93.94
1.5 - 2.5	8609	3.50	97.45
2.5 - 3.5	4173	1.70	99.15
3.5 - 4.5	1754	0.71	99.86
4.5 - 5.5	286	0.12	99.98
5.5 - 6.5	38	0.02	99.99
6.5 - 7.5	13	0.01	100.00
7.5 - 8.5	2	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	5	0.00	100.00

OPERATIONAL MODE SUMMARY
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY, %
IDLE	8763	3.56
CRUISE	129419	52.65
ACCELERATION	63843	25.97
DECELERATION	43784	17.81

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(MILES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWA
NO TRAFFIC	338.39 35.84	119.30 4.55	4.48 0.44	76.07 84.57	152.78 31.92	17.48 1.45
LIGHT UNINFLUENCED	344.15 36.45	606.75 23.12	37.26 3.68	7.49 8.32	127.89 26.72	201.94 16.72
LIGHT INFLUENCED	103.28 10.94	200.62 7.65	10.34 1.02	3.55 3.94	81.24 16.97	15.30 1.27
MEDIUM UNINFLUENCED	60.73 6.43	519.16 19.79	282.45 27.86	1.83 2.04	36.37 7.60	435.45 36.06
MEDIUM INFLUENCED	92.50 9.80	986.45 37.59	511.40 50.45	0.99 1.10	79.79 16.67	388.90 32.21
HEAVY UNINFLUENCED	0.30 0.03	18.78 0.72	22.75 2.24	0.0 0.0	0.06 0.01	31.06 2.57
HEAVY INFLUENCED	4.77 0.50	161.01 6.14	134.36 13.25	0.01 0.01	0.55 0.12	115.20 9.54
HEAVY STOP AND GO	0.15 0.02	11.81 0.45	10.63 1.05	0.01 0.02	0.02 0.00	2.13 0.18
TOTALS (%)	944.27 100.00	2623.88 100.00	1013.67 100.00	89.95 100.00	478.71 100.00	1207.45 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(MINUTES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	1190.13 33.69	296.42 4.01	9.13 0.69	145.13 77.30	208.37 32.00	21.33 1.57
LIGHT UNINFLUENCED	1281.88 36.28	1477.37 19.97	54.17 4.11	22.82 12.15	163.37 25.09	227.12 16.69
LIGHT INFLUENCED	359.92 10.19	496.97 6.72	15.25 1.16	8.03 4.28	118.88 18.26	19.87 1.46
MEDIUM UNINFLUENCED	241.70 6.84	1352.52 18.28	325.33 24.69	8.43 4.49	47.83 7.35	466.68 34.30
MEDIUM INFLUENCED	430.95 12.20	2851.97 38.55	629.75 47.79	3.28 1.75	111.78 17.17	427.68 31.43
HEAVY UNINFLUENCED	0.87 0.02	65.62 0.89	28.67 2.18	0.0 0.0	0.07 0.01	36.53 2.68
HEAVY INFLUENCED	26.60 0.75	701.22 9.48	208.13 15.80	0.02 0.01	0.87 0.13	156.18 11.48
HEAVY STOP AND GO	0.92 0.03	156.00 2.11	47.18 3.58	0.03 0.02	0.03 0.01	5.30 0.39
TOTALS (%)	3532.97 100.00	7398.07 100.00	1317.62 100.00	187.75 100.00	651.20 100.00	1360.70 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(AVERAGE SPEED)
(MPH)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWA
NO TRAFFIC	17.06	24.15	29.45	31.45	43.99	49.17
LIGHT UNINFLUENCED	16.11	24.64	41.27	19.69	46.97	53.35
LIGHT INFLUENCED	17.22	24.22	40.69	26.48	41.00	46.21
MEDIUM UNINFLUENCED	15.08	23.03	52.09	13.05	45.62	55.98
MEDIUM INFLUENCED	12.88	20.75	48.72	18.06	42.83	54.56
HEAVY UNINFLUENCED	20.72	17.18	47.62	0.0	50.22	51.01
HEAVY INFLUENCED	10.75	13.78	38.73	27.20	38.17	44.26
HEAVY STOP AND GO	9.80	4.54	13.52	24.55	42.02	24.09

TRAFFIC DENSITY SUMMARY FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	1870.52	12.95	708.51	11.14	22.73
LIGHT UNINFLUENCED	3226.72	22.33	1325.48	20.85	24.65
LIGHT INFLUENCED	1018.92	7.05	414.33	6.52	24.40
MEDIUM UNINFLUENCED	2442.50	16.91	1335.99	21.01	32.82
MEDIUM INFLUENCED	4455.41	30.84	2060.02	32.40	27.74
HEAVY UNINFLUENCED	131.75	0.91	72.95	1.15	33.22
HEAVY INFLUENCED	1093.02	7.57	415.90	6.54	22.83
HEAVY STOP AND GO	209.47	1.45	24.75	0.39	7.09
TOTALS	14448.29	100.00	6357.92	100.00	26.40

ROAD TYPE SUMMARY
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	3532.97	7398.07	1317.62	187.75	651.20	1360.70	14448.29
TIME,%	24.45	51.20	9.12	1.30	4.51	9.42	100.00
MILES	944.27	2623.88	1013.67	89.95	478.71	1207.45	6357.92
MILES,%	14.85	41.27	15.94	1.41	7.53	18.99	100.00
AVERAGE SPEED (MPH)	16.04	21.28	46.16	28.74	44.11	53.24	26.40
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.24	1.24	1.05	1.16	1.25	1.07	1.22
NUMBER OF TRIPS	3323	1669	295	111	123	212	5733
STOPS/MILE	1.48	1.51	0.09	0.36	0.08	0.02	0.87

SPEED DISTRIBUTION
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	78912	9.11	9.11
0.1 - 2.5	28609	3.30	12.42
2.5 - 7.5	53186	6.14	18.56
7.5 - 12.5	70995	8.20	26.75
12.5 - 17.5	74698	8.63	35.38
17.5 - 22.5	84226	9.73	45.11
22.5 - 27.5	86383	9.97	55.08
27.5 - 32.5	82399	9.51	64.60
32.5 - 37.5	69722	8.05	72.65
37.5 - 42.5	48782	5.63	78.28
42.5 - 47.5	41627	4.81	83.09
47.5 - 52.5	44982	5.19	88.28
52.5 - 57.5	48201	5.57	93.85
57.5 - 62.5	34281	3.96	97.80
62.5 -100.0	19012	2.20	100.00

ACCEL/DECEL DISTRIBUTION
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	113	0.01	0.01
-9.5 - -8.5	14	0.00	0.01
-8.5 - -7.5	57	0.01	0.02
-7.5 - -6.5	240	0.03	0.05
-6.5 - -5.5	907	0.11	0.15
-5.5 - -4.5	3137	0.36	0.52
-4.5 - -3.5	8975	1.04	1.56
-3.5 - -2.5	33344	3.86	5.42
-2.5 - -1.5	45745	5.30	10.72
-1.5 - -0.5	94845	10.99	21.71
-0.5 - 0.5	429978	49.82	71.54
0.5 - 1.5	167382	19.40	90.93
1.5 - 2.5	43734	5.07	96.00
2.5 - 3.5	22351	2.59	98.59
3.5 - 4.5	10211	1.18	99.77
4.5 - 5.5	1734	0.20	99.97
5.5 - 6.5	189	0.02	99.99
6.5 - 7.5	23	0.00	100.00
7.5 - 8.5	3	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	20	0.00	100.00

OPERATIONAL MODE SUMMARY
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	72944	8.45
CRUISE	357002	41.35
ACCELERATION	245777	28.47
DECELERATION	187550	21.73

Appendix C

SELECTED STATISTICS FOR GM DATA UTILIZING EPA WEIGHTINGS

This appendix contains EPA-weighted data for the following data samples:

1. Urban data, urban follows only
2. Urban-rural follow data
3. Total data sample

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MILES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	283.17 38.28	110.76 5.37	2.97 0.55
LIGHT UNINFLUENCED	275.06 37.18	537.71 26.08	30.06 5.61
LIGHT INFLUENCED	65.17 8.81	161.86 7.85	4.15 0.77
MEDIUM UNINFLUENCED	40.02 5.41	476.33 23.10	126.36 23.57
MEDIUM INFLUENCED	72.47 9.80	672.24 32.60	275.77 51.43
HEAVY UNINFLUENCED	0.13 0.02	17.96 0.87	12.86 2.40
HEAVY INFLUENCED	3.70 0.50	80.52 3.91	78.38 14.62
HEAVY STOP AND GO	0.09 0.01	4.52 0.22	5.64 1.05
TOTALS (%)	739.81 100.00	2061.90 100.00	536.19 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(MINUTES)
(%)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	1002.80 36.09	276.58 4.85	7.33 1.00
LIGHT UNINFLUENCED	1006.25 36.21	1333.37 23.37	49.62 6.77
LIGHT INFLUENCED	235.00 8.46	419.12 7.35	5.33 0.73
MEDIUM UNINFLUENCED	166.62 6.00	1219.33 21.37	157.48 21.49
MEDIUM INFLUENCED	339.58 12.22	1936.03 33.94	340.90 46.52
HEAVY UNINFLUENCED	0.40 0.01	63.95 1.12	17.10 2.33
HEAVY INFLUENCED	27.33 0.98	394.90 6.92	130.55 17.81
HEAVY STOP AND GO	0.58 0.02	61.28 1.07	24.55 3.35
TOTALS (%)	2778.57 100.00	5704.57 100.00	732.87 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN DATA
(AVERAGE SPEED)
(MPH)
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY
NO TRAFFIC	16.94	24.03	24.27
LIGHT UNINFLUENCED	16.40	24.20	36.35
LIGHT INFLUENCED	16.64	23.17	46.67
MEDIUM UNINFLUENCED	14.41	23.44	48.14
MEDIUM INFLUENCED	12.80	20.83	48.54
HEAVY UNINFLUENCED	19.98	16.85	45.12
HEAVY INFLUENCED	8.12	12.23	36.02
HEAVY STOP AND GO	9.46	4.42	13.79

TRAFFIC DENSITY SUMMARY FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	1286.72	13.96	396.90	11.89	18.51
LIGHT UNINFLUENCED	2389.23	25.92	842.83	25.25	21.17
LIGHT INFLUENCED	659.45	7.16	231.18	6.93	21.03
MEDIUM UNINFLUENCED	1543.43	16.75	642.71	19.26	24.99
MEDIUM INFLUENCED	2616.52	28.39	1020.48	30.57	23.40
HEAVY UNINFLUENCED	81.45	0.88	30.95	0.93	22.80
HEAVY INFLUENCED	552.78	6.00	162.60	4.87	17.65
HEAVY STOP AND GO	86.42	0.94	10.25	0.31	7.12
TOTALS	9216.00	100.00	3337.90	100.00	21.73

ROAD TYPE SUMMARY
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	TOTALS
TIME(MIN)	2778.57	5704.57	732.87	9216.00
TIME,%	30.15	61.90	7.95	100.00
MILES	739.81	2061.90	536.19	3337.90
MILES,%	22.16	61.77	16.06	100.00
AVERAGE SPEED (MPH)	15.98	21.69	43.90	21.73
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.21	1.15	1.06	1.18
NUMBER OF TRIPS	2874	1375	194	4443
STOPS/MILE	1.57	1.44	0.11	1.26

SPEED DISTRIBUTION
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	56134	10.16	10.16
0.1 - 2.5	21534	3.90	14.06
2.5 - 7.5	39651	7.18	21.23
7.5 - 12.5	51539	9.33	30.56
12.5 - 17.5	56863	10.29	40.85
17.5 - 22.5	63803	11.55	52.40
22.5 - 27.5	65083	11.78	64.18
27.5 - 32.5	62655	11.34	75.52
32.5 - 37.5	51796	9.37	84.90
37.5 - 42.5	31386	5.68	90.58
42.5 - 47.5	20975	3.80	94.37
47.5 - 52.5	15334	2.78	97.15
52.5 - 57.5	9820	1.78	98.92
57.5 - 62.5	4332	0.78	99.71
62.5 -100.0	1610	0.29	100.00

ACCEL/DECEL DISTRIBUTION
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	66	0.01	0.01
-9.5 - -8.5	6	0.00	0.01
-8.5 - -7.5	39	0.01	0.02
-7.5 - -6.5	174	0.03	0.05
-6.5 - -5.5	685	0.12	0.18
-5.5 - -4.5	2286	0.42	0.59
-4.5 - -3.5	6872	1.25	1.84
-3.5 - -2.5	24635	4.48	6.32
-2.5 - -1.5	34133	6.20	12.52
-1.5 - -0.5	63246	11.50	24.02
-0.5 - 0.5	252990	45.98	70.00
0.5 - 1.5	108799	19.77	89.77
1.5 - 2.5	31622	5.75	95.52
2.5 - 3.5	16134	2.93	98.45
3.5 - 4.5	7187	1.31	99.76
4.5 - 5.5	1220	0.22	99.98
5.5 - 6.5	91	0.02	100.00
6.5 - 7.5	13	0.00	100.00
7.5 - 8.5	0	0.0	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	4	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
URBAN DATA
FOR URBAN FOLLOWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	51600	9.38
CRUISE	201377	36.59
ACCELERATION	165139	30.01
DECELERATION	132240	24.03

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(MILES)
(%)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	114.20 48.83	49.47 7.94	0.94 0.15	17.43 58.01	81.83 23.21	16.36 1.61
LIGHT UNINFLUENCED	55.24 23.62	178.79 28.71	24.60 4.05	7.29 24.27	102.12 28.96	163.09 16.05
LIGHT INFLUENCED	45.31 19.37	69.82 11.21	8.86 1.46	2.59 8.61	61.58 17.46	12.44 1.22
MEDIUM UNINFLUENCED	8.48 3.63	113.78 18.27	252.78 41.57	1.73 5.74	31.73 9.00	355.25 34.96
MEDIUM INFLUENCED	9.33 3.99	186.70 29.98	247.27 40.67	0.99 3.29	74.73 21.19	331.67 32.64
HEAVY UNINFLUENCED	0.03 0.01	2.55 0.41	11.33 1.86	0.0 0.0	0.06 0.02	29.67 2.92
HEAVY INFLUENCED	1.27 0.54	21.15 3.40	61.99 10.20	0.01 0.03	0.55 0.16	105.57 10.39
HEAVY STOP AND GO	0.0 0.0	0.49 0.08	0.28 0.05	0.01 0.05	0.02 0.01	2.04 0.20
TOTALS (%)	233.86 100.00	622.75 100.00	608.03 100.00	30.05 100.00	352.62 100.00	1016.07 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(MINUTES)
(%)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	364.03	101.47	1.77	46.77	112.47	19.78
TRAFFIC	44.81	7.25	0.24	54.00	23.55	1.71
LIGHT	227.87	370.13	39.05	22.37	128.88	186.42
UNINFLUENCED	28.05	26.44	5.37	25.83	26.99	16.25
LIGHT	139.22	151.22	14.60	6.00	87.47	16.72
INFLUENCED	17.14	10.80	2.01	6.93	18.32	1.44
MEDIUM	37.10	264.75	280.57	8.13	41.48	383.67
UNINFLUENCED	4.57	18.91	38.61	9.39	8.69	33.09
MEDIUM	40.65	436.65	295.93	3.28	106.20	368.83
INFLUENCED	5.00	31.19	40.72	3.79	22.24	31.81
HEAVY	0.03	10.87	12.85	0.0	0.07	34.95
UNINFLUENCED	0.00	0.78	1.77	0.0	0.01	3.01
HEAVY	3.33	61.68	80.02	0.02	0.87	142.30
INFLUENCED	0.41	4.41	11.01	0.02	0.18	12.27
HEAVY	0.12	3.17	1.92	0.03	0.03	4.92
STOP AND GO	0.01	0.23	0.26	0.04	0.01	0.42
TOTALS	812.35	1399.93	726.70	86.60	477.47	1159.58
(%)	100.00	100.00	100.00	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
URBAN-RURAL DATA
(AVERAGE SPEED)
(MPH)
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO TRAFFIC	18.82	29.25	31.80	22.36	43.66	49.61
LIGHT UNINFLUENCED	14.55	28.98	37.79	19.57	47.54	51.93
LIGHT INFLUENCED	19.53	27.70	36.41	25.89	42.24	44.65
MEDIUM UNINFLUENCED	13.72	25.78	54.06	12.73	45.89	55.56
MEDIUM INFLUENCED	13.77	25.65	50.13	18.06	42.22	53.96
HEAVY UNINFLUENCED	51.77	14.09	52.90	0.0	50.22	50.93
HEAVY INFLUENCED	22.79	20.58	46.48	27.20	38.17	44.51
HEAVY STOP AND GO	0.0	9.32	8.71	24.55	42.02	24.85

TRAFFIC DENSITY SUMMARY FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	646.28	13.86	280.23	9.79	26.02
LIGHT UNINFLUENCED	976.72	20.95	531.13	18.55	32.63
LIGHT INFLUENCED	415.22	8.91	200.59	7.01	28.99
MEDIUM UNINFLUENCED	1015.70	21.78	763.74	26.67	45.12
MEDIUM INFLUENCED	1251.55	26.84	850.69	29.71	40.78
HEAVY UNINFLUENCED	58.77	1.26	43.63	1.52	44.55
HEAVY INFLUENCED	288.22	6.18	190.54	6.65	39.67
HEAVY STOP AND GO	10.18	0.22	2.84	0.10	16.76
TOTALS	4662.63	100.00	2863.39	100.00	36.85

ROAD TYPE SUMMARY
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	812.35	1399.93	726.70	86.60	477.47	1159.58	4662.63
TIME,%	17.42	30.02	15.59	1.86	10.24	24.87	100.00
MILES	233.66	622.75	608.03	30.05	352.62	1016.07	2863.39
MILES,%	8.17	21.75	21.23	1.05	12.31	35.49	100.00
AVERAGE SPEED (MPH)	17.27	26.69	50.20	20.82	44.31	52.57	36.85
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.28	1.70	1.06	1.18	1.36	1.07	1.30
NUMBER OF TRIPS	901	283	209	100	86	189	1768
STOPS/MILE	0.78	0.84	0.03	0.77	0.09	0.02	0.28

SPEED DISTRIBUTION
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	11145	3.99	3.99
0.1 - 2.5	4788	1.71	5.70
2.5 - 7.5	9214	3.30	9.00
7.5 - 12.5	15542	5.56	14.56
12.5 - 17.5	13954	4.99	19.55
17.5 - 22.5	16607	5.94	25.49
22.5 - 27.5	19027	6.81	32.30
27.5 - 32.5	20101	7.19	39.49
32.5 - 37.5	22124	7.91	47.40
37.5 - 42.5	20406	7.30	54.70
42.5 - 47.5	20969	7.50	62.20
47.5 - 52.5	29046	10.39	72.60
52.5 - 57.5	35740	12.79	85.38
57.5 - 62.5	27303	9.77	95.15
62.5 -100.0	13557	4.85	100.00

ACCEL/DECEL DISTRIBUTION
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	18	0.01	0.01
-9.5 - -8.5	7	0.00	0.01
-8.5 - -7.5	12	0.00	0.01
-7.5 - -6.5	43	0.02	0.03
-6.5 - -5.5	200	0.07	0.10
-5.5 - -4.5	765	0.27	0.37
-4.5 - -3.5	2356	0.84	1.22
-3.5 - -2.5	7676	2.75	3.97
-2.5 - -1.5	10730	3.85	7.82
-1.5 - -0.5	28953	10.38	18.20
-0.5 - 0.5	155118	55.61	73.81
0.5 - 1.5	55730	19.98	93.79
1.5 - 2.5	9993	3.58	97.37
2.5 - 3.5	4960	1.78	99.15
3.5 - 4.5	1994	0.71	99.86
4.5 - 5.5	327	0.12	99.98
5.5 - 6.5	35	0.01	99.99
6.5 - 7.5	9	0.00	100.00
7.5 - 8.5	3	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	7	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
URBAN-RURAL DATA
FOR URBAN-RURAL FOLLOWS ONLY

OPERATIONAL MODE	FREQUENCY	FREQUENCY,%
IDLE	10292	3.69
CRUISE	144810	51.89
ACCELERATION	73118	26.20
DECELERATION	50835	18.22

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(MILES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWA
NO TRAFFIC	397.38 40.81	160.22 5.97	3.90 0.34	76.07 84.57	152.78 31.92	17.48 1.45
LIGHT UNINFLUENCED	330.31 33.92	716.50 26.69	54.65 4.78	7.49 8.32	127.89 26.72	201.94 16.72
LIGHT INFLUENCED	110.48 11.35	231.67 8.63	13.01 1.14	3.55 3.94	81.24 16.97	15.30 1.27
MEDIUM UNINFLUENCED	48.50 4.98	590.11 21.98	379.14 33.14	1.83 2.04	36.37 7.60	435.45 36.06
MEDIUM INFLUENCED	81.79 8.40	858.94 31.99	523.03 45.71	0.99 1.10	79.79 16.67	388.90 32.21
HEAVY UNINFLUENCED	0.16 0.02	20.51 0.76	24.19 2.11	0.0 0.0	0.06 0.01	31.06 2.57
HEAVY INFLUENCED	4.97 0.51	101.67 3.79	140.37 12.27	0.01 0.01	0.55 0.12	115.20 9.54
HEAVY STOP AND GO	0.09 0.01	5.01 0.19	5.92 0.52	0.01 0.02	0.02 0.00	2.13 0.18
TOTALS (%)	973.67 100.00	2684.64 100.00	1144.22 100.00	89.95 100.00	478.71 100.00	1207.45 100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(MINUTES)
(%)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY
NO	1366.83	378.05	9.10	145.13	208.37	21.33
TRAFFIC	38.06	5.32	0.62	77.30	32.00	1.57
LIGHT	1234.12	1703.50	88.67	22.82	163.37	227.12
UNINFLUENCED	34.37	23.98	6.07	12.15	25.09	16.69
LIGHT	374.22	570.33	19.93	8.03	118.88	19.87
INFLUENCED	10.42	8.03	1.37	4.28	18.26	1.46
MEDIUM	203.72	1484.08	438.05	8.43	47.83	466.68
UNINFLUENCED	5.67	20.89	30.01	4.49	7.35	34.30
MEDIUM	380.23	2372.68	636.83	3.28	111.78	427.68
INFLUENCED	10.59	33.40	43.63	1.75	17.17	31.43
HEAVY	0.43	74.82	29.95	0.0	0.07	36.53
UNINFLUENCED	0.01	1.05	2.05	0.0	0.01	2.68
HEAVY	30.67	456.58	210.57	0.02	0.87	156.18
INFLUENCED	0.85	6.43	14.43	0.01	0.13	11.48
HEAVY	0.70	64.45	26.47	0.03	0.03	5.30
STOP AND GO	0.02	0.91	1.81	0.02	0.01	0.39
TOTALS	3590.92	7104.50	1459.57	187.75	651.20	1360.70
(%)	100.00	100.00	100.00	100.00	100.00	100.00

ROAD TYPE VERSUS TRAFFIC DENSITY
FOR
TOTAL DATA SAMPLE
(AVERAGE SPEED)
(MPH)
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWA
NO TRAFFIC	17.44	25.43	25.73	31.45	43.99	49.17
LIGHT UNINFLUENCED	16.06	25.24	36.98	19.69	46.97	53.35
LIGHT INFLUENCED	17.71	24.37	39.15	26.48	41.00	46.21
MEDIUM UNINFLUENCED	14.28	23.86	51.93	13.05	45.62	55.98
MEDIUM INFLUENCED	12.91	21.72	49.28	18.06	42.83	54.56
HEAVY UNINFLUENCED	22.43	16.45	48.46	0.0	50.22	51.01
HEAVY INFLUENCED	9.72	13.36	40.00	27.20	38.17	44.26
HEAVY STOP AND GO	7.88	4.66	13.43	24.55	42.02	24.09

TRAFFIC DENSITY SUMMARY FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

TRAFFIC DENSITY	TIME (MIN)	TIME,%	MILES	MILES,%	AVERAGE SPEED (MPH)
NO TRAFFIC	2128.82	14.83	807.83	12.28	22.77
LIGHT UNINFLUENCED	3439.58	23.96	1438.78	21.87	25.10
LIGHT INFLUENCED	1111.27	7.74	455.25	6.92	24.58
MEDIUM UNINFLUENCED	2648.80	18.45	1491.40	22.67	33.78
MEDIUM INFLUENCED	3932.50	27.40	1933.45	29.39	29.50
HEAVY UNINFLUENCED	141.80	0.99	75.98	1.15	32.15
HEAVY INFLUENCED	854.88	5.96	362.78	5.51	25.46
HEAVY STOP AND GO	96.58	0.68	13.19	0.20	8.16
TOTALS	14354.63	100.00	6578.64	100.00	27.50

ROAD TYPE SUMMARY
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

	URBAN LOCAL	URBAN ARTERY	URBAN FREEWAY	RURAL LOCAL	RURAL ARTERY	RURAL FREEWAY	TOTALS
TIME(MIN)	3590.92	7104.50	1459.57	187.75	651.20	1360.70	14354.63
TIME,%	25.02	49.49	10.17	1.31	4.54	9.48	100.00
MILES	973.67	2684.64	1144.22	89.95	478.71	1207.45	6578.64
MILES,%	14.80	40.81	17.39	1.37	7.28	18.35	100.00
AVERAGE SPEED (MPH)	16.27	22.67	47.04	28.74	44.11	53.24	27.50
AVERAGE NUMBER OF OCCURRENCES PER TRIP	1.22	1.25	1.06	1.16	1.25	1.07	1.21
NUMBER OF TRIPS	3775	1658	403	111	123	212	6282
STOPS/MILE	1.38	1.30	0.07	0.36	0.08	0.02	0.76

SPEED DISTRIBUTION
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

SPEED RANGE (MPH)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
ZERO	67509	7.84	7.84
0.1 - 2.5	26460	3.07	10.92
2.5 - 7.5	49215	5.72	16.64
7.5 - 12.5	67980	7.90	24.54
12.5 - 17.5	71256	8.28	32.82
17.5 - 22.5	81174	9.43	42.25
22.5 - 27.5	84901	9.87	52.12
27.5 - 32.5	83829	9.74	61.86
32.5 - 37.5	76019	8.83	70.69
37.5 - 42.5	54075	6.28	76.97
42.5 - 47.5	44492	5.17	82.14
47.5 - 52.5	48335	5.62	87.76
52.5 - 57.5	50170	5.83	93.59
57.5 - 62.5	34828	4.05	97.64
62.5 -100.0	20337	2.36	100.00

ACCEL/DECEL DISTRIBUTION
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

ACCEL/DECEL RANGE (MPH/SEC)	FREQUENCY	FREQUENCY,%	CUMULATIVE FREQUENCY,%
-50.0 - -9.5	93	0.01	0.01
-9.5 - -8.5	17	0.00	0.01
-8.5 - -7.5	60	0.01	0.02
-7.5 - -6.5	236	0.03	0.05
-6.5 - -5.5	910	0.11	0.15
-5.5 - -4.5	3118	0.36	0.52
-4.5 - -3.5	9362	1.09	1.61
-3.5 - -2.5	32708	3.81	5.42
-2.5 - -1.5	45450	5.30	10.72
-1.5 - -0.5	94111	10.97	21.70
-0.5 - 0.5	427571	49.86	71.55
0.5 - 1.5	169322	19.74	91.30
1.5 - 2.5	42125	4.91	96.21
2.5 - 3.5	21379	2.49	98.70
3.5 - 4.5	9371	1.09	99.79
4.5 - 5.5	1602	0.19	99.98
5.5 - 6.5	134	0.02	100.00
6.5 - 7.5	22	0.00	100.00
7.5 - 8.5	4	0.00	100.00
8.5 - 9.5	0	0.0	100.00
9.5 - 50.0	16	0.00	100.00

OPERATICNAL MODE SUMMARY
FOR
TOTAL DATA SAMPLE
FOR ALL FOLLOWS

OPERATIONAL MODE	FREQUENCY	FREQUENCY, %
IDLE	62100	7.24
CRUISE	365442	42.60
ACCELERATION	244104	28.45
DECELERATION	186238	21.71

Appendix D

SUMMARY STATISTICS BY CYCLE

This appendix presents summary statistics for each of the 110 cycles used to generate emissions-speed relationships.

STATISTICS FOR CYCLES GENERATED
WITH 5-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
2109680429	50.29	14.76	19.08	15.87	3.62
1327725215	48.92	14.37	18.84	17.86	4.08
1850807071	48.55	15.61	19.05	16.79	4.11
1149392487	48.54	13.63	19.05	18.77	3.90
1906421087	49.01	14.49	18.27	18.23	4.03
13291391	45.98	17.18	19.70	17.14	3.96
1491985229	48.57	16.31	18.35	16.77	3.77
975806839	49.11	15.52	18.93	16.44	4.05
1428955175	46.12	15.60	19.82	18.47	4.38
1094242485	49.13	14.27	18.68	17.74	3.84

STATISTICS FOR CYCLES GENERATED
WITH 10-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
677815519	31.87	22.15	26.38	19.60	10.41
1231232183	34.01	22.19	24.00	19.80	10.26
2052594349	32.59	21.75	26.16	19.50	10.24
1108135727	31.76	21.95	24.84	21.44	10.50
494609461	32.31	22.18	24.85	20.67	10.38
2106014039	32.61	22.33	22.86	22.20	10.33
92882293	31.64	24.44	23.54	20.37	10.67
485398637	29.04	23.95	26.39	20.63	10.81
1224505365	30.89	23.09	26.11	19.90	10.69
473512053	31.68	22.59	25.96	19.77	10.25

STATISTICS FOR CYCLES GENERATED
WITH 15-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
853321301	24.50	27.58	26.69	21.23	15.99
124304303	24.68	26.14	27.09	22.09	15.89
595418559	24.13	26.54	27.50	21.84	15.80
377742421	24.34	26.83	26.12	22.71	15.89
884913093	24.86	28.10	25.54	21.50	15.86
1160313951	23.87	28.35	26.05	21.73	15.99
2081354365	23.46	27.90	27.12	21.51	15.98
20196639	23.46	30.37	26.09	20.09	15.90
576295815	23.52	28.40	25.94	22.15	15.89
383997893	24.39	27.72	26.10	21.79	15.67

STATISTICS FOR CYCLES GENERATED
WITH 20-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
2076207909	17.35	34.75	24.67	23.23	20.23
917868269	17.34	33.45	26.48	22.73	20.55
1145941869	16.66	35.17	26.36	21.81	20.92
1785253549	17.43	35.48	26.20	20.89	20.57
1662088415	16.68	35.54	26.51	21.26	20.77
930427845	15.85	35.08	27.39	21.68	20.76
763453111	16.88	36.05	25.33	21.74	20.88
1883796199	17.17	34.95	26.18	21.70	20.91
799556455	16.77	34.76	26.36	22.11	20.96
1428082519	17.23	36.46	27.82	18.50	20.96

STATISTICS FOR CYCLES GENERATED
WITH 25-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
261258463	14.20	44.03	24.34	17.43	25.01
828574245	13.91	43.11	25.21	17.76	25.13
2043615135	13.89	42.95	23.40	19.76	25.84
605350991	12.75	41.49	23.48	22.28	25.45
1361589663	13.17	43.08	25.11	18.64	25.46
1729933573	12.62	40.41	27.91	19.05	25.16
1207042885	13.77	40.17	25.44	20.62	25.81
1476581517	13.84	41.86	24.45	19.85	24.84
762960839	12.77	42.19	25.05	20.00	25.15
463948607	13.48	43.48	23.37	19.67	24.95

STATISTICS FOR CYCLES GENERATED
WITH 30-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
727915013	9.90	47.74	23.27	19.09	29.34
1320093351	10.33	48.90	21.93	18.84	30.66
1498759559	10.47	50.45	20.84	18.24	30.69
1949264861	10.07	46.97	23.30	19.67	29.32
828164445	10.12	45.29	24.20	20.39	30.40
1895618959	9.56	49.98	21.96	18.50	30.66
2099533887	10.38	49.62	22.01	17.99	30.31
376722471	9.97	50.37	21.51	18.15	30.89
1971395269	9.62	50.41	21.54	18.43	30.77
1853905133	10.81	50.81	21.94	16.45	30.78

STATISTICS FOR CYCLES GENERATED
WITH 35-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
1898183535	6.73	59.93	19.01	14.33	35.38
1239587141	7.09	54.64	20.84	17.42	35.03
1065449903	7.32	56.66	19.54	16.48	35.05
1549904549	5.67	58.86	18.76	16.70	35.83
6132615	5.90	57.25	20.38	16.47	35.44
1326688213	6.66	56.93	19.40	17.01	35.35
392125223	7.24	54.37	22.38	16.01	35.51
1141502127	7.42	56.80	20.09	15.68	35.66
1576641271	7.11	56.93	18.44	17.52	35.16
1461995447	6.31	58.08	17.90	17.71	35.08

STATISTICS FOR CYCLES GENERATED
WITH 40-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
428609517	3.50	64.93	16.43	15.14	40.63
1844070869	2.22	65.41	17.79	14.58	40.81
1081211767	2.94	65.00	16.30	15.75	40.75
154660405	2.57	64.46	17.73	15.23	40.29
838711551	3.22	66.43	17.07	13.28	40.75
2019760407	2.70	66.98	16.34	13.98	40.76
1300031957	3.48	63.86	18.40	14.25	40.45
1368960077	3.77	63.64	18.25	14.35	40.84
2143343197	3.66	62.73	18.02	15.60	40.46
840605415	2.94	64.71	17.27	15.07	40.82

STATISTICS FOR CYCLES GENERATED
WITH 45-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
1290506151	2.82	69.68	13.87	13.64	45.70
359970973	2.70	69.10	14.67	13.54	45.65
1085110757	2.78	71.22	15.14	10.86	46.34
1567730263	2.09	68.34	16.80	12.77	43.69
738482759	2.55	68.26	16.03	13.17	43.70
1522481581	2.09	68.68	16.27	12.96	44.01
254921599	2.15	68.46	16.88	12.51	43.89
2095918997	2.65	74.30	10.98	12.07	46.45
759952815	1.88	69.00	15.79	13.33	46.50
1539443229	1.91	72.44	13.82	11.83	46.52

STATISTICS FOR CYCLES GENERATED
WITH 50-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
251292455	2.25	72.59	13.48	11.68	50.94
163439645	2.53	72.07	14.10	11.31	50.86
921352365	2.25	74.72	13.12	9.91	50.80
445977741	2.57	70.74	14.32	12.36	50.77
778751045	2.60	74.44	12.10	10.86	50.62
678303815	2.61	72.63	14.26	10.50	50.54
1453250927	2.29	74.38	12.23	11.10	50.93
1774141247	2.45	72.06	13.61	11.88	50.94
488060575	2.52	70.89	14.20	12.39	50.96
1767058805	2.45	73.69	12.69	11.16	50.95

STATISTICS FOR CYCLES GENERATED
WITH 55-MPH NOMINAL AVERAGE SPEED

STARTING RANDOM NUMBER	% TIME AT IDLE	% TIME IN CRUISE	% TIME IN ACCEL.	% TIME IN DECEL.	AVERAGE SPEED
797604965	2.03	78.86	9.70	9.40	54.62
1182910927	1.86	79.13	9.62	9.39	54.70
1471256527	1.38	82.71	8.25	7.66	55.57
1569851863	1.89	79.99	9.87	8.25	54.52
1499493989	2.08	78.98	10.38	8.56	54.50
202541159	2.32	78.69	10.43	8.56	54.62
465620869	2.23	78.06	10.18	9.53	54.48
1185764879	2.10	79.46	9.89	8.55	54.49
1800594799	2.16	77.85	10.07	9.91	54.60
2090343975	2.22	78.36	9.85	9.56	54.38

Appendix E

REGRESSIONS BY GROUP

This appendix gives the regression equations for HC, CO, NO_x, and FE versus speed. The standard error of the estimate, in grams per mile for emissions and miles per gallon for fuel economy and the square of the multiple correction coefficient are also given.

GROUP 1

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	4.41269E00	-2.90973E-01	1.58890E-02	-4.72494E-04	6.94077E-06	-3.92798E-08	.2244	.9992
ln CO	6.71606E00	-2.54663E-01	1.52347E-02	-4.87397E-04	7.58207E-06	-4.49514E-08	3.6820	.9970
NO_x	5.21966E00	-5.34103E-01	2.95325E-02	-6.12941E-04	4.43296E-06		.0553	.9913
FE	3.14595E-01	1.57904E00	-5.74284E-02	1.00371E-03	-6.81351E-06		.1851	.9977

GROUP 2

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	4.33704E00	-2.89572E-01	1.52990E-02	-4.46689E-04	6.48183E-06	-3.63456E-08	.1783	.9993
ln CO	6.70051E00	-2.96978E-01	1.60071E-02	-4.77396E-04	7.06752E-06	-4.03978E-08	1.8075	.9991
NO_x	6.42703E00	-4.50877E-01	2.49624E-02	-5.22665E-04	3.84355E-06		.0865	.9738
FE	4.78551E-01	1.36404E00	-4.37883E-02	7.25078E-04	-4.85636E-06		.1668	.9985

GROUP 3

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.86093E00	-2.69992E-01	1.44221E-02	-4.33638E-04	6.50735E-06	-3.78100E-08	.1017	.9995
ln CO	6.32701E00	-2.91473E-01	1.42949E-02	-3.87852E-04	5.29781E-06	-2.82441E-08	1.0585	.9996
NO_x	4.13593E00	-1.44444E-01	9.86336E-03	-2.23244E-04	1.75242E-06		.0943	.9591
FE	2.65385E-01	1.27663E00	-3.77342E-02	5.97166E-04	-3.91049E-06		.1233	.9993

GROUP 4

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	4.02722E00	-2.99985E-01	1.61351E-02	-4.87491E-04	7.29093E-06	-4.19769E-08	.1256	.9993
ln CO	6.63236E00	-3.05023E-01	1.60497E-02	-4.73969E-04	6.99075E-06	-3.99758E-08	1.8662	.9993
NO_x	5.79617E00	-2.10240E-01	1.24013E-02	-2.67963E-04	2.05192E-06		.1128	.9262
FE	3.11582E-01	1.22364E00	-3.56595E-02	5.65687E-04	-3.76048E-06		.1610	.9988

GROUP 5

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.94796E00	-3.08187E-01	1.68168E-02	-5.06843E-04	7.53855E-06	-4.31596E-08	.1212	.9992
ln CO	6.71513E00	-3.19130E-01	1.53183E-02	-4.22327E-04	5.84948E-06	-3.14969E-08	1.2267	.9997
NO_x	6.46023E00	-7.55328E-02	5.80579E-03	-1.36985E-04	1.15752E-06		.1514	.9072
FE	5.95170E-02	1.25782E00	-3.79929E-02	6.14226E-04	-4.10309E-06		.1521	.9989

GROUP 6

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.48543E00	-2.84985E-01	1.53833E-02	-4.56738E-04	6.73486E-06	-3.83798E-08	.0776	.9991
ln CO	6.52603E00	-3.27107E-01	1.62943E-02	-4.67573E-04	6.71906E-06	-3.74401E-08	1.0521	.9994
NO_x	5.70831E00	-1.13099E-01	9.80543E-03	-2.33511E-04	1.89584E-06		.1421	.9658
FE	1.05747E-01	1.21662E00	-3.49709E-02	5.53173E-04	-3.68781E-06		.1516	.9990

GROUP 7

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.34680E00	-2.87778E-01	1.56820E-02	-4.73179E-04	7.07954E-06	-4.08456E-08	.0674	.9990
ln CO	6.47431E00	-3.31038E-01	1.76179E-02	-5.38583E-04	8.17402E-06	-4.77803E-08	1.1105	.9989
NO_x	6.09245E00	-2.33642E-01	1.55797E-02	-3.51612E-04	2.74548E-06		.1319	.9578
FE	1.71050E-01	1.19930E00	-3.44781E-02	5.49666E-04	-3.69986E-06		.1584	.9989

GROUP 8

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.73630E00	-2.73049E-01	1.53577E-02	-4.60304E-04	6.78527E-06	-3.84880E-08	.1418	.9983
ln CO	6.60705E00	-2.76679E-01	1.72335E-02	-5.58279E-04	8.71678E-06	-5.16980E-08	3.9033	.9943
NO_x	4.65886E00	-3.98303E-01	2.23489E-02	-4.58363E-04	3.27345E-06		.0707	.9845
FE	2.56281E-01	1.67662E00	-6.28727E-02	1.11629E-03	-7.61951E-06		.1991	.9973

GROUP 9

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.59621E00	-2.83620E-01	1.53836E-02	-4.42136E-04	6.28732E-06	-3.46311E-08	.0932	.9990
ln CO	6.21586E00	-2.72054E-01	1.70304E-02	-5.52021E-04	8.62543E-06	-5.11440E-08	3.1396	.9907
NO_x	4.49788E00	-3.26366E-01	1.93983E-02	-4.14076E-04	3.06289E-06		.0624	.9859
FE	-2.23778E-01	1.77169E00	-6.36204E-02	1.09416E-03	-7.31982E-06		.2103	.9977

GROUP 10

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.88993E00	-2.93648E-01	1.62356E-02	-4.84148E-04	7.11591E-06	-4.02861E-08	.1368	.9988
ln CO	6.65254E00	-2.95188E-01	1.86353E-02	-6.21606E-04	9.93657E-06	-5.99779E-08	4.0137	.9943
NO_x	6.28350E00	-5.96082E-01	3.40221E-02	-7.12033E-04	5.17301E-06		.0729	.9915
FE	4.10257E-02	1.55074E00	-5.54787E-02	9.68831E-04	-6.61287E-06		.1984	.9976

GROUP 11

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.64334E00	-2.91072E-01	1.69089E-02	-5.26148E-04	8.02705E-06	-4.70117E-08	.1126	.9981
ln CO	6.70697E00	-3.10618E-01	2.04852E-02	-7.08527E-04	1.16215E-05	-7.15690E-08	4.4093	.9932
NO_x	5.25942E00	-3.92569E-01	2.26475E-02	-4.71276E-04	3.41930E-06		.0757	.9865
FE	4.70690E-01	1.17877E00	-3.72074E-02	6.36953E-04	-4.45778E-06		.2042	.9976

GROUP 12

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.74176E00	-2.83451E-01	1.56948E-02	-4.69759E-04	6.93832E-06	-3.94707E-08	.1238	.9986
ln CO	6.87927E00	-3.41147E-01	2.09446E-02	-6.65891E-04	1.02225E-05	-5.98265E-08	3.7772	.9961
NO_x	4.38870E00	-3.71046E-01	2.40919E-02	-5.18425E-04	3.81148E-06		.0749	.9940
FE	-2.13454E-01	1.39958E00	-4.70246E-02	8.12185E-04	-5.54867E-06		.1581	.9987

GROUP 13

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.18313E00	-2.89353E-01	1.73042E-02	-5.54707E-04	8.64204E-06	-5.13107E-08	.0887	.9972
ln CO	6.18761E00	-3.28888E-01	1.89747E-02	-6.28263E-04	1.00924E-05	-6.12727E-08	1.3753	.9967
NO_x	1.18084E00	4.04203E-01	-1.63630E-02	3.02391E-04	-1.98740E-06		.1387	.9800
FE	9.68329E-01	1.06147E00	-2.68648E-02	4.29095E-04	-3.09349E-06		.2370	.9979

GROUP 14

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.64655E00	-3.04959E-01	1.68416E-02	-5.09623E-04	7.59516E-06	-4.34963E-08	.1015	.9989
ln CO	6.53829E00	-3.32817E-01	1.76277E-02	-5.24123E-04	7.72221E-06	-4.37025E-08	1.4710	.9987
NO_x	5.36873E00	-3.37145E-01	2.24408E-02	-4.98008E-04	3.77435E-06		.0907	.9887
FE	1.46920E-01	1.21411E00	-3.68640E-02	6.12047E-04	-4.18479E-06		.1476	.9989

GROUP 15

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.53239E00	-2.85676E-01	1.63180E-02	-5.00793E-04	7.55067E-06	-4.37187E-08	.1105	.9981
ln CO	6.60045E00	-3.29116E-01	2.10112E-02	-6.89057E-04	1.08390E-05	-6.47125E-08	3.3149	.9943
NO_x	2.96598E00	-2.42909E-01	1.51910E-02	-3.27486E-04	2.42566E-06		.0426	.9928
FE	1.48064E-02	1.39589E00	-4.89727E-02	8.60057E-04	-5.90967E-06		.1732	.9981

GROUP 16

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	3.19966E00	-2.98632E-01	1.84473E-02	-6.16544E-04	9.92062E-06	-6.04021E-08	.2167	.9968
ln CO	6.00592E00	-3.62954E-01	2.32775E-02	-8.15039E-04	1.36261E-05	-8.55909E-08	1.4033	.9930
NO_x	2.47505E00	1.33980E-01	-6.10707E-03	1.14530E-04	-7.15847E-07		.1013	.8475
FE	1.03821E00	9.83122E-01	-2.63471E-02	4.27556E-04	-3.04676E-06		.2210	.9976

GROUP 17

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.59720E00	-3.44633E-01	1.95417E-02	-6.25720E-04	9.78442E-06	-5.83369E-08	.0287	.9984
ln CO	5.88037E00	-3.68756E-01	2.10782E-02	-6.76438E-04	1.06267E-05	-6.36405E-08	.8023	.9961
NO_x	2.32457E00	9.74352E-04	3.14443E-03	-9.47071E-05	8.61185E-07		.0893	.9691
FE	5.61201E-01	1.26436E00	-4.04759E-02	6.81069E-04	-4.65505E-06		.1871	.9980

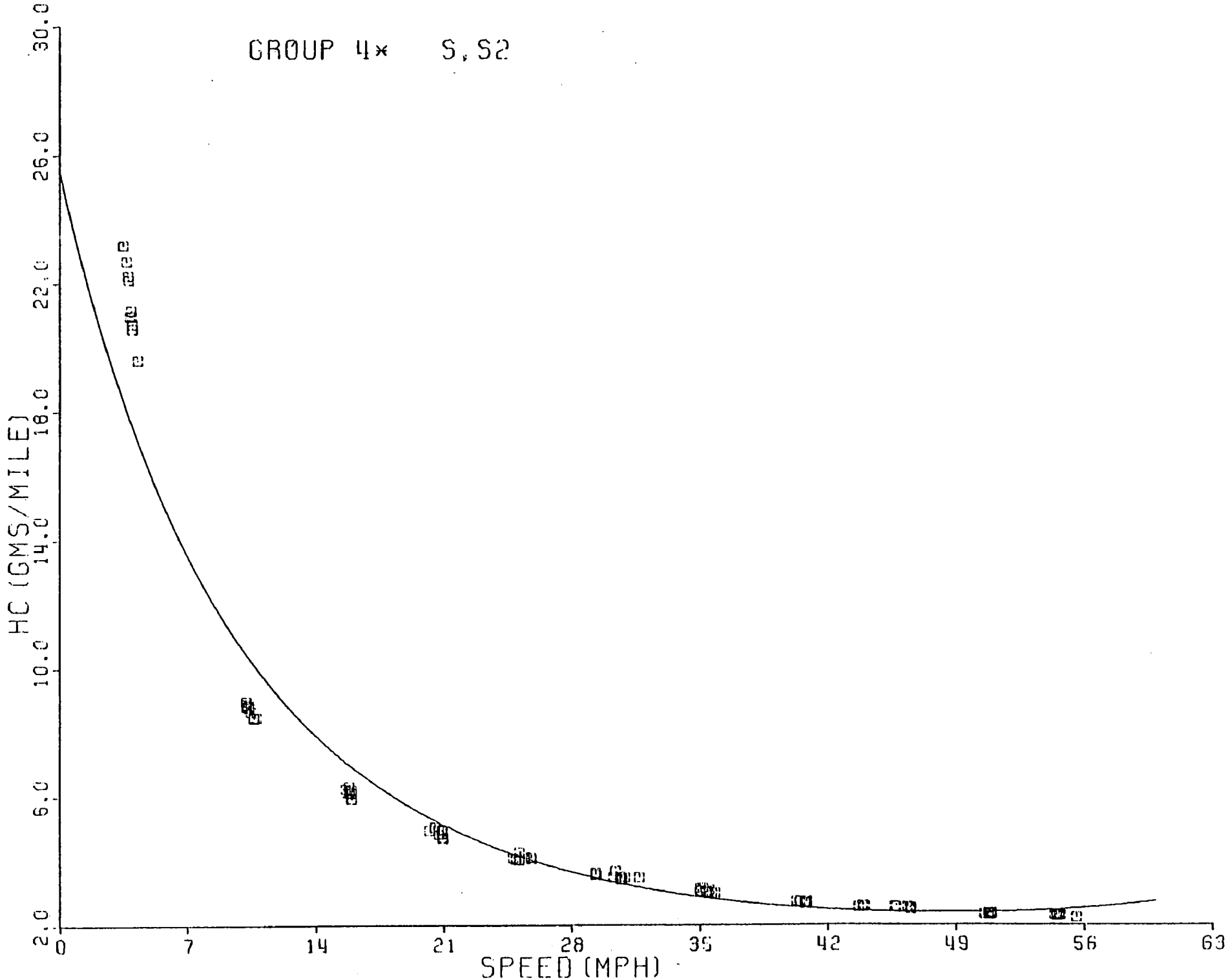
GROUP 18

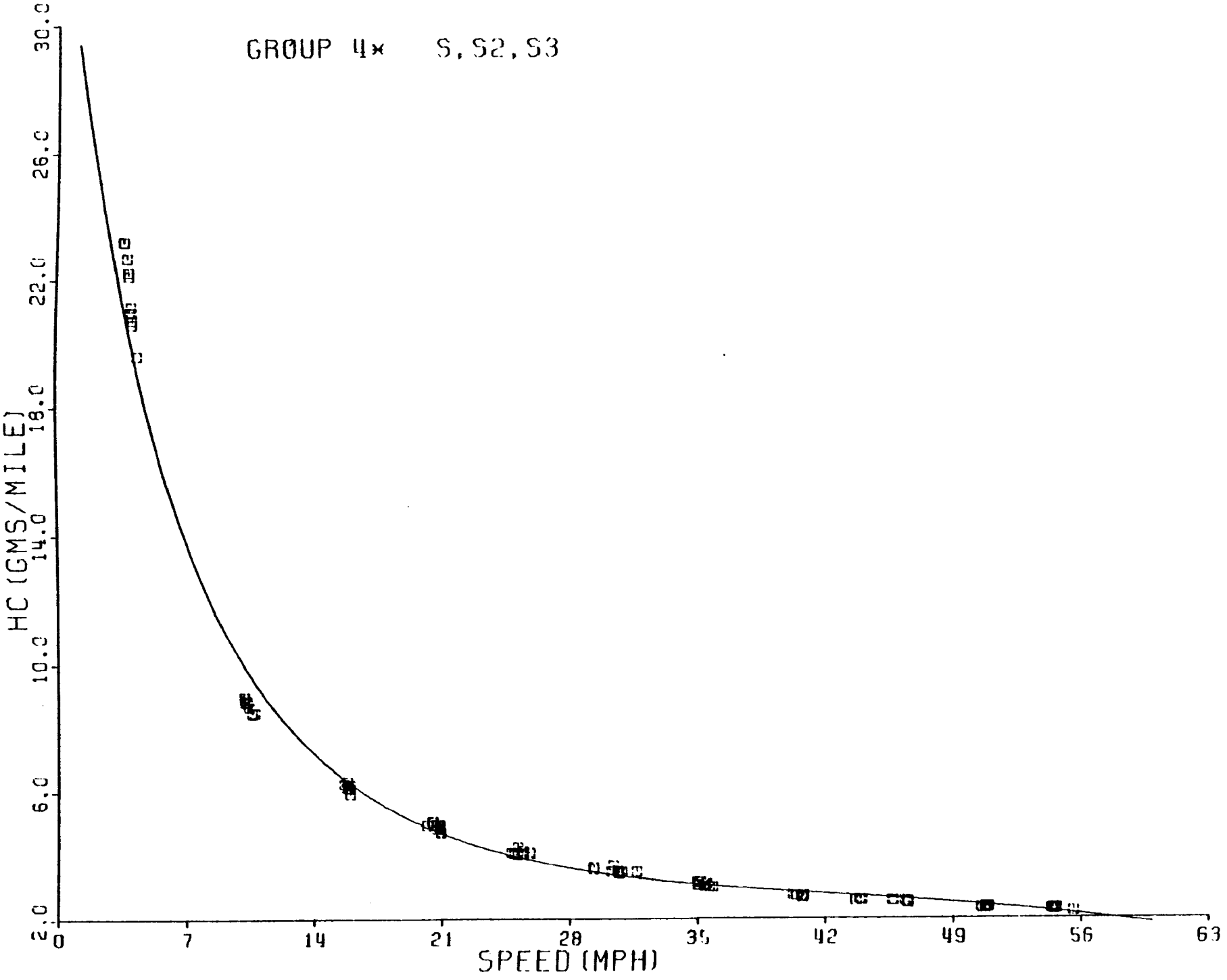
VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.10492E00	-3.35781E-01	2.11609E-02	-7.31550E-04	1.20715E-05	-7.48567E-08	.0280	.9957
ln CO	5.35385E00	-3.91562E-01	2.70721E-02	-9.76178E-04	1.65270E-05	-1.04317E-07	1.0787	.9837
NO_x	1.99784E00	-8.97504E-02	8.19070E-03	-1.99301E-04	1.59865E-06		.0668	.9841
FE	6.44604E-01	1.20566E00	-3.92697E-02	6.63151E-04	-4.50934E-06		.1740	.9980

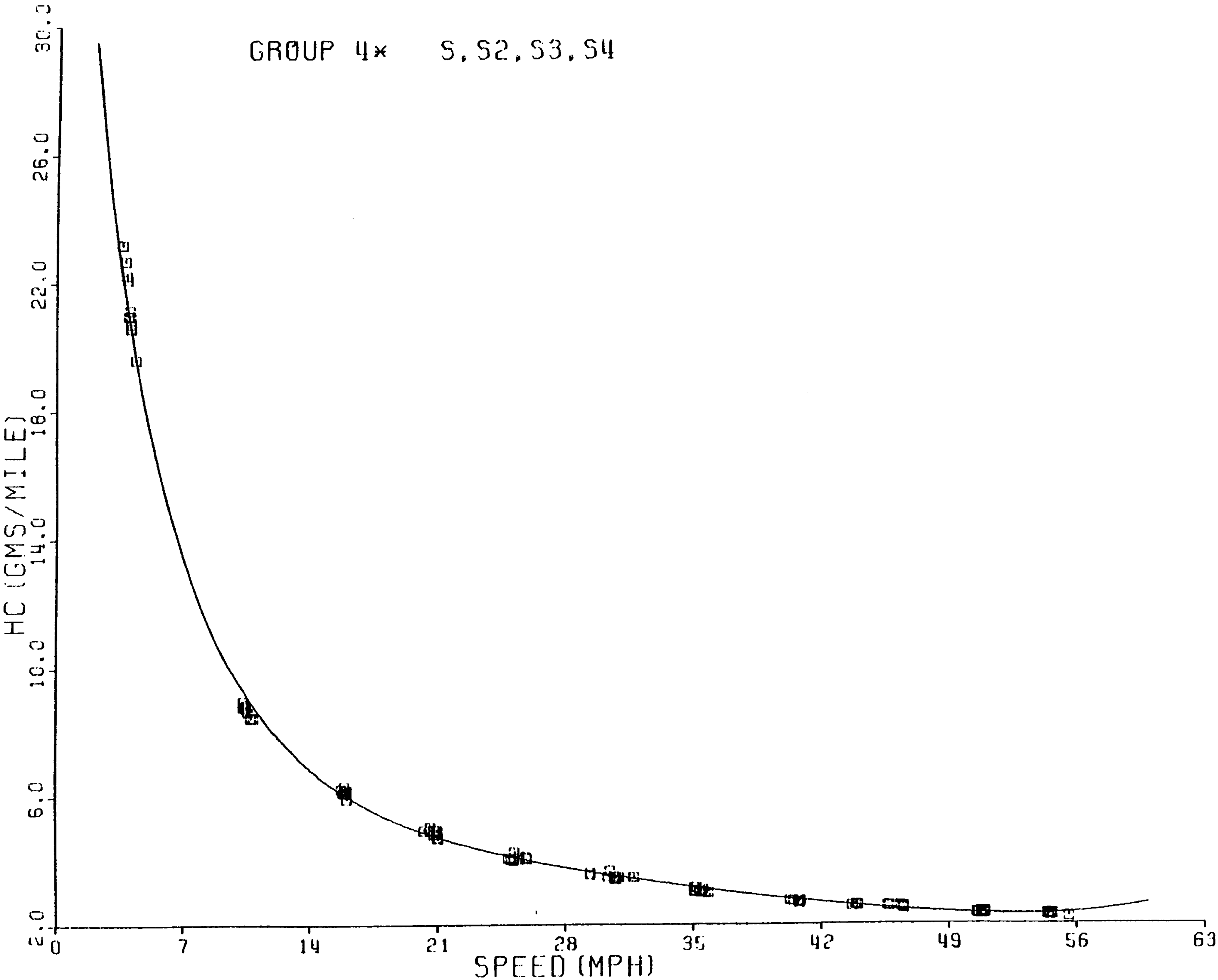
Appendix F

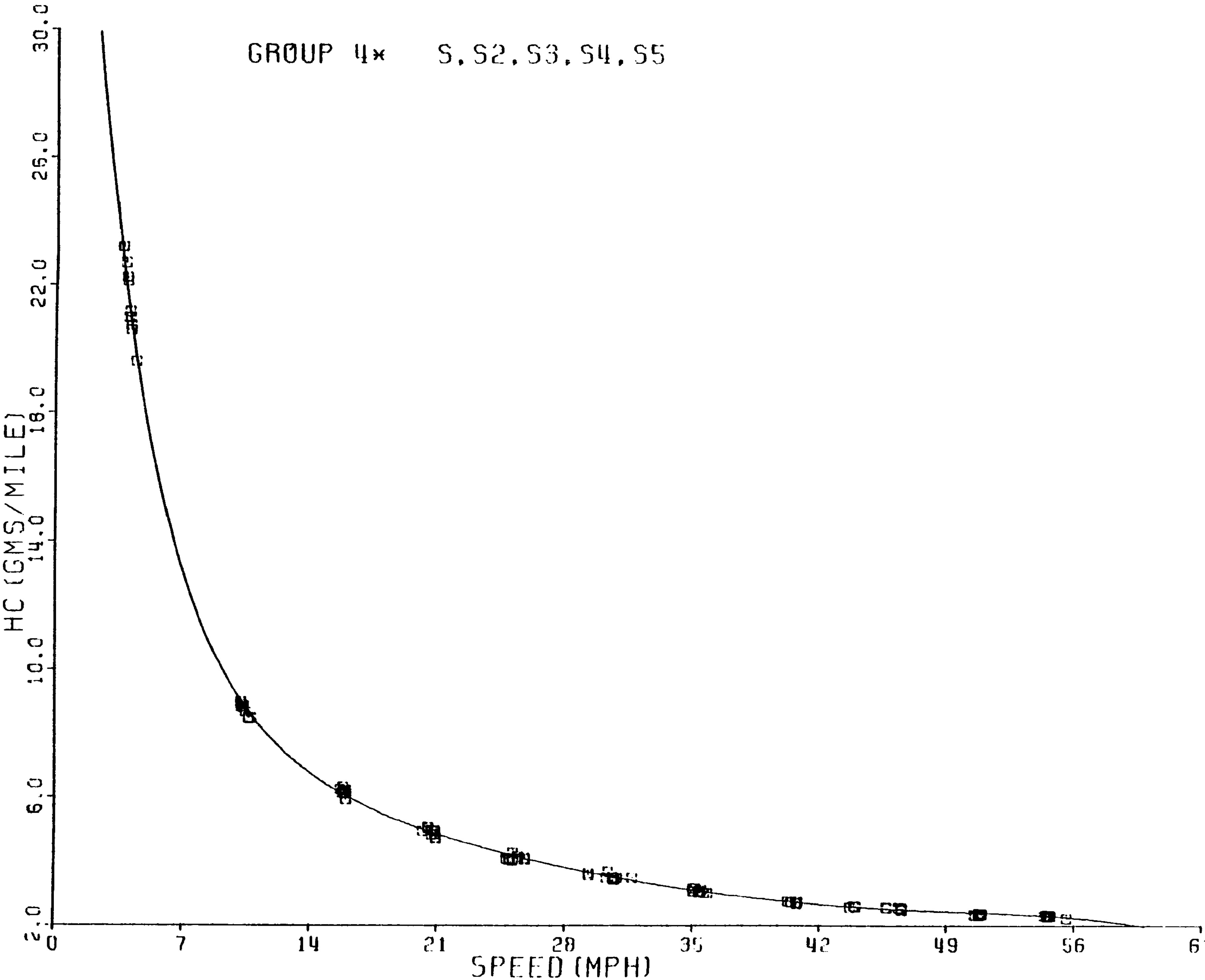
REGRESSION PLOTS BY ORDER

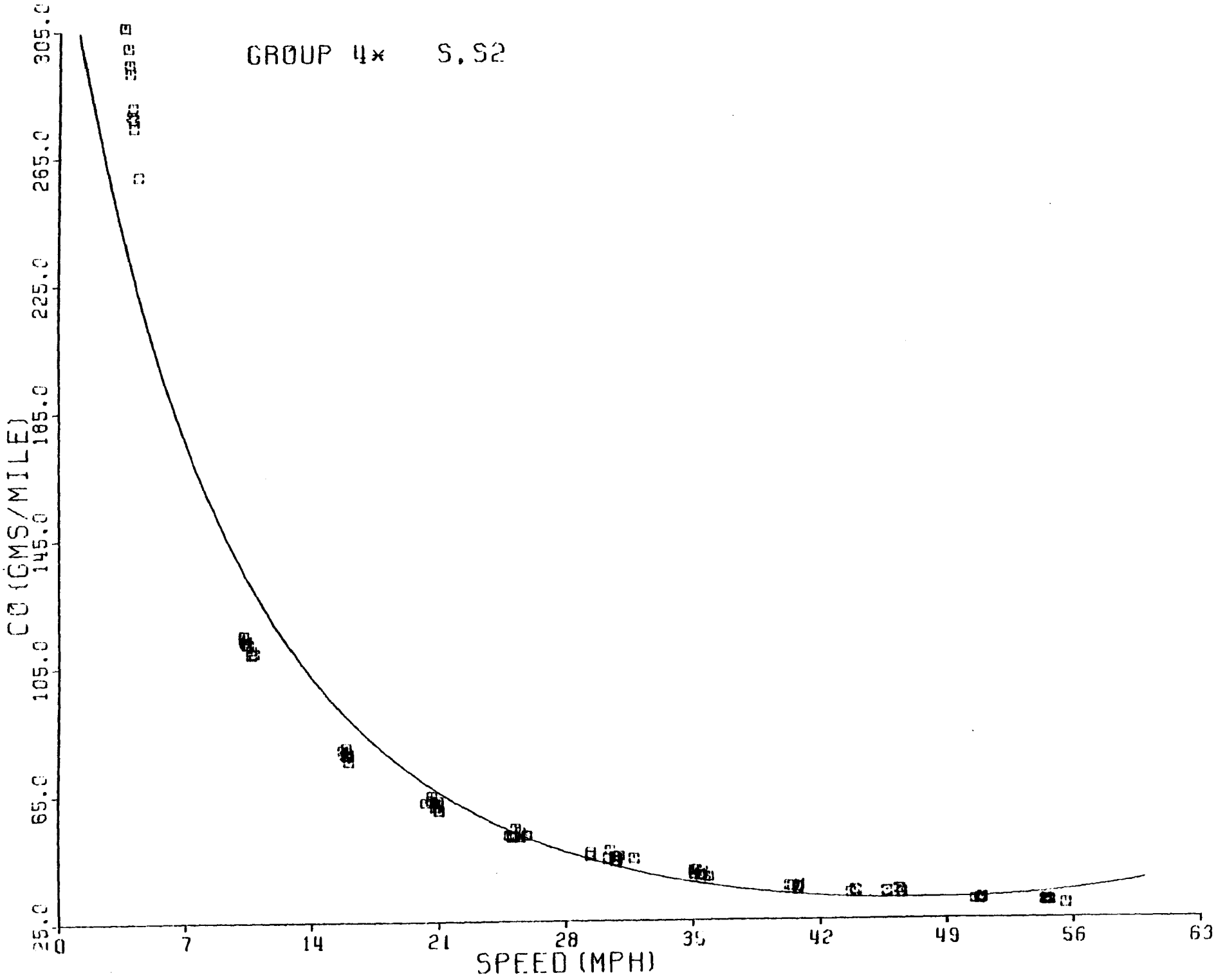
This appendix shows plots of the second-order through fifth-order regressions for HC and CO and the second-order through fourth-order regressions for NO_x and fuel economy all for Model-Year Group 4. In each case, the order of regression is indicated by the last power of speed. For example, the title of a third-order plot would be: Group 4* S,S2,S3.

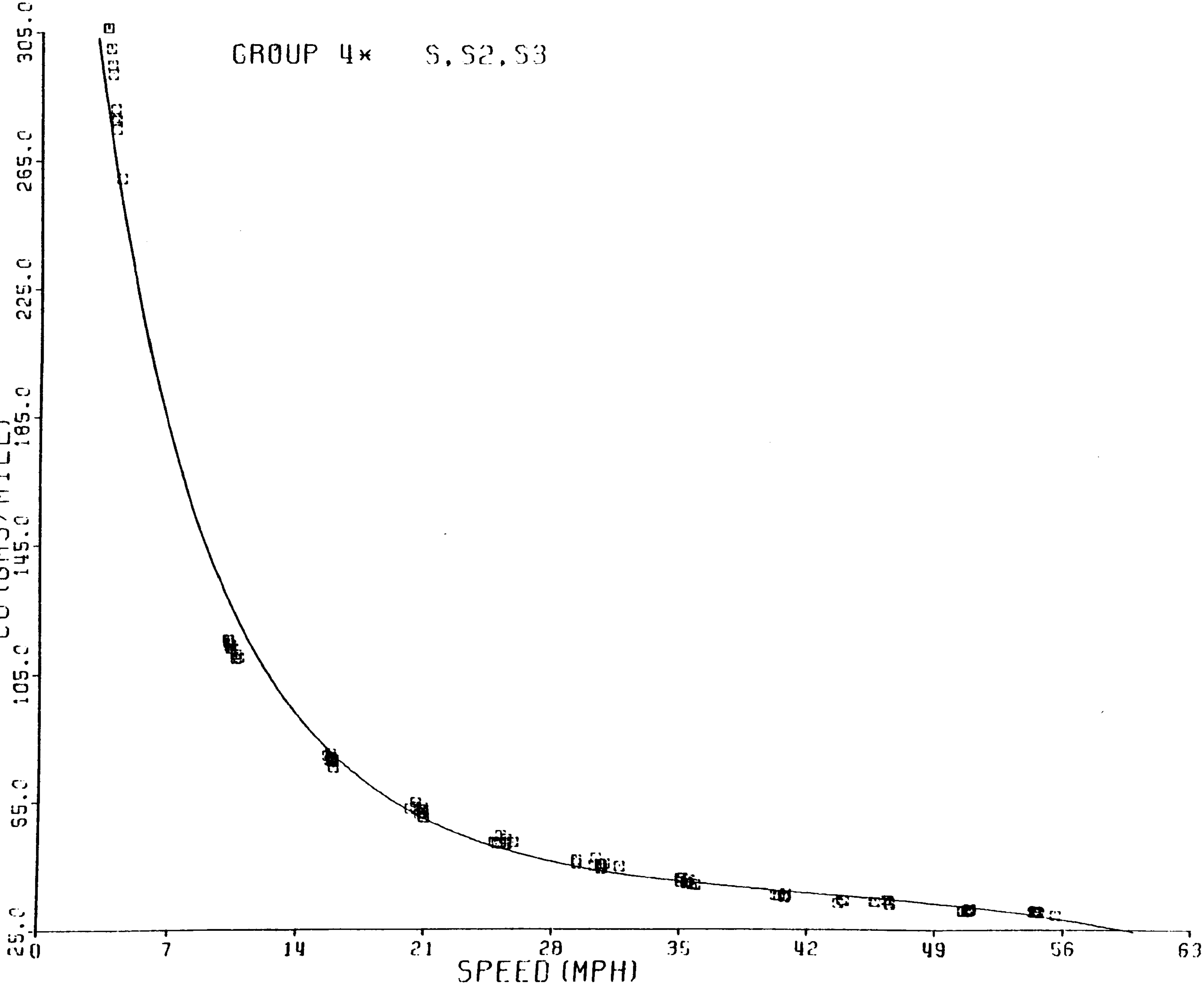

GROUP 4× S, S2
HC (GMS/MILE)
30.0
26.0
22.0
18.0
14.0
10.0
6.0
2.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

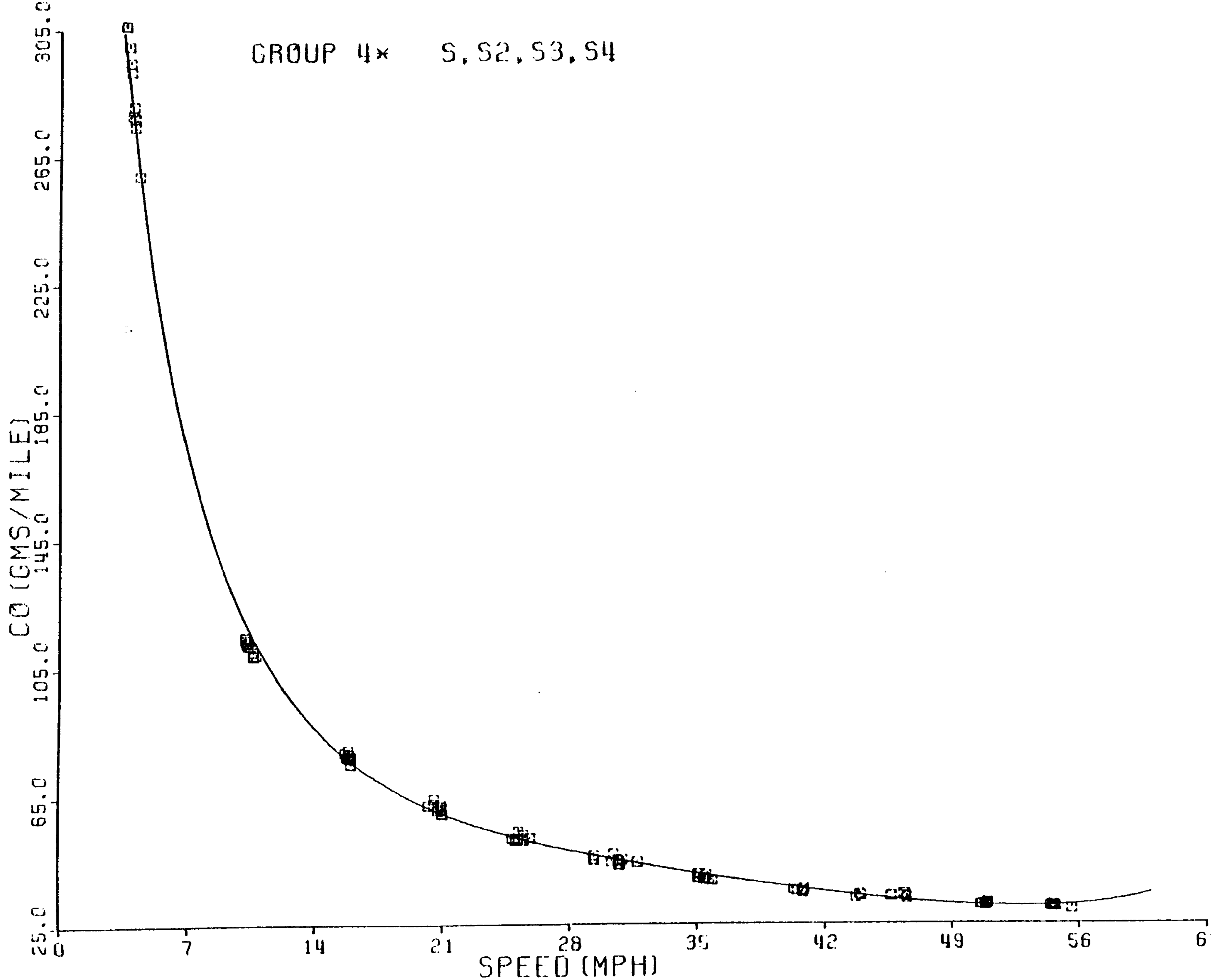

GROUP 4× S, S2, S3
HC (GMS/MILE)
30.0
26.0
22.0
18.0
14.0
10.0
6.0
2.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

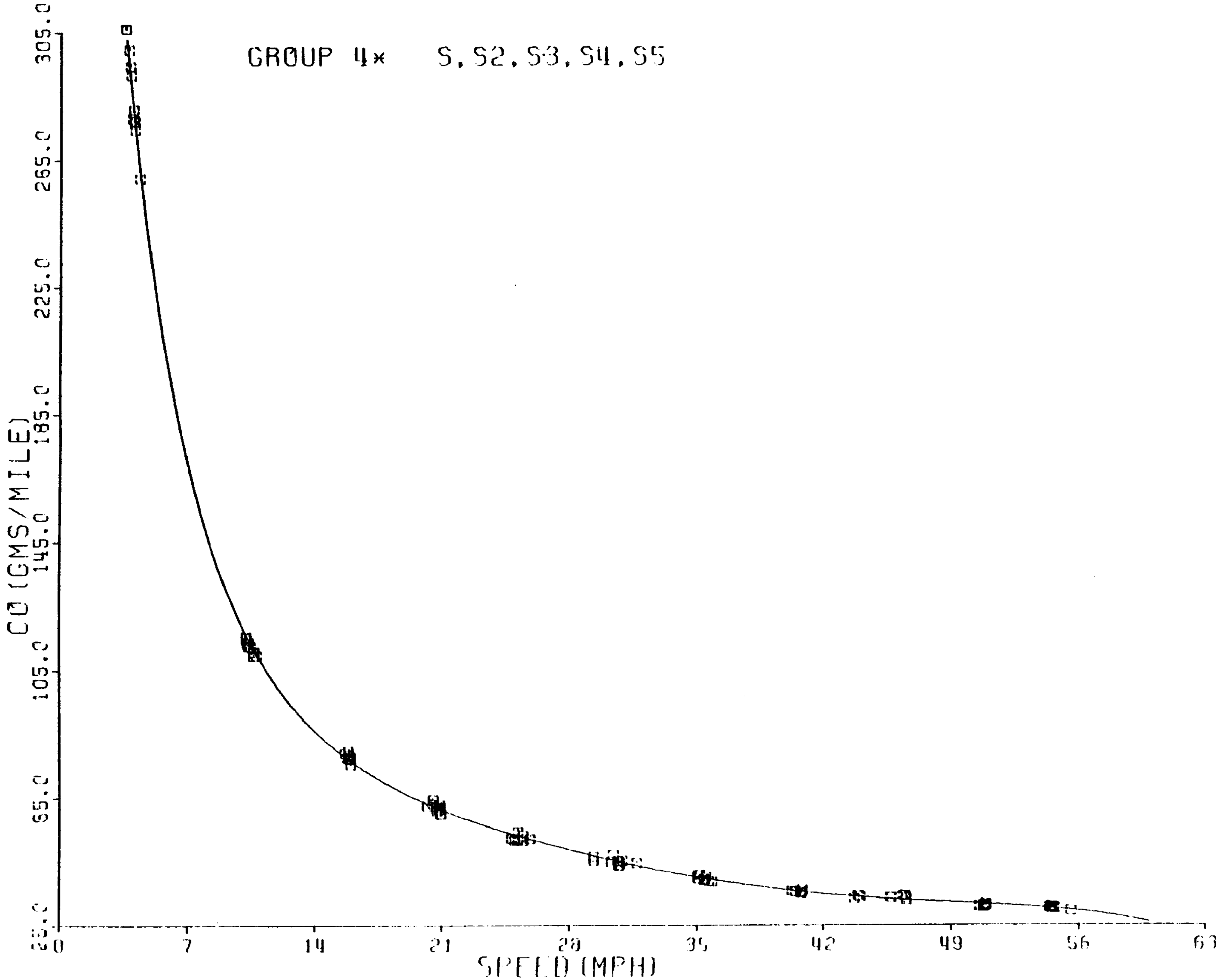

GROUP 4* S,S2,S3,S4
HC (GMS/MILE)
6.0
10.0
14.0
18.0
22.0
26.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

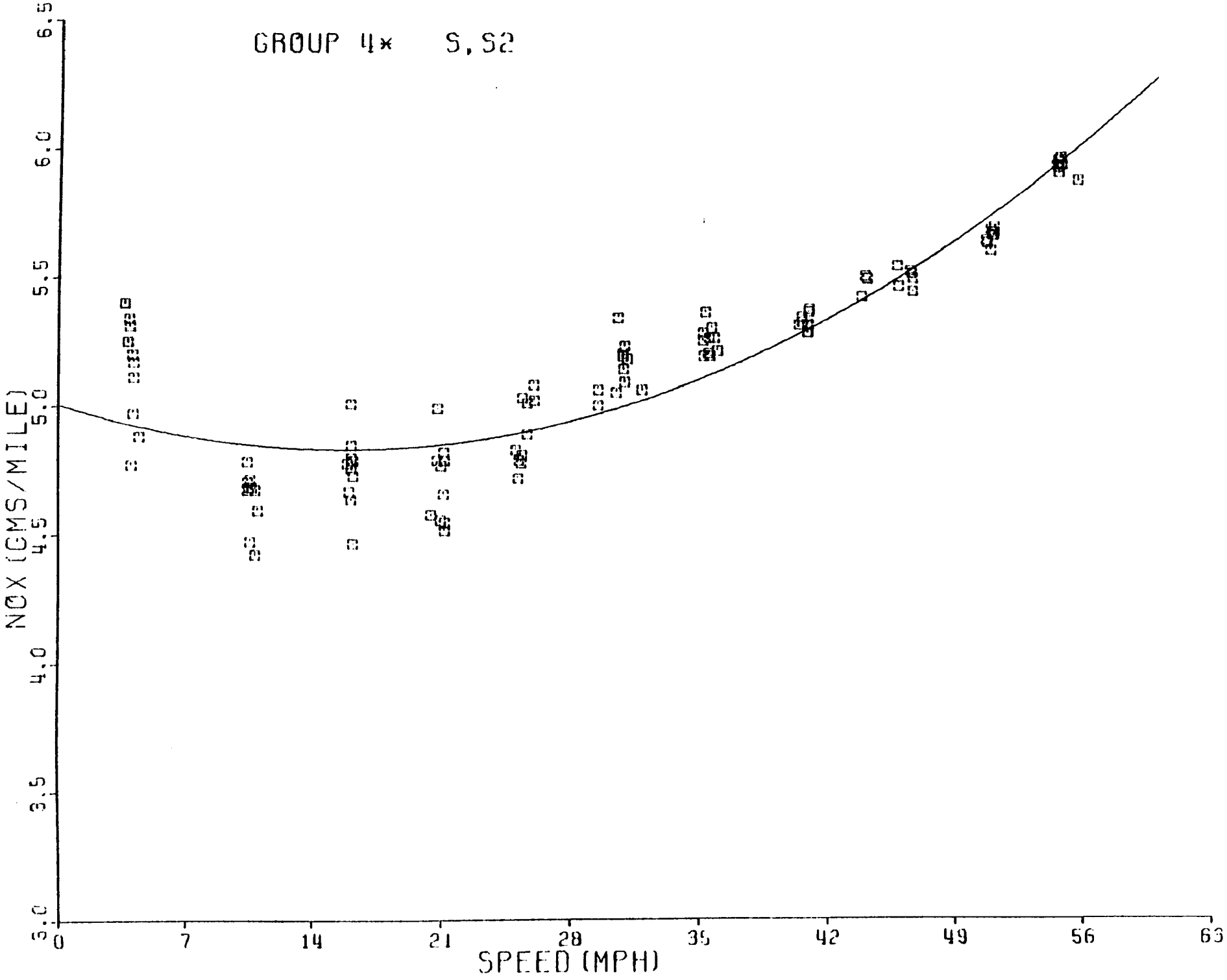

GROUP 4* S,S2,S3,S4,S5
HC (GMS/MILE)
30.0
26.0
22.0
18.0
14.0
10.0
6.0
2.0
SPEED (MPH)
0
7
14
21
28
35
42
49
56
63

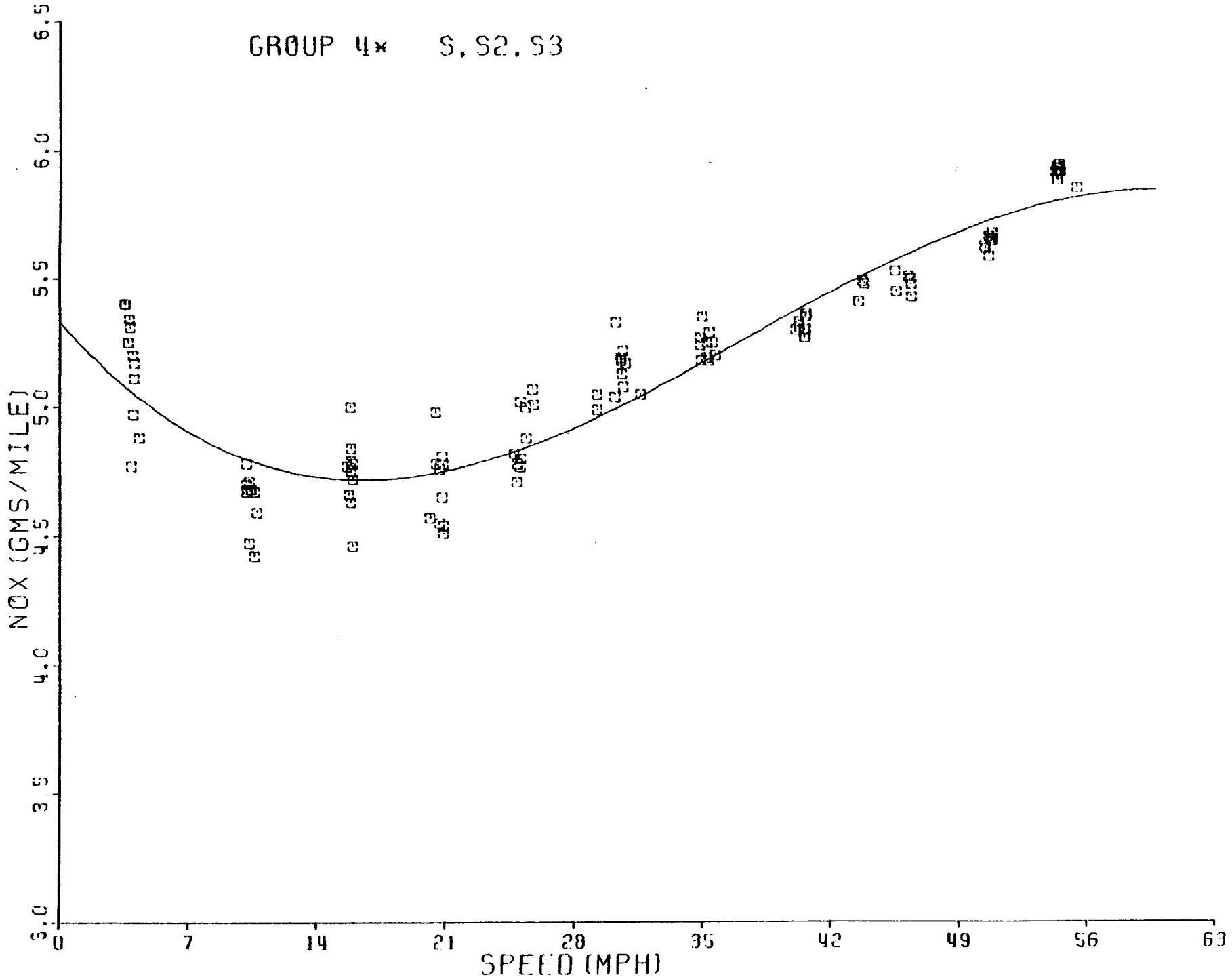

GROUP 4* S,S2
CO (GMS/MILE)
305.0
265.0
225.0
185.0
145.0
105.0
65.0
25.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

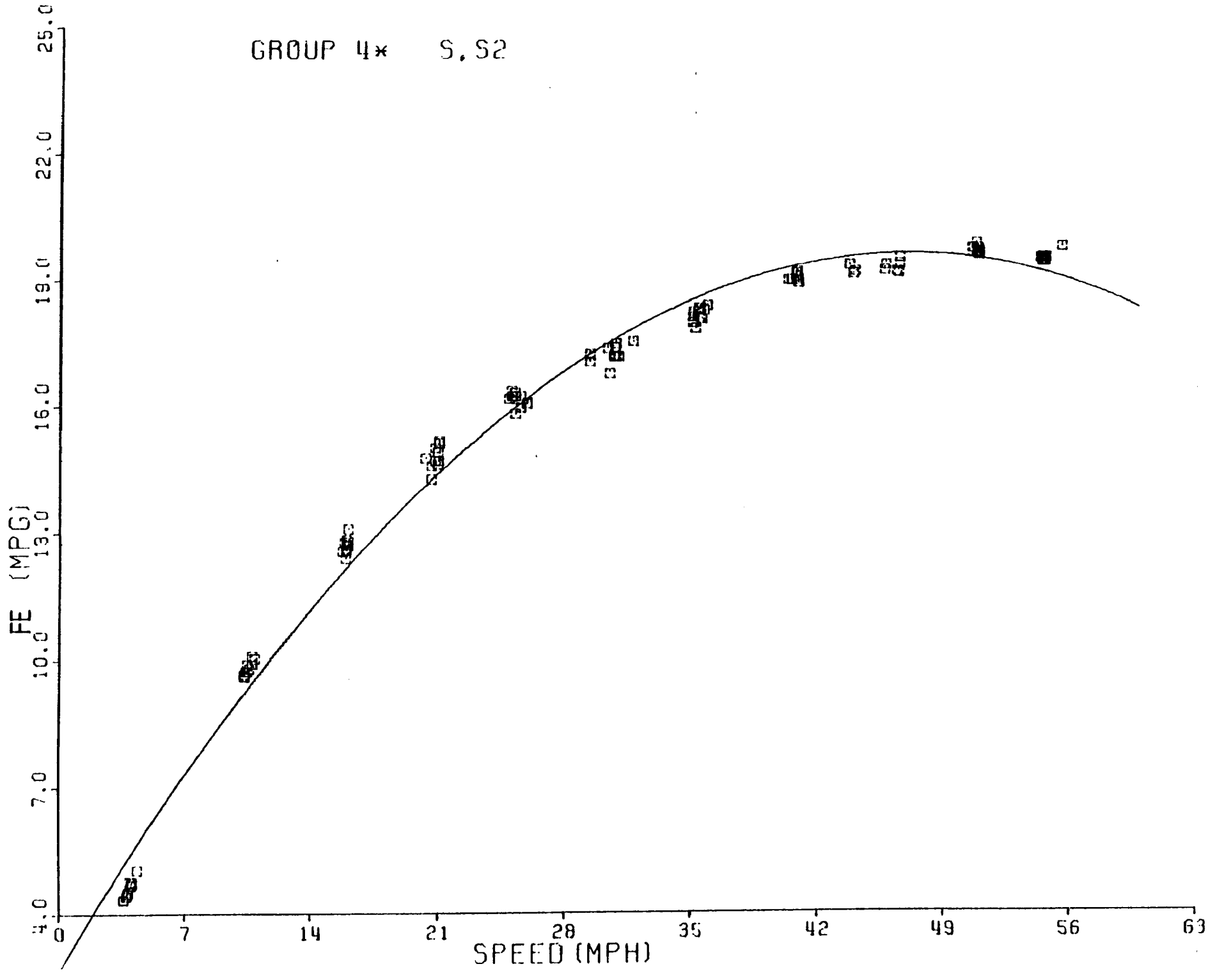

GROUP 4* S,S2,S3
CO (GMS/MILE)
SPEED (MPH)
25.0
55.0
105.0
145.0
185.0
225.0
265.0
305.0
0
7
14
21
28
35
42
49
56
63

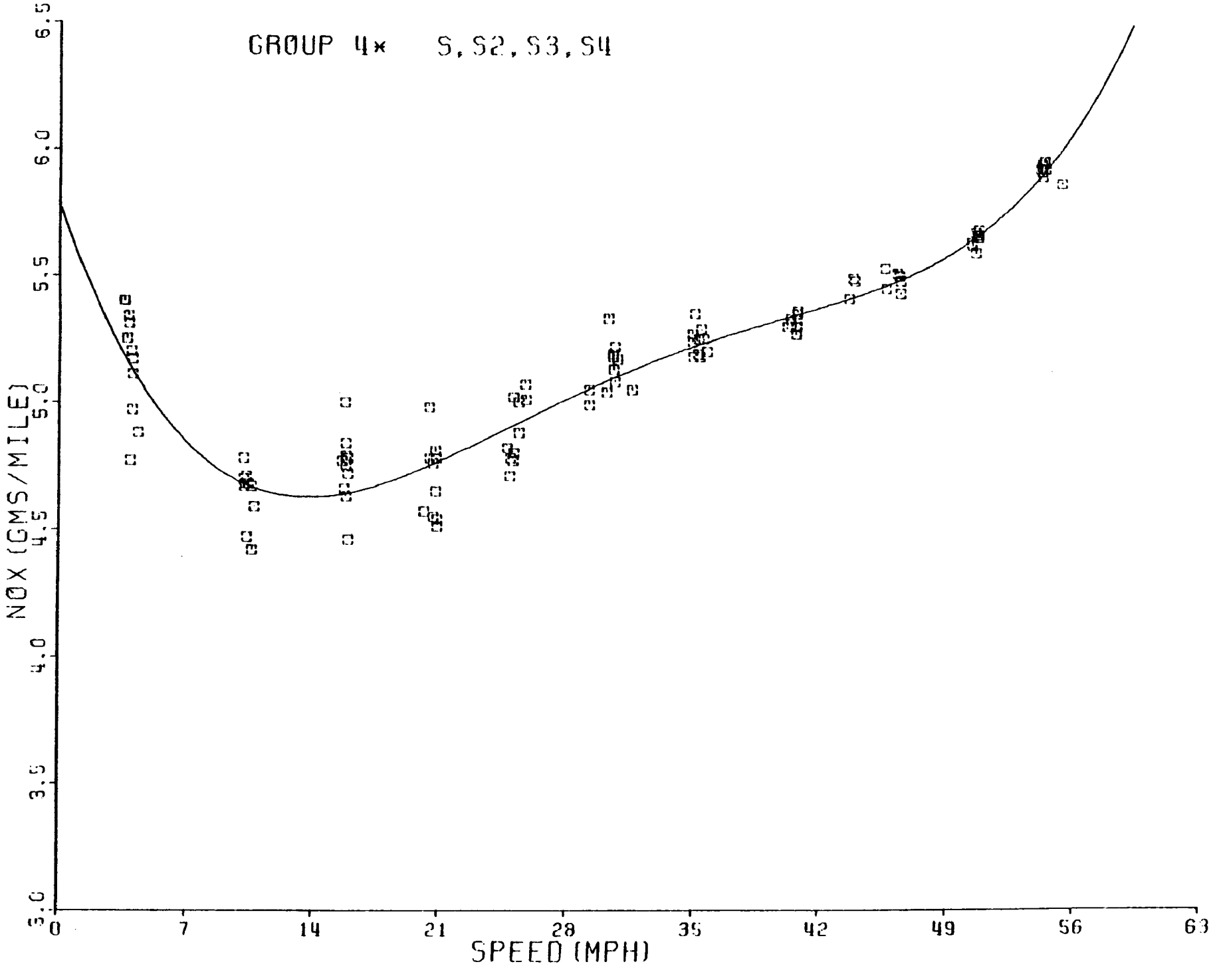

GROUP 4* S, S2, S3, S4
CO (GMS/MILE)
SPEED (MPH)
25.0
65.0
105.0
145.0
185.0
225.0
265.0
305.0
0
7
14
21
28
35
42
49
56
63

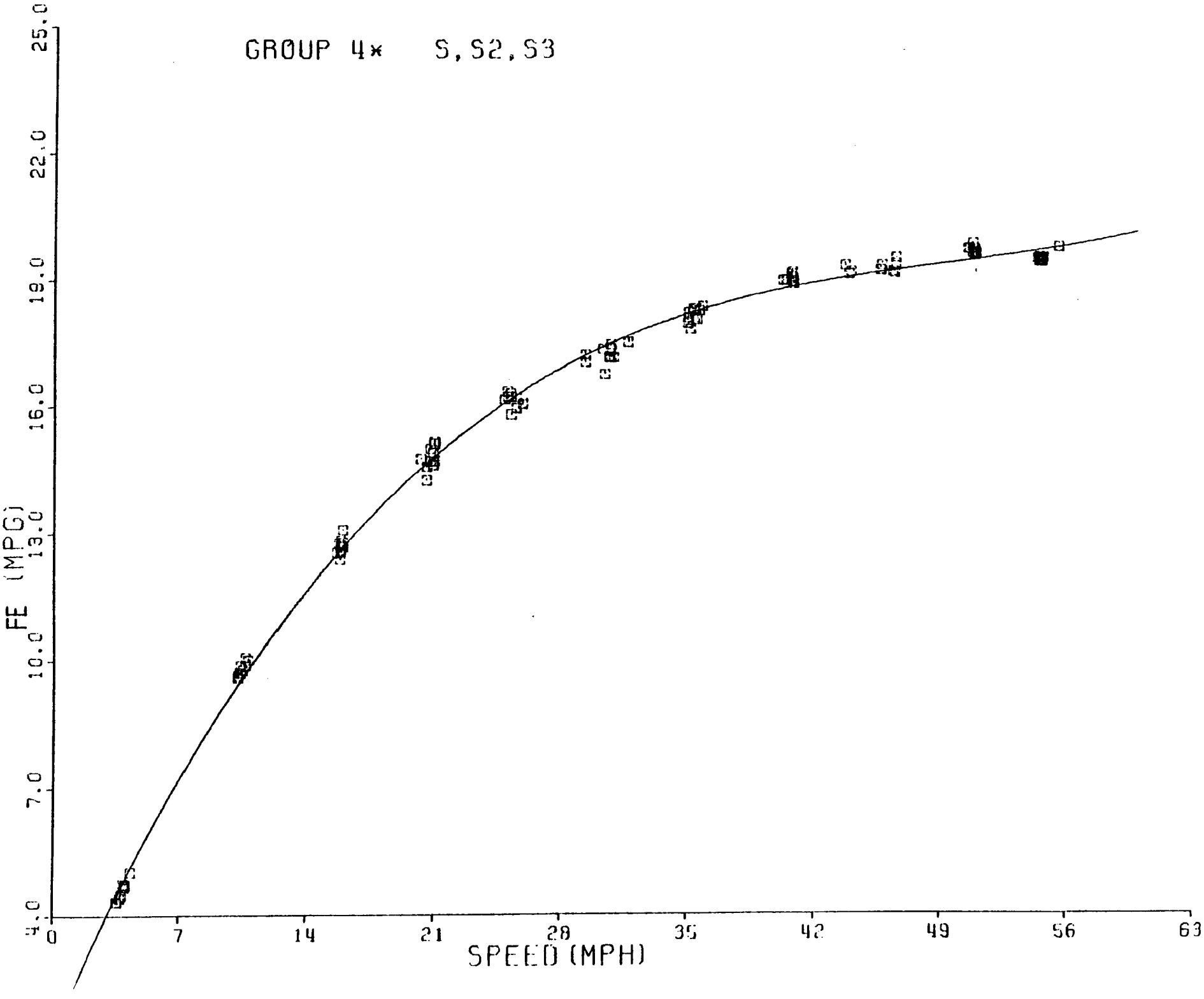

GROUP 4* S, S2, S3, S4, S5
CO (GMS/MILE)
305.0
265.0
225.0
185.0
145.0
105.0
65.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

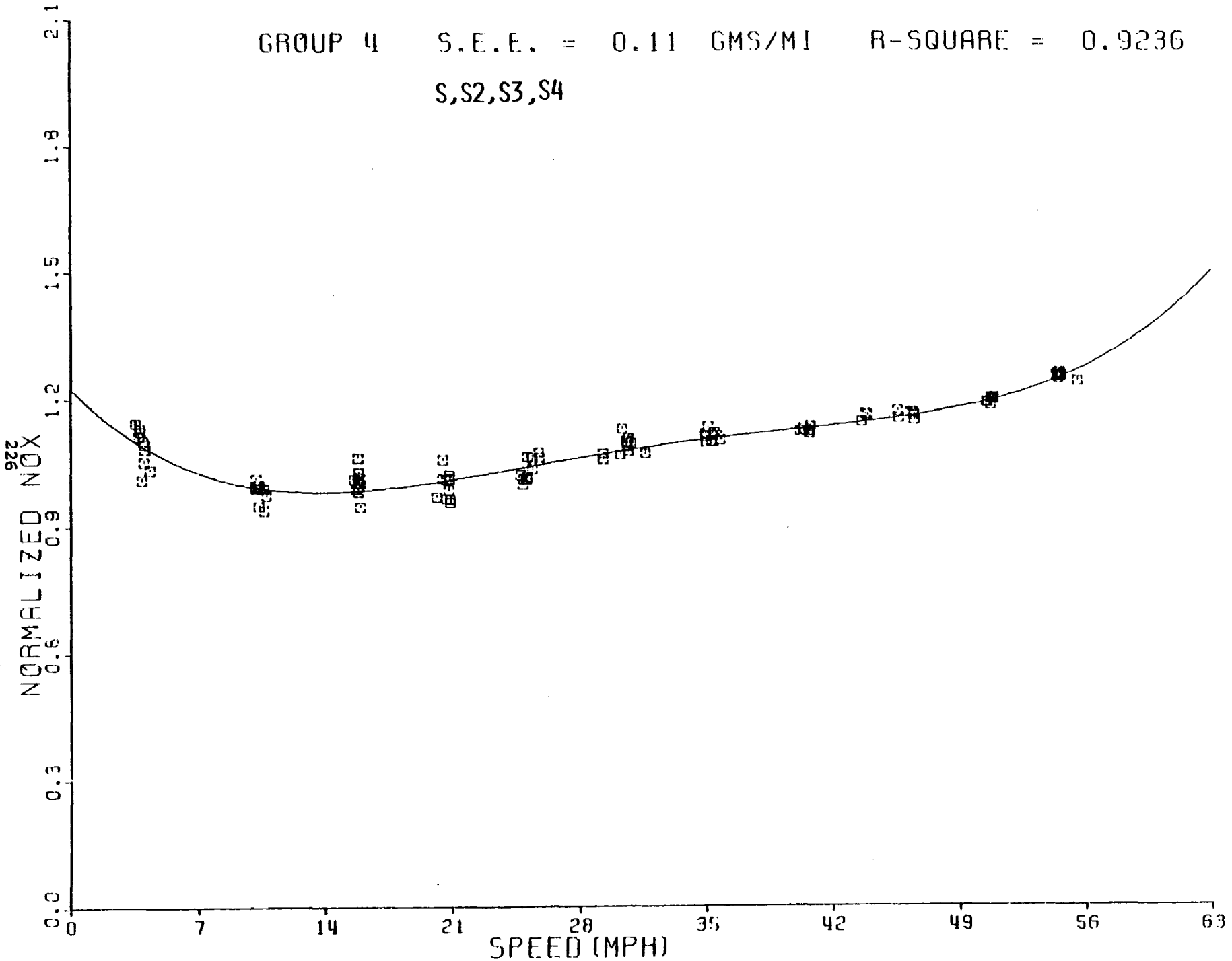

GROUP 4× S, S2
NOX (GMS/MILE)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)


GROUP 4× S, S2, S3
NOX (GMS/MILE)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)


GROUP 4* S, S2
FE (MPG)
4.0
7.0
10.0
13.0
16.0
19.0
22.0
25.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)


GROUP 4× S, S2, S3, S4
NOX (GMS/MILE)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)


GROUP 4× S, S2, S3
FE (MPG)
25.0
22.0
19.0
16.0
13.0
10.0
7.0
4.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)


GROUP 4 S.E.E. = 0.11 GMS/MI R-SQUARE = 0.9236
S,S2,S3,S4
NORMALIZED NOX
226
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

Appendix G

NORMALIZED REGRESSIONS BY GROUP

This appendix gives the normalized regression equations for HC, CO, NO_x, and FE versus speed. The standard error of the estimate is given in correction-factor units.

GROUP 1

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.24612	-2.90973E-01	1.58890E-02	-4.72494E-04	6.94077E-06	-3.92798E-08	.0257	.9992
ln CO	1.81978	-2.54663E-01	1.52347E-02	-4.87397E-04	7.58207E-06	-4.49514E-08	.0275	.9970
NO_x	2.44424	-2.50107E-01	1.38293E-02	-2.87025E-04	2.07585E-06		.0259	.9913
FE	+1.99692E-02	1.00231E-01	-3.64532E-03	6.37113E-05	-4.32493E-07		.0117	.9977

GROUP 2

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.31026	-2.89572E-01	1.52990E-02	-4.46689E-04	6.48183E-06	-3.63456E-08	.0235	.9993
ln CO	2.33989	-2.96978E-01	1.60071E-02	-4.77396E-04	7.06752E-06	-4.03978E-08	.0231	.9991
NO_x	1.68635	-1.18303E-01	6.54975E-03	-1.37139E-04	1.00849E-06		.0227	.9738
FE	3.16192E-02	9.01259E-02	-2.89321E-03	4.79079E-05	-3.20873E-07		.0110	.9985

GROUP 3

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.16556	-2.69992E-01	1.44221E-02	-4.33638E-04	6.50735E-06	-3.78100E-08	.0187	.9995
ln CO	2.44154	-2.91473E-01	1.42949E-02	-3.87852E-04	5.29781E-06	-2.82441E-08	.0217	.9996
NO_x	1.12646	-3.93405E-02	2.68637E-03	-6.08024E-05	4.77286E-07		.0257	.9591
FE	1.80403E-02	8.67828E-02	-2.56510E-03	4.05942E-05	-2.65827E-07		.0084	.9993

GROUP 4

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.39726	-2.99985E-01	1.61351E-02	-4.87491E-04	7.29093E-06	-4.19769E-08	.0246	.9993
ln CO	2.46551	-3.05023E-01	1.60497E-02	-4.73969E-04	6.99075E-06	-3.99758E-08	.0218	.9993
NO_x	1.22677	-4.44978E-02	2.62476E-03	-5.67150E-05	4.34293E-07		.0239	.9262
FE	2.17884E-02	8.55670E-02	-2.49361E-03	3.95575E-05	-2.62964E-07		.0113	.9988

GROUP 5

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.40873	-3.08187E-01	1.68168E-02	-5.06843E-04	7.53855E-06	-4.31596E-08	.0260	.9992
ln CO	2.77804	-3.19130E-01	1.53183E-02	-4.22327E-04	5.84948E-06	-3.14969E-08	.0239	.9997
NO_x	1.01743	-1.18958E-02	9.14365E-04	-2.15740E-05	1.82300E-07		.0238	.9072
FE	4.21009E-03	8.89752E-02	-2.68753E-03	4.34489E-05	-2.90243E-07		.0108	.9989

GROUP 6

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.23217	-2.84985E-01	1.53833E-02	-4.56738E-04	6.73486E-06	-3.83798E-08	.0222	.9991
ln CO	2.78899	-3.27107E-01	1.62943E-02	-4.67573E-04	6.71906E-06	-3.74401E-08	.0251	.9994
NO_x	9.87600E-01	-1.95674E-02	1.69645E-03	-4.04000E-05	3.28001E-07		.0244	.9658
FE	7.47964E-03	8.60534E-02	-2.47354E-03	3.91268E-05	-2.60344E-07		.0107	.9990

GROUP 7

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.25223	-2.87778E-01	1.56820E-02	-4.73179E-04	7.07954E-06	-4.08456E-08	.0226	.9990
ln CO	2.70743	-3.31038E-01	1.76179E-02	-5.38583E-04	8.17402E-06	-4.77803E-08	.0257	.9989
NO_x	1.15917	-4.44536E-02	2.96425E-03	-6.68990E-05	5.22365E-07		.0251	.9578
FE	1.21961E-02	8.55120E-02	-2.45834E-03	3.91921E-05	-2.63806E-07		.0113	.9989

GROUP 8

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.02779	-2.73049E-01	1.53577E-02	-4.60304E-04	6.78527E-06	-3.84880E-08	.0257	.9983
ln CO	1.86919	-2.76679E-01	1.72335E-02	-5.58279E-04	8.71678E-06	-5.16980E-08	.0342	.9943
NO_x	1.88656	-1.61289E-01	9.04995E-03	-1.85609E-04	1.32555E-06		.0286	.9845
FE	1.57755E-02	1.03205E-01	-3.87016E-03	6.87137E-05	-4.69022E-07		.0122	.9973

GROUP 9

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.15056	-2.83620E-01	1.53836E-02	-4.42136E-04	6.28732E-06	-3.46311E-08	.0220	.9990
ln CO	1.82133	-2.72054E-01	1.70304E-02	-5.52021E-04	8.62543E-06	-5.11440E-08	.0388	.9907
NO_x	1.55777	-1.13032E-01	6.71832E-03	-1.43409E-04	1.06079E-06		.0216	.9859
FE	-1.29958E-02	1.02890E-01	-3.69474E-03	6.35430E-05	-4.25096E-07		.0122	.9977

GROUP 10

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.23021	-2.93648E-01	1.62356E-02	-4.84148E-04	7.11591E-06	-4.02861E-08	.0260	.9988
ln CO	2.01421	-2.95188E-01	1.86353E-02	-6.21606E-04	9.93657E-06	-5.99779E-08	.0388	.9943
NO_x	2.04516	-1.94014E-01	1.10736E-02	-2.31754E-04	1.68372E-06		.0237	.9915
FE	2.65680E-03	1.00425E-01	-3.59277E-03	6.27410E-05	-4.28246E-07		.0128	.9976

GROUP 11

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.12230	-2.91072E-01	1.69089E-02	-5.26148E-04	8.02705E-06	-4.70117E-08	.0246	.9981
ln CO	2.04533	-3.10618E-01	2.04852E-02	-7.08527E-04	1.16215E-05	-7.15690E-08	.0417	.9932
NO_x	1.63262	-1.21861E-01	7.03020E-03	-1.46293E-04	1.06141E-06		.0235	.9865
FE	3.50762E-02	8.78429E-02	-2.77272E-03	4.74662E-05	-3.32197E-07		.0152	.9976

GROUP 12

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.15361	-2.83451E-01	1.56948E-02	-4.69759E-04	6.93832E-06	-3.94707E-08	.0253	.9986
ln CO	2.31868	-3.41147E-01	2.09446E-02	-6.65891E-04	1.02225E-05	-5.98265E-08	.0395	.9961
NO_x	1.44825	-1.22444E-01	7.95024E-03	-1.71078E-04	1.25777E-06		.0247	.9940
FE	-1.47721E-02	9.68577E-02	-3.25433E-03	5.62071E-05	-3.83995E-07		.0109	.9987

GROUP 13

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.07346	-2.89353E-01	1.73042E-02	-5.54707E-04	8.64204E-06	-5.13107E-08	.0292	.9972
ln CO	2.57522	-3.28888E-01	1.89747E-02	-6.28263E-04	1.00924E-05	-6.12727E-08	.0371	.9967
NO_x	2.45969E-01	8.41954E-02	-3.40841E-03	6.29880E-05	-4.13975E-07		.0289	.9800
FE	6.80622E-02	7.46090E-02	-1.88828E-03	3.01604E-05	-2.17436E-07		.0167	.9979

GROUP 14

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.34948	-3.04959E-01	1.68416E-02	-5.09623E-04	7.59516E-06	-4.34963E-08	.0277	.9989
ln CO	2.68454	-3.32817E-01	1.76277E-02	-5.24123E-04	7.72221E-06	-4.37025E-08	.0312	.9987
NO_x	1.28169	-8.04874E-02	5.35735E-03	-1.18891E-04	9.01060E-07		.0217	.9887
FE	1.06675E-02	8.81537E-02	-2.67661E-03	4.44393E-05	-3.03848E-07		.0172	.9989

GROUP 15

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.11340	-2.85676E-01	1.63180E-02	-5.00793E-04	7.55067E-06	-4.37187E-08	.0267	.9981
ln CO	2.15487	-3.29116E-01	2.10112E-02	-6.89057E-04	1.08390E-05	-6.47125E-08	.0389	.9943
NO_x	1.53447	-1.25671E-01	7.85919E-03	-1.69428E-04	1.25494E-06		.0220	.9928
FE	1.04531E-03	9.85479E-02	-3.45740E-03	6.07188E-05	-4.17214E-07		.0122	.9981

GROUP 16

VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.11940	-2.98632E-01	1.84473E-02	-6.16544E-04	9.92062E-06	-6.04021E-08	.0736	.9968
ln CO	2.54557	-3.62954E-01	2.32775E-02	-8.15039E-04	1.36231E-05	-8.55909E-08	.0441	.9930
NO_x	7.04805E-01	3.81527E-02	-1.73907E-03	3.26140E-05	-2.03847E-07		.0288	.8475
FE	8.01363E-02	7.58842E-02	-2.03365E-03	3.30017E-05	-2.35170E-07		.0171	.9976

GROUP 17

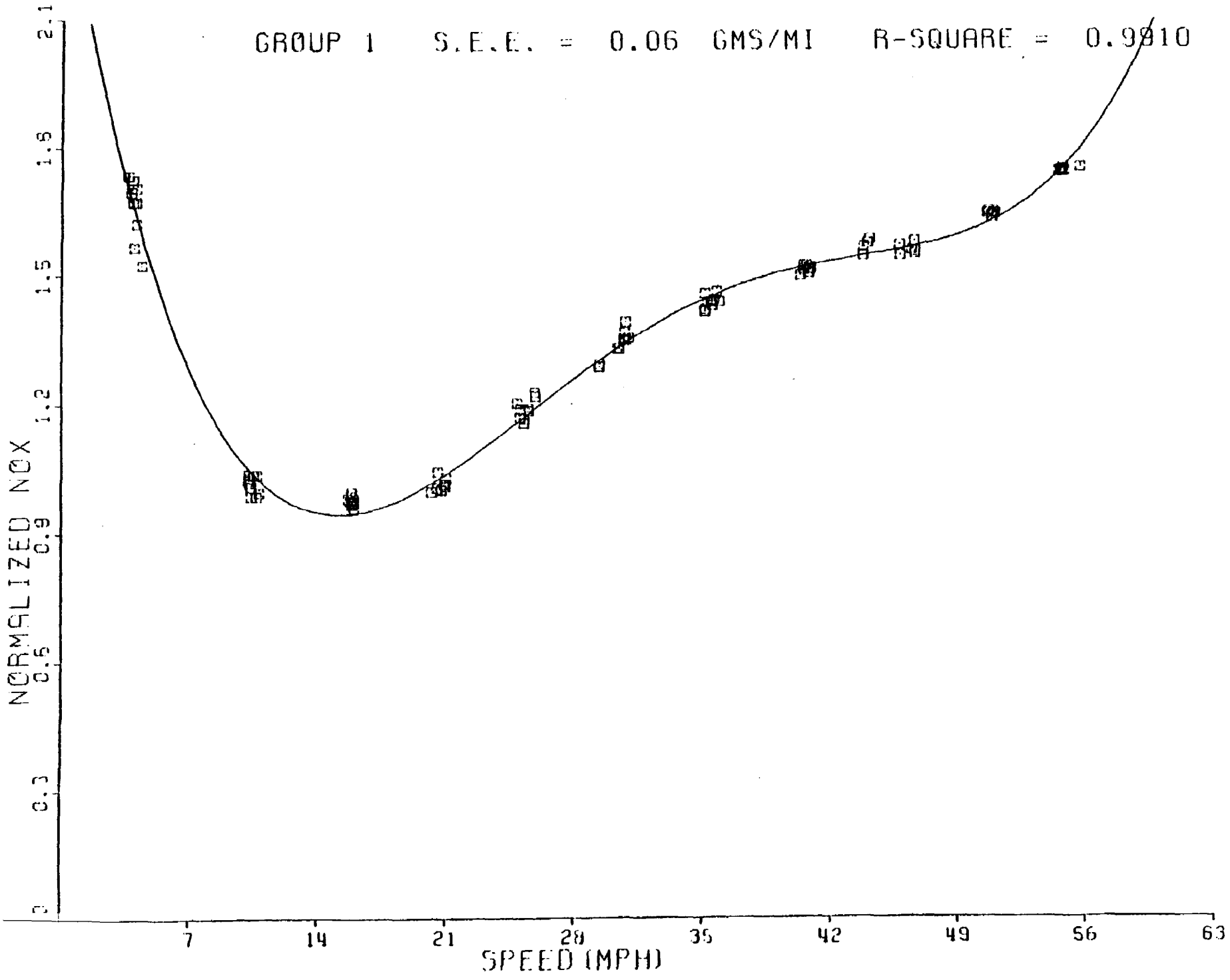
VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.68382	-3.44633E-01	1.95417E-02	-6.25720E-04	9.78442E-06	-5.83369E-08	.0313	.9984
ln CO	2.83929	-3.68756E-01	2.10782E-02	-6.76438E-04	1.06267E-05	-6.36405E-08	.0383	.9961
NO_x	7.83838E-01	3.28549E-04	1.06029E-03	-3.19350E-05	2.90389E-07		.0301	.9691
FE	3.94252E-02	8.88231E-02	-2.84349E-03	4.78461E-05	-3.27024E-07		.0131	.9980

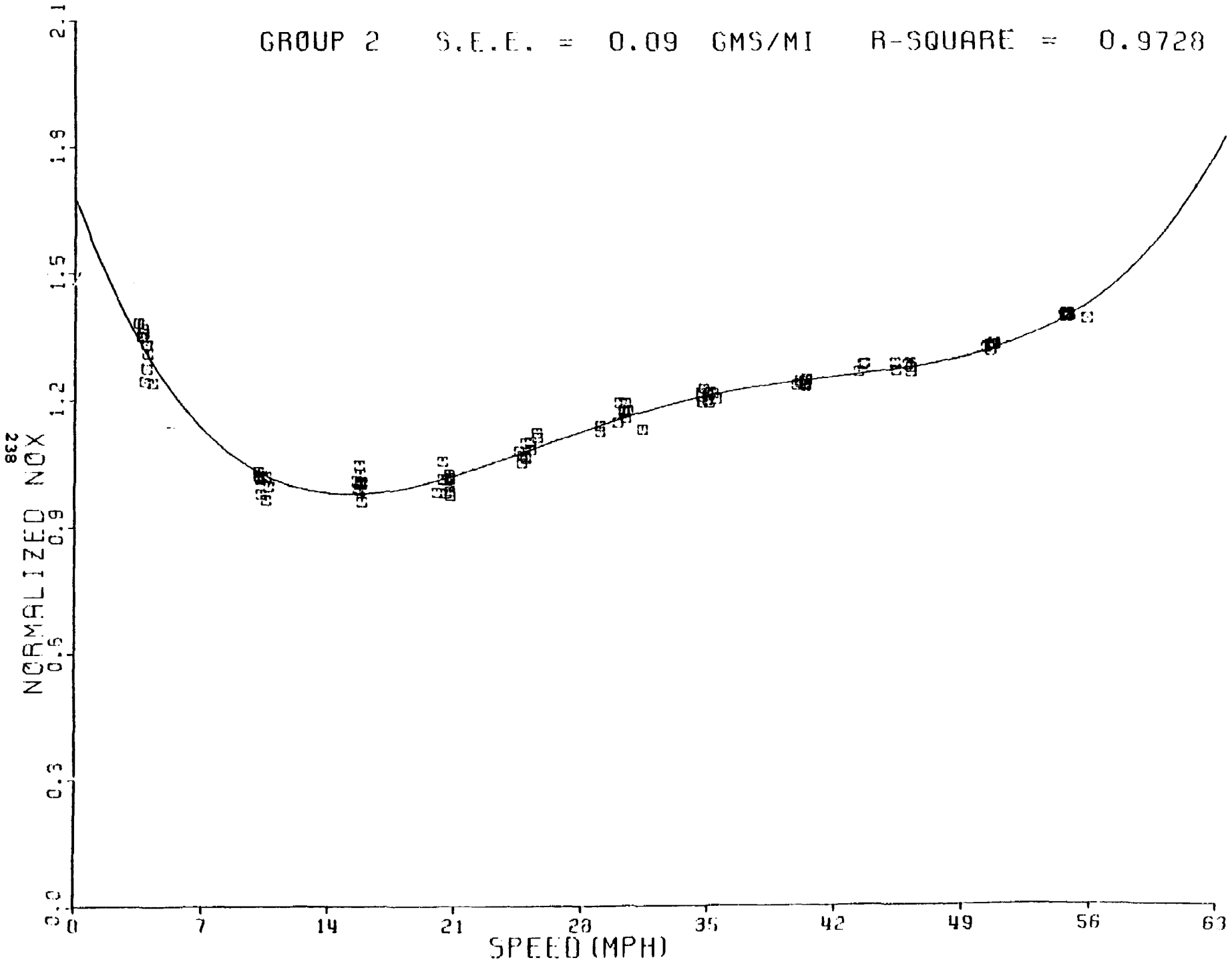
GROUP 18

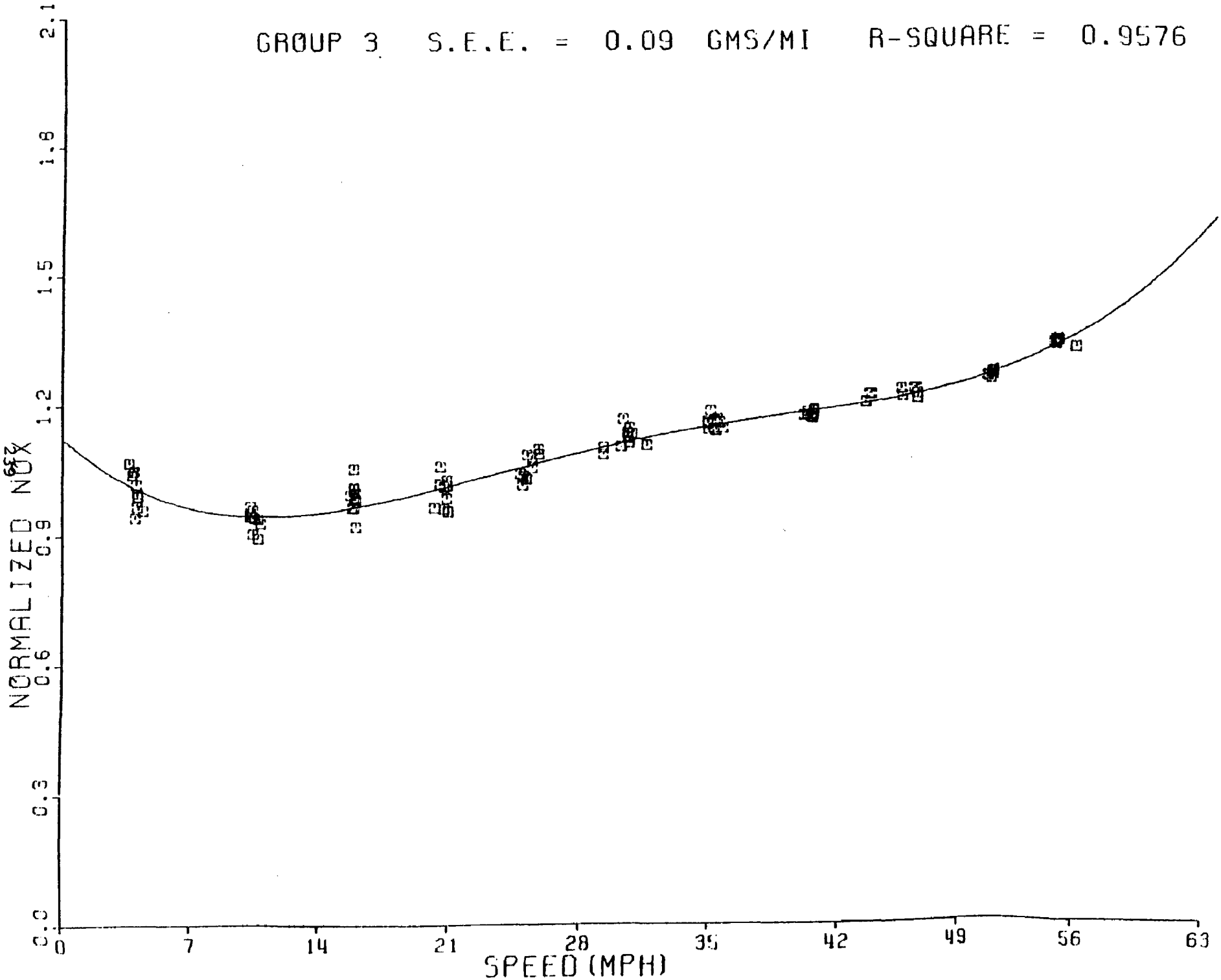
VAR.	A_0	A_1	A_2	A_3	A_4	A_5	S.E.E.	R^2
ln HC	2.39540	-3.35781E-01	2.11609E-02	-7.31550E-04	1.20715E-05	-7.48567E-08	.0374	.9957
ln CO	2.48747	-3.91562E-01	2.70721E-02	-9.76178E-04	1.65270E-05	-1.04317E-07	.0246	.9837
NO_x	9.42131E-01	-4.23240E-02	3.86253E-03	-9.39853E-05	7.53883E-07		.0315	.9841
FE	4.76869E-02	8.91930E-02	-2.90512E-03	4.90590E-05	-3.33595E-07		.0129	.9980

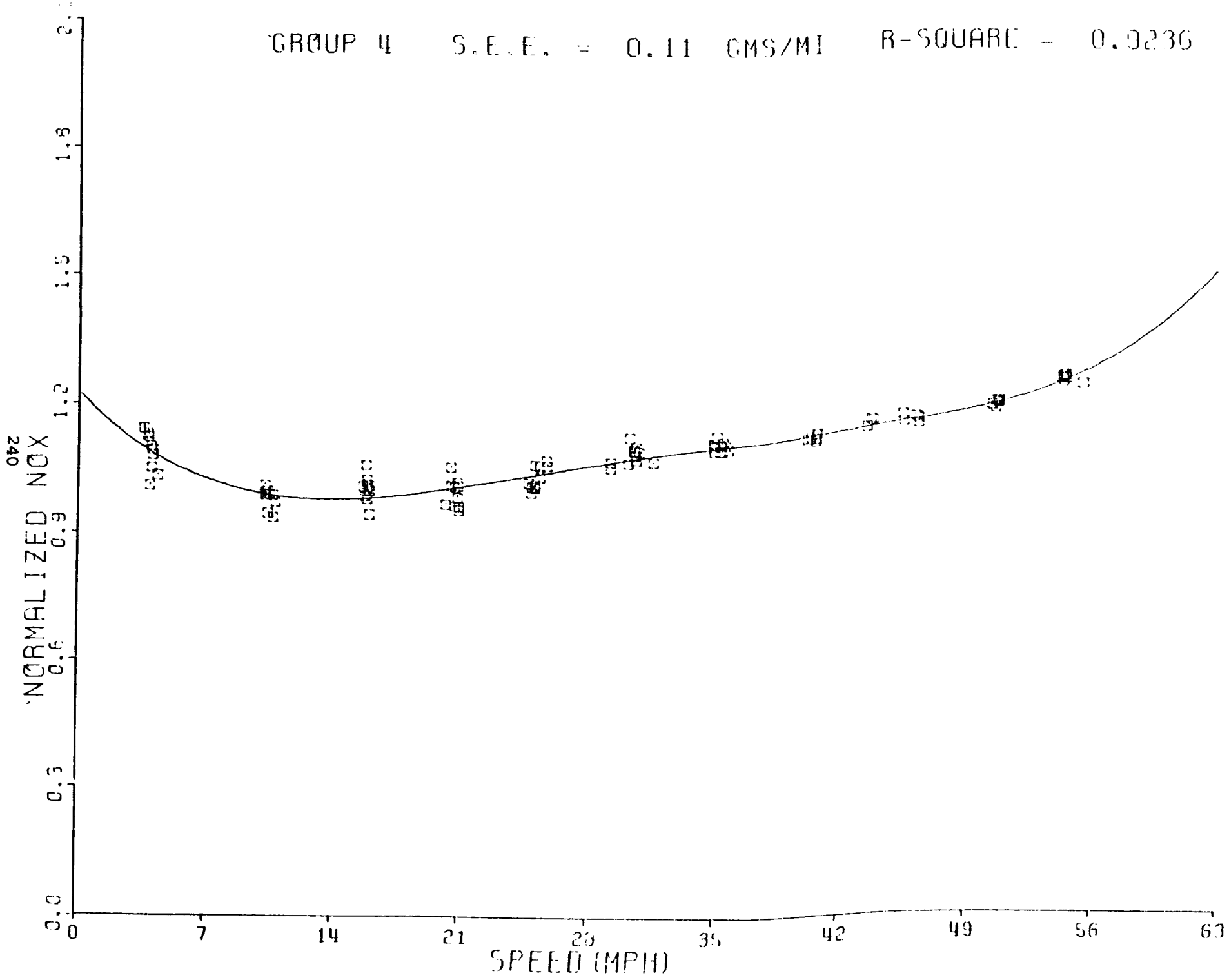
Appendix H

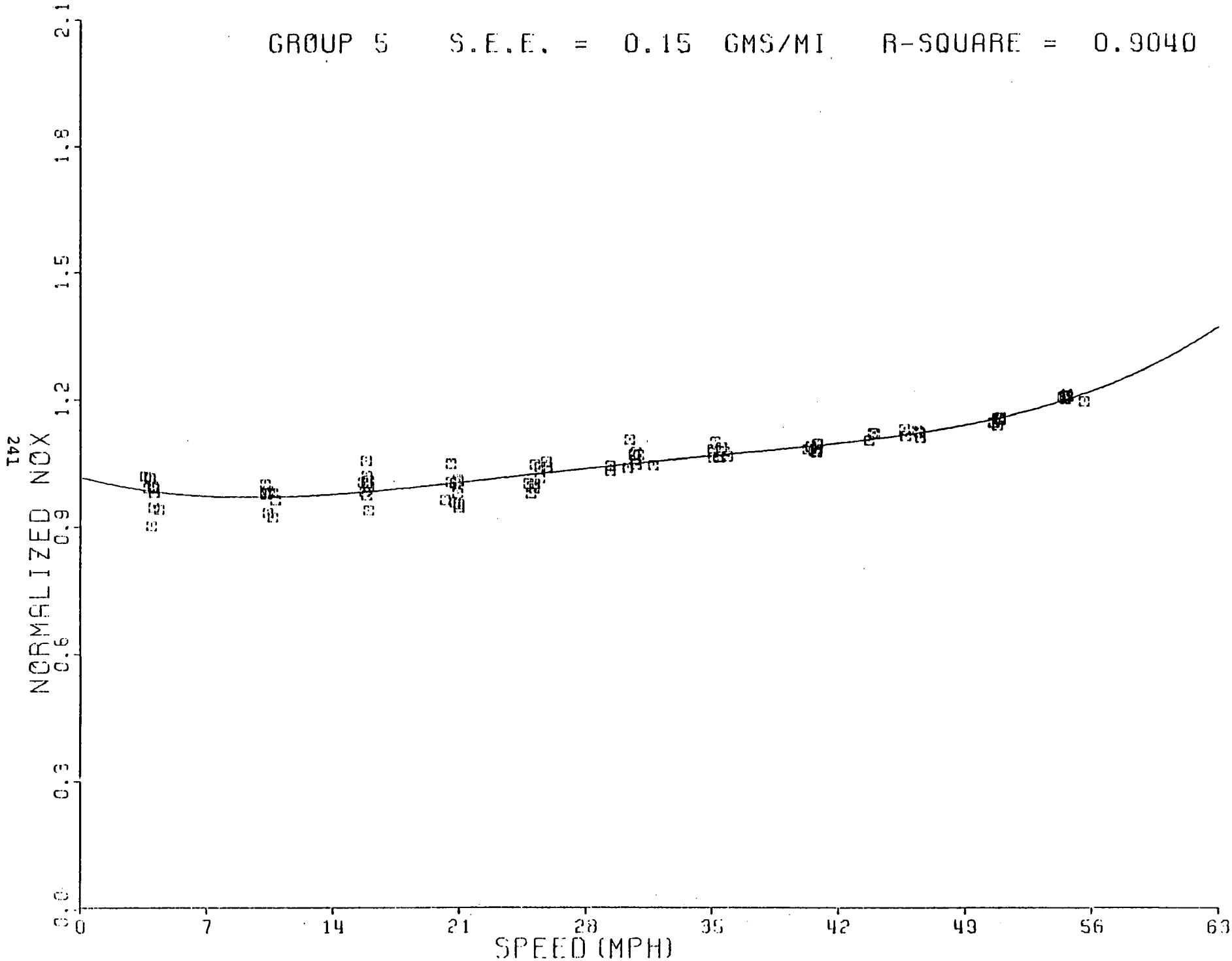
NO_x PLOTS BY GROUP

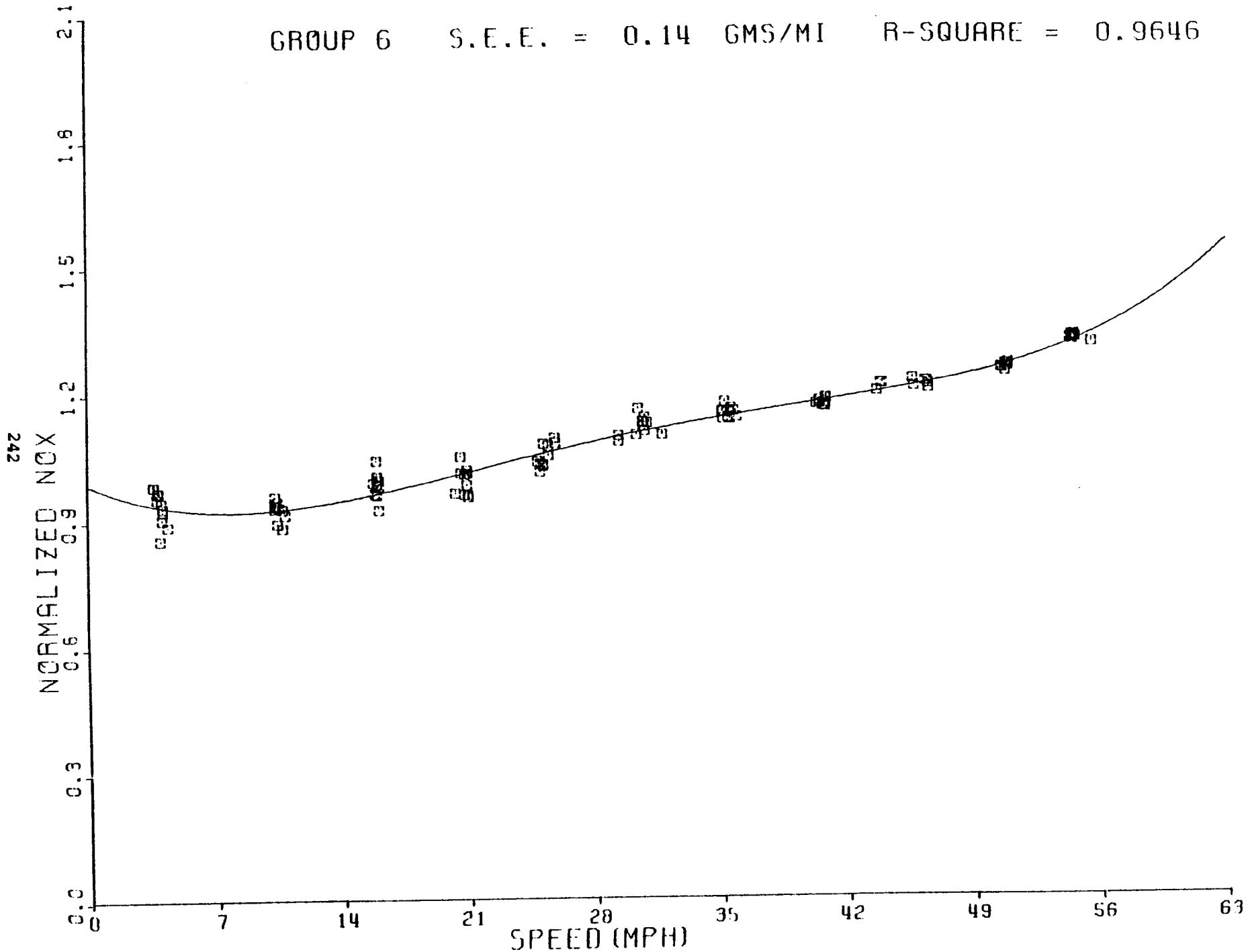

GROUP 1 S.E.E. = 0.06 GMS/MI R-SQUARE = 0.9810
NORMALIZED NOX
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

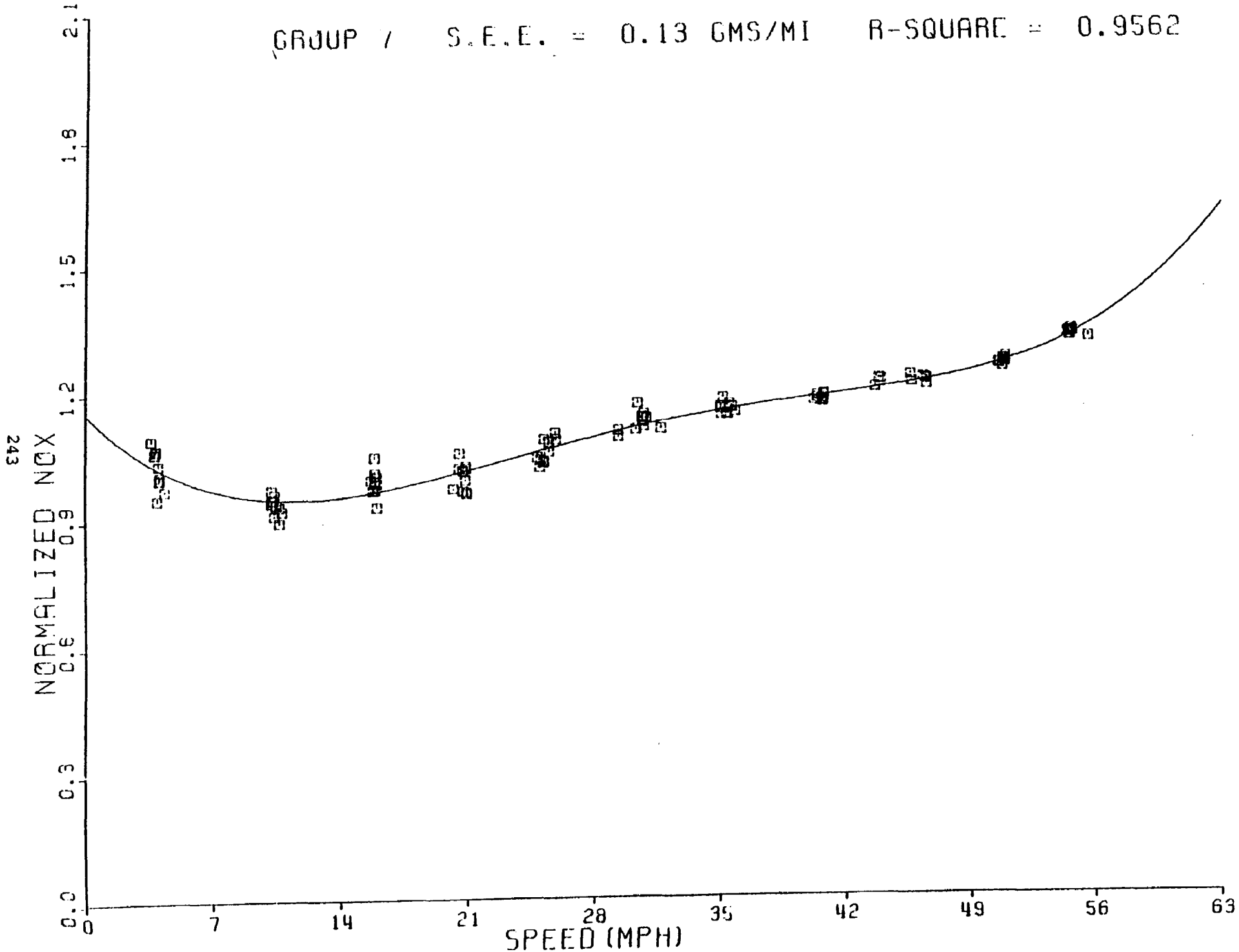

GROUP 2 S.E.E. = 0.09 GMS/MI R-SQUARE = 0.9728
NORMALIZED NOX
238
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

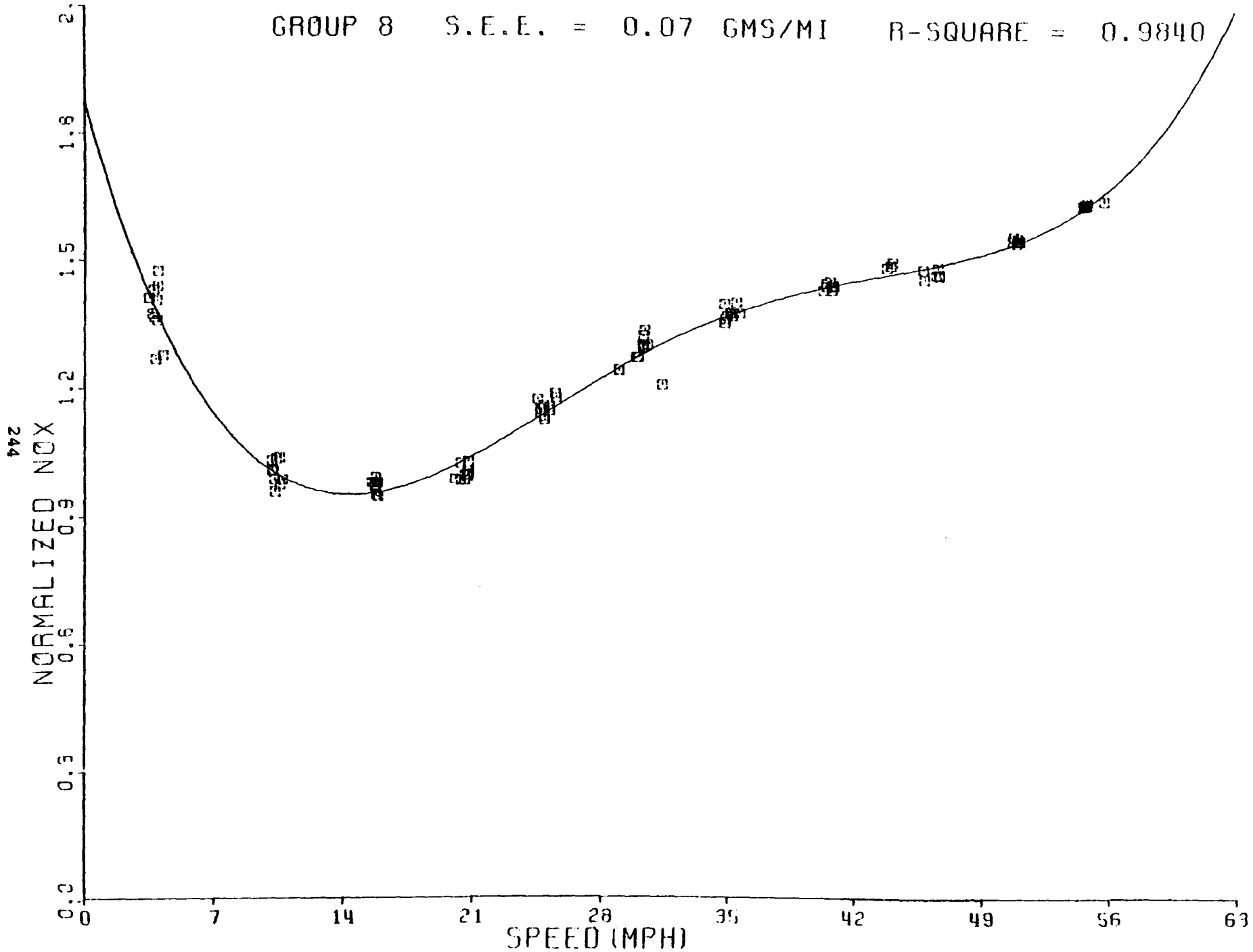

GROUP 3 S.E.E. = 0.09 GMS/MI R-SQUARE = 0.9576
NORMALIZED NOX
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)

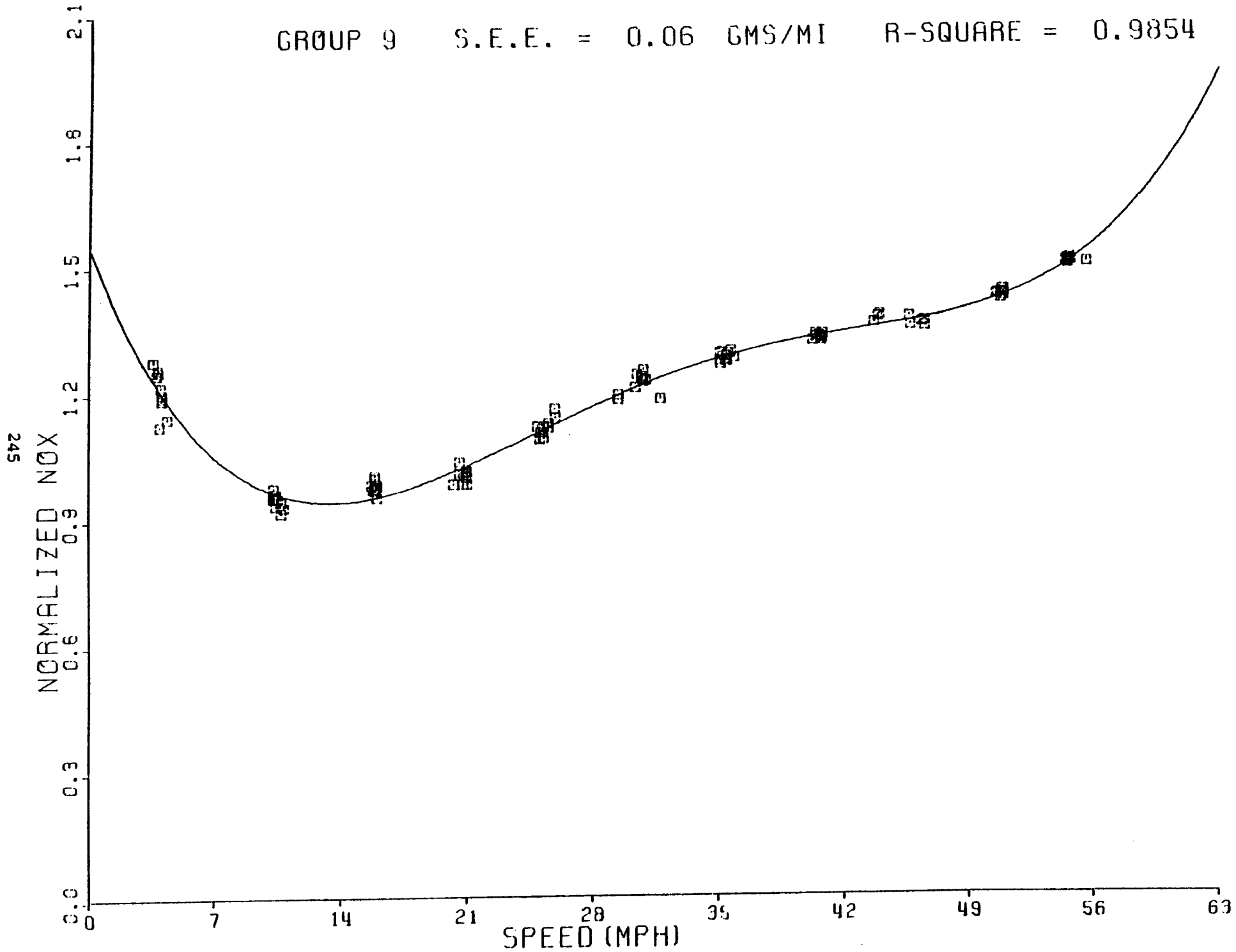

GROUP 4 S.E.E. = 0.11 GMS/MI R-SQUARE = 0.9236
NORMALIZED NOX
240
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

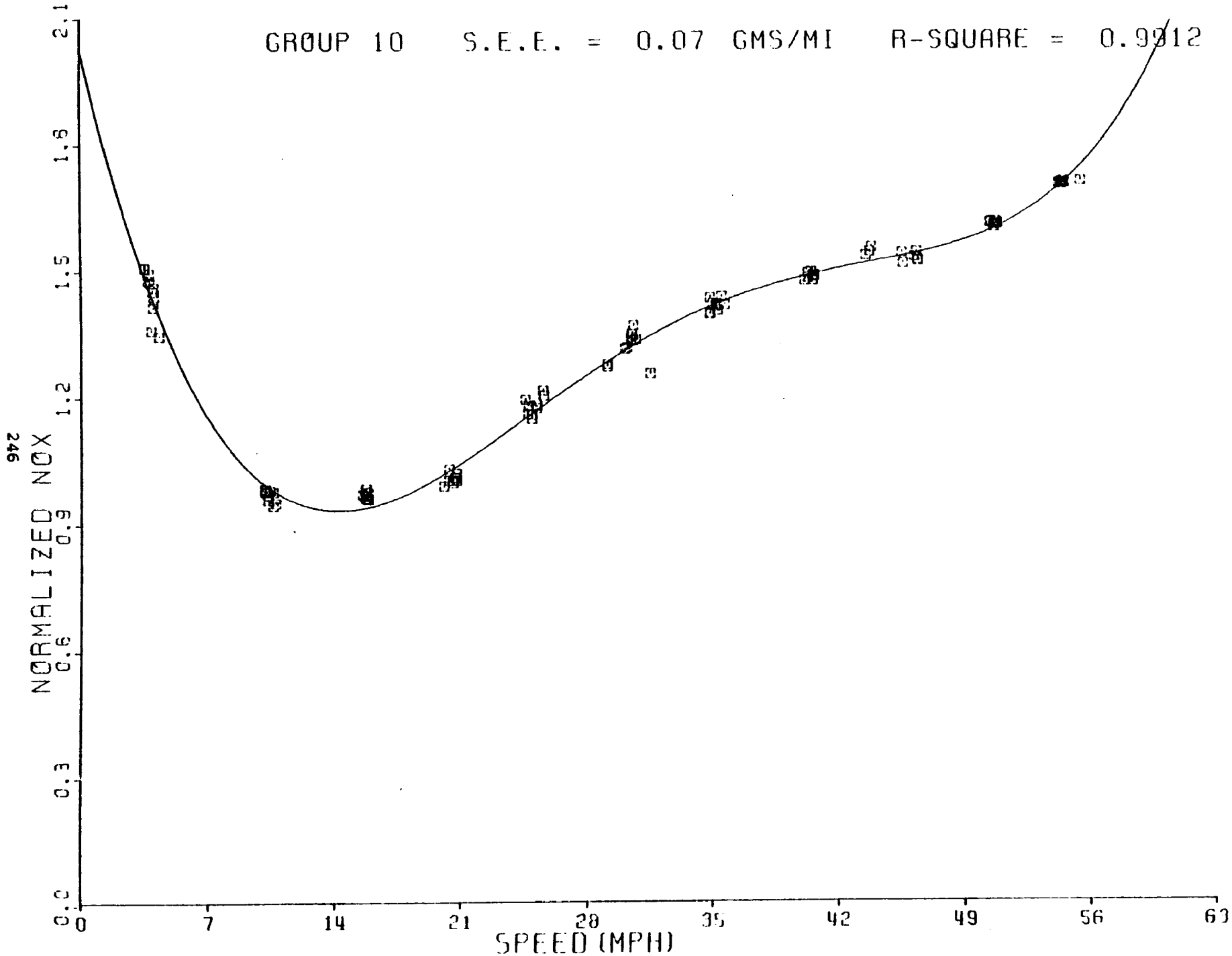

GROUP 5 S.E.E. = 0.15 GMS/MI R-SQUARE = 0.9040
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

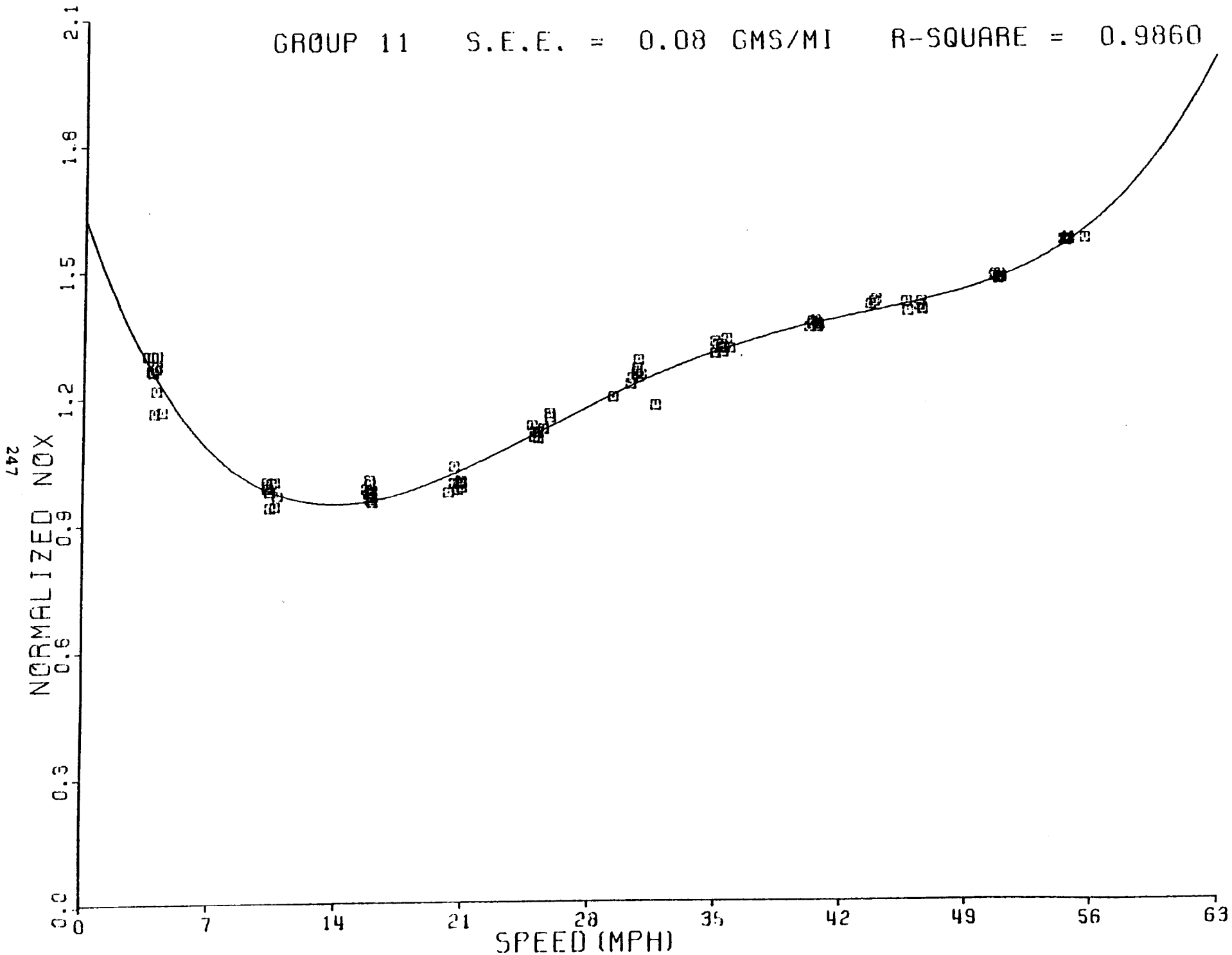

GROUP 6 S.E.E. = 0.14 GMS/MI R-SQUARE = 0.9646
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

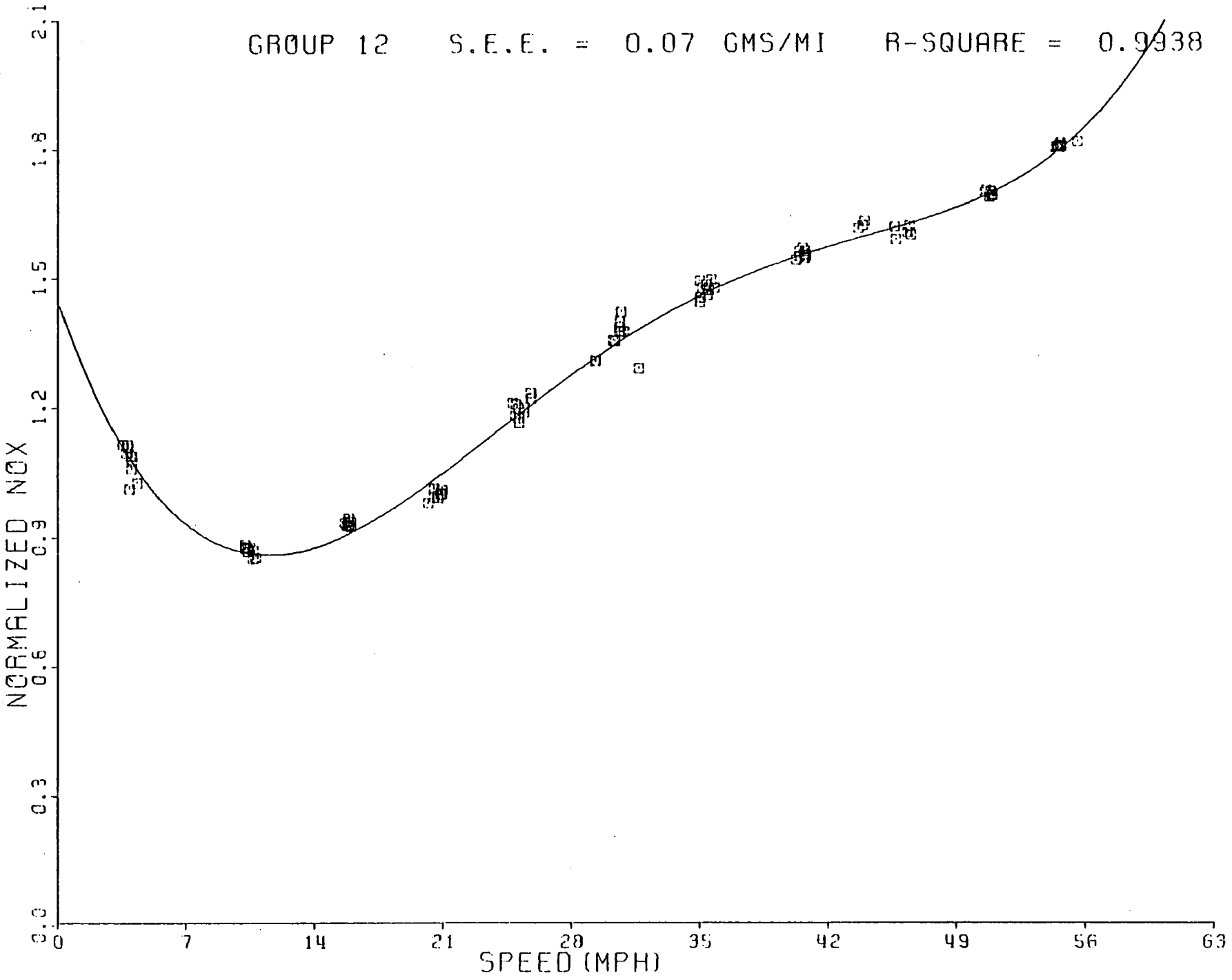

GROUP 1 S.E.E. = 0.13 GMS/MI R-SQUARE = 0.9562
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

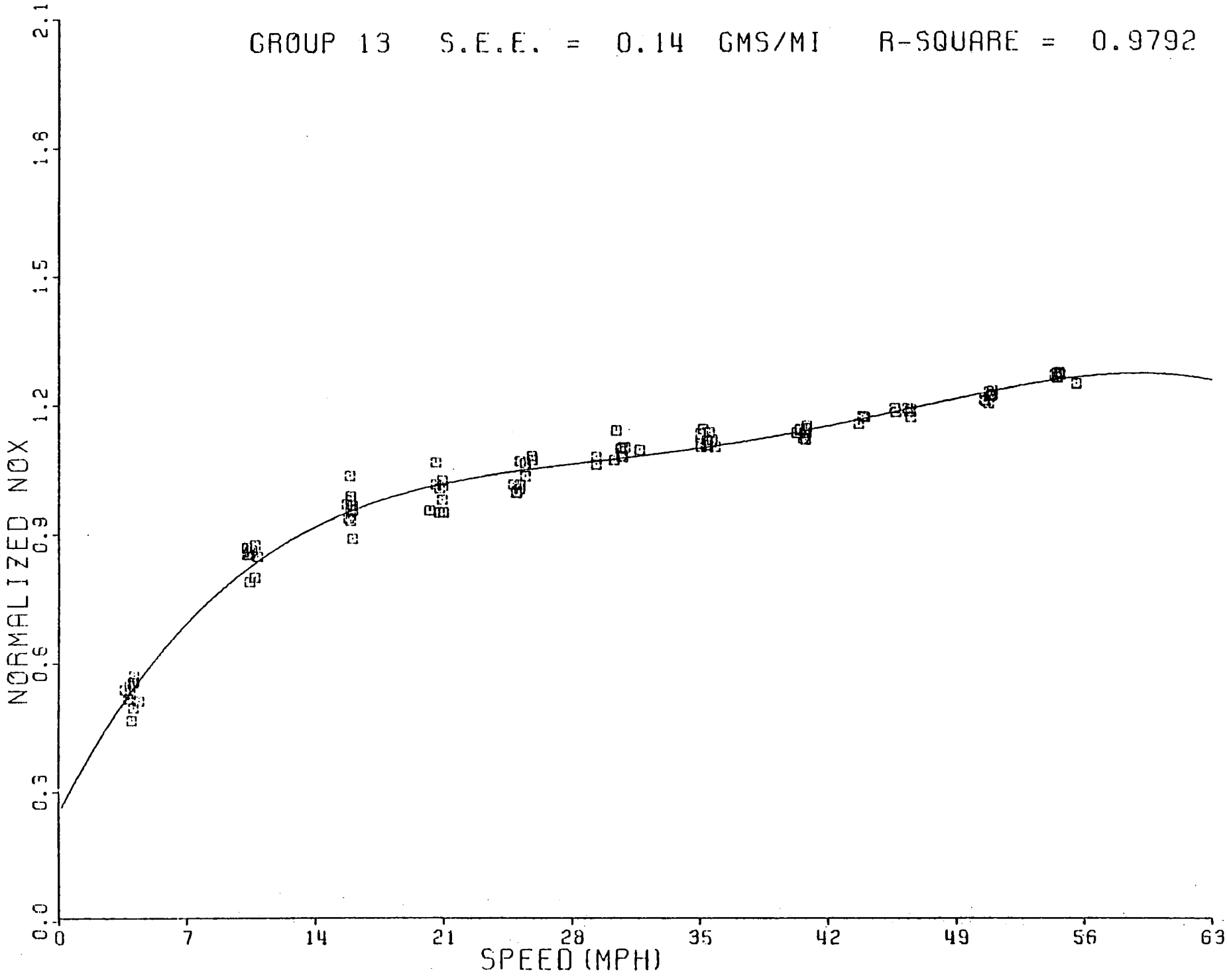

GROUP 8 S.E.E. = 0.07 GMS/MI R-SQUARE = 0.9840
NORMALIZED NOX
SPEED (MPH)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

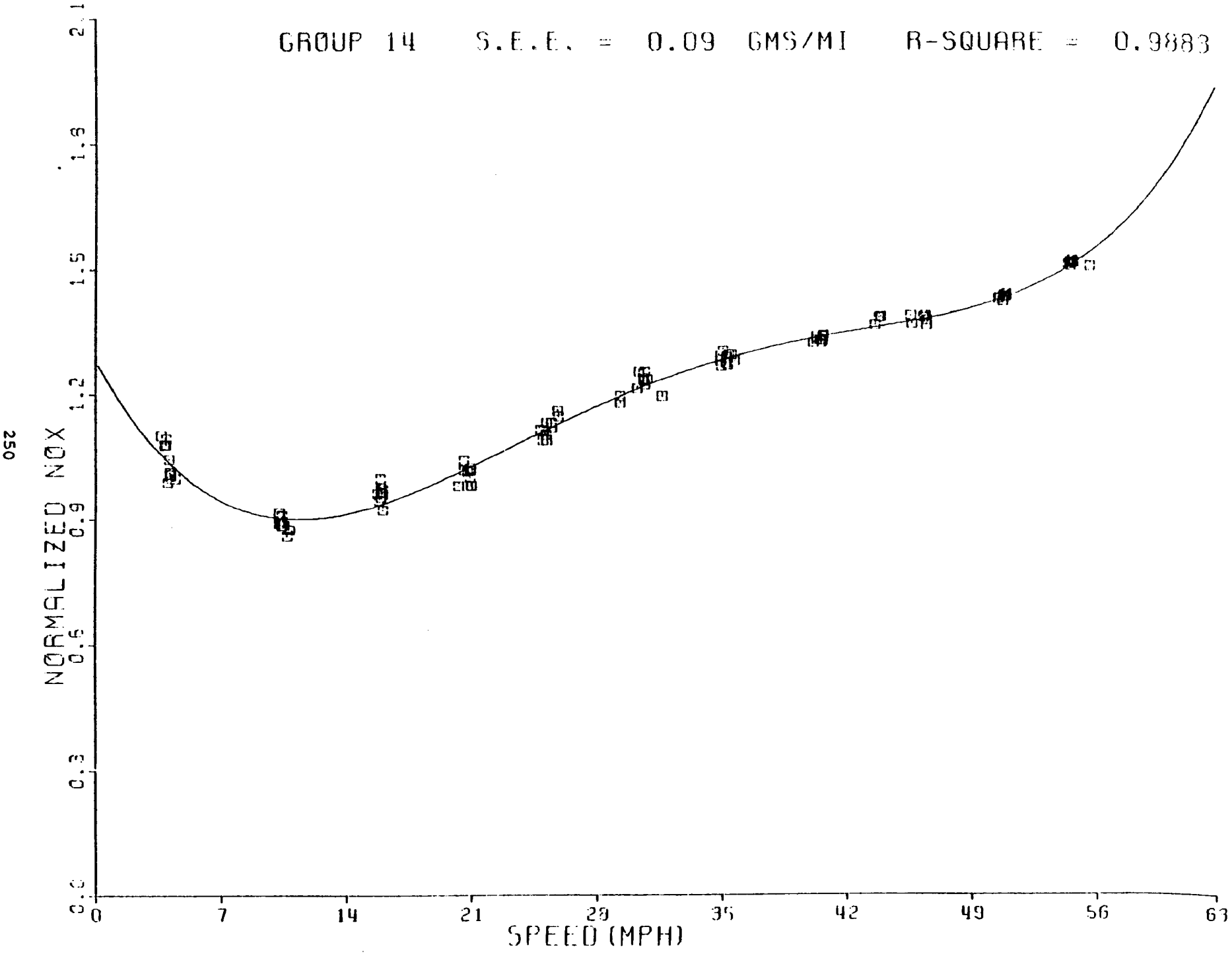

GROUP 9 S.E.E. = 0.06 GMS/MI R-SQUARE = 0.9854
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

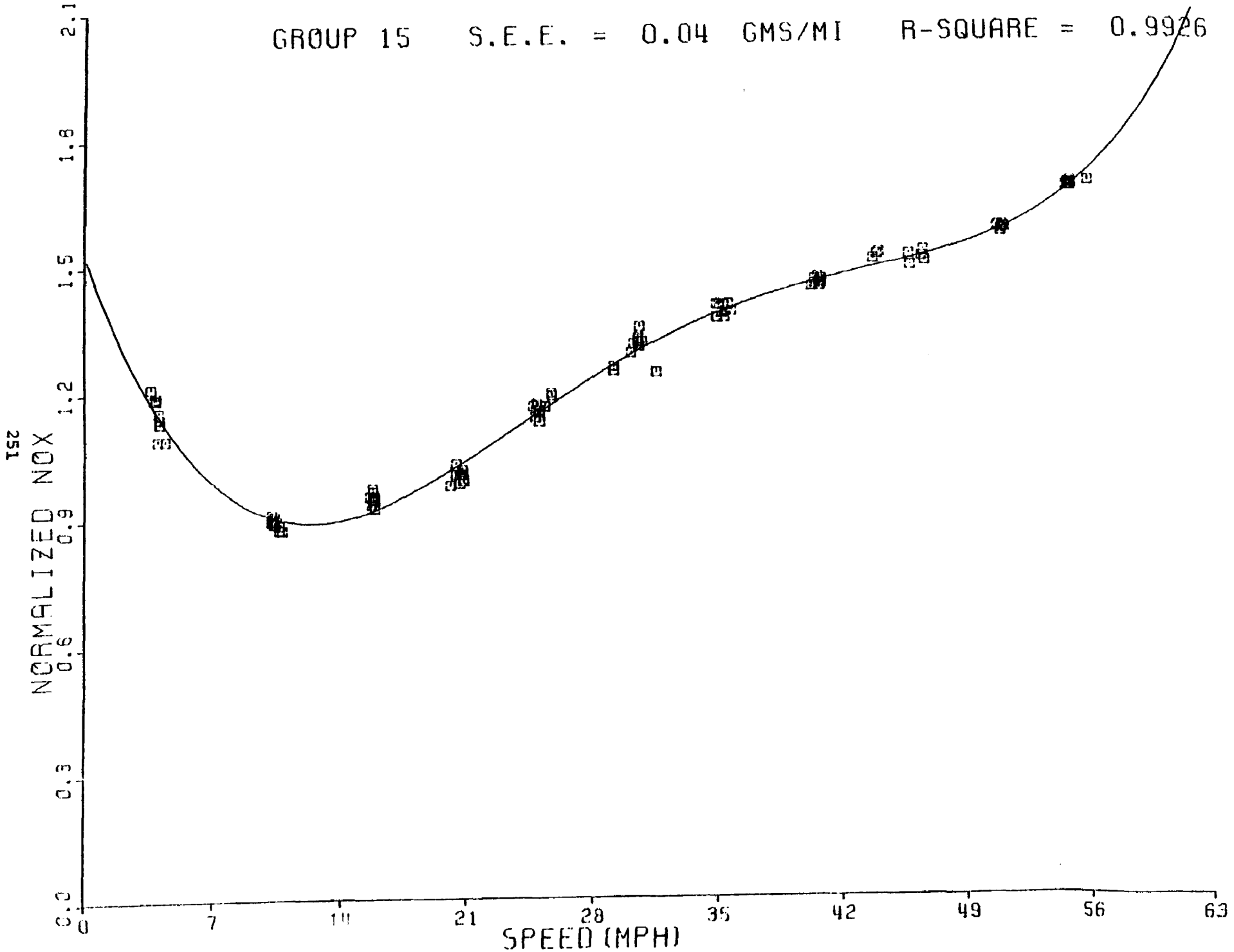

GROUP 10 S.E.E. = 0.07 GMS/MI R-SQUARE = 0.9912
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

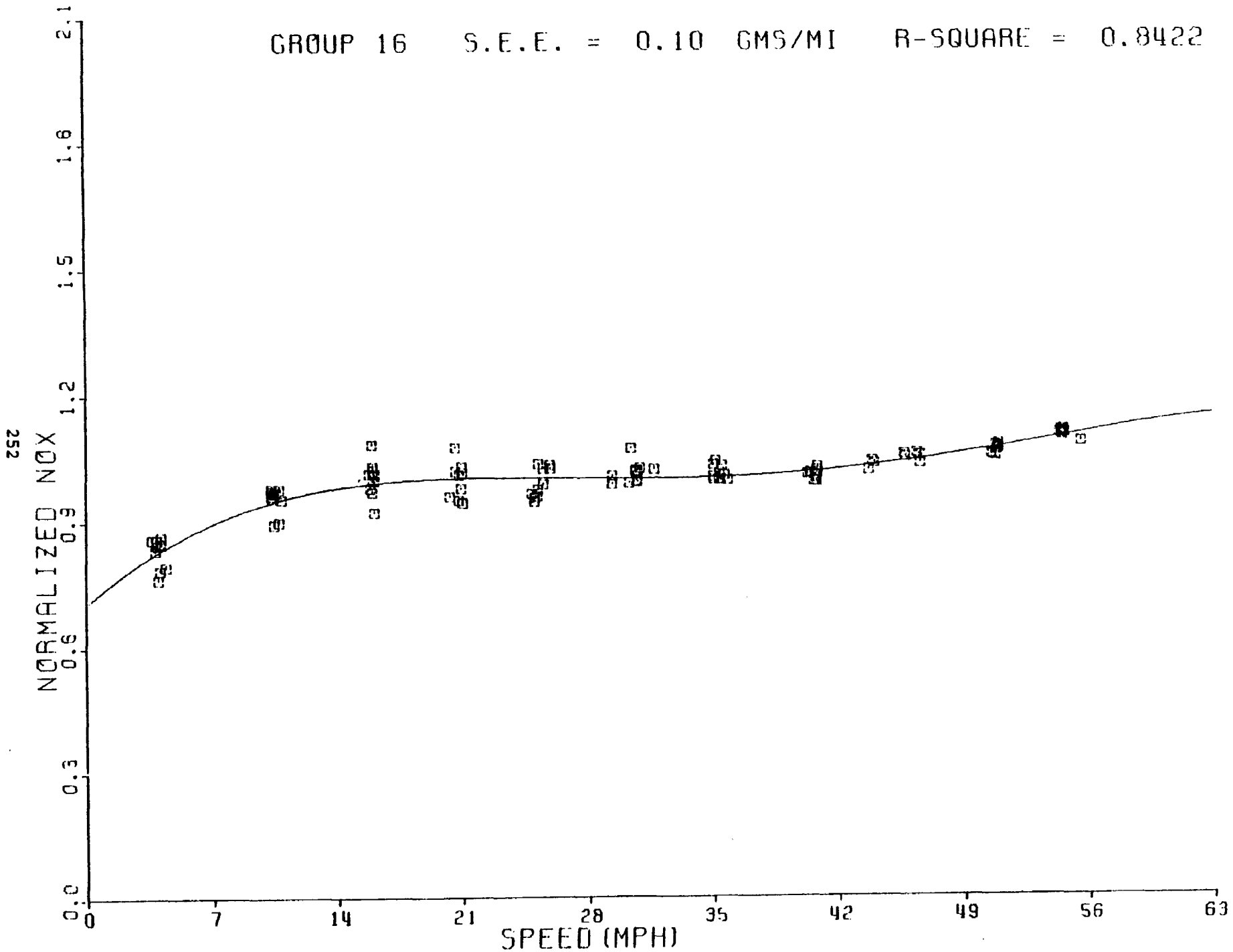

GROUP 11 S.E.E. = 0.08 GMS/MI R-SQUARE = 0.9860
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

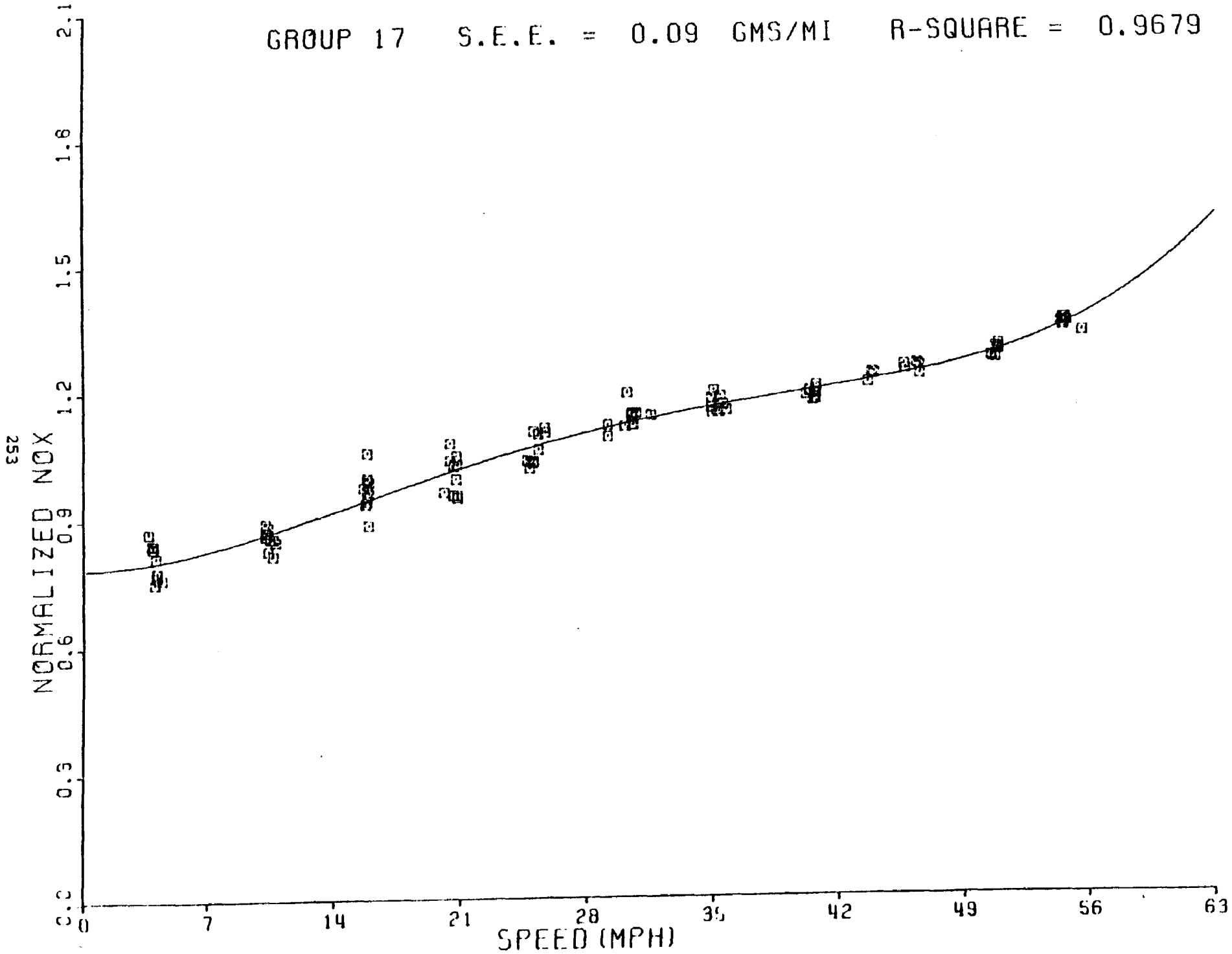

GROUP 12 S.E.E. = 0.07 GMS/MI R-SQUARE = 0.9938
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63

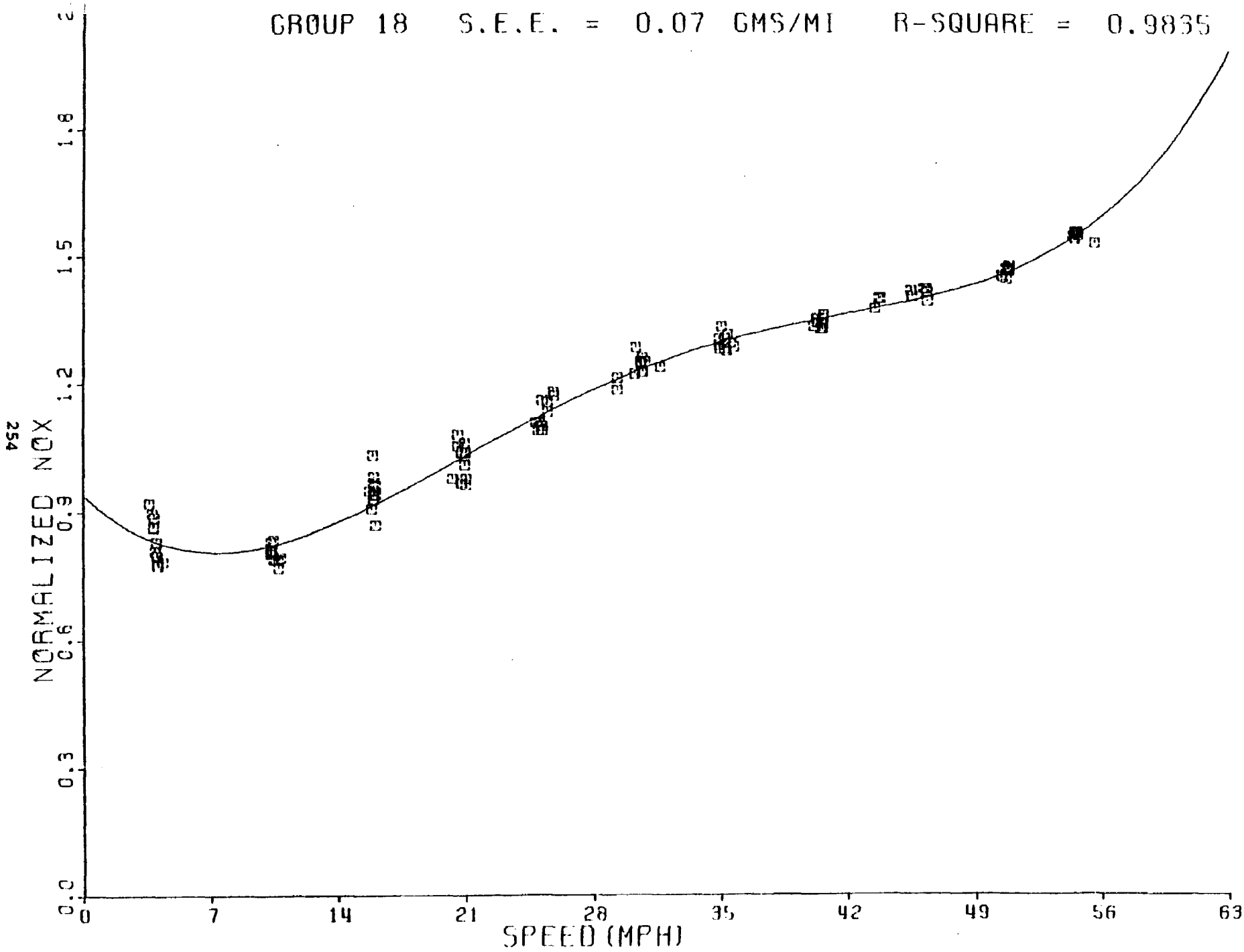

GROUP 13 S.E.E. = 0.14 GMS/MI R-SQUARE = 0.9792
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63


GROUP 14 S.E.E. = 0.09 GMS/MI R-SQUARE = 0.9883
NORMALIZED NOX
SPEED (MPH)
0
7
14
21
28
35
42
49
56
63
0.3
0.6
0.9
1.2
1.5
1.8
2.1
250


GROUP 15 S.E.E. = 0.04 GMS/MI R-SQUARE = 0.9926
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63


GROUP 16 S.E.E. = 0.10 GMS/MI R-SQUARE = 0.8422
NORMALIZED NOX
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
0
7
14
21
28
35
42
49
56
63
SPEED (MPH)


GROUP 17 S.E.E. = 0.09 GMS/MI R-SQUARE = 0.9679
NORMALIZED NOX
SPEED (MPH)
0
7
14
21
28
35
42
49
56
63
0.3
0.6
0.9
1.2
1.5
1.8
2.1


GROUP 18 S.E.E. = 0.07 GMS/MI R-SQUARE = 0.9835
NORMALIZED NOX
SPEED (MPH)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
0
7
14
21
28
35
42
49
56
63

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-460/3-77-011		

4. TITLE AND SUBTITLE
Development of Revised Light-Duty-Vehicle Emission - Average Speed Relationships

5. REPORT DATE
August 1977

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Malcolm Smith and Tom Aldrich

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Olson Laboratories, Inc.
421 East Cerritos Avenue
Anaheim, California 92805

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
Environmental Protection Agency
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA-ORD

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report presents the results of Contract No. 68-03-2222, entitled "Development of Revised Light-Duty Vehicle Emission Average Speed Relationships." The two-fold purpose of the program was (1) to perform a statistical analysis of the GM chase-car data, and (2) to establish regressions of fuel consumption and emissions on average speed over driving cycles generated from combined GM and CAPE-10 data.

Ten cycles were selected at each of 11 nominal speeds ranging from 5 mph to 55 mph. Hot-start estimates of HC, CO, NO_x (all in units of grams per mile), and fuel consumption (in units of miles per gallon) over each of the cycles were obtained for each of 18 model-year groups. The emissions and fuel consumption estimates were regressed on average speed to yield the desired emission-average speed relationship for each model-year group. The equations were then normalized to 19.6 mph, the average speed over the FTP cycle, to yield correction-factor equations. Groups were combined to give composite correction-factor equations for 1975 vehicle population in low-altitude cities and for 1974 vehicle population in high-altitude cities.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release to Public	Unclassified	255
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)