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Evaluation of a Nissan Fast Burn Engine System (NAPS-Z)

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by

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Background

The Environmental Protection Agency (EPA) is interested in new technological developments which will reduce exhaust emissions and improve fuel economy. Because the development of the Fast Burn Engine System (NAPSZ) by the Nissan Motor Company, Ltd., appeared to be a new technological development, the EPA requested a vehicle for testing and evaluation at the Motor Vehicle Emission Laboratory in Ann Arbor. Nissan Motor Company, Ltd., agreed to provide a vehicle for evaluation and agreed that the test program would include a variety of test conditions to enable a complete evaluation of the vehicle characteristics. The engine concept is the result of development aimed at meeting 0.41, 3.4 and 1.0 grams per mile for HC, CO, and NOx, respectively, while improving fuel economy.

The Fast Burn Engine System is being developed to provide a means of reducing NOx emission levels while maintaining or improving upon current fuel economy and performance levels. The EPA has tested several retrofit Exhaust Gas Recirculation (EGR) devices. However, this vehicle provided the opportunity to test an engine concept developed as a unit to allow increased EGR levels. The engine modifications were aimed at eliminating the common problems resulting from high levels of EGR, including reduced fuel economy and performance.

The conclusions from the EPA evaluation of the NAPS-Z can be considered to be quantitatively valid only for the vehicle used. However, it is reasonable to extrapolate the results from the EPA test program to other vehicles in a directional manner. It is reasonable to suggest that similar results are likely to be achieved where a similar engine concept is applied to other types of vehicles.

Summary of Results

1. For the standard test conditions the vehicle met the target levels for HC, CO, and NOx of 0.41, 3.4, and 1.0 grams per mile, respectively.

2. Fuel economy for the standard test conditions was 26.4 miles per gallon for the FTP and 37.2 miles per gallon for the HFET. The "1979 Gas Mileage Guide," second edition cites 23 miles per gallon as the figure for a 1979 Datsun 510 with 5 speed manual transmission.

3. The NAPS-Z met the target emission levels for HC under all test conditions (various shift speeds, inertia weights, and A/C loads), exceeded the target for CO (3.4 gpm) under three test conditions (maximum by 12%), and exceeded NOx (1.0 gpm) under six test conditions (maximum by 28%).

4. As the various combinations of the three test variables were run, the range of emission results for HC was 0.22 to 0.40 gpm, for CO was 1.6 to 3.8 gpm, for NOx was 0.65 to 1.28 gpm. The range for fuel economy was 22.3 to 34.8 miles per gallon for the FTP and was 34.0 to 41.8 miles per gallon for the HFET.

5. The effect that changing the ambient temperature from 0° to 110°F had on HC and CO varied between the FTP and HFET cycles. Increasing the temperature caused NOx to decrease and fuel economy to increase throughout the temperature range on both cycles.

Test Program

The test program employed a variety of test conditions to determine the sensitivity of the vehicle to changes in the test conditions. The vehicle was tested according to the Federal Test Procedure (FTP) and the Highway Fuel Economy Test (HFET) cycles under each of the various combinations of test conditions as shown in Table I and Table III. Testing conducted at the EPA Motor Vehicle Emissions Laboratory involved varying the inertia weight, the shift speed schedule, and the air conditioner horsepower loads. The effect of ambient air temperature changes was investigated at a facility operated by Gulf Research in Pennsylvania.

The vehicle was tested at inertia weights of 2500, 2750[1], and 3000 pounds. This provided an indication of the sensitivity of the engine and its controls to changes in vehicle loading. It also served to indicate the effect on emission and fuel economy levels if the engine was used in a larger vehicle since the engine demonstrated adequate power for such an application.

Three shift speed schedules were used which ranged from the low speed schedule of 9/15/23/30 mph to the standard of 15/25/40/45 to the high speed schedule of 17/29/46/52 mph. This was done to indicate the sensitivity of the vehicle to various driver characteristics and to various driving situations.

The horsepower loading applied during testing was varied among three levels. To establish a baseline, the vehicle was tested in the standard configuration. This included the additional 10% horsepower requirement for air conditioning over the basic road load horsepower requirement. It was also tested without the added 10% horsepower both with and without the A/C in operation at maximum cooling conditions. These configurations provided an indication of the sensitivity of the vehicle to various changes in road loads due to use or non-use of the A/C as well as to any increase in coolant temperature resulting from operation of the air conditioning system.

The ambient temperature testing was conducted to establish the sensitivity of the vehicle to a wide range of ambient conditions. The vehicle was soaked at and run at temperatures ranging from 0° to 110° F. These conditions were intended to simulate the seasonal changes associated with the various geographical regions of the United States.

[1] Normal inertia test weight for the test vehicle.

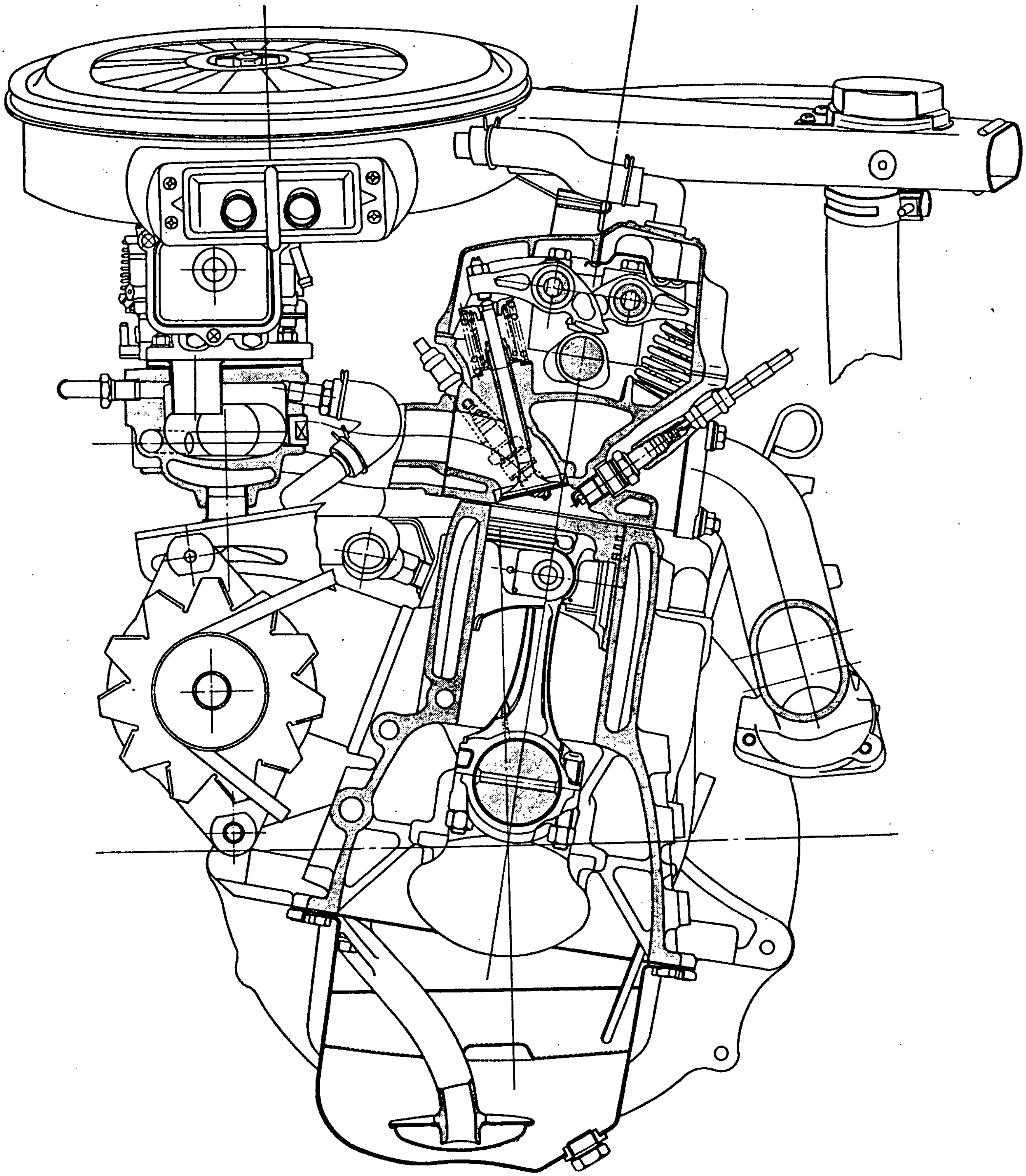


Figure 1 - NAP-Z Engine

Table I

Test Conditions

Variable	Values
Inertia Weight	2500, 2750, and 3000 pounds
Shift Speeds	9/15/23/30, 15/25/40/45, 17/29/46/52
A/C Horsepower Load	base road load, A/C not operating; base road load +10% additional road load, A/C not operating base road load, A/C operating at maximum cooling condition
Ambient Temperature	0,20,40,60,70,80,90,110°F

Vehicle Description

The basic test vehicle was a 1978 Datsun 510 three door hatchback with an inertia weight of 2750 pounds. It was equipped with the experimental 1952 cubic centimeter Nissan Fast Burn Engine System. Power was delivered through a five-speed manual transmission with an overdrive fifth gear with a ratio of 0.854 to 1 and a rear axle ratio of 3.545 to 1. A full description is given in Table II.

Fast Burn Engine Concept

The engine system developed by Nissan to improve both the control of NOx emission levels and to improve fuel economy is essentially a combination of heavy EGR and a fast burn engine. The concept is described in detail in a Technical Paper published by the Society of Automotive Engineers entitled "The Fast Burn with Heavy EGR, New Approach for Low NOx and Improved Fuel Economy" by H. Kuroda, Y. Nakajima, K. Sugihara, Y. Takagi, and S. Muranaka. A brief summary of the SAE paper follows:

Attempts to increase the level of EGR used to control NOx emission levels revealed that engine operating stability is the major limiting factor. Therefore, the authors began an investigation into which combustion characteristic(s) determined operating stability. Pressure readings were taken at four locations within the combustion chamber with various EGR levels. From this information, four types of combustion were identified. The normal burn produced a single, sharp pressure spike at all four locations. A slow normal burn condition was characterized by irregular pulses of a longer duration than the normal burn. A partial burn was characterized by pressure pulses occuring at one to three of the reading locations. The final type noted was a misfire condition where no pressure pulses were recorded.

It was found that the normal burn condition predominated when no EGR was used. As EGR was introduced some slow burn combustion appeared. As the EGR rate was increased the portion of combustion of the slow burn type increased. The engine stability limit, judged by the amount of transverse engine displacement, was reached where combustion was of the normal and slow burn type and prior to the appearance of partial burn and misfire. Further increasing of the EGR level resulted first in the appearance of partial burn and then in the appearance of misfire.

Since it was found that the percentage of slow burn combustion determined the level of stability of the engine, a method of increasing the burn rate was required. Previous developmental work revealed that fast burn engines tended to increase the NOx levels found from conventional engines. However, the combination of a fast burn engine with high levels of EGR appeared to be absent from the previous developmental work. A dual spark plug combustion chamber was developed to accomplish the fast burn desired (see Figure 1).

A conventional engine was used as a baseline for comparison. It was found that the duration of the combustion process in the fast burn engine using a 20% EGR rate was comparable to that of the conventional engine not using EGR. The engine stability limit was reached in the fast burn engine when the EGR rate was at about 33%. In this configuration the fast burn engine yielded lower NOx and HC emission levels as well as an improvement in fuel economy in comparison with the conventional engine.

Discussion of Results

General Data Analysis

From an initial examination of the results displayed in Tables III and IV and in Figures 2 through 21, it appears that changing the test conditions noted above did cause real changes in the emission levels and fuel economy of the vehicle. However, to determine whether the observed differences in the results were satatistically significant, the statistical technique of analysis of variance (ANOVA) was used. The ANOVA technique provides a means for indicating the probability that an observed difference is due to the changing of the subject variable(s) or whether it is due to residual testing error. Briefly, the ANOVA technique compares the differences observed, to the unexplained residual differences, when all but one variable is held constant.

The ANOVA technique also allows the determination of the significance of the combined effect or interaction of two or more of the variables. This indicates whether the combined variables have a synergistic effect, i.e., the combined effect is greater than the sum of individual effects.

The resultant levels of significance are stated in terms of percents. This confidence level indicates the probability that the observed effect is due to the variable(s) being analyzed (see example calculations in Table XI of Appendix D).

FTP and HFET testing was completed for 2750 and 3000 pound inertia weights for all combinations of the three shift speeds and the three A/C horsepower loads. The testing at 2500 pounds was not complete but included all shift speeds for the "no A/C load" condition and all A/C loading conditions for the standard shift speeds. The complete data set from the 2750 and 3000 pound inertia weights was analyzed for all variables and all combinations of variables for both the FTP and HFET. Then separate analyses were conducted for the three inertia weights for the complete "no A/C load" and standard shift speed data sets using the FTP data.

Federal Test Procedure

Standard Test Conditions

The standard test conditions used for the NAPS-Z were 2750 pound inertia weight, ten percent horsepower load added to the standard road load to simulate the A/C load, and shift speeds of 15, 25, 40, and 45 miles per hour. Under these test conditions the average HC, CO, and NOx emission levels were 0.25, 2.8, and 0.70 grams per mile respectively. The vehicle met the 0.41, 3.4, and 1.0 grams per mile maximum levels for which it was designed. The fuel economy was 26.4 miles per gallon.

Effect of Shift Speeds

Each of the three ANOVA tables indicate that the shift schedule was found to significantly affect NOx emission levels and fuel economy but it did not significantly affect CO emission levels. (The summary of results is presented in Table III and in Figures 2 thru 6 and a summary of the ANOVA results is presented in Table V.) The low shift speeds consistently yielded the highest NOx levels while the standard and high shift speeds resulted in lower NOx levels which were equivalent to each other (see Figure 5). The effect of shift speeds on fuel economy clearly showed that an increase in shift speeds resulted in a decrease in the fuel economy (see Figure 6).

The level of significance of the effect of shift speeds on HC emissions varied between analyses (see Figure 2 and Table V). When the 2750 and 3000 pound inertia weights were used for the analysis it was found that shift speed affected the level of HC emissions at the 99% level and that the HC emissions decreased as the shift speeds were increased. The ANOVA for the three inertia weights at the "no A/C horsepower" condition indicated shift speed was not significant at the 90% level. The reason for this is apparent in Figure 2 as the relative ranking of shift speeds by resultant HC levels were different for each inertia weight. This test-to-test variability obscured the real effect of shift speeds found in the other analysis.

Effect of Inertia Weight

Both NOx emission and fuel economy levels were significantly affected by inertia weight changes. NOx was found to increase as the inertia weight was increased (see Figure 5). The fuel economy levels decreased as the inertia weight was increased (see Figure 6).

The significance level of the effect of inertia weight on HC and CO emission levels varied among the three ANOVA evaluations. The ANOVA performed using the 2750 and 3000 pound inertia weights indicated that the significance level of the effect of inertia weight on HC was below 90%. Figure 2 illustrates that the test-to-test variability was large in comparison to slightly higher HC emissions for the 3000 pound inertia weight. However, when all three inertia weights were analyzed, inertia weight was found to affect HC levels at the 95% level. Figure 2 illustrates the reason for this change in results. The variability was substantially reduced when the A/C load and the shift schedule were each held constant in the respective ANOVA evaluations. In both cases HC emissions levels were higher when the inertia weight was higher.

Inertia weight was found to be a significant factor in CO emission levels for two of the three ANOVA evaluations. These were the analyses for the 2750 and 3000 pound inertia weight comparison and the three inertia weight comparison while holding the A/C load constant. In these two cases an increase in inertia weight caused an increase in CO emission levels. In contrast, when the shift speed was held constant the effect of the inertia weight was not significant at the 90% level. This apparent discrepancy is resolved by observing that the results of the tests using the standard shift schedule (see Figure 3) did not follow the trend toward higher CO resulting from higher inertia weight.

Effect of A/C Horsepower Load

The A/C horsepower load level had a significant effect on NOx emission and fuel economy levels but had no effect on HC emission levels. The NOx levels were essentially equivalent between the no A/C load and 10% added load conditions but NOx levels increased when the A/C was operated during the test. Fuel economy was lowest when the A/C was in operation and highest when no A/C load was applied.

The significance of the effect of the A/C load on CO emissions was not consistent between the two ANOVA evaluations. The effect was not significant for the ANOVA using the 2750 and 3000 pound inertia weights because of the variability in results. The effect was signficant at the 99% level for the ANOVA using the three inertia weights at standard shift speeds. CO levels were generally lowest when the A/C was in operation and highest when no A/C load was applied although this effect is somewhat obscured (see Figure 3) by the interactive effect of A/C load and inertia weight.

Interactions

The combined effect of all three variables was not signficant for any of the controlled emissions or fuel economy. The interaction of A/C loading and shift speeds did have a significant effect on each of the above. The combined effect on HC is not clear in Figure 2 as the effect is obscured by the interaction of shift speeds and inertia weights. As the A/C loading increased the CO levels corresponding to standard shift speeds dropped relative to the other shift speeds. NOx levels were lowest for the standard shift when no A/C load was applied but were lowest for the high speed shift when the A/C was in operation. The fuel economy decline due to increased shift speeds was more drastic when the simulated A/C load was not applied than when the A/C was in operation.

The interaction of shift speeds and inertia weight had a significant effect on HC only. For the 2750 pound class the low shift speeds yielded the highest HC values followed by standard and then high shift speeds. For the 3000 pound class no such clear pattern existed (see Figure 2) which indicates a combined effect caused a change in the ranking of the HC levels relating to shift speeds.

The A/C loading and inertia weight changes combined to significantly affect CO levels and fuel economy levels. The high speed shift CO levels were higher relative to CO levels associated with other shift speed for the 3000 pound class than for the 2750 pound class. In the ANOVA analysis of the 2750 and 3000 pound weight class the effect on fuel economy was not significant at the 90% level. However, the effect was significant at the 95% level when all inertia weights were analyzed for standard shift. The result is that the decrease in fuel economy due to the A/C operating is less dramatic as the inertia weight is increased.

Ambient Temperature Effects

The ambient temperature affected HC, CO, and NOx emission levels and fuel economy at the 99% confidence level. HC and NOx levels steadily decreased as the ambient temperature was increased (see Figures 7 and 10). The CO levels dropped with a temperature increase from 0°F to 70°F, remained constant from 70°F to 90°F, and increased from 90°F to 110°F(see Figure 8). Fuel economy improved as the ambient temperature increased throughout the range(see Figure 11).

The ambient temperature results from tests conducted at Gulf Research and Development should not be compared directly to the results of tests conducted at the Motor Vehicle Emissions Laboratory (MVEL). The dynamometer configuration and the analyzers used at Gulf differ from those used at the MVEL. No attempt was made to establish correlation between the laboratories as the intent was to determine the relative effect of ambient temperature in establishing the characteristic response of the vehicle to temperature changes.

Highway Fuel Economy Test

Standard Conditions

The standard test conditions were the same as those used for the FTP. The resultant average HC, CO, and NOx emission levels were 0.06, 0.3, and 1.18 grams per mile, respectively. The average fuel economy was 37.2 miles per gallon.

Effect of Shift Speeds

Shift speeds significantly affected HC and NOx emission levels and fuel economy levels when performing ANOVA on the 2750 and 3000 pound inertia weight classes (see Figures 12-16). The HC results were quite low so the rounding error had a pronounced effect on the results. Despite this effect, the ANOVA evaluation and Figure 7 show that HC levels tended to increase as the shift speed was increased.

The effect on NOx and fuel economy were not similarly affected by rounding. Generally, NOx tended to be lower for the standard shift condition than for the low and high shift conditions (see Figure 15). Fuel economy fell as the shift speeds were increased (see Figure 16).

The ANOVA evaluation determined that the effect of shift speeds on CO levels was not significant at the 90% level. Figure 13 appears to contradict this conclusion as higher shift speeds seem to result in higher CO levels. However, the variability in the data was too large to support the conclusion that this apparent effect was significant.

Effect of Inertia Weight

The inertia weight was found to have no significant effect on HC and to have a significant effect on CO, NOx, and fuel economy levels. Higher CO and NOx emission levels resulted when the inertia weight was increased from 2750 to 3000 pounds. Fuel economy decreased when the inertia weight was increased.

Effect of A/C Horsepower Loads

A/C horsepower load significantly affected NOx and fuel economy but did not affect HC and CO at the 90% level. The highest NOx levels resulted when the A/C was in operation while the simulated A/C load caused only marginally higher NOx levels than the no A/C load condition. Fuel economy was lowest when the A/C was in operation and highest when no A/C load was applied.

Interactions

The combination of A/C loading and shift schedules affected CO, NOx, and fuel economy. CO levels were about equal for the no A/C load and simulated A/C load conditions when the higher shift speeds were used but the no A/C load condition yielded noticeably lower CO levels than the A/C load conditions when the low shift speeds were used (see Figure 13). The effect on NOx and fuel economy were not obvious due to the effect of inertia weight (see Figures 15 and 16). The combined effect of A/C loading and inertia weight significantly affected only CO but this effect was obscured by the effect of shift speeds (see Figure 13).

Ambient Temperature Effects

The ambient temperature had a significant impact on HC, CO, NOx, and fuel economy levels (see Figures 17-21). HC generally decreased from a maximum level at 0°F to a minimum at 90°F and then rose slightly as the temperature increased to 110°F. (The 110° values represent a single test result while the others represent the mean of two results.) CO rose very gradually from a minimum at 0°F to 90°F and then rose dramatically at the 110°F point. NOx levels steadily fell as the temperature was changed from 0°F 110°F. Fuel economy rose gradually as the temperature was increased.

Discussion Summary

The above discussion indicates that the NAPS-Z showed some sensitivity to each of the three variables. However, the actual impact on the results due to each variable was generally small considering the substantial range used for each variable. This can be best realized by comparing the results from the various test conditions at the MVEL to the standard test conditions. None of the averages of the two replications for each test condition exceeded the targeted HC maximum of 0.41 grams per mile for any of the conditions. The highest average HC value (0.39) gpm represented a 56% increase over the standard condition (0.25) gpm) while being 5% below the target level.

Average CO emission levels exceeded the target of 3.4 gpm in only three of the twenty-three conditions (see Table III). The maximum level of 3.8 gpm exceeded the standard condition (2.8 gpm) by 36% and the target by 12%. Average NOx emission levels exceeded the target of 1.0 gpm in six of the twenty-three conditions. The maximum level (1.28 gpm) exceeded the standard condition (0.70 gpm) by 83% and the target by 28%. For the FTP, the fuel economy minimum value (22.3 mpg) was 16% below the standard condition (26.4 mpg) and the maximum value (34.8 mpg) exceeded the standard condition by 32%. For the HFET and fuel economy minimum value (34.0 mpg) was 9% below the standard condition (37.2 mpg) and the maximum value (41.8 mpg) exceeded the standard condition by 12%.

The effects of the ambient temperature on HC and CO varied between the FTP and the HFET. The differences here are understandable as the driving cycles cause the vehicle to operate in different ranges. Also, the FTP is a cold start procedure where the choke is activated initially and the components are initially at the ambient temperature as compared with the HFET where all components are in the normal operating temperature range for the duration of the cycle.

Conclusions

1. The vehicle met the HC, CO, and NOx targets under standard test conditions.

2. The vehicle met the HC target level under all test conditions. The maximum CO and NOx levels exceeded the target levels by 12% and 28% respectively, but the vehicle met these targets for most of the test conditions.

3. Generally, the vehicle was somewhat sensitive to changes in shift speeds, inertia weight, A/C loading and ambient temperature regarding HC, CO, NOx, and fuel economy levels. Though the ranges of differences were not large considering the widely varied test conditions.

4. Fuel economy for the FTP was 26.4 miles per gallon under standard test conditions compared with the 23 miles per gallon fuel economy figure for a similar production 510 vehicle with a manual 5-speed transmission ("1979 Gas Mileage Guide", second edition). This improvement of approximately 3 mpg indicates that the goal of improved fuel economy was met by the Fast Burn Engine System.

5. The vehicle was able to adequately follow the driving schedule even when the low shift speeds were coupled with the highest inertia weight and highest A/C loading.

Table II

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1978 Datsun 510
KHLA10-004508

Engine

type	4 stroke, Otto Cycle, 4 cyl. ohc
bore x stroke	85 mm (3.35 in) x 86 mm (3.39 in)
displacement	1952 cc (119 cu. in.)
compression ratio	8.5 to 1
fuel metering	single, 2 barrel carburetor
fuel requirement	unleaded regular

Drive Train

transmission type	5 speed manual
final drive ratio	3.545 to 1 in fourth gear 3.027 to 1 in fifth gear (overdrive)

Chassis

type	unitized 3
tire size	165 SRx13 radial
curb weight	2325 pounds
inertia weight	2750 pounds
passenger capacity	4

Emission Control System

basic type	Nissan Fast Burn Engine System: fast burn, EGR, exhaust air induction (EAI), oxidation catalyst

Accumulated Mileage

initial odometer mileage	5850 miles
final odometer mileage	9467 miles

Table III

Summary of FTP and HFET Test Results
(grams per mile/miles per gallon)

			2500 IW			2750 IW			3000 IW		
			Low	Standard	High	Low	Standard	High	Low	Standard	High
FTP											
No A/C HP	HC		0.26	0.22	0.24	0.34	0.26	0.23	0.26	0.32	0.29
	CO		2.2	1.8	1.8	2.7	2.8	2.0	2.8	3.8	3.4
	CO_2		251	289	320	268	312	335	270	309	354
	NOx		0.8	0.74	0.68	0.90	0.7	0.73	0.99	0.84	0.87
	MPG		34.8	30.4	27.4	32.4	28.0	26.2	32.2	28.2	24.6
Sim A/C HP	HC			0.24		0.4	0.25	0.25	0.39	0.30	0.26
	CO			3.6		3.0	2.8	2.5	2.7	3.0	2.1
	CO_2			292		296	332	366	299	341	368
	NOx			0.72		1.09	0.7	0.65	1.02	0.84	0.80
	MPG			29.7		29.4	26.4	23.9	29.1	25.6	23.8
A/C On	HC			0.24		0.38	0.3	0.26	0.35	0.28	0.30
	CO			2.4		2.6	1.8	1.6	3.5	2.0	3.4
	CO_2			340		314	352	388	328	351	392
	NOx			0.86		1.18	0.99	0.98	1.28	1.14	1.04
	MPG			25.8		27.8	24.9	22.7	26.6	25.0	22.3
HFET											
No A/C HP	HC		0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.06
	CO		0.2	0.2	0.8	0.2	0.3	0.6	0.4	0.6	0.6
	CO_2		212	214	224	224	236	236	226	227	238
	NOx		1.1	1.1	1.04	1.2	1.23	1.17	1.18	1.07	1.22
	MPG		41.8	41.4	39.2	39.6	37.6	37.2	39.3	39.0	37.1
Sim A/C HP	HC			0.06		0.06	0.06	0.07	0.06	0.06	0.07
	CO			0.6		0.3	0.3	0.7	0.2	0.4	0.8
	CO_2			219		238	238	256	244	245	256
	NOx			1.06		1.19	1.18	1.39	1.27	1.16	1.28
	MPG			40.2		37.4	37.2	34.4	36.2	36.1	34.4
A/C On	HC			0.06		0.06	0.06	0.06	0.06	0.06	0.06
	CO			0.4		0.2	0.2	0.4	0.2	0.2	0.8
	CO_2			244		245	248	256	244	252	259
	NOx			1.4		1.4	1.36	1.44	1.46	1.41	1.4
	MPG			36.2		36.2	35.8	34.5	36.2	35.1	34.0

Table IV

Summary of Results of Ambient Temperature Effects
(grams per mile/miles per gallon)

	0°	20°	40°	60°	70°	80°	90°	110°
					FTP			
HC	1.58	1.06	0.74	0.60	0.44	0.40	0.34	0.38
CO	13.88	9.49	7.84	6.88	4.84	5.30	5.00	7.76
CO_2	424	397	354	348	344	337	344	312
NO_x	1.70	1.32	1.28	1.22	1.20	1.01	0.97	0.89
MPG	18.6	20.2	22.6	24.2	24.8	25.2	24.8	27.0
					HFET			
HC	0.16	0.12	0.13	0.12	0.10	0.10	0.09	0.11*
CO	0.17	0.25	0.22	0.43	0.42	0.56	0.74	4.20
CO_2	248	250	236	238	240	227	237	231
NO_x	1.38	1.36	1.29	1.25	1.18	1.03	1.00	0.71
MPG	33.6	33.4	35.3	36.6	36.3	38.4	36.7	36.7

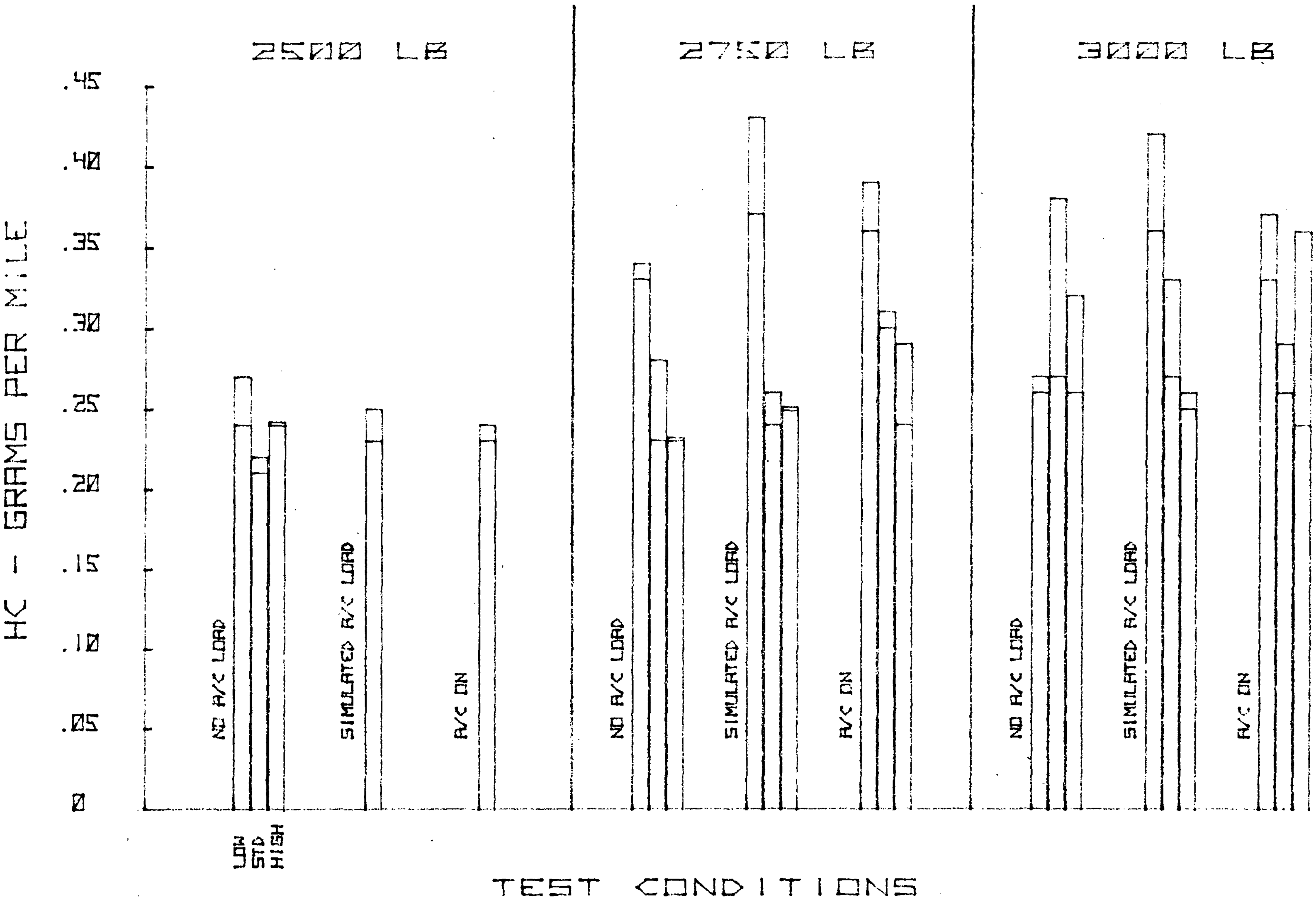
* Represents only one test.

Table V

Analysis of Variance Levels of Confidence
(A "-" indicates not significant at the 90% level.)

2750 vs. 3000	Variable	HC	CO	NOx	MPG
FTP	AC Load	-	-	99%	99%
	Shift Schedule	99%	-	99%	99%
	Inertia Weight	-	99%	99%	95%
	A/C & Shift	95%	90%	90%	99%
	A/C & Inertia Weight	-	95%	-	-
	Shift & Inertia Weight	95%	-	-	-
	A/C & Shift & Inertia Weight	-	-	-	-
2750 vs. 3000					
HFET	A/C Load	-	-	99%	99%
	Shift Schedule	99%	-	99%	99%
	Inertia Weight	-	99%	99%	95%
	A/C & Shift	-	90%	90%	99%
	A/C & Inertia Weight	-	95%	-	-
	Shift & Inertia Weight	-	-	-	-
	A/C & Shift & Inertia Weight	-	-	-	-
2500 vs. 2750 vs. 3000					
FTP	A/C Load vs. IW (Standard Shift Only)				
	Inertia Weight	95%	-	99%	99%
	A/C Load	-	99%	99%	99%
	Inertia Weight & A/C	-	99%	-	95%
2500 vs. 2750 vs. 3000					
FTP	IW vs. Shift (No A/C HP only)				
	Inertia Weight	95%	99%	99%	99%
	Shift Schedule	-	-	99%	99%
	Inertia Weight & Shift	90%	-	-	-
Ambient Temp. Effects					
FTP	Temperature	99%	99%	99%	99%
HFET	Temperature (Does not include 110°)	95%	99%	99%	99%

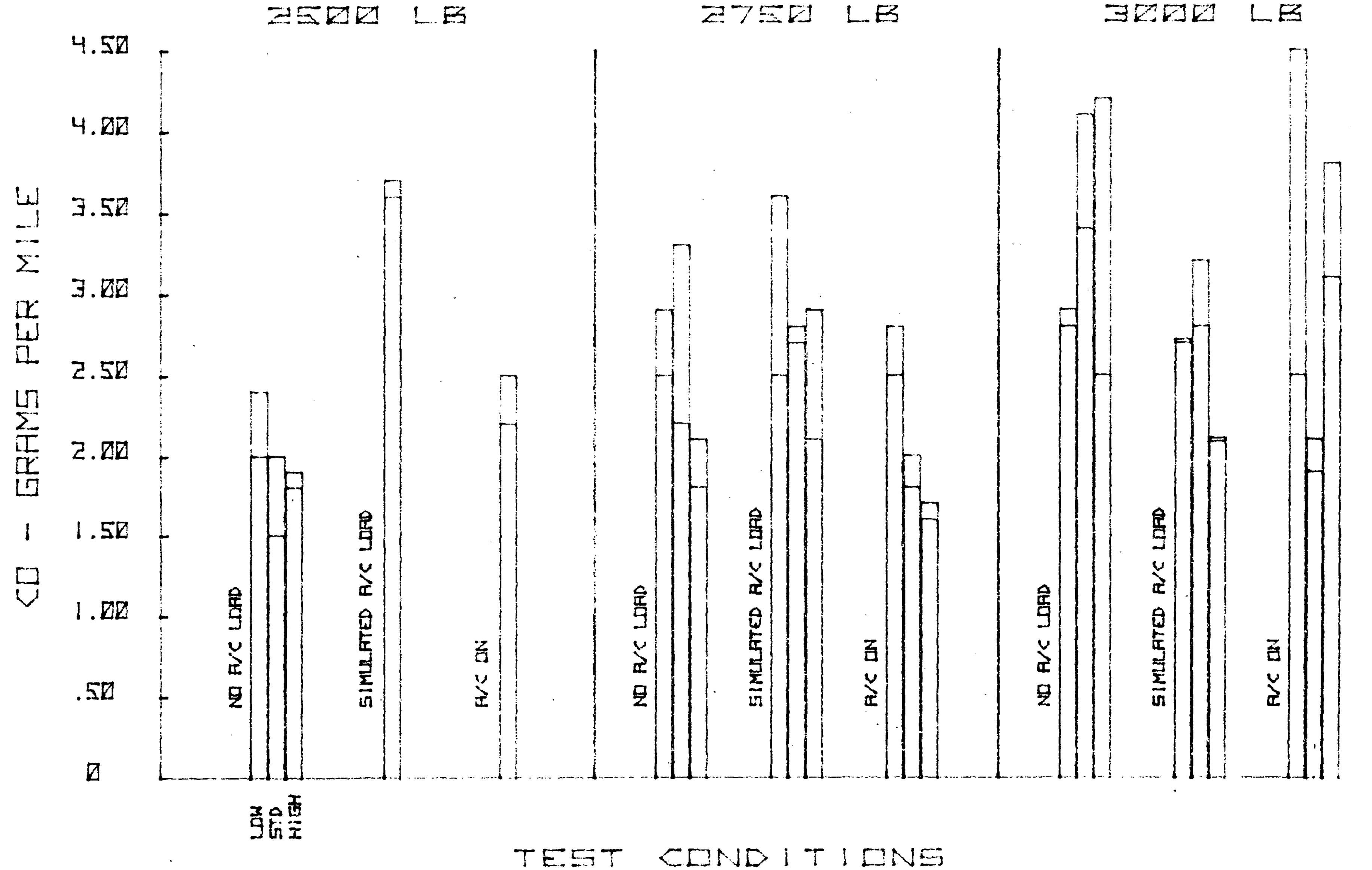
FTP TEST RESULTS



NOTE - (SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP)
(ALL TESTS WERE REPLICATED)

Figure 2

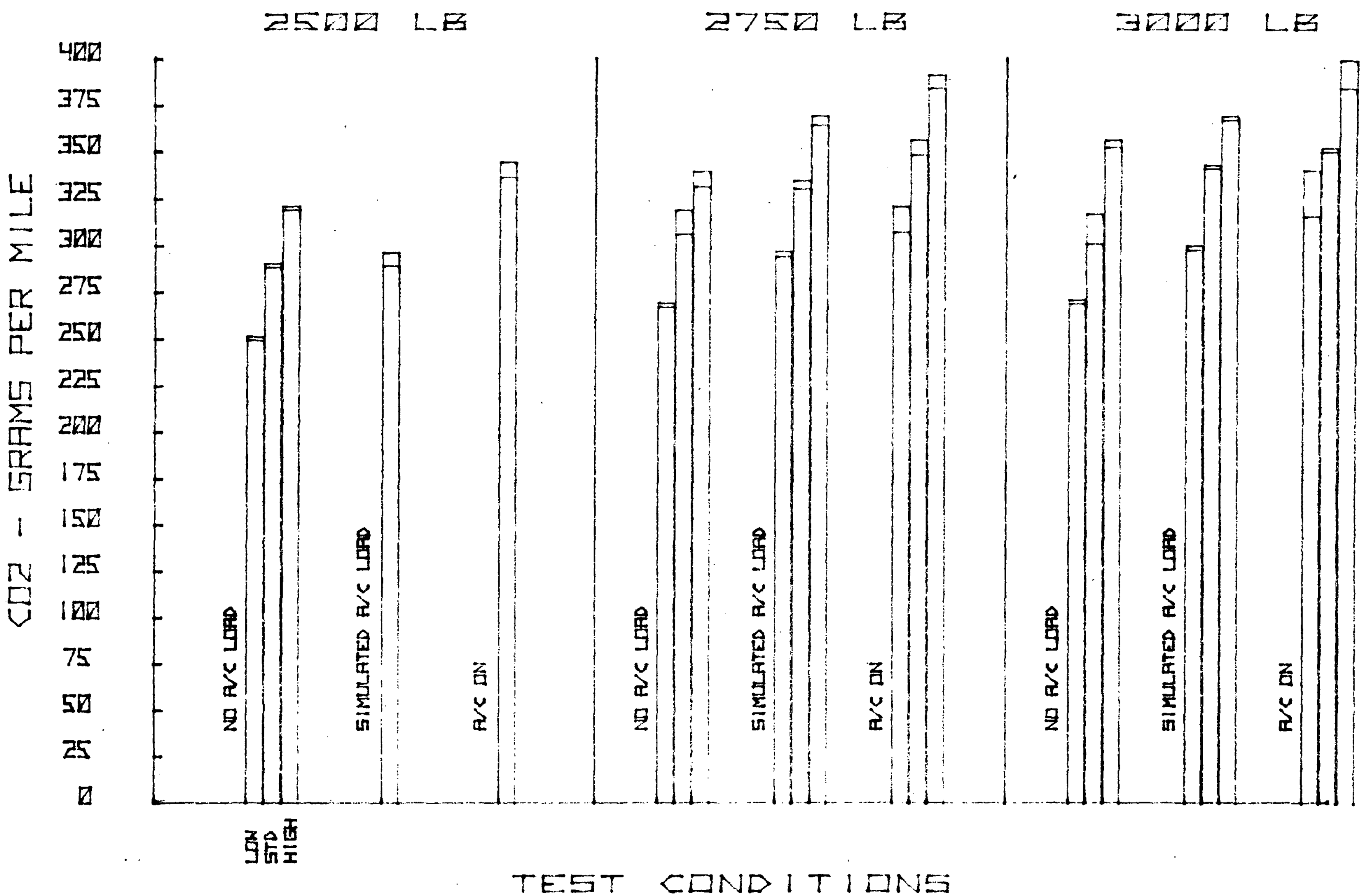
FTP TEST RESULTS



NOTE - <SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP>
<ALL TESTS WERE REPLICATED>

Figure 3

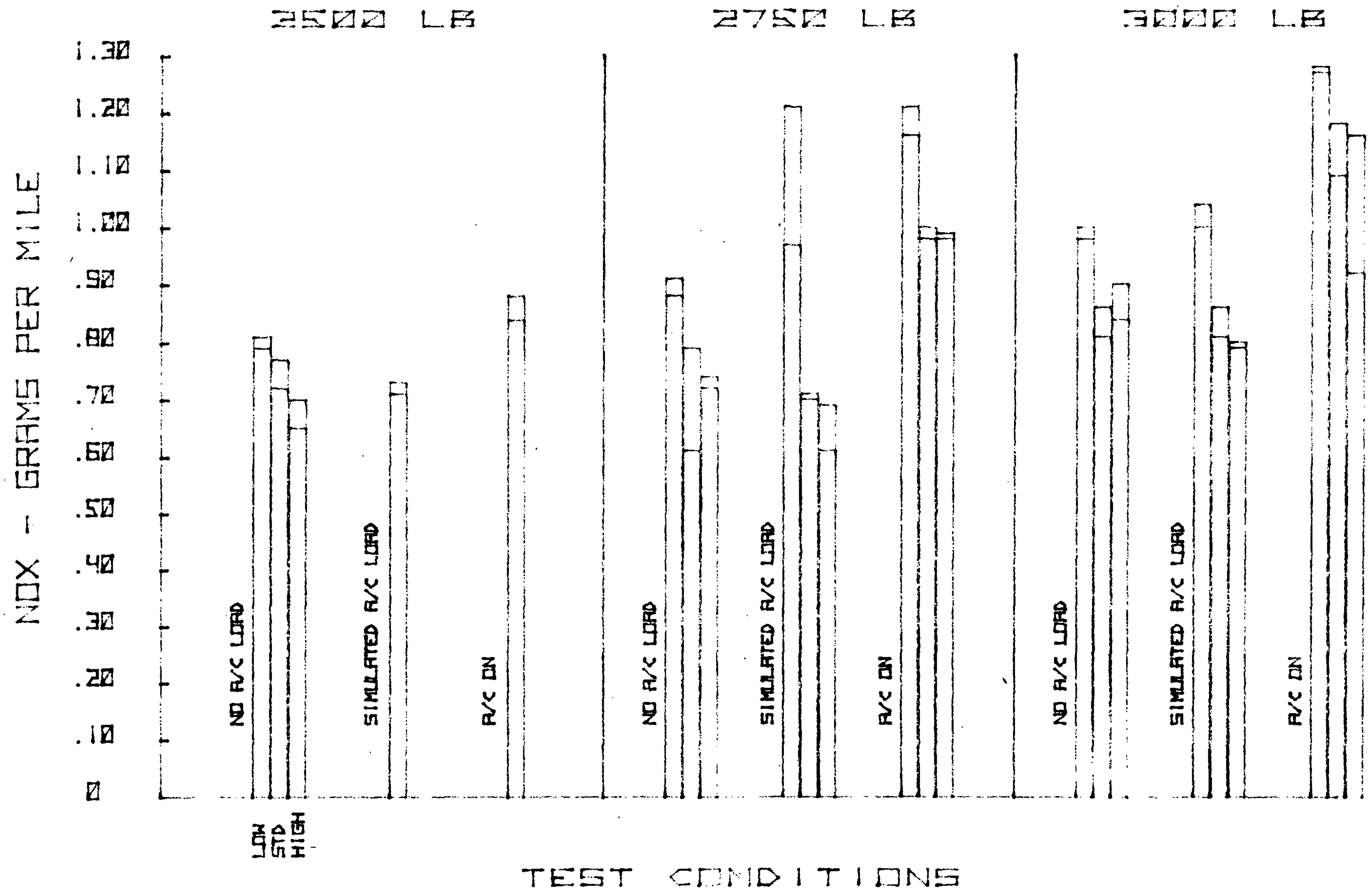
FTP TEST RESULTS



NOTE - <SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP>
<ALL TESTS WERE REPLICATED>

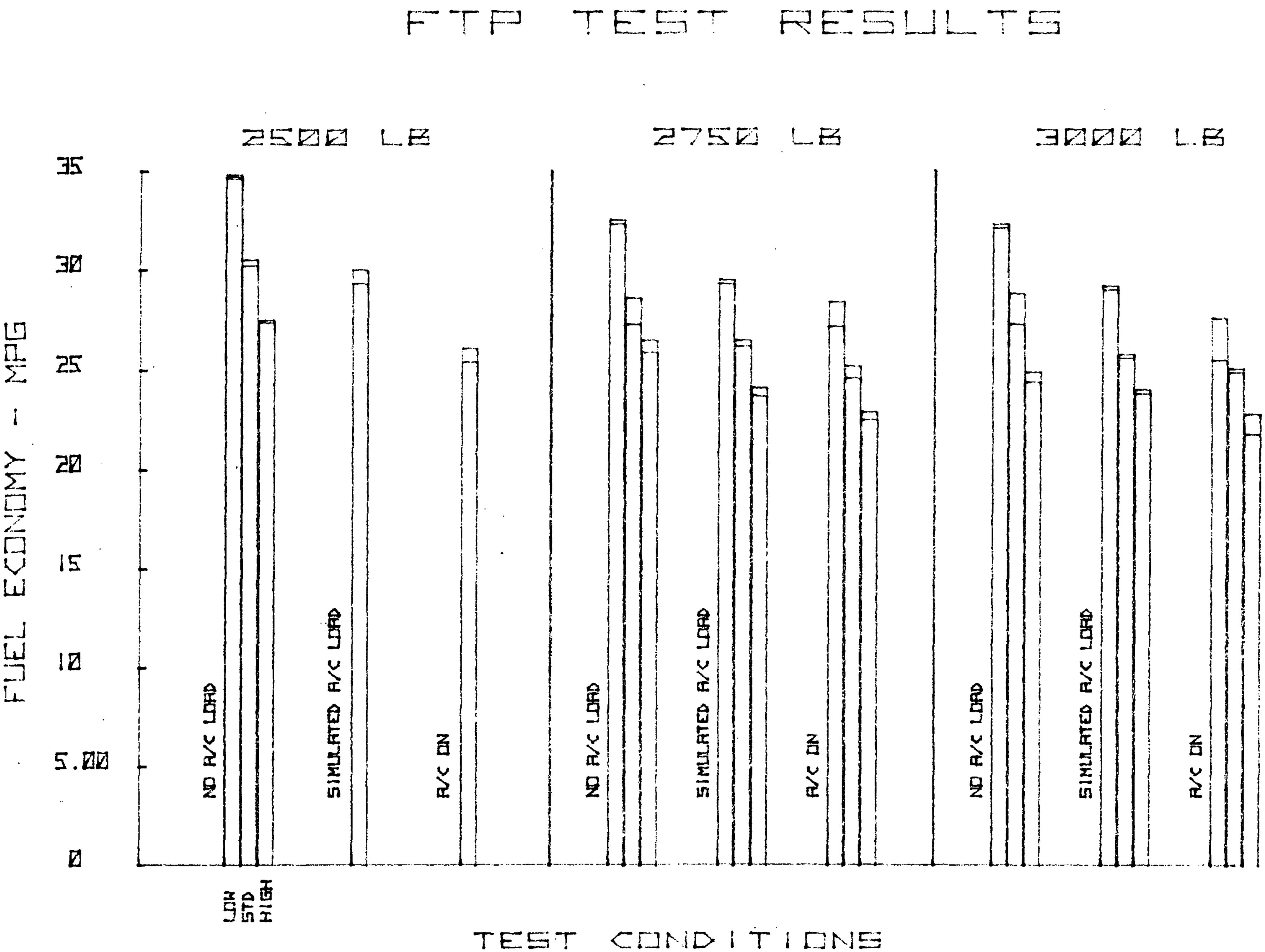
Figure 4

FTP TEST RESULTS



NOTE - <SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP>
<ALL TESTS WERE REPLICATED>

Figure 5



NOTE - (SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP)
(ALL TESTS WERE REPLICATED)

Figure 6

TEMPERATURE EFFECTS
FTP SUMMARY

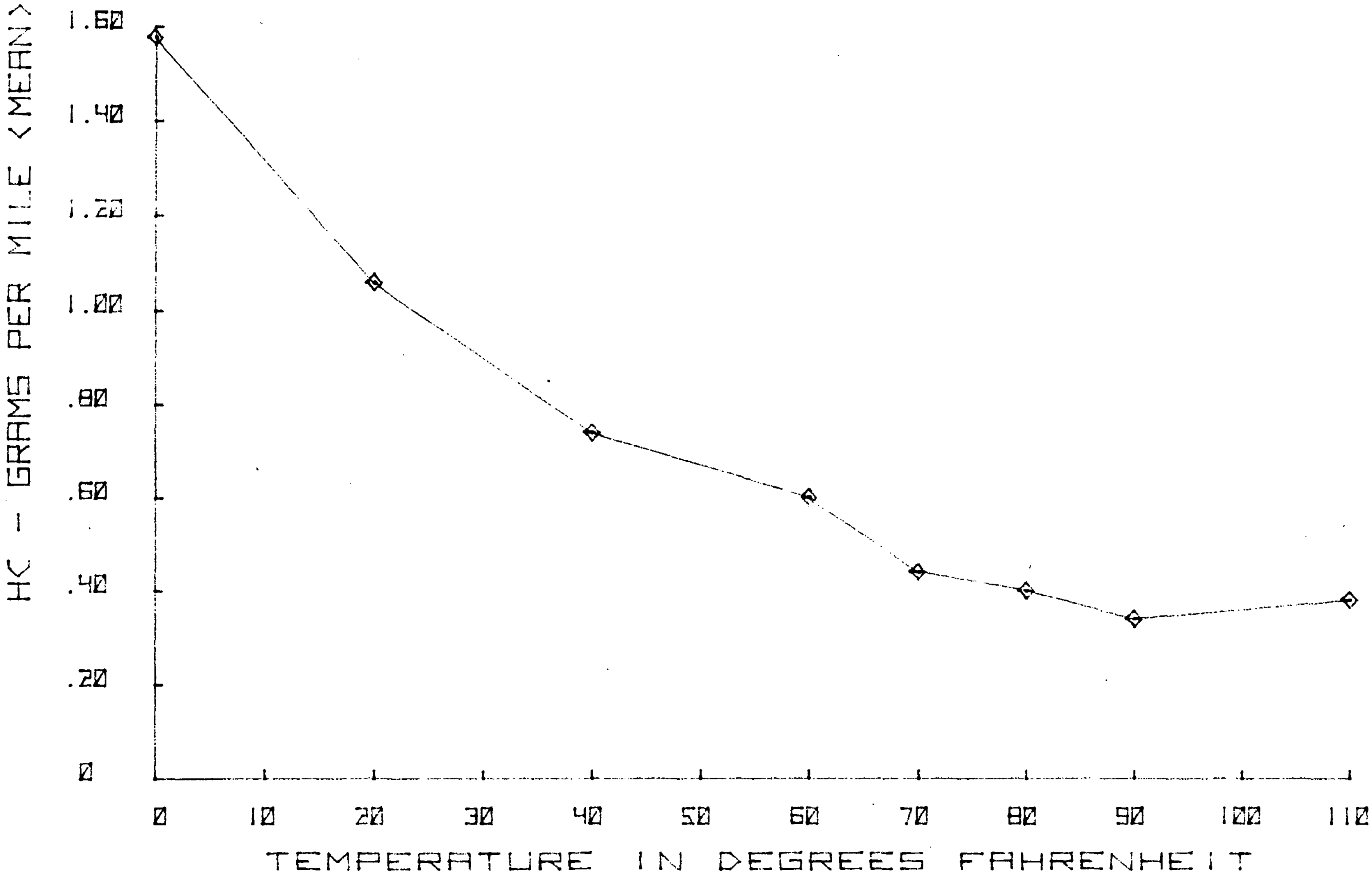
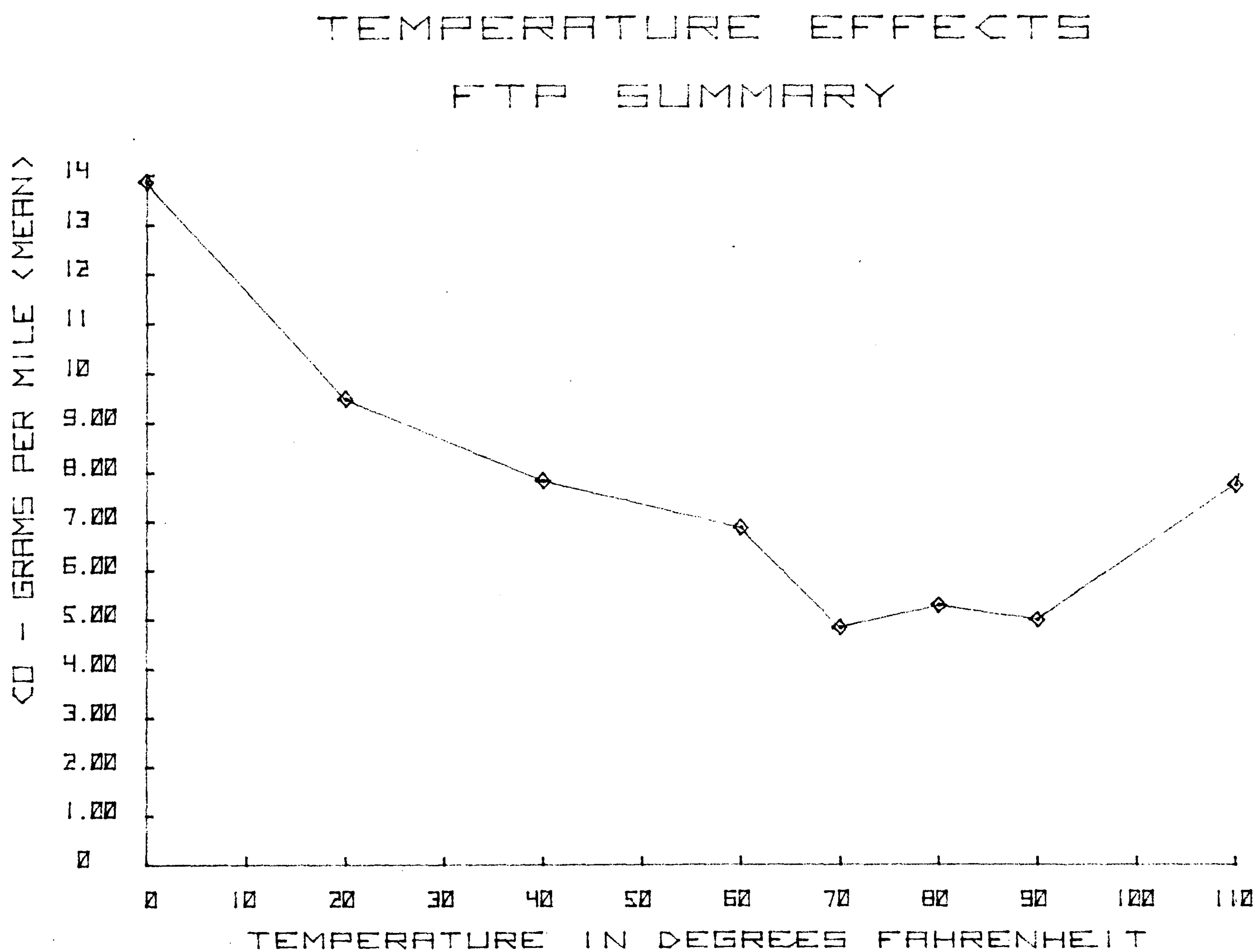


Figure 7



TEMPERATURE EFFECTS
FTP SUMMARY
CO - GRAMS PER MILE (MEAN)
14
13
12
11
10
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0
0
10
20
30
40
50
60
70
80
90
100
110
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 8

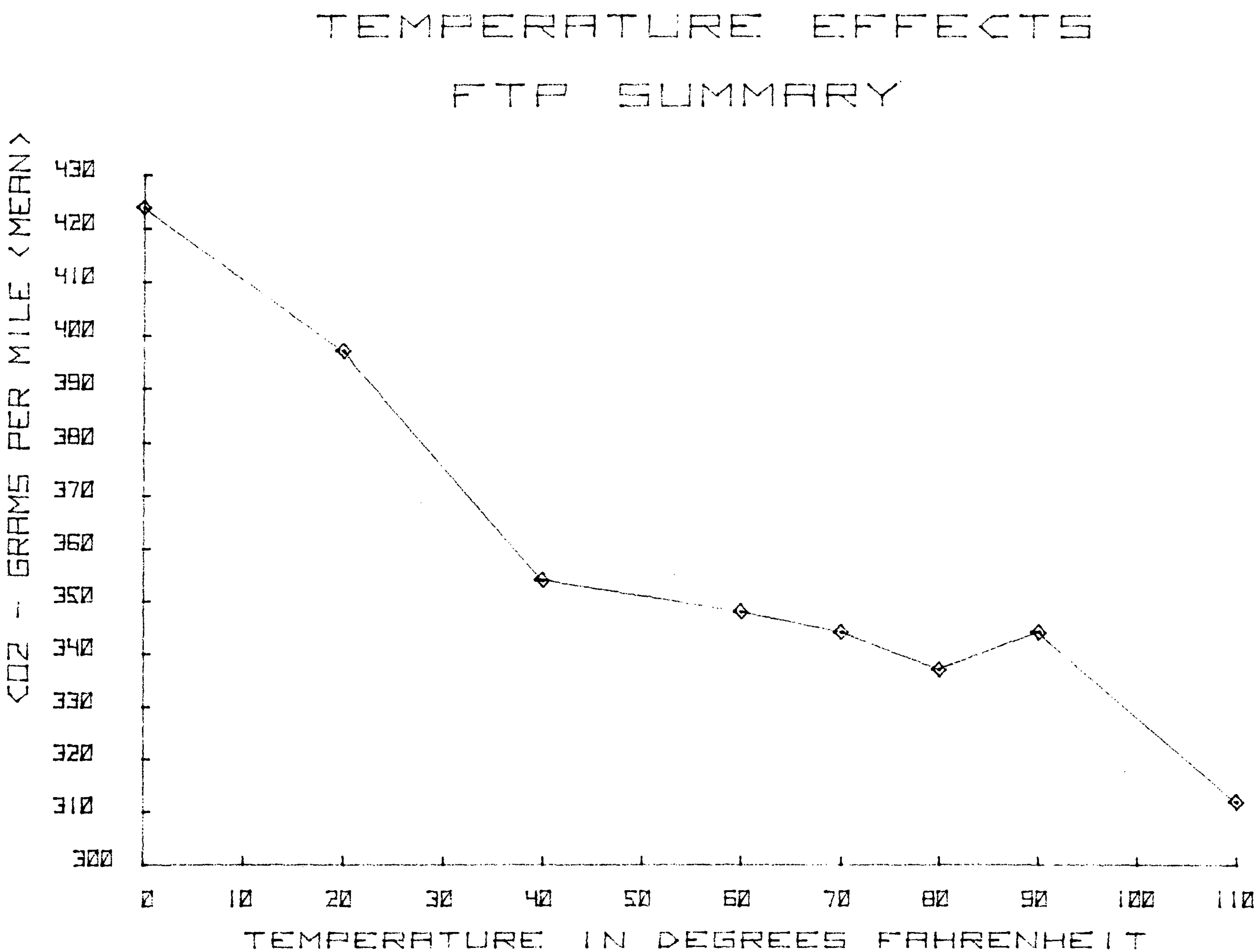

TEMPERATURE EFFECTS
FTP SUMMARY
(CO2 - GRAMS PER MILE (MEAN)
430
420
410
400
390
380
370
360
350
340
330
320
310
300
0
10
20
30
40
50
60
70
80
90
100
110
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 9

TEMPERATURE EFFECTS

FTP SUMMARY

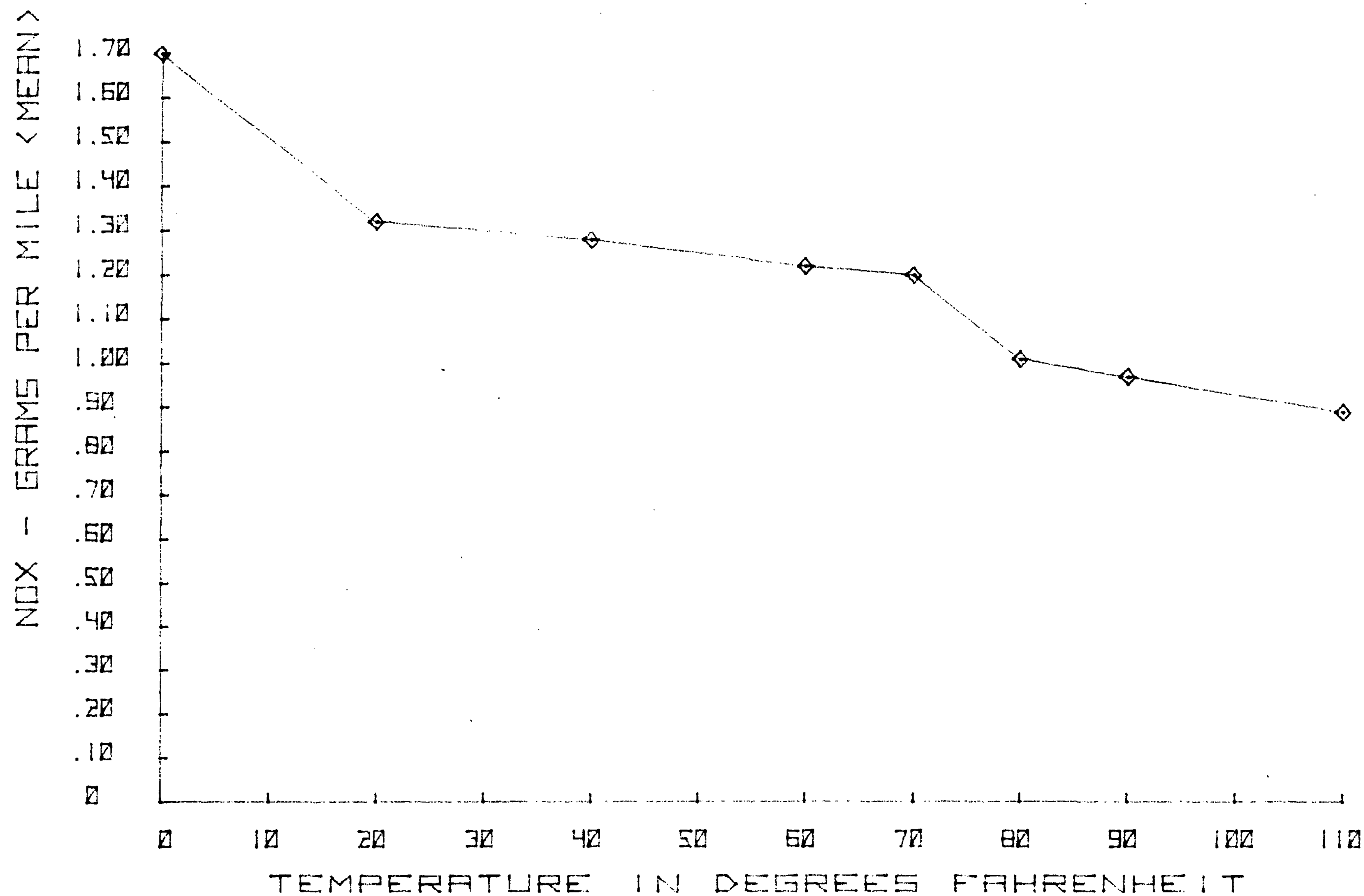


Figure 10

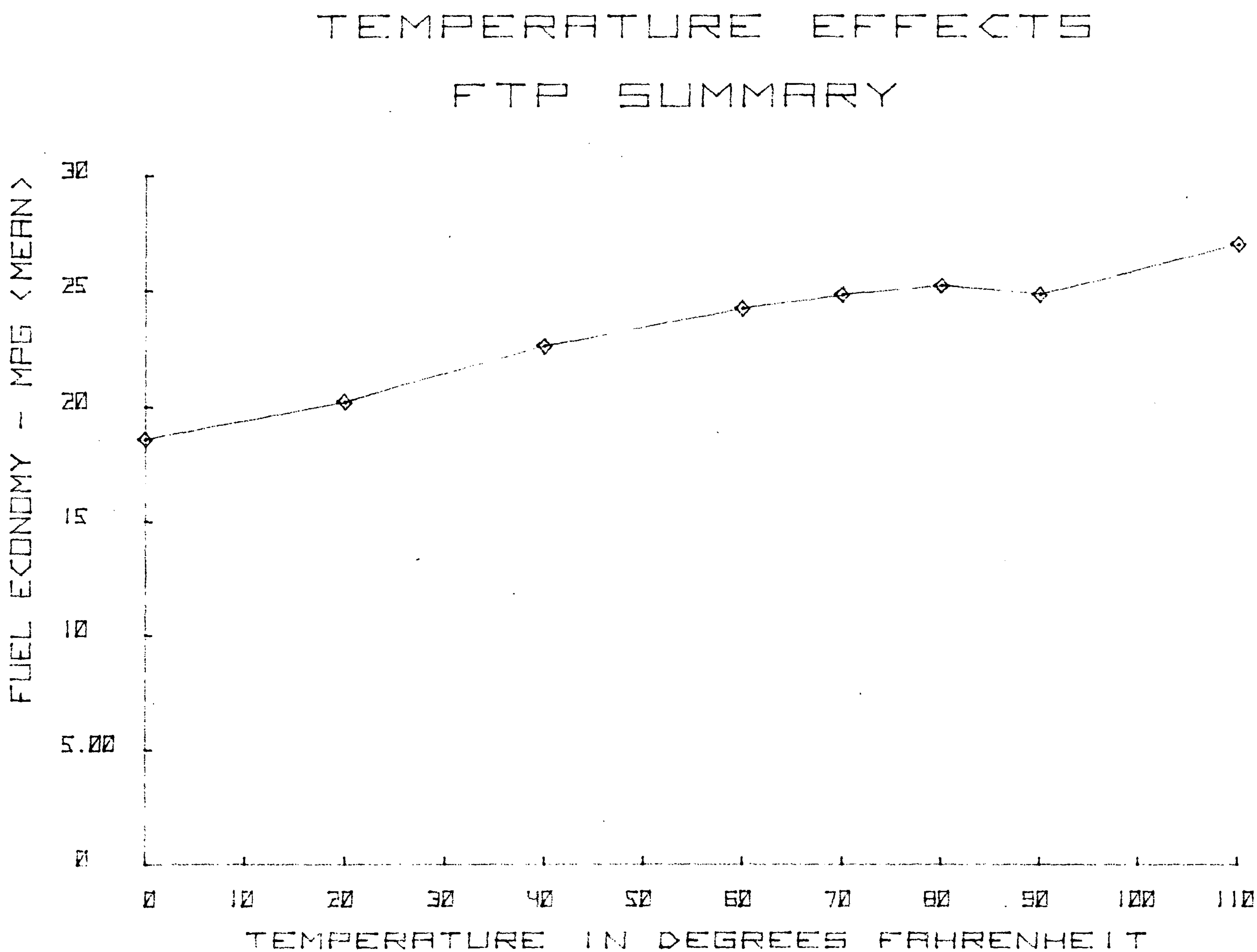
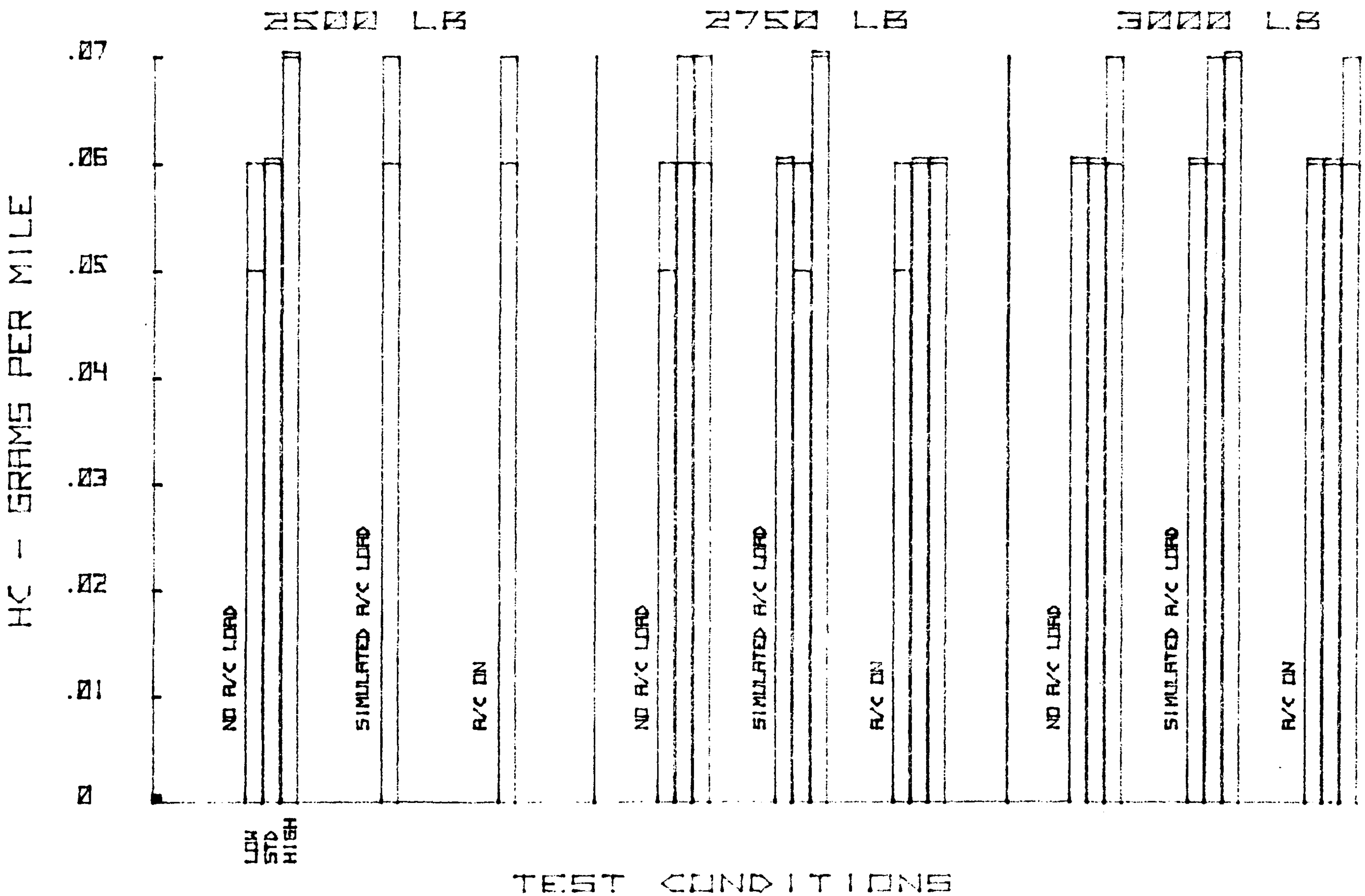

TEMPERATURE EFFECTS
FTP SUMMARY
FUEL ECONOMY - MPG <MEAN>
30
25
20
15
10
5.00
0
0
10
20
30
40
50
60
70
80
90
100
110
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 11

HFET TEST RESULTS

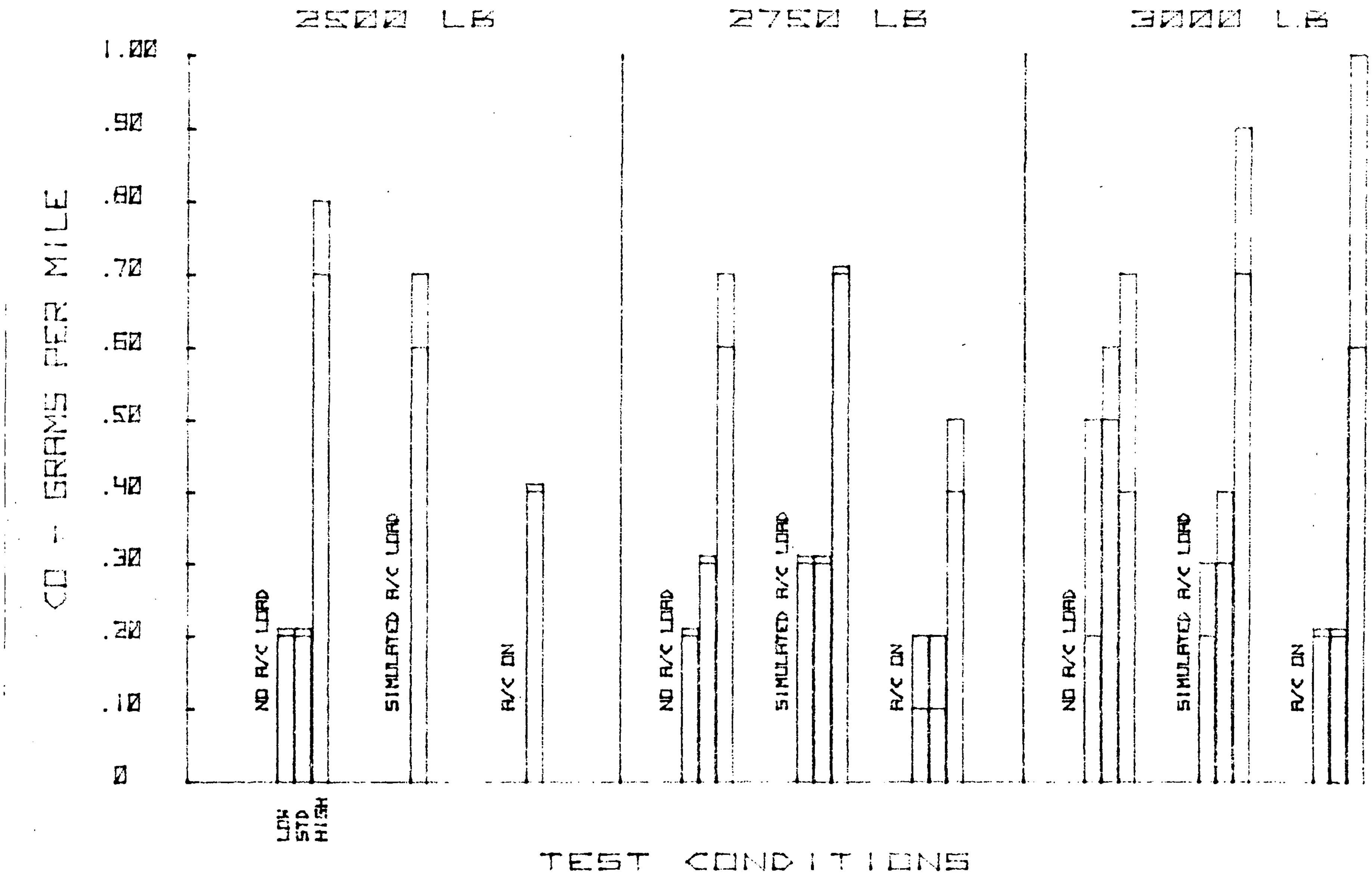


NOTE - <SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP>

<ALL TESTS WERE REPLICATED>

Figure 12

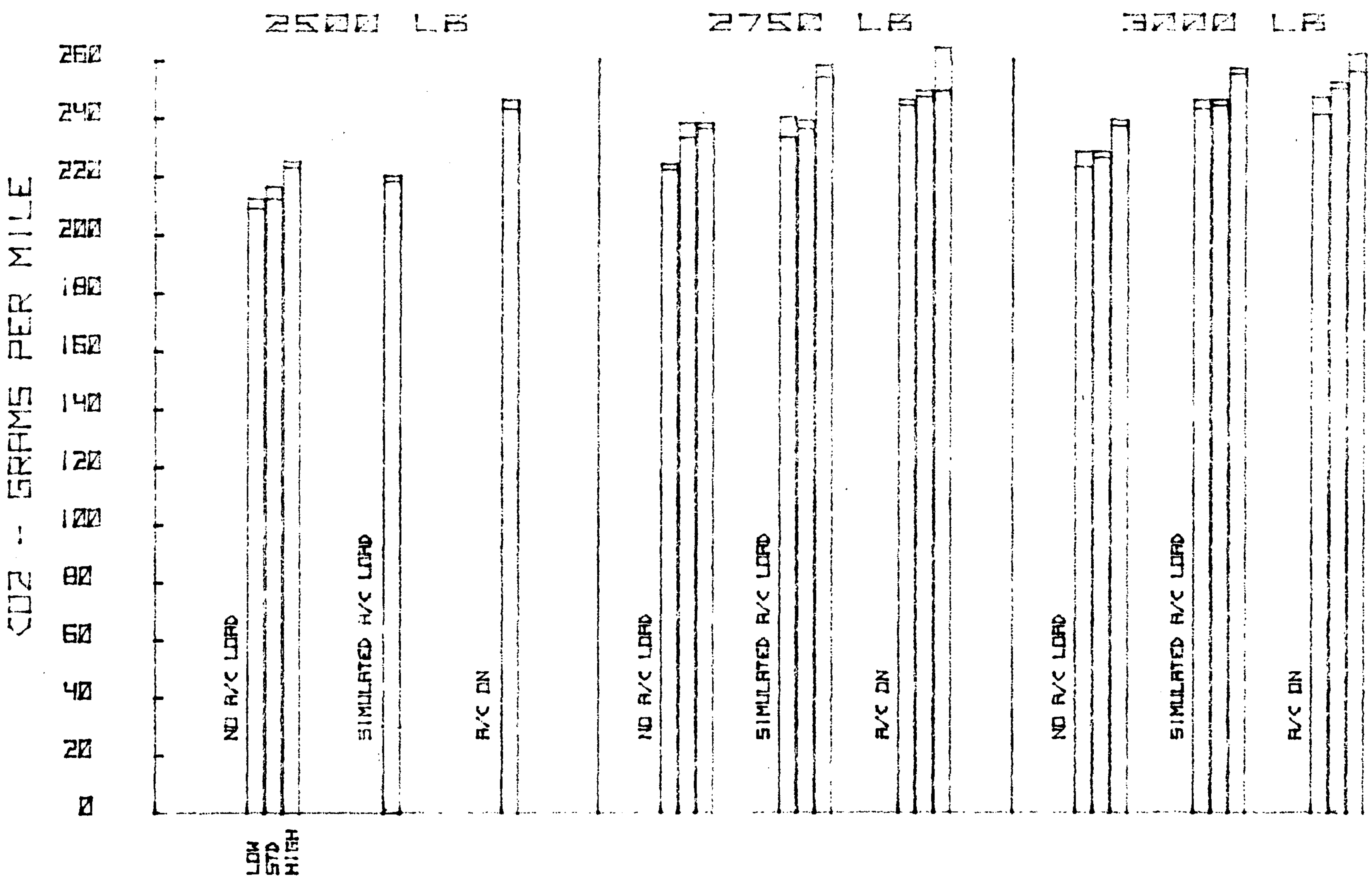
HFET TEST RESULTS



NOTE - <SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP>
<ALL TESTS WERE REPLICATED>

Figure 13

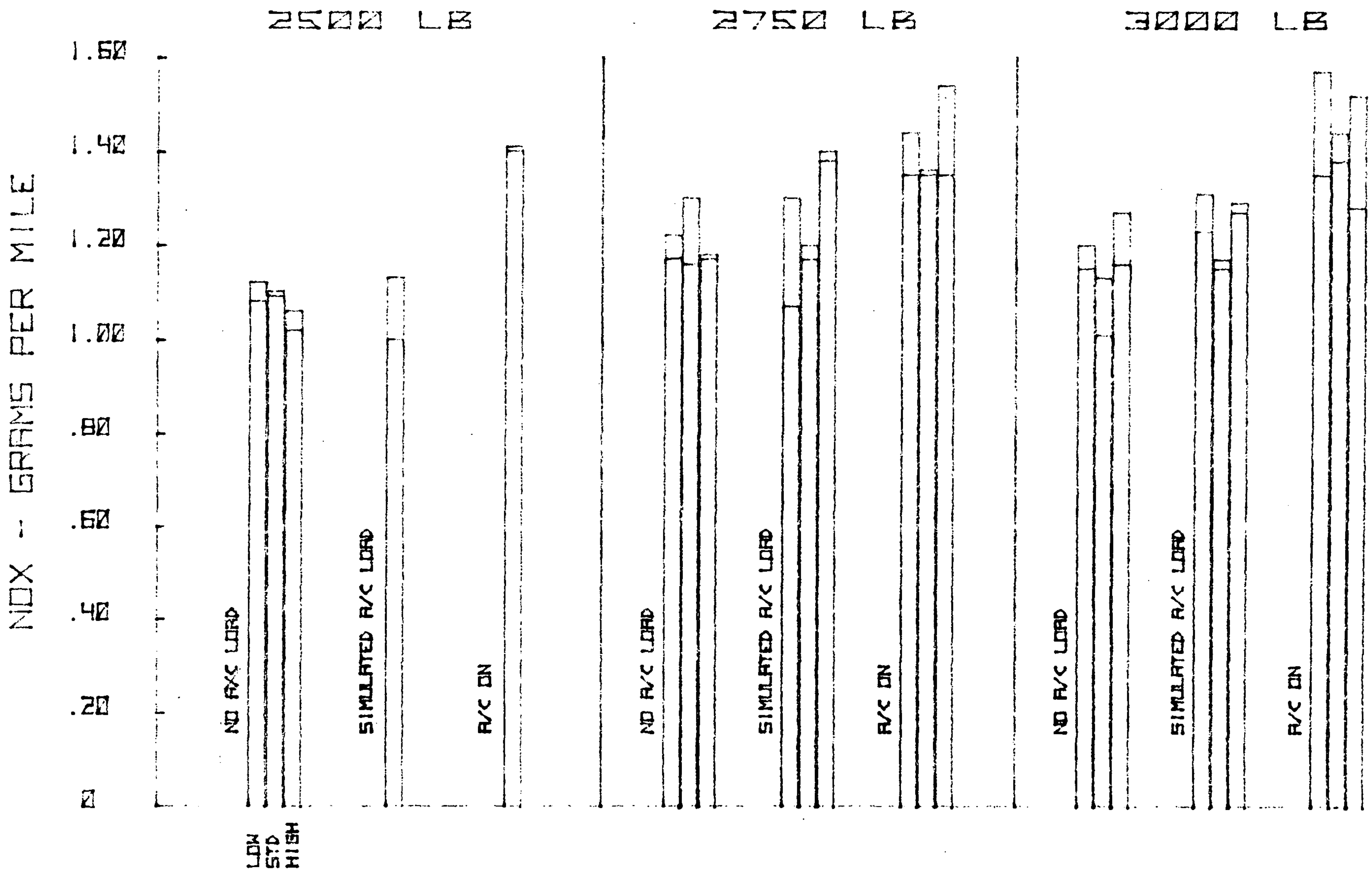
HFET RESULTS



NOTE - (SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP)
(ALL TESTS WERE REPLICATED)

Figure 14

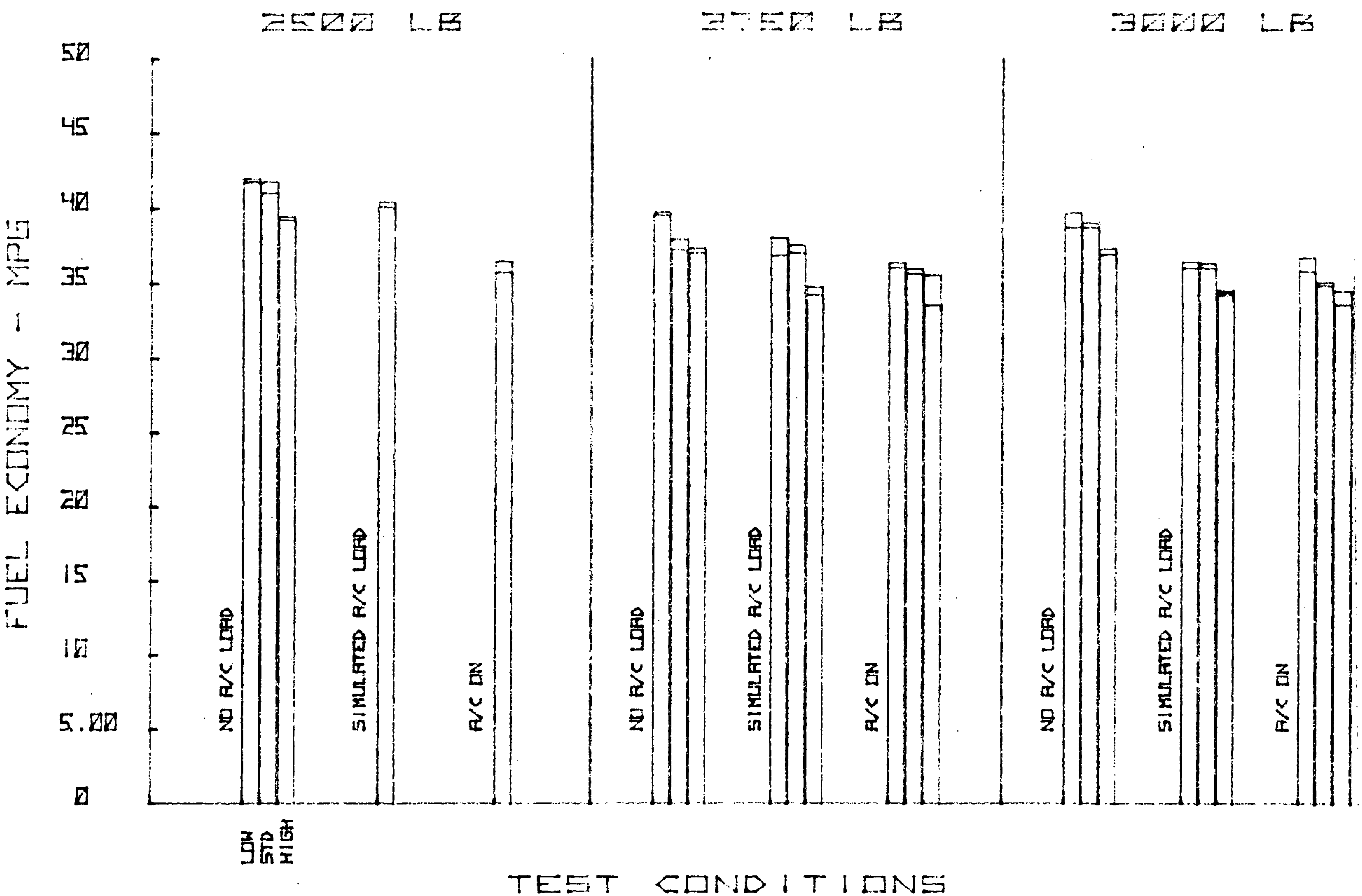
HFET RESULTS



NOTE - (SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP)
(ALL TESTS WERE REPLICATED)

Figure 15

HFET TEST RESULTS



NOTE - (SHIFT SPEEDS ARE AS SHOWN IN FIRST GROUP)
(ALL TESTS WERE REPLICATED)

Figure 16

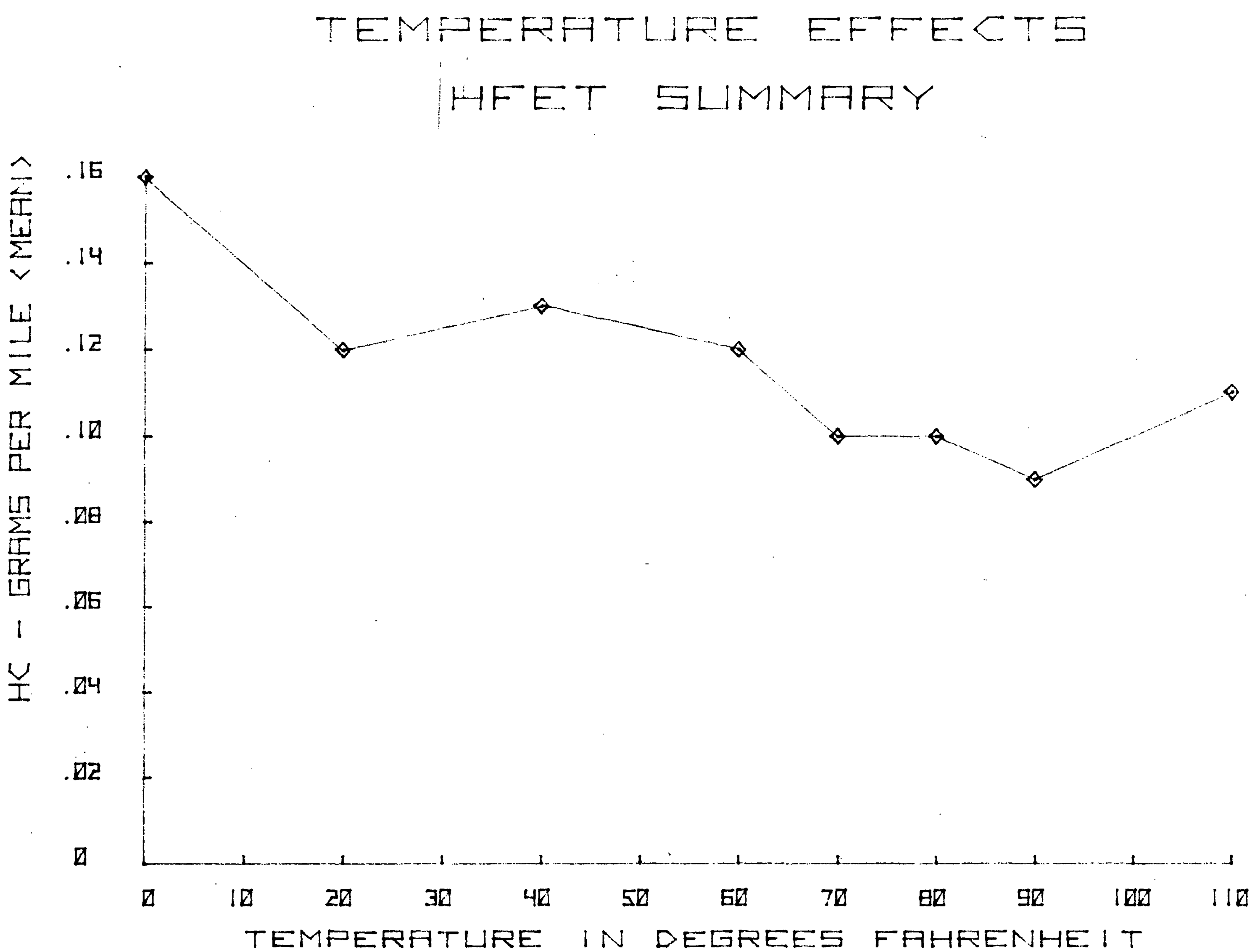

TEMPERATURE EFFECTS
HFET SUMMARY
HC - GRAMS PER MILE <MEAN>
.16
.14
.12
.10
.08
.06
.04
.02
0
0
10
20
30
40
50
60
70
80
90
100
110
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 17

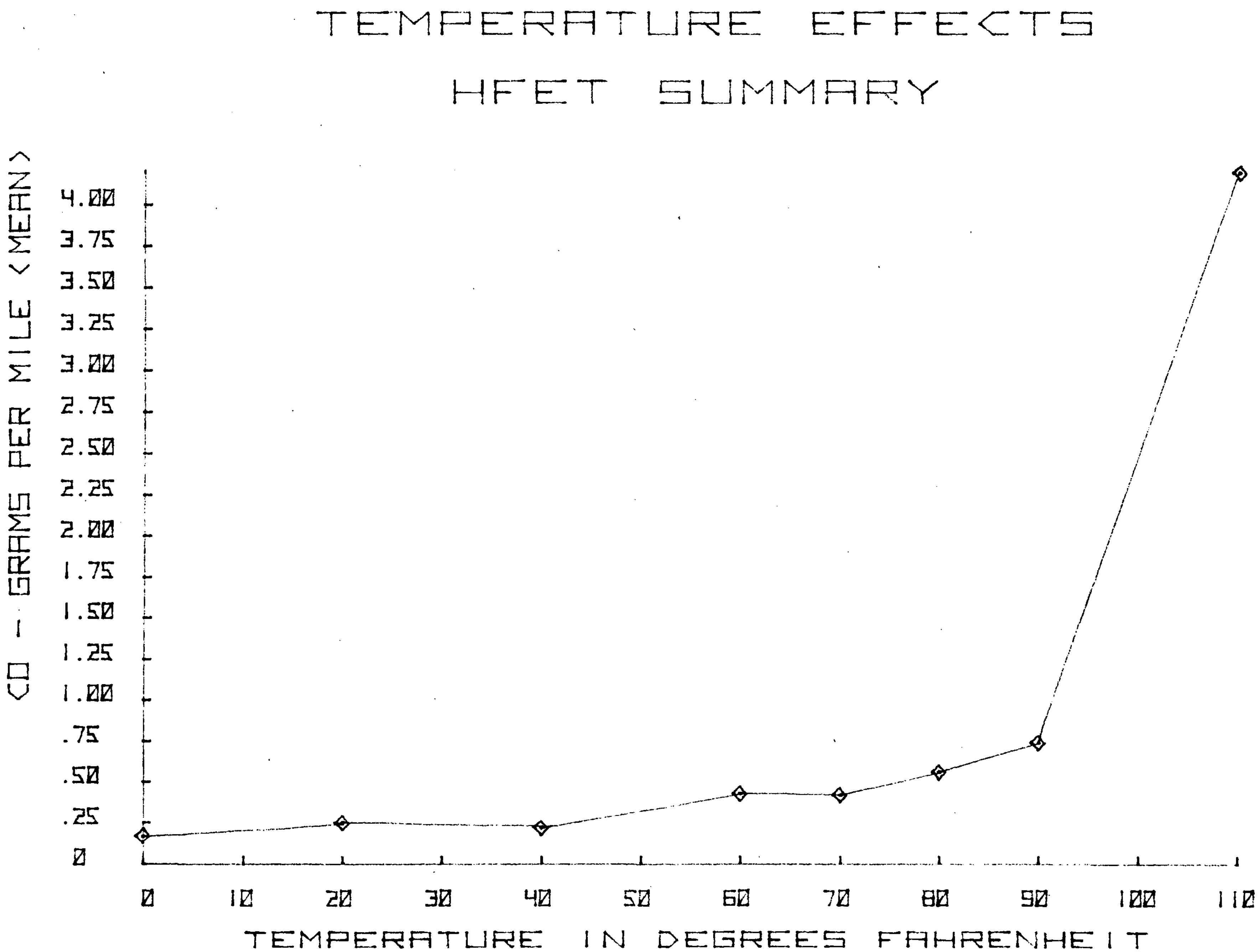

TEMPERATURE EFFECTS
HFET SUMMARY
CO - GRAMS PER MILE (MEAN)
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
.25
0
0
10
20
30
40
50
60
70
80
90
100
110
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 18

TEMPERATURE EFFECTS
HFET SUMMARY

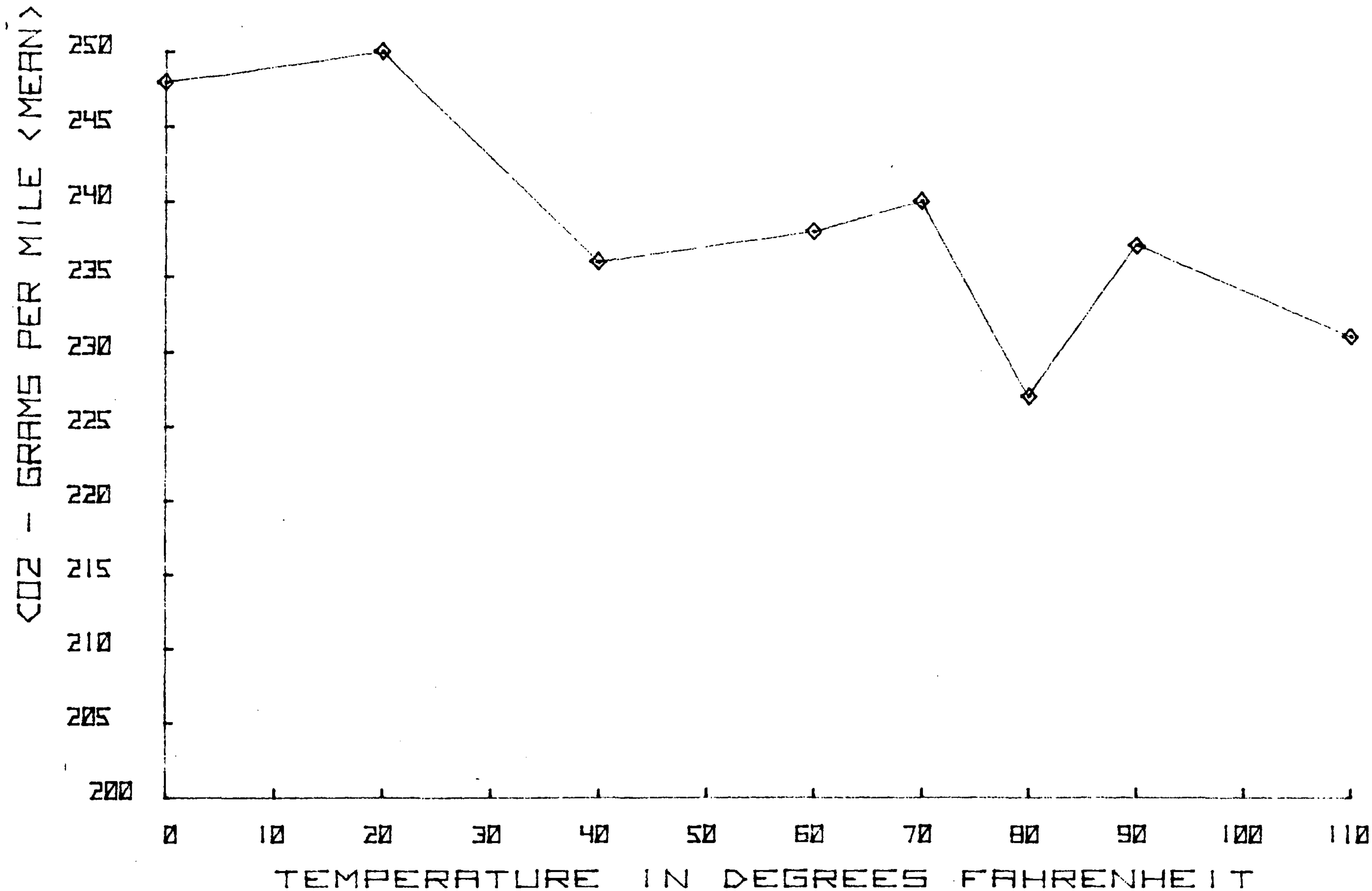


Figure 19

TEMPERATURE EFFECTS
HFET SUMMARY

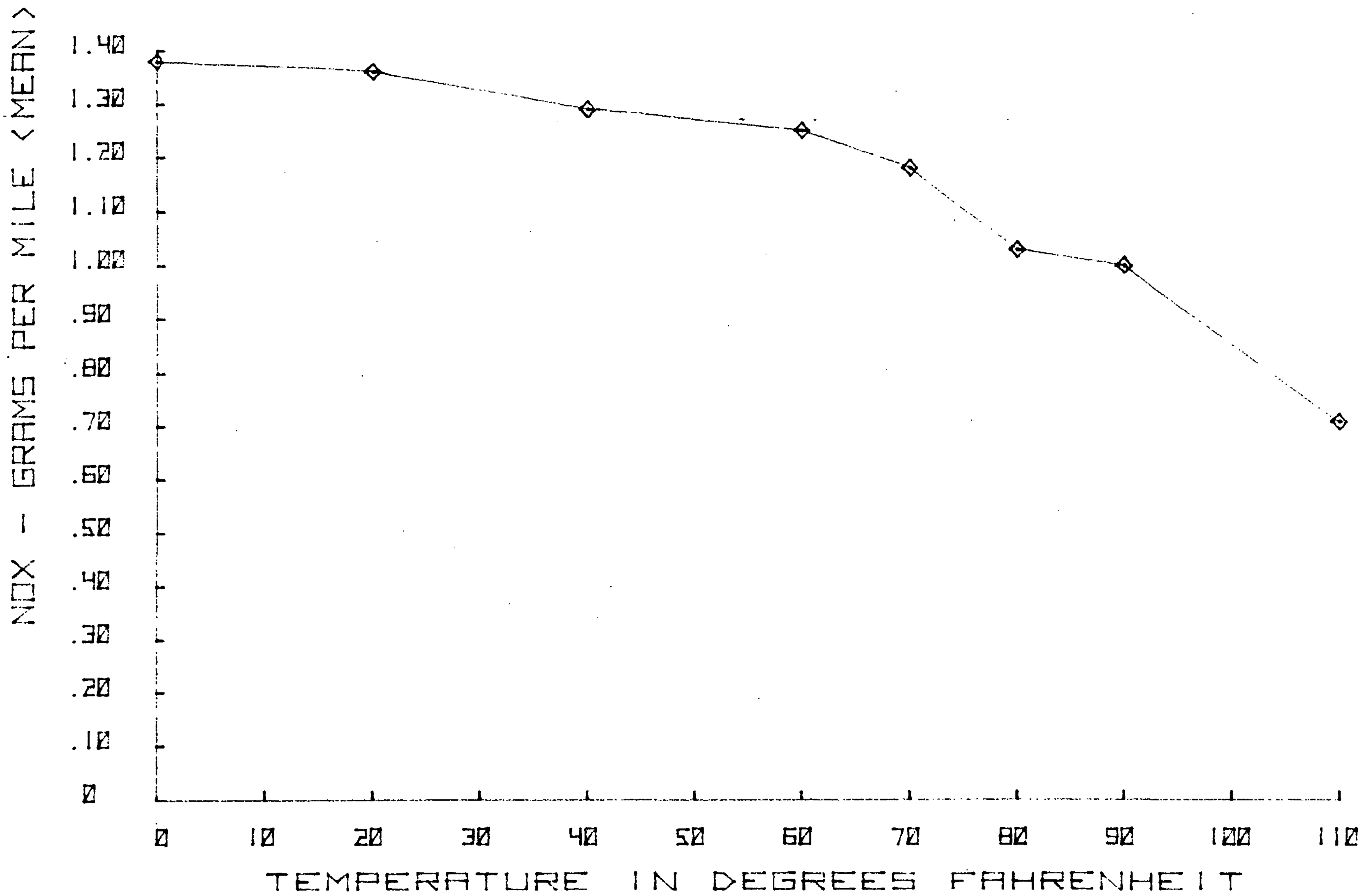


Figure 20

TEMPERATURE EFFECTS
HFET SUMMARY

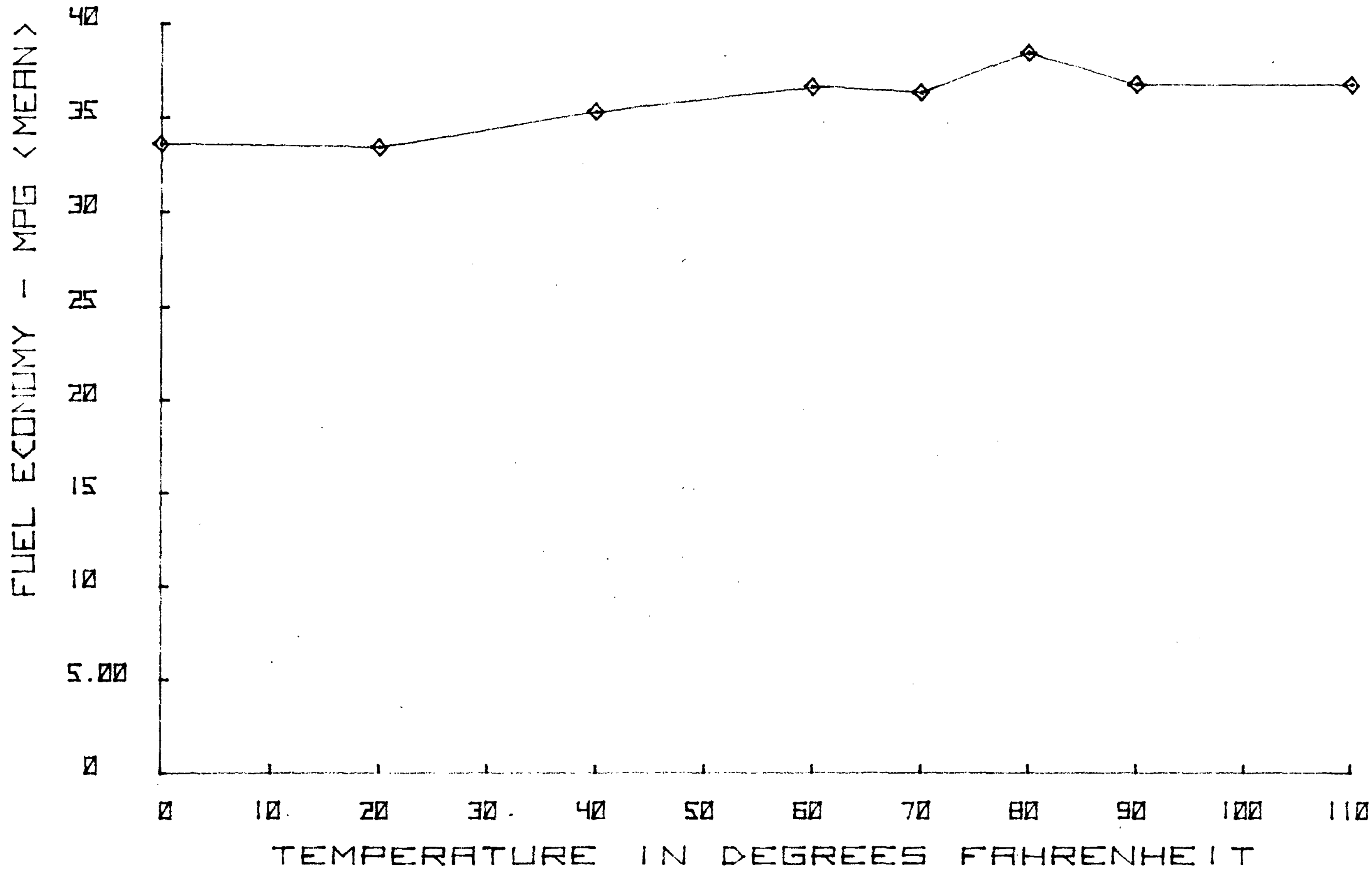


Figure 21

Appendix B

HFET Individual Test Results
(grams per mile/miles per gallon)

3000 Pound Inertia Weight

Shift Schedule		Test Number	No A/C HP	Test Number	Simulated A/C HP	Test Number	A/C Operating
Low	HC	6970	0.06	1935	0.06	6649	0.06
	CO		0.5		0.3		0.2
	CO_2		228		246		247
	NO_x		1.15		1.23		1.57
	MPG		38.7		36		35.8
	HC	6968	0.06	2023	0.06	4879	0.06
	CO		0.2		0.2		0.2
	CO_2		223		243		241
	NO_x		1.2		1.31		1.35
	MPG		39.7		36.4		36.7
Standard	HC	6873	0.06	1934	0.06	4885	0.06
	CO		0.5		0.3		0.2
	CO_2		228		246		252
	NO_x		1.13		1.17		1.38
	MPG		38.7		36		35.1
	HC	6870	0.06	1932	0.07	4883	0.06
	CO		0.6		0.4		0.2
	CO_2		226		244		252
	NO_x		1.01		1.15		1.44
	MPG		39		36.2		35.1
High	HC	6848	0.07	2019	0.07	6845	0.07
	CO		0.7		0.7		1
	CO_2		239		257		262
	NO_x		1.16		1.27		1.28
	MPG		36.9		34.3		33.6
	HC	6969	0.06	2021	0.07	7038	0.06
	CO		0.4		0.9		0.6
	CO_2		237		256		256
	NO_x		1.27		1.29		1.52
	MPG		37.3		34.4		34.5

Appendix B

HFET Individual Test Results
(grams per mile/miles per gallon)

2750 Pound Inertia Weight

Shift Schedule		Test Number	No A/C HP	Test Number	Simulated A/C HP	Test Number	A/C Operating
Low	HC	3258	0.06	1652	0.06	3993	0.06
	CO		0.2		0.3		0.2
	CO_2		224		233		244
	NO_x		1.22		1.07		1.35
	MPG		39.5		38		36.3
	HC	3260	0.05	1659	0.06	3991	0.05
	CO		0.2		0.3		0.1
	CO_2		223		240		246
	NO_x		1.17		1.30		1.44
	MPG		39.7		36.8		36.0
Standard	HC	2216	0.07	1612	0.06	3544	0.06
	CO		0.3		0.3		0.1
	CO_2		233		236		247
	NO_x		1.16		1.17		1.35
	MPG		37.9		37.5		35.9
	HC	2218	0.06	1613	0.05	3255	0.06
	CO		0.3		0.3		0.2
	CO_2		238		239		248
	NO_x		1.3		1.2		1.36
	MPG		37.2		37		35.7
High	HC	2346	0.07	1633	0.07	3899	0.06
	CO		0.7		0.7		0.5
	CO_2		238		258		249
	NO_x		1.17		1.4		1.35
	MPG		37.1		34.2		35.5
	HC	2344	0.06	1661	0.07	3901	0.06
	CO		0.6		0.7		0.4
	CO_2		237		254		264
	NO_x		1.17		1.38		1.54
	MPG		37.2		34.7		33.5

Appendix B

HFET Individual Test Results
(grams per mile/miles per gallon)

2500 Pound Inertia Weight

Shift Schedule		Test Number	No A/C HP	Test Number	Simulated A/C HP	Test Number	A/C Operating
Low	HC	4474	0.05				
	CO		0.2				
	CO_2		212				
	NO_x		1.12				
	MPG		41.7				
	HC	4475	0.06				
	CO		0.2				
	CO_2		211				
	NO_x		1.08				
	MPG		41.9				
Standard	HC	4873	0.06	6911	0.06	6923	0.07
	CO		0.2		0.6		0.4
	CO_2		216		220		243
	NO_x		1.1		1.00		1.41
	MPG		41		40.1		36.4
	HC	4734	0.06	6913	0.07	6921	0.06
	CO		0.2		0.7		0.4
	CO_2		212		218		246
	NO_x		1.09		1.13		1.4
	MPG		41.7		40.4		35.9
High	HC	4875	0.07				
	CO		0.7				
	CO_2		225				
	NO_x		1.02				
	MPG		39.2				
	HC	4877	0.07				
	CO		0.8				
	CO_2		224				
	NO_x		1.06				
	MPG		39.3				

FTP Individual Test Results (bag-by-bag)
(grams per mile/miles per gallon)

2750 Pound Inertia Weight

No A/C Horsepower Load

Shift Schedule		Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	3259	1.062	0.160	0.152	0.34
	CO		7.897	1.662	1.455	2.9
	CO_2		302.035	263.035	256.615	269
	NO_x		1.710	0.378	1.227	0.88
	MPG		27.9	33.3	34.2	32.3
	HC	3257	1.132	0.124	0.134	0.33
	CO		7.555	1.205	1.004	2.5
	CO_2		298.790	261.995	255.401	268
	NO_x		1.791	0.386	1.255	0.91
	MPG		28.2	33.6	34.5	32.5
Standard	HC	2215	0.625	0.191	0.182	0.28
	CO		4.065	1.508	6.069	3.3
	CO_2		354.320	319.266	290.753	319
	NO_x		1.713	0.200	0.550	0.61
	MPG		24.5	27.5	29.5	27.3
	HC	3253	0.521	0.152	0.153	0.23
	CO		5.719	1.299	1.139	2.2
	CO_2		327.417	311.867	280.073	306
	NO_x		1.455	0.430	0.969	0.79
	MPG		26.2	28.2	31.4	28.6
High	HC	2343	0.463	0.176	0.157	0.23
	CO		4.224	1.675	1.452	2.1
	CO_2		353.636	359.744	288.852	339
	NO_x		1.153	0.435	0.945	0.72
	MPG		24.5	24.4	30.4	25.9
	HC	3746	0.478	0.176	0.154	0.23
	CO		3.541	1.435	1.050	1.8
	CO_2		344.301	347.845	289.001	331
	NO_x		1.274	0.443	0.913	0.74
	MPG		25.2	25.3	30.5	26.5

Simulated A/C Horsepower Load

Shift Schedule		Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	2240	1.225	0.148	0.156	0.37
	CO		9.849	1.924	2.001	3.6
	CO_2		322.12	292.96	276.11	294
	NO_x		1.922	0.915	1.219	1.21
	MPG		26.0	29.9	31.7	29.5
	HC	2121	1.229	0.216	0.236	0.43
	CO		7.319	1.210	1.148	2.5
	CO_2		325.78	295.12	279.70	297
	NO_x		2.008	0.390	1.294	0.97
	MPG		26.0	29.8	31.4	29.3
Standard	HC	1611	0.642	0.144	0.134	0.24
	CO		7.120	1.826	1.247	2.8
	CO_2		348.60	341.87	292.94	330
	NO_x		1.174	0.405	0.912	0.70
	MPG		24.5	25.7	30.0	26.5
	HC	1614	0.709	0.154	0.132	0.26
	CO		6.836	1.944	1.028	2.7
	CO_2		353.41	347.19	294.86	334
	NO_x		1.194	0.409	0.918	0.71
	MPG		24.2	25.3	29.9	26.2
High	HC	1662	0.528	0.186	0.161	0.25
	CO		4.713	1.623	1.061	2.1
	CO_2		373.90	388.86	311.30	364
	NO_x		1.584	0.245	0.567	0.61
	MPG		23.2	22.6	28.3	24.1
	HC	2066	0.532	0.185	0.152	0.25
	CO		4.935	2.764	1.571	2.9
	CO_2		382.95	387.45	322.70	369
	NO_x		1.244	0.386	0.849	0.69
	MPG		22.6	22.6	27.2	23.7

A/C Operating

Shift Schedule		Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	4543	1.375	0.133	0.137	0.39
	CO		8.284	1.303	1.481	2.8
	CO_2		328.624	312.863	280.464	307
	NO_x		2.177	0.615	1.448	1.16
	MPG		25.6	28.1	31.3	28.4
	HC	3990	1.254	0.124	0.124	0.36
	CO		7.549	1.183	1.058	2.5
	CO_2		343.503	324.835	296.458	321
	NO_x		2.289	0.648	1.479	1.21
	MPG		24.7	27.1	29.7	27.2
Standard	HC	3547	0.971	0.140	0.142	0.31
	CO		7.611	0.489	0.748	2.0
	CO_2		374.995	369.294	316.436	356
	NO_x		1.624	0.577	1.253	0.98
	MPG		22.7	23.9	27.9	24.6
	HC	2345	0.953	0.120	0.134	0.30
	CO		7.085	0.321	0.693	1.8
	CO_2		362.66	361.061	313.898	348
	NO_x		1.542	0.633	1.299	1.00
	MPG		23.6	24.5	28.1	25.2
High	HC	3898	0.767	0.169	0.149	0.29
	CO		5.460	0.776	0.737	1.7
	CO_2		395.258	416.441	338.887	391
	NO_x		1.470	0.667	1.240	0.99
	MPG		21.8	21.2	26.0	22.5
	HC	3900	0.579	0.160	0.146	0.24
	CO		4.663	0.847	0.748	0.24
	CO_2		392.099	409.900	330.463	384
	NO_x		1.543	0.662	1.173	0.98
	MPG		22.1	21.5	26.7	22.9

FTP Individual Test Results (bag-by-bag)
(grams per mile/miles per gallon)

3000 Pound Inertia Weight

No A/C Horsepower Load

Shift Schedule		Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	4878	0.755	0.139	0.136	0.27
	CO		6.856	1.791	1.550	2.8
	CO_2		289.513	269.395	258.811	271
	NO_x		2.087	0.433	1.202	0.98
	MPG		29.3	32.6	33.9	32.1
	HC	6967*	0.755	0.132	0.145	0.26
	CO		6.856	1.396	2.737	2.9
	CO_2		289.513	264.216	263.319	269
	NO_x		2.148	0.401	1.274	1.00
	MPG		29.3	33.2	33.1	32.3
Standard	HC	6872	1.216	0.155	0.171	0.38
	CO		8.366	2.374	1.528	3.4
	CO_2		310.581	311.717	273.876	301
	NO_x		1.755	0.374	0.914	0.81
	MPG		27.1	28.1	32.0	28.8
	HC	6871	0.704	0.155	0.156	0.27
	CO		11.755	2.387	1.457	4.1
	CO_2		306.365	317.585	281.961	317
	NO_x		1.687	0.380	1.139	0.86
	MPG		23.3	27.6	31.1	27.3
High	HC	6647	0.494	0.208	0.200	0.26
	CO		4.446	2.330	1.414	2.5
	CO_2		352.839	368.164	321.257	352
	NO_x		1.687	0.429	0.985	0.84
	MPG		24.6	23.8	27.4	24.9
	HC	7039	0.695	0.224	0.206	0.32
	CO		12.711	2.251	1.652	4.2
	CO_2		355.630	380.607	310.035	356
	NO_x		1.641	0.499	1.107	0.90
	MPG		23.5	23.0	28.3	24.4

Simulated A/C Horsepower Load

Shift Schedule		Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	2122	1.377	0.170	0.175	0.42
	CO		7.719	1.472	1.320	2.7
	CO_2		322.25	297.55	287.47	300
	NO_x		2.047	0.432	1.440	1.04
	MPG		26.2	29.5	29.5	29.0
	HC	2022	1.237	0.133	0.139	0.36
	CO		7.823	1.413	1.170	2.7
	CO_2		324.92	296.74	280.52	298
	NO_x		1.926	0.435	1.365	1.00
	MPG		26.0	29.6	31.4	29.2
Standard	HC	1933	1.011	0.161	0.144	0.33
	CO		8.764	1.792	1.691	3.2
	CO_2		362.72	349.36	309.30	341
	NO_x		1.561	0.412	0.992	0.81
	MPG		23.4	25.1	28.4	25.6
	HC	1931	0.696	0.166	0.154	0.27
	CO		7.490	1.606	1.615	2.8
	CO_2		361.35	350.21	308.93	341
	NO_x		1.649	0.436	1.046	0.86
	MPG		23.6	25.1	28.4	25.6
High	HC	2018	0.476	0.191	0.183	0.25
	CO		4.476	1.599	1.198	2.1
	CO_2		374.16	388.46	321.51	367
	NO_x		1.251	0.485	1.014	0.79
	MPG		23.2	22.6	27.4	23.9
	HC	2020	0.533	0.201	0.175	0.26
	CO		4.227	1.683	1.313	2.1
	CO_2		375.86	390.56	324.38	369
	NO_x		1.380	0.465	0.989	0.80
	MPG		23.1	22.5	27.1	23.8

A/C Operating

Shift Schedule		Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	6650	1.067	0.135	0.140	0.33
	CO		8.123	1.061	1.124	2.5
	CO_2		336.30	319.733	292.193	316
	NO_x		2.591	0.602	1.558	1.27
	MPG		25.2	27.6	30.1	27.6
	HC	7784	1.135	0.164	0.172	0.37
	CO		15.178	1.707	1.751	4.5
	CO_2		344.257	353.800	308.860	340
	NO_x		2.392	0.705	1.546	1.28
	MPG		23.9	24.8	28.4	25.5
Standard	HC	4884	0.700	0.136	0.146	0.26
	CO		6.737	0.520	1.026	1.9
	CO_2		363.404	362.833	316.112	350
	NO_x		1.814	0.662	1.353	1.09
	MPG		23.6	24.4	27.9	25.1
	HC	4882	0.839	0.143	0.146	0.29
	CO		8.248	0.311	1.431	2.1
	CO_2		363.848	369.019	312.305	352
	NO_x		2.074	0.699	0.843	1.18
	MPG		23.4	24.0	28.2	24.9
High	HC	6844	0.587	0.159	0.141	0.24
	CO		7.867	1.855	2.000	3.1
	CO_2		379.066	412.253	335.402	384
	NO_x		1.617	0.554	1.067	0.92
	MPG		22.5	21.3	26.2	22.8
	HC	7037	1.012	0.186	0.187	0.36
	CO		11.346	1.793	1.999	3.8
	CO_2		393.059	429.449	344.272	399
	NO_x		1.985	0.709	1.380	1.16
	MPG		21.3	20.5	25.5	21.8

* Bag 1 results taken from 4878.

Appendix A

FTP Individual Test Results (bag-by-bag)
(grams per mile/miles per gallon)

2500 Pound Inertia Weight

Shift Schedule		No A/C Horsepower Load					Simulated A/C Horsepower Load					A/C Operating				
		Test Number	Bag 1	Bag 2	Bag 3	Composite	Test Number	Bag 1	Bag 2	Bag 3	Composite	Test Number	Bag 1	Bag 2	Bag 3	Composite
Low	HC	4477	0.834	0.123	0.124	0.27										
	CO		7.000	0.674	0.738	2.0										
	CO_2		280.594	246.646	237.025	251										
	NO_x		1.621	0.338	1.090	0.81										
	MPG		30.1	35.7	37.2	34.8										
	HC	4476	0.662	0.131	0.129	0.24										
	CO		7.115	1.355	0.885	2.4										
	CO_2		278.582	248.513	236.183	251										
	NO_x		1.560	0.327	1.079	0.79										
	MPG		30.4	35.3	37.3	34.7										
Standard	HC	4735	0.496	0.159	0.145	0.22	6910	0.552	0.156	0.140	0.23	6922	0.563	0.140	0.160	0.23
	CO		5.684	1.086	0.946	2.0		8.780	2.662	1.625	3.6		6.816	0.919	1.162	2.2
	CO_2		310.318	296.975	259.749	290		313.242	304.354	266.315	296		348.420	352.104	295.118	336
	NO_x		1.444	0.413	0.935	0.77		1.616	0.341	0.787	0.73		1.383	0.581	1.073	0.88
	MPG		27.6	29.6	33.9	30.2		27.0	28.7	32.9	29.3		24.6	25.1	29.8	26.1
	HC	4736	0.447	0.143	0.141	0.21	6912	0.627	0.150	0.142	0.25	6924	0.583	0.155	0.159	0.24
	CO		5.348	0.556	0.461	1.5		12.423	1.826	0.880	3.7		6.204	1.473	1.585	2.5
	CO_2		314.470	293.679	256.900	288		298.817	299.045	262.251	289		358.552	358.720	303.814	334
	NO_x		1.290	0.396	0.901	0.72		1.419	0.368	0.846	0.71		0.800	0.639	1.239	0.84
	MPG		27.3	30.1	34.4	30.5		27.7	29.3	33.6	30.0		24.0	24.5	28.9	25.4
High	HC	4874	0.473	0.189	0.163	0.24										
	CO		4.353	1.325	1.137	1.9										
	CO_2		330.134	338.203	276.067	319										
	NO_x		1.079	0.397	0.805	0.65										
	MPG		26.2	26.0	31.9	27.5										
	HC	4876	0.481	0.179	0.162	0.24										
	CO		4.442	0.411	1.094	1.8										
	CO_2		336.909	335.532	276.301	320										
	NO_x		1.279	1.182	0.798	0.70										
	MPG		25.7	26.2	31.8	27.4										

Appendix C

Ambient Temperature Effects Individual Test Results
(grams per mile/miles per gallon)

Ambient Temperature °F		Bag 1	Bag 2	Bag 3	Composite	HFET
0°	HC	6.92	0.25	0.45	1.65	0.14
	CO	64.98	0.95	2.99	14.5	0.18
	CO_2	482	430	364	423	248
	NOx	2.42	1.14	2.5	1.76	1.35
	MPG	13.8	19.4	22.6	18.6	33.6
	HC	5.99	0.29	0.53	1.51	0.19
	CO	60.25	0.62	2.54	13.27	0.16
	CO_2	487	430	365	424	248
	NOx	2.61	0.94	2.32	1.65	1.41
	MPG	13.9	19.4	22.6	18.6	33.6
20°	HC	3.73	0.23	0.34	0.97	0.11
	CO	40.83	1.25	1.8	9.46	0.34
	CO_2	447	400	340	394	251
	NOx	2.25	0.7	1.64	1.27	1.39
	MPG	16	20.8	24.3	20.3	33.2
	HC	4.40	0.27	0.44	1.16	0.14
	CO	41.91	0.77	2.26	9.52	0.16
	CO_2	436	418	339	400	248
	NOx	2.52	0.77	1.63	1.36	1.33
	MPG	16.2	19.9	24.3	20	33.6
40°	HC	2.56	0.27	0.38	0.77	0.13
	CO	32.95	1.3	2.62	8.11	0.26
	CO_2	384	356	314	350	238
	NOx	2.39	0.7	1.5	1.26	1.31
	MPG	18.9	23.3	26.2	22.9	35
	HC	2.25	0.26	0.42	0.71	0.13
	CO	30.8	1.32	2.07	7.56	0.18
	CO_2	399	363	322	359	235
	NOx	2.49	0.68	1.58	1.3	1.27
	MPG	18.4	22.9	25.6	22.4	35.6

Appendix C

Ambient Temperature Effects Individual Test Results
(grams per mile/miles per gallon)

Ambient Temperature °F		Bag 1	Bag 2	Bag 3	Composite	HFET
60°	HC	1.91	0.28	0.46	0.66	0.14
	CO	25.63	3.16	3.56	7.78	0.5
	CO_2	383	347	309	344	238
	NOx	2.45	0.7	1.46	1.26	1.25
	MPG	20.4	24.8	27.7	24.4	36.7
	HC	1.52	0.25	0.37	0.54	0.11
	CO	17.82	2.65	3.55	5.99	0.36
	CO_2	382	360	318	353	239
	NOx	2.38	0.6	1.43	1.19	1.25
	MPG	21.1	24	26.9	24	26.4
70°	HC	1.16	0.22	0.3	0.43	0.1
	CO	16.17	2.72	3.02	5.55	0.47
	CO_2	351	356	303	341	239
	NOx	2.43	0.59	1.31	1.16	1.16
	MPG	23	24.2	28.3	25	36.5
	HC	1.26	0.21	0.27	0.44	0.1
	CO	12.41	1.73	2.57	4.14	0.34
	CO_2	358	362	313	348	241
	NOx	2.37	0.59	1.32	1.25	1.2
	MPG	23	23.9	27.5	24.6	36.1
80°	HC	0.94	0.2	0.28	0.38	0.11
	CO	12.77	2.67	3.29	4.91	0.54
	CO_2	345	351	303	337	226
	NOx	2.19	0.48	1.22	1.03	1.05
	MPG	23.8	24.6	28.3	25.3	38.6
	HC	1.08	0.21	0.31	0.42	0.09
	CO	12.96	3.42	4.60	5.69	0.57
	CO_2	346	351	302	337	228
	NOx	2.14	0.48	1.11	0.99	1.01
	MPG	23.7	24.5	28.2	25.2	38.2

Appendix C

Ambient Temperature Effects Individual Test Results
(grams per mile/miles per gallon)

Ambient Temperature °F		Bag 1	Bag 2	Bag 3	Composite	HFET
90°	HC	0.78	0.2	0.25	0.33	0.09
	CO	8.45	3.28	5.15	4.84	0.81
	CO_2	343	346	308	335	234
	NOx	1.86	0.49	1.13	0.94	1.01
	MPG	24.4	24.9	27.6	25.5	37.1
	HC	0.78	0.2	0.26	0.34	0.09
	CO	9.12	3.89	4.61	5.15	0.67
	CO_2	347	368	326	352	240
	NOx	1.9	0.55	1.17	1	0.99
	MPG	24	23.4	26.2	24.2	36.3
110°	HC	0.81	0.23	0.45	0.41	
	CO	6.86	6.6	10.97	7.84	
	CO_2	332	274	305	294	
	NOx	1.8	0.35	1.2	0.88	
	MPG	25.4	30.7	27.0	28.4	
	HC	0.74	0.22	0.32	0.35	0.11
	CO	7.78	6.43	10.07	7.69	4.20
	CO_2	321	347	303	330	231
	NOx	1.69	0.47	1.13	0.9	0.71
	MPG	26.1	24.4	27.4	25.5	36.7

Appendix D

Analysis of Variance
Example: HC from FTP
Columns (c)

Shift Schedule-Rows (r)	Inertia Weight Groups (8)	No A/C HP	Simulated A/C HP	A/C Operating	Tr	Tg
Low	2750	0.37	0.34	0.39		
		0.46	0.33	0.36		
					4.26	
	3000	0.42	0.27	0.33		
		0.36	0.26	0.37		
						5.36
Standard	2750	0.24	0.28	0.31		
		0.26	0.23	0.30		
					3.42	
	3000	0.33	0.38	0.26		
		0.27	0.27	0.29		
						5.50
High	2750	0.25	0.23	0.29		
		0.25	0.23	0.24		
					3.18	
	3000	0.25	0.26	0.24		
		0.26	0.32	0.36		
Tc		3.72	3.40	3.74	Total = 10.86	

Note: Tc - Total of Columns
Tr - Total of Rows
Tg - Total of Groups

Appendix E

$T^2/N = (10.86)^2/36 = 3.2761$

$SSc = \Sigma Tc^2/nrg - T^2/N = 0.0061$

$SSr = \Sigma Tr^2/ncg - T^2/N = 0.0536$

$SSg = \Sigma Tg^2/nrc - T^2/N = 0.0005$

$SScr = \Sigma Tcr^2/ng - T^2N - SSc - SSr = 0.0178$

$SScg = \Sigma Tcg^2/nr - T^2/N - SSc - SSg = 0.0011$

$SSrg = \Sigma Trg^2/nc - T^2/N - SSr - SSg = 0.0103$

$SScrg = \Sigma T^2crg - T^2/N - SSr - SSg - SScr - SScg - SSrg = 0.0074$

$SS\ total = \Sigma x^2 - T^2/N = 0.1241$

SS residual = SS total - SS (all others) = 0.0273

n = 36 (total entries)

n = 2 (# of replications)

c = 3 (# of columns)

r = 3 (# of rows)

g = 2 (# of groups)

Variable	SS	Df	MS	MSR	90%	95%	99%
c	0.0061	2	0.0030	2.000	2.465	3.27	5.27
r	0.0536	2	0.0268	17.867	2.465	3.27	5.27
g	0.0005	1	0.0005	0.333	2.86	4.12	7.42
cr	0.0178	4	0.0045	3.000	2.115	2.64	3.91
cg	0.0011	2	0.0006	0.400	2.465	3.27	5.27
rg	0.0103	2	0.0052	3.467	2.465	3.27	5.27
crg	0.0074	4	0.0019	1.267	2.115	2.64	3.91
total	0.1241	35					
residual	0.0273	18	0.0015				

* The level of significance is determined by finding the largest table value which is less than the MSR calculated and is indicated here by the columns containing underlined values.

Note: ss - sum of squares; ms - mean square; Df - degrees of freedom; MSR - mean square ration (MS/MS of residual)

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