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(Please read Instructions on the reverse before completing)

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		11. CONTRACT/GRANT NO.
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		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

The FuelXpander is a retrofit device, marketed by FuelXpanders, Ltd. of Glen Fall,s N.Y. It is designed to pre-heat the gasoline before it reaches the carburetor. The manufacturer claims the device improves fuel economy, safety and performance. The basic question asked was whether "with a FuelXpander installed on an engine, will the fuel economy, on the average under different outside temperatures, increase, stay the same, or decrease." It was in response to this request, that the TAEB agreed to test the FuelXpander. The conclusions drawn from the EPA evaluation tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving performance improvemnts on the many different types of vehicles that are in actual use requires a much larger sample to test vehicles than is economically feasible in the evaluation test projects conducted by EPA. For promising systems it is necessary that more extensive test programs be carried out.

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Background

The Environmental Protection Agency receives information about many systems which appear to offer potential for emission reduction or fuel economy improvement compared to conventional engines and vehicles. EPA's Emission Control Technology Division is interested in evaluating all such systems, because of the obvious benefits to the Nation from the identification of systems that can reduce emissions, improve fuel economy or both. EPA invites developers of such systems to provide complete technical data on the systems's principle of operation, together with available test data on the system. In those cases for which review by EPA technical staff suggests that the data available shows promise, attempts are made to schedule confirmatory tests at the EPA Motor Vehicle Emission Laboratory at Ann Arbor, Michigan. The results of all such test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The FuelXpander is a retrofit device, marketed by FuelXpanders LTD. of Glen Falls, New York. It is designed to pre-heat the gasoline before it reaches the carburetor. The manufacturer claims the device improves fuel economy, safety, and performance.

The Postal Inspector in Glen Falls requested EPA to test the device to determine if it met its claims. The basic question asked was whether "with a FuelXpander installed on an engine, will the fuel economy, on the average under different outside temperatures, increase, stay the same, or decrease." It was in response to this request, that the TAEB agreed to test the FuelXpander.

The conclusions drawn from the EPA evaluation tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the evaluation test projects conducted by EPA. For promising systems it is necessary that more extensive test programs be carried out.

The conclusions from the EPA evaluation test can be considered to be quantitatively valid only for the specific test vehicle used; however, it is reasonable to extrapolate the results from the EPA test to other types of vehicles in a directional manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles.

Summary of Findings

- The FuelXpander did not demonstrate any statistically significant effect on fuel economy for either vehicle tested in either the FTP or the HFET.

- The FuelXpander either had no effect on emission levels or it caused an increase in the emission levels. The only exception was a decrease of NOx for the HFET tests for the Aspen.

- The FuelXpander did not have a statistically significant effect on evaporative emissions but there appeared to be a trend toward smaller evaporative emission increases as the ambient temperature was increased when the FuelXpander was used.

- Use of the FuelXpander appeared to have a mixed effect on the emission levels as the ambient temperature was increased with the effect being different for each vehicle, test cycle, and emission product.

- The FuelXpander showed either no effect or a detrimental effect on fuel economy when the ambient temperature was increased.

Device Description

The FuelXpander is an after market device, designed to pre-heat gasoline before it reaches the carburetor. The device operates as a tube and shell heat exchanger, constructed of copper and/or brass. It uses the engine coolant as the heat source and transfers this heat to the gasoline by conduction. The FuelXpander is installed in the fuel line as close as possible to the carburetor. The vehicle passenger compartment heater lines are cut and Y fittings are installed to divert part of the engine coolant through the device. Upon entering the device, the fuel is introduced to a chamber through which the water line (heat source) travels. This chamber is designed to transfer engine coolant heat to the fuel. From there, the fuel enters the carburetor in the normal manner.

The following benefits are claimed by the manufacturer[1]:

Performance - "The response to the gas pedal is immediate. Car seems to just glide along. The superior fuel atomization and equal cylinder distribution allows for the elimination of surging, gives smooth pickup and longer spark plug life... This (performance) is improved by more positive acceleration. When one touches the accelerator, hesitations disappear. Vehicle appears to operate as if the pollution devices were not there."

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1 These statements were taken from brochures accompanying the device. There were some differences between the claims made in each brochure, however, they were essentially similar. There was no information indicating which brochure was the most current.

Safety - "The finer atomization of the fuel and more equal distribution does away with the hesitation that is experienced on the late-model cars. Also, the automobile will not stall after repeated panic stops." Safety is increased as most surges and stalling is eliminated, even in repeated panic stops."

Economy - "This device should provide longer plug (spark?) life, longer intervals between tune-ups because of better vaporization and more equal distribution of fuel to each cylinder. In most vehicles gas mileage will improve. Marginal spark plugs will fire this better vaporized and heated fuel mixture. It improves the driving of the vehicle, and when a car is running better, it should give better mileage."

Improved Gas Mileage - "The FuelXpander, by pre-heating the fuel prior to entry into the carburetor, allows for a better air-fuel mixture to be delivered to the cylinders."

Other claims may be found in the brochures that came with the device. Copies of both brochures are contained in the appendix.

The FuelXpander was installed in the test vehicles according to the instructions that came with the device. One set of these instructions (A) noted the device could be positioned for several temperature gains. The second (B) shows only the position designated coolest (the device was installed in the position designated hottest). Both sets of instructions require use of equipment (infra-red gas analyzer or air-fuel ratio gauge) normally available only at some repair shops.

It should be noted that although the device came with a guarantee against defects for a period of one year, the two devices received were both defective. One of the devices leaked water during initial tests and required resoldering to repair. A second device's fuel port was plugged. Unplugging it left foreign material in the fuel chamber.

Test Procedure

Exhaust emission tests were conducted according to the 1977 Federal Test Procedure (FTP), described in the Federal Register of June 28, 1977, and the EPA Highway Fuel Economy Test (HFET), described in the Federal Register of September 10, 1976. Evaporative emissions were tested according to the Federal Register.

The vehicles were tested at ambient cell temperatures of 72°F and 85°F. At these temperatures both vehicles were tested with the simulated dyno air conditioning horsepower (standard road load horsepower setting +10% for A/C) with the vehicle's air conditioning off. Both vehicles were also tested with the standard dyno horsepower and with the vehicle air conditioning on.

The vehicles were tested in the baseline (stock) configuration and with the FuelXpander installed. The baseline tests were done both before and after the device tests at each test condition to minimize bias due to test vehicle variability or change.

All test procedures associated with a given test were conducted at the test temperature. This included preps, overnight soaks, refueling, evaporative emission, heat builds, etc.

Test Vehicles

The test vehicles were a 1976 Dodge Aspen Wagon equipped with a 225 cubic inch engine, three speed automatic transmission, and FR78 x 14 tires and a 1978 Chevrolet Impala equipped with a 350 cubic inch engine, three speed automatic transmission, and HR78 x 15 tires. Both vehicles were equipped with air conditioning. These vehicles were chosen because they are representative of the range of vehicles available. The relatively large power to weight ratio of the 1976 Impala is representative of many full sized cars produced in recent years. The relatively lower power to weight ratio of the the 1976 Aspen is representative of the current trend in automobiles. Detailed descriptions of these two test vehicles are provided in the appendix.

Thermocouples were installed on these vehicles to record appropriate temperatures throughout the test. The temperatures recorded were engine block coolant, coolant into device, fuel into and out of device, and carburetor air temperature.

Results

The object of this test program was to determine if there was significant beneficial change in vehicle emissions, fuel economy, or performance with the FuelXpander installed. Because heating vehicle fuel might adversely affect a vehicle manufacturer's calibration, testing was performed close to both the upper and lower temperature limits (68° and 86°F) of the test procedure. Additionally, operation of the vehicle A/C would tend to increase the temperature of the engine coolant used in the FuelXpander because the A/C condenser is placed forward of the radiator. The vehicles were tested at maximum A/C to investigate this effect. To maximize the A/C effect, A/C-on tests were conducted with the A/C set to maximum, fan set on high, and passenger windows open.

Under the various test conditions the vehicles were tested for gaseous and evaporative emissions. The test procedures used were the FTP, HFET, and evaporative (diurnal plus evaporative). For the evaporative tests the shed procedure, described in the Federal Register of June 28, 1977, was used. This procedure uses a small enclosure (shed) to trap all vehicle HC emissions. The standard for this test is 6 grams HC per test. This procedure is equal to the cannister procedure of 1976 with its equivalent standard of 2 grams of HC per test.

It may appear from an initial examination of the data that the use of the FuelXpander did affect emissions and fuel economy. However, in order to determine whether the observed differences were statistically significant, a statistical test, such as an Analysis of Variance (ANOVA) test, must be performed. This technique analyzes the difference due to the subject variable in relation to the test-to-test variability to determine if the difference is real or due to testing variability. The resultant significance determinations are stated in terms of a percent confidence level. (See Table V for statistical analysis summary).

EFFECT OF THE FUELXPANDER

Federal Test Procedure

The FTP results for the Aspen and Impala are summarized in Tables I and II, respectively. They are also presented in Figures 1 through 4. The results of the statistical analysis and the actual changes between configurations are shown in Table V.

The FuelXpander caused significant increases in HC emissions for the Aspen. This can be seen in Figure 1. The statistical analysis indicates that these increases were significant at the 99% confidence level and ranged from 15% to 43%. In contrast, the FuelXpander did not have a significant effect on HC emission levels from the Impala.

The FuelXpander caused a significant increase in CO emissions from both the Aspen and Impala. The increases for the Aspen were significant at the 95% level and ranged from 4% to 101%. The increases for the Impala were significant at the 90% level and the changes ranged from an 8% decrease to a 51% increase.

NOx and fuel economy were not significantly affected by the FuelXpander for either vehicle. While Figures 3 and 4 show some apparent changes these changes were found to be due to test-to-test variation rather than being attributable to the effect of the FuelXpander.

Evaporative Emission Test

The Evaporative Emission Test results for the Aspen and Impala are summarized in Tables I and II, respectively. They are also shown in Figure 5. The results of the statistical analysis are shown in Table V. Figure 5 indicates that the results vary greatly in magnitude and direction when comparing the FuelXpander to the baseline. Statistical analysis indicated that the FuelXpander did not demonstrate any significant effect on the level of HC evaporative emissions.

Highway Fuel Economy Test

The HFET results for the Aspen and Impala are summarized in Tables III and IV, respectively. They are also presented in Figures 6 through 9. The results of the statistical analysis are shown in Table V.

The Aspen results indicated that the FuelXpander had a significant effect on HFET, HC, CO, and NOx emissions. The HC effect was significant at the 99% level and the increases ranged from 41% to 74%. The CO increase was significant at the 90% level and ranged from a 127% to a 270% increase. The NOx levels decreased due to the FuelXpander at a 95% significance level and the changes ranged from an 11% increase to a 35% decrease.

The FuelXpander did not have a significant effect on HFET fuel economy for the Aspen. The FuelXpander was found not to have any significant effect on any of the regulated emissions or fuel economy for the Impala.

COMBINED EFFECT OF FUELXPANDER AND TEMPERATURE

Federal Test Procedure - Combined Effects

The combined effect of a change in ambient temperature and the effect of the FuelXpander is shown in Table VI. The table shows the percent change in value resulting from a change in ambient temperature. The combined effect can be seen by comparing the percent effect ambient temperature changes had for each of the two configurations within each of the two A/C test conditions.

When using the FuelXpander, the Aspen HC and CO levels tended to show greater increases than the baseline vehicle as the ambient temperature increased. For the FuelXpander, NOx levels appeared to show either a smaller reduction or no change at the higher temperature. Fuel economy tended to increase with temperature in the baseline condition slightly more than with the FuelXpander.

With the FuelXpander the HC levels for the Impala tended to show greater decreases than the baseline vehicle as the ambient temperature increased. The CO level changes and fuel economy changes with temperature did not show a clear pattern. When in the baseline configuration, the NOx levels tended to increase more as the ambient temperature increased.

Highway Fuel Economy Test - Combined Effect

For the Aspen the increase in ambient temperature causes a greater increase in HC emissions with the FuelXpander. Slightly lower CO emission increases with high ambient temperature were found when the FuelXpander was used. The effect of the FuelXpander on NOx levels and fuel economy as the ambient temperature varied did not show a trend.

The combined effect of the FuelXpander and temperature on the Impala did not have a consistent effect on the HC, CO, and NOx emission levels. Fuel economy appeared to be unaffected. These results are shown in Table VI.

Evaporative Emission Test - Combined Effect

For both vehicles the increase in ambient temperature tended to show a smaller increase in evaporative emissions with the FuelXpander. These results are also given in Table VI.

Conclusions

- Aspen HC and CO emission levels for the FTP cycle increased significantly with the use of the FuelXpander.
- NOx and fuel economy levels for the Aspen were not significantly affected by the FuelXpander during the FTP cycle.
- HC levels for the Impala were significantly increased by using the FuelXpander on the FTP cycle.
- CO, NOx, and fuel economy for the Impala on the FTP cycle were not affected by the FuelXpander.
- The FuelXpander did not affect the evaporative emission results.
- The FuelXpander significantly increased HC and CO levels while it decreased NOx levels for the Aspen during the HFET cycle.
- The regulated emissions for the Impala were not significantly affected by the FuelXpander over the HFET cycle.
- The FuelXpander did not significantly affect the fuel economy levels for Aspen and Impala over the HFET cycle.
- For the FTP cycle, relative to baseline, use of the FuelXpander on the Aspen caused a greater increase in HC and CO emissions, no change in NOx emissions, and a smaller increase in fuel economy as the ambient temperature increased.
- For the FTP cycle, relative to baseline, use of the FuelXpander on the Impala caused greater decrease in HC levels, a greater increase in NOx levels, and no pattern of change for the CO and fuel economy levels as the ambient temperature increased.
- Use of the FuelXpander appeared to cause smaller increases in evaporative emissions for both vehicles as the ambient temperature increased.

- For the HFET cycle, relative to baseline, use of the FuelXpander on the Aspen caused greater HC increases, smaller CO increases, and no pattern regarding NOx and fuel economy levels as the ambient temperature increased.

- For the HFET cycle, relative to baseline, use of the FuelXpander on the Impala caused no apparent pattern of change for HC, CO and NOx and had no effect on fuel economy as the ambient temperature increased.

Table I

Aspen Station Wagon FTP Emissions
grams per mile

Average Test Temperature °F	Test Condition	HC	CO	CO_2	NOx	MPG	Evaporative*
71.4	Baseline Dyno A/C hp	.94	6.45	515	2.80	16.9	5.90
72.5	FuelXpander Dyno A/C hp	1.08	6.70	492	2.46	17.5	5.86
70.8	Baseline A/C on	1.06	8.23	539	3.09	16.0	3.90
71.9	FuelXpander A/C on	1.25	11.50	514	3.04	16.6	5.08
85.1	Baseline Dyno A/C hp	.94	4.77	475	2.35	18.3	7.55
85.1	FuelXpander Dyno A/C hp	1.34	9.60	469	2.33	18.2	7.07
84.1	Baseline A/C on	1.02	8.27	523	2.98	16.5	10.43
84.6	FuelXpander A/C on	1.44	16.20	514	2.91	16.3	9.29

Table II

Impala FTP Emissions
grams per mile

Average Test Temperature °F	Test Condition	HC	CO	CO_2	NOx	MPG	Evaporative
72.8	Baseline Dyno A/C hp	.51	10.27	644	1.96	13.4	3.11
74.0	FuelXpander Dyno A/C hp	.62	15.00	635	1.75	13.4	5.88
72.6	Baseline A/C on	.52	11.48	683	2.33	12.6	5.74
74.4	FuelXpander A/C on	.62	17.10	696	2.34	12.2	5.37
85.5	Baseline Dyno A/C hp	.45	7.48	627	1.99	13.9	7.33
84.5	FuelXpander Dyno A/C hp	.49	11.30	625	1.57	13.8	6.69
86.5	Baseline A/C on	.56	13.41	722	2.67	11.9	7.02
85.8	FuelXpander A/C on	.56	12.40	700	2.53	12.3	5.15

* Grams/Test

Table III

Aspen Station Wagon HFET Emissions
grams per mile

Average Test Temperature °F	Test Condition	HC	CO	CO_2	NOx	MPG
71.0	Basline Dyno A/C hp	.22	.43	398	2.91	22.2
71.9	FuelXpander Dyno A/C hp	.31	1.59	399	2.87	22.0
70.5	Baseline A/C on	.24	1.23	416	3.17	21.2
70.9	FuelXpander A/C on	.38	3.86	407	2.73	21.4
83.4	Baseline Dyno A/C hp	.31	2.56	388	2.51	22.5
84.2	FuelXpander Dyno A/C hp	.54	8.23	376	1.62	22.7
84.6	Baseline A/C on	.40	7.09	403	2.39	21.4
84.4	FuelXpander A/C on	.67	16.10	395	2.16	21.0

Table IV

Impala HFET Emissions
grams per mile

Average Test Temperature °F	Test Condition	HC	CO	CO_2	NOx	MPG
73.0	Baseline Dyno A/C hp	.06	.80	477	2.75	18.5
75.5	FuelXpander Dyno A/C hp	.07	1.68	480	2.49	18.4
73.6	Baseline A/C on	.07	1.13	527	3.44	16.8
75.6	FuelXpander A/C on	.09	3.31	513	3.20	17.1
85.6	Baseline Dyno A/C hp	.07	2.43	481	2.60	18.3
84.7	FuelXpander Dyno A/C hp	.10	7.02	475	1.87	18.3
88.7	Baseline A/C on	.15	9.48	539	3.13	16.0
85.8	FuelXpander A/C on	.10	4.89	527	3.18	16.6

Table V

Change From Baseline Due to FuelXpander
Expressed in % at Stated Significance Level (1)

Temp	A/C	HC		CO		NOx		MPG		Evap.	
		Aspen - FTP									
Low	Dyno	15%	S.L.	4%	99%	-12%		4%		-1%	
Low	On	18%	99%	40%	95%	-2%		4%		30%	
High	Dyno	43%	S.L.	101%	S.L.	-1%	**	-1%	**	-6%	**
High	On	41%		96%		-2%		-1%		-11%	
		Impala - FTP									
Low	Dyno	22%		46%	S.L.	-11%		0%		86%	
Low	Dyno	19%		49%	90%	0%		-3%		-6%	
High	Dyno	9%		51%	S.L.	-21%	**	-1%	**	-9%	**
High	On	0%		-8%		-5%		3%		-27%	
		Aspen - HFET									
Low	Dyno	41%	S.L.	270%	S.L.	-1%	S.L.	-1%			
Low	On	58%	99%	214%	90%	-14%	95%	1%			
High	Dyno	74%	S.L.	221%	S.L.	-35%	S.L.	1%			
High	On	68%		127%		11%		-2%			
		Impala									
Low	Dyno	17%		110%		-9%		-1%			
Low	On	29%		193%		-7%		2%			
High	Dyno	43%	**	189%	**	-28%	**	0%	**		
High	On	-33%		-48%		2%		4%			

(1) Significant Level from Analysis of Variance Procedure and Direction of Change.*

S. L. - Significance Level

* + indicates increase; - indicates decrease.

** indicates not significant at 90% confidence level.

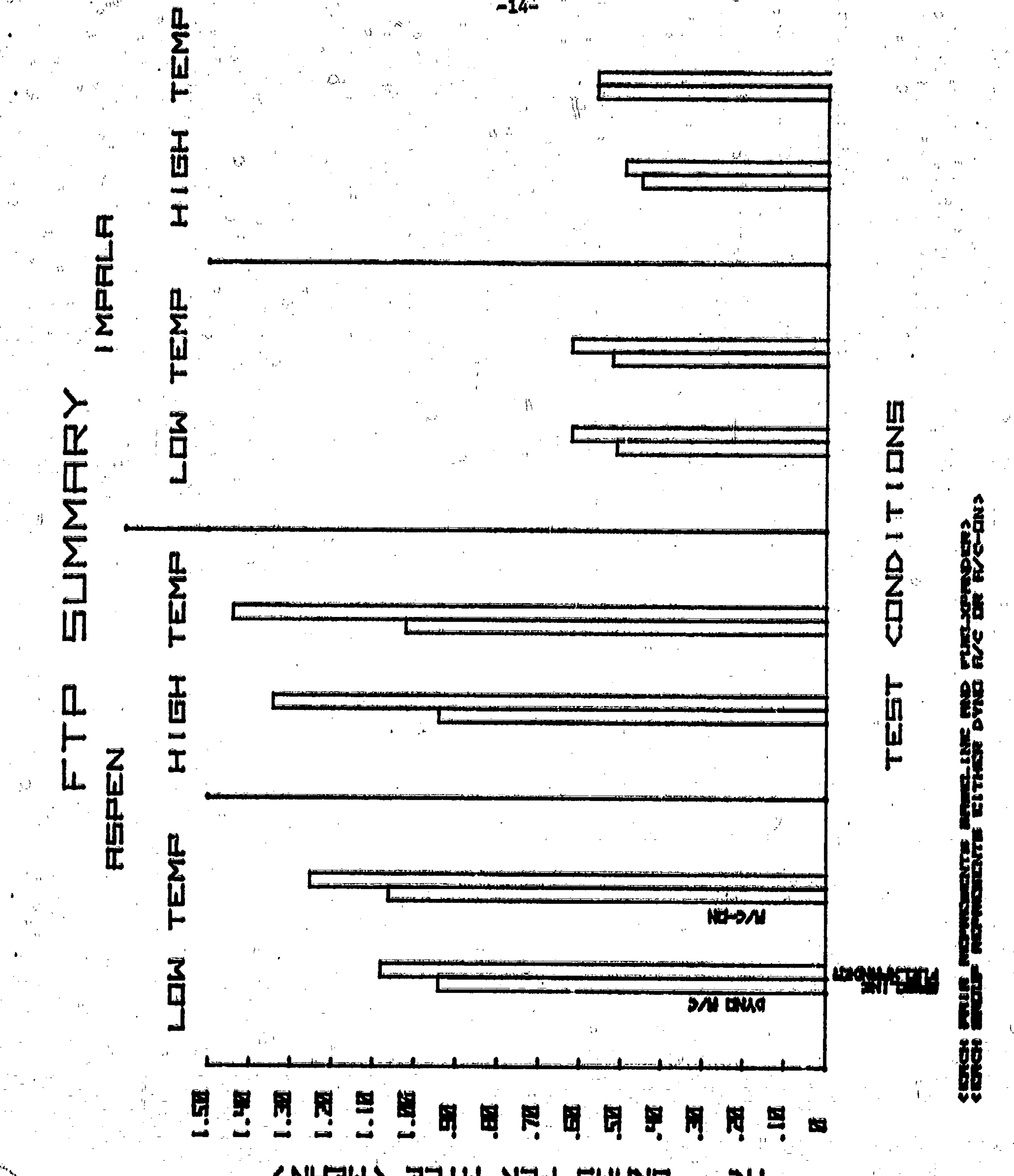
Note: The significance level should not be confused with changes of absolute values but are an indication of the statistical significance of the changes in the values given in Tables I through IV.

Table VI

Percent Change from Low Temperature to High Temperature

Test Condition		HC	CO	NOx	MPG	Evap
Configuration	**A/C**			**Aspen - FTP**		
Baseline	Dyno	0%	-26%	-16%	8%	28%
FuelXpander	Dyno	24%	43%	-5%	4%	21%
Baseline	On	-4%	0%	-4%	3%	167%
FuelXpander	On	15%	41%	-4%	-2%	83%
				Impala - FTP		
Baseline	Dyno	-12%	-27%	2%	4%	136%
FuelXpander	Dyno	-21%	-25%	-10%	3%	14%
Baseline	On	8%	17%	15%	-6%	22%
FuelXpander	On	-10%	-27%	8%	1%	-4%
				Aspen - HFET		
Baseline	Dyno	41%	495%	-14%	1%	
FuelXpander	Dyno	74%	418%	-44%	3%	
Baseline	On	67%	476%	-25%	1%	
FuelXpander	On	76%	317%	-21%	-2%	
				Impala - HFET		
Baseline	Dyno	17%	204%	-5%	-1%	
FuelXpander	Dyno	43%	318%	-25%	-1%	
Baseline	On	114%	739%	-9%	-5%	
FuelXpander	On	11%	48%	-1%	-3%	

Figure 1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IMPALA
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HIGH TEMP
LOW TEMP
HIGH TEMP
LOW TEMP
HIGH TEMP
LOW TEMP
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HC - GRAMS PER MILE <MEAN>
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.10
.20
.30
.40
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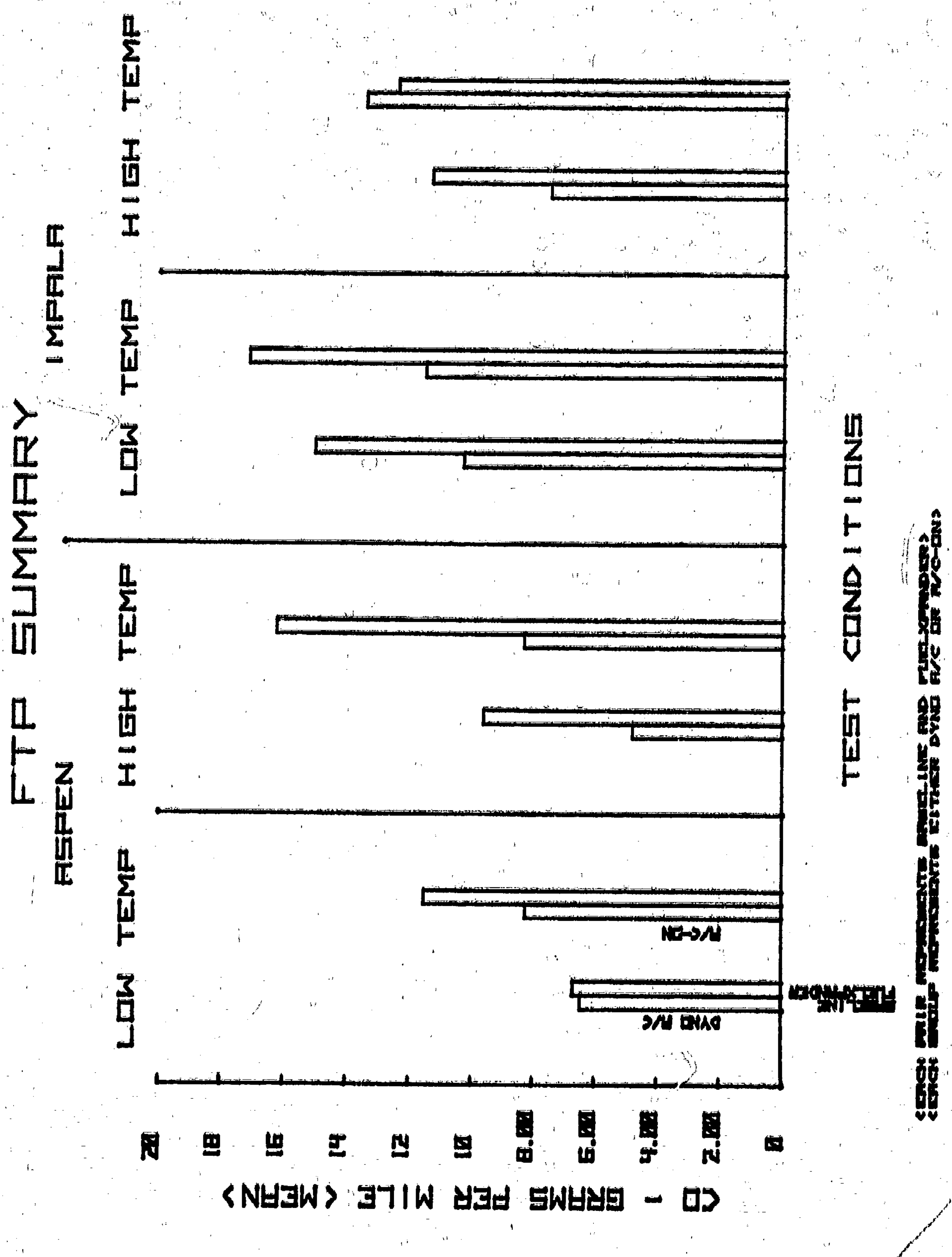
DYNO A/C
A/C-ON

Figure 2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IMPALA
LOW TEMP
HIGH TEMP
LOW TEMP
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TEST CONDITIONS
CO - GRAMS PER MILE <MEAN>
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6.00
8.00
10
12
14
16
18
20
DYNO A/C
BASELINE
FUELXPANDER
A/C-ON
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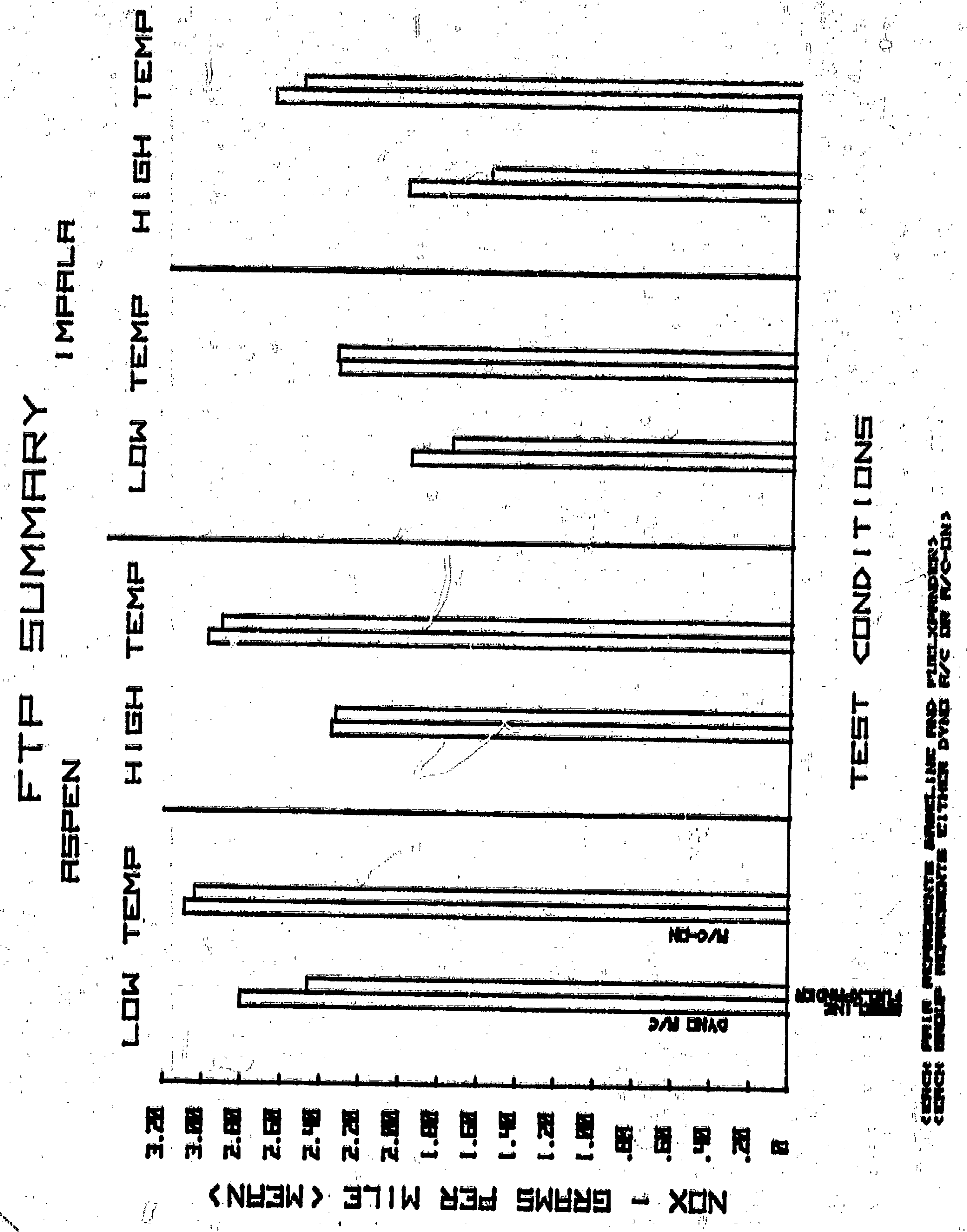
<EACH GROUP REPRESENTS EITHER DYNO A/C OR A/C-ON>

Figure 3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A/C-ON
BASELINE
FUEL-XPANDER
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[redacted] Figure 4

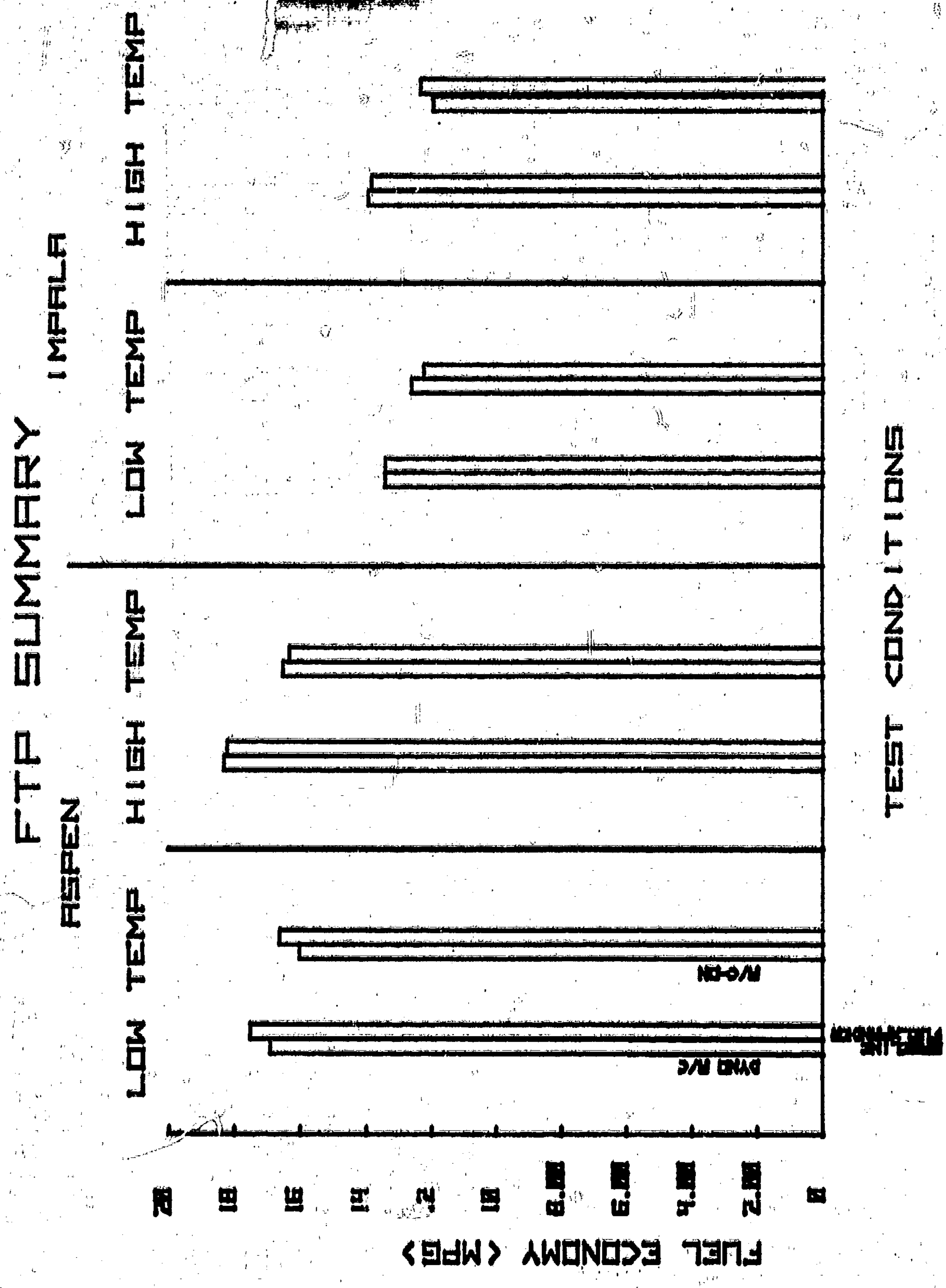
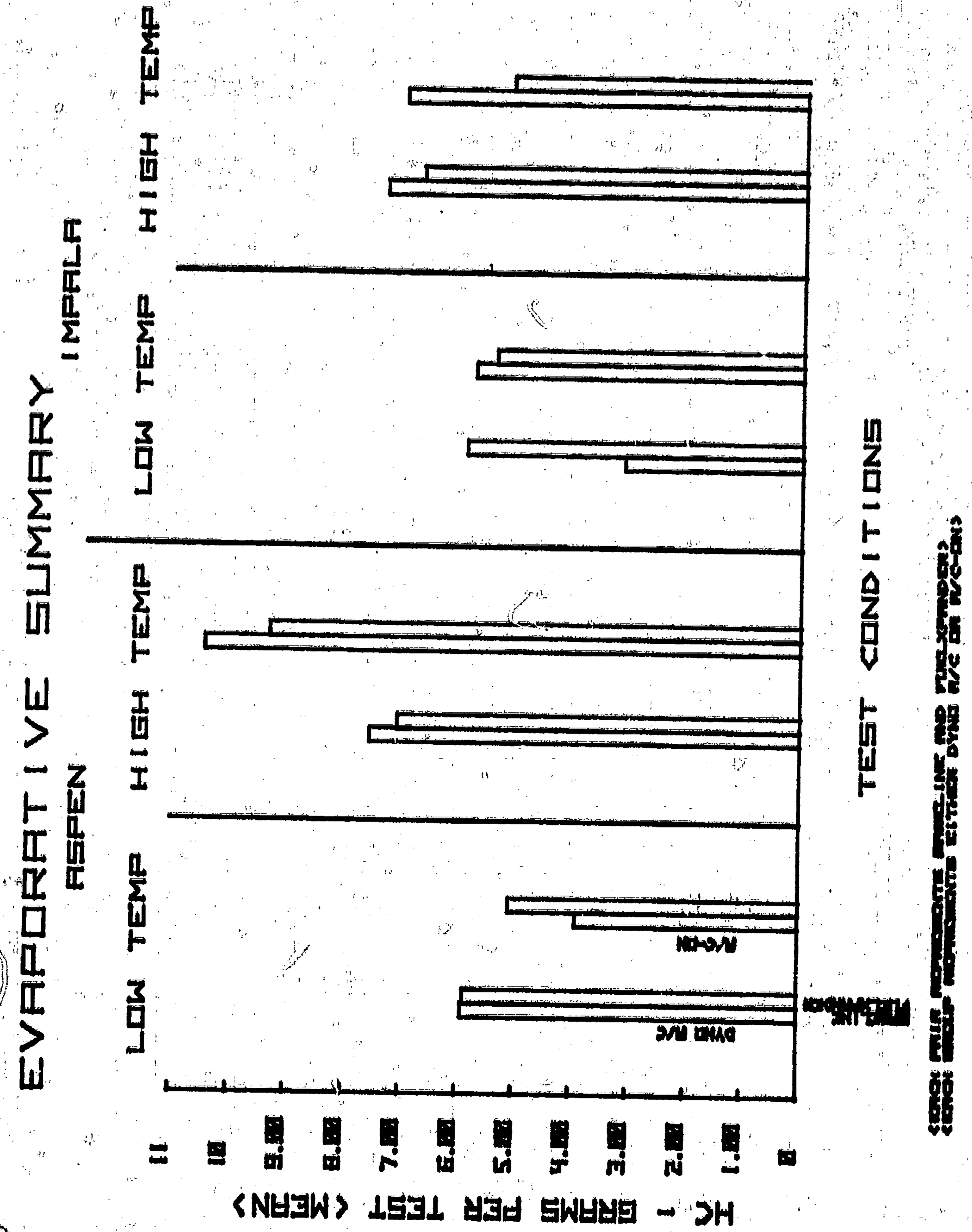


Figure 5


EVAPORATIVE SUMMARY
ASPEN
IMPALA
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HIGH TEMP
LOW TEMP
HIGH TEMP
TEST CONDITIONS
HC - GRAMS PER TEST (MEAN)
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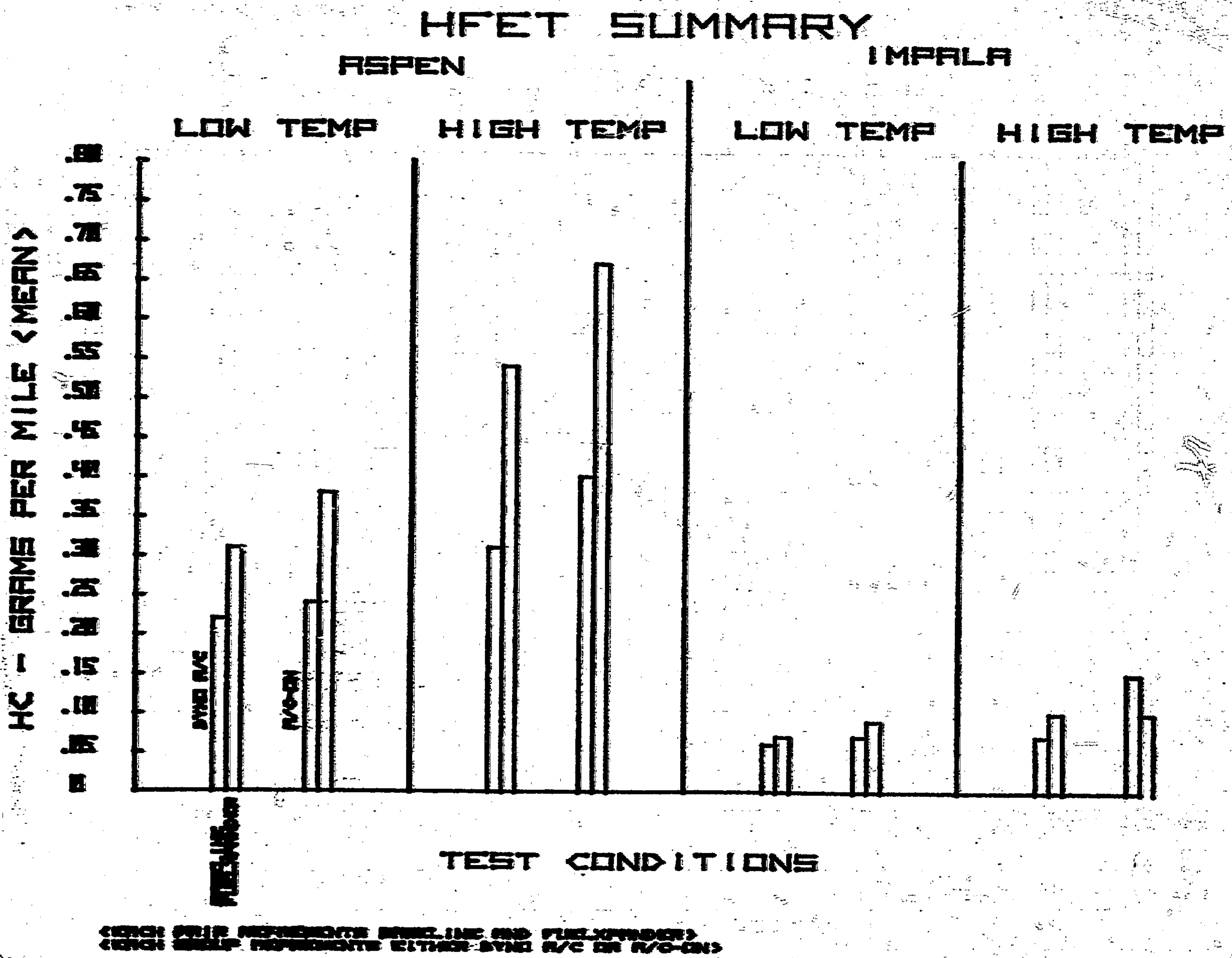
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10
11

Figure 6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IMPALA
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HIGH TEMP
LOW TEMP
HIGH TEMP
HC - GRAMS PER MILE <MEAN>
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.20
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.30
.35
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.55
.60
.65
.70
.75
.80
SYNC A/C
A/C-ON
BASELINE
FUELXPANDER
TEST CONDITIONS
<EACH PAIR REPRESENTS BASELINE AND FUELXPANDER>
<EACH GROUP REPRESENTS EITHER SYNC A/C OR A/C-ON>

Figure 7

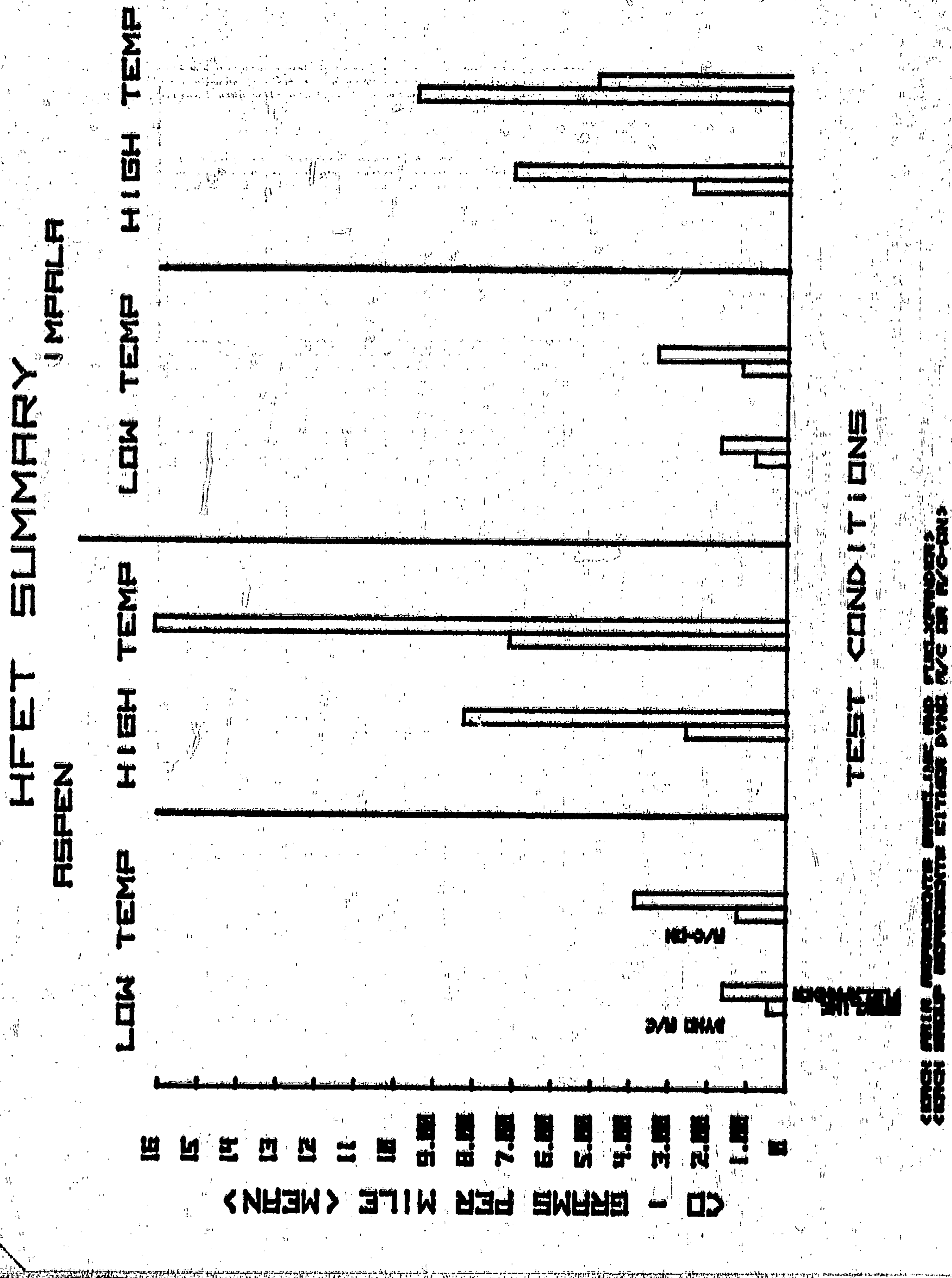

HFET SUMMARY
ASPEN
IMPALA
LOW TEMP
HIGH TEMP
LOW TEMP
HIGH TEMP
TEST CONDITIONS
CO - GRAMS PER MILE (MEAN)

Figure 8

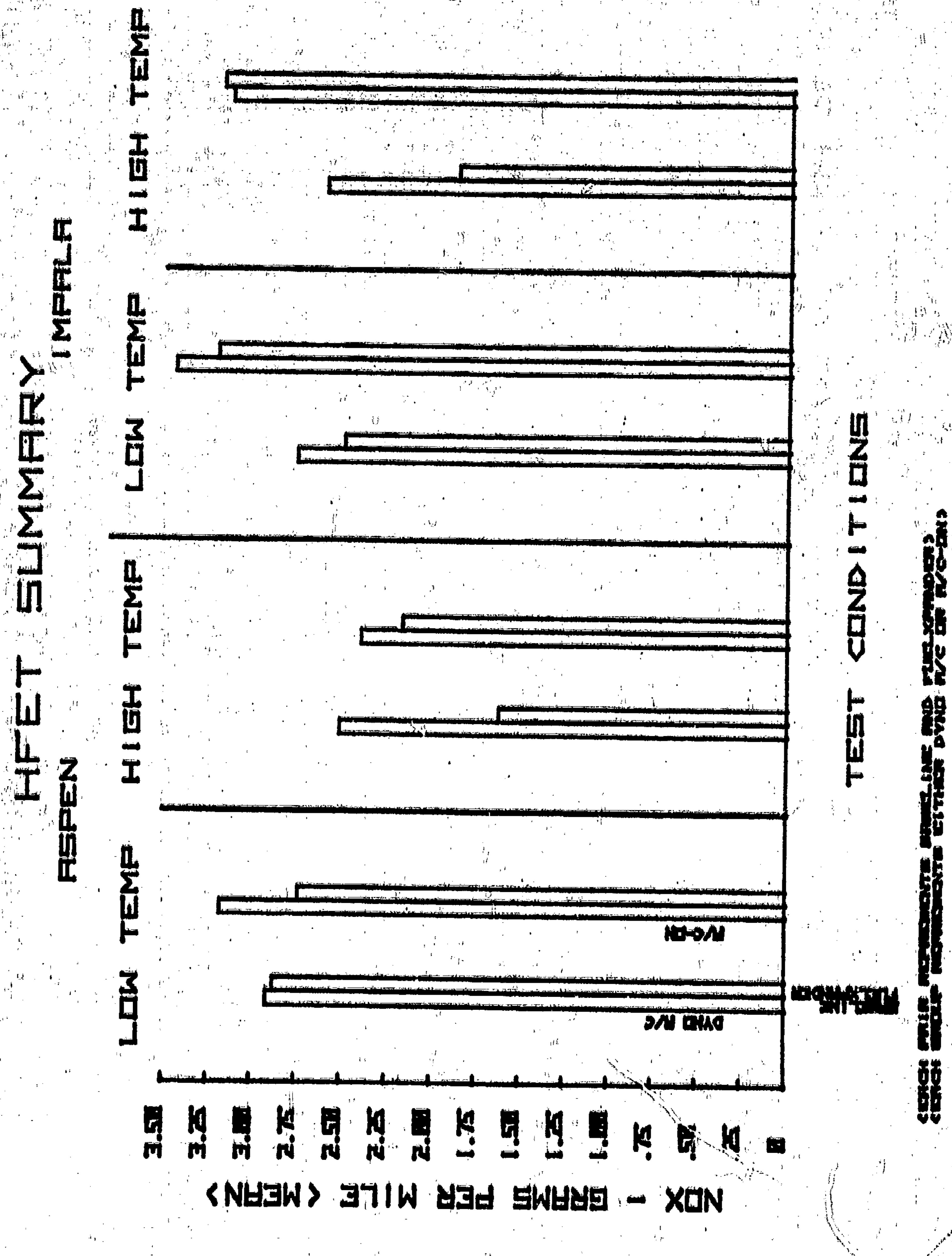
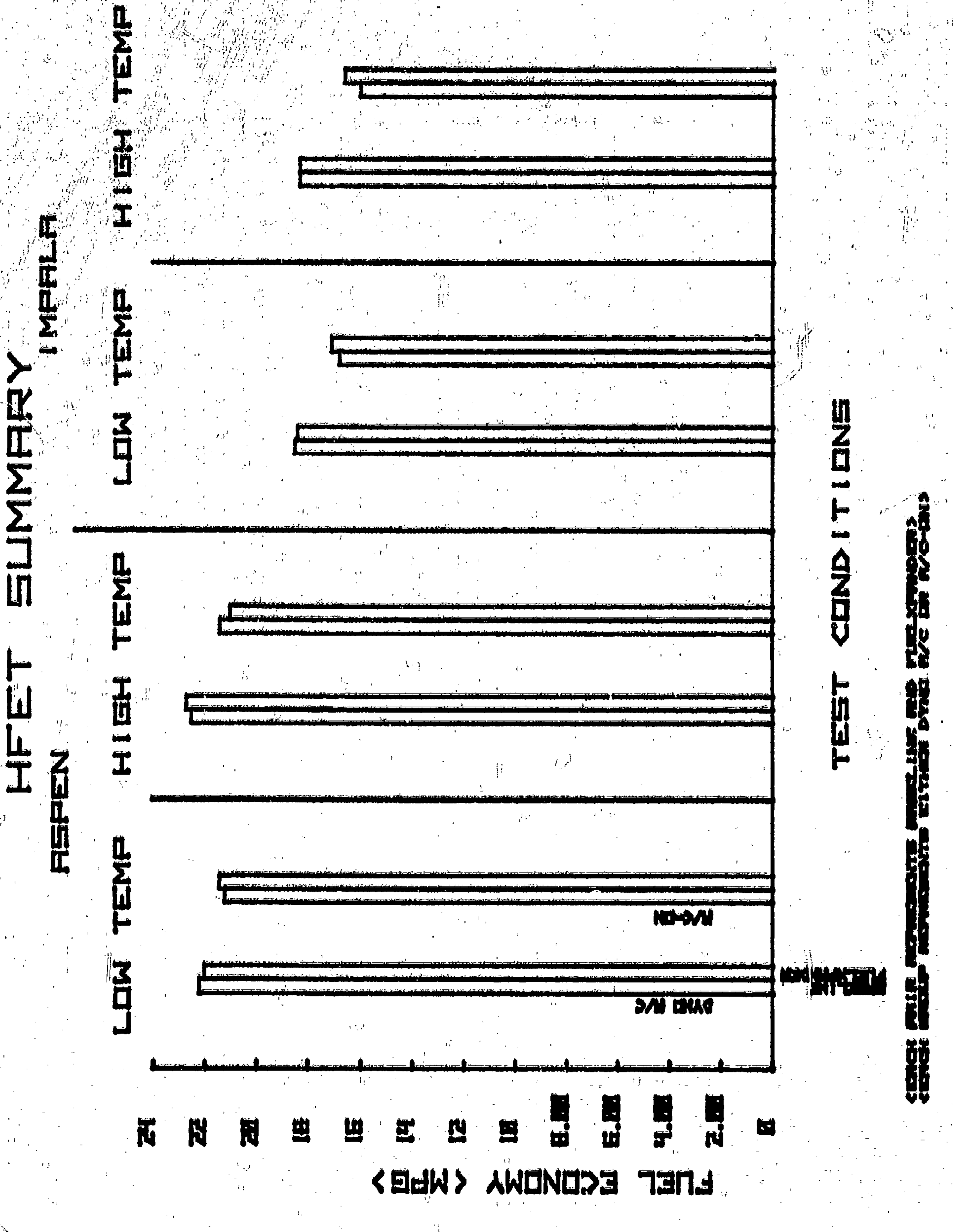

HFET SUMMARY
ASPEN
IMPALA
LOW TEMP
HIGH TEMP
LOW TEMP
HIGH TEMP
TEST (CONDITIONS)
NOX - GRAMS PER MILE (MEAN)
0
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
A/C-ON
DYNO A/C

Figure 9


HFET SUMMARY
ASPEN
IMPALA
LOW TEMP
HIGH TEMP
LOW TEMP
HIGH TEMP
TEST CONDITIONS
FUEL ECONOMY (MPG)
0
2.00
4.00
6.00
8.00
10
12
14
16
18
20
22
24

Appendix A

Analysis of Variance
Example: Aspen HC for FTP

	Groups	A/C HP	A/C on	Tr	Tg
Rows	Low Temp. - Base	0.94	1.06	4.33	3.96
	Low Temp. - FuelXpander	1.08	1.25		5.11
	High Temp. Base	0.94	1.02	4.74	
	High Temp. FuelXpander	1.34	1.44		
	Tc =	4.30	4.77		

$T^2/N = (9.07)^2/8 = -10.28$ $\quad$ $T = 9.07$

$SS\ (total) = \Sigma X^2 - T^2/N = 10.53 - 10.28 = 0.25$

$SSc = \Sigma Tc^2/nrg - T^2/N = 10.31 - 10.28 = 0.03$

$SSr = \Sigma Tr^2/ncg - T^2/N = 10.30 - 10.28 = 0.02$

$SSg = \Sigma Tg^2/nrc - T^2/N = 10.45 - 10.28 = 0.17$

$SS\ (residual) = SS\ (total) - SS\ (all\ others) = 0.25 - 0.22 = 0.03$

Where: N = 8 (total entries)

n = 1 (# of replications)

c = 2 (# of columns)

r = 2 (# of rows)

g = 2 (# of groups)

Summary of Mean Square Ratios

FTP - Aspen	MSR FuelXpander
HC	22.67
CO	7.84
NOx	2.35
MPG	0.54
Evap.	0.01
Impala	
HC	0.18
CO	5.83
NOx	2.80
MPG	0.00
Evap.	0.00
HFET - Aspen	
HC	28.00
CO	5.88
NOx	6.40
MPG	0.13
Impala	
HC	0.00
CO	0.20
NOx	3.58
MPG	1.19

	SS	Df	SS/Df	(MSR) MS/MS(resid)
A/C - column	0.03	C-1=1	0.03	4.00
Temp - row	0.02	r-1=1	0.02	2.67
FX - group	0.17	g-1=1	0.17	22.67
Residual	0.03	7-3=4	0.01	
Total	0.25	N-1=7		

F distribution (Df=1/Df=4)

90%	95%	97.5%	99%
4.54	7.71	12.2	21.2

Compare MS/MS (resid) to F distribution - the difference is significant if the calculated value is greater than the table value.

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1976 Dodge Aspen Wagon
Emission control system - catalytic reactor, exhaust gas recycle

Engine

type	Otto spark, inline, 6 cylinder, OHV
bore x stroke	3.40 x 4.13 in/86.4 x 104.9 mm
displacement	2.25 CID/3687 cc
compression ratio	8.4:1
maximum power @ rpm	-
fuel metering	1 carburetor, 1 Venturi
fuel requirement	Unleaded, 91 Octane, tested with Indolene unleaded

Drive Train

transmission type	Automatic 3 speed
final drive ratio	2.94:1

Chassis

type	separate body/frame, front engine, rear drive
tire size	FR 78 x 14
curb weight	3815 lb
inertia weight	4000 lb
passenger capacity	6

Emission Control System

basic type	catalytic reactor, exhaust gas recirculation

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1976 Chevrolet Impala
Fmission control sytem - Catalytic reactor, exhaust gas recirculation

Engine

type	Otto spark, V-8, OHV
bore x stroke	4.00 x 3.48 in/101.6 x 88.4 mm
displacement	350 CID/5735 cc
compression ratio	8.5:1
maximum power @ rpm	145 HP/108 kW
fuel metering	1 carburetor, 2 Venturi
fuel requirement	unleaded, 91 octane tested with Indolene unleaded

Drive Train

transmission type	Automatic 3-speed
final drive ratio	2.73:1

Chassis

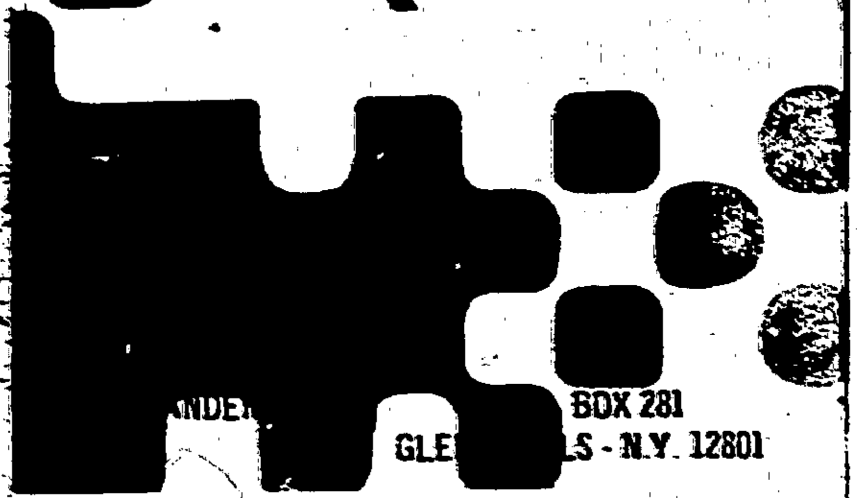
type	Separate frame/body, front engine, rear drive
tire size	HR 78 x 15
curb weight	4266 lbs
inertia weight	4500 lbs
passenger capacity	6

Emission Control System

basic type	Catalytic reactor, exhaust gas recirculation

FOR YOUR DRIVING PLEASURE

FUELXPANDER PAT. PENDING TM



Your Fuel Expander is guaranteed to be free of defects for a period of one (1) year from date of purchase. Any unit found defective will be replaced free of charge.

IMPROVES GAS MILEAGE

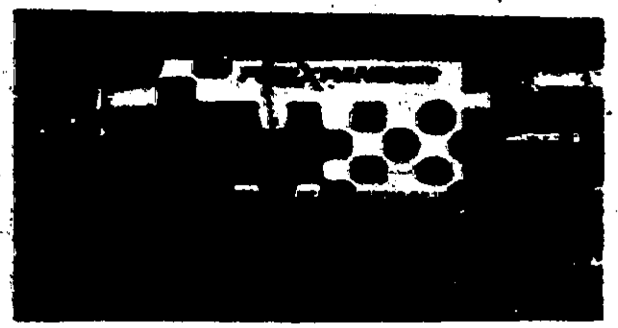
The Fuel Expander, by pre-heating the fuel prior to entry into the carburetor, allows for a better air-fuel mixture to be delivered to the cylinders.

SAFETY

The finer atomization of the fuel and more equal distribution does away with the hesitation that is experienced on the late-model cars. Also, the automobile will not stall after repeated panic stops.

PERFORMANCE

The response to the gas pedal is immediate. Car seems to just glide along. The superior fuel atomization and equal cylinder distribution allows for the elimination of surging, gives smoother pickup and longer spark plug life.



We have all seen the effect of gasoline left in a container in the sun. It expands and overflows. The Fuel Expander is our method of controlled expansion giving you summer conditions all year long. With its benefits of added Economy, Safety and Performance and its *maintenance-free operation, this becomes the ideal retrofit device. Enjoy it and take it with you for your next car.

**Cooling system must be maintained to allow proper operation of the Fuel Expander.*

FUELXPANDER

PAT PENDING TM

INSTALLATION INSTRUCTIONS

**Read through instructions before starting installation.

1. Drain Coolant from radiator, if necessary.
2. Locate Fuel Expander as close to carburetor as possible in horizontal position with water line and fuel line opposite each other, as in Figure 1.
3. Cut heater line and insert Y at A before Ranco valve. NOTE: This is the hot water inlet line going to heater.
4. Cut other heater line and insert second Y at B. NOTE: This is return from heater to water pump. Be sure Y's are inserted in direction of flow.
5. Secure all hose connections with clamps. Tighten carburetor base bolts and screws.
6. Cut fuel line near carburetor WITH TUBE CUTTER. Connect input and output fuel lines with flexible neoprene fuel line at C and D. *On vehicles having in-line fuel filter, reposition filter between expander and carburetor. DO NOT USE HACK SAW.
7. Replace Coolant drained from system. Start engine, run until operating temperature is reached. MAKE SURE DEVICE IS HOT.
8. Attach AIR-FUEL RATIO Gauge. BE SURE CARBURETOR AIR CLEANER IS ON.
9. Rotate unit to desired heat range.
10. Adjust idle circuit to maximum lean position as specified by the manufacturer. (Approximately 14-15 to 1)

You are now ready to enjoy the benefits of economy, safety, and superior performance from your new Fuel Expander.

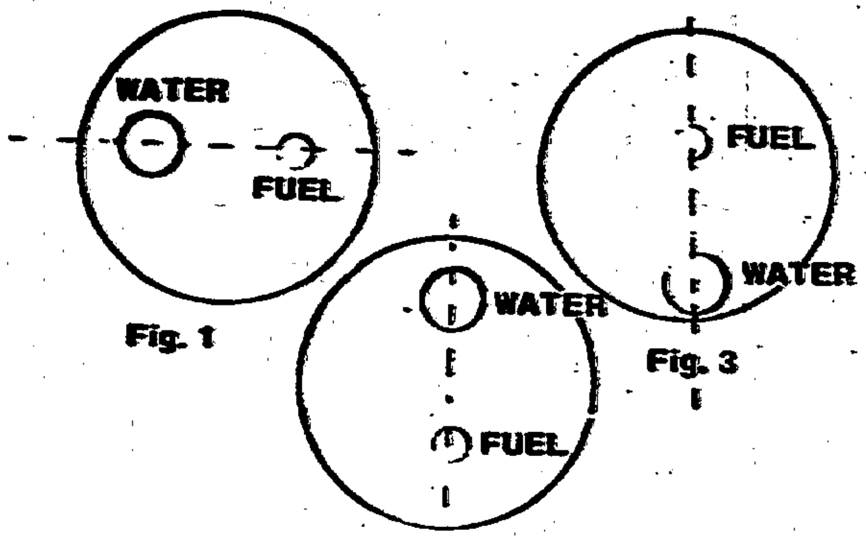
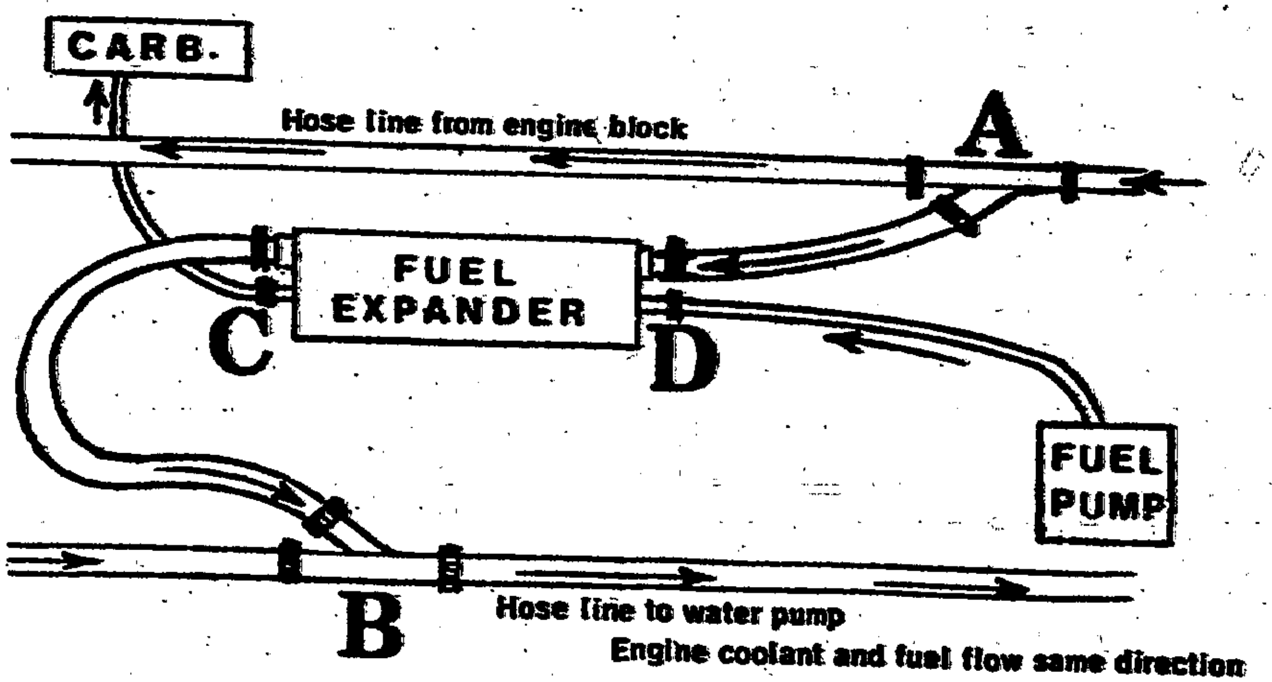


Fig. 1 Fig. 2 Fig. 3

ROTATE UNIT TO HIGHEST READING

Normal - Hottest - Coolest
1 2 3



INTRODUCING

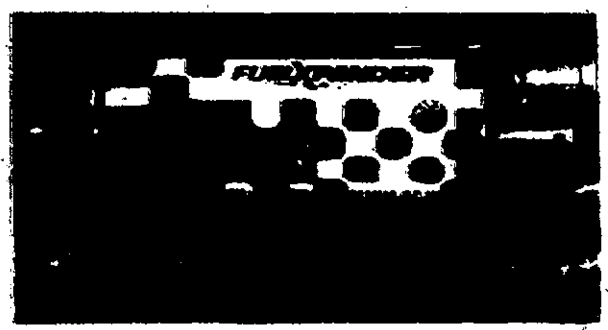
THE

FUELXPANDER

PAT. PENDING '78

A method of preheating fuel prior to introduction to the carburetor giving summer conditions every season of the year.

As there are no moving parts, the fuel expander is maintenance free*. The FuelXpander is constructed from copper and brass. It should enhance your performance for many years to come.



Cooling system must be maintained to allow proper operation of your fuel expander.

ECONOMY

This device should provide longer plug life, longer intervals between tune-ups because of better vaporization and more equal distribution of fuel to each cylinder. In most vehicles, gas mileage will improve. Marginal spark plugs will fire this better vaporized and heated fuel mixture. It improves the driving of the vehicle, and when a car is running better, it should give better mileage.

SAFETY

Safety is increased as most surges and stalling is eliminated, even in repeated panic stops.

PERFORMANCE

This is improved by more positive acceleration. When one touches the accelerator, hesitations disappear. Vehicle appears to operate as if the pollution devices were not there.

FOR YOUR DRIVING PLEASURE

Your Fuel Expander is guaranteed to be free of defects for a period of one (1) year from date of purchase. Any unit found defective will be replaced free of charge.

B188/9

FUELXPANDER

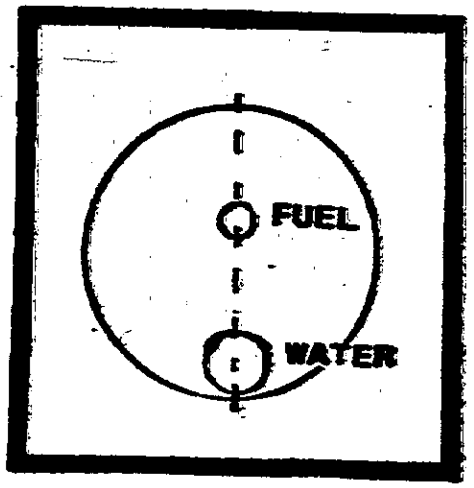
PAT. PENDING TM

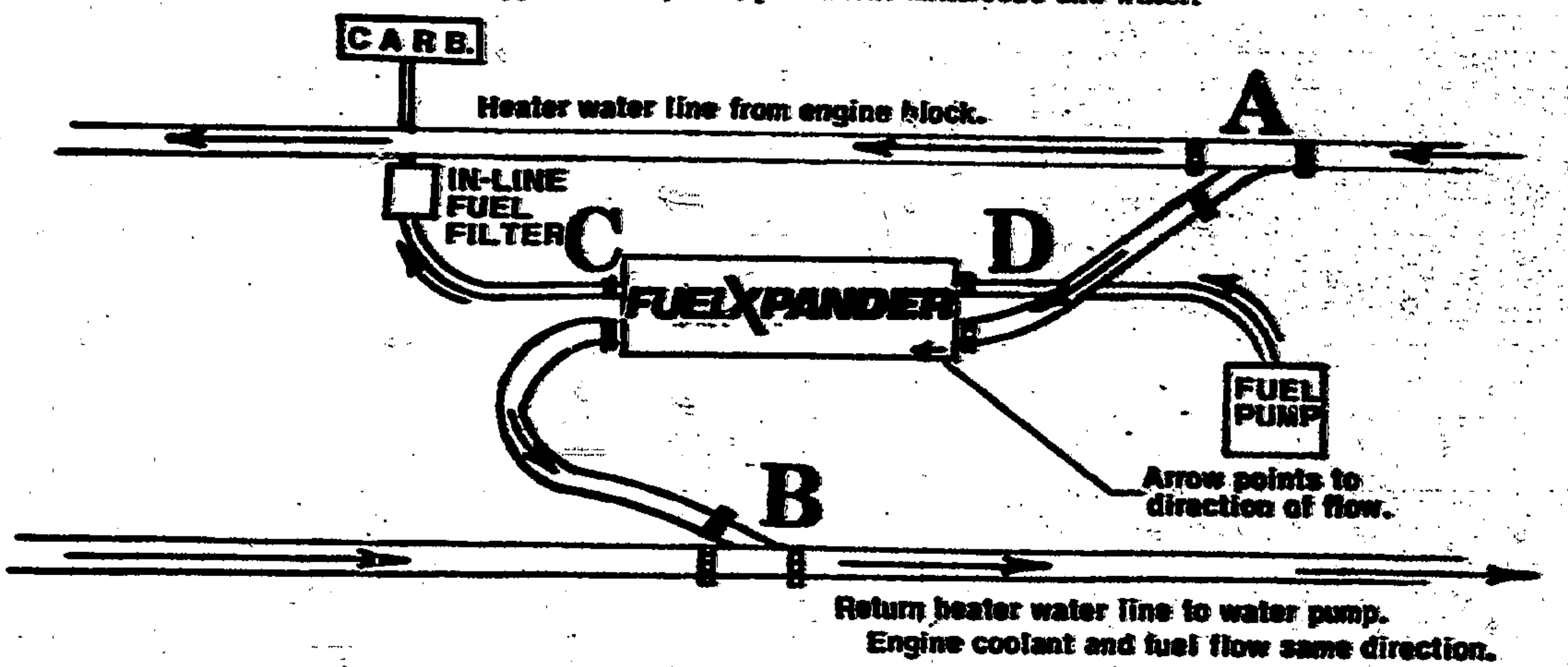
INSTALLATION INSTRUCTIONS

**Read through instructions before starting installation.

1. Drain coolant from radiator as necessary.
2. Locate Fuel Expander approximately 12" from carburetor in horizontal position with water line below fuel line as pictured below, with (←) on expander on inlet side.
3. Attach bracket so position will be held.
4. Cut heater line and insert Y at A before ranco valve. **NOTE:** this is the hot water line going to heater.
5. Cut other heater line and insert Y at B. **NOTE:** this is return from heater to water pump. Be sure Y's are inserted in direction of flow.
6. Secure all hose connections with clamps. Tighten carburetor base bolts and screws.
7. Cut fuel line near carburetor **WITH TUBE CUTTER.** Connect input and output lines with approved neopreme fuel line at C and D. On vehicles having inline fuel filter, reposition filter between expander and carburetor. **DO NOT USE HACKSAW.**
8. Replace coolant drained from system. Start engine, run until operating temprature is reached. **MAKE SURE DEVICE IS HOT.**
9. Attach **AIR – FUEL RATIO** gauge or **INFRA – RED ANALYZER.** Be sure carburetor air cleaner is on, and all lines and pollution devices are attached as required by manufacturer.
10. Adjust idle circuit to maximum lean position as **SPECIFIED BY MANUFACTURER.**

**Manufacturers recommend coolant mixture of approximately 50% permanent antifreeze and water.*





* U.S. GOVERNMENT PRINTING OFFICE: 1980– 651-112/0157