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Evaluation of FIDC System

Final Report

Robert A. Hall
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Prepared for
Department of Energy
Assistant Secretary for Conservation and Solar Applications
Division of Transportation Energy Conservation
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

124

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ABSTRACT

A fuel vapor injector/igniter system developed by the Fuel Injection Development Corporation has been evaluated for its effect on vehicle engine performance, fuel economy, and exhaust emissions. Initially, a single cyclinder engine was operated with the vapor injector/igniter and improved combustion was inferred from the leaner operation achieved with the vapor injector/igniter. However, the improved fuel economy and emissions found during the single cylinder tests were not realized with the multicylinder engine. Multicylinder engine tests were conducted to compare the FIDC system with both a stock and a modified stock configuration. A comparison of cylinder-to-cylinder equivalence ratio distribution was also obtained from the multicylinder engine tests. Finally, the multicylinder engine was installed in a vehicle, and the vehicle was tested on a chassis dynamometer to compare the FIDC system with stock and modified stock configurations. The FIDC configuration demonstrated approximately five percent improved fuel economy over the stock configuration, but the modified stock configuration demonstrated approximately twelve percent improved fuel economy.

The hydrocarbon emissions were approximately two-hundred-thirty percent higher with the FIDC system than with the stock configuration. Both the FIDC system and the modified stock configuration adversely affected driveability. In the final analysis, the FIDC system demonstrated a modest fuel savings, but with the penalty of increased emissions, and loss of driveability.

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CONTENTS

APPENDIXES

Figures

Tables

SECTION I

SUMMARY

The Fuel Injection Development Corporation, FIDC, has developed a fuel vapor injector/igniter system for use on existing automobile engines. The FIDC system consists of two subsystems: a fuel vapor injector/igniter (FVI), and a lean limit controller (LLC). The FVI provides both a means for fuel vapor injection into the cylinder and an ignition source for the charge, while the LLC attempts to control the engine equivalence ratio* (ϕ) to the lean limit of driveability.

JPL was requested to evaluate the FIDC system for the Energy Research and Development Administration.** The overall objective was to measure the effectiveness of the FIDC system under controlled laboratory conditions by comparative experimental data. Engine performance, fuel consumption, and exhaust emissions were used as the criteria for comparison. Data were obtained for a Chevrolet vehicle equipped with and without the FIDC system and operating over the 1975 Federal Test Procedure (FTP) urban driving cycle.

Three groups of tests were performed: steady state (engine map) tests with a single-cylinder, Co-operative Fuel Research (CFR) engine; steady-state (engine map) tests with a multicylinder engine; and Federal Test Procedure (FTP) urban driving cycle tests. The driving cycle tests were used to evaluate three engine configurations: the stock engine; the stock engine modified to match the FIDC system equivalence ratio with "optimum" spark advance; and the same engine with the FIDC system and "optimum" spark advance. These were selected so as to allow a comparison of the FIDC system with a stock vehicle, and with a less complicated means of accomplishing the same equivalence ratio reduction as obtained with the FIDC system.

Tests using a CFR engine were conducted in an effort to understand the effect of the FIDC system on the basic combustion processes. Several combinations of RPM and BMEP were chosen for the steady-state tests. These conditions were selected to encompass the ranges frequently encountered by a multicylinder engine while performing the 1975 Federal Test Procedure Urban driving cycle.

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*Equivalence ratio, ϕ, is the stoichiometric air-fuel ratio divided by the operating air-fuel ratio.

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One steady-state condition was also selected for ignition delay and flame speed tests. These measurements were used to compare the ignition delay and flame speed between the baseline engine and the same engine modified by the installation of the FVI spark plug.

Results of the CFR engine tests show that the FVI portion of the FIDC system does alter the combustion process, and the use of the FVI allowed the CFR engine to run leaner without misfire. The CFR engine showed similar operation both with and without the FVI at equivalence ratios of 0.7 and above. At equivalence ratios from 0.6 to 0.7, the CFR engine with the FVI showed lower fuel consumption, lower HC emissions, lower CO emissions, and higher NO_x emissions. These data support the conclusion that the FVI does improve the combustion process at these leaner operating conditions.

The ignition delay and flame speed data were recorded at an equivalence ratio of about 0.9. No significant differences were observed in these data between the baseline and FVI configurations. Based on the previous paragraph, one might speculate that the ignition delay and flame speed difference, if any, would be observed at equivalence ratios between 0.6 and 0.7. Unfortunately, there was not an opportunity to repeat the ignition delay and flame speed tests.

Multicylinder engine tests were conducted to provide steady-state data for a variety of equivalence ratios (ϕ's), spark advances, BMEPs and RPMs. These data were then used as input for a driving cycle computer simulation program and the computer program in turn was used to select "best" values of equivalence ratio and spark advance. The "best" values of equivalence ratio and spark advance are those which provide least fuel consumption, while maintaining acceptable emissions over the 1975 urban driving cycle. These values were then used with the test engine installed in a vehicle, and the vehicle tested over the 1975 FTP on a chassis dynamometer. Also obtained from some of the steady-state tests were a comparison of cylinder-to-cylinder equivalence ratio distribution, with and without the FIDC system installed.

The engine was connected directly to an eddy-current (EC) dynamometer for the steady-state tests. To provide a basis of comparison for the FIDC system, tests with the stock configuration were made at three different equivalence ratios. This variation in equivalence ratio was accomplished by changing the carburetor main metering jets. The jet sizes were #45 (0.045 in. ID, stock), #44 (0.044 in. ID), and #42 (0.042 in. ID, leanest). The #42 jets were finally selected to approximate the equivalence ratio at which the FIDC configuration operated. Spark advance was manually selected for each test condition. Vacuum and centrifugal advance mechanisms were disabled and the spark advance was adjusted for all steady-state tests to provide MBT (minimum advance for best torque), and two conditions retarded from MBT. These retarded conditions were selected at 98% and 95% of the thermal efficiency obtained at MBT.

Fourteen combinations of engine speed and load were tested. The performance of the FIDC system relative to the stock engine was mixed. That is to say, under some conditions the FIDC system was

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superior while under others it showed a disadvantage. The steady-state engine tests showed neither a systematic advantage nor disadvantage for the FIDC system, but an understanding of how the device worked in practice emerged from these tests.

The control strategy built into the FIDC system is to admit excess air into the intake manifold, and hence lean the air/fuel mixture, until misfire occurs, stop the flow of additional air until smooth engine operation is re-established, and then begin the process again. The degree to which the FIDC system could lean the engine was dependent on the operating condition. In particular at high loads, i.e., manifold pressure close to 1 atm., the amount of additional air that can be aspirated is very limited. This strategy and hardware implementation lead to three broad kinds of operation. They are:

(1) Ineffective. At intake manifold pressures near 1 atmosphere the FIDC system has little or no effect, and the equivalence ratio is not much different from that which the carburetor by itself produces. Fuel consumption and emissions are also little different from the unmodified engine.

(2) Effective. In this case the FIDC system is able to lean the engine, but not to the misfire limit. There were many instances where the effect of the FIDC system was significant, but the misfire limit was not reached. The amount of additional air which could be aspirated was still less than required for misfire and/or the margin between the stock operating condition and misfire was large. This is the condition for which the FIDC system shows a real advantage. The equivalence ratio is reduced, but the combustion process is still regular. Hence, the fuel consumption is reduced and the hydrocarbon and carbon monoxide emissions are improved. Note, however, that unless the equivalence ratio is reduced well below 0.9 the oxides of nitrogen will be increased.

(3) Detrimental. In this case the FIDC system leans the engine to the misfire limit. This is an unfavorable condition since the misfires (or more accurately, severely degraded combustion) lead directly to increased fuel consumption and hydrocarbon emissions.

Tests were made with the FVI configuration and one stock configuration (#42 carburetor jets) to determine the cylinder-to-cylinder equivalence ratio. For these tests the engine was equipped with exhaust headers which permitted emissions measurements from individual cylinder exhaust streams. An individual cylinder equivalence ratio was calculated from these emissions measurements using the carbon balance technique. With the limited number of test conditions, no systematic differences in the distribution characteristics of the two engine configurations could be identified. In particular, no improvement in distribution could be shown for use of the FIDC.

To help establish the best spark advance strategy for the vehicle tests, the steady-state engine data (see Section V) were used to predict the performance of a vehicle over the urban driving cycle using a computer simulation of the cycle. The computer program divides the driving cycle into 1-second increments and uses the vehicle velocity profile, vehicle inertia, tire rolling resistance, and vehicle drive train losses to determine the required engine brake mean effective pressure (BMEP) and engine RPM. Tables of brake specific fuel consumption and brake specific emissions (BSFC, $BSNO_x$, BSCO, BSHC) as functions of BMEP and RPM, which are derived from the steady-state engine dynamometer tests, are used to calculate the fuel consumption and emissions for each time increment. The results for each time increment are then summed to obtain the fuel consumption in miles per gallon (MPG) and emission in grams per mile (g/mi) for the cycle.

The following parameters were selected to be used for the vehicle driving cycle tests:

(1) Number 45 carburetor jets, and a 6 degree initial spark advance were used for the stock vehicle. The 6 degree spark advance is specified for the vehicle, and the number 45 jets provided the average equivalence ratio specified for the stock configuration.

(2) Number 42 carburetor jets, and a 16 degree initial spark advance were used for the modified vehicle. The number 42 jets provided a close approximation to the equivalence ratio of the FIDC system at steady state conditions, and the 16 degree spark advance provided the "best" fuel economy and emissions for this configuration as predicted by the driving cycle computer program.

(3) The number 45 carburetor jets, and an 11 degree initial spark advance were used for the vehicle driving cycle tests with the FIDC system. The jets used with the FIDC system should be stock (by design of the system), and the 11 degree spark advance was predicted to provide the "best" fuel economy and emissions as a result of driving cycle computer program.

The test engine used for the steady-state tests was installed in a 1973 Chevrolet Impala chassis equipped with a 350 Turbo-Hydramatic transmission, a 2.73 rear axle ratio, and G 78 x 15 bias ply tires. The inertia weights selected were those for a 4500 pound car. This is the vehicle configuration for which the FIDC system was developed, although the FIDC vehicle was a 1975 Chevrolet Malibu with the equivalent driveline. Gasoline consumption was determined by using a weigh tank and was also calculated using the carbon balance technique. Exhaust emissions were determined using a constant volume sampling (CVS) system as prescribed in the Federal Register.

The FIDC configuration demonstrated slightly (about 5 percent) better fuel economy than the stock configuration, but the modified stock configuration (i.e., #42 carburetor jets and 16 degree initial advance) produced a fuel economy 12% better than stock. Also, the HC emissions from the FIDC system were about 230 percent higher than those for the modified stock configuration. The FIDC configuration gives significantly poorer HC emissions during the cold start transient portion of the cycle. This indicates that the cold start implementation of the FIDC system is not optimum. Even without this problem, however, the HC emissions for the FICD system would exceed the HC emissions for the modified stock configurations. Both the FIDC system and the modified stock engine adversely affected driveability.

In the final analysis then, the FIDC system is a device which will yield a modest, positive effect on fuel consumption, but at the price of increased emissions, loss of driveability, and the monetary value of the device itself. These disadvantages would seem to outweigh the advantages, particularly in view of the fact that the effects can be achieved by very simple modifications to the basic engine.

SECTION II

INTRODUCTION

Fuel Injection Devlopment Corporation (FIDC), located in Bellmawr, New Jersey, has developed a fuel vapor injection/igniter system for use on existing automobile engines. The FIDC system consists of two subsystems: A fuel vapor injector/igniter (FVI), and a lean limit controller (LLC). The FVI provides both a means for fuel vapor injection into the cylinder and an ignition source for the charge, while the LLC controls the engine equivalence ratio* (ϕ) to the lean limit of driveability.

JPL was requested to evaluate the FIDC system for the Energy Research and Development Administration.** The overall objective was to measure the effectiveness of the FIDC system under controlled laboratory conditions by comparative experimental data. Engine performance, fuel consumption, and exhaust emissions were used as the criteria for comparison. Data were obtained for a Chevrolet vehicle, equipped with and without the FIDC system, and operating over the 1975 Federal Test Procedure (FTP) urban driving cycle. Note that except for altering initial spark timing, no attempt was made to optomize the multicylinder engine for operation with the FIDC system. For example, the exhaust gas recirculation (EGR), and other subsystems of the engine were not altered to maximize the potential benefits from the FIDC system. The FIDC system, being an aftermarket retrofit device, could easily include a change in initial spark timing as part of the installation, but the EGR and similar subsystems would probably not be altered.

This report provides a complete description of the tests performed, and an analysis of the data from those tests. Three groups of tests were performed: steady-state (engine map) test with a single-cylinder, Co-operative Fuel Research (CFR) engine; steady-state (engine map) tests with a multicylinder engine; and Federal Test Procedure (FTP) driving cycle tests. The driving cycle tests were used to evaluate three engine configurations: the stock engine; the stock engine modified to match the FIDC system equivalence ratio with "optimum" spark advance; and the same engine with the FIDC system. These were selected to compare the FIDC system with a stock vehicle, and with a less complicated means of accomplishing the same equivalence ratio reduction obtained with the FIDC system. There is, additionally, a discussion of the predicted FTP driving cycle performance based upon the V-8 steady-state data, a discussion of the operational characteristics of the FIDC system and discussion of the potential application of this FIDC system. The latter considers the system retrofit capability, maintenance, and economics. Finally, there are some driver impressions and concluding remarks.

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*Equivalence ratio, ϕ, is the stoichiometric air-fuel ratio divided by the operating air-fuel ratio.

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SECTION III

DESCRIPTION OF FIDC SYSTEM

The FIDC system, shown schematically in Figure 1 and pictured in Figure 2, consists of two subsystems. These are the Fuel Vapor Injector/Igniter (FVI) and the Lean Limit Controller (LLC). The FVI subsystem includes a fuel delivery system which routes the major portion of an engine's fuel direcly to the stock carburetor. However, a small portion of the fuel is diverted to the FVI's. Each FVI shown in Figure 3 combines the function of the conventional spark plug with a gasoline distribution function. The center electrode of an ordinary spark plug has been replaced with a small piece of tubing. Fuel is fed through the tubing and enters the combustion chamber in the vicinity of spark initiation. Upstream of the center electrode tube are a check valve, capillary tube, pressure regulator, and the normal fuel delivery system. Spark is initiated from the center electrode tube of the spark plug. A ground electrode is provided near the tip of the spark plug shroud.

The fuel which enters the combustion chamber directly through the FVI is in addition to the normal air/fuel mixture from the stock carburetor which enters the combustion chamber via the intake valve. Hence, inclusion of an FVI by itself would cause a "richer" than normal air-fuel mixture in the combustion chamber. A second sybsystem, identified as the Lean Limit Controller (LLC), is used to lean the combustion chamber mixture. The LLC admits "extra" air to the engine's induction system between the carburetor and intake manifold. A solenoid valve controls the amount of "extra" air admitted to the engine. An electronic control module uses an input signal from a magnetic pickup which senses changes in the flywheel rim velocity. The electronic control module output controls the solenoid valve. A sudden decrease in flywheel rim velocity is interpreted as engine misfire. The LLC subsystem is continuously seeking the engine's lean misfire limit. "Extra" air is added until misfire is detected, then a portion of the "extra air" is deleted. The process is continuous while the engine is running.

The FIDC system is designed to operate above 1000 RPM. Below 1000 RPM, the complete FIDC system (FVI and LLC) automatically turns off.

SECTION IV

CFR ENGINE TESTS

Tests using a Co-operative Fuel Research (CFR) engine were conducted in an effort to understand the effect of the FIDC system on the basic combustion processes. Several combinations of RPM & BMEP were chosen for the steady-state tests. These conditions were selected to encompass the ranges frequently encountered by a multi-cylinder engine while performing the Federal Test Procedure (1975 Urban Federal Test Procedure). The test conditions are shown in Figure 4.

The Co-operative Fuel Research (CFR) engine is a single cylinder engine designed for basic combustion and fuel research. The CFR engine at JPL has a 2.8125 inch bore, and 4.50 inch stroke (51.37 CID). The compression ratio is variable from 6.1 to 22.5:1 and was set at 8.5:1 for these tests. The cylinder head is a Removalbe Dome Type (RDH), with a hemispherical contour above the cylinder. The head has a spark plug hole and a 7/8"-18 transducer hole. The piston is dome-topped, and has 3 rings. The valves are inclined at an angle of 30 degrees from vertical (the cylinder center line is vertical). The breaker-points and coil ignition system is used on the CFR engine. The non-standard induction system used at JPL consists of a 2-feet long, 1-3/8 inch I.D. tube through which the engine air is inducted. Gasoline is injected through a pneumatic atomizer into the incoming air stream.

The CFR engine is connected to an appropriately sized eddy-current (EC) dynamometer. The CFR engine and dynamometer are supplied as an assembly by Waukesha Motor Company (the dynamometer is manufactured by Eaton Power Transmission Systems).

The CFR engine induction system was modified as required to accept the installation of the FVI System (note that the LLC was not used for the single cylinder engine tests). The standard spark plug was replaced and the fuel delivery plumbing was split; part of the fuel passes through the FVI, and the remainder through the baseline atomizer. Direct fuel flow measurements were made only of the total fuel being used by the engine. The air and fuel plumbing for the CFR engine, as well as measurement locations, are shown in Figure 5.

Acceptable data for three of the test conditions could not be obtained. Consistent, repeatable ignition could not be obtained at lower loads and/or RPMs. The unobtainable test conditions were: 500 RPM, 50 psi BMEP; 1000 RPM, 50 psi BMEP; 1500 RPM, 25 psi BMEP. Data for four to nine values of equivalence ratio were obtained at each of the remaining test conditions.

One steady-state condition (1500 RPM, 50 psi BMEP) was also selected for ignition delay and flame speed tests. These measurements are used to compare the ignition delay and flame speed between the baseline engine and the same engine modified by the installation of the FVI spark plug. The cylinder pressure as a function of time was recorded on an oscillograph with the engine under load, and also with the engine being motored. A comparison of these data for the two engine configurations can provide insight into any combustion process changes due to the installation of the FYI System.

A. DISCUSSION OF TEST RESULTS

At each operating condition, several equivalence ratios and spark advances were tested. Data were obtained for both the baseline CFR system and the FVI system. The results for one operating condition (2500 RMPM, 50 psi BMEP) are discussed in the main body of this report. The results from this particular operating condition are typical of all the CFR results. A summary of all CFR data is included in Appendix A.

Results for the baseline CFR configuration are given in Table 1. The corresponding data for the FVI system are given in Table 2. In these tables, fuel consumption is expressed in (lbm/Bhp-hr) while emissions are given in (g/min). The air fuel ratio of the engine is expressed in terms of the system equivalence ratio which is defined as follows:

$$\phi \text{ system} = \frac{\dfrac{\dot{M}_A}{\dot{M}_G \, \zeta}}{\dfrac{\dot{M}_A}{\dot{M}_G}}$$

where M_A = Total air flow to the engine

M_G = Total gasoline flow to the engine

ζ = Stoichiometric air fuel ratio (A/F) for test fuel

The total gasoline flow used in this calculation includes both the gasoline to the injector/igniter plug and the gasoline to the atomizer. At each equivalence ratio, three spark advances were tested. A real-time plot was made of torque versus spark advance while holding engine RPM and equivalence ratio constant. The minimum spark advance for best torque (MBT) timing was determined from this plot and was the largest advance tested. The torque values corresponding to 0.98 and 0.95 times the MBT value were calculated, and the corresponding spark timings were read from the plot. Data was recorded at the MBT condition, and the 0.98 and 0.95 MBT conditions. This technique for selecting spark timing resulted in a varying amount of spark retard relative to MBT timing.

Fuel consumption as a function of equivalence ratio is given in Figure 6 for the baseline and FVI configurations. The data shown are for MBT spark timing. The fuel consumption of the engine decreases as the equivalence ratio decreases until the combustion interval become too long for efficient engine operation. In the limit, engine operation ceases completely because of misfires. The baseline CFR configuration reaches its minimum fuel consumption at an equivalence ratio of about 0.7. There is a significant increase in fuel consumption for equivalence ratios less than 0.7. The fuel consumption for the FVI configuration is about the same as that for the baseline configuration for equivalence ratios greater than 0.7. However, the fuel consumption of the FVI configuration continued to decrease for leaner operation, and apparently had not reached its minimum value for an equivalence ratio of about 0.61 (the minimum value tested). Note that the lean limit for the test fuel used is 0.59. Unlike the baseline configuration, there was little or no region of degraded combustion for the FVI. The dividing line between "good" combustion and no combustion was very sharp. Hence the FVI curve of Figure 6 shows no characteristic up-turn of the BSFC curve at lean conditions.

The effect of spark retard on fuel consumption is illustrated in Figure 7 for the baseline and FVI configuration. Data for spark advances which are retarded 7-10° (depending on the S. A. required to give 98% of MBT) from MBT timing are compared with data for MBT spark timing. Except for the lowest equivalence ratio, the retarded spark results in about a 5 percent increase in fuel consumption. For the retarded spark condition, the fuel consumption reaches a minimum for an equivalence ratio of about 0.65 and then increases significantly for leaner operation.

Hydrocarbon (HC) emissions are shown plotted versus equivalence ratio in Figure 8 for the baseline and FVI configurations. The data are for MBT spark timing. As the equivalence ratio is reduced, the HC emissions decrease slightly, reaching a minimum value for an equivalence ratio of about 0.75, and then increase again for leaner equivalence ratios. For the baseline CFR configuration, the HC emissions increase sharply for equivalence ratio less than 0.7 indicating the onset of misfire. This coincides with the sharp increase in fuel consumption shown in Figure 6. Note that this apparent advantage in HC emissions for the FVI system was not realized in the multicylinder tests (see Page 22).

The effect of spark retard on HC emissions is illustrated in Figures 9 and 10 for the baseline and FVI configurations respectively. Again, data for spark advances which are retarded 7-10° from MBT timing are compared with data from MBT spark timing. Hydrocarbon emissions decrease slightly by retarding spark timing, although the amount of spark retard tested is too small to show a significant affect. At equivalence ratios less than 0.7, the FVI configuration produces lower HC emissions than the baseline configuration. At equivalence ratios greater than 0.7, the effect of the hardware configuration on HC emissions was insignificant. Once combustion becomes degraded through reduction of equivalence ratio, spark retard has little or no effect on HC emissions as seen in the Figure 9 data for the baseline engine.

Carbon monoxide (CO) emissions are shown plotted versus equivalence ratio in Figure 11 for the baseline and the FVI configurations. The data are for MBT spark timing. In the baseline CFR configuration, the CO emissions start increasing for equivalence ratios less than approximately 0.75. The CO emissions for the FVI configuration remain constant over the range of equivalence ratios tested. This is, again, an indication that combustion remains stable with the FVI configuration as the equivalence ratio is decreased to near the flammability limit. This is possibly due to the stratified charge provided by the FVI. The baseline configuration combustion becomes erratic at equivalence ratios below approximately 0.75.

Nitrogen oxide (NO_x) emissions are shown plotted versus equivalence ratios in Figure 12 for the baseline and FVI configurations. The data are for MBT spark timing. Decreasing the equivalence ratio below 0.9 is an effective means of reducing NO_x emissions in both configurations. This is probably the result of decreasing peak temperature and decreasing the time at peak temperature for lean combustion conditions. The NO_x emissions for the baseline configuration drop below those for the FVI configuration for equivalence ratios below approximately 0.75 because of the degraded combustion under these lean conditions.

The tradeoff between fuel consumption and NO_x emissions is illustrated in Figure 13. For MBT spark timing, the data for the baseline and FVI configurations can be represented by a single curve for NO_x emissions levels greater than 1.0 g/min. The FVI configuration produced a NO_x level of 0.5 g/min with no fuel consumption penalty; however, the baseline configuration suffers approximately a 10 percent penalty in fuel consumption at the lower NO_x level.

The relationship between the HC and NO_x emissions is shown in Figure 14 for the baseline and FVI configurations. At any given NO_x level, the FVI configuration produced slightly more HC emissions than the baseline configuration. For NO_x emissions levels less than 1.0 g/min, both configurations show significant increases in HC emissions.

These sensitivity test results indicate that at least for some operating conditions, the FVI system shows better lean operating characteristics than the baseline CFR system. However, even with the apparent superior lean operating characteristics of the FVI system, the HC emissions increase at equivalence ratios less than 0.70. These improved lean operating characteristics are consistent with the claims that the FIDC system converts a conventional engine to a stratified charge engine.

B. IGNITION DELAY AND FLAME SPEED DATA

Cylinder pressure-time traces can be used to derive information about ignition delay and combustion duration. This information is useful in evaluating systems which alter the combustion process. Cylinder pressure measurements were made on the CFR engine using both the baseline and FVI configurations. Ignition delay and combustion duration information were obtained from both motoring and firing pressure-time traces. These data were recorded on an oscillograph and successive firing cycles were averaged to arrive at the firing data discussed here.

To help in analyzing pressure-time data, several parameters are defined in Figure 15. An overlay of a firing and a motoring pressure-time trace are shown there. The combustion interval is defined as the period from the initiation of the spark to the peak cylinder pressure. Ignition delay is defined as the period from spark initiation to the first measurable rise in cylinder pressure above the motoring pressure trace. The ignition delay period corresponds to the time required for transition from the spark kernel to a developed flame front.

Significant errors in determining ignition delay and effective combustion duration can arise because of the difficulty in accurately determining the crank angle at which cylinder pressure first rises above the motoring pressure. Two additional parameters are defined to avoid this difficulty. These parameters are given in Figure 16, which shows the normalized pressure difference between the firing and motoring pressure traces as a function of crank angle. An ignition delay parameter α, is defined as the period from spark initiation until cylinder pressure reaches 10 percent of the peak pressure difference between firing and motoring traces. A flame speed parameter β, is defined as the time required for the cylinder pressure to change from 10 percent to 95 percent of the peak pressure difference between firing and motoring traces.

The average firing and motoring pressure-time traces for one of the CFR tests of the FVI configuration are shown in Figure 17. The corresponding normalized pressure difference plot is given in Figure 18. The ignition delay and flame speed data from the six CFR test conditions are shown in Table 3. The tests were run at an equivalence ratio of 0.87 for both the baseline and FVI configurations. Plots of the ignition delay parameters in Figure 19 and the flame speed parameters in Figure 20 reveal no significant difference in the results for the baseline and FVI configurations at equivalence ratios around 0.9. One would expect some differences in ignition delay and flame speed at $\phi = 0.7$. Since the FVI showed improved lean combustion characteristics in terms of fuel consumption and emissions it seems reasonable to expect these are the result of some change in the combustion processes under the lean condition. The planned objective was to compare the combustion characteristics between the baseline and FVI configurations at the same (predetermined) equivalence ratio. This objective was completed, and no difference in the combustion characteristics were observed. Unfortunately, there was not an opportunity to repeat these tests at a lower equivalence ratio. Having the results for $\phi = 0.7$ would not change the conclusions derived from the multicylinder and driving cycle tests.

SECTION V

MULTICYLINDER ENGINE DYNAMOMETER TESTS

Multicylinder engine tests were conducted to provide steady-state data for a variety of equivalence ratios (ϕ's), spark advances, BMEP's and RPMs. These data were then used as input for a driving cycle computer simulation program and the computer program was used to select the best values of spark advance. These best values were then used with the test engine installed in a vehicle, and tested over the 1975 FTP on the chassis dynamometer. Also obtained from some of the steady-state tests, was a comparison of cylinder-to-cylinder equivalence ratio distribution, with and without the FIDC System installed.

The multicylinder engine used for these tests was a 1975 Chevrolet 350-2V engine in the 49 state emissions control configuration. FIDC's development engine and vehicle were duplicated as closely as possible. The engine was assembled using a 1975 engine originally obtained through the Chevrolet dealer parts system. Originally the engine came with a 4-barrel carburetor. The 2-barrel carburetor, manifold, and all emissions equipment required to make the engine into the desired configuration were obtained through the Chevrolet dealer parts system, with the exception of some portions of the carburetor. Replacement parts for the desired engine configuration were strictly adhered to with the exception of the 2-barrel carburetor. In order to simulate the desired test engine configuration, a carburetor was assembled using the main body and other critical parts from a production carburetor. The carburetor assembly is discussed in Section VIII.

The cylinder heads, pistons, and camshaft were verified, through use of the Chevrolet parts book, to be the same as a 1975 49-state vehicle. The exhaust system, including the manifolds, exhaust catalyst, muffler and pipes were purchased for the 1975 49-state vehice, and used for both the engine dynamometer tests and driving cycle tests. Vehicle components which could affect the driving cycle tests were verified with a representative of the FIDC to be the same as those used by FIDC. These items included the Turbo-Hydromatic 350 transmission, 2.73 rear axle ratio, and G78 x 15 tires. All of the engine emissions control hardware were verified with the FIDC representative to be the same as that used on the FIDC development vehicle.

The emissions equipment included a positive crankcase ventilation (PCV) system, exhaust gas recirculation (EGR), early fuel evaporation (EFE) (vacuum operated heat-riser value), and an exhaust catalyst. This engine is not equipped with an air injection reactor (AIR) system. A fuel vapor recovery system, although used on the car being simulated, was not used with the test engine. Fuel was supplied to the carburetor from a pressurized facility fuel delivery and measuring system as shown in Figure 21. The exhaust system configuration is shown in Figure 22.

The engine was connected directly to an eddy-current (EC) dynamometer for the steady-state tests. To provide a basis of comparison to the FIDC system, tests with the stock configuration were made at three different equivalence ratios. This variation in equivalence ratio was accomplished by changing carburetor main metering jets. The jet sizes were #45 (0.045", stock), #44 (0.044"), and #42 (0.042" leanest). The #42 jets were finally selected to approximate the equivalence ratio at which the FIDC configuration operated.

Spark advance was manually selected for each test condition. That is to say, the vacuum and centrifugal advance mechanisms were disabled for the purposes of the steady-state tests. The spark advance was adjusted for all steady-state tests to provide MBT (minimum advance for best torque), and two conditions retarded from MBT. These retarded conditions were selected at 98% and 95% of the torque obtained at MBT. A description of the technique used appears previously in the CFR section of this report. The only difference was that equivalence ratio was not a variable for the multicylinder engine since a carburetor was being tested.

For equivalence ratio distribution tests, the stock exhaust manifolds were replaced with exhaust headers. The exhaust headers were modified to permit sampling the exhaust from each cylinder. From the exhaust gas composition, an equivalence ratio was calculated for each cylinder.

The engine, with the FIDC system and headers for the equivalence ratio distribution test, is shown in Figure 23 connected to the EC dynamometer.

A. SENSITIVITY DATA

Tests were conducted on both the stock and FIDC configurations to determine the sensitivity of fuel consumption and emissions to changes in spark advance. In addition, the equivalence ratio for the stock configuration was varied in order to match the equivalence ratios produced by the FIDC system.

The stock configuration was tested at three equivalence ratios corresponding to three carburetor settings (#45 main metering jets, #44 main metering jets, and #42 main metering jets). Engine operating conditions, shown in Figure 24 were selected to be representative of those encountered in the urban driving cycle. For each run condition, all four engine configurations (i.e., the FVI and three stock systems) were tested at three spark advance settings (MBT timing and two retarded settings). Only data from two engine operating conditions will be discussed here; however, all engine data are included in Appendix B. Also identified on Figure 24 are the four run conditions for which cylinder-to-cylinder distribution data were taken.

The two operating conditions selected for discussion are chosen to represent the relative data extremes. They show the FIDC system at one condition to its best advantage, and at one condition with its least advantage. In general, the data from the other engine conditions lies between these extremes.

Sensitivity data with the engine operating at 1500 RPM and 75 psi BMEP are given in Table 4. The system equivalence ratio is defined in the same way it was defined for the CFR tests (see Section III). For the FIDC configuration, the total gasoline flow includes both the gasoline flow through the carburetor and the gasoline supplied to the injector/igniter plugs. Fuel consumption is expressed in (lb_m/hp-hr), and exhaust emissions are given in (g/min).

Fuel consumption is shown plotted versus equivalence ratio in Figure 25. The data are all for MBT spark timing. All three stock engine configurations are rich ($\phi_{sys} > 1.0$) at this operating condition. Fuel consumption decreases as the stock engine is made to operate at leaner equivalence ratios. The FIDC configuration runs much leaner ($\phi_{sys} = 0.83$) than the stock configurations at this operating condition and likewise shows lower fuel consumption.

In viewing the fuel consumption data shown in Figure 25, one should note that the #42 carburetor jets do a poor job of approximating the equivalence ratio of the FIDC system at 1500 RPM and 75 psi BMEP. The #42 jets were selected to approximate the FIDC system equivalence ratio over the wide RMP/BMEP range experienced for the urban driving cycle. The #42 jets approximate the FIDC system equivalent ratio best when the carburetor is out of the power enrichment regime. At 1500 RPM and 75 psi BMEP, the carburetor power enrichment masks the operation of the main metering circuit.

A comparison of the HC emissions for the four engine configurations is given in Figure 26 for MBT spark timing and for spark retarded from MBT spark timing. For MBT spark timing, the HC emissions for the FVI system are higher than those for the two leaner stock configurations. In all cases, spark retard leads to a reduction in HC emissions; however, the reduction is much larger for the FVI system for this run condition. For the stock configurations, which are all running rich, a reduction in equivalence ratio leads to a reduction in HC emissions.

Oxides of nitrogen (NO_x) emissions are shown plotted versus equivalence ratio in Figure 27 with all engine configurations set at MBT spark timing. For the stock configurations, which are running rich, an increase in equivalence ratio leads to a decrease in NO_x emissions. This results partially from the fact that under rich conditions less oxygen is available for the production of NO_x emissions and partly from the reduced combustion temperature. The NO_x emissions for the FVI system are much higher than those for the stock configurations because the FVI system operates at (for 1500 rpm, 75 psi BMEP) $\phi = 0.83$, which corresponds very nearly to peak NO_x production. Peak NO_x production generally occurs in the equivalence ratio range between 0.85 and 0.95.

The effects of spark advance on fuel consumption and NO_x emissions are given in Figures 28 and 29. As spark timing is retarded from MBT spark advance, fuel consumption increases for all configurations. The NO_x emissions are reduced when the timing is retarded from its MBT value. This reduction in NO_x emissions is a result of both the decrease in peak combustion temperature and the decrease in residence time above the threshold temperatures for NO_x formation.

The tradeoff between fuel consumption and NO_x emissions is illustrated in Figure 30. For the stock configurations, the data for all equivalence ratios and spark advances can be adequately represented by a single curve for this run condition. Reduction of the level of NO_x emissions from 10 g/min to 5 g/min results in a 10 percent increase in fuel consumption. At the same NO_x emissions level, the fuel consumption of the FIDC system is about 7 percent less than those of the stock configurations for this engine operating condition.

The relationship between HC emissions and NO_x emissions is shown in Figure 31. For all engine configurations, retarding the spark from MBT timing reduces both HC and NO_x emissions for this run condition. At the same level of NO_x emissions, the HC emissions of the FIDC configuration are less than those from any of the three stock configurations. (Note that the trends shown in Figure 31 for the multicylinder engine and Figure 14 for the CFR engine cannot be directly compared from the two figures. The multicylinder data shown in Figure 31 indicates the trend while varying spark advance, and maintaining a relatively constant equivalence ratio. Figure 14 shows CFR data which maintains MBT spark advance, and allows equivalence ratio to vary.)

The results for a second run condition will be discussed next. Sensitivity data with the engine operating at 1000 RPM and 25 psi BMEP is given in Table 5. The parameters and the units used are the same as those for the previous set of data.

A plot of fuel consumption versus equivalence ratio is given in Figure 32. As the stock engine is made to operate at leaner equivalence ratios, the fuel consumption decreases as would be expected*. In this case, the fuel consumption of the FIDC system is about 15 percent higher than the fuel consumption of the stock configuration for the same equivalence ratio. The reason for this

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*It is recognized that in Figure 32 the carburetor main jet sizes do not follow the expected progression; i.e. the smallest jet size does not produce the leanest operation. Similar effects can be seen in the tabulated data of Appendix B. No investigation of this apparent anomaly was made, but the most likely explanation is that several carburetor circuits are functioning in parallel. For the purposes of the tests reported here, these effects are not important. The #42 jets were selected so as to produce the same equivalence ratio as the FIDC system over a broad range of operating conditions, and they do that as evidenced by the vehicle test results. However for any particular engine operating condition the #42 jets may not provide the best match or even the leanest operation.

difference is not readily apparent, however the hydrocarbon data described in the next paragraph indicates that the combustion process is degraded.

A comparison of the HC emissions for the four engine configurations is given in Figure 33 for MBT spark timing. For the stock configuration, HC emissions decrease with a decrease in equivalence ratio. The HC emissions of the FIDC system are 165 percent higher than the HC emissions of the stock configuration at the same equivalence ratio. This result, coupled with the previous fuel consumption results, indicates poorer combustion with the FIDC system than with the stock configurations at the operating condition. The excessive hydrocarbons from the FIDC system appear to result primarily from the control strategy. Leaning an engine to the point of misfire must inevitably increase the hydrocarbons. Examination of the data in Table 5 indicates that spark retard is not an effective means of reducing the HC emissions from any of the four engine configurations at this run condition.

Oxides of nitrogen emissions are shown plotted versus equivalence ratio in Figure 34. All data are for MBT spark timing. The stock results show NO_x emissions to be highest for an equivalence ratio of 0.9 as expected, and to decrease as the equivalence ratio is increased. At the same equivalence ratio the NO_x emissions of the FIDC system are 20 percent higher than the NO_x emissions of the stock configuration. The NO_x results are not consistent with the speculated degraded combustion, but the 20 percent difference between the data from the FIDC system and the stock configuration is within the estimated data precision.

The effects of spark advance on fuel consumption and NO_x emissions are given in Figures 35 and 36. Although there is some unexplained scatter in the data, fuel consumption generally increases for the stock configurations as spark timing is retarded from MBT spark advance. The fuel consumption results for the FIDC configuration are insensitive to changes in spark timing over the range of spark advance tested. The NO_x emissions are reduced for all engine configurations when the timing is retarded from its MBT value.

The tradeoff between fuel consumption and NO_x emissions is illustrated in Figure 37. For all four engine configurations, a reduction in the level of NO_x emissions results in an increase in fuel consumption. At the same NO_x level (1.0 g/min), the fuel consumption of the FIDC system is about 15 percent greater than that of the stock configurations for this particular operating condition.

The relationship between HC and NO_x emissions is shown in Figure 38. For all engine configurations, retarding the spark from MBT timing reduces NO_x emissions (see Fig. 29), but has little effect on HC emissions. At the same level of NO_x emissions (1.0 g/min), the HC emissions of the FIDC configuration are about 140 percent higher than those from the stock configurations.

The steady-state engine sensitivity tests were successful from two standpoints. First, the stated objectives, spark advance sensitivity and a match of stock to FIDC equivalence ratio, were met. Second, an understanding of how the FIDC system works in practice began to emerge. As was demonstrated by the two test conditions just discussed, the performance of the FIDC system relative to the stock was mixed. Under some conditions, the FIDC system was superior and under others it showed to a disadvantage.

The control strategy built into the FIDC system is to admit air to the intake manifold, and hence lean the air/fuel mixture, until misfire occurs, stop the flow of additional air until smooth engine operation is re-established, and then begin the process again. The degree to which the FIDC system could lean the engine was dependent on the operating condition. In particular at high loads, i.e. manifold pressure close to 1 atm, the amount of additional air that can be aspirated is very limited. This strategy and hardware implementation lead to three broad kinds of operation. They are:

(1) Ineffective. At intake manifold pressures near 1 atmosphere the FIDC system has little or no effect and the equivalence ratio is not much different from that which the carburetor by itself produces. Fuel consumption and emissions are also little different from the unmodified engine.

(2) Effective. In this case the FIDC system is able to lean the engine, but not to the misfire limit. There were many instances where the effect of the FIDC system was significant but the misfire limit was not reached. The amount of additional air which could be aspirated was still less than required for misfire and/or the margin between the stock operating condition and misfire was large. This is the condition for which the FIDC system shows a real advantage. The equivalence ratio is reduced, but the combustion process is still regular. Hence the fuel consumption is reduced and the hydrocarbon and carbon monoxide emissions are improved. However, it should be noted that unless the equivalence ratio is reduced well below 0.9, the oxides of nitrogen will be higher.

(3) Detrimental. In this case the FIDC system leans the engine to the misfire limit. This is an unfavorable condition since the misfires (or, more accurately, severely degraded combustion) lead directly to both increased fuel consumption and hydrocarbon emissions.

From the steady-state tests no clearly defined advantage for the FIDC system can be identified.

B. CYLINDER-TO-CYLINDER DISTRIBUTION DATA

Tests were made with the FVI configuration and one stock configuration (#42 jet) to determine the cylinder-to-cylinder equivalence ratio distribution. For these tests the engine was equipped with exhaust headers which permitted emissions measurements from individual cylinder exhaust streams. An individual cylinder equivalence ratio was calculated from these emissions measurements using the carbon balance technique. Although the carbon balance technique is not as accurate as the direct mass measurement approach, it is the best available method for calculating individual cylinder equivalence ratios.

Figure 39 is included here to illustrate the magnitude of the difference between the two methods for determining equivalence ratio. The overall system equivalence ration (ϕ_{CB}), calculated by the carbon balance technique, is compared with the overall system equivalence ratio (ϕ_{sys}) based on total gasoline and air supplied to the engine. The better the agreement the closer the data would fall to the 45° line of Figure 39. Under lean conditions ($\phi_{sys} >1$), ϕ_{CB} is about 5 percent less than ϕ_{sys}. Thus the absolute values for the individual cylinder equivalence ratios (see Figures 40-43) may be in error, but it is nevertheless, believed that the relative comparisons between cylinders and between engine configurations are valid.

Cylinder-to-cyliner distribution data were obtained at four engine operating conditions. Comparisons of the equivalence ratio distribution for the FVI and stock configurations are given in Figures 40-43. The individual cylinder equivalence ratios have been normalized with respect to the average equivalence ratio for the eight cylinders. The average equivalence ratios and the standard deviations for each data set are given in Table 6. These parameters are shown plotted versus RPM in Figures 44 and 45. For some of the engine conditions the distributions are very similar, while for others the distributions are quite different. Notice that the system equivalence ratios are different for the FVI and stock configurations. This makes the interpretation of the distribution data more difficult since the leaner equivalence ratio operation would normally have more scatter (i.e. larger standard deviation). With the limited number of test conditions, no systematic differences in the distribution characteristics of the two engine configurations can be identified. In particular, no improvement in distribution could be shown for use of the FIDC system.

C. URBAN DRIVING CYCLE PREDICTIONS

To help establish the best spark advance strategy for the vehicle tests, the steady-state engine data (see Section V) were used to predict the performance of a vehicle over the urban driving cycle using a computer simulation of the cycle. The computer program divides the driving cycle into 1-second increments and uses the vehicle velocity profile, vehicle inertia, tire rolling resistance, and vehicle drivetrain losses to determine the required engine brake mean effective pressure (BMEP) and engine RPM. Tables of brake specific fuel consumption and brake specific emissions (BSFC, $BSNO_x$, BSCO, BSHC) as functions of BMEP and RPM, which are derived from the steady-state engine dynamometer tests, are used to calculate the fuel consumption and emissions for each time increment. The results for each time increment are then summed to obtain the miles per gallon (MPG) and emissions in g/mi for the cycle.

One of the criteria for performing vehicle tests was that only changes to the engine's initial spark advance would be considered. This criterion was adopted because the FIDC system is intended to be a retrofit device, and a recalibration of the distributor advance characteristics would most likely not be a part of a retrofit. However, a resetting of the initial spark advance could easily be a part of installing the system. For the convenience of the reader, the vacuum and centrifugal characteristics used for these tests are shown in Figure 46.

The multicylinder engine dynamometer tests, which have already been described, were performed without using the vacuum and centrifugal advance, but rather the hand-selected spark advance previously described. The data from these tests were assembled into tables of fuel consumption and emissions as a function of BMEP, RPM, and spark advance. Using the recorded data and the computer simulation program, fuel consumption and emissions were computed as a function of five initial spark advances. These were the stock (six degrees BTDC), stock plus five degrees, stock plus 10 degrees, stock plus 15 degrees and stock plus 20 degrees.

Fuel consumption and emissions were computed, using the above parameters, for 4500 and 3500 pound vehicles. The 4500 pound vehicle is the one being tested. The 3500 pound computations were included to observe the effects of the FIDC system on a lighter vehicle, since the industry trend is towards lighter vehicles. These computed results are given in Table 7.

The predicted fuel economy in MPG is shown in Figure 47 plotted versus NO_x emissions in g/mi for a 4500 lb inertia weight vehicle. From the computer simulation a spark advance was selected for the FIDC system that would give its best fuel economy and yet maintain NO_x emissions equivalent to the stock configuration. A spark advance for the modified stock configuration which gave best fuel economy was also selected for the vehicle tests. Note that the spark advance selected gives a slight predicted advantage to the modified stock configuration. Selecting a spark advance to provide the same NO_x values for all configurations would not affect the final conclusions. The spark advances selected for vehicle tests are identified on Figure 47 by the solid symbols. The corresponding HC emissions predictions are shown in Figure 48 plotted versus NO_x emissions. These results indicate that HC emissions for the FIDC configuration should be much higher than the two stock configurations. Similar predictions for a 3500 lb inertia weight vehicle are given in Figures 49 and 50.

Although the absolute magnitudes of the fuel economy and emission predictions from a simulation program are always subject to question, the relative magnitudes are believed to give an adequate indication of how two configurations compare. The predicted results should be used in this relative sense.

The following parameters were selected to be used for the vehicle driving cycle tests: (1) the number 45 jets, and 6 degrees initial spark advance were used for the stock vehicle. The 6 degrees spark advance is specified for the vehicle, and the number 45 jets provided the average equivalence ratio required for the stock configuration. (2) The number 42 jets, and 16 degrees initial sparkadvance were used for the modified vehicle. The number 42 jets provided a close approximation to the equivalence ratio of the FIDC system at steady state conditions, and the 16 degrees spark advance provided the "best" fuel economy and emissions for this configuration as predicted by the driving cycle computer program. (3) The number 45 jets, and 11 degrees initial spark advance were used for vehicle driving cycle tests with the FIDC system. The jets used with a FIDC system should be stock (by design of the system), and the 11 degrees spark advance was predicted to provide the "best" fuel economy and emissions as a result of the driving cycle computer program.

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SECTION VI

DRIVING CYCLE TESTS

Vehicle tests with and without the FIDC system installed were conducted using the 1975 Federal Test Procedures (FTP) as a basis for comparison. Use of the FTP is mandated by the EPA for measuring fuel economy and exhaust emissions. The tests described here were conducted on a CLayton, twin-roll (with 17" roller separation), direct-drive, 125 lb. increment-inertia-weight, chassis dynamometer.

The test engine used for the steady-state tests was installed in a 1973 Chevrolet Impala chassis equipped with a Turbo Hydra-Matic 350 transmission, a 2.73 rear axle ratio, and G 78 x 15 bias ply tires. The inertia weights selected were those for a 4500 pound car. This is the vehicle configuration for which the FIDC system was developed, although the FIDC vehicle was a 1975 Chevrolet Malibu with the equivalent driveline.

Gasoline consumption was determined by using a weigh tank and also calculated using the carbon balance technique. Exhaust emissions were determined as prescribed in the Federal Register using a constant volume sample (CVS) system.

The results of four tests of the stock (baseline) configuration are given in Table 8. Results for the modified stock configuration (#42 carburetor jets) are shown in Table 9. The FIDC configuration results are given in Table 10. Comparisons of the measured results from chassis dynamometer vehicle tests versus the predicted values based on EC dynamometer engine data are shown in Table II. Although the FIDC configuration demonstrated slightly (about 5 percent) better fuel economy than the stock configuration, the FIDC configuration gave less (about 7 percent) fuel economy than the modified stock configuration. Also, the HC emissions from the FIDC system were about 230 percent higher than those for the modified stock configuration. These results are illustrated in the form of bar graphs in Figure 51. Additional insight into the source of the HC emissions is provided in Figure 52 which shows the emissions for the three parts of the urban driving cycle. The FIDC configuration gives signficantly worse HC emissions during the cold start transient portion of the cycle. This indicates that the cold start implementation of the FIDC system is poorly done. Even without this problem, however, the HC emissions for the FIDC system would exceed the HC emissions for the modified stock configurations.

The chassis dynamometer data appears in Appendix C.

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SECTION VII

APPLICATION OF THE FIDC SYSTEM

The retrofit capability of the system provided for testing was straight-forward, and within the capability of a garage or home mechanic. Installation time would probably run up to four or five hours for an inexperienced home mechanic, and might be as short as one and one-half to two hours for an experienced mechanic who has previously installed a system. In all, the installation involved replacing the spark plugs, spark plug wires, installation of some new plumbing to provide fuel to the FVI's, installation and plumbing of a solenoid operated air valve to control air into the air injection manifold, emplacement of an electronic box, and installation of a magnetic sensor in the bell housing close to the flywheel ring gear teeth.

A problem was encountered in installing the magnetic sensor in the bell housing. The difficulty was in finding a location in the bellhousing with enough thickness to tap a hole for the magnetic sensor. The location was constrained by the need to use a drill and tap but also so that the magnectic sensor would not protrude below the bottom of the vehicle.

Special tools were provided by the FIDC to install the spark plugs, and the small tubes which feed fuel to the plugs. Either of these tools could be improvised if it were not readily available. The special spark plug socket is based on a standard socket with slight modification, and the fuel tube insertion tool consists of a small rod, the same diameter as the fuel tubing (one-eighth inch), with the end of the rod stepped down to fit inside the fuel tubing. It serves as an aid to guiding the fuel tubing through the hole in the spark plug wire end boot. Either of these tools (shown in Figure 2) would be inexpensive to purchase.

The relatively small amount of testing reported here provided only limited insight into maintenance problems which may occur. The FVI's would probably have to be occasionally changed, as spark plugs are changed. A frequent reason for changing spark plugs is that the electrodes erode. The FVI's should experience the same erosion. There is also more potential for failure of the FVI's since they contain more components than an ordinary spark plug. They could fail if a contaminant gets lodged in the check valve. The FVI's provided for test in the V8 engine did not require or provide for any gap adjustment. In production, the FVI's will probably cost on the order of a factor of 1.5 to 2 more than ordinary spark plugs, due to their increased number of components.

SECTION VIII

GENERAL DISCUSSION

During the course of the evaluation, several observations were made which bear on the evaluation of the FIDC system, but which cannot be quantified. These observations are reported here.

Each time the FVI's were removed from the engine and reinstalled, it was found that a small portion (about 3/16 inch) of the fuel delivery tubing was lost where it attaches to the FVI spark plug. Attempts to remove and replace the fuel tubing on the FVI were unsuccessful because the FIDC-supplied fuel tubing became brittle where it slipped over the FVI. It was found that cutting off a small portion of the tube at the FVI was much easier. From a maintenance standpoint, installing new fuel delivery tubing each time the FVI's were replaced would eliminate this as a problem.

During the course of testing, some apparent failures of the check valve inside the FVI's were observed. A sharp rise in pressure in the regulated low pressure delivery line to the FVI's was attributed to a check valve failure, although no attempt was made to perform any failure analysis of the FVI's. This problem occurred approximately four times early in the test program, and on both the CFR and V-8 engines. Replacement FVI's were installed to correct each failure.

The insulation on some FVI's exhibited external cracking. This occurred only on FVI's installed on the V-8 engine and in the hottest locations, i.e., cylinders 5 and 6. These locations do not benefit from a good flow of cooling air because of their proximity with the exhaust manifold. The cracked insulation did not pose any apparent functional problems with the FVI's, and no FVI's were replaced solely for cracked insulation. Figure 53 shows a photograph of two FVI's with cracked insulation.

On several occasions, the V-8 engine was run with no fuel flow to the FVI's. It seemed that there was a greater tendency for the engine to misfire under these conditions. This is not too surprising since the spark is well shrouded, and without fuel being fed through the FVI there is less chance of a combustible mixture being in the vicinity of the spark. This is not a problem, as long as the FIDC system is operating as intended, but it could be a problem if there were a failure of the fuel delivery system to the FVI, or a failure of the FVI itself.

Some driver impressions were noted during the chassis dynamometer tests. With both the FIDC system and the modified stock carburetor (with #42 jets) installed, the vehicle performance was very sluggish, and considerable difficulty was encountered in trying to make some of the acceleration ramps in the driving cycle. Of the three configurations tested, the stock configuration was by far the most driveable, but even the stock configuration exhibited small hesitations; a slight indication that the engine was operating too lean. The FIDC and modified carburetor configurations required considerable throttle activity from the driver to accomplish accelerations. This type of throttle activity is of course undesireable since it adversely affects both fuel economy and emissions.

The FIDC system was developed for a 1975 "49 States" vehicle. For the purposes of the tests at JPL, an existing 1973 California vehicle and a 1975 California engine were available, and were "converted" to 1975 49 States devices wherever significant differences which might affect the test results could be identified. The modifications made are noted elsewhere in this report. The only conversion difficulty encountered was with the carburetor.

The vehicle and engine, as originally purchased, were equipped with a four-barrel carburetor set for California emission standards, while the configuration used by FIDC included a 2-barrel carburetor. Two replacemenmt carburetors were purchased through a local Chevrolet dealer parts department, but neither was a duplicate of the production carburetor used by FIDC. This was determined during the early stages of the V-8 steady-state engine tests where it was noted that the replacement carburetors operated at a richer equivalence ratio than had been measured by FIDC. Therefore, the carburetor finally used for the tests reported in Sections V and VI was assembled as follows: the bowl, venturi, main clustor assembly with nozzles, and top (air horn) assembly were borrowed from FIDC, the throttle body (base) plate assembly, power enrichment valve and jets were taken from one of the replacement carburetors, and the "stock" (#45) jets were selected so that the fuel/air ratio would match the nominal fuel/air ratio of a production carbuertor.

During the preparation for the V-8 steady state tests, the operation of the lean limit controller (LLC) was tested to determine its maximum effect; i.e., its maximum ability to provide "extra" air to the engine. The object of running these conditions was to determine the lower limit of how lean the engine could be run, when limited only by the amount of air which could be aspirated through the FIDC feed plate under the carburetor.

A second objective of running these conditions was to record emissions data for the various measured equivalence ratios so that the overall engine equivalence ratios could be inferred from the emissions data. This was necessary so that the effect, if any, of measuring the air flow through the LLC could be determined.

The results of these tests clearly indicated that there was not any effect of the operation of the LLC by connecting the LLC air source into the same measured air which feeds the carburetor. It was also observed that the maximum amount of air which can be added to the engine through the LLC feed plate is dependent upont the engine load (or manifold pressure). For moderate loads, the equivalence ratio could only be reduced from 0.89 to 0.83. At low loads, enough additional air could be added to cause the engine to misfire; $\phi = .78$ to .82. For high loads, little or no additional air could be added to the engine through the LLC. (For the purposes of these tests, high loads are those in the 75-100 psi BMEP range, and low loads are those in the 5-25 psi BMEP range.)

The effect of the LLC solenoid bleed screw valve on emissions was recorded, and the bleed screw was adjusted according to the FIDC instructions. An "average" condition for the 1975 FTP driving cycle, 1800 RPM, 35.6 HP, and 30 degrees BTDC spark advance, was selected. Operating the engine at this steady-state condition, the emissions were recorded at one-half turn increments of the bleed screw. It was determined that about four turns in (from the full counterclockwise position) on the bleed screw produced the "best" combination of HC and NO_x emissions. Approximately 500 ppm HC and 800 ppm NO_x were recorded with the bleed screw four turns in. The bleed screw was left in this position for all subsequent tests.

SECTION IX

CONCLUSIONS AND RECOMMENDATIONS

The FIDC system demonstrated a modest (5%) fuel consumption reduction relative to a stock vehicle when measured according to the Federal Test Procedure. This improvement in fuel consumption was accompanied by a substantial increase in hydrocarbon emissions. A larger reduction in fuel consumption (12%) was demonstrated by "leaning out" the stock engine. This leaning out, which was achieved by re-jetting the carburetor, was accompanied by a small decrease in hydrocarbons. Both these techniques for improving fuel consumption also result in increased oxides of nitrogen emissions and noticeably degraded driveability. The carbon monoxide emissions were reduced for both of the nonstock configurations.

The excessive hydrocarbons from the FIDC system appear to result primarily from the control strategy. Leaning an engine to the point of misfire must inevitably increase the hydrocarbons. The increased oxides of nitrogen are also inherent in the FIDC control strategy, since the operating equivalence ratio is near that for maximum NO_x production. This decrease in equivalence ratio is, of course, what produced the desirable decrease in fuel consumption.

Results of the CFR engine tests show that the FVI portion of the FIDC system does alter the combustion process and the use of the FVI allowed the CFR engine to run leaner without misfire. This positive affect on engine operation was also observed under some operating conditions for the multicylinder engine tests. The use of the FIDC system did alter the cylinder-to-cylinder distribution in the V-8 tests, but no systematic improvement could be identified.

With one exception, installing the FIDC system presented no problems. A person with modest mechanical skills should have no major difficulties, although this definitely would not be a job for a novice. The one problem encountered during installation was the placement of the "misfire detector". Some care and knowledge are required to meet the several conflicting requirements.

In the final analysis, the FIDC system will yield a modest, positive effect on fuel consumption, but at the price of increased emissions, loss of driveability, and the monetary value of the device itself. The disadvantages would seem to outweigh the advantages.

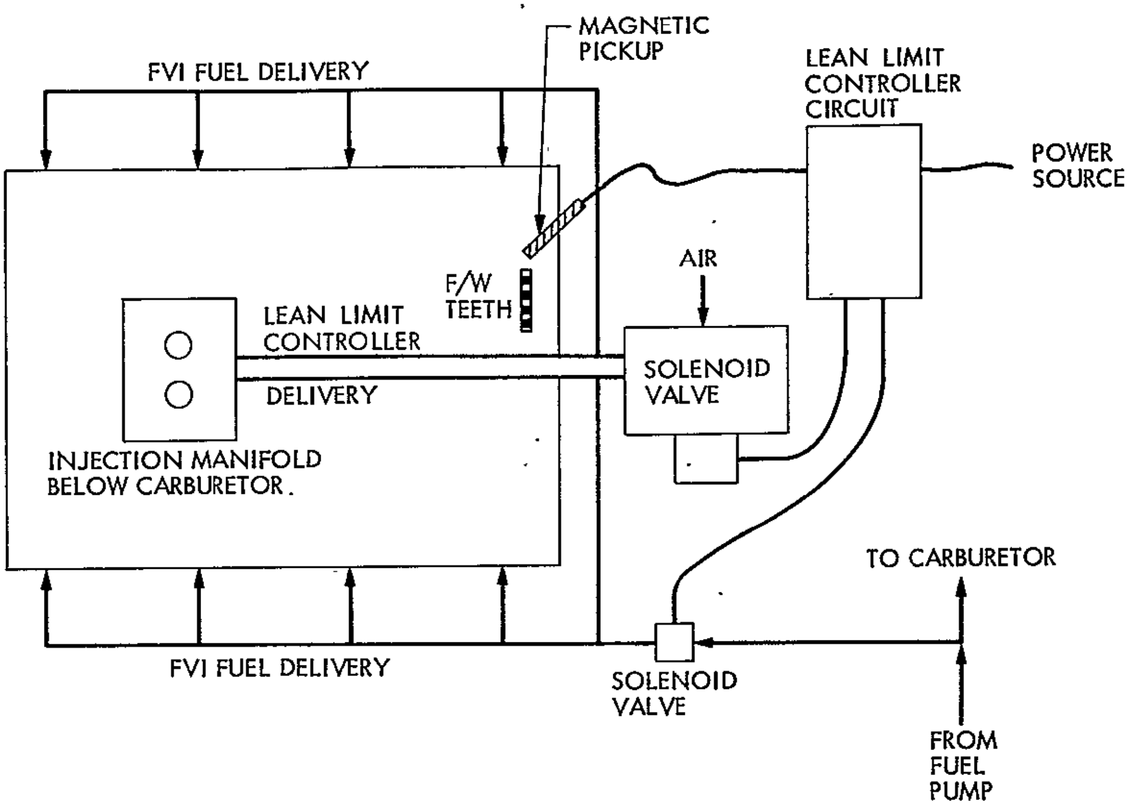

Figure 1. FVI-LLC Schematic

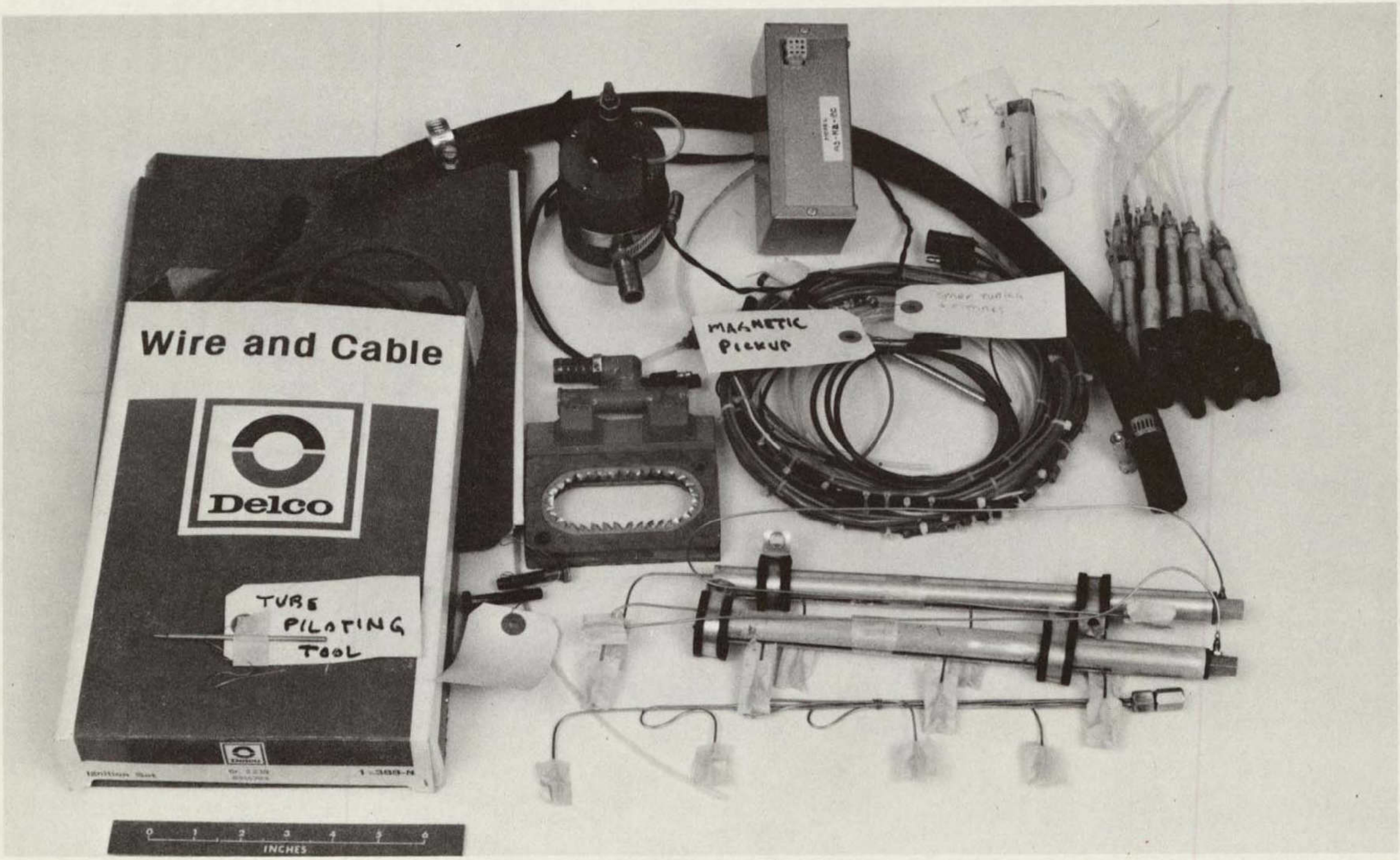

Figure 2. FIDC System Components

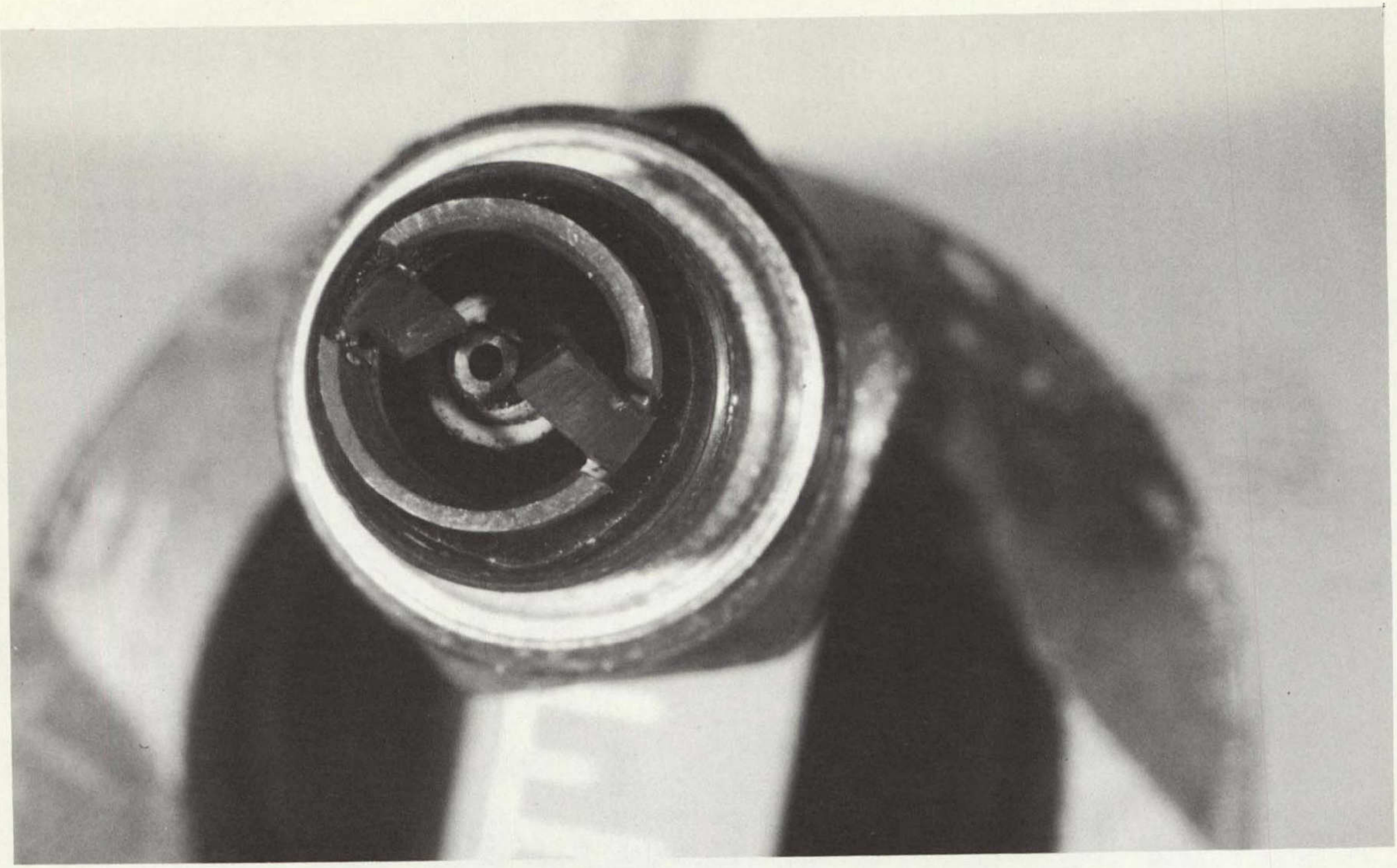

Figure 3. FVI

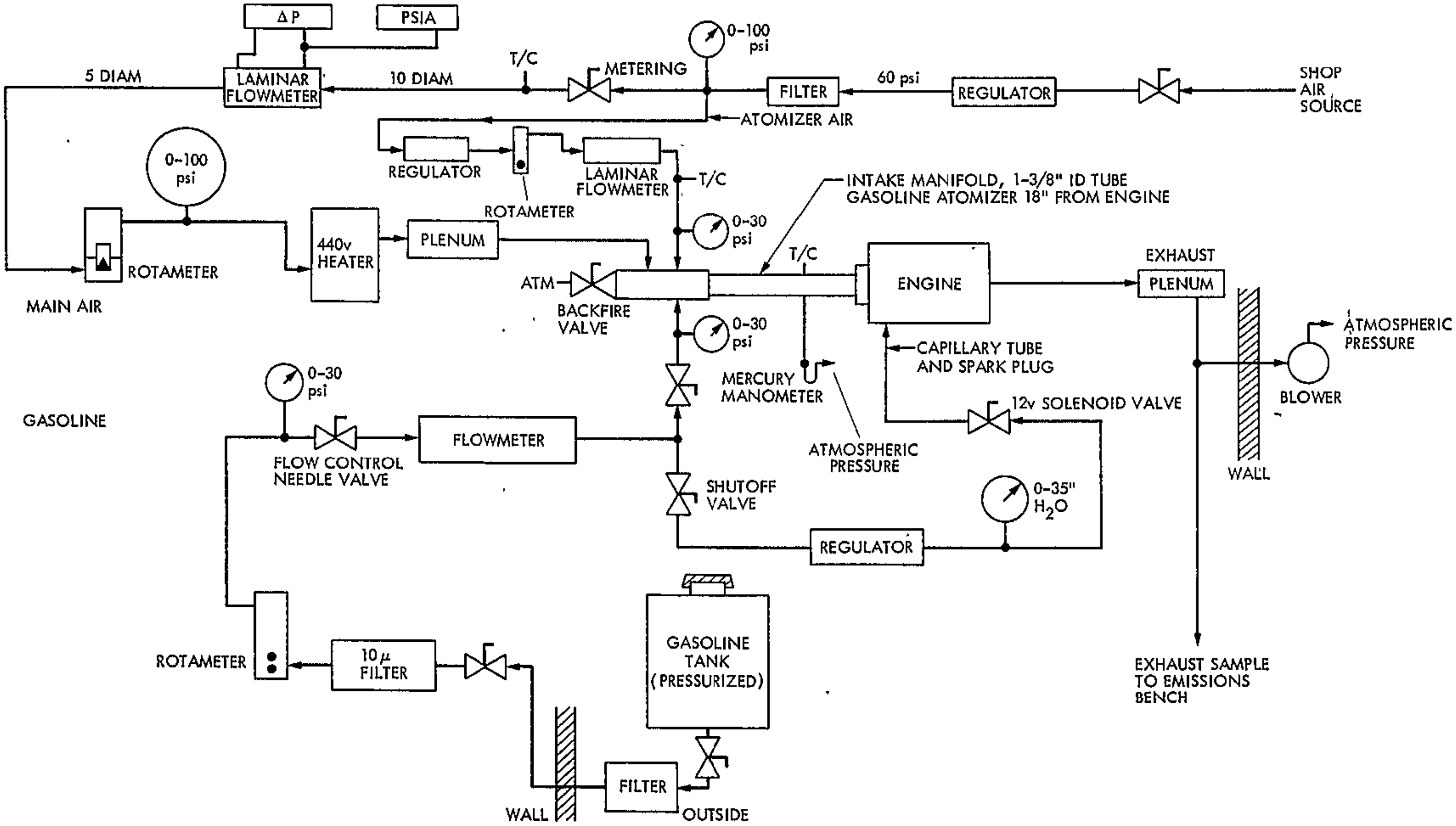

Figure 5. CFR Engine Plumbing for FIDC Tests

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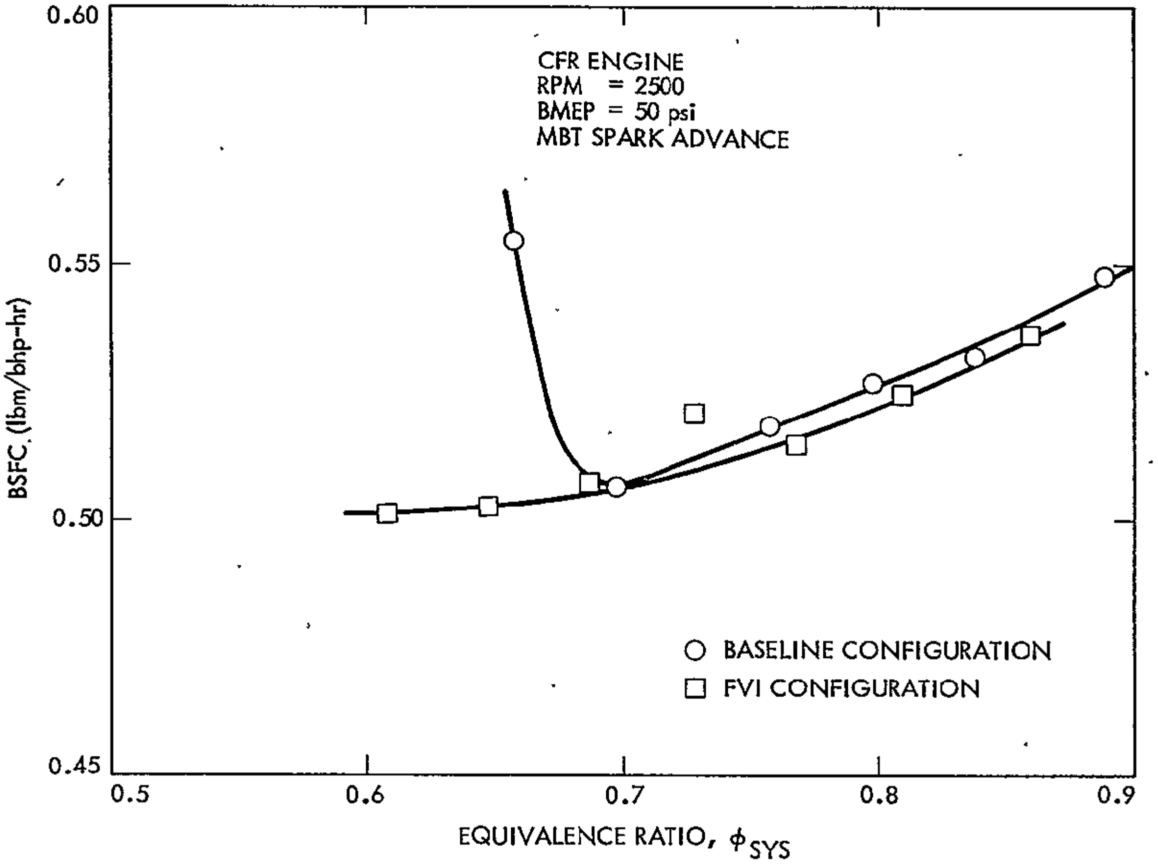

Figure 6. Fuel Consumption Versus Equivalence Ratio for the CFR Sensitivity Tests

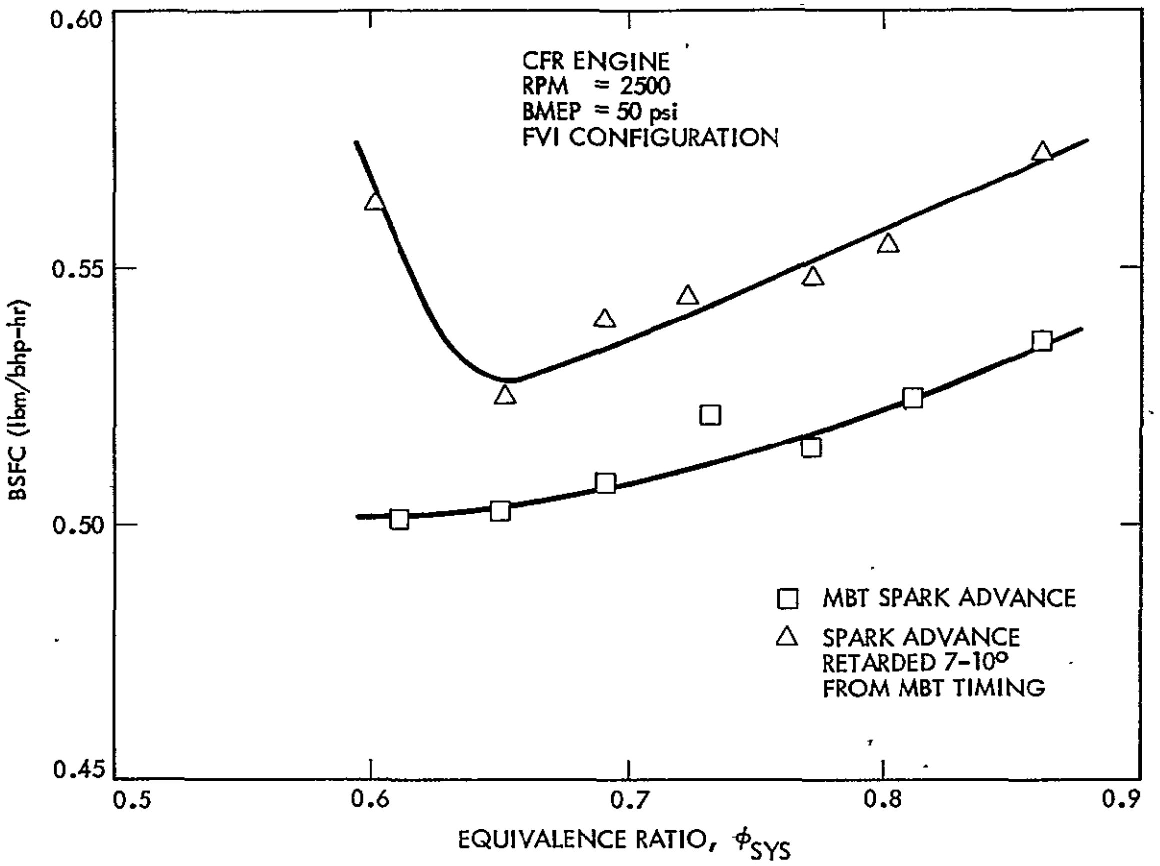

Figure 7. Effect of Spark Retard on Fuel Consumption for CFR Sensitivity Tests

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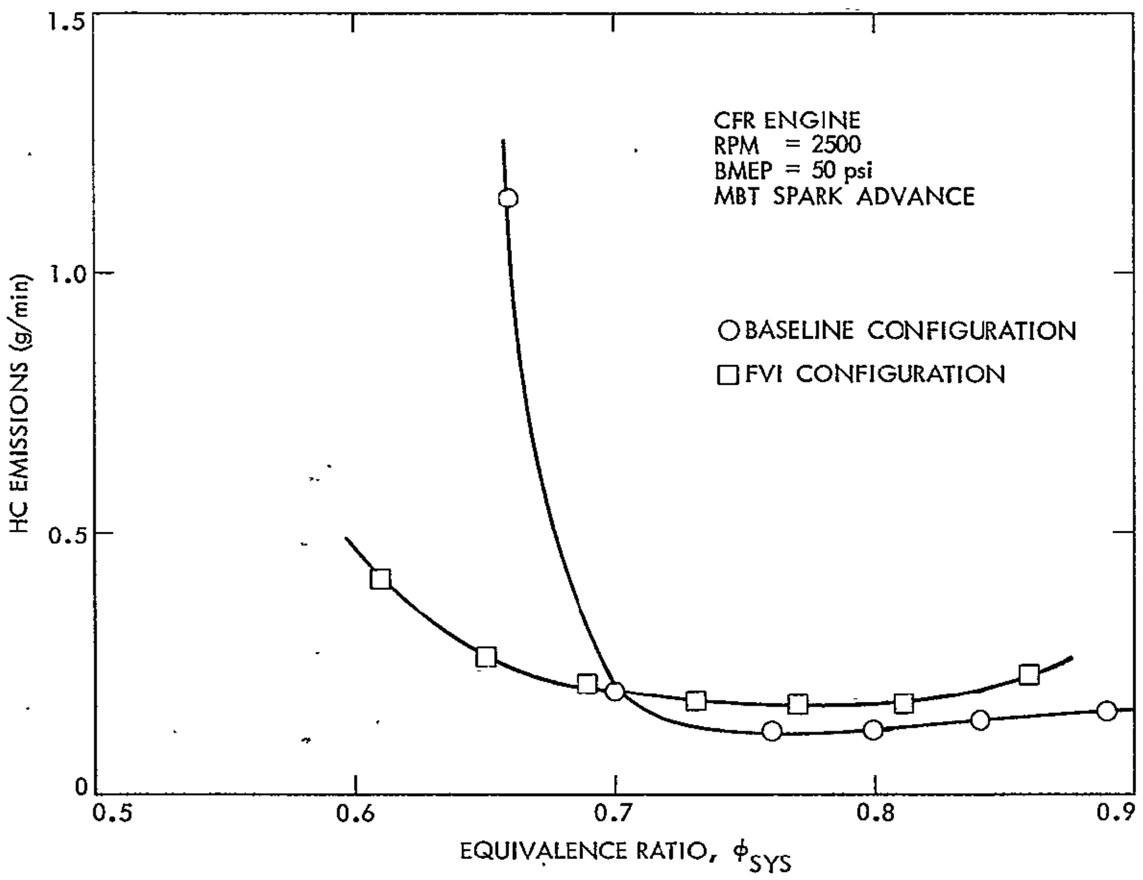

Figure 8. HC Emissions Versus Equivalence Ratio for CFR Sensitivity Tests

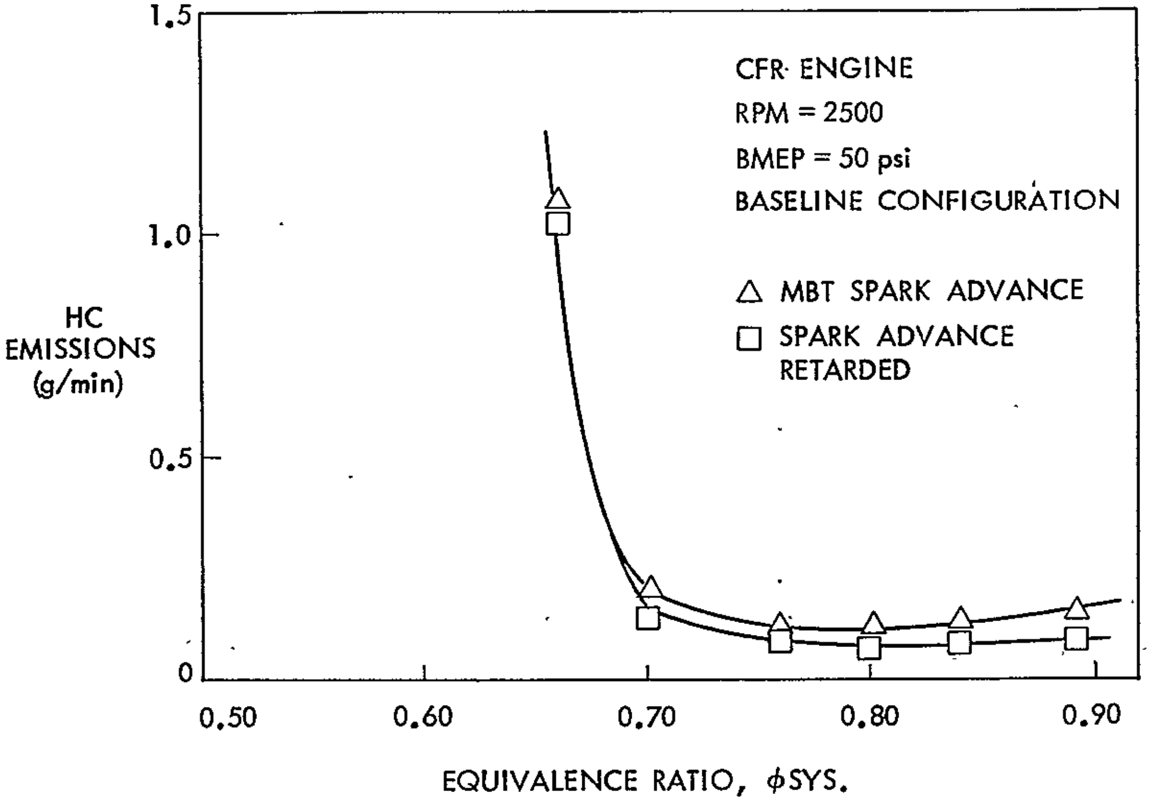

Figure 9. Effect of Spark Retard on HC Emissions for CFR Sensitivity Tests (Baseline Configuration)

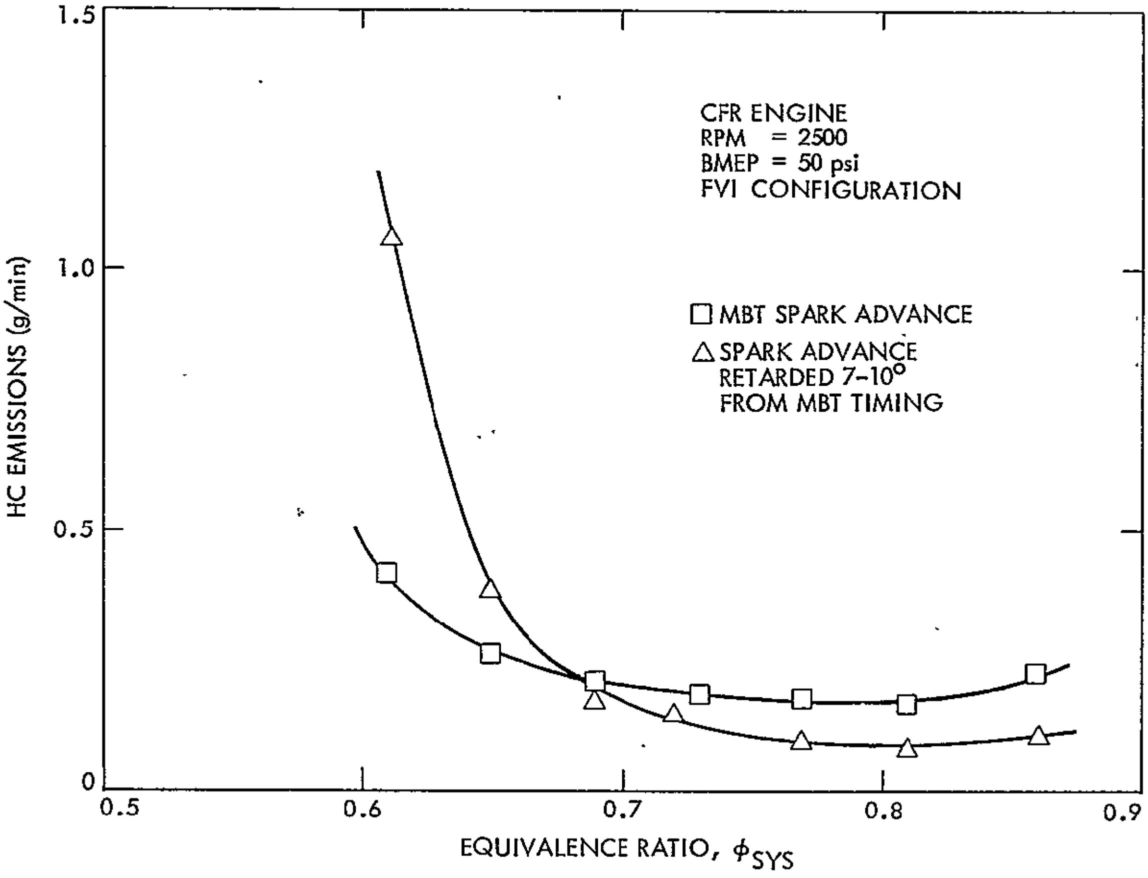

Figure 10. Effect of Spark Retard on HC Emissions for CFR Sensitivity Tests (FVI Configuration)

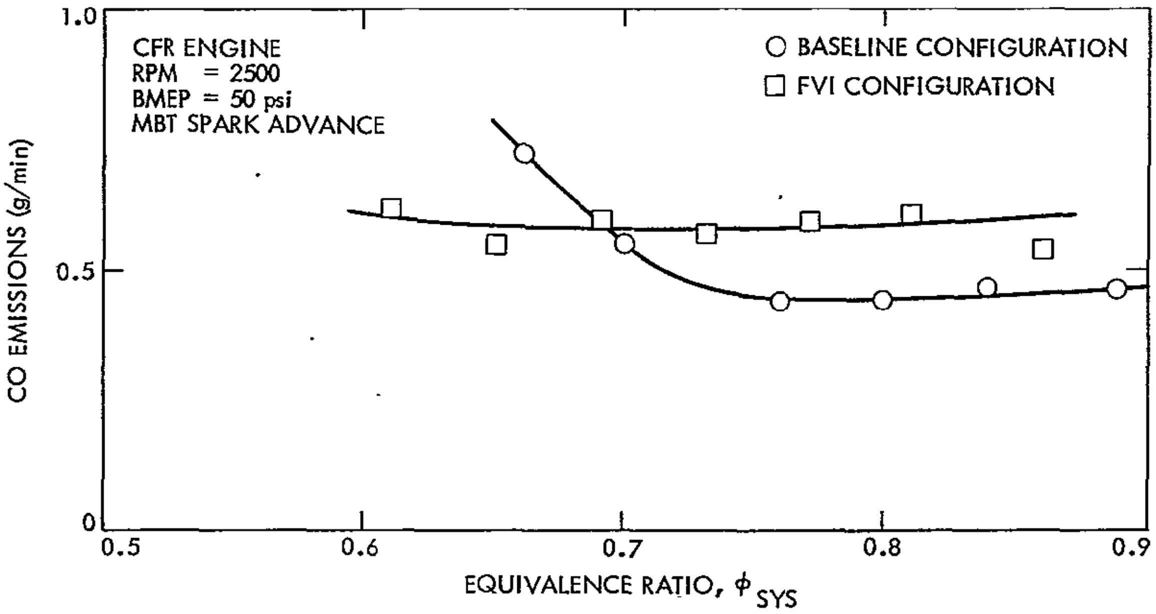

Figure 11. CO Emissions Versus Equivalence Ratio for CFR Sensitivity Tests

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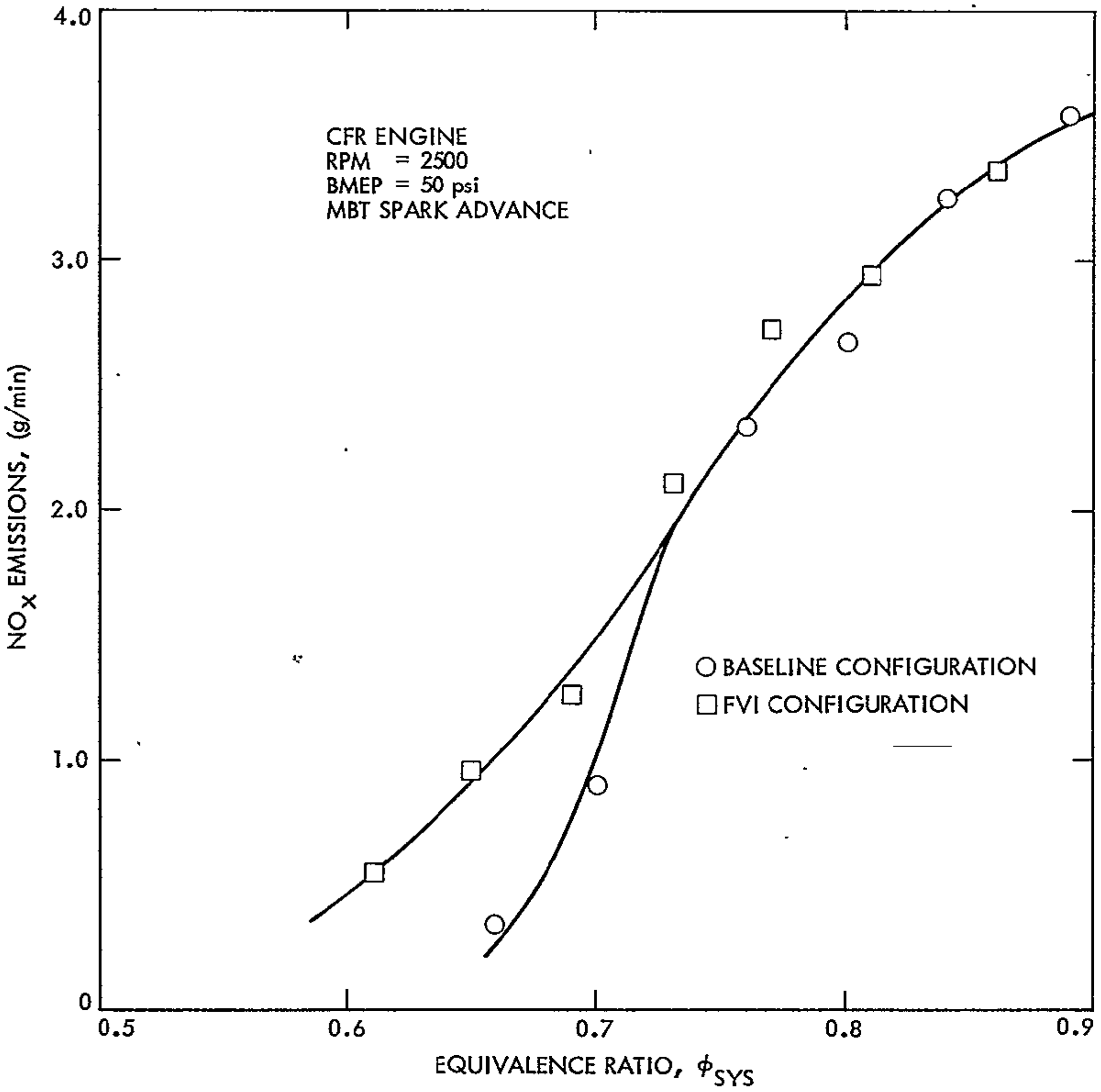

Figure 12. NO$_x$ Emissions Versus Equivalence Ratio for CFR Sensitivity Tests

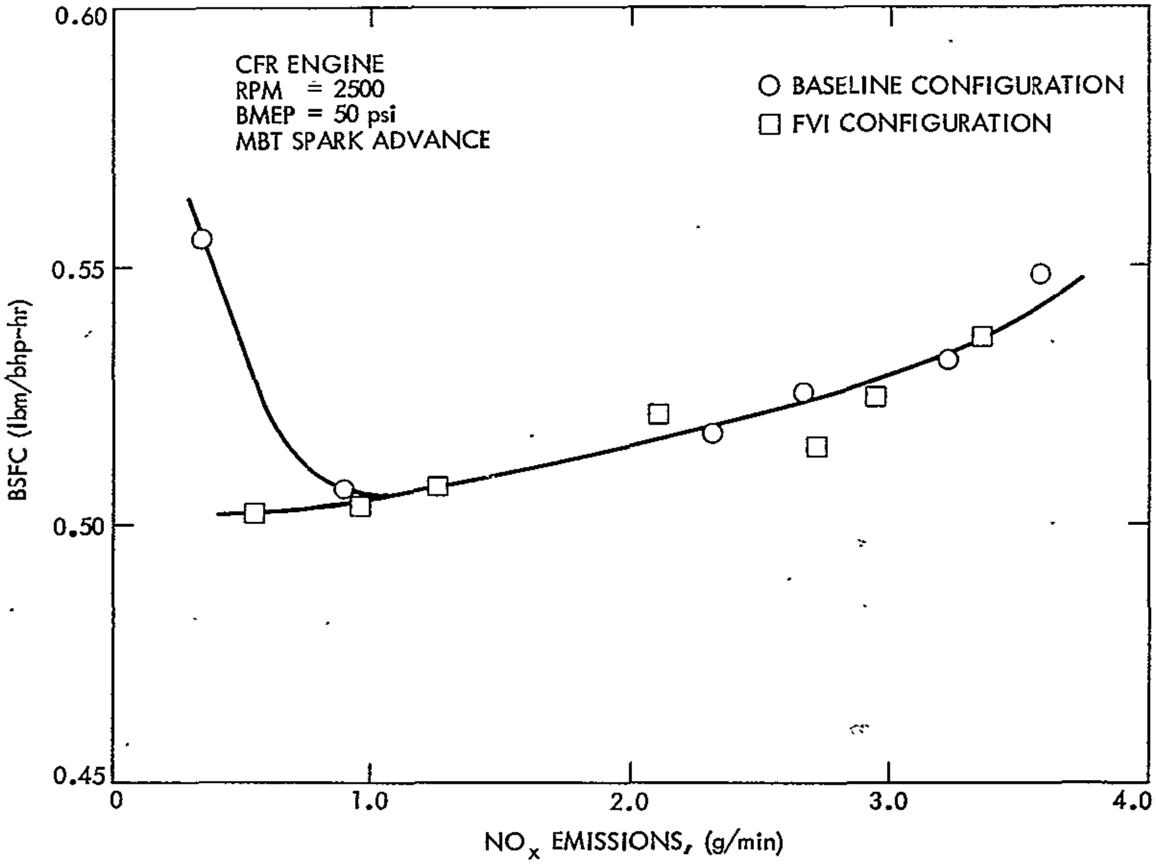

Figure 13. Fuel Consumption Versus NO$_x$ Emissions for CFR Sensitivity Tests

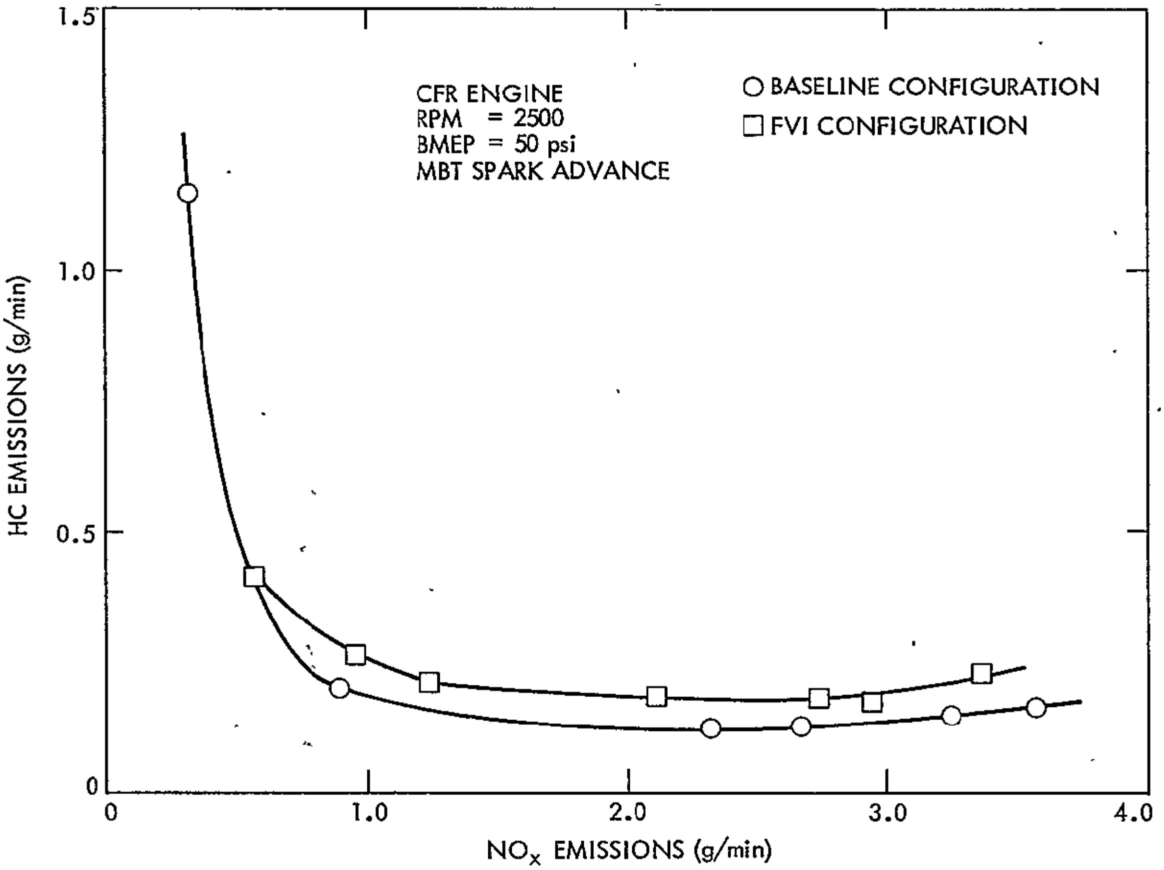

Figure 14. HC Emissions Versus NO$_x$ Emissions for CFR Sensitivity Tests

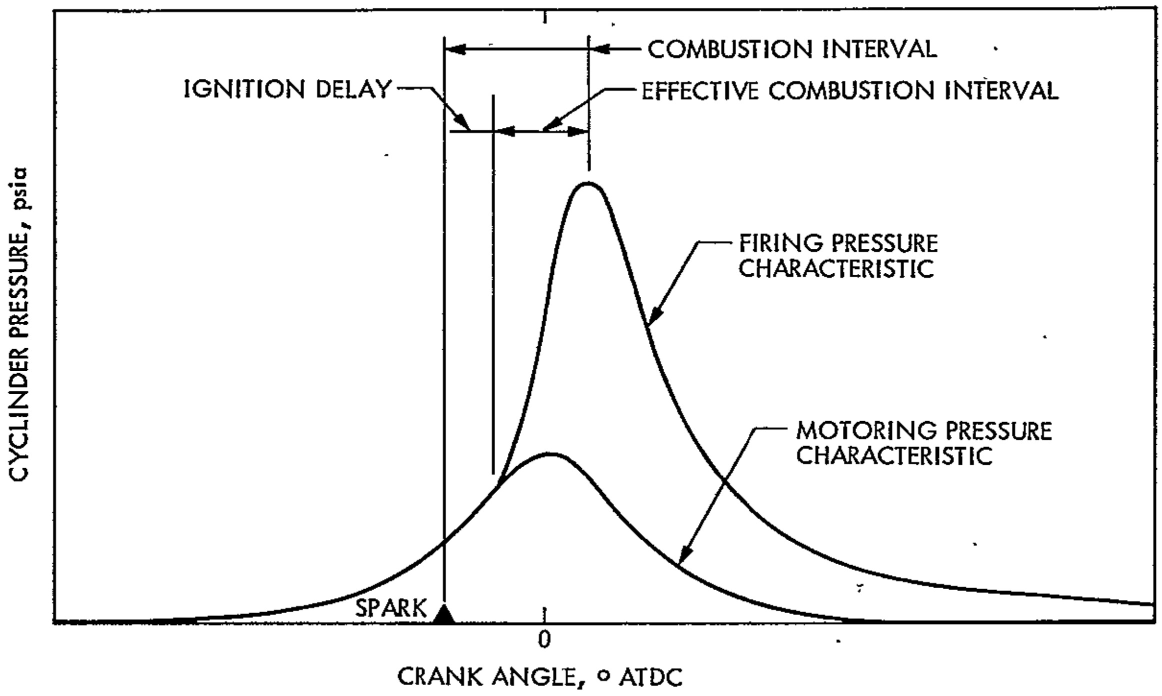

Figure 15. Definition of Ignition Delay and Combustion Interval

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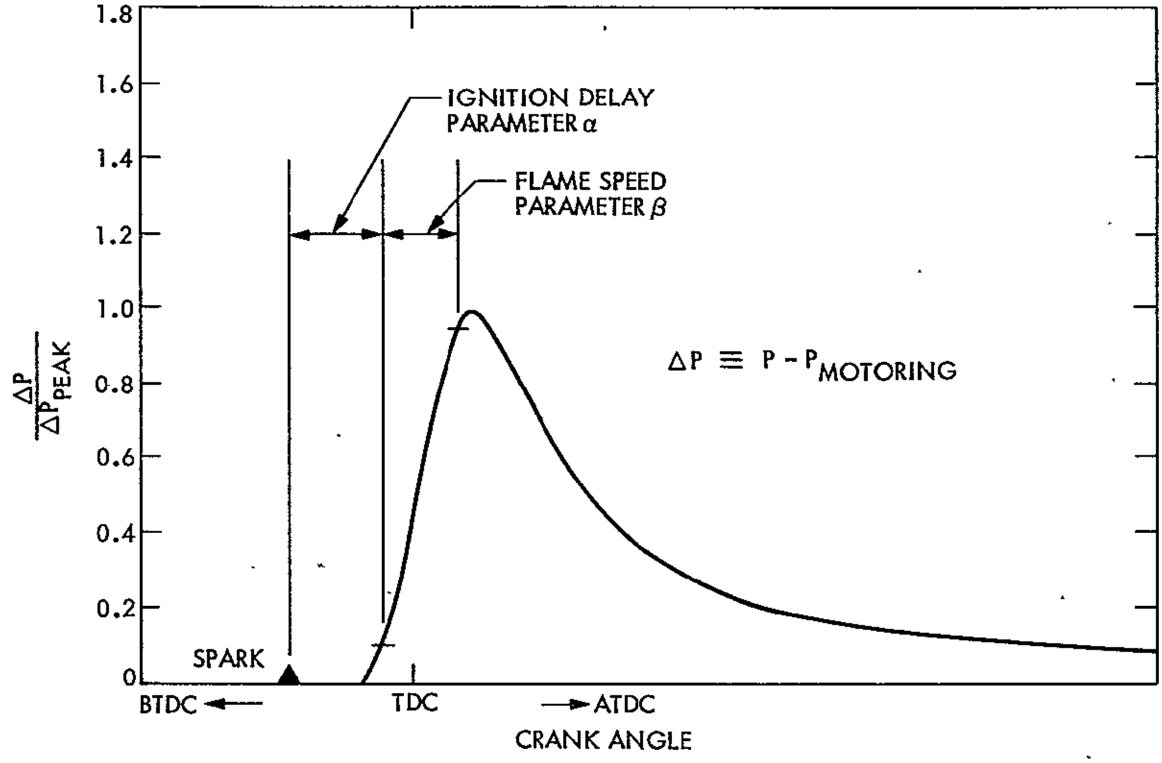
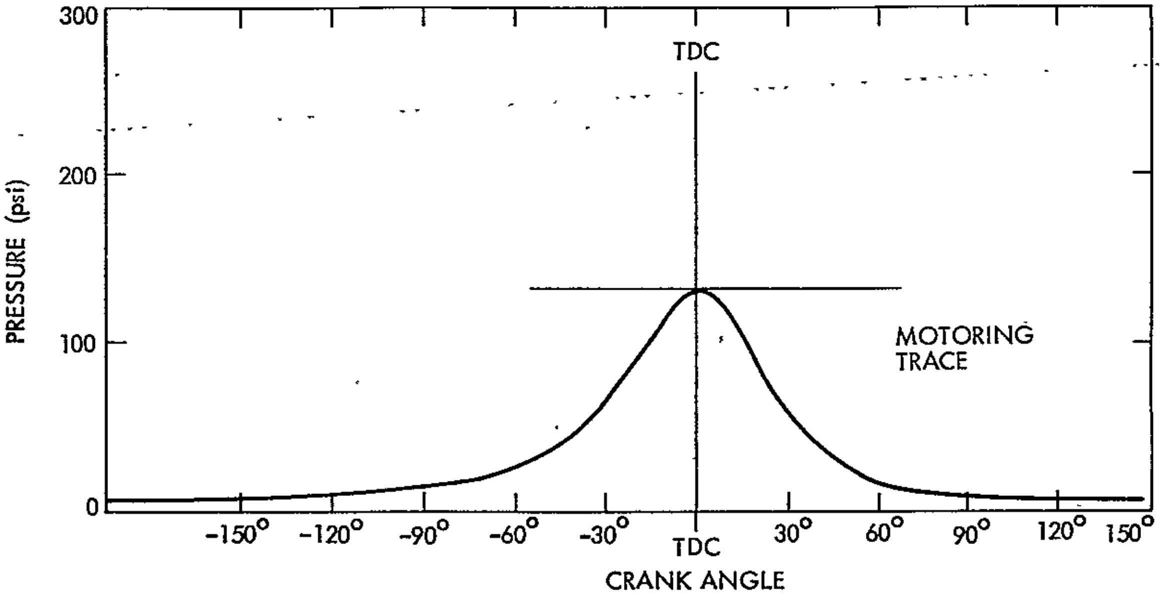


Figure 16. Definition of Ignition Delay Parameter and Flame Speed Parameter



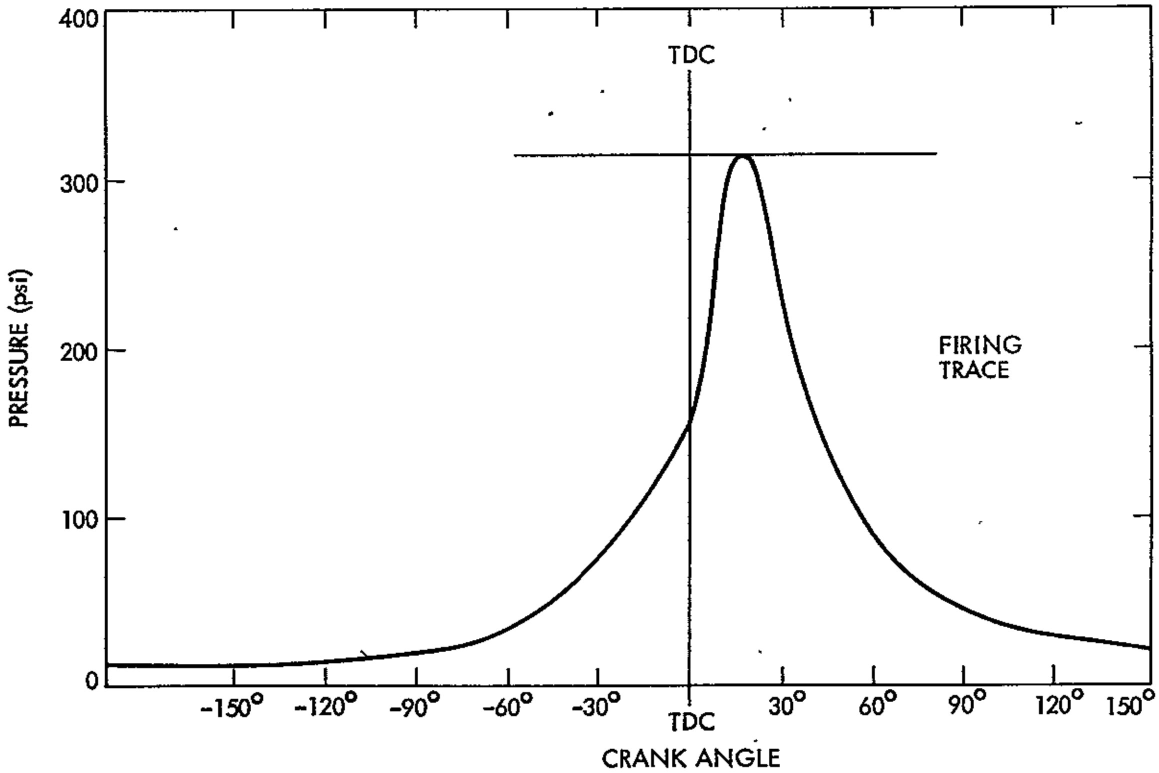


Figure 17. Firing and Motoring Pressure-Time Traces for CFR Test

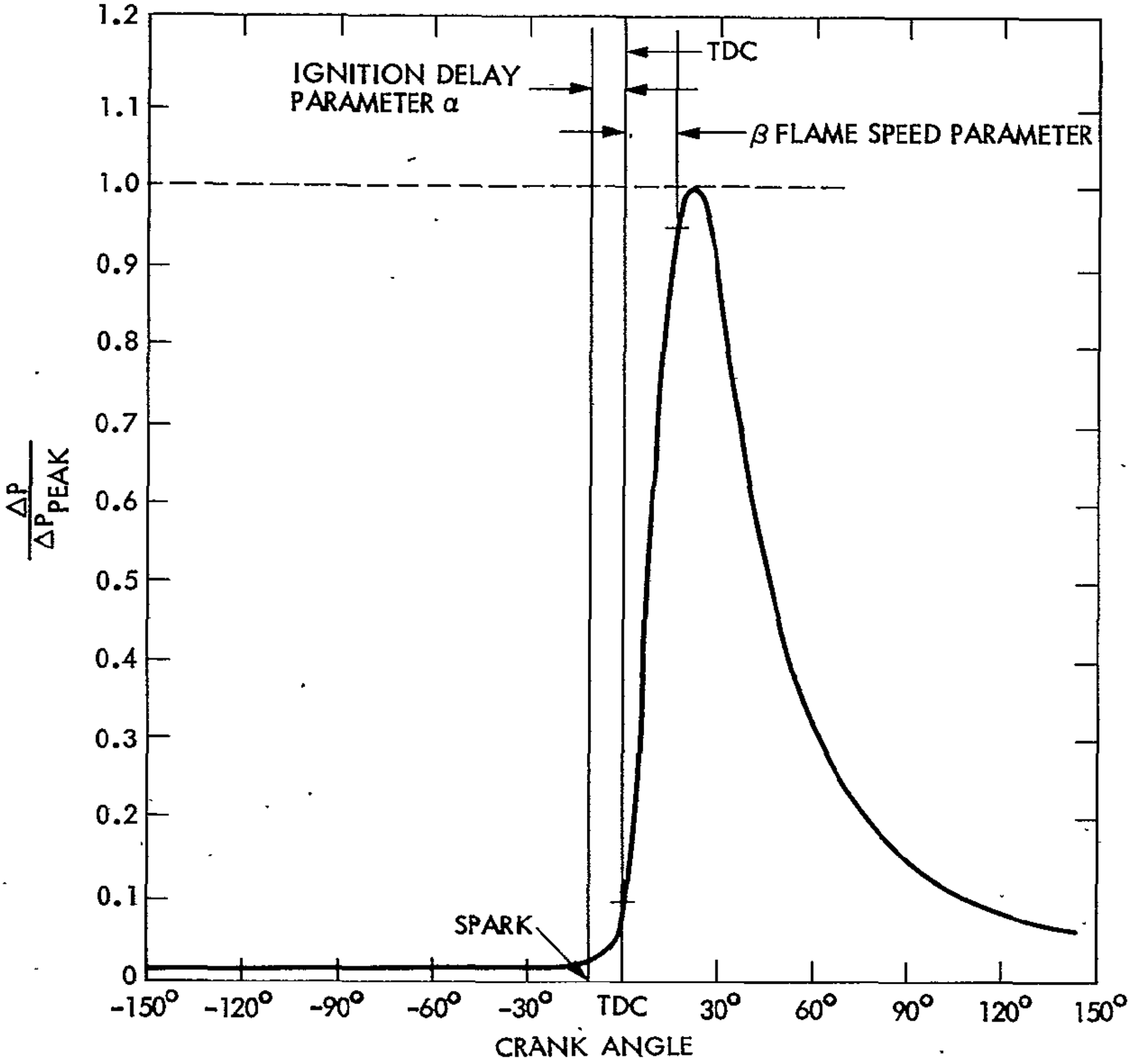


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Figure 18. Ignition Delay Parameter and Flame Speed Parameter for CFR Test

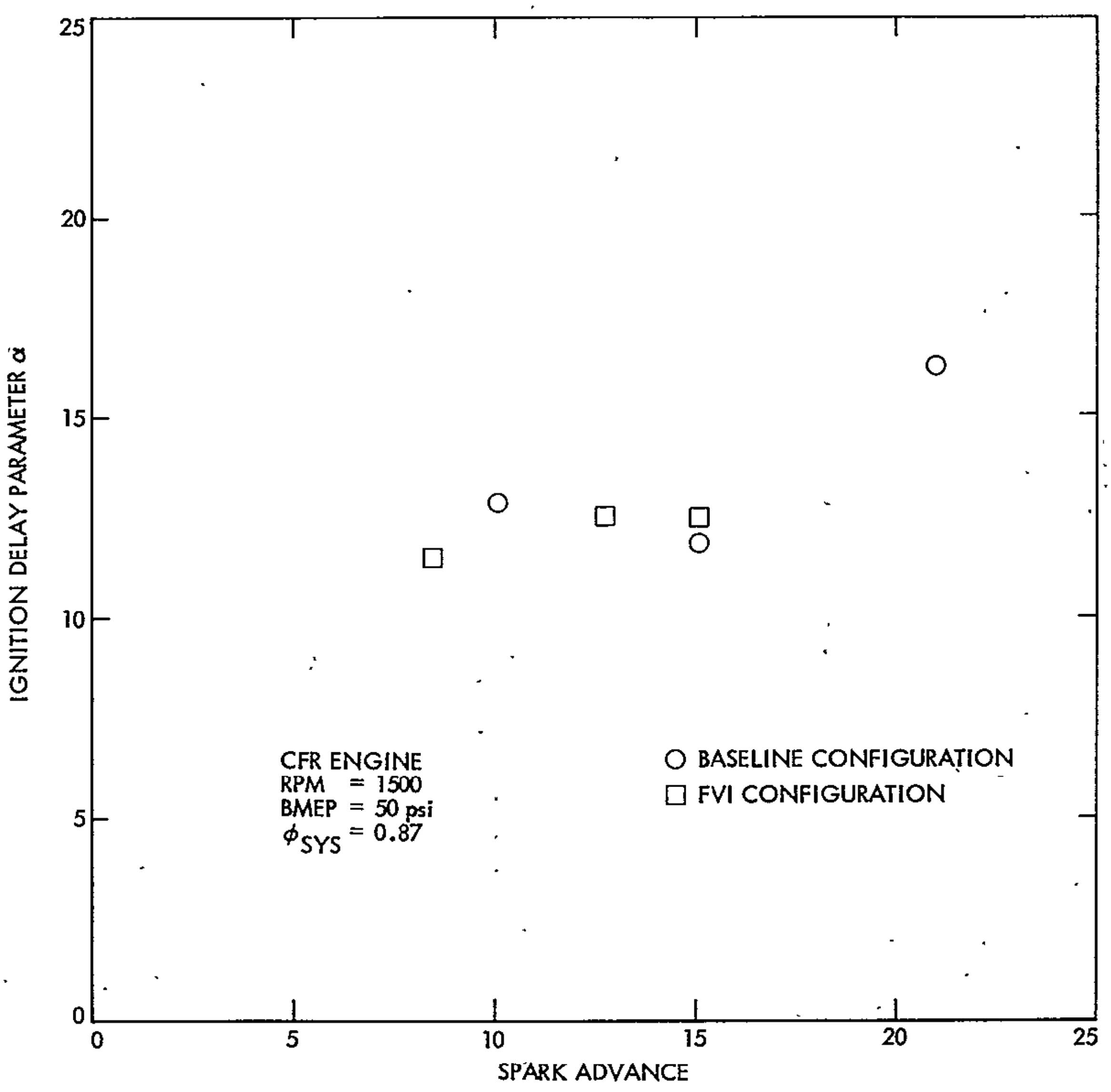

Figure 19. Ignition Delay Parameter Versus Spark Advance for CFR Tests

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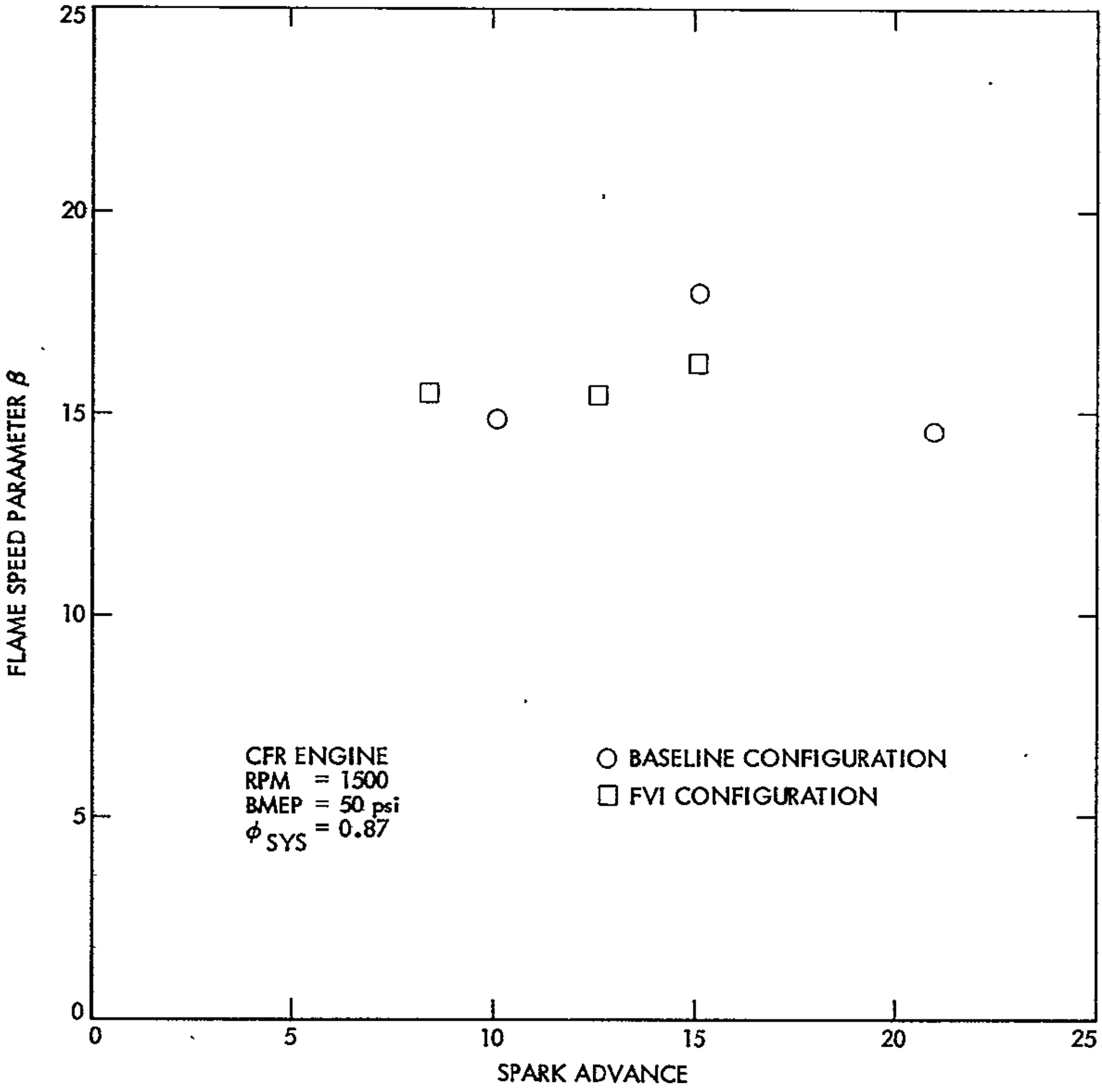

Figure 20. Flame Speed Parameter Versus Spark Advance for CFR Tests

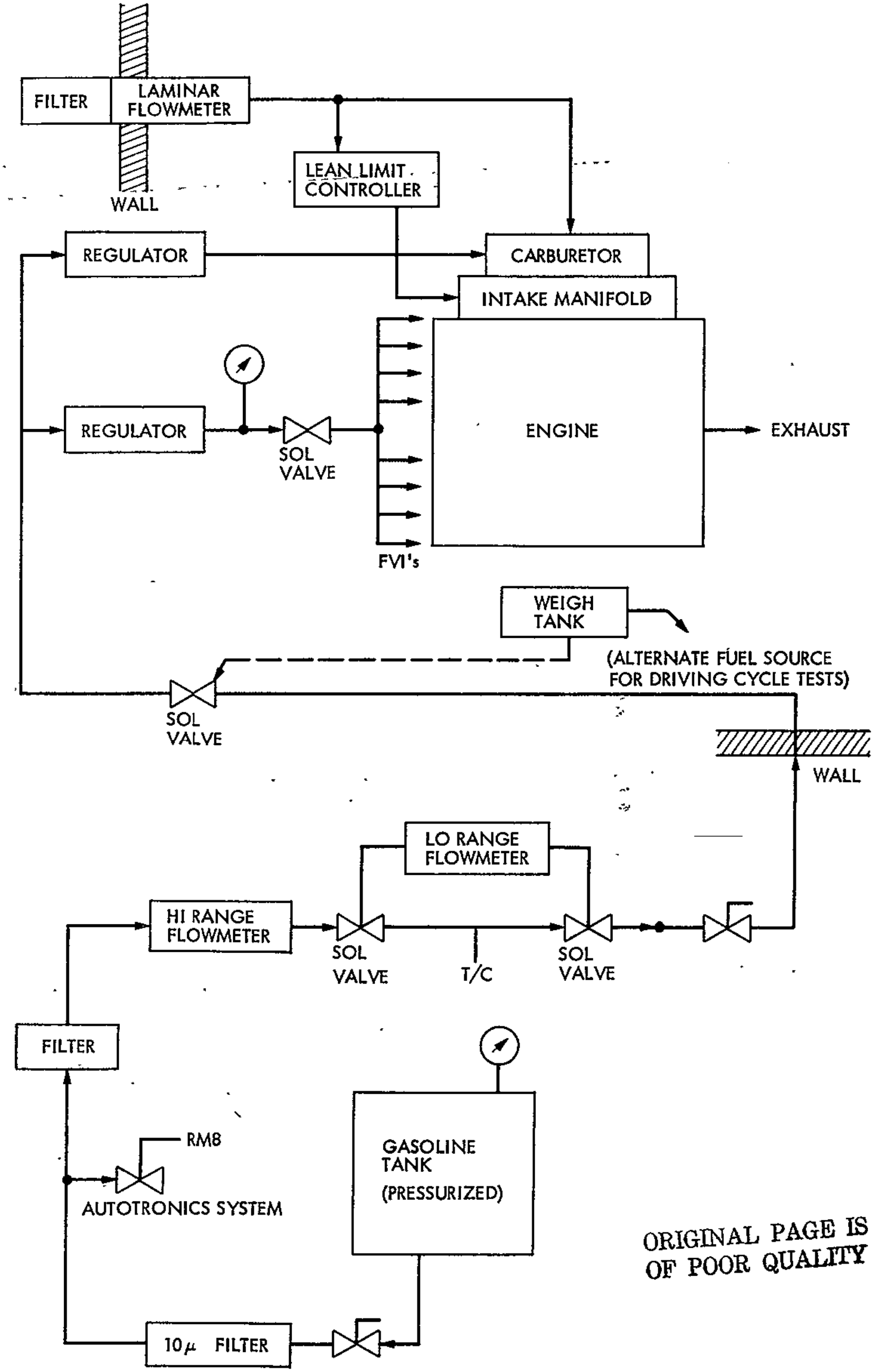

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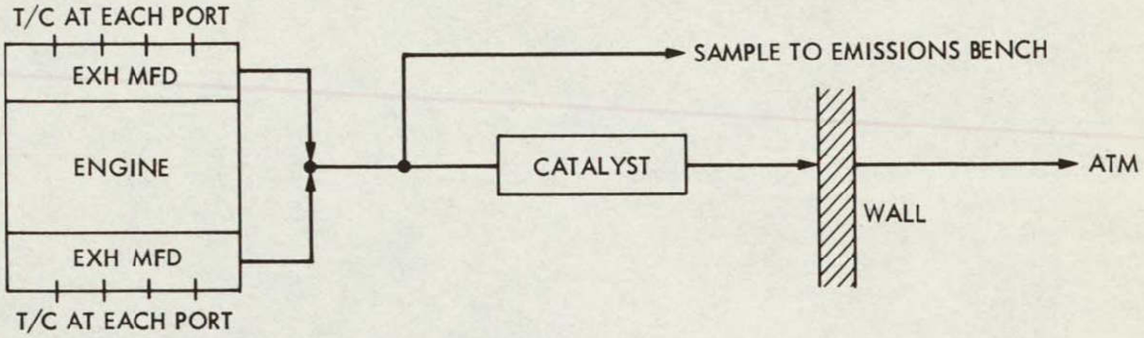
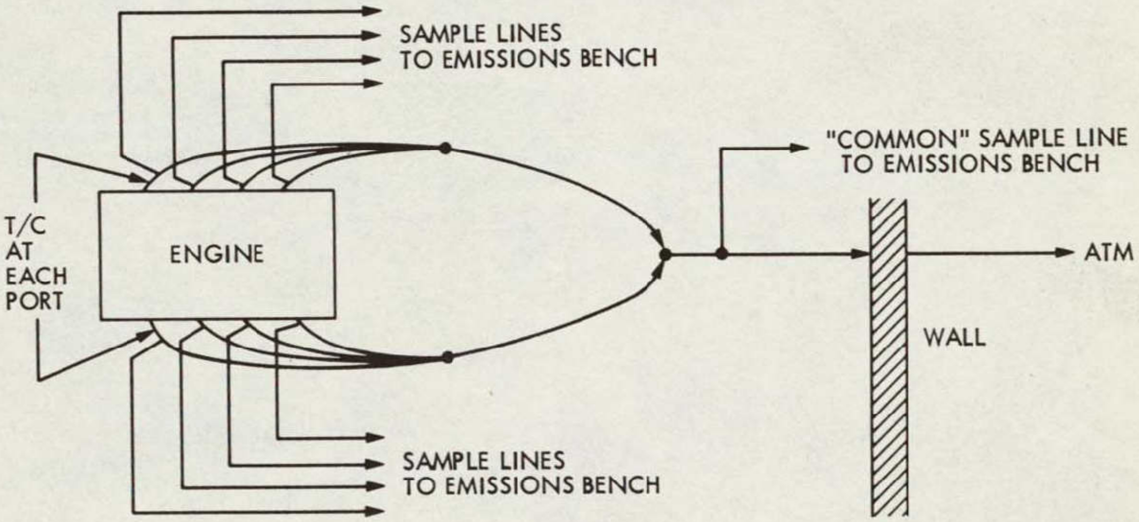
Figure 21. V-8 Engine Plumbing for FIDC Tests



EXHAUST PLUMBING FOR STEADY-STATE TESTS



EXHAUST PLUMBING FOR DISTRIBUTION TESTS

Figure 22. Exhaust Systems for Multicylinder Engine

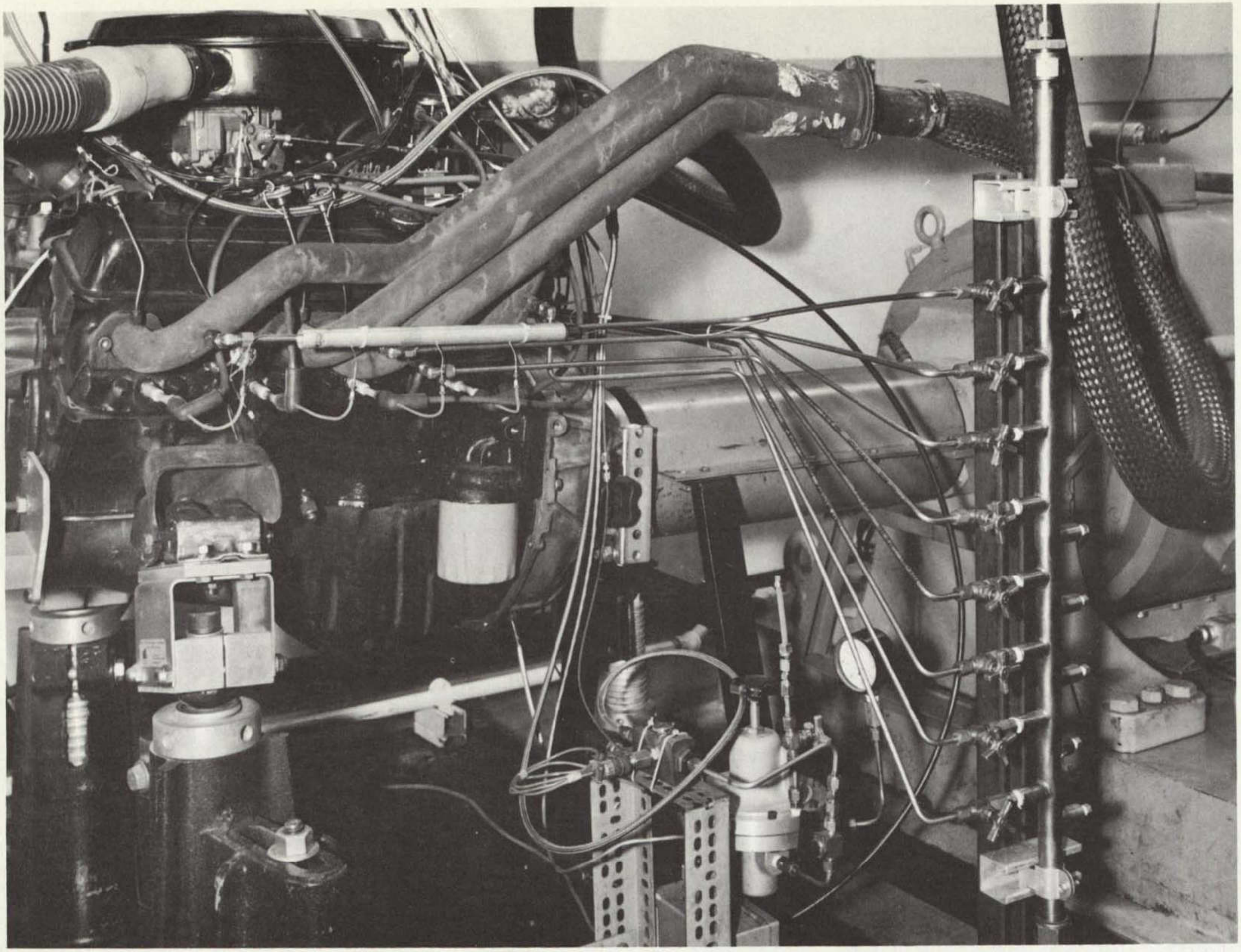


Figure 23. Multicylinder Engine

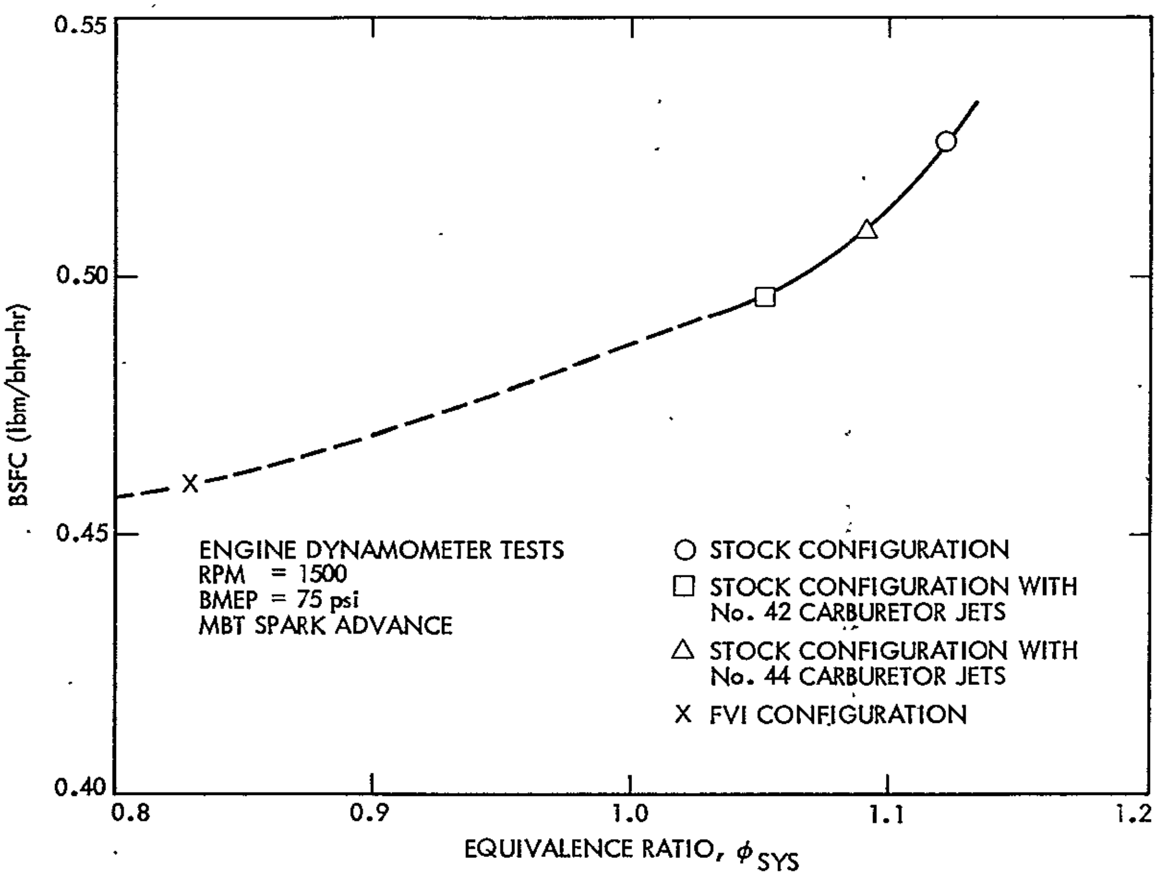


Figure 25. Fuel Consumption Versus Equivalence Ratio for EC Dynamometer Tests

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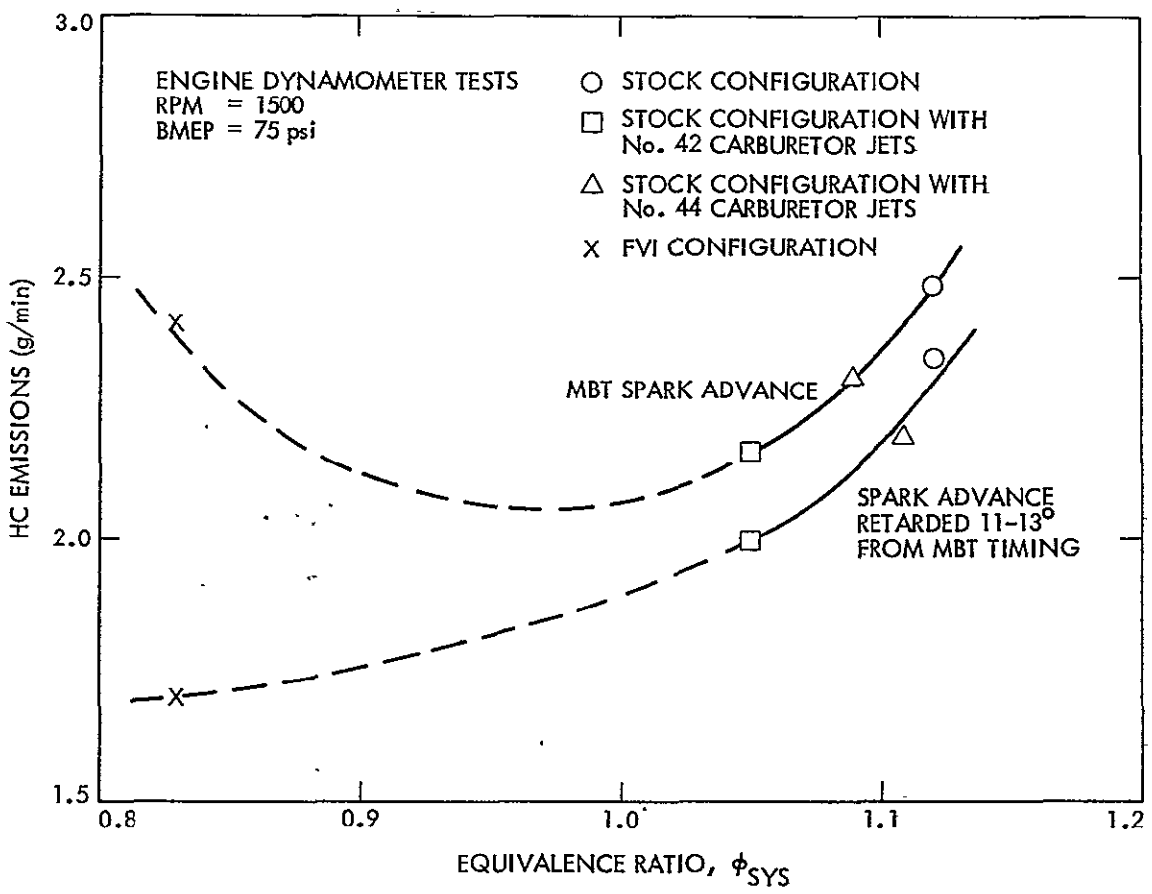

Figure 26. Effect of Spark Retard on HC Emissions for EC Dynamometer Tests

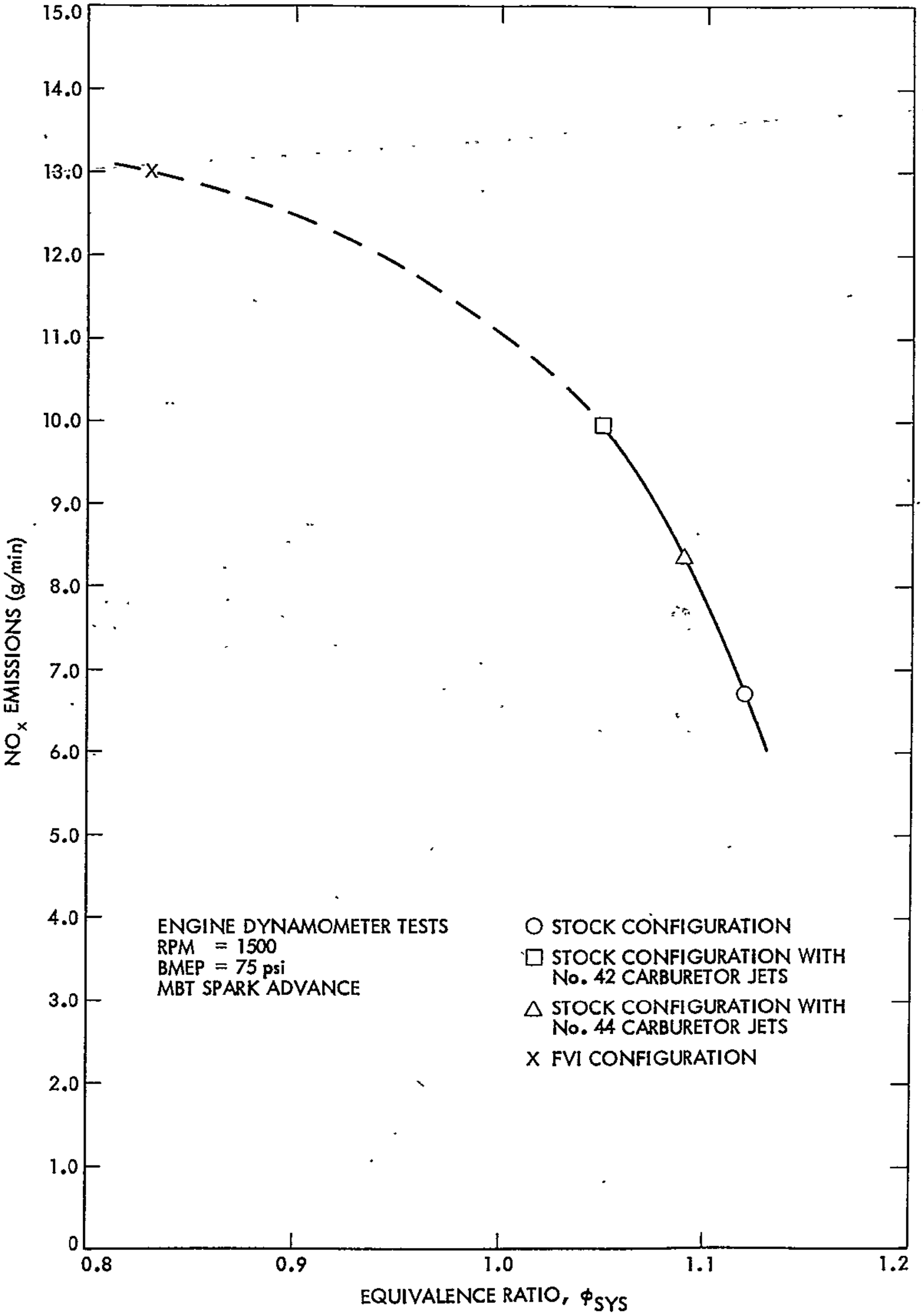

Figure 27. NO$_x$ Emissions Versus Equivalence Ratio for EC Dynamometer Tests

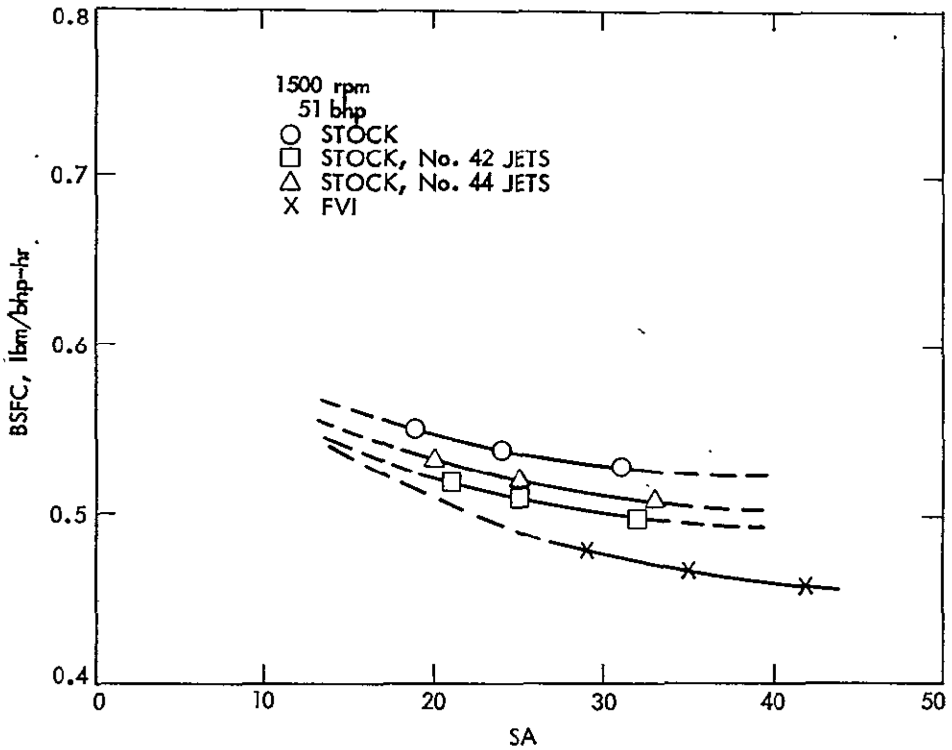

Figure 28. Fuel Consumption Versus Spark Advance for EC Dynamometer Tests

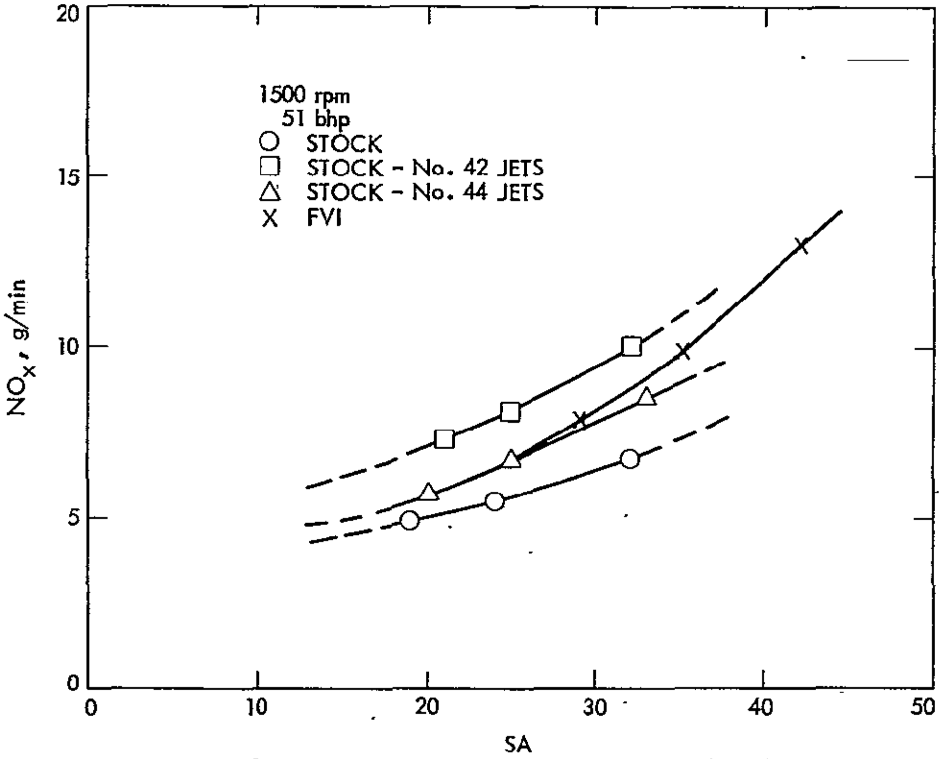

Figure 29. NO_X Emissions Versus Spark Advance EC Dynamometer Tests

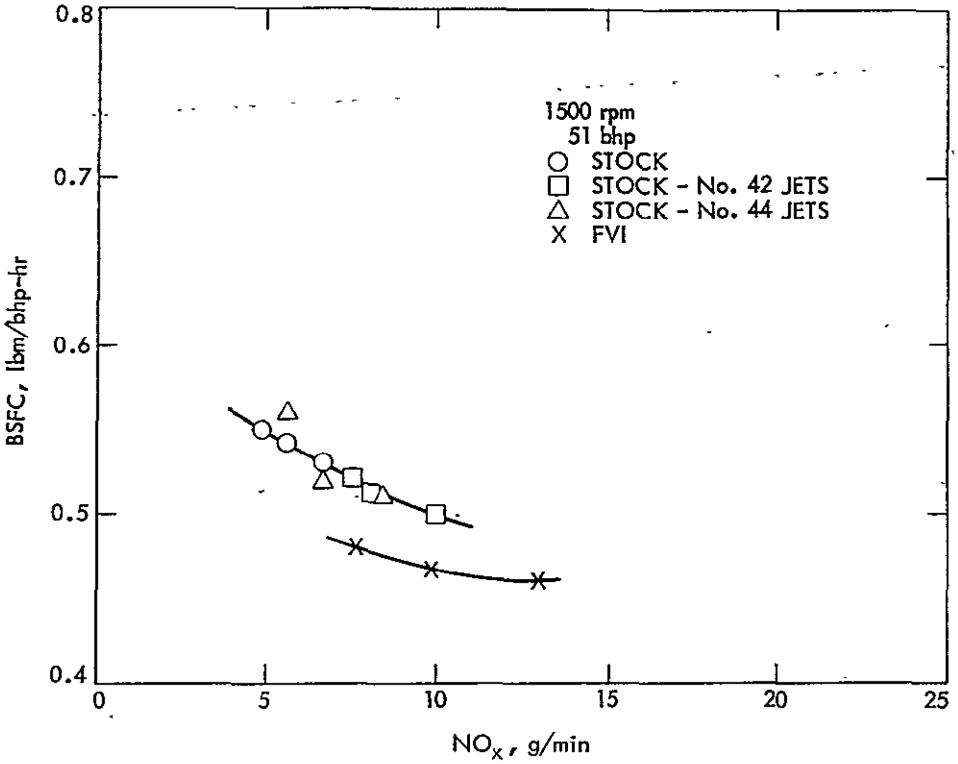

Figure 30. Fuel Consumption Versus NO$_x$ Emissions for EC Dynamometer Tests

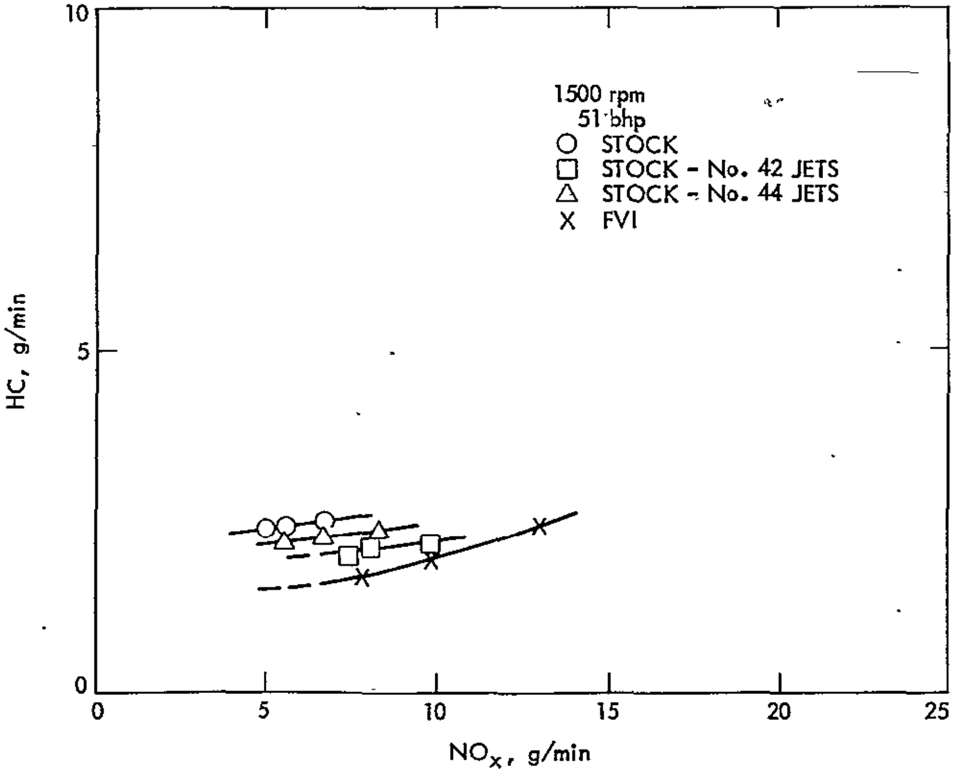

Figure 31. HC Emissions Versus NO$_x$ Emissions for EC Dynamometer Tests

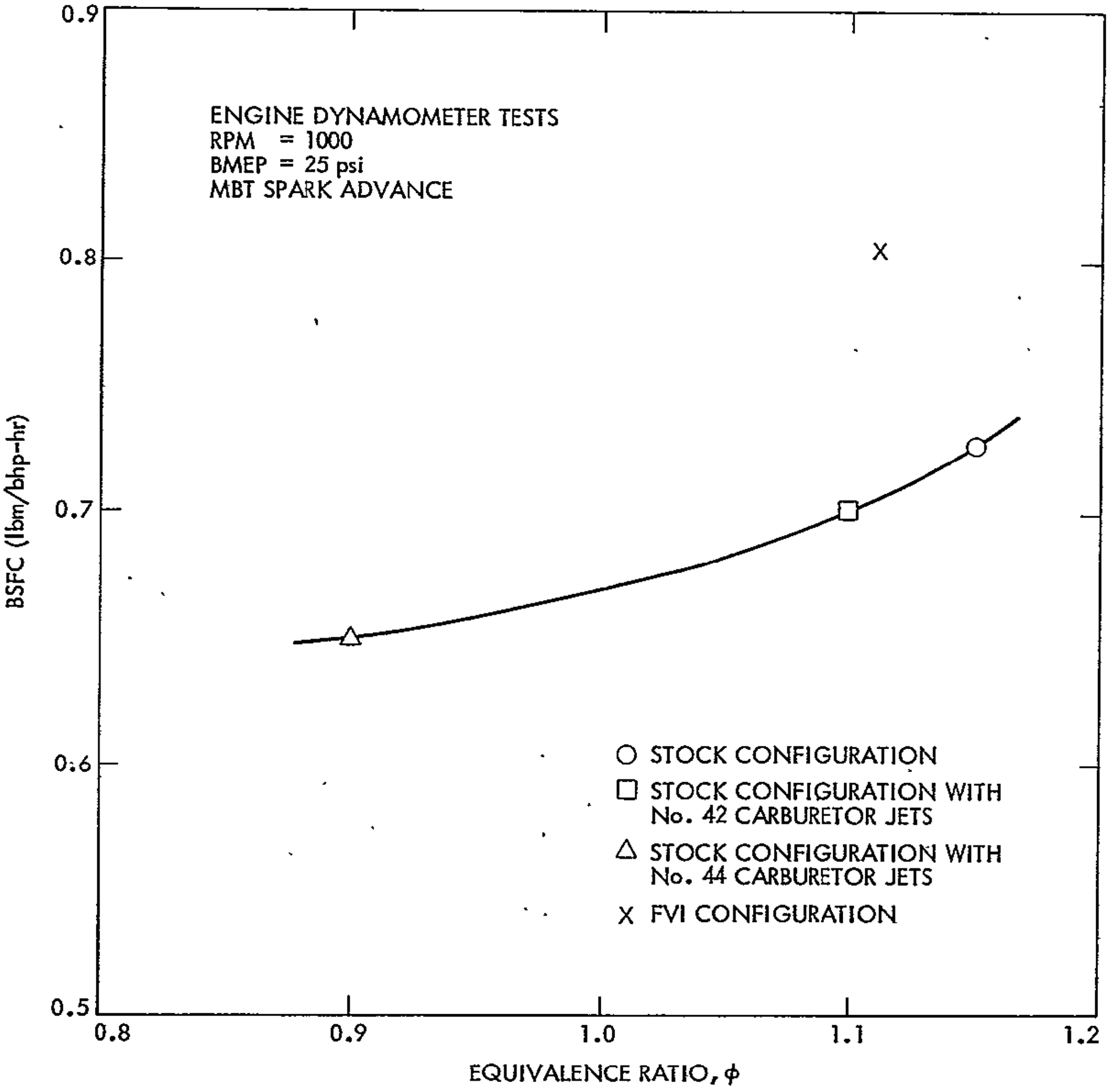

Figure 32. Fuel Consumption Versus Equivalence Ratio for EC Dynamometer Tests

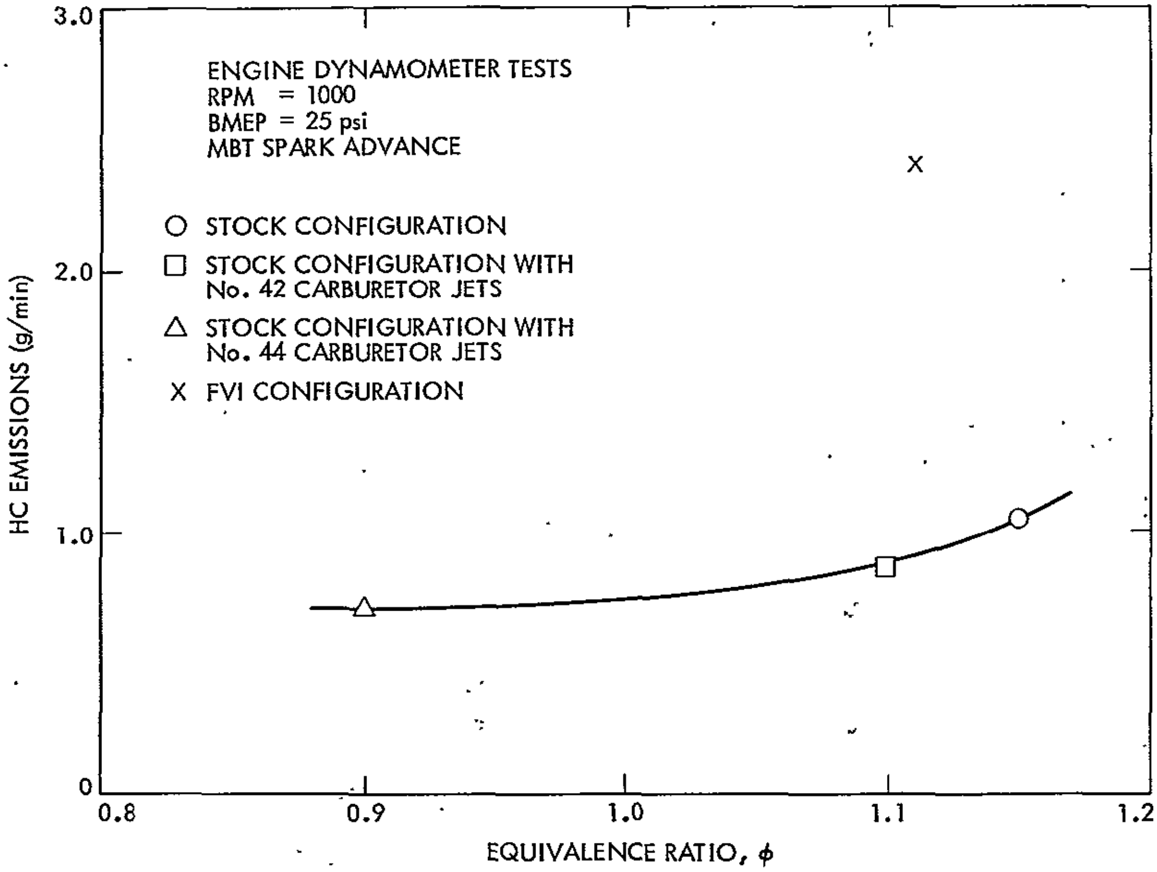

Figure 33. HC Emissions Versus Equivalence Ratio for EC Dynamometer Tests

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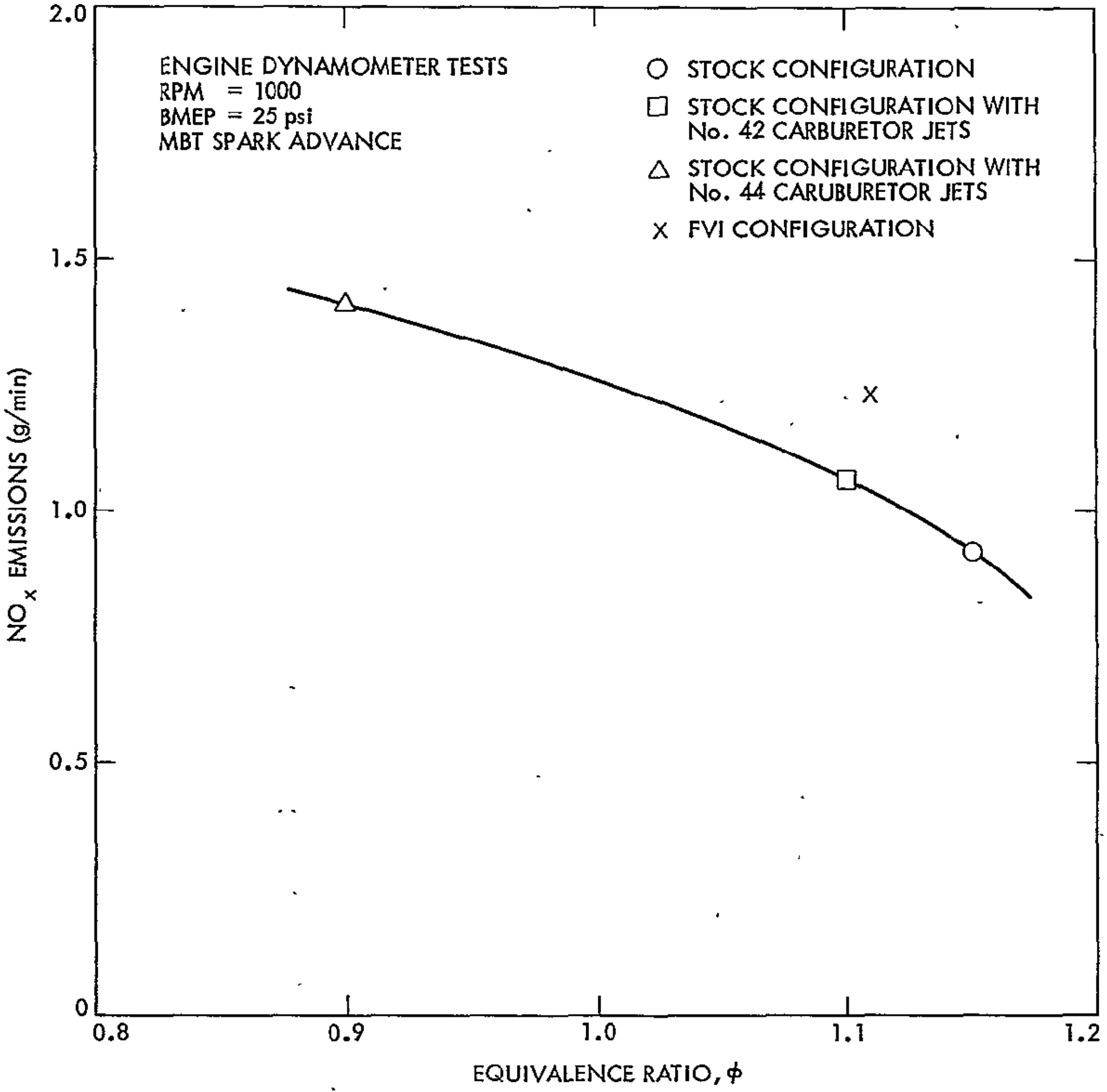

Figure 34. NO_x Emissions Versus Equivalence Ratio for EC Dynamometer Tests

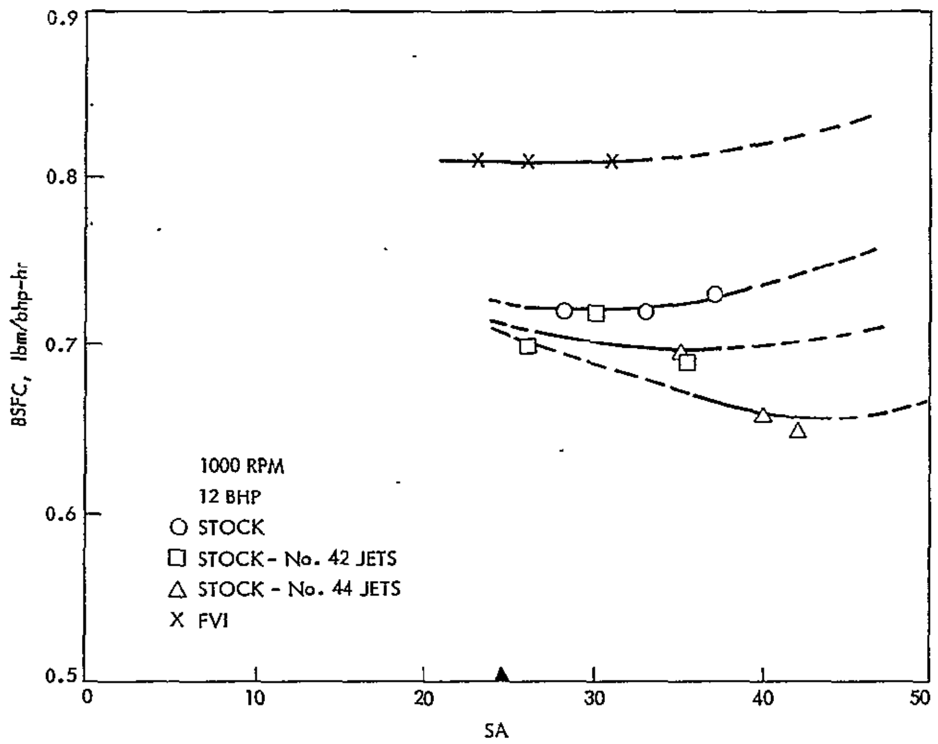

Figure 35. Fuel Consumption Versus Spark Advance for EC Dynamometer Tests

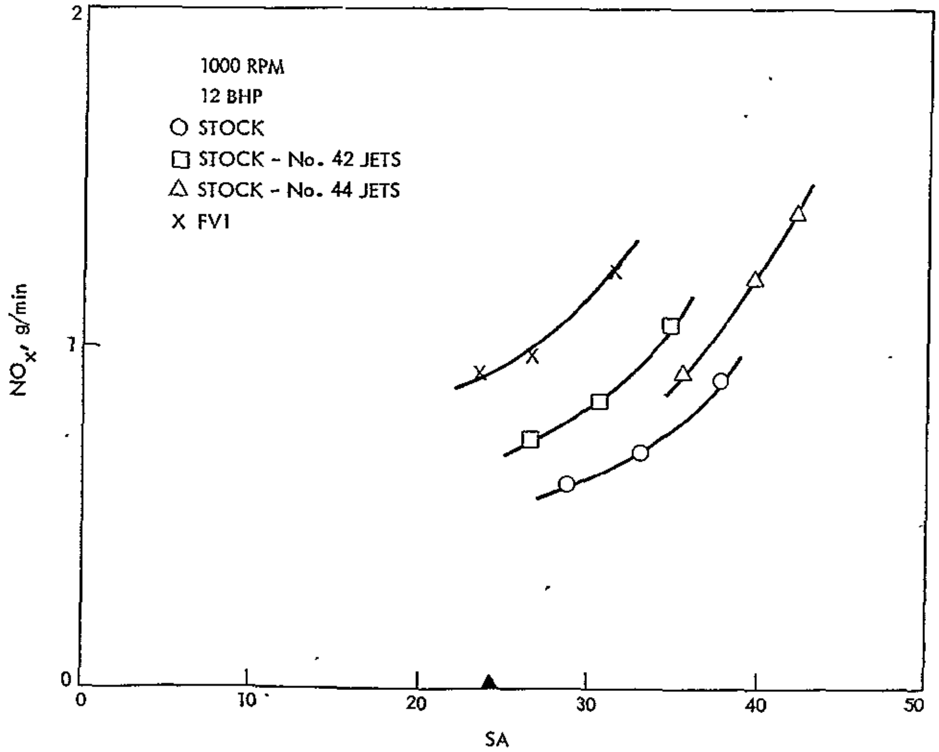

Figure 36. NO_x Emissions Versus Spark Advance for EC Dynamometer Tests

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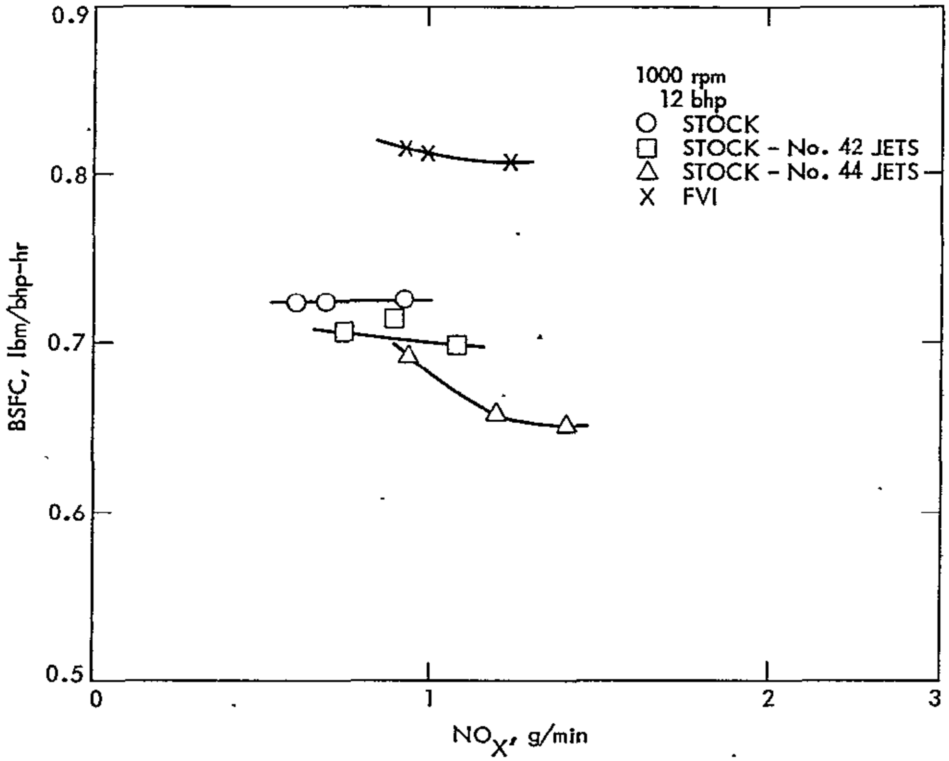

Figure 37. Fuel Consumption Versus NO_x Emissions for EC Dynamometer Tests

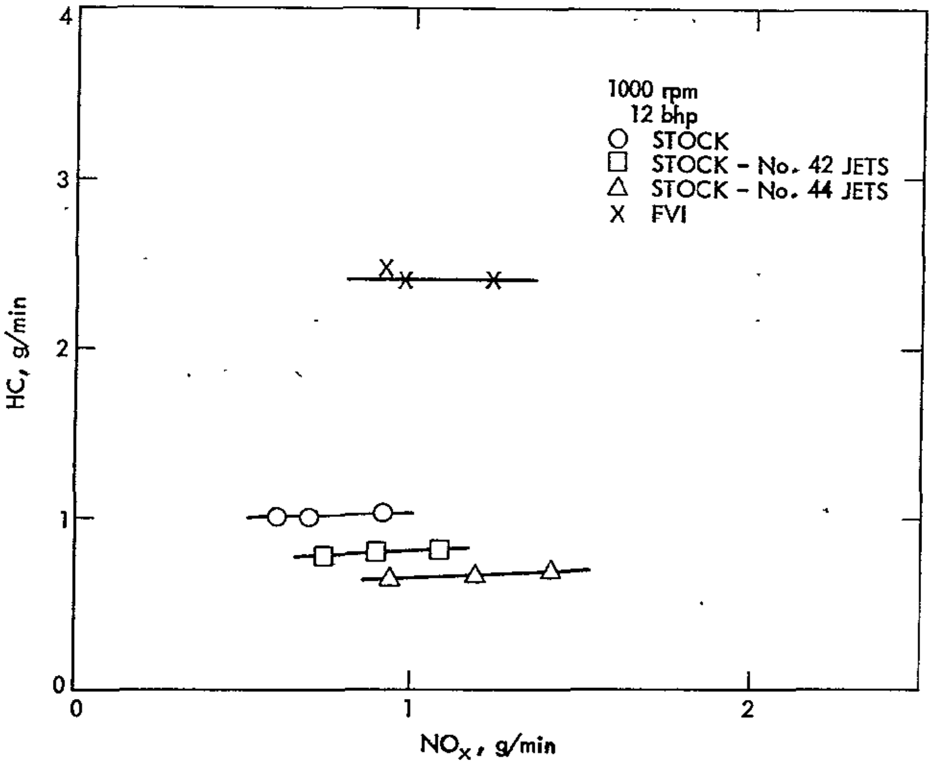

Figure 38. HC Emissions Versus NO_x Emissions for EC Dynamometer Tests

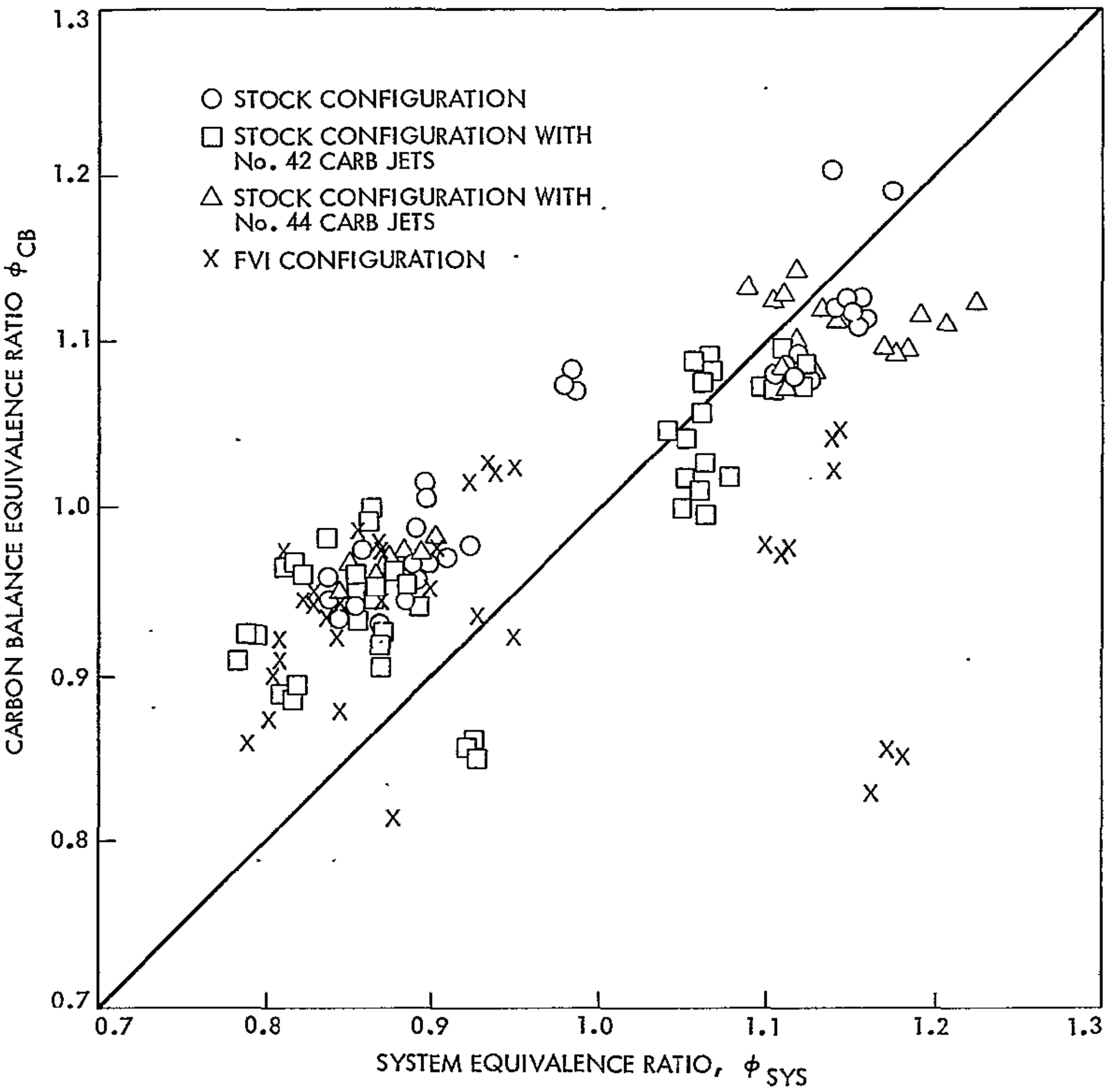

Figure 39. Comparison of System Equivalence Ratio and Carbon Balance Equivalence Ratio for EC Dynamometer Tests

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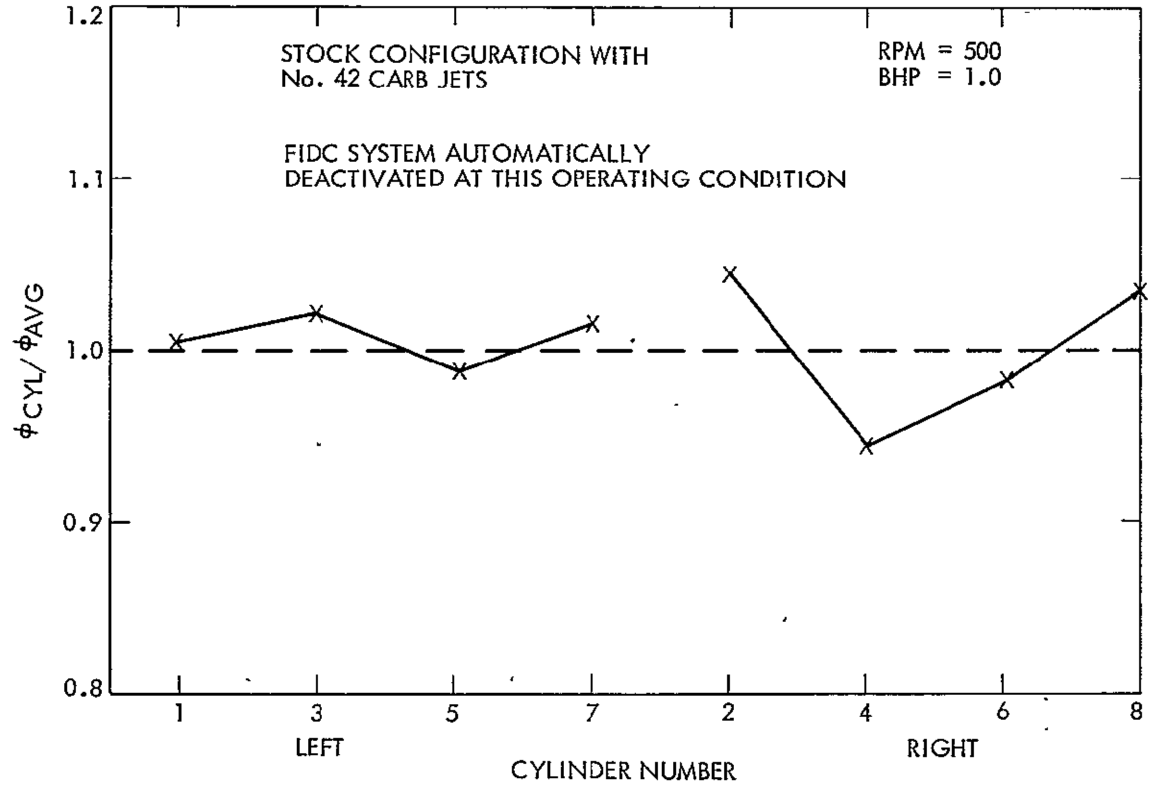

Figure 40. Cylinder-to-Cylinder Distribution of Equivalence Ratios (RPM = 500, BHP = 1.0)

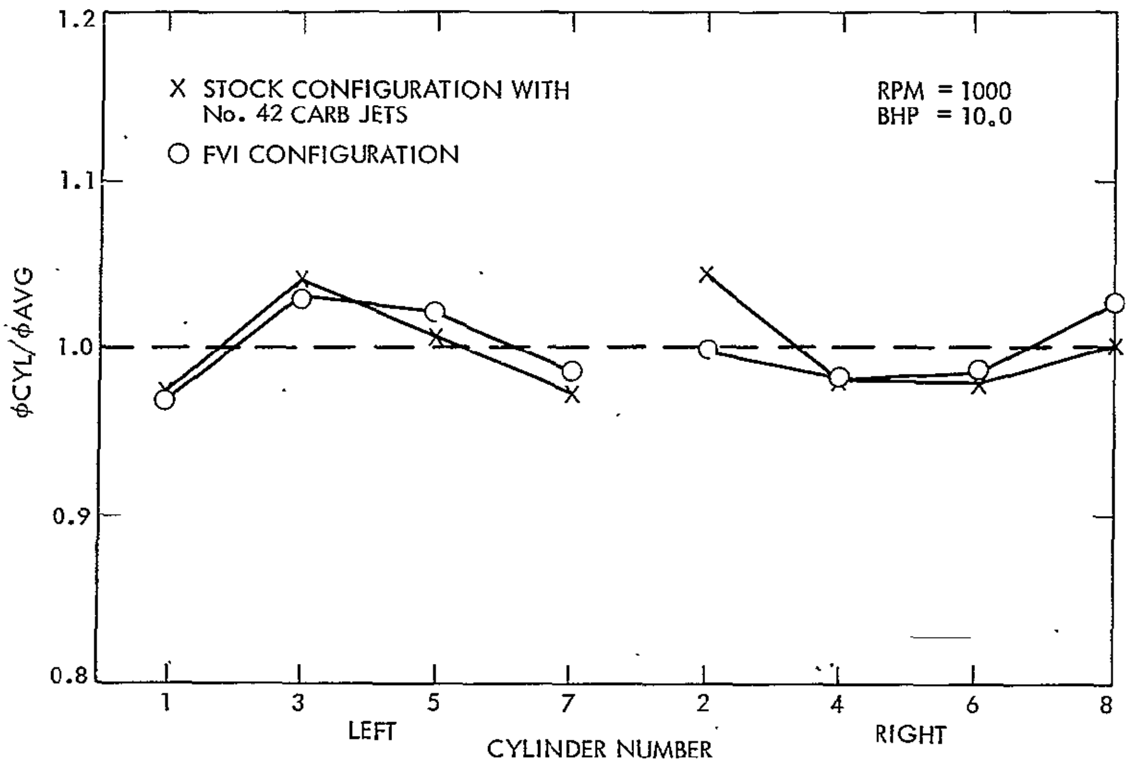

Figure 41. Cylinder-to-Cylinder Distribution of Equivalence Ratios (RPM = 1,000, BHP = 10.0)

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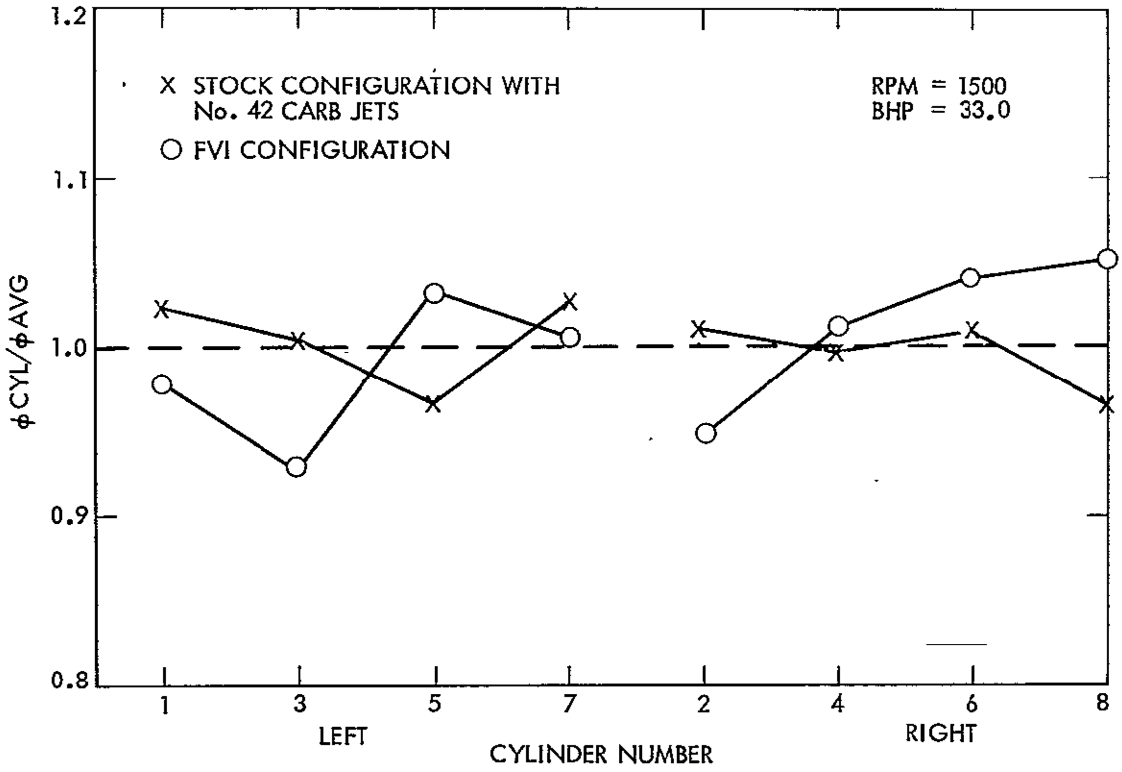

Figure 42. Cylinder-to-Cylinder Distribution of Equivalence Ratios (RPM = 1500, BHP = 33.0)

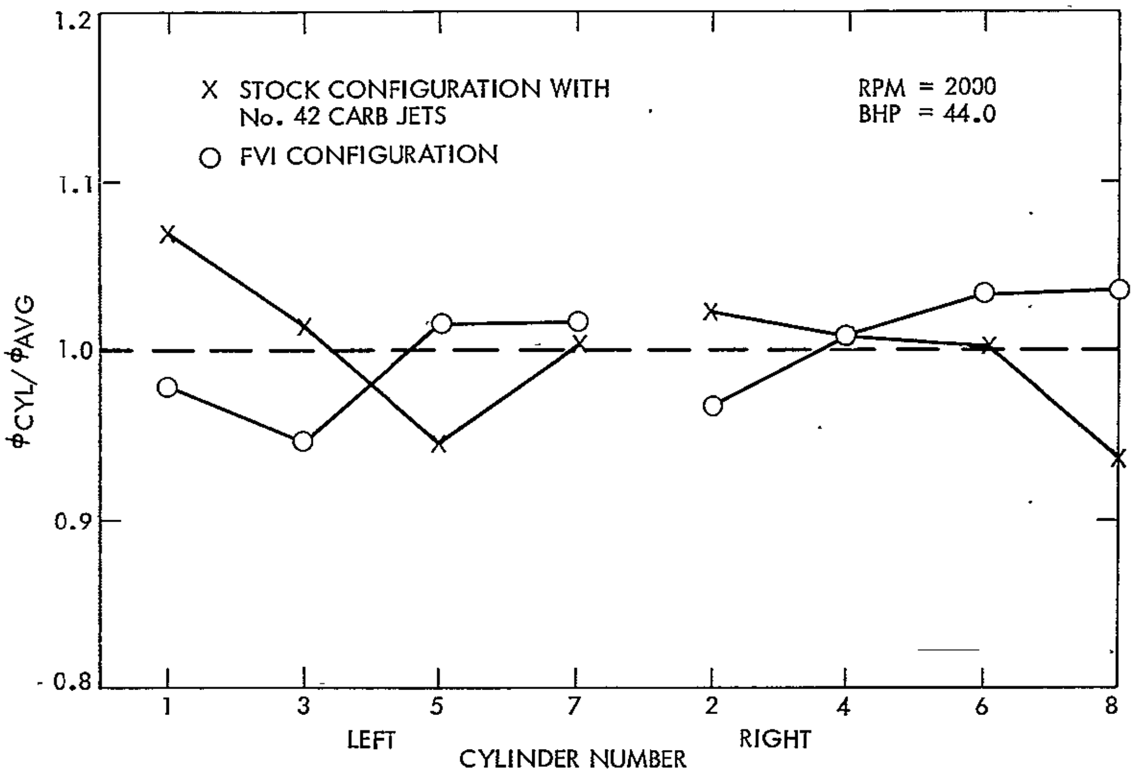

Figure 43. Cylinder-to-Cylinder Distribution of Equivalence Ratios (RPM - 2000, BHP - 44.0)

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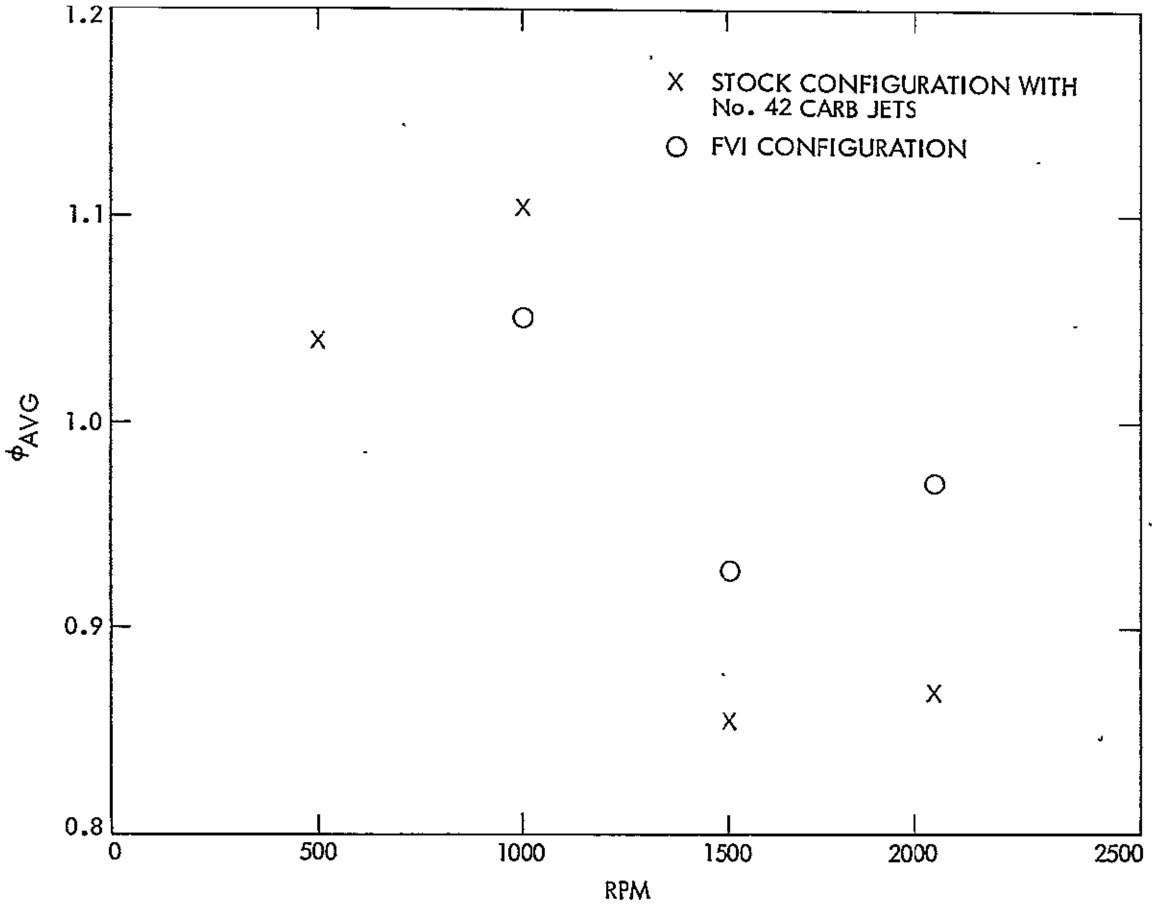

Figure 44. Average Equivalence Ratio for Distribution Tests on EC Dynamometer

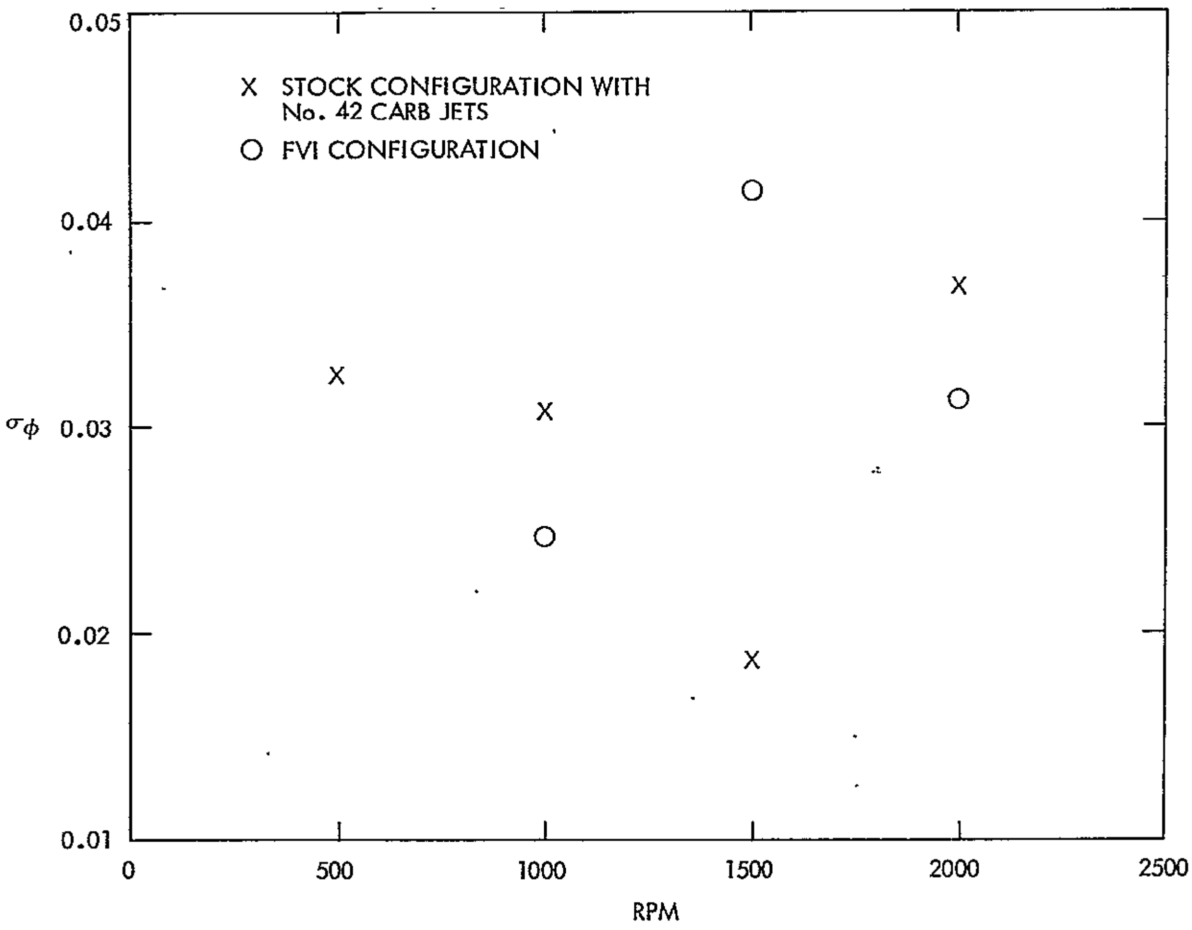

Figure 45. Standard Deviation of Equivalence Ratio for Distribution Tests on EC Dynamometer

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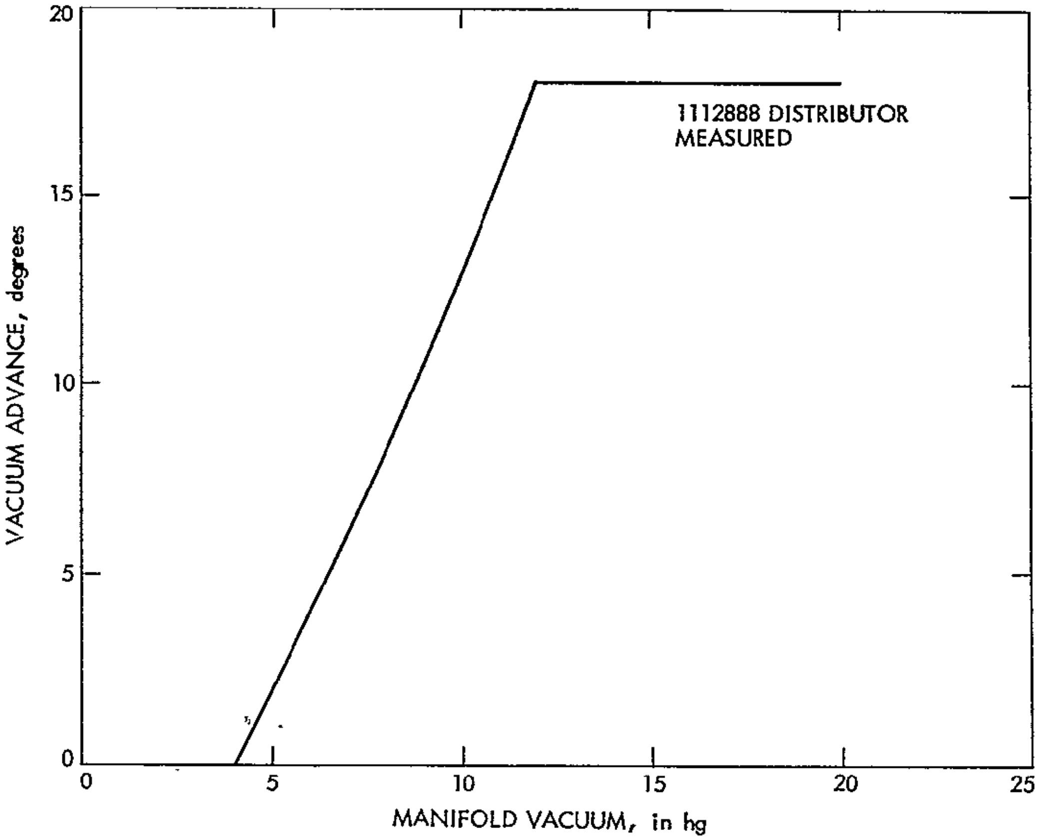

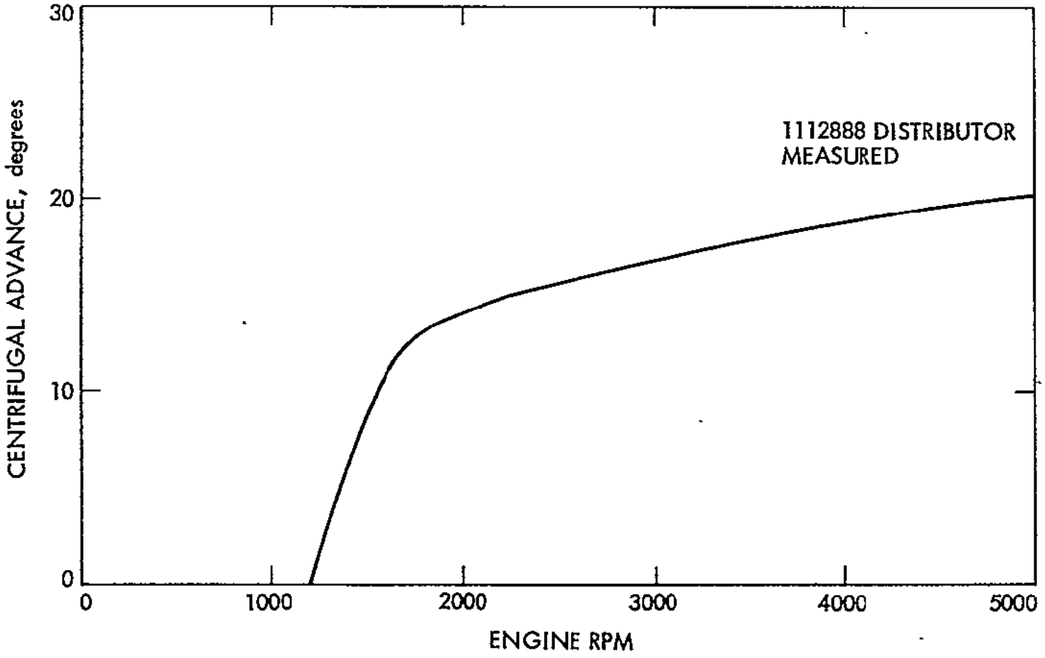

Figure 46. Vacuum and Centrifugal Advance Characteristics of Stock Distributor

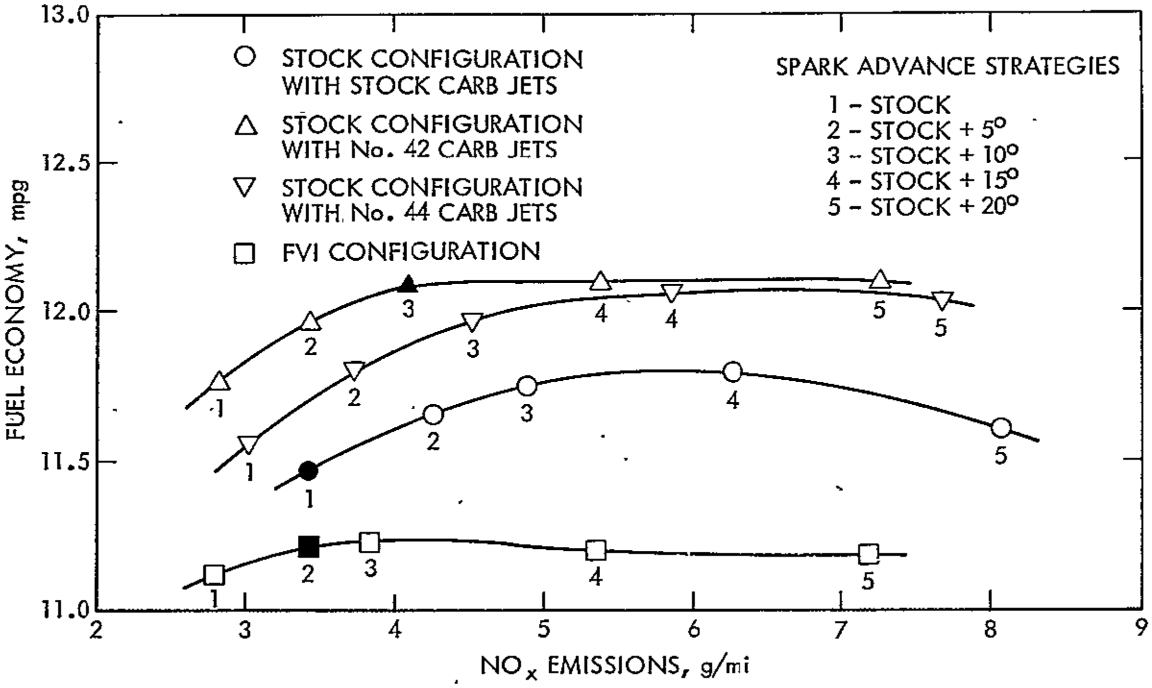

Figure 47. Predicted Urban Fuel Economy and NO$_x$ Emissions (4500 lb Inertia Weight)

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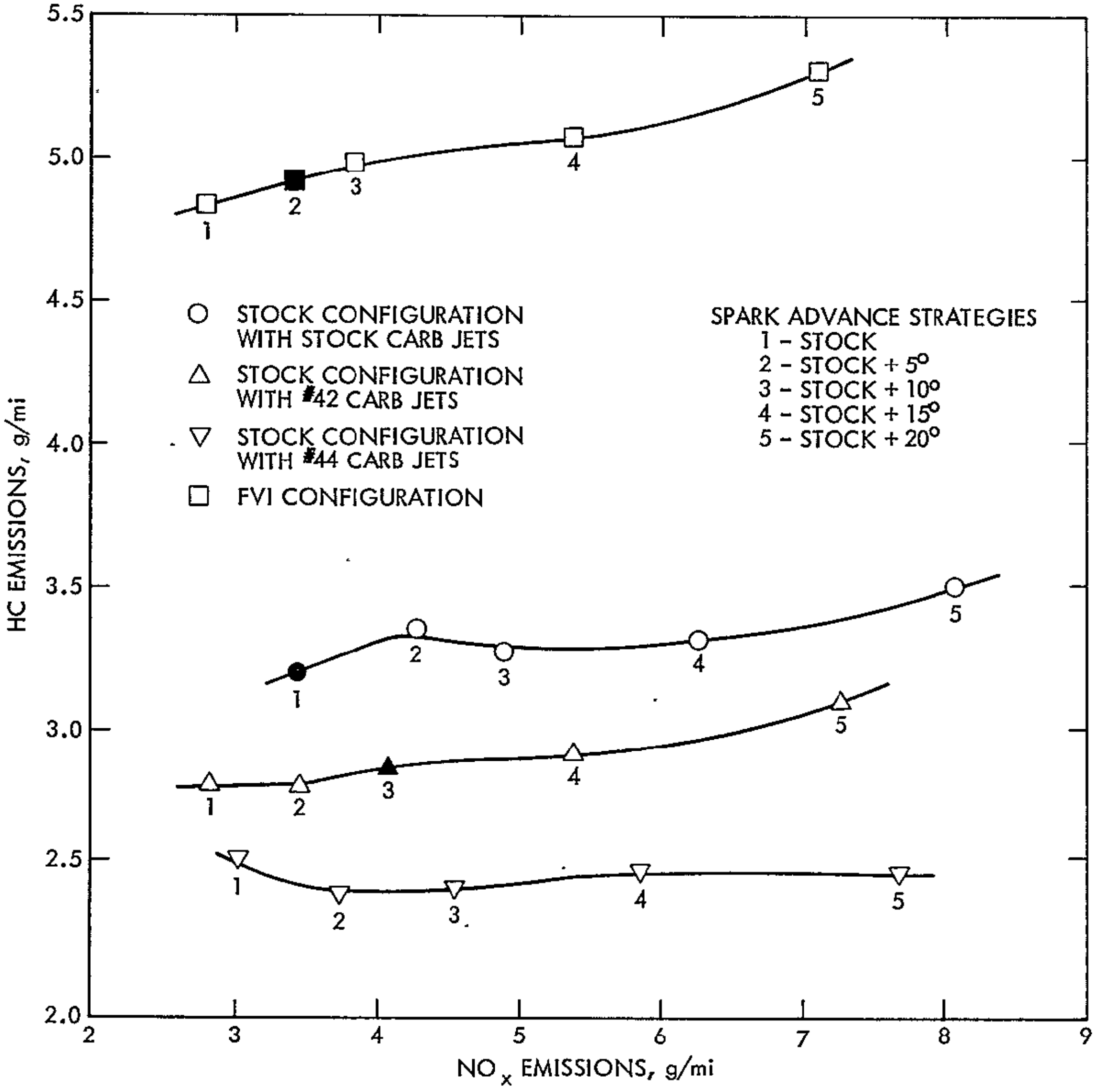

Figure 48. Predicted HC and NO$_x$ Emissions for Urban Driving Cycle (4500 lb Inertia Weight)

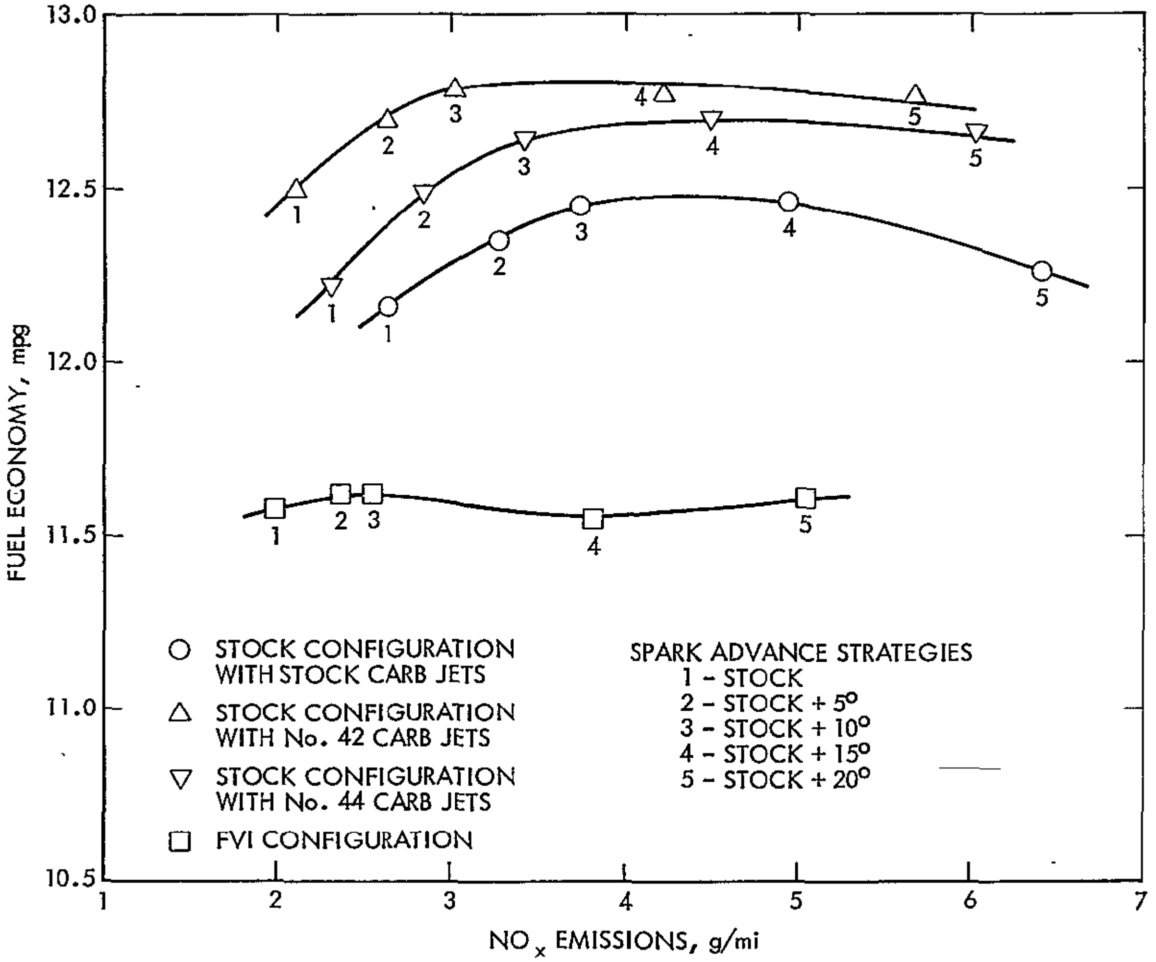

Figure 49. Predicted Urban Fuel Economy and NO$_x$ Emissions (3500 lb Inertia Weight)

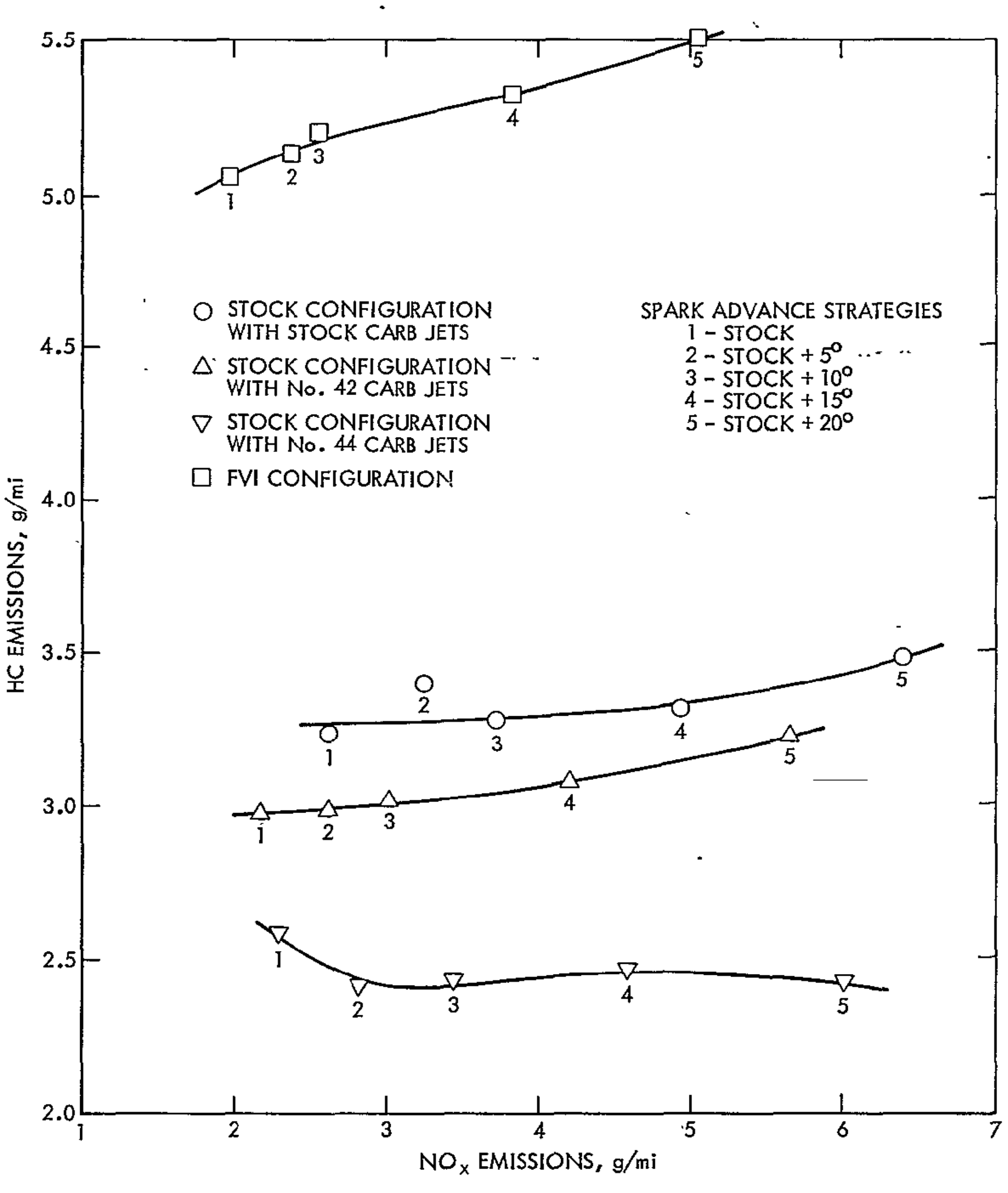

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Figure 50. Predicted HC and NO_x Emissions for Urban Driving Cycle (3500 lb Inertia Weight)

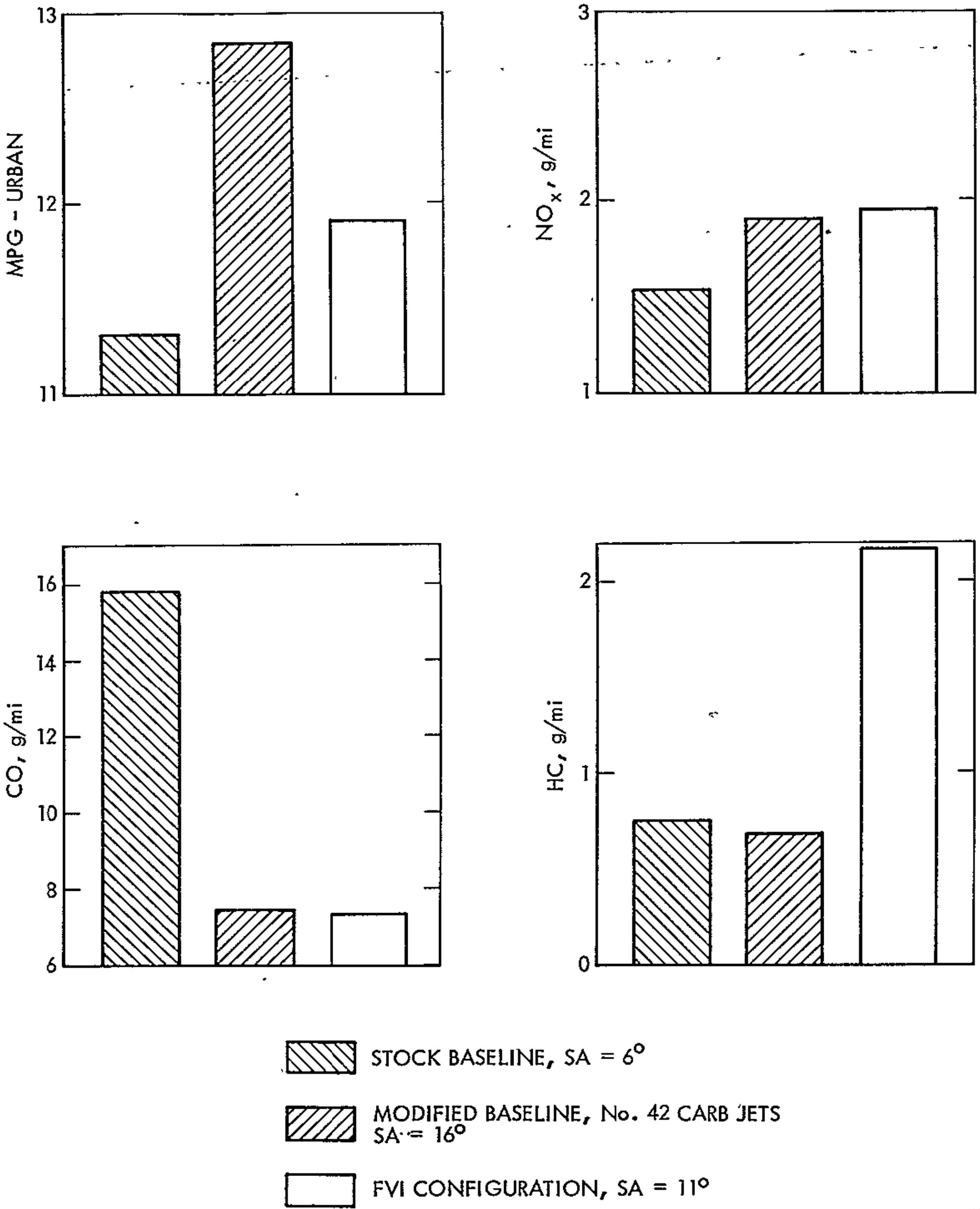

Figure 51. Urban Driving Cycle Results from Chassis Dynamometer Vehicle Tests

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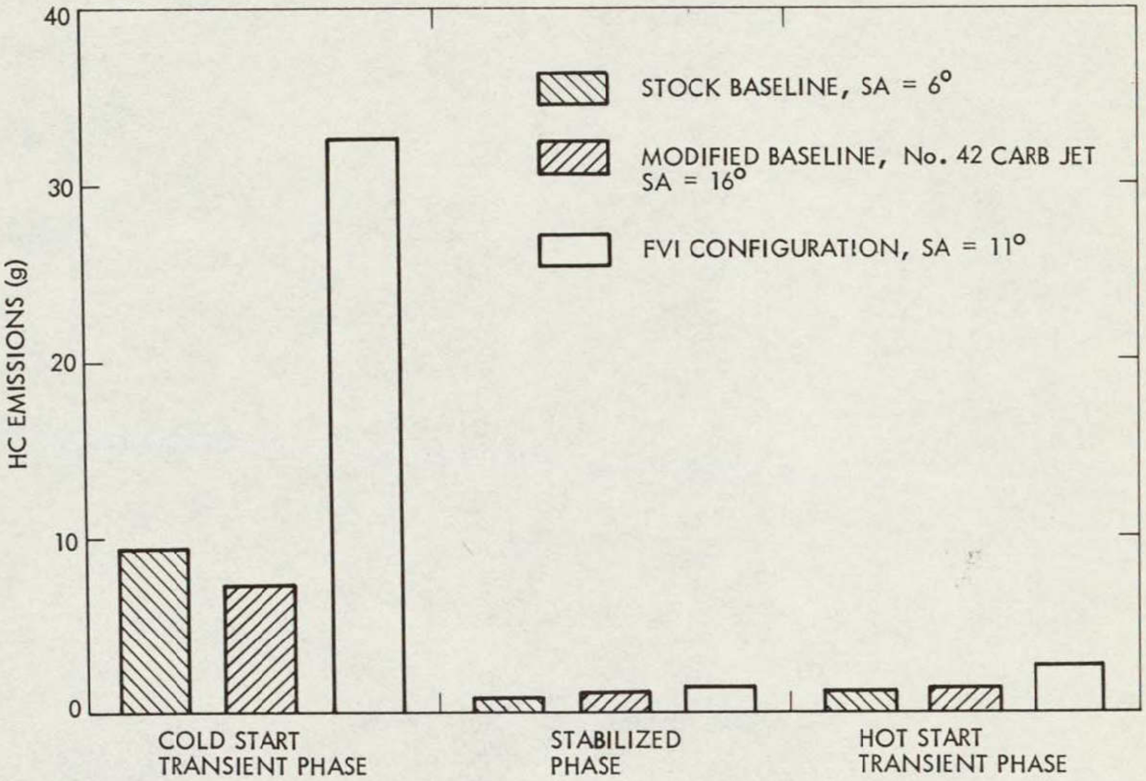

Figure 52. Urban Driving Cycle Hydrocarbon Emissions Results from Chassis Dynamometer Vehicle Tests

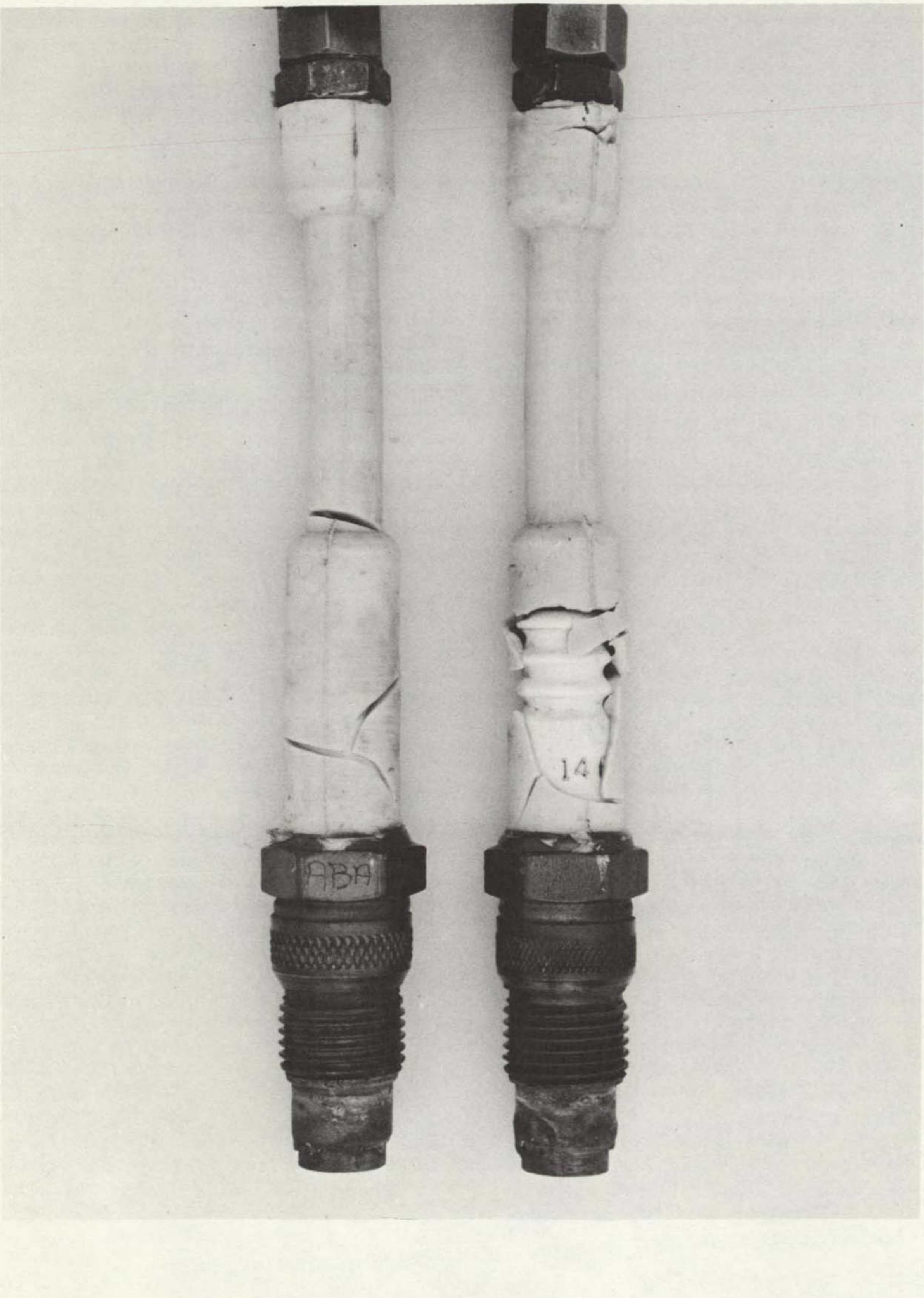

Figure 53. FVI's with Cracked Insulation. Cylinders 5, 6 V8 Engine

Table 2. CFR Sensitivity Data for FVI Configuration
(2500 RPM, 50 psi BMEP)

TEST NUMBER	CONFIG	RPM	BHP	SPARK ADVANCE	ϕ_{SYS}	BSFC (lbs/bhp-hr)	NO_x (g/min)	HC (g/min)	CO (g/min)
7164.2	F	2502.	8.22	24.2	0.86	0.536	3.37	0.22	0.54
7164.3	F	2502.	8.13	20.0	0.86	0.544	2.66	0.17	0.72
7164.4	F	2497.	7.75	14.1	0.86	0.573	1.78	0.10	0.68
7164.5	F	2501.	8.08	25.6	0.81	0.524	2.94	0.17	0.61
7164.6	F	2500.	7.95	21.4	0.80	0.531	2.09	0.13	0.72
7164.7	F	2496.	7.63	16.8	0.80	0.555	1.41	0.08	0.69
7164.8	F	2503.	8.15	28.2	0.77	0.514	2.72	0.18	0.60
7164.9	F	2501.	7.93	22.2	0.77	0.529	1.34	0.13	0.76
7164.10	F	2498.	7.68	18.4	0.77	0.548	1.07	0.10	0.79
7165.2	F	2503.	8.23	30.1	0.73	0.521	2.11	0.19	0.57
7165.3	F	2501.	8.05	24.6	0.73	0.531	1.16	0.17	0.71
7165.4	F	2499.	7.85	21.5	0.72	0.544	0.75	0.15	0.80
7165.5	F	2503.	8.16	31.4	0.69	0.508	1.24	0.21	0.60
7165.6	F	2501.	8.01	28.1	0.69	0.520	0.82	0.20	0.67
7165.7	F	2499.	7.73	24.2	0.69	0.540	0.47	0.19	0.75
7165.8	F	2500.	8.14	36.9	0.65	0.502	0.97	0.27	0.55
7165.9	F	2499.	8.02	32.3	0.65	0.512	0.46	0.32	0.62
7165.10	F	2502.	8.27	29.5	0.65	0.523	0.29	0.38	0.70
7165.11	F	2501.	8.22	43.4	0.61	0.501	0.54	0.41	0.61
7165.12	F	2498.	7.78	39.0	0.60	0.527	0.20	0.75	0.74
7165.13	F	2490.	7.28	35.3	0.60	0.562	0.11	1.06	0.80

F - FVI CONFIGURATION

Table 3. Ignition Delay and Flame Speed Data from CFR Tests

TEST NUMBER	CONFIG	RPM	POWER bhp	SPARK ADVANCE DEGREE BTDC	ϕ_{SYS}	BSFC (lbm/bhp-hr)	NO_x (g/min)	HC (g/min)	CO (g/min)	IGNITION DELAY, α DEGREES	FLAME SPEED, β DEGREES
7159.1	S	1505.	4.90	20.9	$\approx$0.87	0.460	1.61	0.35	0.26	16.3	14.6
7159.2	S	1504.	4.71	15.2	$\approx$0.87	0.479	1.30	0.25	0.28	11.8	18.0
7159.3	S	1503.	4.57	10.1	$\approx$0.87	0.496	0.98	0.23	0.38	12.9	14.9
7159.4	F	1504.	4.89	15.0	0.87	0.487	1.43	0.37	0.35	12.4	16.3
7159.5	F	1503.	4.86	12.6	0.87	0.497	1.27	0.35	0.40	12.4	15.5
7159.6	F	1502.	4.58	8.4	0.86	0.517	0.90	0.32	0.53	11.5	15.5

S - BASELINE CONFIGURATION
F - VFI CONFIGURATION

Table 4. Engine Data from EC Dynamometer Tests (1500 RPM, 75 psi BMEP)

TEST NUMBER	CONFIG	RPM	BHP	SPARK ADVANCE	ϕ_{SYS}	BSFC (lbm/bhp-hr)	NO_x (g/min)	HC (g/min)	CO (g/min)
7299.20	S	1500.	51.88	31.4	1.12	0.527	6.71	2.49	72.2
7299.21	S	1500.	51.59	24.0	1.12	0.537	5.54	2.43	73.0
7299.22	S	1500.	51.31	19.5	1.12	0.552	4.92	2.35	73.7
7304.2	S1	1499.	51.32	32.4	1.05	0.496	9.98	2.16	30.8
7304.3	S1	1499.	51.56	25.3	1.06	0.509	8.05	2.13	35.7
7304.4	S1	1497.	51.49	21.4	1.05	0.516	7.46	1.99	33.7
7306.2	S2	1499.	51.27	32.7	1.09	0.508	8.35	2.31	48.3
7306.3	S2	1498.	51.51	25.3	1.10	0.518	6.64	2.30	57.2
7306.4	S2	1502.	51.34	20.2	1.11	0.533	5.58	2.19	61.6
7293.17	F	1497.	51.13	42.5	0.83	0.460	12.93	2.41	2.4
7293.18	F	1497.	51.22	34.9	0.83	0.465	9.90	1.89	2.7
7293.19	F	1497.	50.51	29.5	0.83	0.476	7.77	1.70	3.1

S - STOCK CONFIGURATION
S1 - STOCK CONFIGURATION WITH #42 CARBURETOR JETS
S2 - STOCK CONFIGURATION WITH #44 CARBURETOR JETS
F - FVI CONFIGURATION

Table 5. Engine Data from EC Dynamometer Tests (1000 RPM, 25 psi BMEP)

TEST NUMBER	CONFIG	RPM	POWER bhp	SPARK ADVANCE DEGREE BTDC	ϕ_{SYS}	BSFC (lbm/bhp-hr)	NO_x (g/min)	HC (g/min)	CO (g/min)
7300.17	S	999.	12.17	37.4	1.15	0.726	0.91	1.02	16.7
7300.18	S	999.	12.19	32.9	1.14	0.722	0.69	1.01	16.8
7300.19	S	997.	12.40	28.7	1.14	0.721	0.60	1.01	17.6
7304.11	S1	1001.	12.38	34.5	1.10	0.698	1.07	0.83	8.1
7304.12	S1	999.	12.04	30.5	1.11	0.716	0.84	0.80	8.3
7304.13	S1	999.	12.52	26.2	1.10	0.704	0.73	0.79	8.4
7306.11	S2	999.	12.60	42.0	0.90	0.650	1.40	0.70	0.8
7306.12	S2	998.	12.49	39.8	0.90	0.657	1.19	0.69	0.9
7306.13	S2	997.	11.85	35.3	0.90	0.692	0.93	0.67	0.9
7293.11	F	997.	12.25	31.1	1.11	0.806	1.23	2.40	11.0
7293.12	F	996.	12.17	26.4	1.11	0.811	0.98	2.40	10.8
7293.13	F	996.	12.25	23.2	1.10	0.814	0.93	2.45	10.5

S - STOCK CONFIGURATION
S1 - STOCK CONFIGURATION WITH #42 CARBURETOR JETS
S2 - STOCK CONFIGURATION WITH #44 CARBURETOR JETS
F - FVI CONFIGURATION

Table 6. Statistical Data for Distribution Tests

DISTRIBUTION TESTS

		STOCK		FVI	
RPM	BHP	ϕ_{AVG}	σ_{ϕ}	ϕ_{AVG}	σ_{ϕ}
500	1.0	1.0402	0.0327	*	*
1000	11.0	1.1026	0.0307	1.0504	0.0248
1500	33.0	0.8529	0.0188	0.9265	0.0415
2000	44.0	0.8689	0.0367	0.9702	0.0314

*FIDC SYSTEM AUTOMATICALLY DEACTIVATED AT THIS OPERATING CONDITION

Table 7. Urban Driving Cycle Predictions Based on EC Dynamometer Data

CONFIG	SPARK ADVANCE	4500 lb. INERTIA WT.			3500 lb. INERTIA WT.		
		MPG	NO_x (g/mi)	HC (g/mi)	MPG	NO_x (g/mi)	HC (g/mi)
S	STOCK (6° BTDC)	11.47	3.45	3.20	12.16	2.63	3.24
S	STOCK + 5°	11.66	4.28	3.36	12.34	3.27	3.40
S	STOCK + 10°	11.76	4.89	3.25	12.45	3.72	3.26
S	STOCK + 15°	11.80	6.28	3.32	12.46	4.93	3.32
S	STOCK + 20°	11.61	8.08	3.51	12.27	6.40	3.50
S1	STOCK	11.76	2.82	2.81	12.50	2.09	2.97
S1	STOCK + 5°	11.97	3.47	2.80	12.69	2.62	2.97
S1	STOCK + 10°	12.08	4.05	2.88	12.78	3.02	3.03
S1	STOCK + 15°	12.10	5.39	2.94	12.77	4.21	3.08
S1	STOCK + 20°	12.10	7.27	3.12	12.76	5.68	3.24
S2	STOCK	11.56	3.03	2.56	12.23	2.30	2.59
S2	STOCK + 5°	11.80	3.74	2.43	12.48	2.83	2.42
S2	STOCK + 10°	11.97	4.54	2.45	12.65	3.43	2.43
S2	STOCK + 15°	12.03	5.85	2.51	12.71	4.58	2.48
S2	STOCK + 20°	12.02	7.69	2.50	12.67	6.02	2.43
F	STOCK	11.13	2.80	4.84	11.58	1.99	5.07
F	STOCK + 5°	11.22	3.42	4.91	11.63	2.37	5.14
F	STOCK + 10°	11.26	3.83	4.99	11.63	2.54	5.22
F	STOCK + 15°	11.21	5.36	5.08	11.55	3.81	5.33
F	STOCK + 20°	11.19	7.10	5.32	11.52	5.05	5.56

S - STOCK CONFIGURATION
S1 - STOCK CONFIGURATION WITH #42 CARBURETOR JETS
S2 - STOCK CONFIGURATION WITH #44 CARBURETOR JETS
F - FVI CONFIGURATION

Table 8. Urban Driving Cycle Results for Stock Baseline Based on Chassis Dynamometer Tests

TEST NUMBER	MPG - URBAN*		NO_x** (g/mi)	CO** (g/mi)	HC** (g/mi)
	WT	C.B.			
15	11.60	12.48	1.43	17.12	0.73
16	11.38	12.16	1.55	12.76	0.55
17	11.15	11.90	1.53	18.99	0.95
18	11.14	11.97	1.60	14.65	0.75
AVERAGE	11.32	12.13	1.53	15.88	0.74

* EPA ESTIMATED MILEAGE FOR THIS VEHICLE IS 13 mpg

** 1975 FEDERAL STANDARDS
NO_X 3.1 g/mi
CO 15 g/mi
HC 1.5 g/mi

Table 9. Urban Driving Cycle Results for Modified Baseline Based on Chassis Dynamometer Tests

ORIGINAL PAGE IS
OF POOR QUALITY

TEST NUMBER	MPG - URBAN		NO_x (g/mi)	CO (g/mi)	HC (g/mi)
	WT	C.B.			
8	12.75	13.69	1.98	8.34	0.70
9	12.79	13.89	1.90	7.69	0.63
10	12.73	13.90	1.87	7.69	0.66
11	13.02	14.04	1.87	6.36	0.64
12	12.88	13.94	1.90	6.62	0.66
AVERAGE	12.83	13.89	1.90	7.34	0.66

Table 10. Urban Driving Cycle Results for FVI Configuration Based on Chassis Dynamometer Tests

TEST NUMBER	MPG - URBAN		NO_x (g/mi)	CO (g/mi)	HC (g/mi)
	WT	C.B.			
3	11.93	12.80		8.30	2.92
5	11.74	12.64	1.90	4.53	1.58
6	11.95	12.54	1.95	7.14	1.58
7	11.97	12.54	1.98	9.08	2.68
AVERAGE	11.90	12.63	1.94	7.26	2.19

Table 11. Measured Versus Predicted Results for Urban Driving Cycle

ENGINE CONFIGURATION	PARAMETER	PREDICTED VALUE BASED ON EC DYNO. ENGINE DATA	MEASURED VALUE FROM CHASSIS DYNO. VEHICLE TEST
STOCK BASELINE SA = 6°	MPG	11.47	11.32 WEIGHT 12.13 CARBON BALANCE
	NO_x (g/mi)	3.45	1.53
	CO (g/mi)		15.88
	HC (g/mi)	3.20	0.74
MODIFIED BASELINE No. 42 CARB JETS SA = 16°	MPG	12.08	12.83 WEIGHT 13.89 CARBON BALANCE
	NO_x (g/mi)	4.09	1.90
	CO (g/mi)		7.34
	HC (g/mi)	2.88	0.66
FVI CONFIGURATION SA = 11°	MPG	11.22	11.90 WEIGHT 12.63 CARBON BALANCE
	NO_x (g/mi)	3.42	1.94
	CO (g/mi)		7.26
	HC (g/mi)	4.92	2.19

APPENDIX A

CFR DATA

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	α IGNITION DELAY	β FLAME SPEED	CONFIG-URATION	BMEP
6/8/77												
7159.1	1505.	4.90	20.9	0	0.4602	1.614	0.262	0.352	16.31°	14.62°	S	50
7159.2	1504.	4.71	15.2	0	0.4788	1.295	0.280	0.251	11.81°	18.0°	S	50
7159.3	1503.	4.57	10.1	0	0.4963	0.975	0.375	0.227	12.94°	14.91°	S	50
7159.4	1504.	4.89	15.0	0.87	0.4871	1.434	0.348	0.369	12.38°	16.31°	F	50
7159.5	1503.	4.86	12.6	0.87	0.4974	1.274	0.406	0.352	12.38°	15.47°	F	50
7159.6	1502.	4.58	8.4	0.86	0.5171	0.899	0.530	0.321	11.53°	15.47°	F	50
7159.7	1504.	4.82	20.1	0.85	0.4817	1.694	0.367	0.368			F	50
7159.8	1505.	4.81	17.1	0.81	0.4772	1.273	0.377	0.337			F	50
7159.9	1504.	4.70	14.3	0.81	0.4900	1.099	0.472	0.360			F	50
7159.10	1503.	4.68	12.0	0.82	0.5000	0.891	0.498	0.336			F	50
7159.11	1505.	4.92	21.1	0.77	0.4720	1.232	0.316	0.326			F	50
7159.12	1503.	4.82	15.6	0.77	0.4783	0.822	0.400	0.332			F	50
7159.13	1503.	4.59	12.6	0.77	0.5044	0.571	0.509	0.314			F	50
6/9/77												
7160.1	1506.	5.06	21.1	0.90	0.4700	1.937	0.287	0.347			F	50
7160.2	1502.	4.79	21.9	0.77	0.4492	1.285	0.330	0.315			F	50
7160.3	1505.	4.73	18.7	0.77	0.4580	1.054	0.363	0.332			F	50
7160.4	1505.	4.58	13.3	0.77	0.4787	0.511	0.479	0.331			F	50
7160.5	2007.	6.60	20.2	0.84	0.4887	2.446	0.508	0.383			F	50
7160.6	2001.	6.51	14.5	0.85	0.4990	1.806	0.686	0.384			F	50
7160.7	1999.	6.08	10.9	0.85	0.5184	1.320	0.789	0.270			F	50
7160.8	2001.	6.42	21.1	0.82	0.4733	2.291	0.522	0.382			F	50
7160.9	2001.	6.28	16.6	0.82	0.5007	1.718	0.669	0.349			F	50
7160.10	1998.	6.08	12.0	0.82	0.5215	1.170	0.887	0.243			F	50
7160.11	2000.	6.45	21.0	0.76	0.4834	1.605	0.605	0.334			F	50
6170.12	1999.	6.36	17.1	0.77	0.4920	1.153	0.747	0.278			F	50
7160.13	1995.	6.82	14.2	0.76	0.6095	1.023	0.980	0.250			F	50
7160.14	2006.	6.59	25.1	0.75	0.4772	1.844	0.456	0.324			F	50
7160.15	2006	6.52	18.9	0.75	0.4829	1.014	0.626	0.279			F	50

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP	CONFIG-URATION
6/9/77										
7160.16	2005.	6.29	15.2	0.75	0.5017	0.732	0.756	0.226	50	F
7160.17	2007.	6.69	27.5	0.71	0.4668	1.405	0.456	0.323	50	F
7160.18	2007.	6.54	22.1	0.71	0.4806	0.779	0.549	0.291	50	F
7160.19	2007.	6.51	18.1	0.71	0.4836	0.430	0.681	0.253	50	F
7160.20	2006.	6.51	30.7	0.66	0.4601	0.506	0.473	0.334	50	F
7160.21	2005.	6.36	26.1	0.66	0.4709	0.397	0.527	0.373	50	F
7160.22	2001.	6.06	22.4	0.66	0.4900	0.210	0.591	0.382	50	F
7160.23	2007.	6.58	36.0	0.62	0.4520	0.452	0.482	0.393	50	F
7160.24	2006.	6.39	31.1	0.62	0.4657	0.274	0.525	0.455	50	F
7160.25	2004.	6.11	28.3	0.62	0.4886	0.162	0.564	0.505	50	F
7160.26	2007.	6.81	45.1	0.58	0.4462	0.541	0.511	0.602	50	F
7160.27	2007.	6.48	38.4	0.58	0.4694	0.139	0.606	0.860	50	F
7160.28	2005.	6.08	33.4	0.57	0.5023	0.057	0.704	1.097	50	F
6/13/77										
7164.1	1500.	4.93	21.3	0.87	0.4840	1.986	0.340	0.422	50	F
7164.2	2502.	8.22	24.2	0.86	0.5363	3.372	0.543	0.216	50	F
7164.3	2502.	8.13	20.0	0.86	0.5439	2.663	0.716	0.166	50	F
7164.4	2497.	7.75	14.1	0.86	0.5734	1.781	0.677	0.096	50	F
7164.5	2501.	8.08	25.6	0.81	0.5238	2.935	0.613	0.171	50	F
7164.6	2500.	7.95	21.4	0.80	0.5313	2.086	0.718	0.130	50	F
7164.7	2496.	7.63	16.8	0.80	0.5551	1.411	0.685	0.077	50	F
7164.8	2503.	8.15	28.2	0.77	0.5136	2.724	0.598	0.182	50	F
7164.9	2501.	7.93	22.2	0.77	0.5294	1.336	0.756	0.131	50	F
7164.10	2498.	7.68	18.4	0.77	0.5482	1.071	0.794	0.095	50	F
6/14/77										
7165.1	1502.	4.91	21.5	0.85	0.4864	1.976	0.359	0.362	50	F
7165.2	2503.	8.23	30.1	0.73	0.5211	2.112	0.566	0.192	50	F
7165.3	2501.	8.05	24.6	0.73	0.5308	1.162	0.711	0.168	50	F
7165.4	2499.	7.85	21.5	0.72	0.5438	0.749	0.802	0.148	50	
7165.5	2503.	8.16	31.4	0.69	0.5078	1.239	0.597	0.211	50	

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP	CONFIGURATION
6/14/77 7165.6	2501.	8.01	28.1	0.69	0.5196	0.815	0.669	0.202	50	F
7165.7	2499.	7.73	24.2	0.69	0.5404	0.472	0.751	0.186	50	F
7165.8	2500.	8.14	36.9	0.65	0.5018	0.968	0.554	0.274	50	F
7165.9	2499.	8.02	32.3	0.65	0.5115	0.460	0.623	0.317	50	F
7165.10	2502.	8.27	29.5	0.65	0.5225	0.290	0.696	0.376	50	F
7165.11	2501.	8.22	43.4	0.61	0.5005	0.543	0.614	0.406	50	F
7165.12	2498.	7.78	39.0	0.60	0.5268	0.197	0.738	0.750	50	F
7165.13	2490.	7.28	35.3	0.60	0.5622	0.111	0.802	1.059	50	F
7165.14	1504.	7.22	14.5	0.86	0.4425	2.770	0.347	0.489	75	F
7165.15	1503.	7.03	10.0	0.86	0.4535	2.242	0.410	0.549	75	F
7165.16	1496.	5.37	7.2	0.85	0.5914	1.888	0.452	0.874	50	F
6/15/77 7166.2	1499.	7.40	16.0	0.82	0.4419	2.955	0.328	0.481	75	F
7166.3	1500.	7.23	10.9	0.82	0.4542	2.227	0.397	0.582	75	F
7166.4	1500.	6.84	7.8	0.82	0.4807	1.615	0.474	0.944	75	F
7166.5	1501.	7.38	16.1	0.78	0.4393	2.391	0.346	0.454	75	F
7166.6	1496.	6.35	12.8	0.78	0.5078	1.669	0.362	0.992	75	F
7166.7	1501.	7.21	17.4	0.75	0.4508	2.005	0.346	0.789	75	F
7166.8	1501.	7.55	22.5	0.70	0.4235	1.776	0.348	0.422	75	F
7166.9	1502.	7.34	20.3	0.70	0.4359	1.391	0.357	0.549	75	F
7166.10	1501.	7.53	25.4	0.66	0.4161	0.923	0.377	0.398	75	F
7166.11	1500.	7.04	22.2	0.66	0.4439	0.555	0.368	1.154	75	F
7166.12	1500.	4.88	21.0	0.86	0.4761	1.939	0.298	0.403	50	S
7166.13	1503.	4.96	21.2	0.90	0.4885	1.830	0.217	0.291	50	S
7166.14	1503.	4.99	21.4	0.87	0.4702	1.717	0.227	0.270	50	S
7166.15	1502.	4.94	16.0	0.85	0.4810	1.132	0.294	0.262	50	S
7166.16	1502.	4.80	12.9	0.86	0.4969	0.862	0.371	0.253	50	S
7166.17	1503.	4.83	21.3	0.82	0.4695	1.334	0.247	0.250	50	S
7166.18	1501.	4.77	19.5	0.82	0.4751	1.116	0.270	0.251	50	S

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP	CONFIG-URATION
6/15/77 7166.19	1500.	4.54	14.5	0.82	0.4990	0.665	0.370	0.238	50	S
7166.20	1502.	4.84	21.9	0.77	0.4643	0.857	0.280	0.252	50	S
7166.21	1501.	4.71	19.1	0.77	0.4767	0.597	0.318	0.256	50	S
7166.22	1500.	4.56	16.2	0.77	0.4915	0.400	0.386	0.252	50	S
7166.23	1500.	4.73	25.4	0.73	0.4647	0.624	0.292	0.313	50	S
7166.24	1500.	4.59	22.6	0.73	0.4766	0.471	0.314	0.333	50	S
7166.25	1499.	4.50	20.9	0.73	0.4836	0.380	0.343	0.330	50	S
7166.25	2002.	6.51	21.0	0.88	0.5158	2.098	0.428	0.311	50	S
7166.27	2000.	6.33	17.2	0.88	0.5324	1.613	0.516	0.269	50	S
7166.28	1998.	6.08	14.3	0.88	0.5511	1.295	0.580	0.200	50	S
7166.29	1502.	4.90	21.6	0.91	0.4506	1.399	1.292	0.347	50	S
6/16/77 7167.1	1503.	4.95	21.4	0.91	0.4843	1.905	0.205	0.287	50	S
7167.2	2004.	6.59	24.3	0.84	0.5043	2.273	0.419	0.287	50	S
7167.3	2004.	6.54	20.9	0.84	0.5099	1.802	0.500	0.293	50	S
7167.4	2002.	6.28	16.4	0.85	0.5354	1.276	0.640	0.267	50	S
7167.5	2003.	6.66	25.0	0.80	0.4968	1.758	0.459	0.214	50	S
7167.6	2004.	6.57	22.3	0.80	0.5043	1.405	0.532	0.285	50	S
7167.7	2002.	6.29	18.5	0.80	0.5265	0.944	0.652	0.261	50	S
7167.8	2004.	6.67	27.1	0.75	0.4858	1.304	0.468	0.217	50	S
7167.9	2003.	6.52	24.3	0.75	0.4982	0.900	0.537	0.288	50	S
7167.10	2000.	6.20	20.6	0.75	0.5219	0.558	0.655	0.271	50	S
7167.11	2004.	6.56	29.3	0.72	0.4889	0.826	0.475	0.241	50	S
7167.12	2002.	6.31	25.2	0.71	0.5082	0.440	0.569	0.355	50	S
7167.13	1999.	6.04	22.4	0.71	0.5267	0.289	0.648	0.291	50	S
7167.14	1501.	4.85	21.3	0.91	0.4756	1.646	0.219	0.253	50	S
6/21/77 7172.1	1499.	4.88	21.3	0.91	0.5028	1.996	0.208	0.307	50	S
7172.2	2502.	8.23	26.4	0.89	0.5484	3.587	0.471	0.155	50	S
7172.3	2501.	8.05	23.4	0.88	0.5545	2.805	0.505	0.117	50	S

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP	CONFIG-URATION
6/21/77 7172.4	2500.	7.89	20.3	0.88	0.5651	2.279	0.470	0.091	50	S
7172.5	2503.	8.29	28.0	0.84	0.5312	3.234	0.468	0.135	50	S
7172.6	2502.	8.13	24.6	0.84	0.5407	2.466	0.454	0.098	50	S
7172.7	2500.	7.84	20.9	0.84	0.5611	1.716	0.552	0.092	50	S
7172.8	2503.	8.19	30.2	0.80	0.5265	2.671	0.439	0.117	50	S
7172.9	2503.	8.13	27.1	0.80	0.5327	2.092	0.486	0.110	50	S
7172.10	2500.	7.83	23.4	0.80	0.5524	1.372	0.490	0.083	50	S
7172.11	2504.	8.32	34.1	0.76	0.5183	2.319	0.436	0.120	50	S
7172.12	2503.	8.17	29.4	0.76	0.5282	1.446	0.487	0.116	50	S
7172.13	2500.	7.90	25.9	0.76	0.5455	0.973	0.523	0.095	50	S
7172.14	2502.	8.35	34.8	0.70	0.5067	0.898	0.558	0.202	50	S
7172.15	2500.	8.20	32.1	0.70	0.5155	0.637	0.578	0.183	50	S
7172.16	2494.	7.69	28.1	0.70	0.5494	0.345	0.622	0.155	50	S
7172.17	2497.	7.78	38.4	0.66	0.5551	0.340	0.719	1.144	50	S
7172.18	2495.	7.30	37.4	0.66	0.5905	0.267	0.785	1.221	50	S
7172.19	2493.	7.60	35.0	0.66	0.5692	0.310	0.800	1.077	75	S
7172.20	1502.	7.19	17.1	0.89	0.4335	2.802	0.252	0.349	75	S
7172.21	1502.	7.06	14.0	0.89	0.4422	2.350	0.286	0.368	75	S
7172.22	1501.	6.71	8.9	0.89	0.4633	1.731	0.400	0.319	75	S
7172.23	1502.	7.10	17.5	0.85	0.4338	2.583	0.288	0.333	75	S
7172.24	1502.	6.94	13.7	0.84	0.4430	2.051	0.341	0.327	75	S
7172.25	1501.	6.65	10.3	0.84	0.4616	1.556	0.452	0.271	75	S
6/23/77 7174.1	1500.	4.87	21.8	0.91	0.4798	1.791	0.205	0.243	75	S
7174.2	1500.	7.26	20.7	0.79	0.4388	2.423	0.278	0.289	75	S
7174.3	1500.	7.08	16.1	0.79	0.4500	1.612	0.332	0.274	75	S
7174.4	1499.	6.82	13.1	0.79	0.4667	1.157	0.428	0.252	75	S
7174.5	1500.	7.20	23.5	0.75	0.4343	1.839	0.288	0.287	75	S
7174.6	1500.	7.03	18.6	0.75	0.4449	1.091	0.338	0.280	75	S

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP	CONFIG-URATION
6/23/77 7174.7	1498.	6.78	15.4	0.75	0.4610	0.733	0.404	0.266	75	S
7174.8	1500.	7.28	27.6	0.71	0.4243	1.349	0.303	0.278	75	S
7174.9	1499.	7.02	22.4	0.70	0.4370	0.661	0.339	0.284	75	S
7174.10	1498.	6.70	23.9	0.70	0.4593	0.346	0.397	0.285	75	S
7174.11	1498.	7.05	34.9	0.66	0.4350	0.786	0.339	1.134	75	S
7174.12	1497.	6.28	30.2	0.66	0.4868	0.413	0.385	1.134	75	S
7174.13	1489.	5.97	25.2	0.66	0.5108	0.204	0.421	1.135	50	S
7174.14	1503.	4.90	21.5	0.92	0.4813	1.619	0.278	0.270	50	S

APPENDIX B

EC Dynamometer Data

Table B-1. Engine Tests - Stock

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
10/27/77 7300.20	998.	2.62	45.0	1.152	1.109	1.9607	0.048	10.2	1.12	5.9
7300.21	997.	2.66	43.3	1.158	1.120	1.9329	0.047	9.8	1.07	6.0
7300.22	998.	2.51	41.5	1.174	1.119	2.0661	0.047	9.8	1.00	5.7
10/27/77 7300.17	999.	12.17	37.34	1.149	1.124	0.7263	0.911	16.7	1.02	27.6
7300.18	999.	12.19	32.9	1.142	1.131	0.7217	0.693	16.8	1.01	27.6
7300.19	997.	12.40	28.6	1.138	1.123	0.7211	0.604	17.6	1.01	28.1
10/27/77 7300.14	1001.	23.32	38.0	0.895	1.006	0.5116	5.322	1.0	1.01	52.5
7300.15	1001.	23.17	32.1	0.890	0.988	0.5212	4.038	1.0	0.97	52.4
7300.16	1001.	23.63	27.5	0.895	1.016	0.5200	3.903	1.1	0.93	54.2
10/27/77 7300.2	1499.	34.96	45.9	0.839	0.957	0.5188	8.287	2.2	1.47	52.6
7300.3	1499.	36.11	40.5	0.859	0.967	0.5159	7.909	2.2	1.36	54.5
7300.4	1497.	35.46	36.0	0.857	0.973	0.5229	6.585	2.3	1.28	53.7
10/27/77 7300.8	1501.	4.71	47.1	1.155	1.125	1.7407	0.164	14.9	0.99	7.1
7300.9	1501.	4.84	46.2	1.141	1.120	1.6644	0.163	15.0	0.99	7.3
7300.10	1501.	4.75	45.3	1.150	1.119	1.6882	0.156	15.1	0.99	7.2
10/27/77 7300.5	1500.	18.75	46.8	0.981	1.074	0.6533	3.315	4.5	0.96	77.9
7300.6	1499.	18.77	42.7	0.984	1.084	0.6523	2.862	4.9	0.92	76.9
7300.7	1498.	18.11	38.3	0.984	1.070	0.6795	2.278	4.7	0.86	77.6
10/26/77 7299.20	1500.	51.88	31.4	1.122	1.084	0.5274	6.708	72.2	2.49	78.3
7299.21	1500.	51.59	24.0	1.124	1.078	0.5367	5.537	73.0	2.43	77.9
7299.22	1500.	51.31	19.5	1.118	1.081	0.5519	4.916	73.7	2.35	77.4
10/26/77 7299.8	2001.	25.34	48.4	0.868	0.935	0.6676	4.574	2.6	0.778	28.7
7299.9	2000.	24.50	45.5	0.870	0.936	0.6968	3.820	2.6	0.724	27.8
7299.10	1999.	24.42	42.4	0.867	0.930	0.6952	3.326	2.7	0.720	27.6
10/26/77 7299.2	1997.	46.66	45.9	0.890	0.956	0.5383	13.134	3.3	1.304	52.4
7299.3	1996.	46.78	36.4	0.895	0.959	0.5454	10.342	3.7	1.086	53.0
7299.4	2002.	47.77	30.3	0.921	0.977	0.5569	9.150	4.0	0.902	54.0
10/26/77 7299.5	2002.	68.91	33.2	1.119	1.087	0.5295	9.198	95.5	3.22	77.9

Table B-1. Engine Tests - Stock (Continutation 1)

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
10/26/77 7299.6	2002.	68.03	26.5	1.121	1.088	0.5416	7.722	97.6	3.20	76.9
7299.7	2002.	68.69	21.0	1.116	1.089	0.5552	7.376	93.4	3.16	77.6
10/26/77 7299.11	1993.	3.86	41.7	1.115	1.077	2.6376	0.247	15.7	0.900	4.4
7299.12	2003.	3.83	40.0	1.117	1.072	2.6444	0.234	15.6	0.86	4.3
7299.13	2000.	3.44	39.1	1.115	1.074	2.9494	0.226	15.5	0.86	3.9
10/26/77 7299.14	2502.	32.02	48.6	0.885	0.945	0.6973	5.974	3.7	0.814	29.0
7299.15	2499.	31.03	45.5	0.887	0.946	0.7186	5.732	3.6	0.772	28.2
7299.16	2499.	30.35	43.0	0.884	0.943	0.7372	5.011	3.5	0.742	27.7
10/26/77 7299.17	2500.	57.68	48.6	0.894	0.959	0.5429	16.922	4.1	0.904	51.4
7299.18	2501.	59.00	44.2	0.898	0.964	0.5460	15.707	4.1	0.834	53.5
7299.19	2499.	58.89	38.0	0.909	0.970	0.5546	13.369	4.0	0.835	53.3

Table B-2. Engine Tests - Modified Stock - #42 Jets

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
10/31/77 7304.20	499.	1.86	35.4	1.063	0.997	1.5533	0.03	0.5	0.73	8.5
7304.21	499.	1.91	33.2	1.077	1.018	1.5129	0.026	0.5	0.73	8.6
7304.22	502.	2.23	31.2	1.061	1.026	1.3452	0.025	0.6	0.71	10.0
10/31/77 7304.23	1004.	3.51	43.0	1.111	1.092	1.5087	0.086	5.0	0.73	7.9
7304.24	1004.	3.49	41.3	1.110	1.089	1.5215	0.074	4.9	0.78	7.9
7304.25	1003.	3.44	39.8	1.101	1.095	1.5346	0.073	4.8	0.69	7.7
10/31/77 7304.11	1001.	12.38	34.5	1.104	1.072	0.6976	1.065	8.1	0.83	28.0
7304.12	999.	12.04	30.5	1.109	1.077	0.7157	0.839	8.3	0.80	27.3
7304.13	999.	12.52	26.2	1.099	1.073	0.7041	0.731	8.4	0.79	28.4
10/31/77 7304.14	1000.	23.37	44.2	0.856	0.932	0.5046	4.895	1.0	1.05	52.9
7304.15	1000.	23.38	38.0	0.850	0.939	0.5052	3.768	1.0	1.04	52.7
7304.16	1000.	23.24	31.8	0.858	0.956	0.5185	3.700	1.1	0.99	52.6
10/31/77 7304.5	1498.	34.47	47.0	0.807	0.888	0.5160	6.612	2.2	1.70	52.2
7304.6	1497.	35.17	43.4	0.811	0.886	0.5176	5.925	2.3	1.69	53.5
7304.7	1503.	35.39	37.4	0.817	0.891	0.5291	4.670	2.6	1.49	53.3
10/31/77 7304.26	1502.	3.86	45.2	0.868	0.926	2.0515	0.198	1.8	2.47	6.1
7304.27	1501.	3.89	42.0	0.869	0.920	2.0487	0.233	1.9	2.47	6.0
7304.28	1499.	3.31	40.2	0.868	0.905	2.3787	0.204	1.8	2.47	5.0
10/31/77 7304.8	1498.	18.98	49.6	0.921	0.958	0.6359	3.453	1.5	0.86	28.7
7304.9	1498.	18.67	46.1	0.923	0.956	0.6496	3.094	1.5	0.82	28.2
7304.10	1496.	18.35	40.3	0.923	0.959	0.6609	2.403	1.7	0.75	27.7
10/31/77 7304.2	1499.	51.32	32.4	1.050	1.000	0.4964	9.980	30.8	2.16	77.5
7304.3	1499.	51.56	25.3	1.059	1.009	0.5087	8.045	35.7	2.13	77.9
7304.4	1497.	51.49	21.4	1.051	1.018	0.5156	7.458	33.7	1.99	77.8
10/28/77 7301.7	1998.	25.05	54.4	0.790	0.923	0.6790	2.810	3.5	3.32	28.4
7301.8	1996.	23.70	49.2	0.791	0.923	0.7193	2.133	3.7	3.27	26.9
7301.9	2002.	24.67	46.4	0.782	0.909	0.7122	1.939	3.9	4.06	27.9
10/28/77 7301.1	1997.	46.92	52.3	0.839	0.944	0.5151	11.517	3.4	1.550	53.2

Table B-2. Engine Tests - Modified Stock - #42 Jets
(Continuation 1)

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	CH gm/min	BMEP
10/28/77 7301.2	1995.	45.97	46.2	0.843	0.934	0.5285	9.442	3.6	1.504	52.3
7301.3	1995.	47.76	40.2	0.864	0.944	0.5251	9.037	3.5	1.116	54.1
10/28/77 7301.4	1999.	69.41	36.4	1.062	1.076	0.4931	14.811	38.5	2.53	78.6
7301.5	1998.	68.95	27.1	1.066	1.081	0.5049	11.679	38.3	2.43	78.2
7301.6	1997.	68.90	22.7	1.065	1.090	0.5175	10.745	35.2	2.30	78.1
10/31/77 7304.29	2002.	4.33	47.6	0.886	0.953	2.3219	0.378	2.3	1.68	4.9
7304.30	1999.	3.53	45.3	0.890	0.943	2.8573	0.345	2.4	1.92	4.0
7304.31	2004.	5.14	42.7	0.884	0.954	2.0675	0.430	2.2	1.34	5.8
10/28/77 7301.10	2004.	4.84	41.2	1.050	1.042	2.0346	0.387	6.1	0.64	5.5
7301.11	2002.	5.12	30.4	1.060	1.057	1.9479	0.378	6.5	0.58	5.8
7301.12	1998.	4.19	42.9	1.039	1.046	2.3162	0.317	5.3	0.48	4.7
10/28/77 7301.16	2501.	31.91	51.4	0.821	0.959	0.7042	4.591	4.7	2.78	28.7
7301.17	2497.	29.92	48.3	0.811	0.966	0.7407	3.693	4.6	2.84	27.0
7301.18	2496.	30.71	45.0	0.816	0.964	0.7411	3.579	4.8	2.82	27.8
10/28/77 7301.13	2495.	57.39	52.2	0.836	0.981	0.5329	12.714	4.4	0.944	51.9
7301.14	2494.	59.23	45.7	0.861	0.992	0.5367	12.439	4.2	0.812	53.8
7301.15	2943.	58.48	40.8	0.863	0.999	0.5469	9.721	4.2	0.656	53.0

Table B-3. Engine Tests - Modified Stock - #44 Jets

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
11/2/77 7306.17	504.	1.97	35.8	1.193	1.115	1.4665	0.012	6.4	0.65	8.8
7306.18	504.	1.93	33.0	1.207	1.109	1.5075	0.012	6.4	0.66	8.8
7306.19	504.	1.92	31.0	1.226	1.123	1.5429	0.012	6.5	0.65	8.7
11/2/77 7306.14	998.	3.12	40.4	1.143	1.112	1.6724	0.059	8.0	0.87	7.1
7306.15	999.	3.30	38.4	1.134	1.118	1.5866	0.059	8.0	0.80	7.5
7306.16	997.	3.17	36.3	1.142	1.115	1.6505	0.053	7.9	0.79	7.2
11/2/77 7306.11	999.	12.60	42.0	0.897	0.975	0.6500	1.404	0.8	0.70	28.5
7306.12	998.	12.49	39.8	0.896	0.978	0.6569	1.192	0.9	0.69	28.3
7306.13	997.	11.85	35.3	0.896	0.977	0.6922	0.934	0.9	0.67	26.6
11/2/77 7306.5	1000.	22.91	43.4	0.858	0.972	0.5194	4.717	1.0	1.08	51.9
7306.6	1001.	23.61	37.7	0.859	0.972	0.5201	4.350	1.0	1.09	53.4
7306.7	999.	23.19	32.2	0.854	0.966	0.5260	3.180	1.1	1.03	52.5
11/1/77 7305.19	1501.	36.22	47.9	0.856	0.960	0.5040	9.543	1.8	1.28	54.6
7305.20	1500.	35.38	39.5	0.857	0.961	0.5157	7.093	2.0	1.16	53.4
7305.21	1499.	34.98	34.3	0.859	0.959	0.5275	5.688	2.3	1.06	52.8
11/3/77 7307.2	1496.	3.53	42.3	1.178	1.095	2.1720	0.104	17.7	1.20	5.3
7307.3	1498.	3.60	44.2	1.183	1.094	2.1371	0.104	17.5	1.17	5.4
7307.4	1496.	3.53	42.3	1.177	1.091	2.1666	0.100	17.7	1.14	5.3
11/1/77 7305.16	1499.	18.91	46.7	0.901	0.970	0.6588	2.841	1.6	0.686	28.5
7305.17	1498.	18.85	43.8	0.898	0.971	0.6665	2.532	1.7	0.672	29.1
7305.18	1497.	18.71	40.4	0.889	0.969	0.6639	2.216	1.8	0.640	28.3
11/2/77 7306.2	1499.	51.27	32.7	1.088	1.132	0.5079	8.349	48.3	2.31	77.4
7306.3	1498.	51.51	25.3	1.103	1.125	0.5176	6.637	57.2	2.30	77.8
7306.4	1502.	51.34	20.2	1.108	1.128	0.5327	5.583	61.6	2.19	77.4
11/1/77 7305.7	2000.	24.68	49.0	0.857	0.948	0.6773	4.137	2.5	0.740	27.9
7305.8	1997.	24.56	46.3	0.858	0.949	0.6774	3.682	2.6	0.714	27.8
7305.9	2001.	24.95	42.7	0.847	0.945	0.6742	3.487	2.7	0.798	28.2
11/1/77 7305.1	1997.	46.71	49.4	0.865	0.955	0.5227	13.129	2.9	1.164	53.1

Table B-3. Engine Tests - Modified Stock - #44 Jets
(Continuation 1).

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
11/1/77 7305.2	1997.	47.67	42.6	0.880	0.969	0.5264	12.191	3.0	1.086	54.0
7305.3	1995.	47.72	37.1	0.879	0.961	0.5275	8.637	3.3	0.930	53.6
11/1/77 7305.4	1998.	68.78	33.4	1.118	1.092	0.5224	11.448	69.4	2.73	77.9
7305.5	1999.	68.72	25.3	1.112	1.091	0.5282	9.125	79.2	2.74	77.8
7305.6	1998.	68.36	21.0	1.117	1.099	0.5413	8.171	79.3	2.66	77.4
11/3/77 7307.5	1998.	4.70	45.6	1.120	1.082	2.1333	0.274	15.2	0.96	5.3
7307.6	1996.	4.47	43.6	1.119	1.074	2.2279	0.260	15.1	0.92	5.1
7307.7	1994.	4.31	40.5	1.124	1.081	2.3194	0.241	15.0	0.88	4.9
11/1/77 7305.10	2500.	31.45	54.2	0.871	0.958	0.6886	6.944	3.5	0.750	28.4
7305.11	2497.	30.57	48.2	0.869	0.959	0.7055	5.514	3.5	0.724	27.8
7305.12	2504.	31.62	44.3	0.870	0.957	0.7040	5.149	3.5	0.680	28.5
11/1/77 7305.13	2497.	58.19	55.5	0.882	0.970	0.5392	19.599	3.8	1.004	52.7
7305.14	2495.	58.21	46.4	0.873	0.967	0.5348	14.552	4.0	0.824	52.8
7305.15	2499.	60.03	39.5	0.894	0.979	0.5408	13.563	3.9	0.700	54.4

Table B-4. Engine Tests FIDC System

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
10/20/77 7293.8	504.	1.71	25.0	1.181	0.850	2.5476	0.035	4.2	0.99	7.5
7293.9	503.	1.67	24.7	1.174	0.856	2.4952	0.036	3.2	0.99	7.8
7293.10	500.	1.30	22.2	1.161	0.830	3.3565	0.027	3.0	0.99	5.6
10/20/77 7293.5	1004.	3.78	32.3	1.140	1.021	1.7415	0.104	11.0	1.56	8.5
7293.6	1008.	3.88	30.3	1.139	1.042	1.6880	0.091	11.6	1.56	8.7
7293.7	1004.	3.94	28.4	1.142	1.046	1.6635	0.080	11.7	1.55	8.9
10/20/77 7293.11	997.	12.25	31.1	1.114	0.974	0.8055	1.231	11.0	2.40	27.8
7293.12	996.	12.17	26.4	1.108	0.972	0.8105	0.983	10.8	2.40	27.7
7293.13	996.	12.25	23.2	1.099	0.978	0.8136	0.931	10.5	2.45	27.9
10/20/77 7293.14	998.	23.34	28.9	0.936	1.021	0.5113	5.709	1.4	1.89	52.9
7293.15	998.	23.23	23.2	0.936	1.027	0.5134	4.324	1.4	1.85	52.7
7293.16	996.	22.53	19.3	0.948	1.025	0.5374	3.265	1.6	1.83	51.2
10/25/77 7298.11	1504.	35.44	46.4	0.829	0.942	0.5093	3.632	2.0	0.049	53.3
7298.12	1503.	34.88	37.3	0.838	0.940	0.5218	2.174	2.2	0.046	52.5
7298.13	1503.	35.32	32.0	0.843	0.923	0.5287	2.125	2.5	0.046	53.3
10/20/77 7293.2	1494.	2.15	34.3	0.925	0.855	4.1564	0.100	2.7	0.261	3.8
7293.3	1493.	2.13	33.1	0.876	0.814	4.1448	0.117	3.0	0.275	3.3
7293.4	1495.	2.83	35.7	0.948	0.922	3.1321	0.091	2.8	0.252	3.9
10/25/77 7298.14	1503.	18.59	47.5	0.927	0.934	0.7943	0.551	1.7	0.026	27.4
7298.15	1502.	18.26	40.4	0.865	0.945	0.7036	0.300	2.0	0.025	27.5
7298.16	1498.	18.67	34.9	0.896	0.952	0.6876	0.209	2.2	0.023	28.2
10/20/77 7293.17	1497.	51.13	42.5	0.830	0.940	0.4596	12.931	2.4	2.41	77.1
7293.18	1497.	51.22	34.8	0.831	0.940	0.4650	9.895	2.7	1.89	77.4
7293.19	1497.	50.51	29.5	0.830	0.950	0.4764	7.772	3.1	1.70	75.4
10/25/77 7298.2	1997.	24.21	47.4	0.789	0.859	0.7110	1.605	3.2	0.033	27.4
7298.3	1997.	24.58	41.1	0.803	0.874	0.6739	1.012	3.2	0.032	27.8
7298.4	1995.	23.34	36.5	0.809	0.920	0.7106	0.951	3.4	0.032	26.5
10/20/77 7293.23	2003.	46.54	40.1	0.864	0.979	0.5188	12.313	3.2	1.59	52.5

Table B-4. Engine Tests FIDC System
(Continuation 1)

DATE DAY TEST NO.	RPM	BHP	SA	ϕ_{SYS}	ϕ_{CB}	BSFC	NO_x gm/min	CO gm/min	HC gm/min	BMEP
10/20/77 7293.24	2000.	46.01	37.7	0.863	0.976	0.5287	9.314	3.6	1.38	52.3
7293.25	1999.	44.48	32.5	0.864	0.975	0.5471	6.719	3.9	0.992	50.3
10/20/77 7293.20	1998.	68.45	40.4	0.839	0.953	0.4633	16.300	4.4	1.568	77.5
7293.21	1996.	67.63	32.0	0.867	0.954	0.4918	12.363	4.9	1.226	76.7
7293.22	1995.	65.55	28.4	0.851	0.953	0.4940	9.687	5.1	1.008	74.4
10/19/77 7292.2	2001.	6.60	43.0	0.923	1.016	1.8674	0.533	3.3	3.51	7.5
7292.3	1998.	5.14	41.7	0.859	0.882	2.3600	0.300	3.5	3.83	5.8
7292.4	2000.	4.65	39.4	0.811	0.874	2.4950	0.207	3.7	4.00	5.3
10/18/77 7291.6	2497.	31.67	50.1	0.806	0.901	0.7314	4.664	5.1	4.74	28.8
7291.7	2495.	29.99	46.5	0.809	0.909	0.7804	3.074	5.1	3.54	27.5
7291.8	2500.	32.45	43.3	0.807	0.894	0.7440	2.621	5.7	3.02	29.3
10/25/77 7298.8	2495.	57.77	45.2	0.838	0.936	0.5453	9.975	5.1	0.372	52.4
7298.9	2495.	58.65	41.3	0.845	0.938	0.5530	9.847	5.2	0.630	53.2
7298.10	2494.	57.28	37.3	0.853	0.937	0.5758	8.134	5.2	0.481	52.0

Table B-5. Distribution Tests

DATE DAY TYPE	TEST NO.	RPM	BHP	SA	BSFC	CYLINDER NO(i)	ϕ_{SYS}	ϕ_{CB_i}	NO_x gm/min	CO gm/min	HC gm/min
11/8/77 7312	1	1998	52.6	52°	0.5085	COMMON 0	0.84	0.909	9.651	3.1	0.464
STOCK W/#42 JETS	101	1997	52.4	52°	0.5101	1	0.84	0.929	13.054	2.7	0.326
STOCK W/#42 JETS	201	1996	52.6	52°	0.5085	2	0.84	0.889	10.543	2.9	0.324
STOCK W/#42 JETS	301	1995	52.7	52°	0.5076	3	0.84	0.882	7.103	3.0	0.286
STOCK W/#42 JETS	401	1999	52.1	52°	0.5114	4	0.84	0.876	14.977	2.0	0.726
STOCK W/#42 JETS	501	1998	52.4	52°	0.5089	5	0.84	0.821	3.376	3.0	0.848
STOCK W/#42 JETS	601	1996	52.5	52°	0.5094	6	0.84	0.870	11.171	2.2	0.512
STOCK W/#42 JETS	701	1995	52.5	52°	0.5094	7	0.84	0.869	11.177	2.8	0.402
STOCK W/#42 JETS	801	1994	52.4	52°	0.5095	8	0.84	0.815	1.539	3.7	0.368
STOCK W/#42 JETS	901	1999	52.1	52°	0.5122	COMMON 0	0.84	0.858	9.784	3.1	0.500
STOCK W/#42 JETS	2	1501	53.4	47°	0.5080	COMMON 0	0.800	0.837	4.64	2.4	0.384
STOCK W/#42 JETS	102	1499	52.9	47°	0.5114	1	0.800	0.870	5.888	2.5	0.372
STOCK W/#42 JETS	202	1499	53.1	47°	0.5092	2	0.800	0.862	5.976	1.8	0.302
STOCK W/#42 JETS	302	1498	52.4	47°	0.5165	3	0.800	0.855	3.868	2.1	0.318
STOCK W/#42 JETS	402	1498	52.6	47°	0.5157	4	0.800	0.851	5.311	1.7	0.332
STOCK W/#42 JETS	502	1498	53.1	47°	0.5099	5	0.800	0.825	1.402	3.0	1.43
STOCK W/#42 JETS	602	1496	52.6	47°	0.5141	6	0.800	0.860	4.941	1.6	0.474
STOCK W/#42 JETS	702	1497	52.9	47°	0.5116	7	0.800	0.875	4.231	1.9	0.420
STOCK W/#42 JETS	802	1496	53.0	47°	0.5114	8	0.800	0.825	0.478	3.1	0.966
STOCK W/#42 JETS	902	1495	52.6	47°	0.5156	COMMON 0	0.800	0.876	4.615	2.4	0.688
11/9/77 7313	2	1001	12.43	34°	0.7153	COMMON 0	1.12	1.087	0.903	17.1	0.366
STOCK W/#42 JETS	102	999	12.49	34°	0.7219	1	1.12	1.076	1.351	4.6	0.208
STOCK W/#42 JETS	202	1000	12.61	34°	0.7127	2	1.12	1.149	0.246	44.6	0.266
STOCK W/#42 JETS	302	1000	12.51	34°	0.7148	3	1.12	1.147	0.326	39.3	0.314
STOCK W/#42 JETS	402	999	12.56	34°	0.7057	4	1.12	1.081	0.791	8.4	0.298
STOCK W/#42 JETS	502	999	12.52	34°	0.7048	5	1.12	1.108	0.492	21.5	0.328
STOCK W/#42 JETS	602	998	12.46	34°	0.7145	6	1.12	1.08	1.101	5.2	0.216
STOCK W/#42 JETS	702	998	12.51	34°	0.7135	7	1.12	1.075	1.493	1.5	0.182

Table B-5. Distribution Tests (Continuation 1)

DATE DAY TYPE	TEST NO.	RPM	BHP	SA	BSFC	CYLINDER $NO_{(i)}$	ϕ_{SYS}	ϕ_{CB_i}	NO_x gm/min	CO gm/min	HC gm/min
CONTINUE 7313	802	997	12.72	34°	0.7050	8	1.12	1.105	0.917	15.8	0.250
STOCK W/#42 JETS	902	997	12.74	34°	0.7109	COMMON 0	1.12	1.096	0.883	16.7	0.386
STOCK W/#42 JETS	3	499	1.94	35°	1.4822	COMMON 0	1.06	1.013	0.022	0.5	0.39
STOCK W/#42 JETS	103	500	2.02	35°	1.4410	1	1.06	1.042	0.035	0.4	0.20
STOCK W/#42 JETS	203	499	2.09	35°	1.3796	2	1.06	1.080	0.030	0.5	0.17
STOCK W/#42 JETS	303	498	1.98	35°	1.4520	3	1.06	1.057	0.022	0.5	0.27
STOCK W/#42 JETS	403	502	2.14	35°	1.3520	4	1.06	0.979	0.013	0.5	0.56
STOCK W/#42 JETS	503	500	2.07	35°	1.3894	5	1.06	1.024	0.019	0.5	0.36
STOCK W/#42 JETS	603	500	2.12	35°	1.3727	6	1.06	1.017	0.016	0.6	0.41
STOCK W/#42 JETS	703	500	2.14	35°	1.3515	7	1.06	1.052	0.025	0.4	0.21
STOCK W/#42 JETS	803	500	2.07	35°	1.3940	8	1.06	1.071	0.025	0.4	0.17
STOCK W/#42 JETS	903	501	2.11	35°	1.3707	COMMON 0	1.06	1.030	0.021	0.5	0.51
11/10/77 7314	1	1500	34.35	46°	0.5164	COMMON 0	0.85	0.917	9.003	2.1	2.03
FVI W/#45 JETS	101	1499	35.25	46°	0.5052	1	0.85	0.907	3.755	2.2	0.95
STOCK W/#45 JETS	201	1498	35.12	46°	0.5077	2	0.85	0.879	2.925	2.1	1.04
STOCK W/#45 JETS	301	1498	34.70	46°	0.5136	3	0.85	0.859	1.712	2.4	4.27
STOCK W/#45 JETS	401	1496	34.72	46°	0.5128	4	0.85	0.938	10.051	1.8	2.34
STOCK W/#45 JETS	501	1495	34.49	46°	0.5162	5	0.85	0.956	12.080	2.0	3.38
STOCK W/#45 JETS	601	1494	34.96	46°	0.5072	6	0.85	0.965	14.084	1.6	1.65
STOCK W/#45 JETS	701	1492	34.80	46°	0.5106	7	0.85	0.933	12.145	2.2	1.44
STOCK W/#45 JETS	801	1491	35.22	46°	0.5045	8	0.85	0.975	13.227	1.7	1.30
STOCK W/#45 JETS	901	1490	35.32	46°	0.5046	COMMON 0	0.85	0.926	10.025	2.1	2.20
STOCK W/#45 JETS	2	1999	46.93	44.5°	0.5019	COMMON 0	0.90	0.953	13.713	3.1	1.47
STOCK W/#45 JETS	102	1996	46.36	44.5°	0.5118	1	0.90	0.950	10.381	2.7	0.90
STOCK W/#45 JETS	202	1994	46.17	44.5°	0.5085	2	0.90	0.938	8.795	2.6	0.910
11/11/77 7315	302	1996	46.56	44.5°	0.5066	3	0.90	0.918	2.896	3.0	1.23
FVI W/#45 JETS	401	1996	45.83	44.5°	0.5103	4	0.90	0.978	15.104	2.2	2.39
STOCK W/#45 JETS	501	1995	46.27	44.5°	0.5055	5	0.90	0.985	13.041	2.6	2.87

Table B-5. Distribution Tests (Continuation 2)

DATE DAY TYPE	TEST NO.	RPM	BHP	SA	BSFC	CYLINDER NO$_{(i)}$	ϕ_{SYS}	ϕ_{CB_i}	NO$_x$ gm/min	CO gm/min	HC gm/min
CONTINUE 7315	601	1993	46.04	44.5°	0.5074	6	0.90	1.002	17.477	2.1	1.79
STOCK W/#45 JETS	701	1991	45.78	44.5°	0.5095	7	0.90	0.986	14.608	2.9	1.37
STOCK W/#45 JETS	801	1998	45.86	44.5°	0.5117	8	0.90	1.005	14.287	2.6	1.102
STOCK W/#45 JETS	901	1996	46.15	44.5°	0.5041	COMMON 0	0.90	0.975	13.369	3.1	1.67
11/14/77 7318	2	999	12.50	31°	0.7019	COMMON 0	1.0	1.052	0.927	3.9	2.15
FVI W/#45 JETS	102	998	12.19	31°	0.7045	1	1.0	1.018	0.997	1.8	1.64
STOCK W/#45 JETS	202	997	11.92	31°	0.7303	2	1.0	1.049	1.303	1.6	1.00
STOCK W/#45 JETS	302	993	10.87	31°	0.8074	3	1.0	1.085	0.918	7.1	2.14
STOCK W/#45 JETS	402	1000	12.02	31°	0.7670	4	1.0	1.031	0.886	1.9	1.54
STOCK W/#45 JETS	502	1001	12.50	31°	0.7418	5	1.0	1.073	1.116	6.6	2.15
STOCK W/#45 JETS	602	1000	12.15	31°	0.7544	6	1.0	1.034	1.072	2.0	1.25
STOCK W/#45 JETS	702	998	12.09	31°	0.7818	7	1.0	1.036	2.390	1.6	1.34
STOCK W/#45 JETS	802	999	12.18	31°	0.7788	8	1.0	1.077	1.585	3.6	1.41
STOCK W/#45 JETS	902	998	12.26	31°	0.7715	COMMON 0	1.0	0.968	1.489	2.8	2.36

APPENDIX C

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Table C-1. Vehicle Tests

DATE DAY	TEST NO.	MPG_{WT}	MPG_{CB}		NO_x	CO	HC	VEHICLE CONFIGURATION
1/12/78 8012	1		12.540	BAG 1 (g)	7.705	129.926	0.747	STOCK - #45 JETS
				BAG 2 (g)	3.446	57.377	1.507	
				BAG 3 (g)	6.159	47.010	1.860	
				AVG WT gm/mi	1.372	18.702	0.386	
1/13/78 8013	2	11.354	12.270	BAG 1 (g)	8.022	183.315	12.118	STOCK - #45 JETS
				BAG 2 (g)	3.044	271.112	8.478	
				BAG 3 (g)	5.801	95.329	4.298	
				AVG WT gm/mi	1.307	53.903	2.152	
1/31/78 8031	13	12.489	13.466	BAG 1 (g)	10.306	163.223	9.127	STOCK - #45 JETS
				BAG 2 (g)	4.254	30.960	1.009	
				BAG 3 (g)	7.964	22.897	1.429	
				AVG WT gm/mi	1.744	15.023	0.756	
2/1/78 8032	14	12.557	13.456	BAG 1 (g)	10.005	159.384	8.812	STOCK - #45 JETS
				BAG 2 (g)	4.400	20.883	0.827	
				BAG 3 (g)	8.166	27.525	1.503	
				AVG WT gm/mi	1.777	13.973	0.728	
2/2/78 8033	15	11.596	12.475	BAG 1 (g)	8.067	160.037	8.737	STOCK - #45 JETS
				BAG 2 (g)	3.668	41.510	1.007	
				BAG 3 (g)	6.315	32.184	1.235	
				AVG WT gm/mi	1.430	17.120	0.727	
2/3/78 8034	16	11.384	12.160	BAG 1 (g)	8.335	125.576	6.641	STOCK - #45 JETS
				BAG 2 (g)	4.250	25.656	0.734	
				BAG 3 (g)	6.672	28.609	1.002	
				AVG WT gm/mi	1.550	12.764	0.553	
2/7/78 8038	17	11.153	11.902	BAG 1 (g)	8.293	200.104	13.145	STOCK - #45 JETS
				BAG 2 (g)	4.162	28.719	0.723	
				BAG 3 (g)	6.478	46.820	1.186	
				AVG WT gm/mi	1.529	18.985	0.948	

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Table C-1. Vehicle Tests (Continuation 1)

DATE DAY	TEST NO.	MPG_{WT}	MPG_{CB}		NO_x	CO	HC	VEHICLE CONFIGURATION
1/23/78 8023	8	12.748	13.691	BAG 1 (g)	10.392	82.403	7.614	MOD STOCK - #42 JETS
				BAG 2 (g)	5.592	20.922	1.227	
				BAG 3 (g)	8.442	10.930	1.279	
				AVG WT gm/mi	1.980	8.336	0.697	
1/24/78 8024	9	12.788	13.890	BAG 1 (g)	10.632	90.014	6.600	MOD STOCK - #42 JETS
				BAG 2 (g)	5.488	12.926	1.031	
				BAG 3 (g)	7.304	10.642	1.458	
				AVG WT gm/mi	1.896	7.689	0.626	
1/25/78 8025	10	12.733	13.904	BAG 1 (g)	10.276	91.104	7.416	MOD STOCK - #42 JETS
				BAG 2 (g)	5.376	13.439	1.069	
				BAG 3 (g)	7.311	8.724	1.146	
				AVG WT gm/mi	1.867	7.688	0.656	
1/26/78 8026	11	13.023	14.036	BAG 1 (g)	9.929	66.559	7.254	MOD STOCK - #42 JETS
				BAG 2 (g)	5.425	13.324	1.004	
				BAG 3 (g)	7.656	10.155	1.170	
				AVG WT gm/mi	1.874	6.359	0.638	
1/27/78 8027	12	12.878	13.935	BAG 1 (g)	9.956	74.396	6.971	MOD STOCK - #42 JETS
				BAG 2 (g)	5.512	12.866	1.070	
				BAG 3 (g)	7.849	8.591	1.523	
				AVG WT gm/mi	1.897	6.615	0.656	

Table C-1. Vehicle Tests (Continuation 2)

DATE DAY	TEST NO.	MPG_{WT}	MPG_{CB}		NO_x	CO	HC	VEHICLE CONFIGURATION
1/16/78 8016	3	11.926	12.795	BAG 1 (g)	10.853	94.300	44.570	FVI
				BAG 2 (g)	0.009	14.274	1.392	
				BAG 3 (g)	0.005	13.426	2.516	
				AVG WT gm/mi	0.621	8.295	2.919	
1/17/78 8017	4	11.936	13.823	BAG 1 (g)	10.341	59.720	27.103	FVI
				BAG 2 (g)	4.512	10.335	1.387	
				BAG 3 (g)	7.577	20.870	3.717	
				AVG WT gm/mi	1.784	6.438	2.037	
1/18/78 8018	5	11.743	12.644	BAG 1 (g)	10.265	44.265	21.146	FVI
				BAG 2 (g)	5.360	8.652	1.175	
				BAG 3 (g)	7.683	10.683	2.651	
				AVG WT gm/mi	1.898	4.530	1.580	
1/19/78 8019	6	11.953	12.535	BAG 1 (g)	11.946	61.766	23.411	FVI
				BAG 2 (g)	5.192	16.913	1.209	
				BAG 3 (g)	7.842	18.822	1.294	
				AVG WT gm/mi	1.948	7.138	1.583	
1/20/78 8020	7	11.967	12.544	BAG 1 (g)	11.387	85.838	40.225	FVI
				BAG 2 (g)	5.516	18.577	1.183	
				BAG 3 (g)	8.006	23.050	3.119	
				AVG WT gm/mi	1.981	9.079	2.680	

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PROGRAM: F.V.I.                          TEST TYPE : 75' FTP-CH        TEST#    3
VEHICLE: CHEVY                           VEHICLE ID: 1L39K3C201052     DATE: 1-16-7
DRIVER : J.A.                            INSTR OPER: P.B.
CYL : 8          CID: 350                TRANS: AUTO               ODOM: 5467.3 MI
SITE: 4          DIW: 4500               ACTHP: 14                 IHP : 11.52

DAY 8016  TAPE P753   BENCH NO. 2  %RH= 51.30  PAMB= 14.060  TAMB= 71.10

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000422 004032
              WORD B =  010444 010444 010444 010441 010441 010444
              BAG DATA INPUT ORDER:  1A,2A,3A,2E,3E,1E,

                                            MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.935       AH = 60.6639        3.629   933.   .3335  10.883
CVS PIN =  12.596     PSAT =   .3771        3.905   928.   .3317  11.774
CVS TIN =  99.400    AHFAC =   .9369        3.620   773.   .2763  13.103
    V0 = .2929                      TOTALS 11.154  2634.   .9414  11.848
                                                        WTD FTP  11.926

                  AMBIENT SAMPLE                   EXHAUST SAMPLE
     BAG %FULL SCL    SCALE     VALUE    %FULL SCL  SCALE       VALUE

CO2-%  1     1.150   4 %           .0397   48.420   4 %          1.7945
CO2-%  2     1.200   4 %           .0413   32.130   4 %          1.1489
CO2-%  3     1.130   4 %           .0390   42.400   4 %          1.5518

NX-PPM 1      .030 100PPMNOX       .0300   77.560 100PPMNOX   77.5600
NX-PPM 2      .020 100PPMNOX       .0200    5.640   1PPMNOX      .0564
NX-PPM 3      .030 100PPMNOX       .0300    6.050   1PPMNOX      .0605

CO-PPM 1      .090 500PPM LO      1.0321   75.330  2KPPM LO 1037.6649
CO-PPM 2      .000 500PPM LO       .7817   27.120 500PPM LO   92.4147
CO-PPM 3      .000 500PPM LO       .7817   39.950 500PPM LO  147.0742

HC-PPM 1    12.060   50PPM LO     6.0300   99.450  1KPPM LO  994.5000
HC-PPM 2    12.460   50PPM LO     6.2300   47.480  50PPM LO   23.7400
HC-PPM 3    11.950   50PPM LO     5.9750   60.650 100PPM LO   60.6500

                  GM EMISSIONS/PHASE                TOTAL  DIL FAC  VMIX
PHASE      CO2         NOX        CO            HC    REVS     (DF)   (CU FT)

   1     2518.471     10.853     94.300     44.570  11643.  6.7078 2758.68
   1      693.985      2.991     25.985     12.282  GM/MI (FOR 3.629 MI)

   2     2720.098       .009     14.274      1.392  19926. 11.5466 4721.25
   2      696.568       .002      3.655       .356  GM/MI (FOR 3.905 MI)

   3     2188.650       .005     13.426      2.516  11741.  8.5211 2781.90
   3      604.600       .001      3.709       .695  GM/MI (FOR 3.620 MI)

TOTAL  7427.220     10.867    122.000     48.478  (GM/TEST)
TOTAL   665.879       .974     10.938      4.346  (GM/MI FOR 11.154 MI)
TOTAL   670.815       .621      8.295      2.919  (WTD GM/MI FOR  7.529 MI)

    COMPOSITE FUEL ECONOMY - MPG            BAG   MPG
1972 COLD FTP( 7.534 MI) =    12.027        1    11.461
1972 HOT FTP ( 7.525 MI) =    13.442        2    12.607
1975 FTP      (11.154 MI) =   12.726        3    14.475
1975 WTD FTP ( 7.529 MI) =    12.795       AVG   12.848

FVI CONFIGURATION - EB1 ON N2 PURGE FOR FIRST MIN.
EB2 NOX ON AIR PURGE FOR FIRST 5 BAG READS.
SA=11, #45 JETS
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    *** BAG * REV  1-24-78 ***   TODAY IS  1-25-78    IT IS  4:06 PM

PROGRAM:  F.V.I.                     TEST TYPE :  75' FTP-CH       TEST#  5
VEHICLE:  CHEVY                      VEHICLE ID:  1L39K3C201052   DATE:  1-18-78
DRIVER :  J.A.                       INSTR OPER:  R.B.
CYL : 8        CID:  350             TRANS:  AUTO          ODOM:  5489.5 MI
SITE: 4        DIW:  4500            ACTHP:  14.0          IHP :  11.5

DAY 8018  TAPE P755   BENCH NO. 2  %RH= 44.90  PAMB= 14.142  TAMB= 73.500

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000422 002022
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                          MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.941      AH = 57.1505      3.590   971.   .3470  10.345
CVS PIN =  12.670    PSAT =    .4086     3.860   919.   .3284  11.752
CVS TIN = 101.000   AHFAC =    .9226     3.606   782.   .2795  12.902
    V0 = .2928                    TOTALS 11.056  2672.   .9550  11.577
                                                     WTD FTP  11.743

                    AMBIENT SAMPLE                  EXHAUST SAMPLE
      BAG %FULL SCL    SCALE    VALUE    %FULL SCL   SCALE     VALUE

CO2-%  1     1.380   4 %          .0472   50.510   4 %        1.8797
CO2-%  2     1.360   4 %          .0466   32.500   4 %        1.1631
CO2-%  3     1.360   4 %          .0466   42.800   4 %        1.5678

NX-PPM 1      .130 100PPMNOX      .1300   74.390 100PPMNOX   74.3900
NX-PPM 2      .130 100PPMNOX      .1300   22.800 100PPMNOX   22.8000
NX-PPM 3      .090 100PPMNOX      .0900   55.210 100PPMNOX   55.2100

CO-PPM 1      .150 500PPM LO     1.1993   98.180 500PPM LO  486.4528
CO-PPM 2      .250 500PPM LO     1.4782   17.680 500PPM LO   56.8362
CO-PPM 3      .000 500PPM LO      .7817   33.070 500PPM LO  116.8602

HC-PPM 1    11.960  50PPM LO     5.9800   94.660 500PPM LO  473.3000
HC-PPM 2    12.460  50PPM LO     6.2300   41.790  50PPM LO   20.8950
HC-PPM 3    12.370  50PPM LO     6.1850   63.660 100PPM LO   63.6600


                    GM EMISSIONS/PHASE                 TOTAL   DIL FAC  VMIX
PHASE      CO2         NOX        CO          HC       REVS     (DF)   (CU FT)

   1   2637.917    10.265     44.265      21.146   11641.   6.7824 2765.79
   1    734.796     2.859     12.330       5.890   GM/MI (FOR 3.590 MI)

   2   2747.973     5.360      8.652       1.175   19905. 11.4440 4729.23
   2    711.910     1.389      2.241        .304   GM/MI (FOR 3.860 MI)

   3   2207.841     7.683     10.693       2.651   11739.  9.4499 2789.07
   3    612.269     2.131      2.962        .735   GM/MI (FOR 3.606 MI)

TOTAL  7593.731    23.309     63.600      24.972   (GM/TEST)
TOTAL   686.843     2.108      5.753       2.259   (GM/MI FOR 11.056 MI)
TOTAL   689.221     1.898      4.530       1.580   (WTD GM/MI FOR  7.459 MI)

    COMPOSITE FUEL ECONOMY - MPG          BAG    MPG
1972 COLD FTP( 7.450 MI) =    11.926       1    11.474
1972 HOT FTP ( 7.466 MI) =    13.246       2    12.379
1975 FTP      (11.056 MI) =   12.614       3    14.321
1975 WTD FTP ( 7.459 MI) =    12.644      AVG   12.725

 FVI ON, SA=6+5=11 BTDC, #45 JETS
EB1 - O2 DATA N.G., CHOKE POSITION (CH 78) QUIT IN COLD 505
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      *** BAG * REV  1-24-78 ***   TODAY IS  1-25-78    IT IS  4:13 PM

PROGRAM: F.V.I.                 TEST TYPE : 75'FTP-CH        TEST# 6
VEHICLE: CHEVY                  VEHICLE ID: 1L39K3C201052    DATE: 1-19-7
DRIVER : J.A.                   INSTR OPER: R.B.
CYL : 8        CID: 350         TRANS: AUTO            ODOM: 5500.4 MI
SITE: 4        DIW: 4500        ACTHP: 14.             IHP : 11.52

DAY 8019  TAPE P756   BENCH NO. 2  %RH= 51.35  PAMB= 14.057  TAMB= 73.30

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000222 004032
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                            MILES GAS-GM     GAL    MPG
CVS DELTAP= 1.933       AH = 65.4427        3.640   975.    .3485  10.446
CVS PIN =  12.600     PSAT =   .4059        3.950   915.    .3270  12.079
CVS TIN = 100.700    AHFAC =   .9570        3.650   787.    .2813  12.977
    V0 = .2929                       TOTALS 11.240  2677.    .9568  11.748
                                                          WTD FTP  11.953

                 AMBIENT SAMPLE                     EXHAUST SAMPLE
      BAG %FULL SCL    SCALE    VALUE     %FULL SCL   SCALE     VALUE

CO2-%  1     5.300    4 %          .1776     54.760     4 %        2.0546
CO2-%  2     5.170    4 %          .1732     35.900     4 %        1.2951
CO2-%  3     5.230    4 %          .1752     47.230     4 %        1.7461

NX-PPM 1      .350 100PPMNOX       .3500     84.200 100PPMNOX   84.2000
NX-PPM 2      .210 100PPMNOX       .2100     21.470 100PPMNOX   21.4700
NX-PPM 3      .120 100PPMNOX       .1200     54.770 100PPMNOX   54.7700

CO-PPM 1      .260 500PPM LO     1.5061     60.560  2KPPM LO   683.3005
CO-PPM 2      .130 500PPM LO     1.1435     31.440 500PPM LO   110.0079
CO-PPM 3      .000 500PPM LO      .7817     52.380 500PPM LO   206.9578

HC-PPM 1    13.550   50PPM LO     6.7750     52.760   1KPPM LO   527.6000
HC-PPM 2    13.900   50PPM LO     6.9500     44.010   50PPM LO    22.0050
HC-PPM 3.   13.230   50PPM LO     6.6150     68.760   50PPM LO    34.3800


                 GM EMISSIONS/PHASE                    TOTAL   DIL FAC   VMIX
PHASE      CO2        NOX        CO          HC       REVS     (DF)   (CU FT)

   1    2714.367    11.946     61.766      23.411   11615.   6.1589 2746.78
   1     745.705     3.282     16.969       6.432   GM/MI (FOR 3.640 MI)

   2    2779.420     5.192     16.913       1.209   19905. 10.2426 4707.24
   2     703.651     1.314      4.282        .306   GM/MI (FOR 3.950 MI)

   3    2287.493     7.842     18.822       1.294   11703.   7.5695 2767.59
   3     626.710     2.148      5.157        .355   GM/MI (FOR 3.650 MI)

TOTAL   7781.280    24.980     97.502      25.915   (GM/TEST)
TOTAL    692.285     2.222      8.675       2.306   (GM/MI FOR 11.240 MI)
TOTAL    691.261     1.948      7.138       1.583   (WTD GM/MI FOR  7.596 MI)

    COMPOSITE FUEL ECONOMY - MPG               BAG    MPG
1972 COLD FTP( 7.590 MI) =    11.818           1     11.186
1972 HOT FTP ( 7.600 MI) =    13.135           2     12.467
1975 FTP     (11.240 MI) =    12.434           3     13.945
1975 WTD FTP ( 7.596 MI) =    12.535          AVG    12.533

 F.V.I. CONFIGURATION, SA=11 ,  #45 JETS - EB1 O2 DATA N.G.; CHOKE
POSITION DATA N.G. SA=11
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     *** BAG * REV  1-24-78 ***    TODAY IS  1-25-78    IT IS  4:13 PM

PROGRAM: F.V.I.                     TEST TYPE : 75'FTP-CH          TEST# 7
VEHICLE: CHEVY                      VEHICLE ID: 1L39K3C201052      DATE: 1-20-78
DRIVER : J.A.                       INSTR OPER: R.B.
CYL : 8        CID: 350             TRANS: AUTO              ODOM: 5511.4MI
SITE: 4        DIW: 4500            ACTHP: 14.               IHP : 11.52

DAY 8020  TAPE P757   BENCH NO. 2  %RH= 43.17  PAMB= 14.124  TAMB= 72.000

OCTAL CODES:  WORD A =  000232 000232 000232 000232 000432 004032
              WORD B =  010244 010244 010244 010244 010244 010244
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                            MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.942      AH = 52.2765         3.632   970.   .3467  10.477
CVS PIN =  12.860    PSAT =    .3887        3.928   914.   .3267  12.025
CVS TIN = 100.800   AHFAC =    .9035        3.628   774.   .2766  13.115
    V0 = .2928                       TOTALS 11.188  2658.   .9500  11.777
                                                          WTD FTP  11.967

                  AMBIENT SAMPLE                      EXHAUST SAMPLE
      BAG %FULL SCL    SCALE    VALUE    %FULL SCL   SCALE      VALUE

CO2-%  1    1.300    4 %          .0446   55.510    4 %        2.0857
CO2-%  2    1.250    4 %          .0429   32.060    4 %        1.1462
CO2-%  3    1.120    4 %          .0387   41.990    4 %        1.5354

NX-PPM 1     .200 100PPMNOX       .2000   92.070 100PPMNOX   92.0700
NX-PPM 2     .160 100PPMNOX       .1600   23.610 100PPMNOX   23.6100
NX-PPM 3     .100 100PPMNOX       .1000   57.830 100PPMNOX   57.8300

CO-PPM 1     .500  2KPPM LO      5.7359   75.170  2KPPM LO 1033.0239
CO-PPM 2     .110  2KPPM LO      1.2242   11.530  2KPPM LO  118.4014
CO-PPM 3     .000  2KPPM LO       .0000   26.240  2KPPM LO  246.7313

HC-PPM 1   14.030  50PPM LO      7.0150   97.870  1KPPM LO  978.7000
HC-PPM 2   13.220  50PPM LO      6.6100   42.240  50PPM LO   21.1200
HC-PPM 3   12.390  50PPM LO      6.1950   72.880 100PPM LO   72.8800


                  GM EMISSIONS/PHASE                    TOTAL  DIL FAC  VMIX
PHASE     CO2        NOX        CO         HC         REVS    (DF)   (CU FT)

   1   2699.550    11.387     85.838     40.225    10496.  5.8596 2531.94
   1    740.515     3.135     23.634     11.075    GM/MI (FOR 3.632 MI)

   2   2757.508     5.516     18.577      1.183    19916. 11.5502 4804.31
   2    702.013     1.404      4.729       .301    GM/MI (FOR 3.928 MI)

   3   2205.588     8.006     23.050      3.119    11746.  8.5493 2833.47
   3    607.935     2.207      6.353       .860    GM/MI (FOR 3.628 MI)

TOTAL  7652.647    24.909    127.465     44.528    (GM/TEST)
TOTAL   684.005     2.226     11.393      3.980    (GM/MI FOR 11.188 MI)
TOTAL   684.219     1.981      9.079      2.680    (WTD GM/MI FOR  7.558 MI)

    COMPOSITE FUEL ECONOMY - MPG          BAG    MPG
1972 COLD FTP( 7.560 MI) =    11.675       1     10.911
1972 HOT FTP ( 7.556 MI) =    13.289       2     12.483
1975 FTP      (11.188 MI) =    12.411       3     14.289
1975 WTD FTP ( 7.558 MI) =    12.544      AVG    12.561

 F.V.I. CONFIGURATION,#45 JETS; CVS ON SPEED #2 UNTIL 110 SEC.;
RADIATOR FAN LEFT ON DURING SOAK. SA=11
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     ◆◆◆ BAG ◆ REV  1-24-78 ◆◆◆    TODAY IS  1-25-78    IT IS  4:14 PM

PROGRAM: F.V.I.                   TEST TYPE : 75'FTP-CH          TEST# 8
VEHICLE: CHEVY                    VEHICLE ID: 1L39K3C201052      DATE: 1-23-7
DRIVER : J.A.                     INSTR OPER: R.B.
CYL : 8         CID: 350          TRANS: AUTO                 ODOM: 5511.6 MI
SITE: 4         DIW:  4500        ACTHP: 14.                  IHP : 11.52

DAY 8023  TAPE P758   BENCH NO. 2  %RH= 31.50  PAMB= 14.093  TAMB= 73.50

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000222 001032
              WORD B =  010244 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                            MILES GAS-GM    GAL     MPG
CVS DELTAP= 1.937      AH = 40.0779         3.599   846.   .3024  11.900
CVS PIN =  12.642    PSAT =   .4086         3.907   870.   .3109  12.565
CVS TIN = 101.000   AHFAC =   .8590         3.608   731.   .2613  13.810
    V0 = .2929                        TOTALS 11.113  2447.   .8746  12.707
                                                          WTD FTP  12.748

                  AMBIENT SAMPLE                        EXHAUST SAMPLE
      BAG %FULL SCL    SCALE     VALUE     %FULL SCL   SCALE       VALUE

CO2-%  1     1.460    4 %            .0498     46.610    4 %          1.7210
CO2-%  2     1.510    4 %            .0515     30.290    4 %          1.0783
CO2-%  3     1.510    4 %            .0515     40.770    4 %          1.4869

NX-PPM 1      .080 100PPMNOX         .0800     81.030 100PPMNOX    81.0300
NX-PPM 2      .150 100PPMNOX         .1500     25.590 100PPMNOX    25.5900
NX-PPM 3      .100 100PPMNOX         .1000     64.870 100PPMNOX    64.8700

CO-PPM 1      .010 500PPM LO         .8095     70.530  2KPPM LO   906.5941
CO-PPM 2      .210 500PPM LO        1.3666     37.400 500PPM LO   135.6321
CO-PPM 3      .040 500PPM LO         .9930     33.610 500PPM LO   119.1551

HC-PPM 1    12.580   50PPM LO       6.2900     87.210 200PPM LO   174.4200
HC-PPM 2    12.970   50PPM LO       6.4850     43.730  50PPM LO    21.8650
HC-PPM 3    12.520   50PPM LO       6.2600     67.060  50PPM-LO    33.5300


                   GM EMISSIONS/PHASE                  TOTAL   DIL FAC   VMIX
PHASE       CO2         NOX         CO         HC      REVS     (DF)   (CU FT)

    1    2400.403     10.392      82.403      7.614  11636.   7.3259 2758.96
    1     667.149      2.888      22.902      2.116  GM/MI (FOR 3.598 MI)

    2    2524.624      5.592      20.922      1.227  19917.  12.2477 4722.44
    2     646.180      1.431       5.355       .314  GM/MI (FOR 3.907 MI)

    3    2092.963      8.442      10.930      1.279  11813.   8.9206 2800.93
    3     580.089      2.340       3.030       .355  GM/MI (FOR 3.608 MI)

TOTAL    7017.989     24.426     114.256     10.120  (GM/TEST)
TOTAL     631.512      2.198      10.281       .911  (GM/MI FOR 11.113 MI)
TOTAL     632.416      1.980       8.336       .697  (WTD GM/MI FOR  7.511 MI)

    COMPOSITE FUEL ECONOMY - MPG           BAG    MPG
1972 COLD FTP( 7.505 MI) =    13.011        1     12.493
1972 HOT FTP ( 7.515 MI) =    14.254        2     13.527
1975 FTP     (11.113 MI) =    13.632        3     15.134
1975 WTD FTP ( 7.511 MI) =    13.691       AVG    13.718

 MODIFIED BASELINE (FVI OFF) - SA=6+10=16; #42 JETS;
SA NOT WORKING UNTIL DURING BAG 2 FILL.
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     *** BAG * REV  1-24-78 ***   TODAY IS  1-25-78    IT IS  4:21 PM

PROGRAM: F.V.I.                TEST TYPE : 75/FTP-CH        TEST# 9
VEHICLE: CHEVY                 VEHICLE ID: 1L39L3C201052    DATE: 1-24-78
DRIVER : J.A.                  INSTR OPER: R.B.
CYL : 8        CID: 350        TRANS: AUTO            ODOM: 5537.5 MI
SITE: 4        DIW: 4500       ACTHP: 14.             IHP : 11.52

DAY 8024  TAPE P759   BENCH NO. 2  %RH= 10.60  PAMB= 14.218  TAMB= 71.500

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000222 001032
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                        MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.955      AH = 12.4257     3.609   871.   .3113  11.594
CVS PIN =  12.740    PSAT =   .3822     3.898   864.   .3088  12.623
CVS TIN =  99.900   AHFAC =   .7727     3.595   712.   .2545  14.128
    V0 = .2926                  TOTALS 11.102  2447.   .9746  12.694
                                                     WTD FTP  12.788

                 AMBIENT SAMPLE              EXHAUST SAMPLE
      BAG %FULL SCL   SCALE   VALUE   %FULL SCL  SCALE    VALUE

CO2-%  1    1.000   4 %         .0348   46.110   4 %        1.7008
CO2-%  2     .990   4 %         .0344   29.450   4 %        1.0463
CO2-%  3     .970   4 %         .0338   38.780   4 %        1.4081

NX-PPM 1     .100 100PPMNOX     .1000   91.630 100PPMNOX   91.6300
NX-PPM 2     .110 100PPMNOX     .1100   27.640 100PPMNOX   27.6400
NX-PPM 3     .110 100PPMNOX     .1100   62.240 100PPMNOX   62.2400

CO-PPM 1     .160 500PPM LO    1.2271   73.470  2KPPM LO  984.8933
CO-PPM 2     .070 500PPM LO     .9765   24.780 500PPM LO   83.2288
CO-PPM 3     .000 500PPM LO     .7817   32.780 500PPM LO  115.6325

HC-PPM 1    9.410  50PPM LO    4.7050   74.850 200PPM LO  149.7000
HC-PPM 2    9.710  50PPM LO    4.8550   35.450  50PPM LO   17.7250
HC-PPM 3   10.030  50PPM LO    5.0150   72.530  50PPM LO   36.2650


                 GM EMISSIONS/PHASE                TOTAL  DIL FAC  VMIX
PHASE     CO2       NOX       CO          HC       REVS    (DF)   (CU FT)

   1   2404.000    10.632    90.014     6.600  11600.  7.3859 2775.05
   1    666.113     2.946    24.942     1.829  GM/MI (FOR 3.609 MI)

   2   2505.150     5.488    12.926     1.031  19906. 12.6847 4762.08
   2    642.676     1.408     3.316      .264  GM/MI (FOR 3.898 MI)

   3   2006.378     7.304    10.642     1.458  11739.  9.4148 2808.30
   3    558.102     2.032     2.960      .405  GM/MI (FOR 3.595 MI)

TOTAL  6915.528    23.424   113.582     9.088  (GM/TEST)
TOTAL   622.908     2.110    10.231      .819  (GM/MI FOR 11.102 MI)
TOTAL   624.392     1.896     7.689      .626  (WTD GM/MI FOR  7.499 MI)

    COMPOSITE FUEL ECONOMY - MPG         BAG   MPG
1972 COLD FTP( 7.507 MI) =   13.066     1    12.471
1972 HOT FTP ( 7.493 MI) =   14.583     2    13.670
1975 FTP     (11.102 MI) =   13.822     3    15.723
1975 WTD FTP ( 7.499 MI) =   13.890    AVG   13.954

 FVI OFF, SA=16, #42 JETS.  P759 RAN AWAY AFTER END OF
DRIVING CYCLE - NO POST TEST HEADERS - BAG READS ON P760
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     *** BAG * REV  1-24-78 ***    TODAY IS  1-25-78    IT IS  4:44 PM

PROGRAM: F.V.I.                   TEST TYPE : 75'FTP-CH         TEST# 10
VEHICLE: CHEVY                    VEHICLE ID: 1L39K3C201052     DATE: 1-25-
DRIVER : J.A.                     INSTR OPER: R.B.
CYL : 8         CID: 350          TRANS: AUTO              ODOM: 5548.5 MI
SITE: 4         DIW: 4500         ACTHP: 14.               IHP : 11.52

DAY 8025  TAPE P761   BENCH NO. 2  %RH= 12.90  PAMB= 14.210  TAMB= 72.8

OCTAL CODES:  WORD A =  000226 000226 000226 000226 000226 001036
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                        MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.951       AH = 15.8150     3.600   884.   .3159  11.395
CVS PIN =  12.745     PSAT =    .3992    3.900   861.   .3077  12.674
CVS TIN = 101.100    AHFAC =    .7824    3.558   712.   .2545  13.982
    V0 = .2927                  TOTALS 11.058  2457.   .8781  12.593
                                                      WTD FTP  12.733

                 AMBIENT SAMPLE                   EXHAUST SAMPLE
     BAG %FULL SCL    SCALE    VALUE    %FULL SCL  SCALE     VALUE

CO2-%  1     1.340    4 %         .0459   45.980    4 %         1.6956
CO2-%  2     1.250    4 %         .0429   29.580    4 %         1.0512
CO2-%  3     1.280    4 %         .0439   39.240    4 %         1.4263

NX-PPM 1      .160 100PPMNOX      .1600   87.560 100PPMNOX   87.5600
NX-PPM 2      .160 100PPMNOX      .1600   26.850 100PPMNOX   26.8500
NX-PPM 3      .100 100PPMNOX      .1000   61.800 100PPMNOX   61.8000

CO-PPM 1      .380 500PPM LO     1.8415   73.930  2KPPM LO  997.7058
CO-PPM 2      .120 500PPM LO     1.1157   25.700 500PPM LO   86.8115
CO-PPM 3      .000 500PPM LO      .7817   27.850 500PPM LO   95.3298

HC-PPM 1    10.280  50PPM LO     5.1400   84.080 200PPM LO  168.1600
HC-PPM 2    10.520  50PPM LO     5.2600   37.230  50PPM-LO   18.6150
HC-PPM 3    10.150  50PPM LO     5.0750   59.260  50PPM LO   29.6300


                 GM EMISSIONS/PHASE                TOTAL  DIL FAC  VMIX
PHASE      CO2       NOX        CO          HC     REVS    (DF)   (CU FT)

   1    2381.683    10.276    91.104      7.416  11614.  7.3945 2774.02
   1     661.579     2.854    25.307      2.060  GM/MI (FOR 3.600 MI)

   2    2492.596     5.376    13.439      1.069  19894. 12.6202 4751.71
   2     639.127     1.379     3.446       .274  GM/MI (FOR 3.900 MI)

   3    2010.822     7.311     8.724      1.146  11706.  9.3136 2795.99
   3     565.155     2.055     2.452       .322  GM/MI (FOR 3.558 MI)

TOTAL  6885.101     22.963   113.267      9.631  (GM/TEST)
TOTAL   622.635      2.077    10.243       .871  (GM/MI FOR 11.058 MI)
TOTAL   623.646      1.867     7.688       .656  (WTD GM/MI FOR  7.476 MI

    COMPOSITE FUEL ECONOMY - MPG          BAG   MPG
1972 COLD FTP( 7.500 MI) =    13.130      1     12.528
1972 HOT FTP ( 7.458 MI) =    14.551      2     13.740
1975 FTP     (11.058 MI) =    13.824      3     15.557
1975 WTD FTP ( 7.476 MI) =    13.904     AVG    13.942

 FVI OFF, SA=6+10=16, #42 JETS; NO TOTALIZED MILES OR SECONDS UNTIL
HOT 505 - USE FTP MILES AND SECONDS
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     *** BAG * REV  1-24-78 ***   TODAY IS  1-26-78    IT IS  2:32 PM

PROGRAM: F.V.I.                TEST TYPE : 75'FTP-CH        TEST# 11
VEHICLE: CHEVY                 VEHICLE ID: 1L39K3C201502    DATE: 1-26-78
DRIVER : J.A.                  INSTR OPER: R.B.
CYL : 8        CID: 350        TRANS: AUTO             ODOM: 5565.7 MI
SITE: 4        DIW: 4500       ACTHP: 14.              IHP : 11.52

DAY 8026  TAPE I013   BENCH NO. 2  %PH= 15.41  PAMB= 14.134  TAMB= 75.420

OCTAL CODES:  WORD A =  000226 000226 000226 000226 000226 001036
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                        MILES GAS-GM    GAL     MPG
CVS DELTAP= 1.943      AH = 20.7346     3.600   865.    .3091  11.645
CVS PIN =  12.669    PSAT =   .4354     3.912   841.    .3006  13.015
CVS TIN = 101.100   AHFAC =   .7968     3.581   706.    .2523  14.192
    V0 = .2928                  TOTALS 11.093  2412.    .8620  12.868
                                                     WTD FTP   13.023

                 AMBIENT SAMPLE              EXHAUST SAMPLE
      BAG %FULL SCL   SCALE   VALUE   %FULL SCL  SCALE    VALUE

CO2-%  1    1.520   4 %          .0518  46.520   4 %         1.7174
CO2-%  2    1.460   4 %          .0498  29.740   4 %         1.0573
CO2-%  3    1.580   4 %          .0538  39.510   4 %         1.4369

NOX-PPM 1    .140 100PPMNOX      .1400  83.640 100PPMNOX    83.6400
NOX-PPM 2    .160 100PPMNOX      .1600  26.740 100PPMNOX    26.7400
NOX-PPM 3    .130 100PPMNOX      .1300  63.850 100PPMNOX    63.8500

CO-PPM 1     .230 500PPM LO     1.4224  63.080  2KPPM LO   734.0328
CO-PPM 2     .010 500PPM LO      .8095  25.550 500PPM LO    86.2248
CO-PPM 3     .000 500PPM LO      .7817  31.760 500PPM LO   111.3439

HC-PPM 1    9.660  50PPM LO     4.8300  82.710 200PPM LO   165.4200
HC-PPM 2   10.400  50PPM LO     5.2000  35.580  50PPM LO    17.7900
HC-PPM 3   10.080  50PPM LO     5.0400  60.480  50PPM LO    30.2400


                 GM EMISSIONS/PHASE                TOTAL  DIL FAC  VMIX
PHASE     CO2       NOX       CO          HC       REVS    (DF)   (CU FT)

   1   2389.083      9.929     66.559      7.254  11599.   7.4142 2754.86
   1    663.634      2.758     18.489      2.015  GM/MI (FOR 3.600 MI)

   2   2479.395      5.425     13.324      1.004  19905. 12.5498 4727.61
   2    633.792      1.387      3.406       .257  GM/MI (FOR 3.912 MI)

   3   2004.692      7.656     10.155      1.170  11720.   9.2345 2783.60
   3    559.813      2.138      2.836       .327  GM/MI (FOR 3.581 MI)

TOTAL  6873.170     23.010     90.037      9.428  (GM/TEST)
TOTAL   619.595      2.074      8.117       .850  (GM/MI FOR 11.093 MI)
TOTAL   619.789      1.874      6.359       .638  (WTD GM/MI FOR  7.501 MI)

    COMPOSITE FUEL ECONOMY - MPG         BAG   MPG
1972 COLD FTP( 7.512 MI) =   13.270      1    12.685
1972 HOT FTP ( 7.493 MI) =   14.676      2    13.857
1975 FTP     (11.093 MI) =   13.965      3    15.687
1975 WTD FTP ( 7.501 MI) =   14.036     AVG   14.077

 FVI OFF, SA=16, #42 JETS
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     *** BAG * REV  1-24-78 ***    TODAY IS  1-27-78    IT IS  2:18 PM

PROGRAM: F.V.I.                      TEST TYPE : 75'FTP-CH          TEST# 12
VEHICLE: CHEVY                       VEHICLE ID: 1L39K3C201052      DATE: 1-27-7
DRIVER : J.A.                        INSTR OPER: R.B.
CYL : 8        CID: 350              TRANS: AUTO               ODOM: 5576.6 MI
SITE: 4        DIW: 4500             ACTHP: 14.                IHP : 11.52

DAY 8027  TAPE I014   BENCH NO. 2  %RH= 21.48  PAMB= 14.160  TAMB= 75.70

OCTAL CODES:  WORD A =  000226 000226 000226 000226 000226 001036
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:   2A,3A,1A,2E,3E,1E,

                                            MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.944      AH = 29.1800         3.613   864.   .3098  11.700
CVS PIN =  12.697    PSAT =    .4395        3.911   859.   .3070  12.739
CVS TIN = 101.800   AHFAC =    .8228        3.604   713.   .2548  14.143
    V0 = .2928                       TOTALS 11.128  2436.   .8706  12.782
                                                           WTD'FTP  12.878

                      AMBIENT SAMPLE                   EXHAUST SAMPLE
      BAG %FULL SCL   SCALE     VALUE    %FULL SCL  SCALE      VALUE

CO2-%  1     1.640    4 %          .0558   46.950    4 %         1.7348
CO2-%  2     1.520    4 %          .0518   30.020    4 %         1.0680
CO2-%  3     1.430    4 %          .0489   39.570    4 %         1.4393

NX-PPM 1      .210 100PPMNOX       .2100   81.170 100PPMNOX    81.1700
NX-PPM 2      .250 100PPMNOX       .2500   26.380 100PPMNOX    26.3800
NX-PPM 3      .140 100PPMNOX       .1400   63.230 100PPMNOX    63.2300

CO-PPM 1      .730 500PPM LO      2.8232   67.000  2K PPM LO  820.4169
CO-PPM 2      .640 500PPM LO      2.5702   25.200 500PPM LO    84.8598
CO-PPM 3      .110 500PPM LO      1.0878   27.600 500PPM LO    94.3288

HC-PPM 1    11.360  50PPM LO      5.6800   79.830 200PPM LO   159.6600
HC-PPM 2    11.950  50PPM LO      5.9750   38.680  50PPM LO    19.3400
HC-PPM 3    11.050  50PPM LO      5.5250   76.670  50PPM LO    38.3350


                   GM EMISSIONS/PHASE                  TOTAL   DIL FAC   VMIX
PHASE       CO2          NOX          CO         HC      REVS     (DF)   (CU FT)

   1    2412.472      9.956      74.396      6.971  11604.   7.3112 2758.58
   1     667.720      2.756      20.591      1.930  GM/MI (FOR 3.613 MI)

   2    2502.645      5.512      12.866      1.070  19898.  12.4253 4730.29
   2     639.899      1.409       3.290       .273  GM/MI (FOR 3.911 MI)

   3    2019.931      7.849       8.591      1.523  11741.   9.2250 2791.15
   3     560.469      2.178       2.384       .423  GM/MI (FOR 3.604 MI)

TOTAL   6935.049     23.318      95.853      9.564  (GM/TEST)
TOTAL    623.207      2.095       8.614       .859  (GM/MI FOR 11.128 MI)
TOTAL    623.931      1.897       6.615       .656  (WTD GM/MI FOR  7.519 MI)

    COMPOSITE FUEL ECONOMY - MPG            BAG    MPG
1972 COLD FTP( 7.524 MI) =    13.140         1     12.558
1972 HOT FTP ( 7.515 MI) =    14.600         2     13.729
1975 FTP     (11.128 MI) =    13.868         3     15.680
1975 WTD FTP ( 7.519 MI) =    13.935        AVG    13.989

 FVI OFF, #42 JETS, SA=16
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     *** BAG * REV  1-24-78 ***    TODAY IS  2-02-78    IT IS  3:50 PM

PROGRAM: F.V.I.                TEST TYPE : 75 FTP-CH        TEST# 15
VEHICLE: CHEVY                 VEHICLE ID: 1L39K3C201052    DATE: 2-2-78
DRIVER : J.A.                  INSTR OPER: R.B.
CYL : 8        CID: 350        TRANS: AUTO               ODOM: 5612.9 MI
SITE: 4        DIW: 4500       ACTHP: 14.0               IHP : 11.52

DAY 8033  TAPE I043   BENCH NO. 2  %RH= 35.03  PAMB= 14.165  TAMB= 73.800

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000222 002032
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                          MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.949      AH = 44.8351       3.633   957.   .3420  10.622
CVS PIN =  12.710    PSAT =    .4127      3.897   965.   .3449  11.299
CVS TIN = 100.200   AHFAC =    .8758      3.594   771.   .2756  13.043
    V0 = .2927                    TOTALS 11.124  2693.   .9625  11.558
                                                         WTD FTP  11.596

                   AMBIENT SAMPLE                  EXHAUST SAMPLE
      BAG %FULL SCL   SCALE    VALUE    %FULL SCL   SCALE     VALUE

CO2-%  1     1.660   4 %         .0564   48.390    4 %         1.7928
CO2-%  2     1.530   4 %         .0521   33.030    4 %         1.1836
CO2-%  3     1.570   4 %         .0535   42.310    4 %         1.5482

NX-PPM 1      .160 100PPMNOX     .1600   61.480 100PPMNOX    61.4800
NX-PPM 2      .180 100PPMNOX     .1800   16.450 100PPMNOX    16.4500
NX-PPM 3      .160 100PPMNOX     .1600   47.670 100PPMNOX    47.6700

CO-PPM 1      .500 500PPM LO    2.1774   94.570  2KPPM LO 1753.3107
CO-PPM 2      .370 500PPM LO    1.8135   63.590 500PPM LO  266.8111
CO-PPM 3      .410 500PPM LO    1.9254   77.730 500PPM LO  350.2177

HC-PPM 1    17.280  50PPM LO    8.6400   40.070 500PPM LO  200.3500
HC-PPM 2    14.160  50PPM LO    7.0800   38.850  50PPM LO   19.4250
HC-PPM 3    12.800  50PPM LO    6.4000   65.290  50PPM LO   32.6450


                 GM EMISSIONS/PHASE              TOTAL   DIL FAC  VMIX
PHASE     CO2        NOX        CO          HC      REVS     (DF)   (CU FT)

   1    2509.002     8.067   160.097      8.737  11619.   6.7398 2772.28
   1     690.339     2.220    44.065      2.405  GM MI (FOR 3.633 MI)

   2    2797.138     3.668    41.510      1.007  19900. 11.0541 4748.11
   2     717.767      .941    10.652       .258  GM/MI (FOR 3.897 MI)

   3    2179.951     6.315    32.184      1.235  11739.  8.4464 2800.91
   3     606.553     1.757     8.955       .344  GM/MI (FOR 3.594 MI)

TOTAL  7485.091    18.050   233.781     10.979  (GM/TEST)
TOTAL   672.878     1.623    21.016       .987  (GM/MI FOR 11.124 MI)
TOTAL   681.663     1.430    17.120       .727  (WTD GM/MI FOR  7.508 MI)

    COMPOSITE FUEL ECONOMY - MPG           BAG   MPG
1972 COLD FTP( 7.530 MI) =    11.813       1    11.559
1972 HOT FTP ( 7.491 MI) =    13.026       2    12.060
1975 FTP     (11.124 MI) =    12.507       3    14.264
1975 WTD FTP ( 7.508 MI) =    12.475      AVG   12.628

 BASELINE STOCK - #45 JETS - SA=6 (SPARK ANGLE NOW REALLY 6 - WAS
ALMOST 13) - IDLE SPEED RESET (LOWER)
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     *** BAG * REV  1-24-78 ***    TODAY IS  2-03-78    IT IS  3:55 PM

PROGRAM: F.V.I.                   TEST TYPE : 75'FTP-CH          TEST# 16
VEHICLE: CHEVY                    VEHICLE ID: 1L39H3C201052    DATE: 2-3-78
DRIVER : J.A.                     INSTR OPER: R.B.
CYL : 8        CID: 350           TRANS: AUTO             ODOM: 5626.2 MI
SITE: 4        DIW: 4500          ACTHP: 14.              IHP : 11.52

DAY 8034  TAPE I049   BENCH NO. 2  %RH= 20.12  PAMB= 14.166  TAMB= 78.50

OCTAL CODES:   WORD A =  000222 000222 000222 000222 000222 001032
               WORD B =  010444 010444 010444 010444 010444 010444
               BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                          MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.945       AH = 29.9501      3.610   949.   .3392  10.644
CVS PIN =  12.704     PSAT =   .4817      3.920   997.   .3563  11.001
CVS TIN = 101.400    AHFAC =   .8253      3.573   779.   .2784  12.833
    V0 = .2928                      TOTALS 11.103  2725.   .9739  11.400
                                                        WTD FTP  11.384

                AMBIENT SAMPLE                  EXHAUST SAMPLE
     BAG %FULL SCL    SCALE    VALUE   %FULL SCL  SCALE     VALUE

CO2-%  1     1.790    4 %         .0607   49.550    4 %          1.9405
CO2-%  2     1.870    4 %         .0633   34.890    4 %          1.2557
CO2-%  3     1.770    4 %         .0600   43.530    4 %          1.5970

NX-PPM 1      .130 100PPMNOX      .1300   67.710 100PPMNOX     67.7100
NX-PPM 2      .120 100PPMNOX      .1200   20.200 100PPMNOX     20.2000
NX-PPM 3      .100 100PPMNOX      .1000   53.650 100PPMNOX     53.6500

CO-PPM 1      .400 500PPM LO     1.8974   85.700  2K PPM LO 1382.3070
CO-PPM 2      .300 500PPM LO     1.6178   44.010 500PPM LO   165.8841
CO-PPM 3      .210 500PPM LO     1.3666   71.530 500PPM LO   312.5600

HC-PPM 1    10.880  50PPM LO     5.4400   76.030 200PPM LO   152.0600
HC-PPM 2    11.320  50PPM LO     5.6600   29.230  50PPM LO    14.6150
HC-PPM 3    11.280  50PPM LO     5.6400   53.960  50PPM LO    26.9800


                GM EMISSIONS/PHASE                 TOTAL   DIL FAC   VMIX
PHASE      CO2          NOX        CO          HC      REVS     (DF)   (CU FT)

   1    2558.650      8.335    125.576      6.641  11590.   6.7204 2758.62
   1     708.767      2.309     34.786      1.840  GM/MI (FOR 3.610 MI)

   2    2940.745      4.250     25.656       .734  19884. 10.5202 4732.73
   2     750.190      1.084      6.545       .187  GM/MI (FOR 3.920 MI)

   3    2231.506      6.672     28.609      1.002  11709.   8.2161 2786.94
   3     624.547      1.867      8.007       .281  GM/MI (FOR 3.573 MI)

TOTAL  7730.901     19.257    179.841      8.378  (GM/TEST)
TOTAL   696.289      1.734     16.198       .755  (GM/MI FOR 11.103 MI)
TOTAL   707.501      1.550     12.764       .553  (WTD GM/MI FOR  7.509 MI)

    COMPOSITE FUEL ECONOMY - MPG            BAG    MPG
1972 COLD FTP( 7.530 MI) =    11.592         1     11.528
1972 HOT FTP ( 7.493 MI) =    12.626         2     11.652
1975 FTP      (11.103 MI) =   12.246         3     13.899
1975 WTD FTP ( 7.509 MI) =    12.160        AVG    12.360

 BASELINE STOCK= FVI OFF, #45 JETS, SA=6
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     *** BAG * REV  1-24-78 ***    TODAY IS  2-07-78    IT IS  3:02 PM

PROGRAM: F.V.I.                 TEST TYPE : 75 FTP-CH        TEST# 17
VEHICLE: CHEVY                  VEHICLE ID: 1L39K3C201052    DATE: 2-7-78
DRIVER : J.A.                   INSTR OPER: R.B.
CYL : 8        CID: 350         TRANS: AUTO             ODOM: 5643.5 MI
SITE: 4        DIW: 4500        ACTHP: 14.              IHP : 11.52

DAY 8038  TAPE I059   BENCH NO. 2  %RH= 45.50  PAMB= 14.110  TAMB= 74.500

OCTAL CODES:   WORD A =  000222 000222 000222 000222 000232 002030
               WORD B =  010444 010444 010444 010444 010444 010444
               BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                              MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.943       AH = 60.0415          3.528   999.   .3570   9.881
CVS PIN =  12.647     PSAT =    .4224         3.900   993.   .3549  10.989
CVS TIN =  99.800    AHFAC =    .9343         3.603   802.   .2866  12.570
    V0 = .2928                         TOTALS 11.031  2794.   .9986  11.047
                                                            WTD FTP  11.153

                  AMBIENT SAMPLE                  EXHAUST SAMPLE
      BAG %FULL SCL    SCALE    VALUE    %FULL SCL   SCALE     VALUE

CO2-%  1    1.500    4 %          .0512    50.110    4 %          1.8634
CO2-%  2    1.510    4 %          .0515    34.530    4 %          1.2417
CO2-%  3    1.590    4 %          .0541    43.300    4 %          1.5878

NX-PPM 1     .180 100PPMNOX       .1800    59.650 100PPMNOX    59.6500
NX-PPM 2     .210 100PPMNOX       .2100    17.570 100PPMNOX    17.5700
NX-PPM 3     .160 100PPMNOX       .1600    46.040 100PPMNOX    46.0400

CO-PPM 1    1.040 500PPM LO      3.6972    16.070   2 %  HI 2206.4666
CO-PPM 2     .550 500PPM LO      2.3176    48.220 500PPM LO  186.1572
CO-PPM 3     .380 500PPM LO      1.8415    50.320  2KPPM LO  510.7401

HC-PPM 1   11.790  50PPM LO      5.8950    59.440 500PPM LO  297.2000
HC-PPM 2   12.190  50PPM LO      6.0950    29.740  50PPM LO   14.8700
HC-PPM 3   12.180  50PPM LO      6.0900    62.750  50PPM LO   31.3750


                  GM EMISSIONS/PHASE                 TOTAL   DIL FAC  VMIX
PHASE      CO2       NOX       CO          HC        REVS     (DF)   (CU FT)

   1    2599.803    8.293   200.104     13.145   11591.  6.3395 2754.57
   1     736.906    2.351    56.719      3.726   GM/MI (FOR 3.528 MI)

   2    2932.449    4.162    28.719       .723   19914. 10.6197 4732.50
   2     751.910    1.067     7.364       .185   GM/MI (FOR 3.900 MI)

   3    2227.622    6.478    46.820      1.186   11737.  8.1608 2789.26
   3     618.269    1.798    12.995       .329   GM/MI (FOR 3.603 MI)

TOTAL  7759.874    18.934   275.643     15.054   (GM/TEST)
TOTAL   703.461     1.716    24.988      1.365   (GM MI FOR 11.031 MI)
TOTAL   712.266     1.529    18.985       .948   (WTD GM/MI FOR  7.471 MI)

    COMPOSITE FUEL ECONOMY - MPG         BAG    MPG
1972 COLD FTP( 7.428 MI) =   11.097       1    10.584
1972 HOT FTP ( 7.503 MI) =   12.590       2    11.606
1975 FTP     (11.031 MI) =   11.871       3    13.862
1975 WTD FTP ( 7.471 MI) =   11.902      AVG   12.018

 BASELINE STOCK- F.V.I. OFF - SA=6 - #45 JETS - DYNO BRAKE
ON @ START -MISSED FIRST RAMP - ONE RESTART (@ START)
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     *** BAG * REV  1-24-78 ***   TODAY IS  2-08-78    IT IS  4:23 PM

PROGRAM: F.V.I.                TEST TYPE : 75'FTP-CH        TEST# 18
VEHICLE: CHEVY                 VEHICLE ID: 1L39K3C201052    DATE: 2-8-78
DRIVER : J.A.                  INSTR OPER: R.B.
CYL : 8        CID: 350        TRANS: AUTO            ODOM: 5654.4 MI
SITE: 4        DIW: 4500       ACTHP: 14.             IHP : 11.52

DAY 8039  TAPE I060   BENCH NO. 2  %RH= 41.11  PAMB= 14.151  TAMB= 75.200

OCTAL CODES:  WORD A =  000222 000222 000222 000222 000222 002032
              WORD B =  010444 010444 010444 010444 010444 010444
              BAG DATA INPUT ORDER:  2A,3A,1A,2E,3E,1E,

                                               MILES GAS-GM    GAL    MPG
CVS DELTAP= 1.951       AH = 55.2971           3.618   978.   .3495  10.351
CVS PIN =  12.689     PSAT =     .4323         3.925  1020.   .3645  10.767
CVS TIN = 101.200    AHFAC =     .9152         3.600   799.   .2856  12.607
    V0 = .2927                         TOTALS 11.143  2797.   .9996  11.147
                                                            WTD FTP  11.140

                  AMBIENT SAMPLE                   EXHAUST SAMPLE
      BAG %FULL SCL    SCALE      VALUE   %FULL SCL   SCALE      VALUE

CO2-%  1     1.500   4 %         .0512   50.160    4 %          1.8654
CO2-%  2     1.480   4 %         .0505   34.880    4 %          1.2553
CO2-%  3     1.360   4 %         .0466   43.920    4 %          1.6126

NX-PPM 1      .110 100PPMNOX     .1100   61.200 100PPMNOX     61.2000
NX-PPM 2      .130 100PPMNOX     .1300   19.670 100PPMNOX     19.6700
NX-PPM 3      .100 100PPMNOX     .1000   49.280 100PPMNOX     49.2800

CO-PPM 1      .440 500PPM LO    2.0094   93.870  2KPPM LO 1721.2318
CO-PPM 2      .160 500PPM LO    1.2271   45.000 500PPM LO  170.5811
CO-PPM 3      .210 500PPM LO    1.3666   72.350 500PPM LO  317.4432

HC-PPM 1    11.230  50PPM LO    5.6150   43.510 500PPM LO  217.5500
HC-PPM 2    11.530  50PPM LO    5.7650   31.880  50PPM LO   15.9400
HC-PPM 3    11.480  50PPM LO    5.7400   60.570  50PPM LO   30.2850


                  GM EMISSIONS/PHASE                    TOTAL  DIL FAC  VMIX
PHASE      CO2        NOX        CO            HC       REVS     (DF)   (CU FT)

   1   2609.949     8.368   156.616        9.600  11619.  6.5071 2762.53
   1    721.379     2.313    43.298        2.653  GM/MI (FOR 3.618 MI)

   2   2970.290     4.590    26.462         .829  19919. 10.5184 4735.93
   2    756.762     1.169     6.742         .211  GM/MI (FOR 3.925 MI)

   3   2276.200     6.810    29.121        1.152  11747.  8.1340 2792.96
   3    632.278     1.892     8.089         .320  GM/MI (FOR 3.600 MI)

TOTAL  7856.438    19.768   212.199       11.581  (GM/TEST)
TOTAL   705.056     1.774    19.043        1.039  (GM/MI FOR 11.143 MI)
TOTAL   715.518     1.602    14.647         .745  (WTD GM/MI FOR  7.533 MI)

    COMPOSITE FUEL ECONOMY - MPG            BAG    MPG
1972 COLD FTP( 7.543 MI) =    11.336         1     11.115
1972 HOT FTP ( 7.525 MI) =    12.496         2     11.547
1975 FTP     (11.143 MI) =    12.012         3     13.728
1975 WTD FTP ( 7.533 MI) =    11.969        AVG    12.130

 BASELINE STOCK (FVI OFF, SA=6, #45 JETS) - ENGINE BACKFIRED
ONCE DURING EACH 505 (ON SAME RAMP @ APPROX. 360 SEC)
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ORIGINAL PAGE IS
OF POOR QUALITY

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