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EPA-AA-TEB-511-81-12

PB84-163062

EPA Evaluation of the V-70 Vapor Injector Device Under Section 511 of the Motor Vehicle Information and Cost Savings Act

by

Thomas J. Penninga

May 1981

Test and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
U.S. Environmental Protection Agency

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

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16. ABSTRACT

This document announces the conclusions of the EPA evaluation of the "V-70 Vapor Injector" device under provisions of Section 511 of the Motor Vehicle Information and Cost Savings Act.

The evaluation of the "V-70 Vapor Injector" device was conducted upon the application of the manufacturer. The device is basically a controlled air bleed device where the air is bubbled through a mixture of water and an additive supplied by the Applicant.

The Applicant submitted insufficient test data to prove that the "V-70 Vapor Injector" device would improve fuel economy. EPA testing of similar devices failed to show a fuel economy benefit. Therefore, it is unlikely that testing of the device would show a fuel economy benefit.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automobiles Fuel Consumption Tests	Air Bleed Device Fuel Economy Gas Saving Device	

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EPA Evaluation of the V-70 Vapor Injector Device under Section 511 of the Motor Vehicle Information and Cost Savings Act

The following is a summary of the information on the device as submitted by the Applicant and the resulting EPA analysis and conclusions. The Applicant has failed to respond to two letters requesting additional information and test data. Therefore, the results of this preliminary evaluation are based on information supplied in the initial application and will be published according to Federal Register 610.30(c).

1. Marketing Identification of the Device:

"V-70 Vapor Injector. (If a new marketing company is organized, the device will be marketed under the name V-80.)"

2. Inventor of the Device and Patents:

A. Inventor

Ivey Herpin

B. Patent

Patent Number 3537434 issued 11-3-70
Patent Number 3716040 issued 2-15-73

3. Manufacturer of the Device:

"Device is currently manufactured by:

Herule Research and Manufacturing, Inc.
P.O. Box 489
Ennis, Texas

4. Manufacturing Organization Principals:

Gene T. Rohl - President
Ivey Herpin - Vice President

5. Marketing Organization in U.S. making Application:

Company not yet organized.

6. Applying Organization Principals:

Elwood Ross
Jay Rodgers
Richard L. Ploch
Ivey Herpin

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7. Description of Device:

A. Purpose of the Device (as supplied by Applicant):

"Attached is a copy of patent #3716040 which outlines the purpose, theory of operation, and gives a detailed description of the construction and operation." See Attachment A.

8. Applicability of the Device (as supplied by Applicant):

"The V-70 will operate on any gasoline operated automobile."

9. Device Installation - Tools and Expertise Required (as supplied by Applicant):

"The device is connected to the automobile by a "T" connector to the vacuum line between the PCV valve and the carburetor. Also, it could be connected through a spacer plate under the carburetor. The unit is held in place by four screws on the base of the unit. Tools required - drill, screw driver, and knife to cut vacuum line." Also included in the application was a page of installation instructions (see attachment B).

10. Device Operation (as supplied by Applicant):

"Instructions are furnished with each unit pertaining to the installation and operation. Copy is enclosed." See Attachment B.

11. Maintenance (claimed):

"When the liquid level reaches the "add" line, one quart of additive and one quart of distilled water is added to bring the liquid level to the "full" mark."

12. Effects on Vehicle Emissions (non-regulated) (claimed):

"We have a copy of a test requested by a company associated with Herule Research & Manufacturing, Inc. which was completed by Dr. James C. Cox, Jr. at Wayland Baptist College. This test was done in 1972. We had a preliminary test made by Scott Environmental Technology, Inc. This test was done in April 1979."

13. Effects on Vehicle Safety (claimed):

"The device would not result in any unsafe conditions endangering the automobile or its occupants or persons or property in close proximity of the automobile."

14. Test Results (Regulated Emissions and Fuel Economy) (submitted by Applicant):

"Enclosed are test results from Dr. Cox's 1972 test and the 1979 preliminary test by Scott Environmental Technology, Inc. Other preliminary tests made by individuals and potential corporate customers used the gallons to miles evaluation, and according to the information furnished to us, is not valid."

15. Analysis

A. Description of Device:

The device is basically a controlled air bleed device where the air is bubbled through a mixture of water and an additive supplied by the Applicant. The device contains an inlet air filter and a baffle to prevent flow of liquid into the engine. The device installs into the PCV - carburetor vacuum line.

B. Applicability of the Device:

The applicability of the device to "operate on any gasoline operated automobile" is judged valid for all gasoline fuel vehicles presently being produced.

C. Device Installation - Tools and Expertise Required:

The device installation appears to be straight forward, well explained, and could be easily carried out by any "mechanically inclined" person.

D. Device Operation:

The Applicant supplied additional installation instructions, but never explained the theory of operation of the device. The patent states that "inducting an additive into the fuel system of a motor vehicle to enhance the combustibility of the fuel by lowering the flashpoint thereof, and to reduce waste due to incomplete combustion." The patent also claims the device "insures a proper ratio between the carbureted fuel and additive vapors."

These explanations do not indicate why the device improves fuel economy. The flash point is the lowest temperature of the fluid that allows inflammable vapors to be formed. It is found by heating the fuel slowly and then sweeping a flame across the surface of the liquid, a distinct flash is obtained at the flash point. The flash points of most gasolines are below 0°F. Lowering the flash point does not necessarily correlate with increased vehicle fuel economy. The reduction of waste due to incomplete combustion is not explained. The application therefore does not explain the true operation of the device. The Applicant was questioned about the actual theory of his device in a December 26, 1979 letter from Charles Gray, Jr. This letter also asked for clarification of several other points in the application and is included as Attachment C. The applicant never responded to this letter.

The second major question about the operation of the device was the make-up of the V-70 Vapor Fuel Additive. The additive was not described in application other than that it was a "specially

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prepared formula of oxygen-bearing petroleum distillates". The December 26, 1979 letter also requested information on this additive.

The analysis of the operation of this device is incomplete due to a lack of information. The device appears to be able to introduce air which has been bubbled through a mixture of water and an unknown additive into the PCV-carburetor vacuum line. The effect of this introduction is not known. There appears to be no theoretical reason to believe that "increased fuel combustion", "elimination of vicious carbon build-up", "smoother, longer engine life", "increased gas mileage", or "reduced harmful hydrocarbon emissions (pollutants)" would occur. Similar vapor air bleed devices tested by EPA showed no significant improvement in fuel economy (see Attachment D).

E. Device Maintenance

Applicant claims that the only maintenance required is to refill the water-additive reservoir when it reaches the "add" indicator. This appears to be the only maintenance required.

F. Effects on Vehicle Emissions (non-regulated):

The Applicant makes no statements about the effect of the device on non-regulated emissions. An analysis cannot be made without the knowledge of the chemical composition of the V-70 Vapor Fuel Additive. As noted above, the required information was requested in the December 26, 1979 letter.

G. Effects on Vehicle Safety:

The Applicant claims the chemical would not result in any unsafe condition. The only safety problem apparent from the application is the V-70 Vapor Fuel Additive. Until the chemical composition is known, an accurate analysis of the device-additive impact on vehicle operation safety cannot be made.

H. Test Results Supplied by Applicant

The Applicant supplied data came from two sources; Wayland Baptist College and Scott Environmental Technology, Inc. There are several problems with the data which do not allow a proper evaluation of the V-70 Vapor Injector. The December 26, 1979 letter (Attachment C) requested additional information. No answer was received. A review of the data is given below:

1. The Scott Environmental Technology, Inc. test data (see Attachment E). A table of the test results is given below:

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Test No.	Test Type	HC gms/mile	CO gms/mile	NOx gms/mile	Fuel Economy MPG
1	Baseline-HFET	.55	12.62	1.17	24.11
2	V-70 Vapor Power - HFET	.57	15.50	1.11	25.99
% Change		(+)3.6%	(+)22.8	(-)5.1	(+)7.8

There are several problems with this data. They are:

a. The test data was run at a laboratory which is not on the EPA list of recognized laboratories. Scott Environmental Technology, Inc. is not on our list because the laboratory has not yet been checked out by EPA personnel in the formal laboratory recognition process.

b. Only Highway Fuel Economy Tests (HFET) were run. The Federal emission standards are based on the Federal Test Procedure (FTP). The HFET emission data is not correlatable to the actual FTP regulated emission standards.

c. Only one HFET was run in each condition. With unknown test repeatability, the validity of the 7.8% increase in fuel economy is questionable.

d. Only one vehicle was tested. Due to the differences in engine/vehicle characteristics it is not possible to extrapolate the tests on one vehicle to all gasoline fuel vehicles.

e. Test laboratories normally maintain about 70 grains water/lb. dry air so as to minimize the humidity correction factor for NOx emissions. We do not understand why Scott Labs would permit the testing when the humidity level was 24 grains/lb. dry air. The amount of water which would vaporize in the V-70 injector would depend on the moisture content of the air coming into the device. Higher moisture content in the inlet air could reduce the effectiveness of the device.

f. The FTP and HFET test procedures require the measurement of HC, CO, CO_2, and NOx background levels and these levels are to be substracted from the bag results. The Scott data indicates only HC background levels were measured.

g. The testing indicates a 22.8% increase in CO which would put many test vehicles over the emission standard.

These problems were noted in the EPA December 26, 1979 letter to the Applicant.

2. The Wayland Baptist College test data (see Attachment F). The testing data is given below: Units are microgram per cubic meter

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Test No.	Test Type	CO	Particulate	HC	NOx	CO_2
23	1500 RPM Baseline	120	100	120	60	80
25	1500 RPM V-70	40	50	60	30	30
24	1000 RPM Baseline	140	80	80	70	90
26	1000 RPM V-70	50	50	40	40	40

There are several problems with this data.

a. This office has never heard of that laboratory before. To the best of our knowledge, Wayland Baptist College is not a qualified independent laboratory for automotive emission testing.

b. The test procedures used in collecting the data are not described. The units of measurement indicate that conventional equipment and techniques were not used. The units of microgram/cubic meter do not compensate for varying exhaust volume.

c. Only two states of operation (1) 1500 RPM in neutral and (2) 1000 RPM in drive, were tested. This data indicates nothing about transient cycles.

d. The data conflicts with the Scott data which showed an increase in HC and CO.

e. The data does not include any fuel consumption measurements.

f. The test vehicle and test equipment were not described.

The two sets of data do not demonstrate the effect of the V-70 Vapor Injector on gasoline powered vehicles. Further testing would be required to make such a documentation. A test plan was developed for the applicant and transmitted in the EPA December 26, 1979 letter. No response was received.

J. <u>EPA Testing V-70 Vapor Injector:</u>

Because the Applicant submitted insufficient test data, a test plan was developed which when completed would demonstrate the results of installing a V-70 Vapor Injector. The Applicant never responded. A second letter was sent December 22, 1980 (see Attachment G). The Applicant did not respond. Therefore, lacking any data to substantiate the applicant's claims, no EPA testing of the V-70 Vapor Injector was performed. Several other devices tested by EPA have introduced water or water alcohol mixtures into

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the combustion chambers. In sufficient quantity such additive can extend the detonation limits of the engine which in turn allows modifications which can improve fuel economy. The amount of additive added by the V-70 Vapor Injector is stated to be about 1.89 ml per mile. At 3785 ml per gallon, a 20 mile per gallon vehicle would use 189.25 ml per mile. The V-70 Injector mixture to mixture plus fuel ratio is about one percent. This value will depend on relative humidity of inlet air. The EPA testing on other devices noticed no change in fuel economy for this small amount of additive. Therefore, it is unlikely that the 1% additive addition from the V-70 Vapor Injector will impact vehicle emissions or fuel economy.

16. Conclusions

The Applicant submitted insufficient test data to prove that the "V-70 Vapor Injector" would improve fuel economy. EPA testing of similar devices failed to show a fuel economy benefit. Therefore, it is unlikely that testing of the device would show a fuel economy benefit.

List of Attachments

Attachment A	Patent #3761040
Attachment B	Installation Instructions
Attachment C	December 26, 1979 letter from C. Gray to Richard C. Ploch.
Attachemnt D	Evaluation of the SCATPAC Device
Attachment E	Emission Results from an Automobile using the Frantz Vapor Injector
Attachment F	An Evaluation of the Econo-Mist Device
Attachment G	Evaluation of the Turbo Vapor Injector
Attachment H	The Mark II Vapor Injector: An Air-Vapor Bleed Device Evaluated
Attachment I	Scott Environmental Technology, Inc.
Attachment J	Wayland Baptist College Data.
Attachment K	December 22, 1980 letter from M. Korth

Title: EPA Evaluation of the V-70 Vapor Injector Device Under Section 511 of the Motor Vehicle Information and Cost Savings Act.

ATTACHMENT A - B

Page(s) 14 - 19

Not clearly reproducible from submitted document. Copy will be furnished upon request from the U. S. Environmental Protection Agency, Emission Control Technology Division, Test & Evaluation Branch, 2565 Plymouth Rd., Ann Arbor, MI 48105.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY ATTACHMENT C

ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR, NOISE AND RADIATION

December 26, 1979

Mr. Richard L. Ploch
12900 Preston Road
Suite 715, L.B. 4
Dallas, Texas 75230

Dear Mr. Ploch:

This is in response to your September 20, 1979 letter which requested EPA to test the "V-70" vaporizer.

As was explained in the Policy Paper previously sent to you, the EPA does not certify or approve retrofit fuel economy devices. When requested by the Federal Trade Commission, the EPA administrator, or the manufacturer of a device, the EPA will evaluate a device. In the case of the manufacturer making the requet, we are required to limit EPA testing to a confirmatory role, i.e. testing by the EPA to confirm results obtained by an independent laboratory. Due to the number of such requests and limitations of our testing facilities, this confirmatory policy is the only practical solution.

A preliminary review of your testing request has been made. While there are several areas that require clarification, the supplied testing data is not sufficient to justify confirmatory testing by the EPA. This letter is written to request more information where required and to present a test plan which will ascertain the validity of the claims made about the "V-70" fuel economy retrofit device.

A. Areas requiring additional information.

Description of the Device

1. a. Please submit information on the additive you put into the water/additive reservoir. Please indicate the chemical makeup of any hydrocarbon constituents.

2. Please indicate amount of fluid injected per amount of fuel consumed i.e. lb. fluid/ lb. fuel.

3. Please indicate why you believe addition of water vapor to the inlet air will reduce fuel consumption. The actual theory of operation of you device is not explained in your application for evaluation.

4. There are several problems with the test data supplied. These problems, given below, do not allow a proper evaluation of "V-70" Vapor Injector.

a. The Scott Laboratory Data

1. This test date was run at a laboratory which is not on our list of recommended laboratories. Scott labs is not on our list because the laboratory has never been checked out by EPA personnel.

2. Only HFET cycle tests were run. The Federal emission standards are based on the Federal Test Procedure (FTP). The HFET emission data is not correlatable to the actual FTP regulated emission standards.

3. Only one HFET was run in each condition. With a 5% test repeatability, the test validity of the 7.8% increase in fuel economy is questionable.

4. Only one vehicle was tested. Due to the differences in engine/vehicle characteristics is not possible extrapolate the tests on one vehicle to all gasoline fueled vehicles.

5. Test laboratories normally maintain about 70 grains water/lb dry in so as to minimize the humidity correction factor for NOx emissions. We do not understand why Scott Labs would permit testing when the humidity level was 24 grains/lb. dry air.

6. The FTP and HFET test procedures require the measurement of HC, CO, CO_2 and NOx background levels and these levels are to be subtracted from the bag results. The Scott data indicates only HC background levels were measured.

7. While a 7.8% increase in fuel economy was noted in the tests, a 22.8% increase in CO was also noted. Such an increase in CO, if realistic, would put many cars over the emission standards.

b. Wayland Baptist College Test Data

1. This office has not heard of that laboratory before. The Wayland Baptist College is not, therefore, to the best of our knowledge, a qualified independent testing laboratory for automotive emission testing.

2. The test procedures used in collecting the data are not described. The units of measurement indicate that conventional equipment and methods were not used.

3. Only two states of operation (1) 1500 RPM in neutral and (2) 1000 RPM in Drive, were tested. This data indicates nothing about transient cycles.

4. This data conflicts with the Scott data which showed an increase in HC and CO.

E. Recommended Test Program to Define Fuel Economy and Emission Effects of "V-70" Vapor Injector.

1. <u>Test Vehicle Selection</u>

Three domestic vehicles with accumulated mileage between 4,000 and 70,000 miles should be chosen. Care should be taken in selecting the vehicles to cover the range of claimed device applicbility. (Example; one 8-cyclinder, one 6-cylinder and one 4-cylinder).

2. <u>Test Vehicle Inspection and Adjustment Prior to Baseline Testing</u>

a. The vehicle should be set to all manufacturers specifications.
b. Check engine for any malfunctions including a scope checkout. Correct any malfunctions noted.
c. Be sure to check the automatic choke and EGR valve for proper operation. Repair if necessary.
d. Replace spark plugs with vehicle manufacturers recommended parts.
e. Replace air filter and PCV valve with vehicle manufacturers recommended products.
f. Change engine oil and filter. Use appropriate manufacturer recommended products.
g. Record all settings, adjustments, readings, maintenance and vehicle data. Include this data in the test reports supplied to EPA.
h. Close control must be kept of these vehicles during the test program. All maintenance, adjustments, mileage accumulation, modifications, and testing must be described, dated, and initialed by the testing laboratory personnel.

3. Baseline Testing

a. Two (2) 1975 Federal Test Procedures (FTP) and two (2) Highway Fuel Economy Tests (HFET) should be performed on each vehicle.

b. Documentation of all tests, including void tests must be supplied by the testing laboratory.

c. No vehicle modifications, or adjustments should be made after baseline testing is begun.

4. Device Installation

The "V-70" Vapor Injector should be installed on all three vehicles per the installation instructions supplied to the EPA with the application for evaluation (see enclosure) with the following item modification to avoid confusing the test results:

a. Part 3, Paragraph 6-Do the optimization routine on all 3 vehicles.

b. Part 3 Paragraph 7- Do not replace the PCV valve (this was done previously)

c. Part 3 Paragraph 8- Do not advance the timing.

5. Device Testing: With Parameters Adjusted

Upon completion of device installation, each vehicle should be tested twice using the 1975 Federal Test Procedure and twice using the Highway Fuel Economy Test. These tests give the effects of the device with fluid.

6. Device Testing: without fluid

Remove all of the fluid from the "V-70" Vapor Injector System reservoir. Make no other vehicle modifications. Test the vehicle in this "dry" condition tow (2) times on the 1975 Federal Test Procedure and two (2) times using the Highway Fuel Economy test. These tests give the effects of the device when operated dry.

7. Data Reporting

The results of the vehicle inspections, maintenance, and tests should be tabulated and sent to Mr. F. Peter Hutchins, 2565 Plymouth Road, Ann Arbor, Michigan 48105.

8. Notification of Intent

Please notify Mr. Hutchins (313-668-4340) as to which independent laboratory will be doing the testing and the expected beginning and completion dates of the testing program prior to initiation of the testing.

The results of this testing program should clearly define the benefits or penalties of the "V-70 Vajor Injector" for both emisions and fuel economy. The data would provide EPA the opportunity to make a clear evaluation of the device. A list of laboratories which should be capable of performing these tests was included in the "EPA Policy Paper on Testing of Retrofit Devices" previously sent to you.

The tests run on the Mark II device were run at the request of the Administrator. The V-70 Vapor Injector does not appear to be very dissimilar from the Mark II. Therefore, testing of the V-70 Vapor Injector as a "new technology" device is, unfortunately, not indicated. Upon completion of the suggested test program, confirmatory testing at the EPA laboratory in Ann Arbor will be performed if so indicated by the data.

If you have questions concerning this testing program, please contact Mr. F. Peter Hutchins of my staff at 3.3-668-4340.

Sincerely,

Charles L. Gray, Director
Emission Control Technology Division

Evaluation of the SCATPAC Device

July 1973

Emission Control Technology Division
Office of Air and Water Programs
Environmental Protection Agency

Background

The ECT Division was contacted by a representative of Cedar Rapids Engineering Company, of Cedar Rapids, Iowa, concerning their retrofit device for automobiles called SCATPAC. After being shown test results performed by Olson Laboratories which showed significant reductions of CO, HC, and NOx on a vehicle with the device installed (as compared to baseline), the ECTD agreed to perform testing of the device on an EPA owned vehicle.

Device Tested

SCATPAC is a vacuum vapor induction system which is attached to the PCV line. Manifold vacuum draws air through a liquid solution of undisclosed chemicals into the base of the carburetor. Vapors from the solution are thus introduced into the manifold. The device comes with all necessary components for the retrofitting to any vehicle with a PCV line and installation time takes less than fifteen minutes.

Test Program

A 1970 Plymouth Valiant 225 CID from the EPA fleet was used for the test program. Four emission tests* were conducted, two without the device and two with the device installed. Before any testing, the vehicle was tuned to the manufacturer's specifications for timing and idle rpm. Idle CO, 1.75%, was not changed. Two tests were then conducted in this stock configuration to be used as the baseline results. The SCATPAC device was then installed and idle CO was adjusted to 1.75% so that the enleanment effect from bleeding the vapors into the PCV line did not influence the emissions (it had dropped to about 1.50%). The vehicle was then tested twice more.

Test Results

The test results are presented in the Appendix of this report, and are summarized below. In addition to emission results, fuel economy was calculated for each test using a carbon balance technique.

*All testing was performed according to the 1975 Federal Test Procedure as outlined in the November 15, 1972, Federal Register for light duty vehicles.

Summary of Test Results
% Decrease from Baseline

HC	2%	
CO	-9%	(increase)
NOx	11%	
MPG	-1%	(increase)

Conclusions

The minor increase in carbon monoxide accompanied by a minor decrease in oxides of nitrogen may reflect a change in the overall air/fuel ratio.

APPENDIX

	Test No.	HC gpm	CO gpm	CO_2 gpm	NOx gpm	Fuel Economy mpg
Baseline	16-530	2.07	29.12	357.5	5.44	21.3
	16-531	2.12	29.16	354.1	5.74	21.4
	Avg.	2.10	29.14	355.8	5.59	21.3
SCATPAC	16-542	2.17	33.98	352.1	5.31	21.2
	16-547	1.94	30.17	341.3	4.73	21.8
	Avg.	2.05	32.07	346.7	5.02	21.5

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Emission Results From An Automobile Using the Frantz Vapor Injector

September 1971

John C. Thomson
Office of Air Programs
ENVIRONMENTAL PROTECTION AGENCY

Background

As part of a continuing evaluation of retrofit devices for used cars, emission tests on the Frantz Vapor Injector system was run. Emission reductions for hydrocarbon (HC) of up to 37%, carbon monoxide (CO) of up to 44%, and nitrogen oxide of up to 35% were claimed. The device was installed on a vehicle supplied by a Louisville, Kentucky newspaper at the newspaper's request. The installer was not told of the purpose of the installation and it is assumed that this was a typical conversion.

Device

The device tested was a vapor injector system produced by the Sky Corporation, Stockton, California. This system added a mixture of air and a vaporized chemical to the positive crank-case ventilation line with the amount of vapor-air mixture dependent on the manifold vacuum.

Test Program

The device was tested on a 1968 Ford Falcon equipped with a 200 cubic-inch six cylinder engine and manual transmission. This engine was also equipped with the original air injection pump. Two different test procedures were used in evaluating the emissions from this device and the vehicle was tested under three differing conditions. The first four tests were with the vapor injector as installed by Frantz and the recommended fluid used. Two of these used the 1972 Federal emission test procedure (LA4) which is a non-repetative self-weighting test using the constand volume sampling system. This procedure required the collection of a representative sample of the total exhaust from the vehicle. The second two tests used the 1971 Federal emission test procedure (7-mode) which is a continuous tailpipe monitoring test using a repetitive driving cycle. In this test certain portions of the exhaust are measured and weighted according to the amoung of driving typical under these conditions. For both sets of tests, carbon monoxide (CO) and carbon dioxide (CO_2) were measured using nondispersive infrared (NDIR). For the 7-mode tests hydrocarbon (HC) and oxides of nitrogen (NOx) were analyzed using NDIR also. In the LA4 tests HC was measured using flame ionization detector (FID) and NOx using chemiluminesence. The amount of fuel used for each test was measured and reported in kilograms. A single 7-mode test using the injector with the fluid removed was run to determine the effect of the fluid.

One 7-mode and one LA4 were run after removing the vapor injector and returning the vehicle to baseline condition.

Results

The results from all tests were reported in Table I with each condition of test identified. Emission results are reported in grams per mile (GPM). As the 7-mode test was the only one used under all three conditions, the results from this test are summarized below:

	HC gpm	CO gpm	NOx gpm	Fuel used kg
Vapor Injector with fluid	2.8	26	4.0	1.1
Vapor Injector no fluid	2.3	24	2.7	1.1
Baseline	2.7	28	3.7	1.1

The lowest results came from using the vapor injector with the fluid removed. The next lowest condition was the baseline with emissions from the vapor injector with fluid highest on two out of three pollutants. Fuel used for all tests was identical.

The LA4 results showed a considerable amount of variation and are therefore not as reliable as the 7-mode answers. The reasons for variability are unknown but indicate an emission reduction with the device installed. The LA4 test with no fluid was voided due to operation error. In order to evaluate this device on the LA4 procedure at least six more tests would be required.

Conclusions

1. The Frantz Vapor Injector system shows some emission reduction on the LA4 test over baseline but significance of the answers is unknown due to a high variability in the data. Insufficient time was available to determine the cause of this emission variability.

2. The best results were obtained from the vapor injector by removing the fluid.

3. The baseline 7-mode tests gave lower emission values than the test with the vapor injector installed.

4. The effectiveness of the vapor injector device for reducing emissions is apparently a function of the air bled into the manifold. This results in a leaner air-fuel mixture.

Table I

Emission Results from a 1968 Ford Falcon

	HC gpm	CO gpm	NOx gpm	Fuel used (total kg)
	(with vapor injector installed)			
LA4	2.9	27	4.0	1.4
LA4	2.3	28	2.0	1.3
7-mode	2.5	25	4.0	1.1
7-mode	3.1	27	3.9	1.1
	(with vapor injector-fluid removed)			
7-mode	2.3	24	2.7	1.1
	(with vapor injector removed - baseline)			
LA4	3.5	38	4.0	1.6
7-mode	2.7	28	3.7	1.1

An Evaluation of the Econo-Mist Device

March 1975

Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

Background

The Emission Control Technology Division (ECTD) was contacted by the General Services Administration (GSA) concerning a vapor injection device for use with automobile engines. The device is called the Econo-Mist and is a product of the FAP Corporation of Albuquerque, New Mexico. GSA had received information that the Econo-Mist reduced hydrocarbon and carbon monoxide emissions and increased fuel economy. At the request of GSA, ECTD agreed to test the device. A sample of the device was brought to the EPA laboratory in Ann Arbor, Michigan by FAP Corporation personnel on January 13, 1975.

The Environmental Protection Agency receives information about many devices for which emission reduction or fuel economy improvement claims are made. In some cases, both claims are made for a single device. In most cases, these devices are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards.

The EPA is interested in evaluating the validity of the claims for all such devices, because of the obvious benefits to the Nation of identifying devices that live up to their claims. For that reason the EPA invites proponents of such devices to provide to the EPA complete technical data on the device's principle of operation, together with test data on the device made by independent laboratories. In those cases in which review by EPA technical staff suggests that the data submitted holds promise of confirming the claims made for the device, confirmatory tests of the device are scheduled at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such confirmatory test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA confirmatory tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving its claimed performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the confirmatory test projects conducted by EPA. 1/ For promising devices it is necessary that more exptensive test programs be carried out.

1/ See Federal Register 38 FR 11334, 3/27/74, for a description of the test protocols proposed for definitive evaluations of the effectiveness of retrofit devices.

The conclusions from the EPA confirmatory tests can be considered to be quantitatively valid only for the specific type of vehicle used in the EPA confirmatory test program. Although it is reasonable to extrapolate the results from the EPA confirmatory test to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles, tests of the device on such other vehicles would be required to reliably quantify results on other types of vehicles.

In summary, a device that lives up to its claims in the EPA confirmatory test must be further tested according to protocols described in footnote 1/, to quantify its beneficial effects on a broad range of vehicles. A device which when tested by EPA does not meet the claimed results would not appear to be a worthwhile candidate for such further testing from the standpoint of the likelihood of ultimately validating the claims made. However, a definitive quantitative evaluation of its effectiveness on a broad range of vehicle types would equally require further tests in accordance with footnote 1/.

Device Description

The Econo-Mist device is a vacuum vapor induction system which attaches to the Positive Crankcase Ventilation (PCV) line of an internal combustion engine. A mixture of water and methanol of approximately 2.5 parts water to 1 part methanol is contained in a glass bottle which can be attached by means of a bracket to a wall in the engine compartment. A hose and fitting are supplied so that a connection between the bottle and the PCV line of the engine can be made.

With the device in operation, vacuum from the engine pulls ambient air through a small orifice in the cap of the bottle and down through a tube which is immersed in the liquid. At the bottom of the bottle the air is released through small holes and bubbles up through the liquid. The resulting vapor is drawn through the vacuum hose which is connected to the cap of the bottle, through the PCV line, and into the engine induction system to be mixed with the fuel and air mixture.

An illustration of the device is on the following page. The device tested has one difference from the figure; in place of the screw (29) for adjusting air flow, the device has a fixed orifice of .022 inch diameter in the top of the cap. FAP Corporation personnel stated that this fixed orifice size gives satisfactory air flow for all vehicles. When the device was installed on the EPA test vehicles they agreed that it was performing satisfactorily, having made a visual inspection of the bubbling occurring within the bottle.

ECONO-MIST

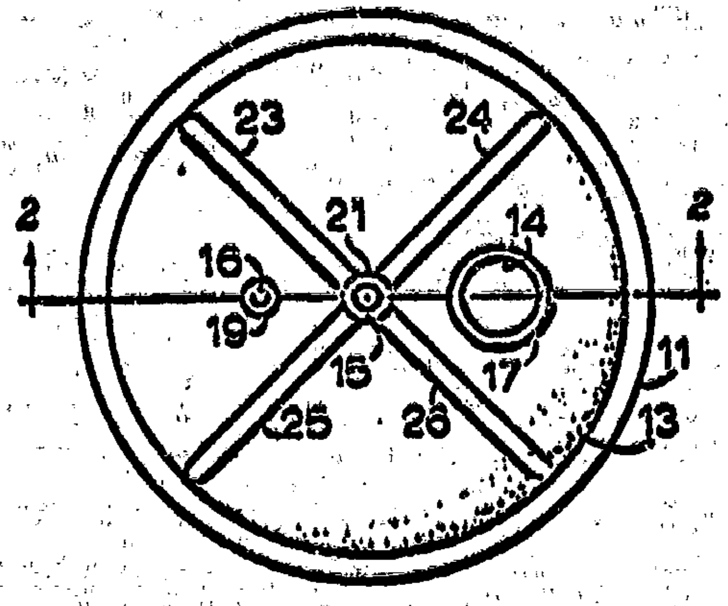

Fig.1

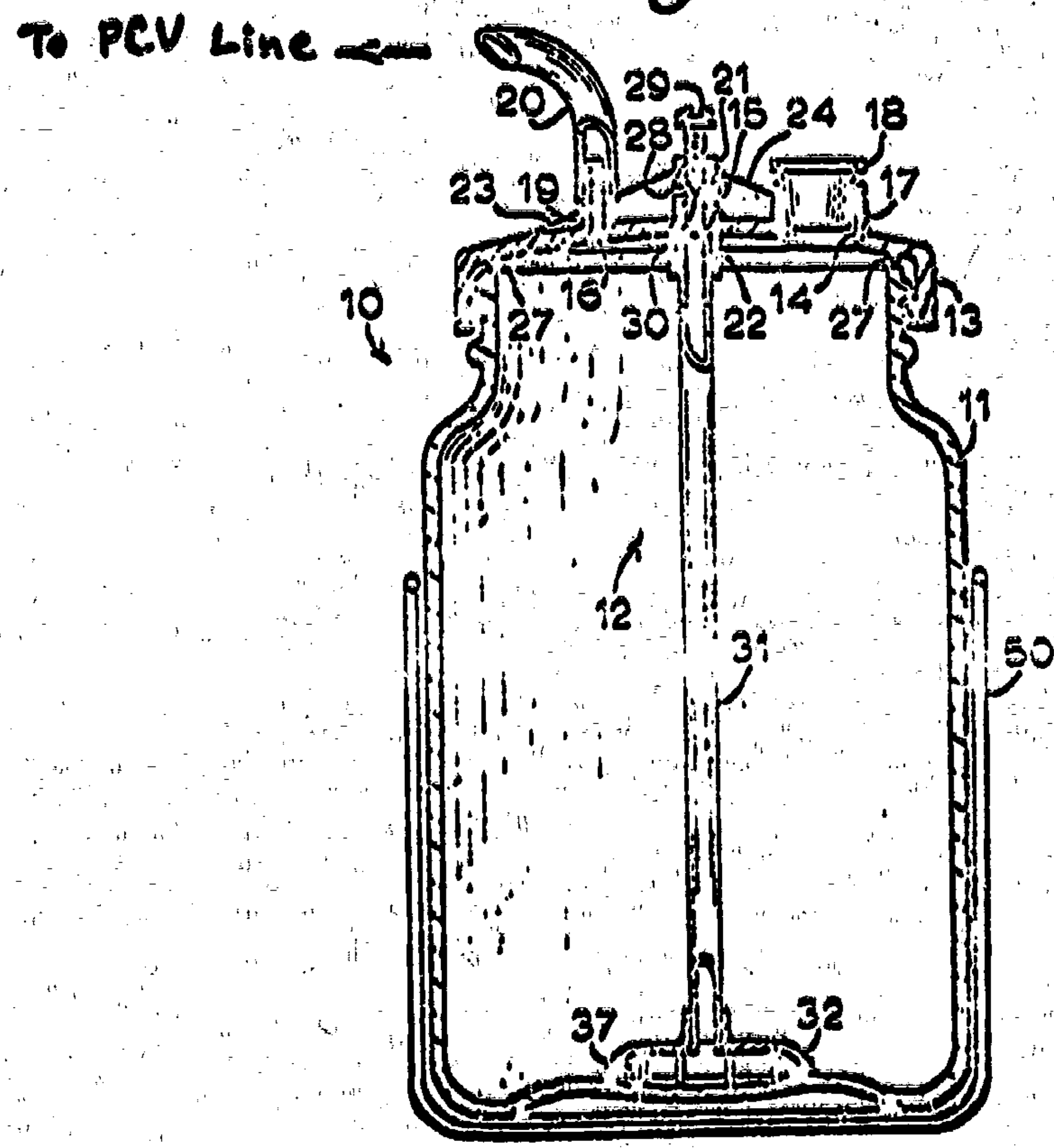

Fig.2

One gallon of fluid reportedly lasts for about 4000 miles of vehicle travel. For the vehicle tested this would mean that of the total volume of liquid entering the engine, the methanol and water mixture contributes only about 0.6 percent.

The device was installed by EPA with representatives from FAP Corporation observing. Installation took about 20 minutes.

Test Procedure

Exhaust emissions tests were conducted according to the 1975 Federal Test Procedure ('75 FTP), described in the Federal Register of November 15, 1972. Additional tests included the EPA Highway Cycle. All tests were conducted using an inertia weight of 3000 pounds (1361 kg) with a road load setting of 10.3 horsepower (7.68 kW) at 50 miles per hour (80.5 km/hr). A 1970 Plymouth Valiant from the EPA test fleet was used for the test program. A complete description of this vehicle is given on a following page.

The vehicle was tested in three different configurations, first at the baseline condition, second with the device installed, and third with the device connected but the bottle of fluid empty. This last condition was run in order to distinguish the effects of the vapor induction from the enleanment effect of simply increasing the air-fuel ratio.

Before the test program began, the vehicle was tuned to the manufacturer's specifications. The carburetor idle mixture adjustment was set to about 0.15% idle CO. This was a setting at which the vehicle had previously shown good driveability and fuel economy and which corresponds to the way a good mechanic would tune the vehicle. No adjustments were made after the device was installed; the idle CO did not noticeably change, even though additional air was entering the engine due to the device, and driveability remained good.

A schedule of the tests run is given below.

1. Baseline tests without device (2 FTP's and 2 Highway Cycles).

2. Baseline tests with device installed and 25 miles accumulated on system (2 FTP's and 2 Highway Cycles).

3. Tests with device installed and more than 300 accumulated miles on system (3 FTP's and 2 Highway Cycles).

4. Tests with device installed but bottle empty of fluid and more than 300 accumulated miles in this configuration (2 FTP's and 2 Highway Cycles).

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1970 Plymouth Valiant
Emission control system - Engine Modification

Engine

type	4 stroke Otto Cycle, OHV, in-line 6 cyl.
bore x stroke	3.40 x 4.12 in./86.36 x 104.78 mm
displacement	225 CID/3688
compression ratio	8.4:1
maximum power @ rpm	145 hp/108 kW @ 4000 rpm
fuel metering	1-V carburetor
fuel requirement	94 RON gasoline

Drive Train

transmission type	3 speed automatic
final drive ratio	2.76:1

Chassis

type	unitized construction, front engine, rear wheel drive
tire size	FR 78-14
curb weight	2920 lbs/1325 kg
inertia weight	3000 lbs
passenger capacity	5

Emission Control System

basic type	positive crankcase ventilation, engine modification

mileage on vehicle at start of test program: 17,850

Test Results

Exhaust emissions data summarized below illustrate that the EPA test vehicle, when fitted with the Econo-Mist device and with 300 miles accumulated with the device installed, achieved reductions in HC and CO emissions of 12% and 24% respectively and an increase in fuel economy of 7%. NOx emissions increased by 1%. Accumulating 300 miles in the system did not significantly change either emissions or fuel economy compared to results when the device was initially installed. When the fluid was emptied and only air was being bled to the engine through the device, the emissions and fuel economy remained essentially the same as they were with the fluid.

'75 FTP Composite Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline - Avg. of 2 tests	1.82 (1.13)	12.0 (7.44)	5.93 (3.68)	20.0 miles/gal (11.8 litres/100 km)
Device at low mileage - avg. of 2 tests	1.56 (.97)	9.52 (5.90)	6.02 (3.73)	21.5 miles/gal (10.9 litres/100 km)
Device with 300 miles - avg. of 3 tests	1.60 (.99)	9.13 (5.66)	6.01 (3.73)	21.1 miles/gal (11.1 litres/100 km)
Device with no fluid and 300 miles - avg. of 2 tests	1.60 (.99)	9.43 (5.85)	5.96 (3.70)	20.7 miles/gal (11.4 litres/100 km)

On the EPA Highway Cycle, the Econo-Mist device had the effect of decreasing HC, CO, and NOx emissions by 2%, 19%, and 3% respectively when the device had accumulated 300 miles. Fuel economy increased by 2%. When the fluid was emptied the emissions and fuel economy remained essentially the same.

Highway Cycle Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline - avg. of 2 tests	.93 (.58)	2.31 (1.43)	6.88 (4.27)	27.8 miles/gal (8.5 litres/100 km)
Device at low mileage - avg. of 2 tests	.87 (.54)	2.09 (1.30)	6.63 (4.11)	28.9 miles/gal (8.1 litres/100 km)
Device with 300 miles - avg. of 2 tests	.91 (.56)	1.87 (1.16)	6.67 (4.14)	28.3 miles/gal (8.3 litres/100 km)
Device with no fluid and 300 miles - avg. of 2 tests	.97 (.60)	2.17 (1.35)	7.24 (4.49)	28.2 miles/gal (8.3 litres/100 km)

Conclusions

The changes in emission and fuel economy which were noted on the test vehicle are attributed to the enleanment effect of the Econo-Mist device and might be matched by bleeding more air to the carburetor. This could be accomplished by leaning out the idle mixture and/or the primary jets, or increasing the flow through the PCV line.

Accumulating over 300 miles on the device did not yield any improvements compared to the results when the device was initially installed.

Appendix

Table I

'75 FTP Composite Results
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

Test Type	HC	CO	CO_2	NOx	Fuel Economy
Baselines (no device)	1.89	13.5	422	5.54	19.8
	1.76	10.4	419	6.32	20.1
Device Baselines	1.61	9.33	397	6.54	21.3
	1.52	9.72	389	5.49	21.7
Device with 300 miles	1.64	9.57	396	5.54	21.3
	1.50	6.82	410	6.08	20.8
	1.67	11.0	398	6.41	21.1
Device with no fluid	1.55	8.45	404	5.33	21.0
	1.65	10.4	411	6.58	20.5

Table II

'75 FTP Individual Bag Results
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

	Bag 1 Cold Transient					Bag 2 Hot Stabilized					Bag 3 Hot Transient				
st Type	HC	CO	CO_2	Nox	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy
elines (no	3.21	53.9	433	6.28	16.8	1.42	2.11	432	4.80	20.2	1.79	4.71	393	6.41	21.8
rice)	2.54	38.5	423	7.22	18.1	1.36	2.03	432	5.33	20.2	1.94	5.19	390	7.53	22.0
rice Base-	2.43	36.3	412	7.65	18.6	1.28	1.80	408	5.68	21.4	1.62	3.39	365	7.36	23.6
es	2.24	36.1	406	6.35	18.9	1.24	2.56	398	4.69	21.9	1.52	3.47	361	6.36	23.9
rice with	2.59	39.1	421	7.07	18.1	1.34	1.21	404	4.50	21.7	1.50	3.28	362	6.39	23.9
0 miles	2.15	24.8	421	7.70	19.0	1.31	1.57	422	4.71	20.7	1.37	3.32	381	7.46	22.7
	2.63	41.9	414	7.67	18.2	1.35	2.65	405	5.28	21.5	1.56	3.55	374	7.61	23.1
rice with	2.29	30.8	422	6.56	18.6	1.24	2.23	424	4.48	20.6	1.59	3.50	351	6.01	24.5
Fluid	2.68	38.4	436	7.89	17.6	1.32	2.26	417	5.55	20.9	1.50	4.96	381	7.58	22.5

Table III

EPA Highway Cycle
Emissions Results and Fuel Economy
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

Test Type	HC	CO	CO_2	NOx	mpg
Baselines (no device)	.94	2.28	312.4	7.01	27.8
	.92	2.34	313.0	6.74	27.8
Device Baselines	.89	2.01	296.3	7.09	29.4
	.84	2.17	305.5	6.17	28.5
Device with 300 miles	.90	1.86	305.8	6.23	28.5
	.92	1.87	309.6	7.10	28.1
Device with no fluid	.95	2.05	309.5	6.72	28.1
	.98	2.27	305.5	7.75	28.4

ATTACHMENT G

44

73-22 RBM

Evaluation of the Turbo Vapor Injector

March 1973

Test and Evaluation Branch
Emission Control Technology Division
Environmental Protection Agency

Background

TVI Marketing Inc. of Lexington, Michigan, requested that EPA test their Turbo Vapor Injector device. Results of testing at Olsen Laboratories showed substantial reductions in carbon monoxide (CO) and hydrocarbon (HC) emissions. The Test and Evaluation Branch scheduled testing of the device.

Device

The Turbo Vapor Injector is a vacuum vapor induction system which is attached to the PCV line. Air is drawn through an alcohol-and-water based solution into the base of the carburetor. The device comes with instructions so that it can be retrofitted to any car including older vehicles without PCV lines.

Test Program

A 1970 Plymouth Valiant, 225 CID, from the EPA fleet was used for the program. Seven tests were conducted, two without the device (baseline), three with the device properly attached, and then two more with the fluid bottle empty so that only air was drawn into the PCV line. These last two tests were conducted at the request of the sales representative who delivered the device to the EPA laboratory.

Prior to the testing, the Valiant's carburetor was set at 2% CO and 650 rpm at idle, and was not adjusted again throughout the testing. All testing was performed in accordance with the 1975 Federal Test Procedure (FTP). Full details of this procedure are found in the November 15, 1972 Federal Register, Volume 37, Number 221, Part II.

All tests were conducted using the standard dynamometer inertia loading for the Valiant which is 3,000 pounds. Test fuel was Indolene Clear (lead-free standard test fuel).

Test Results

The test results are presented in the Appendix of this report. In addition to emission results, fuel economy was determined using a carbon balance method. Emission and fuel consumption results are summarized as follows:

Summary of Results
% Change from Baseline

	TVI Device	TVI (bottle empty)
HC	4.5 decrease	7.6 decrease
CO	17.1 decrease	13.0 decrease
CO_2	9.7 increase	6.9 increase
NOx	26.4 increase	20.7 increase
Fuel Consumption	5.7 increase	3.5 increase

The Turbo Vapor Injector decreased hydrocarbon and carbon monoxide emissions with an accompanying increase in oxides of nitrogen. Fuel consumption rose slightly with the device. Without any fluid, the changes from baseline demonstrated the effect of air/fuel ratio enleanment with the addition of air through the PCV system.

Conclusion

On the EPA test vehicle, the Turbo Vapor Injector reduced carbon monoxide emissions with an accompanying equivalent increase in oxides of nitrogen. No reduction in fuel consumption was observed.

APPENDIX

TVI Test Program - 1975 Federal Test Procedure

Baseline

Test No.	HC gpm	CO gpm	CO_2 gpm	NOx gpm	Fuel Consumption mpg
16-330	2.27	33.55	352.7	4.36	20.9
16-333	2.19	31.19	406.2	5.78	18.9
AVERAGE	2.23	32.37	379.4	5.07	19.9

TVI Device

Test No.	HC gpm	CO gpm	CO_2 gpm	NOx gpm	Fuel Consumption mpg
16-338	2.23	28.01	417.5	6.30	18.6
16-341	1.99	25.82	420.2	6.44	18.81
16-344	2.17	26.59	411.1	6.50	18.93
AVERAGE	2.13	26.81	416.2	6.41	18.82

TVI Device (Bottle Empty)

Test No.	HC gpm	CO gpm	CO_2 gpm	NOx gpm	Fuel Consumption mpg
16-347	2.15	29.48	397.5	5.79	19.4
16-350	1.97	26.86	413.3	6.45	19.0
AVERAGE	2.06	28.17	405.4	6.12	19.2

* U.S. GOVERNMENT PRINTING OFFICE: 1979- 651-112/0096

ATTACHMENT H
76-13 GS

The Mark II Vapor Injector: An Air-Vapor Bleed Device Evaluated

January 1976

Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

Background

The APO Mark II Vapor Injector marketed in the United States by APO of America, Inc., Dallas, Texas is essentially an induction system air-vapor bleed device. It is the fifth device of this basic type to be tested by TAEB in the past five years.[1,2,3,4] The general conclusions of the four previous air-vapor bleed device tests were that fuel economy improvements if any, were small and were attributed to enleanment of the air fuel mixture as opposed to the effects of the added vapors. Similarly exhaust emissions changes were minor and were typical of the results of enleanment of air-fuel ratios near stoichiometry. The Mark II contains several variations on the basic vapor bleed device theme which could alter its performance relative to other devices of this type. In light of these variations and an interest in the Mark II exhibited by the public and some sectors of the government, EPA evaluated the device.

The Environmental Protection Agency receives information about many devices for which emission reduction or fuel economy improvement claims are made. In some cases, both claims are made for a single device. In most cases, these devices are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards.

The EPA is interested in evaluating the validity of the claims for all such devices, because of the obvious benefits to the Nation of identifying devices that live up to their claims. For that reason the EPA invites proponents of such devices to provide to the EPA complete technical data on the device's principle of operation, together with test data on the device made by independent laboratories. In those cases in which review by EPA technical staff suggests that the data submitted hold promise of confirming the claims made for the device, confirmatory tests of the device are scheduled at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such confirmatory test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA confirmatory tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving its claimed performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the confirmatory test projects conducted by EPA.[5] For promising devices it is necessary that more extensive test programs be carried out.

The conclusions from the EPA confirmatory tests can be considered to be quantitatively valid only for the specific type of vehicle used in the EPA confirmatory test program. Although it is reasonable to extrapolate the results from the EPA confirmatory test to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles, tests of the device on such other vehicles would be required to reliably quantify results on other types of vehicles.

In summary, a device that lives up to its claims in the EPA confirmatory test must be further tested according to protocols described in footnote 5, to quantify its beneficial effects on a broad range of vehicles. A device which when tested by EPA does not meet the claimed results would not appear to be a worthwhile candidate for such further testing from the standpoint of the likelihood of ultimately validating the claims made. However, a definitive quantitative evaluation of its effectiveness on a broad range of vehicle types would equally require further tests in accordance with footnote 5.

System Description

The Mark II Vapor Injector is a device for inducting an air-vapor mixture into the intake system of the conventional spark ignited gasoline engine. The point of induction can be the Positive Crankcase Ventilation (PCV) line, a spacer plate installed between the carburetor and the intake manifold, or an idle adjustment screw with a hole through the center. The latter method was chosen for this evaluation because the previous evaluations used the PCV induction point. The spacer plate is essentially the same as the PCV induction point.

The Mark II consists of a large glass jar approximately two-thirds full of a fluid comprised of one part Mark II Econo Mix fluid and two parts water. Air is drawn in through a brass needle valve mounted on the cast aluminum jar cap, and passes through a plastic tube to a plastic bubbler located near the bottom of the jar. After bubbling through the fluid, the resulting air-vapor mixture is drawn out of the bottle through a vacuum hose connected to the jar cap. A .022 inch diameter metering orifice mounted in the vacuum hose restricts the flow of air-vapor mixture to the Vapor Jet, an idle adjustment screw with a hole drilled through the center. The air-vapor mixture is drawn through the Vapor Jet by manifold vacuum. A check valve in the Vapor Jet is intended to prevent reversal of flow.

Figure 1 is a photograph of the Mark II as installed in the vehicle used in this evaluation, a 1971 Chevrolet Vega. As the Mark II is "driven" by manifold vacuum the volume of vapor delivered to the intake manifold is virtually independent of engine displacement. To maximize the effect of the device, a vehicle with a small displacement engine was selected. Table 1 is the vehicle description of the Vega. Figure 2 is a schematic of the Vega carburetor with the Vapor Jet installed.

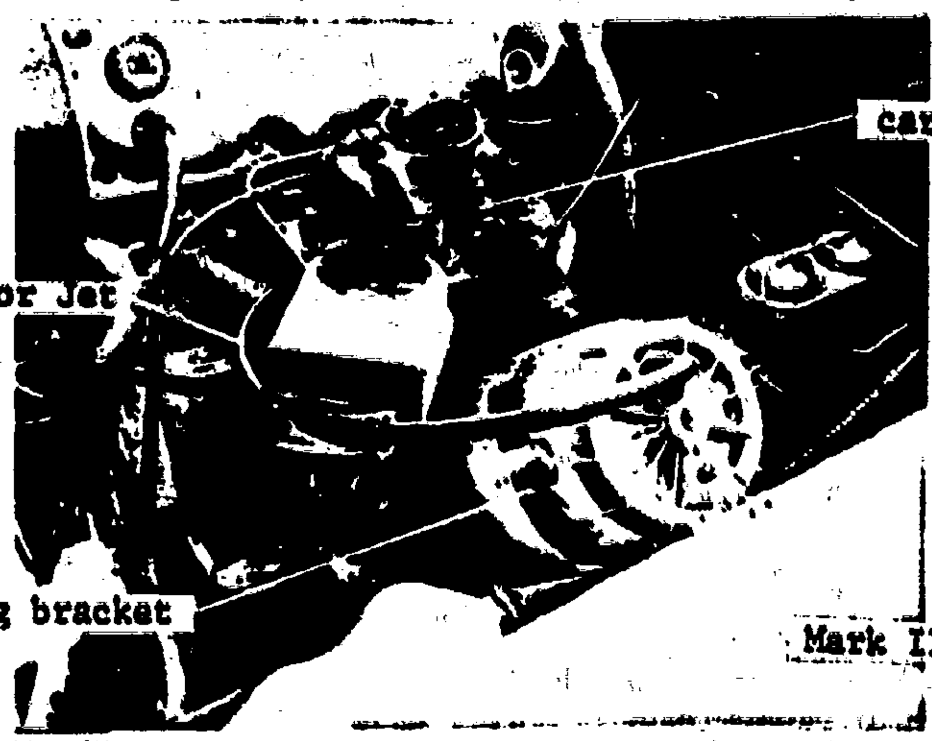

Figure 1 Mark II installation on 1971 Vega (air cleaner removed).

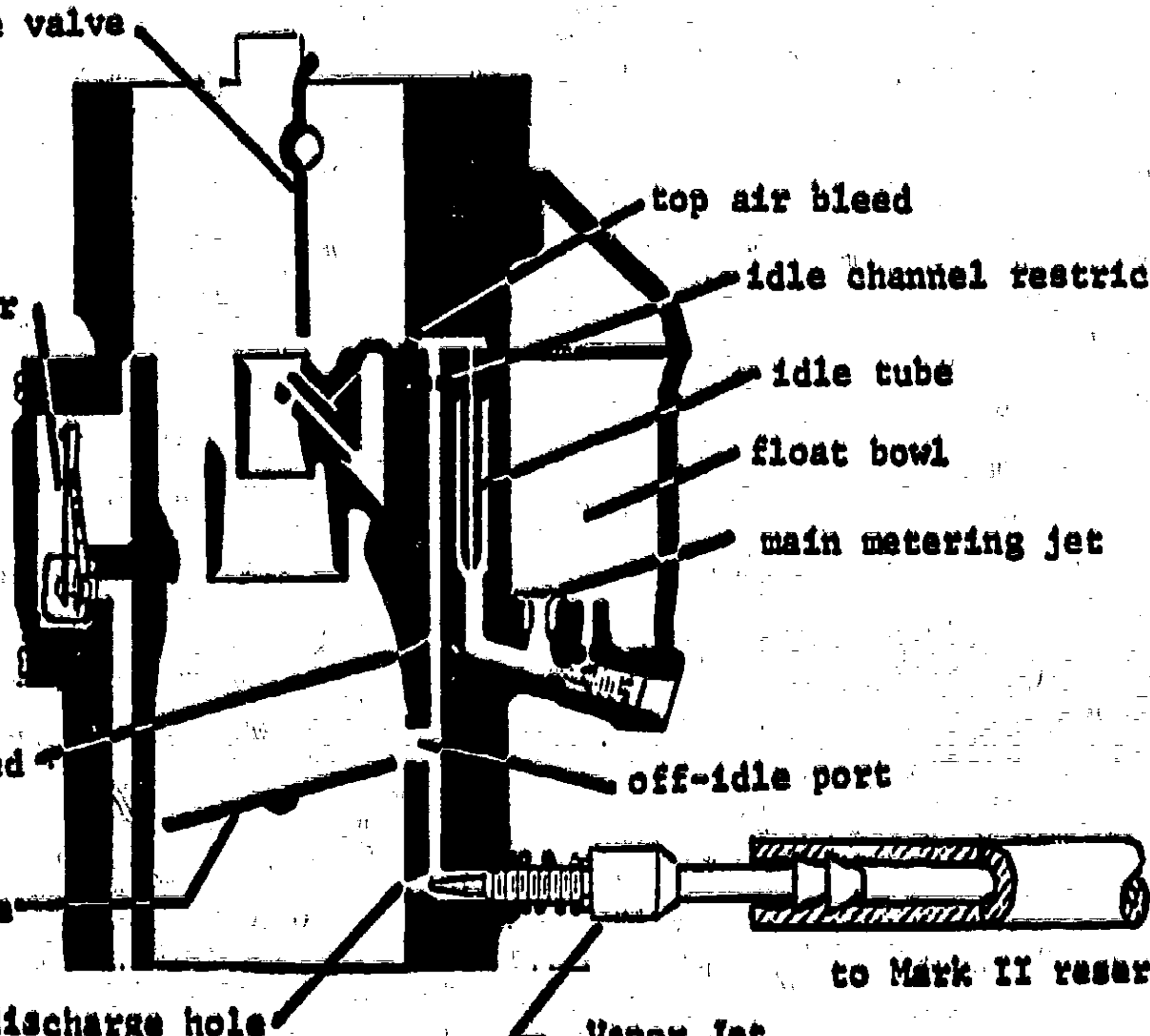

Figure 2 Schematic of Vega carburetor showing idle circuitry with Mark II Vapor Jet installed.

Table 1

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1971 Chevrolet Vega Kammback
Emission control system - PCV

Engine

type	4 cyl. OHC
bore x stroke	3.50 x 3.625 in./88.9 x 92.1 mm
displacement	140 CID/2300 cc
compression ratio	8.0:1
maximum power @ rpm	90 hp/67 kW @ 4400 rpm
fuel metering	1 barrel
fuel requirement	91 RON

Drive Train

transmission type	3 speed manual
final drive ratio	2.53

Chassis

type	front engine, rear drive, unitized body
tire size	A 78 x 13
curb weight	2340
inertia weight	2750
passenger capacity	4

Emission Control System

basic type	PCV
mileage at beginning of test program	11,000 miles

According to Mr. Allen Best, the technical advisor of APO, the composition of the Econo Mix by volume is 65% methanol, 34% acetone, and 1% propylene glycol. The benefits of the vapors of Econo Mix-water mixture claimed in the Mark II owner's manual are a decrease in required octane number of the gasoline used, increased fuel economy, increased power, elimination of carbon deposits, extension of engine life, and reduction of exhaust emissions. EPA evaluates devices in terms of their effects on vehicle emissions, fuel economy, and occasionally performance. Additions of methanol and water to gasoline are known to increase the octane number of fuel and additions of methanol under certain conditions to increase power. Therefore, it was felt desirable to conduct a preliminary evaluation of the possible benefits of the APO device based on information available in the technical literature concerning the various constituents of the APO fluid and measurements of the operating variables of the device. This evaluation is presented in Appendix I.

Test Procedure

Exhaust emissions tests were conducted according to the 1975 Federal Test Procedure ('75 FTP), described in the Federal Register of November 15, 1972, and the EPA Highway Fuel Economy Test (HFET), described in the Federal Register, Volume 39, Number 200, October 15, 1974. Both of these tests are conducted on a chassis dynamometer and employ the Constant Volume Sampling (CVS) procedure, which gives exhaust emissions of HC, CO, NO_x and CO_2 in grams per mile. Fuel economy is calculated by the carbon balance method. The fuel used was Indolene unleaded 96 RON gasoline.

The vehicle was tested in three different configurations: baseline, with the Mark II installed but without any fluid in the jar, and with the Mark II functioning with fluid. The second configuration was tested in order to separate the effect of the fluid vapors from the effect of the air bleed.

Before the baseline testing, the vehicle was tuned to manufacturer's specifications. The carburetor idle mixture adjustment was adjusted to lean best idle, which for this vehicle resulted in a 0.2% idle CO. The idle mixture was adjusted to lean best idle after the installation of the Mark II in each configuration tested. In both cases the idle CO was again 0.2%.

The test schedule plan was two '75 FTP's and two HFET's for each of the following test conditions:

1. Baseline
2. Mark II installed but without fluid
3. Mark II with fluid
4. Mark II with fluid after 1500 miles of operation on the durability driving schedule described in the Federal Register Vol. 37, No. 221, November 15, 1972
5. Mark II without fluid after mileage accumulation
6. Baseline after mileage accumulation

Due to difficulties encountered in the test program additional tests were conducted as discussed in the following section.

Test Results

The test schedule was initially conducted according to plan with some additional tests being conducted to increase confidence in the data. After the 1500 miles, the idle specifications were again set to manufacturer's specification. The two tests following this idle tune had '75 FTP and HFET fuel economy decreases of 8 and 16 percent respectively from the baseline data. Inspection of the vehicle revealed the distributor vacuum line disconnected at the carburetor. The exact time when the vacuum hose was disconnected is not known but it is our belief that the hose was not reconnected during the idle timing check after the mileage accumulation. The results of the above two tests were discarded, the hose was reconnected, and the tests were repeated. Subsequent tests displayed a steady increase in hydrocarbon emissions apparently independent of the test configuration. Concurrent with the hydrocarbon increases was a smaller but still discernible decrease in fuel economy.

Thorough diagnostics revealed low compression in number two cylinder (120 psi vs. 180 psi for the other three cylinders). The head was removed and the exhaust valve of the number two cylinder was observed to be mildly burned due to valve seat warpage. In retrospect it is possible that operating the vehicle with the vacuum leak and no vacuum advance contributed to the valve seat warpage. This valve was replaced and the valve seat ground; great care was taken not to disturb the deposits on the head. After the head was replaced, the car was driven approximately 150 miles with the Mark II functioning. A second series of "after mileage accumulation" tests were run. These are identified alternatively as "after valve replacement" or "after 2,000 miles," as opposed to the original "after 1,500 miles."

The composite results of the '75 FTPs are presented in Table 2; detailed individual bag results are given in Appendix II. The HFET results are given in Table 3. Figures 3 and 4 display the fuel economy values of the '75 FTPs and HFET's respectively. Figure 5 displays the hydrocarbon, carbon monoxide and nitrogen oxides emissions of the '75 FTPs. Three tests (16-1280, 76-1310 and 76-2455) were not included in these Figures because they were determined to be statistically invalid using the Dixon method* on the CO_2 data.

The representatives of the Mark II claim that the device cleans the engine and that it is only after mileage accumulation that the true effects of the device can be measured. Therefore the effect of the exhaust valve-to-seat seal deterioration on the long term effects of the Mark II must be addressed. First, as evidenced in Figure 5 the change in HC emissions, which are indicative of the leak, did not increase until after the mileage accumulation was completed. Thus the mileage accumulation can be assumed to have occurred normally. Second, when the HC emission increased from approximately 1.7 to 2.7 grams per mile (gpm) the fuel economy decreased only 4 to 5 percent and the other gaseous emissions remained virtually unchanged. This indicates that the loss in compression in the one cylinder was relatively minor and that the cylinder continued to fire normally. Again the operation of the Mark II was not

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* Only the tests before mileage accumulation and after the valve replacement were considered because the remaining tests were taken on a malfunctioning engine, as evidenced by the steadily increasing hydrocarbon emissions, which was remedied by the valve replacement.

Figure 3
'75 FTP Composite Fuel Economies
by individual test

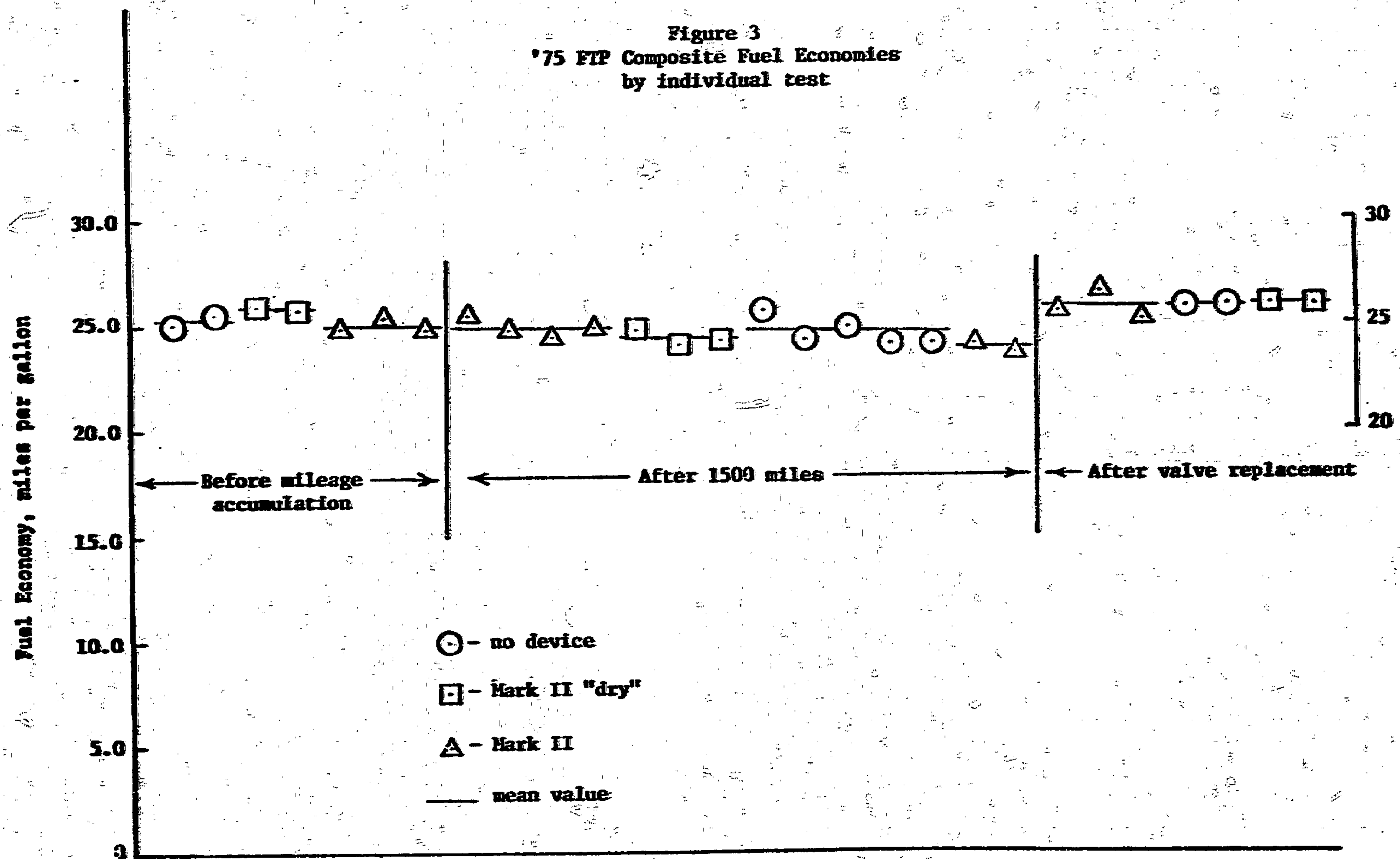

Figure 4
Highway Cycle Fuel Economies
by individual test

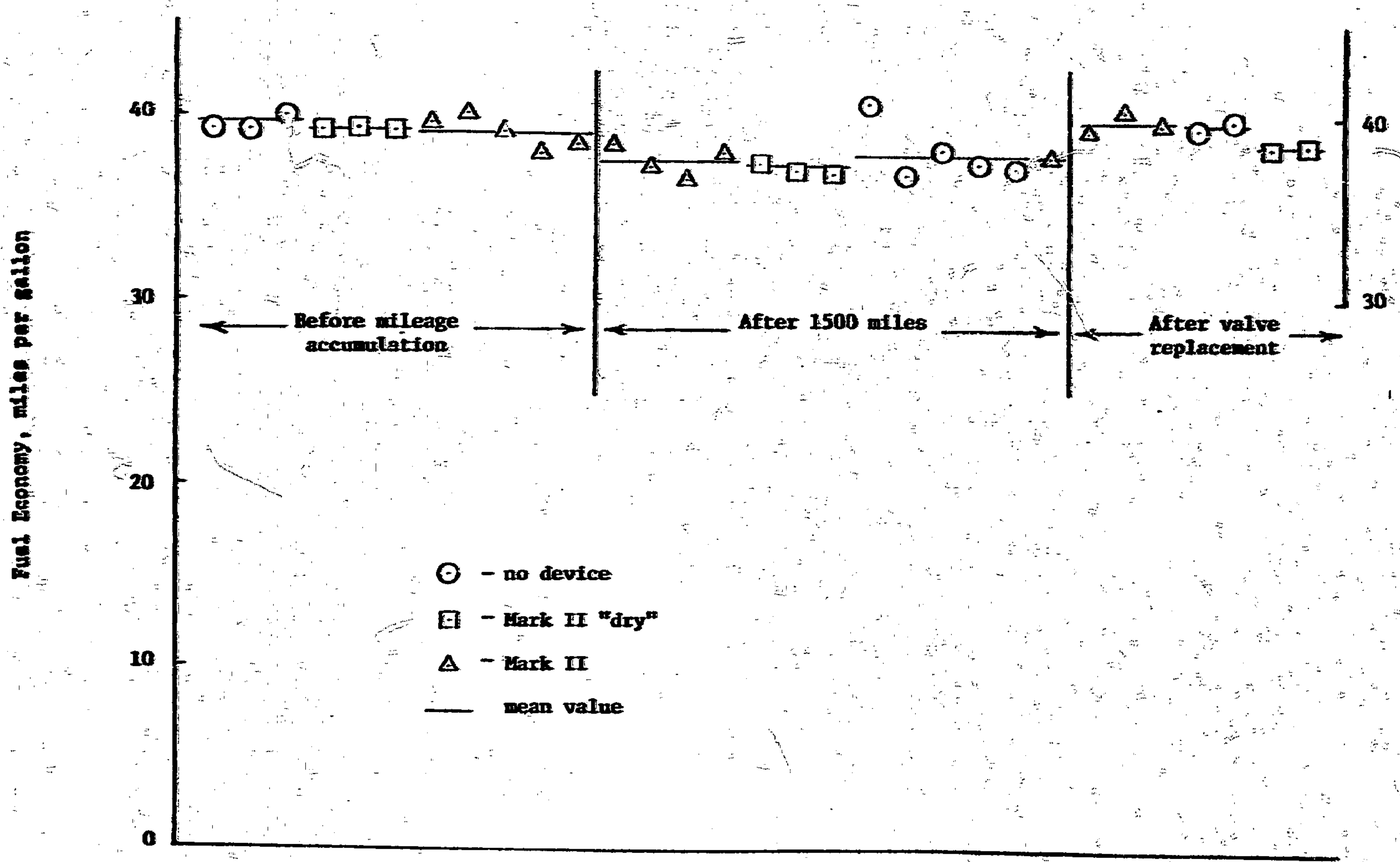

Figure 5
'75 FTP Composite Emission
by individual test

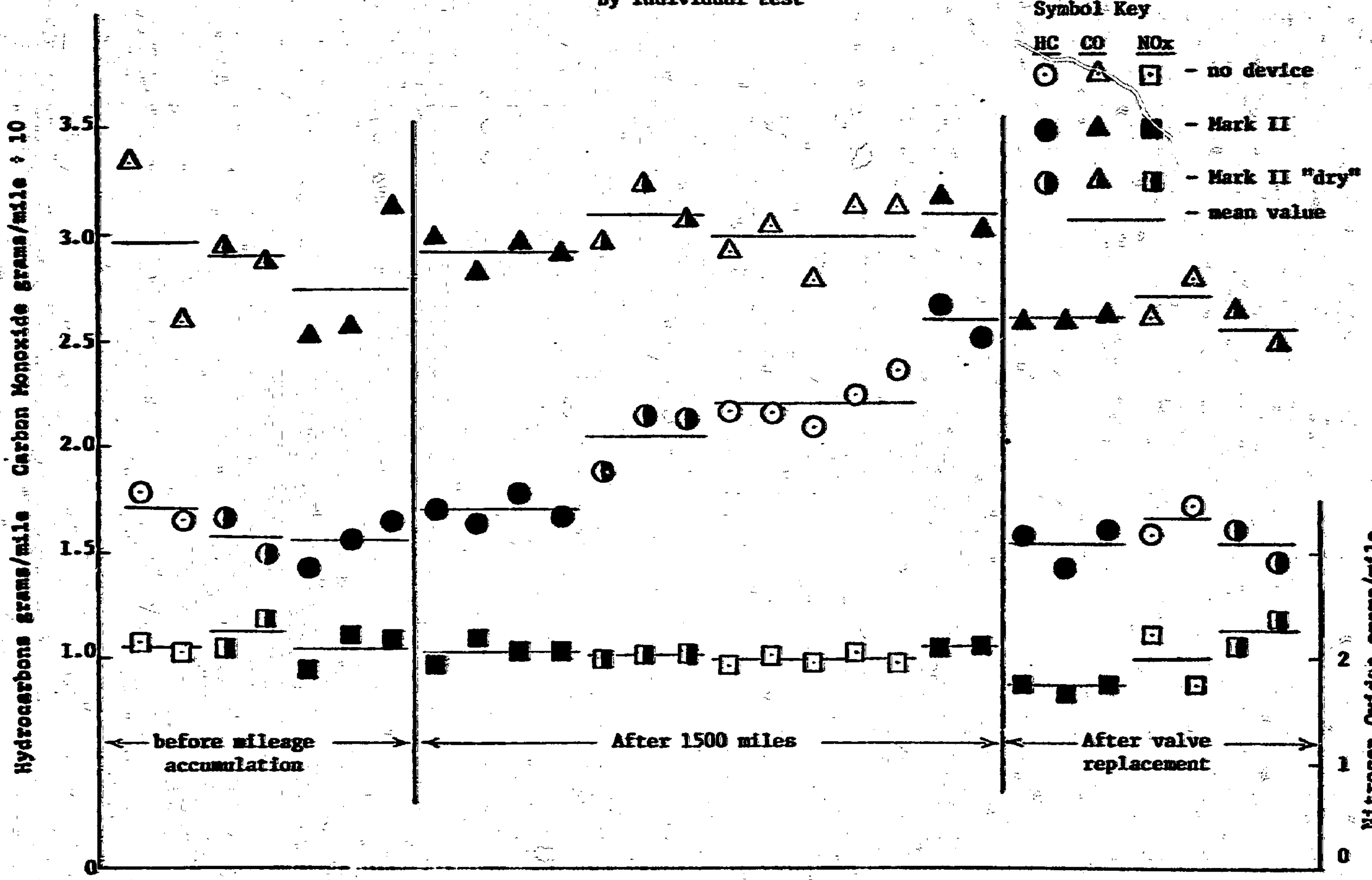

Table 2

'75 FTP Composite Results
Mass Emissions, grams per mile (grams per kilometer)
Fuel Economy, miles per gallon (liters per 100 kilometer)

Test Configuration	HC		CO		CO_2		NOx		Fuel Economy	
Before mileage accumulation										
no device	1.77	(1.10)	33.4	(20.8)	295	(183)	2.12	(1.32)	25.1	(9.37)
"	1.65	(1.03)	25.8	(16.0)	302	(188)	2.04	(1.27)	25.5	(9.23)
Mark II "dry"	1.66	(1.03)	29.4	(18.3)	292	(181)	2.08	(1.29)	25.8	(9.12)
"	1.48	(0.92)	28.6	(17.8)	296	(184)	2.35	(1.46)	25.7	(9.16)
Mark II	1.43	(0.89)	25.2	(15.7)	314	(195)	1.87	(1.16)	24.8	(9.49)
"	1.56	(0.97)	25.7	(16.0)	305	(190)	2.21	(1.37)	25.3	(9.30)
"	1.65	(1.03)	31.3	(19.5)	305	(190)	2.15	(1.34)	24.7	(9.53)
After 1500 miles										
Mark II	1.70	(1.06)	29.9	(18.6)	297	(185)	1.93	(1.20)	25.4	(9.26)
"	1.64	(1.02)	28.5	(17.7)	309	(192)	2.17	(1.35)	24.7	(9.53)
"	1.78	(1.11)	29.6	(18.4)	311	(193)	2.05	(1.27)	24.4	(9.64)
"	1.67	(1.04)	29.1	(18.1)	306	(190)	2.03	(1.26)	24.8	(9.49)
Mark II "dry"	1.88	(1.17)	29.7	(18.5)	306	(190)	1.99	(1.24)	24.7	(9.53)
"	2.15	(1.34)	32.3	(20.1)	311	(193)	2.02	(1.26)	24.0	(9.80)
"	2.13	(1.32)	30.6	(19.0)	311	(193)	2.03	(1.26)	24.2	(9.72)
no device	2.17	(1.35)	29.2	(18.1)	292	(181)	1.93	(1.20)	25.7	(9.16)
"	2.16	(1.34)	30.4	(18.9)	311	(193)	2.02	(1.26)	24.3	(9.68)
"	2.10	(1.31)	27.8	(17.3)	306	(190)	1.97	(1.22)	24.9	(9.45)
"	2.25	(1.40)	31.3	(19.5)	310	(193)	2.05	(1.27)	24.2	(9.72)
"	2.37	(1.47)	31.3	(19.5)	310	(193)	1.95	(1.21)	24.2	(9.72)
Mark II	2.68	(1.67)	31.8	(19.8)	310	(193)	2.09	(1.30)	24.1	(9.76)
"	2.53	(1.57)	30.3	(18.8)	320	(199)	2.11	(1.31)	23.6	(9.97)
After valve replacement										
Mark II	1.47	(0.91)	27.6	(17.2)	331	(206)	1.96	(1.22)	23.4	(10.1)
	1.58	(0.98)	26.0	(16.2)	301	(187)	1.76	(1.09)	25.6	(9.19)
	.84	(0.92)	23.1	(14.4)	268	(167)	1.43	(0.89)	28.9	(8.14)
"	1.43	(0.89)	26.0	(16.2)	290	(180)	1.68	(1.04)	26.5	(8.88)
"	1.61	(1.00)	26.2	(16.3)	306	(190)	1.76	(1.09)	25.2	(9.34)
no device	1.59	(0.99)	26.1	(16.2)	298	(185)	2.21	(1.37)	25.8	(9.12)
"	1.73	(1.08)	28.0	(17.4)	295	(182)	1.75	(1.09)	25.9	(9.08)
Mark II "dry"	1.61	(1.00)	26.4	(16.4)	296	(184)	2.10	(1.31)	25.9	(9.08)
"	1.46	(0.91)	24.9	(15.5)	299	(186)	2.35	(1.46)	25.9	(9.08)

Table 3

Highway Cycle Results
Mass emissions, grams per mile (gram per kilometer)
Fuel economy, miles per gallon (liters per 100 kilometer)

Test configuration	HC	CO	CO_2	NOx	Fuel economy	Temp. °F	Rel. hum. %	Baro. P. " Hg
Before mileage accumulation								
Mark II	0.91 (0.57)	8.97 (5.57)	207 (129)	3.55 (2.21)	39.6 (5.94)	68.0	76	28.57
"	0.88 (0.55)	8.40 (5.22)	205 (127)	3.32 (2.06)	40.1 (5.87)	68.0	61	28.50
"	0.88 (0.55)	9.16 (5.69)	210 (131)	3.37 (2.09)	39.1 (6.02)	68.0	61	28.48
Mark II "dry"	0.90 (0.56)	8.10 (5.03)	211 (131)	3.33 (2.07)	39.2 (6.00)	65.5	64	28.46
"	0.91 (0.57)	8.12 (5.05)	210 (131)	3.32 (2.06)	39.3 (5.99)	66.0	52	28.47
"	0.90 (0.56)	8.46 (5.26)	210 (131)	3.40 (2.11)	39.2 (6.00)	66.0	58	28.46
no device	0.88 (0.55)	8.30 (5.16)	210 (131)	3.41 (2.12)	39.3 (5.99)	68.0	55	28.48
"	0.88 (0.55)	8.31 (5.16)	206 (128)	3.36 (2.09)	39.9 (5.90)	65.0	52	28.48
"	0.88 (0.55)	8.02 (4.98)	206 (128)	3.38 (2.10)	40.0 (5.88)	66.0	58	28.44
Mark II	0.75 (0.47)	5.84 (3.63)	222 (138)	3.86) (2.40)	37.9 (6.21)	65.5	45	29.34
"	0.86 (0.53)	7.55 (4.69)	221 (137)	3.77 (2.34)	37.7 (6.24)	69.0	55	28.85
After 1500 miles								
Mark II	0.89 (0.55)	9.66 (6.00)	213 (132)	3.32 (2.06)	38.4 (6.13)	70.5	42	28.91
"	0.87 (0.54)	7.88 (4.90)	223 (139)	3.66 (2.27)	37.2 (6.33)	72.0	44	29.09
"	0.92 (0.57)	8.60 (5.34)	227 (141)	3.64 (2.26)	36.5 (6.45)	66.5	51	29.01
"	0.91 (0.57)	8.75 (5.44)	217 (135)	3.32 (2.06)	38.0 (6.19)	65.0	52	28.84
Mark II "dry"	0.89 (0.55)	7.78 (4.84)	222 (138)	3.44 (2.14)	37.4 (6.29)	70.5	47	29.16
"	0.96 (0.60)	9.62 (5.98)	222 (138)	3.46 (2.15)	37.0 (6.36)	68.0	53	28.98
"	1.00 (0.62)	10.10 (6.28)	222 (138)	3.25 (2.02)	36.8 (6.39)	71.0	53	28.99
no device	0.93 (0.58)	7.15 (4.44)	204 (127)	3.06 (1.90)	40.6 (5.80)	69.0	47	29.18
"	1.00 (0.62)	8.30 (5.16)	224 (139)	3.38 (2.10)	36.9 (6.38)	71.0	46	28.98
"	1.02 (0.63)	8.66 (5.38)	216 (134)	3.04 (1.89)	38.2 (6.16)	73.5	43	28.70
"	1.03 (0.64)	10.18 (6.33)	225 (140)	3.55 (2.21)	36.4 (6.46)	70.0	46	28.75
"	1.13 (0.70)	8.55 (5.31)	222 (138)	3.55 (2.21)	37.2 (6.33)	70.0	49	28.98
Mark II	1.01 (0.63)	6.92 (4.30)	220 (137)	3.55 (2.21)	37.9 (6.21)	73.0	44	29.25
After valve replacement								
Mark II	0.81 (0.50)	9.10 (5.66)	236 (147)	3.07 (1.91)	35.1 (6.70)	77.0	56	29.12
"	0.88 (0.55)	8.01 (4.98)	211 (131)	3.04 (1.89)	39.2 (6.00)	71.0	49	29.07
"	0.36 (0.22)	7.31 (4.54)	185 (115)	2.45 (1.52)	44.8 (5.25)	71.0	46	29.04
"	0.75 (0.47)	7.70 (4.79)	226 (140)	3.40 (2.11)	36.9 (6.38)	70.0	46	29.21
"	0.83 (0.52)	7.92 (4.92)	205 (127)	2.94 (1.83)	40.3 (5.84)	69.0	51	29.13
"	0.90 (0.56)	8.89 (5.53)	208 (129)	2.93 (1.82)	39.4 (5.97)	67.5	35	29.03
no device	0.89 (0.55)	7.97 (4.95)	207 (129)	3.55 (2.21)	39.9 (5.90)	70.0	76	29.08
"	0.94 (0.58)	9.37 (5.82)	207 (129)	2.85 (1.77)	39.4 (5.97)	67.5	48	28.87
Mark II "dry"	0.88 (0.55)	8.31 (5.16)	216 (134)	3.51 (2.18)	38.2 (6.16)	74.0	33	29.05
"	0.88 (0.55)	7.90 (4.91)	215 (134)	3.56 (2.21)	38.5 (6.11)	74.0	31	29.05

changed and the cylinder deposits if affected at all would only be slightly altered in the one cylinder. Third, when the valve was replaced considerable care was taken not to disturb the combustion chamber deposits. It is our conclusion therefore that the tests taken after the valve was replaced are valid representations of the effect of the Mark II after approximately 2,000 miles.

Table 4 contains the average fuel economies and standard deviations of the three configurations tested before and after mileage accumulation for the '75 FTP. Also shown are the percent improvement and t test value* using the no-device configuration before mileage accumulation as the base sample. The final column in this table is the resolution to the t test null hypothesis, i.e., that there is no significant difference between the configuration and the base sample with a confidence level of 90%. A "yes" in this column indicates that there is a significant difference at that confidence level. By this test none of the configurations showed a significant difference from the base sample. While some of the configurations showed mean percent improvements of 2.0 percent, these changes were not sufficiently different from the test-to-test variability to be considered significant.

Table 5 is the same format as Table 6 for the Highway cycle fuel economies. While the configurations showed decreases in fuel economy up to 3.3 percent, none were found to be significantly different from the observed variability.

Table 6 is again the same format for the hydrocarbon, carbon monoxide, and nitrogen oxides emissions of the '75 FTPs. Many of the configurations showed mean percent reductions in the order of 10 percent, and the Mark II after 2000 miles showed a 16.7 percent reduction in nitrogen oxides. Despite the apparently large percentages of reduction, none of these were found to be significantly different from the test-to-test variability.

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* The t tests were calculated using an overall standard deviation calculated by averaging the variances of the six test sets (3 configurations before and 3 after 2000 miles) using the equation:

$$\sigma^2_{av.} = \sum_{i=1}^{6} n_i \sigma_i^2 / \sum_{i=1}^{6} n_i$$

where n_i = sample size of test set i

σ_i^2 = the variance (standard deviation squared) of test i

This involves the reasonable assumption that while the mean value of the test sets may vary, the test-to-test variability within each set is the same for all six sets.

Table 4

'75 FTP Fuel Economy Statistics

Test configuration	Sample size	Mean mpg	Standard dev. mpg	Standard dev. %	Percent improvement*	t*	Significantly different at 90% confidence
Before mileage accumulation							
no device	2	25.3	±0.3	±1.1	-	-	-
Mark II	3	24.9	±0.3	±1.3	-1.6	+1.21	No
Mark II "dry"	2	25.8	±0.1	±0.3	+2.0	-1.38	No
After 2000 miles							
no device	2	25.8	±0.1	±0.3	+2.0	-1.38	No
Mark II	3	25.8	±0.7	±2.6	+2.0	-1.52	No
Mark II "dry"	2	25.9	±0.0	±0.0	+2.4	-1.66	No

* All percent improvement and t tests conducted with no device before mileage accumulation used as the base sample. The t tests were calculated using an overall standard deviation of ±0.36 mpg for the '75 FTP fuel economy.

Table 5

Highway Cycle Fuel Economy Statistics

Test configuration	Sample size	Mean mpg	Standard dev. mpg	Standard dev. %	Percent improvement*	t*	Significantly different at 90% confidence
Before mileage accumulation							
no device	3	39.7	±0.4	±1.0	-	-	-
Mark II	5	38.9	±1.0	±2.7	-2.1	+1.72	No
Mark II "dry"	3	39.2	±0.1	±0.1	-1.3	+0.96	No
After 2000 miles							
no device	2	39.6	±0.4	±0.9	-0.3	+0.17	No
Mark II	3	39.6	±0.6	±1.5	-0.3	+0.19	No
Mark II "dry"	2	38.4	±0.2	±0.6	-3.3	+2.23	No

* All percent improvement and t tests conducted with no device before mileage accumulation used as the base sample. The t tests were calculated using an overall standard deviation of ±0.64 mpg for the Highway Cycle fuel economy.

Table 6

'75 FTP Composite Emissions Statistics

Test configuration	Sample size	Hydrocarbons: Mean g/mi.	Standard dev. g/mi.	Standard dev. %	Percent reduction*	t*	Significantly different at 90% confidence	Carbon Monoxide: Mean g/mi.	Standard dev. g/mi.	Standard dev. %	Percent reduction*	t*	Significantly different at 90% confidence
Before mileage accumulation													
no device	2	1.71	±0.08	±5.0	—	—	—	29.6	±5.4	±18.2	—	—	—
Mark II	3	1.55	±0.11	±7.2	+9.6	+1.69	No	27.4	±3.4	±12.4	+7.4	+0.91	No
Mark II "dry"	2	1.57	±0.13	±8.1	+8.2	+1.35	No	29.0	±0.6	± 2.0	+2.0	+0.23	No
After 2000 miles													
no device	2	1.66	±0.10	±6.0	+2.9	+0.48	No	27.1	±1.3	± 5.0	+8.6	+0.94	No
Mark II	3	1.54	±0.10	±6.3	+9.9	+1.79	No	26.1	±0.1	± 0.4	+11.9	+1.45	No
Mark II "dry"	2	1.54	±0.11	±6.9	+10.2	+1.63	No	25.6	±1.1	± 4.1	+13.3	+1.51	No

Test configuration	Sample size	Nitrogen Oxides: Mean g/mi.	Standard dev. g/mi.	Standard dev. %	Percent reduction*	t*	Significantly different at 90% confidence
Before mileage accumulation							
no device	2	2.08	±0.06	±2.7	—	—	—
Mark II	3	2.07	±0.18	±6.7	+0.5	+0.06	No
Mark II "dry"	2	2.22	±0.19	±8.6	-6.5	-0.77	No
After 2000 miles							
no device	2	1.98	±0.33	±16.4	+4.8	+0.55	No
Mark II	3	1.73	±0.05	±2.7	+16.7	+2.12	No
Mark II "dry"	2	2.22	±0.18	±7.9	-7.0	-0.77	No

* All percent reduction and t tests conducted with no device before mileage accumulation used as a base sample. The t tests were calculated using overall standard deviations of:

±0.10 g/mi. for HC
±2.65 g/mi. for CO
±0.18 g/mi. for NOx

Table 7 gives the levels of change that were necessary to be considered significantly different at 90% confidence with the observed test variability and different sample sizes. This shows that a sample size of 7 is required to be able to detect with 90% confidence a difference equal to the standard deviation. Sample sizes of this order can be obtained in this analysis if all the before mileage accumulation tests are grouped and compared to all the after 2000 miles tests. This grouping should reveal any overall shifts in emissions or fuel economy with mileage accumulation and thus reveal any long term benefit of the Mark II. Table 8 shows the results of this grouping for the emissions over the '75 FTP and for the fuel economies over the '75 FTP and HFET. Under the column titled "Comparative Statistics" are given the percent change in the group means, the t test score and the resolution of the same t test null hypothesis as used in Tables 4, 5, and 6.

The CO and NOx emissions showed reductions of 7% and 8% respectively but just missed being significantly different from test-to-test variability. The '75 FTP fuel economy improvement of 2% was found significantly different. From this there appeared to be a slight but real improvement in the 75 FTP fuel economy after mileage accumulation with the Mark II. There was no corresponding improvement in the HFET fuel economy.

Any fuel economy benefits that would result from the alteration of the combustion chamber deposit, would be expected to be reflected in both the 75 FTP and HFET. Thus it was difficult to envision a long term effect of the Mark II that would tend to improve only the low speed stop-and-go type driving fuel economy.

Table 9 shows the combined city/highway fuel economy of the test vehicle in the different configurations tested. Also shown is the fuel consumed and its cost over a period of one year of average driving, assuming the annual mileage of 10,000 miles and gasoline cost of $.60/gallon. The Mark II after mileage accumulation showed a savings of $2.58 over the no-device configuration before mileage accumulation. The price of the Mark II with Vapor Jet is listed at $47.90. The owner's manual recommends refilling the Mark II with Econo Mix ($1.95 for a 15 oz. can) every 90 days, yielding an annual operating expense of $7.80. Thus, at least for the test vehicle the Mark II does not appear economically justifiable.

Table 7
Percent difference between sample means detectable at 90% confidence as a function of sample size

	Overall Std. dev.%	Percent difference detectable with no. of tests* equal to 2	3	4	5	7	10
'75 FTP Emissions							
HC	±5.8	±17.1	±10.2	±8.0	±6.9	±5.6	±4.5
CO	±9.0	±26.1	±15.6	±12.3	±10.5	±8.5	±6.9
NOx	±8.7	±25.3	±15.1	±11.9	±10.2	±8.2	±6.7
Fuel Economy							
75 FTP	±1.4	±4.2	±2.5	±2.0	±1.7	±1.4	±1.1
HFET	±1.6	±4.7	±2.8	±2.2	+1.9	±1.5	±1.2

* No. of tests is for both samples, each having the same indicated number of individual tests, i.e. the number 5 indicates two samples of 5 tests each for a total of 10 tests.

Table 8

'75 FTP emissions	Before mi. accum. Sample size	Mean g/mi	After 2000 mi. Sample size	Mean g/mi	Comparative Statistics Percent change*	t*	Significantly different at 90% confidence
HC	7	1.60	7	1.57	-1.9	0.56	No
CO	7	28.5	7	26.2	-7.1	1.61	No
NOx	7	2.11	7	1.94	-8.1	1.78	No
Fuel Economy		mpg		mpg			
'75 FTP	7	25.3	7	25.8	+1.9	2.92	Yes
HFET	11	39.2	7	39.3	+0.3	0.32	No

* Before mileage accumulation mean values were used as base sample for percent change and t test. Overall standard deviations used are those given in Tables 4, 5, and 6.

Table 9

Configuration	Composite* fuel economy mpg	Gasoline used** per year gallons	Gasoline*** cost per year
Before mileage accumulation			
no device	30.2	331.1	$198.66
Mark II	29.7	336.7	$202.02
Mark II "dry"	30.4	328.9	$194.34
After 2000 miles			
no device	30.6	326.8	$196.08
Mark II	30.6	326.8	$196.08
Mark II "dry"	30.3	330.0	$198.00

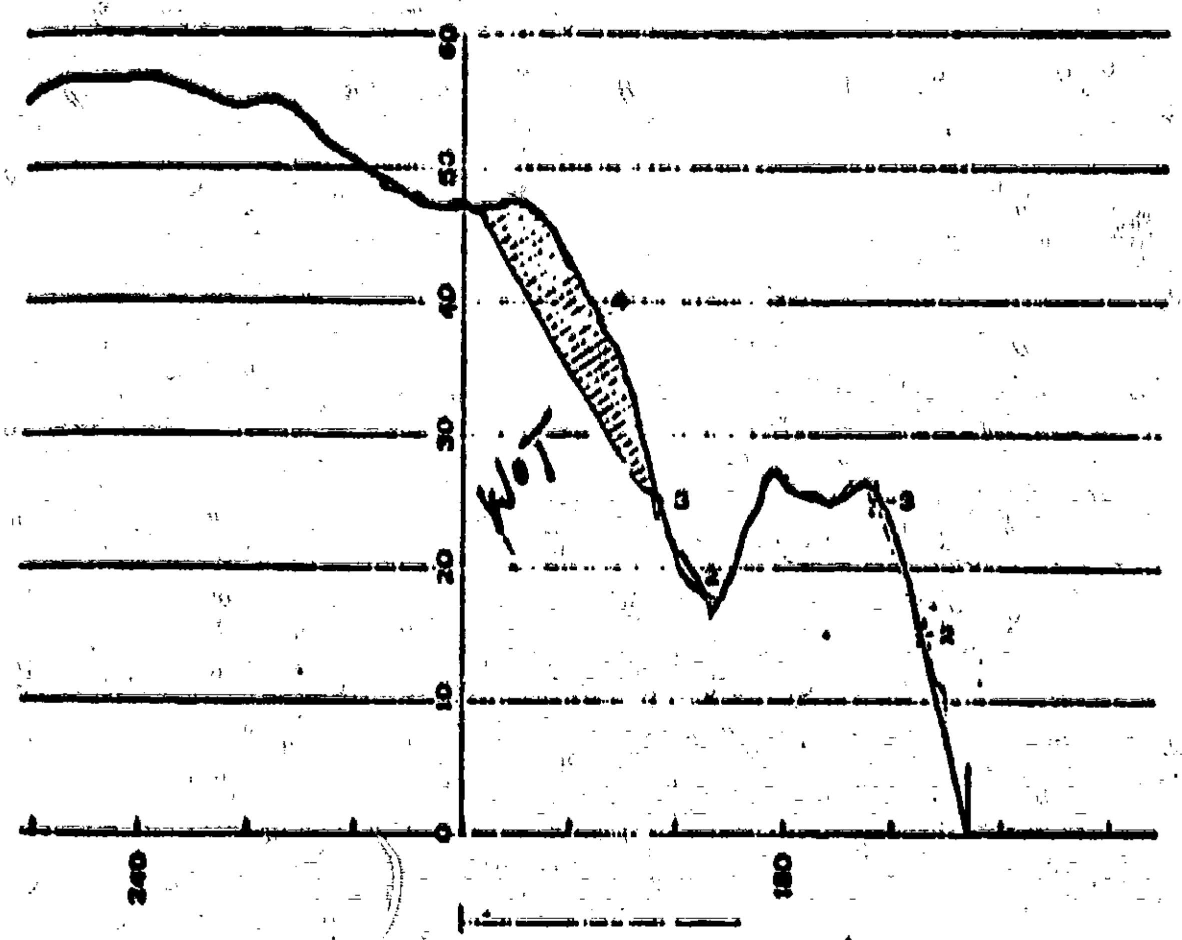
Performance of the vehicle was not specifically examined, but the vehicle was unable to maintain the hard acceleration occurring from 180 to 200 seconds into the transient cycle of the '75 FTP. Figure 6 shows this section of the driving cycle, with the cross hatched area representing the difference between the prescribed speed time trace (upper curve) and the vehicle's actual speed time trace. The "WOT" on the trace was written by the driver indicating that the throttle was wide open. Had any power improvements occurred, the vehicle would have been better able to follow the prescribed trace and the cross hatched area would have been smaller. Since no noticeable changes in this area were produced by any of the configurations tested, it was concluded that no noticeable changes in vehicle performance occurred.

* Composite fuel economy = $\dfrac{1}{\dfrac{.55}{\text{'75 FTP F.E.}} + \dfrac{.45}{\text{Highway F.E.}}}$

** Annual mileage 10,000 miles

*** Gasoline cost of $.60/gallon

Figure 6



Typical speed-time trace for the Vega in the region of 180 to 240 seconds into the '75 FTP. Cross-hatched area added for clarity.

Conclusions

The calculations of the preliminary analysis show that the quantities of water, methanol, and acetone added by the Mark II are considerably smaller than additions reported in the literature that produced measureable changes in octane requirement, power, or fuel economy. The Mark II can be considered as a small auxiliary carburetor, which under favorable conditions delivers a mixture with an air fuel ratio near stoichiometric. If this addition to the total carbureted mixture were ignored, the apparent increase in fuel economy was calculated to be around 0.3 percent on the '75 FTP. If the Mark II were operated "dry" it could increase the overall air fuel ratio by 0.28 at idle. Depending on the original air fuel ratio, this could produce small but measurable changes in emission levels and low speed fuel economy. Possible long term effects of the Mark II were not considered in the preliminary analysis.

The test results show that all configurations tested yielded the same emissions and fuel economy within test-to-test variability. By combining all tests before mileage accumulation and comparing them to all the after-2000 mile tests, a significant 2% increase in '75 FTP fuel economy was observed with mileage accumulation. There was not a corresponding increase in HFET fuel economy. Throughout the testing sequence no improvements in vehicle performance were observed.

Based on the results from the test car, the operating expenses of the Mark II exceeded the savings in fuel by a factor of three. It is the conclusion of the analysis that the purchase price and operating expenses of the Mark II do not appear to be justified by the insignificant changes in emission levels and minor fuel economy improvement produced by the Mark II.

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Preliminary analysis of Mark II Vapor Injector

The purpose of this preliminary analysis is to determine the approximate concentration of the various vapors in the carbureted air fuel mixture, and to compare them to concentrations, reported in the literature, known to produce measurable effects.

Mark II Econo Mix fluid is 65% methanol, 34% acetone and 1% propylene glycol by volume. This is mixed one part to two parts water by volume. As only the vapors of this mixture are used and the vapor pressure of propylene glycol is low (less than 1 mm of Hg at 100°F), we will not include it in our analysis.

Water vapor is normally added to air-fuel mixtures because it is present in the air. The effects of increasing humidity are fairly well known. It lowers the octane requirement of the engine, i.e. it acts as a knock suppressor. Potter et al found that at 70°F a change in relative humidity from 30 to 60 percent decreased the required motor octane number (MON) of the fuel for an automobile engine from 88 to 86. Ingamells, Stone, Gerber and Ungelman[7] found studying eight automobiles that the effects of humidity changes on required octane number was linear with the equation:

$$\Delta \text{ O.N.} = - K \, \Delta H \text{ (grains/lb absolute humidity)}$$

K was observed to vary from 0.04 to 0.09 for the cars tested with an average of 0.045. This is in good agreement with Potter, yielding a 1.4 O.N. decrease versus the 2 from Potter for the 30% change in relative humidity at 70°F.

As a diluent, water vapor also decreases the charge density and indicated thermal efficiency. Slight power improvement is possible with increasing humidity if the engine was previously spark limited and can take advantage of the increased octane number by increasing spark advance and/or increasing charge density (opening the throttle more for a normally aspirated engine).

Nichols, El-Messiri and Newhall[9] investigated the effects of inlet manifold water injection on oxides of nitrogen emissions. They found that at air-fuel ratios near stoichiometry, 30 to 50 percent reduction of nitric oxide emissions were observed with a water to fuel weight ratio (W/F) of 0.50. The effects of water injection on percent reduction of NOx appeared linear in the range of W/F = 0 - 0.5. The effectiveness of water in this regard was attributed primarily to its high latent heat of vaporization resulting in lower peak combustion temperatures.

Obert[10] investigated injections of liquid water and water-alcohol mixtures into the intake manifold as a means of knock suppression. While effective, it required large amounts of water, around 50% of the fuel volume. This technique has been used for airplane engines during take-off. Much of the effectiveness of this method has been attributed by Obert to the high latent heat of vaporization of the liquids.

Methanol has been widely investigated as a possible fuel blending component and alternate fuel. Ingamells and Lindquist[11] found, using different unleaded gasolines, that the addition of 5% by volume methanol increased the MON by 0.1 to 1.5 octane number (ON) while the addition of 10% methanol increased the MON by 1.6 to 2.5 ON. They also reported that on a miles per gallon basis the addition of 10% methanol produced an average 3.2% fuel economy loss for a six car fleet in commuter type driving. Wigg and Lunt[12] reported the effects of the addition of 15% methanol by volume to gasoline on the exhaust emissions of cars operated over the '75 FTP. For a 1973 car the methanol addition resulted in a 36% increase in HC, a 50% decrease in CO, and a 24% decrease in NOx. These effects however were attributed to 1) the enleanment effect of using the alcohol blends in carburetors designed for gasoline (The addition of 15% methanol increased the equivalence ratio by about 0.1 unit.), and 2) the relatively higher latent heat of vaporization of methanol resulting in a cooler inlet charge and lower peak flame temperatures. In Powell's[11] review of racing motor-fuel blends he estimates a 20% gain in power for high compression ratio engines using methanol instead of regular gasoline. This was attributed to methanol's 1) ability to burn richer of stoichiometric than gasoline, 2) higher octane number and 3) higher heat of vaporization producing cooler, denser inlet charges. This power increase also entailed a specific fuel consumption of methanol being about three times that of gasoline.

The use of acetone in fuels has not been considered very much because it and other ketones promote the formation of gum. For this reason, production gasolines generally limit naturally occurring ketones to .005 weight percent.[12] Powell reported that acetone was sometimes used in racing fuels in concentrations of 5% or less. It was used with methanol blends as a blend stabilizer and water tolerance booster because of its high solvent powers. Gumming and other fuel system problems associated with acetone and methanol are prevented by draining and flushing of the system after each race.

Turning now to the Mark II we can reasonably approximate the concentrations of water, methanol, and acetone contributed by the device to the induction mixture. First the operating variables of the device were measured. With the aerator valve on the Mark II reservoir adjusted according to the manufacturer's instructions, the air flow into the valve was measured with a wet test meter. The air flow was 1.4 cubic feet per hour with the engine idling and at steady state 50 mph cruise. At wide open thottle the flow was less than .02 cubic feet per hour. The maximum flow rate measured, 2.6 cubic feet per hour, was with the valve wide open (an improper setting according to the instructions). The temperature of the reservoir fluid was measured throughout a '75 FTP and Highway test with the reservoir installed in the car but not connected to the vacuum source. As there was no air bubbling through the fluid the evaporative heat losses associated with it were not present. The initial temperature was 80°F and the final temperature after 60 minutes was 93°F and still rising slowly. The vacuum in the bottle with the air bubbling rate properly adjusted was 10 inches of mercury. For convenience we will use an air flow of 1.4 cubic feet per hour, reservoir temperature of 100°F and an absolute pressure in the bottle of 20 in. Hg in our calculations below.

Calculation of weight of air, water, methanol and acetone delivered per hour by the Mark II:

<u>Assumptions</u>

1. Air entering bottle is at 80°F and at 50% relative humidity.

2. Fluid mixture obeys Raoult's Law, i.e. each component's equilibrium vapor pressure above the liquid is equal to the vapor pressure of the pure component's equilibrium vapor pressure at that temperature times the mole fraction of that component in the liquid mixture.

3. The vapor-liquid concentrations are in equilibrium after bubbling.

Given the Econo Mix composition of 65% methanol, 34% acetone and 1% propylene glycol, mixed with 2 parts water; the resulting mixture per litre is:

water	667 ml
methanol	217 ml
acetone	113 ml
propylene glycol	3 ml
	1000 ml

Component	Density g/litre	Molec. Wt.	Moles/litre pure component	Mole fraction in mixture
water	1.00	18.0	55.6	.842
methanol	0.79	32.0	24.7	.122
acetone	0.79	58.1	13.6	.035
propylene glycol	1.04	76.1	13.7	.001

Absolute pressure in bottle is 20 in. Hg or 510 mm Hg.

Component	Mole fraction in liquid	Vapor pressure of pure component at 100°F in mm Hg	Partial pressure above mixture	Mole fraction in air vapor mixture
water	.842	49	43.3	.085
methanol	.122	230	28.1	.055
acetone	.035	380	13.5	.026
propylene glycol	.001	1	0.0	.000
air	----	----	425.	.834
Total			510	1.000

Below the composition of one mole of air-vapor mixture (22.4 ℓ at standard conditions of 0°C and 1 atm.) and the weight and volumes of these components delivered per hour by the Mark II are shown.

Component	Weight per 1 mole of mixture* in grams	Weight delivered in one hour in grams**	Liquid volume delivered in one hour in ml.
water	1.53	3.28	3.28
methanol	1.76	3.77	4.77
acetone	1.51	3.23	4.09
propylene glycol	0.00	.00	.00
air	24.0	51.4	----

* Molecular weight x mole fraction in air-vapor mixture

** Total volume of vapor mixture delivered to the engine by the Mark II at STP is:

$$(1.4 \text{ cu. ft./hr.}) \left(\frac{510 \text{ mm Hg}}{425 \text{ mm Hg}} \right) = 1.7 \text{ cu. ft./hr. or } 48 \text{ ℓ/hr.}$$

Calculating the fuel consumed by the test vehicle and the vapor components delivered by the Mark II during the '75 FTP, Highway test and idle:

Cycle	Driving Time hours	Distance miles	Vega F.E.	Gasoline consumed Gallons	ml.
'75 FTP	.521	11.1	25.7	.432	1635
Highway	.21	10.2	39.3	.260	982
Idle	1.0	0.0	--	.4+	1500

\+ Estimated from the following idle fuel consumption data from reference 13. '75 Ford Pinto - .426 gal./hr. '75 VW Rabbit - .388 gal./hr.

Component	'75 FTP Volume ml.	Vol.%	Highway Volume ml.	Vol.%	Idle Volume ml.	Vol.%
water	1.71	0.10	0.69	0.07	3.28	0.22
methanol	2.49	0.15	1.00	0.10	4.77	0.32
acetone	2.13	0.13	0.86	0.09	4.09	0.27
gasoline	1635.	99.63	982.	99.70	1500.	99.20
Total	1641.		985.		1512.	

Thus we see that considering the vapor components contributed by the Mark II as part of the fuel, they represent a very small fraction: only 0.30% on the Highway test, 0.37% on the '75 FTP and 0.80% at idle. This checks well with the observed consumption of 550 ml of reservoir fluid during the accumulation of 1600 miles. With a composite fuel economy of 30.4 mpg, 52 gallons or 200 litres of gasoline were used yielding a 0.28% by volume addition of the reservoir fluid.

Water addition due to the Mark II amounted to at most 0.22% and of that, slightly over 50% was the original humidity of the air entering the Mark II. Assuming an overall stoichiometric air fuel ratio, this amounts to a 1.4* grains of water addition per pound of incoming air. This is equivalent to[8] a humidity change of a little less than one relative humidity point at 80°F. Using Ingamells et al[7] equation for the effect of humidity on octane requirement we can expect a decrease of 0.06 O.N. due to the water contributed by the Mark II. This small change in O.N. is not measurable. Using the linear relationship of water addition to percent reduction of NOx observed by Nichols et al[9], we would expect a 0.2 to 0.3 percent reduction in NOx emissions due to the water additions of the Mark II if this water were in a liquid state when it entered the intake manifold. Since the Mark II adds only water vapor the benefits of the high latent heat of vaporization are lost. Thus the actual effect would be smaller than the 0.2 to 0.3 percent reduction above, which is already way below our test-to-test variability. Most important of all however is the fact that normal day-to-day weather variations produce humidity changes that dwarf those produced by the Mark II.

The maximum methanol addition of 0.32 volume percent is an order of magnitude smaller than reported additions of 5% that produced a .1 to 1.5 octane number change. Assuming that the effects of methanol addition to gasoline are linear with the percentage of volume addition, we can estimate the emissions changes over the '75 FTP from the Wigg and Lunt[12] data. That is a 15% by volume addition of methanol to gasoline resulted in a 36% increase in HC, a 50% decrease in CO, and a 24% decrease in NOx. Thus we might expect a 0.8% increase in HC, a 1.1% decrease in CO, and a 0.5% decrease in NOx. Again with the Mark II the effect of the high latent heat of vaporization of methanol is lost so the effect on NOx would be less. These small changes are not measurable on the '75 FTP because of the test-to-test variability. Methanol additions of 0.25% are routinely added to production winter gasolines by some oil companies[14] to prevent ice crystal formation in the fuel. This small addition is not known to have any measurable effect on any engine variable.

$$ ^{*}\ .0022 \text{ vol. fraction } H_2O \times \frac{1.00 \text{ density } H_2O}{.739 \text{ density of gasoline}} \times \frac{\text{lb. gasoline}}{15 \text{ lb. air}} \times 7000 \text{ grains/lb.} = 1.4 \text{ grains } H_2O/\text{lb. air.} $$

As mentioned earlier acetone is avoided in production gasolines. It has been used in methanol blend racing fuels, in concentrations up to 5%, as a blend stabilizer, not for any known benefits as an octane or power booster. The maximum concentration of acetone contributed by the Mark II was 0.27%. It is unlikely that this small a concentration would produce any measurable effects.

As methanol and acetone are combustible, the Mark II can be considered as an auxiliary carburetor. Below is a calculation of its equivalence ratio. (Equivalence ratio is the observed air-to-fuel ratio by weight divided by the stoichiometrically correct air-fuel ratio for that fuel. A rich mixture will have an equivalence ratio less than 1.0 and a lean mixture will have one greater than 1.0)

Component	Mole fraction in air vapor mixture	moles of O_2 per mole of component for complete oxidation	Mole fraction of O_2 require
methanol	.055	1.5	.083
acetone	.026	4.0	.104
air	.834	---	---
O_2 .21 x .834 =	.175	---	---
		Total	.187

So equivalence ratio is $\frac{.175}{.187}$ = .935 or slightly rich.

So when the Mark II reservoir fluid is fresh and at 100°F the air-vapor mixture is rich. When the reservoir is cooler, the mixture will be leaner. Also with mileage accumulation, as the conentrations of methanol and acetone are depleted, the mixture will become leaner. Since the methanol and acetone represent at most only 0.59% of the fuel their effect on the overall air-fuel ratio is minimal. If the Mark II were operated without fluid ("dry"), the air entering would lean the carbureted mixture. At idle an original A/F of 15.0:1 would go up to:

$$\frac{6.0\text{ lb. air/hr.} + (1.4\text{ cu. ft air/hr.} \times .079\text{ lb/cu. ft air})}{.4\text{ lb. fuel/hr.}} = 15.28$$

or a 1.8% increase. The effects of air-fuel ratio changes on fuel economy and emissions are well documented; and while this is the maximum increase expected, it is sufficient at certain air fuel ratios to produce small but measurable changes in emissions and low speed fuel economy. This would be operating the Mark II strictly as air bleed, and similar results could be obtained by leaning the normal idle mixture adjustment.

Since the fuel economies of this report are calculated by the carbon balance method the carbon added by the Mark II is counted. In the calculation, a carbon-to-hydrogen ratio and a density typical of gasoline are used. This creates an error if a gasoline is used that is not typical.

For the '75 FTP we can determine the error in the calculated fuel economy which resulted when 0.28% of the fuel was not typical gasoline but was acetone and methanol.

Fuel	1 Density grams/gallon	2 (Grams of Carbon) (Gram molec. wt. of fuel)	1 x 2	3 Volume fraction	1 x 2 x 3
Gasoline	2798	.866	2423	.9972	2416
Methanol	2990	.375	1120	.0015	1.7
Acetone	2990	.620	1850	.0013	2.4
			Total		2420

Percent error = $(1 - \frac{2420}{2423}) \times 100 = 0.12\%$

That is the calculated fuel economy is 0.12% higher than actuality. At 25.0 mpg this error amounts to .030 mpg, or beyond the significance to which we report fuel economy.

If the methanol and acetone were not considered as fuel during the '75 FTP, the calculated fuel economy would be $(1 - \frac{2416}{2423}) \times 100 = 0.29\%$ higher than actuality.

For 25.0 mpg this amounts to .072 mpg. This then is the magnitude of change we would expect by ignoring the fuel content of the Mark II vapors, measuring only the volume of gasoline consumed and dividing it into the miles traveled, as the typical motorist might do. Even though this is technically incorrect it still represents a very minor change in fuel economy.

Not discussed above is the possible long term effects of the device such as altered combustion chamber deposit quality or quantity. In evaluating aftermarket devices, TAEB is not particularly concerned with these changes unless they affect the emissions, fuel economy, or performance of the vehicle.

Appendix II

'75 FTP Individual Bag Results
Mass emission, grams per mile
Fuel economy, miles per gallon

	Bag 1 Cold Transient					Bag 2 Hot Stabilized					Bag 3 Hot Transient							
Test Number	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy	Temp. °F	Rel. Hum. %	Baro. P " Hg
19-8205	2.41	53.8	295	2.28	22.9	1.45	25.6	312	1.85	24.9	1.91	33.0	262	2.53	27.8	74.5	46	29.02
19-8224	2.69	41.9	316	2.15	22.8	1.27	20.1	312	1.69	25.5	1.58	24.6	272	2.48	28.1	73.0	46	29.35
19-8277	2.42	52.9	293	2.18	23.1	1.30	19.9	309	1.81	25.8	1.79	30.0	260	2.34	28.3	71.5	49	28.75
19-8324	2.36	57.3	307	2.49	21.9	1.16	17.3	304	2.02	26.5	1.44	28.6	272	2.87	27.6	74.5	41	29.03
16-8721	2.34	47.3	303	2.44	23.0	1.02	16.6	336	2.07	24.3	1.54	24.9	282	1.06	27.2	75.0	34	29.48
15-8740	2.90	48.2	299	2.25	23.1	1.10	17.5	324	1.94	25.0	1.41	24.4	275	2.71	27.9	65.5	45	29.34
15-8810	2.41	50.0	292	2.30	23.4	1.27	22.1	32?	1.86	24.6	1.80	34.9	281	2.57	26.0	71.5	48	28.83
15-9009	2.68	45.9	298	2.22	23.4	1.31	23.7	31?	1.61	25.1	1.70	29.6	265	2.33	28.0	74.0	38	28.90
13-9019	2.42	44.1	302	2.31	23.4	1.35	23.3	332	1.85	23.8	1.59	26.5	270	2.66	28.0	72.0	44	29.09
15-9037	2.98	47.4	307	2.29	22.7	1.39	23.5	332	1.72	23.8	1.62	27.7	275	2.49	27.4	72.0	40	29.01
15-9064	2.50	46.5	301	2.24	23.2	1.43	23.4	329	1.75	23.9	1.52	26.9	266	2.41	28.3	74.0	38	28.84
16-9086	3.31	48.4	298	2.17	23.1	1.47	24.0	326	1.83	24.1	1.58	26.6	275	2.53	27.6	74.0	40	29.17
15-9162	4.08	56.0	302	2.13	22.0	1.59	24.8	334	1.77	23.5	1.79	28.8	276	2.43	27.1	74.0	41	28.98
16-9179	3.77	51.1	303	2.24	22.5	1.65	23.7	333	1.72	23.6	1.92	28.2	275	2.47	27.3	74.0	46	28.99
16-9192	4.04	53.2	291	2.14	22.9	1.67	22.2	309	1.60	25.4	1.69	24.6	261	2.42	29.1	70.0	46	29.13
16-9219	3.91	55.2	304	2.18	22.0	1.69	21.7	330	1.77	24.0	1.76	28.2	280	2.39	26.9	73.0	40	28.98
16-9237	3.18	48.4	299	2.13	23.1	1.79	19.4	328	1.71	24.4	1.88	28.4	270	2.34	27.6	72.8	45	28.70
15-9427	3.15	53.9	308	2.14	22.0	2.06	23.7	330	1.78	23.7	1.94	28.8	274	2.51	27.2	72.5	40	28.73
15-647	3.41	51.9	300	2.16	22.6	2.07	24.0	332	1.80	23.6	2.16	29.5	276	2.45	26.9	73.0	44	28.96
15-719	3.73	52.9	311	2.37	21.9	2.46	24.8	319	1.62	24.2	2.30	29.3	293	2.76	25.6	74.0	48	29.18
15-720	3.48	54.1	311	2.37	21.8	2.30	22.0	341	1.71	23.2	2.24	29.2	285	2.67	26.4	73.0	44	29.25
14-1290	2.59	50.8	318	2.00	21.9	0.99	18.1	356	1.74	22.9	1.56	28.2	293	2.36	25.9	77.0	33	29.12
76-1988	2.76	47.2	290	2.03	23.8	1.11	18.0	318	1.51	25.4	1.57	25.3	279	2.03	27.4	71.0	49	29.06
76-1310	2.13	41.3	258	1.52	26.9	0.46	16.9	324	1.42	25.2	0.70	24.6	231	1.68	32.8	72.0	44	29.03
76-2434	2.60	55.7	281	1.71	23.6	0.95	15.5	311	1.48	28.2	1.45	23.4	255	2.02	29.9	72.5	46	29.13
76-2552	2.89	51.4	291	1.74	23.3	1.12	16.2	331	1.65	24.6	1.59	26.4	267	1.99	28.3	71.5	46	29.03
76-2629	2.54	48.6	284	2.36	24.1	1.20	18.0	314	1.94	25.7	1.60	24.6	277	2.59	27.6	71.0	76	29.08
76-2641	3.15	54.8	295	1.85	22.7	1.21	19.1	309	1.49	25.9	1.64	24.8	261	2.15	29.1	70.5	45	28.87
76-1645	2.41	50.1	289	2.19	23.6	1.22	17.5	318	1.95	25.4	1.76	23.6	257	2.33	29.3	80.0	46	29.03
76-1658	2.08	44.7	294	2.40	23.9	1.12	17.1	321	2.25	25.3	1.64	24.9	260	2.50	29.2	77.0	27	29.09

SET 1808 01 0579

TECHNICAL REPORT
ON
FUEL ECONOMY TEST
FOR
V-70 SUPER VAPOR POWER DEVICE

Prepared For:

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May 3, 1977

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Scott Environmental Technology Inc.

SET 1808 01 0579

1.0 INTRODUCTION

On April 18, 1979, Scott Environmental Technology, Inc. performed two preliminary highway fuel economy tests under contract to Product Promotions Inc. (Sponsor). The tests were performed on a late model automobile to determine the fuel saving and pollutant reducing capabilities of "The V-70 Super Vapor Power" device. These preliminary tests were also performed to determine the feasibility of further testing.

The test procedure used was that developed by the Environmental Protection Agency (EPA) which simulates non-urban (open highway) driving conditions. The vehicle was tested first in the stock condition to provide "baseline" exhaust emission and fuel economy data. The vehicle was then retested for exhaust emissions and fuel economy after the device was installed for a direct comparison between the results of the two tests. The remaining sections of this report describe the test vehicle, device, test procedures and the results obtained.

2.0 TEST VEHICLE DESCRIPTION

The fuel economy tests were performed on a 1978 Chevrolet Monte Carlo (VIN: 1Z37488451044) equipped with a 305 cubic inch V-8 engine and 2 barrel carburetor, automatic transmission and air conditioning. It was also equipped with the standard General Motors emission control equipment. Mileage of the vehicle prior to the baseline test was 28772.6.

3.0 DESCRIPTION OF DEVICE

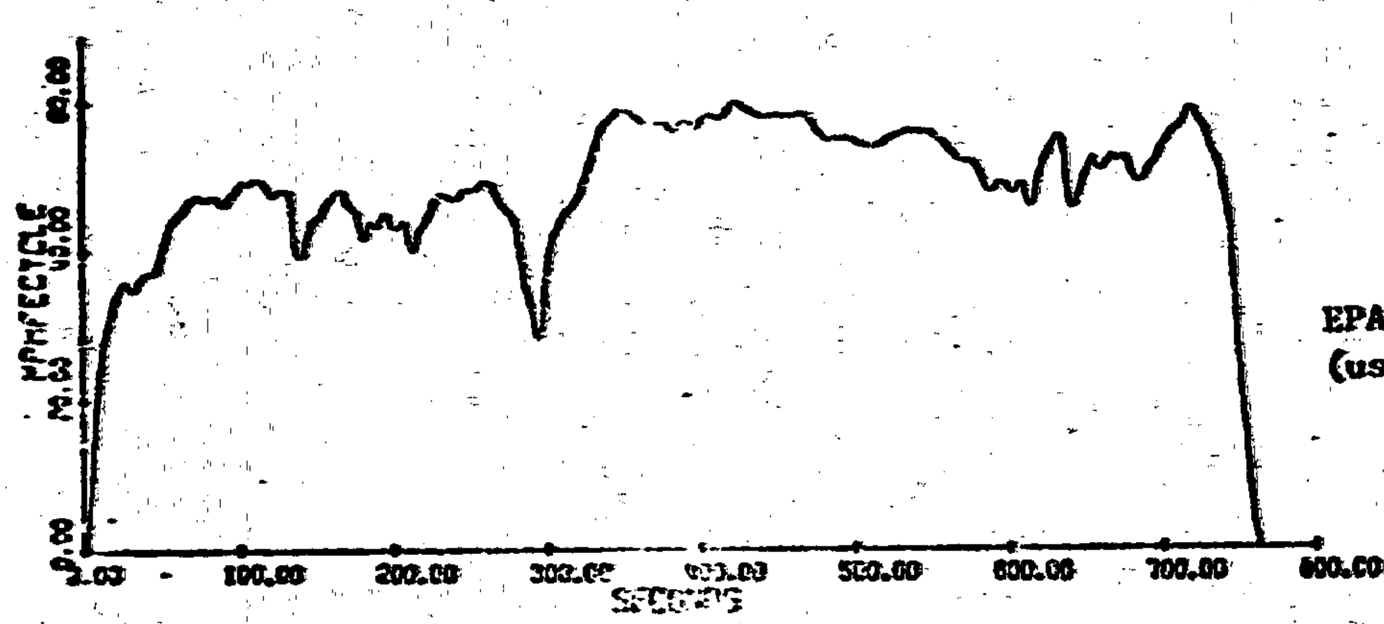
The Sponsor's device, called "The V-70 Vapor Power" consists of a "Lexan Plastic Reservoir" on which is mounted a metal plate cover. This cover has incorporated in it, a "hose and check valve connection", a "metering device" and a "two stage aerator". Also included with this device are two one-quart containers of a liquid containing methanol (percentage of methanol unknown by Scott), one of which is poured into the reservoir along with two quarts of distilled water.

A vacuum source is required for the operation of this device. The source of vacuum recommended by the manufacturer is the primary intake manifold vacuum port that is normally connected to the positive crankcase ventilation (PCV) valve with a flexible hose. This hose was severed at its midpoint and two of the three connection points of the plastic tee (supplied with the device) was connected to each of the severed ends of the hose. Using this vacuum source, air is drawn in through the "metering device", creating a bubbling or aeration action in the liquid solution contained in the reservoir by the "two-stage aerator".

The fluid mixture in the reservoir, called "V-70 Vapor Fuel Additive, is a specially prepared formula of oxygen-bearing petroleum distillates which when added with water produces the vapor" for this system of vapor injection.

4.0 DESCRIPTION OF TEST PROCEDURES

The procedure utilized for the fuel economy tests was the 1976 Federal "Highway Fuel Economy Test" (HFET). This test procedure (Figure 1.0) was developed by the EPA specifically to assess fuel economy of a vehicle during non-urban driving. The HFET was constructed from actual speed-versus time traces generated by an instrumented test vehicle driven over, and averaged from, a variety of non-urban roads which preserves the non-steady-state characteristics of real-world driving. The average speed during the test is 48.2 mph and the test length is 10.2 miles approximating average non-urban trip length. The testing was performed on Scotts chassis dynamometer where, through the use of flywheel and a waterbrake, the loads that the vehicle would actually encounter on the road are reproduced. The vehicle's exhaust is collected, diluted and thoroughly mixed with filtered background air, and a known constant volume flow is obtained by the use of a positive displacement pump. This procedure is known as Constant Volume Sampling (CVS). The constant volume sampler is used to collect the exhaust emissions during the test. A portion of the exhaust gas mixture is collected in Tedlar bags for



EPA Highway Cycle
(used in Highway Fuel Economy Test)

FIGURE 1 OFFICIAL FEDERAL TEST CYCLE

subsequent analysis. After the sample has been collected, it is transferred to analyzers where the concentrations of hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2) and oxides of nitrogen (NO_x) in the sample bag are determined. The analyzers provided for the determination of HC concentrations by flame ionization detector (FID), CO and CO_2 concentrations by non-dispersive infrared (NDIR) analysis, and NO_x concentrations by chemiluminescence (CL) analysis.

The initial or baseline test was performed with the vehicle in its normal, or stock configuration. An inertia weight of 3500 pounds was selected on the chassis dynamometer, the vehicle accelerated up to, and stabilized at, 50 mph and the road load adjusted to the EPA specified setting of 12.3. The vehicle was decelerated to 0 mph (idle) and the HFET was performed. The vehicle was operated over two (2) complete cycles. The first cycle being only a warm-up for the second cycle which is used for the exhaust measurements.

After completion of the baseline test, Scott personnel installed the Sponsor's device following the instructions supplied with it. No adjustments were made to the engine or emission control systems other than installing the tee fitting in the PCV valve vacuum line.

The vehicle was tested the second time with the device installed following the same procedures as during the baseline test.

5.0 CALCULATIONS

The concentration of HC, CO, CO_2 and NO_x are obtained by subtracting the background levels of the gases from those measured in the sample bags. The resultant values are referred to as corrected concentrations. The grams per mile figures are obtained from calculations using the corrected concentrations and the total volume flow during each of the three test phases to arrive at a mass value for each pollutant (HC, CO, CO_2 and NO_x). Once the mass emissions for each test phase are known, the emissions in grams per mile are calculated using the following formula:

$$Y_{wm} = (0.43\ Y_{ct} + 0.57 Y_{ht} + Y_s) \div 7.5$$

where

Y_{wm} = weighted mass emissions of each pollutant, i.e. HC, CO or NO_x in grams per vehicle mile.

Y_{ct} = mass emissions as calculated from the "transient" phase of the cold start test, in grams per test phase.

Y_{ht} = mass emissions as calculated from the "transient" phase of the hot start test, in grams per test phase.

Y_s = mass emissions as calculated from the "stabilized" phase of the cold start test, in grams per test phase.

The cold start and hot start bags are weighted 0.43 and 0.57 respectively.

Detailed explanations of the calculations can be found in the Federal Register.

6.0 SUMMARY

Exhaust emission concentrations as collected in the integrated bag samples, were calculated using appropriate instrument calibration factors. This "raw" concentration data was then converted to grams of pollutant per test mile (based on a 10.242 mile test). This data, including all measured parameters used in the mass emission computations for the HFET, is included in Tables 1.0 and 2.0.

Fuel economy for each test was calculated using the procedure outlined earlier in Federal Register Volume 41, Number 218, Part 600 "Fuel Economy of Motor Vehicles", November 10, 1976. The urban fuel consumption rates for each test are included at the bottom of Tables 1.0 and 2.0.

The data presented in Table 3.0 summarizes the vehicle exhaust emission and fuel economy tests performed. The exhaust emissions are presented in grams per mile (GPM) for total hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen (NO_x). Fuel economy measurements are shown in miles per gallon (MPG).

7.0 DISCUSSION

The data in Summary Table 3.0 show that the Sponsor's "V-70 Super Power" device improved the fuel economy of the vehicle for the highway economy test by 7.8% but it also increased the hydrocarbons and carbon monoxide emissions by 3.6% and 22.8% respectively as compared to the baseline test.

The tests described in this report indicate that the device produced improved fuel economy from the test vehicle. However, great care must be taken in interpreting results obtained from any tests involving a single vehicle. The data cannot be extrapolated to estimate the effects of the device on other vehicles or on the overall vehicle population. Valid conclusions regarding the general effectiveness of this device cannot be rendered until additional tests on representative vehicles are performed.

To fully determine the efficiency of this device, Scott recommends further tests consisting of at least:

1. Five FTP's and HFET's before and after device installation on the same automobile.

or 2. Accumulate mileage on original test car to determine if device shows improvement with time.

or 3. Item number 2 of the SET Proposal No. 0112-03-2179-15 of April 6, 1979.

or 4. All of the above.

Scott Environmental Technology Inc.
PLUMSTEADVILLE, PA. 18949 PHONE: 215-766-8861 TWX: 510-665-9344

TABLE 1.0

HIGHWAY FUEL ECONOMY

EXHAUST EMISSION DATA SHEET

Vehicle	1978 Monte Carlo	Odometer:		Date	4/18/79
VIN	1Z37483451044	Finish	28795.9	Project	1808-01
License	PA 3H0-400	Start	28777.3	Run	1
Trans.	Automatic	Miles	--	Device	Baseline
Carb.	1 bbls. 2	Idle rpm	500 (D)	Dyn. Load	12.3 RHP @ 50 MPH
Engine	V-8 CID 305	BIT	4°BTDC	Dyn. Inertia	3500#
Analyst	D. Gulick	Driver	S. Stranick	Calculator	D. Gulick

Dry Bulb Temp., F	73	Barometric Press., mm Hg	748.07
Wet Bulb Temp., F	52	CVS Pump Press., mm Hg	15.24
Gr. Water/Lb. Dry Air	24	(P) Sample Press., mm Hg	732.83
(K) Factor	0.8066	(V) CVS Pump Disp., CFR	0.3107
(T) Sample Temp., R	576	(N) CVS Pump Revolutions	13769

DILUTE EXHAUST MEASUREMENTS

COMPONENT		PVN/TM	FACTOR	GRAMS/MILE	
ppm HC dil.	96.33				
ppm HC Air	4.98				
ppm HC exh.	91.35	531.42211	11.348×10^{-6}	0.55	HC
ppm CO exh.	1037	531.42211	22.905×10^{-6}	12.62	CO
% CO_2 exh.	1.81	531.42211	36.022×10^{-2}	346.49	CO_2
ppm NO	--				
ppm NO_2	--				
ppm NO_x	72.65				
(ppm NO_x) (K)	58.60	531.42211	37.628×10^{-6}	1.17	NO_x
MPG	24.114				

Scott Environmental Technology Inc.
PLUMSTEADVILLE, PA. 18949 PHONE: 215-766-8861 TWX: 510-665-9344

TABLE 2.0

HIGHWAY FUEL ECONOMY

EXHAUST EMISSION DATA SHEET

Vehicle	1978 Chevrolet Monte Carlo	Odometer:		Date	4/18/79
VIN	1Z37488451044	Finish	28816.4	Project	1808-01
License	PA 3H0-400	Start	28797.9	Run	2
Trans.	Automatic	Miles	—	Device	V-70 Vaporizer
Carb.	1 bbls. 2	Idle rpm	500 (D)	Dyn. Load	12.3 RHP @ 50 MPH
Engine	V-8 CID 305	BIT	4° BTDC	Dyn. Inertia	3500#
Analyst	D. Gulick	Driver	S. Stranick	Calculator	D. Gulick

Dry Bulb Temp., F	73	Barometric Press., mm Hg	748.07
Wet Bulb Temp., F	52	CVS Pump Press., mm Hg	15.24
Gr. Water/Lb. Dry Air	24	(P) Sample Press., mm Hg	732.83
(K) Factor	0.8066	(V) CVS Pump Disp., CFR	0.3107
(T) Sample Temp., R	578	(N) CVS Pump Revolutions	13791

DILUTE EXHAUST MEASUREMENTS

COMPONENT		PVN/TM	FACTOR	GRAMS/MILE	
ppm HC dil.	99.98				
ppm HC Air	5.67				
ppm HC exh.	94.31	530.42944	11.349×10^{-6}	0.57	HC
ppm CO exh.	1276	530.42944	22.905×10^{-6}	15.50	CO
CO_2 exh.	1.65	530.42944	36.022×10^{-2}	315.27	CO_2
ppm NO	—				
ppm NO_2	—				
ppm NO_x	68.69				
(ppm NO_x) (K)	55.41	530.42944	37.628×10^{-6}	1.11	NO_x
MPG	25.99				

SET 1808 01 0579

TABLE 3.0

SUMMARY OF PRELIMINARY FUEL ECONOMY TEST RESULTS

Test No.	Test Type	Fuel Economy (MPG)	HC (GPM)	CO (GPM)	NO_x (GPM)
1	No device (Baseline)	24.11	0.55	12.62	1.17
2	Device (V-70 Vapor Power)	25.99	0.57	15.50	1.11
	Percent Change	+7.8%	+3.6%	+22.8%	-5.1%

Attachment J

WAYLAND BAPTIST COLLEGE

Plainview, Texas 79072

Department of Chemistry

March 24, 1972

Mr. Virgil A. Archer, President
General Magnum, Inc.
265 Garden Mall, Exchange Park
P. O. Box 45440
Dallas, Texas 75245

Dear Mr. Archer:

Accompanying this letter you will please find the results, given in summary form, of my chemical analysis of the two Exhaust Emission Samples which were taken March 22. These samples were taken after the V-70 had been installed on the vehicle and represent the effect of such installation.

You will also find, by way of comparison, the results of samples, taken on February 20, prior to the installation of the V-70. I believe that these results will show a considerable decrease in pollutants has been achieved as a result of the installation of the V-70.

I certify that all work was done by me.

Thanking you for this opportunity to be of service, I am,

Yours very truly,

James C. Cox, Jr.

James C. Cox, Jr., Ph.D., LL.B.
Professor of Chemistry

Dr. James C. Cox, Jr., Head, Department of Chemistry, Wayland Baptist College

Education: B. S. summa cum laude (Chem., Math), W. Va. Wesleyan College, 1940
M. S. (organic chemistry), University of Delaware, 1947
Ph.D. (physical organic chemistry), University of Delaware, 1949
LL.B. (honors), University of Maryland, 1955
Advanced Study: Washington College of Law, American University, George Washington University

Research Fellowships: DuPont Fellow, 1948-1949
Carnegie Fellow, 1949-1951
Texas Fellow, 1959-1964

Consultant: DuPont, Texaco, Continental Oil, Cities Service, Gulf States Utilities, Anderson Chemical Co.

Lectureships: Texas Academy of Science Visiting Lecturer, 1961-1963
National Science Foundation Lecturer, 1961, 1963

Professorships: University of Delaware, 1946-1949
Wesleyan, 1949-1951 (Dept. Head)
Middle Tennessee State University, summer, 1950 (Visiting Professor)
U. S. Naval Academy, 1951-1955
Lamar University, 1955-1965 (and Research Director)
University of Baghdad, IRAQ 1966-1967 (Visiting Professor)
Oral Roberts University, 1965-1968 (Dept. Head and Division Director)
Wayland Baptist College, 1968-present (Dept. Head)

Research Experience: DuPont, 1940-1943 (nylon synthesis, acids synthesis, analysis)
Anderson Chemical C., summer 1949 (water purification)
DuPont, summer 1946), (dyes)
DuPont, summer 1961 (elastomers)
Texaco, summer 1962 (fuel additives)

Ph.D. dissertation topic: Oxidation (combustion)

Publications: more than 100 in field Books: six

Abstractor, CHEM. ABSTRACTS, 1948-present, more than 10,000 published abstracts
Abstractor, ACTA CHEMICA SCANDINAVICA, 1952-1962

Editor, THE CONDENSER, 1957-1965

Director, Gulf States Project (water pollution), 1957-1965

Honors: Outstanding Professor Award, 1962
Piper Professor Award, nominee 1970, 1971

Listed (Biography): WHO'S WHO IN SOUTH AND SOUTHWEST, LEADERS OF AMERICAN SCIENCE, AMERICAN MEN OF SCIENCE, DICTIONARY OF INTERNATIONAL BIOGRAPHY, WORLD WHO'S WHO IN SCIENCE AND COMMERCE, WORLD WHO'S WHO IN FINANCE AND INDUSTRY, WHO'S WHO IN AMERICAN EDUCATION, WHO'S WHO IN AMERICAN COLLEGES AND UNIVERSITIES, COMMUNITY LEADERS OF AMERICA, WHO'S WHO IN METHODISM, OUTSTANDING EDUCATORS OF AMERICA, others.

March 24, 1972
Page 3

EXHAUST EMISSION TESTS

COMPARED WITH SAMPLE 23 (1500) RPM, IN NEUTRAL) WITHOUT V-70

Particulates	100	Micrograms	per	cubic	meter
Hydrocarbons	120	"	"	"	"
Oxides of Nitrogen	60	"	"	"	"
Sulfur Dioxide	80	"	"	"	"
Carbon Monoxide	120	"	"	"	"

SAMPLE 25 (1500 RPM, IN NEUTRAL) WITH V-70

Particulates	50	Micrograms	per	cubic	meter
Hydrocarbons	60	"	"	"	"
Oxides of Nitrogen	30	"	"	"	"
Sulfur Dioxide	30	"	"	"	"
Carbon Monoxide	40	"	"	"	"

COMPARED WITH SAMPLE 24 (1000 RPM, IN DRIVE AND BRAKINGWITHOUT V-70

Particulates	80	Micrograms	per	cubic	meter
Hydrocarbons	80	"	"	"	"
Oxides of Nitrogen	70	"	"	"	"
Sulfur Dioxide	90	"	"	"	"
Carbon Monoxide	140	"	"	"	"

SAMPLE 26 (1000 RPM, IN DRIVE AND BRAKING) WITH V-70

Particulates	50	Micrograms	per	cubic	meter
Hydrocarbons	40	"	"	"	"
Oxides of Nitrogen	40	"	"	"	"
Sulfur Dioxide	40	"	"	"	"
Carbon Monoxide.	50	"	"	"	"

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

December 22, 1980

OFFICE OF
AIR, NOISE AND RADIATION

Mr. Richard L. Plock
12900 Preston Road
Suite 715, L. B. 4
Dallas, TX 75230

Dear Mr. Plock:

On December 26, 1979 we sent you a suggested test plan for obtaining data from an independent laboratory on your device, the "V-70 Vapor Injector". Since we have not heard from you, we have assumed that you are withdrawing your request for an evaluation at the EPA laboratory.

Recently EPA reevaluated their policy on the amount of data required from an independent laboratory before an EPA evaluation would be considered. Instead of duplicate cold-start tests on three vehicles as required in the past we now require duplicate hot-start tests on only two vehicles. I am enclosing a description of the new test policy along with an application format in case you may wish to reapply for an EPA evaluation of your device.

We would appreciate a response from you informing us of the action you plan to take on this matter. If you do not plan to apply for EPA testing we would like to close out our file on your device.

Sincerely,

Merrill W. Korth

Merrill W. Korth, Device Evaluation Coordinator
Test and Evaluation Branch

Enclosure