EPA-AA-TEB-511-80-4

EPA Evaluation of the "Goodman Engine System"

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By

Thomas J. Penninga

April 1980

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

Billing Code 6560-01

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 610]

[FRL ____________]

FUEL ECONOMY RETROFIT DEVICES

Announcement of Fuel Economy Retrofit Device Evaluation for "Goodman Engine System, Model 1800."

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of Fuel Economy Retrofit Device Evaluation.

SUMMARY: This document announces the conclusions of the EPA evaluation of the Goodman Engine System, Model 1800 under the provisions of Section 511 of the Motor Vehicle Information and Cost Savings Act.

FOR FURTHER INFORMATION CONTACT: F. Peter Hutchins, Emission Control Technology Division, Office of Mobile Source Air Pollution Control, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, Michigan 48105, 313-668-4340.

SUMMARY OF EVALUATION: The overall conclusion of this report is that the Goodman Engine System, Model 1800 device does not have any significant effect on regulated emissions or fuel economy. A small reduction in Nitrous Oxides (NOx) exhaust emissions on the Federal Highway Fuel Economy Test Procedure (HFET) was noted.

The Columbia Broadcasting System (CBS) data generated at the Transporation Research Center cannot be used to evaluate the Goodman Engine System Model 1800 device because too many extraneous variables such as altered timing, higher compression ratio, different camshaft, different test fuels, and 13,000 miles between the "before and after" tests were introduced to make comparative analysis possible. The Environmental Protection Agency data was run on a suitable test vehicle with available unleaded fuel. The Goodman Engine System Model 1800 device was judged by the inventor to be operating properly during the EPA testing. The EPA data does not substantiate the claims made about the device.

The Goodman Engine System Model 1800 device appears to operate safely and does not appear to cause emission of any non-regulated emissions. It is suggested that future installation instructions specify the type of antifreeze to be used in the device. Several antifreeze compounds such as ethylene-glycol are known to cause engine damage.

The reduction in NOx on the HFET cycle does suggest some promise for a better developed water injection system. However, no significant improvement in fuel economy was noted.

Date

David G. Hawkins
Assistant Administrator
for Air, Noise, and Radiation

EPA Evaluation of "Goodman Engine System, Model 1800"
Under Section 511 of the Motor Vehicle Information and Cost Savings Act

The following is a summary of the information on the device as supplied by the applicant and the resulting EPA analysis and conclusions.

1. Marketing Identification of the Device: Goodman Engine System, Model 1800

2. Inventor of the Device and Patents: The inventor of the device is Toronta P. Goodman, P.O. Box 4, Summitt Point, West Virginia 25446. While no patent number has yet been granted an application for a patent, Serial No. 64373, has been made.

3. Manufacturer of the Device:

   Goodman System Corporation
   P.O. Box 4
   Summitt Point, West Virginia 25446

4. Manufacturing Organizations Principals:

   Mitchell Sachs
   Toronta P. Goodman
   Fritz Bell
   H. Crosby Foster, II

(Company Title and Positions are not known to the EPA).

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

   Akin, Gump, Haver & Feld*
   Suite 400
   1333 New Hampshire Avenue, N.W.
   Washington, D.C. 20036

6. Identity of Applicant:

   Edward S. Knight, Esquire
   Akin, Gump, Haver & Feld*
   1333 New Hampshire Avenue, N.W.
   Washington, D.C. 20036

* Note: This law firm provides counsel for Goodman Engine Systems, Inc.

7. Description of the Device: (As supplied by the applicant):

"An injection nozzle injects a finely divided spray of fluid, such as water or a water solution, into the cylinders of the engine in response to a flow of atomizing air. The nozzle is connected to a fluid supply reservoir and to the outlet line of an air-injection pump that normally supplies pressurized air to the exhaust system of the engine. The air-injection pump provides the supply of atomizing air to the nozzle with the pressure of the air and therefore the fluid injection being responsive to both the engine speed and the exhaust gas pressure. The injected fluid advantageously functions as a cooling agent to suppress detonation and provide smoother engine operation and greater fuel efficiency."

8. Claimed Applicability of the Device:

"The Goodman Engine System, Model 1800, is applicable to the vast majority of automobiles and light-duty trucks powered by an internal combustion engine and sold in the United States that have an air injection pump which supplies pressurized air to the exhaust system of the engine, i.e., a smog pump. The device's operation and efficiency is not limited by vehicle make or model, engine size, carburetion, transmission type or ignition type. The only specific vehicle requirements are (1) the existence of the smog pump and (2) the physical availability of a suitable place to locate the device's nozzle downstream of the air filter."

9. Device Installation, Tools Required, Expertise Required (claimed):

See Attachment A.

10. Device Maintenance (claimed):

"Proper maintenance of the Goodman Engine System, Model 1800 does not require special skills or tools. The only maintenance is as follows:

a. Refill water tank: The water level should be checked and water added if necessary at regular intervals, such as when the operator put(s) gasoline into the vehicle.

b. Remove the device's nozzle and flush with ordinary vinegar every 20,000 miles: The tools and skills required are those specified ... on device installation.

c. Add antifreeze to water: During the months of the year when the operator would mix antifreeze with the water in the vehicle's radiator, it is recommended that a mixture of water and antifreeze, at a 1:1 ratio, be utilized in the water tank in lieu of water alone."

11. Effects on Vehicle Emission (non-regulated) (claimed):

"As more fully set forth and documented by the information referred to in the ... test results, the Goodman Engine System, Model 1800, during normal operation and function, will not cause a vehicle utilizing the device to emit into the ambient air any non-regulated substance other than an insignificant amount of water vapor, in a quantity differing from that emitted in the operation of the vehicle without the device."

12. Safety of the Device (claimed):

"The Goodman Engine System, Model 1800, does not interact with the vehicle operator during the device's operation and function. It is not, therefore, operator dependant. Even if the device should fail to function, such malfunction would not result in any unsafe condition endangering the vehicle or its occupants, or person or property in close proximity to the vehicle. The following are three scenarios encompassing the totality of possible device malfunctions.

a. The device is utilized without water in the container:

If this situation should occur, the vehicle will simply operate as if the device had not been installed. That is, the vehicle's fuel economy and emissions will be those the vehicle would report, holding engine tuning, tire pressure, operator performance and the like constant, without the device. In other words, no dangerous or adverse condition will results if the device is utilized on a vehicle without water in the water container.

b. The water container breaks:

If this situation occurs, and the water is lost, the effect on the vehicle will be the same as that described in (a) above. The only difference, of course, is that the water will be spilt onto the ground and subsequently will evaporate.

c. The hoses leak or become disconnected:

If this situation should occur, the effect on the vehicle will be the same as that described in (a) above. As more fully described and documented in the section on test results, such an occurance will not adversely affect the ambient air to any significant degree."

13. Test Results - Regulated Emissions and Fuel Economy (supplied by applicant):

a. Transcript and comments pertaining to a "60 Minutes" television program entitled "Those Crazy Men in their Driving Machines," which was broadcast over the CBS Television network on June 10, 1979.

b. Test results prepared for CBS News by the Transportation Research Center (TRC) of Ohio entitled "Effects of Engine Modifications on Fuel Conumption, Emissions and Performance."

c. Letter from Dr. Engleman, Professor of Engineering at Ohio State University.

14. Information Gathered by EPA:

a. A 1979 Ford Fiesta was tested on seven Federal Test Procedures and seven Highway Fuel Economy Tests. These tests included 3 baseline sequences, 2 sequences with the Goodman Engine System, Model 1800 operating, and two with the Goodman Engine System Model 1800 installed but without fluid in the reservior. A summary of the test data is given in Attachment B. Copies of the original data sheets are given in Attachment C.

b. SAE Paper #690018 entitled "Inlet Manifold Water Injection for Control of Nitrogen Oxides - Theory and Experiment."

c. Contract #DAA D05-72-C-0053, Report #ADA00332 entitled "Water Induction Studies in a Military Spark Ignition Engine."

d. SAE Paper by R. I. Potter - preprinted in 1948 entitled "Use of Anti-Detonant Injection in a High Compression Ratio Engine."

e. SAE Paper by C. H. Hartesveldt - preprinted in 1948 entitled "Anti-Detonant Injection."

f. Taylor and Taylor, Copyright 1961 entitled "The Internal Combustion Engine," Chapter 6 - "Effects of Operating Variables on Detonation."

g. Edward Obert, Copyright 1973 entitled "Internal Combustion Engines and Air Pollution," Chapter 9 - "Knock and the Engine Variables."

h. Henein and Patterson, copyright 1972 entitled "Emissions from Combustion Engines."

i. Verbal discussion with the inventor during the week of 9-21-79 as to the Goodman Device.

j. EPA letter to Edward S. Knight requesting information about the device and supplied test data (see Attachment G). A second letter reaffirming the request for information was sent on 10-23-79 (see Attachment H). The answer was supplied by the inventor on 11-6-79 (see Attachment I).

k. 1978 Ford Fiesta Deterioration Data (see Attachment E).

l. Octane Analysis of Test Fuel - Shell Unleaded (see Attachment F).

15. Analysis:

a. Description of the device: The description given in the application varied slightly from the device supplied by Goodman Systems Corporation for EPA testing. Mr. Goodman, the inventor, stated that the "improved system" does not require a float bowl fluid reservoir and that the height of the reservoir was not critical. He stated that a two (2) foot change in reservoir height would result in only an eight (8) percent change in the amount of water injected. He further stated that the device, as tested, was the Goodman Engine System, Model 1800.

b. Applicability of the device: The applicability requirements stated in the application appear to be correct.

c. Device Installation: The installation is straightforward and does not require any special skills or tools. The installation instructions supplied in the application adequately enable an average "back-yard" mechanic to install the device in less than an hour.

d. Device Maintenance: The maintenance requirements specified in the application appear to be correct. However, because of the proximity of the reference to engine coolant antifreeze and antifreeze for the device - some statement that the types of antifreeze involved are different needs to be included.

e. Effects on Vehicle Emissions (non-regulated): The device, installed according to the installation instructions should have no effect on unregulated emissions.

f. Safety of the Device: The statements made about the safety effects of the device appear to be correct.

g. Test Results Supplied by the Applicant:

1) The transcript of the "60 Minutes" program cannot realistically be considered as test data. Because the thoughts and opinions of the commentators are based mainly on the TRC test data, this test data should be analyzed, not the transcript itself.

2) TRC Test Report: This data is summarized in Attachment D. There are several problems with this data that do not allow extrapolation of the Fuel Economy and Emission improvements to all domestic vehicles with air pumps. The problems are noted below:

a) Different test fuels were used in the before-and-after tests. The baseline test was run on Shell unleaded whereas the modified test sequence was run on Shell Super Unleaded. The use of a higher octane fuel for the after modified tests could decrease the tendency to detonate in the modified engine. This switch in test fuels makes comparisons of "before and after" test data difficult as the differences in fuel economy and exhaust emissions cannot be attributed only to the engine modifications. A letter addressing this problem was sent to the attorney representing Goodman Systems Corporation. This letter requested explanation on the different fuels question and on several of the following points. A copy of the letter is given in Attachment G. When no response to the letter arrived, a second letter prompting a response was sent (see Attachment H). The response dated November 6, 1979 stated that the fuel change was performed without the knowledge of Goodman System Company Inc. personnel. The fuel for the SAE "on-the-road" testing was apparently purchased by driving the vehicle into town and filling it at a local gasoline station. The differences in winter and summer fuel would also add another variable to the submitted test data.

b) The application for evaluation is unclear as to the modifications made to the Fiesta test vehicle engine. The "60 Minutes" transcript mentions different pistons, a reworked head, a modified cam shaft and a compression ratio increase. The EPA September 11, 1979 letter requested clarification of the engine modifications. The November 6, 1979 response answered the questions as shown below:

"The engine modifications are as follows:

The pistons were replaced with a set of Arias forged units having a shallower combustion chamber to raise the compression ratio to a measured 12:6 to 1. To get the necessary exhaust valve clearance at that compression ratio, it was necessary to recess the exhaust valve into the cylinder head approximately .100 inches. During the course of development, several camshafts were tried; both more or less agressive in their action. During the experimentation, the original camshaft was sold to a customer of the shop. When it was determined that the original camshaft was very nearly ideal for the speed range used, a replacement was obtained. There were no Fiesta part number camshafts available, so a Ford replacement for a cc Pinto or Capri was installed.

The valve action is so nearly the same as the original that the difference is undetectable. The major difference is in the width of the lobes, since the Pinto and Capri camshafts sometimes wore prematurely and the Fiesta lobes were made somewhat wider to give more bearing area. The amount of vacuum advance was increased slightly and the mechanical advance was reduced slightly, as is normal when increasing the compression ratio. As we will discuss later, the effect of the water is such that the timing may be adjusted to more optimum conditions of performance and emissions than is the usual case. Also, due to the cooling effect of the water, the EGR valve is no longer required to suppress the formation of NOx, so it was disconnected. The carburetor jetting remained the same."

These modifications make it impossible to extract the effects of the Goodman System Model 1800 device from the other engine modifications. These other changes are <u>not</u> part of the Goodman System Model 1800 device as presented in the application.

c) There was a significant difference in test cell humidity settings between the "before and after" tests. While this parameter is not specified for proper FTP testing, comparison testing with large humidity differences may make comparison of results difficult especially for NOx.

d) No duplicate FTP testing was performed. The variability of the vehicle and emission test equipment is significant, i.e., on the order of 5%. One isolated test at each test point gives low confidence in any comparative analysis.

e) The performance tests differed in transmission shift point rpm. The baseline testing was shifted at 6100 rpm. The modified version was shifted at 5000 rpm. The difference makes comparisons of performance data difficult. Depending on the torque curves for the engine, this difference would widen or narrow the differences in the acceleration data.

f) There was an extended milage interval between the baseline and modified tests. This 13,320 mile interval would by itself cause changes in fuel economy and emissions. This milage interval detracts from the comparability of the two test sequences.

The fuel economy data for the 1978 Fiesta durability vehicle was plotted vs. milage accumulation (see Attachment J). This plot shows fuel economy increases as milage increases. In particular, this graph shows a large increase in fuel economy for this vehicle between 9,200 and 22,520 miles (the CBS Fiesta test points). The improvement is about 13%. While this vehicle may have not been representative, vehicles used in the emissions certification process are supposed to be representative of the production vehicles. The usual equation for fuel economy vs. milage accumulation based on thousands of in-use vehicles is:

$$\frac{\text{mpg at (x miles)}}{\text{mpg at 4000 miles}} = .846 + .018 * (\ln (\text{x miles}))$$

This equation predicts a 1.64% increase in fuel economy between 9,200 and 22,520 miles. A linear fit shows an expected .5 mpg or 2.0% for the 1978 durability vehicle. The chart shows the linear line end points with (+) signs.

What this discussion points out is that testing over a large milage interval introduces significant fuel economy variability. To minimize such variability testing should be run as close together as possible. If possible final baselines should also be run.

g) The performance data showed several instances where the modified vehicle bogged down, detonated badly, stalled, and would only reach 4,700 rpm. This data suggests that the modified engine long term durability is questionable.

h) The increase in HC and CO emissions is significant. A 62.4% increase in HC would put many vehicles over the applicable emission standards.

The exhaust emission standards given in the application while correctly stated, were incorrectly applied. The emission standards for a model year must be in the context of the regulations for which they were intended. Because exhaust emissions on vehicles may deteriorate over the useful life of the vehicles, 50,000 miles of milage accumulation are put on durability vehicles to determine the level of deterioration. The best fit line for their exhaust emission data (each vehicle is tested every 5,000 miles and at each major maintenance point) is calculated and the resulting multiplicative deterioration factors (DF) for HC, CO and NOx are determined. Various calibrations in the same engine family are then run to 4,000 miles and tested (identified as "data vehicles"). The results of these tests are multiplied by the applicable DF and this product must be below the standards listed in the application. A further description of this process can be found in Federal Register 86.078-28. The applicable deterioration factors (4K to 50K miles) for the 1978 Ford Fiesta, 49-state vehicle are:

HC DF	CO DF	NOx DF
1.914	1.462	1.060

Using these DFs, the "before and after" test data supplied in the application compares to the emission standards as follows:

	Baseline	Baseline x DF	Percent of Standard	Modified	Modified x DF	Percent Standard
HC	.58	1.110	74%	.942	1.803	120.2%
CO	6.23	9.108	60.7%	7.926	11.588	77.25%
NOx	1.52	1.611	80.6%	1.576	1.67	83.5%

This analysis, using DFs, shows that the modified version may not have passed the HC standard for 1978 light-duty vehicles. Because the test milage was above 4000 miles and insufficient data was presented to establish a deterioration factor for the modified vehicle, the analysis applied the production DF to the test data as presented. The point here is that the data does <u>not</u> indicate that the vehicle passed the emission standards as indicated in the application.

3) The letter by Dr. Engelman does not supply any test data, only his expert opinion that properly performed water injection will both lower NOx exhaust emissions and lower octane requirements. He expected little improvement in fuel economy with just addition of water injection. However Dr. Engelman states that the decrease in NOx and octane requirements allow alteration to the vehicle engine to improve fuel economy (see Attachment K).

h. The Information Gathered by EPA

1) The MVEL Test Data: The Goodman device was installed by its inventor, Mr. Goodman. Proper operation was confirmed by running the vehicle for 10 minutes at 50 mph and measuring the water consumed. Mr. Goodman said that a quart of fuel would be used in this 10 minute interval. If properly operating, the Goodman System would have injected water at a rate equal to 5% of the fuel consumed. The water used was replaced with water from a 25cc graduated cylinder. The total fluid consumed in the 10 minute test period was 1.69 fluid ounces or 5.28% of the fuel consumed. This 5% expected flow rate was reconfirmed in Mr. Goodman's November 6, 1979 letter. Therefore it appears that the Goodman System Model 1800 device was properly installed and functioning correctly during the MVEL testing. Mr. Goodman stated that "If it was off this is where I would adjust it to ", " the way I want it."

As shown in Attachment B the test results were gathered using an FTP and HFET test cycles. Three baseline test sequences were run. Then two test sequences with the Goodman device installed and operating followed by two sequences with the device installed but without H_2O. If the Goodman System Model 1800 device did reduce NOx and improve fuel economy the expected results would show improved fuel economy and reduced NOx in part B. Part C should agree with part A.

Attachment B also indicates the percent change in emissions and fuel economy for the FTP and HFET testing. Based on test-to-test repeatability it appears that the only statistically significant effect of the Goodman System Model 1800 device was the reduction in NOx on the HFET cycle. The 1.2% increase in fuel economy and the 2.24% decrease in NOx emissions during the Urban Cycle show that no effective change can be attributed to the Goodman System Model 1800 device.

The fuel used in this testing was not Indolene Clear. Instead, at the request of Goodman Systems Inc. Shell Unleaded Fuel was purchased at the local gas station. A 50 gallon drum was purged and drained 3 times with Indolene HO and then drained. The barrel was brought to the gas station and filled from the unleaded pump. All of the subsequent testing was run with this fuel. Shell Unleaded was chosen because similar fuel was used during the TRC testing. A sample of the test fuel was sent to Ethyl Corporation for Octane analysis. Attachment F displays the octane test results. The RON of 91.35 is about mid-range of unleaded fuel tests taken in the 1977-1978 MVMA National Fuel Survey. Extracts of the data are given below (summer fuel - July, 1978):

Location	Shell	Average for all Unleaded Fuel Sampled
Albuquerque	91.8	91.0
Atlanta	96.1	93.2
Baltimore	94.3	91.3
Billings	None	90.7
Boston	95.8	93.1
Chicago	92.6	92.1
Cleveland	95.0	92.4
Detroit	92.2	92.5

16. Conclusions:

The overall conclusion of this report is that the Goodman Engine System Model 1800 does not have any significicnat effect on regulated emissions or fuel economy. A small reduction in NOx exhaust emissions on the HFET cycle was noted.

The CBS data generated at TRC cannot be used to evaluate the Goodman Engine System Model 1800 device. Too many extraneous variables were introduced to make comparative analysis possible. It appears that the "60 Minutes" program did not really evaluate the device properly.

The EPA-MVEL data was run on a suitable test vehicle with available unleaded fuel. The Goodman Engine System Model 1800 device was operating properly during the EPA testing. The EPA data does not substantiate the claims made about the device.

The Goodman Engine System Model 1800 device appears to operate safely and does not appear to emit any non-regulated emissions. It is suggested that future installation instructions specify the antifreeze to be used. Several antifreeze compounds such as ethylene-glycol will cause engine damage.

The reduction in NOx on the HFET cycle does suggest some promise for a better developed water injection system. However, no significant improvement in fuel economy was noted.

List of Attachments

A - Installation Instructions Supplied by the Applicant.

B - Summary of EPA Goodman Engine System, Model 1800 Testing.

C - MVEL Test Data Sheets.

D - TRC Testing Summary

E - 1978 Ford Fiesta Deterioration Factor Data.

F - Octane Analysis of Shell Unleaded Fuel.

G - Copy of EPA September 11, 1979 Letter Requesting Additional Information.

H - Copy of EPA October 16, 1979 Letter Prompting Response.

I - Copy of 11-6-79 Letter from P. Goodman to M. Walsh Responding to EPA September 11, 1979 Letter.

J - Plots of 1978 Ford Fiesta Fuel Economy.

K - August 22, 1979 Letter from Dr. Engelman of Ohio State University.

Installation Instructions
for the
GOODMAN ENGINE SYSTEM
MODEL 1800

1. Locate the air-injection pump (Fig. 1, No. 20). Identify intake hose (Fig. 1, No. 32) and output hose (Fig.1, No. 26). The intake hose will either have its own air cleaner or will share one with the engine air cleaner (Fig.1, No. 36). The output hose goes from the air-injection pump through a valve (Fig. 1, No. 31) that regulates air flow to a distribution manifold (Fig. 1, No. 16). Although the valve on some vehicles is built directly into the air-injection pump and the distribution manifold is part of the cylinder head, the basic layout and operation is identical.

Tap into the air pressure line (Fig. 1, No. 26) between the control valve (Fig., 1 No. 24) and the anti-backfire valve (Fig.1, No. 31). To do this take part No. 44 (Fig. 2) and insert it into the air pressure line (Fig. 1, No. 30).

3. Remove the top of the engine air cleaner (Fig.1, No. 36). The fluid injection nozzle, Part No. 34 (See Figs. 4 & 5), must be positioned so that the fluid spray will be evenly divided among the cylinders. Utilize the below listed applications for the following carburetor configurations:

(1) SINGLE-BARREL CARBURETOR:

Position the fluid injection nozzle at the lower side of the chock plate, as close to the center as possible.

(2) TWO-BARREL, SINGLE CARBURETOR:

With both barrels open at the same time, position the fluid injection nozzle at the center of the two barrels on the lower side of the choke plate. (This configuration is generally found on American made 6-cylinder and V-8 engines.)

(3) TWO-BARREL OR SINGLE-BARREL CARBURETOR WITH A PRIMARY AND SECONDARY THROTTLE OPENING

Position the fluid injection nozzle at the primary side of the carburator -- usually the side nearest to the engine. (This configuration is generally found on imports such as the Capri, Fiat, Fiesta and Pinto).

(4) FOUR-BARREL, SINGLE CARBURETOR

Position the fluid injection nozzle at the center of the primary side.

(5) TWO OR MORE CARBURETORS, SINGLE BARREL EACH

Unless all carburetors are fed from a common air box that lends itself to an appropriate placement of the fluid injection nozzle so that it can be positioned without the fluid spray impacting the side or favoring one carburetor, position each fluid injection nozzle at the center of each carburetor.

(6) TWO OR MORE CARBURETORS WITH TWO OR MORE BARRELS

Same installation as specified in (5), with fluid injection nozzle positioned over the primary side unless all barrels open at the same time. If this is so, a separate fluid injection nozzle must be utilized for each barrel.

(7) FUEL INJECTION WITH ONE THROTTLE PLATE

Position the fluid injection nozzle at the center of the throttle plate, on the atmospheric side.

(8) FUEL INJECTION WITH MULTIPLE THROTTLE PLATES

Same installation as (5).

4. After determining the appropriate fluid nozzle application by following the procedures indicated in STEP 3, remove the ngine air cleaner from the vehicle (Fig., 1, No. 36). Remove the

top of the engine air cleaner. Drill a 3/4 inch hole in the top : the engine air cleaner in the appropriate position for the fluid injection nozzle as determined by the procedures in STEP 3.

5. Insert fluid injection nozzle into the hole drilled in the top of the engine air cleaner. Check for proper placement of fluid injection nozzle as specified in STEP 3. If the hole has been misplaced, a patch kit will be supplied and a new hole can be drilled. Press retaining washer.

6. Install fluid storage container in engine compartment using brackets provided. The fluid storage container may be placed anywhere in the engine compartment so long as the top of the ntainer is at least three inches below the fluid injection nozzle, but not lower than eighteen inches.

7. Connect Hose No. 40 (Fig. 1) to the bottom fitting of the fluid storage container. Place the non-spring loaded, one-way valve on the opposite end of Hose No. 40. Connect this end of Hose No. 40 to the top fitting on the fluid injection nozzle (Fig. 1, No. 34).

8. Connect Hose No. 42 (Fig. 1) to Part No. 44. In the opposite end of Hose No. 42, insert the spring-loaded, one-way valve, and then insert this into the bottom fitting of the fluid injection nozzle (Fig. 1, No. 34).

9. Examine the installation to ensure proper application. Make sure that none of the hoses are crimped or interfere with any of the engine's moving parts. If fluid injection nozzle does not fit snugly, seal with a small bead of conventional silicone sealant.

10. Fill fluid storage container with water. If outside temperatures will fall near or below 32° F, add antifreeze in a 1:1 ratio.

Goodman Engine System Model 1800
EPA Testing Summary

I. Federal Test Procedure

A. Baseline Data

Date	HC (gm/mi)	CO (gm/mi)	NOx (gm/mile)	Fuel Economy (mi/gal)
9-11-79	.31	4.4	1.40	26.2
9-12-79	.30	3.6	1.31	26.2
9-13-79	.30	4.5	1.31	26.3
Average	.303	4.17	1.34	26.23
Std. Dev.	.006	.49	.052	0.057
s/m̄	1.90%	11.84%	3.88	0.22%

B. With Goodman Engine System Model 1800 Installed and Operating

Date	HC (gm/mi)	CO (gm/mi)	NOx (gm/mile)	Fuel Economy (mi/gal)
9-18-79	.33	4.7	1.30	26.5
9-19-79	.31	4.5	1.32	26.6
Average	.32	4.6	1.31	26.55
Percent Change	(+)5.61%	(+)10.31%	(-)2.24%	(+)1.22%

C. With Goodman Engine System Model 1800 Installed but no Fluid in Reservoir

Date	HC (gm/mi)	CO (gm/mi)	NOx (gm/mile)	Fuel Economy (mi/gal)
9-20-79	.29	4.4	1.49	27.0
9-21-79	.32	4.3	1.48	26.9
Average	.305	4.35	1.485	26.95
Percent Change/Baseline	(+)0.66%	(+)4.32%	(+)10.82%	(+)2.74%
Percent Change/Part B	(-)4.69%	(-)5.43%	(+)13.36	(+)1.50%

II. Highway Fuel Economy Test

A. Baseline Data

Date	HC (gm/mi)	CO (gm/mi)	NOx (gm/mile)	Fuel Economy (mi/gal)
9-11-79	.06	.3	2.20	38.3
9-12-79	.06	.2	2.17	38.5
9-13-79	.06	.2	2.15	38.6
Average	.06	.23	2.173	38.47
Std. Dev.	0.0	.058	.025	.15
$s/\sqrt{m}$	0.0%	24.7%*	1.16%	.39%

B. With Goodman Engine System Model 1800 Installed and Operating

9-18-79	.06	.2	1.86	38.5
9-19-79	.06	.2	2.00	39.0
Average	.06	.2	1.93	38.75
Percent Change	0.0%	(-)13.0%*	(-)5.146%	(+).73%

C. With Goodman Engine System Model 1800 Installed but no Fluid in Reservoir

9-20-79	.06	.2	2.23	38.8
9-21-79	.06	.2	2.29	39.0
Average	.06	.2	2.26	38.9
Percent Change/Baseline	0.0%	(+)13.0%*	(+)4.0%	(+)1.12%
Percent Change/Part B	0.0%	0.0%	(+)17.1%	(+)0.387%

* Extremely low numbers make comparative analysis questionable.

VEHICLE SPECIFICATION REPORT - (STANDARD) - DATE OF ENTRY : 9/10/79

VEHICLE SPECIFICATIONS

MANUFACTURER	VEHICLE ID / VER		REPRESENTED CARLINE	MODEL CODE	DRIVE CODE	SOURCE
FORD	GCFH•E34449	0		SEDAN	FRONT DRIVE STR. LEFT	OTHER

VEHICLE TYPE	ACTUAL VEHICLE MODEL	MODEL YEAR	ACT YEAR	DRIVE AXL WTS FULL TANK	DRIVE AXL WTS EMPTY TANK	CURB WEIGHT	INRTIA CLASS	O/D CDE	ACTUAL DYNO HP	TIRE & RIM SIZES	TIRE - SPECIFICATIONS MFR	CONSTR	SWL N	SWL H	ALT N	ALT H	PSI FT	PSI RR
NON-CER	FIESTA	79	79			1900P	2000P	2	7.3	145SR12								

PRIMARY DURABILITY VEHICLE IDENTIFICATION OR ASSIGNED DF (IF APPLICABLE) — ALT. MANUFACTURER

ENGINE SPECIFICATIONS

DISPLACEMENT	BORE	STROKE	RATED HP	ENGINE TYPE	ENGINE CONFIGURATION	NO. CYL	NO. CARBS	TOTAL NO. BARRELS	FUEL SYSTEM MFR/MODEL	FUEL INJECTION	COMP. RATIO	COAST-DOWN TM
98. E	3.2 E	3.1 E	66	OTTO SPARK	IN-LINE	4	1	2	WEBER		8.6	

IGNITION TIMING 1	IGNITION TIMING 2	TIM. TOL.	TIMING RPM	RPM TOL.	TIM. GEAR	% CO LEFT	% CO RIGHT	% CO COMB.	CO TOL.	IDLE RPM	IDLE TOL.	IDLE GEAR	ENGINE FAMILY	ENGINE CODE
12B			850										1.6H(1X89)	

DRIVE TRAIN AND CONTROL SYSTEM SPECIFICATIONS

AXLE RATIO	N/V RATIO	ODOMETER	A/C INSTALLED	EXHAUST TYPE	CRANKCASE SYSTEM	TRANSMISSION CONFIGURATION	TRANSMISSION CODE	EVAPORATION SYSTEM	FUEL TYPE
3.58	.	MILES	NO	SINGLE RIGHT REAR	CLOSED	M-4		CANISTER	UNLEADED (AT EPA-IND HO)

MAIN-TANK CAPACITY	MAIN-TANK VOLUME	AUX.-TANK CAPACITY	AUX.-TANK VOLUME	SHIFT SPEED	EVAPORATIVE EMISSION FAMILY	CODE	SALES CLASS
.				SPECIAL SHIFT SPDS (MAN OR S-A)	C-2		

CONTROL SYSTEM TYPES

EXHAUST RECYCLE	AIR PUMP	OXIDATION CATALYST		

VEHICLE SPECIFICATION COMMENTS

SHIFT SPEEDS PF: 1-2 @ 10MPH, 2-3@20MPH, 3-4@40MPH

DYNO SITE:D207 TEST # 79-9897

1979 LIGHT DUTY VEHICLE ANALYSIS

PROCESSED: 15:30:01 SEP 13, 1979

MFR. CODE	VEHICLE I.D.	VER-SION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			EXPERIMENTAL / CVS 75-LATER

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	#2	RPM	GEAR	% CO LEFT	RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
28.99	63.7	71.6	F	27C

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-13-79	10	D207	2000	5.3		2239.0	45.00	1.0127	65.2	

BAG 1 3.602 MILES 5.797 KM 8399. ROLL REVS. VMIX= 2797.0 CU.FT. DILUTION FACTOR = 15.208

SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	48.0	72.13	15	2.6	3.87	68.51 PPM	3.13	0.869	0.540			
NOX-CHEM	16	57.1	58.26	16	0.1	0.11	58.16 PPM	8.92	2.477	1.539	MPG	KPL	L/100KM
CO2	23	35.3	0.836	23	2.0	0.042	0.797 %	1154.54	320.501	199.150	26.2	11.14	9.0
CO	18	76.7	379.71	18	0.0	0.0	379.71 PPM	35.01	9.720	6.040			

BAG 2 3.905 MILES 6.284 KM 9104. ROLL REVS. VMIX= 4743.0 CU.FT. DILUTION FACTOR = 22.137.

SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	14.3	10.55	14	4.9	3.60	7.11 PPM	0.55	0.141	0.088			
NOX-CHEM	14	39.5	10.00	14	0.3	0.08	9.93 PPM	2.58	0.661	0.411	MPG	KPL	L/100KM
CO2	23	26.0	0.595	23	1.9	0.040	0.557 %	1367.74	350.284	217.656	24.9	10.57	9.5
CO	17	39.3	96.34	17	0.0	0.0	96.34 PPM	15.06	3.858	2.397			

BAG 3 3.581 MILES 5.763 KM 8349. ROLL REVS. VMIX= 2764.0 CU.FT. DILUTION FACTOR = 17.171

SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	22.8	16.87	14	4.9	3.60	13.48 PPM	0.61	0.170	0.106			
NOX-CHEM	15	79.3	39.72	15	0.2	0.10	39.63 PPM	6.01	1.678	1.042	MPG	KPL	L/100KM
CO2	23	32.9	0.772	23	1.9	0.040	0.735 %	1051.89	293.755	182.531	29.9	12.70	7.9
CO	17	27.1	66.09	17	0.0	0.0	66.09 PPM	6.02	1.682	1.045			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.30	4.5	329.	1.31
BEFORE ROUNDING	0.2990	4.474	328.72	1.3130
GRAMS/KM	0.186	2.78	204.	0.82
BEFORE ROUNDING	0.16583	2.7802	204.26	0.8158

	MPG	KPL	L/100KM
WEIGHTED VALUES	26.3	11.2	8.9
	26.3131	11.2113	8.9195
72-74 FTP	25.5	10.8	9.2
	25.4928	10.8381	9.2266
UNWEIGHTED FTP	26.8	11.4	8.8
	26.7616	11.3775	8.7892

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40

DYNO SITE:0207 TEST # 79-9898 | 1979 HIGHWAY FUEL ECONOMY ANALYSIS | PROCESSED: 08:23:47 SEP 14, 1979

VER. CODE	VEHICLE I.D.	VER-SION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCF8WE34449	0							2000	7.3			EXPERIMENTAL / HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMINGS #1	#2	RPM	GEAR	% CO LEFT	RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
28.97	62.8	71.7	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVD H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-13-79	11	0207	2000	5.3		2250.0	45.00	0.9915	61.2	

BAG 1 10.241 MILES 16.481 KM 23877. ROLL REV. VMIX= 4059.0 CU.FT. DILUTION FACTOR = 11.545

SITE #A2IS	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	16.1	11.99	14	5.9	3.69	8.51 PPM	0.56	0.055	0.034			
NOX-CHEM	17	39.9	100.95	17	0.0	0.0	100.95 PPM	22.01	2.149	1.335	MPG	KPL	L/100KM
CO2	23	46.8	1.158	23	2.1	0.044	1.118 %	2350.25	229.500	142.605	38.6	16.39	6.1
CO	17	6.7	16.18	17	0.0	0.0	16.18 PPM	2.17	0.211	0.131			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.2	229.	2.15
BEFORE ROUNDING	0.0552	0.211	229.49	2.1469
GRAMS/KM	0.034	0.13	143.	1.34
BEFORE ROUNDING	0.03430	0.1314	142.60	1.3352

	MPG	KPL	L/100KM
WEIGHTED VALUES	38.6	16.3	6.1
	38.6403	16.3469	6.1173
72-74 FTP	38.6	16.4	6.1
	38.5737	16.3993	6.0977
UNWEIGHTED FTP	38.6	16.4	6.1
	38.5737	16.3993	6.0977

COMMENTS: FIESTA: TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40

DYNO SITE:D207 TEST # 79-9893

1979 LIGHT DUTY VEHICLE ANALYSIS

PROCESSED: 15:07:58 SEP 11, 1979

MFR. CODE	VEHICLE I.D.	VER-SION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFHWE34449	0							2000	7.3			EXPERIMENTAL / CVS 75-LATER

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	RPM	GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.26	63.0	71.0	F	27C

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-11-79	10	D207	2000	5.3		2157.6	45.00	0.9974	64.4	

BAG 1 3.585 MILES 5.770 KM 8359. ROLL REVS. VMIX= 2854.0 CU.FT. DILUTION FACTOR = 15.418

SITE #A215	EXHAUST SAMPLE RANGE	EXHAUST METER	EXHAUST CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND METER	BACKGROUND CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	49.6	74.54	15	2.8	4.17	70.65 PPM	3.29	0.918	0.571			
NOX-CHEM	16	56.9	58.06	16	0.2	0.21	57.86 PPM	8.92	2.488	1.546	MPG	KPL	L/100KM
CO2	23	34.8	0.823	23	2.2	0.046	0.779 %	1152.36	321.427	199.726	26.0	11.07	9.0
CO	18	78.9	391.18	18	0.1	0.47	390.74 PPM	36.77	10.255	6.372			

BAG 2 3.821 MILES 6.150 KM 8910. ROLL REVS. VMIX= 4798.0 CU.FT. DILUTION FACTOR = 22.459

SITE #A215	EXHAUST SAMPLE RANGE	EXHAUST METER	EXHAUST CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND METER	BACKGROUND CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	14.1	10.40	14	5.1	3.75	6.82 PPM	0.53	0.140	0.087			
NOX-CHEM	14	43.8	11.08	14	0.5	0.13	10.95 PPM	2.84	0.743	0.462	MPG	KPL	L/100KM
CO2	23	25.7	0.587	23	2.1	0.044	0.545 %	1354.82	354.531	220.295	24.6	10.46	9.6
CO	17	34.7	84.90	17	0.2	0.48	84.44 PPM	13.36	3.496	2.172			

BAG 3 3.576 MILES 5.755 KM 8338. ROLL REVS. VMIX= 2803.0 CU.FT. DILUTION FACTOR = 17.347

SITE #A215	EXHAUST SAMPLE RANGE	EXHAUST METER	EXHAUST CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND METER	BACKGROUND CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	22.1	16.35	14	5.2	3.82	12.75 PPM	0.58	0.163	0.101			
NOX-CHEM	15	86.2	43.13	15	0.2	0.10	43.03 PPM	6.52	1.822	1.132	MPG	KPL	L/100KM
CO2	23	32.6	0.764	23	2.0	0.042	0.725 %	1052.33	294.266	182.849	29.8	12.67	7.9
CO	17	27.3	66.58	17	0.1	0.24	66.36 PPM	6.13	1.715	1.066			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.31	4.4	331.	1.40
BEFORE ROUNDING	0.3083	4.411	331.03	1.4035
GRAMS/KM	0.192	2.74	206.	0.87
BEFORE ROUNDING	0.19157	2.7413	205.69	0.8720

	MPG	KPL	L/100KM
WEIGHTED VALUES	26.2	11.1	9.0
	26.1675	11.1073	9.0030
72-74 FTP	25.3	10.8	9.3
	25.2929	10.7531	9.2996
UNWEIGHTED FTP	26.6	11.3	8.8
	26.6095	11.3128	8.8394

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40
1 FALSE START ON BAG 1

6110 0

DYNO SITE:D207 TEST # 79-9894

1979 HIGHWAY FUEL ECONOMY ANALYSIS

PROCESSED: 15:11:01 SEP 11, 1979

MFR. CODE	VEHICLE I.D.	VER-SION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE: EXPERIMENTAL / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	RPM	GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS -/

BARO MHG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.26	62.0	71.3	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-11-79	11	0207	2000	5.3		2169.0	45.00	0.9734	59.3	

BAG 1 10.198 MILES 16.413 KM 23778. ROLL REVS. VMIX= 4132.0 CU.FT. DILUTION FACTOR = 11.715

SITE #A215

	EXHAUST SAMPLE RANGE	EXHAUST SAMPLE METER	EXHAUST SAMPLE CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND SAMPLE METER	BACKGROUND SAMPLE CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	MASS EMISSIONS GMS/MI	MASS EMISSIONS GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	17.2	12.70	14	5.0	3.68	9.34 PPM	0.63	0.062	0.038			
NOX-CHEM	17	40.7	102.96	17	0.0	0.0	102.96 PPM	22.43	2.199	1.367	MPG	KPL	L/100KM
CO2	23	46.2	1.140	23	2.0	0.042	1.102 %	2359.13	231.326	143.739	38.2	16.25	6.2
CO	17	9.0	21.76	17	0.3	0.72	21.10 PPM	2.88	0.282	0.175			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.3	231.	2.20
BEFORE ROUNDING	0.0618	0.281	231.32	2.1992
GRAMS/KM	0.038	0.18	144.	1.37
BEFORE ROUNDING	0.03840	0.1751	143.73	1.3665

	MPG	KPL	L/100KM
WEIGHTED VALUES	38.3	16.2	6.2
	38.2805	16.2233	6.1639
72-74 FTP	38.2	16.3	6.1
	38.2481	16.2609	6.1496
UNWEIGHTED FTP	38.2	16.3	6.1
	38.2481	16.2609	6.1496

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40

6110 0

DYNO SITE:D207 TEST # 79-9896 | 1979 HIGHWAY FUEL ECONOMY ANALYSIS | PROCESSED: 12:58:41 SEP 13, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	VER. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFH.E34449	0							2000	7.3			EXPERIMENTAL / HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT (GAUGE EMPTY)	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	RPM	GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.17	62.5	70.3	F	27

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-12-79	11	0207	2000	5.3		2210.0	45.00	0.9891	63.1	

BAG 1 10.191 MILES 16.401 KM 23761. ROLL REVS. VMIX= 4103.0 CU.FT. DILUTION FACTOR = 11.723

SITE #A215

	EXHAUST SAMPLE RANGE	EXHAUST SAMPLE METER	EXHAUST SAMPLE CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND SAMPLE METER	BACKGROUND SAMPLE CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	MASS EMISSIONS GMS/MI	MASS EMISSIONS GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	17.6	12.56	14	5.2	3.82	9.06 PPM	0.51	0.060	0.037			
NOX-CHEM	16	101.4	100.68	16	0.0	0.0	100.68 PPM	22.13	2.171	1.349	MPG	KPL	L/100KM
CO2	23	46.2	1.150	23	1.9	0.040	1.104 %	2346.67	230.269	143.083	38.4	16.34	6.1
CO	17	5.5	14.00	17	0.0	0.0	14.00 PPM	1.89	0.186	0.116			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.2	230.	2.17
BEFORE ROUNDING	0.0595	0.185	230.26	2.1714
GRAMS/KM	0.037	0.12	143.	1.35
BEFORE ROUNDING	0.03700	0.1155	143.08	1.3492

	MPG	KPL	L/100KM
WEIGHTED VALUES	38.5	16.3	6.1
	38.4726	16.3476	6.1170
72-74 FTP	38.4	16.3	6.1
	38.4495	16.3465	6.1174
UNWEIGHTED FTP	38.4	16.3	6.1
	38.4495	16.3465	6.1174

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECAIL SHIFT SPEED OF 10-20-40

6110 0

DYNO SITE:D207 TEST # 79-9896

DYNO SITE:D207 TEST # 79-9895

1979 LIGHT DUTY VEHICLE ANALYSIS

PROCESSED: 13:38:40 SEP 13, 1979

MFR. CODE	VEHICLE I.D.	VER-SION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCF8#E34449	0							2000	77.3			EXPERIMENTAL / CVS 75-LATER

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	#2	RPM	GEAR	% CO LEFT	RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.18	63.2	70.6	F	27C

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-12-79	09	D207	2000	5.3		2198.8	45.00	1.0062	66.7	

BAG 1 3.572 MILES 5.749 KM 8328. ROLL REVS. VMIX= 2837.0 CU.FT. DILUTION FACTOR = 15.313
SITE #A215

	EXHAUST RANGE	METER	CONC.	BACKGROUND RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	48.1	72.28	15	3.0	4.46	68.10 PPM	3.15	0.883	0.549			
NOX-CHEM	16	54.6	55.79	16	0.2	0.21	55.59 PPM	8.60	2.406	1.495	MPG	KPL	L/100KM
CO2	23	35.5	0.841	23	2.1	0.044	0.800 %	1176.01	329.245	204.584	25.9	10.99	9.1
CO	18	54.4	265.49	18	0.3	1.42	264.15 PPM	24.71	6.917	4.298			

BAG 2 3.825 MILES 6.156 KM 8918. ROLL REVS. VMIX= 4782.0 CU.FT. DILUTION FACTOR = 22.482
SITE #A215

	EXHAUST RANGE	METER	CONC.	BACKGROUND RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	14.3	10.55	14	5.8	4.26	6.48 PPM	0.51	0.132	0.082			
NOX-CHEM	14	39.9	10.10	14	1.0	0.26	9.86 PPM	2.57	0.672	0.417	MPG	KPL	L/100KM
CO2	23	25.7	0.587	23	2.0	0.042	0.547 %	1355.30	354.338	220.175	24.6	10.48	9.5
CO	17	32.1	78.45	17	0.4	0.96	77.53 PPM	12.22	3.196	1.986			

BAG 3 3.554 MILES 5.719 KM 8286. ROLL REVS. VMIX= 2789.0 CU.FT. DILUTION FACTOR = 17.510
SITE #A215

	EXHAUST RANGE	METER	CONC.	BACKGROUND RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	22.7	16.80	14	5.8	4.26	12.78 PPM	0.58	0.164	0.102			
NOX-CHEM	15	79.7	39.92	15	0.3	0.15	39.78 PPM	6.05	1.701	1.057	MPG	KPL	L/100KM
CO2	23	32.3	0.756	23	2.0	0.042	0.717 %	1035.65	291.419	181.080	30.1	12.78	7.8
CO	17	30.0	73.26	17	0.2	0.48	72.80 PPM	6.69	1.884	1.170			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.30	3.6	332.	1.31
BEFORE ROUNDING	0.2968	3.608	331.85	1.3144
GRAMS/KM	0.184	2.24	206.	0.82
BEFORE ROUNDING	0.18444	2.2421	206.20	0.8167

	MPG	KPL	L/100KM
WEIGHTED VALUES	26.2	11.2	9.0
	26.1899	11.1502	8.9683
72-74 FTP	25.2	10.7	9.3
	25.2313	10.7269	9.3223
UNWEIGHTED FTP	26.6	11.3	8.8
	26.6256	11.3197	8.8341

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40
ROLL REVS FOR BAG 1 CALCULATED FROM PAST DATA

6110 0

DYNO SITE:D207 TEST # 79-9900

1979 HIGHWAY FUEL ECONOMY ANALYSIS

PROCESSED: 09:00:47 SEP 19, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVERDRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			EXPERIMENTAL / HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	IGNITION TIMING RPM	IGNITION TIMING GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.01	62.0	71.4	F	27C

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-18-79	11	D207	2000	5.3		2315.0	45.00	0.9759	59.1	

BAG 1 10.216 MILES 16.441 KM 23019. ROLL REVS. VMIX= 4082.0 CU.FT. DILUTION FACTOR = 11.632

SITE #A215	EXHAUST SAMPLE RANGE	EXHAUST SAMPLE METER	EXHAUST SAMPLE CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND SAMPLE METER	BACKGROUND SAMPLE CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	MASS EMISSIONS GMS/MI	MASS EMISSIONS GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	17.1	12.63	14	4.6	3.38	9.54 PPM	0.64	0.062	0.039			
NOX-CHEM	16	87.9	88.01	16	0.1	0.11	87.91 PPM	18.97	1.857	1.154	MPG	KPL	L/100KM
CO2	23	46.5	1.149	23	1.9	0.040	1.113 %	2353.17	230.345	143.130	38.4	16.33	6.1
CO	17	6.9	16.67	17	0.0	0.0	16.67 PPM	2.24	0.220	0.136			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.2	230.	1.86
BEFORE ROUNDING	0.0622	0.219	230.34	1.8567
GRAMS/KM	0.039	0.14	143.	1.15
BEFORE ROUNDING	0.03867	0.1364	143.12	1.1537

	MPG	KPL	L/100KM
WEIGHTED VALUES	38.5	16.3	6.1
	38.4726	16.3433	6.1187
72-74 FTP	38.4	16.3	6.1
	38.4266	16.3368	6.1211
UNWEIGHTED FTP	38.4	16.3	6.1
	38.4266	16.3368	6.1211

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40

6110 0

DYNO SITE:D207 TEST # 79-9901

1979 LIGHT DUTY VEHICLE ANALYSIS

PROCESSED: 09:20:29 SEP 21, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			EXPERIMENTAL / CVS 75-LATER

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	#2	RPM	GEAR	% CO LEFT	RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.26	62.1	70.7	F	276

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-19-79	10	D207	2000	5.3		2345.	45.	0.9800	61.8	

BAG 1 3.546 MILES 5.706 KM 8267. ROLL REVS. VMIX= 2835.0 CU.FT. DILUTION FACTOR = 15.623

SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	44.0	66.09	15	2.6	3.87	62.47 PPM	2.89	0.816	0.507			
NOX-CHEM	16	54.0	55.20	16	0.0	0.0	55.20 PPM	8.31	2.342	1.456			
CO2	23	34.5	0.815	23	2.1	0.044	0.773 %	1135.77	320.325	199.041			
CO	18	74.1	366.20	18	0.1	0.47	365.75 PPM	34.19	9.642	5.991			

MPG	KPL	L/100KM
26.2	11.15	9.0

BAG 2 3.818 MILES 6.144 KM 8901. ROLL REVS. VMIX= 4809.0 CU.FT. DILUTION FACTOR = 22.813

SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	15.5	11.44	14	5.2	3.82	7.79 PPM	0.61	0.160	0.100			
NOX-CHEM	14	42.3	10.70	14	0.1	0.03	10.68 PPM	2.73	0.714	0.444			
CO2	23	25.3	0.577	23	2.2	0.046	0.533 %	1327.92	347.841	216.138			
CO	17	37.2	91.11	17	0.0	0.0	91.11 PPM	14.45	3.784	2.351			

MPG	KPL	L/100KM
25.0	10.64	9.4

BAG 3 3.546 MILES 5.706 KM 8267. ROLL REVS. VMIX= 2802.0 CU.FT. DILUTION FACTOR = 17.796

SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	26.9	19.94	14	4.8	3.53	16.61 PPM	0.76	0.214	0.133			
NOX-CHEM	15	91.2	40.66	15	0.1	0.05	40.61 PPM	6.04	1.703	1.058			
CO2	23	31.8	0.743	23	2.2	0.046	0.700 %	1015.61	286.436	177.983			
CO	17	31.9	77.96	17	0.0	0.0	77.96 PPM	7.20	2.031	1.262			

MPG	KPL	L/100KM
30.5	12.99	7.7

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.31	4.5	325.	1.32
BEFORE ROUNDING	0.3107	4.515	325.28	1.3226
GRAMS/KM	0.193	2.81	202.	0.82
BEFORE ROUNDING	0.19308	2.8060	202.12	0.8218

	MPG	KPL	L/100KM
WEIGHTED VALUES	26.6	11.3	8.8
	26.6266	11.3159	8.8370
72-74 FTP	25.6	10.9	9.2
	25.6069	10.8866	9.1855
UNWEIGHTED FTP	27.0	11.5	8.7
	27.0313	11.4921	8.7015

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40
DEVICE INSTALLED

6110 0

DYNO SITE:D207 TEST # 79-9901

DYNO SITE:0207 TEST # 79-9902

1979 HIGHWAY FUEL ECONOMY ANALYSIS

PROCESSED: 07:08:07 SEP 24, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVERDRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			EXPERIMENTAL / HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	#2	RPM	GEAR	% CO LEFT	RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.26	61.8	71.3	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-19-79	11	0207	2000	5.3		2356.	45.	0.9692	58.5	

BAG 1 10.163 MILES 16.355 KM 23695. ROLL REVS. VMIX= 4124.0 CU.FT. DILUTION FACTOR = 11.872

SITE #A215	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	16.1	11.89	14	4.5	3.31	8.86 PPM	0.60	0.059	0.036			
NOX-CHEM	16	94.2	93.95	16	0.0	0.0	93.95 PPM	20.34	2.001	1.244	MPG	KPL	L/100KM
CO2	23	45.7	1.126	23	2.3	0.048	1.082 %	2311.06	227.407	141.304	38.9	16.54	6.0
CO	17	6.9	16.67	17	0.0	0.0	16.67 PPM	2.27	0.223	0.139			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.2	227.	2.00
BEFORE ROUNDING	0.0586	0.223	227.40	2.0012
GRAMS/KM	0.036	0.14	141.	1.24
BEFORE ROUNDING	0.03647	0.1385	141.30	1.2435

	MPG	KPL	L/100KM
WEIGHTED VALUES	39.0	16.6	6.0
	38.9800	16.5756	6.0329
72-74 FTP	38.9	16.5	6.0
	38.9230	16.5478	6.0430
UNWEIGHTED FTP	38.9	16.5	6.0
	38.9230	16.5478	6.0430

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40
DEVICE INSTALLED

DYNO SITE:0207 TEST # 79-9903 | 1979 LIGHT DUTY VEHICLE ANALYSIS | PROCESSED: 09:20:37 SEP 21, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	MFR. REP. INIT.	RON. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFB*E34449	0							2000	7.3			EXPERIMENTAL / CVS 75-LATER

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	RPM	GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME
			EMPTY												

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.13	61.0	70.3	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-~~19~~ 20-79	08	D207	2000	5.3		2386.	45.	0.9619	58.8	

BAG 1 3.585 MILES 5.770 KM 8359. ROLL REVS. VMIX= 2809.0 CU.FT. DILUTION FACTOR = 15.641
SITE #A215

	EXHAUST RANGE	EXHAUST METER	EXHAUST CONC.	BACKGROUND RANGE	BACKGROUND METER	BACKGROUND CONC.	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	45.0	67.60	15	2.6	3.97	63.98 PPM	2.94	0.819	0.509			
NOX-CHEM	15	67.7	68.63	16	0.0	0.0	68.63 PPM	10.04	2.801	1.741	MPG	KPL	L/100KM
CO2	23	34.3	0.809	23	2.0	0.042	0.770 %	1120.47	312.532	194.198	26.7	11.37	8.8
CO	18	82.1	407.94	18	0.0	0.0	407.94 PPM	37.78	10.538	6.548			

BAG 2 3.883 MILES 6.249 KM 9053. ROLL REVS. VMIX= 4784.0 CU.FT. DILUTION FACTOR = 22.937
SITE #A215

	EXHAUST RANGE	EXHAUST METER	EXHAUST CONC.	BACKGROUND RANGE	BACKGROUND METER	BACKGROUND CONC.	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	14.3	10.55	14	4.8	3.53	7.18 PPM	0.56	0.144	0.090			
NOX-CHEM	14	48.6	12.27	14	0.3	0.08	12.20 PPM	3.04	0.783	0.487	MPG	KPL	L/100KM
CO2	23	25.2	0.575	23	2.0	0.042	0.535 %	1324.83	341.205	212.015	25.5	10.86	9.2
CO	17	34.8	85.15	17	0.0	0.0	85.15 PPM	13.43	3.459	2.149			

BAG 3 3.582 MILES 5.764 KM 8351. ROLL REVS. VMIX= 2781.0 CU.FT. DILUTION FACTOR = 17.608
SITE #A215

	EXHAUST RANGE	EXHAUST METER	EXHAUST CONC.	BACKGROUND RANGE	BACKGROUND METER	BACKGROUND CONC.	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	22.6	16.73	14	4.8	3.53	13.40 PPM	0.61	0.170	0.106			
NOX-CHEM	15	92.1	46.04	15	0.2	0.10	45.94 PPM	6.66	1.858	1.155	MPG	KPL	L/100KM
CO2	23	32.2	0.754	23	2.0	0.042	0.714 %	1028.88	287.260	178.495	30.6	13.00	7.7
CO	17	23.3	56.73	17	0.0	0.0	56.73 PPM	5.20	1.452	0.902			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.29	4.4	321.	1.49
BEFORE ROUNDING	0.2905	4.371	320.53	1.4938
GRAMS/KM	0.181	2.72	199.	0.93
BEFORE ROUNDING	0.18052	2.7163	199.16	0.9282

	MPG	KPL	L/100KM
WEIGHTED VALUES	27.0	11.5	8.7
	26.9683	11.4924	8.7013
72-74 FTP	26.1	11.1	9.0
	26.1179	11.1038	9.0058
UNWEIGHTED FTP	27.4	11.7	8.6
	27.4160	11.6557	8.5794

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40
DEVICE INSTALLED, WATER RESERVOIR EMPTY

DYNO SITE:D207 TEST # 79-9904

1979 HIGHWAY FUEL ECONOMY ANALYSIS

PROCESSED: 09120142 SEP 21, 1979

MFR. CODE	VEHICLE I.D.	VER-SION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			EXPERIMENTAL / HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	RPM	GEAR	% CO LEFT	% CO RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
29.13	61.3	70.8	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-20-79	09	D207	2000	5.3		2397.	45.	0.9643	58.3	

BAG 1 10.239 MILES 16.478 KM 23873. ROLL REVS. VMIX= 4094.0 CU.FT. DILUTION FACTOR = 11.753

SITE #A215

	EXHAUST SAMPLE RANGE	EXHAUST SAMPLE METER	EXHAUST SAMPLE CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND SAMPLE METER	BACKGROUND SAMPLE CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	MASS EMISSIONS GMS/MI	MASS EMISSIONS GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	16.6	12.26	14	4.5	3.31	9.23 PPM	0.62	0.060	0.037			
NOX-CHEM	17	42.3	106.98	17	0.0	0.0	106.98 PPM	22.87	2.234	1.388	MPG	KPL	L/100KM
CO2	23	46.1	1.137	23	1.9	0.040	1.101 %	2335.34	228.083	141.724	38.8	16.49	6.1
CO	17	6.1	14.73	17	0.0	0.0	14.73 PPM	1.99	0.194	0.121			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.2	228.	2.23
BEFORE ROUNDING	0.0602	0.194	228.08	2.2319
GRAMS/KM	0.037	0.12	142.	1.39
BEFORE ROUNDING	0.03745	0.1206	141.72	1.3881

	MPG	KPL	L/100KM
WEIGHTED VALUES	38.8	16.5	6.1
	38.8094	16.4625	6.0744
72-74 FTP	38.8	16.5	6.1
	38.8147	16.5018	6.0599
UNWEIGHTED FTP	38.8	16.5	6.1
	38.8147	16.5018	6.0599

COMMENTS: FIESTA TESTING OF GOODMAN SYSTEMS MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40
DEVICE INSTALLED, WATER RESERVOIR EMPTY

DYNO SITE:0207 TEST # 79-9905

1979 LIGHT DUTY VEHICLE ANALYSIS

PROCESSED: 07:08:13 SEP 24, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCFBWE34449	0							2000	7.3			EXPERIMENTAL / CVS 75-LATER

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	RPM	GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
28.95	61.0	71.0	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-21-79	08	0207	2000	5.3		2429.4	45.00	0.9591	56.5	

BAG 1 3.569 MILES 5.743 KM 8321. ROLL REVS. VMIX= 2814.0 CU.FT. DILUTION FACTOR = 15.639
SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	52.5	78.92	15	3.1	4.61	74.60 PPM	3.43	0.961	0.597			
NOX-CHEM	16	67.4	68.34	16	0.0	0.0	68.34 PPM	9.99	2.799	1.739	MPG	KPL	L/100KM
CO2	23	34.3	0.809	23	2.0	0.042	0.770 %	1122.46	314.518	195.433	26.6	11.30	8.9
CO	18	80.1	397.46	18	0.3	1.42	396.13 PPM	36.75	10.298	6.399			

BAG 2 3.869 MILES 6.227 KM 9022. ROLL REVS. VMIX= 4752.0 CU.FT. DILUTION FACTOR = 22.748
SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	13.9	10.25	14	4.8	3.53	6.88 PPM	0.53	0.138	0.086			
NOX-CHEM	14	45.8	11.58	14	0.2	0.05	11.53 PPM	2.85	0.735	0.457	MPG	KPL	L/100KM
CO2	23	25.4	0.580	23	2.0	0.042	0.540 %	1328.29	343.271	213.299	25.4	10.80	9.3
CO	17	34.4	84.16	17	0.2	0.48	83.70 PPM	13.11	3.389	2.106			

BAG 3 3.586 MILES 5.770 KM 8360. ROLL REVS. VMIX= 2775.0 CU.FT. DILUTION FACTOR = 17.586
SITE #A215

	EXHAUST SAMPLE RANGE	METER	CONC.	BACKGROUND SAMPLE RANGE	METER	CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	22.7	16.80	14	5.0	3.68	13.33 PPM	0.60	0.169	0.105			
NOX-CHEM	15	94.0	46.97	15	0.2	0.10	46.88 PPM	6.76	1.884	1.171	MPG	KPL	L/100KM
CO2	23	32.2	0.754	23	2.0	0.042	0.714 %	1026.67	286.333	177.919	30.6	13.02	7.7
CO	17	27.1	66.09	17	0.0	0.0	66.09 PPM	6.05	1.686	1.048			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.32	4.3	322.	1.48
BEFORE ROUNDING	0.3160	4.347	321.72	1.4760
GRAMS/KM	0.196	2.70	200.	0.92
BEFORE ROUNDING	0.19639	2.7014	199.91	0.9171

	MPG	KPL	L/100KM
WEIGHTED VALUES	26.9	11.4	8.7
	26.8916	11.4354	8.7447
72-74 FTP	26.0	11.0	9.1
	25.9651	11.0389	9.0588
UNWEIGHTED FTP	27.3	11.6	8.6
	27.3222	11.6158	8.6089

COMMENTS: FIESTA TESTING OF GOODMAN MODEL 1800 DEVICE
SPECIAL SHIFT SPEEDS OF 10-20-40

6110 0

DYNO SITE:D207 TEST # 79-9906

1979 HIGHWAY FUEL ECONOMY ANALYSIS

PROCESSED: 07:08:17 SEP 24, 1979

MFR. CODE	VEHICLE I.D.	VERSION	EVAP	MFR. REP. INIT.	RUN. CHG.	RETEST CODE	ACHP	ALT. H.P. METH.	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
													EXPERIMENTAL
30	GCFBWE34449	0							2000	7.3			HWFE

PREP DATE	CURB WEIGHT	DRIVE AXLE WEIGHT	GAUGE EMPTY	AXLE MEASURE	IGNITION TIMING #1	IGNITION TIMING #2	IGNITION TIMING RPM	IGNITION TIMING GEAR	% CO LEFT	% CO RIGHT	% CO COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS - /

BARO "HG	WET BULB	DRY BULB	UNITS	CVS UNIT
28.97	60.5	71.0	F	270

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED DYNO H.P.	DVU H.P.	ODOM.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-21-79	09	D207	2000	5.3		2452.1	45.00	0.9490	54.6	

BAG 1 10.224 MILES 16.455 KM 23839. ROLL REVS. VMIX= 4082.0 CU.FT. DILUTION FACTOR = 11.755

SITE #A215	EXHAUST SAMPLE RANGE	EXHAUST SAMPLE METER	EXHAUST SAMPLE CONC.	BACKGROUND SAMPLE RANGE	BACKGROUND SAMPLE METER	BACKGROUND SAMPLE CONC.	CORRECTED CONCENTRATIONS	MASS EMISSIONS GMS.	MASS EMISSIONS GMS/MI	MASS EMISSIONS GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	15.8	11.66	14	4.7	3.45	8.50 PPM	0.57	0.055	0.034			
NOX-CHEM	17	44.2	111.74	17	0.1	0.25	111.50 PPM	23.39	2.288	1.422	MPG	KPL	L/100KM
CO2	23	46.1	1.137	23	2.0	0.042	1.099 %	2324.41	227.339	141.262	38.9	16.55	6.0
CO	17	5.6	13.52	17	0.0	0.0	13.52 PPM	1.82	0.178	0.111			

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.06	0.2	227.	2.29
BEFORE ROUNDING	0.0554	0.177	227.33	2.2880
GRAMS/KM	0.034	0.11	141.	1.42
BEFORE ROUNDING	0.03444	0.1105	141.26	1.4217

	MPG	KPL	L/100KM
WEIGHTED VALUES	39.0	16.6	6.0
	38.9800	16.5819	6.0306
72-74 FTP	38.9	16.6	6.0
	38.9484	16.5586	6.0391
UNWEIGHTED FTP	38.9	16.6	6.0
	38.9484	16.5586	6.0391

COMMENTS: FIESTA TESTING OF GOODMAN SYSTEMS MODEL 1800
SPECIAL SHIFT SPEEDS OF 10-20-40

6110 0

DYNO SITE 0207 TEST # [illegible]

| [illegible] DUTY VEHICLE ANALYSIS |

PROCESSED: 0715812? SEP 19, 1979

MFR. CODE	VEHICLE I.D.	[illegible]	ALT. H.F. [illegible]	EQUIVALENT TEST WEIGHT	ACTUAL DYNO H.P.	TRANS. CONFG.	OVER-DRIVE CODE	TEST TYPE / TEST PROCEDURE
30	GCF?AE34449			2000	7.3			EXPERIMENTAL / CVS 75-LATER

[illegible] DATE	CURB WEIGHT	[illegible] WEIGHT	[illegible]	[illegible]	/--- [illegible] ---/	/------ A CO ------/ LEFT	RIGHT	COMB	IDLE RPM	GEAR	SOAK PERIOD	MEASURED COASTDOWN TIME

/- AMBIENT TEST CONDITIONS -/

BARO [illegible]	WET BULB	DRY BULB [illegible]	[illegible]
29.92	62.7	71.2 F	27?

TEST DATE	HR.	DYNO SITE	ACTUAL INERTIA SETTING	INDICATED [illegible]	DYN H.P.	ODO.	TIRE PRESSURE	NOX FACTOR	RELATIVE HUMIDITY	ALDEHYDES
9-18-79	09	0207	2000	[illegible]		23?1.0	45.00	?.?925	62.6	

BAG 1 3.580 MILES 5.761 KM [illegible] V?? [illegible] CU.FT. DILUTION FACTOR = 15.245

SITE #A215

	RANGE	METER	CONC. (EXHAUST SAMPLE)	RANGE	METER	CONC. (BACKGROUND SAMPLE)	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	15	52.?	76.16	1?	2.7	[illegible]	74.41 PPM	3.41	0.952	0.591			
NOX-CHEM	16	5?.3	[illegible]	1?	0.1	[illegible]	[illegible] PPM	8.05	2.249	1.398			
CO2	23	35.1	[illegible]	23	2.0	[illegible]	0.7?? %	1149.63	321.164	199.562			
CO	1?	41.7	[illegible]	1?	0.0	0.0	[illegible] PPM	37.52	10.482	6.513			

MPG	KPL	L/100KM
26.0	11.07	9.0

BAG 2 3.858 MILES 6.273 KM [illegible] V??? [illegible] CU.FT. DILUTION FACTOR = 22.313

SITE #A215

	RANGE	METER	CONC. (EXHAUST SAMPLE)	RANGE	METER	CONC. (BACKGROUND SAMPLE)	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	15.?	11.74	14	[illegible]	[illegible]	8.44 PPM	0.66	0.168	0.105			
NOX-CHEM	14	42.9	[illegible]	14	[illegible]	[illegible]	10.74 PPM	2.76	0.707	0.439			
CO2	23	25.9	[illegible]	23	2.1	0.044	0.548 %	1349.73	346.280	215.168			
CO	17	[illegible]	[illegible]	17	0.0	0.0	?7.59 PPM	15.31	3.927	2.440			

MPG	KPL	L/100KM
25.1	10.68	9.4

BAG 3 3.555 MILES 5.7?? KM [illegible] V??? 27??.0 CU.FT. DILUTION FACTOR = 17.281

SITE #A215

	RANGE	METER	CONC. (EXHAUST SAMPLE)	RANGE	METER	CONC. (BACKGROUND SAMPLE)	CORRECTED CONCENTRATIONS	GMS.	GMS/MI	GMS/KM	AUX. FIELD1	AUX. FIELD2	AUX. CODE
HC-FID	14	24.6	1?.7	14	5.1	?.7?	14.54 PPM	0.66	0.164	0.115			
NOX-CHEM	15	81.7	4?.91	15	[illegible]	[illegible]	40.95 PPM	6.04	1.705	1.060			
CO2	23	32.7	[illegible]	23	2.1	[illegible]	0.725 %	1041.13	291.727	181.271			
CO	17	28.5	[illegible]	17	[illegible]	[illegible]	?8.31 PPM	5.23	1.749	1.086			

MPG	KPL	L/100KM
30.1	12.78	7.8

WEIGHTED VALUES	HC	CO	CO2	NOX
GRAMS/MILE	0.33	4.7	326.	1.?0
BEFORE ROUNDING	0.331?	[illegible]	325.25	1.2??3
GRAMS/KM	0.207	2.9?	203.	[illegible]
BEFORE ROUNDING	0.20747	2.?100	202.72	0.?055

	MPG	KPL	L/100KM
WEIGHTED VALUES	26.5	11.3	8.9
	26.5169	11.2506	8.8883
72-74 FTP	25.6	10.9	9.2
	25.5625	10.8677	9.2015
UNWEIGHTED FTP	26.9	11.4	8.8
	26.8624	11.4204	8.7562

COMMENTS: FIESTA TESTING OF GOODMAN MODEL TP69 DEVICE
SPECIAL SHIFT SPEEDS OF 1?-20-40
DEVICE INSTALLED

[illegible]

Attachment D

Summary of TRC Fiesta Testing

Date	HC (gm/mi)	CO (gm/mi)	NOx (gm/mile)	Fuel Economy (mi/gal)	Comments
10-4-78	.58	6.23	1.52	30.17	B/L
4-20-79	.942	7.926	1.576	34.05	Device
Percent	(+)62.4%	(+)27.2%	(+)3.68%	(+)12.92%	

II. Performance Data (Averages)

A. 0-60 mph (sec.)

	Unmodified	Modified
South	18.13 Std. Dev. = .76	14.61 Std. Dev. = .42
North	16.7 Std. Dev. = 1.15	14.8 Std. Dev. = N/A

B. Quarter Mile Times (sec.)

South	21.41 Std. Dev. = .32	19.86 Std. Dev. = .2
North	21.08 Std. Dev. = .56	20.26 Std. Dev. = N/A

III SAE J-1082a Fuel Economy Test

	Urban (mpg)	Suburban (mpg)	Interstate (mpg)
Unmodified	21.97	36.80	37.04
Modified	25.27	36.66	39.70
Percent Change	(+)15.0%	(-)0.38%*	(+)6.70%

*Explained in Attachment I.

1977 D E T E R I O R A T I O N F A C T O R S

PROCESSED: 11:16:49 AUG 20, 1976

LIGHT DUTY TEST, WITH 13 POINTS. MODEL YEAR: 77 MANUFACTURE CODE: 31 MODEL NAME: FIESTA

VEHICLE I.D. 1ST CAR: 792-1.6-563A FUEL SYSTEM : 1 CRB 2 BBL TRANS : M-4 CONTROL SYS : AIR INJECTION
VEHICLE I.D. 2ND CAR: COMP. RATIO : 8.5 AXLE : 3.33 CATALYTIC REACTOR
ENGINE FAMILY : F1.6G1CV3 INERTIA CL. : 2000 LB N/V : 51.0 EXHAUST RECYCLE
FUEL TYPE : IND UNLEADED, 100 OCT DISPL. : 98.0 CI EVAP SYS : CANISTER
COMMENTS :

MILES	HC	CO	NOX	EVAP	CO2	F.E.
5051.	0.720	11.700	0.890	0.010	312.000	26.6701
9838.	0.380	5.400	1.000	0.060	378.000	22.8849
14838.	0.660	9.500	0.860	0.140	340.000	24.8509
14993.	0.620	8.400	1.050	0.0	342.000	24.8408
19890.	0.630	9.200	0.970	0.090	302.000	27.8605
24882.	1.040	10.200	1.010	0.040	323.000	25.9176
29839.	0.790	8.600	0.800	0.0	302.000	27.8986
29925.	0.890	13.000	0.840	0.0	278.000	29.4516
34955.	0.530	10.000	0.950	0.0	350.000	24.1492
39839.	0.800	9.400	0.950	0.0	299.000	28.0495
44839.	0.530	8.300	0.810	0.0	313.000	27.0725
44888.	0.520	7.000	0.780	0.0	309.000	27.5838
49889.	0.850	13.400	0.670	0.010	294.000	27.9221

4000. TO 50000. MILES

	HC	CO	NOX	EVAP	CO2	F.E.
SLOPE =	0.00000172	0.00002735	-0.00000471	-0.00000150	-0.00091731	0.00006559
INTERCEPT =	0.64104009	8.78104636	1.02254875	0.06901494	344.27639653	24.71522614
CORR. COEF =	0.13724558	0.17772309	0.62271556	0.49067931	0.48804642	0.50282937
COEF. OF DET =	0.0188	0.0316	0.3878	0.2408	0.2382	0.2528
STD. ERROR =	0.188105	2.291264	0.089553	0.040425	24.820015	1.705982
4000.(CALC) =	0.647931	8.890448	1.003706	0.063	340.607171	24.9776
50000.(CALC) =	0.727174	10.148565	0.787012	-0.006	298.411076	27.9949
DETERIORATION FACTOR =	1.122	1.142	0.784	-0.069*	0.876	1.121

* * THIS VEHICLE EXCEEDS 1977 CALIFORNIA STATE EMISSION STANDARDS

Attachment E

ETHYL CORPORATION
RESEARCH AND DEVELOPMENT DEPARTMENT · RESEARCH LABORATORIES
1600 WEST EIGHT MILE ROAD · FERNDALE, MICHIGAN 48220 · (313) 564-6940

November 9, 1979

Mr. John Kekich
EPA
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Mr. Kekich:

The results of test PO #A-1138-NMLX are as follows:

Motor	82.23
Research	91.35

Sincerely,

J. B. Hinkamp

J. B. Hinkamp

JBH:sh

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 11 1979

OFFICE OF
AIR, NOISE, AND RADIATION

Edward S. Knight, Esquire
Akin, Gump, Hauer & Feld
1333 New Hampshire Avenue, N.W.
Suite 400
Washington, D.C. 20036

Dear Mr. Knight:

This is in response to your application for evaluation of a fuel economy retrofit device under section 511 of the Energy Policy and Conservation Act on behalf of your client, Goodman System Corporation.

A preliminary analysis of the Goodman System Model 1800 application has been completed. This analysis while limited in scope, has raised several questions about your clients system and the testing performed on the "60 Minutes" test vehicle.

The question areas are listed below:

1. Attachment D, a letter from Dr. Helmuth Engleman, Professor of Mechanical Engineering at Ohio State University was not included in the original application package. Mr. George Kittredge of my staff was informed that this letter was accidentally not included in the packet and would be forwarded. If you have not already done so, please send this letter.

2. The test fuels used in the before and after modification tests were different. The before modification tests were run with Shell Unleaded, whereas the modified testing was run with Shell Super Unleaded. Why? The use of a higher octane fuel for the after modification test could decrease the tendency to detonate in the modified engine. This switch in test fuels makes comparisons of "before and after" test data difficult, since the differences in fuel economy and exhaust emissions cannot be attributed only to the engine modifications.

3. The application is unclear as to the modifications made to the Fiesta test vehicle engine. The "60 Minutes" transcript mentions different pistons, a reworked head, a modified cam shaft, and a compression ratio increase. Engine variables such as valve timing and compression ratio do have an effect on vehicle exhaust emissions and fuel economy. These unspecified engine modifications also make comparisons of "before and after test data" almost impossible. However, please ask your client to detail what engine modifications were made so as to help us to understand their efforts.

4. The exhaust emission standards given in Exhibit E, while correctly stated, are incorrectly applied. The emission standards for a model year must be in the context of the regulations for which they were intended. Because exhaust emissions on vehicles may deteriorate over the useful life of the vehicles, 50,000 miles of mileage accumulation are put on durability vehicles to determine the level of deterioration. The best fit line for their exhaust emission data (each vehicles is tested every 5,000 miles and at each major maintenance point) is calculated and the resulting multiplicative deterioration factors (DF) for HC, CO and NOx are determined. Various calibrations in the same engine family are then run to 4,000 miles and tested identified as "data vehicles." The results of these tests are multiplied by the applicable DF and this product must be below the standards listed in Exhibit E. A further description of this process can be found in Federal Register 86.078-28. The applicable deterioration factors (4K to 50K miles) for the 1978 Ford Fiesta, 49-state are:

HC DF	CO DF	NOx DF
1.914	1.462	1.060

Using these DFs, the "before and after" test data supplied in the application compares to the emission standards as follows:

	Baseline	Baseline x DF	Percent of Standard	Modified	Modified x DF	Percent Standard
HC	.58	1.110	74%	.942	1.803	120.2%
CO	6.23	9.108	60.7%	7.926	11.5878	77.25%
NOx	1.52	1.611	80.6%	1.576	1.67	83.5%

This analysis, using DF, shows that the modified version might not have passed the HC standard for 1978 light-duty vehicles. Because the test mileage was above 4000 miles and insufficient data was presented to establish a deterioration factor for the modified vehicle, the analysis applied the production DF to the test data as presented. The point here is that the data does not indicate that the vehicle passed the emission standards as indicated in Attachment D. Further testing is required before such a statement can be made.

5. The "before and after" tests were run at significantly different humidity settings. While this parameter is not specified for proper FTP testing, comparison testing with large humidity differences may make the comparison difficult.

6. The reason why water injection, by itself, will improve fuel economy is not explained in your application and is contrary to most of the literature now published about water injection. It is agreed that water injection will suppress detonation and therefore will allow modifications to the engine which are normally precluded because of detonation. These modifications, which may include turbocharging or supercharging, higher compression ratio, advanced spark timing, different valve timing hotter inlet air, hotter spark plugs, leaner mixtures, or use of lower octane fuel, usually either improve fuel economy and/or performance or permit the use of lower cost fuel. Exhibit A of your application states that "the injected fluid absorbs heat in the combustion chamber." This lower heat will result in a smaller pressure rise and lower thermal efficiency in non-knocking engines. According to Obert, an improvement in power of up to 6% may be gained by water injection used on an engine which experienced knock prior to water injection.

The injection of water into the air inlet upstream of the carburetor should slightly enrichen the fuel/air mixture as there will be less oxygen in the intake air. This will cause lower fuel economy. Because the Goodman Engine System, Model 1800, appears to contradict these theories, a more complete explanation is needed describing why the water injection alone improves fuel economy.

7. As in any testing, there is some test-to-test variability due to both the vehicle and the test equipment. Because of the +5 to 10% variation in results of cold start FTP testing, duplicate or triplicate tests are usually run. The tests run on your vehicle were single tests with a 6 1/2 month interval between tests. Based on these two tests, the confidence with which a 7% increase in fuel economy can be claimed is very low.

8. The type of anti-freeze to be added to the water for operation in cold ambient conditions was not specified. Please ask your client to describe the type and recommended manufacturer of this anti-freeze.

9. The amount of water injected by the Goodman Systems Model 1800 device was not specified. Please ask your client to provide us with the pound water/pound fuel ratio.

10. Because of the above mentioned problem areas with the device description and your FTP test results, it is proposed that the Goodman Systems Model 1800 device be installed on an EPA supplied test vehicle and tested at the EPA Motor Vehicle Emissions Laboratory in Ann Arbor, Michigan. This will allow the EPA to expeditiously evaluate your device. The following test schedule is proposed. Please ask your client to comment on the testing scenario. If it is acceptable, please ask him to contact Mr. Hutchins of my staff to coordinate testing dates. His telephone number is (313) 668-4340).

Test Vehicle: Ford Fiesta, 1978, as tested at TRC.

Baseline Testing: FTP, HFET (three times)

Installation of Device: *

Modified Testing: FTP, HFET (two times)

Modified Testing (no water): FTP, HFET (two times)

---

* Goodman Systems Model 1800 to be installed per installation instruction (Exhibit B). No other modifications will be made to the vehicle.

Complete testing of the device according to this scenario would require about one week after completion of baseline testing which could be performed prior to your arrival if so desired. The total cost of this testing would be absorbed by the EPA. Because of other high priority projects, advance scheduling is required. Upon proper resolution of the above mentioned problems areas and completion of the testing, it is hoped that a final EPA evaluation can be arrived at expeditiously.

Sincerely yours,

Michael P. Walsh
Deputy Assistant Administrator
for Mobile Source Air Pollution Control

cc: Mitchell Sacks
R. D. Folsom

10-23-79

Mr. Edward S. Knight, Esquire
Adkin, Gump, Hauer, and Feld
1333 New Hamsphire Avenue, N.W.
Suite 400
Washington, D.C. 20036

Dear Mr. Knight:

On September 21, 1979, the Environmental Protection Agency's testing of the Goodman System Model 100 fuel economy retrofit device was completed. This testing was performed as part of the EPA optional testing pursuant to your "Application for Evaluation of a Fuel Economy Retrofit Device under Section 511 of the Energy Policy and Conservation Act."

Prior to initiation of the testing, a letter was sent to your office asking for clarification on several points presented in your application for evaluation. As of October 23, 1979, EPA has not received any response to these requests. On October 11, 1979, your telephone conversation with Mr. Penninga of my staff indicated that a second "511 Application" would soon be presented to EPA.

The EPA needs to complete the evaluation of the Goodman Systems Model 1800 as expeditiously as possible. If it is your desire to have your response to the September 21, 1979 letter considered in the published evaluation, please forward your response to this office before October 30, 1979.

Sincerely yours,

/s/ MPW

Michael P. Walsh
Deputy Assistant Administrator
for Mobile Source Air Pollution Control

ANR-455:GKITTREDGE:EVJ:WSMW:737:X50596:10-23-79

Penninga - A2

Attachment I

THE GOODMAN SYSTEM COMPANY, INC.

GAS SAVING DEVICES

West Virginia Office:
4 Berryville Pike
Summit Point, W. Va. 25446

New York Office:
2A Byram Brook Place
Armonk, N.Y. 10504

November 6, 1979

cc George
Bruce E.
Charles — action

Mr. Michael P. Walsh
Deputy Assistant Administrator
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Walsh:

This is in regard to your letter of September 11, 1979. The following are answers to the questions you posed in the aforementioned letter to Mr. Ed Knight.

I. We as the inventors did not choose the fuels used for the tests. We were under the impression that the first fuel used was Indolene Clear as specified for the FTP, however, since we were not present for the first test, we have no way of knowing what fuel was used. At the time of the second test we were told that the supply of Indolene Clear was very short. In view of the anticipated mileage we were asked if we would mind substituting another fuel, such as Super Shell. We agreed, since one of our claims was increased fuel economy on any grade of fuel. Actually the car travelled some 2300 miles for the "on the road" test at Transportation Research Center (TRC). When fuel was needed, it was driven into town and filled up, a somewhat more true to life situation than that practiced at the EPA lab in Ann Arbor. In addition, even though it was observed that fuel was being poured from a barrel labeled Indolene Clear, there is no proof of what is actually in the barrel. In any event, the quality of fuel is in either case much less than the Indolene Clear, which is 98 RON, some 4 or 5 RON numbers higher than the very best publicly available fuel, and almost 10 full point higher than the average unleaded fuel.

II. The engine modifications are as follows:

A. The pistons were replaced with a set of Arias forged units having a shallower combustion chamber to raise the compression ratio to a measured 12:6 to 1. To get the necessary exhaust valve clearance at that compression ratio, it was necessary to recess the exhaust valve into the cylinder head approximately .100". During the course of development, several camshafts were tried; both more or less aggressive in their action. During the experimentation, the original camshaft was sold to a customer of the shop. When it was determined that the original camshaft was very nearly ideal for the speed range used, a replacement was obtained. There were no Fiesta part number camshafts available, so a Ford replacement for a cc Pinto or Capri was installed.

11-9 copy to D. Hardy

11-15 copy to Bruce Eccles

RECEIVED NOV 8 1979

A. The valve action is so nearly the same as the original that the difference is undetectable. The major difference is in the width of the lobes, since the Pinto and Capri camshafts sometimes wore prematurely and the Fiesta lobes were made somewhat wider to give more bearing area. The amount of vacuum advance was increased slightly and the mechanical advance was reduced slightly, as is normal when increasing the compression ratio. As we will discuss later, the effect of the water is such that the timing may be adjusted to more optimum conditions of performance and emissions than is the usual case. Also, due to the cooling effect of the water, the EGR valve is no longer required to suppress the formation of NO_x, so it was disconnected. The carburetor jetting remained the same.

Consider also that the "60 Minutes" transcript was the result of many hours of filming, and was not intended to be a technical discussion, nor was it in any wasy edited by the inventors.

III. Any projection as to the future emission levels is just that, a projection and nothing more. However, in our defense:

A. The only area of real concern is HC, which is the easiest to eliminate by carburetor and/or timing adjustment and is easily checked by equipment that is available at the average dealership. Also, the report by TRC mentions that the engine was over heating during the acceleration runs. What they did not mention is the engine was run at full throttle until it became so hot the starter would not crank the motor until it was cooled. After the emissions test and the acceleration runs, but prior to the "on the track" mileage tests, the pistons were replaced with another set with new rings. The cylinder block was not rebored, nor were any valves replaced. Since that time the car has been driven about 25,000 miles and oil consumption has been so low as to not require the addition of any oil between changes which are done at about 5,000 miles. During this time, the car has been used for some extended high speed trips as well as day to day commuting, and includes several testing sessions by newspapers and automotive magazines, which means acceleration runs and generally treatment far more severe than a car is normally subjected to especially in relation to the FTP for accumulation of 50,000 miles. The spark plugs, a standard Bosch part, were changed at approximately 24,000 miles and the valves have been adjusted once. Except for changing the oil and water filters as well as cleaning the water injection nozzle at about 20,000 miles, there had been no other maintenance at all indicating at least a non-complicated life. So, since hydrocarbons are a results of generally either unburned gasoline due to a loss of engine 'tune', or as a result of engine wear causing excessive oil consumption, we feel confident that the long term HC emissions will not be a problem, especially in view of Dr. Engleman's statement that "if anything, the life of components exposed to combustion should be longer due to the cooler running". In my personal experience in the automotive rebuilding world, it seems that one of the first parts of the emission control system to fail is the EGR valve, usually in the closed position which results in improved performance and mileage for the consumer, so as a result, it is almost never repaired. Still, we must agree, further testing should be done,

A. -since the TRC tests were the first time the car had been tested, so unless we are willing to assume that the optimum settings were found on the first attempt; these results should be improved with further refinement.

IV. It is our understanding that acceptable correction factors were included in the TRC data to correct for such things as the temperature, humidity, barometric pressure, fuel temperature, etc., since these things are constantly changing from day to day, we must assume that the control of the weather is beyond even the legislative powers of Congress, or they have been missing a sure way to get re-elected.

V. There are some studies such as "Water Induction Studies In Spark Ignition Engines" done in October 1974 by Moffitt & Lestz for the DOD (DOD #AFRL-46-AD-A003332) that indicate that under some conditions of load with inferior fuel improvements of up to 20% have been found in engines that were not audibly detonating. Unfortunately, most of the studies done on water addition to gasoline engines have been done outside the bounds of emission controls, so that we have little information about the effects on emissions. In my talks with Professor Engleman, Mr. Lestz and others, it has become clear that the accurate control and uniform atomization of the water is essential if the problem of excessive HC and CO is to be avoided. The reduction of NOx is an accepted fact, since the water helps to avoid the extremes of pressure and temperature which produce NOx, yet because these extremes of pressure occur at or near TDC, they produce little or no useful power output. The action of the water is that it passes through the carburetor and past the intake valve in the form of liquid droplets of a uniform size. Thus, the density of the incoming charge is increased and the temperature is reduced. Just after ignition, the water becomes steam absorbing some 1100 calories per gram and at the same time it tries to expand 1708 times its volume as a liquid. Thus we have absorbed a tremendous amount of heat just at the time that NOx is formed and transformed that excess of heat into a pressure which is then maintained during the power portion of the stroke. It follows that the atomization must be uniform to ensure that all cylinders receive equal amounts of water and the droplet size small enough to ensure that all the water turns to steam without adversely affecting the rest of the combustion process. The accurate metering of the water is critical. If there is too much water, the losses incurred from the cooling more than offset the gain from the expansion of the steam, resulting in a loss of power and a rise in HC and CO. If there is too little water, the peak pressures can become so high as to cause detonation and resultant engine damage as well as causing the formation of NOx.

VI. As for Mr. Obert:

It is hard to claim any specific improvement in fuel economy in an engine that is detonating, since even a small amount of detonation can cause complete engine failure in a very short time, which results in no power due to a lack of an engine. It must be remembered that if we are not concerning ourselves with emissions, engine efficiency is almost a direct function of the amount of NOx, since it is produced in proportion to the peak temperature and pressures in the combustion chamber. I am not familiar with Mr. Obert's work, but I believe that he was not working within the constraints of any emission levels.

VI. The injection of water in liquid, for the amount that we are using (i.e.: 3 to 10% of the gas by volume) does not appreciably reduce the quantity of air. Anyway, maximum power is produced from most engines when the fuel/air ratio is near stoichiometric, and most engines today run just slightly leaner than the optimum for maximum power in order to reduce the amount of HC.

Basically, we believe that the use of a <u>properly calibrated</u> and <u>atomized water injection system</u> frees the engine designer from the more normal ways of reducing emission, i.e.: retarded spark timing, low and inefficient compression ratios and the recycling of exhaust gases, all of which severely restrict engine efficiency. One only need look at the current state of the art production engines, large struggling masses of iron producing tremendous amounts of waste heat, producing approximately one-half the horsepower per cubic inch that our engine is producing, their sheer mass necessitating ever larger ancilliaries such as tires, radiators, brakes, etc., which in turn need ever larger engines. As noted in the CBS transcript, we do not claim that this should be the end of the research, only a good start for what we have had to start with.

VII. Two things. One, we had some trouble with the choke turning itself back in the urban cycle, since it was run at just above freezing on a very damp night, a condition that we had never encountered in our day to day driving. The conditions were such that the engine was producing so little heat that the combination of the additional cooling of the water droplets on the choke plate overcame the electric choke heating coil which is only 5 watts. A simple adjustment to the intake preheat air box has since cured the trouble, otherwise the suburban cycle should have shown a gain somewhere between the 15% and the 7.2% shown for the urban and highway cycles respectively. As for the accuracy of the indicated gain, it was the result of testings per SAE Fuel Economy Measurement Road Test Procedure - SAE J1082a which is outlined in the TRC report. Note that the test requires that two consecutive runs be made within 2% fuel economy and time. (Note: This test was done by measuring the gas in the way we buy it. IE in the liquid form, not by counting carbon molecules in the exhaust. I personally prefer this method, even though the mileage by the carbon balance method showed a greater average gain, something on the order of 13% - from 30.17 mpg to 34.05 mpg.)

For whatever it is worth, in day to day driving for 5,000 miles before the engine was modified, the cumulative average was just over 33 mpg. Since the modifications, the mileage under the same conditions with the same general routes and drivers has averaged about 43 mpg. In the Popular Science test, Ray Hill reports a 41 mpg average, including several acceleration runs and crossing the mountains in and out of the Shandoah Valley twice with three people and luggage. (November, 1979 issue) Mother Earth News tester David Schoonmaker reported 51 mpg under somewhat less brutal driving with only two passengers.

VIII. We used any available source of methanol such as "Solox" shellac thinner in a concentration sufficient to prevent freezing. In the event that the system is accidentally allowed to freeze, no permanent damage is done to the system. Generally, just allowing the car to sit for a few minutes with the engine running will thaw the system. Incidentally, although the addition of alcohol is suppose to be beneficial by both lowering the temperature and raising the octane rating, we have found no proveable differences. The type of alcohol is not critical either; the system has been run on Gin, and while the car may in fact be happier, it in no way demonstrates this by performing better.

IX. The amount of water used by our system is dependent upon the temperature, load and speed of the engine. No water is used under periods of deceleration, idling, or during warm up. In general highway cruise, the rate is about 5% of the gasoline use by volume and under periods of heavy load or acceleration the rate automatically increases to about 10%. In our average driving, the water consumption is about 5% of the fuel consumption. The exact amount, IE, whether it is 5 or 6% at a given time does not seem to be as important as the quality of atomization and cylinder to cylinder distribution.

Respectively submitted,

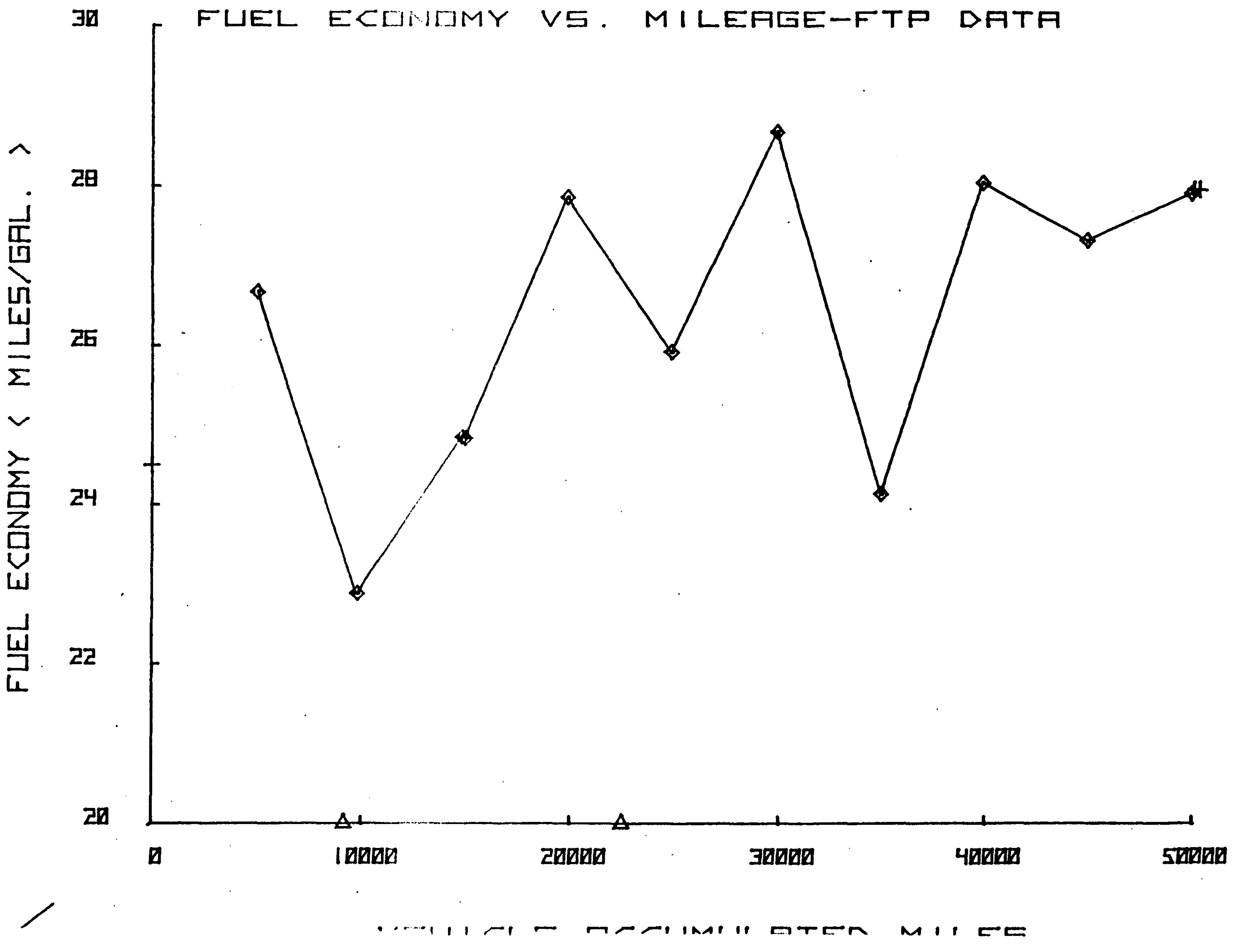
Toronta P. Goodman

Typed By:

Leanice M. Smith

Leanice M. Smith

1978 FIESTA FUEL ECONOMY



ATTACHMENT J

THE OHIO STATE UNIVERSITY

August 22, 1979

Mr. T. P. Goodman
Goodman Engine, Inc.
685 N. Loudoun Street
Winchester, Va. 22601

Dear Pat:

You had asked that I put in writing the reasons for my enthusiasm for the modifications you made to improve fuel mileage of the Ford Fiesta shown on "60 Minutes." Please feel free to show this explanation to anyone who may be interested.

I am enclosing some pages from a report on which I was co-author in 1943, still in some libraries as NACA Wartime Report No. E-20, and a page which is part of the supplementary notes I hand out in my course here at the Ohio State University, Mechanical Engineering 630, Internal Combustion Engines, and have been using since 1973.

I would describe your system as the addition of a fully modulating water injection system which incorporates an atomizing air pump, and otherwise no additional parts except that some engines might be improved by substitute parts to fully exploit the water injection. By this I mean the parts substitutions incorporated in the Fiesta.

The great benefit of water injection is its function as an internal coolant, which has two extremely important effects:

1) It reduces the fuel OCTANE requirement.
2) It reduces the Nitrogen Oxide emissions.

The cooling effect of the water is shown in Figure 11 of the NACA Report. The mean effective gas temperature is used in heat transfer calculations to predict engine temperatures at altitude, etc. The drop in mean effective temperature is primarily the result of lower temperature at the end of combustion; the effect during the compression stroke is rather trivial. It is the cooling during and after combustion which provides both the anti-knock effect and the reduced Nitrogen Oxide emission.

The actual benefit in a specific engine-vehicle combination will depend on a number of details: Compression ratio, cam profiles, carburetion, transmission, and the torque converter (if any) match. Without any changes at all except the addition of the water injection system, it is doubtful that much mileage change would be noted, but I must add here that the R-2600 engine covered in the NACA Report improved about 2 per cent with fine water spray at the intake ports, and lost as much as 7 per cent with the water entering the supercharger inlet from a 3/8-inch tube.

Based on this experience, I consider the fine atomization of your system essential. There may be some benefit to mileage if the mist is vaporized by a manifold hot-spot, but that possibility is one I would like to test one day.

One group or category of engines which can benefit greatly from water injection is the older high-compression high-performance type which has to be run with retarded ignition timing on the fuels available today. Originally designed and built for 100 RON premium gasoline, these are running with retardedtiming and resulting poor mileage. With water injection, the timing could be restored to optimum with substantial improvement. In addition, the NOX emissions would drop substantially.

Another category in which substantial improvement is possible is in engines having an acceleration-retard in the vacuum advance circuit. The water injection system as a substitute for the acceleration retard would be more effective in reducing the NOX emission (purpose of the accel-retard) and would improve both mileage and acceleration. Acceleration and full-load fuel-air ratio on such engines could be set leaner, reducing the carbon monoxide and unburned hydrocarbon emissions as well as further improving the mileage.

Your own demonstration vehicle, the Fiesta, is another category. You got improved mileage and improved performance by increasing the compression ratio, which actually raised the fuel octane requirement. The water injection makes it possible to run on regular gasoline, and the NOX is decreased from its earlier level.

It is conceivable to me that we may be forced to consider increasing the yield of gasoline from crude by going to a lower octane product. Today's cars could run on, say, 70 octane with water injection.

In my opinion, the fine modulation of the amount of water injected is a rather important feature of your system. For best efficiency, it is desirable to keep combustion temperature from becoming too low. If there is too much quenching (due to cooling) combustion is slow and less work is done on the piston, and in the extreme, misfires may result, giving poorer mileage in either case, and a large increase in hydrocarbon emission in the case of the misfire. It is a fact that the residual gas in the cylinder as the exhaust valve closes provides a sort of automatic exhaust gas recirculation. This residual gas is inert, having been burned, and reduces the flame temperature. It is a large fraction of the burning charge at part throttle, and so provides considerable cooling effect. At full throttle, it is a much smaller fraction of the charge, provides far less cooling, and as a result it is at full throttle that most of the NOX emissions are generated. For this reason, the water injection rate should be highest for any given engine rpm at wide open throttle and should TAPER OFF to zero water flow at some part-throttle value of manifold vacuum or other parameter. Yours is the only system I am aware of which incorporates this full modulation.

I believe it is important that everyone who may be concerned realizes that any water injection system will reduce the nitrogen oxide emissions. It is in other areas that the differences between various systems become important. I regard the full modulation of the water flow rate which you have incorporated, and the atomization you are using, as important features. From my own experience in engine testing with water injection, I know these make a difference in how an engine runs.

I trust that the foregoing is a satisfactory explanation of what your system does to provide the results we have seen. If it is not, I would be happy to expound. I hasten to add that an engine is thermodynamically even more complicated than it is mechanically, and such exposition would take time. Your system is based on sound fundamental principles, and I will gladly do my best to clarify how it works for both mileage and low emissions.

Sincerely,

Helmuth W. Engelman

Helmuth W. Engelman, PhD, PE
Associate Professor