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Vechile Programs and Compliance Division
Office of Mobile Sources
U.S. Environmental Protection Agency

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EPA Laboratory Evaluation of the Inset Fuel Stabilizer Aftermarket Retrofit Device for Motor Vehicles

Summary

Laboratory testing of an aftermarket retrofit device named Inset Fuel Stabilizer was conducted at EPA's National Vehicle and Fuel Emissions Laboratory to determine its effect on vehicle exhaust emissions and fuel economy. The results of testing this product led to the conclusion that it had no positive or negative effect on exhaust emissions or fuel economy. Use of this device on the test vehicles provided no benefit.

Introduction

This report describes the U.S. Environmental Protection Agency (EPA) testing and evaluation of Inset Industries, Inc.'s Inset Fuel Stabilizer (hereafter Inset) retrofit device. Testing of such devices is performed under the authority of 42 USC 7525, and 49 USC 32918. Regulations defining the program are found in 40 CFR 610. All tests were conducted at EPA's National Vehicle and Fuel Emissions Laboratory (NVFEL) in Ann Arbor, Michigan. This testing and evaluation was requested by EPA's Region II (representing New Jersey, New York, Puerto Rico and the U.S. Virgin Islands) which received the request for an EPA evaluation from the state of New Jersey Division of Consumer Affairs. The New Jersey Division of Consumer Affairs procured a new Inset device and turned it over to EPA for testing. Subsequent to completion of emissions and fuel economy testing using the Inset unit provided by the New Jersey Division of Consumer Affairs, six other Inset units were provided by the Division of Fleet Management, Essex County, New Jersey. Two of these Inset units were opened to allow inspection of the construction and internal components of the device. The four other Inset units supplied by Essex County were not used.

According to a four page, full color brochure (no date or document number) from Inset Industries, Inc., "the Fuel Stabilizer incorporates a revolutionary technology which allows fuel to burn completely. As fuel passes through the stabilizer, the fuel molecules are aligned to cause an optimum burn within the combustion chamber."

In its Internet web site (dated March 18, 1999), Inset Industries, Inc. states:

> "As a result [of using the Inset device], each engine will experience the following benefits:
>
> Significantly reduced emissions
> Improved fuel mileage & performance
> Helps to reduce maintenance costs"

The Test Program

The purpose of the test program conducted by EPA's Office of Mobile Sources (OMS) was to satisfy the request by EPA Region II to conduct a controlled technical

evaluation of the Inset device in a manner that would objectively determine whether use of the Inset device would have a statistically significant effect, either positively or negatively, on the exhaust emissions and fuel economy of the vehicles tested.

Evaluations of devices by EPA employ a minimum of two different vehicles with three or more vehicles being preferable. Vehicles selected are representative of the operational fleet at large. The evaluation of the Inset device reported herein is based on testing three different vehicles: a 1996 Chevrolet Lumina, a 1994 Ford Probe, and a 1998 Pontiac Bonneville which were tested in the order shown; i.e. testing first the Chevrolet, then the Ford, and finally the Pontiac. A 1997 Toyota was initially selected as a test vehicle. However, all tests performed on the Toyota were invalidated because the vehicle's evaporative emission control system had inadvertently not been returned to operation following inspection of the vehicle prior to performance of any tests. Therefore, the Toyota tests are not included in this evaluation.

Some difference in emissions and fuel economy measurements is almost always present between tests on a vehicle which had not undergone any change between the tests. While this test-to-test variability is generally not large, it could lead to erroneous conclusions when comparison is being made between different vehicle configurations. To address this concern, replicate tests in each configuration are performed. Triplicate tests in each configuration are usually performed. Constraints on the availability of testing facilities can limit the number of tests performed in each configuration to two. Conversely, if laboratory facilities are readily available, some amount of quadruplicate testing may be practical. As a result of laboratory constraints, testing of the Chevrolet Lumina was limited to duplicate tests in each configuration. In the case of the other two vehicles, availability of laboratory facilities allowed performance of some quadruplicate testing.

EPA testing evaluated the exhaust emissions and fuel economy effects of the Inset device using standard federal test methods as used for certification and recall programs. The standard test methods employed were the Federal Test Procedure (FTP) for determination of exhaust emissions and fuel economy (city), and the Highway Fuel Economy Test (HFET) for determination of fuel economy under highway driving conditions. All emissions and fuel economy tests performed in this program were performed on a twin roll water brake dynamometer. The fuel used in this program for emission testing, fuel economy determinations and mileage accumulation on the road was test gasoline, commonly referred to as Indolene. Indolene is a generic name for gasoline manufactured with closely controlled tolerances so that little variability exists between batches. Because of these controls in its production, it is an ideal fuel for use in engine/vehicle development and emission measurement programs. No attempt was made in this program to evaluate any effect on driveability, power or maintenance costs which may be associated with the Inset device.

Operation of the Inset Device as Described by the Manufacturer

The manufacturer states that the Inset device aligns the fuel molecules before the fuel enters the vehicle engine. The manufacturer claims that this molecular alignment results in an optimum burn of the fuel. No further explanation is provided of how the device is claimed to work. Specific claims are not made pertaining to the size of the improvements attributed to the device. The manufacturer also claimed that there are no maintenance requirements applicable to the Inset device.

General Appearance, Size and Construction of the Inset Device

The Inset device employed in the emissions and fuel economy evaluation reported herein gave the appearance of having been made from a silver colored bar of metal which was just under 4 and 1/4 inch in length by just under 2 inches in diameter. A smooth rounded transition was present between each of the ends and the tubular side of the unit. Threaded nipples were welded to each end. There are no other readily identifiable marks or lines on the surface of the unit which could be used in identifying its method of construction. The coloring and general appearance of the device is consistent with the statement by Inset Industries, Inc. that stainless steel is used in the construction of Inset devices. The word "in" is stamped on one end of the unit and "out" is stamped on the other end. Light shone into a nipple at one end of the unit cannot be seen at the other end. Fuel does, however pass through the unit. A label attached to the unit shows the name "Inset Industries, Inc."; the name of the device, "The Fuel Stabilizer" with an arrow pointing from the end of the unit identified as "in" to the end identified as "out"; a partial address "Oakland, NJ"; the serial number of the unit employed in this evaluation, "C - 0570"; and the following disclaimer "Removal of tag will void Warranty". A piece of electric wire for grounding the unit, a hose clamp to attach the wire to the unit, and a piece of fuel hose and fitting came with the unit. A photograph of this unit is shown in Figure 1.

The overall appearance of the six Inset units provided by the Division of Fleet Management, Essex County, New Jersey was the same as that of the Inset unit used in the testing program. These units were just under seven inches long, and were just under two inches in diameter; i.e. they were longer than, and essentially the same diameter as the unit used in the testing program. The labels contained the same language as that previously detailed for the unit used in emissions and fuel economy testing. The labels contained two additional items. These items were a telephone number ((201) 337-7447), and a California Air Resources Board Executive Order number as follows; ARB E.O. #D-282. Two of these six Inset units were opened to allow viewing of the interior of the units. The serial number of the unit shown in Figures 2, and 3 was 001063. Opening of the units was achieved by cutting just enough material away at each end, on a lathe, to free the end caps from the tube that formed the outer longitudinal shell of the unit. The unit at this level of disassembly is shown in Figure 2. Within the outer shell, and welded to each end plate and the external nipples was a straight piece of ½ inch stainless steel tube (Figure 3). Within this tube was a thin piece of stainless steel plate which was twisted around its longitudinal axis (Figure 3). The width of the plate was such that it was essentially an interference fit with the inside surface of the tube, i.e. it was held firmly in place. By being twisted, the plate prevents the passage of light through the unit. The inner surface of the ½ inch tube, and of the nipples, and the surfaces of the twisted plate are the only parts of the Inset device which come into contact with fuel as it flows through the device. Also within the shell was a spiral of stainless steel tubing (Figure 3). The pitch of the spiral was not uniform, but averaged approximately 3/4 inch. The interior diameter of the spiral was approximately one and one quarter inch. Since flattening of the tube occurred during forming of the spiral, a precise determination of the size of the tube was not possible. The most probable diameter of the tube used in manufacturing the spiral was 1/4 inch. Both ends of the spiral were sealed. One end by what appeared to have been heating followed by being squeezing or hammering flat, the other by squeezing or hammering flat, folding and then again hammering or squeezing flat. Within the spiral was approximately 5 ml of a fairly fine greenish black powder. The spiral was held in place, and prevented from rattling around within the shell and between the end plates by a coarse powdery material. This material was brownish green in color and gave off an unpleasant odour. There were

approximately 220 ml of this material in the device.

An extensive analysis of the powdery material found on the inside of the Inset device was conducted in the EPA chemical laboratory. A mix of several inorganic and organic compounds was found, but it was concluded that these would have no effect on the fuel passing through the Inset device as there was no physical contact between the fuel and the material. It was concluded that the powdery material analyzed could have no effect on exhaust emissions nor fuel economy.

The source of the very unpleasant odor associated with the powdery material was not identified.

Inset device. Unit used in the vehicle test program covered in this report

Figure 1

Inset device. During opening process. With end caps freed from tubular body of the device.

Figure 2

Inset device. Internal components (excluding powdery materials).

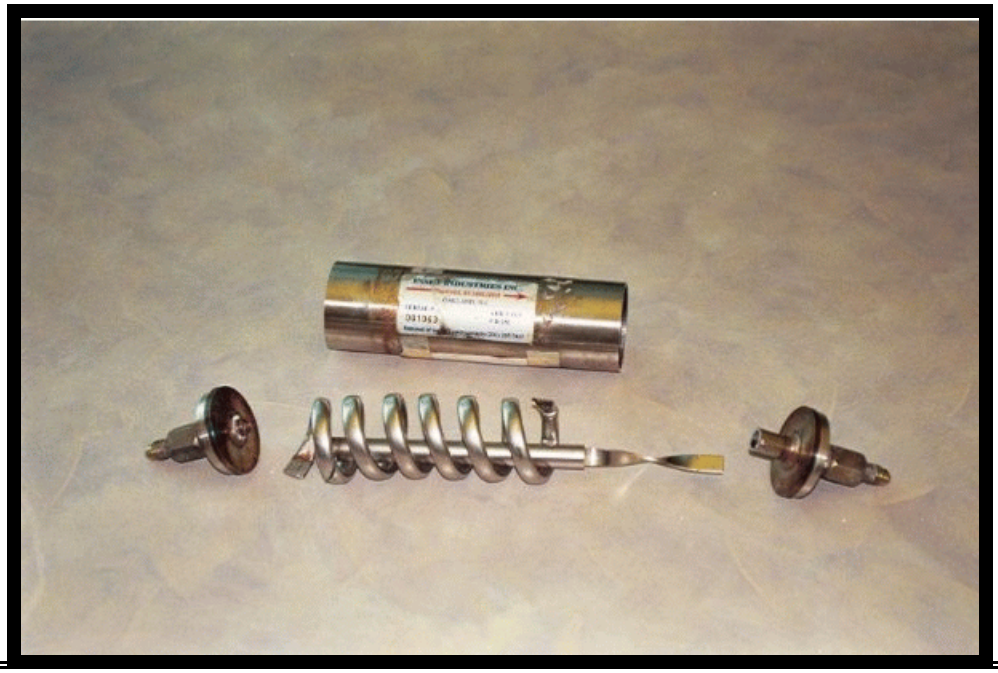

Figure 3

EPA Test Plan

The test plan developed by EPA used three different test vehicles selected by the evaluation team at the laboratory. The vehicles were:

1. A 1996 Chevrolet Lumina equipped with a 3.1 liter engine, and automatic transmission. The odometer reading at the start of testing was 22,748 miles. Engine Family Code: TGM3.1V8GFEK. VIN: 2G1WL52M8T1162331.

2. A 1994 Ford Probe equipped with a 2.5 liter engine, and automatic transmission. The vehicle odometer read 38,760, miles at the start of testing. Engine Family Code: RFM2.5VJGBEA. VIN: 1ZVLT22B2R5153457.

3. A 1998 Pontiac Bonneville equipped with a 3.8 liter engine and automatic transmission. The odometer reading at the start of testing was 8,512 miles, Engine Family Code: WGMXV03.8047. VIN: 1G2HX52K2WH202539.

Each test vehicle was subjected to inspection and maintenance identical to that performed on consumer owned vehicles in the Vehicle Programs and Compliance Division (VPCD) in-use emissions testing program. Each vehicle was tuned to manufacturer's specifications and any malfunctioning part was replaced.

The test phases for each test vehicle from which test data was acquired were as follows:

1. Stock configuration FTP, (the city drive cycle), and HFET tests were performed to establish the emission output and fuel economy prior to the installation of the Inset device. Performance of one FTP and one HFET is referred to in this report as a test sequence.
   In the case of the Chevrolet Lumina, the test sequence was performed twice. In the case of the Ford Probe and the Pontiac Bonneville, the test sequence was performed three times. No adjustments were made to any engine or emission control component between tests.

2. The Inset device was installed in the vehicle fuel line in accordance with the manufacturer's installation instructions, and the vehicle was tested again. The same test sequences as used for the stock configuration tests were employed, i.e., the FTP and HFET tests were conducted to develop data on the effect of the Inset device. The test sequence was conducted twice on the Chevrolet Lumina and four times on both the Ford Probe and the Pontiac Bonneville. No adjustments were made to any engine or emission control component between tests.

3. Each vehicle was driven over a standard mileage accumulation course of 150 miles per circuit until it had attained approximately 10% of the mileage recorded on the odometer after completion of the last test sequence with the Inset device. This mileage accumulation amounted to approximately 2200 miles for the Chevrolet Lumina, 4000 miles for the Ford Probe, and 900 miles for the Pontiac Bonneville. No adjustments were made to any engine or emission control component during or after mileage accumulation.

4. Upon completion of mileage accumulation with the Inset device installed, each vehicle underwent testing for emissions and fuel economy. The test sequence was performed twice on the Chevrolet Lumina and three times for both the Ford Probe and Pontiac Bonneville. No adjustments were made to any engine or emission control component between tests.

5. The Inset device was removed at the completion of testing following mileage accumulation, i.e., each test vehicle was returned to its stock configuration. Each vehicle was tested in stock configuration following mileage accumulation. The number of test sequences performed on each vehicle was the same as those preformed in the initial stock configuration testing, i.e., duplicate sequences on the Chevrolet Lumina and triplicate sequences on the Ford Probe and Pontiac Bonneville. Again, no adjustments were made to any engine or emission control component between tests.

Results

The results of the emissions and fuel economy testing are shown in Tables 1 through 3. Test results for the Chevrolet Lumina are contained in Table 1, those for the Ford Probe are in Table 2, and Table 3 contains the test results from the Pontiac Bonneville. Each of the vehicles used in this evaluation program were in compliance with the emissions standards applicable to the model year in which the vehicle was produced (see Tables 1 through 3 for the test results and Table 4 for the applicable emissions standards).

Analysis and Conclusions

The test data were analysed to determine whether use of the Inset device caused any statistically significant changes in either emissions or fuel economy. These analyses were performed using the two sided t-test. Analyses were performed with the test data from each vehicle as a discrete data set and again with all of the vehicle data combined into a single data set as a means of projecting to the larger fleet of vehicles on the nation's roads. In each case, all data from the stock vehicle configuration were grouped together and treated as the reference, or baseline data set. All data collected with the Inset device installed were grouped together and treated as the data set to be analysed for changes.

At the 95% confidence level, the analyses showed:

1. That the Inset device did not have any effect on total hydrocarbon (THC), non-methane hydrocarbon (NMHC), carbon monoxide (CO), and oxides of nitrogen (NOx) emissions, or on fuel economy measured on the Federal Test Procedure, or on fuel economy measured on the Highway Fuel Economy Test of the Ford Probe or the Pontiac Bonneville when test results from each vehicle were treated as stand alone data sets.

2. That the Inset device did not have any effect on total hydrocarbon, non-methane hydrocarbon or carbon monoxide emissions, or on fuel economy measured on the FTP, or on fuel economy measured on the HFET for the Chevrolet Lumina. The analysis showed a statistically significant difference for oxides of nitrogen emissions with the Chevrolet Lumina. The difference, when rounded to a whole number was a ten percent decrease.

3. That the Inset device did not have any effect on total hydrocarbon, non-methane hydrocarbon, carbon monoxide, and oxides of nitrogen emissions, or on fuel economy measured on the Federal Test Procedure, or on fuel economy measured on the Highway Fuel Economy Test when the data from the three vehicles were grouped together to form a single data set.

In the statistical analyses of these data, the two-sided t-test was performed to compare average emissions and fuel economy when the vehicle is and is not equipped with the Inset device. The two-sided t-test is used to distinguish between two competing hypotheses: one states that there is no difference between the true averages (the null hypothesis); the other states that either a positive or negative difference exists (the alternative hypothesis). The null hypothesis is rejected if the difference in the sample averages is so great that it’s probability of occurrence is “too small” to be explained merely by the randomness of the samples. By convention, the critically small probability is taken as five percent (0.05), known as the level of significance of the test. When a large number of such tests are conducted in which the null hypothesis is true, we expect that about 5% of the tests will mistakenly reject that hypothesis simply by random chance.

In the present analysis, the t-test was applied a total of twenty times: for three pollutants and two fuel economy cases with each of the three vehicles, and when all vehicles were grouped together. As described above, only one of these twenty tests (the NOx emission analytical result obtained from the Chevrolet Lumina), found a statistically significant

difference in the averages for the vehicle with and without the Inset device. This exactly matches the 5% rejection rate (one of twenty) that is expected when in fact no true difference exists. The conclusion drawn from the data, and the analysis of the data is that the Inset device did not have any effect, either positive or negative on either emissions or fuel economy.

Inspection of the interior of the sectioned Inset devices, showed that fuel as it flows through the device comes in contact with only the inner surface of central tube, the surfaces of the twisted plate within the central tube, and the inner surfaces of the nipples at each end of the device. Since the process of passing fuel through the Inset device entails nothing more than flowing the fuel through a piece of pipe, there is no technical basis to support a claim that the device modifies the fuel, and as a result causes an optimum burn of the fuel. The conclusion drawn from inspection of the interior of the Inset device is that it can not have any effect on either emissions or fuel economy.

Test Vehicle: Chevrolet Lumina. (1996 Model Year)					
Vehicle Configuration	**Test Date**	**Federal Test Procedure. (Emissions; g/mile. Fuel Economy: r**			
		THC	**NMHC**	**CO**	**NOx**
Stock vehicle. Baseline test 1 before device installation.	12/17/97	0.203	0.183	1.927	0.233
Stock vehicle. Baseline test 2 before device installation.	12/19/97	0.217	0.197	1.946	0.214
Stock vehicle. Baseline test 3 before device installation.	No test	---	---	---	---
Inset installed. Test 1 before mileage accumulation.	01/06/98	0.173	0.153	2.044	0.199
Inset installed. Test 2 before mileage accumulation.	01/07/98	0.150	0.133	1.726	0.216
Inset installed. Test 3 before mileage accumulation.	No test	---	---	---	---
Inset installed. Test 4 before mileage accumulation.	No test	---	---	---	---
Inset installed. Test 1 after mileage accumulation.	01/30/98	0.171	0.153	1.790	0.194
Inset installed. Test 2 after mileage accumulation.	02/03/98	0.180	0.161	2.003	0.201
Inset installed. Test 3 after mileage accumulation.	No test	---	---	---	---
Stock vehicle. Baseline test 1 after mileage accumulation.	02/23/98	0.155	0.138	2.072	0.220
Stock vehicle. Baseline test 2 after mileage accumulation.	02/27/98	0.167	0.148	1.994	0.229
Stock vehicle. Baseline test 3 after mileage accumulation.	No test	---	---	---	---

Table 1

Test Vehicle: Ford Probe. (1994 Model Year)					
Vehicle Configuration	**Test Date**	**Federal Test Procedure. (Emissions; g/mile. Fuel Economy: r**			
		THC	**NMHC**	**CO**	**NOx**
Stock vehicle. Baseline test 1 before device installation.	04/22/98	0.201	0.185	2.009	0.354
Stock vehicle. Baseline test 2 before device installation.	04/23/98	.0232	0.214	2.162	0.358
Stock vehicle. Baseline test 3 before device installation.	04/24/98	0.185	0.169	1.812	0.385
Inset installed. Test 1 before mileage accumulation.	05/06/98	0.233	0.214	2.475	0.310
Inset installed. Test 2 before mileage accumulation.	05/08/98	0.189	0.174	1.984	0.335
Inset installed. Test 3 before mileage accumulation.	05/12/98	0.187	0.172	1.917	0.383
Inset installed. Test 4 before mileage accumulation.	05/20/98	0.222	0.206	2.479	0.284
Inset installed. Test 1 after mileage accumulation.	07/09/98	0.209	0.195	1.998	0.278
Inset installed. Test 2 after mileage accumulation.	07/14/98	0.211	0.196	1.850	0.339
Inset installed. Test 3 after mileage accumulation.	07/31/98	0.201	0.186	1.889	0.293
Stock vehicle. Baseline test 1 after mileage accumulation.	07/15/98	0.185	0.169	2.080	0.290
Stock vehicle. Baseline test 2 after mileage accumulation.	07/16/98	0.194	0.179	1.722	0.327
Stock vehicle. Baseline test 3 after mileage accumulation.	07/17/98	0.199	0.185	1.815	0.343

Table 2

Test Vehicle: Pontiac Bonneville. (1998 Model Year)					
Vehicle Configuration	**Test Date**	**Federal Test Procedure. (Emissions; g/mile. Fuel Economy: r**			
		THC	**NMHC**	**CO**	**NOx**
Stock vehicle. Baseline test 1 before device installation.	09/04/98	0.066	0.054	0.806	0.168
Stock vehicle. Baseline test 2 before device installation.	09/10/98	0.064	0.053	1.034	0.173
Stock vehicle. Baseline test 3 before device installation.	09/11/98	0.053	0.044	0.740	0.134
Inset installed. Test 1 before mileage accumulation.	09/16/98	0.055	0.047	0.598	0.167
Inset installed. Test 2 before mileage accumulation.	09/18/98	0.054	0.045	0.541	0.193
Inset installed. Test 3 before mileage accumulation.	09/22/98	0.060	0.051	0.805	0.170
Inset installed. Test 4 before mileage accumulation.	09/24/98	0.074	0.064	1.209	0.159
Inset installed. Test 1 after mileage accumulation.	10/06/98	0.062	0.053	0.705	0.154
Inset installed. Test 2 after mileage accumulation.	10/07/98	0.054	0.046	0.461	0.169
Inset installed. Test 3 after mileage accumulation.	10/08/98	0.051	0.044	0.394	0.142
Stock vehicle. Baseline test 1 after mileage accumulation.	10/14/98	0.066	0.056	0.750	0.140
Stock vehicle. Baseline test 2 after mileage accumulation.	10/15/98	0.069	0.058	0.958	0.161
Stock vehicle. Baseline test 3 after mileage accumulation.	10/23/98	0.080	0.069	1.239	0.147

Table 3

Emission Standards Applicable to Vehicles Used in the Evaluation Program. (g/mile)				
Model Year	**THC**	**NMHC**	**CO**	**NOx**
1994	0.41	-----	3.4	1.0
1996	0.41	0.25	3.4	0.4
1998	0.41	0.25	3.4	0.4

Table 4