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THE EFFECT OF
FPC-1 FUEL ADDITIVE ON
EMISSIONS AND FUEL ECONOMY
PROJECT NO. 7858-004

This report corrects errors in emissions and fuel economy data tables presented in the May 7, 1982 report. The conclusion and appendices of original test data are unchanged.

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1.0 INTRODUCTION AND SUMMARY

Emissions, fuel economy, and driveability tests were run on a 1979 Chevrolet Malibu at Systems Control, Inc. (SC) to determine the effect of FPC-1 fuel catalyst. The emission tests performed were duplicate hot start city and highway driving cycles specified by the Environmental Protection Agency (EPA) for light-duty vehicles. Fuel economy measurements were taken according to the J1082 road test procedures defined by the Society of Automotive Engineers (SAE). Driveability was evaluated using the Coordinating Research Council (CRC) cold start and driveway road test. After 3,000 miles using FPC-1, emissions were found to be unaffected. Fuel economy increased approximately 3 to 5 percent during EPA tests and approximately 7 percent on J1082 road tests. Driveability as measured by the CRC procedure was improved.

2.0 TEST PROGRAM

This section describes the methodology used in this test program and presents the test results.

2.1 TEST VEHICLE

An SC fleet vehicle (#072) was used and is described in Table 1. The vehicle was given an inspection to determine its operability and running condition. An engine out sampling probe was installed. A fifth wheel and fluidyne were installed for the J1082 procedure. A vacuum gauge was installed for the CRC driveability procedure.

2.2 TEST PROCEDURES

The test protocol consisted of vehicle preparation, accumulation of 300 miles on untreated test fuel, baseline tests, tests after immediately switching to FPC-1 treated fuel, and accumulation of 3,000 miles using a combination of city street and highway driving. Tests were performed at 1,500 miles and 3,000 miles.

Table 1. - VEHICLE DESCRIPTION

| | |
|---|---------------------------------------|
| Make: | Chevrolet |
| Model: | Malibu |
| Year: | 1979 |
| Vehicle ID Number: | 1W35J0K511705 |
| Body Style: | 4 door Station Wagon |
| Engine Type: | 267 CID (4.4L) V8/2 Barrel Carburetor |
| Transmission: | Automatic |
| Tire Make/Type: | Uniroyal P19575/R14 |
| Engine Family Code: | 910G2U/9B3-1 |
| Vehicle Weight (with instruments driver, observer) | 4,027 pounds |
| Dynamometer Inertia Weight: | 4,000 pounds |
| Dynamometer Horsepower: | 12.5 horsepower |
| Emission Calibration: | Federal Low Altitude |
| Emission Controls: | CAT-EFE-EGR |

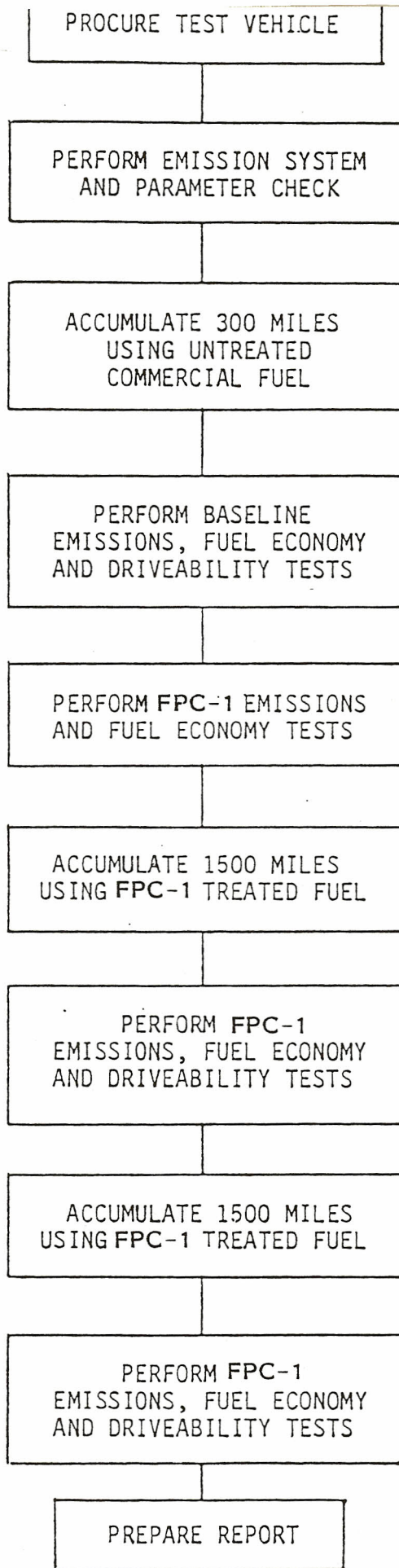


Figure 1. Flowchart for FPC-1 Test Program

The same batch of commercially available regular grade gasoline from Utah was used for all mileage accumulation and testing. Treated fuel was prepared by mixing one (1) fluid ounce of FPC-1 (Batch #D41281) to 12.5 gallons of gasoline. Pipettes were used to accurately measure the FPC-1 at the rate of 2.4 milliliters per gallon of gasoline. For testing, 5 gallon batches were prepared prior to test. For mileage accumulation, FPC-1 was added to the vehicle's fuel tank midway through each fueling. The fuel tank was not topped off so that the amount of catalyst could be calculated based on a known volume of fuel dispensed into the vehicle.

The emission test sequence consisted of duplicate LA-4/HFET driving cycles. The LA-4 was driven as a hot start test. The LA-4 was the first two phases of the 1975 Federal Test Procedure (FTP). The two LA-4 cycles constituted the duplicate city test. The LA-4 driving cycle was a continuous sequence of non-repetitive idles, accelerations, cruises, and decelerations simulating urban driving. Upon completion of the LA-4, the test vehicle was soaked for 10 minutes before the start of the Highway Fuel Economy Test (HFET). The HFET was preceded by a 3-minute cruise at 50 mph followed by a 2-second idle. The HFET simulates freeway driving. Duplicate tests were performed at zero miles without, and with, FPC-1 after 1500 miles and after 3000 miles of using FPC-1. Figure 1 shows the flowchart for testing the vehicle.

Duplicate road fuel economy and driveability tests were also performed at zero miles on untreated fuel and at 1500 and 3000 miles using FPC-1 treated fuel. Fuel economy tests were performed using the SAE J1082 Suburban (SAE-S) and Interstate (SAE-I) cycles. Tests were performed on road routes close to SC's laboratory.

The CRC driveability test was performed on a road route originating at SC's laboratory. The test included a cold start and a number of driving maneuvers during the 3.6 mile test. Vehicle performance including hesitation, stumble, surging, idle quality and stalling were evaluated using a standardized system of weighting factors and demerits based on the nature and perceived severity of each undesirable characteristic.

Table 2. - Emission Data Summary
(1979 Chevrolet Malibu)

| Test Miles | Using FPC-1 | Test Type | Tail Pipe (Gm/Mi) | | | | Engine Out (Gm/Mi) | | | Converter (%) Efficiency | | | |
|------------|-------------|-----------|-------------------|-------|-----------------|-----------------|--------------------|-------|-----------------|--------------------------|----|-----------------|----|
| | | | HC | CO | NO _x | CO ₂ | HC | CO | NO _x | HC | CO | NO _x | |
| 0 | No | LA-4 | 1 | 0.622 | 7.421 | 0.570 | 528.5 | 3.92 | 11.39 | 0.68 | 84 | 35 | 16 |
| | | | 2 | 0.444 | 6.346 | 0.553 | 523.3 | 3.98 | 10.73 | 0.66 | 89 | 41 | 16 |
| | | Mean | 0.533 | 6.884 | 0.562 | 525.9 | 3.95 | 22.06 | 0.67 | 86 | 38 | 16 | |
| | | HFET | 1 | 0.172 | 1.765 | 0.584 | 412.8 | 1.96 | 5.04 | 0.64 | 91 | 65 | 8 |
| | | | 2 | 0.177 | 1.700 | 0.589 | 406.6 | 1.97 | 5.00 | 0.64 | 91 | 66 | 8 |
| | | | Mean | 0.175 | 1.733 | 0.586 | 409.7 | 1.96 | 5.02 | 0.64 | 91 | 66 | 8 |
| 0 | Yes | LA-4 | 1 | 0.548 | 7.883 | 0.536 | 527.9 | 4.60 | 12.85 | 0.67 | 88 | 39 | 19 |
| | | | 2 | 0.556 | 7.826 | 0.549 | 527.0 | 4.35 | 12.91 | 0.67 | 87 | 39 | 18 |
| | | | Mean | 0.552 | 7.854 | 0.542 | 527.4 | 4.48 | 12.88 | 0.57 | 88 | 39 | 18 |
| | | HFET | 1 | 0.196 | 2.117 | 0.591 | 416.2 | 2.15 | 5.60 | 0.65 | 91 | 62 | 9 |
| | | | 2 | 0.186 | 2.215 | 0.595 | 419.3 | 2.08 | 5.77 | 0.66 | 91 | 62 | 9 |
| | | | Mean | 0.191 | 2.166 | 0.593 | 417.8 | 2.12 | 5.68 | 0.66 | 91 | 62 | 9 |
| 1500 | Yes | LA-4 | 1 | 0.550 | 4.058 | 0.619 | 510.1 | 3.61 | 8.15 | 0.73 | 85 | 50 | 15 |
| | | | 2 | 0.603 | 6.143 | 0.595 | 511.7 | 3.74 | 10.49 | 0.69 | 84 | 41 | 14 |
| | | | Mean | 0.577 | 5.101 | 0.607 | 510.9 | 3.68 | 9.32 | 0.71 | 84 | 46 | 14 |
| | | HFET | 1 | 0.146 | 1.038 | 0.648 | 405.1 | 1.67 | 4.14 | 0.69 | 91 | 75 | 7 |
| | | | 2 | 0.163 | 1.441 | 0.639 | 408.9 | 1.79 | 4.57 | 0.68 | 91 | 69 | 6 |
| | | | Mean | 0.154 | 1.240 | 0.644 | 407.0 | 1.73 | 4.36 | 0.68 | 91 | 72 | 6 |
| 3000 | No | LA-4 | 1 | 0.546 | 6.693 | 0.554 | 504.1 | 4.85 | 10.87 | 0.68 | 89 | 38 | 19 |
| | | | 2 | 0.505 | 5.956 | 0.586 | 499.5 | 4.54 | 10.29 | 0.72 | 89 | 42 | 18 |
| | | | Mean | 0.526 | 6.325 | 0.570 | 501.8 | 4.70 | 10.58 | 0.70 | 89 | 40 | 18 |
| | | HFET | 1 | 0.243 | 1.473 | 0.571 | 400.4 | 2.22 | 4.57 | 0.63 | 89 | 68 | 9 |
| | | | 2 | 0.193 | 1.054 | 0.574 | 398.9 | 2.39 | 4.60 | 0.68 | 92 | 77 | 16 |
| | | | Mean | 0.218 | 1.264 | 0.573 | 399.7 | 2.31 | 4.59 | 0.66 | 90 | 72 | 12 |

2.3 TEST RESULTS

Summary emissions data are shown in Table 2. Summary fuel economy and driveability data are shown in Table 3. The effect of FPC-1 as a percent increase (decrease) relative to initial baselinereults are shown in Table 4. Deatailed data, including copies of computer printouts and data sheets are shown in the appendix.

Since all tests were performed in duplicate, the significance of the effect of FPC-1 could be evaluated statistically. A two tailed t-test at a 90% level of confidence was used to compare each parameter to its corresponding value for the baseline test.

Emission levels were generally unaffected by FPC-1. The only significant effect, an 8% increase in NO_x emissions, was observed after approximately 1500 miles with FPC-1. After accumulating 3000 miles, emission levels were not significantly different than baseline.

Fuel economy, as measured by the LA-4 and HFET tests, decreased slightly immediately after using FPC-1. After 3000 miles, however, fuel economy had increased 4.9% for the LA-4 and 2.6% for the HFET. Both improvements were statistically significant. Fuel economy for the SAE J1082 Suburban cycle increased 6.6% and 6.7% after 1500 and 3000 miles respectively, which were both statistically significant. Fuel economy for the SAE J1082 Interstate cycle increased 2.5% after 1500 miles, which was not significant; and 7.9% after 3000 miles, which was significant.

Driveability demerits after 1500 miles increased slightly but the increase was not statistically significant. After 3000 miles, demerits had decreased 30% which was statistically significant. The improvement in driveability was reflected mainly in decreased part throttle surging and hesitation on wide open throttle accelerations.

Generally, the data may be summarized as follows:

Table 3. - Fuel Economy and Driveability Data Summary
(1979 Chevrolet Malibu)

| <u>Test Miles</u> | <u>Using FPC-1</u> | <u>Test</u> | <u>Fuel Economy (MPG)</u> | | | | <u>Driveability (Demerits)</u> |
|-------------------|--------------------|-------------|---------------------------|-------------|--------------|--------------|--------------------------------|
| | | | <u>LA-4</u> | <u>HFET</u> | <u>SAE-S</u> | <u>SAE-I</u> | |
| 0 | No | 1 | 17.127 | 22.311 | 18.851 | 20.707 | 51 |
| | | 2 | 17.366 | 22.655 | 18.797 | 21.726 | 53 |
| | | Mean | 17.245 | 22.483 | 18.824 | 21.217 | 52 |
| 0 | Yes | 1 | 17.128 | 22.101 | - | - | - |
| | | 2 | 17.160 | 21.931 | - | - | - |
| | | Mean | 17.144 | 22.016 | - | - | - |
| 1500 | Yes | 1 | 17.917 | 22.803 | 20.073 | 21.685 | 65 |
| | | 2 | 17.743 | 22.553 | 20.050 | 21.827 | 54 |
| | | Mean | 17.830 | 22.678 | 20.061 | 21.756 | 60 |
| 3000 | Yes | 1 | 17.982 | 23.014 | 20.231 | 22.684 | 31 |
| | | 2 | 18.188 | 23.142 | 19.983 | 23.083 | 40 |
| | | Mean | 18.085 | 23.078 | 20.107 | 22.884 | 36 |

Table 4. - Effect of FPC-1 in 1979 Chevrolet Malibu

| | | <u>Percent Change From Baseline</u> | | |
|-------------------------|---------------------|-------------------------------------|-------------------|-------------------|
| | | <u>0 Miles</u> | <u>1500 Miles</u> | <u>3000 Miles</u> |
| <u>Emissions (LA-4)</u> | | | | |
| | HC | +3.6% | +8.2% | -1.3% |
| | CO | +14.1% | -25.9% | -8.1% |
| | NO _x | -3.6% | +8.0%* | +2.0% |
| ∞ | <u>Fuel Economy</u> | | | |
| | LA-4 | -0.6% | +3.4%* | +4.9%* |
| | HFET | -2.1% | +0.9% | +2.6%* |
| | SAE-Suburban | - | +6.6%** | +6.7%** |
| | SAE-Interstate | - | +2.5% | +7.9%* |
| <u>Driveability</u> | | | | |
| | Demerits | - | +15.4% | -30.8%* |

*Change is significant at 90% level of confidence

**Change is significant at 99% level of confidence

- FPC-1 did not significantly affect emissions of hydrocarbons, carbon monoxide or oxide of nitrogen. Emissions showed a maximum effect at 1500 miles, which may be real or may be an artifact.

- FPC-1 resulted in a statistically significant improvement in fuel economy after 1500 miles as measured by the EPA LA-4 dynamometer cycle and the SAE J1082 Suburban cycle: and after 3000 miles as measured by the EPA HFET dynamometer cycle and the SAE J1082 Interstate Cycle. There was no fuel economy improvement immediately after switching to FPC-1 treated fuel.

- FPC-1 resulted in statistically significant improvement in driveability after 3000 miles.