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# Evaluation of XRG #1 a Fuel Additive

by

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## Background

The Environmental Protection Agency receives information about many systems which appear to offer potential for emission reduction or fuel economy improvement compared to conventional engines and vehicles. EPA's Emission Control Technology Division is interested in evaluating all such systems because of the obvious benefits to the Nation from the identification of systems that can reduce emissions, improve fuel economy, or both. EPA invites developers of such systems to provide complete technical data on the system's principle of operation, together with available test data on the system. In those cases for which review by EPA technical staff suggests that the data available shows promise, attempts are made to schedule tests at the EPA Motor Vehicle Emission Laboratory at Ann Arbor, Michigan. The results of all such test projects are set forth in a series of Test and Evaluation Reports, of which this report is one.

In February of 1978 the EPA tested NRG #1, a fuel additive developed and marketed by NRG International, Inc. of Clayville, New York. Contrary to NRG's claims, the test results showed, "neither a general increase in fuel economy nor a decrease in emissions associated with the addition of NRG #1 to the fuel." (1)(Evaluation of NRG #1, A Fuel Additive, TAEB Report 77-19, February 1978).*

In response to a request from the Federal Trade Commission for more in-depth information on NRG #1 (now referred to as "XRG #1") (2) this new series of tests was performed.

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

The conclusions from the EPA evaluation test can be considered to be quantitively valid only for the specific test cars used; however, it is reasonable to extrapolate the results from the EPA test to other types of vehicles in a directional manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles.

## Summary of Findings

There was no significant change in emissions or fuel economy through the use of XRG #1 for the group of vehicles tested.

For individual vehicles, the Citation showed a 2% fuel economy improvement on the FTP and 4% fuel economy improvement on the HFET. There was no significant increase or decrease in fuel economy for the Dart and Fairmont for either the FTP or HFET.

* Numbers in parenthesis designate references at the end of this report.

## Description

XRG #1 is a fuel additive developed and marketed by XRG International, Inc., (formerly NRG International) of Clayville, New York.

XRG #1 is recommended by the manufacturer for use "with all grades of gasoline and diesel fuel used in internal combustion engines." It is mixed directly with fuel in the vehicle's tank in a ratio of 1:1600 (0.08 fl. oz. additive per gallon fuel). The following benefits are claimed by the manufacturer when the additive is used in an automotive gasoline engine (3):

- Increased fuel economy of 10-25%.
- Decreased exhaust emissions.
- Increased engine power.
- Decreased starting time in cold weather.
- Decreased dieseling tendency.
- Decreased carbon buildup inside engine.

The manufacturer claims these benefits occur over a period of time of continued usage. That is, there are some immediate benefits from usage of the fuel additive but full benefits are obtained only after several tankfuls of the XRG #1 additive doped fuel. In addition, to retain these benefits, XRG #1 usage must be continued.

## Test Vehicle Description

The three test vehicles used in this study were:

A 1980 Chevrolet Citation equipped with a 2.8 litre V-6 engine and an automatic transmission. This vehicle used EGR, an oxidation catalyst, and pulsating air injection for emission control.

A 1975 Dodge Dart equipped with a 225 cubic inch inline 6-cylinder engine and an automatic transmission. This vehicle was calibrated to meet the 1975 California emission standards. This vehicle used an air pump, EGR, and an oxidation catalyst for emission control.

A 1979 Ford Fairmont equipped with a 140 cubic inch inline 4-cylinder engine and automatic transmission. This vehicle used an oxidation catalyst for emission control.

A complete description of these vehicles is given in the test vehicle description in Appendix A.

## Test Procedure

Exhaust emission tests were conducted according to the 1977 Federal Test Procedure (FTP) described in the Federal Register of June 28, 1977, and the EPA Highway Fuel Economy Test (HFET), described in the Federal Register of September 10, 1976. The vehicles were not tested for evaporative emissions.

Prior to baseline testing, each vehicle was given a specification check and inspection. The ignition timing, idle speed, and fast idle speed were checked for agreement with the manufacturer's specifications given on the Vehicle Emission Control Information label affixed to the engine compartment. Each vehicle met its manufacturer's specifications and therefore no adjustments were required.

The vehicles were inspected for engine vacuum leaks, proper connection of vacuum hoses, functioning PCV valve, oil and water levels, and general condition of engine compartment. Each vehicle was in satisfactory condition when initially inspected.

Because the manufacturer's claims for XRG #1 additive included both immediate and long term benefits (3) the test program included testing both immediately after initial additive usage and after-mileage accumulation with the additive. Each vehicle was tested in three different conditions:

1. Baseline - as received.
2. With XRG #1 (vehicle fuel tank drained, refueled with additive doped fuel and prepped before this test).
3. After 500 miles with XRG #1.

At each test condition duplicate FTP and HFET tests were conducted. The accumulation of 500 miles using fuel with XRG #1 consisted of sequences of 10 HFET driving cycles and one LA-4 (the basic FTP cycle) driving cycle. The relatively high average speed of the HFET (48 mph) was expected to minimize the amount of time to achieve those additive benefits that are based on vehicle mileage accumulation. Mileage accumulation was accomplished on a dynamometer.

In addition, one vehicle, that was used in later test programs, received baseline tests after the 500 mile XRG #1 tests.

All testing was performed using the same gasoline batch. Two barrels of the gasoline batch were doped with the XRG #1 at the manufacturer's prescribed doseage of 1600 parts gasoline to one part XRG #1. This XRG #1 doped gasoline was used for all XRG #1 tests and mileage accumulation.

## Discussion of Results

### General Data Analysis

The objective of this test program was to determine if there was a significant beneficial change in vehicle emissions, fuel economy, or performance through the use of the fuel additive XRG #1.

The results of these tests are summarized in Tables I and II. Results of individual tests are given in Tables V through X in Appendix B. The results of the statistical analysis and actual changes between configurations are shown in Tables III and IV.

Table I

Average Vehicle FTP Emissions
grams per mile

| Test Condition | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|
| | | Chevrolet Citation - FTP | | | |
| Baseline | .35 | 1.93 | 450 | 1.55 | 19.5 |
| XRG #1 | .32 | 2.03 | 449 | 1.62 | 19.6 |
| XRG #1 @ 500 miles | .33 | 1.86 | 440 | 1.61 | 20.0 |
| | | Dodge Dart - FTP | | | |
| Baseline | .63 | 7.90 | 568 | 1.81 | 15.3 |
| XRG #1 | .65 | 8.64 | 583 | 1.72 | 14.8 |
| XRG #1 @ 500 miles | .48 | 6.93 | 563 | 1.85 | 15.4 |
| | | Ford Fairmont - FTP | | | |
| Baseline | .76 | 8.40 | 400 | 1.83 | 21.3 |
| XRG #1 | .71 | 8.57 | 402 | 1.83 | 21.2 |
| XRG #1 @ 500 miles | .74 | 7.74 | 404 | 1.85 | 21.2 |

Table II

Average Vehicle HFET Emissions
grams per mile

| Test Condition | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|
| | | Chevrolet Citation - HFET | | | |
| Baseline | .07 | .02 | 313 | 1.29 | 28.4 |
| XRG #1 | .06 | .00 | 310 | 1.25 | 28.6 |
| XRG #1 @ 500 miles | .07 | .00 | 300 | 1.47 | 29.5 |
| | | Dodge Dart - HFET | | | |
| Baseline | .05 | .15 | 368 | 2.58 | 24.1 |
| XRG #1 | .04 | .11 | 374 | 2.17 | 23.7 |
| XRG #1 @ 500 miles | .04 | .10 | 364 | 2.41 | 24.4 |
| | | Ford Fairmont - HFET | | | |
| Baseline | .15 | .63 | 317 | 2.48 | 27.9 |
| XRG #1 | .14 | .68 | 320 | 2.52 | 27.6 |
| XRG #1 @ 500 miles | .14 | .58 | 313 | 2.35 | 28.2 |

Table III

FTP Change From Baseline Due to XRG #1 Fuel
Expressed in % at Minimum Stated Confidence Level*

| Test Condition | HC | CO | NOx | MPG |
|---|---|---|---|---|
| Chevrolet Citation - FTP<br>XRG #1 at 500 miles | -6%*** | -4%*** | 4% 93% C.L. | 2% 99% C.L. |
| Dodge Dart - FTP<br>XRG #1 at 500 miles | -24%*** | -12%*** | 2%*** | 1%*** |
| Ford Fairmont - FTP<br>XRG #1 at 500 miles | -3%*** | -8% 94% C.L. | 1%*** | 0% |
| Combined Effect - All Vehicles<br>XRG 31 at 500 miles | *** | *** | *** | *** |

Table IV

HFET Change From Baseline Due to XRG #1 Fuel
Expressed in % Change at Minimum Confidence Level*

| Test Condition | HC | CO | NOx | MPG |
|---|---|---|---|---|
| Chevrolet Citation - HFET<br>XRG #1 at 500 miles | --- | --- | 14% 99% C.L. | 5% 99% C.L. |
| Dodge Dart - HFET<br>XRG #1 at 500 miles | --- | --- | -7%*** | 1%*** |
| Ford Fairmont - HFET<br>XRG #1 at 500 miles | --- | --- | -5%*** | 1%*** |
| Combined Effect - All Vehicles<br>XRG #1 at 500 miles | --- | --- | *** | *** |

* Confidence level from statistical "t" test procedure and direction of change.

C.L. - Confidence Level

**+ indicates increase; - indicate decrease.

*** indicates change not significant at 90% confidence level. That there is no significant change.

Note: The confidence level should not be confused with changes of absolute values but are an indication of the statistical significance of the changes in the values given in Tables I and II.

Note: The confidence level was not calculated for the initial XRG #1 tests.

Note: Percent change not calculated for HC and CO emissions for HFET. See text.

From an initial review of the data given in Tables III and IV, it may appear that use of XRG #1 did cause some small changes in individual vehicle emissions or fuel economy. However, in order to determine whether the apparent differences were statistically significant, a significance test, such as a "t" test must be performed. This technique analyzes the difference due to the subject variable in relation to test to test variability to determine if the difference is real or is due to testing variability. The resultant significance determinations are stated in terms of the minimum percent confidence level that can be ascribed to the observed difference.

The "t" test technique allows the determination of the effect of one variable (use of XRG #1 additive) on a vehicle. The "t" test is also able to indicate how representative the effect of the variable is for a group of vehicles. The resultant levels of significance are stated in terms of percents. This confidence level indicates the probability of assigning differences to the variable (use of XRG #1 additive) being analyzed. With a test program of the size performed, changes with confidence levels below 90% are not significant.

EFFECT OF XRG #1

Federal Test Procedure

The use of XRG #1 did not significantly affect the HC emissions for the Citation, Dart or Fairmont.

The use of XRG #1 caused mixed effects on CO emissions. There was no significant change in the Citation's or Dart's CO emissions. The Fairmont's emissions decreased 8% (at the 94% confidence level).

The use of XRG #1 caused mixed effects on NOx emissions. The Citation's NOx emissions increased 4% at the 93% confidence level. XRG #1 did not significantly affect the NOx emissions on the Dart or Fairmont.

The use of XRG #1 did not significantly affect the fuel economy of the Dart or Fairmont. (The Citation's fuel economy showed a slight improvement, 2% (at 99% confidence level).

When the FTP results were analyzed to determine the effects of XRG #1 on the group of vehicles, the analysis showed that the use of XRG #1 did not significantly affect either HC, CO and NOx emissions or fuel economy.

Highway Fuel Economy Test

The HC and CO emissions for all three vehicles were quite low both with and without use of the additive. HC and CO emissions are usually very low for most vehicles on the HFET. Thus, even a very small change such as .01 grams per mile could appear as a 5% to 30% relative change. Therefore, since the results were low and similar, there was no significant change in HC or CO emissions caused by the use of XRG #1.

The use of XRG #1 caused mixed results on NOx emissions. The Citation's NOx emissions increased 14% at the 99% confidence level. The Dart's and Fairmont's NOx emissions were not significantly affected.

The use of XRG #1 did not significantly affect the fuel economy of the Dart or Fairmont. The Citation's fuel economy showed a slight improvement, 4% at the 99% confidence level.

The analysis of the HFET results to determine the effects of XRG #1 on the group of vehicles showed that the use of XRG #1 did not significantly affect either HC, CO and NOx emissions or fuel economy.

Discussion of Additive Components and Their Effects

According to the manufacturer, XRG #1 is composed mostly of isopropol alcohol and toluene. It also contains a small amount of ferrous sulphate, nitro benzene and water (4). An exact chemical breakdown was not given.

Toluene is a normal component of gasoline. Unleaded gasoline is reported to presently contain 10 to 15% toluene and leaded gasoline 5 to 10% toluene (5). Premium leaded fuel is 6% toluene. Individual gasoline fuel samples have had up to 45% toluene.

Conclusions

Although a few individual tests indicated slight improvements in emissions or fuel economy through the use of XRG #1, several tests indicated small emission or fuel economy penalties. A significant but small improvement in fuel economy was noted on one vehicle for the FTP and HFET. However, for the group of vehicles, XRG#1 showed no significant effect on vehicle emissions or fuel economy.

## References

1. Evaluation of NRG #1, a Fuel Additive. TAEB Technical Report 77-19, February 1978.

2. Telephone conversation between Mr. F. Peter Hutchins, Project Manager, EPA and Mr. Brian Boshart, engineer, XRG International Inc., on August 8, 1979.

3. NRG Fuel Additive, product information brochure (Note XRG = NRG).

4. Letter dated September 16, 1977 from Mr. Brian F. Boshart, NRG International to Mr. Craig Harvey, EPA. Subject, NRG contents and previous test program schedule.

5. Telephone conversation between Mr. F. Peter Hutchins, EPA and Mr. William Meyer, Gulf Research and Development, on September 4, 1979. Subject, toluene in gasolines.

# Appendix A

## TEST VEHICLE DESCRIPTION

Chassis model year/make - 1980 Chevrolet Citation

Vehicle ID - 1X117AW150868

### Engine

| | |
|---|---|
| type | V-6, 4-Cycle |
| bore x stroke | 89 x 76 mm/3.50 x 2.99 in. |
| displacement | 2800 cc/170.9 CID |
| compression ratio | 8.5 to 1 |
| maximum power at rpm | 115 hp/85.8 kW |
| fuel metering | 2 Venturi Carburetor |
| fuel requirement | unleaded, tested with Indolene HO unleaded |

### Drive Train

| | |
|---|---|
| transmission type | 3-speed automatic |
| final drive ratio | 2.53 |

### Chassis

| | |
|---|---|
| type | 4 door sedan |
| tire size | P185/80R13 |
| curb weight | 2905 lb/1318 kg. |
| inertia weight | 3000 lb. |
| passenger capacity | 5 |

### Emission Control System

| | |
|---|---|
| basic type | Oxidation catalyst<br>EGR<br>Pulsating air injection |

### Vehicle Odometer Mileage

6730 miles at start of test program

7480 miles at end of test program

# TEST VEHICLE DESCRIPTION

Chassis model year/make - 1975 Dodge Dart
Emission control system - Air Pump, Catalyst EGR
Vehicle I.D. - LH41C5B290359

## Engine

| | |
|---|---|
| type | Inline 6, 4-cycle |
| bore x stroke | 3.40 X 4.125 in. |
| displacement | 225 CID/3687 cc |
| compression ratio | 8.4:1 |
| fuel metering | 1 Venturi, carburetor |
| fuel requirement | unleaded, tested with Indolene HO unleaded |

## Drive Train

| | |
|---|---|
| transmission type | 3-speed automatic |
| final drive ratio | 2.75 |

## Chassis

| | |
|---|---|
| type | 4 door sedan |
| tire size | D78 X 14 |
| inertia weight | 3500 lb. |
| passenger capacity | 6 |

## Emission Control System

| | |
|---|---|
| basic type | air pump<br>oxidation catalyst<br>EGR<br>calibrated to 1975 California standards |

## Vehicle Odometer Mileage

20635 miles at start of test program
21950 miles at end of test program

# TEST VEHICLE DESCRIPTION

Chassis model year/make - 1979 Ford Fairmont
Vehicle I.D. 9X92Y175689

## Engine

| | |
|---|---|
| type | Inline 4, 4-cycle |
| bore x stroke | 3.80 X 3.10 in./96.5 X 78.7 mm. |
| displacement | 140 CID/2.3 1 |
| compression ratio | 9.0:1 |
| maximum power | 92 hp/68.6 k W |
| fuel metering | 2 Venturi, carburetor |
| fuel requirement | unleaded, tested with Indolene HO unleaded |

## Drive Train

| | |
|---|---|
| transmission type | 3-speed automatic |
| final drive ratio | 3.08 |

## Chassis

| | |
|---|---|
| type | 4 door sedan |
| tire size | BR 78 X 14 |
| curb weight | 2800 lb/1270 kg |
| inertia weight | 3000 lb. |
| passenger capacity | 5 |

## Emission Control System

| | |
|---|---|
| basic type | oxidation catalyst |

## Vehicle Odometer Mileage

10890 miles at start of test program
11525 miles at end of test program

Table V

Chevrolet Citation FTP Emissions
grams per mile

| Test Condition | Test # | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|---|
| Baseline | 79-9919 | .39 | 2.29 | 452 | 1.54 | 19.4 |
| Baseline | 79-9921 | .32 | 1.66 | 450 | 1.56 | 19.5 |
| Baseline | 79-9923 | .33 | 1.73 | 450 | 1.56 | 19.5 |
| Baseline | 79-9925 | .34 | 2.03 | 449 | 1.52 | 19.6 |
| XRG (14 miles) | 79-9927 | .32 | 2.23 | 450 | 1.60 | 19.5 |
| XRG (55 miles) | 79-9929 | .31 | 1.83 | 447 | 1.63 | 19.7 |
| XRG (524 miles) | 79-9931 | .35 | 1.87 | 441 | 1.57 | 19.9 |
| XRG (552 miles) | 79-9978 | .32 | 1.91 | 440 | 1.65 | 20.0 |
| XRG (591 miles) | 79-9980 | .32 | 1.80 | 439 | 1.62 | 20.0 |

Table VI

Dodge Dart FTP Emissions
grams per mile

| Test Condition | Test # | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|---|
| Baseline | 79-9778 | .83 | 9.94 | 579 | 1.60 | 14.9 |
| Baseline | 79-9781 | .79 | 8.58 | 591 | 1.52 | 14.6 |
| Baseline (769 miles) | 80-0246 | .38 | 6.06 | 547 | 1.99 | 15.9 |
| Baseline (1192 miles) | 80-0735 | .50 | 7.00 | 553 | 2.11 | 15.7 |
| XRG (8 miles) | 79-9782 | .46 | 7.00 | 583 | 1.72 | 14.9 |
| XRG (42 miles) | 79-9784 | .84 | 10.27 | 583 | 1.71 | 14.7 |
| XRG (521 miles) | 79-9786 | .49 | 6.68 | 566 | 1.89 | 15.3 |
| XRG (554 miles) | 79-9788 | .47 | 7.12 | 562 | 1.78 | 15.4 |
| XRG (595 miles) | 79-9986 | .47 | 6.99 | 561 | 1.87 | 15.5 |

Table VII

Ford Fairmont FTP Emissions
grams per mile

| Test Condition | Test # | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|---|
| Baseline | 79-9909 | .76 | 8.29 | 400 | 1.83 | 21.3 |
| Baseline | 79-9911 | .76 | 8.50 | 400 | 1.82 | 21.3 |
| XRG (5 miles) | 79-9913 | .72 | 8.58 | 403 | 1.83 | 21.2 |
| XRG (52 miles) | 79-9915 | .70 | 8.56 | 400 | 1.83 | 21.3 |
| XRG (509 miles) | 79-9917 | .74 | 7.88 | 403 | 1.91 | 21.2 |
| XRG (540 miles) | 79-9984 | .74 | 7.59 | 404 | 1.79 | 21.2 |

Table VIII

Chevrolet Citation HFET Emissions
grams per mile

| Test Condition | Test # | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|---|
| Baseline | 79-9920 | .07 | .00 | 311 | 1.20 | 28.5 |
| Baseline | 79-9922 | .07 | .05 | 316 | 1.35 | 28.0 |
| Baseline | 79-9924 | .07 | .01 | 313 | 1.24 | 28.3 |
| Baseline | 79-9926 | .07 | .01 | 310 | 1.37 | 28.6 |
| XRG(24 miles) | 79-9928 | .06 | .00 | 309 | 1.27 | 28.7 |
| XRG (66 miles) | 79-9930 | .06 | .00 | 310 | 1.22 | 28.6 |
| XRG (536 miles) | 79-9932 | .07 | .00 | 301 | 1.47 | 29.4 |
| XRG (568 miles) | 79-9979 | .07 | .00 | 299 | 1.44 | 29.6 |
| XRG (608 miles) | 79-9981 | .07 | .00 | 299 | 1.50 | 29.6 |

Table IX

Dodge Dart HFET Emissions
grams per mile

| Test Condition | Test # | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|---|
| Baseline | 79-9779 | .05 | .09 | 379 | 2.02 | 23.4 |
| Baseline | 79-9780 | .05 | .08 | 374 | 2.01 | 23.7 |
| Baseline (781 miles) | 80-0316 | .05 | .19 | 356 | 2.79 | 24.9 |
| Baseline (1228 miles) | 80-0734 | .06 | .22 | 362 | 3.48 | 24.5 |
| XRG (19 miles) | 79-9783 | .04 | .12 | 376 | 2.07 | 23.6 |
| XRG (53 miles) | 79-9785 | .04 | .09 | 372 | 2.27 | 23.8 |
| XRG (532 miles) | 79-9787 | .04 | .06 | 364 | 2.40 | 24.4 |
| XRG (565 miles) | 79-9789 | .05 | .09 | 365 | 2.34 | 24.3 |
| XRG (606 miles) | 79-9987 | .04 | .14 | 364 | 2.48 | 24.4 |

Table X

Ford Fairmont HFET Emissions
grams per mile

| Test Condition | Test # | HC | CO | $CO_2$ | NOx | MPG |
|---|---|---|---|---|---|---|
| Baseline | 79-9910 | .14 | .55 | 316 | 2.50 | 28.0 |
| Baseline | 79-9912 | .15 | .70 | 317 | 2.45 | 27.8 |
| XRG (24 miles) | 79-9914 | .14 | .68 | 320 | 2.44 | 27.6 |
| XRG (63 miles) | 79-9916 | .14 | .67 | 319 | 2.61 | 27.7 |
| XRG (520 miles) | 79-9918 | .13 | .57 | 312 | 2.31 | 28.3 |
| XRG (551 miles) | 79-9985 | .14 | .59 | 314 | 2.39 | 28.1 |

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