Hauser Laboratories

Evaluation of Mix-I-Go

As A Performance-Enhancing

Fuel Additive

Description of Work

Hauser Laboratories was engaged to evaluate the effectiveness of Mix-I-Go (MXO) as a gasoline fuel additive. Mix-I-Go has been marketed in the United States by Bell Performance, Inc. (formerly Bell Additives and Bell Laboratories) since its formulation in 1909 as the first fuel additive on record.

The test program was designed to investigate the properties which are associated with the claims for the product. The major emphasis was on fuel economy. The key claims made for the product are:

1. Reduced emissions
2. Improved fuel economy
3. Improved upper cylinder lubrication
4. Increased horsepower
5. Increased compression
6. Improved cleanliness of operation
7. Water dispersion and elimination

Vehicles studied were typical vehicles which might be owned and operated by anyone. Fuels used were those obtained from a local supplier.

The overall test program combined a mix of laboratory studies with field studies. Field studies were of moderate duration to approximate field claims that at least 3,000 miles were needed to allow the product enough time to demonstrate maximum benefits. The lab studied were oriented to provide more immediate and, hence, more selective information.

Results Summary

The following is a summation of data from several performance evaluations conducted in the test program:

1. The overall improvement in fuel efficiency observed in the test fleet was 8.2%.
2. The overall reduction in emissions observed in the test fleet was 21.7% for hydrocarbons and 25.8% for carbon monoxide.
3. The average improvement in fuel efficiency observed in dynamometer studies of two test vehicles was 12.0%.

4. The average reduction in emissions observed in dynamometer studies of two vehicles was 10.3% for hydrocarbons and 14.8% for carbon monoxide.
5. In stationary engine tests, the use of Mix-I-Go and gasoline demonstrated a repeatable improvement in fuel economy of 6.5%. This improvement was immediate and reversible when regular fuel was substituted for the Mix-I-Go blend (and vice-versa).

Having completed the test program, the laboratory is willing to make the following statements regarding the claims made for the product Mix-I-Go:

1. Mix-I-Go reduces hydrocarbon and carbon monoxide emissions from gasoline internal combustion engines when used according to the manufacturers' specifications.
2. Mix-I-Go improves fuel economy in internal combustion engines when used according to the manufacturers' specifications.
3. Engine test data neither substantiates or disproves the claim that upper cylinder lubrications is improved with the use of Mix-I-Go with gasoline in internal combustion engines. However, identification of a lubricating oil component in the Mix-I-Go confirms the availability of a lubricant at the upper cylinder location during combustion. In that lubricating oil components are absent in gasoline, their presence in a Mix-I-Go/gasoline blend should enhance upper cylinder lubrication.
4. The laboratory did not directly evaluate the claim that Mix-I-Go affects horsepower output from internal combustion engines. They did observe economy increases that translate to improved power production from the engine, thereby suggesting improved horsepower.
5. The laboratory found a modest improvement in compression in the engine that was studied after using Mix-I-Go.
6. Spark plug cleanliness and overall cylinder cleanliness were observed during the use of Mix-I-Go in the test program.

Results

1. Chemical Tests

Results of the laboratory chemical testing are seen in Table 1. Based on these test there was no significant difference between the test fuels and the test fuels with Mix-I-Go. This was anticipated due to the small quantity of Mix-I-Go required (1 ounce to 10 gallons of fuel) and its similar properties.

In addition to the surface tension date listed on Table 1, the laboratory measutred the surface tension of gasoline with and without Mix-I-Go before and after washing with water. Interfacial surface tension of gasoline/water was measured weith and without Mix-I-Go. The surface tension results were the same for both samples.

Discussion

No significant differences were observed between the test fuels with and without Mix-I-Go added. The slight change in gum content (ASTM D-381) can be attributed to the upper cylinder lubricant (oil) that is in the Mix-I-Go formulation. This material would be evident from the test but would have no bearing on gum formation in actual applications.

Table 1 – Chemical Test Data

ASTM Test Name and Designation	**Standard Test Fuel**		**Test Fuel and 1 Oz MXO/10 Gals Fuel**		
	Leaded	**Unleaded**	**Leaded**	**Unleaded**	**Mix-I-Go**
Vapor Pressure, psi (D-323)	10.1	9.2	**	**	0.0
Lead Content, % by wt (D-2547)	0.57	0.01	**	**	<0.02
Copper Strip Corrosion (D-130)	1a	1b	1a	1b	---
Existent Gum mg/100ml					
Washed	0.6	1.0	9.2	4.0	--- 2
Unwashed	5.0	12.4	12.6	17.8	709
Sulfur Content % by Wt (D-1266)	0.06	0.08			0.21
Engler Distillation (Deg F) (D-86)					
Initial BP	92	88	**	**	304
5% Over	125	112	**	**	327
10% Over	136	129	**	**	331
20% Over	150	161	**	**	333
30% Over	171	192	**	**	337
40% Over	191	219	**	**	343
50% Over	212	241	**	**	349
60% Over	234	263	**	**	352
70% Over	260	287	**	**	357
80% Over	299	316	**	**	365
90% Over	357	367	**	**	382
95% Over	407	406	**	**	402
End Point	427	427	**	**	406
Recovery % by Wt	97.0	98.0	**	**	97.5
Residue % by Wt	1.0	1.5	**	**	2.0
Loss, % by Wt	2.0	1.0	**	**	0.5
Surface Tension, Dynes/cm (D-1331)	19.0	---	19.1	---	

Gum Solubility, % of total	5	5	5	5	
Water Content of fuel, ppm	217	---	227	---	

** = Mix-I-Go would have no effect on these values.

2. Bench Tests

Two engines were used in performing the laboratory's small engine bench tests. Both engines were Briggs and Stratton engines modified to accept emission reading equipment and attached to a water pump. Engine #1 suffered mechanical problems shortly after the initial tests were performed. Accordingly the use of this engine was terminated. A second engine was obtained (new), broken in and then shifted to the test program. This engine was mechanically sound throughout the test program. Numerous tests were performed by alternately shifting to and from the use of Mix-I-Go.

Result and Discussion

The following list is a tabulation of the result from the first engine. The fuel used in all tests was leaded regular.

Engine #1 Economy Tests	**Average Minutes/Gallon**	**Standard Deviation**	**% Change from Baseline Data**
Baseline economy study minutes of operation per gallon of fuel	361.9*	9.46	---
Economy data while using Mix-I-Go	386.5*	8.04	+6.8

* = Five data points averaged for each calculation

The results from engine #1 show a modest increase in fuel economy with the use of Mix-I-Go with the regular fuel. Due to the mechanical problem that developed, the laboratory was unable to perform additional studies on this engine. The data obtained does represent over 70 hours of test operations including over 32 hours of operation utilizing the Mix-I-Go additive treated in the fuel.

The spark plug used throughout this test sequence was examined periodically as were the cylinder head and valves. These were all black and sooty at the completion of the baseline (untreated) study. At the completion of the Mix-I-Go study, the cylinder head, valves and plugs were all light-grey to white in color. The porcelain on the plugs was clearly visible.

Engine #2 Economy Tests	Average Minutes run/gallon	Standard Deviation	Data Points Averaged	% Change from Baseline Data
Test 1 – Baseline economy study minutes of operation per gallon of fuel	466.7	6.90	10	---
Test 2 – Economy data while using Mix-I-Go	494.2	8.73	15	+5.9
Test 3 – Economy data with regular fuel after Mix-I-Go	467.7	8.46	6	+0.2
Test 4 – Economy data with a return to Mix-I-Go	501.9	2.71	2	+7.5
Test 5 – Economy data with regular fuel after Mix-I-Go	468.3	6.73	2	+0.3

Engine #2 – Emission Tests

Emission data for engine #2 was taken during economy test 1, 2, 3, and 4. Throughout these tests the emissions were consistently reduced. Even when the Mix-I-Go additive was removes for a short period of time the emissions remained lower than the baseline data. The overall reduction in hydrocarbons from 700ppm to 580ppm was -17.1%. The overall reduction on carbon monoxide from 3.0% to 1.6% was -46.7%.

Although the overall economy changes in the above tests were modest, they are significant. It is particularly significant to note that the observed economy improvements are lost almost immediately upon return to regular untreated fuel. Likewise, the gains are noticed again immediately upon reintroduction of the additive. Another important observation was made during test 2. The initial economy given for the unit was only 4.9%. After 60 hours, the economy gain was 7.5%. This suggests that an induction period is necessary for full benefits to be noticed. The average gain over the test period was 5.9%.

3. Road Evaluation

The vehicles chosen, their specification and the results summary are seen on Tables 2 and 3. The primary observations made from this study include:

- 8.2% fleet average economy improvement
- 21.7% fleet average reduction on hydrocarbon emission
- 25.8% fleet average reduction on carbon monoxide emission
- Reduced carbon formation on spark plugs

Significantly, none of the vehicles which completed the test program showed zero or negative economy change. All vehicles demonstrated improvements in fuel economy and in emissions.

Data validation for the fuel economy studies was good. Each data point consisted of at least four test runs. Each statistical average (with the exception of vehicle #9) consisted of three or more tests, or 12 or more runs. The maximum deviation from the average for the data in any vehicle on a run-to-run basis was 1.5%.

A second form of data validation was taken from the actual fuel/mileage records. This is similar to the fleet economy test procedures practiced by others. The laboratory considered these results important, but only as validation of the in-situ measurements.

The compression tests performed on vehicle #2 (see Table 4) demonstrates an overall improvement in compression of 4.8% based upon the baseline information. This increase is twice the measurement error of 2.5%. The increase is real but modest. The laboratory subjective observation of spark plug condition, also seen in Table 4, is real and significant. However, no quantitations were recorded for this.

Table 2 – Selected Fleet Vehicles

Vehicle Number	Model, Make, Year	Engine Size	Transmission Type	Emission Label Number	Initial Mileage	Fuel Type Used	Engine Timing (BTDC)	Dwell Angle	Idle (rpm)	Spark Plug Gap	Oil Type
1	1972 Oldsmobile Cutlass	8 cyl 455 CID	3 speed automatic	CCS Exhaust Emission Control	87,000	Regular	12	28	600	.03	10W40
2	1973 Datsun 240Z	6 cyl 239 C	4 speed manual	None	83,000	Regular	13	49	800	.031	10W40
3	1977 Oldsmobile Delta 88	8 cyl 350 CID	3 speed automatic	None	58,000	Unleaded	8	NA	600	.033	10W40
4	1976 Buick Century Wagon	8 cyl 258 CID	3 speed automatic	40 54	82,000	Unleaded	12	NA	650	.03	10W40
5	1975 AMC Pacer	6 cyl 258 CID	3 speed automatic	Hidden under voltage regulator	87,300	Unleaded	12	16	1000	.03	10W40
6	1979 Honda Accord	4 cyl 107 CID	5 speed manual	Engine family 79EK	44,000	Regular	10	NA	850	.042	10W40
7	1974 Datsun B-210	4 cyl 78.7 CID	4 speed manual	Engine family Nissan 5 A13	49,269	Regular	8	56	800	.032	10W40
8	1979 Dodge Eldorado	8 cyl 440 CID	Automatic	01C2EY	30,000	Regular	11	40	750	.035	10W50
9	1980 Chevy Citation	4 cyl 2.8L	4 speed manual		23,000	Unleaded	8	NA	1050	.060	10W40
10	1980 Ford Bronco	8 cyl 302 CID	4 speed manual 4WD	Evap Family EGR	29,700	Unleaded	12	NA	800	.044	10W40

Discussions

Review of the completed test program brings several topics to mind which need some discussion. Some of the properties intended for study were found difficult to examine on a real-time basis. Others were less difficult to examine and afforded rapid, accurate evaluations.

The bench studies performed were most revealing. In both cases, immediate benefits were observed when the fuel blends were used. The economy increases and emission decreases noted were all significant and well within the expected error for the test data. Apparently, two phenomena are operating with the use of Mix-I-Go. The laboratory observed the immediate effect of the test fuel blends, and a longer term additional increase in fuel economy and emission reduction. The bench engines were not particularly dirty. Each had been maintained properly and kept in good operating condition. Apparently, the engine condition was such that only a modest, long-term effect could be observed. The modest, long-term gains were consistent with the induction period noted in the vehicle study and with observations reported from the field applications.

The bench engines permitted easy examinations of the spark plugs and internal engine conditions. In the cases where the laboratory did examine the cylinder head and piston head along with the inlet/outlet valve and the spark plugs, the use of Mix-I-Go turned brown/black deposits to white/grey deposits or no deposits at all.

This phenomena was repeatable and reversible. Spark plug cleanliness of the same type was noted in the vehicle study. In all cases the effect was observed subjectively; an objective measurement was not developed.

The most important and enlightening studies were the vehicle studies. Economy increases and emission reductions were consistently observed in all vehicles. The in situ studies were verified by dynamometer studies. The improvements observed during the dynamometer studies actually exceeded the improvements observed in the in situ studies. The in situ studies were more flexible, more immediate, more cost-effective and of greater duration than the dynamometer studies.

Both the in situ fleet data and the dynamometer test data for economy increases exceed the minimum fuel economy gains established by the EPA as considered significant for the fleet size. The EPA specifies the following minimum fuel economy improvements versus size of test fleet.

Fleet Size	Average Improvement Required
2	8%
3	7%
4	6%
5	5%
10	4%
25	2%

The fleet average increase of 8.2% for seven vehicles is clearly in excess of these minimum limits as is the selected dynamometer fleet of 2 at 12% increase.

The overall emission reduction for hydrocarbons and carbon monoxide of 21.7% and 25.8% is very significant. In these days of environmental awareness and efforts as pollution reduction, these results are very important.

The results of this study point out that in situ real time measurements of vehicle performance can be most meaningful in describing the operation of vehicles under study for fuel economy. It is conceivable that numerous devices and fuel additives could be effectively evaluated in this way where more classical techniques are not effective or are too slow. The following precautions should be taken. Real time measurements are affected by the type of driving to which a vehicle is subjected. The laboratory observed economy increases after long highway trips, for example. The effect was transient and can be averaged from the data. However, avoidance of the problem would be better. The scheduled mileage program which the laboratory utilized is better and should contains an appropriate mix of highway and city mileage. This assures less variation in engine condition.

The laboratory observed that the protocol for in situ testing of economy must be carefully standardized and followed. Vehicle weight and tire pressure affect vehicle economy and should be carefully checked. Vehicle maintenance should be performed in the normal fashion, but new tune-ups should be made just prior to any milestone throughout the test program, but changes should bbe made at the normal change frequency. Weather and seasonal variations should be taken into account when interpreting the results from any in situ study. It is important that one test driver be used to evaluate any one vehicle. Changes in test driver can affect the test results.

In summary, it can be concluded that the test program described in this report was an effective and valid program to evaluate the use of Mix-I-Go as a fuel additive. The results from this program show that proper use of Mix-I-Go will improve the overall performance of an automobile and reduce the emissions from the vehicle.