EVALUATION

OF

FPC-1 FUEL PERFORMANCE CATALYST

BY

KNOXVILLE TRANSPORTATION AUTHORITY
KNOXVILLE, TENNESSEE

PREPARED FOR

KNOXVILLE TRANSPORTATION AUTHORITY

BY

J.R.C. ENTERPRISES, INC.
TEMPE, ARIZONA

MATERIALS HEREIN PROVIDED

BY

KNOXVILLE TRANSPORTATION AUTHORITY

U.H.I. CORPORATION

AND

J.R.C. ENTERPRISES, INC.

INTRODUCTION

FPC-1 Fuel Performance Catalyst is the designation of a ferrous picrate (picric acid) chemical aggregate developed to enhance the combustion of all liquid hydrocarbon fuels. The FPC-1 formulation has undergone extensive testing at independent and university affiliated laboratories.

Test procedures have included the EPA Standardized Federal Test Procedures (FTP), hot and cold cycles, Highway Fuel Economy Test (HFET), both carbon mass balance procedures, the Coordinated Research Council Cold Start Driveability Test, and steady state engine dynamometer testing. These tests have provided documentation which confirm the FPC-1 chemical formulation to create the following benefits when added to liquid hydrocarbon fuels.

1) Increased fuel efficiency, (or improved fuel economy).

2) Reduced emissions of harmful pollutants and visible smoke.

3) Improved driveability, (engine performance).

This report will discuss the results and conclusions of an engine performance evaluation using this unique fuel combustion catalyst. The test was conducted by Knoxville Transportation Authority, (K-TRANS), Knoxville, Tennessee, in cooperation J.R.C. Enterprises, Tempe, Arizona, the distributor of FPC-1. An explanation of the test procedures used to determine the effect of the catalyst on fuel economy based upon the carbon mass balance technique will be documented herein in accordance with these test results.

In accordance with the recommendation of Mr. Arnold Burkhart, Vice-President, American Transit Corporation, and the request of Mr. John R. Andrews, General Manager, K-TRANS, meetings were held between Mr. Andrews, Mr. Rudy Burchell, Superintendent of Maintenance, K-TRANS, and J.R. Challis, J.R.C. Enterprises, Inc., wherein it was decided to institute a test program whereby the maximum savings that could be realized by K-TRANS from the use of FPC-1 Fuel Performance Catalyst could be evaluated and documented. The procedure decided upon was the carbon mass balance technique.

It was further decided that K-TRANS and J.R.C. Enterprises, Inc., would jointly chart fuel usage on all buses as support data, (it was understood it could be in excess of six months before this data could show anything conclusive). Although reduction in visible smoke was a major concern, it was agreed that in this, Phase I, the use of FPC-1 treated fuel should be proven cost effective based upon fuel economy improvement alone. Were this successful in conjunction with a reduction in visible smoke, Phase II testing involving long term use of FPC-1 and ongoing evaluation of the reduction in carbon related maintenance could then be instituted.

Although the entire fleet fueling system was to be treated subsequently allowing MPG evaluation of all K-TRANS buses, seven (7) buses were selected by Mr. Burchell for the carbon mass balance evaluation. These units were selected by Mr. Burchell as a good representation of the K-TRANS fleet and, according to K-TRANS records, were the most consistent in their recent performance and MPG averages. The buses selected are as follows:

K-TRANS Bus I.D. No.	Engine
807	Detroit 6V-71
820	Detroit 6V-71
825	Detroit 6V-71
847	Detroit 6V-92
849	Detroit 6V-92
856	Detroit 6V-92
875	Detroit 6V-92

CARBON MASS BALANCE TEST

Until late 1973, vehicle fuel economy had been determined primarily by using various test track or road test procedures. In September, 1973, the U.S. Environental Protection Agency, (EPA) introduced a method of determining vehicle fuel economy in conjunction with its chassis dynamometer emissions test. This method determines fuel consumption based upon vehicle exhaust emissions through a "carbon balance" calculation rather than a direct measurement of fuel consumed.

Starting in 1974, the carbon balance method was used solely in the EPA CVS-cold start emissions test cycle, (LA-4 Cycle). In 1975, the cycle was modified adding a hot start, (FTP). A highway test was also developed, (HFET).

A series of tests done by Ford Motor Company compared the traditional fuel measurement techniques, (volumetric or gravimetric), to the carbon balance method. The results, published in SAE Technical Paper Series 75002 entitled, "Improving the Measurement of Chassis Dynamometer Fuel Economy", confirmed,

> "..fuel economy results obtained by carbon mass calculation of carbon containing components in the vehicle exhaust are at least as accurate and repeatable as those obtained by direct fuel measurement of fuel consumed."

It was from this concept that U.H.I. Corporation, the manufacturer of FPC-1, derived the technique of determining fuel consumption changes in previous tests and that used by J.R.C. Enterprises, Inc. in this test with K-TRANS. Although not as controlled a test as obtainable in a laboratory, the method used has consistently proven to be far more accurate than monthly MPG fleet comparisons. The technique uses state-of-the-art NDIR instruments measuring carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), and hydrocarbons (HC) with an anemometer and thermometer to measure exhaust airflow and temperature respectively.

On November 12, 1984, all buses were brought to the Knoxville Maintenance Center for Carbon Mass Balance baseline testing. Each bus was equipped with an engine tachometer and put under a reproducible load. Numerous readings were taken with the Sun Electric MGA-90 Multiple Gas Analyzer, anemometer, and thermometer on each bus to establish an average percentage in carbon dioxide (CO_2), carbon monoxide (CO), and oxygen ($O2_)$, plus average hydrocarbons (HC) in parts per million (PPM) and exhaust flow (CFM) and temperature (F').

All readings were taken and resultant averages calculated under the supervision of Mr. Burchell and/or K-TRANS personnel designated by Mr. Burchell. Copies of all data were submitted to Mr. Burchell upon test comletion.

The fuel tanks were treated by Mr. Challis upon completion of baseline testing at a one part FPC-1 Fuel Performance Catalyst to 1600 parts fuel ratio. The K-TRANS personnel was instructed in treatment ratios and procedures for future treatments during the ongoing test period. A reporting system was also established to provide a record of all fuel deliveries and the FPC-1 used for each fuel delivery treatment. Fuel consumption data was collected in the usual manner throughout the subsequent test period to be submitted to J.R.C. Enterprises, Inc., for comparison.

On June 21, 1985, after all test buses had exceeded the 150 hours or 6,000 mile recommended break-in period, test procedures were duplicated as in the baseline testing. Again, all readings were taken and resultant averages calculated under the supervision of Mr. Burchell.

Exhibit A illustrates the actual Carbon Balance Formula. Exhibit B depicts the Carbon Mass Balance test results on the K-TRANS fleet.

SUMMARY AND CONCLUSIONS

The carbon mass balance results confirm a cumulative 10.48% improvement in fuel economy in the test fleet. Although this result is higher than that normally realized from similar fleet application, (normal average is 6% to 8%), there is no doubt that a substantial reduction in fuel consumption was resultant.

Carbon Mass Balance Formula

ASSUMPTIONS: C_8H_{15} and SG = 0.78
Time is constant
Load is constant
RPM is constant

DATA:

pf1 = Calculated Performance Factor (Baseline)
pf2 = Calculated Performance Factor (Treated)
PF1 = Performance Factor (adjusted for Baseline exhaust mass)
PF2 = Performance Factor (adjusted for Treated exhaust mass)
T = Temperature (F^O)
F = Flow (exhaust CFM)
SG = Specific Gravity
VF = Volume Fraction

$VFCO_2$ = "reading" ÷ 100
VFO_2 = "reading" ÷ 100
VFHC = "reading" ÷ 1,000,000
VFCO = "reading" ÷ 100

EQUATIONS:

$$1wt=(VFHC)(86)+(VFCO)(28)+(VFCO_2)(44)+(VFO_2)(32)+[(1\text{-}VFHC\text{-}VFCO\text{-}VFO_2\text{-}VFCO_2)(28)]$$

$$pf1 \text{ or } pf2 = \frac{2952.3 \times Mwt}{86(VFHC)+13.89(VFCO)+13.89(VFCO_2)}$$

$$PF1 \text{ or } PF2 = \frac{pf \times (T+460)}{F}$$

PERCENT INCREASE (OR DECREASE) IN FUEL ECONOMY $\left(\frac{PF_2 - PF_1}{PF_1}\right) \times 100$

Exhibit B

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CARBON MASS BALANCE

CUMULATIVE AVERAGES

Baseline		Treated	
CO_2	5.46%	CO_2	4.87%
O_2	13.39%	O_2	11.58%
HC	5.67 ppm	HC	10.53 ppm
CO	0.0205%	CO	0.180%
Temp.	588.5' F	Temp.	541.4' F
Flow	1425 cfm	Flow	1328.5 cfm

Volume Fractions

$vfCO_2$	0.0546	$vfCO_2$	0.0487
vfO_2	0.1339	vfO_2	0.1158
vfHC	0.00000567	vfHC	0.00001053
vfCO	0.000205	vfCO	0.0018

Molecular Weights and Performance Factors

Mwt_1	29.4095	Mwt_2	29.2430
pf_1	113985.0840	pf2	122921.7190
PF_1	83869.0250	PF_2	92656.2359

$$\frac{8787.2109}{83869.0250} \times 100 = 10.48\%$$

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1) Increased fuel efficiency (or improved fuel economy).
2) Reduced emissions of harmful pollutants and visable smoke.
3) Improved driveability (engine performance).
4) Substantial reduction in carbon related maintenance.
5) Reduced wear of engine components extending engine life.

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PF_1	83869.0250	PF_2	92656.2359

$$92656.2359 - 83869.0250 = 8787.2109$$

$$\frac{8787.2109}{83869.0250} \times 100 = 10.48\%$$

Exhibit C

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