# AN EVALUATION OF FPC-1 FUEL PERFORMANCE CATALYST

BY

VOGEL DISPOSAL
MARS, PENNSYLVANIA

REPORT PREPARED BY:

UHI CORPORATION
PROVO, UTAH

DECEMBER 9, 1987

UHI CORPORATION

AND

RESEARCH DEVELOPMENT PRODUCTS INC.

# UHI TECHNICAL REPORT


## Abstract

A test program to determine the effect of FPC-1 fuel catalyst on the fuel economy of the Vogel Disposal fleet of trucks, in Mars, Pennsylvania, was conducted under the direction of Ed Nusser with RDP Inc., and Ken McAlpine, of Vogel Disposal. The reduction in fuel consumption was determined from a carbon-balance method which is based on measurements of the exhaust gases from the trucks. Results of the test show that the catalyst can provide a minimum cost savings of 5.2% for the diesel fleet which was evaluated.


## Introduction

This report summarizes the results of field tests conducted on Vogel Disposal fleet trucks to measure the reduction in fuel consumption due to an iron-based fuel catalyst, FPC-1.

The fuel catalyst, an aftermarket product containing ferrous picrate, has been subjected to extensive engine testing in independent laboratories at universities and Environmental Protection Agency (EPA) recognized facilities. These tests, in both gasoline and diesel powered vehicles, have demonstrated that the catalyst can provide fuel savings ranging from about 2% to 10%, depending upon factors such as the operation and condition of the equipment, and the fuel quality.

The tests have included the EPA Federal Test Procedure (FTP) and Highway Fuel Economy Test (HFET), the Society of Automotive Engineers (SAE) J-1082 Suburban and Interstate Test Cycles, CRC cold start driveability test, and a computerized engine dynamometer test sequence.

Over a decade of field testing, primarily in heavy duty diesel fleets, substantiates the laboratory and road test results, and suggests an average in-use improvement in fuel economy greater than that predicted by the EPA and SAE test. Field applications have also shown that the catalyst inhibits the formation of hard carbon deposits on pistons, valves and other combustion chamber surfaces, and gradually consumes pre-existing carbon deposits, which potentially further reduces maintenance and operating costs.

Until late 1973, vehicle fuel consumption was measured primarily by various test track or road test procedures. In September 1973, the U.S. Environmental Protection Agency utilized a carbon balance method to determine fuel economy in conjunction with its chassis dynamometer vehicle emissions test. This method relies on measurements of vehicle exhaust flow and emissions rather than direct measurement of fuel consumption.

By 1974, the carbon balance method was used solely in the EPA cold start emissions test cycle (LA-4 Cycle). In 1975, the cycle was modified by adding a hot start, and was known as the Federal Test Procedure (FTP). Later a highway driving simulation was developed which is known as the Highway Fuel Economy Test (HFET).

A series of tests by Ford Motor Company compared techniques of direct measurement of fuel consumption (volumetric or gravimetric) to the carbon balance method. The results, published as SAE Paper 75002, entitled "Improving the Measurement of Chassis Dynamometer Fuel Economy," stated

> "...fuel economy results obtained by carbon mass balance 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."

The study also determined that the critical factors in the measurement of fuel consumption with the carbon balance method are the measurement of $CO_2$, the use of standardized test equipment and procedures, and correction for differences in ambient conditions. The complete paper is included in Appendix A.

**UHI Test Procedures**

The fuel consumption test method utilized by UHI and RDP involves exhaust gas measurements of a stationary vehicle. No chassis dynamometer is required so driver error and tire/roll slippage are eliminated as sources of inaccuracy. The method produces a value of equipment fuel consumption with FPC-1 relative to a baseline value established with the same vehicle. Although the test is not as controlled as a laboratory test, care is taken to ensure consistency and accuracy. Engine speed and load are duplicated from test to test, and measurements of exhaust and ambient temperature and pressure are made to perform appropriate corrections. The carbon balance method represents a practical, economic and repeatable approach to determine relative fuel consumption in the field.

Exhaust gases are analyzed by state-of-the-art infrared (NDIR) exhaust gas analyzers made by the Sun Electric Corporation (SGA-9000) to measure $CO_2$, CO and unburned hydrocarbons, which are all carbon-containing exhaust gases. In addition, oxygen concentration in the exhaust is measured. The SGA-9000 is approved by the EPA for vehicle emissions analysis and is calibrated internally using calibration gases recommended by Sun

Electric. Specifications for the analyzer are given in Appendix B.

### Technical Approach

A fleet of diesel powered trucks owned and operated by Vogel Disposal was selected for the FPC-1 evaluation. Table I shows the engine and mileage of the four vehicles used throughout the test. All the trucks which were originally included in the baseline test fleet were also included in the treated segment of the evaluation, except for unit number 64, which was eliminated from the evaluation because of a tachometer problem.

The SGA-9000 exhaust analyzer and the thermocouple instrumentation were calibrated and a leak test on the sampling hose and connections was performed. Each truck engine was then brought up to stable operating temperature as indicated by the engine water temperature and exhaust temperature. No exhaust gas measurements were made until each truck engine had stabilized at the operating condition selected for the test. No. 2 diesel fuel was exclusively used throughout the evaluation.

The baseline fuel consumption test consisted of five sets of measurements of CO2, CO, unburned hydrocarbons (measured as CH4), O2, and exhaust temperature, made at 30 second intervals for each engine test speed of 1900 rpm and 1600 rpm. The measurements are summarized in Table II, and the actual measurements are contained in Appendix C. These measurements are used to develop a trend line for the actual running condition and efficiency level of each vehicle tested. The data collected during the Vogel Disposal evaluation demonstrated a continuous downward trend in readings. For this reason, only the last data points were used from both the treated and baseline data sheets, because they best represented the lowest point in which the readings would attain.

After the baseline test, on October 24, 1987, the fuel storage tank, from which the fleet is exclusively fueled, was treated with FPC-1 at the recommended level of 1 oz. of catalyst to 12.5 gallons of diesel fuel (1:1600 volume ratio). The trucks were then operated with the treated fuel and accumulated an average of 4457 miles per truck when, on November 28, 1987, the fuel consumption test described above was repeated for each truck. The measurements for the trucks with treated fuel are also summarized in Table II, and the actual measurements are contained in Appendix D.

Throughout the entire fuel consumption test, an internal self-calibration of the exhaust analyzer was performed after every two sets of measurements to correct instrument drift. A new analyzer exhaust gas filter was installed before both the baseline and treated fuel test series.

Engine operating speeds of 1600 rpm and 1900 rpm were selected to demonstrate the correlation of the exhaust analysis with fuel consumption. Though the higher engine speed is more realistic, less fuel would be consumed by the engine operating at the lower speed for the same load. For a diesel engine with no air flow throttling, this will result in lower volumetric concentrations of carbon-containing exhaust gases, which can be observed from the measurements obtained from the exhaust analyzer during the evaluation.

From the exhaust gas concentrations measured during the test, the molecular weight of each constituent, and the temperature of the exhaust stream, the fuel consumption may be expressed as a "performance factor" which relates the fuel consumption of the treated fuel to the baseline. The calculations are based on the assumption that the fuel characteristics, engine operating conditions and test conditions are essentially the same throughout the test. Appendix E summarizes the assumptions and equations required for the calculations.

**Results**

Table III shows the overall performance factors for the fleet for the baseline and treated fuel tests at 1600 rpm. At 1600 rpm the minimum improvement in fuel economy for the fleet was 5.1%. It should be noted, that all tests were conducted under a no-load condition which only shows minimum fuel economy improvements. Under loaded conditions, consistent improvements of up to 5%, above no load conditions,can be expected.

Table IV shows the overall performance factors for the fleet for the baseline and treated fuel tests at 1900 rpm. At 1900 rpm the minimum improvement in fuel economy for the fleet was 5.3%. Of the five trucks originally selected to be tested, all of the trucks were available for the treated fuel portion of the evaluation,except for unit number 64.

The average minimum fuel economy improvement, at both rpm's, for the entire fleet was 5.2%.

Also, the inline particulate filter showed a marked reduction in solid particulates during the treated segment of the evaluation. This is important to note since the filter was accessed to the exhaust stream for only 39 minutes during the baseline segment of the test as compared to 50 minutes for the treated segment of the evaluation.

## Conclusions

The following conclusions may be made from the results of the FPC-1 evaluation conducted for Vogel Disposal:

* The addition of FPC-1 to the diesel fuel used by Vogel Disposal resulted in minimum fuel economy improvements of 5.1% at 1600 rpm and 5.3% at 1900 rpm.

* The particulate filter used during the baseline and treated segment of the evaluation clearly showed that the test fleet was running cleaner during the FPC-1 Treated segment of the evaluation.

* Reductions in soot fall out were observed by Ken McAlpine, Fleet superintendent with Vogel Disposal, during the FPC-1 treated fuel segment of the evaluation.

Baseline Treated

Table I

Trucks Used
Throughout FPC-1 Evaluation Tests

| Unit No. | Type | Engine | Miles |
|---|---|---|---|
| 60 | Mack | 300 | 5,847 |
| 67 | Mack | 300 | 4,916 |
| 69 | Mack | 300 | 3,891 |
| 94 | Mack | 300 | 3,173 |

## Table II

**Summary of Exhaust Measurements During Baseline and Treated Fuel Tests**

| Engine Speed | $CO_2$ Vol% | CO Vol% | $O_2$ Vol% | HC ppm | Exhaust Temp |
|---|---|---|---|---|---|
| 1600 | | | | | |
| Base | 2.05 | 0.028 | 18.2 | 12.5 | 332.0 F |
| Treated | 1.99 | 0.028 | 18.6 | 13.0 | 320.3 F |
| 1900 | | | | | |
| Base | 2.48 | 0.033 | 17.7 | 11.8 | 368.3 F |
| Treated | 2.38 | 0.033 | 18.1 | 12.3 | 361.3 F |

## Table III

### Volume Fractions and Performance Factor
### 1600 R.P.M.

| | Baseline | Treated |
|---|---|---|
| VFCO | 0.000275 | 0.000275 |
| VFHC | 0.0000125 | 0.000013 |
| VFCO2 | 0.0205 | 0.0199 |
| VFO2 | 0.1823 | 0.1860 |

| | | | |
|---|---|---|---|
| Mwt1 | 29.0579 | Mwt2 | 29.0632 |
| pf1 | 296187.6330 | pf2 | 304970.7864 |
| PF1 | 179755.2531 | PF2 | 188864.0513 |

$$188864.0513 - 179755.2531 = \frac{9,108.7982}{179755.2531} \times 100 = 5.1\%$$

## Table IV

### Volume Fractions and Performance Factor
### 1900 R.P.M.

| | Baseline | Treated |
|---|---|---|
| VfCO | 0.00033 | 0.00033 |
| VFHC | 0.00001175 | 0.00001225 |
| VFCO2 | 0.0248 | 0.0238 |
| VFO2 | 0.1770 | 0.1813 |

| | | | |
|---|---|---|---|
| Mwt1 | 29.1055 | Mwt2 | 29.1067 |
| pf1 | 245511.1741 | pf2 | 255635.2977 |
| PF1 | 109922.6516 | PF2 | 115676.7328 |

$$115676.7328 - 109922.6516 = \frac{5,754.0812}{109922.6516} \times 100 = 5.3\%$$

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST Nov. 28, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 300 MACK

I.D. NUMBER 67 MILEAGE (OR HOURS) 132,816

TYPE OF TEST

AMBIENT AIR TEMPERATURE 49

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .03 | 13 | 2.45 | 18.0 | 375 | 1900 |
| 2. | .03 | 13 | 2.45 | 18.0 | 376 | 1900 |
| 3. | .03 | 13 | 2.44 | 18.1 | 379 | 1900 |
| 4. | .03 | 13 | 2.44 | 18.0 | 380 | 1900 |
| 5. | .03 | 13 | 2.43 | 18.0 | 383 | 1900 |
| 6. | .02 | 13 | 2.04 | 18.5 | 346 | 1600 |
| 7. | .02 | 13 | 2.04 | 18.4 | 345 | 1600 |
| 8. | .02 | 13 | 2.03 | 18.6 | 342 | 1600 |
| 9. | .02 | 13 | 2.03 | 18.5 | 341 | 1600 |
| 10. | .02 | 14 | 2.03 | 18.4 | 339 | 1600 |

START TIME: 10:23 END TIME: 10:33 LENGTH OF TEST: 10

Signature of technicians

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY: VOGEL

DATE OF TEST: NOV 28, 1987

TYPE OF EQUIPMENT TESTED:

ENGINE TYPE AND SPECS: 300 MACK

I.D. NUMBER: 69     MILEAGE (OR HOURS): 71,547

TYPE OF TEST:

AMBIENT AIR TEMPERATURE:

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .04 | 15 | 2.69 | 17.9 | 369 | 1900 |
| 2. | .04 | 15 | 2.69 | 17.8 | 370 | 1900 |
| 3. | .04 | 15 | 2.68 | 17.9 | 372 | 1900 |
| 4. | .04 | 15 | 2.68 | 17.8 | 373 | 1900 |
| 5. | .04 | 15 | 2.68 | 17.8 | 374 | 1900 |
| 6. | .04 | 15 | 2.16 | 18.4 | 338 | 1600 |
| 7. | .04 | 15 | 2.17 | 18.3 | 336 | 1600 |
| 8. | .04 | 15 | 2.17 | 18.4 | 334 | 1600 |
| 9. | .04 | 15 | 2.16 | 18.3 | 332 | 1600 |
| 10. | .04 | 15 | 2.16 | 18.4 | 329 | 1600 |

START TIME: 10:08     END TIME: 10:18     LENGTH OF TEST: 10

Signature of technicians: 

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST Nov. 28, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 300 MACK

I.D. NUMBER 94 MILEAGE (OR HOURS) 41,913

TYPE OF TEST

AMBIENT AIR TEMPERATURE 52

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .01 | 9 | 2.12 | 18.3 | 342 | 1900 |
| 2. | .01 | 9 | 2.11 | 18.3 | 343 | 1900 |
| 3. | .01 | 10 | 2.11 | 18.4 | 348 | 1900 |
| 4. | .02 | 10 | 2.10 | 18.4 | 348 | 1900 |
| 5. | .02 | 10 | 2.07 | 18.5 | 353 | 1900 |
| 6. | .02 | 10 | 1.82 | 18.7 | 325 | 1600 |
| 7. | .02 | 10 | 1.84 | 18.7 | 324 | 1600 |
| 8. | .02 | 10 | 1.85 | 18.7 | 321 | 1600 |
| 9. | .02 | 10 | 1.82 | 18.6 | 320 | 1600 |
| 10. | .01 | 11 | 1.83 | 18.6 | 320 | 1600 |

FAN 1.99

START TIME: 10:44 END TIME: 10:53 LENGTH OF TEST: 9

Signature of technicians

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST OCT 24, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 300 MACK

I.D. NUMBER 60 MILEAGE (OR HOURS) 360,071

TYPE OF TEST

AMBIENT AIR TEMPERATURE

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .04 | 10 | 2.42 | 17.9 | 336 | 1900 |
| 2. | .04 | 10 | 2.41 | 17.8 | 337 | 1900 |
| 3. | .04 | 12 | 2.41 | 17.9 | 343 | 1900 |
| 4. | .04 | 12 | 2.48 | 17.7 | 346 | 1900 |
| 5. | .04 | 12 | 2.41 | 17.9 | 350 | 1900 |
| 6. | .04 | 14 | 1.94 | 18.4 | 311 | 1600 |
| 7. | .04 | 14 | 1.94 | 18.4 | 310 | 1600 |
| 8. | .04 | 14 | 1.98 | 18.3 | 307 | 1600 |
| 9. | .04 | 14 | 1.90 | 18.3 | 305 | 1600 |
| 10. | .04 | 13 | 1.88 | 18.5 | 302 | 1600 |

START TIME: 10:23 END TIME: 10:32 LENGTH OF TEST: 9

Signature of technicians

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST OCT 24, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 300 MACK

I.D. NUMBER 67 MILEAGE (OR HOURS) 127,900

TYPE OF TEST

AMBIENT AIR TEMPERATURE

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .104 | 13 | 2.55 | 17.6 | 367 | 1900 |
| 2. | .103 | 13 | 2.54 | 17.5 | 368 | 1900 |
| 3. | .03 | 12 | 2.49 | 17.6 | 373 | 1900 |
| 4. | .103 | 12 | 2.48 | 17.5 | 376 | 1900 |
| 5. | .103 | 12 | 2.45 | 17.6 | 380 | 1900 |
| 6. | .03 | 13 | 2.12 | 18.1 | 351 | 1600 |
| 7. | .02 | 13 | 2.10 | 18.1 | 350 | 1600 |
| 8. | .02 | 13 | 2.09 | 18.2 | 349 | 1600 |
| 9. | .02 | 13 | 2.11 | 18.1 | 348 | 1600 |
| 10. | .02 | 13 | 2.08 | 18.1 | 346 | 1600 |

START TIME: 10:38 END TIME: 10:46 LENGTH OF TEST: 8

Signature of technicians

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL DISPOSAL SERVICE

DATE OF TEST OCT 24, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 300 MACK

I.D. NUMBER 69 MILEAGE (OR HOURS) 67,656

TYPE OF TEST

AMBIENT AIR TEMPERATURE 52

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .05 | 12 | 2.87 | 17.3 | 375 | 1900 |
| 2. | .05 | 12 | 2.72 | 17.3 | 375 | 1900 |
| 3. | .05 | 13 | 2.79 | 17.5 | 379 | 1900 |
| 4. | .04 | 13 | 2.75 | 17.4 | 380 | 1900 |
| 5. | .04 | 13 | 2.85 | 17.5 | 385 | 1900 |
| 6. | .04 | 13 | 2.26 | 18.1 | 345 | 1600 |
| 7. | .04 | 12 | 2.25 | 18.0 | 344 | 1600 |
| 8. | .03 | 12 | 2.23 | 18.1 | 340 | 1600 |
| 9. | .03 | 12 | 2.23 | 18.0 | 339 | 1600 |
| 10. | .04 | 13 | 2.21 | 18.2 | 337 | 1600 |

START TIME: 10:08 END TIME: 10:18 LENGTH OF TEST: 8

Signature of technicians

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

HoT
OFF
Road

## EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST OCT 24, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 300 MACK

I.D. NUMBER 94    MILEAGE (OR HOURS) 38,740

TYPE OF TEST

AMBIENT AIR TEMPERATURE

### EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .02 | 10 | 2.20 | 18.0 | 344 | 1900 |
| 2. | .02 | 13 | 2.21 | 17.9 | 345 | 1900 |
| 3. | .02 | 13 | 2.19 | 17.9 | 353 | 1900 |
| 4. | .01 | 10 | 2.18 | 17.8 | 356 | 1900 |
| 5. | .02 | 10 | 2.22 | 17.8 | 358 | 1900 |
| 6. | .01 | 10 | 2.00 | 18.1 | 346 | 1600 |
| 7. | .01 | 10 | 2.01 | 18.2 | 344 | 1600 |
| 8. | .02 | 11 | 2.02 | 18.1 | 344 | 1600 |
| 9. | .01 | 12 | 2.03 | 18.1 | 344 | 1600 |
| 10. | .01 | 11 | 2.02 | 18.1 | 343 | 1600 |

START TIME: 11:40    END TIME: 11:46    LENGTH OF TEST: 6

Signature of technicians

RDP INC
Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

# EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST Nov 28, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 237 MACK

I.D. NUMBER 64 MILEAGE (OR HOURS) 190,199

TYPE OF TEST

AMBIENT AIR TEMPERATURE

## EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .04 | 15 | 2.40 | 18.2 | 340 | 1900 |
| ? 2. | .04 | 15 | 2.39 | 18.1 | 341 | 1900 |
| 3. | .04 | 15 | 2.35 | 18.2 | 346 | 1900 |
| 4. | .04 | 15 | 2.35 | 18.2 | 347 | 1900 |
| 5. | .04 | 17 | 2.35 | 18.2 | 351 | 1900 |
| 6. | .04 | 17 | 1.99 | 18.6 | 324 | 1600 |
| 7. | .04 | 17 | 2.00 | 18.6 | 323 | 1600 |
| 8. | .04 | 17 | 2.00 | 18.7 | 321 | 1600 |
| 9. | .04 | 17 | 2.01 | 18.6 | 321 | 1600 |
| 10. | .04 | 17 | 1.98 | 18.6 | 320 | 1600 |

START TIME: 9:54 END TIME: 10:03 LENGTH OF TEST: 9

Signature of technicians

RDP INC

Research Development Products • P.O. Box 156 Evans City, PA 16033 • 412/538-8842

TACK?

## EXHAUST GAS ANALYSIS FORM

NAME OF COMPANY VOGEL

DATE OF TEST OCT 24, 1987

TYPE OF EQUIPMENT TESTED

ENGINE TYPE AND SPECS 237 MACK

I.D. NUMBER 64 MILEAGE (OR HOURS) 186,790

TYPE OF TEST

AMBIENT AIR TEMPERATURE 61

### EXHAUST READINGS

| | CO | HC | $CO_2$ | $O_2$ | EX. TEMP. | RPM |
|---|---|---|---|---|---|---|
| 1. | .04 | 17 | 2.16 | 17.9 | 324 | 1900 |
| 2. | .04 | 17 | 2.16 | 17.9 | 327 | 1900 |
| 3. | .04 | 16 | 2.14 | 18.1 | 332 | 1900 |
| 4. | .04 | 16 | 2.14 | 18.1 | 334 | 1900 |
| 5. | .04 | 17 | 2.15 | 18.0 | 338 | 1900 |
| 6. | .04 | 19 | 1.95 | 18.2 | 326 | 1600 |
| 7. | .04 | 19 | 1.97 | 18.2 | 326 | 1600 |
| 8. | .04 | 19 | 1.98 | 18.3 | 327 | 1600 |
| 9. | .04 | 19 | 1.97 | 18.4 | 327 | 1600 |
| 10. | .04 | 19 | 1.97 | 18.4 | 327 | 1600 |

START TIME: 11:00 END TIME: 11:08 LENGTH OF TEST: 8

Signature of technicians