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EVALUATION OF EMISSIONS DURABILITY OF OFF-ROAD LPG ENGINES EQUIPPED WITH THREE-WAY CATALYST

By

Vlad L. C. Ulmet

FINAL REPORT

Prepared For

California Air Resources Board
South Coast Air Quality Management District
U.S. Environment Protection Agency

November 2000

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ABSTRACT

Research was done to assess the long term durability of closed-loop three-way catalyst technology in nonroad large spark-ignited (LSI) engine applications. Two LPG-fueled forklift trucks with three-way catalyst systems having accumulated more than 4,000 hours use were selected. Recorded in-field operation parameters were used to generate a new transient cycle. The engines and the emission control systems from the two forklift trucks were tested for emission performance under several steady-state conditions, and over five different transient test cycles. Performance deterioration trends were established through the use of both new and aged emission control system components. Failed catalytic converter mufflers discovered at the end-user site were investigated for failure mode. A brief fuel sensitivity study with an "off spec" LPG composition was also conducted. Finally, a test was performed to measure fuel temperatures in the bulk liquid volume of the tank of a gasoline forklift truck in near-continuous operation.

Composite emission results for the ISO C2 and D2 steady state tests on the aged systems were well within the limits of CARB's adopted LSI emission standards. Transient operation emissions for all the five transient cycles were below the worst case of 14 g/hp-hr CO, and 2.8 g/hp-hr THC+NO_x.

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EXECUTIVE SUMMARY

Background - In order to meet ambient air standards in California by the year 2010, the California Air Resources Board finalized in October of 1998 emission standards for nonroad spark-ignition engines rated over 19 kW (large SI engines). At that time, there was limited information on the durability of emission control systems in industrial applications, and on the ability of manufacturers to control emissions at operating modes not represented by the steady-state test cycle. Furthermore, there was little information available to describe typical engine operation, especially with respect to the degree of transient operation. It was also desired to study the effects of varying LPG fuel quality on emissions. Since the U.S. Environmental Protection Agency had also started the process of proposing new emissions standards for this engine category, the purpose of this research was to generate information to address these issues. Concerns that high tank fuel temperatures in gasoline-powered industrial equipment could cause high evaporative emissions were also addressed.

Approach - With the assistance of the EPA, SwRI selected the test site and a list of potential test equipment. After on-site screening, two LPG-fueled forklift trucks with three-way catalyst systems installed for more than 4,000 hours were selected for the test program. In-use operating data was taken and analyzed, and later used for the development of a new transient cycle. Performance of the engines and emission control systems from the two forklift trucks was evaluated at Southwest Research Institute's Department of Emission Research laboratory.

Results - Two forklift trucks from "Trout Blue Chelan Apples and Pears," located in Chelan, Washington were selected for the test program. The two Hyster-made forklift trucks were powered by a GM 181 c.i.d. and a Mazda 121 c.i.d. engine. They had both been retrofitted with Terminox ™ closed-loop fuel control and three-way catalytic converter muffler systems marketed by Engine Control Systems, Ltd.

Several hours of in-use operation data including vehicle speed, engine speed, throttle position, manifold absolute pressure, and intake and ambient temperature were logged at the site. Subsequently, the engines and emission control systems were shipped to SwRI for emission tests, and replacement rental forklift trucks were provided for the end-user.

Steady-state emission testing using the ISO 8178 seven-mode C2 cycle, as well as a 36-mode map was used to assess the impact of deterioration of emission control components on both engines. "Best NO_x" calibrations were developed for both engines in order to assess the performance level potential. The highlights of the steady-state emission results are summarized in the following table.

C2 CYCLE EMISSION RESULTS SUMMARY
BEST NO_x CALIBRATION WITH NEW OXYGEN SENSOR

Engine	Configuration	Emissions (g/hp-hr) and Catalyst Efficiency (%)				
		THC	CH_4	NMHC	CO	NO_x
Mazda	Old Catalyst	0.22	0.04	0.18	3.25	0.29
		89.6%	68.8%	91.0%	84.2%	96.6%
	New Catalyst	0.28	0.06	0.22	1.59	0.30
		86.7%	51.2%	89.0%	92.3%	96.5%
GM	Old Catalyst	0.10	0.04	0.06	1.84	0.77
		94.1%	70.8%	96.2%	88.0%	91.1%
	New Catalyst	0.11	0.03	0.08	0.28	0.14
		93.5%	77.6%	94.9%	98.2%	98.4%

Two, five-minute segments of operating data were selected from each forklift truck, representing a most typical portion, and a most transient portion, respectively. Together with a five-minute portion from the welder cycle, they were used as the building blocks for a new transient cycle for these type engines. The two engines were also tested using the FTP, Backhoe Loader (BHL), Backhoe Loader-Crawler Tractor (BHL-CT), and Welder transient cycles. Brake specific emissions and tailpipe emission concentrations were recorded. Results are summarized in the following table.

TRANSIENT TESTS EMISSION RESULTS
BEST NO_x CALIBRATION WITH NEW OXYGEN SENSOR

Engine	Configuration	Test Cycle	Soak [min]	Emissions, g/hp-hr				
				THC	CH_4	NMHC	CO	NO_x
Mazda	Old Catalyst	FTP	20	0.76	0.12	0.64	11.96	1.13
Mazda	New Catalyst	FTP	20	0.38	--	0.38	3.10	2.39
Mazda	Old Catalyst	BHL-CT	20	0.37	0.10	0.27	9.12	0.95
Mazda	New Catalyst	BHL-CT	20	0.30	--	0.30	4.63	0.78
Mazda	Old Catalyst	New	7	0.54	--	0.54	9.85	0.55
Mazda	Old Catalyst	Welder	5	0.61	--	0.61	8.38	0.85
GM	Old Catalyst	FTP	20	0.27	0.09	0.19	4.88	0.88
GM	New Catalyst	FTP	20	0.30	0.06	0.24	2.84	0.76
GM	Old Catalyst	BHL	3	0.29	0.10	0.19	3.98	0.67
GM	New Catalyst	NEW	5	0.19	0.06	0.14	1.85	0.29
GM	Old Catalyst	NEW	5	0.33	0.11	0.22	7.02	0.82

Analysis of the failed catalytic converter mufflers identified poor canning tolerance control to be the cause of these failures.

For the fuel sensitivity investigation, a mix of 90 percent propane and 10 percent butane, representing the lower quality end of the HD10 LPG specification, was used. Results with the new forklift cycle and the old catalytic muffler on the Mazda engine showed an increase in brake specific CO and NO_x emissions of 25% and 40%, respectively.

Conclusions - It was determined that long term catalyst durability was very good. Good emission control system performance throughout a 5,000-hour useful life period will require periodic maintenance. It is likely that at least once during the useful life period, the oxygen sensor will have to be replaced.

Although the five transient test cycles are significantly different from one another, emissions levels were very similar. All fell below the worst case of 14 g/hp-hr CO and 2.8 g/hp-hr THC+NO_x.

I. INTRODUCTION

Off-road equipment powered by gasoline and LPG engines over 19 kW contributes significantly to the South Coast Air Basin's mobile source emissions inventory. In October 1998, the California Air Resources Board finalized emission standards for nonroad spark-ignition engines rated over 19 kW (large SI engines). The Environmental Protection Agency has also started the process of proposing new emission standards for this engine type. Prior to this research, there was limited information on the durability of emission control systems in industrial applications. Furthermore, there was little information available to describe typical engine operation, especially with respect to the degree of transient operation.

The primary objective of this project was to develop information regarding the emissions durability of LPG-fueled large spark-ignited engines. With the assistance of the EPA, SwRI selected a test site and two LPG-fueled forklift trucks with three-way catalyst systems with more than 4,000 hours use. Forklift truck operating data were taken for development of a new transient cycle. The engines and emission control systems from the two forklift trucks were then tested at Southwest Research Institute's Department of Emission Research.

Test matrix Tables 7 and 8 should be used to identify steady-state hardware configurations throughout this report. Tables 12 and 14 serve the same purpose for the transient test results.

II. FIELD MEASUREMENTS

A. Background

In Task 1 of the project, SwRI measured in-use engine operational parameters (load and speed) on two LPG-fueled forklift trucks fitted with closed-loop fuel control systems and three-way catalytic converters that had accumulated 4,000-6,000 hours of operation. With the assistance of the EPA, SwRI selected the test site and a list of potential test equipment.

B. Test Site

The selected test site was the packaging plant and warehouses of "Trout Blue Chelan Apples and Pears," located in Chelan, Washington. Trout is one of the main apple growers in the state. Currently, they have approximately 60 LPG-fueled Hyster and Caterpillar forklift trucks retrofitted with Terminox™ three-way emission control systems marketed by Engine Control Systems Ltd. of Ontario, Canada. The Terminox systems were installed by the local Hyster dealership and by Trout Apple's two maintenance mechanics.

Operation at this site was representative of forklift truck applications, with high usage and minimal maintenance. However, a detailed log of repairs and maintenance was kept for each of the forklift trucks.

C. Selection of Forklift Trucks

The selection criteria were:

- emission control system hours of use (>4,000 hours desired)
- system integrity assessed using a diagnostic tool and tailpipe emissions levels, and
- general engine and forklift truck condition.

Table 1 summarizes information for the trucks inspected.

TABLE 1. INSPECTED FORKLIFT TRUCKS

Truck No.		29	28	32	30	16
Truck	Make	HYSTER	HYSTER	HYSTER	HYSTER	HYSTER
	Model	S50XL	S50XL	S50XL	S50XL	H30XL
	Capacity	5250 lbs	5250 lbs	5250 lbs	5250 lbs	3500 lbs
	Year	1994		1995		
	S/N	C187V09931R	C187V09932R	C187V13988S	C187V09621R	C001807982K
Engine	Make	GM	GM	GM	GM	MAZDA
	Model	181	181	181	181	M121G
	CID	181	181	181	181	121
Terminox	Installation Date	5/5/1997	5/19/1997	2/13/1997	8/26/1997	4/11/1997
	Truck Hours at Installation	5,597	5,980	2,861	4,019	12,673
	Truck Hours at Inspection	11,178	10,507	8,010	8,368	16,707
	System Hours at Inspection	5,581	4,527	5,149	4,349	4,034
	Date of Inspection	2/14/00	2/15/00	2/15/00	2/15/00	2/16/00

1. Truck No. 29

This was the first truck examined. Emission control system operation was found to be within parameters, and instrumentation with the data logging equipment was begun on February 14, 2000.

2. Truck No. 28

This was the second truck examined for testing. It was taken out of service and parked in the work area during the morning of February 15, 2000. While parked and prior to any work being performed on it, the electrical harness caught fire due to a short circuit.

3. Truck No. 32

This truck was brought to the work area after truck no. 28 was declared irreparable in useful time. The Terminox system control box was not working. An attempt was made to replace a blown fuse in the control box. The new fuse was immediately blown, indicating a short circuit in the control box. The control box from truck no. 28 was removed and installed on truck no. 32 with a new fuse. The closed-loop control system was then found to be working properly. After instrumenting the truck, the engine was started, and a short engine warm-up procedure was performed prior to emission testing. Fast warm-up is typically achieved at WOT (wide-open throttle) with full tilt on the mast. Less than two minutes after beginning this procedure, the hydraulic pump shaft broke,

rendering the truck unusable. After-hours service support was summoned from the local Hyster dealership to change the pump.

A no-load emissions check showed that the catalytic converter muffler was inactive. The counterweight was taken off to gain access to the muffler. It was removed, and it was observed that retention of the ceramic substrate had been lost. The catalytic muffler, manufactured by Engine Control Systems Ltd. (P/N 600031W, S/N 57551), was set aside for future failure mode investigation. The catalytic converter muffler (S/N 7922) from truck no. 28 (disabled due to the electrical harness problem) was removed and found to have the same type of failure. It, too, was set aside for future failure mode investigation.

4. Truck No. 30

The same type of catalytic converter muffler failure was found (S/N 7926). It, too, was set aside for future failure mode investigation.

5. Truck No. 16

Although the closed-loop fuel control system appeared to be working well on this truck, tailpipe emissions showed a rich air fuel ratio, favoring high NO_x conversion. Given the otherwise normal operation of the truck, the likely cause was suspected to be O_2 sensor condition. A new sensor was installed, proving the diagnosis right. Emissions characteristics changed to the opposite extreme -- lean mixture under load with low NO_x conversion. After the emission test, the old sensor was reinstalled on the truck with the data logging instrumentation. The driver commented that this truck ran for only eight hours on a bottle of LPG, while all the other trucks that he has operated ran in excess of twelve hours per bottle.

D. Tailpipe Emissions

Tailpipe emissions measurement was used as part of the screening process, and to identify if any exhaust system leaks were present. Since no leaks were detected on the two forklifts selected, it was decided to ship only the engines to SwRI for subsequent testing.

A four-gas ECOM S portable analyzer, made available on loan by Engine Control Systems Ltd., was used for emissions measurement. All of the catalytic converter mufflers tested had a NPT port after the catalyst, allowing connection of the sampling probe. Engines and catalysts were warmed up prior to emissions sampling. Results are summarized in Table 2.

TABLE 2. EMISSIONS RESULTS SUMMARY

Date: 2/14/00					
Visual ID: Yellow Flag			Model: S50XL		
Truck No: 29			Truck Hrs.: 11,178		
S/N: C187V09931R			Terminox Hrs.: 5,581		
Mode	**CO, ppm**	**NO, ppm**	**NO_2, pm**	**NO_x, ppm**	**O_2, %**
WOT/no load	126	284	4	288	0.1
WOT/full tilt	427	179	5	184	0.0
Idle	2	183	6	189	1.8
Note: Due to the proximity of the sampling port to the end of the tailpipe, at idle, a certain amount of dilution of the sample is observed (1.8% O_2).					
Date: 2/16/00					
Visual ID: Blue/White Flag			Model: H30XL		
Truck No.: 16			Truck Hrs.: 16,707		
S/N: C001B07982K			Terminox Hrs.: 4,034		
Mode	**CO, ppm**	**NO, ppm**	**NO_2, ppm**	**NO_x, ppm**	**O_2, %**
WOT/no load					
WOT/full tilt	3500	323	0	323	0.0
Idle					
Note: System was diagnosed with O_2 sensor problem (running rich). Test was interrupted.					
Date: 2/16/00					
Visual ID: Blue/White Flag			Model: H30XL		
Truck No: 16			Truck Hrs.: 16,707		
S/N: C001B07982K			Terminox Hrs.: 4,034		
Mode	**CO, ppm**	**NO, ppm**	**NO_2, ppm**	**NO_x, ppm**	**O_2, %**
WOT/no load	46	82	0	82	0.2
WOT/full tilt	0	1980	1	1981	0.3
Idle	121	62	8	70	2.8
Note: New O_2 sensor. Due to the proximity of the sampling port to the end of the tailpipe, at idle, a certain amount of dilution of the sample is observed (2.8% O_2). Lean calibration (low NO_x conversion).					

Based on previous experience, engine out, raw gas concentrations at WOT/full tilt should be 2000-3000 ppm NO_x, 3000-8000 ppm CO, and 0.3-0.8 percent O_2 for approximate stoichiometric air fuel ratio. Therefore, the tailpipe emission levels presented in Table 2 were considered acceptable.

E. Data Logging Instrumentation

Trucks no. 16 and 29 were selected for detailed emissions testing at SwRI. Before the engines were removed from the trucks for shipment, the duty cycles and operating characteristics of the trucks were to be documented. The trucks were instrumented, and the following data representing normal operation were logged at 5 Hz:

- engine speed
- manifold absolute pressure (indicative of engine load)
- throttle position
- vehicle speed
- intake air temperature
- ambient air temperature

A magnetic pickup was used on the alternator pulley fan blades for engine speed input, as shown in Figures 1 and 2. The engine speed multiplier was determined using an optical tachometer pointed at the crankshaft pulley.

Manifold absolute pressure (unported vacuum) was used as an indirect indication of engine load, as shown in Figure 3. New air filters were installed in both trucks. Barometric pressure recorded at the test site was 28.84 in. Hg., approximately 0.5 in. Hg. lower than at the time the pressure transducers were calibrated at SwRI.

For measurement of throttle position, a rotary potentiometer was attached to the throttle valve shaft via a flexible link, as shown in Figure 4. Zero percent and 100 percent open throttle positions were calibrated on each forklift truck.

Vehicle speed data were based on the rotational speed of the forklift's front wheel. A 184-tooth ring (from an engine flywheel) was attached to the inner side-wall of the tire so it would not get torn during operation. A magnetic pickup determined wheel rotation speed (see Figures 5 and 6), which was converted to vehicle speed.

Temperatures were measured using K-type thermocouples. A thermocouple was attached to the air filter housing on each truck, as shown in Figures 7 and 8.

The trucks were fitted with flags for ease of identification on the video recording. Truck No. 29 had a yellow flag, and Truck No. 16 had a flag with blue stripes on a white background, as seen in Figures 9 and 10.

At the invitation of the EPA project manager, two representatives from NACCO Materials Handling Group, Inc. witnessed the forklift truck instrumentation and data logging. Mr. Curt Schulz, P.E. (Tel: 503-721-6927) and Mr. David R. Smith (Tel: 503-721-6927) of NACCO's Counterbalanced Development Center assisted with instrumentation efforts.

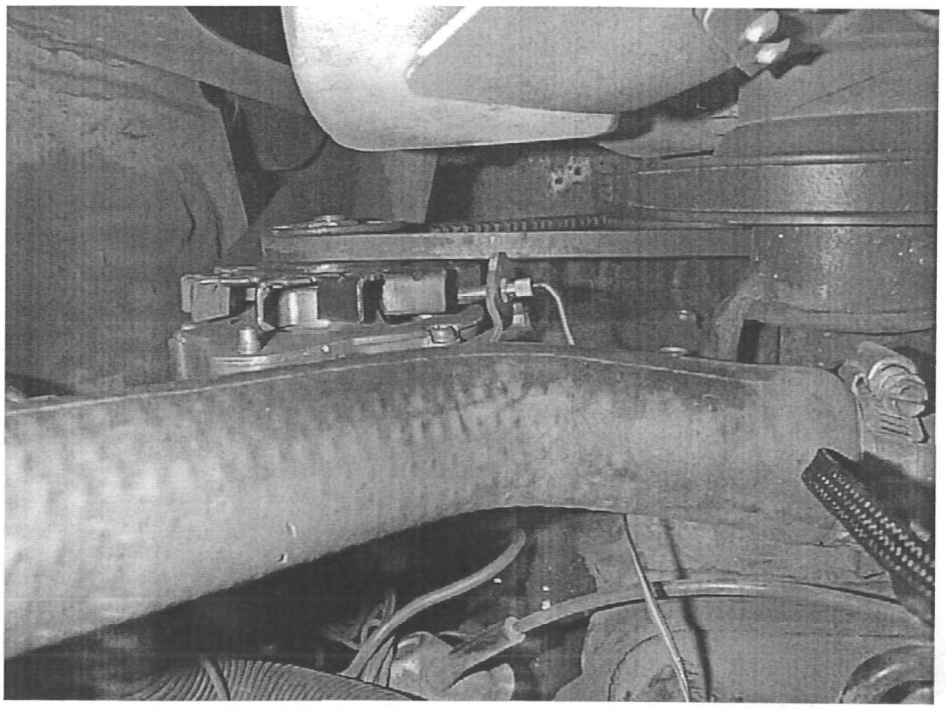

FIGURE 1. TRUCK 16, ENGINE SPEED PICKUP

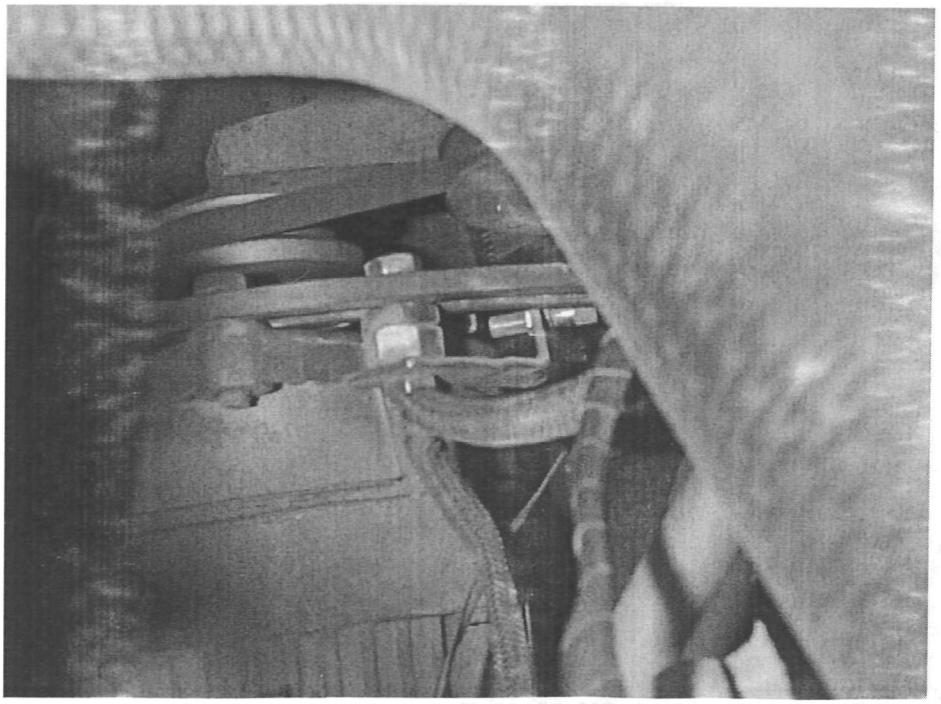

FIGURE 2. TRUCK 29, ENGINE SPEED PICKUP

FIGURE 3. ABSOLUTE MANIFOLD PRESSURE SAMPLING PORT

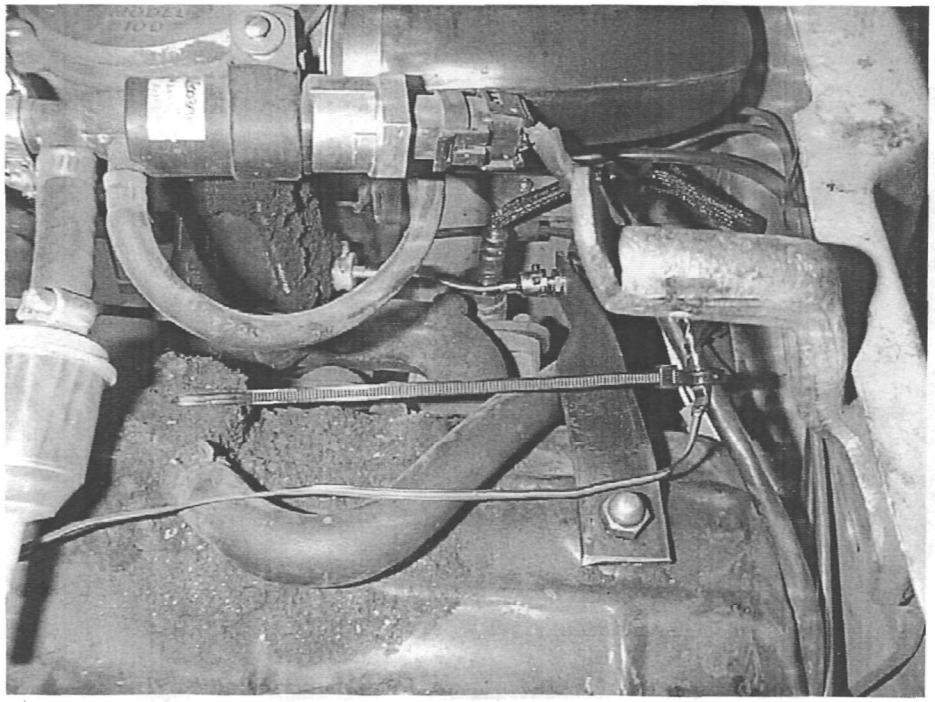

FIGURE 4. TRUCK 16, THROTTLE POSITION SENSOR

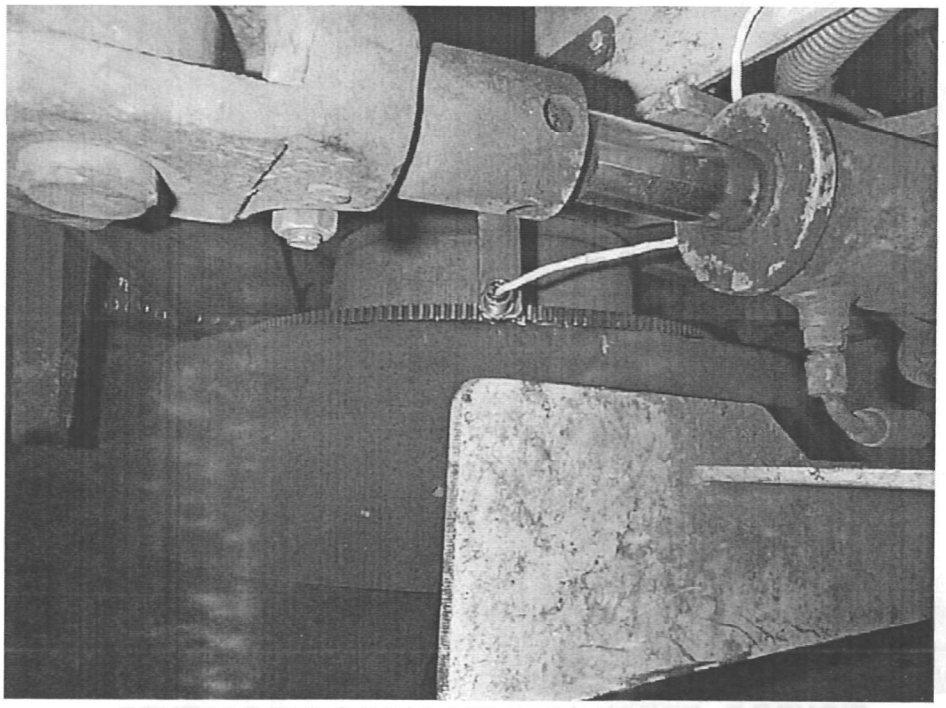

FIGURE 5. TRUCK 16, VEHICLE SPEED PICKUP

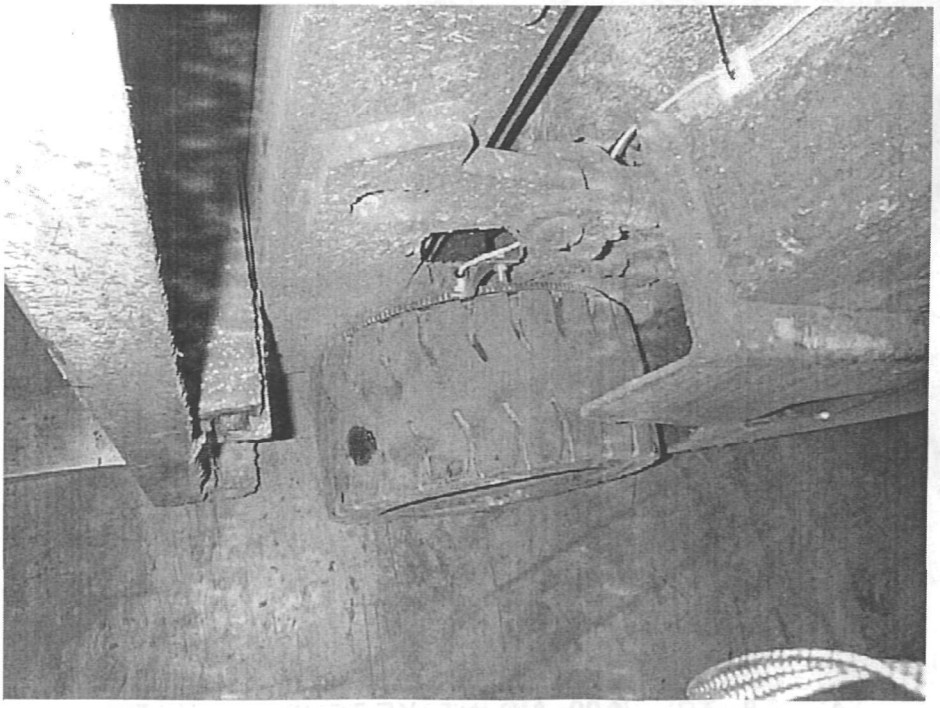

FIGURE 6. TRUCK 29, VEHICLE SPEED PICKUP

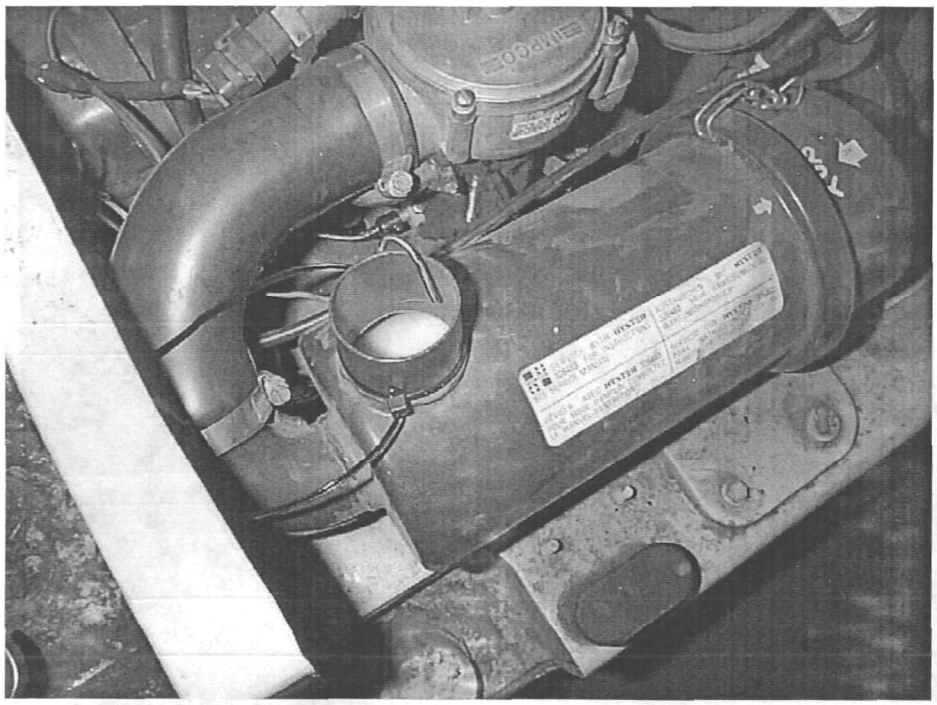

FIGURE 7. TRUCK 16, AIR INTAKE TEMPERATURE

TABLE 8. TRUCK 29, AIR INTAKE TEMPERATURE

FIGURE 9. TRUCK 16

FIGURE 10. TRUCK 29

F. Duty Cycles

Forklift truck operators were assigned specific trucks and tasks, therefore it was not possible to switch operators on the test trucks.

1. Truck No. 29

This forklift truck was used to feed the automated packaging line with apples. It would pick up four crates of 3,850 ± 50 lb total weight (approximately 80 percent of the lift capacity) from the cold storage areas, and bring them to the conveyor lines. If there was no space on these lines, the crates were placed in front of them. Lift height on the conveyors was 19 inches. The crates were of cubic shape with a side of 46 inches, stacked eight high in the cold storage areas, therefore, the pick-up height was almost 200 inches. The duty cycle between pick-up and drop-off was 90 ± 10 seconds. Approximately six hours of operation were logged on this truck. This activity is illustrated in Figure 11.

2. Truck No. 16

This forklift truck was used to feed the automated packaging line with packing material. It would pick up skids of 800 ± 50 lb total weight (approximately 23 percent of the lift capacity) from different storage areas, and bring them to the conveyor lines. Its mode of operation had frequent engine shut-downs, since the operator had to partially unpack or unwrap the freight. The unloading area was very narrow, and required a lot of small maneuvers. Approximately four hours of operation were logged on this truck. This activity is illustrated in Figure 12.

Operating details for each truck were recorded on 8 mm videotape. The time stamp of the images has an offset of approximately 2 hr and 2 ½ minutes to the internal clock time of the dataloggers. After the operational characteristics of each truck were recorded in detail, the camera was placed at a vantage point to record activity in the unloading areas.

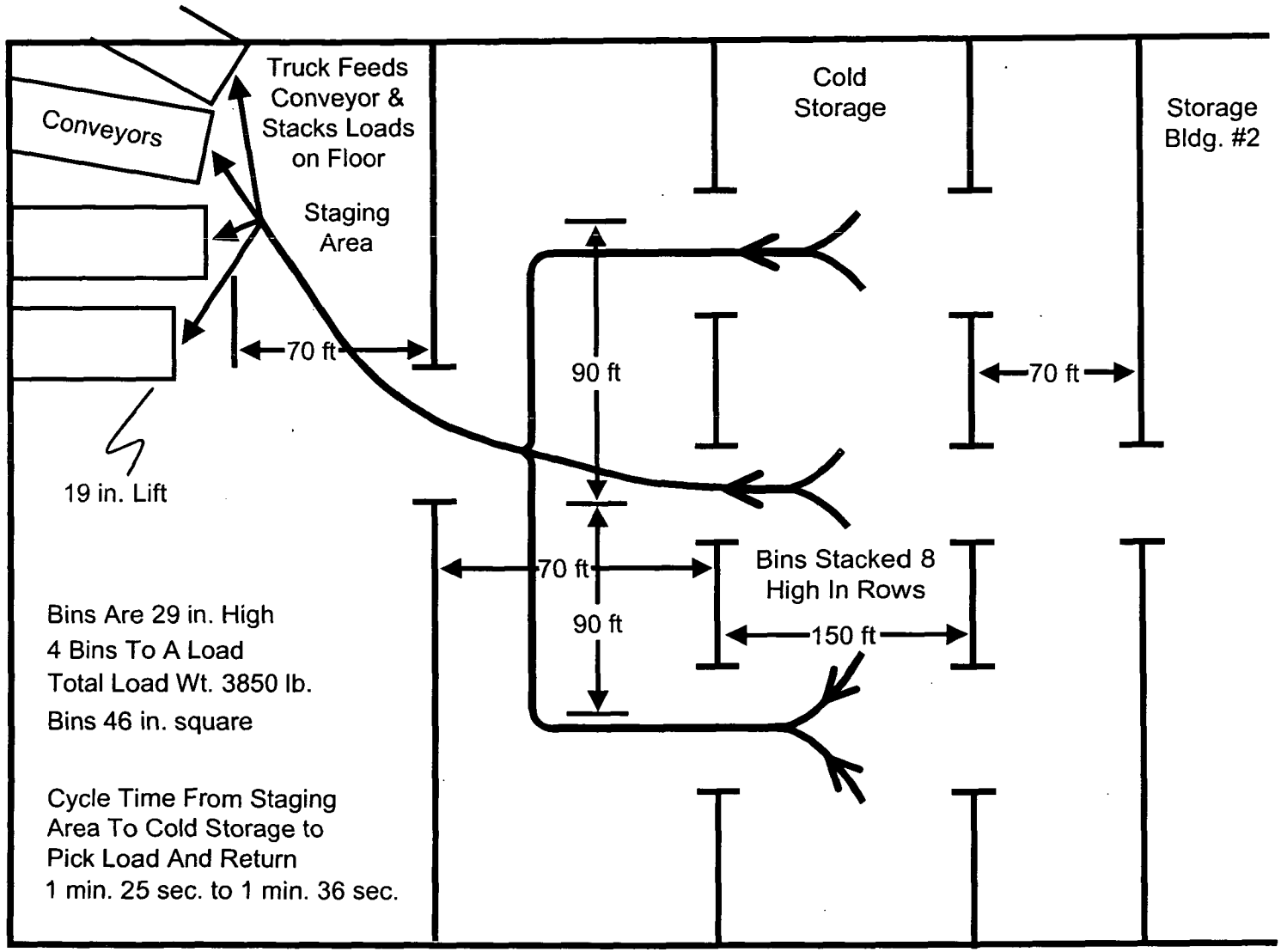

FIGURE 11. AREA OF OPERATION FOR TRUCK 29

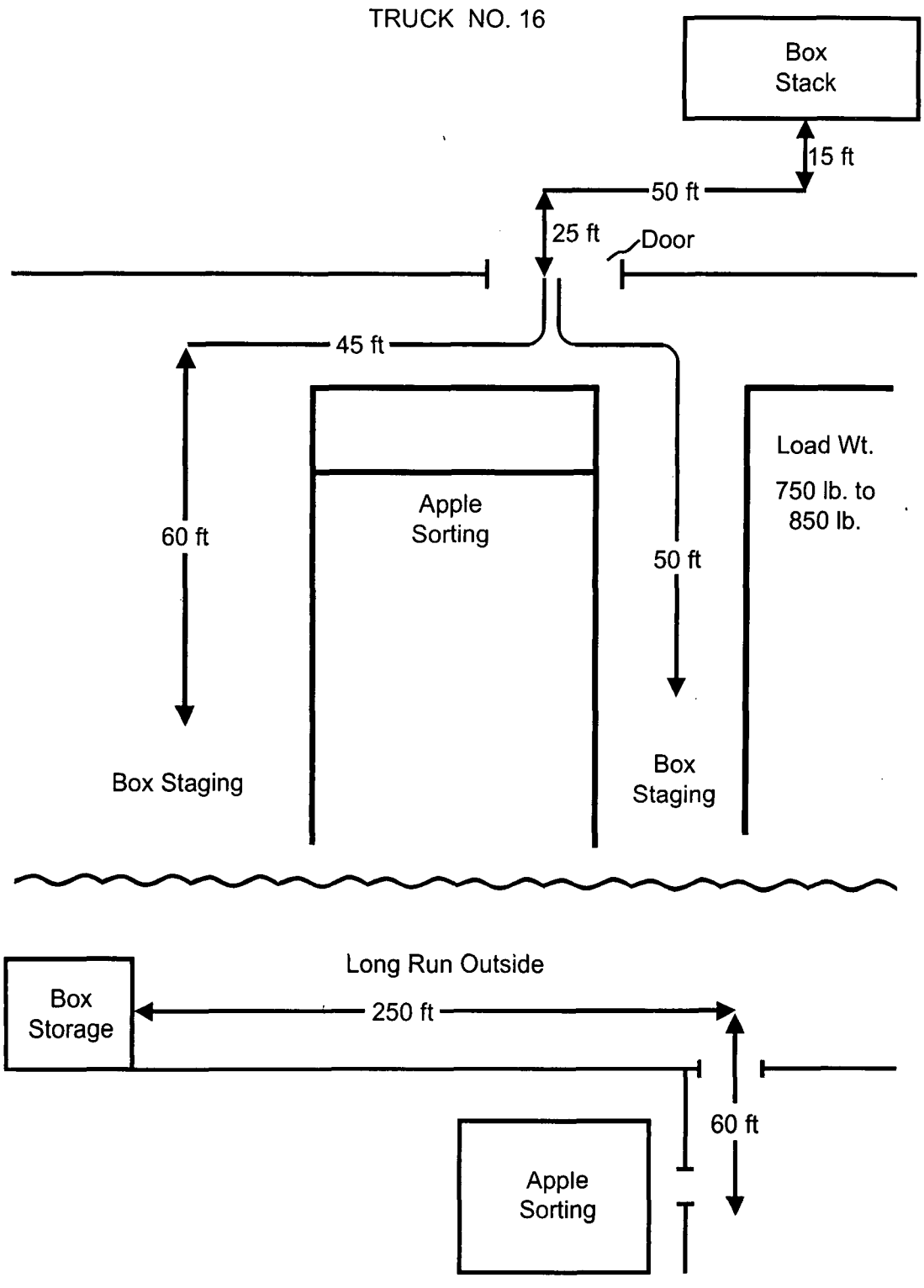

FIGURE 12. AREA OF OPERATION FOR TRUCK 16

G. Field Measurements - Data Analysis

The first step of the data analysis was the validation and subsequent filtering of the logged data following the instructions of the U.S. EPA Program Manager. For this purpose, a data template was created with a segment length of 30 seconds. The entire data sets for both trucks were scrolled on the computer screen, visually checked for consistency, continuity and transducer drift, and the time stamps for the idle periods, and cold and warm engine starts were logged.

Since the purpose of Task 1 was principally transient operation characterization, it was decided that every idle period of 20 seconds or longer would be removed from the data set by truncating all but the first and last one to three seconds. The variation in length, of one to three seconds, of the beginning and end time intervals of a 20-second or longer idle period was necessary to ensure a natural continuity of the logged engine data. Engine starts were also filtered out. A summary of the data filtering for the two sample populations is presented in Table 3. No "smoothing" was applied to any of the recorded parameters.

TABLE 3. LOGGED DATA SAMPLE POPULATION DETAILS

Truck No.	Raw Data Set (No. of Lines)	Filtered Data Set (No. of Lines)	% Filtered
16	50,523	34,898	30.92
29	95,910	66,871	30.27

The EPA asked for scatter plots and frequency distribution analysis of the main engine operating variables (engine speed, throttle position, and manifold absolute pressure). Appendix A Figures A-8 through A-19 present the scatter plots for each truck based on filtered and unfiltered data sets. Although almost one third of the logged data was removed from each of the sample populations (data sets), there are minimal differences between the scatter plots based on filtered and unfiltered data sets. However, in the area of the plots corresponding to engine speed below 600 rpm and at zero percent throttle position, the deletion of the segments corresponding to engine starts is visible.

During the data validation process, it was observed that the throttle position transducers on both trucks had drifted from their original calibrations (0 to 100% throttle) by less than ±3 percent. The recorded values were re-normalized using the following algorithm:

$$TPS_N = (TPS_{orig} - TPS_{min})/(TPS_{max} - TPS_{min}) \times 100$$

where: TPS_N - re-normalized throttle position
TPS_{orig} - recorded throttle position

TPS_{min} - minimum recorded throttle position (<0)
TPS_{max} - maximum recorded throttle position (>100)

For statistical analysis, each of the three parameters of interest (engine speed, throttle position, and manifold absolute pressure) was broken down into predetermined ranges, and data points were then binned in cells bounded by these ranges. The relative frequency of occurrence (RFO) for each cell was defined as the number of occurrences counted in a given cell, divided by the total number of occurrences (number of data points in the population). Therefore, the sum of the RFOs for each analyzed parameter adds up to 100 percent.

Although the analysis of engine speed is based on raw, un-normalized data, a direct comparison between operating characteristics of the two different trucks is still possible since both had the same idle speed (600 rpm) and almost identical governed speed (2700 rpm). It was observed from the raw data plots that the mechanical engine speed governor on Truck 16 provided tighter and more precise control, while the pneumatic engine speed governor on Truck 29 allowed brief "over-speed" excursions to 2800 rpm.

For the frequency distribution plots in Figures 13 through 19, bars representing RFO values for the different cells are centered on the upper limit of each range. Consistent with on-site observations, RFOs for Truck 16 show that it had a lighter duty cycle, lifting payloads of 25-30 percent of its capacity, and driven almost exclusively at closed or part throttle. This can be concluded from the fact that although both trucks have almost identical RFO numbers for the idle speed, Truck 16 has an RFO only about one-tenth that of Truck 29 for the 0-2 percent throttle position cell. For all other cells below 40 percent throttle position, Truck 16 has higher RFOs than Truck 29 (Figures 13 and 14). Truck 16 also has higher RFOs than Truck 29 in the low engine speed range from 800 rpm to 1500 rpm. For engine speeds above 1600 rpm and throttle positions above 40 percent, Truck 29 has higher RFOs. Results of statistical analysis of engine speed and throttle position are presented in numerical format in Appendix B, Tables B-1 and B-2.

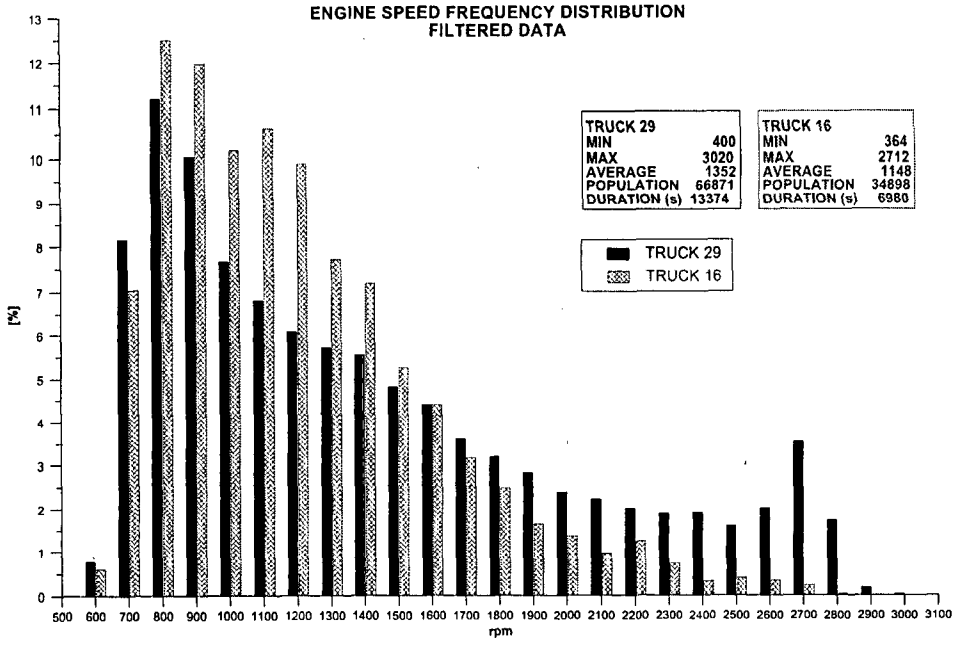

FIGURE 13. ENGINE SPEED FREQUENCY DISTRIBUTION, 100 RPM RANGES, FILTERED DATA

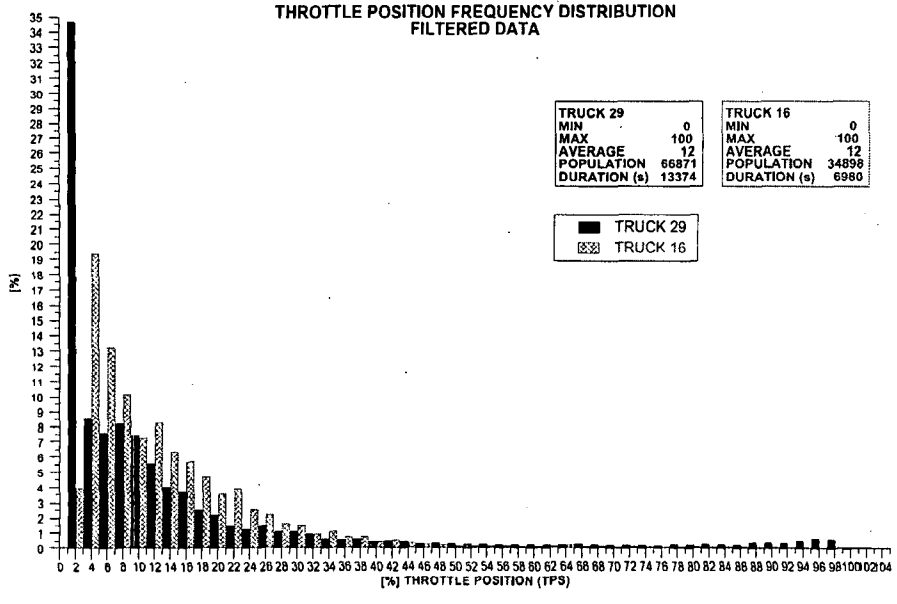

FIGURE 14. THROTTLE POSITION FREQUENCY DISTRIBUTION, 2% RANGES, FILTERED DATA

Manifold pressure data can not be directly compared between the two trucks since

they are air intake configuration-specific (see Figure 15 and Table B-3). However, since manifold absolute pressure is proportional to load, they appear to correlate well with the two different characteristics of the duty cycles observed for the two trucks.

A better characterization of modes of operation for the two trucks is shown in 3-D histograms of throttle position vs. engine speed (see Figures 16 through 19 and Table B-4). These figures clearly show the baseline characteristics for each of the populations.

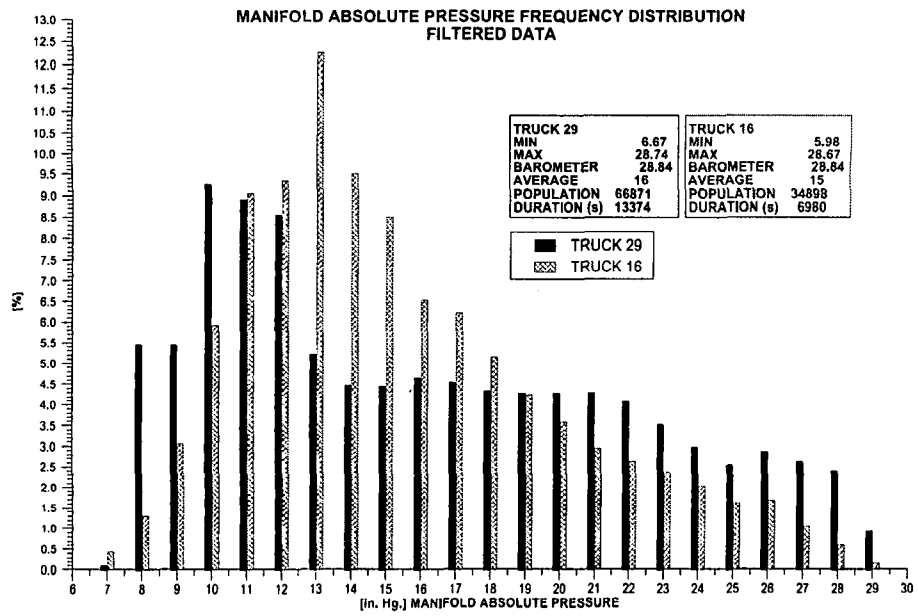

FIGURE 15. MANIFOLD ABSOLUTE PRESSURE FREQUENCY DISTRIBUTION, 1 IN. HG. RANGES, FILTERED DATA

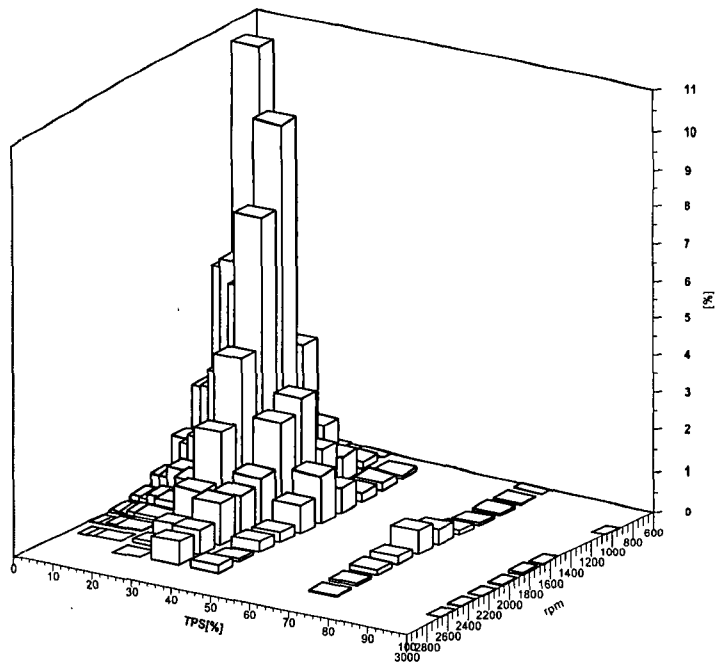

FIGURE 16. TRUCK 16, THROTTLE POSITION VS. ENGINE SPEED FREQUENCY DISTRIBUTION, FILTERED DATA - VIEW 1

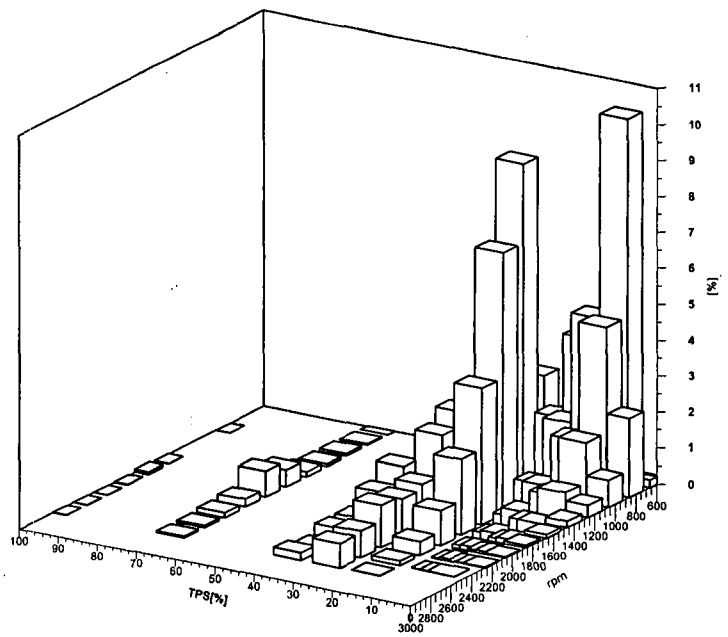

FIGURE 17. TRUCK 16, THROTTLE POSITION VS. ENGINE SPEED FREQUENCY DISTRIBUTION, FILTERED DATA - VIEW 2

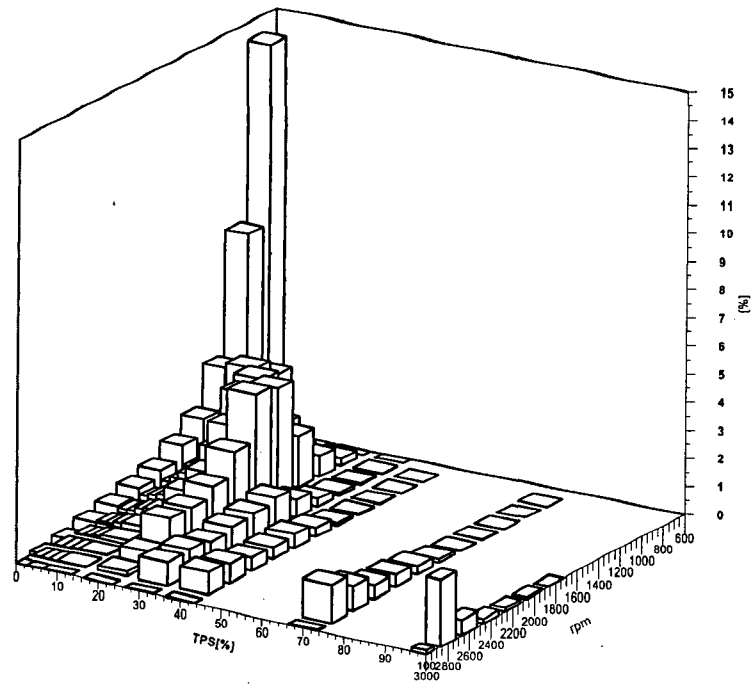

FIGURE 18. TRUCK 29, THROTTLE POSITION VS. ENGINE SPEED FREQUENCY DISTRIBUTION, FILTERED DATA - VIEW 1

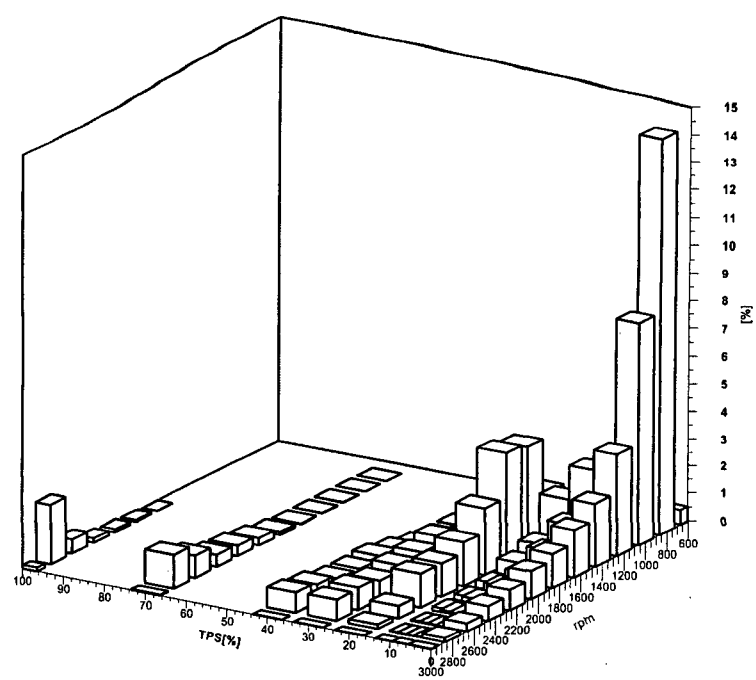

FIGURE 19. TRUCK 29, THROTTLE POSITION VS. ENGINE SPEED FREQUENCY DISTRIBUTION, FILTERED DATA - VIEW 2

III. STEADY-STATE EMISSIONS RESULTS

Following collection of on-site operating data, the local Hyster dealer removed the engines and accessories from the two trucks, and the engines and accessories were shipped to SwRI for emissions testing. These trucks were replaced with equivalent rental equipment for the duration of the testing program. New, replacement emission components, as well as the necessary engine diagnostic and programming tools were procured.

The main goal of this project was the assessment of emission control system durability by examining the performance deterioration of three-way catalyst systems installed on two forklift trucks with more than 4000 hours of use. To determine sources of deterioration, individual emission components were replaced with new components, and the engines were retested. Both the Mazda and the GM engines completed steady-state testing in the following configurations:

• "As Found" (AF)	engine out - no catalyst, old (aged) catalyst (OC), new catalyst (NC)
• "Fueling adjustments" (F) (if necessary)	engine out - no catalyst, old (aged) catalyst (OC), new catalyst (NC)
• "New Oxygen Sensor" (NS)	engine out - no catalyst, old (aged) catalyst (OC), new catalyst (NC)
• "Maintenance" (M)	engine out - no catalyst, old (aged) catalyst (OC), new catalyst (NC)
• "Best Calibration" (BC) for NO_x	engine out - no catalyst, old (aged) catalyst (OC), new catalyst (NC)

Each of the above 15 configurations was tested in the seven shaded modes listed in Table 5, which were used as the basis for the ISO 8178 C2 cycle calculation. Mazda engine mode 22 was found to be considerably leaner than the other modes. Mixer "fueling adjustments" (F) were made for this mode, and the engine was then retested to show the effect of this adjustment. The periodic maintenance procedure, performed in accordance with the OEM service manuals, consisted of spark plug replacement, ignition timing adjustment, valve lash adjustment, and cleaning of the mixer. A "best calibration" (BC) for NO_x was developed, and emissions map data covering all the points in Table 5 was obtained. Rated speeds were determined as follows:

1) Generation of lug curve. Measure maximum power vs. engine speed per 40 CFR 86.1332.

2) Normalization of lug curve. Normalize the lug curve by:
   - Identifying the point (power and speed) on the lug curve where maximum power occurs;
   - Normalizing the power values of the lug curve by dividing them by the maximum power and multiplying the resulting values by 100; and
   - Normalizing the engine speed values of the lug curve by dividing them by the speed at which maximum power occurs and multiplying the resulting values by 100.

3) Determination of rated speed. Calculate the rated speed from the following speed factor analysis.
   - For a given power/speed point, the speed factor is the normalized distance to the power/speed point from the zero-power, zero-speed point. The value of the speed factor is defined as:

$$Speed\ factor = \sqrt{(power)^2 + (speed)^2}$$

4) Determine the maximum value of speed factors for all the power/speed data points on the lug curve. Rated speed is defined as the speed where the maximum value for the speed factor occurs.

Since the rated speed definition described above differs from the ISO 8178 procedure, the Mazda engine was also tested referencing the true rated speed of the engine, at which maximum power occurs. This result is presented as mode 37, and may be compared to the mode 36 result, which uses the above described rated speed definition. Differences in rated speed and power for the Mazda and GM engines are shown in Table 4.

TABLE 4. ENGINE RATED SPEEDS AND POWERS

	Mazda Engine		GM Engine	
	rpm	hp	rpm	hp
Speed Factor Procedure	2,533	35.7	2,631	29.5
ISO Procedure	2,440	37	2,171	32

TABLE 5. STEADY-STATE TEST MODES [a]

Mode	Speed (% from idle to rated)	Torque (% at that speed)	Mode	Speed (% from idle to rated)	Torque (% at that speed)
1	**idle**	—	**19**	**60**	**50**
2	20	10	**20**	**60**	**75**
3	20	25	21	60	85
4	20	40	**22**	**60**	**100**
5	20	55	23	80	10
6	20	70	24	80	25
7	20	85	25	80	40
8	20	100	26	80	55
9	40	10	27	80	70
10	40	25	28	80	85
11	40	40	29	80	100
12	40	55	30	rated	10
13	40	70	**31**	**rated**	**25**
14	40	85	32	rated	40
15	40	100	33	rated	55
16	**60**	**10**	34	rated	70
17	**60**	**25**	35	rated	85
18	60	40	36	rated	100

[a] C2 modes are bold and shaded. Note that modes 19 and 20 depart from the pattern to fit the C2 cycle.

Forklift engines operate at idle with high auxiliary loads from the engine cooling fan and hydraulic pump. These loads were simulated in the test cell with the dynamometer, since both the cooling fan and the hydraulic pump were removed in the test stand configuration. To maintain the target 600 rpm idle speed, a load of over 30 lb-ft was applied to the Mazda engine, and a load of 60 lb-ft was applied to the GM engine. For the no-load idle test mode, the speed governor had to be deactivated, and the idle speed readjusted. Also, at no-load idle, the catalysts were below their light-off temperatures, and therefore not reducing emissions. In order to cover both real life operation and the ISO procedure requirements, two idle modes were run on both engines in all tests. Mode 1 was idle with load, typically described as Curb Idle Transmission Torque (CITT). Mode 1A

was no-load idle. Through the addition of these supplemental modes, a total of four different composite emissions results could be calculated for the Mazda engine, and two different composite results for the GM engine. These are summarized in Table 6. Differences in emissions were generally small, with a small NO_x response observed with the loaded idle mode.

TABLE 6. IMPACT OF MODE DEFINITION ON EMISSION RESULTS BEST CALIBRATION, NEW CATALYST

Engine and Modes	C2 Emissions, g/hp-hr			BSFC, lb/hp-h
	HC	CO	NO_x	
Mazda Engine				
ISO Rated Speed, CITT>0	0.21	1.56	0.49	0.59
ISO Rated Speed, CITT=0	0.28	1.56	0.30	0.57
EPA Rated Speed, CITT>0	0.21	1.59	0.49	0.59
EPA Rated Speed, CITT=0	0.28	1.59	0.30	0.57
GM Engine				
EPA Rated Speed, CITT>0	0.10	0.30	0.44	0.68
EPA Rated Speed, CITT=0	0.11	0.28	0.14	0.65

Unless otherwise stated, results reported are based on speed factor rated speed and no-load idle. Detailed results using the different mode definitions can be found in Appendix C for the Mazda engine, and Appendix D for the GM engine.

A. Mazda Engine (Truck 16)

As identified on-site at Trout Apples, the oxygen sensor on this engine was malfunctioning, allowing operation at richer than normal air-fuel ratios. However, during engine start-up in the test cell, it was observed that the engine was running lean. A crack was found at the base of the throttle body which had become "unplugged" as a result of the steam cleaning of the engine prior to test cell installation. Accumulated dirt had apparently kept the crack sealed when tailpipe emission measurements were being taken on-site. A new throttle body was procured and installed during the maintenance procedure. For initial testing, an epoxy patch was applied over the crack. During the first set of "As Found" tests, it was observed that in Mode 22 (intermediate speed, full load), the engine was running very lean. For subsequent tests, this was corrected by opening the power valve from its initial position of approximately 2/3, to full rich.

Table 7 contains the description of the individual 9-mode tests performed on this engine, and the configuration identification codes used in this report.

TABLE 7. MAZDA ENGINE TEST MATRIX CODES [a] (TRUCK 16)

	As Found (AF)		Fuel Adjustment (F)		Fuel Adjustment + Maintenance (F&M)
	Old Sensor (OS)	New Sensor (NS)	Old Sensor (OS)	New Sensor (NS)	New Sensor (NS)
No Cat (NC)	A	B	J	K	L
Old Cat (Old_C, (OC))	D	C	I	H	M
New Cat (New_C, (NC))	E	X	F	G	N
Old Cat					O (Cal. 1)
Old Cat					P (Cal. 2)
Old Cat					Q (Cal. 3)
Old Cat					R Cal. 4)
New Cat					S (Cal.3)
New Cat					T (Cal. 4)
New Cat					U [b] (Cal. 4)
No Cat					V (Cal. 4)
Old Cat					M1/M2/M3/M4 [c] (Cal. 4)

[a] Codes designate individual 9-mode tests
[b] Run in open loop
[c] Groups of modes to comprise complete emissions map

Closed-loop fuel control systems are currently being installed on LPG-fueled industrial engines to minimize personnel exposure to CO when the equipment is used indoors. As expected, the original calibrations of the closed-loop fuel control systems on both the GM and the Mazda engines were found to have a lean bias for maximum CO reduction.

Mazda engine original calibration, C2 cycle emission results (Figures 20 and 21) for tests D through G, show that the emissions impact of the malfunctioning original oxygen sensor, is far more significant than catalyst aging. The old oxygen sensor displayed a slower response and a shift in the lean/rich switch point causing a 0.12 air/fuel ratio decrease (shift towards richer mixture) in the average air/fuel for the C2 cycle. The average air/fuel ratio was calculated from the recorded modal averages for all the C2 cycle modes, excluding idle. Replacing the old oxygen sensor with a new one re-established the intended lean bias of the calibration, causing the C2 cycle brake specific CO to drop 98.5% for the tests with the original catalytic converter muffler, and 97.4% for the new catalytic converter muffler. As a result, the brake specific (NO_x+THC) doubled in both configurations. After the mechanical fuel flow adjustment to cure the lean operation in

mode 22, and maintenance work that included the replacement of the old oxygen sensor, results showed that this lean bias, original calibration did not meet CARB standards for NO_x+THC. However, it was noted that in the original "as found" configuration with the old defective oxygen sensor, C2 cycle emissions were in compliance.

Subsequently, a "best NO_x" calibration was obtained through four iterations. Using calibration 4, C2 cycle results of 3.16 g/hp-hr CO and 0.51 g/hp-hr THC + NO_x were obtained for test (R) with the original catalytic converter muffler. Corresponding results for test (T) with the new catalytic converter muffler were 1.56 g/hp-hr CO and 0.58 g/hp-hr THC + NO_x. Throughout the steady-state tests on the Mazda engine, the new catalytic converter muffler had better CO conversion efficiency, but slightly worse NO_x conversion efficiency, compared to the original part, although the supplier stated that there are no catalyst formulation differences between the two units. Therefore, based on the last results with the "best NO_x" calibration, it can be noted that over 4,000 hours of use, this catalyst's performance deterioration caused a twofold increase in C2 cycle CO emissions and no change in NO_x emissions. It was also noted that due to the flexibility offered by the programmable closed-loop fuel control system used, an "indoor-use friendly" calibration, minimizing both CO and NO_x could be obtained. C2 cycle results for calibration 2, used in test P in conjunction with the new oxygen sensor and original catalytic converter muffler, are 0.78 g/hp-hr CO and 1.26 g/hp-hr THC + NO_x.

Figures 22 and 23 present the full emissions map for this engine, with emissions plotted versus normalized engine speed and normalized load. These results were obtained using the "best NO_x" calibration in conjunction with the new oxygen sensor and original catalytic converter muffler. The emissions map shows that all measured modal emission levels fell below CARB standards. Further, calibration optimization and mechanical fuel adjustments could reduce the high full load CO emissions. Also note that the no-load idle emission levels presented in the figures are expressed in g/hr.

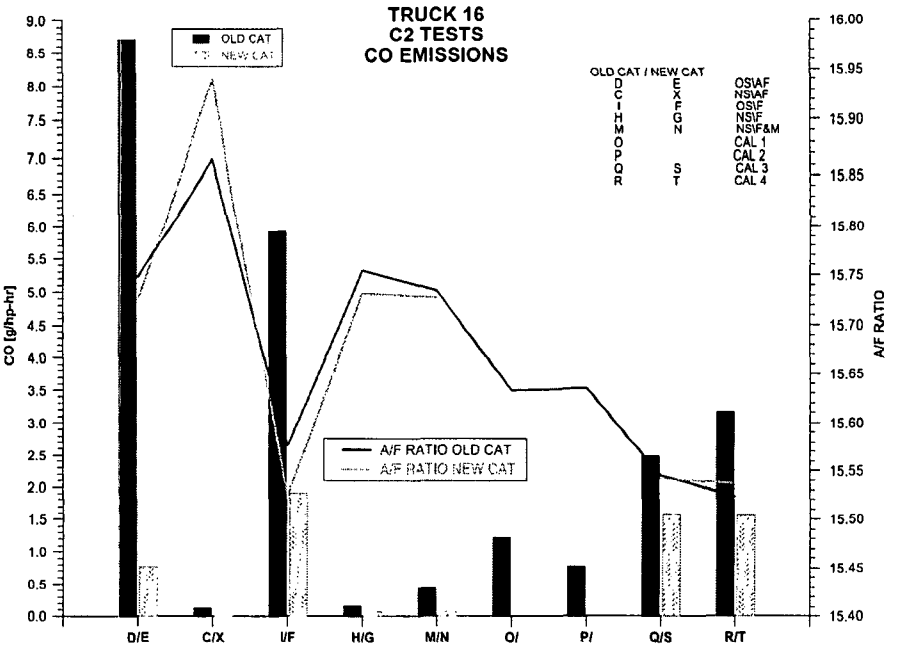

FIGURE 20. TRUCK 16, ALL C2 CYCLE CO EMISSIONS RESULTS

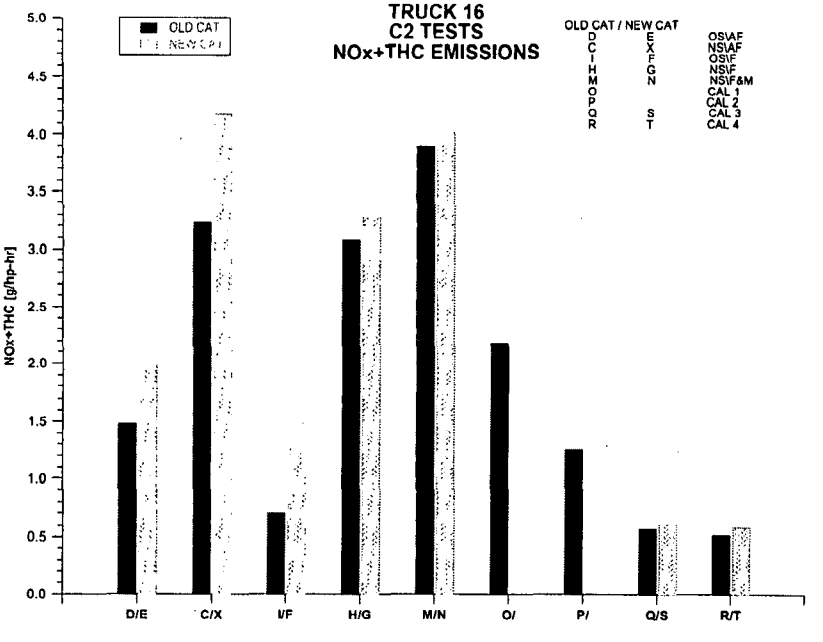

FIGURE 21. TRUCK 16, ALL C2 CYCLE NO_X+THC EMISSIONS RESULTS

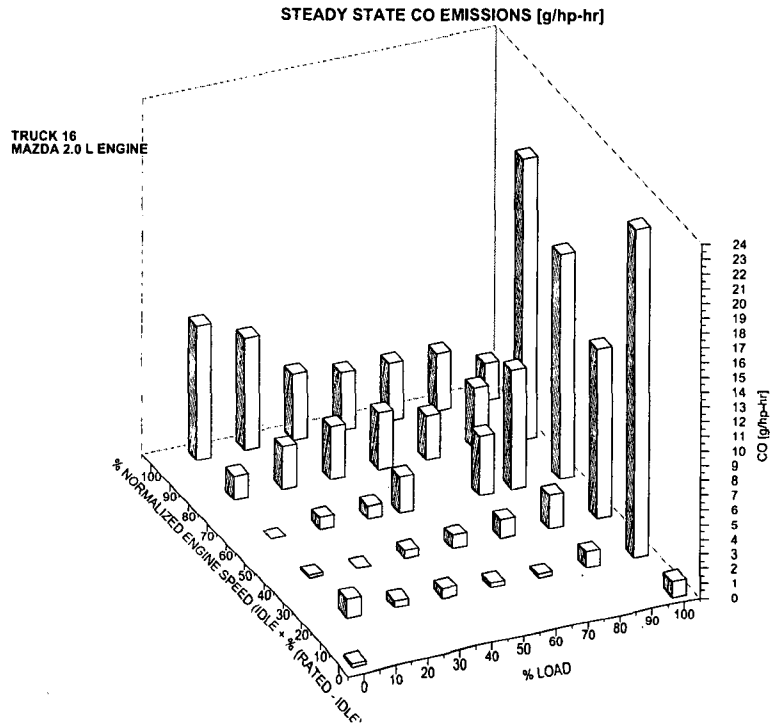

FIGURE 22. TRUCK 16, STEADY-STATE CO EMISSIONS RESULTS OVER NORMALIZED SPEED AND LOAD

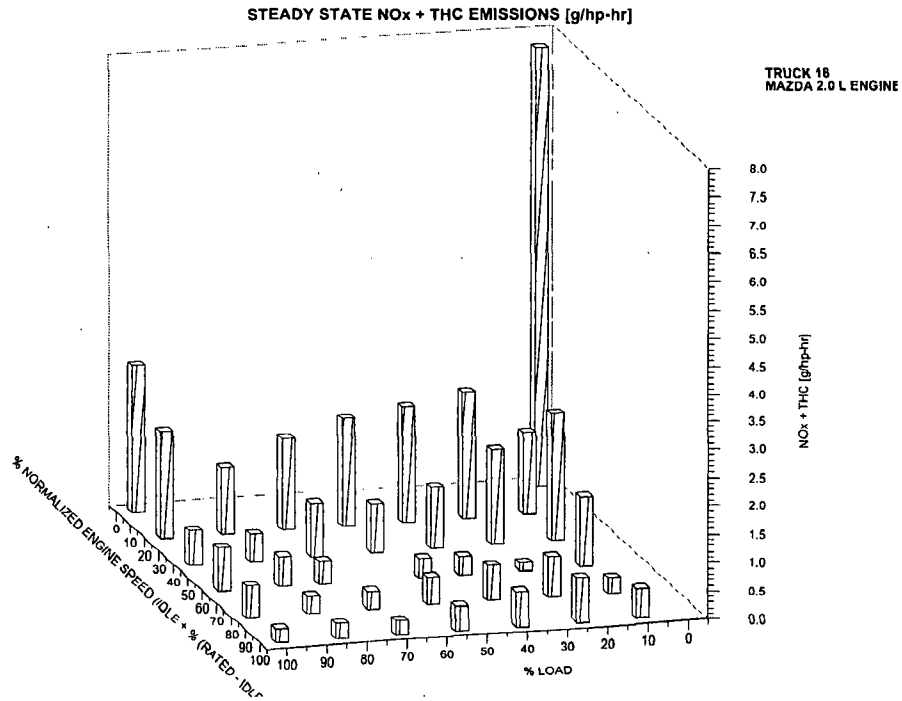

FIGURE 23. TRUCK 16, STEADY-STATE NO_X+THC EMISSIONS RESULTS OVER NORMALIZED SPEED AND LOAD

B. GM Engine (Truck 29)

One of the two identical substrates inside the catalytic converter muffler from Truck 29 was loose, and was reduced in volume by abrasion due to vibration. The catalyst parts were removed from the original converter and re-canned with a loss of only 18 percent in total catalyst volume. Results of a failure mode analysis are presented in Section VII.

Table 8 contains the description of the individual 8-mode tests performed on this engine, and the corresponding configuration identification codes used in this report.

TABLE 8. GM ENGINE TEST MATRIX CODES [a] (TRUCK 29)

	As Found (AF)	Maintenance (M)
	Old Sensor (OS)	New Sensor (NS)
No Cat (NC)	GA	GF
Old Cat (Old_C, (OC))	GC	GD
New Cat (New_C, (NC))	GB	GE
Old Cat		GH (Best cal.)
New Cat		GG (Best cal.)
No Cat		GI (Best cal.)
Old Cat		GJ/GK/GL/GM/GN [b]
New Cat		XG/XGO/XGP/XGQ [b]

[a] Codes designate individual 8-mode tests
[b] Groups of modes to comprise complete emissions map

The GM engine original calibration, C2 cycle emission results (Figures 24 and 25) for tests GC through GE show a much smaller emissions impact of oxygen sensor aging than on the Mazda engine. Furthermore, emission results for the "as found" configuration on this engine were very similar to Mazda results after its malfunctioning oxygen sensor was replaced. In spite of the 18% loss in volume of the original catalyst, NO_x emissions were lower than with the new unit for all the original calibration tests. However, the "best NO_x" calibration results show a deterioration by a factor of 6.6 for C2 cycle CO in the new catalyst/old catalyst comparison, and a corresponding threefold increase in NO_x+THC for the test with the original catalytic converter muffler. Note that these proportional differences are magnified by the low levels being compared.

All results are included in the appendices. Results from steady-state tests performed on both engines are presented in Figures A-40 through A-73, Appendix A. Figures A-40 through A-43 show C2 cycle results for both engines using both old and new catalysts. Figures A-44 and A-45 show catalytic muffler inlet temperatures for both engines. Figures A-46 through A-63 show detailed modal emissions results for both engines, both with and without catalysts. Figures A-64 through A-73 present the full emissions map for both engines, with emissions plotted versus engine speed and load. Detailed numerical results for both engines are in Appendix B, Tables B-5 through B-27.

Approximate D2 cycle composite emissions, pertinent to constant speed applications, were calculated using emission levels recorded in modes 36, 34, 33, 31, and 30. Results are approximate because the load factors in modes 34 and 33 are 5 percent lower and higher, respectively, than the standard mode definitions for the cycle. Results are listed in Tables B-16 and B-17 for the Mazda engine, and Tables B-23, B-24, B-26, and B-27 for the GM engine.

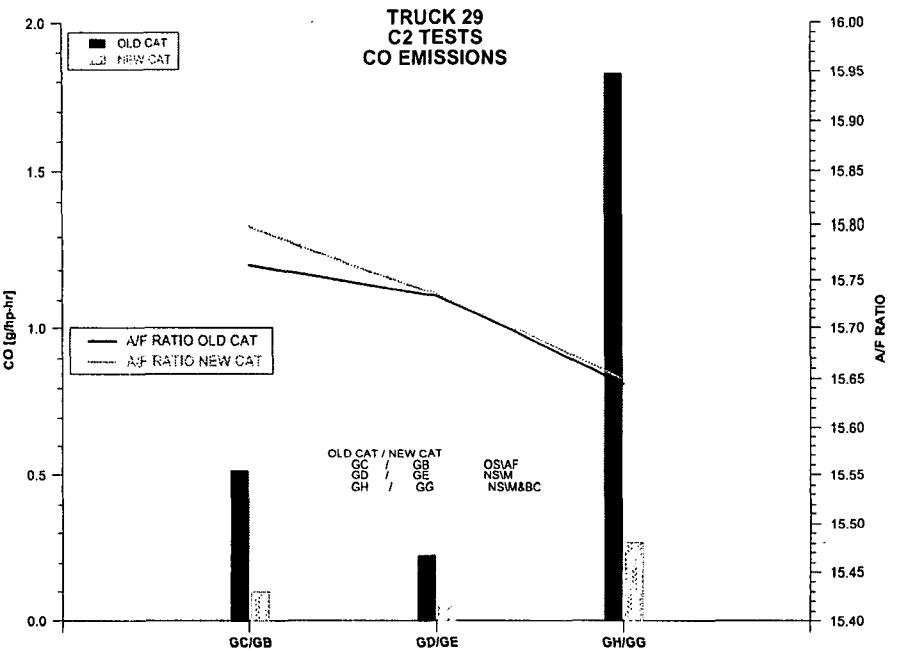

FIGURE 24 TRUCK 29, ALL C2 CYCLE CO EMISSIONS RESULTS

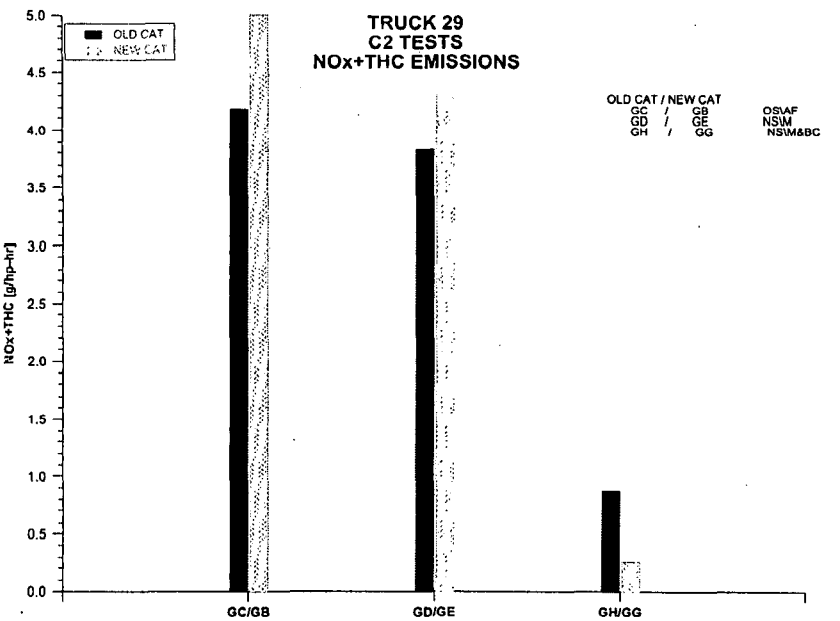

FIGURE 25. TRUCK 29, ALL C2 CYCLE NO_X+THC EMISSIONS RESULTS

IV. TRANSIENT CYCLE DEVELOPMENT

A. Defining Typical Data Segments

Segments of data collected from the operation of the two forklift trucks were individually identified to represent a "typical" interval of truck application. Each "typical" cycle was developed based on data segments selected according to rankings of chi-square statistics. The most typical cycle for each forklift was defined as the contiguous 5-minute segment of data that most closely represented the speed and throttle populations depicted from the entire forklift data collection. The chi-square statistic was computed for each 5-minute moving window data segment. The segment with the smallest χ^2 statistic identified the 5-minute segment that contained the speed and throttle data points most similar to the overall forklift data population. The following steps were used to rank data segments for developing typical cycles from gathered in-use data:

1) Define "bins" sized at 200 rpm for speed. Throttle bins varied because of the skewness of the throttle values. Bin intervals for throttle ranged from 2-30%. The same interval bins for speed and throttle were used for both forklift trucks. Intervals were not uniformly spaced.
2) Sort entire data file (34,898 observations for Truck 16, and 66,781 observations for Truck 29) into speed and throttle bins.
3) Compute a frequency table to indicate the number of observations contained in each bin.
4) Define data segments starting at every 1-minute time interval. Data segment length is 5 minutes.
5) Sort each 5-minute data segment into similar speed and throttle bins.
6) Compute a chi-square statistic[a] to compare the frequency distribution of each sample window against the population frequency distribution for each individual forklift.
7) Repeat steps 4-6 for all 216 5-minute data segments for Truck 29, and all 111 5-minute data segments for Truck 16.
8) Sort the chi-square statistics in increasing time order, and by increasing chi-square rank.

---

[a] The chi-square test statistic is:

$$\Sigma(O_i - E_i)^2 / E_i$$

where O_i is the observed frequency in the ith interval of the 5-minute sample window, and E_i is the expected frequency of the ith interval based on the frequency distribution of the entire time of operation (population).

Table 9 lists all the identified typical cycle segments for the two forklift trucks. The selections used are shaded. For Truck 16, the segment with the best chi-square statistic had too much idle operation to be considered valid.

TABLE 9. TYPICAL CYCLE DATA SEGMENTS FOR THE TWO FORKLIFT TRUCKS

Truck	Observation Index	Time (sec)	Chi-Square Statistic
16	20701	4140	341.9
16	**20401**	**4080**	**360.5**
16	20101	4020	368.5
16	19801	3960	370.3
16	9001	1800	393.5
29	**9901**	**1980**	**297.6**
29	9601	1920	298.7
29	36001	7200	338.4
29	9001	1800	346.2

B. Defining Highly Transient Delta Speed and Delta Throttle Data Segments

High transient operation was defined as in-use forklift operations having the largest change in power based on either speed or throttle changes. Development of high transient cycles for speed and throttle required a method for assessing the extent of transient speed and throttle within each 5-minute contiguous data segment. Incremental delta speed and delta throttle values were computed and summed to discriminate between data segments for defining the most highly transient 5-minute data segments. For developing the high-transient cycles, the data segments having the largest summed value for the delta speed and delta throttle were selected for use in developing the high transient speed and high transient throttle cycles. The following steps were used to rank data segments for developing high transient cycles from gathered in-use data:

1) Compute delta speed and delta throttle values for each ith observation as:

   Delta Speed = ABS(Speed(i+1) - Speed(i)) where i=observation number

   Delta Throttle = ABS (Throttle(i+1) - Throttle(i)) where i=observation number

2) Data were sampled at every 1-minute interval starting at time=0. The data segment length was 5 minutes.

3) Represent each 5-minute data segment by the following two values: (1) sum of the delta speed values, and (2) sum of the delta throttle values.

4) Summarize data by (1) increasing time order, (2) decreasing order of

assumed delta speed at values, and (3) decreasing order of assumed delta throttle at values.

Tables 10 and 11 list all the high delta speed and high delta throttle data segments for the two forklift trucks, respectively. The used selections are shaded.

TABLE 10. HIGH DELTA SPEED DATA SEGMENTS FOR THE TWO FORKLIFT TRUCKS

Truck	Observation Index	Time (sec)	Sum Delta Speed
16	**4501**	**900**	**76778.2**
16	3901	780	76775.2
16	4201	840	76472.6
29	**18301**	**3660**	**103210**
29	22801	4560	102530
29	23101	4620	99300

TABLE 11. HIGH DELTA THROTTLE DATA SEGMENTS FOR THE TWO FORKLIFT TRUCKS

Truck	Observation Index	Time (sec)	Sum Delta Throttle
16	**4501**	**900**	**3514.9**
16	4201	840	3480.9
16	5101	1020	3374.2
29	**18301**	**3660**	**3815.5**
29	23801	4620	3655.1
29	22801	4560	3536.3

The details of the operation of the two trucks during the selected time segments are presented in Figures 26 through 29.

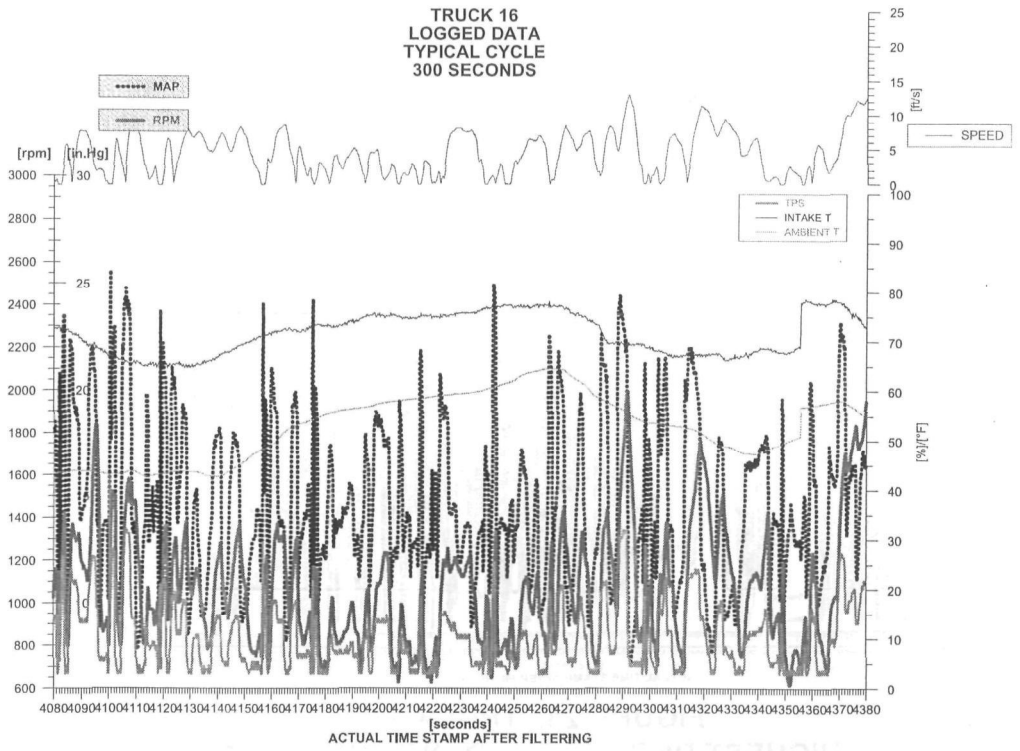

FIGURE 26. TRUCK 16, TYPICAL CYCLE

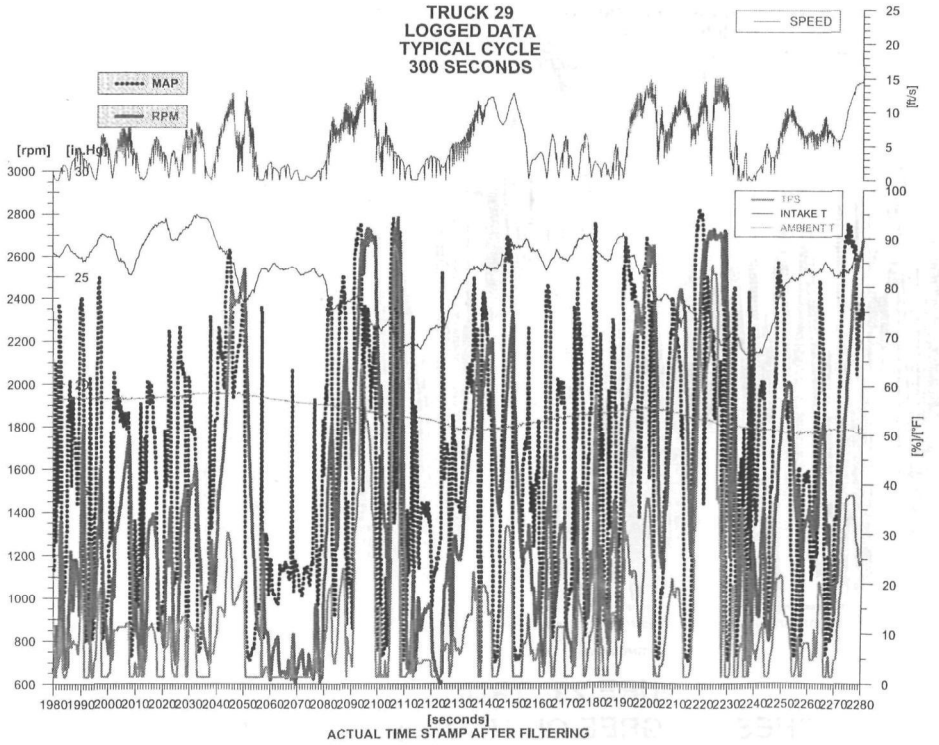

FIGURE 27. TRUCK 29, TYPICAL CYCLE

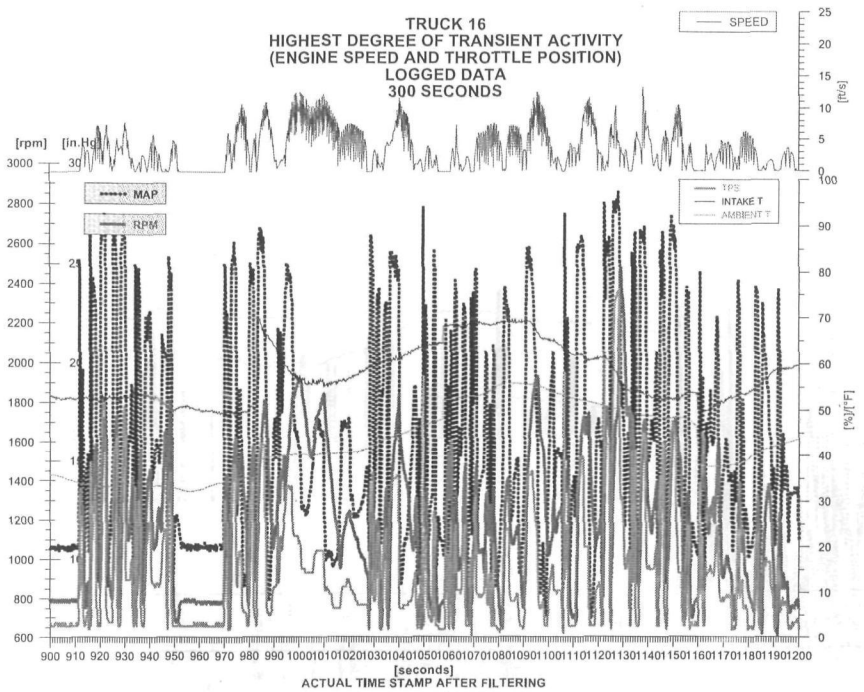

FIGURE 28. TRUCK 16,
HIGHEST DEGREE OF TRANSIENT CYCLE

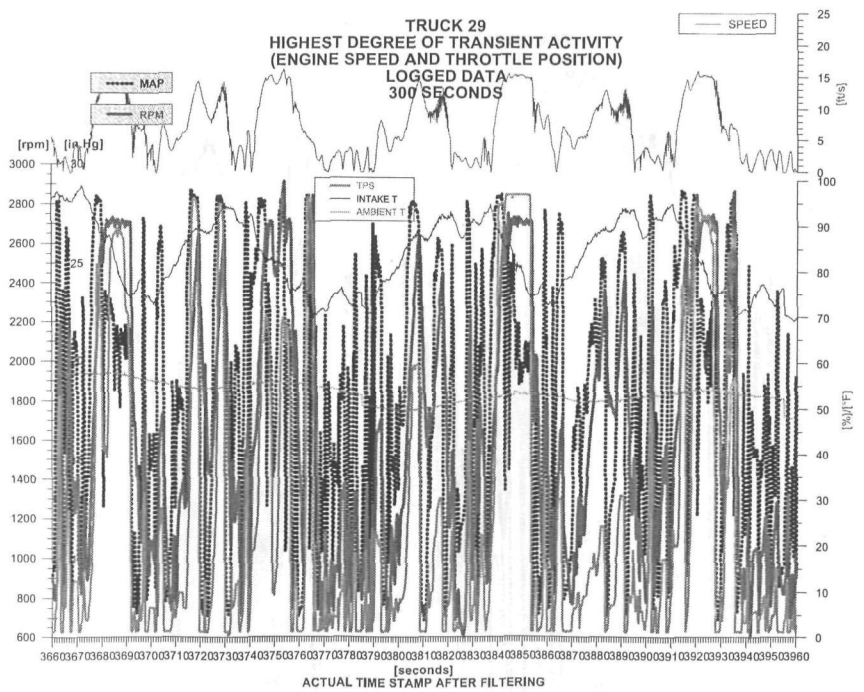

FIGURE 29. TRUCK 29,
HIGHEST DEGREE OF TRANSIENT CYCLE

C. Torque Measurements

Since torque information could not be obtained directly in the field, it was necessary to create a torque signal in the laboratory based on available data. Initially, it was thought that torque information could be developed from a correlation of in-field throttle position, engine speed, and manifold absolute pressure data with a map of steady-state engine operation. After further consideration, a more direct approach was formulated where the engine was commanded in the test cell so as to duplicate the field operating data. This required development of new control algorithms.

The engines were installed sequentially in Cell 2, where all the transient test work for this project was conducted. They were both brought to the "as found" configuration, with the old oxygen sensor, catalyst, calibration, and fuel adjustments. A lug curve was generated. The results from three runs for each of the two five-minute segments were averaged. A very good duplication of the field operation was achieved for the two, five-minute segments on both engines as shown in Figures 30 and 31. The measured average torque and speed traces for both engines were normalized using the corresponding "as found" engine maps (lug curves) following the FTP procedure.

D. New Cycle Construction

The new cycle was generated using the normalized segments in this order:

Truck 29	- 5	minutes "most typical" operation
	- 2.5	minutes "highest level of transients" operation
Truck 16	- 2.5	minutes "highest level of transients" operation
	- 5	minutes "most typical" operation
Welder cycle	- 5	minutes

The five-minute segment of the welder cycle used was identified by the EPA Project Manager. Figure 32 shows the new cycle.

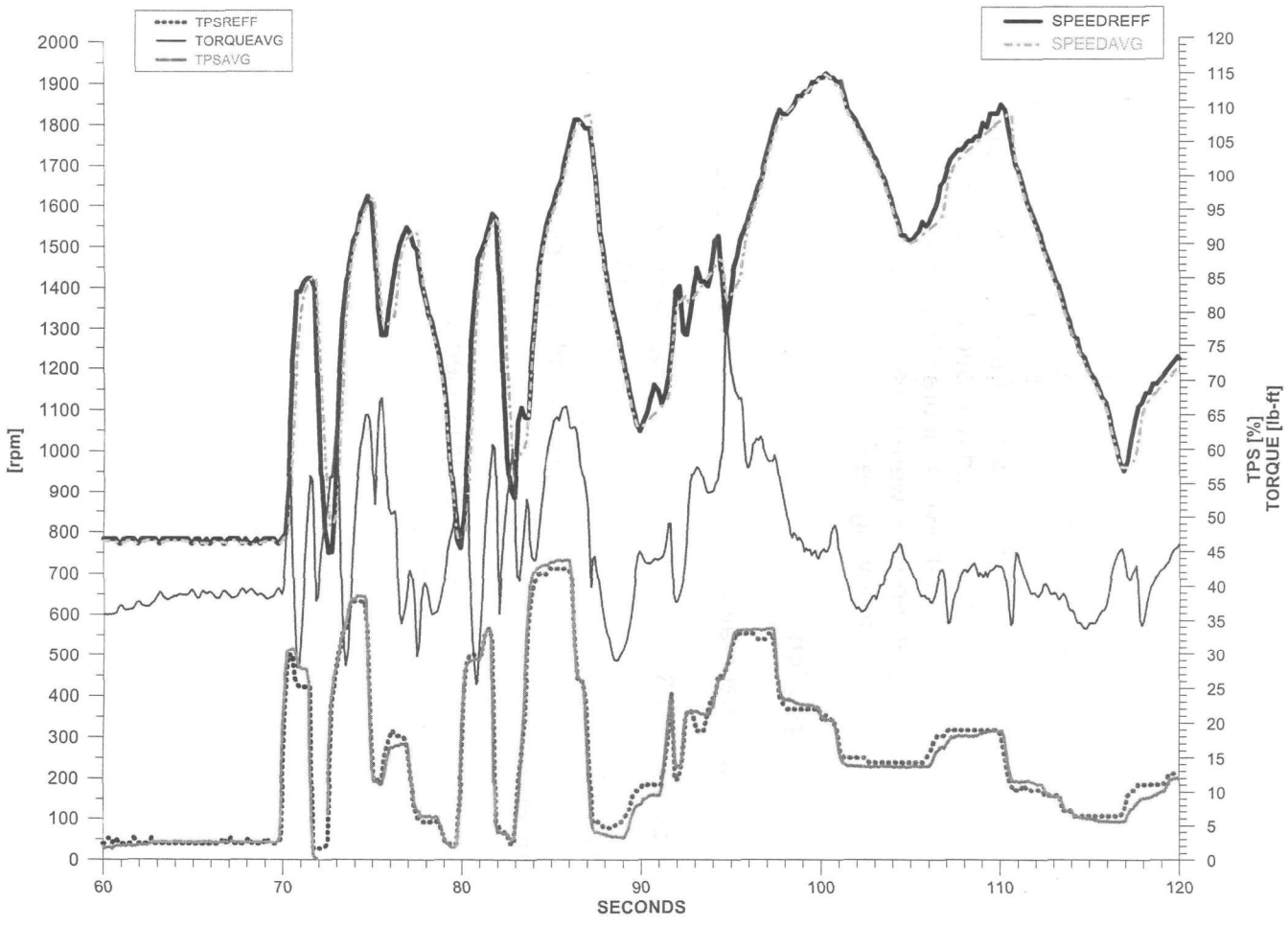

FIGURE 30. TRUCK 16, MAZDA ENGINE - SAMPLE OF TEST CELL DUPLICATION OF THE "HIGHEST DEGREE OF TRANSIENT OPERATION" SEGMENT, THREE-RUN-AVERAGE

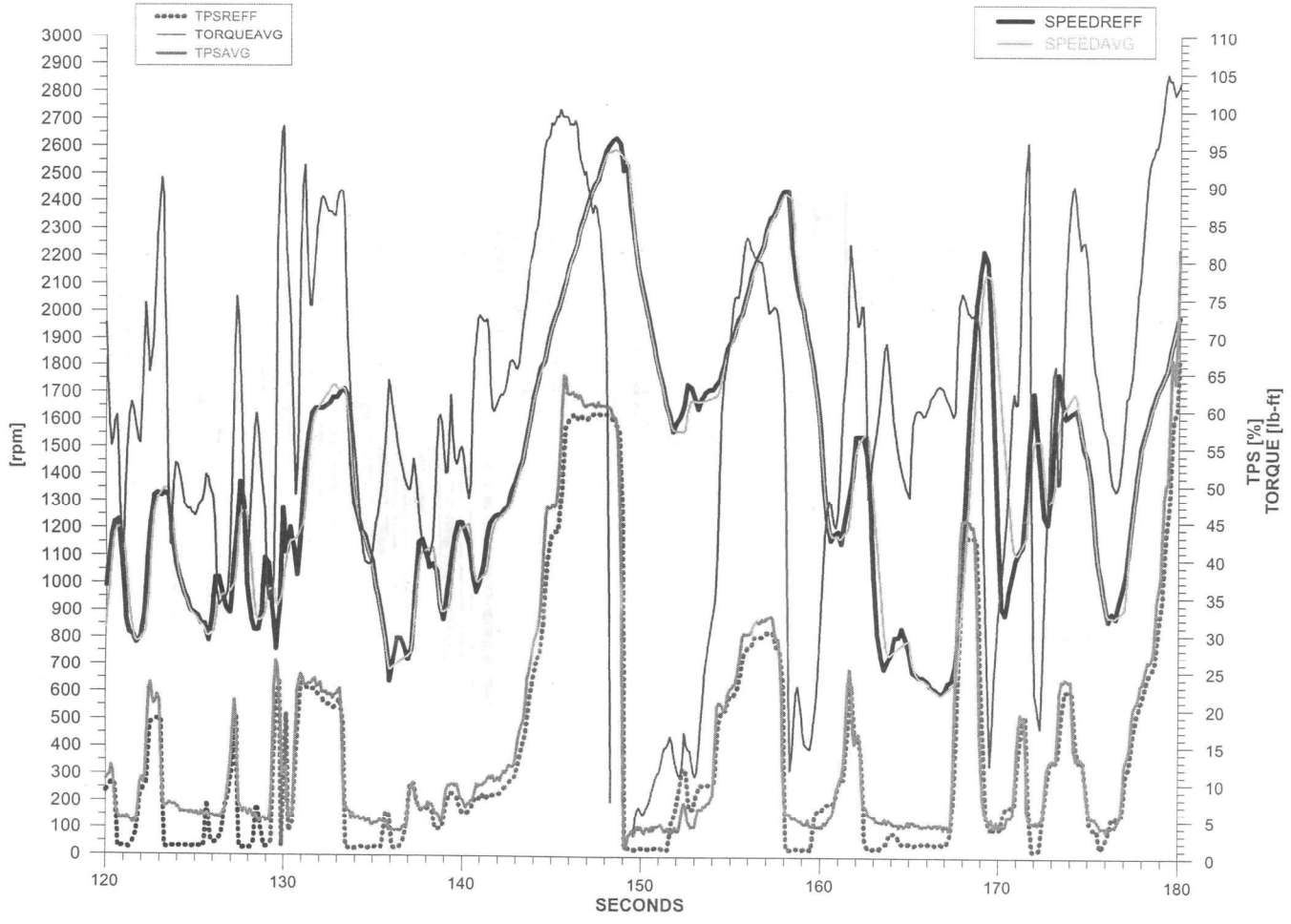

FIGURE 31. TRUCK 29, GM ENGINE - SAMPLE OF TEST CELL DUPLICATION OF THE "HIGHEST DEGREE OF TRANSIENT OPERATION" SEGMENT, THREE-RUN-AVERAGE

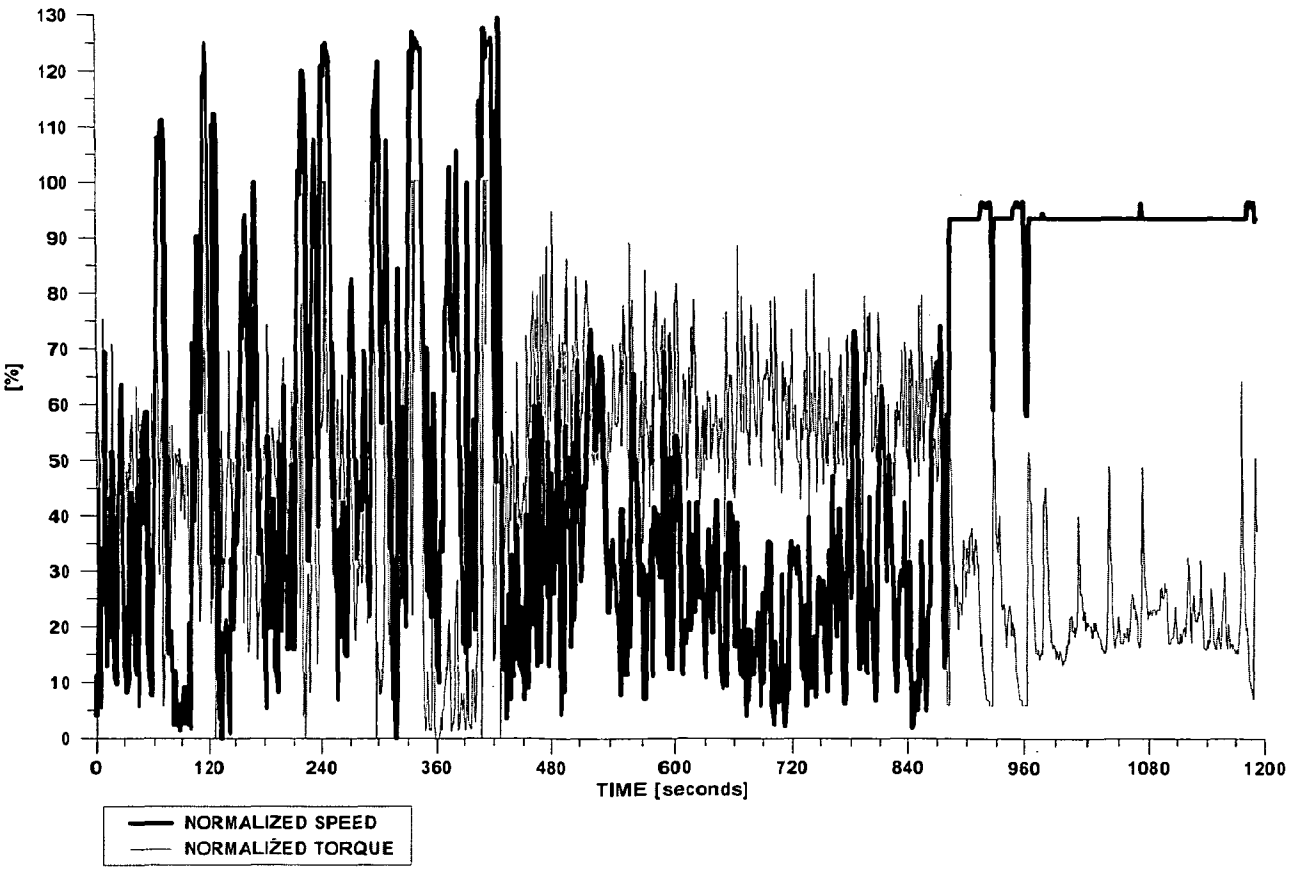

FIGURE 32. NEW COMPOSITE CYCLE

V. TRANSIENT TEST EMISSION RESULTS

Tables 12 and 14 contain all the transient test emission results for both engines in chronological order. Tables 13 and 15 contain a summary of the results with averages for repeated runs calculated where applicable. For each run, the following details are listed:

- Test number
- Run number for data logged with LabVIEW platform 1 (LV1)
- Run number for data logged with LabVIEW platform 2 (LV2)
- Cycle type
- Cycle duration
- Soak time duration
- Hardware configuration (old catalyst, new catalyst, etc.)
- Calibration identifier
- Brake-specific emissions

During the first part of the transient work targeted mainly at torque measurements, emission performance was also recorded. Subsequently, the short five-minute test runs were also used for the "best NO_x" calibration optimization, idle fuel mixture adjustment strategy, and old catalyst and old sensor versus new catalyst and new sensor emission performance comparison. Emission results in Table 12 for the Mazda engine over the "most typical" and the "highest degree of transients" cycles show that, at least for these short cycles, NO_x emissions can be reduced by a minimum of 50% by carefully controlling idle fuel mixture at stoichiometry. In the "as found" configuration, the Mazda engine generated higher CO and NO_x emissions on the highly transient cycle segment. The reverse was observed in the "best calibration" test, where higher emissions were observed with the "typical" cycle segment. The GM engine had the exact opposite trend.

TABLE 12. TRUCK 16, MAZDA ENGINE - ALL TRANSIENT TEST EMISSIONS RESULTS

TEST	RUN #	RUN #	CYCLE	DUR. [min]	SOAK [min]	CONFIG.	CAL.	BSHC [g/hp-hr]	BSCO [g/hp-hr]	BSNO$_x$ [g/hp-hr]	BSCO$_2$ [g/hp-hr]	BSFC [lb/hp-hr]	CH$_4$ [g/hp-hr]	NMHC [g/hp-hr]	COMMENTS
MT_M1	609	MAP_1	MAP			AS FOUND	7644								
MT_T1	611	T1	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.96	1.49	6.44	744	0.55	0.00	0.96	PRACTICE RUNS
MT_T2	612	T2	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.76	0.74	5.41	739	0.55	0.00	0.76	PRACTICE RUNS
MT_T3	613	T3	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.83	1.15	5.99	739	0.55	0.00	0.83	PRACTICE RUNS
MT-T4	615	T4	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.83	0.14	11.17	737	0.55	0.00	0.83	PRACTICE RUNS
MT-T5	616	T5	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.65	1.55	4.88	735	0.54	0.00	0.65	PRACTICE RUNS
MT-T6	617	T6	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.66	0.60	6.27	721	0.53	0.00	0.66	PRACTICE RUNS
MT-D1	618	D1	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.58	1.63	5.72	721	0.53	0.00	0.58	PRACTICE RUNS
MT-D2	619	D2	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.46	2.34	5.00	724	0.54	0.00	0.46	PRACTICE RUNS
MT-D3	620		H. DELTA	0:05	0:05	OS/OC/AF	7644	0.67	0.00	10.92	738	0.55	0.00	0.67	PRACTICE RUNS
MT-TT1	623	TT1	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.66	0.97	4.90	710	0.53	0.00	0.66	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT-TT2	624	TT2	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.78	1.27	5.52	727	0.54	0.00	0.79	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT-TT3	625	TT3	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.61	1.03	5.01	716	0.53	0.00	0.61	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT-DD1	626	DD1	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.65	2.62	5.49	727	0.54	0.00	0.65	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT-DD2	627	DD2	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.72	0.64	9.32	716	0.53	0.00	0.72	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT-DD3	628	DD3	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.60	3.00	5.25	709	0.53	0.00	0.60	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT_M2	629	M_2	MAP			NS//F&M	7644								
MT-DD4	631	DD4	H. DELTA	0:05	0:05	NS/OC/F&M	7644	0.58	3.42	4.81	710	0.53	0.00	0.58	EMISSIONS PERFORMANCE
MT-TT4	632	TT4	TYPICAL	0:05	0:05	NS/OC/F&M	7644	0.64	1.23	5.84	720	0.53	0.00	0.64	EMISSIONS PERFORMANCE
MT_M3	633	M_3	MAP			NS//F&M	8644								
MT-TT5	635	TT5	TYPICAL	0:05	0:05	NS/OC/F&M	8644	0.57	2.84	3.08	721	0.54	0.00	0.57	EMISSIONS PERFORMANCE
MT-DD5	636	DD5	H. DELTA	0:05	0:05	NS/OC/F&M	8644	0.59	6.47	2.73	717	0.54	0.00	0.59	EMISSIONS PERFORMANCE
MT_M4	638	M_4	MAP			NS//F&M	8633								
MT-TT6	640	TT6	TYPICAL	0:05	0:05	NS/OC/F&M	8633	0.89	4.70	3.92	710	0.53	0.00	0.89	WITH LEAN IDLE
MT-TT7	641	TT7	TYPICAL	0:05	0:05	NS/OC/F&M	8633	0.60	5.69	1.40	711	0.53	0.00	0.60	WITH RICH IDLE
MT-DD6	642	DD6	H. DELTA	0:05	0:05	NS/OC/F&M	8633	0.76	0.07	9.38	741	0.55	0.00	0.76	WITH LEAN IDLE
MT-DD7	643	DD7	H. DELTA	0:05	0:05	NS/OC/F&M	8533	1.07	17.11	2.19	683	0.53	0.00	1.07	WITH RICH IDLE
MT-DD8	644	DD8	H. DELTA	0:05	0:05	NS/OC/F&M	8533	0.22	4.25	1.10	707	0.53	0.00	0.23	WITH RICH IDLE
MT_M5	930		MAP			NS//F&M	8633								
053100H1	955	H1	FTP	0:20	0:20	NS/OC	8633	0.77	13.07	1.02	703	0.53	0.13	0.64	WITH 20 MIN SOAK
053100H2	956	H2	FTP	0:20	0:20	NS/OC	8633	0.77	13.19	1.02	697	0.53	0.14	0.63	WITH 20 MIN SOAK
053100H3	957	H3	FTP	0:20	0:05	NS/OC	8643	0.34	4.61	0.88	711	0.53	0.11	0.23	BEST CAL & NO SOAK
053100H4	958	H4	FTP	0:20	0:20	NS/OC	8643	0.76	11.96	1.13	702	0.53	0.12	0.64	BEST CAL 'WITH 20 MIN SOAK
053100H5	959	H5	BHL-CT	0:20	0:20	NS/OC	8643	0.37	9.12	0.95	699	0.53	0.10	0.27	BEST CAL 'WITH 20 MIN SOAK
053100H6	960	H6	BHL-CT	0:20	0:20	NS/NC	8643	0.30	4.63	0.78	687	0.51	0.00	0.30	BEST CAL 'WITH 20 MIN SOAK
053100H7	961	H7	FTP	0:20	0:20	NS/NC	8643	0.38	3.10	2.39	705	0.52	0.00	0.38	BEST CAL 'WITH 20 MIN SOAK
MAP 1	148	975	MAP			NS/OC	8643								
HOT-NEW-1	151	977	NEW	0:20	0:03	NS/OC	8643	0.66	7.50	0.14	774	0.58	0.15	0.52	PRACTICE RUN W/SPEED GOVERNOR
HOT-NEW2	152	977	NEW	0:20	0:05	NS/OC	8643	0.58	6.66	0.15	761	0.57	0.13	0.45	PRACTICE RUN W/O SPEED GOVERNOR
HOT-NEW3	153	977	NEW	0:20	0:05	NS/OC	8643	0.61	6.97	0.19	765	0.57	0.15	0.46	PRACTICE RUN W/O SPEED GOVERNOR
HOT-NEW4	155	978	NEW	0:20	0:48	NS/OC	8643	0.69	8.51	0.39	786	0.59	0.12	0.57	NO<0 TORQUE PRACTICE RUN W/O SPEED
HOT-NEW5	156	978	NEW	0:20	0:10	NS/OC	8643	0.66	8.45	0.24	782	0.59	0.14	0.52	PRACTICE RUN W/O SPEED GOVERNOR
HOT-NEW6	157	978	NEW	0:20	0:07	NS/OC	8643	0.60	7.61	0.35	732	0.55	0.12	0.48	PRACTICE RUN W/O SPEED GOVERNOR
HOT-NEW-7	159	n.a.	NEW	0:20	0:09	NS/OC	8643	0.68	8.09	0.22	784	0.59	0.13	0.55	PRACTICE RUN W/O SPEED GOVERNOR
HOT-NEW8	173	n.a.	NEW	0:20	0:28	NS/OC	8643	0.72	10.65	0.75	786	0.59	0.00	0.72	BEST STATS\EMISSIONS PERFORMANCE
HOT-NEW9	220	979	NEW	0:20	0:07	NS/OC	8643	0.65	9.66	0.51	822	0.62	0.00	0.65	BEST STATS\EMISSIONS PERFORMANCE
HOT-NEW10	233	979	NEW	0:20	0:12	NS/OC	8643	0.67	9.92	0.52	813	0.61	0.00	0.67	
HOT-NEW11	234	979	NEW	0:20	0:07	NS/OC	8643	0.54	9.85	0.55	863	0.65	0.00	0.54	BEST STATS\EMISSIONS PERFORMANCE
HOT-NEW12	235	979	NEW	0:20	0:08	NS/OC	8643	0.63	12.67	0.72	832	0.63	0.00	0.63	10% BUTANE, 90% PROPANE
HOT-NEW13	237	979	NEW	0:20	0:08	NS/OC	8643	0.68	13.16	0.81	828	0.63	0.00	0.68	10% BUTANE, 90% PROPANE
HOT-NEW14	239	979	NEW	0:20	0:05	NS/OC	8643	0.57	11.68	0.70	828	0.62	0.00	0.57	10% BUTANE, 90% PROPANE
WELDER-1	241	980	WELDER	0:20	0:05	NS/OC	8643	0.76	8.53	1.00	1142	0.85	0.00	0.76	
WELDER-2	242	980	WELDER	0:20	0:01	NS/OC	8643	0.55	8.85	0.85	1084	0.81	0.00	0.55	
WELDER-3	243	980	WELDER	0:20	0:04	NS/OC	8643	0.51	7.76	0.70	1110	0.83	0.00	0.51	

TABLE 13. TRUCK 16, MAZDA ENGINE - SUMMARY OF TRANSIENT TEST EMISSIONS RESULTS

TEST NUMBER	CYCLE	DUR. [min]	SOAK [min]	CONFIG.	CAL.	BSHC [g/hp-hr]	BSCO [g/hp-hr]	BSNO$_x$ [g/hp-hr]	BSCO$_2$ [g/hp-hr]	BSFC [lb/hp-hr]	CH$_4$ [g/hp-hr]	NMHC [g/hp-hr]	COMMENTS
MT_M1	MAP			AS FOUND	7644								
AVERAGE OF 6 RUNS	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.78	0.94	6.69	736	0.54	0.00	0.78	PRACTICE RUNS
AVERAGE OF 3 RUNS	TYPICAL	0:05	0:05	OS/OC/AF	7644	0.69	1.09	5.14	718	0.53	0.00	0.69	CYCLE DEVELOPMENT RUNS (AS FOUND)
AVERAGE OF 3 RUNS	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.57	1.33	7.21	728	0.54	0.00	0.57	PRACTICE RUNS
AVERAGE OF 3 RUNS	H. DELTA	0:05	0:05	OS/OC/AF	7644	0.66	2.09	6.69	717	0.53	0.00	0.66	CYCLE DEVELOPMENT RUNS (AS FOUND)
MT_M2	MAP			NS//F&M	7644								
MT-DD4	H. DELTA	0:05	0:05	NS/OC/F&M	7644	0.58	3.42	4.81	710	0.53	0.00	0.58	EMISSIONS PERFORMANCE
MT-TT4	TYPICAL	0:05	0:05	NS/OC/F&M	7644	0.64	1.23	5.84	720	0.53	0.00	0.64	EMISSIONS PERFORMANCE
MT_M3	MAP			NS//F&M	8644								
MT-TT5	TYPICAL	0:05	0:05	NS/OC/F&M	8644	0.57	2.84	3.08	721	0.54	0.00	0.57	EMISSIONS PERFORMANCE
MT-DD5	H. DELTA	0:05	0:05	NS/OC/F&M	8644	0.59	6.47	2.73	717	0.54	0.00	0.59	EMISSIONS PERFORMANCE
MT_M4	MAP			NS//F&M	8633								
MT-TT6	TYPICAL	0:05	0:05	NS/OC/F&M	8633	0.89	4.70	3.92	710	0.53	0.00	0.89	EMISSIONS PERFORMANCE W/ LEAN IDLE
MT-TT7	TYPICAL	0:05	0:05	NS/OC/F&M	8633	0.60	5.69	1.40	711	0.53	0.00	0.60	EMISSIONS PERFORMANCE W/ RICH IDLE
MT-DD6	H. DELTA	0:05	0:05	NS/OC/F&M	8633	0.76	0.07	9.38	741	0.55	0.00	0.76	EMISSIONS PERFORMANCE W/ LEAN IDLE
MT-DD7	H. DELTA	0:05	0:05	NS/OC/F&M	8533	1.07	17.11	2.19	683	0.53	0.00	1.07	EMISSIONS PERFORMANCE W/ RICH IDLE
MT-DD8	H. DELTA	0:05	0:05	NS/OC/F&M	8533	0.22	4.25	1.10	707	0.53	0.00	0.23	EMISSIONS PERFORMANCE W/ RICH IDLE
MT_M5	MAP			NS//F&M	8633								
AVERAGE OF 2 RUNS	FTP	0:20	0:20	NS/OC	8633	0.77	13.13	1.02	700	0.53	0.14	0.63	WITH 20 MIN SOAK
053100H3	FTP	0:20	0:05	NS/OC	8643	0.34	4.61	0.88	711	0.53	0.11	0.23	BEST CAL & NO SOAK
053100H4	FTP	0:20	0:20	NS/OC	8643	0.76	11.96	1.13	702	0.53	0.12	0.64	BEST CAL 'WITH 20 MIN SOAK
053100H5	BHL-CT	0:20	0:20	NS/OC	8643	0.37	9.12	0.95	699	0.53	0.10	0.27	BEST CAL 'WITH 16 MIN SOAK
053100H6	BHL-CT	0:20	0:20	NS/NC	8643	0.30	4.63	0.78	687	0.51	0.00	0.30	BEST CAL 'WITH 16 MIN SOAK
053100H7	FTP	0:20	0:20	NS/NC	8643	0.38	3.10	2.39	705	0.52	0.00	0.38	BEST CAL 'WITH 20 MIN SOAK
MAP 1	MAP			NS/OC	8643								
HOT-NEW8	NEW	0:20	0:10	NS/OC	8643	0.72	10.65	0.75	786	0.59	0.00	0.72	BEST STATS\EMISSIONS PERFORMANCE RUN
HOT-NEW9	NEW	0:20	0:07	NS/OC	8643	0.65	9.66	0.51	822	0.62	0.00	0.65	BEST STATS\EMISSIONS PERFORMANCE RUN
HOT-NEW11	NEW	0:20	0:07	NS/OC	8643	0.54	9.85	0.55	863	0.65	0.00	0.54	BEST STATS\EMISSIONS PERFORMANCE RUN
AVERAGE OF 3 RUNS	NEW	0:20	0:08	NS/OC	8643	0.63	12.51	0.74	829	0.63	0.00	0.63	10% BUTANE, 90% PROPANE
AVERAGE OF 3 RUNS	WELDER	0:20	0:05	NS/OC	8643	0.61	8.38	0.85	1112	0.83	0.00	0.61	WELDER

TABLE 14. TRUCK 29, GM ENGINE - ALL TRANSIENT TEST EMISSIONS RESULTS

TEST NUMBER	RUN LV1 #	RUN LV2 #	CYCLE	DUR. [min]	SOAK [min]	CONFIG.	CAL.	BSHC [g/hp-hr]	BSCO [g/hp-hr]	BSNO$_x$ [g/hp-hr]	BSCO$_2$ [g/hp-hr]	BSFC [lb/hp-hr]	CH$_4$ [g/hp-hr]	NMHC [g/hp-hr]	COMMENTS
MAP 2	96	n.a.	MAP			OS/OC	6543								AS FOUND
HOT-1T	99	966	TYPICAL	0:05	0:05	OS/OC	6543	0.35	6.27	3.92	568	0.43	0.05	0.29	AS FOUND
HOT-3T	101	966	TYPICAL	0:05	0:05	OS/OC	6543	0.39	4.74	4.23	764	0.57	0.12	0.27	AS FOUND
HOT-3TA	102	966	TYPICAL	0:05	0:05	OS/OC	6543	0.33	3.10	4.23	763	0.57	0.09	0.24	AS FOUND
HOT-1H	103	966	H.DELTA	0:05	0:05	OS/OC	6543	0.54	4.99	4.98	751	0.56	0.13	0.41	AS FOUND
HOT-2H	104	966	H.DELTA	0:05	0:05	OS/OC	6543	0.58	5.86	4.83	746	0.56	0.00	0.58	AS FOUND
HOT-3H	105	966	H.DELTA	0:05	0:05	OS/OC	6543	0.52	4.36	4.76	738	0.55	0.13	0.39	AS FOUND
HOT-4T	106	967	TYPICAL	0:05	0:05	OS/OC	8643	0.59	9.52	0.75	848	0.64	0.20	0.39	BEST CAL/OLD CAT/OLD SENSOR
HOT-5T	107	967	TYPICAL	0:05	0:05	OS/OC	8643	0.59	8.99	0.75	810	0.61	0.18	0.42	BEST CAL/OLD CAT/OLD SENSOR
HOT-4H	108	967	H.DELTA	0:05	0:05	OS/OC	8643	0.78	12.62	1.25	816	0.62	0.20	0.58	BEST CAL/OLD CAT/OLD SENSOR
HOT-5H	109	967	H.DELTA	0:05	0:05	OS/OC	8643	0.85	13.25	1.30	817	0.62	0.22	0.63	BEST CAL/OLD CAT/OLD SENSOR
MAP 3	113	968	MAP			NS/NC	8643								
HOT-6T	115	969	TYPICAL	0:05	0:05	NS/NC	8643	0.29	3.43	0.07	835	0.62	0.11	0.18	BEST CAL/NEW CAT/NEW SENSOR
HOT-7T	116	969	TYPICAL	0:05	0:05	NS/NC	8643	0.31	2.67	0.07	824	0.61	0.10	0.20	BEST CAL/NEW CAT/NEW SENSOR
HOT-6H	117	969	H.DELTA	0:05	0:05	NS/NC	8643	0.32	3.33	0.28	817	0.61	0.10	0.22	BEST CAL/NEW CAT/NEW SENSOR
HOT-7H	118	969	H.DELTA	0:05	0:05	NS/NC	8643	0.45	3.72	0.15	813	0.60	0.13	0.32	BEST CAL/NEW CAT/NEW SENSOR
MAP 1	964	n.a.	MAP			NS/NC	7643								
GM_FTP_1_2211	995	958	FTP	0:20	0:20	NS/NC	7643	0.30	1.32	1.49	665	0.49	0.06	0.25	20 MIN SOAK/NEW CAT/NEW
GM_FTP_2_3211	996	958	FTP	0:20	0:20	NS/NC	8643	0.32	2.72	0.79	700	0.52	0.06	0.26	20 MIN SOAK/NEW CAT/NEW
GM_FTP_3_3211	998	959	FTP	0:20	0:20	NS/NC	8643	0.29	2.97	0.74	668	0.50	0.06	0.22	20 MIN SOAK/NEW CAT/NEW
GM_FTP_4_3211	1	959	FTP	0:20	0:03	NS/NC	8643	0.15	1.02	0.73	668	0.49	0.06	0.10	3 MIN WARM-UP/2-3 MIN SOAK
GM_FTP_5_3211	2	959	FTP	0:20	0:02	NS/NC	8643	0.14	0.92	0.88	666	0.49	0.05	0.09	2 MIN SOAK
BHL_2	35	963	BHL	0:16	0:20	NS/OC	8643	0.41	5.91	0.83	694	0.52	0.10	0.31	20 MIN SOAK/OLD CAT/NEW SENSOR
BHL_3	36	963	BHL	0:16	0:20	NS/OC	8643	0.44	6.71	0.91	683	0.51	0.11	0.32	20 MIN SOAK/OLD CAT/NEW SENSOR
BHL_4	37	963	BHL	0:16	0:02	NS/OC	8643	0.27	4.14	0.68	691	0.51	0.10	0.17	3 MIN WARM-UP/2 MIN SOAK
BHL_5	38	963	BHL	0:16	0:04	NS/OC	8643	0.30	3.82	0.66	688	0.51	0.10	0.21	4 MIN SOAK
GM_FTP_6_3211	40	964	FTP	0:20	0:03	NS/OC	8643	0.28	5.33	0.89	627	0.47	0.09	0.19	3 MIN WARM-UP/2 MIN SOAK
GM_FTP_7_3211	41	964	FTP	0:20	0:03	NS/OC	8643	0.27	4.42	0.87	616	0.46	0.09	0.18	3 MIN SOAK
HOT-NEW1	135	972	NEW	0:20	0:05	NS/OC	8643	0.36	7.68	0.92	867	0.65	0.12	0.24	5 MIN SOAK/OLD CAT/NEW SENSOR
HOT-NEW-2	137	972	NEW	0:20	0:05	NS/OC	8643	0.34	7.20	0.62	910	0.68	0.13	0.20	5 MIN SOAK/OLD CAT/NEW SENSOR
HOT-NEW-3	144	972	NEW	0:20	0:05	NS/OC	8643	0.33	7.31	0.90	779	0.58	0.09	0.24	5 MIN SOAK/OLD CAT/NEW SENSOR
HOT-NEW-4	145	972	NEW	0:20	0:06	NS/OC	8643	0.29	5.89	0.86	776	0.58	0.09	0.19	5 MIN SOAK/OLD CAT/NEW SENSOR
HOT-NEW-5	146	972	NEW	0:20	0:05	NS/NC	8643	0.19	1.90	0.30	802	0.59	0.06	0.14	5 MIN SOAK/NEW CAT/NEW SENSOR
HOT-NEW-6	147	972	NEW	0:20	0:05	NS/NC	8643	0.19	1.80	0.27	799	0.59	0.06	0.14	5 MIN SOAK/NEW CAT/NEW SENSOR

TABLE 15. TRUCK 29, GM ENGINE - SUMMARY OF TRANSIENT TEST EMISSIONS RESULTS

TEST NUMBER	CYCLE	DUR. [min]	SOAK [min]	CONFIG.	CAL.	BSHC [g/hp-hr]	BSCO [g/hp-hr]	BSNO$_x$ [g/hp-hr]	BSCO$_2$ [g/hp-hr]	BSFC [lb/hp-hr]	CH$_4$ [g/hp-hr]	NMHC [g/hp-hr]	COMMENTS
MAP 2	MAP			OS/OC	6543								AS FOUND
AVERAGE 3 RUNS	TYPICAL	0:05	0:05	OS/OC	6543	0.36	4.70	4.13	699	0.52	0.09	0.27	AS FOUND (OLD CAT/OLD SENSOR)
AVERAGE 2 RUNS	TYPICAL	0:05	0:05	OS/OC	8643	0.59	9.25	0.75	829	0.62	0.19	0.40	BEST CAL/OLD CAT/OLD SENSOR
AVERAGE 2 RUNS	TYPICAL	0:05	0:05	NS/NC	8643	0.30	3.05	0.07	830	0.62	0.11	0.19	BEST CAL/NEW CAT/NEW SENSOR
AVERAGE 3 RUNS	H.DELTA	0:05	0:05	OS/OC	6543	0.55	5.07	4.86	745	0.56	0.09	0.46	AS FOUND (OLD CAT/OLD SENSOR)
AVERAGE 2 RUNS	H.DELTA	0:05	0:05	OS/OC	8643	0.82	12.93	1.28	816	0.62	0.21	0.60	BEST CAL/OLD CAT/OLD SENSOR
AVERAGE 2 RUNS	H.DELTA	0:05	0:05	NS/NC	8643	0.38	3.53	0.21	815	0.61	0.11	0.27	BEST CAL/NEW CAT/NEW SENSOR
MAP 1	MAP			NS/NC	7643								
GM_FTP_1_2211	FTP	0:20	0:20	NS/NC	7643	0.30	1.32	1.49	665	0.49	0.06	0.25	20 MIN SOAK/NEW CAT/NEW SENSOR
AVERAGE 2 RUNS	FTP	0:20	0:20	NS/NC	8643	0.30	2.84	0.76	684	0.51	0.06	0.24	20 MIN SOAK/NEW CAT/NEW SENSOR
AVERAGE 2 RUNS	FTP	0:20	0:03	NS/NC	8643	0.15	0.97	0.80	667	0.49	0.05	0.09	3 MIN WARM-UP/2-3 MIN SOAK
AVERAGE 2 RUNS	FTP	0:20	0:03	NS/OC	8643	0.27	4.88	0.88	622	0.46	0.09	0.19	3 MIN WARM-UP/2 MIN SOAK
AVERAGE 2 RUNS	BHL	0:16	0:20	NS/OC	8643	0.42	6.31	0.87	688	0.52	0.11	0.32	20 MIN SOAK/OLD CAT/NEW SENSOR
AVERAGE 2 RUNS	BHL	0:16	0:03	NS/OC	8643	0.29	3.98	0.67	689	0.51	0.10	0.19	3 MIN WARM-UP/2 MIN SOAK
AVERAGE 4 RUNS	NEW	0:20	0:05	NS/OC	8643	0.33	7.02	0.82	833	0.62	0.11	0.22	5 MIN SOAK/OLD CAT/NEW SENSOR
AVERAGE 2 RUNS	NEW	0:20	0:05	NS/NC	8643	0.19	1.85	0.29	801	0.59	0.06	0.14	5 MIN SOAK/NEW CAT/NEW SENSOR

A. Transient Cycles

Five significantly different transient cycles were used to test the emissions performance of the two engines. These cycles were:

- Heavy-duty on-highway Otto-cycle federal test procedure (FTP)
- Backhoe Loader cycle (BHL)
- Combined Backhoe Loader - Crawler Tractor (BHL-CT) cycle
- Welder cycle
- New cycle

The Backhoe Loader (BHL) cycle was run on the GM engine, and the Combined Backhoe Loader - Crawler Tractor (BHL-CT) cycle was run on the Mazda engine. The Backhoe Loader cycle (BHL) and the Combined Backhoe Loader - Crawler Tractor (BHL-CT) cycle were developed by SwRI under contract for the EPA from nonroad diesel equipment operating data. Normalized 1 Hz cycle command traces are presented in Figures 33 through 36. Due to the hysteresis in the engine governor's speed control and the resulting impact on torque output, most of the transient tests on both engines were run with the governor disabled. Cycle tuning efforts were limited to the level necessary to ensure the tests were valid representations of emissions performance.

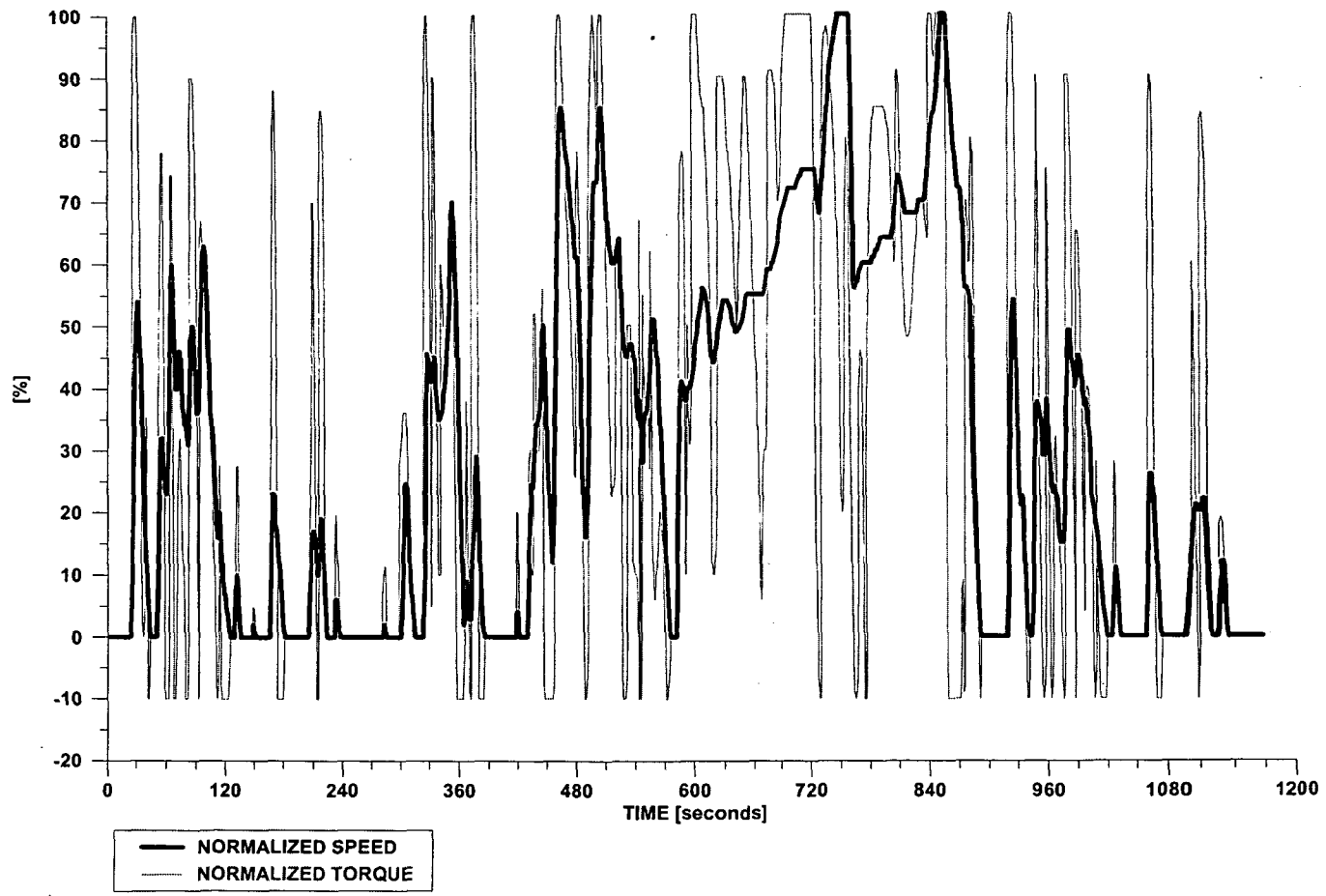

FIGURE 33. FTP CYCLE

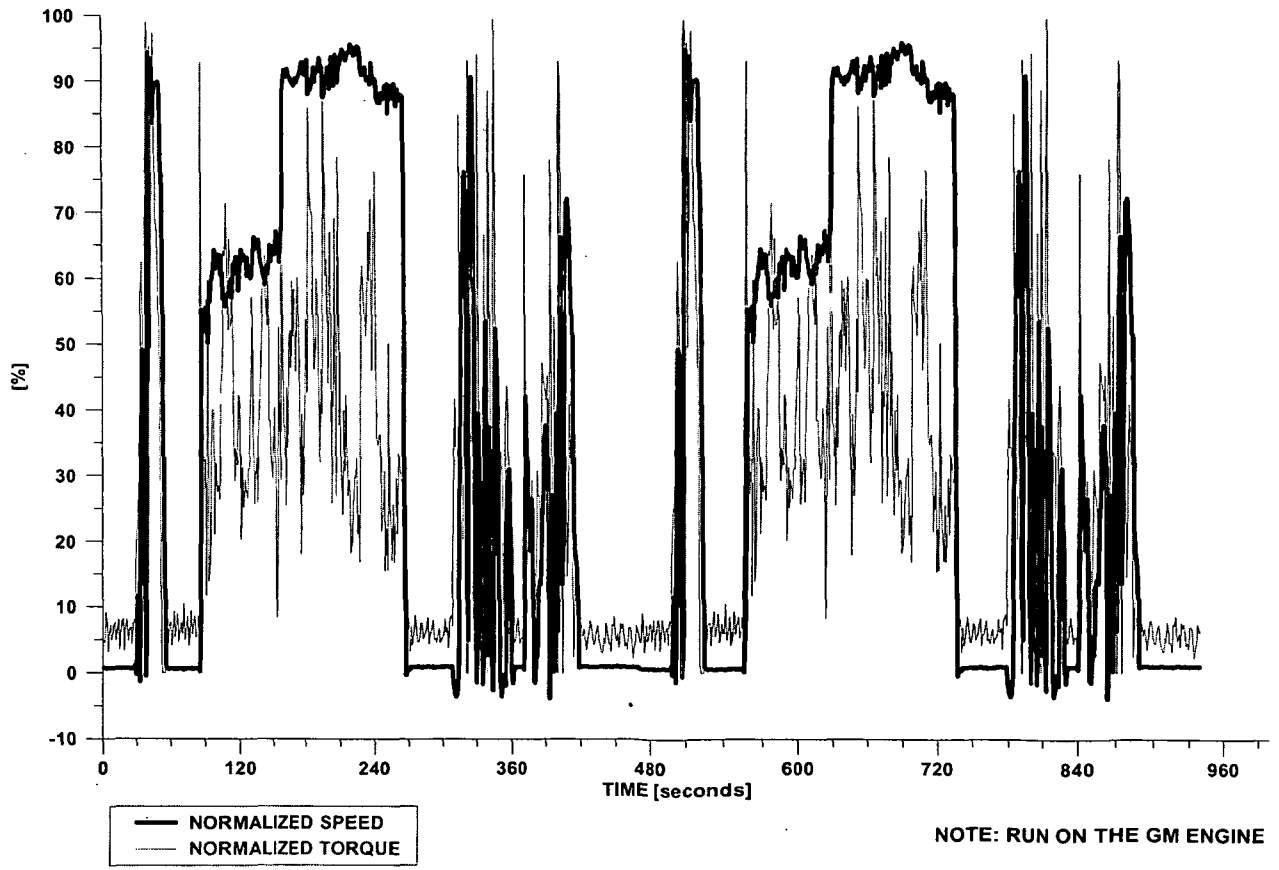

FIGURE 34. BACKHOE LOADER CYCLE (BHL)

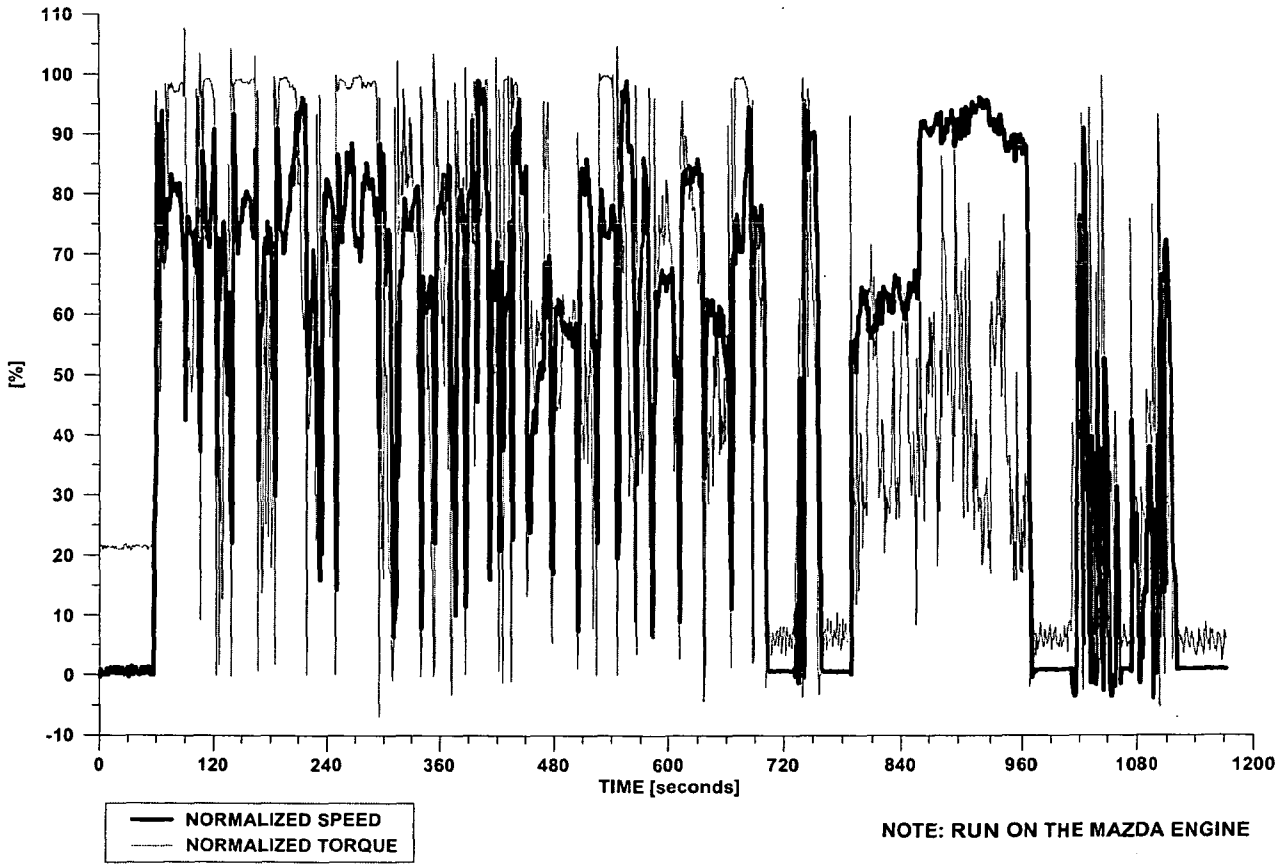

FIGURE 35. COMBINED BHL - CRAWLER TRACTOR CYCLE (BHL-CT)

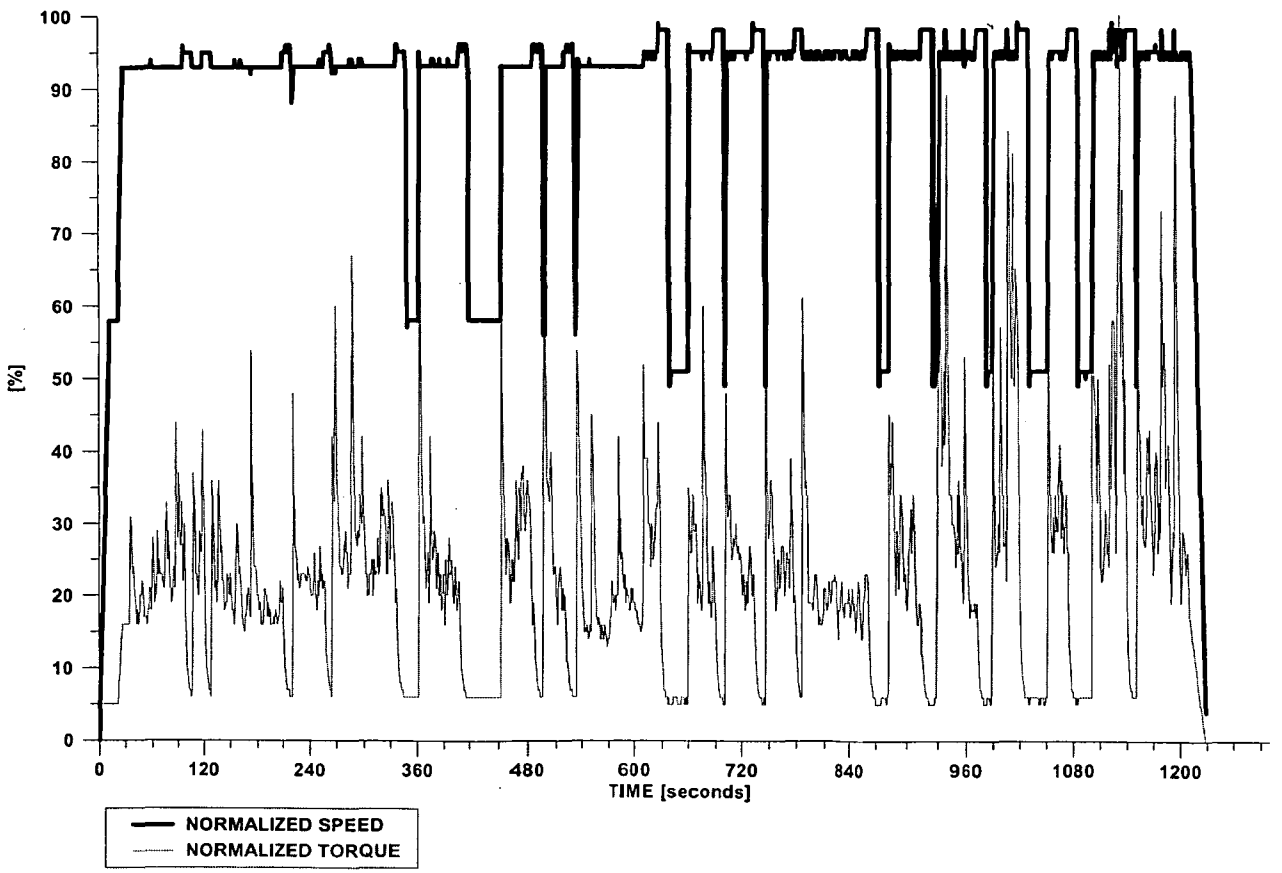

FIGURE 36. WELDER CYCLE

B. Brake Specific Emissions and Emission Concentrations Control Factors

Raw exhaust emission concentrations were measured during transient testing on both engines at 1 Hz. This information serves two purposes. First, it enables application-specific fine-tuning of the closed-loop calibration strategy, and second, it helps target the occurrences of maximum levels of critical pollutants. A large number of industrial LSI engines operate indoors, where OSHA regulations mandate maximum allowable ambient concentrations for both CO and NO_x at a 25 ppm level for 8 hours of exposure. Therefore from a work safety point of view, information on emission concentration is necessary for ventilation system sizing. For dedicated indoor applications, fuel control calibrations should target minimum levels for both NO_x and CO, rather than minimum NO_x only.

1. Soak Time

Soak time, which is defined as the period of time between the end of engine conditioning and the beginning of the actual transient emission test, can have a large effect on emission results. During the soak, the catalyst bed temperature decreases as a result of a natural cool down. The longer the soak time, the lower the catalyst bed temperature at the beginning of the emission test, and therefore the longer it will take the catalyst to reach light-off temperature. GM engine results presented in Figures 41 and 42 show emission effects of a 20 minute and a 3 minute soak time, respectively, ahead of the FTP cycle runs. A 50% reduction in light-off time from 30 seconds to 15 seconds leads to a 60% reduction in CO levels, from 2.72 g/hp-hr to 1.02 g/hp-hr, and a 50% reduction in HC. A similar trend was observed in the backhoe loader cycle runs, as shown in Figures 46 and 47. However, with this cycle, the reduction in before light-off emissions yields a proportionally smaller impact on total brake specific emissions. Both CO and HC were reduced approximately 30%. For all five transient cycles, light-off temperatures were always reached in less than two minutes from the beginning of the cycle, independent of the length of the soak time, as shown Figures 37 through 51.

2. Calibration

The term "best calibration" used throughout this report refers specifically to a maximum NO_x reduction goal. The same calibration strategy was used on both engines, for both steady-state and transient tests. Reported performance levels are therefore not representative of an optimization effort that would take into consideration the CO versus NO_x trade-off, necessary for indoor applications. In this context, it is conceivable that the CO tailpipe concentrations could be further reduced. The very high before catalyst light-off emissions recorded in Figures 37, 39, 44 and 45 for the Mazda engine could be reduced by further leaning of the idle mixture. Further improvement could also be obtained by fine tuning the calibration to the specific application. A welder or pump calibration should be different from that of a forklift truck, which in turn could have two different calibrations for indoor or outdoor use.

3. Closed-Loop Fuel Controller

Both engines had the same model of closed-loop fuel control system installed. This five to six year old, first generation digital closed-loop fuel controller uses engine speed for its internal clock frequency. Therefore, its reaction time increases with a decrease in engine speed. This leads to increased A/F amplitude variation around the stoichiometric control point at low engine speeds. For steady state operation at low engine speeds, the impact on emissions is minimal, but still noticeable as presented in Figures 22 and 23. The new transient cycle is characterized by a high frequency of fast throttle opening and closing at low engine speeds. The high CO peaks presented in Figures 48 through 51, show the cumulative effect of +/- 0.8 A/F ratio fluctuations coupled with the strong rich bias of the calibration. Nevertheless, a cycle-specific, and therefore application-specific optimization of the calibration could have significantly improved performance. Also, second generation controllers with an internal, engine speed-independent clock frequency, could further reduce emissions levels through more precise air-fuel ratio control.

4. Catalytic Converter

The two engines were fitted with catalyst sizes that yielded comparable exhaust gas space velocities. However, the loss of retention of one of the substrates in the original GM engine catalytic converter muffler led to an 18% reduction in total catalyst volume. The combined effects of the volume reduction and aging allow a clear definition of the deterioration trend for the original system installed on this engine. FTP cycle results presented in Figures 42 and 43 show a threefold increase of peak CO concentrations, from 1000 ppm with the new catalyst to 3000 ppm with the original catalyst. Brake specific CO emissions increased in excess of 300%, from 1.02 to 4.42 g/hp-hr. NO_x increased only 19%, from 0.73 to 0.87 g/hp-hr. These correspond to conversion efficiency losses of 6 - 16% for CO and less than one percent for NO_x. If a 98% CO conversion efficiency is assumed for the new catalyst, a fourfold increase of tailpipe emissions would correspond to a 92% conversion efficiency for the original catalyst. Similarly, for a 96% assumed efficiency for the new catalyst, the same deterioration ratio would correspond to a 80% efficiency for the old catalyst (98% down to 92%, or worst case 96% down to 80%.) Figures 38 and 39 show similar deterioration ratios for CO for this engine when tested over the new cycle, but the corresponding loss of CO performance is smaller. NO_x effectively doubled from 0.30 to 0.62 g/hp-hr for these runs.

Both transient and steady-state results obtained with the Mazda engine show that the new catalyst produced better CO conversion, but worse NO_x conversion than the original catalyst. FTP tests 4 and 5 (run name H7) in Table 12 show CO levels of 11.96 g/hp-hr with the old catalyst, versus 3.10 g/hp-hr with the new catalyst. NO_x results with the old and new catalyst were 1.13 g/hp-hr versus 2.39 g/hp-hr, respectively. Results presented in Figures 44 and 45 for the backhoe loader - crawler tractor cycle show a good match between the twofold increase in peak CO concentration, and the almost doubled CO levels compared to the new catalyst. NO_x results for this cycle show a 22% deterioration on the old catalyst compared to the new catalyst.

5. Engines

Throughout the transient test program, the Mazda engine had higher brake specific emissions than the GM engine. This difference can be explained in part by the different torque output characteristics of the two engines. The smaller displacement Mazda engine had less torque than the GM, which led to more frequent throttle activity, which in turn put more demand on the closed-loop fuel control system, adding perturbation to the air-fuel ratio. Note that the scale for Mazda engine gas concentrations in Figures 37, 44 and 45 is different from the rest in order to accommodate higher peak values.

As a general observation, it can be stated that although the five transient test cycles were significantly different from one another, emissions performance levels were very similar. All fell below the worst case of 14 g/hp-hr CO and 2.8 g/hp-hr THC+NO_x.

C. Fuel Sensitivity Results

As part of the work statement, a fuel sensitivity test was also performed. In spite of efforts to obtain information on the composition of an "off spec", worst case LPG fuel, no usable details were obtained. After discussions with the EPA Program Manager, it was decided to use a mix of 90 percent propane and 10 percent butane as representative of the lower quality end of the HD10 LPG specification. Emissions data over three runs was generated using the new forklift cycle with the old catalytic muffler. Results listed in Table 12 for the Mazda engine show an increase in brake specific emissions of 25% for CO and 40% for NO_x.

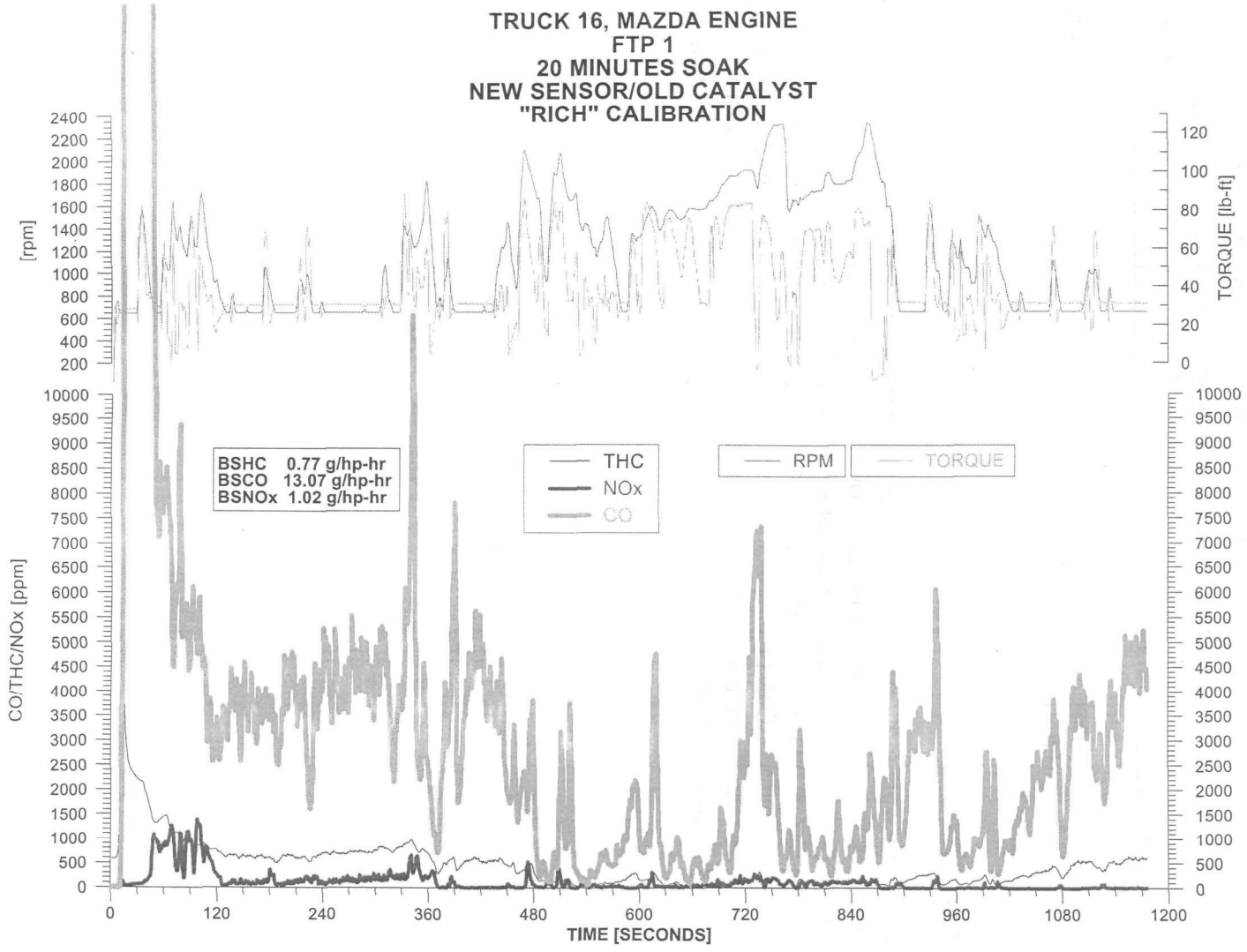

FIGURE 37. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 1 AFTER 20 MIN. SOAK WITH RICH CALIBRATION, OLD CATALYST

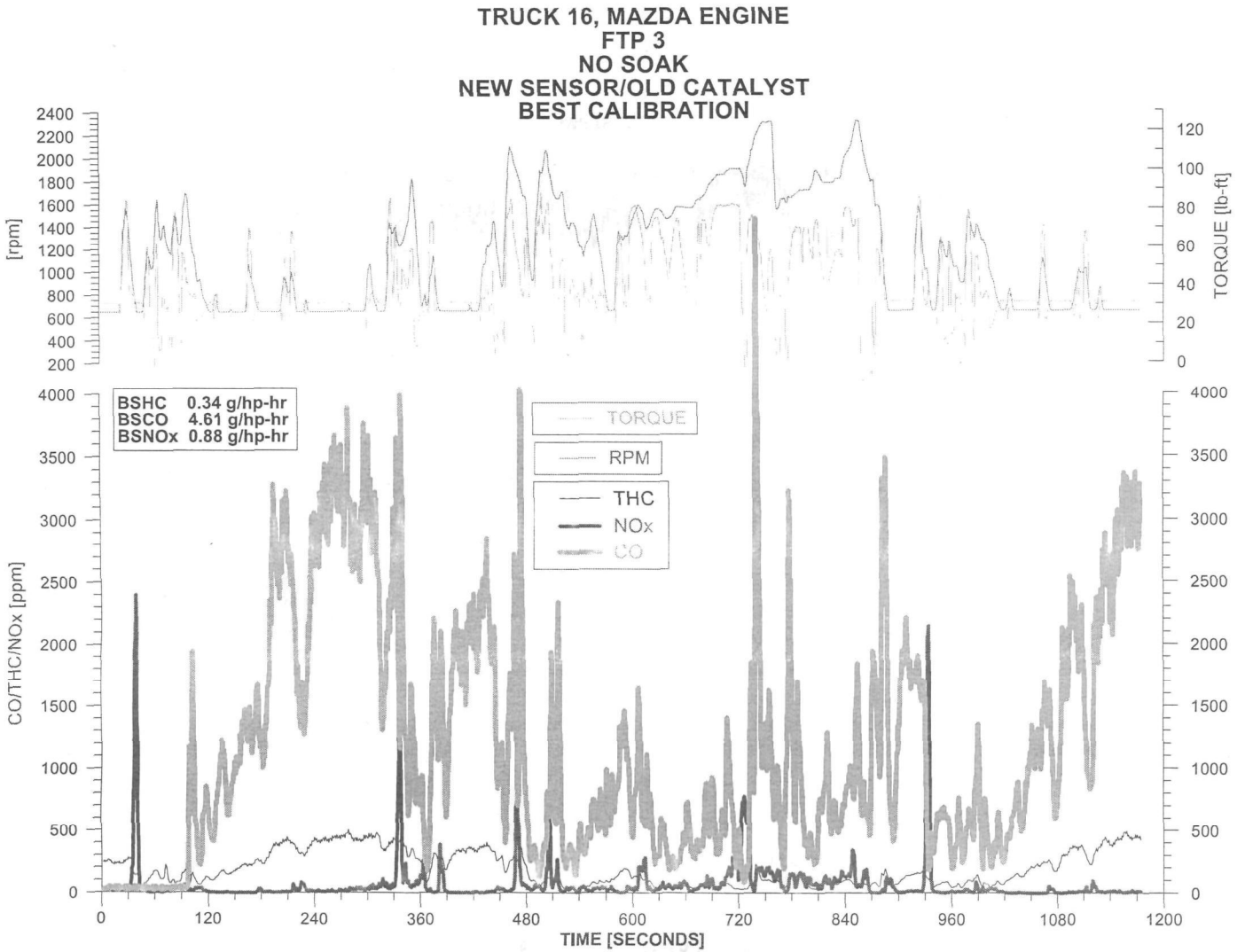

FIGURE 38. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 3 AFTER NO SOAK WITH BEST CALIBRATION, OLD CATALYST

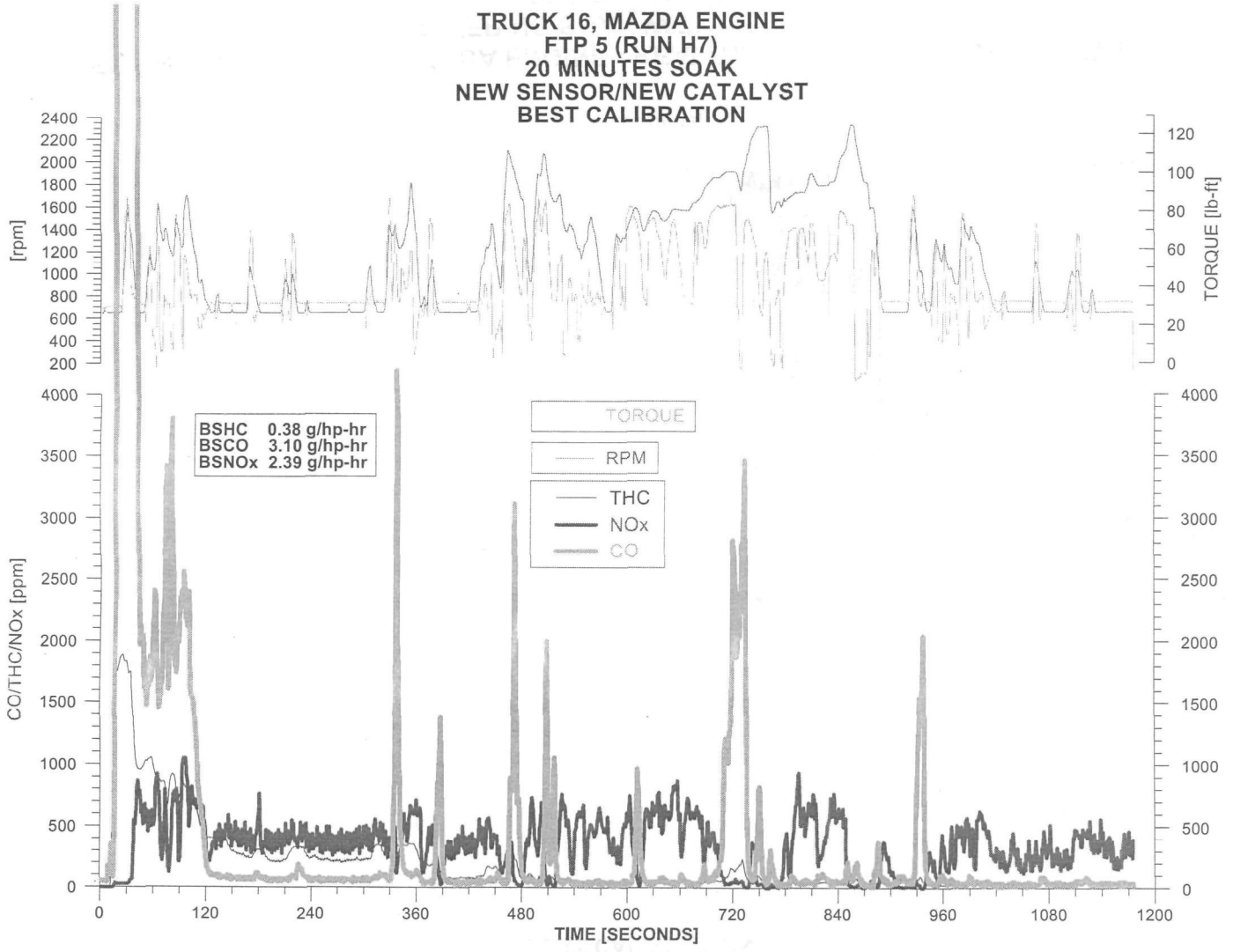

FIGURE 39. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 5 AFTER 20 MIN. SOAK WITH BEST CALIBRATION, NEW CATALYST

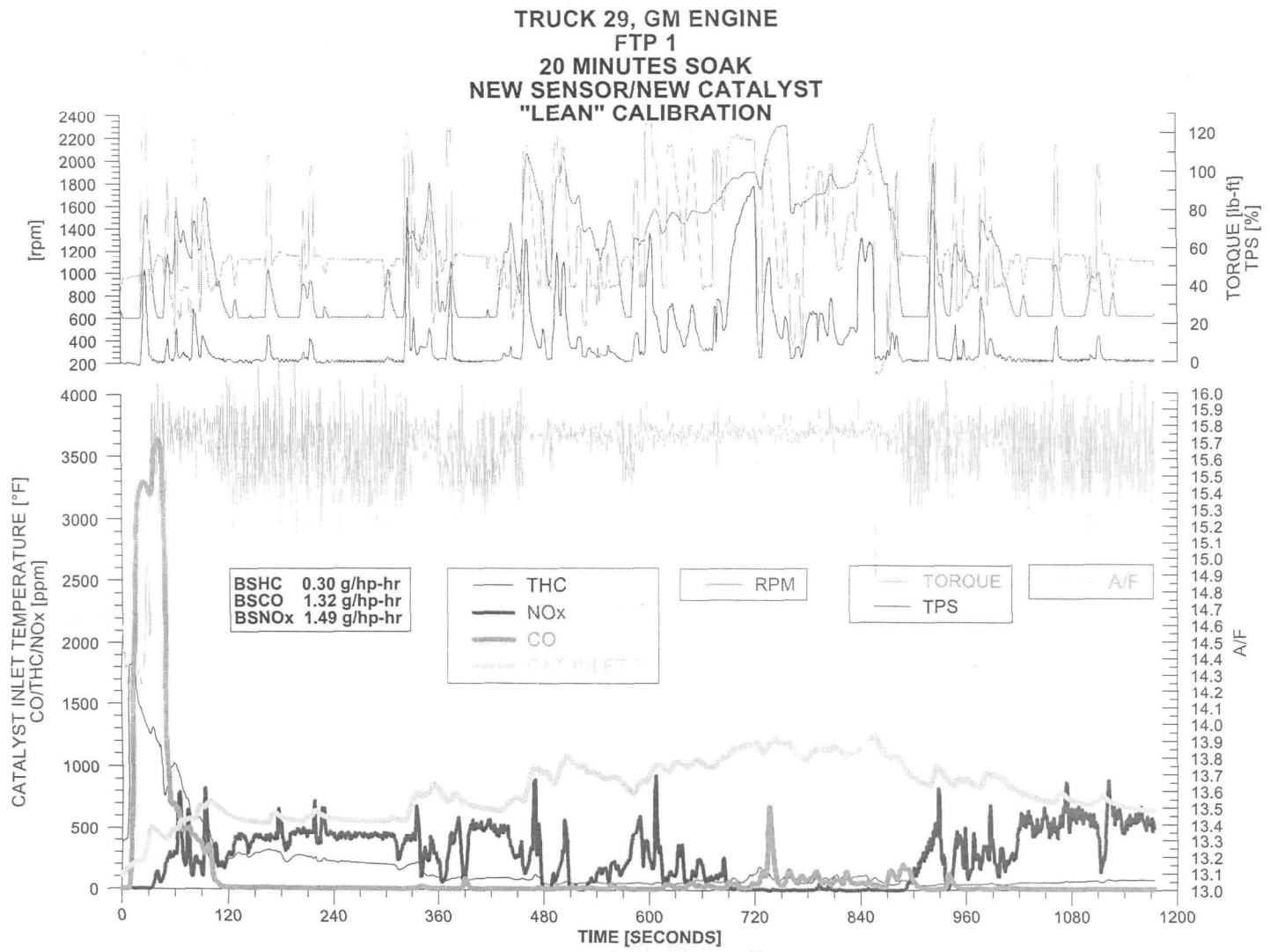

FIGURE 40. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 1 AFTER 20 MIN. SOAK WITH "LEAN" CALIBRATION, NEW CATALYST

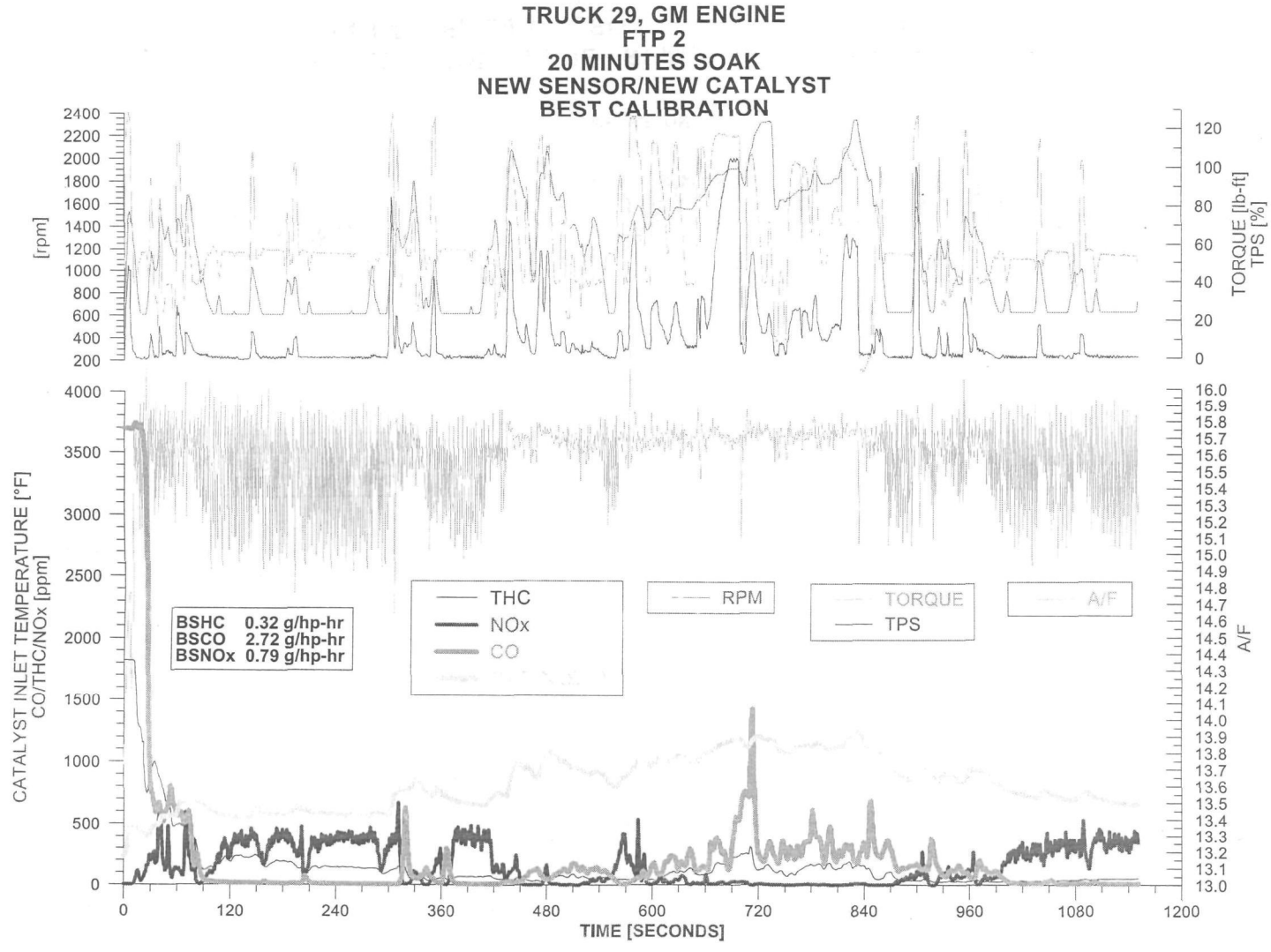

FIGURE 41. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 2 AFTER 20 MIN. SOAK WITH BEST CALIBRATION, NEW CATALYST

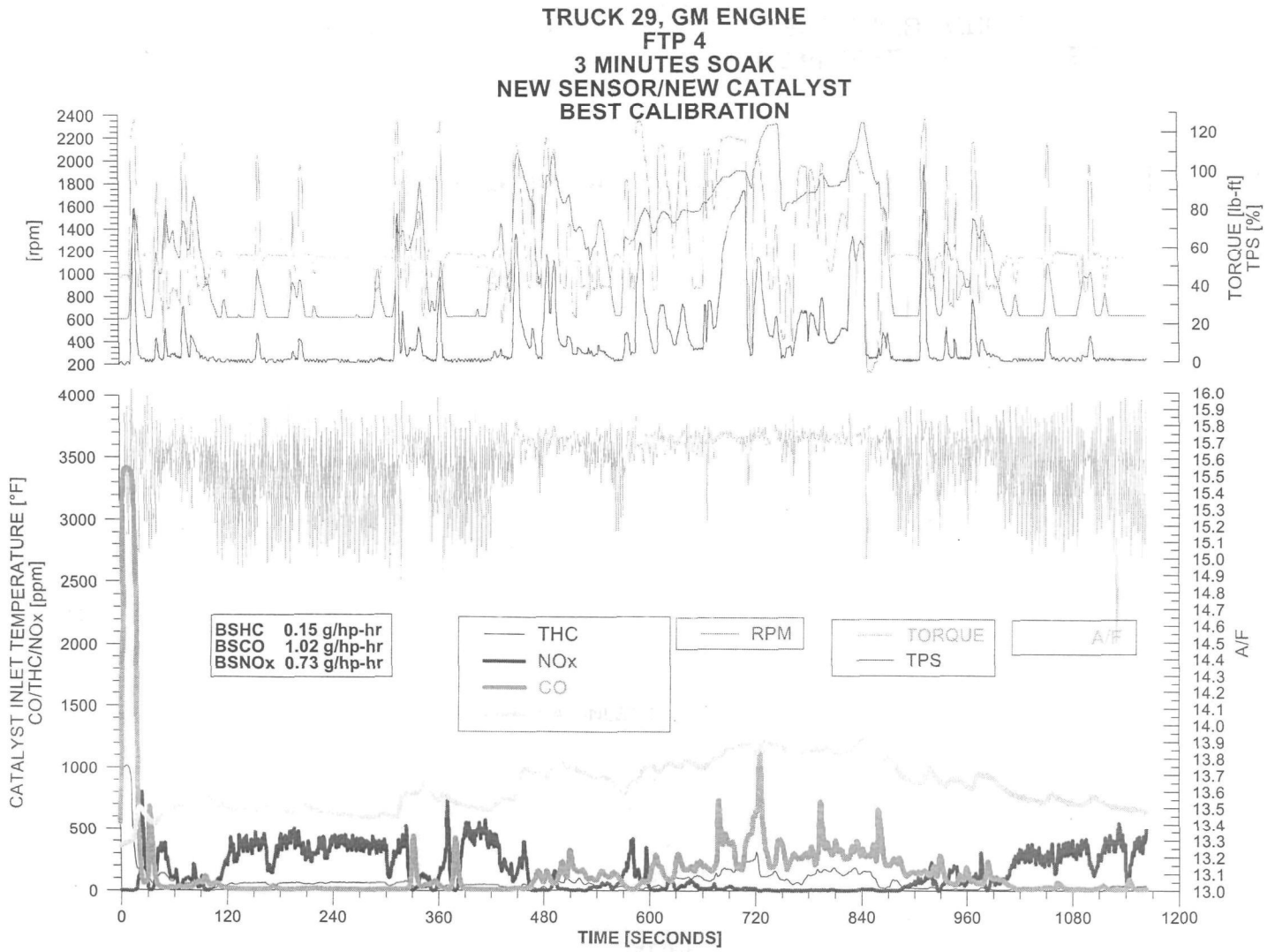

FIGURE 42. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 4 AFTER 3 MIN. SOAK WITH BEST CALIBRATION, NEW CATALYST

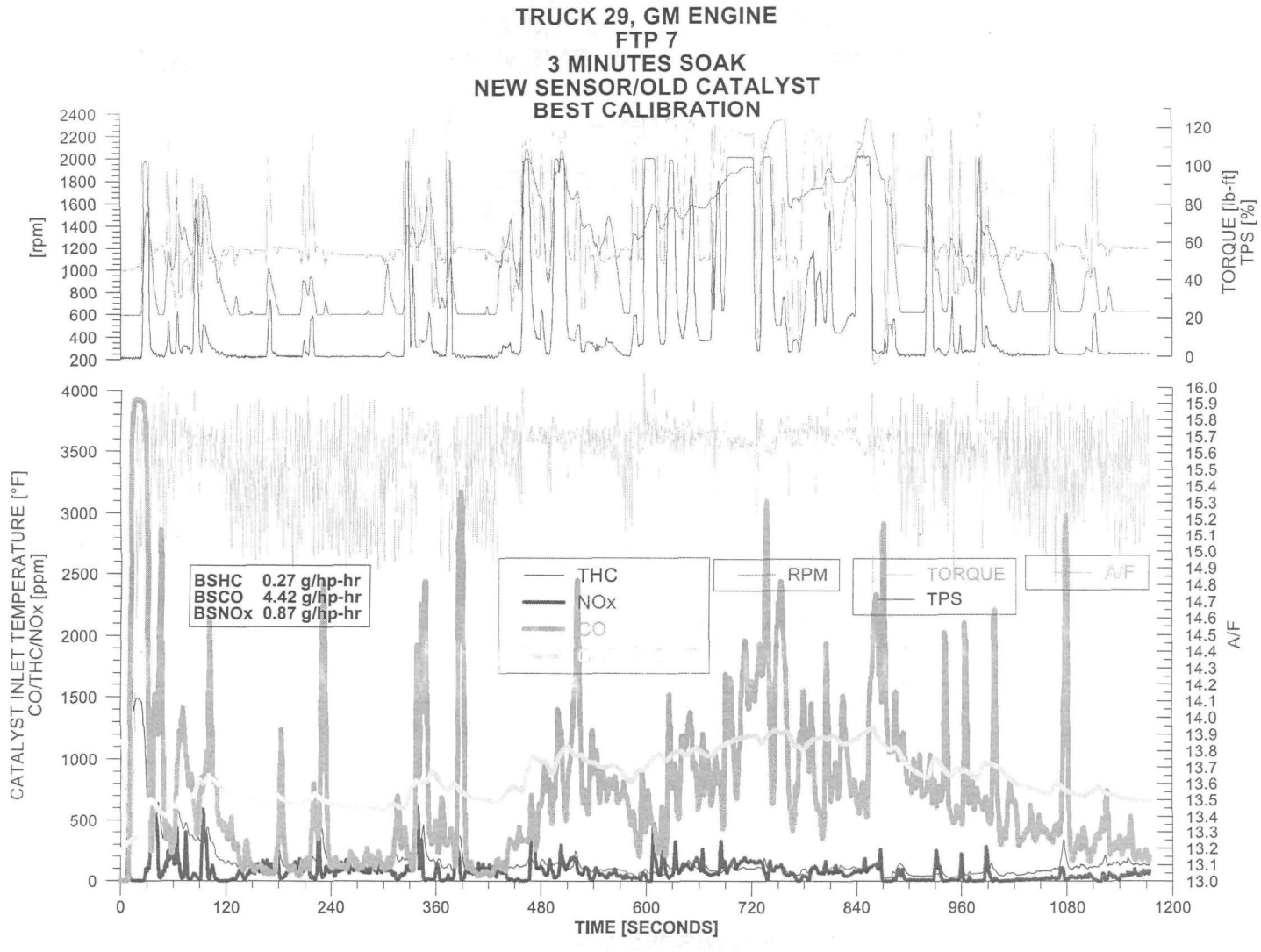

FIGURE 43. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, FTP RUN 7 AFTER 3 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

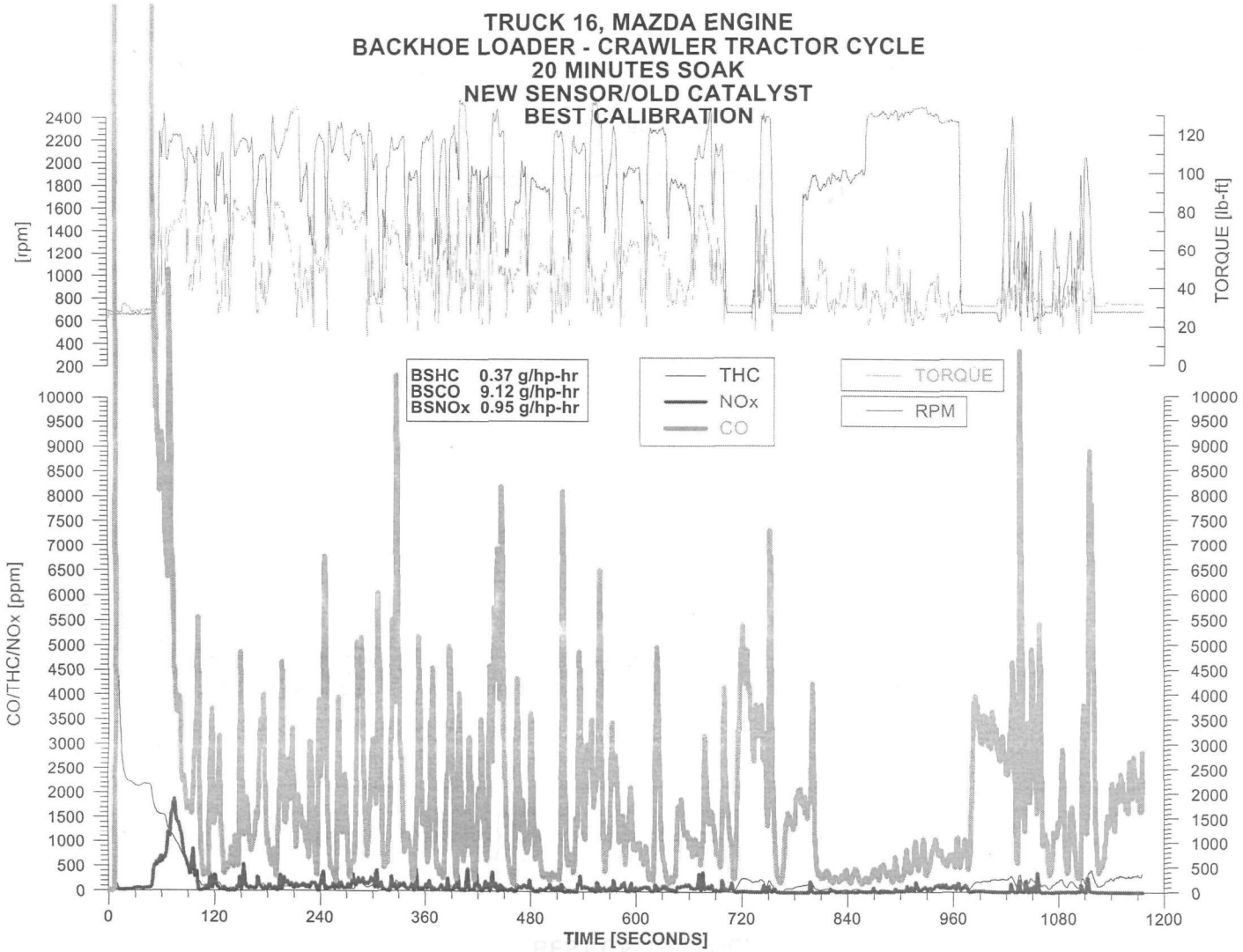

FIGURE 44. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, BACKHOE LOADER - CRAWLER TRACTOR CYCLE RUN 1 AFTER 20 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

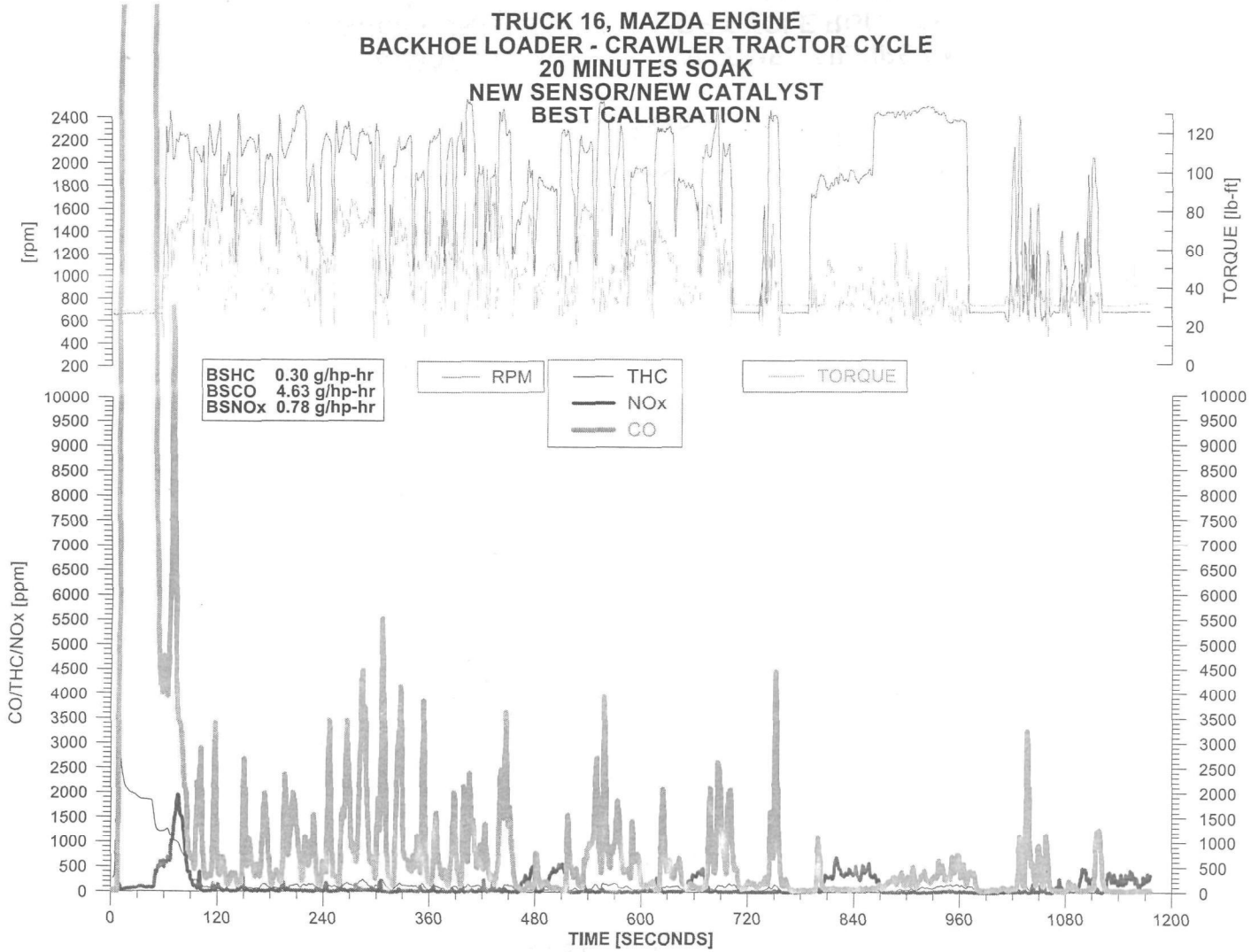

FIGURE 45. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, BACKHOE LOADER - CRAWLER TRACTOR CYCLE RUN 2 AFTER 20 MIN. SOAK WITH BEST CALIBRATION, NEW CATALYST

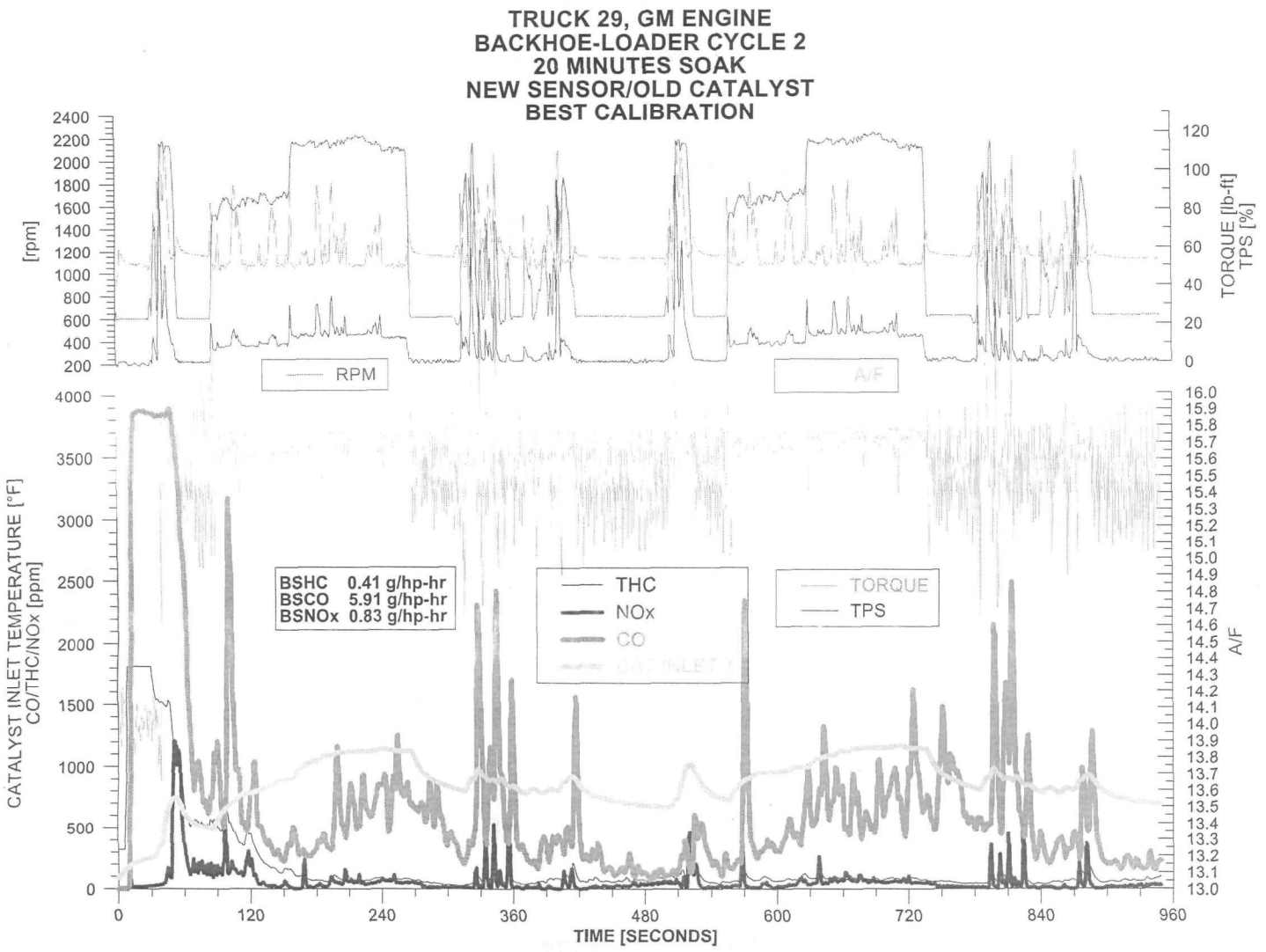

FIGURE 46. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, BACKHOE LOADER CYCLE RUN 2 AFTER 20 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

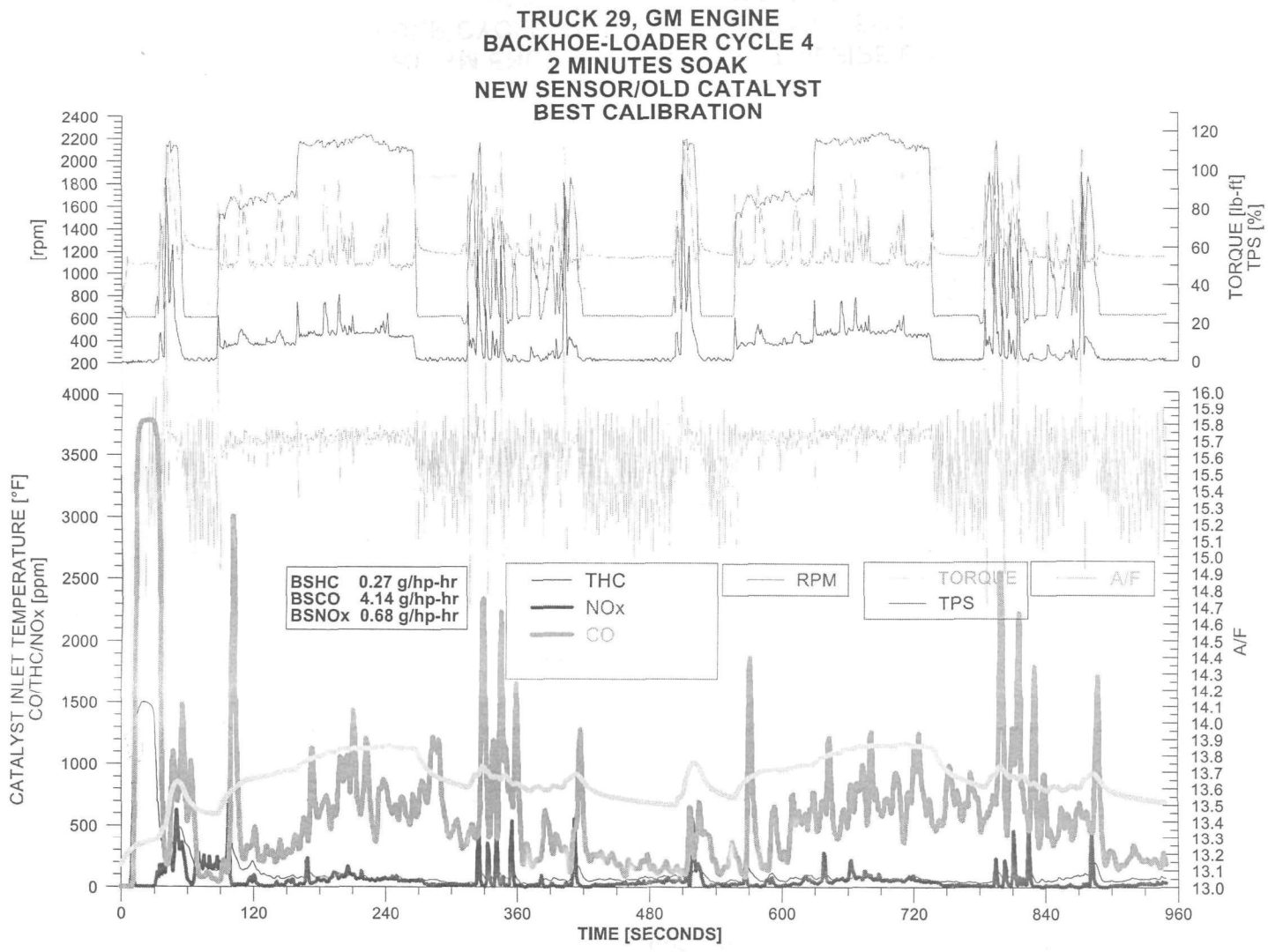

FIGURE 47. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, BACKHOE LOADER CYCLE RUN 4 AFTER 2 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

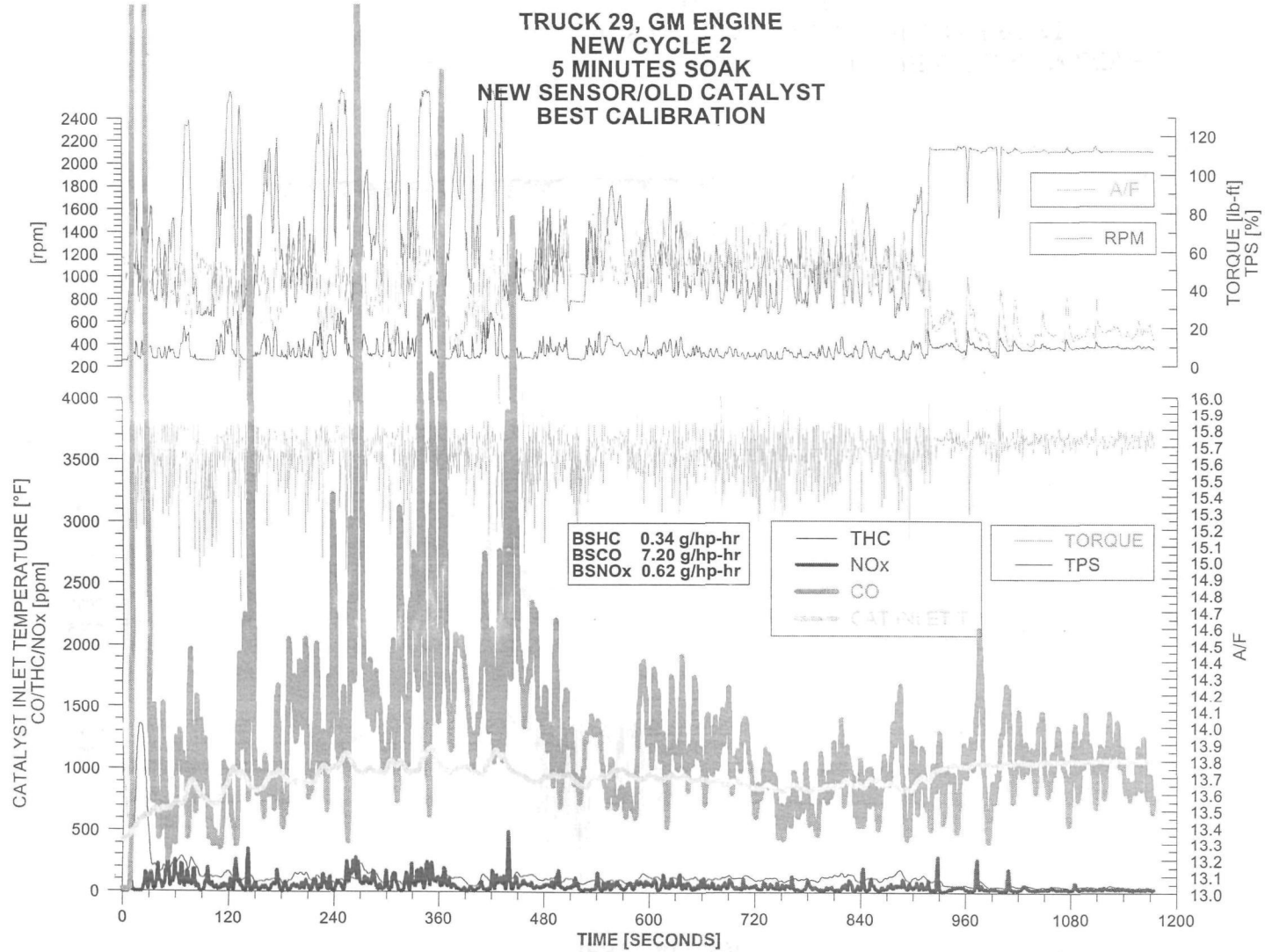

FIGURE 48. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, NEW TRANSIENT CYCLE RUN 2 AFTER 5 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

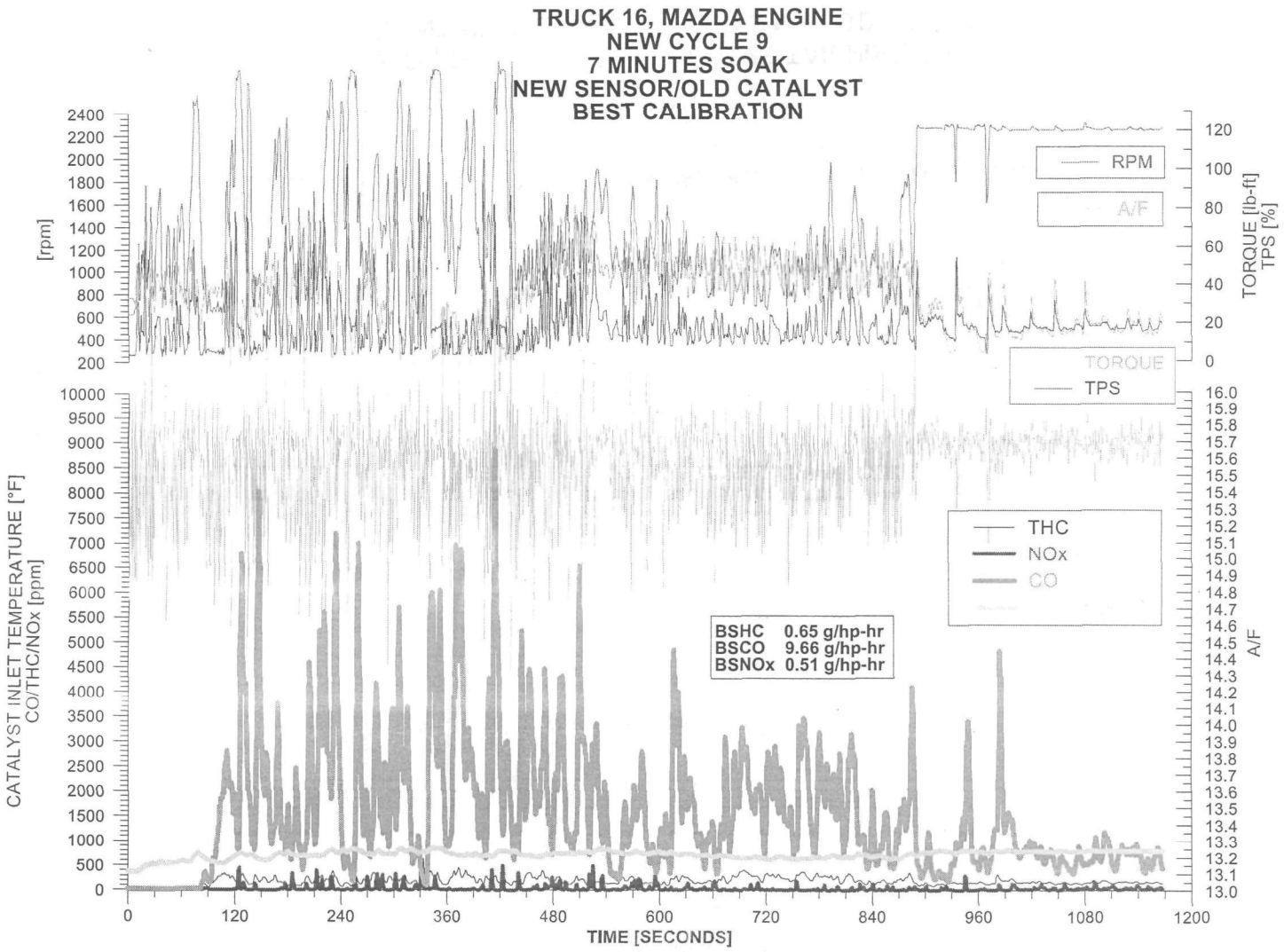

FIGURE 49. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, NEW TRANSIENT CYCLE RUN 9 AFTER 7 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

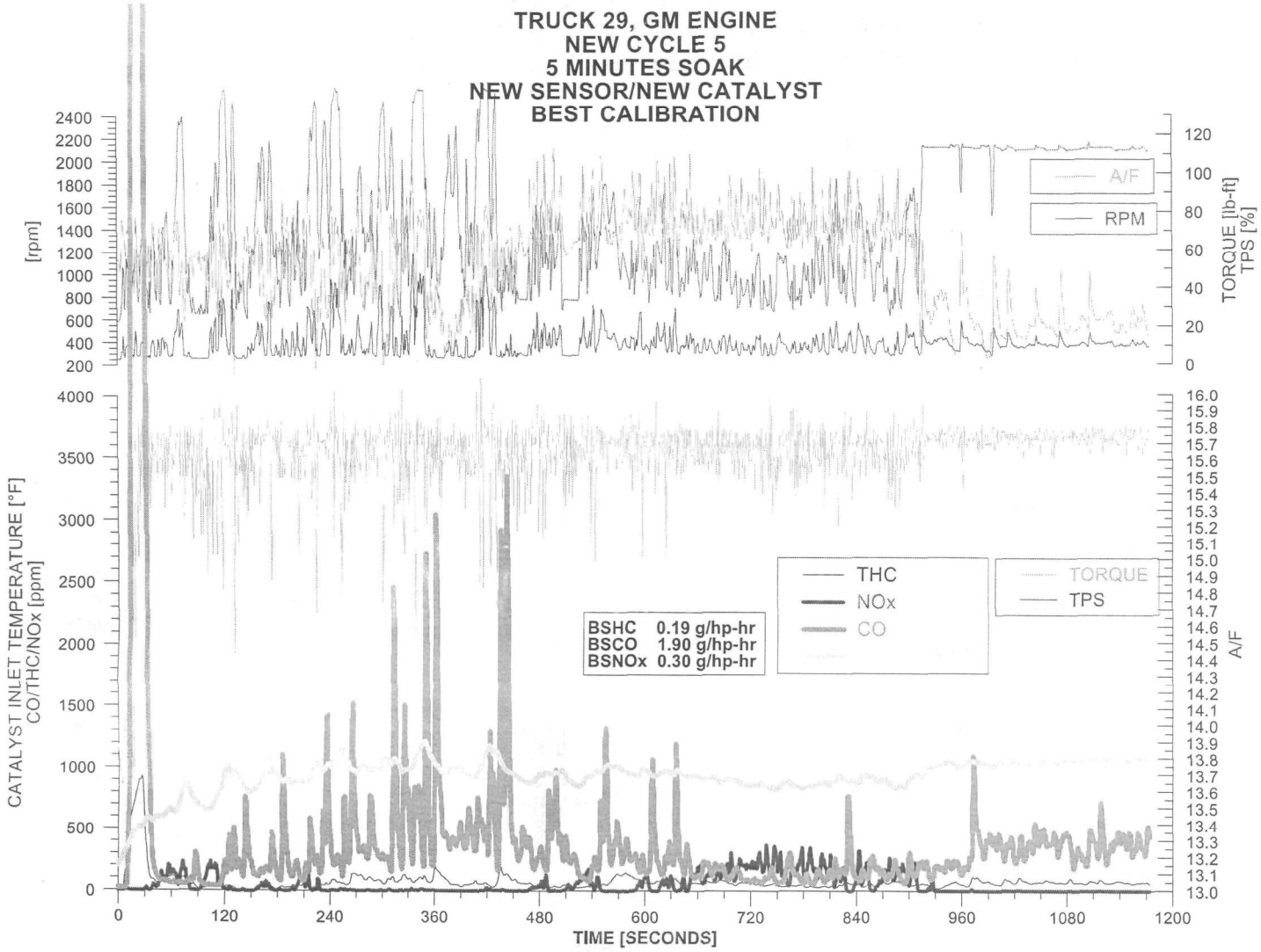

FIGURE 50. TRUCK 29, GM ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, NEW TRANSIENT CYCLE RUN 5 AFTER 5 MIN. SOAK WITH BEST CALIBRATION, NEW CATALYST

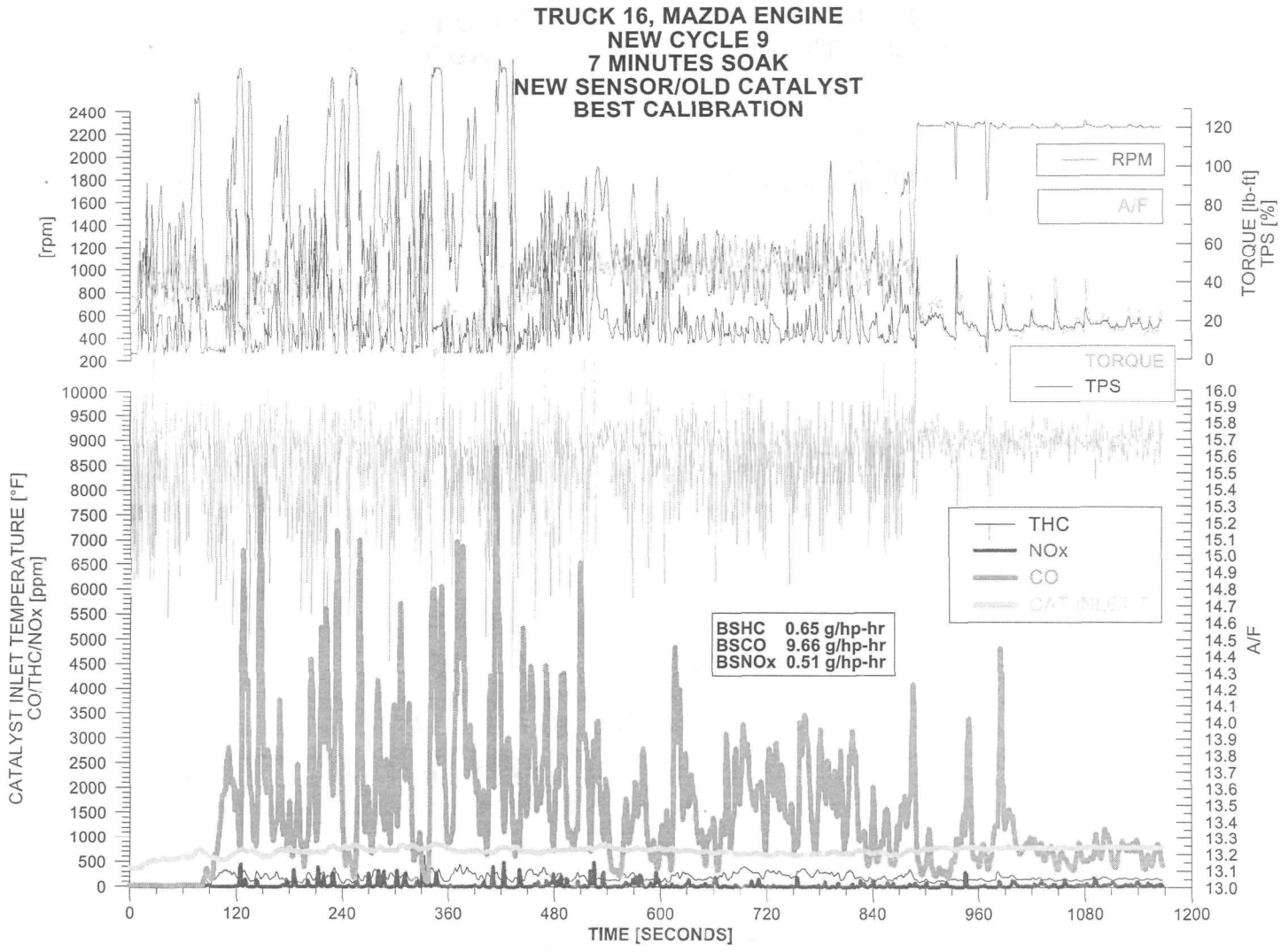

FIGURE 51. TRUCK 16, MAZDA ENGINE - REAL-TIME TAILPIPE EMISSION LEVELS, NEW TRANSIENT CYCLE RUN 9 AFTER 7 MIN. SOAK WITH BEST CALIBRATION, OLD CATALYST

VI. FUEL TEMPERATURE MEASUREMENT

The goal of this test was to measure bulk liquid volume fuel temperatures in the tank of a gasoline forklift truck in near-continuous operation. A CLARK C500 YS 60 forklift truck with a 6,000 lb capacity belonging to Southwest Research Institute's Department of Emission Research, was used.

The test was performed outdoors in a completely shaded area during a windless day. The length of the straight-line, no gradient run was approximately 60 ft. A palletized weight of 1,200 lb was used for load simulation. A simple sequence of runs with and without load, with lifts up to half mast height was carried out for over four hours. Every hour, a ten minute break was introduced. The fuel tank was 3/4 full at the beginning of the test.

Four thermocouples were installed on the truck for temperature measurement. One thermocouple was placed in the middle of the tank for bulk liquid temperature measurement. Another was located above the liquid in the empty volume to measure tank vapor temperature. A third thermocouple was attached to the outside wall of the fuel tank in the engine compartment. The fourth thermocouple was attached at mid-height to the rear leg of the roll cage for ambient temperature measurement. Signals from the thermocouples were sent to a datalogger using a sampling rate of 0.2 Hz (5-second interval).

After three hours, the tank bulk liquid temperature reached a plateau of 3-4°F above ambient temperature. During the ten minute breaks, the engine was not running and there was no cooling air flow in the engine compartment. Due to the heat transfer from the engine, temperatures 8-15°F above ambient were recorded. This caused the vapor temperature in the tank to rise 2-3°F above the bulk liquid temperature. It is apparent from Figure 52 that the vapor temperatures would continue to rise if the soak period were longer.

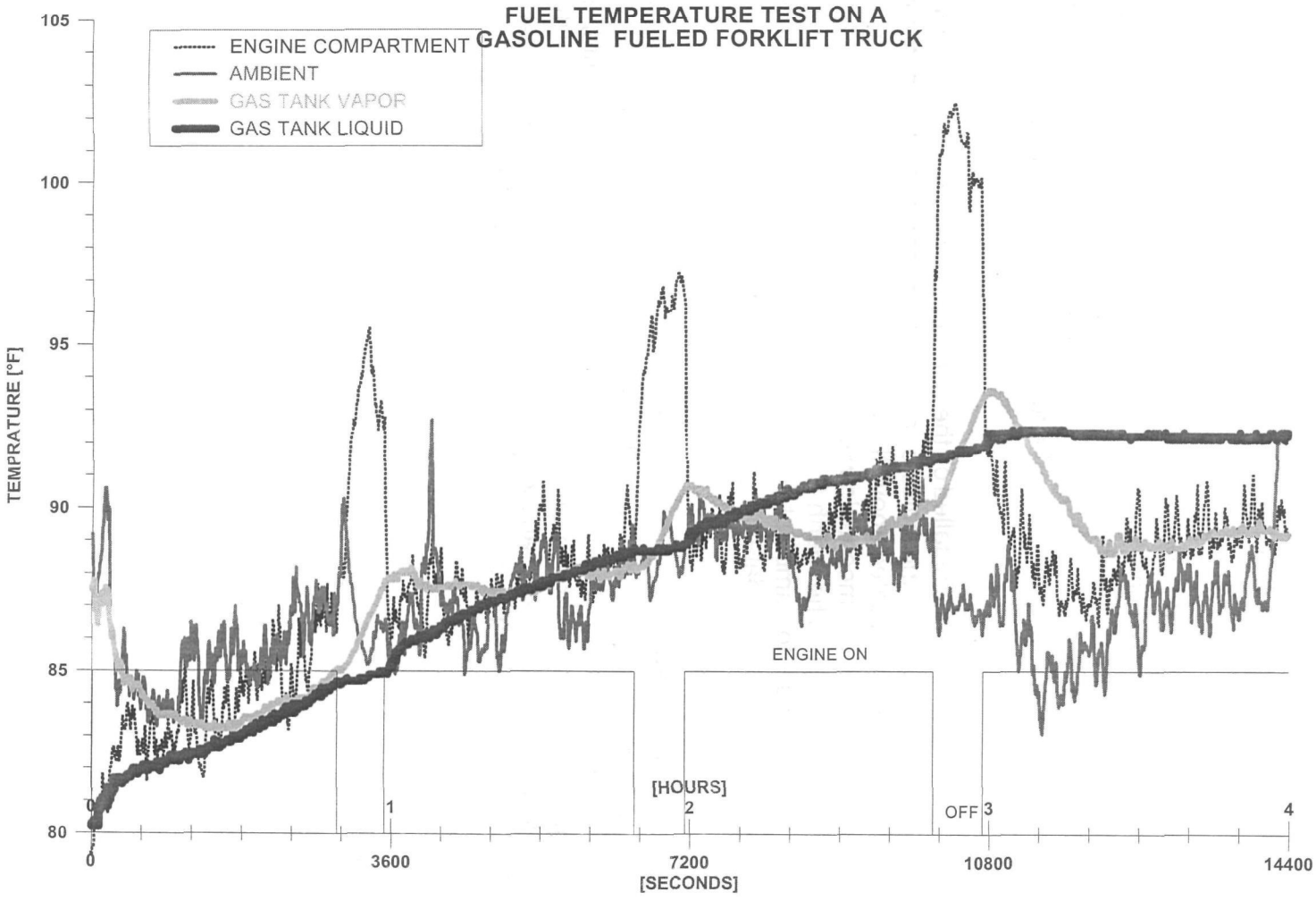

FIGURE 52. FUEL TEMPERATURE TEST ON A GASOLINE- FUELED CLARK C500 YS60 FORKLIFT TRUCK

VII. ANALYSIS OF FAILED CATALYTIC CONVERTER MUFFLERS

Three failed catalytic converter mufflers were discovered during truck selection. Two of these were retained for analysis by SwRI, and the third was returned to the manufacturer. Further, upon arrival of the two engines at SwRI, it was discovered that the muffler from Truck 29, S/N B7923 also had at least one loose substrate based on the rattling sound it produced while shaken by hand.

A. Sample Preparation and Measurement Procedure

Figure 53 shows the Truck 29 catalytic muffler with a welded attachment for test cell installation. The protrusion of the weld seam from the circular surface of the cylindrical body was ground off at both ends of the can for circumference measurements. See Figure 54. These measurements were performed using a PI-tape. A PI-tape is used to determine the diameter of a cylinder with a precision of 0.001 inch and is sold with a certificate of accuracy traceable to the National Institute of Standards and Technology. The muffler end caps were cut using a bandsaw allowing further inspection and measurement of the center sections containing the ceramic substrates.

B. Failure Mode Analysis

Upon inspection of the ceramic substrates, it was concluded that none had suffered from overheating. In both mufflers, with the serial numbers B 7923 and B 7922, one of the two substrates in each can had suffered loss of retention and subsequent mechanical abrasion from contact with the metal container. The intumescent mat had completely decomposed and was washed away by the flow of exhaust gas. Figures 55, 56, and 57 show details of muffler S/N B 7923. In muffler S/N A 57551, both substrates were reduced to egg-sized pieces, the final stage of the same failure type.

The canned substrate assembly consists of the ceramic monolith, a layer of intumescent mat, and a rolled sheet metal wrap. The mat serves a dual role of mechanical retention of the substrate, once the prescribed mounting pressure is ensured, and sealant so that the exhaust flow can pass only through the catalyst and not around it. In order to achieve the expected assembly durability, mat manufacturers prescribe a range of gaps between the substrate and the metal wrap, that are specific to the kind of mat used. In this case, a common canning technique called "butt-welding" was used. A rolled piece of sheet metal is placed around the mat-wrapped substrate, squeezed until the two edges meet, and welded. Control of the gap and therefore the mounting pressure is achieved through accurate control of the length of the metal wrap before rolling. Table 16 contains the measurement results, material tolerances, gap calculations based on common linear tolerance stack-up, and recommended gaps for the mat used. Also, values for recommended and as found wrap lengths have been calculated.

TABLE 16. FAILED CATALYTIC CONVERTER MUFFLERS - MEASUREMENTS AND CALCULATIONS

			Muffler S/N		
			B7923	A57551	B7922
Can Diameter	Inlet	[in]	5.050	5.033	5.050
	Outlet	[in]	5.048	5.034	5.052
	Average	[in]	5.049	5.034	5.051
Substrate Diameter	Min.	[in]	4.621	4.621	4.621
	Max.	[in]	4.680	4.699	4.699
	Nominal	[in]	4.660	4.660	4.660
Sheet Metal Thickness	Min.	[in]	0.059	0.059	0.059
	Max.	[in]	0.065	0.062	0.062
	Nominal	[in]	0.062	0.060	0.060
Calculated Gap	Min.	[mm]	3.039	2.668	2.891
	Max.	[mm]	3.942	3.745	3.967
	Nominal	[mm]	3.365	3.207	3.429
Prescribed Gap	Min.	[mm]	2.100	2.100	2.100
	Max.	[mm]	3.650	3.650	3.650
	Target	[mm]	2.900	2.900	2.900
Wrap Length As Found	Min.	[in]	15.658	15.618	15.673
	Max.	[in]	15.677	15.628	15.683
	Nominal	[in]	15.667	15.623	15.678
Prescribed Wrap	Min.	[in]	15.425	15.478	15.478
	Max.	[in]	15.604	15.604	15.604
	Nominal	[in]	15.552	15.547	15.547

NOTE:
- Substrate diameter and sheet metal thickness tolerances were supplied by the manufacturer of the catalytic converter mufflers.
- The prescribed gap tolerances for the type of intumescent mat used were found in the product applications catalog.

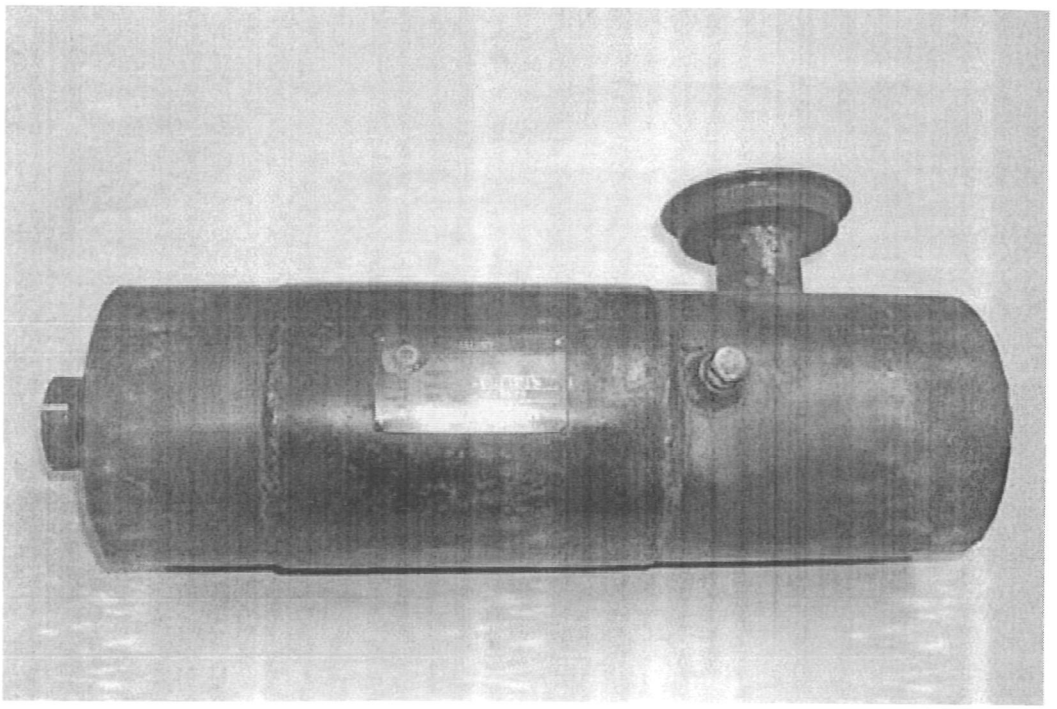

FIGURE 53. TRUCK 29, CATALYTIC MUFFLER S/N B 7923

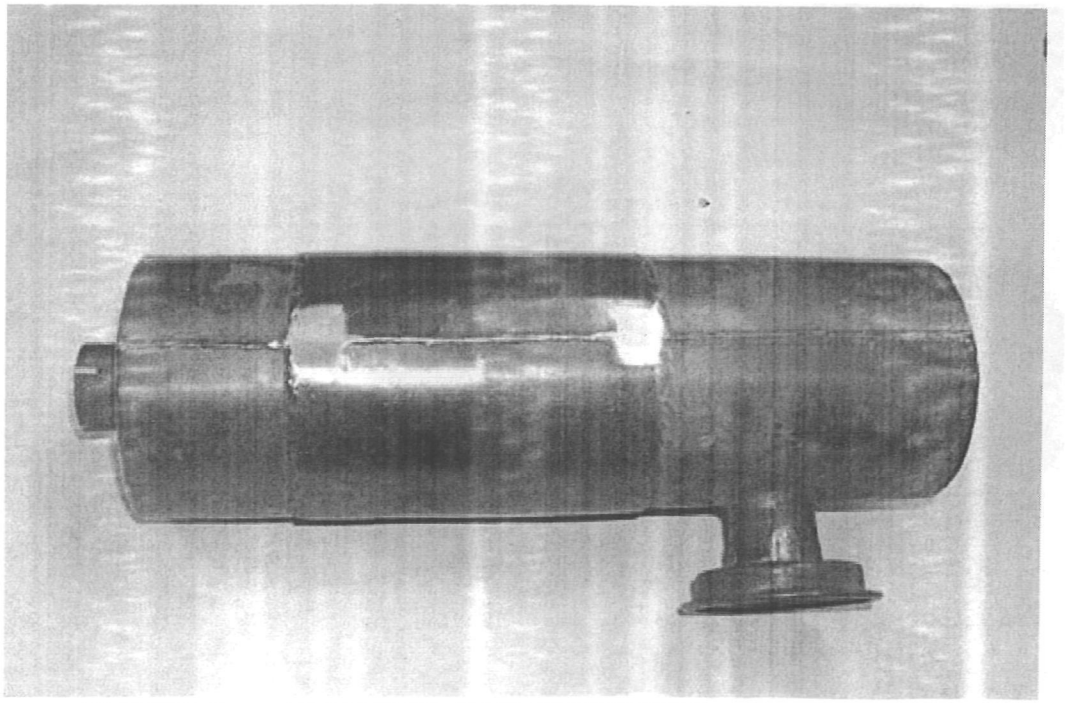

FIGURE 54. TRUCK 29, CATALYTIC MUFFLER S/N B 7923 WITH GROUND WELD SEAM

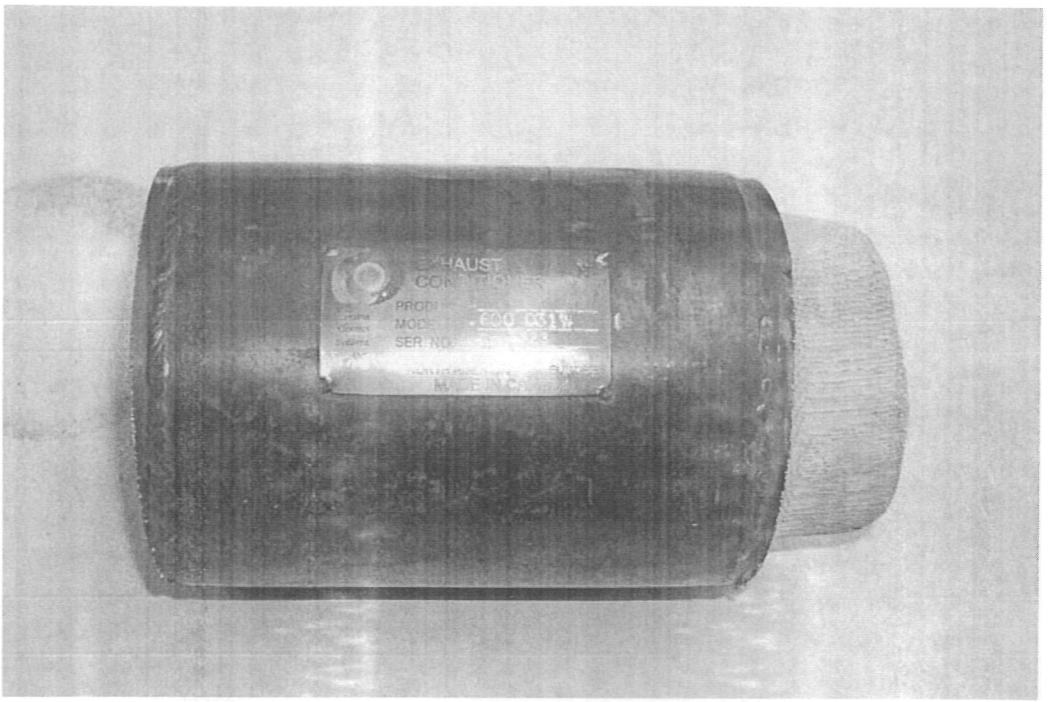

FIGURE 55. TRUCK 29, CATALYTIC MUFFLER S/N B 7923
FAILED END, DETAIL 2

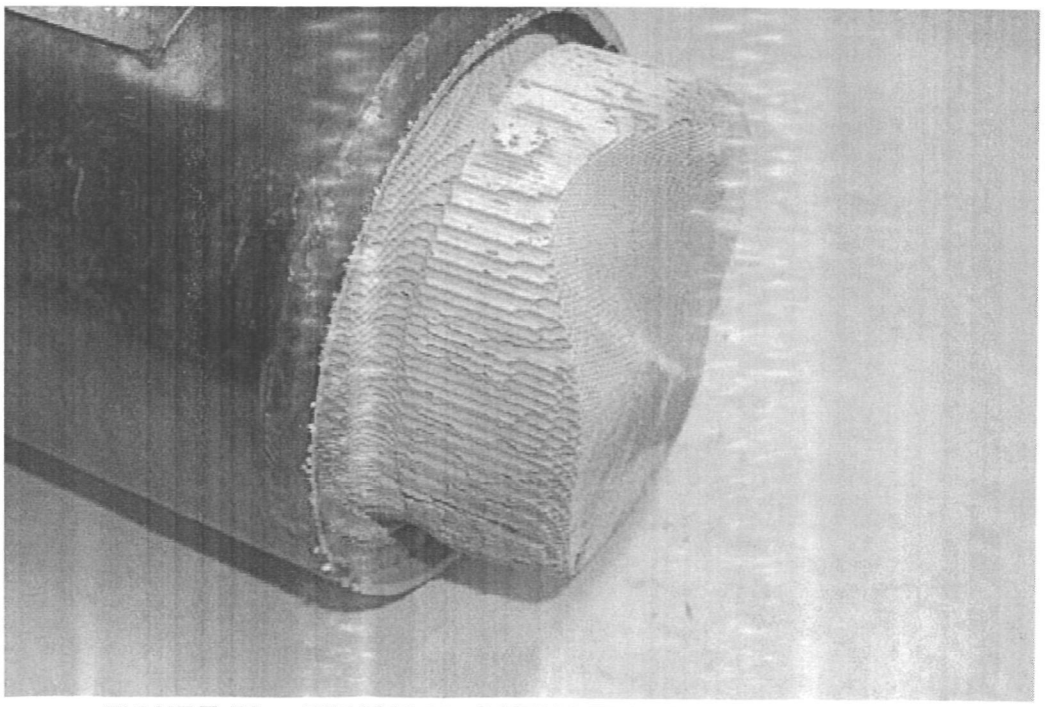

FIGURE 56. TRUCK 29, CATALYTIC MUFFLER S/N 7923
FAILED END, DETAIL 3

The maximum calculated gap based on outside diameter of the can and the worst case scenario of tolerance stack-up exceeds the maximum prescribed gap for the three catalytic converter mufflers investigated.

C. Repair of Test Sample

The center piece of catalytic converter muffler S/N B 7923 was cut through the middle in order to remove the partially damaged substrate as shown in Figure 57. Subsequently, the substrate was machined to a suitable cylindrical shape and re-canned. Flanges, V-clamps, and welding were used to restore the functionality of the catalytic muffler, and allowed its use throughout the emission test program. Figure 58 shows the repaired unit.

At the end of the program, it again became apparent while handling the muffler that a substrate was loose. It was the second half of the dual bed, which was still intact when the body was first cut for inspection. This failure happened during testing at SwRI due to the above mentioned reasons. Performance of this catalytic converter muffler may have been somewhat degraded by a portion of the exhaust flow bypassing the second substrate. Figure 59 shows details of the failure.

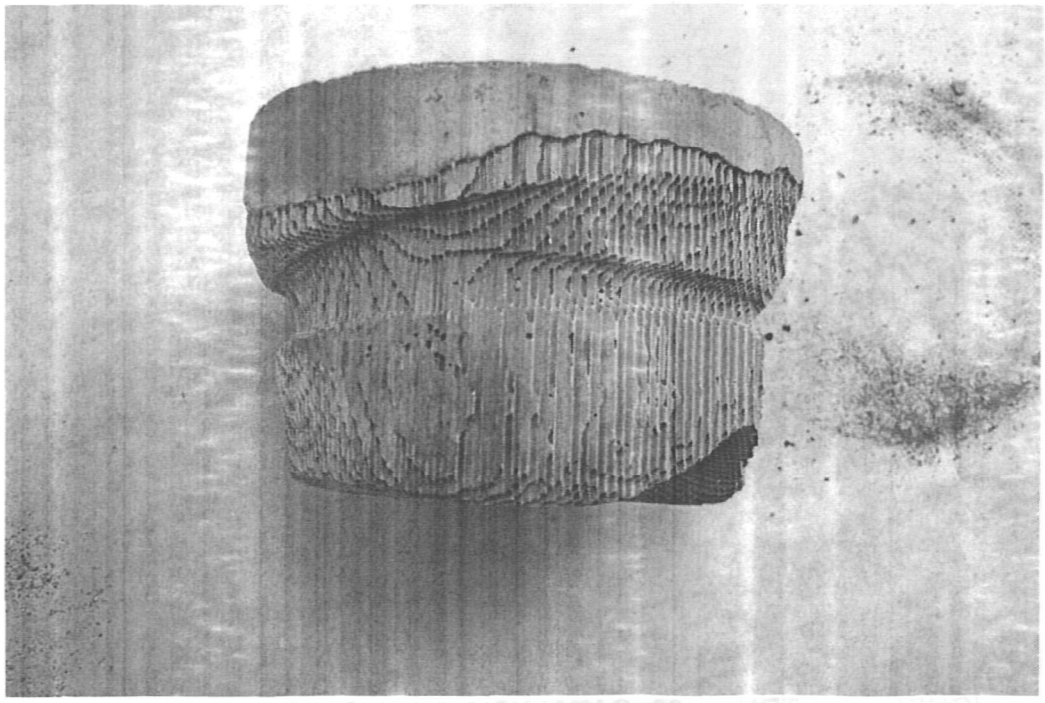

FIGURE 57. TRUCK 29, DAMAGED CATALYST SUBSTRATE

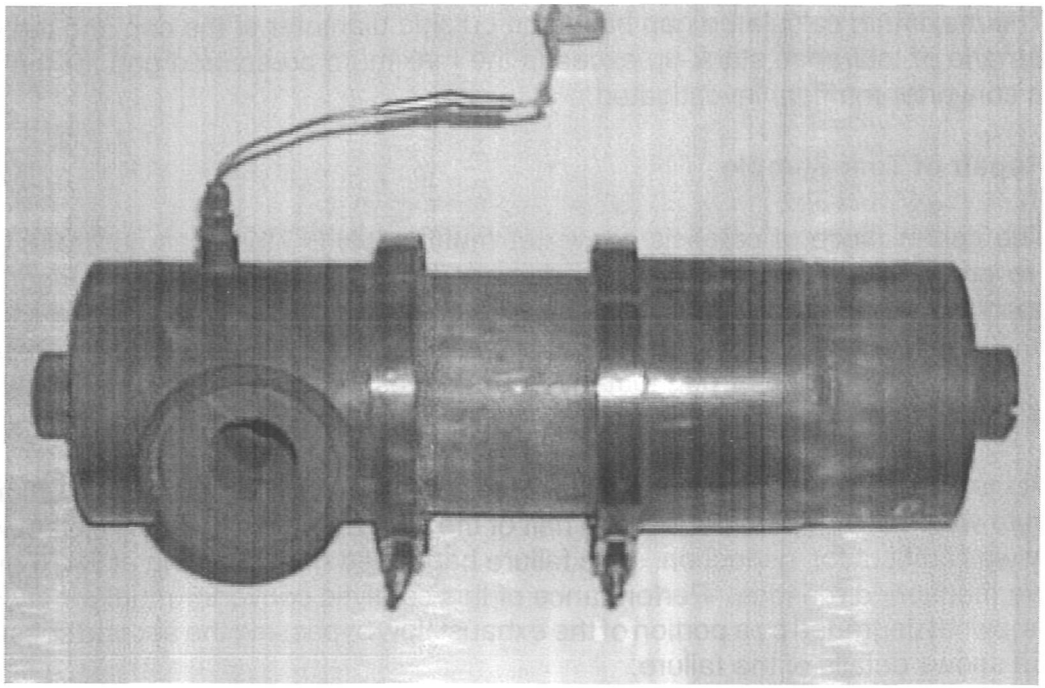

FIGURE 58. TRUCK 29, REPAIRED CATALYTIC MUFFLER

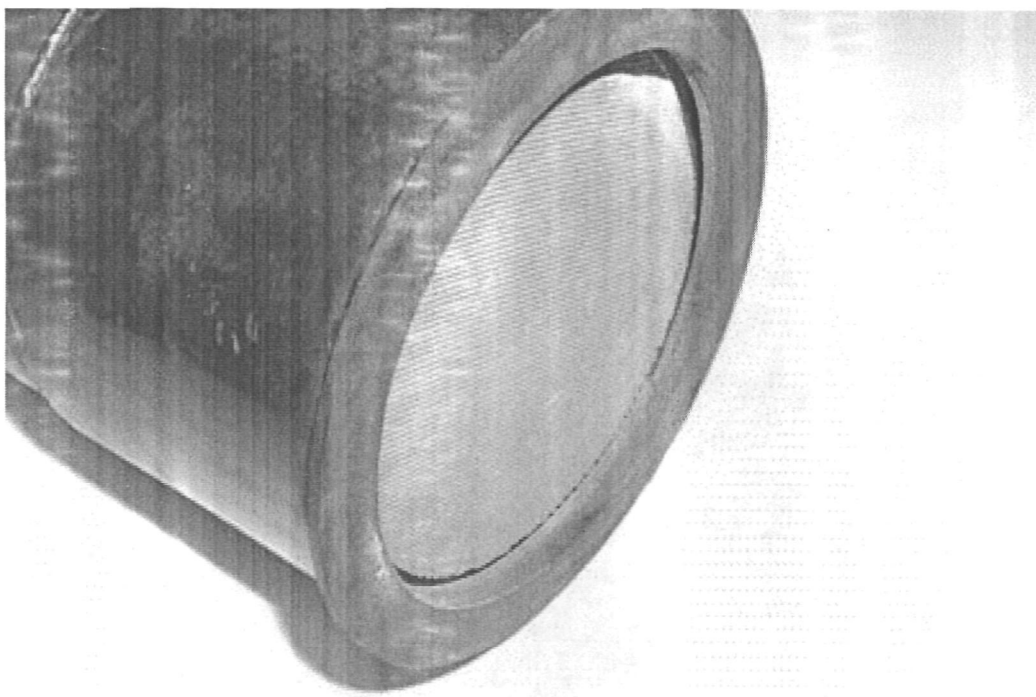

FIGURE 59. TRUCK 29, CATALYTIC CONVERTER MUFFLER SECOND OBSERVED FAILURE

VIII. FACILITY DESCRIPTION

Steady-state tests were performed in Cell 2. Transient tests were performed in Cell 13. All equipment, procedures and calculations used for testing are in conformance with 40 CFR Part 86 and Part 90.

The test cells are outfitted with the following equipment:

A. Cell 2

- 260 hp General Electric DC dynamometer
- Lebow (rotary transformer) in-line torquemeter
- LabView PC for engine and dynamometer control, and data acquisition
- Full exhaust CVS-PDP dilution system. Dilution air is filtered and temperature controlled

Nominal primary dilution tunnel total flow rate used was 1500 cfm.

B. Cell 13

- 175 hp Midwest eddy-current dynamometer
- SHC Model 10100 load cell attached to a moment arm to measure engine torque
- Full exhaust CVS-PDP dilution system. Dilution air is filtered and temperature controlled.

Nominal primary dilution tunnel total flow rate used was 1000 cfm.

Diluted exhaust samples were collected in Tedlar bags and analyzed on a separate bag sample analysis cart using the following instruments:

- Beckman Model 400 FID analyzer to measure bag sample hydrocarbon levels
- Rosemount Model 951A chemiluminescent analyzer measures bag sample NO_x concentrations
- Horiba Model OPE-15 non-dispersive infrared analyzer for measuring exhaust bag samples for CO
- Beckman Model 868 non-dispersive infrared analyzer for measuring CO_2.

APPENDIX A

FIGURES

STEADY-STATE EMISSION TEST RESULTS

FIGURES A-1 Thru A-40

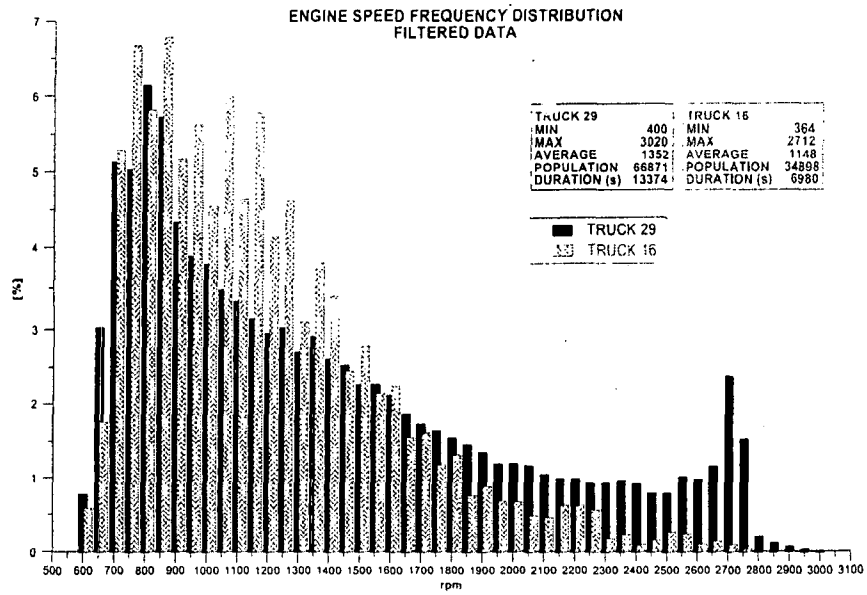

FIGURE A-1. ENGINE SPEED FREQUENCY DISTRIBUTION, 50 RPM RANGES, FILTERED DATA

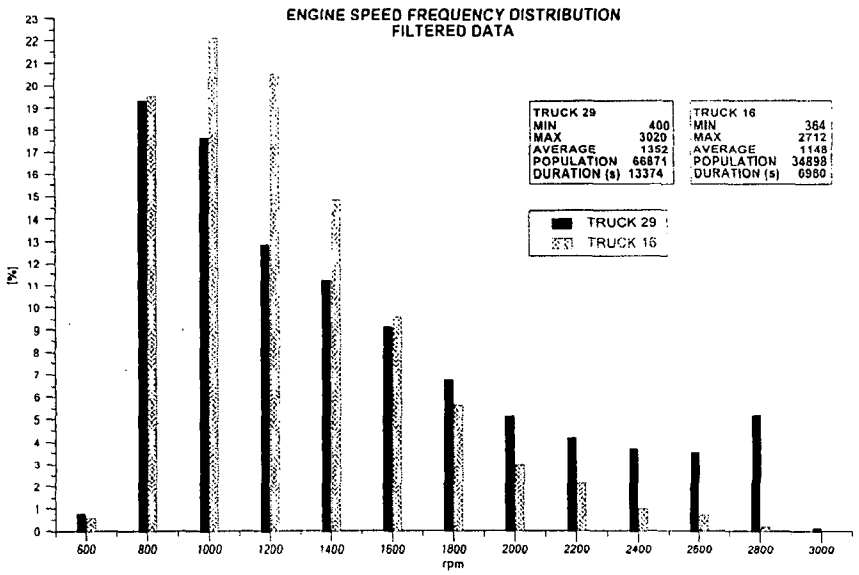

FIGURE A-2. ENGINE SPEED FREQUENCY DISTRIBUTION, 200 RPM RANGES, FILTERED DATA

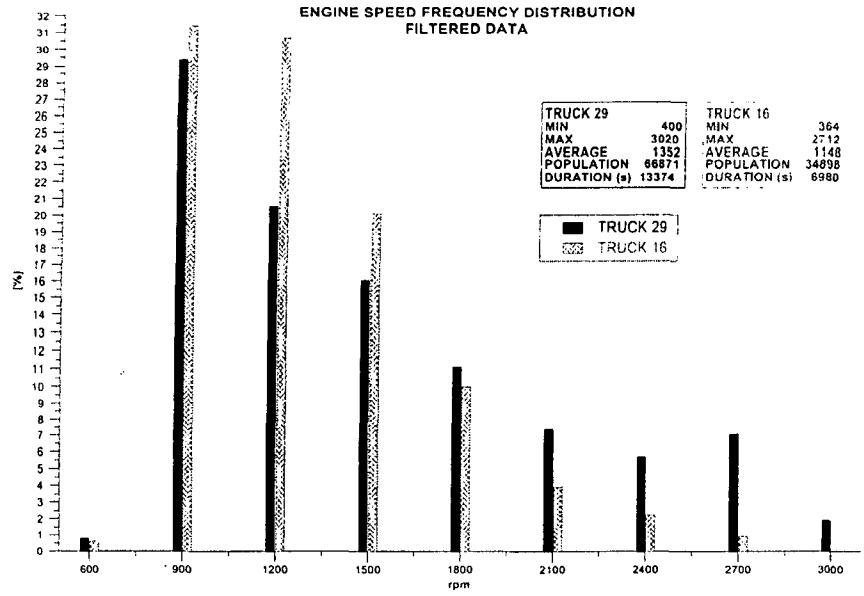

FIGURE A-3. ENGINE SPEED FREQUENCY DISTRIBUTION, 300 RPM RANGES, FILTERED DATA

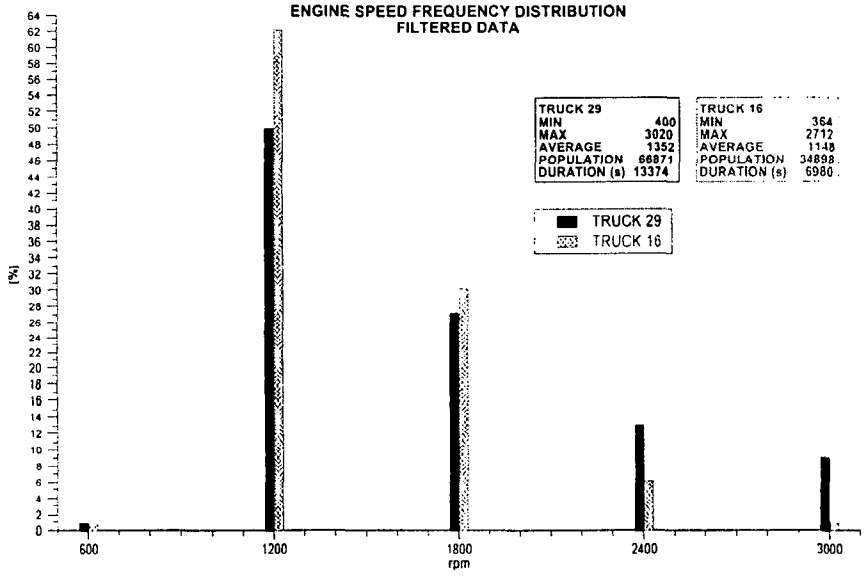

FIGURE A-4. ENGINE SPEED FREQUENCY DISTRIBUTION, 600 RPM RANGES, FILTERED DATA

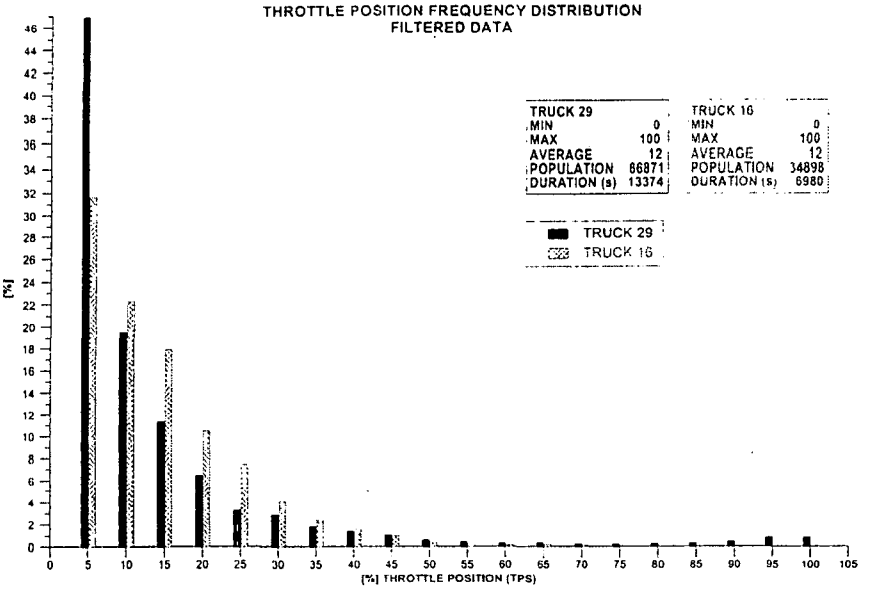

FIGURE A-5. THROTTLE POSITION FREQUENCY DISTRIBUTION, 5% RANGES, FILTERED DATA

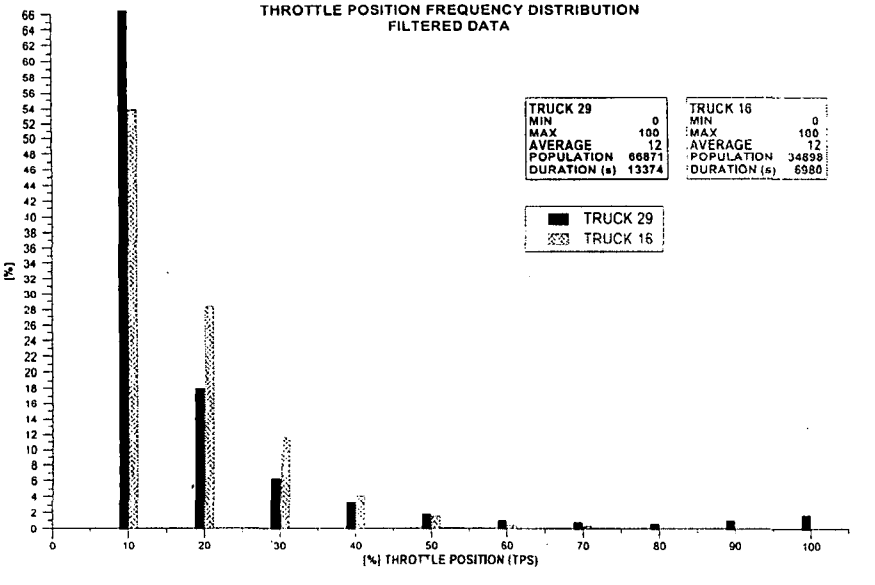

FIGURE A-6. THROTTLE POSITION FREQUENCY DISTRIBUTION, 10% RANGES, FILTERED DATA

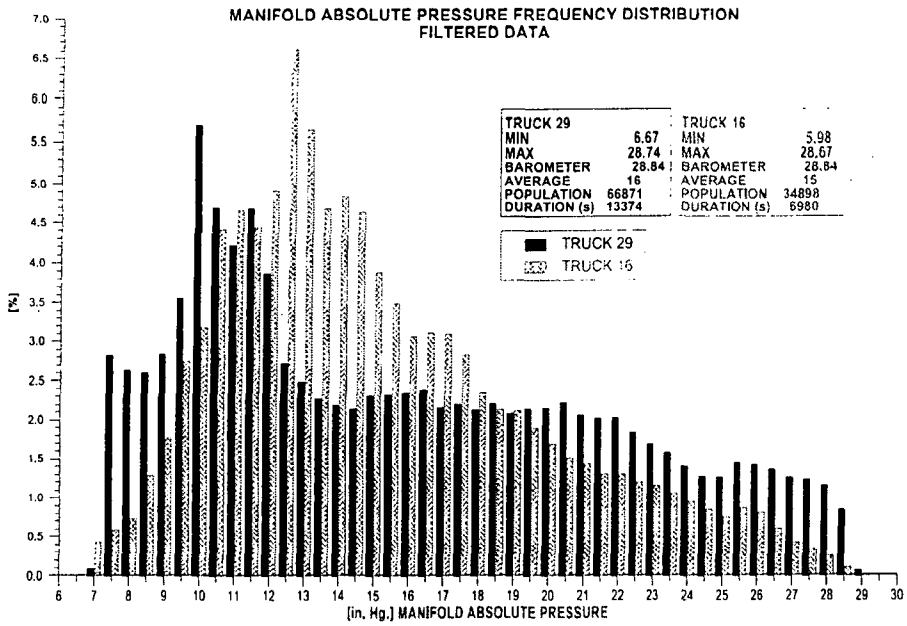

FIGURE A-7.
MANIFOLD ABSOLUTE PRESSURE FREQUENCY DISTRIBUTION, 0.5 IN. HG. RANGES, FILTERED DATA

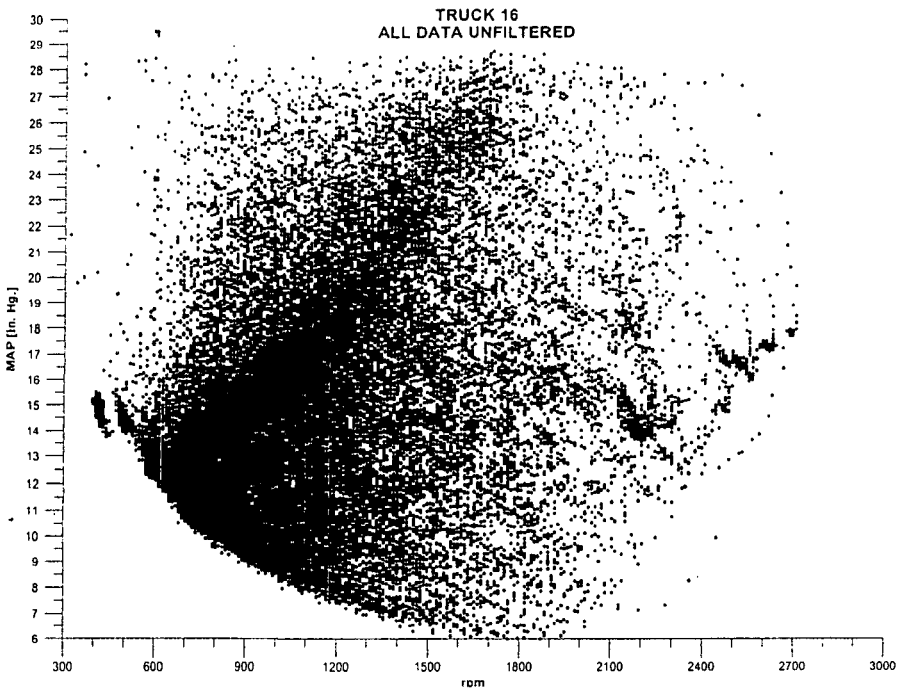

FIGURE A-8. TRUCK 16, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. ENGINE SPEED, UNFILTERED DATA

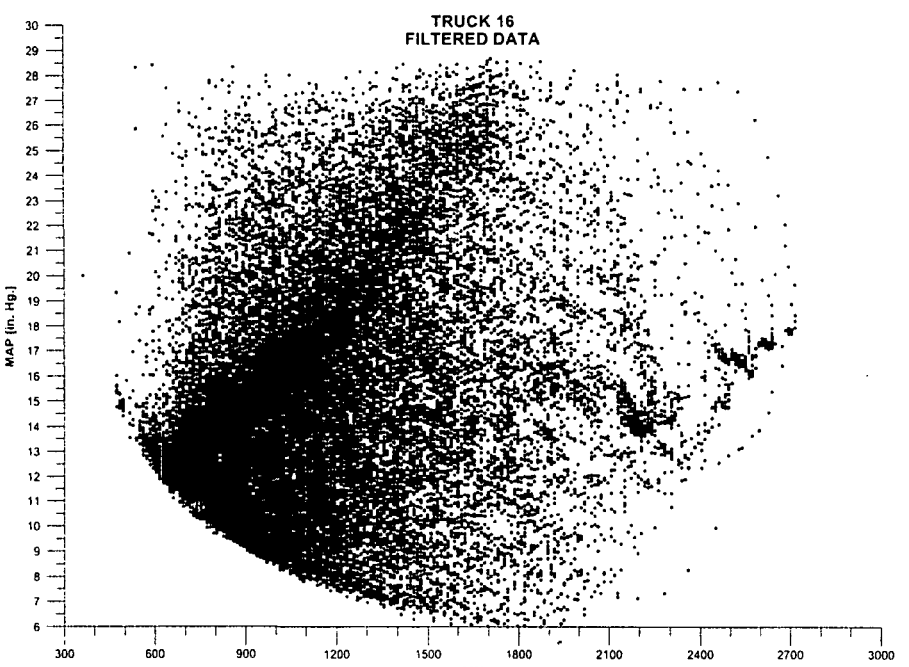

FIGURE A-9. TRUCK 16, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. ENGINE SPEED, FILTERED DATA

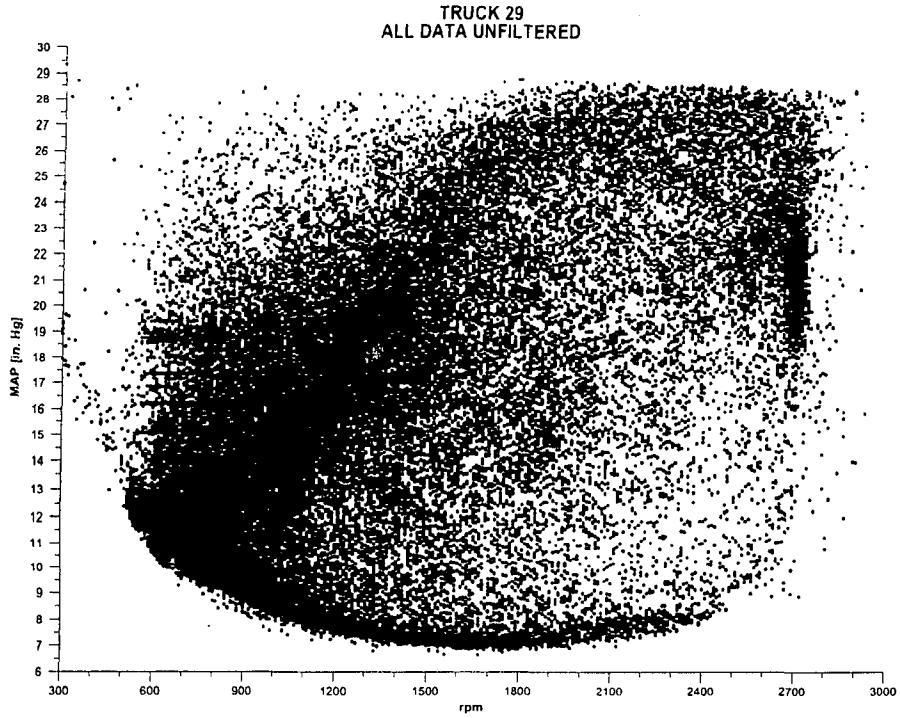

FIGURE A-10. TRUCK 29, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. ENGINE SPEED, UNFILTERED DATA

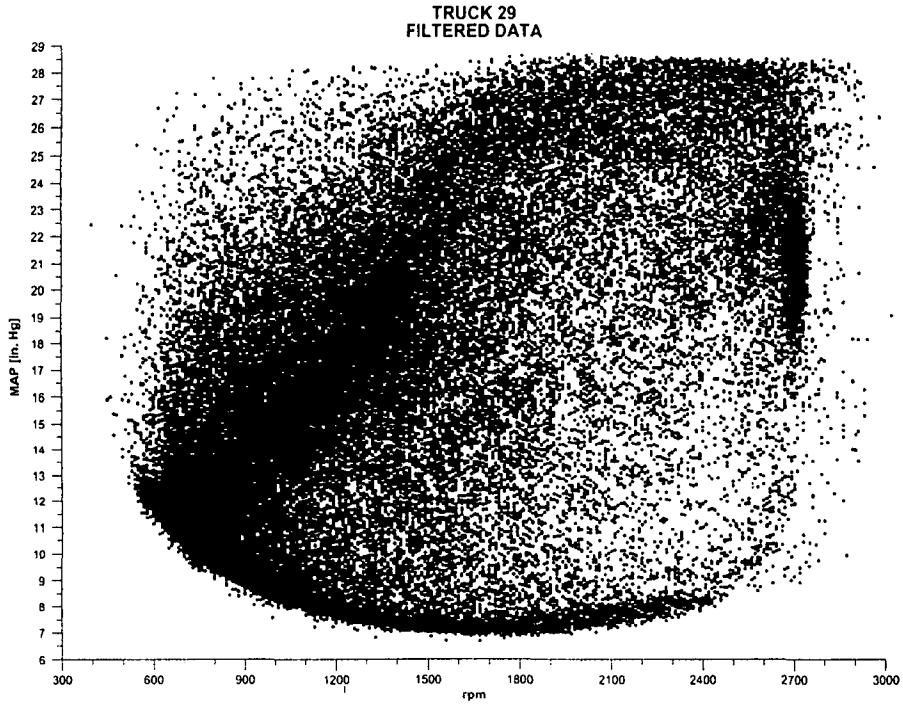

FIGURE A-11. TRUCK 29, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. ENGINE SPEED, FILTERED DATA

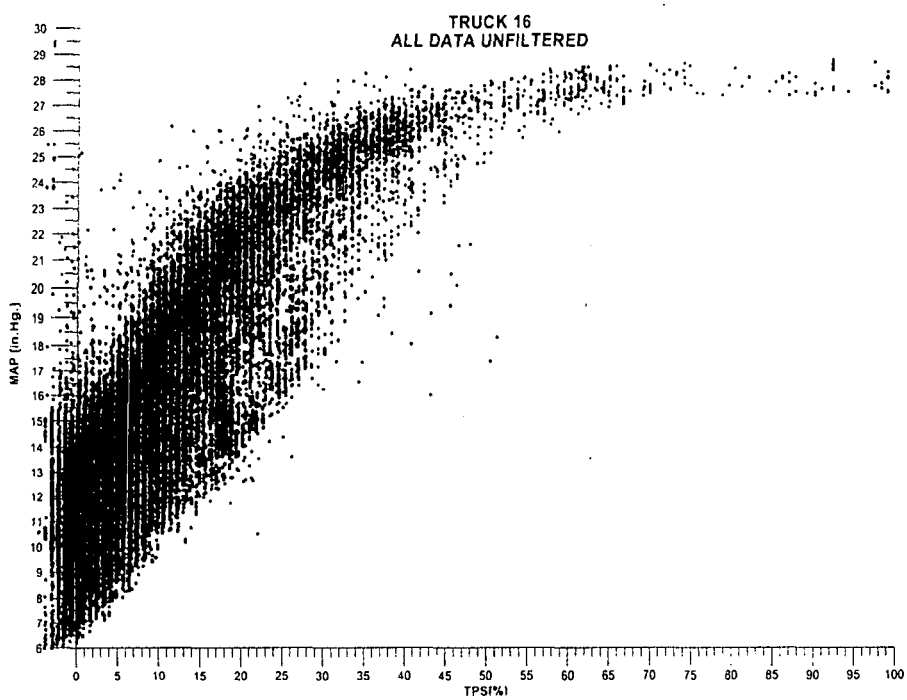

FIGURE A-12. TRUCK 16, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. THROTTLE POSITION, UNFILTERED DATA

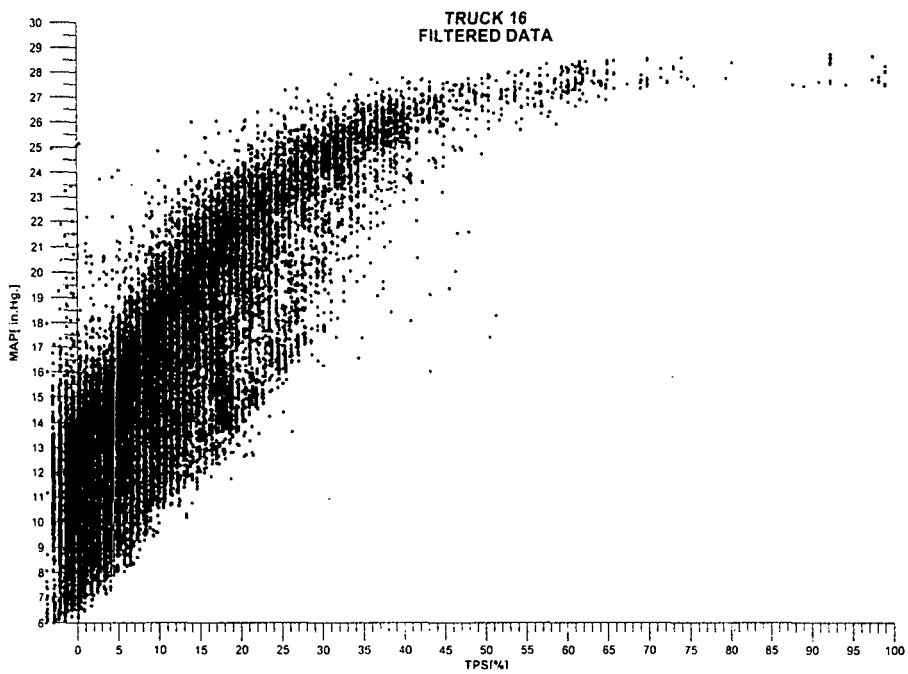

FIGURE A-13. TRUCK 16, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. THROTTLE POSITION, FILTERED DATA

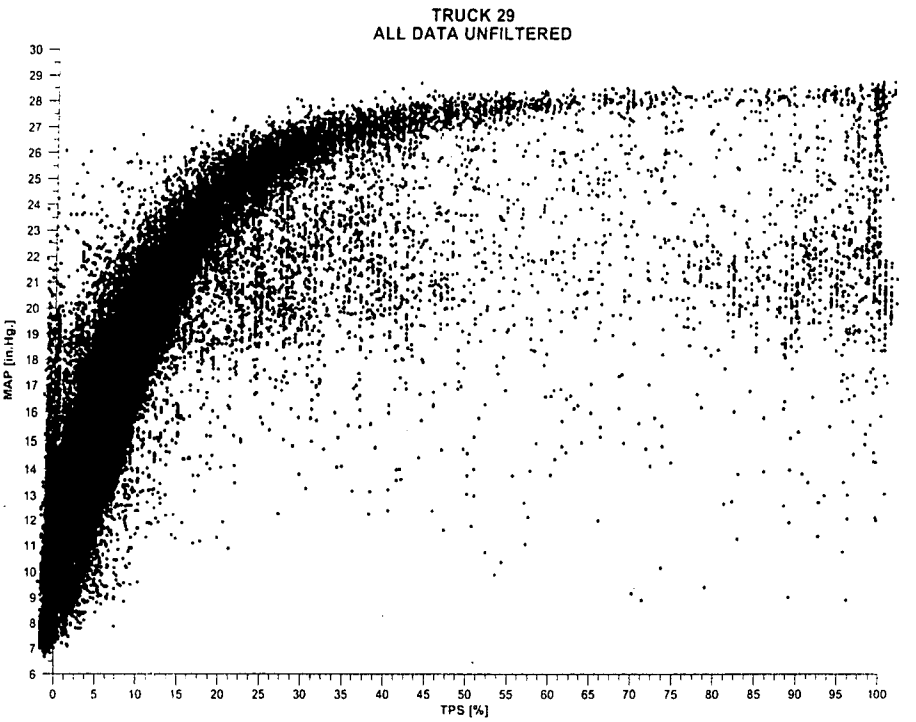

FIGURE A-14. TRUCK 29, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. THROTTLE POSITION, UNFILTERED DATA

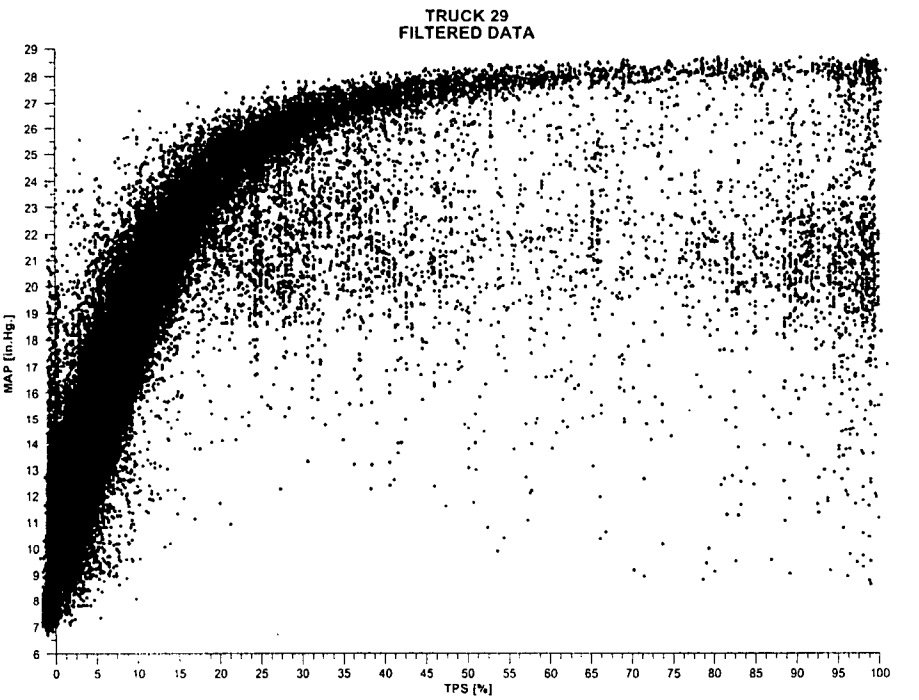

FIGURE A-15. TRUCK 29, SCATTER PLOT MANIFOLD ABSOLUTE PRESSURE vs. THROTTLE POSITION, FILTERED DATA

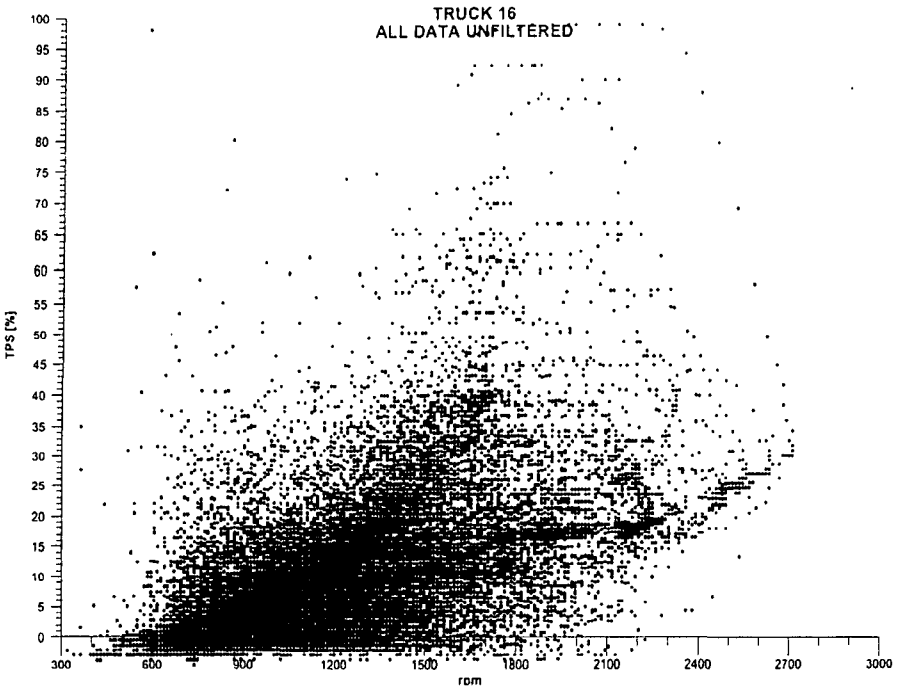

FIGURE A-16. TRUCK 16, SCATTER PLOT THROTTLE POSITION vs. ENGINE SPEED UNFILTERED DATA

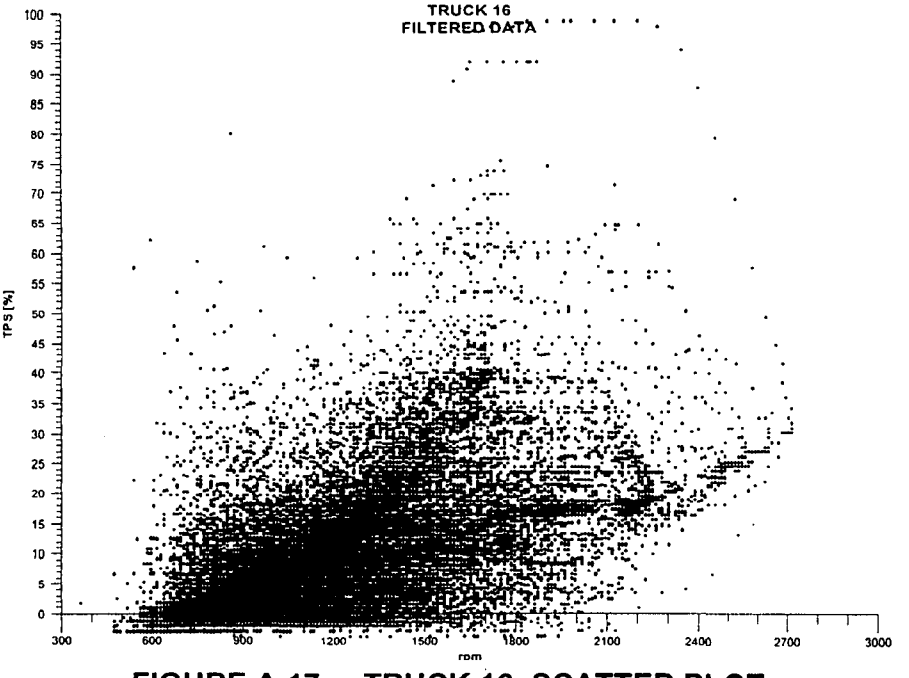

FIGURE A-17. TRUCK 16, SCATTER PLOT THROTTLE POSITION vs. ENGINE SPEED FILTERED DATA

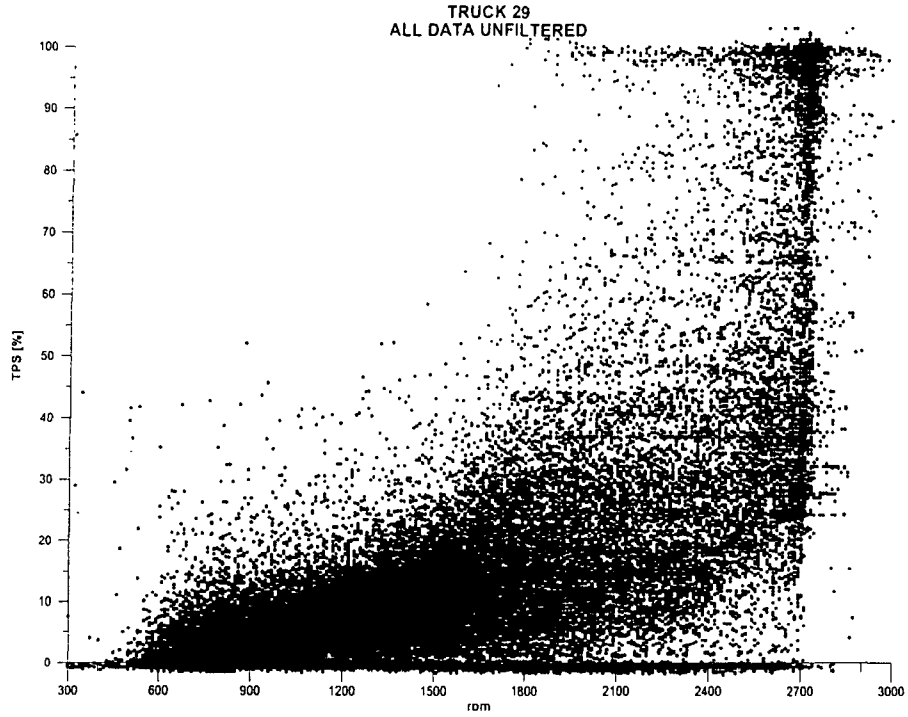

FIGURE A-18. TRUCK 29, SCATTER PLOT THROTTLE POSITION vs. ENGINE SPEED UNFILTERED DATA

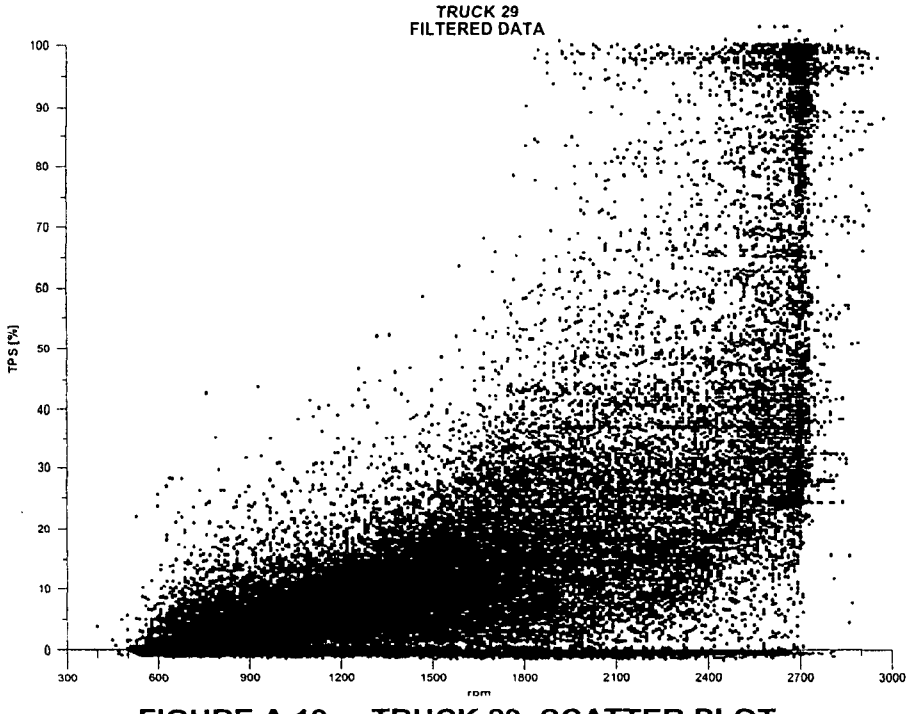

FIGURE A-19. TRUCK 29, SCATTER PLOT THROTTLE POSITION vs. ENGINE SPEED FILTERED DATA

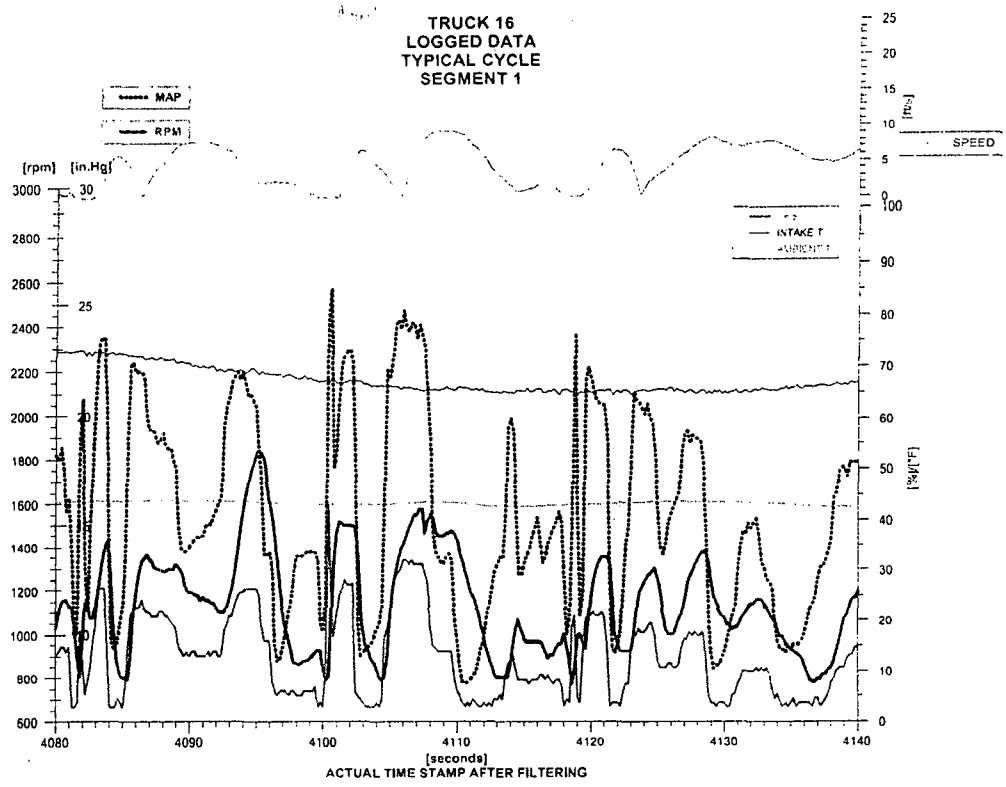

FIGURE A-20. TRUCK 16, TYPICAL CYCLE SEGMENT 1

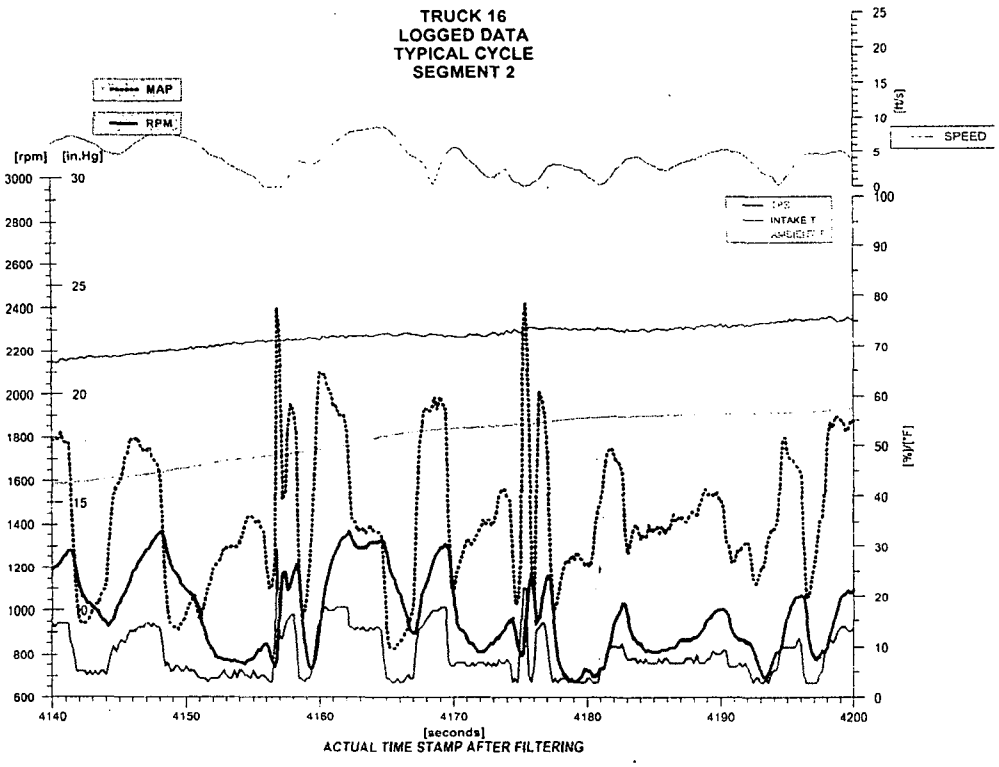

FIGURE A-21. TRUCK 16, TYPICAL CYCLE SEGMENT 2

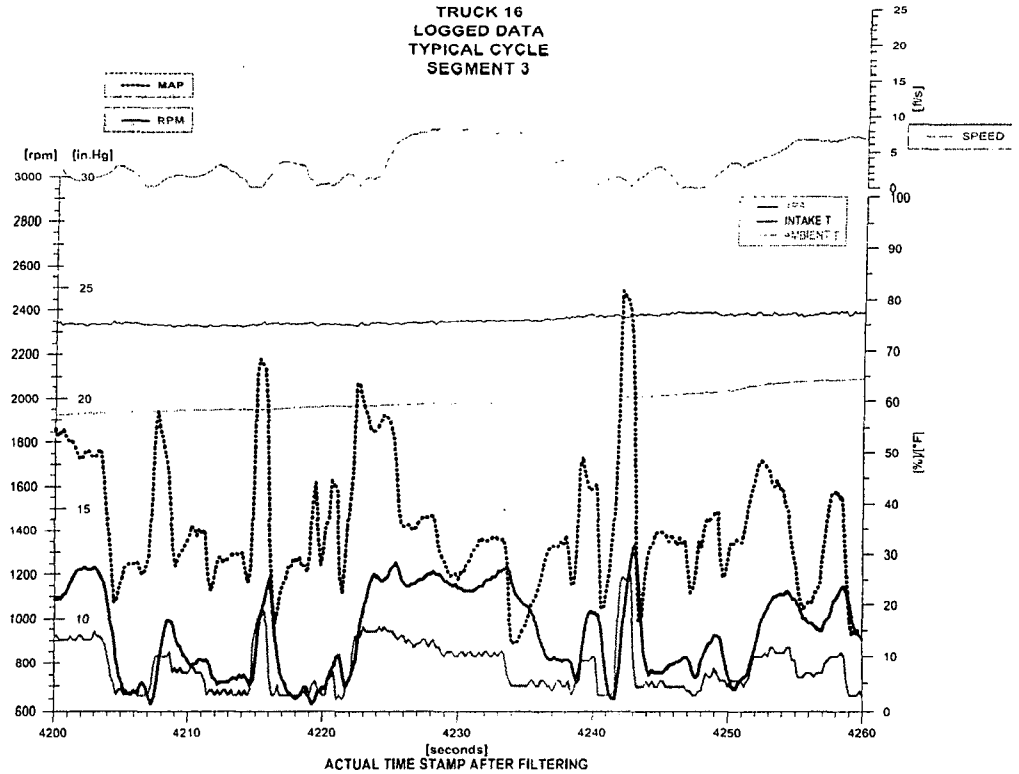

FIGURE A-22. TRUCK 16, TYPICAL CYCLE SEGMENT 3

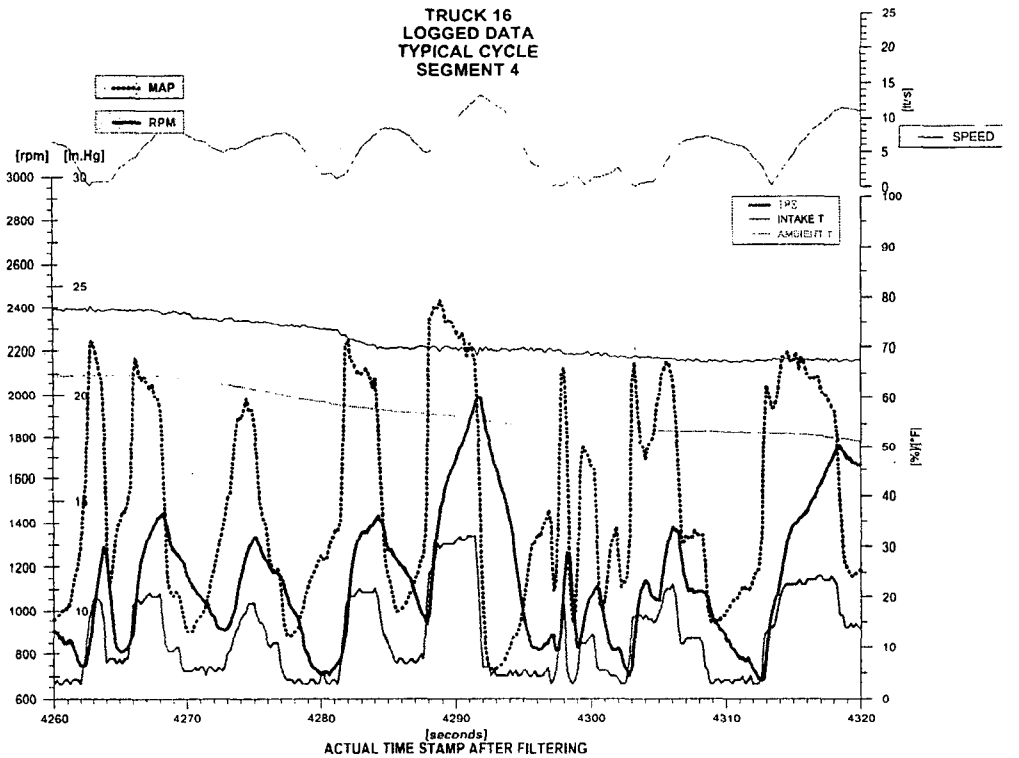

FIGURE A-23. TRUCK 16, TYPICAL CYCLE SEGMENT 4

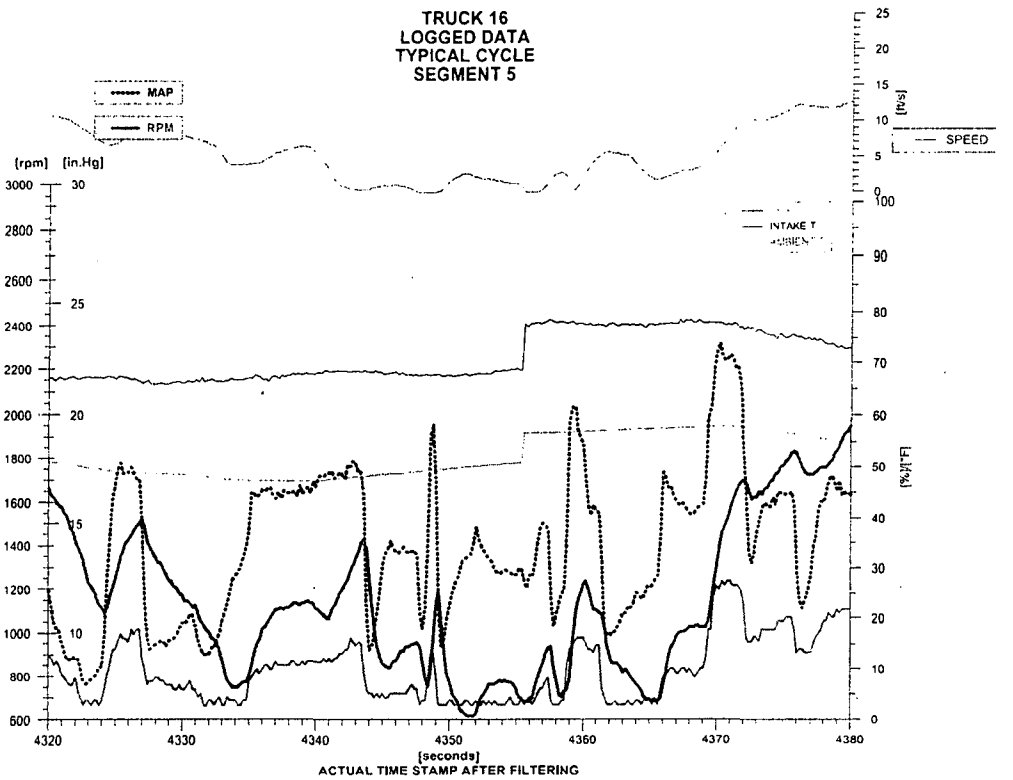

FIGURE A-24. TRUCK 16, TYPICAL CYCLE SEGMENT 5

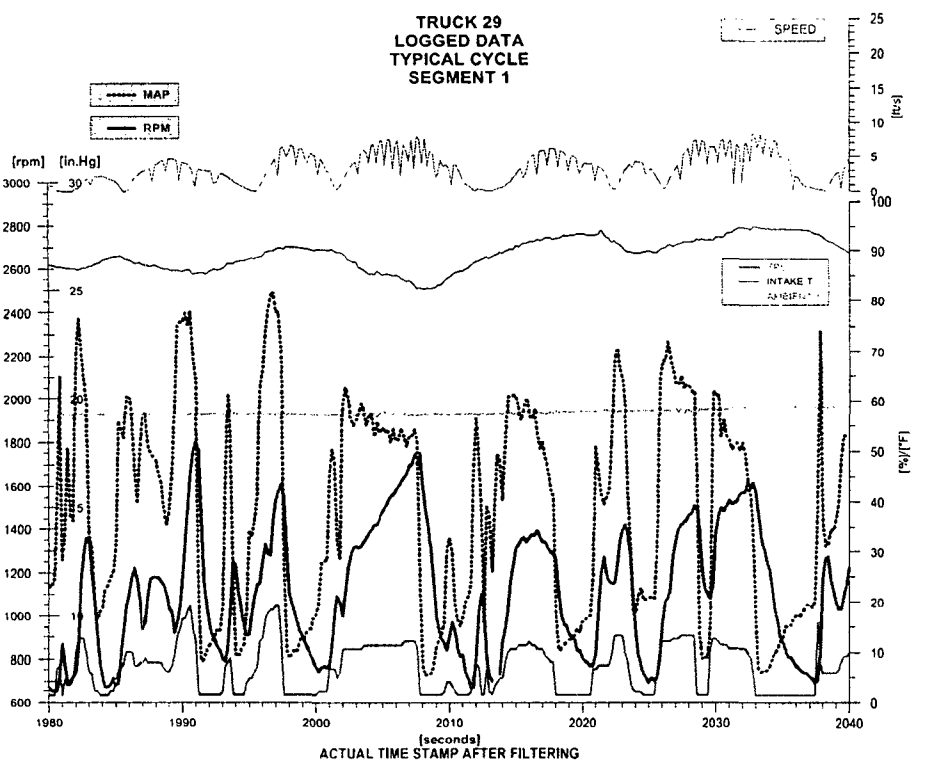

FIGURE A-25. TRUCK 29, TYPICAL CYCLE SEGMENT 1

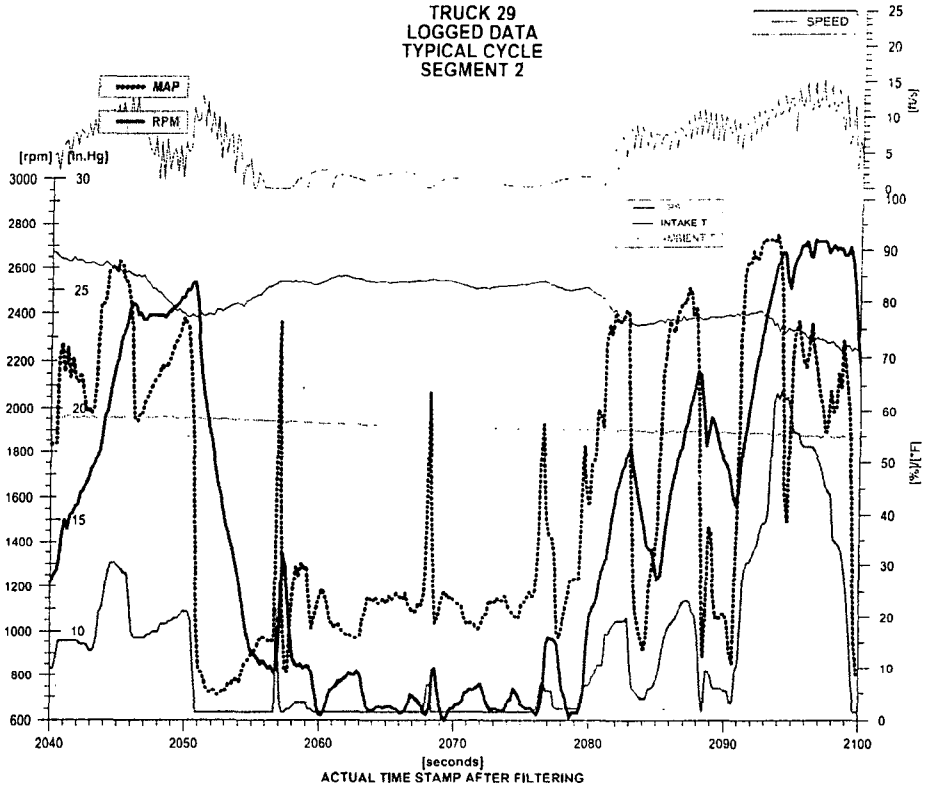

FIGURE A-26. TRUCK 29, TYPICAL CYCLE SEGMENT 2

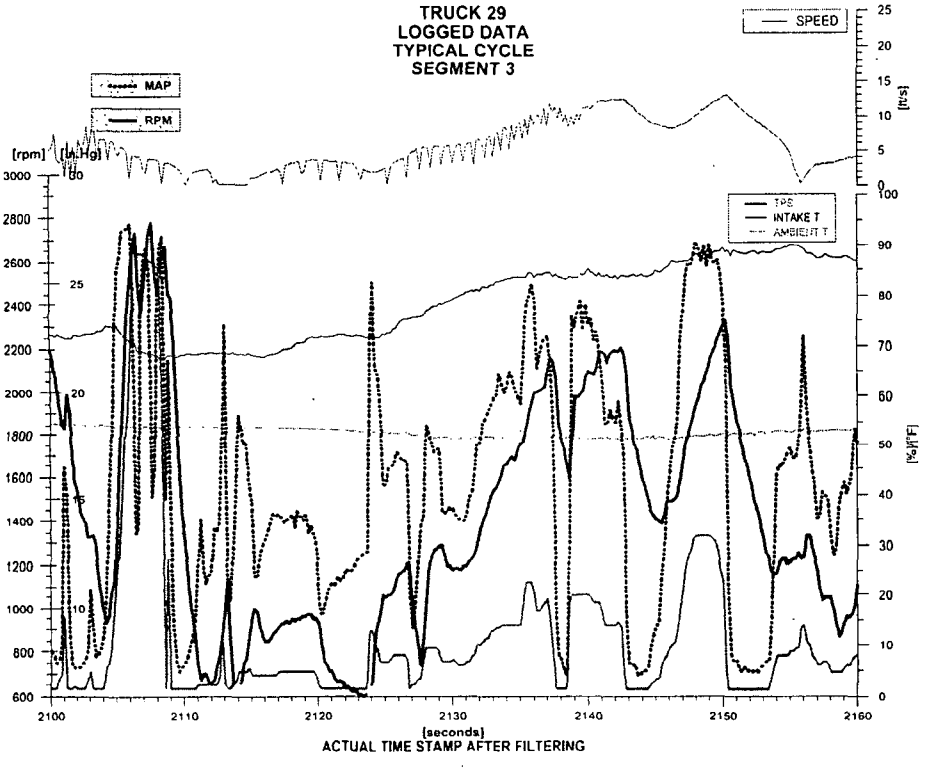

FIGURE A-27. TRUCK 29, TYPICAL CYCLE SEGMENT 3

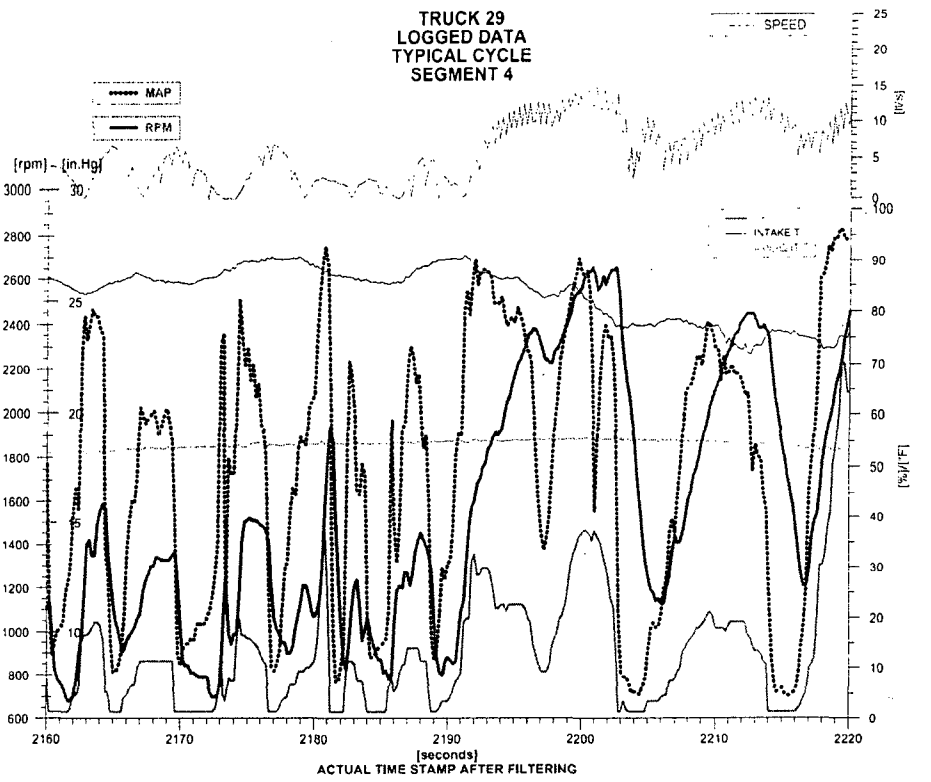

FIGURE A-28. TRUCK 29, TYPICAL CYCLE SEGMENT 4

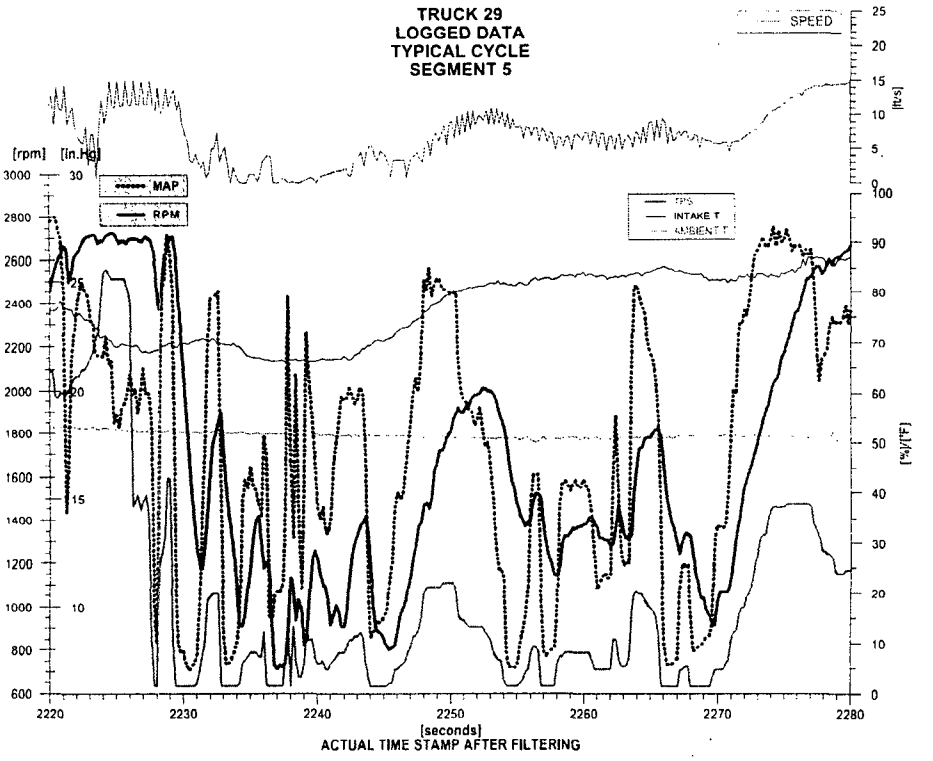

FIGURE A-29. TRUCK 29, TYPICAL CYCLE SEGMENT 5

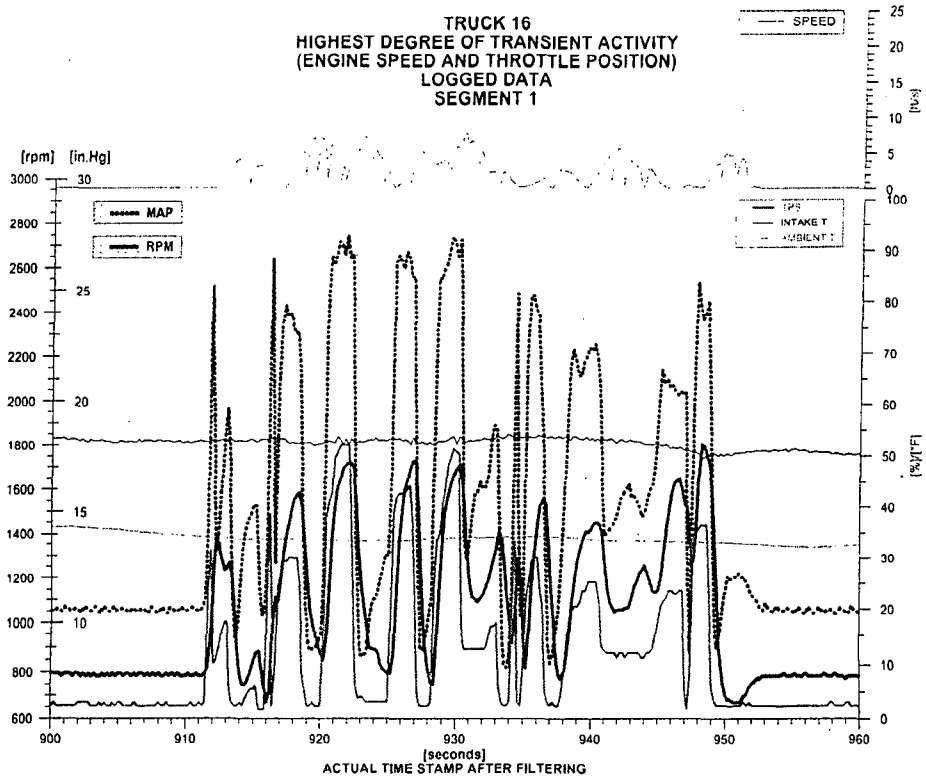

FIGURE A-30. TRUCK 16, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 1

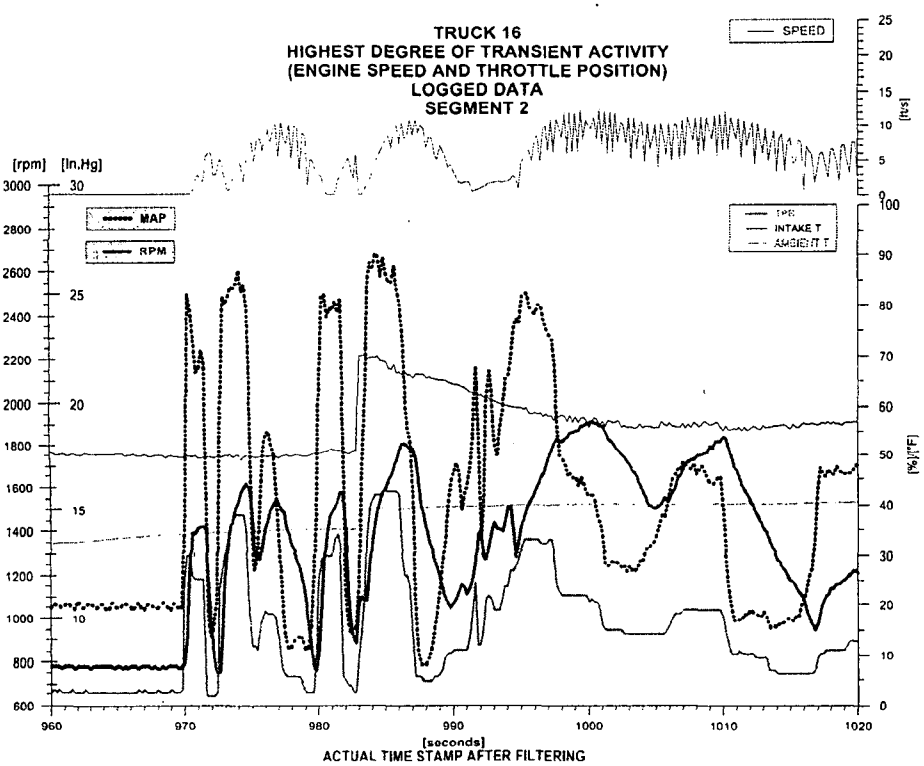

FIGURE A-31. TRUCK 16, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 2

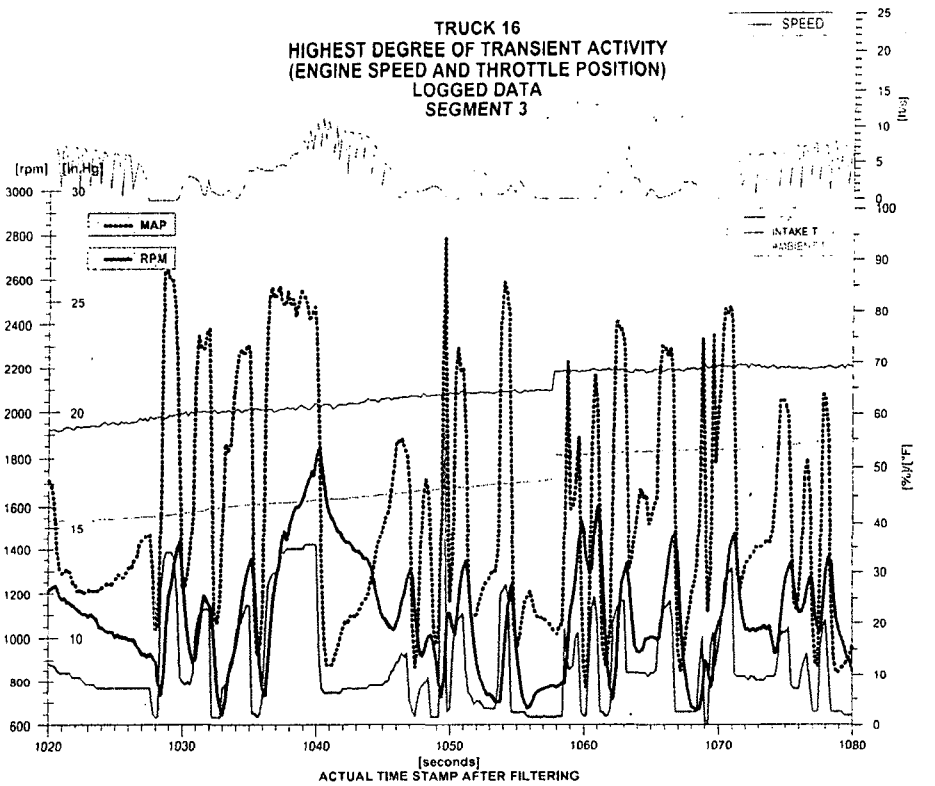

FIGURE A-32. TRUCK 16, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 3

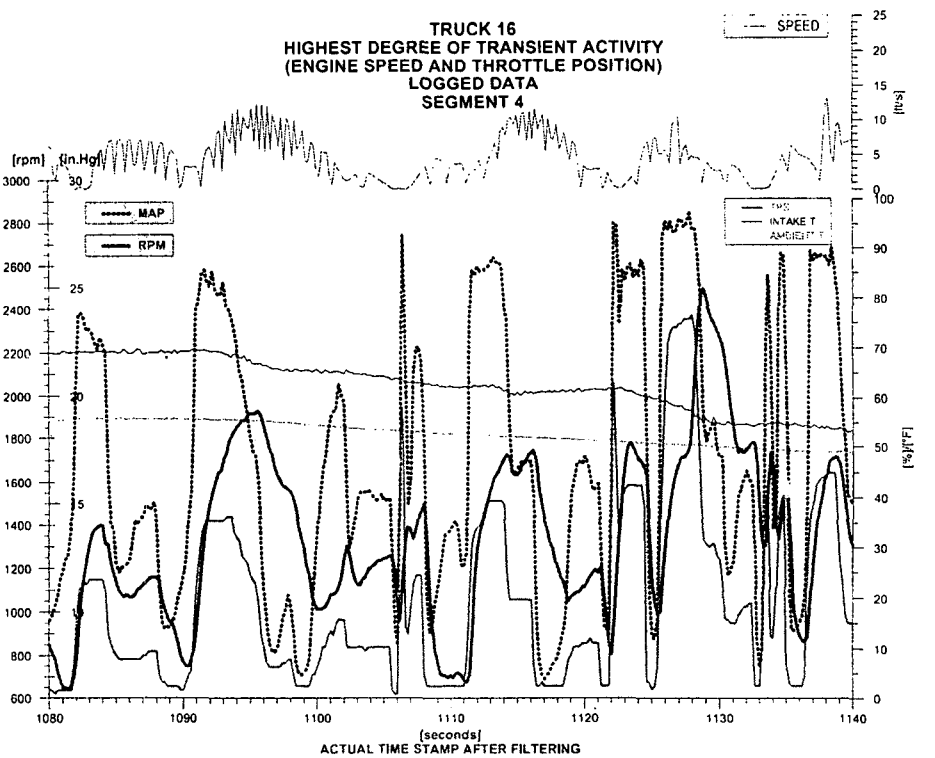

FIGURE A-33. TRUCK 16, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 4

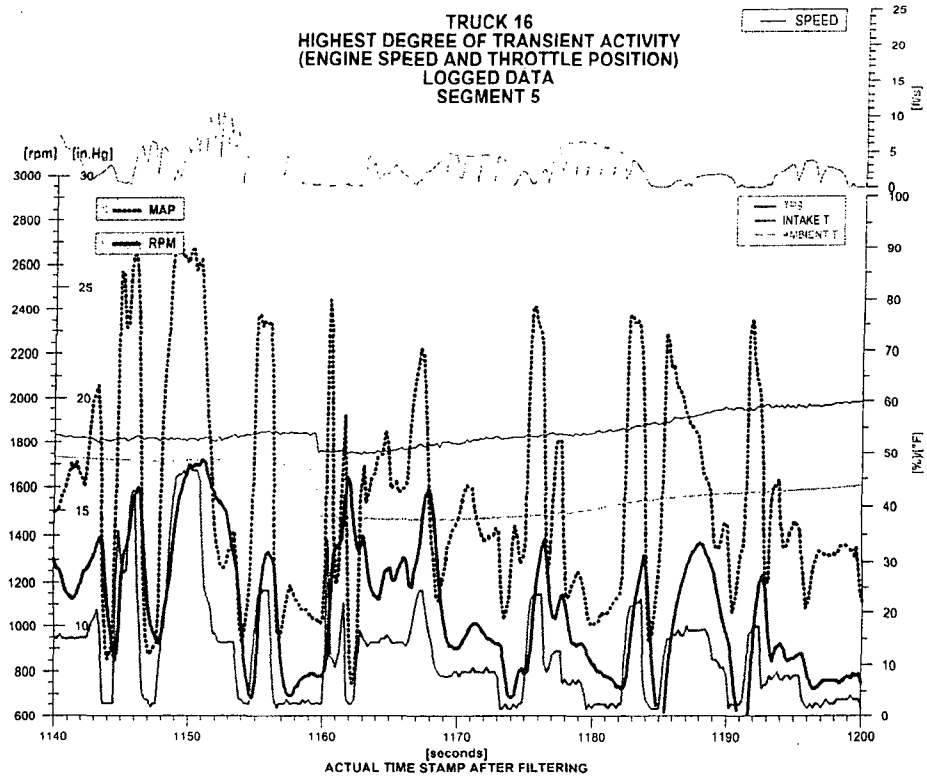

FIGURE A-34. TRUCK 16, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 5

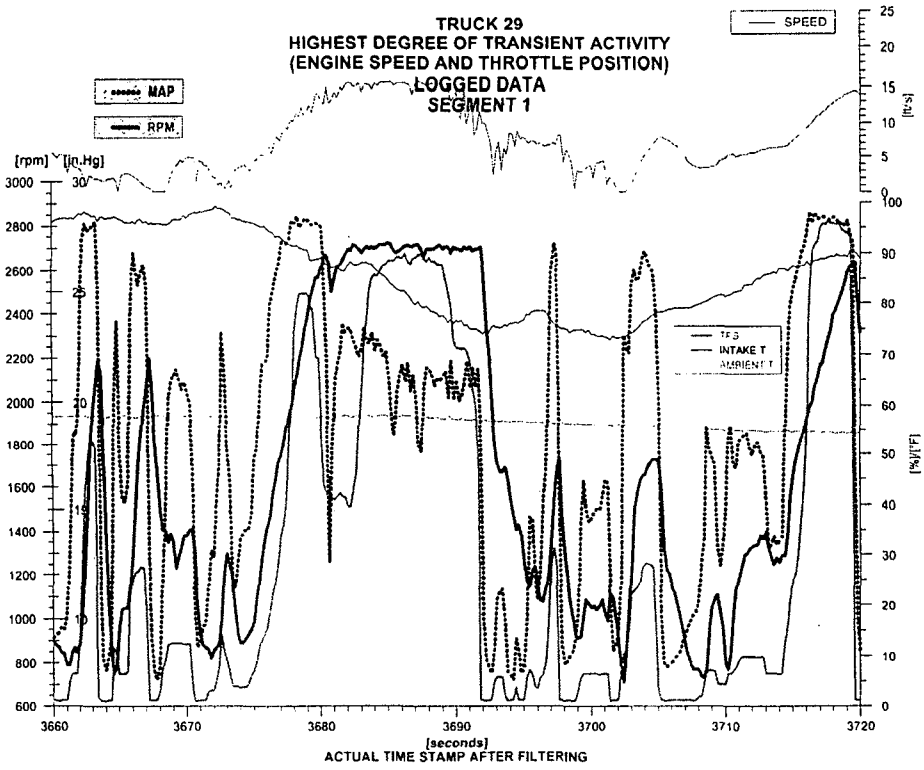

FIGURE A-35. TRUCK 29, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 1

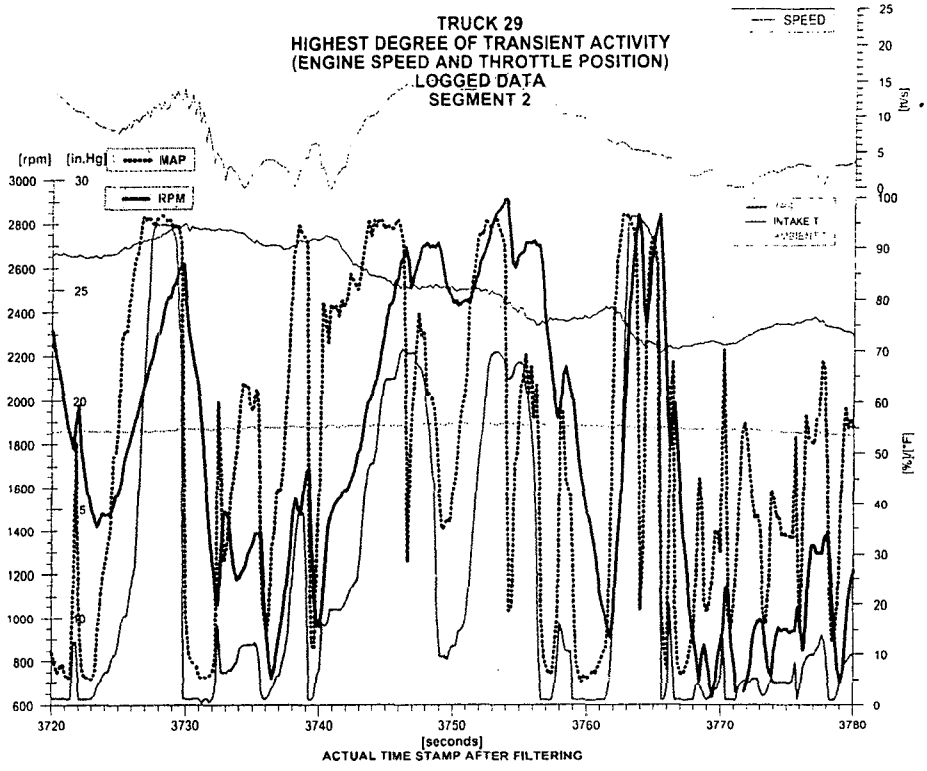

FIGURE A-36. TRUCK 29, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 2

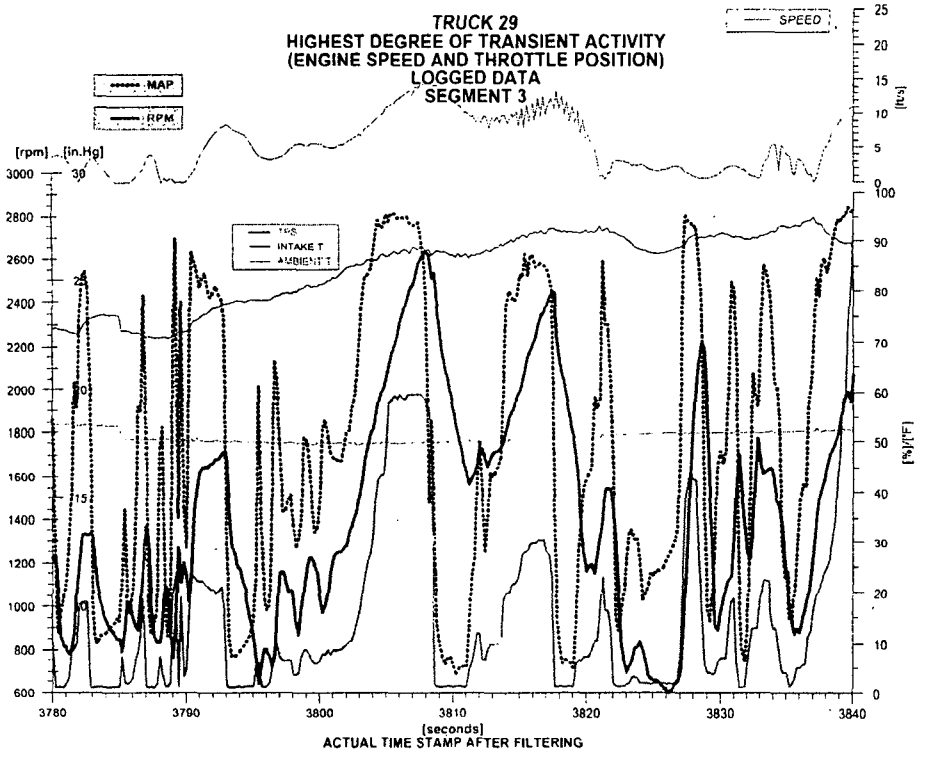

FIGURE A-37. TRUCK 29, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 3

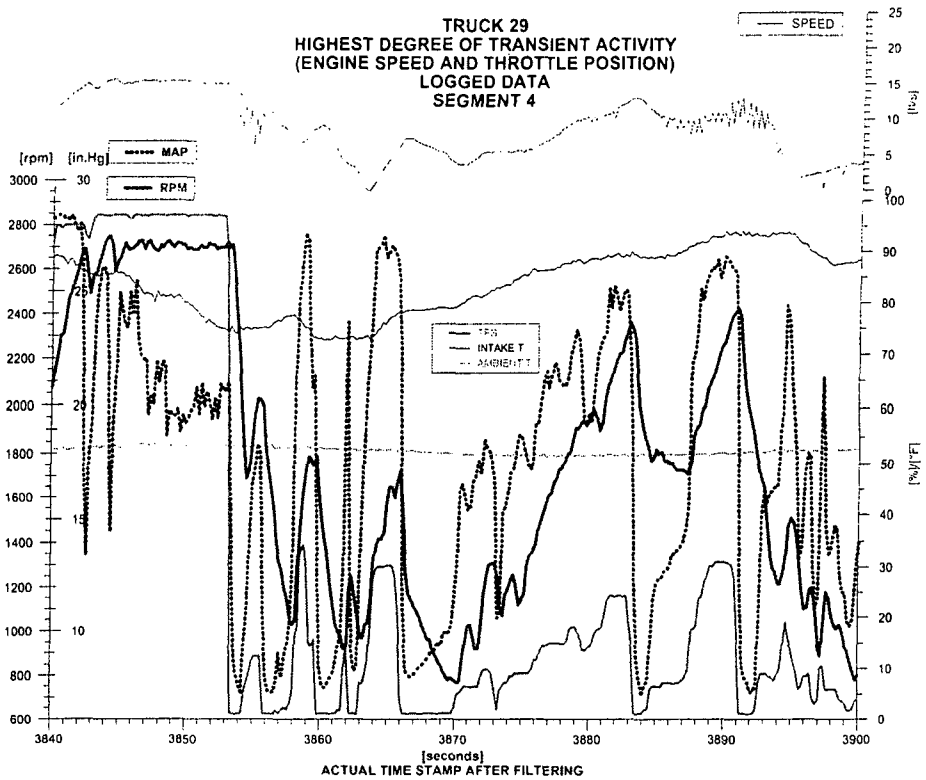

FIGURE A-38. TRUCK 29, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 4

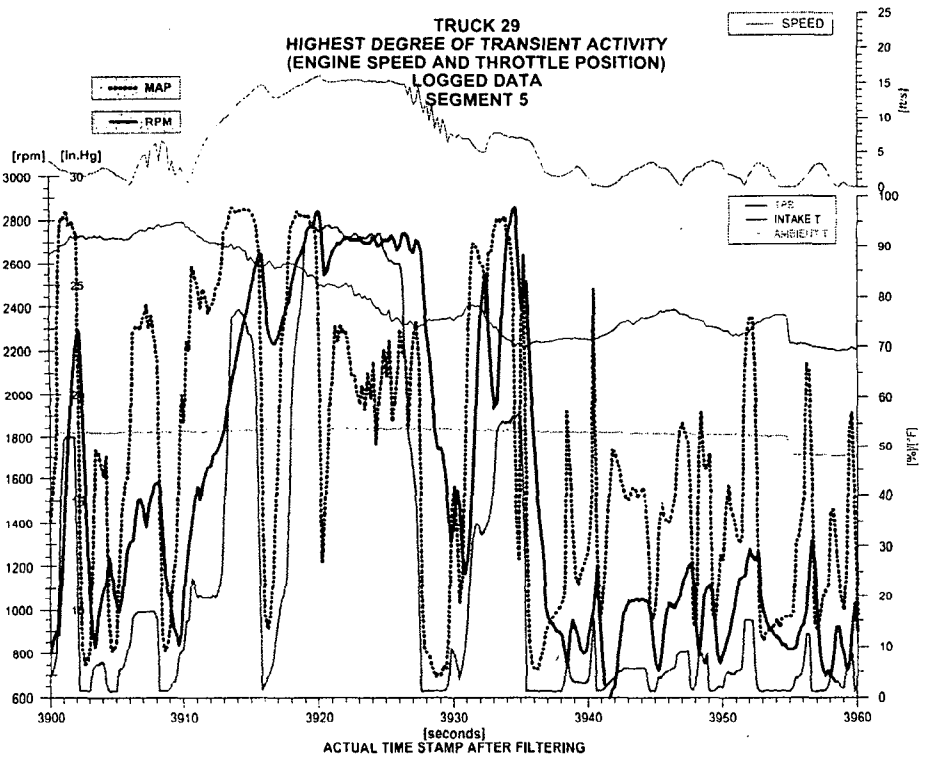

FIGURE A-39. TRUCK 29, HIGHEST DEGREE OF TRANSIENT CYCLE SEGMENT 5

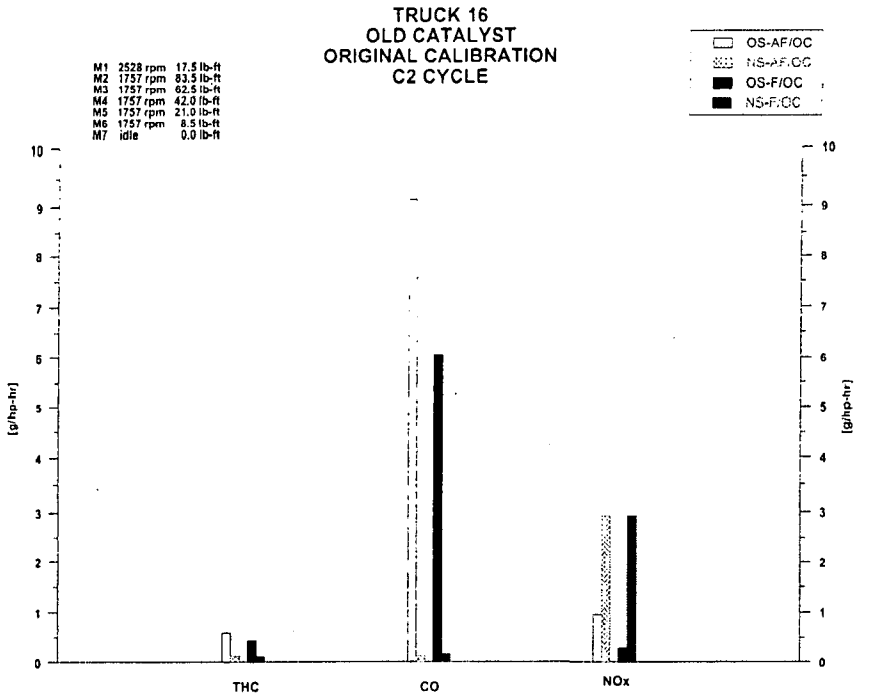

FIGURE A-40. TRUCK 16, OLD CATALYST, ORIGINAL CALIBRATION, C2 CYCLE RESULTS

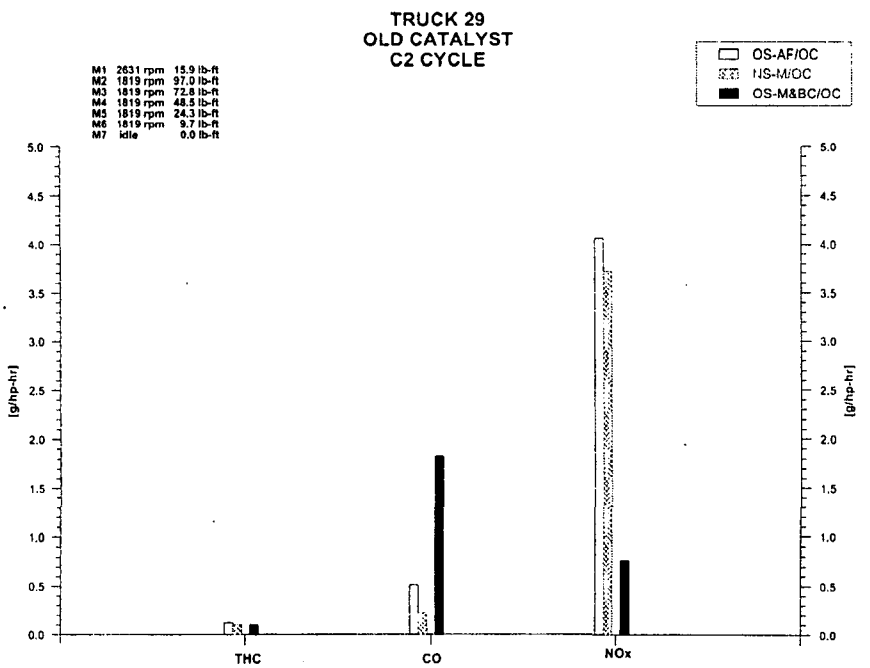

FIGURE A-41. TRUCK 29, OLD CATALYST, C2 CYCLE RESULTS

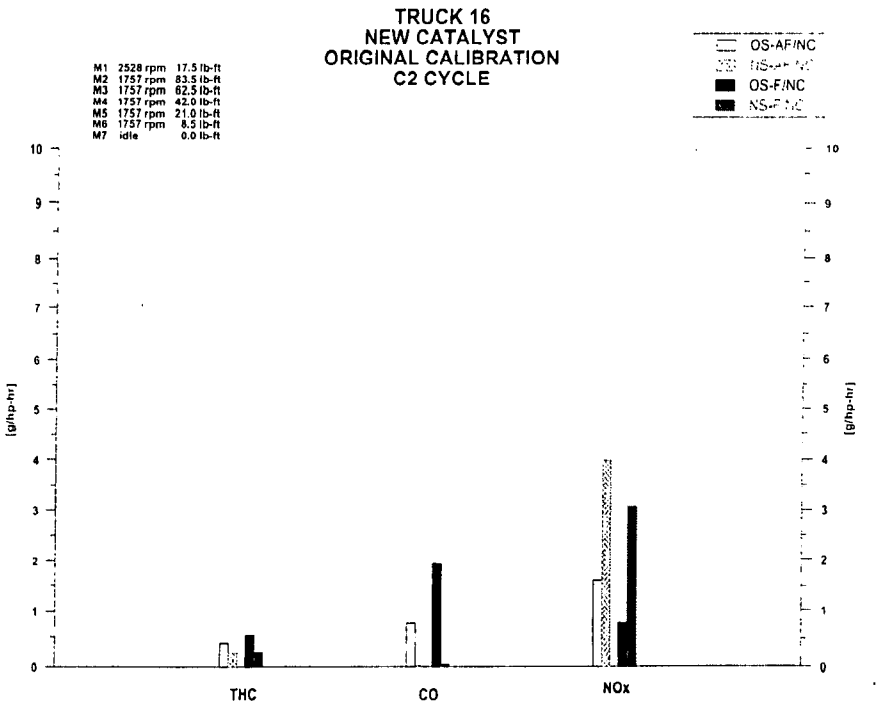

FIGURE A-42. TRUCK 16, NEW CATALYST, ORIGINAL CALIBRATION, C2 CYCLE RESULTS

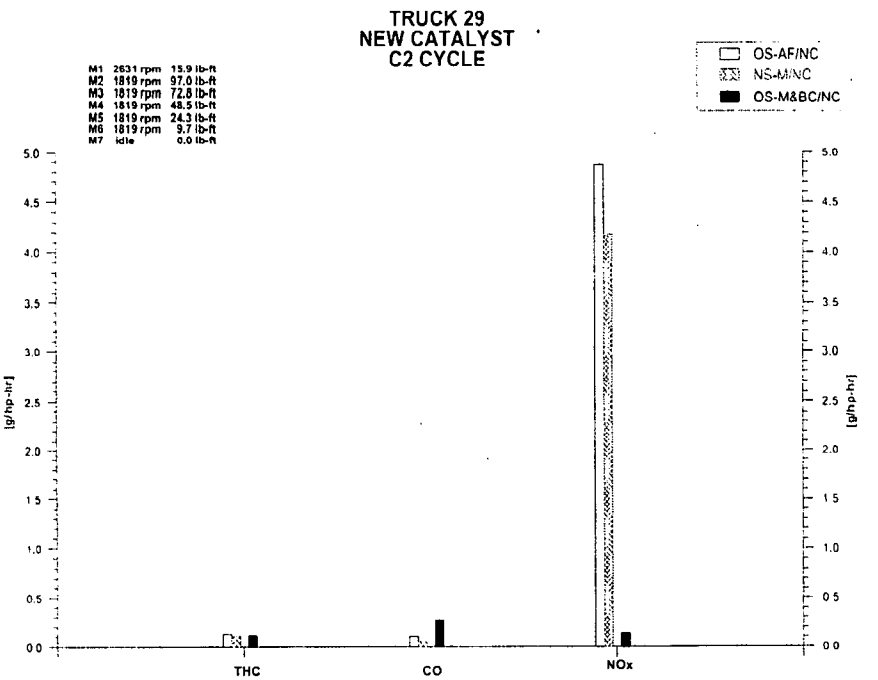

FIGURE A-43. TRUCK 29, NEW CATALYST, C2 CYCLE RESULTS

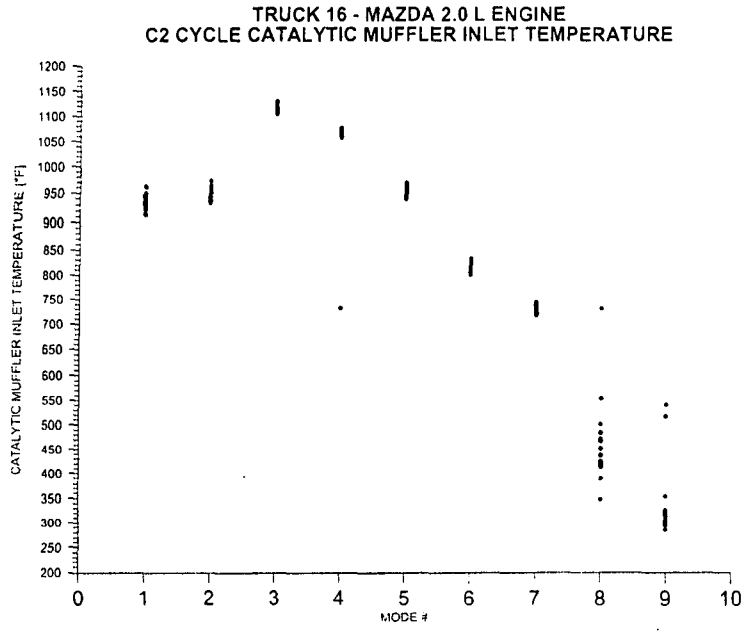

FIGURE A-44. TRUCK 16, MAZDA 2.0 L ENGINE C2 CYCLE CATALYTIC MUFFLER INLET TEMPERATURE

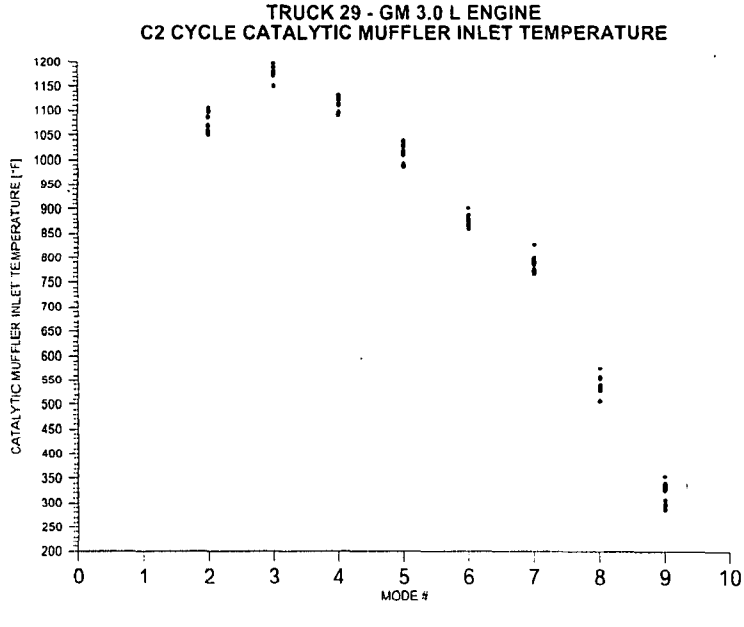

FIGURE A-45. TRUCK 29, GM 3.0L ENGINE C2 CYCLE CATALYTIC MUFFLER INLET TEMPERATURE

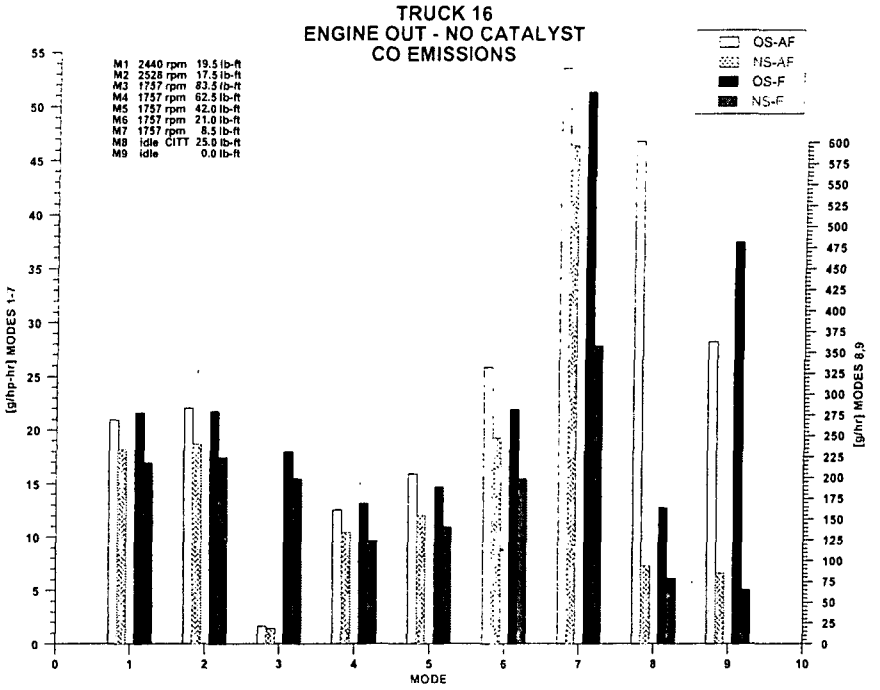

FIGURE A-46. TRUCK 16, ENGINE-OUT - NO CATALYST, ORIGINAL CALIBRATION, CO EMISSIONS RESULTS

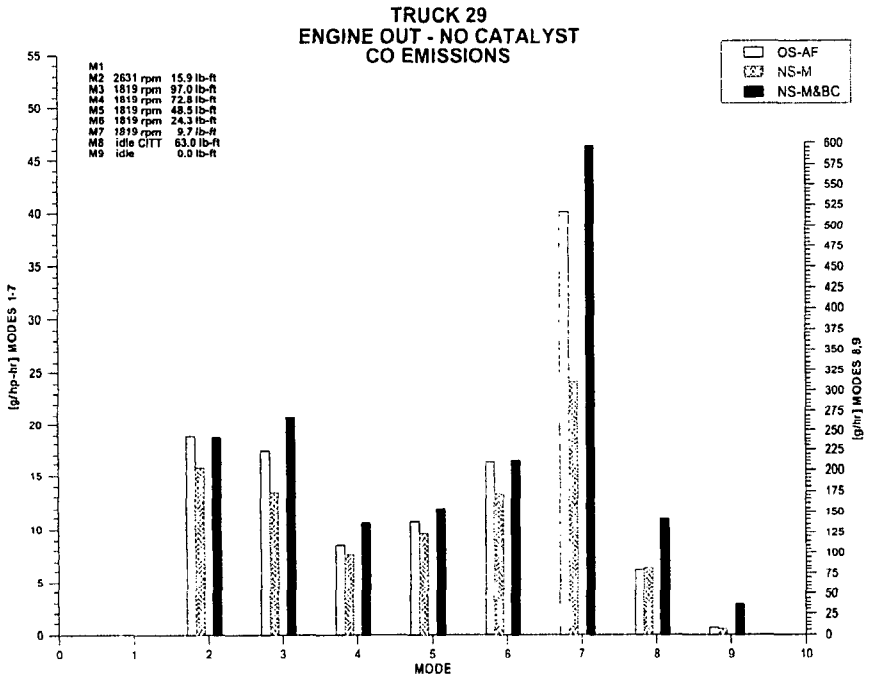

FIGURE A-47. TRUCK 29, ENGINE-OUT - NO CATALYST, CO EMISSIONS RESULTS

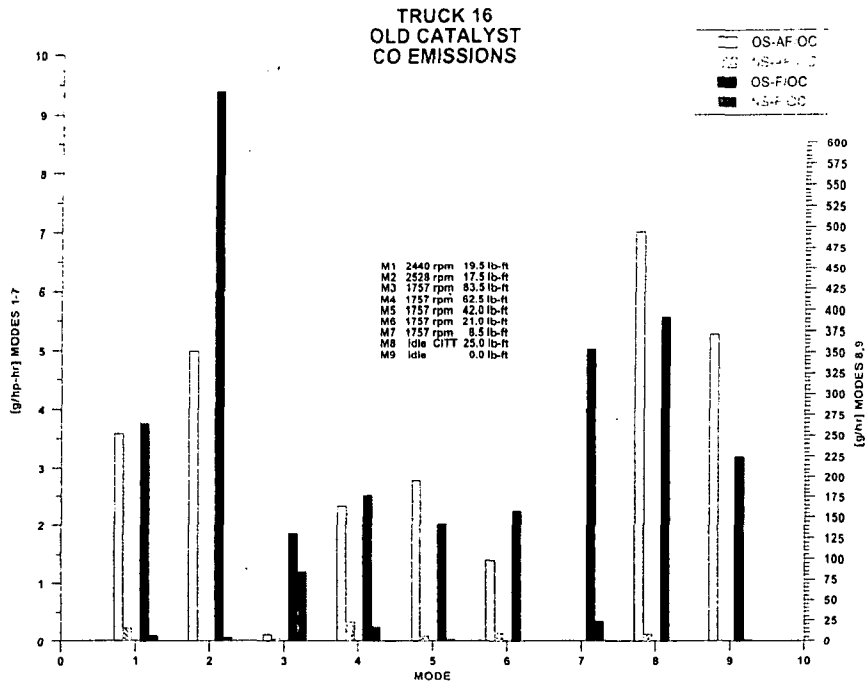

FIGURE A-48. TRUCK 16, OLD CATALYST, ORIGINAL CALIBRATION, CO EMISSIONS RESULTS

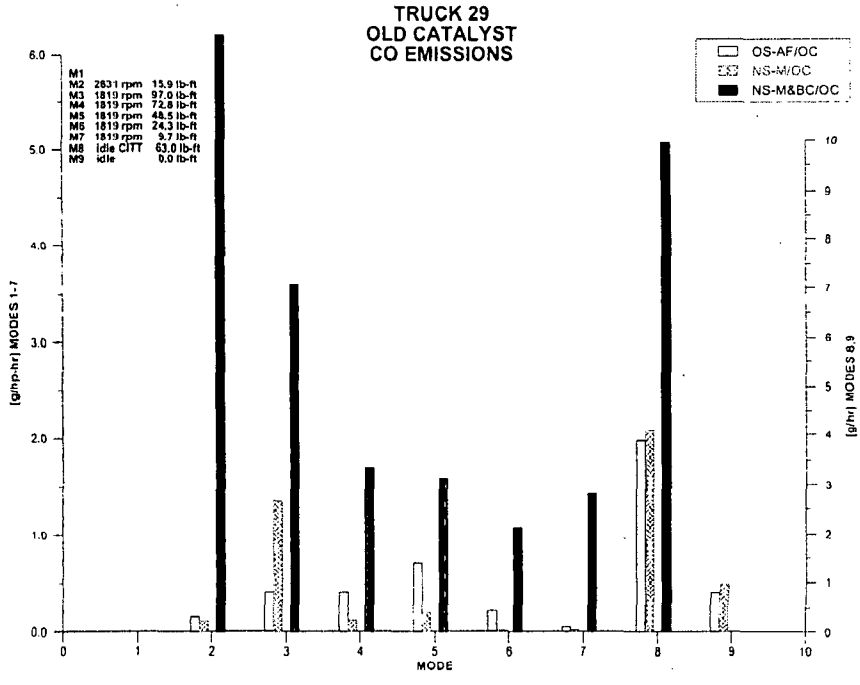

FIGURE A-49. TRUCK 29, OLD CATALYST, CO EMISSIONS RESULTS

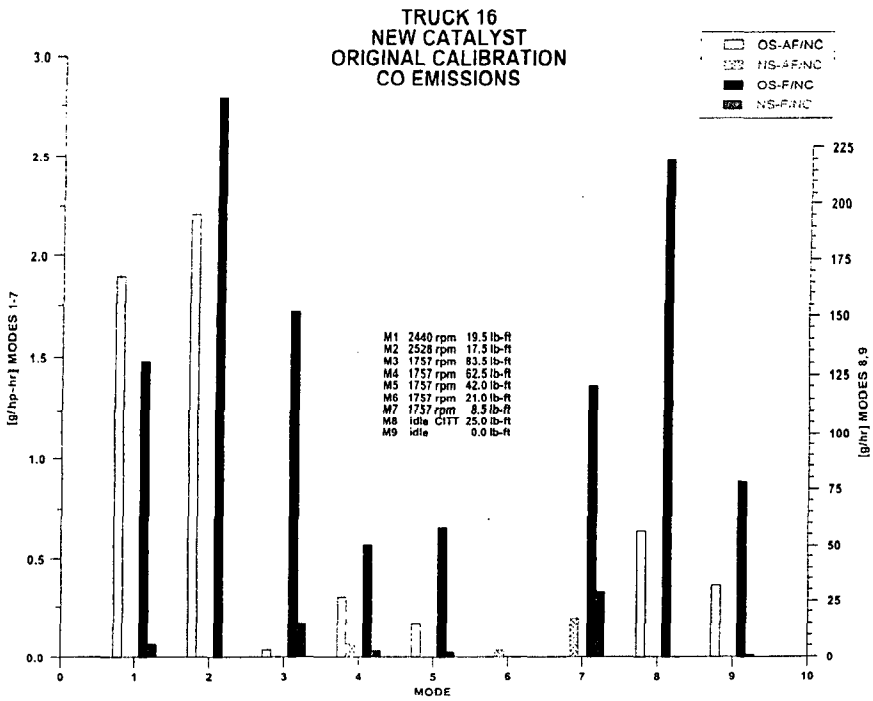

FIGURE A-50. TRUCK 16, NEW CATALYST, ORIGINAL CALIBRATION, CO EMISSIONS RESULTS

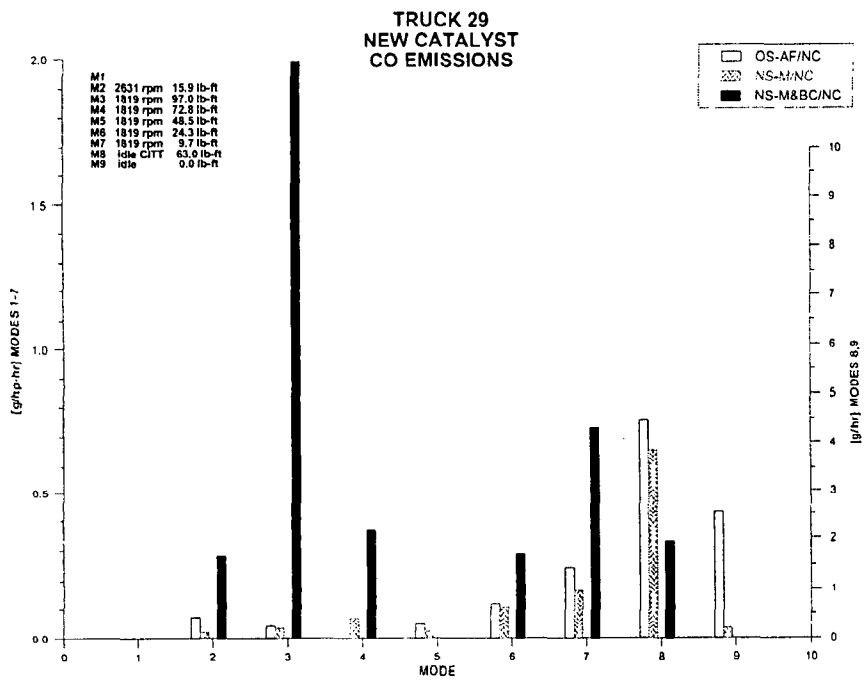

FIGURE A-51. TRUCK 29, NEW CATALYST, CO EMISSIONS RESULTS

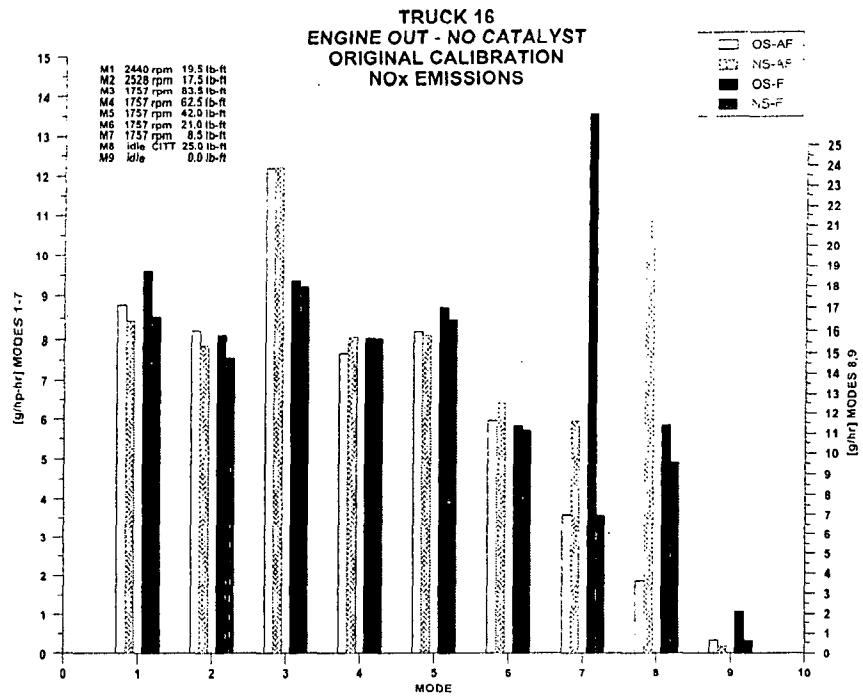

FIGURE A-52. TRUCK 16, ENGINE-OUT - NO CATALYST, ORIGINAL CALIBRATION, NO_X EMISSIONS RESULTS

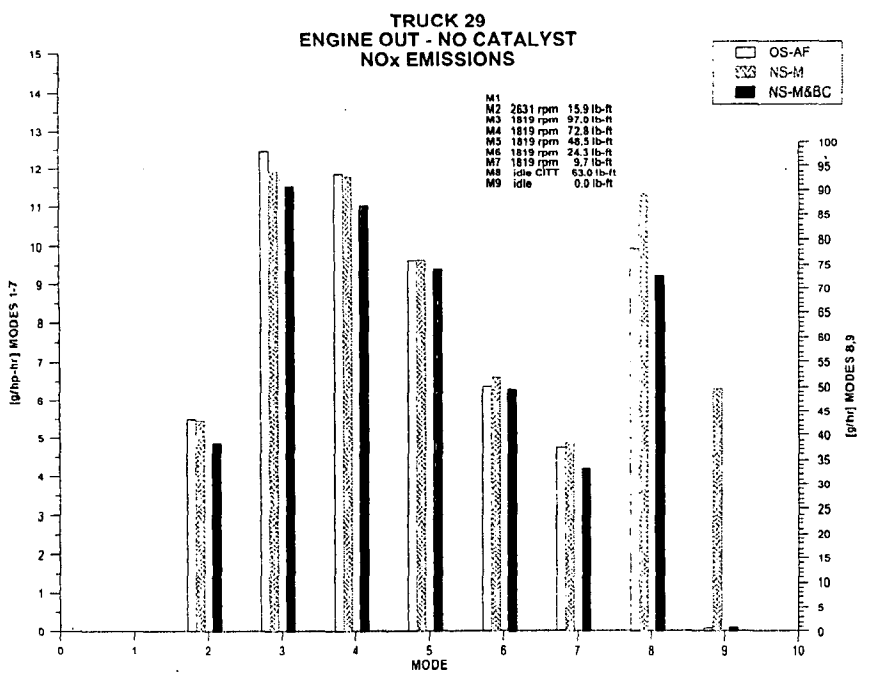

FIGURE A-53. TRUCK 29, ENGINE-OUT - NO CATALYST, NO_X EMISSIONS RESULTS

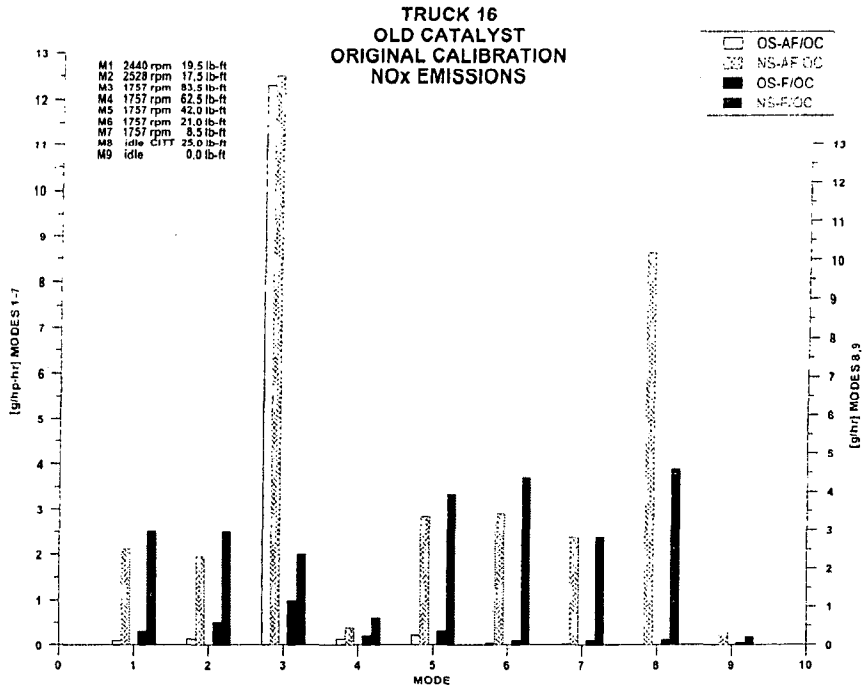

FIGURE A-54. TRUCK 16, OLD CATALYST, ORIGINAL CALIBRATION, NO_X EMISSIONS RESULTS

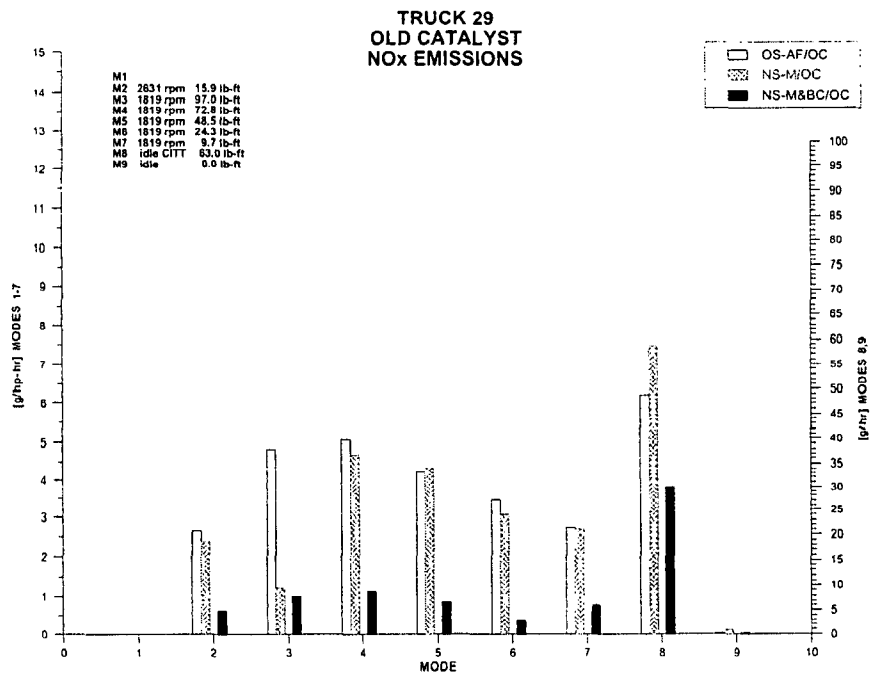

FIGURE A-55. TRUCK 29, OLD CATALYST, NO_X EMISSIONS RESULTS

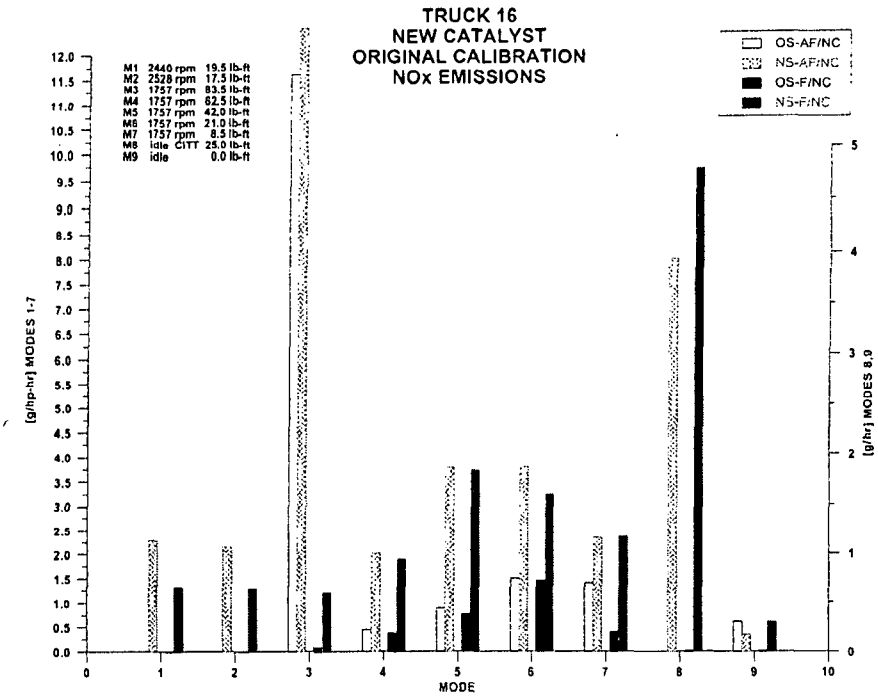

FIGURE A-56. TRUCK 16, NEW CATALYST, ORIGINAL CALIBRATION, NO_X EMISSIONS RESULTS

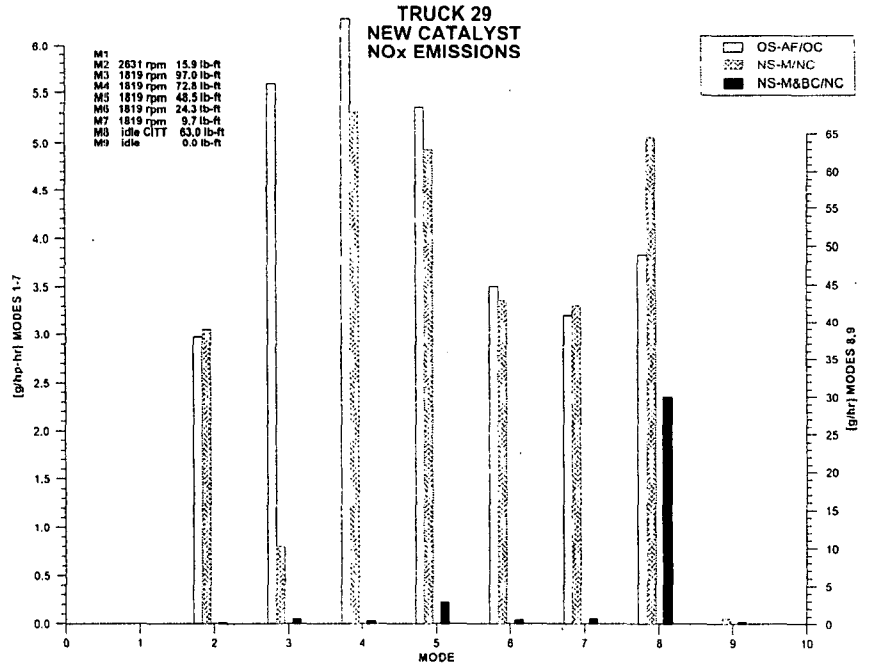

FIGURE A-57. TRUCK 29, NEW CATALYST, NO_X EMISSIONS RESULTS

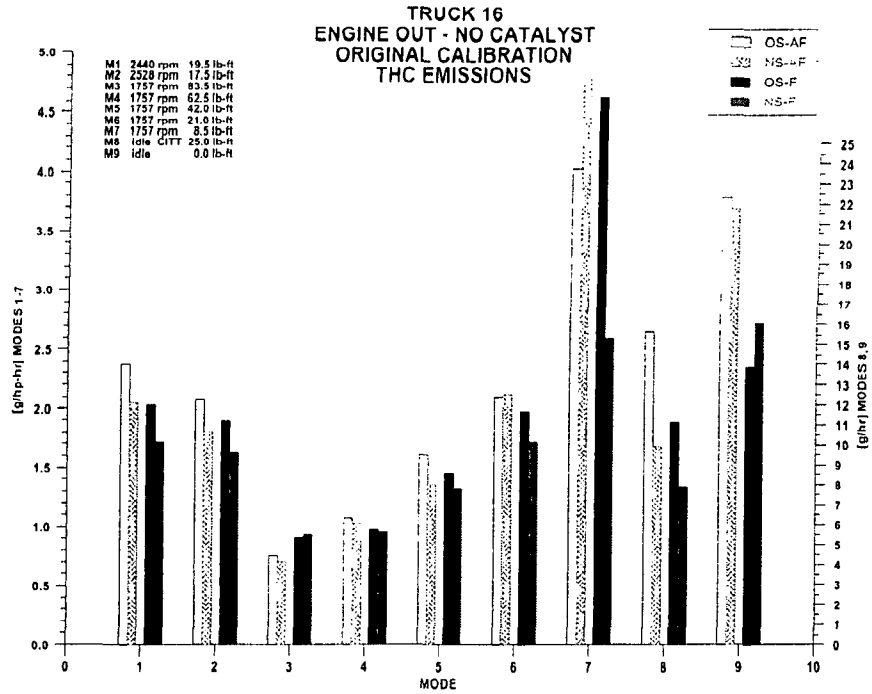

FIGURE A-58. TRUCK 16, ENGINE-OUT - NO CATALYST, ORIGINAL CALIBRATION, THC EMISSIONS RESULTS

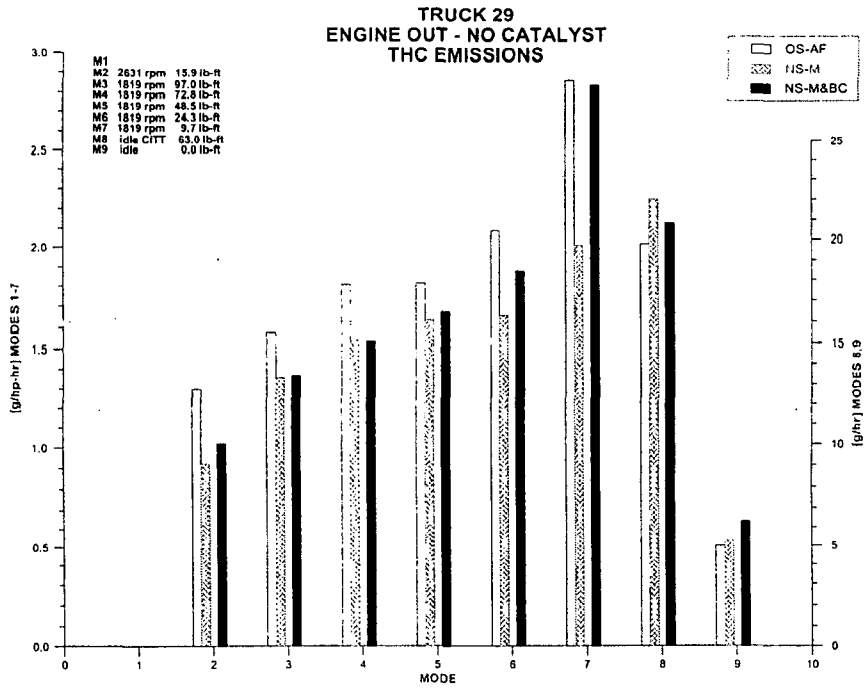

FIGURE A-59. TRUCK 29, ENGINE-OUT - NO CATALYST, THC EMISSIONS RESULTS

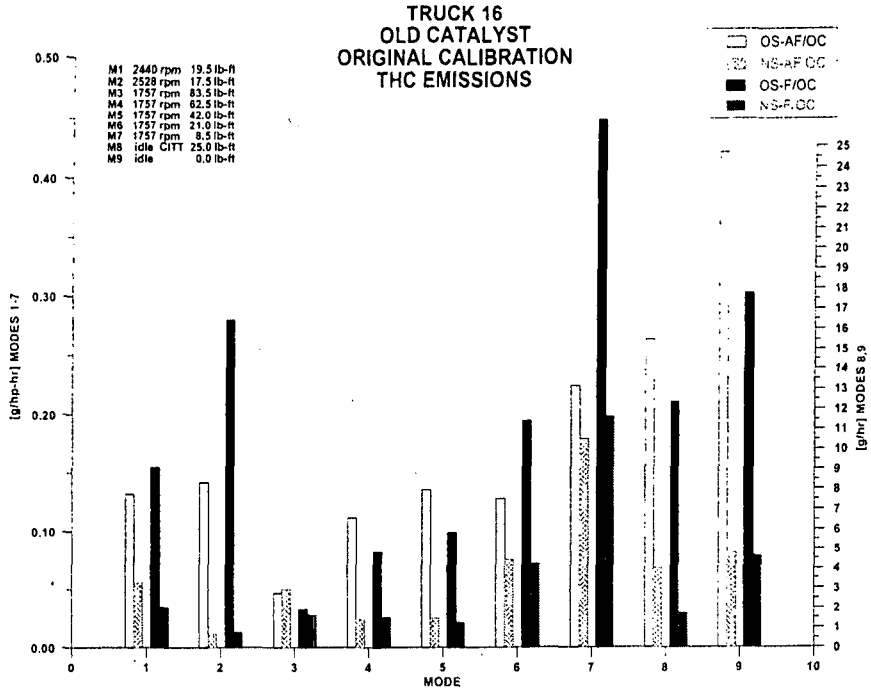

FIGURE A-60. TRUCK 16, OLD CATALYST, ORIGINAL CALIBRATION, THC EMISSIONS RESULTS

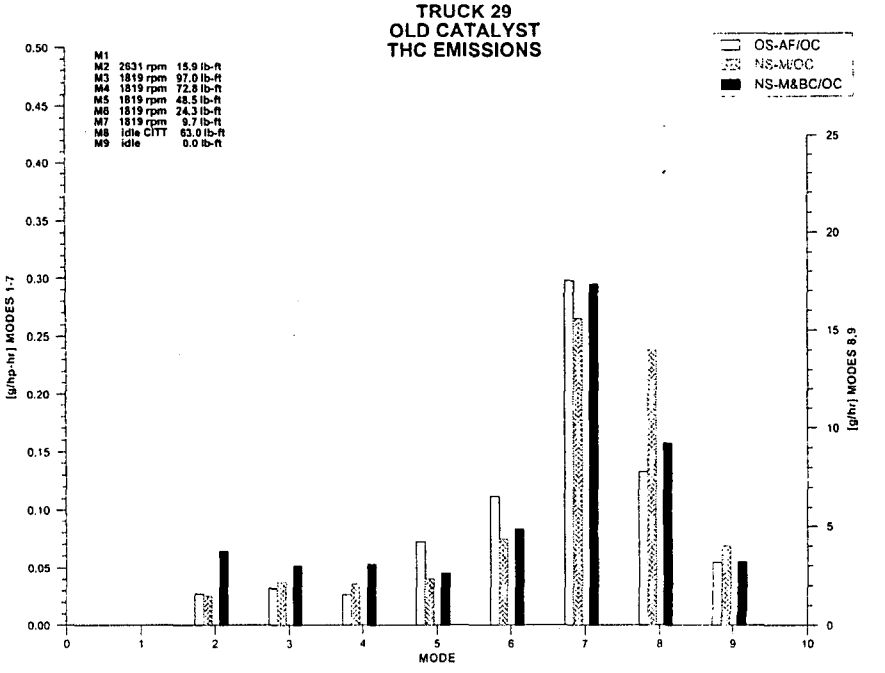

FIGURE A-61. TRUCK 29, OLD CATALYST, THC EMISSIONS RESULTS

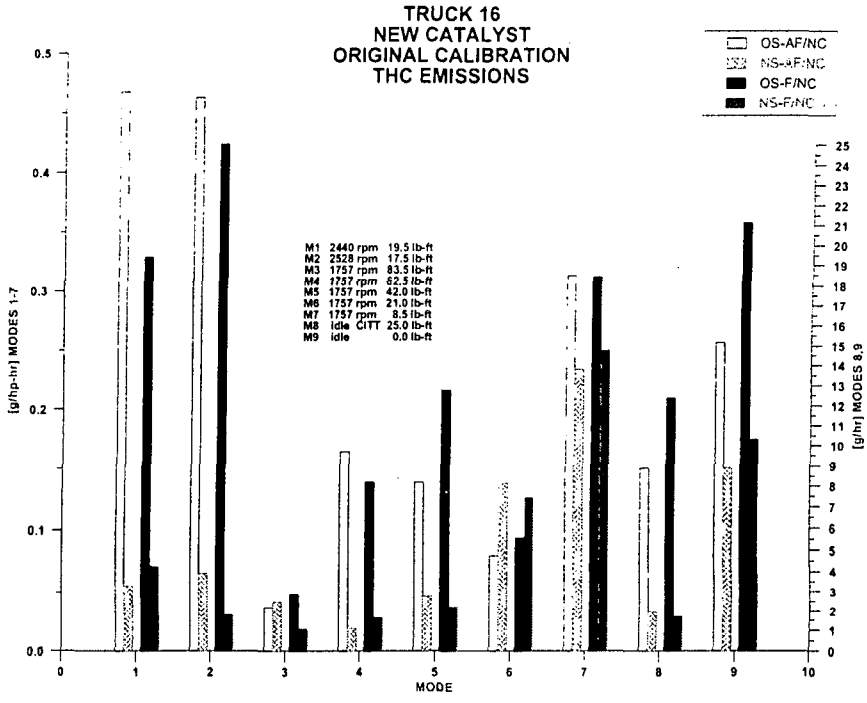

FIGURE A-62. TRUCK 16, NEW CATALYST, ORIGINAL CALIBRATION, THC EMISSIONS RESULTS

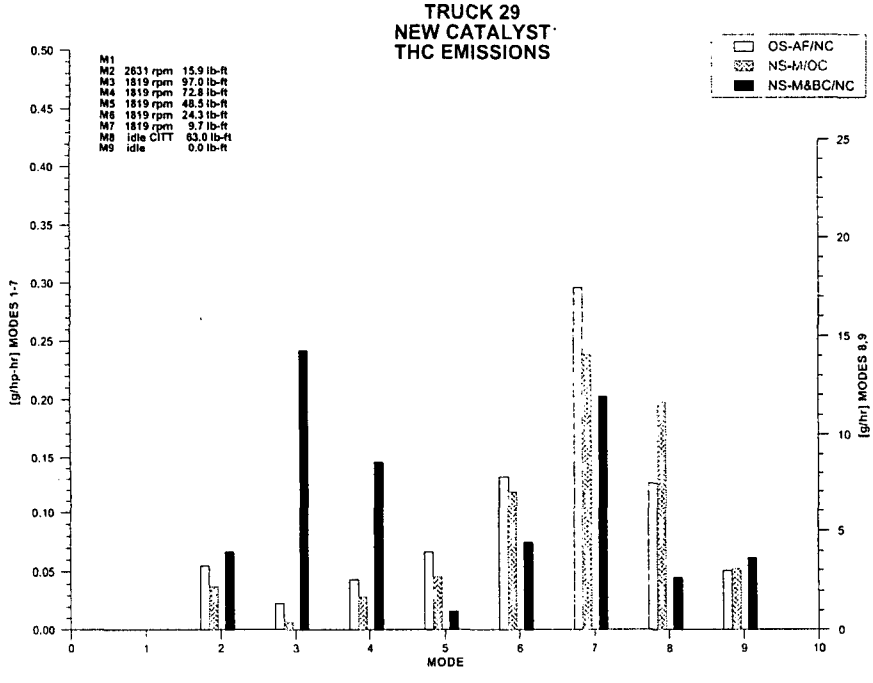

FIGURE A-63. TRUCK 29, NEW CATALYST, THC EMISSIONS RESULTS

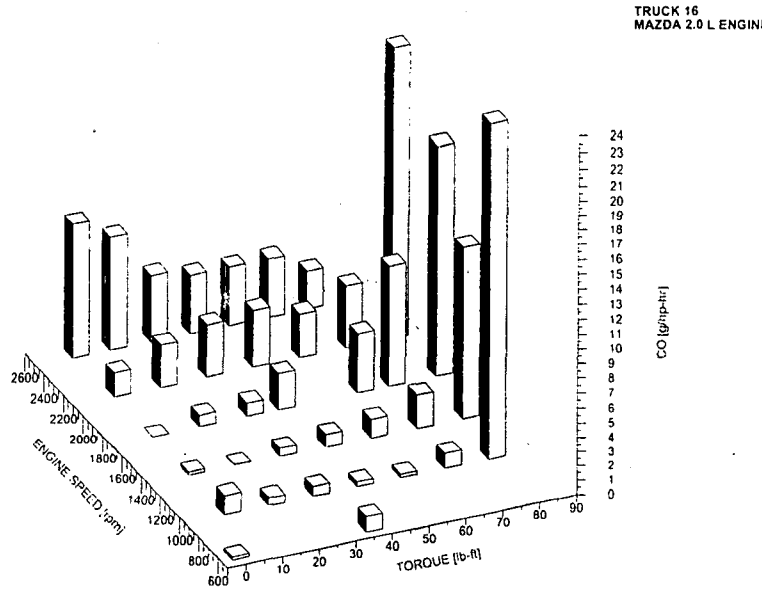

FIGURE A-64. TRUCK 16, STEADY-STATE CO EMISSIONS RESULTS

STEADY STATE CO EMISSIONS [g/hp-hr]

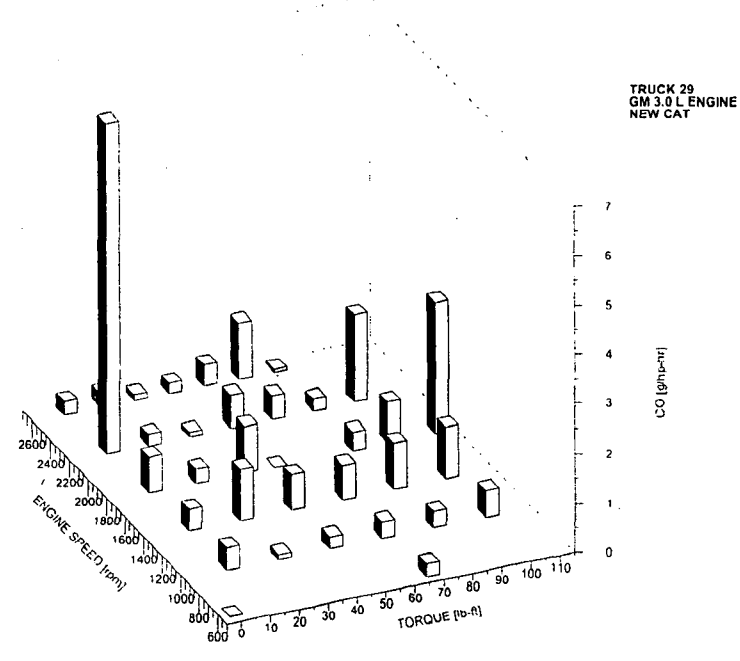

FIGURE A-65. TRUCK 29, STEADY-STATE CO EMISSIONS RESULTS

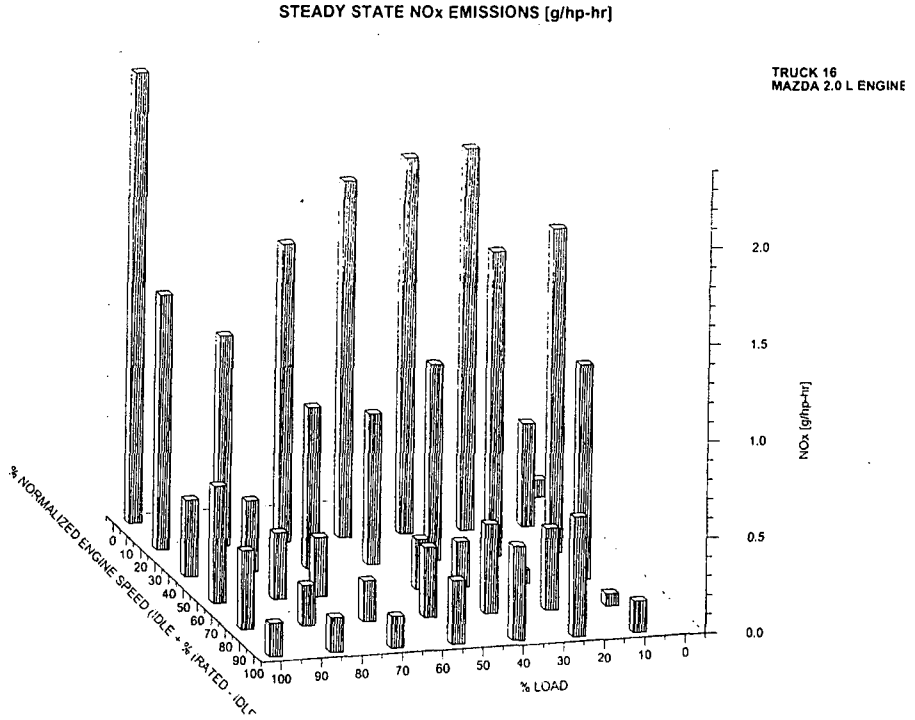

FIGURE A-66. TRUCK 16, STEADY-STATE NO_X EMISSIONS RESULTS OVER NORMALIZED SPEED AND LOAD

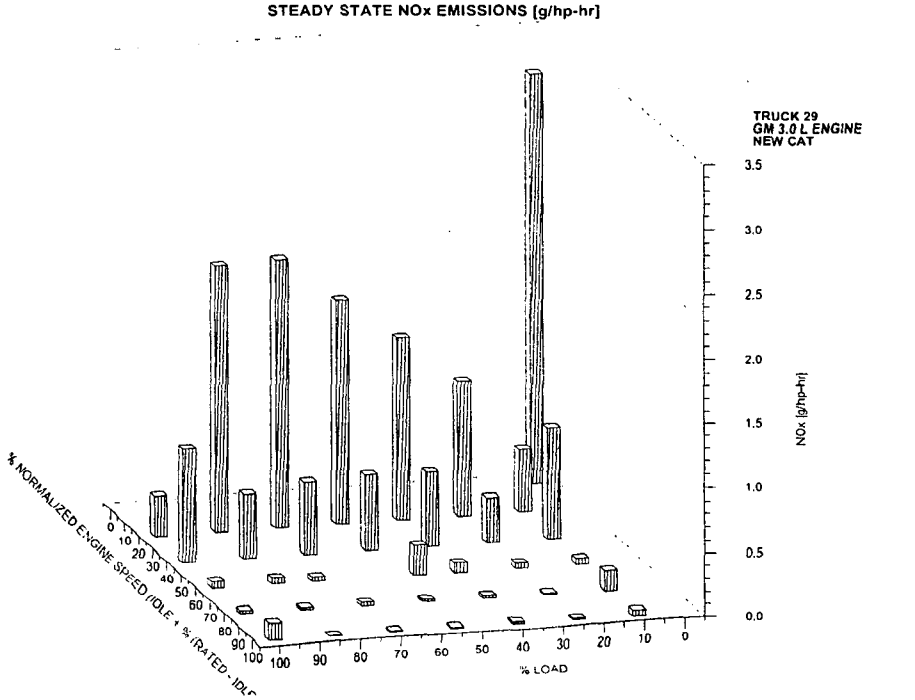

FIGURE A-67. TRUCK 29, STEADY-STATE NO_X EMISSIONS RESULTS OVER NORMALIZED SPEED AND LOAD

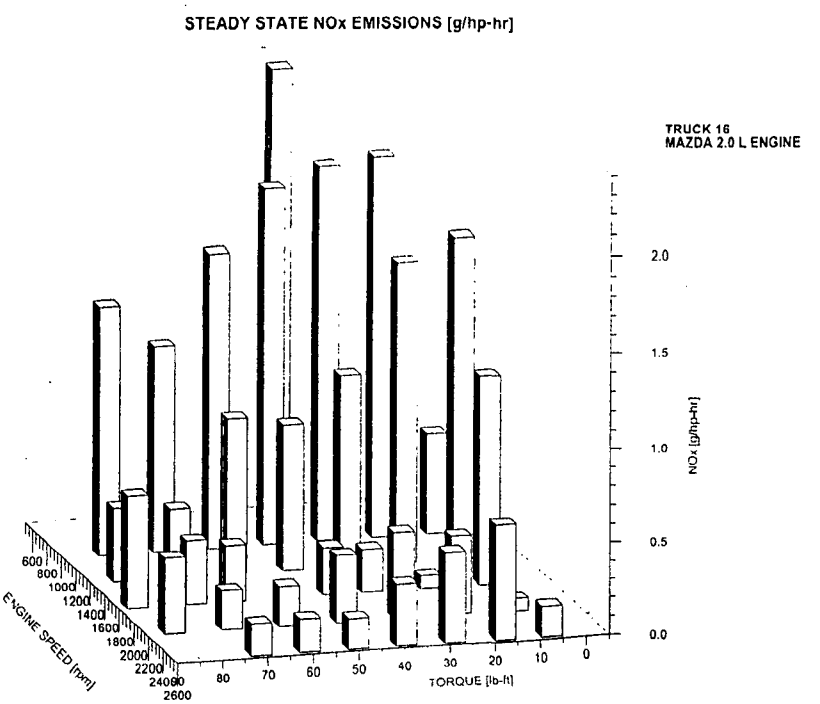

FIGURE A-68. TRUCK 16, STEADY-STATE NO_X EMISSIONS RESULTS

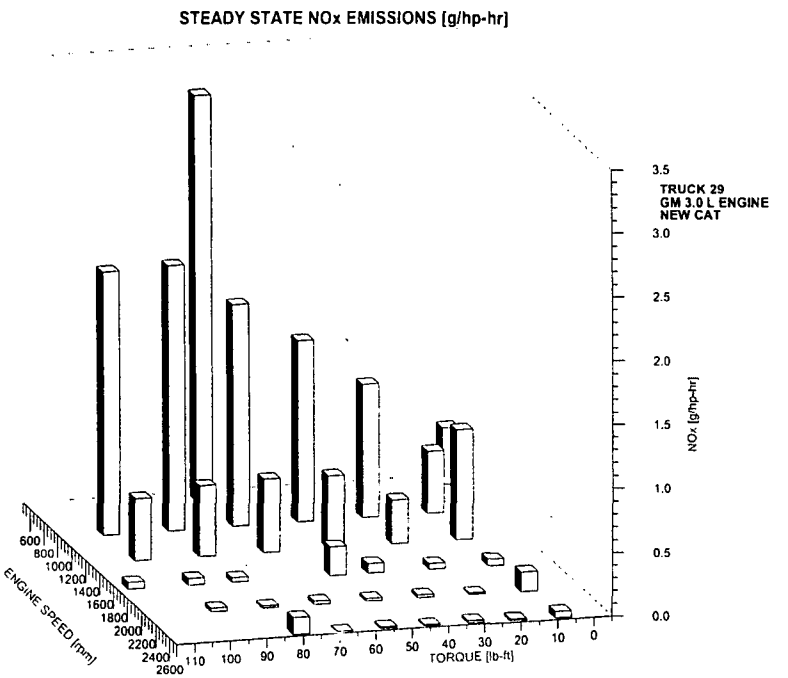

FIGURE A-69. TRUCK 29, STEADY-STATE NO_X EMISSIONS RESULTS

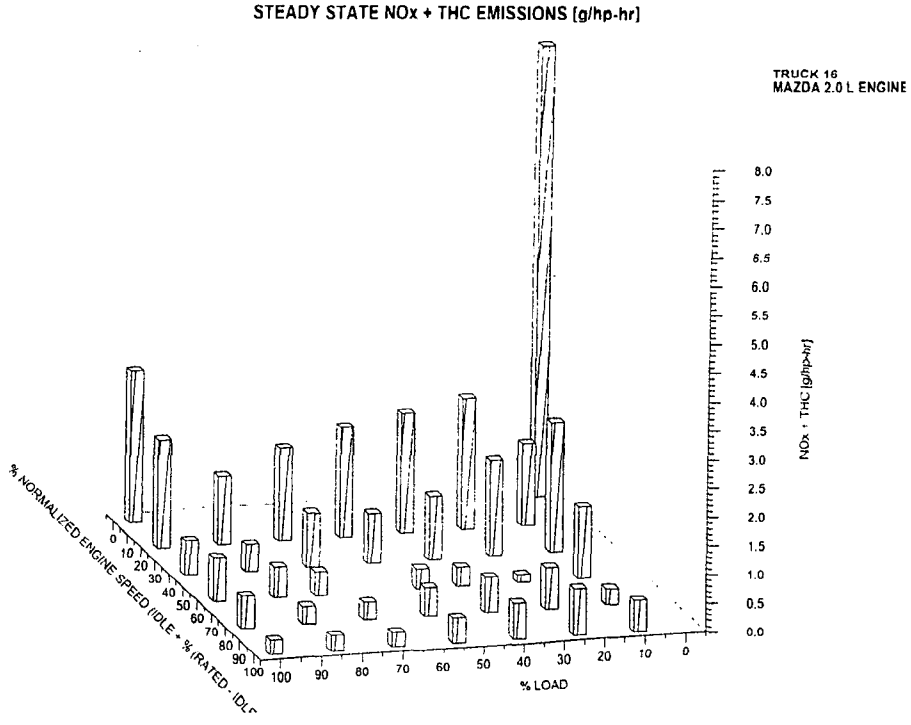

FIGURE A-70. TRUCK 16, STEADY-STATE NO_X+THC EMISSIONS RESULTS OVER NORMALIZED SPEED AND LOAD

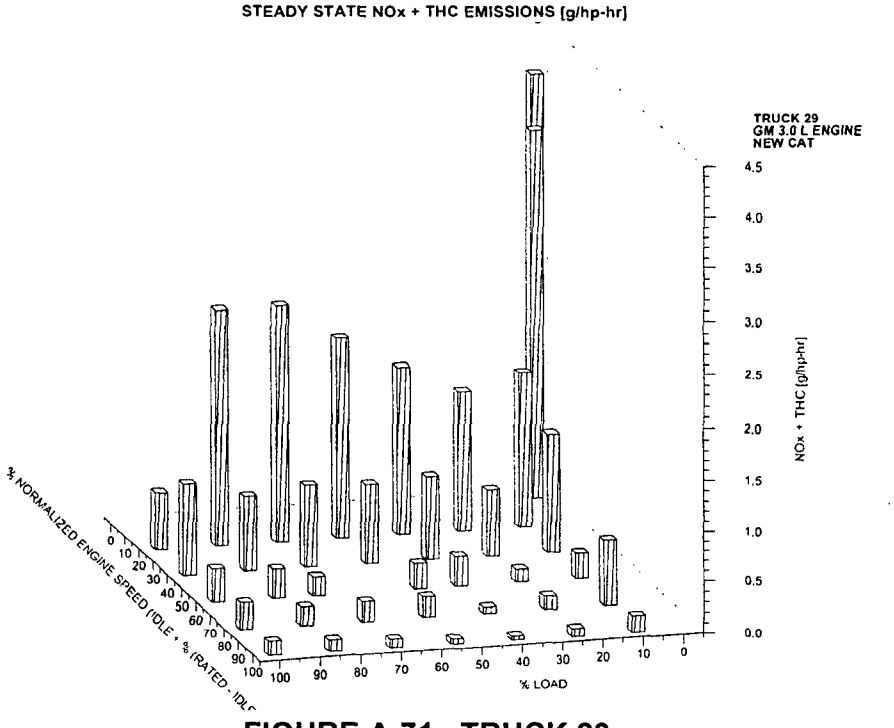

FIGURE A-71. TRUCK 29, STEADY-STATE NO_X+THC EMISSIONS RESULTS OVER NORMALIZED SPEED AND LOAD

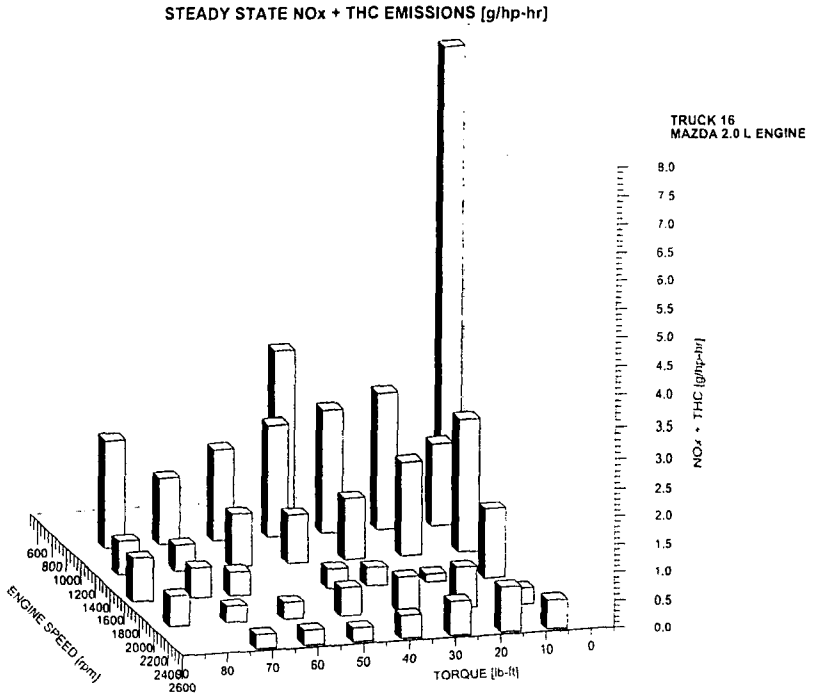

FIGURE A-72. TRUCK 16, STEADY-STATE NO_X+THC EMISSIONS RESULTS

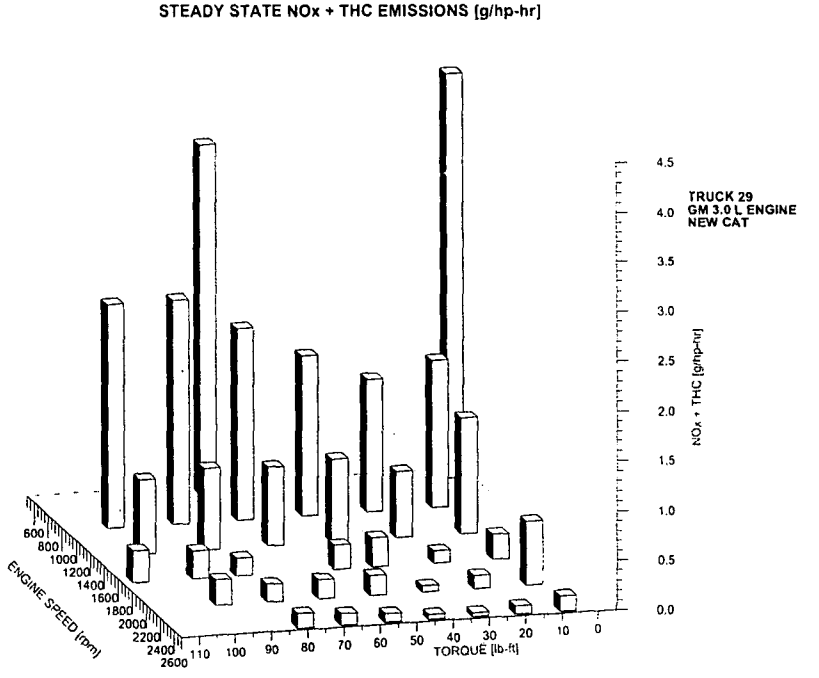

FIGURE A-73. TRUCK 29, STEADY-STATE NO_X+THC EMISSIONS RESULTS

APPENDIX B

Tables

APPENDIX B - LIST OF TABLES

APPENDIX B - LIST OF TABLES

STEADY-STATE EMISSION TEST RESULTS

TABLES 5 - 27
MODAL EMISSIONS, CATALYST EFFICIENCY, C2 AND D2 COMPOSITE RESULTS

FIELD DATA FREQUENCY DISTRIBUTION
TABLES 1 - 4

TABLE B-1. ENGINE SPEED FREQUENCY DISTRIBUTION, %

RPM	TRUCK 29	TRUCK16
600	0.79	0.60
650	3.03	1.76
700	5.14	5.28
750	5.03	6.67
800	6.15	5.82
850	5.72	6.79
900	4.32	5.17
950	3.88	5.64
1000	3.78	4.53
1050	3.47	5.98
1100	3.34	4.62
1150	3.13	5.76
1200	2.95	4.12
1250	3.02	4.60
1300	2.70	3.09
1350	2.91	3.78
1400	2.62	3.39
1450	2.53	2.45
1500	2.26	2.79
1550	2.26	2.13
1600	2.10	2.23
1650	1.86	1.55
1700	1.73	1.60
1750	1.64	1.17
1800	1.55	1.30
1850	1.46	0.77
1900	1.34	0.88
1950	1.19	0.68
2000	1.19	0.67
2050	1.16	0.49
2100	1.05	0.45
2150	0.99	0.62
2200	0.99	0.62
2250	0.93	0.56
2300	0.93	0.17
2350	0.96	0.22
2400	0.92	0.08
2450	0.79	0.14
2500	0.80	0.26
2550	1.01	0.23
2600	0.98	0.09
2650	1.15	0.13
2700	2.36	0.08
2750	1.52	0.03
2800	0.20	0.00
2850	0.10	0.00
2900	0.06	0.00
2950	0.03	0.00
3000	0.00	0.00

RPM	TRUCK 29	TRUCK16
600	0.79	0.60
700	8.16	7.04
800	11.18	12.49
900	10.04	11.96
1000	7.65	10.17
1100	6.81	10.60
1200	6.08	9.89
1300	5.72	7.70
1400	5.53	7.17
1500	4.79	5.23
1600	4.36	4.36
1700	3.59	3.15
1800	3.18	2.48
1900	2.81	1.65
2000	2.37	1.35
2100	2.20	0.94
2200	1.98	1.24
2300	1.86	0.72
2400	1.88	0.30
2500	1.59	0.40
2600	1.99	0.32
2700	3.52	0.21
2800	1.72	0.03
2900	0.16	0.00
3000	0.03	0.00

RPM	TRUCK 29	TRUCK16
600	0.79	0.60
900	29.38	31.49
1200	20.54	30.66
1500	16.04	20.10
1800	11.14	9.99
2100	7.38	3.94
2400	5.72	2.27
2700	7.09	0.93
3000	1.91	0.03

RPM	TRUCK 29	TRUCK16
600	0.79	0.60
1200	49.92	62.14
1800	27.18	30.09
2400	13.11	6.20
3000	9.01	0.96

RPM	TRUCK 29	TRUCK16
600	0.79	0.60
800	19.34	19.53
1000	17.69	22.12
1200	12.88	20.49
1400	11.25	14.87
1600	9.15	9.60
1800	6.77	5.63
2000	5.18	2.99
2200	4.19	2.18
2400	3.74	1.03
2600	3.58	0.72
2800	5.23	0.24
3000	0.19	0.00

	TRUCK 29	TRUCK16
MIN	400	364
MAX	3020	2712
AVG	1352	1148
POP	66871	34899
DUR	13374	6980

TABLE B-2. [%] THROTTLE POSITION FREQUENCY DISTRIBUTION, %

TPS	TRUCK 29	TRUCK16
2	34.66	3.91
4	8.54	19.41
6	7.62	13.20
8	8.18	10.14
10	7.41	7.23
12	5.57	8.24
14	4.01	6.36
16	3.65	5.67
18	2.45	4.63
20	2.14	3.50
22	1.43	3.84
24	1.19	2.51
26	1.44	2.19
28	1.06	1.60
30	1.06	1.47
32	0.93	0.94
34	0.63	1.09
36	0.54	0.76
38	0.64	0.78
40	0.45	0.43
42	0.50	0.58
44	0.44	0.32
46	0.25	0.21
48	0.32	0.16
50	0.24	0.09
52	0.21	0.08
54	0.20	0.05
56	0.15	0.08
58	0.15	0.04
60	0.15	0.07
62	0.15	0.05
64	0.13	0.12
66	0.18	0.03
68	0.12	0.06
70	0.10	0.00
72	0.10	0.03
74	0.10	0.01
76	0.09	0.02
78	0.13	0.01
80	0.13	0.00
82	0.16	0.01
84	0.15	0.00
86	0.12	0.00
88	0.26	0.00
90	0.23	0.00
92	0.23	0.00
94	0.39	0.02
96	0.55	0.00
98	0.49	0.00
100	0.01	0.03

TPS	TRUCK 29	TRUCK16
5	46.89	31.59
10	19.52	22.30
15	11.35	17.90
20	6.47	10.50
25	3.28	7.47
30	2.90	4.15
35	1.81	2.46
40	1.38	1.54
45	1.06	1.03
50	0.68	0.33
55	0.49	0.17
60	0.36	0.15
65	0.40	0.18
70	0.28	0.09
75	0.24	0.05
80	0.30	0.01
85	0.37	0.01
90	0.54	0.00
95	0.83	0.03
100	0.84	0.04

TPS	TRUCK 29	TRUCK16
10	66.41	53.89
20	17.82	28.40
30	6.18	11.62
40	3.19	4.00
50	1.74	1.36
60	0.85	0.33
70	0.68	0.27
80	0.55	0.06
90	0.92	0.01
100	1.67	0.06

TPS	TRUCK 29	TRUCK16
20	84.23	82.29
40	9.37	15.63
60	2.59	1.68
80	1.22	0.33
100	2.59	0.07

	TRUCK 29	TRUCK16
MIN	0	0
MAX	100	100
AVG	12	12
POP	66871	34899
DUR	13374	6980

TABLE B-3. [IN. HG.] MANIFOLD ABSOLUTE PRESSURE FREQUENCY DISTRIBUTION, %

MAP	TRUCK 29	TRUCK16
7.0	0.10	0.43
7.5	2.82	0.59
8.0	2.64	0.72
8.5	2.60	1.29
9.0	2.84	1.77
9.5	3.56	2.75
10.0	5.70	3.18
10.5	4.70	4.41
11.0	4.22	4.66
11.5	4.69	4.43
12.0	3.87	4.92
12.5	2.72	6.62
13.0	2.48	5.63
13.5	2.27	4.67
14.0	2.19	4.84
14.5	2.13	4.63
15.0	2.31	3.88
15.5	2.32	3.48
16.0	2.33	3.05
16.5	2.38	3.11
17.0	2.15	3.09
17.5	2.21	2.82
18.0	2.13	2.34
18.5	2.21	2.13
19.0	2.07	2.11
19.5	2.14	1.88
20.0	2.14	1.68
20.5	2.23	1.51
21.0	2.06	1.42
21.5	2.02	1.31
22.0	2.03	1.31
22.5	1.83	1.19
23.0	1.68	1.15
23.5	1.58	1.06
24.0	1.40	0.95
24.5	1.27	0.86
25.0	1.26	0.74
25.5	1.43	0.87
26.0	1.41	0.81
26.5	1.36	0.60
27.0	1.26	0.42
27.5	1.22	0.34
28.0	1.15	0.24
28.5	0.85	0.11
29.0	0.07	0.01

MAP	TRUCK 29	TRUCK16
7	0.10	0.43
8	5.46	1.31
9	5.44	3.06
10	9.26	5.93
11	8.91	9.06
12	8.56	9.35
13	5.21	12.26
14	4.46	9.51
15	4.44	8.51
16	4.65	6.54
17	4.53	6.20
18	4.33	5.16
19	4.28	4.24
20	4.28	3.56
21	4.28	2.93
22	4.05	2.61
23	3.51	2.34
24	2.98	2.01
25	2.53	1.60
26	2.84	1.68
27	2.61	1.02
28	2.37	0.58
29	0.92	0.12

MAP	TRUCK 29	TRUCK16
MIN	6.7	6.0
MAX	28.7	28.7
AVG	16	15
BAR	28.8	28.8
POP	66871	34899
DUR	13374	6980

TABLE B-4. THROTTLE POSITION VS. ENGINE SPEED FREQUENCY DISTRIBUTION, %

Throttle Position, %	Engine Speed, rpm													
	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	TOTAL
Truck 29														
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.00*
2	0.52	14.39	8.08	3.71	2.28	1.73	1.23	0.99	0.74	0.54	0.30	0.15	0.00	*34.66*
4	0.18	2.75	3.36	0.89	0.50	0.34	0.22	0.14	0.08	0.03	0.02	0.02	0.00	*8.54*
6	0.05	1.08	3.04	1.68	0.63	0.52	0.30	0.15	0.08	0.04	0.02	0.01	0.00	*7.62*
8	0.02	0.54	1.59	2.95	1.35	0.78	0.38	0.28	0.16	0.09	0.03	0.01	0.00	*8.18*
10	0.01	0.28	0.81	1.69	2.24	0.96	0.70	0.33	0.20	0.13	0.03	0.02	0.00	*7.41*
20	0.01	0.26	0.74	1.83	3.90	4.07	2.42	1.57	1.20	1.21	0.44	0.16	0.00	*17.82*
30	0.00	0.03	0.06	0.11	0.28	0.63	1.09	0.92	0.83	0.67	0.80	0.76	0.01	*6.18*
40	0.00	0.00	0.01	0.02	0.04	0.11	0.32	0.48	0.41	0.43	0.63	0.73	0.02	*3.19*
70	0.00	0.00	0.00	0.00	0.02	0.02	0.11	0.27	0.38	0.44	0.79	1.21	0.03	*3.26*
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.11	0.17	0.51	2.16	0.13	*3.14*
TOTAL	*0.79*	*19.34*	*17.69*	*12.88*	*11.25*	*9.15*	*6.77*	*5.18*	*4.19*	*3.74*	*3.58*	*5.23*	*0.19*	
Truck 16														
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.00*
2	0.22	2.20	0.76	0.34	0.18	0.09	0.07	0.03	0.01	0.00	0.00	0.00	0.00	*3.91*
4	0.27	10.52	5.01	2.05	0.97	0.36	0.15	0.07	0.02	0.00	0.00	0.00	0.00	*19.41*
6	0.05	4.44	5.22	2.09	0.85	0.37	0.11	0.05	0.01	0.00	0.00	0.00	0.00	*13.20*
8	0.01	0.90	4.59	2.54	1.07	0.60	0.24	0.12	0.06	0.01	0.00	0.00	0.00	*10.14*
10	0.01	0.34	2.42	2.65	1.09	0.41	0.18	0.10	0.03	0.00	0.00	0.00	0.00	*7.23*
20	0.04	0.85	3.31	9.50	7.30	3.80	2.11	0.97	0.39	0.12	0.01	0.00	0.00	*28.40*
30	0.00	0.17	0.56	1.02	2.65	2.28	1.21	1.08	1.19	0.74	0.69	0.00	0.00	*11.62*
40	0.00	0.07	0.18	0.23	0.62	1.20	0.76	0.32	0.32	0.08	0.21	0.00	0.00	*4.00*
70	0.01	0.03	0.06	0.07	0.14	0.47	0.72	0.22	0.14	0.06	0.04	0.00	0.00	*1.95*
100	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.03	0.01	0.01	0.01	0.00	0.00	*0.13*
TOTAL	*0.60*	*19.53*	*22.12*	*20.49*	*14.87*	*9.60*	*5.63*	*2.99*	*2.18*	*1.03*	*0.96*	*0.00*	*0.01*	

TABLE B-5. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS A, B, C AND D, OLD CATALYST

A-D

A								D						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37A	2.35	0.18	2.17	20.74	8.72	15.581	933	0.13	0.02	0.11	3.58	0.11	15.594	960
31A	2.21	0.20	2.02	23.49	8.74	15.573	951	0.14	0.03	0.11	4.99	0.15	15.587	972
22A	0.76	0.02	0.74	1.66	12.28	16.709	1106	0.05	0.01	0.04	0.12	12.32	16.851	1111
20A	1.07	0.08	0.99	12.47	7.64	15.601	1053	0.11	0.01	0.10	2.32	0.15	15.620	1064
19A	1.56	0.10	1.46	15.44	7.93	15.548	933	0.14	0.01	0.12	2.78	0.23	15.566	940
17A	2.14	0.17	1.96	26.30	6.01	15.457	801	0.13	0.02	0.11	1.40	0.05	15.535	816
16A	4.51	0.46	4.05	59.96	3.98	15.256	721	0.22	0.05	0.17	0.00	0.01	15.485	741
1A [g/hr]	15.65	1.74	13.91	601.62	3.64	13.481	425	15.50	0.63	14.87	493.64	0.02	13.641	440
1AA [g/hr]	22.28	2.91	19.37	362.67	0.61	13.267	295	24.70	1.38	23.32	371.27	0.02	12.627	324

A-D EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	94.4	90.8	94.7	82.7	98.8	15.594	960
31	93.6	85.2	94.4	78.8	98.3	15.587	972
22	93.9	75.7	94.5	92.5	-0.3	16.851	1111
20	89.6	87.0	89.8	81.4	98.0	15.620	1064
19	91.4	85.4	91.8	82.0	97.1	15.566	940
17	94.0	87.7	94.6	94.7	99.2	15.535	816
16	95.1	88.6	95.8	100.0	99.7	15.485	741
1	1.0	63.7	-6.9	17.9	99.5	13.641	440
1A	-10.9	52.4	-20.4	-2.4	97.3	12.627	324
AVERAGE	**71.3**	**79.6**	**69.8**	**69.7**	**87.5**	**15.167**	
AVG W/O IDLE	**93.1**	**85.8**	**93.6**	**87.4**	**84.4**	**15.748**	

[redacted] OLD SENSOR

COMPOSITE RESULTS C2					
TEST	THC	CH_4	NMHC	CO	NO_x
A	2.11	0.18	1.93	24.96	7.64
D	0.56	0.04	0.52	8.80	0.93
EFF[%]	**73.4**	**76.7**	**73.0**	**64.7**	**87.9**

B-C

B								C						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37A	2.09	0.11	1.98	18.53	8.58	15.692	935	0.06	0.01	0.05	0.22	2.14	15.704	948
31A	1.93	0.12	1.82	19.91	8.39	15.687	960	0.01	0.00	0.01	0.00	1.96	15.691	962
22A	0.71	0.03	0.69	1.46	12.26	17.111	1106	0.05	0.01	0.04	0.04	12.50	16.754	1114
20A	1.04	0.08	0.95	10.41	8.02	15.672	1060	0.02	0.01	0.02	0.32	0.37	15.679	1059
19A	1.41	0.09	1.32	12.44	8.35	15.701	943	0.02	0.02	0.01	0.09	2.82	15.712	943
17A	1.96	0.12	1.84	17.69	5.87	15.752	806	0.08	0.03	0.05	0.14	2.90	15.750	826
16A	3.82	0.34	3.48	37.07	4.71	15.773	735	0.18	0.12	0.06	0.00	2.37	15.773	744
1A [g/hr]	9.96	1.12	8.83	93.48	21.66	15.790	433	4.02	0.52	3.50	8.56	10.19	15.769	422
1AA [g/hr]	21.79	0.67	21.12	84.85	0.33	15.605	303	4.77	0.36	4.41	0.00	0.31	15.442	322

B-C EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	97.4	93.1	97.6	98.8	75.1	15.704	948
31	99.4	100.0	99.4	100.0	76.6	15.691	962
22	93.0	44.8	94.8	96.9	-2.0	16.754	1114
20	97.7	89.9	98.4	96.9	95.4	15.679	1059
19	98.2	82.5	99.3	99.3	66.2	15.712	943
17	96.2	74.9	97.5	99.2	50.6	15.750	826
16	95.3	65.1	98.3	100.0	49.6	15.773	744
1	59.6	53.5	60.4	90.8	52.9	15.769	422
1A	78.1	46.7	79.1	100.0	5.3	15.442	322
AVERAGE	**90.6**	**72.3**	**91.6**	**98.0**	**52.2**	**15.808**	
AVG W/O IDLE	**96.7**	**78.6**	**97.9**	**98.7**	**58.8**	**15.866**	

[redacted] NEW SENSOR

COMPOSITE RESULTS C2					
TEST	THC	CH_4	NMHC	CO	NO_x
B	1.93	0.11	1.82	15.35	7.89
C	0.12	0.03	0.10	0.12	3.10
EFF[%]	**93.6**	**76.4**	**94.6**	**99.2**	**60.8**

TABLE B-6. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS
RUNS H, I, J AND K, OLD CATALYST

J-I

J								I						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37J	1.97			20.93	9.31	15.595	941	0.15			3.64	0.29	15.588	941
31J	2.08			23.94	8.91	15.573	946	0.27			8.90	0.49	15.560	941
22J	0.89			17.48	9.08	15.715	1125	0.03			1.87	1.01	15.755	1128
20J	1.00			13.40	8.15	15.599	1075	0.08			2.46	0.22	15.614	1067
19J	1.52			15.34	9.05	15.556	945	0.10			2.00	0.30	15.573	947
17J	1.98			21.87	5.78	15.498	810	0.18			2.12	0.10	15.499	823
16J	3.92			57.85	4.05	15.189	723	0.47			5.30	0.12	15.444	731
1J [g/hr]	13.85			480.72	2.11	13.655	555	12.37			392.15	0.16	15.791	731
1AJ [g/hr]	19.14			341.21	0.31	13.151	298	17.78			224.98	0.07	13.146	321

J-I EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	92.4			82.6	96.9	15.588	941
31	87.3			62.8	94.5	15.560	941
22	96.3			89.3	88.9	15.755	1128
20	91.9			81.7	97.3	15.614	1067
19	93.6			87.0	96.7	15.573	947
17	90.7			90.3	98.2	15.499	823
16	87.9			90.8	97.0	15.444	731
1	10.7			18.4	92.6	15.791	731
1A	7.1			34.1	78.7	13.146	321
AVERAGE	**73.1**			**70.8**	**93.4**	**15.330**	
AVG W/O IDLE	**91.4**			**83.5**	**95.6**	**15.576**	

OLD SENSOR
POWER VALVE ADJUSTMENT

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
J	1.94			24.13	8.04
I	0.42			6.23	0.29
EFF[%]	**78.2**			**74.2**	**96.4**

K-H

K								H						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37K	1.66			16.40	8.25	15.718	930	0.03			0.11	2.51	15.714	927
31K	1.75			18.63	8.06	15.723	941	0.01			0.07	2.39	15.710	939
22K	0.93			15.38	9.13	15.766	1119	0.03			1.20	1.99	15.799	1128
20K	0.97			9.74	8.03	15.705	1074	0.03			0.25	0.61	15.791	731
19K	1.36			11.15	8.59	15.717	949	0.02			0.03	3.46	15.717	961
17K	1.68			15.09	5.54	15.755	814	0.07			0.00	3.52	15.764	816
16K	2.75			29.54	3.76	15.781	738	0.21			0.35	2.52	15.789	733
1K [g/hr]	7.92			78.97	9.57	15.756	414	1.75			0.60	4.61	15.794	414
1AK [g/hr]	16.09			65.69	0.61	15.703	314	4.63			1.80	0.24	15.706	323

K-H EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	97.9			99.3	69.5	15.714	927
31	99.3			99.6	70.3	15.710	939
22	97.0			92.2	78.2	15.799	1128
20	97.3			97.5	92.4	15.791	731
19	98.4			99.7	59.7	15.717	961
17	95.9			100.0	36.4	15.764	816
16	92.4			98.8	33.0	15.789	733
1	78.0			99.2	51.9	15.794	414
1A	71.2			97.3	59.8	15.706	323
AVERAGE	**91.9**			**98.2**	**61.2**	**15.754**	
AVG W/O IDLE	**96.9**			**98.2**	**62.8**	**15.755**	

OLD SENSOR
POWER VALVE ADJUSTMENT

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
K	1.68			14.18	7.69
H	0.11			0.16	2.96
EFF[%]	**93.2**			**98.9**	**61.5**

TABLE B-7. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS L, M AND O, OLD CATALYST

L-M

L								M						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37L	1.95	0.16	1.79	17.52	10.49	15.710	927	0.04	0.03	0.01	0.07	3.55	15.710	931
31L	2.27	0.22	2.05	17.61	9.92	15.703	949	0.07	0.02	0.05	0.19	3.14	15.712	943
22L	1.05	0.05	1.01	18.46	10.01	15.757	1104	0.04	0.02	0.02	2.75	1.31	15.774	1114
20L	1.16	0.05	1.11	10.55	9.60	15.689	1075	0.04	0.04	0.00	0.18	1.15	15.678	1062
19L	1.58	0.11	1.46	11.40	10.05	15.718	959	0.02	0.02	0.01	0.07	4.14	15.715	955
17L	2.30	0.13	2.17	17.18	8.86	15.746	816	0.09	0.04	0.05	0.00	4.44	15.754	814
16L	3.35	0.23	3.12	28.74	5.46	15.793	742	0.20	0.16	0.04	0.35	3.50	15.802	728
1L [g/hr]	11.25	0.40	10.85	94.67	35.37	15.855	502	8.63	0.48	8.15	79.05	19.12	15.893	348
1AL [g/hr]	6.48	0.52	5.97	69.91	3.70	15.836	543	11.90	0.41	11.49	12.95	1.26	15.998	289

L-M EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	98.2	81.5	99.7	99.6	66.1	15.710	931
31	97.1	92.9	97.6	98.9	68.4	15.712	943
22	96.6	64.8	98.0	85.1	86.9	15.774	1114
20	96.4	21.2	100.0	98.3	88.0	15.678	1062
19	98.5	86.1	99.5	99.4	58.8	15.715	955
17	96.2	69.8	97.8	100.0	49.9	15.754	814
16	94.0	30.5	98.8	98.8	35.9	15.802	728
1	23.3	-19.0	24.9	16.5	45.9	15.893	348
1A	-83.6	20.1	-92.5	81.5	65.9	15.998	289
AVERAGE	68.5	49.8	69.3	86.4	62.9	15.782	
AVG W/O IDLE	96.7	63.8	98.8	97.2	64.9	15.735	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
L	1.86	0.12	1.74	15.11	9.63
M	0.24	0.04	0.21	0.46	3.63
EFF[%]	86.9	71.5	88.0	96.9	62.3

CALIBRATION 1 5434

O

THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
0.10	0.05	0.05	0.95	0.41	15.636	922
0.08	0.06	0.03	1.10	0.30	15.640	943
0.08	0.03	0.05	6.25	0.52	15.575	1119
0.09	0.03	0.06	3.49	0.32	15.596	1070
0.05	0.02	0.03	0.64	0.17	15.623	967
0.10	0.10	0.00	0.06	4.36	15.658	832
0.45	0.25	0.20	0.22	6.88	15.703	744
7.76	0.14	7.62	0.00	0.08	15.770	427
7.66	0.36	7.30	2.18	34.79	16.766	319
					15.774	
					15.633	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
O	0.21	0.06	0.15	1.23	1.97
EFF[%]					

TABLE B-8. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS P, Q AND V, OLD CATALYST

CALIBRATION 2 5444

P

THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
0.03	0.02	0.01	0.18	0.08	15.654	929
0.02	0.02	0.00	0.44	0.09	15.653	946
0.08	0.03	0.04	7.45	0.67	15.555	1112
0.04	0.03	0.01	1.20	0.19	15.655	1068
0.03	0.01	0.01	0.24	0.34	15.639	961
0.06	0.05	0.00	0.12	2.97	15.628	824
0.27	0.27	0.00	0.16	3.21	15.663	729
2.91	0.42	2.49	3.76	24.74	15.685	470
11.80	0.00	11.80	0.82	0.08	15.941	308
					15.675	
					15.635	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
P	0.24	0.03	0.20	0.80	1.02
EFF[%]					

V-Q **CALIBRATION 3** 6444

V

MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37V	2.33	0.20	2.13	22.83	9.82	15.571	916
31V	2.60	0.23	2.36	24.75	9.50	15.569	944
22V	1.23	0.09	1.14	23.29	9.80	15.468	1117
20V	1.22	0.09	1.13	16.91	8.63	15.517	1076
19V	1.67	0.09	1.57	15.97	8.94	15.555	960
17V	2.42	0.16	2.26	24.56	7.40	15.506	800
16V	3.74	0.32	3.42	44.47	4.98	15.496	726
1V [g/hr]	12.04	0.61	11.44	155.97	38.52	15.360	479
1AV [g/hr]	15.46	0.59	14.87	41.38	0.61	15.740	324

Q

THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
0.19	0.07	0.12	3.27	0.39	15.577	930
0.21	0.11	0.10	5.78	0.66	15.572	942
0.10	0.03	0.08	7.91	0.43	15.488	1114
0.12	0.03	0.08	5.33	0.31	15.559	1066
0.09	0.03	0.06	1.96	0.32	15.584	951
0.14	0.08	0.06	0.87	0.09	15.524	813
0.36	0.05	0.31	0.01	1.88	15.512	722
1.51	0.42	1.10	4.92	10.27	15.369	485
7.65	0.44	7.21	0.00	0.00	15.932	355

V-Q APPROXIMATE EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	91.9	64.9	94.4	85.7	96.0	15.577	930
31	91.8	52.4	95.7	76.7	93.0	15.572	942
22	91.6	71.4	93.2	66.0	95.6	15.488	1114
20	90.5	62.3	92.7	68.5	96.4	15.559	1066
19	94.5	70.9	95.9	87.7	96.4	15.584	951
17	94.2	46.5	97.5	96.5	98.8	15.524	813
16	90.4	84.0	91.0	100.0	62.3	15.512	722
1	87.4	31.2	90.4	96.8	73.3	15.369	485
1A	50.5	25.2	51.6	100.0	100.0	15.932	355
AVERAGE	**87.0**	**56.5**	**89.2**	**86.4**	**90.2**	**15.568**	
AVG W/O IDLE	**92.1**	**64.6**	**94.4**	**83.0**	**91.2**	**15.545**	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
V	2.13	0.13	2.00	20.59	8.52
Q	0.24	0.05	0.19	2.62	0.34
EFF[%]	**88.6**	**59.7**	**90.5**	**87.3**	**96.0**

TABLE B-9. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS V AND R, OLD CATALYST

V-R — CALIBRATION 4 — 6544

V								R						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37V	1.95	0.16	1.79	17.52	10.49	15.557	937	0.22	0.11	0.12	5.78	0.57	15.567	912
31V	2.27	0.22	2.05	17.61	9.92	15.562	961	0.19	0.13	0.06	7.60	0.62	15.551	936
22V	1.05	0.05	1.01	18.46	10.01	15.475	1112	0.16	0.05	0.11	15.28	0.61	15.406	1104
20V	1.16	0.05	1.11	10.55	9.60	15.590	1058	0.11	0.04	0.07	4.06	0.31	15.573	1069
19V	1.58	0.11	1.46	11.40	10.05	15.555	954	0.09	0.03	0.06	2.44	0.26	15.549	952
17V	2.30	0.13	2.17	17.18	8.86	15.515	805	0.07	0.02	0.05	0.79	0.07	15.512	806
16V	3.35	0.23	3.12	28.74	5.46	15.505	719	0.12	0.07	0.05	0.00	1.11	15.509	733
1V [g/hr]	11.25	0.40	10.85	94.67	35.37	15.344	473	1.28	0.56	0.72	4.53	9.76	15.385	468
1AV [g/hr]	6.48	0.52	5.97	69.91	3.70	15.713	328	7.69	0.21	7.48	0.21	0.09	15.872	322

V-R EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	88.6	33.8	93.5	67.0	94.6	15.567	912
31	91.7	40.1	97.2	56.8	93.7	15.551	936
22	84.5	-19.4	89.2	17.3	93.9	15.406	1104
20	90.8	32.0	93.6	61.5	96.8	15.573	1069
19	94.5	71.5	96.2	78.6	97.4	15.549	952
17	96.9	84.9	97.7	95.4	99.2	15.512	806
16	96.3	69.2	98.4	100.0	79.6	15.509	733
1	88.6	-39.7	93.4	95.2	72.4	15.385	468
1A	-18.6	58.7	-25.3	99.7	97.6	15.872	322
AVERAGE	79.3	36.8	81.5	74.6	91.7	15.547	
AVG W/O IDLE	91.9	44.6	95.1	68.1	93.6	15.524	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
V	2.13	0.13	2.00	20.59	8.52
R	0.22	0.04	0.18	3.25	0.29
EFF[%]	89.6	68.8	91.0	84.2	96.6

TABLE B-10. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS A, B, E AND X, NEW CATALYST

A-E

A								E						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37A	2.35	0.18	2.17	20.74	8.72	15.581	933	0.45	0.13	0.32	1.82	0.00	15.570	930
31A	2.21	0.20	2.02	23.49	8.74	15.573	951	0.44	0.14	0.30	2.10	0.00	15.572	933
22A	0.76	0.02	0.74	1.66	12.28	16.709	1106	0.04	0.02	0.02	0.04	11.27	16.743	1107
20A	1.07	0.08	0.99	12.47	7.64	15.601	1053	0.17	0.05	0.12	0.31	0.45	15.609	1057
19A	1.56	0.10	1.46	15.44	7.93	15.548	933	0.14	0.07	0.07	0.17	0.91	15.574	944
17A	2.14	0.17	1.96	26.30	6.01	15.457	801	0.08	0.07	0.01	0.00	1.49	15.528	806
16A	4.51	0.46	4.05	59.96	3.98	15.256	721	0.33	0.31	0.02	0.00	1.48	15.481	728
1A [g/hr]	15.65	1.74	13.91	601.62	3.64	13.481	425	8.90	5.00	3.90	56.52	0.00	13.478	423
1AA [g/hr]	22.28	2.91	19.37	362.67	0.61	13.267	295	15.17	7.72	7.44	31.88	0.31	12.545	328

A-E EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	80.8	25.4	85.4	91.2	100.0	15.570	930
31	80.1	29.6	85.0	91.1	100.0	15.572	933
22	95.3	9.2	97.9	97.9	8.2	16.743	1107
20	84.4	43.2	87.7	97.5	94.1	15.609	1057
19	91.1	34.5	94.9	98.9	88.6	15.574	944
17	96.3	58.5	99.6	100.0	75.2	15.528	806
16	92.7	33.0	99.4	100.0	62.8	15.481	728
1	43.2	-187.4	72.0	90.6	100.0	13.478	423
1A	31.9	-165.5	61.6	91.2	49.8	12.545	328
AVERAGE	**77.3**	**-13.3**	**87.1**	**95.4**	**75.4**	**15.122**	
AVG W/O IDLE	**88.7**	**33.3**	**92.9**	**96.7**	**75.5**	**15.725**	

[redacted] OLD SENSOR

COMPOSITE RESULTS C2					
TEST	THC	CH_4	NMHC	CO	NO_x
A	2.11	0.18	1.93	24.96	7.64
E	0.40	0.20	0.20	0.78	1.61
EFF[%]	**81.0**	**-14.7**	**89.8**	**96.9**	**78.9**

B-X

B								X						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37B	2.09	0.11	1.98	18.53	8.58	15.692	935	0.06			0.00	2.29	15.711	943
31B	1.93	0.12	1.82	19.91	8.39	15.687	960	0.06			0.00	2.10	15.716	940
22B	0.71	0.03	0.69	1.46	12.26	17.111	1106	0.04			0.00	12.33	17.166	1108
20B	1.04	0.08	0.95	10.41	8.02	15.672	1060	0.02			0.07	2.05	15.693	1061
19B	1.41	0.09	1.32	12.44	8.35	15.701	943	0.05			0.00	3.88	15.733	940
17B	1.96	0.12	1.84	17.69	5.87	15.752	806	0.12			0.03	3.42	15.777	804
16B	3.82	0.34	3.48	37.07	4.71	15.773	735	0.25			0.21	2.49	15.791	731
1B [g/hr]	21.79	1.12	8.83	93.48	0.33	15.790	433	1.92			0.40	3.94		
1AB [g/hr]	21.79	0.67	21.12	84.85	0.33	15.605	303	8.90			0.01	0.17		

B-X EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	97.4			100.0	73.3	15.711	943
31	96.7			100.0	74.9	15.716	940
22	94.2			100.0	-0.6	17.166	1108
20	98.2			99.4	74.4	15.693	1061
19	96.6			100.0	53.6	15.733	940
17	93.7			99.8	41.7	15.777	804
16	93.5			99.4	47.0	15.791	731
1	91.2			99.6	-1094		
1A	59.1			100.0	49.3		
AVERAGE	**91.2**			**99.8**	**-75.6**	**15.941**	
AVG W/O IDLE	**95.8**			**99.8**	**52.0**	**15.941**	

[redacted] NEW SENSOR

COMPOSITE RESULTS C2					
TEST	THC	CH_4	NMHC	CO	NO_x
B	1.93	0.11	1.82	15.35	7.89
X	0.22	0.00	0.00	0.02	3.95
EFF[%]	**88.5**			**99.9**	**50.0**

TABLE B-11. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS F, G, J AND K, NEW CATALYST

J-F

J								F							
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37J	1.97			20.93	9.31	15.595	941	0.33	0.12	0.21	1.47	0.00	15.564	934
31J	2.08			23.94	8.91	15.573	946	0.41	0.13	0.28	2.74	0.00	15.564	932
22J	0.89			17.48	9.08	15.715	1125	0.05	0.02	0.03	1.75	0.09	15.674	1106
20J	1.00			13.40	8.15	15.599	1075	0.14	0.04	0.10	0.57	0.37	15.602	1056
19J	1.52			15.34	9.05	15.556	945	0.21	0.00	0.21	0.64	0.75	15.556	943
17J	1.98			21.87	5.78	15.498	810	0.09	0.07	0.02	0.00	1.45	15.513	806
16J	3.92			57.85	4.05	15.189	723	0.33	0.27	0.05	1.44	0.42	15.200	718
1J [g/hr]	13.85			480.7	2.11	13.655	555	12.36	2.82	9.54	219.8	0.01	13.232	392
1AJ [g/hr]	19.14			341.2	0.31	13.151	298	21.16	4.45	16.71	78.12	0.01	12.668	323

J-F EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	83.4			93.0	100.0	15.564	934
31	80.1			88.6	100.0	15.564	932
22	94.4			90.0	99.1	15.674	1106
20	86.3			95.8	95.5	15.602	1056
19	86.1			95.8	91.7	15.556	943
17	95.3			100.0	75.0	15.513	806
16	91.6			97.5	89.6	15.200	718
1	10.8			54.3	99.6	13.232	392
1A	-10.6			77.1	97.5	12.668	323
AVERAGE	**68.6**			**88.0**	**94.2**	**14.952**	
AVG W/O IDLE	**88.2**			**94.4**	**93.0**	**15.525**	

OLD SENSOR POWER VALVE ADJUSTMENT

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
J	1.94			24.13	8.04
F	0.53	0.11	0.42	1.98	0.78
EFF[%]	**72.8**			**91.8**	**90.3**

K-G

K								G							
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37K	1.66			16.40	8.25	15.718	930	0.07	0.00	0.07	0.06	1.31	15.697	944
31K	1.75			18.63	8.06	15.723	941	0.03	0.03	0.00	0.00	1.32	15.702	939
22K	0.93			15.38	9.13	15.766	1119	0.02	0.01	0.01	0.17	1.20	15.785	1105
20K	0.97			9.74	8.03	15.705	1074	0.03	0.01	0.02	0.04	1.91	15.682	1057
19K	1.36			11.15	8.59	15.717	949	0.04	0.03	0.01	0.03	3.67	15.721	950
17K	1.68			15.09	5.54	15.755	814	0.13	0.07	0.06	0.00	3.24	15.760	813
16K	2.75			29.54	3.76	15.781	738	0.25	0.20	0.05	0.32	2.38	15.782	737
1K [g/hr]	7.92			78.97	9.57	15.756	414	1.70	0.27	1.43	0.20	4.79	15.723	419
1AK [g/hr]	16.09			65.69	0.61	15.703	314	10.31	0.53	9.78	1.18	0.31	15.563	320

K-G EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	95.7			99.6	84.1	15.697	944
31	98.2			100.0	83.6	15.702	939
22	98.1			98.9	86.8	15.785	1105
20	97.1			99.6	76.3	15.682	1057
19	97.3			99.8	57.2	15.721	950
17	92.5			100.0	41.6	15.760	813
16	91.0			98.9	36.6	15.782	737
1	78.5			99.7	50.0	15.723	419
1A	35.9			98.2	49.6	15.563	320
AVERAGE	**87.2**			**99.4**	**62.9**	**15.713**	
AVG W/O IDLE	**95.7**			**99.5**	**66.6**	**15.733**	

NEW SENSOR POWER VALVE ADJUSTMENT

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
K	1.68			14.18	7.69
G	0.23	0.05	0.18	0.06	3.05
EFF[%]	**86.2**			**99.6**	**60.3**

TABLE B-12. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS L AND N, NEW CATALYST

L-N

L								N						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37L	1.95	0.16	1.79	17.52	10.49	15.710	927	0.06	0.04	0.02	0.00	3.26	15.706	930
31L	2.27	0.22	2.05	17.61	9.92	15.703	949	0.06	0.06	0.00	0.00	2.32	15.703	956
22L	1.05	0.05	1.01	18.46	10.01	15.757	1104	0.03	0.01	0.02	0.85	0.64	15.751	1105
20L	1.16	0.05	1.11	10.55	9.60	15.689	1075	0.01	0.01	0.00	0.00	1.65	15.676	1071
19L	1.58	0.11	1.46	11.40	10.05	15.718	959	0.07	0.04	0.03	0.00	4.28	15.709	953
17L	2.30	0.13	2.17	17.18	8.86	15.746	816	0.13	0.11	0.02	0.06	5.15	15.761	800
16L	3.35	0.23	3.12	28.74	5.46	15.793	742	0.38	0.17	0.21	0.00	4.01	15.790	731
1L [g/hr]	11.25	0.40	10.85	94.67	35.37	15.855	502	2.69	0.58	2.11	3.98	21.91	15.823	441
1AL [g/hr]	6.48	0.52	5.97	69.91	3.70	15.836	543	1.52	0.44	1.08	0.00	1.71	15.832	518

L-N EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	97.1	78.3	98.8	100.0	68.9	15.706	930
31	97.6	74.8	100.0	100.0	76.7	15.703	956
22	97.0	70.0	98.2	95.4	93.6	15.751	1105
20	98.9	84.1	99.6	100.0	82.8	15.676	1071
19	95.6	68.6	97.7	100.0	57.4	15.709	953
17	94.6	18.0	99.1	99.7	41.9	15.761	800
16	88.6	26.9	93.2	100.0	26.6	15.790	731
1	76.1	-45.1	80.6	95.8	38.0	15.823	441
1A	76.5	13.9	81.9	100.0	53.9	15.832	518
AVERAGE	**91.3**	**43.3**	**94.4**	**99.0**	**60.0**	**15.750**	
AVG W/O IDLE	**95.6**	**60.1**	**98.1**	**99.3**	**64.0**	**15.728**	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
L	1.86	0.12	1.74	15.11	9.63
N	0.11	0.06	0.05	0.07	3.84
EFF[%]	**94.3**	**51.9**	**97.3**	**99.6**	**60.1**

TABLE B-13. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS V AND S, NEW CATALYST

V-S — CALIBRATION 3 — 6444

V								S						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37V	2.33	0.20	2.13	22.83	9.82	15.571	916	0.32	0.12	0.20	2.23	0.00	15.574	941
31V	2.60	0.23	2.36	24.75	9.50	15.569	944	0.28	0.14	0.14	2.57	0.02	15.570	951
22V	1.23	0.09	1.14	23.29	9.80	15.468	1117	0.17	0.05	0.12	5.60	0.08	15.473	1116
20V	1.22	0.09	1.13	16.91	8.63	15.517	1076	0.20	0.01	0.19	1.51	0.06	15.592	1061
19V	1.67	0.09	1.57	15.97	8.94	15.555	960	0.20	0.07	0.13	1.50	0.20	15.556	937
17V	2.42	0.16	2.26	24.56	7.40	15.506	800	0.18	0.07	0.11	0.74	0.56	15.522	808
16V	3.74	0.32	3.42	44.47	4.98	15.496	726	0.27	0.16	0.12	0.15	1.47	15.508	723
1V [g/hr]	12.04	0.61	11.44	156.0	38.52	15.360	479	0.86	0.40	0.46	1.01	13.07	15.381	454
1AV [g/hr]	15.46	0.59	14.87	41.38	0.61	15.740	324	7.48	0.11	7.36	0.22	0.40	15.952	305

V-S APPROXIMATE EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	86.3	39.5	90.6	90.2	100.0	15.574	941
31	89.2	39.5	94.1	89.6	99.8	15.570	951
22	86.0	38.8	89.6	76.0	99.2	15.473	1116
20	84.0	90.4	83.4	91.0	99.3	15.592	1061
19	87.8	26.7	91.5	90.6	97.8	15.556	937
17	92.6	55.8	95.2	97.0	92.5	15.522	808
16	92.7	50.5	96.6	99.7	70.5	15.508	723
1	92.8	33.2	96.0	99.4	66.1	15.381	454
1A	51.6	80.6	50.5	99.5	34.5	15.952	305
AVERAGE	84.8	50.5	87.5	92.5	84.4	15.570	
AVG W/O IDLE	88.4	48.7	91.6	90.6	94.1	15.542	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
V	2.13	0.13	2.00	20.59	8.52
S	0.32	0.07	0.25	1.60	0.30
EFF[%]	84.8	47.1	87.3	92.2	96.5

TABLE B-14. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS RUNS V AND T, NEW CATALYST

V-T — CALIBRATION 4 — 6544

V								T						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
37V	2.33	0.20	2.13	22.83	9.82	15.557	937	0.29	0.06	0.23	2.70	0.02	15.557	937
31V	2.60	0.23	2.36	24.75	9.50	15.562	961	0.27	0.14	0.13	3.25	0.01	15.562	961
22V	1.23	0.09	1.14	23.29	9.80	15.475	1112	0.18	0.04	0.14	5.44	0.07	15.475	1112
20V	1.22	0.09	1.13	16.91	8.63	15.590	1058	0.19	0.05	0.14	1.82	0.05	15.590	1058
19V	1.67	0.09	1.57	15.97	8.94	15.555	954	0.19	0.06	0.14	1.40	0.18	15.555	954
17V	2.42	0.16	2.26	24.56	7.40	15.515	805	0.16	0.05	0.10	0.64	0.64	15.515	805
16V	3.74	0.32	3.42	44.47	4.98	15.505	719	0.30	0.18	0.12	0.00	1.47	15.505	719
1V [g/hr]	12.04	0.61	11.44	156.0	38.52	15.344	473	0.97	0.29	0.68	0.21	11.78	15.344	473
1AV [g/hr]	15.46	0.59	14.87	41.38	0.61	15.713	328	5.61	0.16	5.45	0.00	0.00	15.713	328

V-T EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
37	87.7	72.2	89.1	88.2	99.8	15.557	937
31	89.7	40.8	94.5	86.9	99.9	15.562	961
22	85.3	56.1	87.5	76.6	99.2	15.475	1112
20	84.6	48.7	87.5	89.3	99.4	15.590	1058
19	88.4	41.1	91.3	91.2	97.9	15.555	954
17	93.5	64.9	95.4	97.4	91.3	15.515	805
16	92.0	42.0	96.6	100.0	70.5	15.505	719
1	92.0	52.4	94.1	99.9	69.4	15.344	473
1A	63.7	72.1	63.4	100.0	100.0	15.713	328
AVERAGE	86.3	54.5	88.8	92.2	92.0	15.535	
AVG W/O IDLE	88.7	52.2	91.7	89.9	94.0	15.537	

NEW SENSOR
POWER VALVE ADJUSTMENT
MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
V	2.13	0.13	2.00	20.59	8.52
T	0.28	0.06	0.22	1.59	0.30
EFF[%]	86.7	51.2	89.0	92.3	96.5

TABLE B-15. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS [g/hr]

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [lb-ft]	THC [g/hr]	CH_4 [g/hr]	NMHC [g/hr]	CO [g/hr]	NO_x [g/hr]	CO_2 [g/hr]	FUEL [lb/hr]	A/F	CAT IN [°F]
37	R_CFR	25	2382	20	2384	20.0	2.03	0.97	1.06	52.54	5.14	8663	6.45	15.57	912
36	100	100	2528	71.0	2530	71.0	2.68	0.64	2.04	85.23	5.93	19636	14.57	15.61	1231
35	100	85	2528	60.4	2528	60.0	2.66	0.71	1.96	111.79	5.19	18049	13.43	15.57	1194
34	100	70	2528	49.7	2526	50.0	2.10	0.86	1.24	93.30	3.97	15233	11.33	15.58	1159
33	100	55	2528	39.1	2526	39.0	1.89	0.74	1.15	73.24	6.23	13350	9.92	15.57	1083
32	100	40	2528	28.4	2530	28.0	1.84	0.97	0.87	60.23	6.63	11230	8.35	15.58	1008
31	100	25	2528	17.3	2528	17.5	1.59	1.10	0.49	64.04	5.24	8918	6.65	15.55	936
30	100	10	2528	7.1	2538	7.0	1.27	0.94	0.33	30.71	0.56	7166	5.32	15.54	882
29	80	100	2142	84.0	2142	84.0	5.35	2.12	3.23	650.13	14.07	18863	14.66	15.27	1185
28	80	85	2142	71.4	2150	71.5	2.85	0.70	2.15	122.13	6.17	17181	12.80	15.57	1168
27	80	70	2142	58.8	2142	59.0	2.43	0.71	1.71	72.36	5.09	15027	11.16	15.59	1127
26	80	55	2142	46.2	2148	46.5	2.62	0.75	1.87	73.59	6.95	12709	9.45	15.57	1061
25	80	40	2142	33.6	2140	33.5	2.08	0.73	1.34	49.22	6.37	10204	7.58	15.56	969
24	80	25	2142	21.0	2140	21.0	2.50	1.11	1.39	24.77	3.65	7979	5.91		875
23	80	10	2142	8.4	2144	8.5	0.75	0.65	0.09	5.60	0.22	5233	3.86	15.52	795
22	60	100	1757	86.0	1758	86.0	4.68	1.56	3.12	438.74	17.51	14941	11.52	15.41	1104
21	60	85	1757	73.1	1758	74.0	4.64	1.36	3.28	199.93	8.57	14118	10.64	15.46	1092
20	60	75	1757	64.5	1758	65.0	2.32	0.78	1.54	88.36	6.68	12837	9.56	15.57	1069
19	60	50	1757	43.0	1758	43.5	1.27	0.47	0.80	35.51	3.80	9195	6.82	15.55	952
18	60	40	1757	34.4	1750	35.0	1.02	0.47	0.55	10.57	2.77	7379	5.45	15.54	893
17	60	25	1757	21.5	1760	21.5	0.51	0.14	0.37	5.68	0.50	5989	4.42	15.51	806
16	60	10	1757	8.6	1763	9.0	0.37	0.22	0.15	0.00	3.36	4707	3.47	15.51	733
15	40	100	1371	83.0	1374	83.0	4.37	2.24	2.13	250.06	8.65	11670	8.90	15.29	978
14	40	85	1371	70.6	1374	71.0	1.70	0.60	1.10	42.33	6.91	9637	7.15	15.52	981
13	40	70	1371	58.1	1374	58.5	1.68	0.57	1.11	19.45	12.81	9416	6.96	15.53	944
12	40	55	1371	45.7	1372	45.5	1.03	0.52	0.51	10.46	9.32	7373	5.45	15.50	856
11	40	40	1371	33.2	1374	33.5	0.79	0.54	0.25	4.92	8.92	6098	4.50	15.50	756
10	40	25	1371	20.8	1368	20.5	0.47	0.36	0.11	0.23	8.44	4724	3.48	15.50	686
9	40	10	1371	8.3	1372	8.5	1.28	0.52	0.76	0.42	3.73	3213	2.37	15.44	587
8	20	100	986	80.0	986	80.0	8.51	2.64	5.87	334.08	19.87	7736	6.10	15.08	824
7	20	85	986	68.0	982	69.5	1.33	0.48	0.85	13.96	14.19	7409	5.48	15.45	829
6	20	70	986	56.0	974	56.0	0.69	0.28	0.40	2.36	16.05	6207	4.58	15.45	775
5	20	55	986	44.0	984	44.5	0.57	0.41	0.17	2.74	15.40	5500	4.06	15.45	714
4	20	40	986	32.0	992	32.5	0.78	0.28	0.49	3.91	11.96	4338	3.20	15.42	623
3	20	25	986	20.0	990	20.5	1.16	0.45	0.71	1.98	7.63	3391	2.50	15.40	546
2	20	10	986	8.0	992	8.0	1.35	0.61	0.74	1.96	0.81	2427	1.79	15.26	452
1	IDLE	CITT	600	36.5	602	36.5	1.28	0.56	0.72	4.53	9.76	2965	2.19	15.39	468
1A	IDLE	-	600	0.0	708	0.0	7.69	0.21	7.48	0.21	0.09	1227	0.92	15.87	322

TABLE B-16. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS [g/hp-hr]

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [lb-ft]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	CO_2 [g/hp-hr]	FUEL [lb/hp-hr]	A/F	CAT IN [°F]
37	R_CFR	25	2382	20	2384	20.0	0.22	0.11	0.12	5.79	0.57	954.2	0.71	15.57	912
36	100	100	2528	71.0	2530	71.0	0.08	0.02	0.06	2.49	0.17	574	0.43	15.61	1231
35	100	85	2528	60.4	2528	60.0	0.09	0.02	0.07	3.87	0.18	625	0.47	15.57	1194
34	100	70	2528	49.7	2526	50.0	0.09	0.04	0.05	3.88	0.17	633	0.47	15.58	1159
33	100	55	2528	39.1	2526	39.0	0.10	0.04	0.06	3.90	0.33	712	0.53	15.57	1083
32	100	40	2528	28.4	2530	28.0	0.14	0.07	0.06	4.47	0.49	833	0.62	15.58	1008
31	100	25	2528	17.3	2528	17.5	0.19	0.13	0.06	7.60	0.62	1059	0.79	15.55	936
30	100	10	2528	7.1	2538	7.0	0.37	0.28	0.10	9.08	0.16	2118	1.57	15.54	882
29	80	100	2142	84.0	2142	84.0	0.16	0.06	0.09	18.98	0.41	551	0.43	15.27	1185
28	80	85	2142	71.4	2150	71.5	0.10	0.02	0.07	4.17	0.21	587	0.44	15.57	1168
27	80	70	2142	58.8	2142	59.0	0.10	0.03	0.07	3.01	0.21	624	0.46	15.59	1127
26	80	55	2142	46.2	2148	46.5	0.14	0.04	0.10	3.87	0.37	668	0.50	15.57	1061
25	80	40	2142	33.6	2140	33.5	0.15	0.05	0.10	3.61	0.47	748	0.56	15.56	969
24	80	25	2142	21.0	2140	21.0	0.29	0.13	0.16	2.89	0.43	933	0.69		875
23	80	10	2142	8.4	2144	8.5	0.21	0.19	0.03	1.61	0.06	1508	1.11	15.52	795
22	60	100	1757	86.0	1758	86.0	0.16	0.05	0.11	15.24	0.61	519	0.40	15.41	1104
21	60	85	1757	73.1	1758	74.0	0.19	0.05	0.13	8.07	0.35	570	0.43	15.46	1092
20	60	75	1757	64.5	1758	65.0	0.11	0.04	0.07	4.06	0.31	590	0.44	15.57	1069
19	60	50	1757	43.0	1758	43.5	0.09	0.03	0.06	2.44	0.26	631	0.47	15.55	952
18	60	40	1757	34.4	1750	35.0	0.09	0.04	0.05	0.91	0.24	633	0.47	15.54	893
17	60	25	1757	21.5	1760	21.5	0.07	0.02	0.05	0.79	0.07	831	0.61	15.51	806
16	60	10	1757	8.6	1763	9.0	0.12	0.07	0.05	0.00	1.11	1558	1.15	15.51	733
15	40	100	1371	83.0	1374	83.0	0.20	0.10	0.10	11.52	0.40	537	0.41	15.29	978
14	40	85	1371	70.6	1374	71.0	0.09	0.03	0.06	2.28	0.37	519	0.39	15.52	981
13	40	70	1371	58.1	1374	58.5	0.11	0.04	0.07	1.27	0.84	615	0.45	15.53	944
12	40	55	1371	45.7	1372	45.5	0.09	0.04	0.04	0.88	0.78	620	0.46	15.50	856
11	40	40	1371	33.2	1374	33.5	0.09	0.06	0.03	0.56	1.02	696	0.51	15.50	756
10	40	25	1371	20.8	1368	20.5	0.09	0.07	0.02	0.04	1.58	885	0.65	15.50	686
9	40	10	1371	8.3	1372	8.5	0.58	0.23	0.34	0.19	1.68	1447	1.07	15.44	587
8	20	100	986	80.0	986	80.0	0.57	0.18	0.39	22.24	1.32	515	0.41	15.08	824
7	20	85	986	68.0	982	69.5	0.10	0.04	0.07	1.07	1.09	570	0.42	15.45	829
6	20	70	986	56.0	974	56.0	0.07	0.03	0.04	0.23	1.55	598	0.44	15.45	775
5	20	55	986	44.0	984	44.5	0.07	0.05	0.02	0.33	1.85	660	0.49	15.45	714
4	20	40	986	32.0	992	32.5	0.13	0.05	0.08	0.64	1.95	707	0.52	15.42	623
3	20	25	986	20.0	990	20.5	0.30	0.12	0.18	0.51	1.98	877	0.65	15.40	546
2	20	10	986	8.0	992	8.0	0.90	0.41	0.49	1.30	0.53	1606	1.19	15.26	452
1	IDLE	CITT	600	36.5	602	36.5	0.31	0.13	0.17	1.08	2.33	709	0.52	15.39	468
1A	IDLE	[g/hr]	600	0.0	708	0.0	7.69	0.21	7.48	0.21	0.09	1227	0.92	15.87	322

APPROXIMATE D2 CYCLE COMPOSITE RESULTS	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	CO_2 [g/hp-hr]	FUEL [lb/hp-hr]
	0.11	**0.06**	**0.06**	**4.43**	**0.30**	**751.6**	**0.56**

TABLE B-17. TRUCK 16, MAZDA ENGINE, STEADY STATE EMISSIONS RESULTS [g/kW-hr]

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [N-m]	THC [g/kW-hr]	CH_4 [g/kW-hr]	NMHC [g/kW-hr]	CO [g/kW-hr]	NO_x [g/kW-hr]	CO_2 [g/kW-hr]	FUEL [kg/kW-hr]	A/F	CAT IN [°C]
37	R_CFR	25	2382	20	2384	27.1	0.30	0.14	0.16	7.76	0.76	1280	0.43	15.57	489
36	100	100	2528	71.0	2530	96.3	0.10	0.02	0.08	3.34	0.23	770	0.26	15.61	666
35	100	85	2528	60.4	2528	81.4	0.12	0.03	0.09	5.19	0.24	838	0.28	15.57	646
34	100	70	2528	49.7	2526	67.8	0.12	0.05	0.07	5.20	0.22	849	0.29	15.58	626
33	100	55	2528	39.1	2526	52.9	0.13	0.05	0.08	5.24	0.45	954	0.32	15.57	584
32	100	40	2528	28.4	2530	38.0	0.18	0.10	0.09	5.99	0.66	1117	0.38	15.58	542
31	100	25	2528	17.3	2528	23.7	0.25	0.18	0.08	10.20	0.83	1420	0.48	15.55	502
30	100	10	2528	7.1	2538	9.5	0.50	0.37	0.13	12.18	0.22	2841	0.96	15.54	472
29	80	100	2142	84.0	2142	113.9	0.21	0.08	0.13	25.45	0.55	738	0.26	15.27	640
28	80	85	2142	71.4	2150	97.0	0.13	0.03	0.10	5.60	0.28	787	0.27	15.57	631
27	80	70	2142	58.8	2142	80.0	0.14	0.04	0.10	4.03	0.28	837	0.28	15.59	608
26	80	55	2142	46.2	2148	63.1	0.18	0.05	0.13	5.19	0.49	896	0.30	15.57	571
25	80	40	2142	33.6	2140	45.4	0.20	0.07	0.13	4.84	0.63	1003	0.34	15.56	521
24	80	25	2142	21.0	2140	28.5	0.39	0.17	0.22	3.88	0.57	1251	0.42		468
23	80	10	2142	8.4	2144	11.5	0.29	0.25	0.04	2.16	0.09	2022	0.68	15.52	424
22	60	100	1757	86.0	1758	116.6	0.22	0.07	0.15	20.44	0.82	696	0.24	15.41	595
21	60	85	1757	73.1	1758	100.4	0.25	0.07	0.18	10.82	0.46	764	0.26	15.46	589
20	60	75	1757	64.5	1758	88.2	0.14	0.05	0.09	5.45	0.41	791	0.27	15.57	576
19	60	50	1757	43.0	1758	59.0	0.12	0.04	0.07	3.27	0.35	847	0.28	15.55	511
18	60	40	1757	34.4	1750	47.5	0.12	0.05	0.06	1.22	0.32	849	0.28	15.54	479
17	60	25	1757	21.5	1760	29.2	0.09	0.03	0.07	1.06	0.09	1115	0.37	15.51	430
16	60	10	1757	8.6	1763	12.2	0.17	0.10	0.07	0.00	1.49	2089	0.70	15.51	390
15	40	100	1371	83.0	1374	112.6	0.27	0.14	0.13	15.44	0.53	721	0.25	15.29	526
14	40	85	1371	70.6	1374	96.3	0.12	0.04	0.08	3.06	0.50	696	0.23	15.52	527
13	40	70	1371	58.1	1374	79.3	0.15	0.05	0.10	1.70	1.12	825	0.28	15.53	507
12	40	55	1371	45.7	1372	61.7	0.12	0.06	0.06	1.18	1.05	832	0.28	15.50	458
11	40	40	1371	33.2	1374	45.4	0.12	0.08	0.04	0.75	1.37	933	0.31	15.50	402
10	40	25	1371	20.8	1368	27.8	0.12	0.09	0.03	0.06	2.12	1187	0.40	15.50	363
9	40	10	1371	8.3	1372	11.5	0.77	0.31	0.46	0.26	2.25	1941	0.65	15.44	308
8	20	100	986	80.0	986	108.5	0.76	0.24	0.52	29.83	1.77	691	0.25	15.08	440
7	20	85	986	68.0	982	94.3	0.14	0.05	0.09	1.44	1.46	765	0.26	15.45	443
6	20	70	986	56.0	974	76.0	0.09	0.04	0.05	0.31	2.07	802	0.27	15.45	413
5	20	55	986	44.0	984	60.4	0.09	0.07	0.03	0.44	2.48	885	0.30	15.45	379
4	20	40	986	32.0	992	44.1	0.17	0.06	0.11	0.86	2.61	948	0.32	15.42	328
3	20	25	986	20.0	990	27.8	0.40	0.16	0.25	0.69	2.65	1177	0.39	15.40	286
2	20	10	986	8.0	992	10.9	1.20	0.54	0.66	1.74	0.72	2154	0.72	15.26	233
1	IDLE	CITT	600	36.5	602	49.5	0.41	0.18	0.23	1.45	3.13	950	0.32	15.39	242
1A	IDLE	[g/hr]	600	0.0	708	0.0	10.31	0.29	10.03	0.28	0.12	1645	0.56	15.87	161

APPROXIMATE D2 CYCLE COMPOSITE RESULTS	THC [g/kW-hr]	CH_4 [g/kW-hr]	NMHC [g/kW-hr]	CO [g/kW-hr]	NO_x [g/kW-hr]	CO_2 [g/kW-hr]	FUEL [kg/kW-hr]
	0.15	0.07	0.08	5.94	0.40	1008	0.75

TABLE B-18. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS
RUNS GA, GC, GD AND GF, OLD CATALYST

GA-GC

GA								GC						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
31GA	1.30	0.17	1.13	18.94	5.49	15.756	1053	0.03	0.03	0.00	0.16	2.63	15.756	1052
22GA	1.58	0.12	1.46	17.40	12.47	15.733	1150	0.03	0.01	0.02	0.40	4.84	15.732	1175
20GA	1.81	0.12	1.68	8.63	11.84	15.744	1090	0.03	0.01	0.01	0.40	5.05	15.742	1096
19GA	1.81	0.13	1.68	10.73	9.64	15.758	988	0.07	0.03	0.04	0.72	4.23	15.751	991
17GA	2.08	0.18	1.90	16.18	6.38	15.770	869	0.11	0.08	0.04	0.21	3.46	15.787	876
16GA	2.86	0.36	2.49	40.07	4.73	15.809	784	0.30	0.21	0.09	0.05	2.72	15.835	790
1GA [g/hr]	19.76	0.56	19.20	79.06	78.14	15.975	528	7.79	0.79	7.00	3.89	48.89	15.874	539
1AGA [g/hr]	4.99	0.25	4.74	7.22	0.57	18.170	296	3.18	0.19	2.99	0.79	0.28	18.987	339

GA-GC EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
31	97.9	83.6	100.0	99.1	52.1	15.756	1052
22	98.0	92.5	98.5	97.7	61.2	15.732	1175
20	98.5	88.5	99.3	95.4	57.4	15.742	1096
19	96.1	74.6	97.7	93.3	56.1	15.751	991
17	94.6	57.1	98.1	98.7	45.7	15.787	876
16	89.6	43.3	96.3	99.9	42.5	15.835	790
1	60.6	-40.7	63.5	95.1	37.4	15.874	539
1A	36.2	25.2	36.8	89.1	50.8	18.987	339
AVERAGE	**83.9**	**53.0**	**86.3**	**96.0**	**50.4**	**16.18**	
AVG W/O IDLE	**95.8**	**73.2**	**98.3**	**97.3**	**52.5**	**15.77**	

[redacted] OLD SENSOR

COMPOSITE RESULTS C2					
TEST	THC	CH_4	NMHC	CO	NO_x
GA	1.94	0.15	1.79	13.61	8.95
GC	0.12	0.05	0.07	0.50	4.06
EFF[%]	**93.8**	**68.9**	**95.9**	**96.3**	**54.7**

GF-GD

GF								GD						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
31GF	0.92	0.12	0.80	15.71	5.44	15.734	1086	0.03	0.01	0.01	0.11	2.38	15.733	1103
22GF	1.35	0.11	1.24	13.49	11.89	15.671	1189	0.04	0.01	0.03	1.35	1.20	15.630	1190
20GF	1.54	0.11	1.43	7.61	11.78	15.734	1125	0.04	0.01	0.02	0.13	4.67	15.742	1128
19GF	1.63	0.11	1.52	9.61	9.66	15.729	1020	0.04	0.03	0.01	0.19	4.34	15.741	1038
17GF	1.66	0.14	1.52	13.33	6.59	15.745	886	0.07	0.06	0.01	0.01	3.04	15.757	901
16GF	2.01	0.21	1.79	24.22	4.88	15.813	793	0.26	0.19	0.07	0.01	2.67	15.803	826
1GF [g/hr]	21.99	0.59	21.40	81.67	89.24	15.786	575	14.01	0.69	13.32	4.08	58.64	15.966	555
1AGF [g/hr]	5.27	0.19	5.08	6.00	49.64	18.463	335	4.02	0.11	3.91	0.98	0.84	18.229	356

GF-GD EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
31	97.2	88.8	98.5	99.3	56.3	15.733	1103
22	97.3	91.4	97.8	90.0	89.9	15.630	1190
20	97.7	88.5	98.4	98.4	60.4	15.742	1128
19	97.6	77.9	99.0	98.0	55.1	15.741	1038
17	95.6	54.3	99.3	99.9	53.9	15.757	901
16	86.8	11.3	95.8	99.9	45.2	15.803	826
1	36.3	-16.6	37.7	95.0	34.3	15.966	555
1A	23.8	44.8	23.0	83.7	98.3	18.229	356
AVERAGE	**79.0**	**55.0**	**81.2**	**95.5**	**61.7**	**16.07**	
AVG W/O IDLE	**95.3**	**68.7**	**98.1**	**97.6**	**60.1**	**15.73**	

[redacted] NEW SENSOR MAINTENANCE

COMPOSITE RESULTS C2					
TEST	THC	CH_4	NMHC	CO	NO_x
GF	1.66	0.13	1.53	11.34	9.60
GD	0.11	0.04	0.07	0.22	3.74
EFF[%]	**93.6**	**69.9**	**95.6**	**98.1**	**61.1**

TABLE B-19. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS RUNS GI AND GH, OLD CATALYST

GI-GH

GI								GH						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
31GI	1.02	0.14	0.88	18.84	4.85	15.664	1069	0.06	0.05	0.01	6.20	0.62	15.617	1060
22GI	1.36	0.13	1.24	20.85	11.55	15.547	1176	0.05	0.02	0.03	3.60	1.01	15.578	1181
20GI	1.54	0.11	1.42	10.64	11.04	15.659	1112	0.05	0.02	0.04	1.69	1.13	15.660	1111
19GI	1.67	0.12	1.55	12.04	9.40	15.708	1010	0.04	0.03	0.02	1.60	0.85	15.664	1015
17GI	1.87	0.16	1.72	16.42	6.29	15.695	864	0.08	0.04	0.04	1.08	0.37	15.671	879
16GI	2.83	0.39	2.44	46.39	4.20	15.614	769	0.29	0.18	0.11	1.44	0.76	15.686	774
1GI [g/hr]	20.87	0.90	19.97	140.43	72.60	15.673	526	9.27	0.88	8.39	9.96	30.03	15.680	534
1AGI [g/hr]	6.31	0.40	5.90	37.28	0.73	16.044	288	3.22	0.65	2.56	0.00	0.28	15.962	304

GI-GH EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
31	93.7	61.9	98.9	67.1	87.2	15.617	1060
22	96.2	86.2	97.2	82.8	91.2	15.578	1181
20	96.5	85.4	97.4	84.1	89.8	15.660	1111
19	97.3	79.4	98.7	86.7	90.9	15.664	1015
17	95.6	73.1	97.6	93.4	94.2	15.671	879
16	89.6	53.8	95.3	96.9	81.8	15.686	774
1	55.6	2.2	58.0	92.9	58.6	15.680	534
1A	49.0	-62.2	56.6	100.0	60.8	15.962	304
AVERAGE	**84.2**	**47.5**	**87.5**	**88.0**	**81.8**	**15.69**	
AVG W/O IDLE	**94.8**	**73.3**	**97.5**	**85.2**	**89.2**	**15.65**	

NEW SENSOR
MAINTENANCE
BEST CALIBRATION

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
GI	1.77	0.14	1.62	15.30	8.61
GH	0.10	0.04	0.06	1.84	0.77
EFF[%]	**94.1**	**70.8**	**96.2**	**88.0**	**91.1**

TABLE B-20. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS
RUNS GA, GB, GE AND GF, NEW CATALYST

GA-GB

GA

MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
31GA	1.30	0.17	1.13	18.94	5.49	15.756	1053
22GA	1.58	0.12	1.46	17.40	12.47	15.733	1150
20GA	1.81	0.12	1.68	8.63	11.84	15.744	1090
19GA	1.81	0.13	1.68	10.73	9.64	15.758	988
17GA	2.08	0.18	1.90	16.18	6.38	15.770	869
16GA	2.86	0.36	2.49	40.07	4.73	15.809	784
1GA [g/hr]	19.76	0.56	19.20	79.06	78.14	15.975	528
1AGA [g/hr]	4.99	0.25	4.74	7.22	0.57	18.170	296

GB

THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
0.05	0.05	0.01	0.07	2.98	15.842	1050
0.02	0.01	0.01	0.04	5.59	15.722	1172
0.04	0.02	0.02	0.00	6.30	15.795	1091
0.07	0.05	0.02	0.05	5.36	15.808	992
0.13	0.11	0.03	0.12	3.50	15.767	857
0.30	0.27	0.03	0.24	3.21	15.825	788
7.43	0.70	6.73	4.45	48.82	16.021	508
2.98	0.04	2.94	2.53	0.04	18.992	338

GA-GB EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
31	95.8	70.8	99.4	99.6	45.7	15.842	1050
22	98.5	93.6	99.0	99.8	55.2	15.722	1172
20	97.6	80.0	98.9	100.0	46.8	15.795	1091
19	96.3	61.3	99.0	99.5	44.4	15.808	992
17	93.7	40.1	98.6	99.3	45.1	15.767	857
16	89.6	26.7	98.8	99.4	32.2	15.825	788
1	62.4	-25.8	65.0	94.4	37.5	16.021	508
1A	40.3	84.0	38.0	65.0	92.5	18.992	338
AVERAGE	**84.3**	**53.8**	**87.1**	**94.6**	**49.9**	**16.22**	
AVG W/O IDLE	**95.3**	**62.1**	**99.0**	**99.6**	**44.9**	**15.79**	

OLD SENSOR

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
GA	1.94	0.15	1.79	13.61	8.95
GB	0.12	0.06	0.06	0.10	4.87
EFF[%]	**93.6**	**57.7**	**96.6**	**99.3**	**45.6**

GF-GE

GF

MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
31GF	0.92	0.12	0.80	15.71	5.44	15.734	1086
22GF	1.35	0.11	1.24	13.49	11.89	15.671	1189
20GF	1.54	0.11	1.43	7.61	11.78	15.734	1125
19GF	1.63	0.11	1.52	9.61	9.66	15.729	1020
17GF	1.66	0.14	1.52	13.33	6.59	15.745	886
16GF	2.01	0.21	1.79	24.22	4.88	15.813	793
1GF [g/hr]	5.27	0.19	5.08	6.00	49.64	15.786	575
1AGF [g/hr]	5.27	0.19	5.08	6.00	49.64	18.463	335

GE

THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
0.04	0.03	0.01	0.02	3.05	15.753	1084
0.01	0.00	0.01	0.03	0.80	15.660	1189
0.03	0.01	0.01	0.07	5.30	15.740	1120
0.05	0.04	0.01	0.02	4.93	15.743	1030
0.12	0.10	0.02	0.11	3.36	15.739	879
0.24	0.21	0.03	0.16	3.30	15.790	800
11.65	0.66	10.99	3.86	64.54	16.047	541
3.07	0.00	3.07	0.20	0.78	18.357	327

GF-GE EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
31	95.9	76.3	98.9	99.9	43.9	15.753	1084
22	99.5	99.0	99.5	99.8	93.2	15.660	1189
20	98.1	87.4	99.0	99.1	55.0	15.740	1120
19	97.2	67.4	99.5	99.8	49.0	15.743	1030
17	92.9	30.2	98.5	99.2	49.0	15.739	879
16	88.1	3.4	98.2	99.3	32.4	15.790	800
1	-120.9	-237.3	-116.4	35.7	-30	16.047	541
1A	41.8	100.0	39.5	96.7	98.4	18.357	327
AVERAGE	**61.6**	**28.3**	**64.6**	**91.2**	**48.9**	**16.10**	
AVG W/O IDLE	**95.3**	**60.6**	**98.9**	**99.5**	**53.7**	**15.74**	

NEW SENSOR MAINTENANCE

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
GF	1.66	0.13	1.53	11.34	9.60
GE	0.10	0.05	0.05	0.06	4.21
EFF[%]	**93.7**	**59.3**	**96.6**	**99.5**	**56.1**

TABLE B-21. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS RUNS GI AND GG, NEW CATALYST

GI-GG

GI								GG						
MODE	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	A/F	CAT IN [°F]
31GI	1.02	0.14	0.88	18.84	4.85	15.664	1069	0.07	0.05	0.02	0.28	0.01	15.667	1097
22GI	1.36	0.13	1.24	20.85	11.55	15.547	1176	0.24	0.07	0.18	1.99	0.05	15.552	1198
20GI	1.54	0.11	1.42	10.64	11.04	15.659	1112	0.15	0.04	0.11	0.37	0.04	15.666	1132
19GI	1.67	0.12	1.55	12.04	9.40	15.708	1010	0.02	0.00	0.02	0.00	0.23	15.683	1028
17GI	1.87	0.16	1.72	16.42	6.29	15.695	864	0.08	0.03	0.04	0.29	0.05	15.668	878
16GI	2.83	0.39	2.44	46.39	4.20	15.614	769	0.20	0.10	0.10	0.73	0.05	15.637	798
1GI [g/hr]	20.87	0.90	19.97	140.4	72.60	15.673	526	2.67	0.69	1.98	1.9	24.41	15.646	533
1AGI [g/hr]	6.31	0.40	5.90	37.3	0.73	16.044	288	3.64	0.84	2.81	0.01	0.44	15.915	330

GI-GG EFFICIENCY

MODE	THC [%]	CH_4 [%]	NMHC [%]	CO [%]	NO_x [%]	A/F	CAT IN [°F]
31	93.4	66.2	97.9	98.5	99.7	15.667	1097
22	82.2	47.8	85.7	90.4	99.5	15.552	1198
20	90.5	66.9	92.4	96.5	99.7	15.666	1132
19	99.0	100.0	98.9	100.0	97.5	15.683	1028
17	96.0	79.9	97.4	98.3	99.3	15.668	878
16	92.9	74.4	95.8	98.4	98.7	15.637	798
1	87.2	23.7	90.1	98.6	66.4	15.646	533
1A	42.2	-107.1	52.4	100.0	38.8	15.915	330
AVERAGE	**85.4**	**44.0**	**88.8**	**97.6**	**87.5**	**15.68**	
AVG W/O IDLE	**92.3**	**72.5**	**94.7**	**97.0**	**99.1**	**15.65**	

[redacted]
NEW SENSOR
MAINTENANCE
BEST CALIBRATION

COMPOSITE RESULTS C2

TEST	THC	CH_4	NMHC	CO	NO_x
GI	1.77	0.14	1.62	15.30	8.61
GG	0.11	0.03	0.08	0.28	0.14
EFF[%]	**93.5**	**77.6**	**94.9**	**98.2**	**98.4**

TABLE B-22. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS [g/hr] OLD CATALYST

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [lb-ft]	THC [g/hr]	CH_4 [g/hr]	NMHC [g/hr]	CO [g/hr]	NO_x [g/hr]	CO_2 [g/hr]	FUEL [lb/hr]	A/F	CAT IN [°F]
G36	100	100	2631	80.0	2626	79.5	1.44	0.57	0.86	27.87	33.02	24076	17.77	15.67	1319
G35	100	85	2631	68.0	2630	67.5	0.92	0.43	0.49	24.92	30.19	22560	16.65	15.67	1291
G34	100	70	2631	56.0	2628	56.0	0.69	0.43	0.27	37.11	16.42	20096	14.85	15.65	1248
G33	100	55	2631	44.0	2630	43.5	0.46	0.41	0.05	38.45	9.26	17520	12.95	15.64	1204
G32	100	40	2631	32.0	2630	31.5	0.44	0.35	0.09	22.69	6.18	15058	11.12	15.64	1144
G31	100	25	2631	20.3	2620	20.5	0.66	0.56	0.10	63.43	6.35	13210	9.81	15.62	1060
G30	100	10	2631	8.0	2622	8.0	0.41	0.19	0.22	17.21	1.25	9883	7.30	15.65	1022
G29	80	100	2225	95.0	2228	95.0	6.84	2.96	3.87	181.90	24.25	23760	17.73	15.58	1273
G28	80	85	2225	80.8	2222	80.5	2.12	0.87	1.25	24.40	21.51	21148	15.61	15.67	1238
G27	80	70	2225	66.5	2228	66.5	1.38	0.73	0.65	17.38	14.77	18185	13.42	15.68	1195
G26	80	55	2225	52.3	2222	52.0	0.94	0.52	0.42	17.42	11.56	15940	11.76	15.67	1139
G25	80	40	2225	38.0	2226	38.5	0.42	0.29	0.13	5.00	10.05	14318	10.55	15.68	1081
G24	80	25	2225	23.8	2228	24.0	1.29	0.76	0.54	28.01	3.63	11238	8.31	15.66	993
G23	80	10	2225	9.5	2222	9.5	1.27	0.98	0.30	41.22	1.39	9135	6.78	15.62	900
G22	60	100	1819	110.0	1816	110.0	4.85	1.67	3.17	178.85	24.83	20552	15.36	15.56	1194
G21	60	85	1819	93.5	1826	94.0	2.41	0.80	1.61	19.81	21.59	18827	13.90	15.68	1169
G20	60	75	1819	81.4	1814	81.5	1.50	0.47	1.03	47.69	31.72	16049	11.88	15.66	1111
G19	60	50	1819	54.3	1816	54.5	0.85	0.48	0.37	30.09	16.10	13696	10.13	15.66	1015
G18	60	40	1819	44.0	1818	44.5	1.91	1.08	0.84	31.96	9.46	11974	8.86	15.64	975
G17	60	25	1819	27.1	1822	27.5	0.79	0.40	0.39	10.32	3.51	9080	6.70	15.67	879
G16	60	10	1819	10.9	1818	10.5	1.07	0.66	0.41	5.23	2.77	7238	5.34	15.69	774
G15	40	100	1412	118.0	1412	118.0	1.91	0.38	1.54	21.74	38.73	17090	12.62	15.66	1083
G14	40	85	1412	100.3	1414	100.5	4.07	0.88	3.19	57.27	29.29	14866	11.03	15.66	1034
G13	40	70	1412	82.6	1410	82.5	3.20	0.99	2.21	52.20	21.43	13177	9.77	15.65	967
G12	40	55	1412	64.9	1408	64.5	3.47	1.26	2.20	60.56	17.25	11169	8.31	15.63	903
G11	40	40	1412	47.2	1418	48.0	3.33	1.48	1.85	46.71	8.25	9678	7.19	15.63	837
G10	40	25	1412	29.5	1412	29.0	3.20	1.52	1.67	30.64	1.56	6978	5.18	15.61	738
G9	40	10	1412	11.8	1406	11.5	3.21	1.21	2.01	15.58	1.66	5444	4.04	15.64	635
G8	20	100	1006	119.0	1008	119.0	12.63	2.59	10.04	264.22	66.46	12164	9.29	15.52	895
G7	20	85	1006	101.2	1004	101.5	5.16	1.45	3.71	75.57	24.83	10772	8.03	15.61	845
G6	20	70	1006	83.3	1002	82.5	5.78	1.44	4.34	68.02	20.06	9424	7.03	15.61	793
G5	20	55	1006	65.5	1010	65.5	6.10	1.35	4.74	52.21	13.63	8039	6.00	15.62	737
G4	20	40	1006	47.6	1004	48.0	8.40	1.28	7.12	55.04	12.60	6580	4.93	15.59	658
G3	20	25	1006	29.8	1002	30.0	6.96	1.01	5.96	20.22	6.17	5195	3.87	15.66	595
G2	20	10	1006	11.9	1010	12.0	8.54	0.72	7.82	64.52	1.62	3567	2.72	15.60	480
G1	IDLE	CITT	600	68.0	604	68.0	9.27	0.88	8.39	9.96	30.03	4840	3.60	15.68	534
G1A	IDLE	0	600	0.0	606	0.0	3.22	0.65	2.56	0.00	0.28	1624	1.20	15.96	304

TABLE B-23. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS [g/hp-hr]
OLD CATALYST

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [lb-ft]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	CO_2 [g/hp-hr]	FUEL [lb/hp-hr]	A/F	CAT IN [°F]
G36	100	100	2631	80.0	2626	79.5	0.04	0.01	0.02	0.70	0.83	606	0.45	15.67	1319
G35	100	85	2631	68.0	2630	67.5	0.03	0.01	0.01	0.74	0.89	667	0.49	15.67	1291
G34	100	70	2631	56.0	2628	56.0	0.02	0.02	0.01	1.32	0.59	717	0.53	15.65	1248
G33	100	55	2631	44.0	2630	43.5	0.02	0.02	0.00	1.77	0.43	804	0.59	15.64	1204
G32	100	40	2631	32.0	2630	31.5	0.03	0.02	0.01	1.44	0.39	955	0.70	15.64	1144
G31	100	25	2631	20.3	2620	20.5	0.06	0.05	0.01	6.20	0.62	1292	0.96	15.62	1060
G30	100	10	2631	8.0	2622	8.0	0.10	0.05	0.06	4.31	0.31	2475	1.83	15.65	1022
G29	80	100	2225	95.0	2228	95.0	0.17	0.07	0.10	4.51	0.60	590	0.44	15.58	1273
G28	80	85	2225	80.8	2222	80.5	0.06	0.03	0.04	0.72	0.63	621	0.46	15.67	1238
G27	80	70	2225	66.5	2228	66.5	0.05	0.03	0.02	0.62	0.52	645	0.48	15.68	1195
G26	80	55	2225	52.3	2222	52.0	0.04	0.02	0.02	0.79	0.53	725	0.53	15.67	1139
G25	80	40	2225	38.0	2226	38.5	0.03	0.02	0.01	0.31	0.62	877	0.65	15.68	1081
G24	80	25	2225	23.8	2228	24.0	0.13	0.07	0.05	2.75	0.36	1104	0.82	15.66	993
G23	80	10	2225	9.5	2222	9.5	0.32	0.24	0.07	10.26	0.35	2273	1.69	15.62	900
G22	60	100	1819	110.0	1816	110.0	0.13	0.04	0.08	4.70	0.65	540	0.40	15.56	1194
G21	60	85	1819	93.5	1826	94.0	0.07	0.02	0.05	0.61	0.66	576	0.43	15.68	1169
G20	60	75	1819	81.4	1814	81.5	0.05	0.02	0.04	1.69	1.13	570	0.42	15.66	1111
G19	60	50	1819	54.3	1816	54.5	0.04	0.03	0.02	1.60	0.85	727	0.54	15.66	1015
G18	60	40	1819	44.0	1818	44.5	0.12	0.07	0.05	2.07	0.61	777	0.58	15.64	975
G17	60	25	1819	27.1	1822	27.5	0.08	0.04	0.04	1.08	0.37	952	0.70	15.67	879
G16	60	10	1819	10.9	1818	10.5	0.29	0.18	0.11	1.44	0.76	1991	1.47	15.69	774
G15	40	100	1412	118.0	1412	118.0	0.06	0.01	0.05	0.69	1.22	539	0.40	15.66	1083
G14	40	85	1412	100.3	1414	100.5	0.15	0.03	0.12	2.12	1.08	549	0.41	15.66	1034
G13	40	70	1412	82.6	1410	82.5	0.14	0.04	0.10	2.36	0.97	595	0.44	15.65	967
G12	40	55	1412	64.9	1408	64.5	0.20	0.07	0.13	3.50	1.00	646	0.48	15.63	903
G11	40	40	1412	47.2	1418	48.0	0.26	0.11	0.14	3.60	0.64	747	0.55	15.63	837
G10	40	25	1412	29.5	1412	29.0	0.41	0.19	0.21	3.93	0.20	895	0.66	15.61	738
G9	40	10	1412	11.8	1406	11.5	1.04	0.39	0.65	5.06	0.54	1768	1.31	15.64	635
G8	20	100	1006	119.0	1008	119.0	0.55	0.11	0.44	11.57	2.91	533	0.41	15.52	895
G7	20	85	1006	101.2	1004	101.5	0.27	0.07	0.19	3.90	1.28	555	0.41	15.61	845
G6	20	70	1006	83.3	1002	82.5	0.37	0.09	0.28	4.32	1.27	599	0.45	15.61	793
G5	20	55	1006	65.5	1010	65.5	0.48	0.11	0.38	4.14	1.08	638	0.48	15.62	737
G4	20	40	1006	47.6	1004	48.0	0.92	0.14	0.78	6.00	1.37	717	0.54	15.59	658
G3	20	25	1006	29.8	1002	30.0	1.22	0.18	1.04	3.53	1.08	908	0.68	15.66	595
G2	20	10	1006	11.9	1010	12.0	3.70	0.31	3.39	27.96	0.70	1546	1.18	15.60	480
G1	IDLE	CITT	600	68.0	604	68.0	1.19	0.11	1.07	1.27	3.84	619	0.46	15.68	534
G1A	IDLE	[g/hr]	600	0.0	606	0.0	3.22	0.65	2.56	0.00	0.28	1624	1.20	15.96	304

APPROXIMATE D2 CYCLE COMPOSITE RESULTS	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	CO_2 [g/hp-hr]	FUEL [lb/hp-hr]
	0.03	**0.02**	**0.01**	**2.26**	**0.56**	**865.2**	**0.64**

TABLE B-24. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS [g/kW-hr] OLD CATALYST

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [N-m]	SPEED [rpm]	TORQUE [N-m]	THC [g/kW-hr]	CH_4 [g/kW-hr]	NMHC [g/kW-hr]	CO [g/kW-hr]	NO_x [g/kW-hr]	CO_2 [g/kW-hr]	FUEL [kg/kW-hr]	A/F	CAT IN [°C]
G36	100	100	2631	108.5	2626	107.8	0.05	0.02	0.03	0.94	1.11	812	0.27	15.67	715
G35	100	85	2631	92.2	2630	91.6	0.04	0.02	0.02	0.99	1.20	895	0.30	15.67	699
G34	100	70	2631	76.0	2628	76.0	0.03	0.02	0.01	1.78	0.79	962	0.32	15.65	676
G33	100	55	2631	59.7	2630	59.0	0.03	0.03	0.00	2.37	0.57	1079	0.36	15.64	651
G32	100	40	2631	43.4	2630	42.7	0.04	0.03	0.01	1.93	0.53	1280	0.43	15.64	618
G31	100	25	2631	27.5	2620	27.8	0.09	0.07	0.01	8.32	0.83	1732	0.58	15.62	571
G30	100	10	2631	10.9	2622	10.9	0.14	0.06	0.07	5.78	0.42	3319	1.11	15.65	550
G29	80	100	2225	128.8	2228	128.8	0.23	0.10	0.13	6.05	0.81	791	0.27	15.58	689
G28	80	85	2225	109.6	2222	109.2	0.08	0.03	0.05	0.96	0.85	833	0.28	15.67	670
G27	80	70	2225	90.2	2228	90.2	0.07	0.03	0.03	0.83	0.70	864	0.29	15.68	646
G26	80	55	2225	70.9	2222	70.5	0.06	0.03	0.03	1.06	0.70	972	0.33	15.67	615
G25	80	40	2225	51.5	2226	52.2	0.03	0.02	0.01	0.41	0.83	1177	0.39	15.68	583
G24	80	25	2225	32.3	2228	32.6	0.17	0.10	0.07	3.69	0.48	1480	0.50	15.66	534
G23	80	10	2225	12.9	2222	12.9	0.42	0.33	0.10	13.75	0.47	3048	1.03	15.62	482
G22	60	100	1819	149.2	1816	149.2	0.17	0.06	0.11	6.31	0.88	725	0.25	15.56	645
G21	60	85	1819	126.8	1826	127.5	0.10	0.03	0.07	0.81	0.89	773	0.26	15.68	631
G20	60	75	1819	110.4	1814	110.5	0.07	0.02	0.05	2.27	1.51	765	0.26	15.66	599
G19	60	50	1819	73.6	1816	73.9	0.06	0.03	0.03	2.14	1.15	975	0.33	15.66	546
G18	60	40	1819	59.7	1818	60.4	0.17	0.09	0.07	2.78	0.82	1042	0.35	15.64	524
G17	60	25	1819	36.8	1822	37.3	0.11	0.06	0.05	1.45	0.49	1276	0.43	15.67	471
G16	60	10	1819	14.8	1818	14.2	0.40	0.24	0.15	1.93	1.02	2670	0.89	15.69	412
G15	40	100	1412	160.0	1412	160.0	0.08	0.02	0.07	0.92	1.64	722	0.24	15.66	584
G14	40	85	1412	136.0	1414	136.3	0.20	0.04	0.16	2.84	1.45	737	0.25	15.66	557
G13	40	70	1412	112.0	1410	111.9	0.19	0.06	0.13	3.16	1.30	798	0.27	15.65	519
G12	40	55	1412	88.0	1408	87.5	0.27	0.10	0.17	4.70	1.34	866	0.29	15.63	484
G11	40	40	1412	64.0	1418	65.1	0.34	0.15	0.19	4.83	0.85	1001	0.34	15.63	447
G10	40	25	1412	40.0	1412	39.3	0.55	0.26	0.29	5.27	0.27	1200	0.40	15.61	392
G9	40	10	1412	16.0	1406	15.6	1.40	0.53	0.87	6.79	0.72	2371	0.80	15.64	335
G8	20	100	1006	161.4	1008	161.4	0.74	0.15	0.59	15.51	3.90	714	0.25	15.52	479
G7	20	85	1006	137.3	1004	137.7	0.36	0.10	0.26	5.22	1.72	744	0.25	15.61	451
G6	20	70	1006	113.0	1002	111.9	0.49	0.12	0.37	5.80	1.71	803	0.27	15.61	423
G5	20	55	1006	88.8	1010	88.8	0.65	0.14	0.51	5.56	1.45	856	0.29	15.62	391
G4	20	40	1006	64.6	1004	65.1	1.23	0.19	1.04	8.04	1.84	962	0.33	15.59	348
G3	20	25	1006	40.4	1002	40.7	1.63	0.24	1.40	4.74	1.44	1217	0.41	15.66	313
G2	20	10	1006	16.1	1010	16.3	4.97	0.42	4.54	37.50	0.94	2073	0.72	15.60	249
G1	IDLE	CITT	600	92.2	604	92.2	1.59	0.15	1.44	1.71	5.15	830	0.28	15.68	279
G1A	IDLE	[g/hr]	600	0.0	606	0.0	4.31	0.88	3.44	0.00	0.38	2178	0.73	15.96	151

APPROXIMATE	THC [g/kW-hr]	CH_4 [g/kW-hr]	NMHC [g/kW-hr]	CO [g/kW-hr]	NO_x [g/kW-hr]	CO_2 [g/kW-hr]	FUEL [kg/kW-hr]
D2 CYCLE COMPOSITE RESULTS	0.04	0.03	0.01	3.03	0.75	1160	0.86

TABLE B-25. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS [g/hr] NEW CATALYST

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [lb-ft]	THC [g/hr]	CH_4 [g/hr]	NMHC [g/hr]	CO [g/hr]	NO_x [g/hr]	CO_2 [g/hr]	FUEL [lb/hr]	A/F	CAT IN [°F]
XG36	100	100	2631	78.0	2632	78.0	0.54	0.13	0.42	2.46	5.11	27143	20.00	15.67	1322
XG35	100	85	2631	66.3	2628	65.5	3.68	2.12	1.56	37.72	0.11	22863	16.89	15.62	1270
XG34	100	70	2631	54.6	2630	54.5	2.00	1.10	0.90	12.00	0.36	21542	15.89	15.66	1245
XG33	100	55	2631	42.9	2632	42.5	0.86	0.67	0.19	4.40	0.20	18173	13.39	15.67	1203
XG32	100	40	2631	31.2	2630	31.5	0.37	0.23	0.14	1.93	0.27	15599	11.49	15.68	1164
XG31	100	25	2631	20.3	2636	20.5	0.69	0.50	0.19	2.89	0.14	13157	9.70	15.67	1097
XG30	100	10	2631	7.8	2630	7.5	0.41	0.35	0.06	0.99	0.18	11613	8.56	15.67	1033
XG29	80	100	2225	97.0	2226	97.0	9.51	3.51	6.00	73.04	1.06	25765	19.09	15.58	1271
XG28	80	85	2225	82.5	2226	82.5	5.72	0.22	5.49	8.09	0.55	22469	16.57	15.67	1247
XG27	80	70	2225	67.9	2232	68.0	4.76	1.66	3.10	13.68	0.79	20121	14.85	15.65	1195
XG26	80	55	2225	53.4	2234	53.0	4.04	1.59	2.45	14.70	0.48	17406	12.85	15.65	1139
XG25	80	40	2225	38.8	2222	38.5	0.63	0.38	0.25	1.61	0.36	14553	10.72	15.67	1078
XG24	80	25	2225	24.3	2226	24.5	1.22	0.80	0.42	2.38	0.12	12553	9.25	15.67	1007
XG23	80	10	2225	9.7	2218	9.5	1.97	1.09	0.88	26.88	0.63	9047	6.70	15.62	899
XG22	60	100	1819	110.0	1820	110.0	10.16	2.16	8.01	100.97	2.04	20278	15.08	15.53	1187
XG21	60	85	1819	93.5	1820	94.0	7.40	1.87	5.53	26.23	1.71	19601	14.49	15.65	1163
XG20	60	75	1819	82.5	1822	83.0	4.19	1.08	3.11	10.59	1.02	18158	13.40	15.67	1132
XG19	60	50	1819	55.0	1816	54.5	0.31	0.00	0.31	0.00	4.33	13786	10.16	15.68	1028
XG18	60	40	1819	44.0	1820	44.0	3.40	1.31	2.09	14.22	1.16	11914	8.80	15.64	977
XG17	60	25	1819	27.5	1812	27.5	0.71	0.30	0.42	2.70	0.43	9846	7.26	15.67	878
XG16	60	10	1819	11.0	1824	11.5	0.81	0.40	0.41	2.91	0.21	7722	5.69	15.64	798
XG15	40	100	1412	117.0	1410	117.0	1.42	0.51	0.91	5.00	27.36	18099	13.34	15.64	1078
XG14	40	85	1412	99.5	1412	99.5	7.01	1.28	5.73	27.65	13.12	15968	11.81	15.63	1028
XG13	40	70	1412	81.9	1414	82.0	5.95	1.15	4.80	20.31	12.21	14007	10.35	15.63	973
XG12	40	55	1412	64.4	1414	64.5	3.84	1.03	2.80	12.15	9.94	11927	8.81	15.64	927
XG11	40	40	1412	46.8	1412	47.0	3.38	1.16	2.21	9.15	7.13	10006	7.39	15.63	840
XG10	40	25	1412	29.3	1408	29.5	2.52	1.03	1.48	8.24	2.71	7765	5.74	15.62	754
XG9	40	10	1412	11.7	1408	11.5	0.95	0.82	0.13	1.35	2.64	5968	4.40	15.61	649
XG8	20	100	1006	118.0	1008	118.0	5.89	1.43	4.47	92.49	6.94	12956	9.66	15.46	888
XG7	20	85	1006	99.5	1008	99.5	3.53	0.87	2.66	10.47	39.47	11560	8.54	15.62	854
XG6	20	70	1006	81.9	1006	82.0	2.67	0.75	1.93	5.21	32.71	9453	6.98	15.63	793
XG5	20	55	1006	64.4	1006	64.5	2.31	1.08	1.23	4.07	21.47	7624	5.63	15.61	742
XG4	20	40	1006	46.8	1002	46.0	1.62	0.82	0.81	2.15	12.47	6950	5.13	15.59	661
XG3	20	25	1006	29.3	1004	29.5	1.58	0.84	0.74	0.59	5.91	5395	3.98	15.60	596
XG2	20	10	1006	11.7	1006	11.5	2.19	0.81	1.38	0.98	1.06	3828	2.83	15.53	493
XG1	IDLE	CITT	600	66.0	612	66.0	2.67	0.69	1.98	1.94	24.41	5409	3.99	15.65	533
XG1A	IDLE	0	600	0.0	606	0.0	3.64	0.84	2.81	0.01	0.44	1878	1.39	15.92	330

TABLE B-26. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS [g/hp-hr] NEW CATALYST

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [lb-ft]	SPEED [rpm]	TORQUE [lb-ft]	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	CO_2 [g/hp-hr]	FUEL [lb/hp-hr]	A/F	CAT IN [°F]
XG36	100	100	2631	80.0	2632	78.0	0.01	0.00	0.01	0.06	0.13	694	0.51	15.67	1322
XG35	100	85	2631	68.0	2628	65.5	0.11	0.06	0.05	1.15	0.00	698	0.52	15.62	1270
XG34	100	70	2631	56.0	2630	54.5	0.07	0.04	0.03	0.44	0.01	789	0.58	15.66	1245
XG33	100	55	2631	44.0	2632	42.5	0.04	0.03	0.01	0.21	0.01	853	0.63	15.67	1203
XG32	100	40	2631	32.0	2630	31.5	0.02	0.01	0.01	0.12	0.02	989	0.73	15.68	1164
XG31	100	25	2631	20.3	2636	20.5	0.07	0.05	0.02	0.28	0.01	1279	0.94	15.67	1097
XG30	100	10	2631	8.0	2630	7.5	0.11	0.09	0.02	0.26	0.05	3092	2.28	15.67	1033
XG29	80	100	2225	95.0	2226	97.0	0.23	0.09	0.15	1.78	0.03	627	0.46	15.58	1271
XG28	80	85	2225	80.8	2226	82.5	0.16	0.01	0.16	0.23	0.02	643	0.47	15.67	1247
XG27	80	70	2225	66.5	2232	68.0	0.16	0.06	0.11	0.47	0.03	696	0.51	15.65	1195
XG26	80	55	2225	52.3	2234	53.0	0.18	0.07	0.11	0.65	0.02	772	0.57	15.65	1139
XG25	80	40	2225	38.0	2222	38.5	0.04	0.02	0.02	0.10	0.02	894	0.66	15.67	1078
XG24	80	25	2225	23.8	2226	24.5	0.12	0.08	0.04	0.23	0.01	1209	0.89	15.67	1007
XG23	80	10	2225	9.5	2218	9.5	0.49	0.27	0.22	6.70	0.16	2255	1.67	15.62	899
XG22	60	100	1819	110.0	1820	110.0	0.27	0.06	0.21	2.65	0.05	532	0.40	15.53	1187
XG21	60	85	1819	93.5	1820	94.0	0.23	0.06	0.17	0.81	0.05	602	0.44	15.65	1163
XG20	60	75	1819	81.4	1822	83.0	0.15	0.04	0.11	0.37	0.04	631	0.47	15.67	1132
XG19	60	50	1819	54.3	1816	54.5	0.02	0.00	0.02	0.00	0.23	732	0.54	15.68	1028
XG18	60	40	1819	44.0	1820	44.0	0.22	0.09	0.14	0.93	0.08	781	0.58	15.64	977
XG17	60	25	1819	27.1	1812	27.5	0.08	0.03	0.04	0.29	0.05	1038	0.76	15.67	878
XG16	60	10	1819	10.9	1824	11.5	0.20	0.10	0.10	0.73	0.05	1933	1.43	15.64	798
XG15	40	100	1412	118.0	1410	117.0	0.05	0.02	0.03	0.16	0.87	576	0.42	15.64	1078
XG14	40	85	1412	100.3	1412	99.5	0.26	0.05	0.21	1.03	0.49	597	0.44	15.63	1028
XG13	40	70	1412	82.6	1414	82.0	0.27	0.05	0.22	0.92	0.55	634	0.47	15.63	973
XG12	40	55	1412	64.9	1414	64.5	0.22	0.06	0.16	0.70	0.57	687	0.51	15.64	927
XG11	40	40	1412	47.2	1412	47.0	0.27	0.09	0.17	0.72	0.56	792	0.58	15.63	840
XG10	40	25	1412	29.5	1408	29.5	0.32	0.13	0.19	1.04	0.34	982	0.73	15.62	754
XG9	40	10	1412	11.8	1408	11.5	0.31	0.27	0.04	0.44	0.86	1936	1.43	15.61	649
XG8	20	100	1006	119.0	1008	118.0	0.26	0.06	0.20	4.08	0.31	572	0.43	15.46	888
XG7	20	85	1006	101.2	1008	99.5	0.18	0.05	0.14	0.55	2.07	605	0.45	15.62	854
XG6	20	70	1006	83.3	1006	82.0	0.17	0.05	0.12	0.33	2.08	602	0.44	15.63	793
XG5	20	55	1006	65.5	1006	64.5	0.19	0.09	0.10	0.33	1.74	617	0.46	15.61	742
XG4	20	40	1006	47.6	1002	46.0	0.19	0.09	0.09	0.24	1.42	792	0.58	15.59	661
XG3	20	25	1006	29.8	1004	29.5	0.28	0.15	0.13	0.11	1.05	957	0.71	15.60	596
XG2	20	10	1006	11.9	1006	11.5	0.99	0.37	0.63	0.45	0.48	1738	1.28	15.53	493
XG1	IDLE	CITT	600	68.0	612	66.0	0.35	0.09	0.26	0.25	3.17	703	0.52	15.65	533
XG1A	IDLE	[g/hr]	600	0.0	606	0.0	3.64	0.84	2.81	0.01	0.44	1878	1.39	15.92	330

APPROXIMATE D2 CYCLE COMPOSITE RESULTS	THC [g/hp-hr]	CH_4 [g/hp-hr]	NMHC [g/hp-hr]	CO [g/hp-hr]	NO_x [g/hp-hr]	CO_2 [g/hp-hr]	FUEL [lb/hp-hr]
	0.06	**0.04**	**0.02**	**0.29**	**0.03**	**928.8**	**0.68**

TABLE B-27. TRUCK 29, GM ENGINE, STEADY STATE EMISSIONS RESULTS [g/kW-hr] NEW CATALYST

			SET		MEASURED										
MODE	SPEED	LOAD [%]	SPEED [rpm]	TORQUE [N-m]	SPEED [rpm]	TORQUE [N-m]	THC [g/kW-hr]	CH_4 [g/kW-hr]	NMHC [g/kW-hr]	CO [g/kW-hr]	NO_x [g/kW-hr]	CO_2 [g/kW-hr]	FUEL [kg/kW-hr]	A/F	CAT IN [°C]
XG36	100	100	2631	108.5	2632	105.8	0.02	0.00	0.01	0.08	0.18	931	0.31	15.67	717
XG35	100	85	2631	92.2	2628	88.8	0.15	0.09	0.06	1.54	0.00	935	0.31	15.62	688
XG34	100	70	2631	76.0	2630	73.9	0.10	0.05	0.04	0.59	0.02	1059	0.35	15.66	674
XG33	100	55	2631	59.7	2632	57.6	0.05	0.04	0.01	0.28	0.01	1144	0.38	15.67	650
XG32	100	40	2631	43.4	2630	42.7	0.03	0.02	0.01	0.16	0.02	1326	0.44	15.68	629
XG31	100	25	2631	27.5	2636	27.8	0.09	0.06	0.02	0.38	0.02	1715	0.57	15.67	592
XG30	100	10	2631	10.9	2630	10.2	0.15	0.13	0.02	0.35	0.07	4147	1.39	15.67	556
XG29	80	100	2225	128.8	2226	131.6	0.31	0.11	0.20	2.38	0.03	840	0.28	15.58	689
XG28	80	85	2225	109.6	2226	111.9	0.22	0.01	0.21	0.31	0.02	862	0.29	15.67	675
XG27	80	70	2225	90.2	2232	92.2	0.22	0.08	0.14	0.63	0.04	934	0.31	15.65	646
XG26	80	55	2225	70.9	2234	71.9	0.24	0.09	0.15	0.87	0.03	1035	0.35	15.65	615
XG25	80	40	2225	51.5	2222	52.2	0.05	0.03	0.02	0.13	0.03	1198	0.40	15.67	581
XG24	80	25	2225	32.3	2226	33.2	0.16	0.10	0.05	0.31	0.02	1621	0.54	15.67	541
XG23	80	10	2225	12.9	2218	12.9	0.66	0.36	0.29	8.98	0.21	3024	1.02	15.62	482
XG22	60	100	1819	149.2	1820	149.2	0.36	0.08	0.28	3.55	0.07	713	0.24	15.53	642
XG21	60	85	1819	126.8	1820	127.5	0.30	0.08	0.23	1.08	0.07	807	0.27	15.65	628
XG20	60	75	1819	110.4	1822	112.6	0.20	0.05	0.14	0.49	0.05	846	0.28	15.67	611
XG19	60	50	1819	73.6	1816	73.9	0.02	0.00	0.02	0.00	0.31	981	0.33	15.68	554
XG18	60	40	1819	59.7	1820	59.7	0.30	0.11	0.18	1.25	0.10	1048	0.35	15.64	525
XG17	60	25	1819	36.8	1812	37.3	0.10	0.04	0.06	0.38	0.06	1392	0.47	15.67	470
XG16	60	10	1819	14.8	1824	15.6	0.27	0.13	0.14	0.98	0.07	2593	0.87	15.64	426
XG15	40	100	1412	160.0	1410	158.7	0.06	0.02	0.04	0.21	1.17	773	0.26	15.64	581
XG14	40	85	1412	136.0	1412	135.0	0.35	0.06	0.29	1.39	0.66	800	0.27	15.63	553
XG13	40	70	1412	112.0	1414	111.2	0.36	0.07	0.29	1.23	0.74	851	0.29	15.63	523
XG12	40	55	1412	88.0	1414	87.5	0.30	0.08	0.22	0.94	0.77	921	0.31	15.64	497
XG11	40	40	1412	64.0	1412	63.7	0.36	0.12	0.23	0.97	0.76	1062	0.36	15.63	449
XG10	40	25	1412	40.0	1408	40.0	0.43	0.17	0.25	1.40	0.46	1317	0.44	15.62	401
XG9	40	10	1412	16.0	1408	15.6	0.41	0.36	0.06	0.59	1.15	2596	0.87	15.61	343
XG8	20	100	1006	161.4	1008	160.0	0.35	0.08	0.26	5.48	0.41	767	0.26	15.46	476
XG7	20	85	1006	137.3	1008	135.0	0.25	0.06	0.19	0.73	2.77	812	0.27	15.62	457
XG6	20	70	1006	113.0	1006	111.2	0.23	0.06	0.16	0.44	2.79	807	0.27	15.63	423
XG5	20	55	1006	88.8	1006	87.5	0.25	0.12	0.13	0.44	2.33	828	0.28	15.61	394
XG4	20	40	1006	64.6	1002	62.4	0.25	0.12	0.12	0.33	1.91	1062	0.36	15.59	350
XG3	20	25	1006	40.4	1004	40.0	0.38	0.20	0.18	0.14	1.40	1283	0.43	15.60	313
XG2	20	10	1006	16.1	1006	15.6	1.33	0.49	0.84	0.60	0.64	2331	0.78	15.53	256
XG1	IDLE	CITT	600	92.2	612	89.5	0.47	0.12	0.35	0.34	4.26	943	0.32	15.65	278
XG1A	IDLE	[g/hr]	600	0.0	606	0.0	4.89	1.12	3.77	0.01	0.60	2518	0.85	15.92	166

APPROXIMATE D2 CYCLE COMPOSITE RESULTS	THC [g/kW-hr]	CH_4 [g/kW-hr]	NMHC [g/kW-hr]	CO [g/kW-hr]	NO_x [g/kW-hr]	CO_2 [g/kW-hr]	FUEL [kg/kW-hr]
	0.07	**0.05**	**0.03**	**0.39**	**0.03**	**1246**	**0.92**

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OLD O2 SENSOR/NO CAT

Test No.: A
Date: 4/17/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target				Measured		C-E	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37A	2440	25	19.1	300.2	2446	19.5	6.9	81.6	6.0	29.17	0.921	1.000	0.977	1.018
31A	2528	25	17.4	300.0	2534	17.5	7.0	83.3	6.1	29.17	0.922	1.000	0.978	1.021
22A	1757	100	80.0	300.0	1756	80.0	11.3	84.2	6.3	29.17	0.926	1.000	0.975	1.022
20A	1757	75	60.0	300.2	1758	60.0	9.6	84.1	6.4	29.17	0.928	1.000	0.976	1.023
19A	1757	50	40.0	300.0	1758	40.0	7.1	83.8	6.3	29.16	0.926	1.000	0.977	1.022
17A	1757	25	20.0	300.0	1762	20.5	5.0	82.4	5.9	29.16	0.920	1.000	0.978	1.020
16A	1757	10	8.0	300.1	1756	8.0	3.7	81.7	5.8	29.16	0.917	1.000	0.980	1.019
1A	600	CITT	27.0	300.0	604	27.0	2.3	79.8	5.5	29.16	0.914	1.000	0.981	1.016
1AA	600	-	0.0	300.0	678	0.0	1.3	78.8	5.2	29.15	0.909	1.000	0.981	1.014

	BHP from	Gram/Hour						Unweighted Modal Contribution g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37A	9.1	21.4	1.63	19.7	188.3	79.2	8971.5	2.35	0.18	2.17	20.74	8.72	988.3
31A	8.4	18.7	1.65	17.1	198.4	73.8	9110.1	2.21	0.20	2.02	23.49	8.74	1078.4
22A	26.7	20.4	0.59	19.8	44.4	328.4	15181.2	0.76	0.02	0.74	1.66	12.28	567.6
20A	20.1	21.4	1.60	19.8	250.4	153.4	12537.3	1.07	0.08	0.99	12.47	7.64	624.2
19A	13.4	20.9	1.34	19.6	206.8	106.2	9187.4	1.56	0.10	1.46	15.44	7.93	686.0
17A	6.9	14.7	1.19	13.5	180.8	41.4	6503.2	2.14	0.17	1.96	26.30	6.01	945.8
16A	2.7	12.1	1.22	10.8	160.4	10.6	4702.6	4.51	0.46	4.05	59.96	3.98	1757.9
1A	3.1	15.7	1.74	13.9	601.6	3.6	2128.4	5.04	0.56	4.48	193.57	1.17	684.8
1AA	0.0	22.3	2.91	19.4	362.7	0.6	1118.9						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	2.00 g/hp-hr		2.69 g/kW-hr
BSCH4	=	0.16 g/hp-hr	=	0.21 g/kW-hr
BSNMHC	=	1.85 g/hp-hr	=	2.48 g/kW-hr
BSCO	=	28.90 g/hp-hr	=	38.75 g/kW-hr
BSNOx	=	7.70 g/hp-hr	=	10.32 g/kW-hr
BSCO2	=	821.78 g/hp-hr	=	1102.00 g/kW-hr
BSFC	=	0.64 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	2.12 g/hp-hr		2.84 g/kW-hr
BSCH4	=	0.18 g/hp-hr	=	0.24 g/kW-hr
BSNMHC	=	1.94 g/hp-hr	=	2.60 g/kW-hr
BSCO	=	24.78 g/hp-hr	=	33.23 g/kW-hr
BSNOx	=	7.65 g/hp-hr	=	10.25 g/kW-hr
BSCO2	=	804.37 g/hp-hr	=	1078.66 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.38 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.99 g/hp-hr		2.67 g/kW-hr
BSCH4	=	0.16 g/hp-hr	=	0.21 g/kW-hr
BSNMHC	=	1.84 g/hp-hr	=	2.46 g/kW-hr
BSCO	=	29.10 g/hp-hr	=	39.02 g/kW-hr
BSNOx	=	7.70 g/hp-hr	=	10.32 g/kW-hr
BSCO2	=	826.32 g/hp-hr	=	1108.10 g/kW-hr
BSFC	=	0.65 lb/hp-hr	=	0.39 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	2.11 g/hp-hr		2.83 g/kW-hr
BSCH4	=	0.18 g/hp-hr	=	0.24 g/kW-hr
BSNMHC	=	1.93 g/hp-hr	=	2.59 g/kW-hr
BSCO	=	24.96 g/hp-hr	=	33.47 g/kW-hr
BSNOx	=	7.64 g/hp-hr	=	10.25 g/kW-hr
BSCO2	=	808.84 g/hp-hr	=	1084.65 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.38 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2 SENSOR/NO CAT

Test No.: B
Date: 4/18/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured			Intake Air			Engine			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37B	2440	25	19.0	300.0	2440	19.0	6.7	79.5	5.4	29.15	0.912	1.000	0.977	1.016
31B	2528	25	17.3	300.0	2532	17.5	6.8	80.5	5.5	29.15	0.914	1.000	0.977	1.017
22B	1757	100	80.0	300.1	1760	80.0	11.1	79.5	5.4	29.15	0.911	1.000	0.976	1.015
20B	1757	75	60.0	299.9	1754	60.0	9.3	80.5	5.5	29.15	0.914	1.000	0.977	1.017
19B	1757	50	40.0	299.9	1756	40.5	6.9	79.9	5.5	29.15	0.913	1.000	0.978	1.016
17B	1757	25	20.0	300.0	1758	19.5	4.7	78.8	5.2	29.15	0.909	1.000	0.978	1.014
16B	1757	10	8.0	300.0	1758	7.5	3.6	78.1	5.2	29.15	0.908	1.000	0.979	1.013
1B	600 CITT		26.5	299.9	602	26.5	1.9	76.4	4.9	29.15	0.904	1.000	0.980	1.011
1AB	600 -		0.0	300.0	662	0.0	1.1	75.4	4.8	29.15	0.902	1.000	0.982	1.009

	BHP from	Gram/Hour						Brake Specific Emissions g/bhp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37B	8.8	18.4	0.93	17.5	163.7	75.7	8795.2	2.09	0.11	1.98	18.53	8.58	995.8
31B	8.4	16.3	0.99	15.3	168.0	70.8	8900.8	1.93	0.12	1.82	19.91	8.39	1055.1
22B	26.8	19.1	0.69	18.4	39.1	328.8	14970.5	0.71	0.03	0.69	1.46	12.26	558.4
20B	20.0	20.8	1.68	19.1	208.5	160.7	12235.4	1.04	0.08	0.95	10.41	8.02	610.7
19B	13.5	19.1	1.23	17.8	168.4	113.1	9066.7	1.41	0.09	1.32	12.44	8.35	669.6
17B	6.5	12.8	0.78	12.0	115.5	38.3	6125.0	1.96	0.12	1.84	17.69	5.87	938.3
16B	2.5	9.6	0.86	8.7	93.0	11.8	4686.5	3.82	0.34	3.48	37.07	4.71	1868.6
1B	3.0	10.0	1.12	8.8	93.5	21.7	2436.9	3.28	0.37	2.91	30.78	7.13	802.4
1AB	0.0	21.8	0.67	21.1	84.9	0.3	1303.2						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	1.73 g/hp-hr		2.32 g/kW-hr
BSCH4	=	0.12 g/hp-hr	=	0.16 g/kW-hr
BSNMHC	=	1.61 g/hp-hr	=	2.16 g/kW-hr
BSCO	=	15.43 g/hp-hr	=	20.69 g/kW-hr
BSNOx	=	8.28 g/hp-hr	=	11.10 g/kW-hr
BSCO2	=	814.39 g/hp-hr	=	1092.10 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	1.94 g/hp-hr		2.60 g/kW-hr
BSCH4	=	0.11 g/hp-hr	=	0.15 g/kW-hr
BSNMHC	=	1.83 g/hp-hr	=	2.45 g/kW-hr
BSCO	=	15.28 g/hp-hr	=	20.49 g/kW-hr
BSNOx	=	7.91 g/hp-hr	=	10.60 g/kW-hr
BSCO2	=	794.64 g/hp-hr	=	1065.61 g/kW-hr
BSFC	=	0.61 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.72 g/hp-hr		2.31 g/kW-hr
BSCH4	=	0.12 g/hp-hr	=	0.16 g/kW-hr
BSNMHC	=	1.60 g/hp-hr	=	2.15 g/kW-hr
BSCO	=	15.50 g/hp-hr	=	20.79 g/kW-hr
BSNOx	=	8.27 g/hp-hr	=	11.08 g/kW-hr
BSCO2	=	817.38 g/hp-hr	=	1096.11 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.93 g/hp-hr		2.59 g/kW-hr
BSCH4	=	0.11 g/hp-hr	=	0.15 g/kW-hr
BSNMHC	=	1.82 g/hp-hr	=	2.43 g/kW-hr
BSCO	=	15.35 g/hp-hr	=	20.59 g/kW-hr
BSNOx	=	7.89 g/hp-hr	=	10.59 g/kW-hr
BSCO2	=	797.58 g/hp-hr	=	1069.55 g/kW-hr
BSFC	=	0.61 lb/hp-hr	=	0.37 kg/kW-hr

Southwest Research Institute - Department of Emissions Research

Custom, ISO Calcs Emission Test Results

Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2 /OLD CAT

Test No.: C
Date: 4/18/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37C	2440	25	19.0	300.0	2434	19.0	6.8	81.6	5.8	29.15	0.917	1.000	0.977	1.019
31C	2528	25	17.0	300.7	2530	17.0	6.9	81.7	5.8	29.15	0.917	1.000	0.978	1.019
22C	1757	100	80.0	300.1	1760	80.0	11.4	81.3	5.7	29.16	0.916	1.000	0.975	1.018
20C	1757	75	60.0	299.9	1758	60.5	9.6	81.7	5.8	29.16	0.917	1.000	0.975	1.019
19C	1757	50	40.0	300.0	1760	40.5	7.1	81.7	5.8	29.15	0.917	1.000	0.976	1.019
17C	1757	25	20.0	300.0	1756	20.5	5.0	80.9	5.5	29.15	0.914	1.000	0.979	1.018
16C	1757	10	8.0	300.2	1760	8.0	3.7	80.2	5.5	29.15	0.914	1.000	0.979	1.017
1C	600	CITT	26.0	300.0	602	26.0	1.9	78.2	5.2	29.14	0.908	1.000	0.980	1.014
1AC	600	-	0.0	300.0	692	0.0	1.1	76.0	4.8	29.14	0.903	1.000	0.981	1.010

Mode	BHP from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37C	8.8	0.5	0.06	0.4	2.0	18.8	9277.6	0.06	0.01	0.05	0.22	2.14	1053.3
31C	8.2	0.1	0.00	0.1	0.0	16.1	9325.4	0.01	0.00	0.01	0.00	1.96	1138.8
22C	26.8	1.3	0.38	1.0	1.2	335.2	15504.5	0.05	0.01	0.04	0.04	12.50	578.3
20C	20.3	0.5	0.17	0.3	6.6	7.5	12960.0	0.02	0.01	0.02	0.32	0.37	640.0
19C	13.6	0.3	0.21	0.1	1.2	38.3	9627.2	0.02	0.02	0.01	0.09	2.82	709.3
17C	6.9	0.5	0.21	0.3	1.0	19.9	6748.1	0.08	0.03	0.05	0.14	2.90	984.8
16C	2.7	0.5	0.32	0.2	0.0	6.4	5027.7	0.18	0.12	0.06	0.00	2.37	1871.7
1C	3.0	4.0	0.52	3.5	8.6	10.2	2600.3	1.35	0.18	1.18	2.88	3.43	873.8
1AC	0.0	4.8	0.36	4.4	0.0	0.3	1530.5						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.11 g/hp-hr		0.15 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.08 g/hp-hr	=	0.11 g/kW-hr
BSCO	=	0.28 g/hp-hr	=	0.37 g/kW-hr
BSNOx	=	3.27 g/hp-hr	=	4.39 g/kW-hr
BSCO2	=	859.14 g/hp-hr	=	1152.10 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.13 g/hp-hr		0.17 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.10 g/hp-hr	=	0.13 g/kW-hr
BSCO	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSNOx	=	3.10 g/hp-hr	=	4.16 g/kW-hr
BSCO2	=	840.78 g/hp-hr	=	1127.49 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.11 g/hp-hr		0.15 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.08 g/hp-hr	=	0.11 g/kW-hr
BSCO	=	0.26 g/hp-hr	=	0.35 g/kW-hr
BSNOx	=	3.27 g/hp-hr	=	4.38 g/kW-hr
BSCO2	=	863.13 g/hp-hr	=	1157.46 g/kW-hr
BSFC	=	0.64 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.12 g/hp-hr		0.17 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.10 g/hp-hr	=	0.13 g/kW-hr
BSCO	=	0.12 g/hp-hr	=	0.16 g/kW-hr
BSNOx	=	3.10 g/hp-hr	=	4.15 g/kW-hr
BSCO2	=	844.70 g/hp-hr	=	1132.74 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OLD O2 /OLD CAT

Test No.: D
Date: 4/16/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured			CB	Intake Air			Dilute			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37D	2440	25	19.0	299.9	2434	19.0	6.8	82.7	6.0	29.12	0.920	1.000	0.978	1.022
31D	2528	25	16.9	300.1	2532	17.0	6.9	83.4	6.1	29.11	0.923	1.000	0.976	1.023
22D	1757	100	80.0	300.0	1758	80.0	11.4	83.3	6.0	29.11	0.921	1.000	0.974	1.023
20D	1757	75	60.0	299.9	1758	60.5	9.7	83.7	6.2	29.11	0.924	1.000	0.975	1.024
19D	1757	50	40.0	326.6	1758	40.0	7.1	83.3	6.1	29.10	0.923	1.000	0.977	1.023
17D	1757	25	20.0	300.1	1752	19.5	4.8	82.8	6.0	29.10	0.921	1.000	0.978	1.023
16D	1757	10	8.0	300.1	1758	8.0	3.6	82.3	5.9	29.09	0.919	1.000	0.979	1.022
1D	600 CITT		27.0	300.0	600	27.0	2.3	80.6	5.6	29.09	0.914	1.000	0.980	1.019
1AD	600 -		0.0	300.1	690	0.0	1.4	79.1	5.3	29.09	0.910	1.000	0.980	1.017

	BHP from	Grams/Hour						Weighted Mode Emissions (g/hr)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37D	8.8	1.2	0.15	1.0	31.5	0.9	9205.6	0.13	0.02	0.11	3.58	0.11	1044.8
31D	8.2	1.2	0.24	0.9	40.9	1.2	9358.0	0.14	0.03	0.11	4.99	0.15	1142.2
22D	26.8	1.2	0.14	1.1	3.3	329.8	15432.6	0.05	0.01	0.04	0.12	12.32	576.4
20D	20.3	2.3	0.21	2.0	47.0	3.1	13034.0	0.11	0.01	0.10	2.32	0.15	643.6
19D	13.4	1.8	0.20	1.6	37.2	3.1	9511.3	0.14	0.01	0.12	2.78	0.23	710.2
17D	6.5	0.8	0.14	0.7	9.1	0.3	6512.2	0.13	0.02	0.11	1.40	0.05	1001.6
16D	2.7	0.6	0.14	0.5	0.0	0.0	4938.9	0.22	0.05	0.17	0.00	0.01	1846.2
1D	3.1	15.5	0.63	14.9	493.6	0.0	2255.7	5.03	0.21	4.82	160.07	0.01	731.4
1AD	0.0	24.7	1.38	23.3	371.3	0.0	1200.8						

MODES									
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.40 g/hp-hr	=	0.53 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.37 g/hp-hr	=	0.50 g/kW-hr
BSCO	=	10.84 g/hp-hr	=	14.53 g/kW-hr
BSNOx	=	0.92 g/hp-hr	=	1.23 g/kW-hr
BSCO2	=	855.70 g/hp-hr	=	1147.50 g/kW-hr
BSFC	=	0.64 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.56 g/hp-hr	=	0.75 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.52 g/hp-hr	=	0.70 g/kW-hr
BSCO	=	8.70 g/hp-hr	=	11.66 g/kW-hr
BSNOx	=	0.92 g/hp-hr	=	1.23 g/kW-hr
BSCO2	=	837.26 g/hp-hr	=	1122.77 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.38 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.40 g/hp-hr	=	0.54 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.37 g/hp-hr	=	0.50 g/kW-hr
BSCO	=	10.95 g/hp-hr	=	14.68 g/kW-hr
BSNOx	=	0.93 g/hp-hr	=	1.24 g/kW-hr
BSCO2	=	860.49 g/hp-hr	=	1153.91 g/kW-hr
BSFC	=	0.65 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.56 g/hp-hr	=	0.75 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.52 g/hp-hr	=	0.70 g/kW-hr
BSCO	=	8.80 g/hp-hr	=	11.80 g/kW-hr
BSNOx	=	0.93 g/hp-hr	=	1.24 g/kW-hr
BSCO2	=	841.96 g/hp-hr	=	1129.07 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.38 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OLD O2 /NEW CAT

Test No.: E
Date: 4/19/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured				Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37E	2440	25	19.6	300.1	2450	20.0	6.7	78.2	5.2	28.98	0.909	1.000	0.976	1.019
31E	2528	25	17.5	300.0	2524	17.5	6.5	78.5	5.2	28.98	0.909	1.000	0.976	1.020
22E	1757	100	83.0	300.0	1758	83.0	11.2	78.8	5.3	28.99	0.910	1.000	0.973	1.020
20E	1757	75	62.3	300.0	1754	62.0	9.5	79.5	5.3	28.99	0.911	1.000	0.975	1.021
19E	1757	50	41.5	300.1	1756	41.5	7.0	79.1	5.4	28.98	0.911	1.000	0.975	1.021
17E	1757	25	20.8	299.9	1762	21.0	4.9	77.5	5.1	28.99	0.908	1.000	0.977	1.018
16E	1757	10	8.3	300.1	1754	8.5	3.5	76.8	5.0	28.98	0.905	1.000	0.978	1.017
1E	600	CITT	26.5	300.0	600	26.5	2.0	75.4	4.8	28.99	0.903	1.000	0.979	1.015
1AE	600	-	0.0	301.7	682	0.0	1.3	74.6	4.6	28.99	0.900	1.000	0.980	1.013

	BHP from	Gaseous						Dilute Weighted Modal Emissions					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37E	9.3	4.2	1.25	3.0	17.0	0.0	9018.0	0.45	0.13	0.32	1.82	0.00	966.3
31E	8.4	3.7	1.16	2.5	17.6	0.0	8780.9	0.44	0.14	0.30	2.10	0.00	1043.9
22E	27.8	1.0	0.55	0.4	1.0	313.2	15205.1	0.04	0.02	0.02	0.04	11.27	547.3
20E	20.7	3.4	0.94	2.5	6.4	9.3	12831.1	0.17	0.05	0.12	0.31	0.45	619.9
19E	13.9	1.9	0.91	1.0	2.3	12.6	9518.2	0.14	0.07	0.07	0.17	0.91	685.8
17E	7.0	0.6	0.51	0.1	0.0	10.5	6601.3	0.08	0.07	0.01	0.00	1.49	936.8
16E	2.8	0.9	0.87	0.1	0.0	4.2	4738.6	0.33	0.31	0.02	0.00	1.48	1666.7
1E	3.0	8.9	5.00	3.9	56.5	0.0	2535.7	2.94	1.65	1.29	18.69	0.00	838.5
1AE	0.0	15.2	7.72	7.4	31.9	0.3	1649.4						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.30 g/hp-hr		0.40 g/kW-hr
BSCH4	=	0.16 g/hp-hr	=	0.21 g/kW-hr
BSNMHC	=	0.14 g/hp-hr	=	0.19 g/kW-hr
BSCO	=	1.18 g/hp-hr	=	1.58 g/kW-hr
BSNOx	=	1.59 g/hp-hr	=	2.14 g/kW-hr
BSCO2	=	819.47 g/hp-hr	=	1098.91 g/kW-hr
BSFC	=	0.61 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.40 g/hp-hr		0.54 g/kW-hr
BSCH4	=	0.20 g/hp-hr	=	0.27 g/kW-hr
BSNMHC	=	0.20 g/hp-hr	=	0.27 g/kW-hr
BSCO	=	0.77 g/hp-hr	=	1.03 g/kW-hr
BSNOx	=	1.60 g/hp-hr	=	2.14 g/kW-hr
BSCO2	=	804.68 g/hp-hr	=	1079.08 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.29 g/hp-hr		0.39 g/kW-hr
BSCH4	=	0.16 g/hp-hr	=	0.21 g/kW-hr
BSNMHC	=	0.14 g/hp-hr	=	0.18 g/kW-hr
BSCO	=	1.19 g/hp-hr	=	1.59 g/kW-hr
BSNOx	=	1.60 g/hp-hr	=	2.15 g/kW-hr
BSCO2	=	822.94 g/hp-hr	=	1103.57 g/kW-hr
BSFC	=	0.61 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.40 g/hp-hr		0.54 g/kW-hr
BSCH4	=	0.20 g/hp-hr	=	0.27 g/kW-hr
BSNMHC	=	0.20 g/hp-hr	=	0.26 g/kW-hr
BSCO	=	0.78 g/hp-hr	=	1.04 g/kW-hr
BSNOx	=	1.61 g/hp-hr	=	2.16 g/kW-hr
BSCO2	=	808.07 g/hp-hr	=	1083.62 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OLD O2/NEW CAT

Test No.: F
Date: 4/19/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured			C-B	Intake Air			Exhaust			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37F	2440	25	19.5	300.0	2440	19.5	6.6	81.3	5.7	28.99	0.917	1.000	0.977	1.024
31F	2528	25	17.0	300.0	2524	17.0	6.5	80.5	5.6	28.98	0.915	1.000	0.977	1.023
22F	1757	100	85.0	300.0	1756	85.0	11.5	80.5	5.6	28.98	0.915	1.000	0.975	1.023
20F	1757	75	63.8	300.0	1760	63.5	9.4	81.1	5.7	28.98	0.917	1.000	0.976	1.024
19F	1757	50	42.5	300.0	1756	43.0	7.2	80.2	5.6	28.98	0.914	1.000	0.977	1.023
17F	1757	25	21.3	300.1	1758	21.0	4.8	79.5	5.4	28.98	0.912	1.000	0.978	1.022
16F	1757	10	8.5	299.9	1756	8.5	3.5	78.9	5.2	28.98	0.909	1.000	0.980	1.020
1F	600	CITT	21.0	299.9	608	21.0	1.9	76.5	5.0	28.98	0.905	1.000	0.981	1.017
1AF	600	-	0.0	300.0	686	0.0	1.4	75.4	4.6	29.98	0.900	1.000	0.982	0.981

	BHP from	Dilute Bag Results						Weighted Results					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37F	9.1	3.0	1.10	1.9	13.3	0.0	8875.7	0.33	0.12	0.21	1.47	0.00	979.7
31F	8.2	3.4	1.10	2.3	22.4	0.0	8738.8	0.41	0.13	0.28	2.74	0.00	1069.4
22F	28.4	1.4	0.44	1.0	49.8	2.4	15511.0	0.05	0.02	0.03	1.75	0.09	545.9
20F	21.3	2.9	0.88	2.0	12.1	7.8	12721.6	0.14	0.04	0.10	0.57	0.37	597.9
19F	14.4	3.0	0.00	3.0	9.2	10.8	9754.4	0.21	0.00	0.21	0.64	0.75	678.5
17F	7.0	0.7	0.49	0.2	0.0	10.2	6457.3	0.09	0.07	0.02	0.00	1.45	918.6
16F	2.8	0.9	0.78	0.2	4.1	1.2	4751.1	0.33	0.27	0.05	1.44	0.42	1670.0
1F	2.4	12.4	2.82	9.5	219.8	0.0	2163.5	5.07	1.16	3.91	90.19	0.00	887.8
1AF	0.0	21.2	4.45	16.7	78.1	0.0	1685.8						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.38 g/hp-hr		0.51 g/kW-hr
BSCH4	=	0.08 g/hp-hr	=	0.11 g/kW-hr
BSNMHC	=	0.29 g/hp-hr	=	0.39 g/kW-hr
BSCO	=	4.22 g/hp-hr	=	5.66 g/kW-hr
BSNOx	=	0.77 g/hp-hr	=	1.03 g/kW-hr
BSCO2	=	800.17 g/hp-hr	=	1073.03 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.52 g/hp-hr		0.70 g/kW-hr
BSCH4	=	0.11 g/hp-hr	=	0.15 g/kW-hr
BSNMHC	=	0.41 g/hp-hr	=	0.55 g/kW-hr
BSCO	=	1.91 g/hp-hr	=	2.56 g/kW-hr
BSNOx	=	0.77 g/hp-hr	=	1.03 g/kW-hr
BSCO2	=	792.35 g/hp-hr	=	1062.55 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.38 g/hp-hr		0.51 g/kW-hr
BSCH4	=	0.08 g/hp-hr	=	0.11 g/kW-hr
BSNMHC	=	0.30 g/hp-hr	=	0.40 g/kW-hr
BSCO	=	4.31 g/hp-hr	=	5.78 g/kW-hr
BSNOx	=	0.78 g/hp-hr	=	1.04 g/kW-hr
BSCO2	=	803.94 g/hp-hr	=	1078.09 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.53 g/hp-hr		0.71 g/kW-hr
BSCH4	=	0.11 g/hp-hr	=	0.15 g/kW-hr
BSNMHC	=	0.42 g/hp-hr	=	0.56 g/kW-hr
BSCO	=	1.98 g/hp-hr	=	2.65 g/kW-hr
BSNOx	=	0.78 g/hp-hr	=	1.04 g/kW-hr
BSCO2	=	796.08 g/hp-hr	=	1067.55 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/NEW CAT

Test No.: G
Date: 4/18/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target		Measured					Intake Air			Dilution			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37G	2440	25	19.3	299.9	2444	19.5	6.0	81.9	5.8	28.96	0.918	1.000	0.978	1.026
31G	2528	25	16.5	300.2	2525	16.5	6.5	82.6	5.8	29.95	0.918	1.000	0.979	0.993
22G	1757	100	84.0	300.0	1762	84.0	11.8	82.3	5.7	29.95	0.916	1.000	0.976	0.992
20G	1757	75	63.0	299.9	1750	63.0	9.6	83.3	5.9	29.95	0.920	1.000	0.977	0.994
19G	1757	50	42.0	300.0	1760	42.5	7.0	83.3	6.1	28.94	0.922	1.000	0.978	1.029
17G	1757	25	21.0	300.0	1756	21.0	4.7	82.3	5.9	28.94	0.919	1.000	0.978	1.028
16G	1757	10	8.4	300.0	1762	9.0	3.6	81.7	5.8	28.93	0.918	1.000	0.980	1.027
1G	600	CITT	0.0	300.0	606	18.0	1.5	80.6	5.6	28.93	0.915	1.000	0.981	1.025
1AG	600	-	0.0	300.0	678	0.0	1.0	78.5	5.2	28.93	0.909	1.000	0.981	1.021

	BHP from	Grams/BHP-hr						Uncorrected Mode Results, lb/hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37G	9.1	0.6	0.00	0.6	0.6	11.9	8147.8	0.07	0.00	0.07	0.06	1.31	897.8
31G	7.9	0.2	0.25	0.0	0.0	10.4	8797.0	0.03	0.03	0.00	0.00	1.32	1109.8
22G	28.2	0.5	0.24	0.3	4.7	33.9	15980.9	0.02	0.01	0.01	0.17	1.20	567.2
20G	21.0	0.6	0.19	0.4	0.8	40.0	13061.9	0.03	0.01	0.02	0.04	1.91	622.1
19G	14.2	0.5	0.37	0.2	0.4	52.3	9468.3	0.04	0.03	0.01	0.03	3.67	664.7
17G	7.0	0.9	0.49	0.4	0.0	22.7	6369.0	0.13	0.07	0.06	0.00	3.24	907.3
16G	3.0	0.8	0.61	0.1	1.0	7.2	4816.4	0.25	0.20	0.05	0.32	2.38	1592.7
1G	2.1	1.7	0.27	1.4	0.2	4.8	1988.4	0.82	0.13	0.69	0.10	2.31	957.8
1AG	0.0	10.3	0.53	9.8	1.2	0.3	1279.6						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.09 g/hp-hr		0.12 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSCO	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNOx	=	3.11 g/hp-hr	=	4.17 g/kW-hr
BSCO2	=	787.14 g/hp-hr	=	1055.55 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.23 g/hp-hr		0.31 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.19 g/hp-hr	=	0.25 g/kW-hr
BSCO	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNOx	=	3.04 g/hp-hr	=	4.07 g/kW-hr
BSCO2	=	775.48 g/hp-hr	=	1039.92 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.09 g/hp-hr		0.12 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSCO	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNOx	=	3.13 g/hp-hr	=	4.19 g/kW-hr
BSCO2	=	797.43 g/hp-hr	=	1069.35 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.23 g/hp-hr		0.31 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.18 g/hp-hr	=	0.25 g/kW-hr
BSCO	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNOx	=	3.05 g/hp-hr	=	4.09 g/kW-hr
BSCO2	=	785.69 g/hp-hr	=	1053.61 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/OLD CAT

Test No.: H
Date: 4/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37H	2440	25	19.5	300.0	2438	19.5	6.5	75.4	4.7	29.21	0.902	1.000	0.986	1.007
31H	2528	25	17.6	300.0	2526	17.5	6.6	75.4	4.8	29.21	0.903	1.000	0.987	1.007
22H	1757	100	87.0	300.0	1762	87.0	12.0	75.4	4.8	29.21	0.903	1.000	0.984	1.007
20H	1757	75	69.3	300.1	1760	66.0	10.0	76.8	5.0	29.21	0.906	1.000	0.985	1.009
19H	1757	50	43.5	300.2	1756	43.0	7.0	76.8	5.0	29.21	0.906	1.000	0.987	1.009
17H	1757	25	21.8	319.4	1752	22.0	4.8	76.0	4.8	29.21	0.903	1.000	0.989	1.008
16H	1757	10	8.7	300.0	1756	8.5	3.5	75.0	4.7	29.21	0.901	1.000	0.989	1.006
1H	600	CITT	0.0	300.0	606	19.0	1.6	73.7	4.5	29.21	0.898	1.000	0.990	1.004
1AH	600	-	0.0	300.1	688	0.0	1.0	77.1	5.1	29.21	0.907	1.000	0.990	1.010

Mode	BHP from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37H	9.0	0.3	0.00	0.0	1.0	22.8	8778.0	0.03	0.00	0.00	0.11	2.51	970.2
31H	8.4	0.1	0.00	0.0	0.6	20.1	8963.9	0.01	0.00	0.00	0.07	2.39	1065.6
22H	29.2	0.8	0.00	0.0	35.0	58.2	16192.2	0.03	0.00	0.00	1.20	1.99	554.8
20H	22.1	0.6	0.00	0.0	5.5	13.5	13522.6	0.03	0.00	0.00	0.25	0.61	611.3
19H	14.4	0.3	0.00	0.0	0.4	49.7	9517.0	0.02	0.00	0.00	0.03	3.46	661.9
17H	7.3	0.5	0.00	0.0	0.0	25.9	6518.2	0.07	0.00	0.00	0.00	3.52	888.3
16H	2.8	0.6	0.00	0.0	1.0	7.2	4721.9	0.21	0.00	0.00	0.35	2.52	1660.3
1H	2.2	1.7	0.00	0.0	0.6	4.6	2103.5	0.80	0.00	0.00	0.28	2.10	957.9
1AH	0.0	4.6	0.00	0.0	1.8	0.2	1404.4						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.07 g/hp-hr		0.09 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.15 g/hp-hr	=	0.20 g/kW-hr
BSNOx	=	3.03 g/hp-hr	=	4.07 g/kW-hr
BSCO2	=	784.96 g/hp-hr	=	1052.63 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.11 g/hp-hr		0.15 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.16 g/hp-hr	=	0.22 g/kW-hr
BSNOx	=	2.96 g/hp-hr	=	3.98 g/kW-hr
BSCO2	=	773.70 g/hp-hr	=	1037.54 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.07 g/hp-hr		0.09 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.14 g/hp-hr	=	0.19 g/kW-hr
BSNOx	=	3.03 g/hp-hr	=	4.06 g/kW-hr
BSCO2	=	789.38 g/hp-hr	=	1058.56 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.11 g/hp-hr		0.15 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.16 g/hp-hr	=	0.22 g/kW-hr
BSNOx	=	2.96 g/hp-hr	=	3.97 g/kW-hr
BSCO2	=	778.09 g/hp-hr	=	1043.42 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OLD O2/OLD CAT

Test No.: I
Date: 4/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target				Measured				Intake Air					Factors
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37I	2440	25	20.0	299.9	2442	20.0	6.8	78.8	5.2	29.20	0.909	1.000	0.986	1.013
31I	2528	25	17.3	300.0	2532	17.5	6.5	78.5	5.2	29.20	0.908	1.000	0.987	1.012
22I	1757	100	86.0	300.1	1752	86.0	12.0	78.2	5.2	29.19	0.909	1.000	0.984	1.012
20I	1757	75	64.5	299.9	1754	64.0	9.4	79.5	5.4	29.20	0.912	1.000	0.986	1.014
19I	1757	50	43.0	300.1	1754	42.5	7.2	79.1	5.3	29.19	0.910	1.000	0.987	1.013
17I	1757	25	21.5	300.1	1758	22.0	5.0	78.2	5.2	29.19	0.909	1.000	0.988	1.012
16I	1757	10	8.6	300.1	1752	8.5	3.5	77.5	5.2	29.19	0.908	1.000	0.990	1.011
1I	600	CITT	0.0	300.0	608	20.5	1.9	76.0	4.8	29.19	0.903	1.000	0.991	1.008
1AI	600	-	0.0	300.1	704	0.0	1.3	75.0	4.6	29.19	0.900	1.000	0.991	1.007

	BHP from	Grams/Hour						Grams/BHP-Hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37I	9.3	1.4	0.00	0.0	33.9	2.7	9143.5	0.15	0.00	0.00	3.64	0.29	982.8
31I	8.4	2.2	0.00	0.0	75.1	4.2	8738.0	0.27	0.00	0.00	8.90	0.49	1035.8
22I	28.7	0.9	0.00	0.0	53.6	28.9	16262.6	0.03	0.00	0.00	1.87	1.01	567.0
20I	21.4	1.7	0.00	0.0	52.6	4.6	12643.5	0.08	0.00	0.00	2.46	0.22	591.4
19I	14.2	1.4	0.00	0.0	28.4	4.2	9662.3	0.10	0.00	0.00	2.00	0.30	680.9
17I	7.4	1.4	0.00	0.0	15.6	0.8	6787.7	0.18	0.00	0.00	2.12	0.10	921.6
16I	2.8	1.3	0.00	0.0	15.0	0.3	4767.4	0.47	0.00	0.00	5.30	0.12	1684.0
1I	2.4	12.4	0.00	0.0	392.2	0.2	1898.2	5.21	0.00	0.00	165.05	0.07	798.9
1AI	0.0	17.8	0.00	0.0	225.0	0.1	1313.8						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.33 g/hp-hr		0.44 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	8.64 g/hp-hr	=	11.59 g/kW-hr
BSNOx	=	0.28 g/hp-hr	=	0.38 g/kW-hr
BSCO2	=	800.86 g/hp-hr	=	1073.95 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.42 g/hp-hr		0.56 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	5.93 g/hp-hr	=	7.95 g/kW-hr
BSNOx	=	0.28 g/hp-hr	=	0.38 g/kW-hr
BSCO2	=	791.37 g/hp-hr	=	1061.22 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.34 g/hp-hr		0.45 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	8.96 g/hp-hr	=	12.02 g/kW-hr
BSNOx	=	0.29 g/hp-hr	=	0.39 g/kW-hr
BSCO2	=	802.75 g/hp-hr	=	1076.48 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.42 g/hp-hr		0.57 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	6.23 g/hp-hr	=	8.36 g/kW-hr
BSNOx	=	0.29 g/hp-hr	=	0.39 g/kW-hr
BSCO2	=	793.20 g/hp-hr	=	1063.68 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OLD O2/NO CAT

Test No.: J
Date: 4/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured			CVS	Intake Air			Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37J	2440	25	19.8	300.1	2438	20.0	6.3	80.6	5.6	29.17	0.915	1.000	0.987	1.016
31J	2528	25	17.5	300.0	2530	17.0	6.3	81.3	5.8	29.17	0.917	1.000	0.987	1.018
22J	1757	100	86.0	299.8	1756	86.0	11.0	80.9	5.6	29.17	0.915	1.000	0.985	1.017
20J	1757	75	64.5	300.1	1760	64.5	9.1	81.9	5.8	29.17	0.919	1.000	0.986	1.019
19J	1757	50	43.0	300.0	1757	43.0	6.8	81.7	5.8	29.17	0.918	1.000	0.987	1.018
17J	1757	25	21.5	299.9	1756	21.0	4.4	80.6	5.6	29.17	0.915	1.000	0.989	1.017
16J	1757	10	8.6	300.0	1758	8.5	3.4	79.6	5.4	29.17	0.912	1.000	0.989	1.015
1J	600 CITT		0.0	300.0	602	19.5	1.8	76.8	5.0	29.16	0.906	1.000	0.990	1.011
1AJ	600 -		0.0	300.0	702	0.0	1.1	75.8	4.8	29.16	0.903	1.000	0.991	1.009

	BHP from	g/hp-hr						g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37J	9.3	18.3	0.00	0.0	194.3	86.4	8231.7	1.97	0.00	0.00	20.93	9.31	886.6
31J	8.2	17.1	0.00	0.0	196.0	72.9	8179.2	2.08	0.00	0.00	23.94	8.91	999.4
22J	28.8	25.5	0.00	0.0	502.9	261.1	14009.4	0.89	0.00	0.00	17.48	9.08	487.1
20J	21.6	21.5	0.00	0.0	289.6	176.1	11820.3	1.00	0.00	0.00	13.40	8.15	546.8
19J	14.4	21.8	0.00	0.0	220.7	130.2	8877.9	1.52	0.00	0.00	15.34	9.05	617.0
17J	7.0	13.9	0.00	0.0	153.6	40.6	5663.7	1.98	0.00	0.00	21.87	5.78	806.5
16J	2.8	11.1	0.00	0.0	164.5	11.5	4300.8	3.92	0.00	0.00	57.85	4.05	1512.3
1J	2.2	13.9	0.00	0.0	480.7	2.1	1605.3	6.21	0.00	0.00	215.38	0.94	719.2
1AJ	0.0	19.1	0.00	0.0	341.2	0.3	963.3						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	1.85 g/hp-hr		2.48 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	26.22 g/hp-hr	=	35.16 g/kW-hr
BSNOx	=	8.09 g/hp-hr	=	10.86 g/kW-hr
BSCO2	=	714.13 g/hp-hr	=	957.65 g/kW-hr
BSFC	=	0.56 lb/hp-hr	=	0.34 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	1.93 g/hp-hr		2.59 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	23.95 g/hp-hr	=	32.11 g/kW-hr
BSNOx	=	8.07 g/hp-hr	=	10.82 g/kW-hr
BSCO2	=	703.67 g/hp-hr	=	943.63 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.33 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.85 g/hp-hr		2.49 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	26.42 g/hp-hr	=	35.43 g/kW-hr
BSNOx	=	8.06 g/hp-hr	=	10.81 g/kW-hr
BSCO2	=	718.95 g/hp-hr	=	964.11 g/kW-hr
BSFC	=	0.56 lb/hp-hr	=	0.34 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.94 g/hp-hr		2.60 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	24.13 g/hp-hr	=	32.36 g/kW-hr
BSNOx	=	8.04 g/hp-hr	=	10.78 g/kW-hr
BSCO2	=	708.41 g/hp-hr	=	949.98 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.34 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: *Otto*
Engine S/N: VA-546078
NEW O2/NO CAT

Test No.: K
Date: 4/21/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured			C-B	Intake Air			Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37K	2440	25	19.9	299.9	2442	20.0	6.3	75.1	4.7	29.27	0.901	1.000	0.986	1.004
31K	2528	25	17.5	300.1	2530	17.5	6.3	73.2	4.4	29.27	0.896	1.000	0.985	1.001
22K	1757	100	87.0	300.0	1760	87.0	10.8	75.4	4.8	29.27	0.902	1.000	0.984	1.005
20K	1757	75	65.3	300.1	1755	65.5	9.0	75.0	4.6	29.28	0.900	1.000	0.984	1.004
19K	1757	50	43.5	300.1	1758	44.0	6.7	74.0	4.5	29.28	0.899	1.000	0.986	1.002
17K	1757	25	21.8	299.9	1754	21.5	4.4	74.7	4.6	29.28	0.900	1.000	0.987	1.003
16K	1757	10	8.7	300.8	1756	8.5	3.2	72.9	4.3	29.29	0.895	1.000	0.988	1.000
1K	600	CITT	0.0	300.0	604	18.5	1.5	74.6	4.6	29.29	0.900	1.000	0.989	1.003
1AK	600	-	0.0	300.1	688	0.0	1.0	74.0	4.5	29.29	0.899	1.000	0.989	1.002

	BHP from	Emissions (g/hr)						Weighted Modal Emissions (g/hp-hr)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37K	9.3	15.5	0.00	0.0	152.6	76.8	8233.1	1.66	0.00	0.00	16.40	8.25	885.0
31K	8.4	14.7	0.00	0.0	157.1	67.9	8312.1	1.75	0.00	0.00	18.63	8.06	985.6
22K	29.1	27.1	0.00	0.0	448.3	266.0	13863.1	0.93	0.00	0.00	15.38	9.13	475.6
20K	21.9	21.2	0.00	0.0	213.2	175.7	11852.5	0.97	0.00	0.00	9.74	8.03	541.4
19K	14.7	20.0	0.00	0.0	164.2	126.5	8812.8	1.36	0.00	0.00	11.15	8.59	598.2
17K	7.2	12.0	0.00	0.0	108.3	39.8	5772.9	1.68	0.00	0.00	15.09	5.54	804.2
16K	2.8	7.8	0.00	0.0	83.8	10.7	4252.5	2.75	0.00	0.00	29.54	3.76	1499.2
1K	2.1	7.9	0.00	0.0	79.0	9.6	1830.6	3.73	0.00	0.00	37.18	4.51	861.9
1AK	0.0	16.1	0.00	0.0	65.7	0.6	1163.0						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	1.54 g/hp-hr		2.07 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	14.28 g/hp-hr	=	19.15 g/kW-hr
BSNOx	=	7.84 g/hp-hr	=	10.52 g/kW-hr
BSCO2	=	704.78 g/hp-hr	=	945.11 g/kW-hr
BSFC	=	0.54 lb/hp-hr	=	0.33 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	1.68 g/hp-hr		2.25 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	14.07 g/hp-hr	=	18.87 g/kW-hr
BSNOx	=	7.70 g/hp-hr	=	10.33 g/kW-hr
BSCO2	=	694.11 g/hp-hr	=	930.80 g/kW-hr
BSFC	=	0.53 lb/hp-hr	=	0.32 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.55 g/hp-hr		2.08 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	14.39 g/hp-hr	=	19.30 g/kW-hr
BSNOx	=	7.83 g/hp-hr	=	10.50 g/kW-hr
BSCO2	=	709.23 g/hp-hr	=	951.07 g/kW-hr
BSFC	=	0.54 lb/hp-hr	=	0.33 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.68 g/hp-hr		2.25 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	14.18 g/hp-hr	=	19.01 g/kW-hr
BSNOx	=	7.69 g/hp-hr	=	10.31 g/kW-hr
BSCO2	=	698.50 g/hp-hr	=	936.69 g/kW-hr
BSFC	=	0.53 lb/hp-hr	=	0.33 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/NO CAT

Test No.: L
Date: 4/27/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

MAINTENANCE DONE

	Target			Measured				Intake Air			Ratios			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37L	2382	25	20.0	300.0	2390	20.0	6.5	78.0	10.1	29.08	0.990	1.000	0.979	1.024
31L	2528	25	18.0	299.7	2538	19.0	6.9	78.3	10.4	29.08	0.994	1.000	0.978	1.024
22L	1757	100	85.0	300.1	1754	85.0	11.0	78.1	10.1	29.08	0.989	1.000	0.977	1.024
20L	1757	75	63.8	300.0	1758	64.0	9.6	78.8	10.1	29.07	0.989	1.000	0.978	1.025
19L	1757	50	42.5	299.9	1761	43.0	7.3	78.8	10.2	29.07	0.990	1.000	0.979	1.025
17L	1757	25	21.3	299.9	1752	21.0	4.8	78.1	10.1	29.07	0.989	1.000	0.980	1.024
16L	1757	10	8.5	300.0	1758	8.5	3.4	77.3	10.2	29.07	0.990	1.000	0.981	1.023
1L	600 CITT		0.0	300.1	606	29.0	2.0	76.4	10.0	29.07	0.987	1.000	0.982	1.022
1AL	600 -		0.0	300.2	1380	0.0	2.1	75.4	10.1	29.07	0.989	1.000	0.982	1.021

	BHP from	Brake Specific Emissions (g/bhp-hr)						Dry/Weight Modal Emissions (g/hr)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37L	9.1	17.8	1.47	16.3	159.4	95.4	8490.0	1.95	0.16	1.79	17.52	10.49	933.4
31L	9.2	20.8	2.01	18.8	161.6	91.0	9007.7	2.27	0.22	2.05	17.61	9.92	981.5
22L	28.4	29.8	1.29	28.6	524.0	284.0	14024.3	1.05	0.05	1.01	18.46	10.01	494.1
20L	21.4	24.8	1.13	23.7	226.0	205.6	12629.0	1.16	0.05	1.11	10.55	9.60	589.6
19L	14.4	22.8	1.64	21.1	164.3	144.8	9532.7	1.58	0.11	1.46	11.40	10.05	661.2
17L	7.0	16.1	0.91	15.2	120.4	62.1	6274.7	2.30	0.13	2.17	17.18	8.86	895.1
16L	2.8	9.5	0.67	8.9	81.7	15.5	4424.3	3.35	0.23	3.12	28.74	5.46	1555.7
1L	3.3	11.3	0.40	10.9	94.7	35.4	2518.1	3.36	0.12	3.24	28.29	10.57	752.4
1AL	0.0	6.5	0.52	6.0	69.9	3.7	2775.4						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	1.92 g/hp-hr		2.58 g/kW-hr
BSCH4	=	0.12 g/hp-hr	=	0.16 g/kW-hr
BSNMHC	=	1.80 g/hp-hr	=	2.42 g/kW-hr
BSCO	=	15.51 g/hp-hr	=	20.79 g/kW-hr
BSNOx	=	10.18 g/hp-hr	=	13.65 g/kW-hr
BSCO2	=	781.07 g/hp-hr	=	1047.42 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	1.85 g/hp-hr		2.48 g/kW-hr
BSCH4	=	0.12 g/hp-hr	=	0.16 g/kW-hr
BSNMHC	=	1.72 g/hp-hr	=	2.31 g/kW-hr
BSCO	=	15.10 g/hp-hr	=	20.25 g/kW-hr
BSNOx	=	9.66 g/hp-hr	=	12.96 g/kW-hr
BSCO2	=	785.27 g/hp-hr	=	1053.05 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.94 g/hp-hr		2.61 g/kW-hr
BSCH4	=	0.12 g/hp-hr	=	0.16 g/kW-hr
BSNMHC	=	1.82 g/hp-hr	=	2.44 g/kW-hr
BSCO	=	15.51 g/hp-hr	=	20.80 g/kW-hr
BSNOx	=	10.15 g/hp-hr	=	13.61 g/kW-hr
BSCO2	=	784.04 g/hp-hr	=	1051.39 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.86 g/hp-hr		2.50 g/kW-hr
BSCH4	=	0.12 g/hp-hr	=	0.17 g/kW-hr
BSNMHC	=	1.74 g/hp-hr	=	2.33 g/kW-hr
BSCO	=	15.11 g/hp-hr	=	20.26 g/kW-hr
BSNOx	=	9.63 g/hp-hr	=	12.92 g/kW-hr
BSCO2	=	788.24 g/hp-hr	=	1057.03 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.37 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/OLD CAT

Test No.: M
Date: 4/27/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
MAINTENANCE DONE

	Target		Measured		C-B	Intake Air				Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37M	2382	25	20.0	300.0	2378	20.0	6.7	76.5	10.3	29.14	0.992	1.000	0.979	1.020
31M	2528	25	17.3	300.1	2532	17.5	6.7	75.8	10.3	29.14	0.992	1.000	0.979	1.019
22M	1757	100	85.0	300.2	1758	85.0	11.9	75.7	10.4	29.13	0.994	1.000	0.976	1.019
20M	1757	75	63.8	300.0	1752	63.5	9.5	75.8	10.0	29.13	0.987	1.000	0.978	1.019
19M	1757	50	42.5	300.0	1758	43.0	7.2	75.7	10.1	29.13	0.989	1.000	0.979	1.019
17M	1757	25	21.3	300.0	1752	21.0	4.7	75.1	10.0	29.13	0.987	1.000	0.980	1.018
16M	1757	10	8.5	300.0	1758	8.5	3.4	74.6	10.1	29.12	0.990	1.000	0.981	1.018
1Ma	600	CITT	0.0	300.2	610	21.0	1.6	74.3	10.3	29.12	0.992	1.000	0.982	1.018
1AMa	600	-	0.0	300.0	692	0.0	1.0	74.8	10.5	29.12	0.996	1.000	0.983	1.019

	BHP from	Grams/Hour						Weighted Mass (g/hp-hr)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37M	9.1	0.3	0.27	0.1	0.6	32.2	9135.0	0.04	0.03	0.01	0.07	3.55	1008.3
31M	8.4	0.5	0.13	0.4	1.6	26.5	9150.3	0.07	0.02	0.05	0.19	3.14	1085.0
22M	28.5	1.0	0.46	0.6	78.3	37.4	15988.5	0.04	0.02	0.02	2.75	1.31	561.8
20M	21.2	0.9	0.88	0.0	3.9	24.4	12880.7	0.04	0.04	0.00	0.18	1.15	608.2
19M	14.4	0.3	0.23	0.1	1.0	59.5	9837.9	0.02	0.02	0.01	0.07	4.14	683.8
17M	7.0	0.6	0.27	0.3	0.0	31.1	6361.1	0.09	0.04	0.05	0.00	4.44	907.7
16M	2.8	0.6	0.46	0.1	1.0	9.9	4667.0	0.20	0.16	0.04	0.35	3.50	1641.0
1Ma	2.4	8.6	0.48	8.2	79.0	19.1	2031.8	3.54	0.20	3.35	32.47	7.85	834.6
1AMa	0.0	11.9	0.41	11.5	12.9	1.3	1247.7						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.19 g/hp-hr		0.25 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.20 g/kW-hr
BSCO	=	1.54 g/hp-hr	=	2.06 g/kW-hr
BSNOx	=	3.94 g/hp-hr	=	5.29 g/kW-hr
BSCO2	=	801.06 g/hp-hr	=	1074.22 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.24 g/hp-hr		0.32 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.21 g/hp-hr	=	0.28 g/kW-hr
BSCO	=	0.45 g/hp-hr	=	0.61 g/kW-hr
BSNOx	=	3.65 g/hp-hr	=	4.90 g/kW-hr
BSCO2	=	788.22 g/hp-hr	=	1057.01 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.19 g/hp-hr		0.26 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.21 g/kW-hr
BSCO	=	1.55 g/hp-hr	=	2.08 g/kW-hr
BSNOx	=	3.92 g/hp-hr	=	5.26 g/kW-hr
BSCO2	=	804.46 g/hp-hr	=	1078.78 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.24 g/hp-hr		0.33 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.21 g/hp-hr	=	0.28 g/kW-hr
BSCO	=	0.46 g/hp-hr	=	0.62 g/kW-hr
BSNOx	=	3.63 g/hp-hr	=	4.87 g/kW-hr
BSCO2	=	791.57 g/hp-hr	=	1061.50 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.36 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/NEW CAT

Test No.: N
Date: 4/27/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
MAINTENANCE DONE

	Target			Measured				Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37N	2382	25	20.0	300.0	2390	20.0	6.6	75.4	10.7	29.15	1.000	1.000	0.978	1.019
31N	2528	25	18.0	299.9	2532	18.0	6.7	75.0	10.3	29.15	0.993	1.000	0.978	1.017
22N	1757	100	86.0	300.1	1760	86.0	11.4	73.6	10.3	29.15	0.992	1.000	0.975	1.015
20N	1757	75	64.5	300.0	1760	65.0	9.9	73.7	10.1	29.15	0.989	1.000	0.976	1.015
19N	1757	50	43.0	299.9	1757	43.0	7.1	73.6	10.3	29.16	0.992	1.000	0.978	1.015
17N	1757	25	21.5	300.0	1758	21.0	4.8	76.0	12.3	29.15	1.029	1.000	0.979	1.022
16N	1757	10	8.6	300.0	1762	8.5	3.5	72.4	10.3	29.16	0.992	1.000	0.981	1.014
1N	600	CITT	0.0	300.0	602	29.5	2.0	72.9	10.5	29.16	0.997	1.000	0.982	1.015
1AN	600	-	0.0	300.0	1330	0.0	2.0	73.2	10.9	29.16	1.003	1.000	0.982	1.016

	BHP from	Measured g/hr						Dry g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37N	9.1	0.5	0.32	0.2	0.0	29.6	8918.5	0.06	0.04	0.02	0.00	3.26	980.5
31N	8.7	0.5	0.48	0.0	0.0	20.1	9064.3	0.06	0.06	0.00	0.00	2.32	1044.4
22N	28.8	0.9	0.39	0.5	24.6	18.4	15382.2	0.03	0.01	0.02	0.85	0.64	533.8
20N	21.8	0.3	0.18	0.1	0.0	35.9	13371.9	0.01	0.01	0.00	0.00	1.65	614.0
19N	14.4	1.0	0.51	0.5	0.0	61.5	9700.0	0.07	0.04	0.03	0.00	4.28	674.5
17N	7.0	0.9	0.75	0.1	0.4	36.2	6496.7	0.13	0.11	0.02	0.06	5.15	923.9
16N	2.9	1.1	0.49	0.6	0.0	11.4	4804.3	0.38	0.17	0.21	0.00	4.01	1682.2
1N	3.4	2.7	0.58	2.1	4.0	21.9	2634.2	0.79	0.17	0.62	1.18	6.48	778.4
1AN	0.0	1.5	0.44	1.1	0.0	1.7	2722.4						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.06 g/hp-hr	=	0.09 g/kW-hr
BSCO	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSNOx	=	4.23 g/hp-hr	=	5.67 g/kW-hr
BSCO2	=	807.97 g/hp-hr	=	1083.49 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.11 g/hp-hr	=	0.14 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSCO	=	0.07 g/hp-hr	=	0.09 g/kW-hr
BSNOx	=	3.90 g/hp-hr	=	5.22 g/kW-hr
BSCO2	=	809.41 g/hp-hr	=	1085.42 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.06 g/hp-hr	=	0.09 g/kW-hr
BSCO	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSNOx	=	4.17 g/hp-hr	=	5.60 g/kW-hr
BSCO2	=	811.13 g/hp-hr	=	1087.72 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.11 g/hp-hr	=	0.14 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSCO	=	0.07 g/hp-hr	=	0.09 g/kW-hr
BSNOx	=	3.84 g/hp-hr	=	5.16 g/kW-hr
BSCO2	=	812.57 g/hp-hr	=	1089.65 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.36 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/OLD CAT/CAL 1

Test No.: O
Date: 4/26/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

MAINTENANCE DONE

Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37O	2382	25	20.5	300.0	2384	20.5	6.5	76.8	10.5	29.17	0.997	1.000	0.979	1.020
31O	2528	25	17.8	299.9	2532	18.0	6.9	77.1	10.8	29.16	1.002	1.000	0.979	1.021
22O	1757	100	86.0	300.0	1758	86.0	11.9	76.5	10.5	29.17	0.997	1.000	0.976	1.019
20O	1757	75	64.5	300.1	1760	64.5	9.8	77.1	10.5	29.17	0.996	1.000	0.977	1.020
19O	1757	50	43.0	300.0	1760	43.5	7.4	77.1	10.5	29.16	0.997	1.000	0.978	1.020
17O	1757	25	21.5	299.9	1762	22.0	5.0	76.4	10.5	29.16	0.996	1.000	0.980	1.019
16O	1757	10	8.6	303.7	1750	8.5	3.8	75.4	10.3	29.16	0.993	1.000	0.981	1.018
1O	600	CITT	0.0	304.5	608	29.5	1.0	71.8	8.8	29.15	0.967	1.000	0.984	1.011
1AO	600	-	0.0	300.0	694	0.0	2.0	71.8	9.2	29.15	0.973	1.000	0.983	1.011

Mode	BHP from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37O	9.3	0.9	0.49	0.4	8.8	3.8	8870.4	0.10	0.05	0.05	0.95	0.41	953.8
31O	8.7	0.7	0.48	0.2	9.6	2.6	9293.8	0.08	0.06	0.03	1.10	0.30	1070.9
22O	28.8	2.3	0.80	1.5	179.8	14.9	15891.8	0.08	0.03	0.05	6.25	0.52	552.0
20O	21.6	1.9	0.67	1.3	75.4	6.9	13124.7	0.09	0.03	0.06	3.49	0.32	607.2
19O	14.6	0.7	0.33	0.4	9.4	2.5	10019.5	0.05	0.02	0.03	0.64	0.17	687.2
17O	7.4	0.7	0.75	0.0	0.5	32.2	6835.7	0.10	0.10	0.00	0.06	4.36	925.9
16O	2.8	1.3	0.71	0.6	0.6	19.5	5093.9	0.45	0.25	0.20	0.22	6.88	1798.0
1O	3.4	7.8	0.14	7.6	0.0	0.1	1315.8	2.27	0.04	2.23	0.00	0.02	385.1
1AO	0.0	7.7	0.36	7.3	2.2	34.8	2701.6						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.21 g/hp-hr	=	0.28 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.21 g/kW-hr
BSCO	=	1.18 g/hp-hr	=	1.59 g/kW-hr
BSNOx	=	1.42 g/hp-hr	=	1.90 g/kW-hr
BSCO2	=	796.52 g/hp-hr	=	1068.14 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.21 g/hp-hr	=	0.28 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.20 g/kW-hr
BSCO	=	1.22 g/hp-hr	=	1.63 g/kW-hr
BSNOx	=	1.97 g/hp-hr	=	2.64 g/kW-hr
BSCO2	=	818.69 g/hp-hr	=	1097.86 g/kW-hr
BSFC	=	0.60 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.21 g/hp-hr	=	0.28 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.21 g/kW-hr
BSCO	=	1.19 g/hp-hr	=	1.60 g/kW-hr
BSNOx	=	1.42 g/hp-hr	=	1.90 g/kW-hr
BSCO2	=	802.42 g/hp-hr	=	1076.05 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.21 g/hp-hr	=	0.28 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.20 g/kW-hr
BSCO	=	1.23 g/hp-hr	=	1.65 g/kW-hr
BSNOx	=	1.97 g/hp-hr	=	2.65 g/kW-hr
BSCO2	=	824.68 g/hp-hr	=	1105.89 g/kW-hr
BSFC	=	0.61 lb/hp-hr	=	0.37 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/OLD CAT/CAL 2

Test No.: P
Date: 4/28/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
MAINTENANCE DONE

Mode	Target Speed rpm	Target Load %	Target Torque ft-lb	Target Time sec	Measured Speed rpm	Measured Torque ft-lb	Measured Fuel lb/hr	Intake Air Temp F	Intake Air Humid g/kg	Intake Air Baro in-hg	Factors NOx Hum	Factors Part. Hum	Factors Dry Wet	Factors F (NA)
37P	2382	25	20.0	300.1	2380	20.0	6.4	78.8	10.1	29.13	0.990	1.000	0.980	1.023
31P	2528	25	17.0	300.0	2528	17.0	6.7	78.8	10.3	29.13	0.992	1.000	0.980	1.023
22P	1757	100	86.0	300.0	1760	86.0	11.9	78.1	10.3	29.13	0.992	1.000	0.976	1.022
20P	1757	75	64.5	300.2	1758	64.5	9.6	78.8	10.3	29.13	0.992	1.000	0.979	1.023
19P	1757	50	43.0	299.9	1760	43.0	7.4	78.8	10.1	29.13	0.990	1.000	0.979	1.023
17P	1757	25	21.5	300.2	1752	21.0	4.8	78.1	10.3	29.12	0.992	1.000	0.980	1.022
16P	1757	10	8.6	300.0	1758	8.5	3.5	77.2	10.3	29.12	0.992	1.000	0.981	1.021
1P	600 CITT		0.0	300.0	608	35.0	2.3	74.2	9.5	29.11	0.979	1.000	0.982	1.016
1AP	600 -		0.0	299.9	688	0.0	1.0	73.2	9.6	29.11	0.979	1.000	0.982	1.015

Mode	BHP from Work	Grams/Hour HC	CH4	NMHC	CO	NOx	CO2	Grams/BHP-hr HC	CH4	NMHC	CO	NOx	CO2
37P	9.1	0.2	0.19	0.1	1.6	0.8	8647.4	0.03	0.02	0.01	0.18	0.08	953.5
31P	8.2	0.2	0.18	0.0	3.6	0.7	9044.8	0.02	0.02	0.00	0.44	0.09	1105.2
22P	28.8	2.2	0.91	1.3	214.7	19.4	15842.5	0.08	0.03	0.04	7.45	0.67	549.6
20P	21.6	0.9	0.66	0.2	26.0	4.1	12994.0	0.04	0.03	0.01	1.20	0.19	602.0
19P	14.4	0.4	0.18	0.2	3.4	4.9	10009.3	0.03	0.01	0.01	0.24	0.34	694.9
17P	7.0	0.4	0.38	0.0	0.9	20.8	6566.2	0.06	0.05	0.00	0.12	2.97	937.6
16P	2.8	0.8	0.76	0.0	0.5	9.1	4814.1	0.27	0.27	0.00	0.16	3.21	1692.7
1P	4.1	2.9	0.42	2.5	3.8	24.7	3076.9	0.72	0.10	0.61	0.93	6.10	758.6
1AP	0.0	11.8	0.00	11.8	0.8	0.1	1256.2						

WEIGHT	MODES 37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.09 g/hp-hr		0.12 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSCO	=	0.83 g/hp-hr	=	1.12 g/kW-hr
BSNOx	=	1.42 g/hp-hr	=	1.91 g/kW-hr
BSCO2	=	826.68 g/hp-hr	=	1108.58 g/kW-hr
BSFC	=	0.61 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.24 g/hp-hr		0.32 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.20 g/hp-hr	=	0.27 g/kW-hr
BSCO	=	0.78 g/hp-hr	=	1.05 g/kW-hr
BSNOx	=	1.02 g/hp-hr	=	1.37 g/kW-hr
BSCO2	=	796.98 g/hp-hr	=	1068.75 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.09 g/hp-hr		0.12 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSCO	=	0.85 g/hp-hr	=	1.14 g/kW-hr
BSNOx	=	1.43 g/hp-hr	=	1.92 g/kW-hr
BSCO2	=	834.09 g/hp-hr	=	1118.52 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.37 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.24 g/hp-hr		0.32 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.20 g/hp-hr	=	0.27 g/kW-hr
BSCO	=	0.80 g/hp-hr	=	1.07 g/kW-hr
BSNOx	=	1.02 g/hp-hr	=	1.37 g/kW-hr
BSCO2	=	804.22 g/hp-hr	=	1078.45 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/OLD CAT/CAL 3

Test No.: QQ
Date: 5/2/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

MAINTENANCE DONE

	Target		Measured					Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37QQ	2382	25	20.0	299.9	2386	20.5	6.7	73.7	10.0	29.11	0.987	1.000	0.979	1.016
31QQ	2528	25	17.8	300.1	2528	18.0	6.8	73.7	10.1	29.12	0.990	1.000	0.980	1.017
22QQ	1757	100	87.0	300.0	1758	87.0	11.8	73.2	10.3	29.11	0.992	1.000	0.976	1.016
20QQ	1757	75	65.3	300.0	1758	65.5	9.4	74.6	10.4	29.11	0.994	1.000	0.977	1.019
19QQ	1757	50	43.5	300.0	1762	44.5	6.7	74.6	10.4	29.10	0.994	1.000	0.978	1.019
17QQ	1757	25	21.8	300.0	1754	21.5	4.9	73.7	10.1	29.09	0.989	1.000	0.980	1.017
16QQ	1757	10	8.7	300.1	1758	8.5	3.6	72.9	10.1	29.09	0.989	1.000	0.981	1.016
1QQ	600 CITT		36.5	303.0	608	36.5	2.3	71.7	10.1	29.09	0.990	1.000	0.981	1.015
1AQQ	600 -		0.0	300.1	702	0.0	0.9	71.4	10.1	29.09	0.990	1.000	0.982	1.014

	BHP from	Grams/Hour						Unweighted Weighted Emissions (Mode 8)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37QQ	9.3	1.8	0.65	1.1	30.5	3.7	9088.9	0.19	0.07	0.12	3.27	0.39	975.7
31QQ	8.7	1.8	0.96	0.9	50.0	5.7	9177.8	0.21	0.11	0.10	5.78	0.66	1059.7
22QQ	29.1	3.0	0.73	2.3	230.5	12.6	15635.0	0.10	0.03	0.08	7.91	0.43	536.8
20QQ	21.9	2.5	0.74	1.8	116.7	6.8	12504.8	0.12	0.03	0.08	5.33	0.31	570.4
19QQ	14.9	1.4	0.41	1.0	29.2	4.8	8999.9	0.09	0.03	0.06	1.96	0.32	602.9
17QQ	7.2	1.0	0.60	0.4	6.2	0.6	6599.9	0.14	0.08	0.06	0.87	0.09	919.7
16QQ	2.8	1.0	0.15	0.9	0.0	5.3	4906.1	0.36	0.05	0.31	0.01	1.88	1725.6
1QQ	4.2	1.5	0.42	1.1	4.9	10.3	3074.1	0.36	0.10	0.26	1.16	2.43	726.8
1AQQ	0.0	7.6	0.44	7.2	0.0	0.0	1248.6						

MODES									
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.14 g/hp-hr		0.19 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.09 g/hp-hr	=	0.12 g/kW-hr
BSCO	=	2.56 g/hp-hr	=	3.44 g/kW-hr
BSNOx	=	0.49 g/hp-hr	=	0.66 g/kW-hr
BSCO2	=	771.81 g/hp-hr	=	1035.00 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.24 g/hp-hr		0.32 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.19 g/hp-hr	=	0.25 g/kW-hr
BSCO	=	2.49 g/hp-hr	=	3.33 g/kW-hr
BSNOx	=	0.33 g/hp-hr	=	0.44 g/kW-hr
BSCO2	=	742.84 g/hp-hr	=	996.15 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.33 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.14 g/hp-hr		0.19 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.09 g/hp-hr	=	0.12 g/kW-hr
BSCO	=	2.70 g/hp-hr	=	3.62 g/kW-hr
BSNOx	=	0.51 g/hp-hr	=	0.68 g/kW-hr
BSCO2	=	775.60 g/hp-hr	=	1040.08 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.24 g/hp-hr		0.33 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.19 g/hp-hr	=	0.25 g/kW-hr
BSCO	=	2.62 g/hp-hr	=	3.51 g/kW-hr
BSNOx	=	0.34 g/hp-hr	=	0.46 g/kW-hr
BSCO2	=	746.51 g/hp-hr	=	1001.07 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.34 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/OLD CAT/CAL 4

Test No.: RR
Date: 5/2/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

MAINTENANCE DONE

	Target			Measured			Intake Air			Exhaust			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37RR	2382	25	20.0	300.0	2384	20.0	6.4	73.0	9.9	29.10	0.985	1.000	0.979	1.016
31RR	2528	25	17.3	300.0	2528	17.5	6.6	71.7	9.6	29.12	0.980	1.000	0.979	1.013
22RR	1757	100	86.0	300.7	1758	86.0	11.5	75.0	11.7	29.12	1.018	1.000	0.976	1.021
20RR	1757	75	64.5	300.1	1758	65.0	9.6	71.8	9.0	29.10	0.971	1.000	0.978	1.013
19RR	1757	50	43.0	300.1	1758	43.5	6.8	71.0	9.2	29.11	0.973	1.000	0.979	1.012
17RR	1757	25	21.5	300.1	1760	21.5	4.4	70.3	9.2	29.11	0.973	1.000	0.981	1.011
16RR	1757	10	8.6	300.0	1763	9.0	3.5	74.3	11.5	29.11	1.014	1.000	0.981	1.020
1RR	600 CITT		36.5	300.0	602	36.5	2.2	69.7	8.8	29.11	0.967	1.000	0.982	1.009
1ARR	600 -		0.0	299.9	708	0.0	0.9	68.7	9.3	29.11	0.975	1.000	0.983	1.009

	BHP from	Straight Rich						Brake Specific Emissions g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37RR	9.1	2.0	0.97	1.1	52.5	5.1	8662.8	0.22	0.11	0.12	5.78	0.57	953.6
31RR	8.4	1.6	1.10	0.5	64.0	5.2	8917.8	0.19	0.13	0.06	7.60	0.62	1058.6
22RR	28.7	4.7	1.56	3.1	438.7	17.5	14940.7	0.16	0.05	0.11	15.28	0.61	520.2
20RR	21.7	2.3	0.78	1.5	88.4	6.7	12837.4	0.11	0.04	0.07	4.06	0.31	590.3
19RR	14.6	1.3	0.47	0.8	35.5	3.8	9194.5	0.09	0.03	0.06	2.44	0.26	631.9
17RR	7.2	0.5	0.14	0.4	5.7	0.5	5988.7	0.07	0.02	0.05	0.79	0.07	832.0
16RR	3.0	0.4	0.22	0.2	0.0	3.4	4706.6	0.12	0.07	0.05	0.00	1.11	1556.4
1RR	4.2	1.3	0.56	0.7	4.5	9.8	2965.1	0.31	0.13	0.17	1.08	2.33	708.0
1ARR	0.0	7.7	0.21	7.5	0.2	0.1	1226.8						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.12 g/hp-hr		0.16 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.07 g/hp-hr	=	0.10 g/kW-hr
BSCO	=	3.23 g/hp-hr	=	4.33 g/kW-hr
BSNOx	=	0.45 g/hp-hr	=	0.60 g/kW-hr
BSCO2	=	762.98 g/hp-hr	=	1023.16 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.34 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.22 g/hp-hr		0.30 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.18 g/hp-hr	=	0.25 g/kW-hr
BSCO	=	3.16 g/hp-hr	=	4.23 g/kW-hr
BSNOx	=	0.29 g/hp-hr	=	0.39 g/kW-hr
BSCO2	=	735.02 g/hp-hr	=	985.66 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.33 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.12 g/hp-hr		0.16 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.07 g/hp-hr	=	0.10 g/kW-hr
BSCO	=	3.32 g/hp-hr	=	4.45 g/kW-hr
BSNOx	=	0.45 g/hp-hr	=	0.60 g/kW-hr
BSCO2	=	767.88 g/hp-hr	=	1029.73 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.22 g/hp-hr		0.30 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.18 g/hp-hr	=	0.24 g/kW-hr
BSCO	=	3.25 g/hp-hr	=	4.35 g/kW-hr
BSNOx	=	0.29 g/hp-hr	=	0.39 g/kW-hr
BSCO2	=	739.80 g/hp-hr	=	992.07 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.33 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model:	1993 MAZDA 4-121G	Test No.: S	LPG HD5
Engine Desc.:	2L (121 CID) 4IL	Date: 5/3/00	HCR: 2.669 FID Resp: 1.20
Engine Cycle:	Otto	Program SSDIL: 2.24-R	H= 0.183 C= 0.817
Engine S/N:	VA-546078	Cell: 13 Bag Cart: 1	
NEW O2/NEW CAT/CAL 3		**POWER VALVE ADJUSTED**	**W/MAINTENANCE**

	Target			Measured			CB	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37S	2382	25	20.3	300.1	2386	21.0	6.7	72.3	9.9	29.08	0.985	1.000	0.977	1.015
31S	2528	25	17.8	299.9	2526	18.0	6.7	72.8	10.3	29.09	0.992	1.000	0.976	1.017
22S	1757	100	85.0	300.1	1760	85.0	11.5	71.6	10.4	29.09	0.994	1.000	0.974	1.015
20S	1757	75	63.8	300.0	1762	63.5	9.4	71.7	10.1	29.09	0.990	1.000	0.975	1.015
19S	1757	50	42.5	300.0	1754	42.5	6.8	71.1	10.1	29.09	0.990	1.000	0.977	1.014
17S	1757	25	21.3	300.1	1762	22.0	4.8	70.8	10.5	29.09	0.997	1.000	0.978	1.014
16S	1757	10	8.5	300.1	1760	8.5	3.4	70.3	10.6	29.09	0.997	1.000	0.979	1.014
1S	600	CITT	36.0	300.1	604	36.0	2.1	73.6	12.8	29.08	1.040	1.000	0.980	1.022
1AS	600	-	0.0	299.9	720	0.0	0.9	69.1	9.9	29.08	0.985	1.000	0.981	1.011

	BHP	Grams/Hour						Unweighted Modal BS (g/hp-hr)					
Mode	from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37S	9.5	3.0	1.14	1.9	21.3	0.0	9117.6	0.32	0.12	0.20	2.23	0.00	956.0
31S	8.7	2.4	1.22	1.2	22.3	0.1	9105.5	0.28	0.14	0.14	2.57	0.02	1052.1
22S	28.5	4.9	1.52	3.4	159.5	2.2	15391.5	0.17	0.05	0.12	5.60	0.08	540.5
20S	21.3	4.2	0.18	4.0	32.3	1.2	12740.7	0.20	0.01	0.19	1.51	0.06	598.2
19S	14.2	2.9	0.99	1.9	21.3	2.9	9249.8	0.20	0.07	0.13	1.50	0.20	651.6
17S	7.4	1.3	0.51	0.8	5.5	4.1	6506.4	0.18	0.07	0.11	0.74	0.56	881.9
16S	2.8	0.8	0.45	0.3	0.4	4.2	4633.3	0.27	0.16	0.12	0.15	1.47	1629.7
1S	4.1	0.9	0.40	0.5	1.0	13.1	2895.8	0.21	0.10	0.11	0.24	3.16	699.7
1AS	0.0	7.5	0.11	7.4	0.2	0.4	1139.6						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.22 g/hp-hr	0.29 g/kW-hr
BSCH4	=	0.07 g/hp-hr =	0.10 g/kW-hr
BSNMHC	=	0.14 g/hp-hr =	0.19 g/kW-hr
BSCO	=	1.59 g/hp-hr =	2.14 g/kW-hr
BSNOx	=	0.50 g/hp-hr =	0.67 g/kW-hr
BSCO2	=	789.60 g/hp-hr =	1058.85 g/kW-hr
BSFC	=	0.58 lb/hp-hr =	0.36 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.22 g/hp-hr	0.29 g/kW-hr
BSCH4	=	0.07 g/hp-hr =	0.10 g/kW-hr
BSNMHC	=	0.14 g/hp-hr =	0.19 g/kW-hr
BSCO	=	1.61 g/hp-hr =	2.16 g/kW-hr
BSNOx	=	0.50 g/hp-hr =	0.68 g/kW-hr
BSCO2	=	794.06 g/hp-hr =	1064.84 g/kW-hr
BSFC	=	0.59 lb/hp-hr =	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.33 g/hp-hr	0.44 g/kW-hr
BSCH4	=	0.07 g/hp-hr =	0.09 g/kW-hr
BSNMHC	=	0.26 g/hp-hr =	0.34 g/kW-hr
BSCO	=	1.58 g/hp-hr =	2.12 g/kW-hr
BSNOx	=	0.30 g/hp-hr =	0.40 g/kW-hr
BSCO2	=	761.11 g/hp-hr =	1020.65 g/kW-hr
BSFC	=	0.56 lb/hp-hr =	0.34 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.32 g/hp-hr	0.43 g/kW-hr
BSCH4	=	0.07 g/hp-hr =	0.09 g/kW-hr
BSNMHC	=	0.25 g/hp-hr =	0.34 g/kW-hr
BSCO	=	1.60 g/hp-hr =	2.14 g/kW-hr
BSNOx	=	0.30 g/hp-hr =	0.40 g/kW-hr
BSCO2	=	765.41 g/hp-hr =	1026.42 g/kW-hr
BSFC	=	0.57 lb/hp-hr =	0.34 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/NEW CAT/CAL 4

Test No.: T
Date: 5/3/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

W/MAINTENANCE

	Target				Measured			CVS		Intake Air			Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37T	2382	25	20.0	300.0	2386	20.0	6.3	74.3	9.9	29.09	0.985	1.000	0.979	1.018
31T	2528	25	17.5	314.2	2524	17.5	6.7	74.7	10.1	29.09	0.989	1.000	0.979	1.019
22T	1757	100	86.0	300.0	1748	86.0	11.8	73.2	9.8	29.10	0.983	1.000	0.977	1.016
20T	1757	75	64.5	300.1	1748	64.0	9.3	73.7	9.6	29.10	0.981	1.000	0.978	1.016
19T	1757	50	43.0	299.9	1762	43.0	7.1	73.7	9.8	29.07	0.983	1.000	0.979	1.017
17T	1757	25	21.5	300.2	1754	21.0	4.7	73.6	10.2	29.07	0.990	1.000	0.980	1.018
16T	1757	10	8.6	304.3	1752	8.5	3.3	72.9	10.1	29.07	0.989	1.000	0.981	1.017
1T	600	CITT	35.0	300.0	604	34.5	2.1	71.7	10.0	29.07	0.987	1.000	0.982	1.015
1AT	600	-	0.0	300.9	734	0.0	0.9	71.3	10.5	29.07	0.997	1.000	0.982	1.016

	BHP from	Grams/Hour						Unweighted Mass Emissions g/hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37T	9.0	2.6	0.50	2.1	24.4	0.1	8524.7	0.29	0.06	0.23	2.70	0.02	942.2
31T	8.4	2.2	1.15	1.1	27.3	0.1	9013.5	0.27	0.14	0.13	3.25	0.01	1074.7
22T	28.5	5.1	1.10	4.1	155.1	2.1	15716.0	0.18	0.04	0.14	5.44	0.07	551.2
20T	21.2	4.0	0.97	3.0	38.5	1.0	12496.2	0.19	0.05	0.14	1.82	0.05	589.2
19T	14.4	2.8	0.80	2.0	20.1	2.7	9569.7	0.19	0.06	0.14	1.40	0.18	666.0
17T	7.0	1.1	0.38	0.7	4.5	4.5	6311.5	0.16	0.05	0.10	0.64	0.64	904.3
16T	2.8	0.8	0.52	0.3	0.0	4.1	4510.8	0.30	0.18	0.12	0.00	1.47	1602.0
1T	3.9	1.0	0.29	0.7	0.2	11.8	2851.9	0.25	0.07	0.17	0.05	2.98	722.4
1AT	0.0	5.6	0.16	5.4	0.0	0.0	1170.7						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.21 g/hp-hr		0.28 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.20 g/kW-hr
BSCO	=	1.56 g/hp-hr	=	2.10 g/kW-hr
BSNOx	=	0.49 g/hp-hr	=	0.66 g/kW-hr
BSCO2	=	796.47 g/hp-hr	=	1068.06 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.28 g/hp-hr		0.38 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.22 g/hp-hr	=	0.30 g/kW-hr
BSCO	=	1.56 g/hp-hr	=	2.09 g/kW-hr
BSNOx	=	0.30 g/hp-hr	=	0.40 g/kW-hr
BSCO2	=	768.90 g/hp-hr	=	1031.09 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.21 g/hp-hr		0.28 g/kW-hr
BSCH4	=	0.07 g/hp-hr	=	0.09 g/kW-hr
BSNMHC	=	0.14 g/hp-hr	=	0.19 g/kW-hr
BSCO	=	1.59 g/hp-hr	=	2.13 g/kW-hr
BSNOx	=	0.49 g/hp-hr	=	0.66 g/kW-hr
BSCO2	=	803.16 g/hp-hr	=	1077.03 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.28 g/hp-hr		0.38 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.09 g/kW-hr
BSNMHC	=	0.22 g/hp-hr	=	0.29 g/kW-hr
BSCO	=	1.59 g/hp-hr	=	2.13 g/kW-hr
BSNOx	=	0.30 g/hp-hr	=	0.40 g/kW-hr
BSCO2	=	775.47 g/hp-hr	=	1039.90 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
OPEN LOOP/NEW CAT

Test No.: U
Date: 5/3/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

W/MAINTENANCE

	Target		Measured					Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37U	2382	25	20.3	300.1	2386	20.0	7.1	75.8	11.4	29.02	1.013	1.000	0.980	1.025
31U	2528	25	17.5	299.9	2530	17.5	7.3	76.3	10.9	29.02	1.004	1.000	0.979	1.025
22U	1757	100	86.0	300.0	1752	85.5	14.3	76.5	10.9	29.02	1.004	1.000	0.979	1.025
20U	1757	75	64.5	300.4	1756	64.5	10.4	77.1	10.9	29.01	1.004	1.000	0.979	1.026
19U	1757	50	43.0	370.0	1752	43.0	7.7	77.5	11.3	29.00	1.010	1.000	0.980	1.027
17U	1757	25	21.5	300.0	1759	21.0	5.0	77.9	11.1	29.00	1.007	1.000	0.980	1.028
16U	1757	10	8.6	347.2	1756	9.0	3.4	77.1	11.1	28.96	1.008	1.000	0.981	1.028
1U	600	CITT	34.0	300.0	604	34.0	2.2	75.7	10.7	28.95	1.000	1.000	0.982	1.026
1AU	600	-	0.0	300.1	736	0.0	0.9	75.7	11.4	28.99	1.012	1.000	0.982	1.026

	BHP from	Grams/Hour						Dilute Mode Emissions g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37U	9.0	29.5	0.00	0.0	1199.9	0.4	7683.7	3.26	0.00	0.00	132.66	0.04	849.5
31U	8.4	29.1	0.00	0.0	1148.2	0.3	7985.0	3.47	0.00	0.00	136.64	0.03	950.3
22U	28.4	64.3	0.00	0.0	4724.4	1.0	11843.6	2.26	0.00	0.00	166.33	0.04	417.0
20U	21.5	39.1	0.00	0.0	2422.8	0.8	10183.2	1.82	0.00	0.00	112.94	0.04	474.7
19U	14.4	33.8	0.00	0.0	1507.3	0.4	8045.2	2.35	0.00	0.00	104.88	0.03	559.8
17U	7.0	19.4	0.00	0.0	550.8	0.1	5875.3	2.76	0.00	0.00	78.59	0.01	838.4
16U	3.0	10.5	0.00	0.0	181.6	0.0	4357.7	3.51	0.00	0.00	60.59	0.01	1454.3
1U	3.9	9.6	0.00	0.0	64.9	0.2	2851.7	2.45	0.00	0.00	16.64	0.05	731.2
1AU	0.0	6.5	0.00	0.0	0.0	0.1	1261.8						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	2.63 g/hp-hr		3.52 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	104.86 g/hp-hr	=	140.62 g/kW-hr
BSNOx	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSCO2	=	697.69 g/hp-hr	=	935.60 g/kW-hr
BSFC	=	0.64 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	2.58 g/hp-hr		3.46 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	103.80 g/hp-hr	=	139.20 g/kW-hr
BSNOx	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSCO2	=	671.72 g/hp-hr	=	900.78 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	2.64 g/hp-hr		3.53 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	104.97 g/hp-hr	=	140.76 g/kW-hr
BSNOx	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSCO2	=	702.61 g/hp-hr	=	942.19 g/kW-hr
BSFC	=	0.64 lb/hp-hr	=	0.39 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	2.59 g/hp-hr		3.47 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	103.90 g/hp-hr	=	139.33 g/kW-hr
BSNOx	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSCO2	=	676.53 g/hp-hr	=	907.22 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/NO CAT/CAL 4

Test No.: V
Date: 5/4/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
W/MAINTENANCE

Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37V	2382	25	20.3	300.0	2382	20.5	6.5	74.7	11.9	29.03	1.023	1.000	0.977	1.024
31V	2528	25	17.8	299.8	2522	18.0	6.5	75.7	12.0	29.03	1.024	1.000	0.978	1.025
22V	1757	100	86.0	300.1	1758	86.0	11.7	75.1	12.2	29.03	1.027	1.000	0.971	1.025
20V	1757	75	64.5	300.0	1756	65.0	9.3	75.7	12.1	29.03	1.025	1.000	0.973	1.025
19V	1757	50	43.0	300.0	1758	43.5	6.9	75.4	12.2	29.03	1.027	1.000	0.975	1.025
17V	1757	25	21.5	300.1	1760	21.0	4.5	74.7	12.1	29.03	1.026	1.000	0.973	1.024
16V	1757	10	8.6	300.1	1758	9.0	3.4	74.6	12.5	29.04	1.033	1.000	0.975	1.024
1V	600	CITT	38.0	299.9	604	37.0	2.2	73.0	12.0	29.04	1.024	1.000	0.976	1.022
1AV	600	-	0.0	300.1	710	0.0	1.0	72.3	11.9	29.03	1.022	1.000	0.979	1.020

Mode	BHP from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37V	9.3	21.6	1.84	19.8	212.3	91.3	8489.4	2.33	0.20	2.13	22.83	9.82	912.8
31V	8.6	22.4	2.01	20.4	214.0	82.1	8479.7	2.60	0.23	2.36	24.75	9.50	980.8
22V	28.8	35.3	2.52	32.8	670.6	282.3	14747.1	1.23	0.09	1.14	23.29	9.80	512.2
20V	21.7	26.5	1.94	24.6	367.4	187.6	12024.3	1.22	0.09	1.13	16.91	8.63	553.3
19V	14.6	24.3	1.38	22.9	232.4	130.2	8992.7	1.67	0.09	1.57	15.97	8.94	617.8
17V	7.0	17.0	1.10	15.9	173.0	52.1	5760.4	2.42	0.16	2.26	24.56	7.40	818.0
16V	3.0	11.3	0.96	10.3	133.9	15.0	4419.4	3.74	0.32	3.42	44.47	4.98	1467.8
1V	4.2	12.0	0.61	11.4	156.0	38.5	2644.9	2.83	0.14	2.69	36.70	9.06	622.4
1AV	0.0	15.5	0.59	14.9	41.4	0.6	1196.7						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	2.06 g/hp-hr		2.76 g/kW-hr
BSCH4	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSNMHC	=	1.93 g/hp-hr	=	2.59 g/kW-hr
BSCO	=	22.34 g/hp-hr	=	29.96 g/kW-hr
BSNOx	=	9.16 g/hp-hr	=	12.28 g/kW-hr
BSCO2	=	737.20 g/hp-hr	=	988.58 g/kW-hr
BSFC	=	0.57 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	2.12 g/hp-hr		2.84 g/kW-hr
BSCH4	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSNMHC	=	1.98 g/hp-hr	=	2.66 g/kW-hr
BSCO	=	20.49 g/hp-hr	=	27.48 g/kW-hr
BSNOx	=	8.54 g/hp-hr	=	11.46 g/kW-hr
BSCO2	=	713.82 g/hp-hr	=	957.23 g/kW-hr
BSFC	=	0.55 lb/hp-hr	=	0.34 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	2.07 g/hp-hr		2.78 g/kW-hr
BSCH4	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSNMHC	=	1.94 g/hp-hr	=	2.60 g/kW-hr
BSCO	=	22.44 g/hp-hr	=	30.10 g/kW-hr
BSNOx	=	9.13 g/hp-hr	=	12.25 g/kW-hr
BSCO2	=	740.26 g/hp-hr	=	992.69 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	2.13 g/hp-hr		2.86 g/kW-hr
BSCH4	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSNMHC	=	2.00 g/hp-hr	=	2.68 g/kW-hr
BSCO	=	20.59 g/hp-hr	=	27.61 g/kW-hr
BSNOx	=	8.52 g/hp-hr	=	11.43 g/kW-hr
BSCO2	=	716.78 g/hp-hr	=	961.21 g/kW-hr
BSFC	=	0.56 lb/hp-hr	=	0.34 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
NEW O2/NEW CAT

Test No.: X
Date: 4/24/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured			C-B	Intake Air			Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
37X	2440	25	19.5	300.0	2442	19.5	6.2	76.8	5.1	28.00	0.908	1.000	0.983	1.053
31X	2528	25	17.0	300.0	2544	17.0	6.4	76.4	4.9	29.00	0.905	1.000	0.983	1.016
22X	1757	100	82.0	300.1	1760	82.0	10.8	75.8	4.8	29.00	0.903	1.000	0.980	1.015
20X	1757	75	61.5	300.1	1756	62.0	9.3	76.0	4.8	29.00	0.903	1.000	0.981	1.015
19X	1757	50	41.0	300.0	1754	41.0	6.8	75.8	4.8	29.00	0.903	1.000	0.982	1.015
17X	1757	25	20.5	300.1	1748	20.0	4.6	75.0	4.6	29.02	0.900	1.000	0.985	1.013
16X	1757	10	8.2	300.0	1754	8.5	3.5	74.0	4.6	29.02	0.899	1.000	0.985	1.011
1X	600 CITT		0.0	300.6	602	18.0	1.4	78.2	5.2	29.02	0.909	1.000	0.986	1.018
1AX	600 -		0.0	300.0	670	0.0	1.0	73.2	4.4	29.04	0.897	1.000	0.987	1.009

	BHP from	Grams/Hour						Dry/Wet Corrected Emissions - g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37X	9.1	0.5	0.00	0.0	0.0	20.8	8474.4	0.06	0.00	0.00	0.00	2.29	934.1
31X	8.2	0.5	0.00	0.0	0.0	17.3	8687.5	0.06	0.00	0.00	0.00	2.10	1055.3
22X	27.5	1.1	0.00	0.0	0.0	338.9	14714.5	0.04	0.00	0.00	0.00	12.33	535.4
20X	20.7	0.4	0.00	0.0	1.4	42.6	12559.4	0.02	0.00	0.00	0.07	2.05	605.9
19X	13.7	0.7	0.00	0.0	0.0	53.1	9183.1	0.05	0.00	0.00	0.00	3.88	670.7
17X	6.7	0.8	0.00	0.0	0.2	22.8	6193.2	0.12	0.00	0.00	0.03	3.42	930.2
16X	2.8	0.7	0.00	0.0	0.6	7.1	4706.7	0.25	0.00	0.00	0.21	2.49	1655.0
1X	2.1	1.9	0.00	0.0	0.4	3.9	1946.4	0.93	0.00	0.00	0.19	1.91	944.9
1AX	0.0	8.9	0.00	0.0	0.0	0.2	1371.8						

	MODES								
WEIGHT	37	31	22	20	19	17	16	1	1A
1	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.06	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.00	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 1 ISO RATED SPEED & CITT > 0

BSHC	=	0.10 g/hp-hr	=	0.14 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNOx	=	4.01 g/hp-hr	=	5.38 g/kW-hr
BSCO2	=	794.88 g/hp-hr	=	1065.94 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 2 ISO RATED SPEED & CITT = 0 (C2)

BSHC	=	0.22 g/hp-hr	=	0.30 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.02 g/hp-hr	=	0.03 g/kW-hr
BSNOx	=	3.95 g/hp-hr	=	5.30 g/kW-hr
BSCO2	=	785.08 g/hp-hr	=	1052.80 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-hr

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.10 g/hp-hr	=	0.14 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNOx	=	4.01 g/hp-hr	=	5.38 g/kW-hr
BSCO2	=	800.93 g/hp-hr	=	1074.05 g/kW-hr
BSFC	=	0.59 lb/hp-hr	=	0.36 kg/kW-hr

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.22 g/hp-hr	=	0.30 g/kW-hr
BSCH4	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSNMHC	=	0.00 g/hp-hr	=	0.00 g/kW-hr
BSCO	=	0.02 g/hp-hr	=	0.03 g/kW-hr
BSNOx	=	3.95 g/hp-hr	=	5.29 g/kW-hr
BSCO2	=	791.07 g/hp-hr	=	1060.83 g/kW-hr
BSFC	=	0.58 lb/hp-hr	=	0.35 kg/kW-hr

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
CAL. 4/OLD CAT

Test No.: M1
Date: 5/4/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
W/MAINTENANCE

	Target			Measured			Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
36	2528	100	71.0	300.0	2530	71.0	14.6	77.9	12.9	29.03	1.041	1.000	0.971	1.030
35	2528	85	60.4	300.1	2528	60.0	13.4	80.2	12.6	29.02	1.037	1.000	0.973	1.033
34	2528	70	49.7	300.0	2526	50.0	11.3	80.6	12.5	29.02	1.033	1.000	0.973	1.033
33	2528	55	39.1	300.1	2526	39.0	9.9	80.6	12.5	29.02	1.033	1.000	0.973	1.033
32	2528	40	28.4	300.2	2530	28.0	8.3	80.5	12.6	29.02	1.037	1.000	0.974	1.033
30	2528	10	7.1	300.1	2538	7.0	5.3	80.2	12.8	29.01	1.039	1.000	0.976	1.033
29	2142	100	84.0	300.1	2142	84.0	14.7	80.2	12.8	29.01	1.040	1.000	0.973	1.034
28	2142	85	71.4	300.8	2150	71.5	12.8	80.9	12.5	29.00	1.033	1.000	0.971	1.034
27	2142	70	58.8	300.0	2142	59.0	11.2	81.3	12.4	29.00	1.031	1.000	0.972	1.034

	BHP from	Grams/Hour						Unweighted Modal Contribution grams/hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
36	34.1	2.7	0.64	2.0	85.2	5.9	19636.5	0.08	0.02	0.06	2.50	0.17	576.4
35	28.8	2.7	0.71	2.0	111.8	5.2	18049.4	0.09	0.02	0.07	3.89	0.18	627.7
34	24.0	2.1	0.86	1.2	93.3	4.0	15232.8	0.09	0.04	0.05	3.90	0.17	636.0
33	18.7	1.9	0.74	1.1	73.2	6.2	13350.0	0.10	0.04	0.06	3.92	0.33	714.8
32	13.4	1.8	0.97	0.9	60.2	6.6	11229.9	0.14	0.07	0.06	4.48	0.49	836.1
30	3.4	1.3	0.94	0.3	30.7	0.6	7166.0	0.38	0.28	0.10	9.11	0.17	2125.9
29	34.1	5.4	2.12	3.2	650.1	14.1	18863.3	0.16	0.06	0.09	19.06	0.41	553.1
28	29.1	2.9	0.70	2.2	122.1	6.2	17180.6	0.10	0.02	0.07	4.20	0.21	591.0
27	24.0	2.4	0.71	1.7	72.4	5.1	15026.8	0.10	0.03	0.07	3.02	0.21	627.06

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
CAL. 4/OLD CAT

Test No.: M2
Date: 5/5/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

W/MAINTENANCE

	Target			Measured			Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
26	2142	55	46.2	300.0	2148	46.5	9.5	80.9	12.2	29.00	1.028	1.000	0.975	1.034
25	2142	40	33.6	299.8	2140	33.5	7.6	80.6	12.5	28.99	1.033	1.000	0.976	1.034
24	2142	25	21.0	300.2	2140	21.0	5.9	71.7	12.5	29.06	1.033	1.000	0.977	1.020
23	2142	10	8.4	302.6	2144	8.5	3.9	72.8	12.2	29.06	1.028	1.000	0.979	1.021
21	1757	85	73.1	300.1	1758	74.0	10.6	73.8	12.1	29.05	1.027	1.000	0.974	1.022
18	1757	40	34.4	304.1	1750	35.0	5.5	74.0	12.0	29.06	1.024	1.000	0.976	1.022
15	2142	100	83.0	302.2	1374	83.0	8.9	73.7	12.1	29.06	1.027	1.000	0.974	1.022
14	1371	85	70.6	300.0	1374	71.0	7.2	73.7	12.0	29.06	1.024	1.000	0.975	1.022
13	1371	70	58.1	299.9	1374	58.5	7.0	74.0	12.2	29.05	1.028	1.000	0.976	1.023

	BHP from	Grams/bhp-hr						Unweighted Modal Contribution g/bhp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
26	18.9	2.6	0.75	1.9	73.6	6.9	12708.8	0.14	0.04	0.10	3.89	0.37	671.1
25	13.6	2.1	0.73	1.3	49.2	6.4	10204.3	0.15	0.05	0.10	3.62	0.47	750.0
24	8.6	2.5	1.11	1.4	24.8	3.6	7979.3	0.29	0.13	0.16	2.89	0.43	931.9
23	3.5	0.7	0.65	0.1	5.6	0.2	5233.0	0.21	0.19	0.03	1.61	0.06	1506.4
21	24.8	4.6	1.36	3.3	199.9	8.6	14117.6	0.19	0.05	0.13	8.07	0.35	569.9
18	11.5	1.0	0.47	0.5	10.6	2.8	7379.3	0.09	0.04	0.05	0.92	0.24	641.3
15	21.7	4.4	2.24	2.1	250.1	8.6	11670.1	0.20	0.10	0.10	11.51	0.40	537.4
14	18.6	1.7	0.60	1.1	42.3	6.9	9636.9	0.09	0.03	0.06	2.28	0.37	518.8
13	15.3	1.7	0.57	1.1	19.4	12.8	9415.7	0.11	0.04	0.07	1.27	0.84	615.20

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model:	1993 MAZDA 4-121G	Test No.: M3		LPG HD5
Engine Desc.:	2L (121 CID) 4IL	Date: 5/5/00		HCR: 2.669 FID Resp: 1.20
Engine Cycle:	Otto	Program SSDIL: 2.24-R		H= 0.183 C= 0.817
Engine S/N:	VA-546078	Cell: 13	Bag Cart: 1	
CAL. 4/OLD CAT		**POWER VALVE ADJUSTED**		**W/MAINTENANCE**

	Target			Measured			CVS	Intake Air			Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
12	1371	55	45.7	300.0	1372	45.5	5.4	74.0	12.2	29.07	1.027	1.000	0.976	1.022
11	1371	40	33.2	300.0	1374	33.5	4.5	73.8	12.2	29.07	1.027	1.000	0.976	1.022
10	1371	25	20.8	300.0	1368	20.5	3.5	73.2	12.2	29.07	1.027	1.000	0.976	1.021
9	1371	10	8.3	300.1	1372	8.5	2.4	73.0	12.4	29.07	1.031	1.000	0.978	1.021

	BHP from	Grams/Hour						Ungoghted Model Calculations g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
12	11.9	1.0	0.52	0.5	10.5	9.3	7373.1	0.09	0.04	0.04	0.88	0.78	620.6
11	8.8	0.8	0.54	0.2	4.9	8.9	6097.8	0.09	0.06	0.03	0.56	1.02	696.1
10	5.3	0.5	0.36	0.1	0.2	8.4	4724.5	0.09	0.07	0.02	0.04	1.58	884.7
9	2.2	1.3	0.52	0.8	0.4	3.7	3213.2	0.58	0.23	0.34	0.19	1.68	1447.9

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 MAZDA 4-121G
Engine Desc.: 2L (121 CID) 4IL
Engine Cycle: Otto
Engine S/N: VA-546078
CAL. 4/OLD CAT

Test No.: M4
Date: 5/5/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
POWER VALVE ADJUSTED

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
W/MAINTENANCE

	Target				Measured		C-B	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
8	986	100	80.0	300.0	986	80.0	6.1	73.2	12.4	29.07	1.033	1.000	0.976	1.021
7	986	85	68.0	300.1	982	69.5	5.5	74.6	12.8	29.07	1.040	1.000	0.977	1.024
6	986	70	56.0	300.0	974	56.0	4.6	74.7	12.6	29.08	1.036	1.000	0.978	1.023
5	986	55	44.0	300.0	984	44.5	4.1	74.7	12.8	29.07	1.039	1.000	0.977	1.024
4	986	40	32.0	299.9	992	32.5	3.2	74.7	12.8	29.06	1.039	1.000	0.978	1.024
3	986	25	20.0	300.2	990	20.5	2.5	74.0	12.5	29.06	1.033	1.000	0.978	1.023
2	986	10	8.0	300.1	992	8.0	1.8	74.3	13.0	29.05	1.043	1.000	0.979	1.024

	BHP from	Grams/Hour						Unweighted Modal Contribution g/hp-h					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
8	15.0	8.5	2.64	5.9	334.1	19.9	7736.0	0.57	0.18	0.39	22.24	1.32	514.9
7	12.8	1.3	0.48	0.8	14.0	14.2	7409.4	0.10	0.04	0.07	1.09	1.11	578.3
6	10.4	0.7	0.28	0.4	2.4	16.0	6207.3	0.07	0.03	0.04	0.23	1.55	598.0
5	8.3	0.6	0.41	0.2	2.7	15.4	5500.3	0.07	0.05	0.02	0.33	1.85	659.5
4	6.1	0.8	0.28	0.5	3.9	12.0	4338.5	0.13	0.05	0.08	0.64	1.95	707.3
3	3.9	1.2	0.45	0.7	2.0	7.6	3390.6	0.30	0.12	0.18	0.51	1.98	878.1
2	1.5	1.4	0.61	0.7	2.0	0.8	2426.8	0.90	0.41	0.49	1.30	0.53	1605.6

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
OLD O2 SENSOR/NO CAT

Test No.: GA
Date: 5/15/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured				Intake Air					
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GA	2631	25	15.9	300.1	2630	16.0	9.3	80.4	12.4	29.25	1.031	1.000	0.975	1.025
22GA	1819	100	97.0	300.1	1820	97.0	15.0	79.8	12.1	29.24	1.025	1.000	0.972	1.023
20GA	1819	75	72.8	300.0	1822	73.0	12.2	80.5	12.1	29.24	1.026	1.000	0.976	1.024
19GA	1819	50	48.5	301.3	1812	48.0	9.4	79.8	11.9	29.24	1.023	1.000	0.976	1.023
17GA	1819	25	24.3	299.9	1818	25.0	6.8	78.8	11.4	29.24	1.013	1.000	0.979	1.021
16GA	1819	10	9.7	303.0	1818	9.5	5.1	76.8	11.4	29.24	1.013	1.000	0.980	1.019
1GA	600	CITT	63.0	300.0	602	63.0	3.5	75.0	11.1	29.24	1.006	1.000	0.981	1.016
1AGA	600	-	0.0	300.1	608	0.0	1.3	72.9	10.9	29.24	1.003	1.000	0.982	1.012

	BHP from	Gram/Test						Weighted Modal Emissions g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GA	8.3	12.1	1.30	10.8	147.6	47.3	12433.8	1.45	0.16	1.29	17.75	5.70	1495.7
31GA	8.0	10.4	1.32	9.1	151.7	44.0	12381.9	1.30	0.17	1.13	18.94	5.49	1545.2
22GA	33.6	53.2	4.16	49.0	584.9	419.2	19280.0	1.58	0.12	1.46	17.40	12.47	573.6
20GA	25.3	45.7	3.07	42.6	218.4	299.9	16095.9	1.81	0.12	1.68	8.63	11.84	635.7
19GA	16.6	30.1	2.17	27.9	177.7	159.6	12344.2	1.81	0.13	1.68	10.73	9.64	745.4
17GA	8.7	18.0	1.53	16.5	140.0	55.2	8925.5	2.08	0.18	1.90	16.18	6.38	1031.3
16GA	3.3	9.4	1.19	8.2	131.9	15.6	6621.7	2.86	0.36	2.49	40.07	4.73	2012.0
1GA	7.2	19.8	0.56	19.2	79.1	78.1	4524.5	2.74	0.08	2.66	10.94	10.82	626.3
1AGA	0.0	5.0	0.25	4.7	7.2	0.6	1698.6						

		MODES							
WEIGHT		31	22	20	19	17	16	1	1A
1		0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2		0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3		0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4		0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	2.15 g/hp-hr		2.88 g/kW-hr
BSCH4	=	0.16 g/hp-hr	=	0.21 g/kW-hr
BSNMHC	=	1.99 g/hp-hr	=	2.67 g/kW-hr
BSCO	=	14.62 g/hp-hr	=	19.61 g/kW-hr
BSNOx	=	10.05 g/hp-hr	=	13.47 g/kW-hr
BSCO2	=	930.29 g/hp-hr	=	1247.52 g/kW-hr
BSFC	=	0.71 lb/hp-hr	=	0.43 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.94 g/hp-hr		2.61 g/kW-hr
BSCH4	=	0.15 g/hp-hr	=	0.21 g/kW-hr
BSNMHC	=	1.79 g/hp-hr	=	2.40 g/kW-hr
BSCO	=	13.61 g/hp-hr	=	18.25 g/kW-hr
BSNOx	=	8.95 g/hp-hr	=	12.01 g/kW-hr
BSCO2	=	890.47 g/hp-hr	=	1194.12 g/kW-hr
BSFC	=	0.68 lb/hp-hr	=	0.41 kg/kW-h

Southwest Research Institute - Department of Emissions Research

Custom, ISO Calcs Emission Test Results

Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
OLD O2 SENS./NEW CAT

Test No.: GB
Date: 5/15/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target			Measured & C.B.				Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GB	2631	25	16.5	300.1	2630	17.0	9.2	83.3	12.6	29.18	1.035	1.000	0.976	1.031
22GB	1819	100	97.5	300.0	1818	97.5	15.3	82.7	12.4	29.18	1.032	1.000	0.973	1.030
20GB	1819	75	73.1	300.0	1826	73.5	12.3	83.0	12.6	29.17	1.035	1.000	0.974	1.031
19GB	1819	50	48.8	300.1	1821	49.0	9.5	82.3	12.3	29.17	1.030	1.000	0.976	1.030
17GB	1819	25	24.4	299.9	1816	24.0	6.8	80.9	12.0	29.17	1.023	1.000	0.978	1.027
16GB	1819	10	9.8	300.1	1815	9.5	5.2	79.8	11.8	29.16	1.021	1.000	0.980	1.026
1GB	600	CITT	61.0	300.0	600	61.0	3.5	77.5	11.5	29.16	1.015	1.000	0.980	1.022
1AGB	600	-	0.0	300.0	602	0.0	1.2	76.4	11.3	29.16	1.011	1.000	0.981	1.021

	BHP from	Grams/Hour						Unweighted Modal Contribution g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GB	8.5	0.6	0.42	0.2	0.6	25.9	12389.1	0.07	0.05	0.02	0.07	3.04	1452.1
31GB	8.5	0.5	0.41	0.1	0.6	25.2	12536.7	0.05	0.05	0.01	0.07	2.98	1478.2
22GB	33.6	0.8	0.27	0.5	1.4	187.9	20781.2	0.02	0.01	0.01	0.04	5.59	618.3
20GB	25.5	1.1	0.62	0.5	0.0	160.3	16649.8	0.04	0.02	0.02	0.00	6.30	654.2
19GB	16.9	1.1	0.86	0.3	0.8	90.6	12921.9	0.07	0.05	0.02	0.05	5.36	764.0
17GB	8.3	1.1	0.88	0.2	1.0	29.0	9188.6	0.13	0.11	0.03	0.12	3.50	1111.0
16GB	3.3	1.0	0.87	0.1	0.8	10.5	7116.4	0.30	0.27	0.03	0.24	3.21	2181.0
1GB	6.9	7.4	0.70	6.7	4.4	48.8	4669.2	1.07	0.10	0.97	0.64	7.04	673.2
1AGB	0.0	3.0	0.04	2.9	2.5	0.0	1622.8						

MODES								
WEIGHT	31	22	20	19	17	16	1	1A
1	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.19 g/hp-hr		0.25 g/kW-hr
BSCH4	=	0.07 g/hp-hr	=	0.10 g/kW-hr
BSNMHC	=	0.11 g/hp-hr	=	0.15 g/kW-hr
BSCO	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSNOx	=	5.56 g/hp-hr	=	7.46 g/kW-hr
BSCO2	=	965.35 g/hp-hr	=	1294.53 g/kW-hr
BSFC	=	0.71 lb/hp-hr	=	0.43 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.12 g/hp-hr		0.17 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.09 g/kW-hr
BSNMHC	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSCO	=	0.10 g/hp-hr	=	0.14 g/kW-hr
BSNOx	=	4.87 g/hp-hr	=	6.54 g/kW-hr
BSCO2	=	922.54 g/hp-hr	=	1237.12 g/kW-hr
BSFC	=	0.68 lb/hp-hr	=	0.41 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
OLD O2 SENS./OLD CAT

Test No.: GC
Date: 5/16/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target				Measured		ECB	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GC	2631	25	17.3	300.0	2640	17.5	8.9	81.7	12.4	29.09	1.032	1.000	0.976	1.032
22GC	1819	100	102.0	300.0	1820	102.0	15.5	81.6	12.4	29.09	1.032	1.000	0.973	1.032
20GC	1819	75	76.5	300.0	1822	76.5	12.5	80.9	12.4	29.09	1.032	1.000	0.973	1.031
19GC	1819	50	51.0	300.0	1818	51.0	9.8	80.9	12.4	29.08	1.032	1.000	0.976	1.031
17GC	1819	25	25.5	300.1	1820	26.0	7.1	78.5	11.9	29.08	1.022	1.000	0.976	1.027
16GC	1819	10	10.2	300.2	1816	10.5	5.4	77.1	12.0	29.08	1.024	1.000	0.978	1.025
1GC	600 CITT		66.0	299.9	606	66.0	3.8	75.7	11.7	29.08	1.019	1.000	0.978	1.023
1AGC	600 -		0.0	311.6	612	0.0	1.2	73.6	11.4	29.08	1.012	1.000	0.980	1.020

	BHP from	Grams/Hour						Unweighted Modal Emissions g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GC	8.5	0.4	0.26	0.2	3.5	23.1	12223.0	0.05	0.03	0.02	0.41	2.70	1432.0
31GC	8.8	0.2	0.24	0.0	1.4	23.1	12102.7	0.03	0.03	0.00	0.16	2.63	1375.9
22GC	35.3	1.1	0.33	0.8	14.1	170.9	21061.9	0.03	0.01	0.02	0.40	4.84	596.0
20GC	26.5	0.7	0.37	0.3	10.6	134.1	16929.0	0.03	0.01	0.01	0.40	5.05	637.8
19GC	17.7	1.3	0.59	0.7	12.6	74.6	13240.4	0.07	0.03	0.04	0.72	4.23	750.1
17GC	9.0	1.0	0.68	0.3	1.9	31.2	9622.9	0.11	0.08	0.04	0.21	3.46	1068.1
16GC	3.6	1.1	0.75	0.3	0.2	9.9	7333.4	0.30	0.21	0.09	0.05	2.72	2018.2
1GC	7.6	7.8	0.79	7.0	3.9	48.9	5099.8	1.02	0.10	0.92	0.51	6.42	670.1
1AGC	0.0	3.2	0.19	3.0	0.8	0.3	1673.0						

MODES									
WEIGHT		31	22	20	19	17	16	1	1A
1		0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2		0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3		0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4		0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.18 g/hp-hr		0.24 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSCO	=	0.54 g/hp-hr	=	0.73 g/kW-hr
BSNOx	=	4.71 g/hp-hr	=	6.31 g/kW-hr
BSCO2	=	941.43 g/hp-hr	=	1262.45 g/kW-hr
BSFC	=	0.69 lb/hp-hr	=	0.42 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.12 g/hp-hr		0.16 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.07 g/hp-hr	=	0.10 g/kW-hr
BSCO	=	0.50 g/hp-hr	=	0.67 g/kW-hr
BSNOx	=	4.06 g/hp-hr	=	5.44 g/kW-hr
BSCO2	=	895.84 g/hp-hr	=	1201.33 g/kW-hr
BSFC	=	0.66 lb/hp-hr	=	0.40 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: GD
Date: 5/17/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	NT Info			Measured			C-B	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GD	2631	25	17.8	300.0	2640	18.0	9.3	81.6	11.8	28.94	1.020	1.000	0.978	1.036
22GD	1819	100	104.5	300.1	1820	104.5	15.7	82.3	12.2	28.94	1.028	1.000	0.974	1.038
20GD	1819	75	78.4	300.0	1818	78.5	12.4	82.7	12.2	28.94	1.028	1.000	0.976	1.038
19GD	1819	50	52.3	300.1	1821	52.5	10.1	81.9	11.9	28.94	1.023	1.000	0.977	1.037
17GD	1819	25	26.1	300.1	1820	26.5	7.1	80.5	11.8	28.93	1.020	1.000	0.977	1.035
16GD	1819	10	10.5	300.1	1822	10.5	5.5	78.8	11.4	28.92	1.013	1.000	0.978	1.032
1GD	600	CITT	66.0	300.0	608	65.5	3.7	77.1	11.2	28.92	1.009	1.000	0.980	1.030
1AGD	600	-	0.0	300.0	602	0.0	1.3	75.7	11.2	28.92	1.009	1.000	0.982	1.028

	BHP from	Grams/Hour						Brake Specific g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GD	9.0	0.3	0.12	0.2	2.3	18.7	11783.4	0.04	0.01	0.02	0.26	2.07	1307.5
31GD	9.0	0.2	0.12	0.1	1.0	21.5	12579.8	0.03	0.01	0.01	0.11	2.38	1390.3
22GD	36.2	1.3	0.36	1.0	48.9	43.3	21267.1	0.04	0.01	0.03	1.35	1.20	587.2
20GD	27.2	1.0	0.34	0.6	3.4	126.9	16800.6	0.04	0.01	0.02	0.13	4.67	618.4
19GD	18.2	0.7	0.46	0.3	3.5	78.9	13737.6	0.04	0.03	0.01	0.19	4.34	754.9
17GD	9.2	0.7	0.57	0.1	0.1	27.9	9595.5	0.07	0.06	0.01	0.01	3.04	1044.2
16GD	3.6	1.0	0.69	0.3	0.1	9.7	7522.7	0.26	0.19	0.07	0.01	2.67	2062.8
1GD	7.6	14.0	0.69	13.3	4.1	58.6	4961.6	1.85	0.09	1.76	0.54	7.73	654.2
1AGD	0.0	4.0	0.11	3.9	1.0	0.8	1755.3						

MODES								
WEIGHT	31	22	20	19	17	16	1	1A
1	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.24 g/hp-hr		0.32 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.19 g/hp-hr	=	0.25 g/kW-hr
BSCO	=	0.26 g/hp-hr	=	0.35 g/kW-hr
BSNOx	=	4.49 g/hp-hr	=	6.02 g/kW-hr
BSCO2	=	932.68 g/hp-hr	=	1250.72 g/kW-hr
BSFC	=	0.69 lb/hp-hr	=	0.42 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.11 g/hp-hr		0.14 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.05 g/kW-hr
BSNMHC	=	0.07 g/hp-hr	=	0.09 g/kW-hr
BSCO	=	0.22 g/hp-hr	=	0.29 g/kW-hr
BSNOx	=	3.74 g/hp-hr	=	5.01 g/kW-hr
BSCO2	=	891.11 g/hp-hr	=	1194.98 g/kW-hr
BSFC	=	0.66 lb/hp-hr	=	0.40 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: GE
Date: 5/17/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target				Measured									
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GE	2631	25	18.8	300.1	2530	18.5	9.8	85.6	12.3	28.89	1.029	1.000	0.977	1.044
22GE	1819	100	105.0	299.9	1820	105.0	15.9	84.6	12.1	28.89	1.026	1.000	0.974	1.042
20GE	1819	75	78.8	300.1	1818	78.5	12.9	85.4	12.1	28.90	1.026	1.000	0.975	1.043
19GE	1819	50	52.5	299.9	1818	53.0	10.1	84.4	12.1	28.89	1.026	1.000	0.977	1.042
17GE	1819	25	26.3	300.1	1818	26.5	7.1	83.1	12.0	28.88	1.023	1.000	0.978	1.041
16GE	1819	10	10.5	300.1	1820	10.5	5.5	82.4	12.0	28.87	1.023	1.000	0.979	1.040
1GE	600 CITT		66.0	300.1	608	65.5	3.7	80.6	11.6	28.87	1.016	1.000	0.980	1.037
1AGE	600 -		0.0	299.9	598	0.0	1.2	78.2	11.2	28.86	1.008	1.000	0.982	1.033

	BHP from												
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GE	9.5	0.4	0.19	0.2	0.0	23.6	12751.8	0.05	0.02	0.03	0.00	2.48	1338.8
31GE	8.9	0.3	0.25	0.1	0.2	27.2	13354.8	0.04	0.03	0.01	0.02	3.05	1498.3
22GE	36.4	0.2	0.04	0.2	1.2	29.3	21627.8	0.01	0.00	0.01	0.03	0.80	594.4
20GE	27.2	0.8	0.38	0.4	1.9	144.1	17460.2	0.03	0.01	0.01	0.07	5.30	642.6
19GE	18.3	0.8	0.69	0.1	0.4	90.4	13757.0	0.05	0.04	0.01	0.02	4.93	750.0
17GE	9.2	1.1	0.88	0.2	1.0	30.8	9604.3	0.12	0.10	0.02	0.11	3.36	1046.6
16GE	3.6	0.9	0.75	0.1	0.6	12.0	7437.9	0.24	0.21	0.03	0.16	3.30	2046.3
1GE	7.6	11.6	0.66	11.0	3.9	64.5	5028.7	1.54	0.09	1.45	0.51	8.51	663.3
1AGE	0.1	3.1	0.00	3.1	0.2	0.8	1594.8						

MODES								
WEIGHT	31	22	20	19	17	16	1	1A
1	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.21 g/hp-hr		0.29 g/kW-hr
BSCH4	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSNMHC	=	0.15 g/hp-hr	=	0.21 g/kW-hr
BSCO	=	0.10 g/hp-hr	=	0.14 g/kW-hr
BSNOx	=	5.04 g/hp-hr	=	6.76 g/kW-hr
BSCO2	=	938.09 g/hp-hr	=	1257.98 g/kW-hr
BSFC	=	0.69 lb/hp-hr	=	0.42 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.10 g/hp-hr		0.14 g/kW-hr
BSCH4	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSNMHC	=	0.05 g/hp-hr	=	0.07 g/kW-hr
BSCO	=	0.06 g/hp-hr	=	0.07 g/kW-hr
BSNOx	=	4.21 g/hp-hr	=	5.65 g/kW-hr
BSCO2	=	893.71 g/hp-hr	=	1198.47 g/kW-hr
BSFC	=	0.66 lb/hp-hr	=	0.40 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NO CAT

Test No.: GF
Date: 5/17/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

	Target				Measured		C-B	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GF	2631	25	19.0	300.0	2626	18.5	9.3	81.9	13.0	28.97	1.044	1.000	0.976	1.037
22GF	1819	100	109.0	300.2	1818	109.0	15.7	82.3	13.1	28.98	1.046	1.000	0.972	1.038
20GF	1819	75	81.8	300.1	1816	82.0	13.2	82.4	13.0	28.97	1.044	1.000	0.974	1.038
19GF	1819	50	54.5	300.1	1810	54.0	9.7	81.7	12.9	28.98	1.041	1.000	0.976	1.037
17GF	1819	25	27.3	299.9	1812	27.5	7.2	80.9	12.7	28.98	1.037	1.000	0.977	1.035
16GF	1819	10	10.9	300.1	1822	11.0	5.3	79.9	12.8	28.98	1.040	1.000	0.979	1.034
1GF	600	CITT	68.0	300.3	608	68.0	3.9	78.8	12.4	28.98	1.032	1.000	0.979	1.032
1AGF	600	-	0.0	299.9	592	0.0	1.2	76.0	11.6	28.98	1.016	1.000	0.981	1.027

	BHP from	Grams/Hour						Weighted Mode Emissions g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GF	9.6	9.7	1.17	8.5	157.1	54.8	12919.2	1.02	0.12	0.89	16.45	5.74	1352.5
31GF	9.3	8.5	1.11	7.4	145.3	50.3	12371.4	0.92	0.12	0.80	15.71	5.44	1337.2
22GF	37.7	50.9	4.33	46.6	508.9	448.7	20348.2	1.35	0.11	1.24	13.49	11.89	539.4
20GF	28.4	43.7	3.12	40.5	215.7	334.0	17399.7	1.54	0.11	1.43	7.61	11.78	613.6
19GF	18.6	30.4	2.14	28.3	178.9	179.8	12796.8	1.63	0.11	1.52	9.61	9.66	687.8
17GF	9.5	15.8	1.30	14.5	126.4	62.4	9525.4	1.66	0.14	1.52	13.33	6.59	1004.5
16GF	3.8	7.7	0.82	6.8	92.4	18.6	6965.3	2.01	0.21	1.79	24.22	4.88	1825.9
1GF	7.9	22.0	0.59	21.4	81.7	89.2	5050.3	2.79	0.07	2.72	10.37	11.33	641.2
1AGF	0.1	5.3	0.19	5.1	6.0	49.6	1586.1						

MODES									
WEIGHT		31	22	20	19	17	16	1	1A
1		0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2		0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3		0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4		0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.87 g/hp-hr		2.50 g/kW-hr
BSCH4	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSNMHC	=	1.74 g/hp-hr	=	2.33 g/kW-hr
BSCO	=	12.29 g/hp-hr	=	16.48 g/kW-hr
BSNOx	=	10.09 g/hp-hr	=	13.54 g/kW-hr
BSCO2	=	875.55 g/hp-hr	=	1174.11 g/kW-hr
BSFC	=	0.66 lb/hp-hr	=	0.40 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.66 g/hp-hr		2.22 g/kW-hr
BSCH4	=	0.13 g/hp-hr	=	0.17 g/kW-hr
BSNMHC	=	1.53 g/hp-hr	=	2.05 g/kW-hr
BSCO	=	11.34 g/hp-hr	=	15.20 g/kW-hr
BSNOx	=	9.60 g/hp-hr	=	12.87 g/kW-hr
BSCO2	=	831.91 g/hp-hr	=	1115.59 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.38 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: GG
Date: 5/18/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL

	Target			Measured & Calculated			Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GG	2631	25	20.3	300.0	2636	20.5	9.7	84.2	12.8	29.01	1.040	1.000	0.976	1.039
22GG	1819	100	110.0	300.0	1824	110.0	16.6	83.4	12.5	29.01	1.033	1.000	0.972	1.037
20GG	1819	75	82.5	300.0	1822	83.0	13.4	84.2	12.8	29.01	1.040	1.000	0.974	1.039
19GG	1819	50	55.0	300.0	1816	54.5	10.2	83.4	12.4	29.01	1.031	1.000	0.976	1.037
17GG	1819	25	27.5	300.0	1812	27.5	7.3	81.8	12.4	29.00	1.031	1.000	0.978	1.035
16GG	1819	10	11.0	299.9	1824	11.5	5.7	80.9	12.1	29.01	1.026	1.000	0.979	1.033
1GG	600 CITT		66.0	300.0	612	66.0	4.0	78.9	12.0	29.00	1.025	1.000	0.980	1.031
1AGG	600 -		0.0	300.1	606	0.0	1.4	77.5	11.9	29.00	1.022	1.000	0.981	1.029

	BHP from	Grams/Hour						Weighted Mass Emissions gm/hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GG	10.5	0.8	0.37	0.4	1.7	0.2	13533.5	0.07	0.04	0.04	0.17	0.02	1294.8
31GG	10.2	0.7	0.50	0.2	2.9	0.1	13157.1	0.07	0.05	0.02	0.28	0.01	1283.9
22GG	38.1	9.2	2.50	6.7	75.8	2.0	22369.1	0.24	0.07	0.18	1.99	0.05	587.9
20GG	28.7	4.2	1.08	3.1	10.6	1.0	18158.4	0.15	0.04	0.11	0.37	0.04	633.1
19GG	18.8	0.3	0.00	0.3	0.0	4.3	13786.5	0.02	0.00	0.02	0.00	0.23	734.6
17GG	9.5	0.7	0.30	0.4	2.7	0.4	9845.6	0.08	0.03	0.04	0.29	0.05	1041.2
16GG	4.0	0.8	0.40	0.4	2.9	0.2	7722.0	0.20	0.10	0.10	0.73	0.05	1937.6
1GG	7.7	2.7	0.69	2.0	1.9	24.4	5408.7	0.35	0.09	0.26	0.25	3.19	706.5
1AGG	0.0	3.6	0.84	2.8	0.0	0.4	1878.0						

	MODES							
WEIGHT	31	22	20	19	17	16	1	1A
1	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.10 g/hp-hr		0.14 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.07 g/hp-hr	=	0.10 g/kW-hr
BSCO	=	0.30 g/hp-hr	=	0.40 g/kW-hr
BSNOx	=	0.44 g/hp-hr	=	0.59 g/kW-hr
BSCO2	=	920.55 g/hp-hr	=	1234.46 g/kW-hr
BSFC	=	0.68 lb/hp-hr	=	0.41 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.11 g/hp-hr		0.15 g/kW-hr
BSCH4	=	0.03 g/hp-hr	=	0.04 g/kW-hr
BSNMHC	=	0.08 g/hp-hr	=	0.11 g/kW-hr
BSCO	=	0.28 g/hp-hr	=	0.37 g/kW-hr
BSNOx	=	0.14 g/hp-hr	=	0.19 g/kW-hr
BSCO2	=	876.60 g/hp-hr	=	1175.53 g/kW-hr
BSFC	=	0.65 lb/hp-hr	=	0.39 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: GH
Date: 5/18/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

BEST CAL

	Target			Measured			CVS	Intake Air			Exhaust			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GH	2631	25	20.3	299.9	2620	20.5	9.8	83.3	12.6	29.98	1.035	1.000	0.975	1.003
22GH	1819	100	108.5	300.0	1816	108.5	14.4	84.6	13.3	28.98	1.050	1.000	0.972	1.041
20GH	1819	75	81.4	300.0	1814	81.5	11.9	85.2	13.4	28.98	1.051	1.000	0.973	1.042
19GH	1819	50	54.3	300.0	1816	54.5	10.1	85.5	13.3	28.98	1.050	1.000	0.974	1.042
17GH	1819	25	27.1	300.1	1822	27.5	6.7	85.4	13.0	28.98	1.044	1.000	0.976	1.042
16GH	1819	10	10.9	300.2	1818	10.5	5.3	84.1	12.4	28.97	1.032	1.000	0.978	1.039
1GH	600	CITT	68.0	300.0	604	68.0	3.6	82.3	12.4	28.98	1.032	1.000	0.979	1.037
1AGH	600	-	0.0	302.2	606	0.0	1.2	80.9	12.2	28.98	1.027	1.000	0.980	1.034

	BHP from	Raw Exhaust						Weighted Mass Emissions					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GH	10.5	0.7	0.49	0.2	61.1	5.5	12831.1	0.07	0.05	0.02	5.81	0.53	1221.0
31GH	10.2	0.7	0.56	0.1	63.4	6.4	13209.7	0.06	0.05	0.01	6.20	0.62	1291.6
22GH	37.5	1.9	0.65	1.3	134.9	38.0	19386.7	0.05	0.02	0.03	3.60	1.01	516.8
20GH	28.2	1.5	0.47	1.0	47.7	31.7	16049.4	0.05	0.02	0.04	1.69	1.13	570.1
19GH	18.8	0.8	0.48	0.4	30.1	16.1	13695.6	0.04	0.03	0.02	1.60	0.85	726.9
17GH	9.5	0.8	0.40	0.4	10.3	3.5	9079.9	0.08	0.04	0.04	1.08	0.37	952.1
16GH	3.6	1.1	0.66	0.4	5.2	2.8	7237.9	0.29	0.18	0.11	1.44	0.76	1991.9
1GH	7.8	9.3	0.88	8.4	10.0	30.0	4839.6	1.19	0.11	1.07	1.27	3.84	618.6
1AGH	0.1	3.2	0.65	2.6	0.0	0.3	1624.0						

		MODES							
WEIGHT		31	22	20	19	17	16	1	1A
1		0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2		0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3		0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4		0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	0.18 g/hp-hr		0.24 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.13 g/hp-hr	=	0.18 g/kW-hr
BSCO	=	1.97 g/hp-hr	=	2.64 g/kW-hr
BSNOx	=	1.14 g/hp-hr	=	1.53 g/kW-hr
BSCO2	=	876.45 g/hp-hr	=	1175.32 g/kW-hr
BSFC	=	0.65 lb/hp-hr	=	0.39 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	0.10 g/hp-hr		0.14 g/kW-hr
BSCH4	=	0.04 g/hp-hr	=	0.06 g/kW-hr
BSNMHC	=	0.06 g/hp-hr	=	0.08 g/kW-hr
BSCO	=	1.84 g/hp-hr	=	2.47 g/kW-hr
BSNOx	=	0.77 g/hp-hr	=	1.03 g/kW-hr
BSCO2	=	836.34 g/hp-hr	=	1121.53 g/kW-hr
BSFC	=	0.62 lb/hp-hr	=	0.38 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NO CAT

Test No.: GI
Date: 5/18/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL

Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
31GI	2631	25	20.0	300.0	2622	20.0	9.2	80.5	13.4	29.14	1.052	1.000	0.975	1.030
22GI	1819	100	110.0	300.2	1816	110.0	16.4	80.2	13.6	29.14	1.056	1.000	0.971	1.030
20GI	1819	75	82.5	300.1	1822	82.5	12.7	81.7	13.7	29.15	1.058	1.000	0.973	1.032
19GI	1819	50	55.0	299.9	1818	55.0	10.1	80.6	13.2	29.15	1.048	1.000	0.974	1.030
17GI	1819	25	27.5	300.0	1822	28.0	7.4	80.5	13.4	29.15	1.051	1.000	0.975	1.030
16GI	1819	10	11.0	304.8	1818	10.5	5.5	79.8	13.2	29.16	1.048	1.000	0.976	1.028
1GI	600	CITT	65.0	300.0	602	65.0	3.8	76.8	11.5	29.16	1.015	1.000	0.977	1.021
1AGI	0	-	0.0	300.0	612	0.0	1.3	76.8	12.6	29.16	1.035	1.000	0.980	1.023

Mode	BHP from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
37GI	10.3	11.0	1.50	9.5	202.3	51.9	12647.8	1.07	0.15	0.93	19.70	5.05	1231.3
31GI	10.0	10.2	1.44	8.8	188.3	48.4	12139.6	1.02	0.14	0.88	18.84	4.85	1214.4
22GI	38.0	51.9	4.78	47.1	793.1	439.4	20893.0	1.36	0.13	1.24	20.85	11.55	549.3
20GI	28.6	44.0	3.26	40.7	304.4	316.0	16607.9	1.54	0.11	1.42	10.64	11.04	580.2
19GI	19.1	31.9	2.34	29.6	229.4	179.0	13306.7	1.67	0.12	1.55	12.04	9.40	698.5
17GI	9.7	18.2	1.52	16.7	159.4	61.0	9698.4	1.87	0.16	1.72	16.42	6.29	999.0
16GI	3.6	10.3	1.42	8.9	168.8	15.3	7160.4	2.83	0.39	2.44	46.39	4.20	1968.3
1GI	7.5	20.9	0.90	20.0	140.4	72.6	4813.5	2.80	0.12	2.68	18.84	9.74	645.9
1AGI	0.1	6.3	0.40	5.9	37.3	0.7	1695.0						

MODES								
WEIGHT	31	22	20	19	17	16	1	1A
1	0.00	0.02	0.05	0.32	0.30	0.10	0.15	0.00
2	0.00	0.02	0.05	0.32	0.30	0.10	0.00	0.15
3	0.06	0.02	0.05	0.32	0.30	0.10	0.15	0.00
4	0.06	0.02	0.05	0.32	0.30	0.10	0.00	0.15

Composite Results 3 EPA RATED SPEED & CITT > 0

BSHC	=	1.95 g/hp-hr		2.61 g/kW-hr
BSCH4	=	0.15 g/hp-hr	=	0.20 g/kW-hr
BSNMHC	=	1.80 g/hp-hr	=	2.41 g/kW-hr
BSCO	=	16.57 g/hp-hr	=	22.22 g/kW-hr
BSNOx	=	9.49 g/hp-hr	=	12.73 g/kW-hr
BSCO2	=	869.98 g/hp-hr	=	1166.64 g/kW-hr
BSFC	=	0.66 lb/hp-hr	=	0.40 kg/kW-h

Composite Results 4 EPA RATED SPEED & CITT = 0

BSHC	=	1.77 g/hp-hr		2.37 g/kW-hr
BSCH4	=	0.14 g/hp-hr	=	0.19 g/kW-hr
BSNMHC	=	1.62 g/hp-hr	=	2.18 g/kW-hr
BSCO	=	15.30 g/hp-hr	=	20.51 g/kW-hr
BSNOx	=	8.61 g/hp-hr	=	11.54 g/kW-hr
BSCO2	=	831.52 g/hp-hr	=	1115.07 g/kW-hr
BSFC	=	0.63 lb/hp-hr	=	0.39 kg/kW-h

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: CJ
Date: 5/19/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

BEST CAL/MODES REST

	Target			Measured			C-B	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
G36	2631	100	80.0	300.0	2626	79.5	17.8	81.7	13.1	29.12	1.045	1.000	0.970	1.032
G35	2631	85	68.0	299.5	2630	67.5	16.7	85.0	13.7	29.11	1.058	1.000	0.970	1.038
G34	2631	70	56.0	300.2	2628	56.0	14.8	85.1	14.2	29.11	1.067	1.000	0.972	1.039
G33	2631	55	44.0	299.9	2630	43.5	13.0	85.4	13.7	29.11	1.058	1.000	0.974	1.038
G32	2631	40	32.0	300.1	2630	31.5	11.1	84.9	13.6	29.11	1.056	1.000	0.974	1.038
G30	2631	10	8.0	300.0	2622	8.0	7.3	85.0	13.6	29.09	1.056	1.000	0.976	1.038

	BHP from	Grams/Hour						Unweighted Modal Contribution g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
G36	39.7	1.4	0.57	0.9	27.9	33.0	24075.6	0.04	0.01	0.02	0.70	0.83	605.8
G35	33.8	0.9	0.43	0.5	24.9	30.2	22560.4	0.03	0.01	0.01	0.74	0.89	667.5
G34	28.0	0.7	0.43	0.3	37.1	16.4	20096.0	0.02	0.02	0.01	1.32	0.59	717.1
G33	21.8	0.5	0.41	0.0	38.4	9.3	17519.8	0.02	0.02	0.00	1.76	0.42	804.1
G32	15.8	0.4	0.35	0.1	22.7	6.2	15058.1	0.03	0.02	0.01	1.44	0.39	954.6
G30	4.0	0.4	0.19	0.2	17.2	1.2	9883.5	0.10	0.05	0.06	4.31	0.31	2473.3

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: GK
Date: 5/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

BEST CAL/MODES REST

	Target			Measured			CFR	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
G29	2225	100	95.0	300.1	2228	95.0	17.7	77.1	11.2	29.16	1.009	1.000	0.971	1.021
G28	2225	85	80.8	300.0	2222	80.5	15.6	78.6	10.8	29.16	1.002	1.000	0.973	1.023
G27	2225	70	66.5	300.0	2228	66.5	13.4	78.2	10.9	29.16	1.003	1.000	0.973	1.022
G26	2225	55	52.3	300.7	2222	52.0	11.8	77.9	10.9	29.16	1.003	1.000	0.976	1.022
G25	2225	40	38.0	300.5	2226	38.5	10.6	75.8	10.1	29.16	0.989	1.000	0.977	1.018
G24	2225	25	23.8	300.1	2228	24.0	8.3	75.4	10.3	29.16	0.992	1.000	0.978	1.018

	BHP from	Gravimetric g/hr						Uncorrected Modal Concentration ppm					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
G29	40.3	6.8	2.96	3.9	181.9	24.3	23759.6	0.17	0.07	0.10	4.51	0.60	589.6
G28	34.1	2.1	0.87	1.3	24.4	21.5	21148.2	0.06	0.03	0.04	0.72	0.63	621.0
G27	28.2	1.4	0.73	0.7	17.4	14.8	18184.6	0.05	0.03	0.02	0.62	0.52	644.6
G26	22.0	0.9	0.52	0.4	17.4	11.6	15940.1	0.04	0.02	0.02	0.79	0.53	724.4
G25	16.3	0.4	0.29	0.1	5.0	10.0	14318.3	0.03	0.02	0.01	0.31	0.62	877.5
G24	10.2	1.3	0.76	0.5	28.0	3.6	11238.5	0.13	0.07	0.05	2.75	0.36	1103.5

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: GL
Date: 5/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL/MODES REST

	Target			Measured			Intake Air			Corrections			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
G23	2225	10	9.5	300.0	2222	9.5	6.8	74.0	9.8	29.17	0.984	1.000	0.978	1.015
G22	1819	100	110.0	302.3	1816	110.0	15.4	75.4	10.5	29.17	0.996	1.000	0.974	1.018
G21	1819	85	93.5	300.1	1826	94.0	13.9	76.6	10.5	29.17	0.996	1.000	0.974	1.019
G18	1819	40	44.0	300.1	1818	44.5	8.9	75.0	10.0	29.17	0.987	1.000	0.977	1.016
G15	1412	100	118.0	300.1	1412	118.0	12.6	75.1	10.1	29.17	0.989	1.000	0.975	1.017
G14	1412	85	100.3	300.0	1414	100.5	11.0	74.7	10.0	29.17	0.987	1.000	0.976	1.016

	BHP from	Grams/Hour						Unweighted Modal Contribution g/hp-hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
G23	4.0	1.3	0.98	0.3	41.2	1.4	9135.1	0.32	0.24	0.07	10.25	0.35	2272.4
G22	38.0	4.8	1.67	3.2	178.8	24.8	20552.1	0.13	0.04	0.08	4.70	0.65	540.3
G21	32.7	2.4	0.80	1.6	19.8	21.6	18826.8	0.07	0.02	0.05	0.61	0.66	576.1
G18	15.4	1.9	1.08	0.8	32.0	9.5	11974.1	0.12	0.07	0.05	2.08	0.61	777.4
G15	31.7	1.9	0.38	1.5	21.7	38.7	17089.8	0.06	0.01	0.05	0.69	1.22	538.6
G14	27.1	4.1	0.88	3.2	57.3	29.3	14866.5	0.15	0.03	0.12	2.12	1.08	549.4

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: GM
Date: 5/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL/MODES REST

	Engine				Measured			Intake Air			Exhaust			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
G13	1412	70	82.6	300.1	1410	82.5	9.8	75.4	10.1	29.16	0.989	1.000	0.977	1.017
G12	1412	55	64.9	300.1	1408	64.5	8.3	74.7	10.1	29.16	0.989	1.000	0.978	1.016
G11	1412	40	47.2	300.1	1418	48.0	7.2	74.6	10.1	29.16	0.989	1.000	0.978	1.016
G10	1412	25	29.5	300.1	1412	29.0	5.2	74.0	9.8	29.17	0.984	1.000	0.979	1.015
G9	1412	10	11.8	300.0	1406	11.5	4.0	72.9	9.8	29.16	0.984	1.000	0.980	1.013
G8	1006	100	119.0	305.5	1008	119.0	9.3	74.0	10.3	29.15	0.993	1.000	0.976	1.016

	BHP	Grams/Hour						Dry Weighted Modal Contribution g/hour					
Mode	from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
G13	22.1	3.2	0.99	2.2	52.2	21.4	13177.2	0.14	0.04	0.10	2.36	0.97	595.1
G12	17.3	3.5	1.26	2.2	60.6	17.2	11168.7	0.20	0.07	0.13	3.50	1.00	646.1
G11	13.0	3.3	1.48	1.8	46.7	8.2	9677.8	0.26	0.11	0.14	3.61	0.64	747.0
G10	7.8	3.2	1.52	1.7	30.6	1.6	6978.1	0.41	0.19	0.21	3.93	0.20	894.9
G9	3.1	3.2	1.21	2.0	15.6	1.7	5444.0	1.04	0.39	0.65	5.05	0.54	1765.3
G8	22.8	12.6	2.59	10.0	264.2	66.5	12163.7	0.55	0.11	0.44	11.57	2.91	532.6

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./OLD CAT

Test No.: GN
Date: 5/20/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL/MODES REST

	Target			Measured			CVS	Intake Air			Dynos			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
G7	1006	85	101.2	300.0	1004	101.5	8.0	76.2	10.8	29.15	1.002	1.000	0.977	1.020
G6	1006	70	83.3	299.9	1002	82.5	7.0	76.4	10.9	29.15	1.003	1.000	0.977	1.020
G5	1006	55	65.5	299.9	1010	65.5	6.0	76.3	10.9	29.15	1.003	1.000	0.978	1.020
G4	1006	40	47.6	300.0	1004	48.0	4.9	75.8	10.5	29.14	0.997	1.000	0.978	1.019
G3	1006	25	29.8	300.0	1002	30.0	3.9	74.7	10.7	29.14	0.999	1.000	0.979	1.018
G2	1006	10	11.9	300.2	1010	12.0	2.7	73.7	10.7	29.13	1.000	1.000	0.980	1.017

	BHP from	Grams/Hour						Unweighted Modal Correlation (g/hp-hr)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
G7	19.4	5.2	1.45	3.7	75.6	24.8	10771.7	0.27	0.07	0.19	3.89	1.28	555.1
G6	15.7	5.8	1.44	4.3	68.0	20.1	9424.2	0.37	0.09	0.28	4.32	1.27	598.8
G5	12.6	6.1	1.35	4.7	52.2	13.6	8039.3	0.48	0.11	0.38	4.14	1.08	637.8
G4	9.2	8.4	1.28	7.1	55.0	12.6	6579.7	0.92	0.14	0.78	6.00	1.37	716.7
G3	5.7	7.0	1.01	6.0	20.2	6.2	5195.1	1.22	0.18	1.04	3.53	1.08	907.6
G2	2.3	8.5	0.72	7.8	64.5	1.6	3567.4	3.71	0.31	3.40	28.02	0.70	1549.4

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: XG
Date: 5/22/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL/MODES REST

	Target			Measured			Intake Air			Feedback			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
XG36	2631	100	78.0	310.6	2632	78.0	20.0	79.2	13.6	29.02	1.055	1.000	0.969	1.033
XG35	2631	85	66.3	300.0	2628	65.5	16.9	82.1	13.5	29.02	1.053	1.000	0.971	1.037
XG34	2631	70	54.6	300.1	2630	54.5	15.9	81.9	13.1	29.02	1.046	1.000	0.971	1.036
XG33	2631	55	42.9	300.0	2632	42.5	13.4	83.0	13.4	29.02	1.052	1.000	0.973	1.038
XG32	2631	40	31.2	299.9	2630	31.5	11.5	82.6	13.6	29.01	1.056	1.000	0.973	1.038
XG30	2631	10	7.8	301.3	2630	7.5	8.6	82.3	13.1	29.01	1.046	1.000	0.974	1.037

	BHP from	Gram/Test						Unweighted Model Emissions g/hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
XG36	39.0	0.5	0.13	0.4	2.5	5.1	27143.3	0.01	0.00	0.01	0.06	0.13	696.6
XG35	32.6	3.7	2.12	1.6	37.7	0.1	22862.8	0.11	0.06	0.05	1.16	0.00	700.5
XG34	27.2	2.0	1.10	0.9	12.0	0.4	21542.3	0.07	0.04	0.03	0.44	0.01	792.8
XG33	21.2	0.9	0.67	0.2	4.4	0.2	18172.8	0.04	0.03	0.01	0.21	0.01	856.6
XG32	15.7	0.4	0.23	0.1	1.9	0.3	15599.1	0.02	0.01	0.01	0.12	0.02	992.7
XG30	3.8	0.4	0.35	0.1	1.0	0.2	11613.2	0.11	0.09	0.02	0.26	0.05	3075.8

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: XG
Date: 5/22/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

BEST CAL/MODES REST

	Target			Measured			Q.F.	Intake Air			Factors			
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
XG29	2225	100	97.0	348.5	2226	97.0	19.1	83.0	13.8	28.99	1.059	1.000	0.968	1.039
XG28	2225	85	82.5	300.1	2226	82.5	16.6	84.2	15.9	28.99	1.104	1.000	0.969	1.045
XG27	2225	70	67.9	300.0	2232	68.0	14.8	83.8	13.8	28.99	1.060	1.000	0.970	1.041
XG26	2225	55	53.4	299.9	2234	53.0	12.8	84.2	13.6	28.99	1.055	1.000	0.972	1.041
XG25	2225	40	38.8	300.0	2222	38.5	10.7	84.5	13.5	28.99	1.054	1.000	0.973	1.041
XG24	2225	25	24.3	300.1	2226	24.5	9.3	83.3	13.5	28.99	1.053	1.000	0.974	1.039

	BHP from	Grams/Hour						Unweighted Mode Contribution g/hr					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
XG29	41.2	9.5	3.51	6.0	73.0	1.1	25764.8	0.23	0.09	0.15	1.77	0.03	625.4
XG28	40.7	5.7	0.22	5.5	8.1	0.5	22468.6	0.14	0.01	0.13	0.20	0.01	552.2
XG27	28.8	4.8	1.66	3.1	13.7	0.8	20120.9	0.17	0.06	0.11	0.48	0.03	698.9
XG26	22.5	4.0	1.59	2.5	14.7	0.5	17406.5	0.18	0.07	0.11	0.65	0.02	775.0
XG25	16.2	0.6	0.38	0.2	1.6	0.4	14553.5	0.04	0.02	0.02	0.10	0.02	897.0
XG24	10.3	1.2	0.80	0.4	2.4	0.1	12553.0	0.12	0.08	0.04	0.23	0.01	1214.0

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: XGO
Date: 5/23/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL/MODES REST

	Target			Measured									
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
XG23	2225	10	9.7	312.7	2218	9.5	6.7	82.4	12.8	28.97	1.040	1.000	0.977	1.038
XG22	1819	100	110.0	300.1	1820	110.0	15.1	84.2	13.5	28.97	1.053	1.000	0.972	1.041
XG21	1819	85	93.5	300.0	1820	94.0	14.5	86.0	13.6	28.97	1.056	1.000	0.971	1.044
XG18	1819	40	44.0	307.1	1820	44.0	8.8	85.4	13.8	28.96	1.059	1.000	0.974	1.044
XG15	1412	100	117.0	300.1	1410	117.0	13.3	85.6	13.9	28.96	1.062	1.000	0.971	1.044
XG14	1412	85	99.5	300.0	1412	99.5	11.8	85.2	13.8	28.96	1.059	1.000	0.971	1.044

	BHP from	Grams/Hour						Unweighted Modal Emissions (g/hp-hr)					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
XG23	4.0	2.0	1.09	0.9	26.9	0.6	9046.9	0.49	0.27	0.22	6.71	0.16	2258.1
XG22	38.1	10.2	2.16	8.0	101.0	2.0	20278.2	0.27	0.06	0.21	2.65	0.05	531.9
XG21	32.6	7.4	1.87	5.5	26.2	1.7	19601.4	0.23	0.06	0.17	0.81	0.05	601.9
XG18	15.3	3.4	1.31	2.1	14.2	1.2	11913.8	0.22	0.09	0.14	0.93	0.08	781.2
XG15	31.4	1.4	0.51	0.9	5.0	27.4	18098.6	0.05	0.02	0.03	0.16	0.87	576.3
XG14	26.7	7.0	1.28	5.7	27.6	13.1	15967.7	0.26	0.05	0.21	1.03	0.49	597.0

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: XGP
Date: 5/23/00
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817
BEST CAL/MODES REST

	Target				Measured			C-B	Intake Air			Factors		
Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
XG13	1412	70	81.9	300.0	1414	82.0	10.4	85.1	14.1	28.95	1.065	1.000	0.973	1.044
XG12	1412	55	64.4	300.0	1414	64.5	8.8	85.3	13.9	28.95	1.062	1.000	0.974	1.044
XG11	1412	40	46.8	300.0	1412	47.0	7.4	85.2	13.9	28.94	1.061	1.000	0.975	1.044
XG10	1412	25	29.3	300.1	1408	29.5	5.7	85.1	13.3	28.94	1.050	1.000	0.977	1.043
XG9	1412	10	11.7	300.0	1408	11.5	4.4	84.1	13.3	28.94	1.050	1.000	0.975	1.042
XG8	1006	100	118.0	300.0	1008	118.0	9.7	84.8	13.2	28.93	1.048	1.000	0.974	1.043

	BHP from	Grams/Hour						Unweighted Modal Contribution g/hp-h					
Mode	Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
XG13	22.1	5.9	1.15	4.8	20.3	12.2	14006.5	0.27	0.05	0.22	0.92	0.55	634.4
XG12	17.4	3.8	1.03	2.8	12.1	9.9	11927.4	0.22	0.06	0.16	0.70	0.57	686.9
XG11	12.6	3.4	1.16	2.2	9.1	7.1	10006.0	0.27	0.09	0.17	0.72	0.56	791.9
XG10	7.9	2.5	1.03	1.5	8.2	2.7	7765.4	0.32	0.13	0.19	1.04	0.34	982.3
XG9	3.1	0.9	0.82	0.1	1.4	2.6	5967.9	0.31	0.27	0.04	0.44	0.86	1935.1
XG8	22.6	5.9	1.43	4.5	92.5	6.9	12955.6	0.26	0.06	0.20	4.08	0.31	572.1

Southwest Research Institute - Department of Emissions Research
Custom, ISO Calcs Emission Test Results
Project No. 08-3377-001

Engine Model: 1993 GM 181
Engine Desc.: 3L (181 CID) 4IL
Engine Cycle: Otto
Engine S/N: 14097080
NEW O2 SENS./NEW CAT

Test No.: XGQ
Date: 5/22/0C
Program SSDIL: 2.24-R
Cell: 13 Bag Cart: 1
MAINTENANCE DONE

LPG HD5
HCR: 2.669 FID Resp: 1.20
H= 0.183 C= 0.817

BEST CAL/MODES REST

Mode	Speed rpm	Load %	Torque ft-lb	Time sec	Speed rpm	Torque ft-lb	Fuel lb/hr	Temp F	Humid g/kg	Baro in-hg	NOx Hum	Part. Hum	Dry Wet	F (NA)
XG7	1006	85	99.5	300.0	1008	99.5	8.5	85.1	13.9	28.93	1.061	1.000	0.975	1.045
XG6	1006	70	81.9	332.7	1006	82.0	7.0	85.2	13.8	28.93	1.060	1.000	0.976	1.045
XG5	1006	55	64.4	300.0	1006	64.5	5.6	85.0	13.8	28.93	1.059	1.000	0.977	1.044
XG4	1006	40	46.8	299.9	1002	46.0	5.1	84.1	13.4	28.92	1.051	1.000	0.978	1.043
XG3	1006	25	29.3	300.0	1004	29.5	4.0	84.0	13.3	28.91	1.049	1.000	0.978	1.043
XG2	1006	10	11.7	300.0	1006	11.5	2.8	83.0	12.9	28.91	1.041	1.000	0.979	1.041

Mode	BHP from Work	HC	CH4	NMHC	CO	NOx	CO2	HC	CH4	NMHC	CO	NOx	CO2
XG7	19.1	3.5	0.87	2.7	10.5	39.5	11559.6	0.18	0.05	0.14	0.55	2.07	605.5
XG6	15.2	2.7	0.75	1.9	5.2	32.7	9453.2	0.18	0.05	0.13	0.34	2.15	620.5
XG5	12.4	2.3	1.08	1.2	4.1	21.5	7624.3	0.19	0.09	0.10	0.33	1.74	616.9
XG4	8.8	1.6	0.82	0.8	2.1	12.5	6950.5	0.19	0.09	0.09	0.24	1.42	792.1
XG3	5.6	1.6	0.84	0.7	0.6	5.9	5394.5	0.28	0.15	0.13	0.11	1.05	956.5
XG2	2.2	2.2	0.81	1.4	1.0	1.1	3828.5	0.99	0.37	0.63	0.44	0.48	1733.9