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Heavy-Duty Fuel Economy Program Phase V—Investigation of a Heavy-Duty 3-Way Catalyst System

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Heavy-Duty Fuel Economy Program Phase V — Investigation of a Heavy-Duty 3-Way Catalyst System

by

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Prepared for

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FOREWORD

This project phase was initiated by the Emission Control Technology Division, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, Michigan 48105. Previous phases of this project have been reported in previous final reports. The effort on which this report is based was conducted by the Department of Emissions Research, Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas 78284. This phase of the project, authorized by Modification 11 to Contract 68-03-2220, was initiated August 10, 1979, and was terminated December 10, 1983. This project phase was identified within SwRI as Project 05-4311-005.

The SwRI Project Leader was Mr. Charles Urban, who supervised all work conducted in this phase of the project. Mr. Karl Springer was Project Manager and was involved in the technical and fiscal negotiation of the initial project and this project phase. The Project Officers for this project phase were Mr. William M. Pidgeon and Mr. Larry C. Landman of the Emission Control Technology Division, Environmental Protection Agency.

ABSTRACT

This report describes the laboratory effort toward evaluation of a three-way catalyst and feedback fuel injection system with a heavy-duty gasoline engine. Described are efforts toward obtaining a suitable feedback fuel system and the limited test results obtained using the subsequently selected throttle-body fuel injection system. Average emissions values over the EPA transient test, with the system only partially optimized, were 0.52 HC, 7.5 CO, and 3.4 NO_x in grams per kilowatt-hour (0.39, 5.6, and 2.5 g/hp-hr).

SUMMARY

The major objective of this project phase was to evaluate emissions and fuel consumption with a heavy-duty gasoline engine using three-way catalysts and a feedback fuel system. Initially, multipoint manifold fuel injection was selected for use, but such a system subsequently could not be obtained. Throttle-body fuel-injection, with feedback controls, was subsequently selected and used in this project phase.

The system consisted of a 1975 Chevrolet 350 CID heavy-duty basic engine, a throttle-body fuel-injection system with feedback fuel control (as used on the 1982 Corvette 350 engine), and three-way and oxidation catalysts obtained from Engelhard. For these evaluations, dual exhaust systems were utilized.

Each bank of the exhaust system consisted of an exhaust manifold with air injection, about three feet of exhaust tubing, a three-way catalyst, (Englehard 112834), a short section of exhaust tubing with air injection and an oxidation catalytic converter (Englehard 112833). The exhausts from the two banks were combined after the oxidation catalysts. In one of the exhaust banks, an oxygen sensor was installed between the exhaust manifold and the three-way catalytic converter. To provide sufficient oxygen to maximize oxidation over the EPA transient heavy-duty cycle, it was necessary to utilize two air pumps, each having a displacement of 0.3 liter (19 cu. in.).

After assembly, debugging, and minimal systems optimization, several transient emissions evaluations were conducted. The average test values with a system in a quasi-optimized configuration were as follows:

	Composite Value Over the EPA Transient Cycle					
	Work kW-hr (hp-hr)	Emissions, g/kW-hr (g/hp-hr)				SFC, kg/kW-hr (lb/hp-hr)
		HC	CO	CO_2	NO_x	
Project Results	7.8	0.52	7.5	1169	3.4	0.37
	(10.4)	(0.39)	(5.6)	(782)	(2.5)	(0.61)
Project Goals	--	(1.30)	(15.50)	--	(4.5)	--

Several emissions evaluations were then conducted using a transient cycle obtained from MVMA. The average results for the MVMA transient cycle tests are compared with the previous results as follows:

Composite Value Over the Transient Cycle						
	Work,	Emissions, g/kW-hr				SFC,
Cycle	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr
MVMA	9.0	0.46	9.8	1103	3.1	0.35
EPA	7.8	0.52	7.5	1169	3.4	0.37

The MVMA cycle had a higher composite power output and produced some reduction of HC and NO_x emissions and fuel consumption.

The stated emissions goals in g/kW-hr (g/hp-hr) of 1.9 (1.3) for HC, 20.8 (15.5) for CO, and 6.0 (4.5) for NO_x were met. This project phase was terminated, however, prior to attempts to achieving the goal of the lowest emissions and fuel consumption practical, within the available contract level of effort.

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I. INTRODUCTION

This report covers the efforts toward obtaining a desired feedback fuel system and the limited evaluations conducted using a three-way catalyst along with the subsequently selected throttle-body fuel-injection system. Previous emissions control phases of this Heavy-Duty Fuel Economy Program involved methods other than three-way catalysts.(1,2,3)*

A. Phase V Objective

The major objective of this project phase was to evaluate emissions and fuel consumption benefits using a three-way catalyst and a feedback fuel system with a heavy-duty gasoline engine. Five tasks, plus the final report, were initially involved in this project.

B. Phase V Scope of Work

The scope of work for this Phase V of the project was divided into several tasks, and underwent a number of major changes during the course of this project phase.

1. Task 1 - Selection of Test Engine

An available 1975 model Chevrolet 350 heavy-duty (HD) engine (Engine 1) was examined at the start of this project phase. This engine, used in a previous phase of this project, was found to be in good condition.

According to a representative in the Chevrolet Engineering section, there were no significant changes made to the basic 350 HD engine since 1975. In accord with approval from the EPA Project Officer, it was decided to utilize this available 1975 model engine in this project phase.

2. Task 2 - Component Acquisition

The intent of this project was to utilize the best available feedback fuel system. At the time this project was initiated, multipoint manifold fuel-injection was seriously being considered by Bendix for heavy-duty engine applications. Provisions were made for Bendix to provide such a system. Before the system was provided, however, Bendix essentially disbanded their entire heavy-duty fuel-injection operations, and an appropriate fuel-injection system was no longer obtainable from them. Obtaining a suitable multipoint fuel-injection system from another supplier was pursued, but this attempt was unsuccessful.

At that point, this project was put into a hold position until an alternate fuel system was selected. Throttle-body injection appeared to be a very desirable candidate, but a system was not available at that time. Throttle-

*Numbers in parentheses are references listed at the end of this report.

body injection was subsequently used on some 1982 model GM light-duty engines; one such application being the 350 CID engine used in the Corvette. This throttle-body fuel-injection system, with feedback fuel-control, was procured and adapted to the 350 HD engine.

Three-way catalysts were obtained from Engelhard Industries for use in this project. The exhaust configuration consisted of dual exhaust systems, each involving a three-way catalyst followed by an oxidation catalyst. Additional air was injected between the three-way and the oxidation catalysts.

3. Task 3 - System Optimization

A dynamometer test cell capable of operation over the HD transient cycle was to be utilized for optimization evaluations of the engine with the throttle-body fuel-injection system. The ultimate goal of this optimization was to achieve the lowest emissions and fuel consumption practical, within the proposed level of effort. It was initially desired to achieve emission levels in grams per kilowatt-hour below 1.8 for HC, 20.8 for CO, and 6.0 for NO_x (in g/bhp-hr below 1.3 for HC, 15.5 for CO, and 4.5 for NO_x) in the transient test. In addition, it was desired that curb idle HC and CO emissions be below 970 ppmC and 0.47 percent, respectively. This project, however, was terminated shortly after meeting the stated transient test emissions goals. Termination occurred prior to optimization toward achieving the lowest practical emissions and fuel consumption.

4. Other Tasks

Other tasks included or considered at some point in this project phase were optimized system testing, durability testing, and vehicle testing.

II. EQUIPMENT, INSTRUMENTATION AND PROCEDURES

This section describes the engine, facilities, instrumentation, procedures and fuel utilized in this phase of the project.

A. Engine

The Chevrolet 350-V8 heavy-duty gasoline engine utilized in this phase of the project was a 1975 model used in Series 50-60 trucks and Series 60 buses, except in California. This engine was originally equipped with a two-barrel carburetor and the original displacement and bore and stroke were as follows:

Displacement	5737 cc	350 cu. in.
Bore & Stroke	102 x 88 mm	4.0 x 3.48 in.

This engine was identified as Engine 1 when utilized in the previous Phase II of the project.

B. Dynamometer and Controls

The overall control scheme for the transient tests consisted of two independently closed-loop systems. The speed was controlled by the dynamometer, and the torque by the engine.

The dynamometer system consisted of an Eaton Dynamatic Model E-200, with proprietary quick-unload circuitry. This dynamometer had a motoring capacity of 150 kW (200 hp) and an absorption capacity of 373 kW (500 hp). This quick-unload circuitry was necessary to speed up the ordinarily sluggish response of this type of dynamometer. Although this dynamometer can absorb power at speeds of up to 5000 rpm, the motoring speed was a maximum of 3500 rpm.

To provide transient command signals, an Ithaco CompuDAS I/10 provided essentially continuous analog output. Speed control feedback is provided by a D.C. tachometer which is directly driven by the engine.

The torque control loop consisted of the following main elements:

- Analog command signal
- Servo amplifier
- Servomotor attached to throttle
- Driveshaft torquemeter
- Strain gage conditioner

The analog command from the CompuDAS I/10 is fed to the torque command inputs of the servo amplifier. The signal from the strain gage conditioner goes into the torque feedback input. An error amplifier decides the direction and magnitude of the current to the throttle/servomotor. Two adjustments are available on the servo amplifier. The span control adjusts the torque command level appropriately for the engine being tested. The gain control adjusts the responsiveness of the system. It is adjusted to the position at which minor oscillation begins at a couple of points in the cycle.

C. Transient Test

The transient test procedure, utilized in this project phase, is described in detail in Reference 4. The elements of the procedure are described as follows:

- The engine is mapped for maximum available torque versus speed over the range of speeds encountered during the transient test. This speed range is from 400 rpm (or 200 rpm below idle, whichever is higher) to 15 percent above rated speed. The mapping is accomplished in a single sweep from low speed to high speed. These data are used as determined, without correction to standard atmospheric conditions.

- The required cycle is determined, at one second intervals, in terms of rpm and torque.

- Practice runs are made to insure that the regression line tolerances are being met.

- After an overnight soak, a cold-start transient test in run. Whereas the procedure calls for only a single emissions sample bag to be taken during the test, in this project four bags were taken, dividing the 1167 second test into four subcycles (272, 307, 316, and 272 seconds for the NYNF, LANF, LAF, and NYNF). This breakdown of the cycle provides data to enable more detailed analyses of the emission control system.

- After a twenty-minute soak, the cycle is repeated for a hot-start test.

- The regression line data is analyzed to determine if the cycles were run within required tolerance.

- The emission data is analyzed and results for the cycle computed.

The following four gaseous emissions were measured:

- Hydrocarbons (HC)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)
- Oxides of Nitrogen (NO_x)

All emissions were measured from bagged samples.

The test cell has two environmental control systems. The first is a wall-mounted air conditioner which insures that the test cell is the proper temperature for an overnight cold soak. A second system provides temperature and humidity conditioned air to the test cell. Filtered air from outside the building is passed through a chilled water spray chamber to establish the proper absolute humidity level. The air then passes through a demister followed by an electrically heated reheat section to establish a 25°C (77°F) temperature. Temperature and dewpoint are monitored as closely as practical to the engine inlet. Humidity control design requirements are 10.7±2.1 grams of water per kilogram (75±15 grains of water per pound) of dry air. Generally, the actual control of humidity is significantly better than these limits.

The CVS system used is essentially a scaled-up version of the system used for emissions testing of light-duty vehicles. Nominal CVS flow rate utilized was 40 m^3/min (1400 CFM). This CVS flow is that necessary to prevent water condensation in the bags for the high speed and power Los Angeles Freeway (LAF) driving segment, without over diluting the exhaust during the two New York Non-Freeway (NYNF) segments of the cycle. The remaining Los Angeles Non-Freeway (LANF) segment involves intermediate speed and power.

D. Fuel

A single batch of EM-338 unleaded exhaust emissions fuel was used for all evaluations conducted in this project. The properties of this fuel are given in Table 1.

TABLE 1. PROPERTIES OF GASOLINE FOR EMISSIONS TESTING

Code Number: EM-338
Produce Name: *Amoco Indolene H01112R*

Required Items(4)	ASTM Test Method	Value
Octane, Research	D2699	97.7
Sensitivity	--	8.2
Lead (organic), g/gal	--	<0.002
Distillation:		
IBP, °F	D86	85
10% point, °F	D86	135
50% point, °F	D86	230
90% point, °F	D86	315
EP, °F	D86	397
Sulfur, wt. %	D1266	0.01
Phosphorus, g/gal	--	0.000
RVP, psi	D323	8.7
Hydrocarbon composition:		
Olefins, %	D1319	23.7
Aromatics, %	D1319	2.1
Saturates, %	D1319	74.2[a]
Other Items		
Gravity, API, @ 60°F	D287	59.5
Gravity, Specific, @ 60°F	--	0.741
Carbon, wt. %	D3178	85.61 ± 0.27
Hydrogen, wt. %	D3178	13.84 ± 0.07

[a]Remainder

III. COMPONENT ACQUISITION AND APPLICATION

This section describes the efforts expended in the acquisition and application of three-way catalytic converters and a feedback fuel system. Also included are the limited emissions test results obtained with these control systems installed on a Chevrolet 350 HD engine.

A. Acquisition of a Fuel System and Catalysts

At the time the proposal was written, Bendix was active in the development of fuel injection systems for heavy-duty gasoline engines and planned to provide a system for use in this project. However, by the time the contract for this project was subsequently signed, the heavy-duty gasoline fuel injection section at Bendix had essentially been disbanded. They no longer had any funds that could be used to provide a system, but they offered to assemble a system at cost.

After a period of time, approval was obtained to issue a purchase order to Bendix for a fuel injection system. By that time, however, Bendix no longer had any qualified personnel available that could be assigned to this procurement. Bosch was then contacted to see if they could provide a fuel injection system for use in this project. Indications were that they had minimal interest in providing such a system.

With the lack of interest in heavy-duty gasoline fuel injection by the potential manufacturers, it became apparent that a suitable system would not become available for use in this project. Information was then obtained on some other types of fuel systems for use in this project; one such system being the Electrosonic Type 5 Engine Control System from Autotronic Controls Corporation, another being the throttle-body fuel-injection.

Subsequently, a throttle-body fuel-injection system with feedback fuel-control was used on some models of GM light-duty engines; one such application being the 350 CID engine used in the Corvette. The decision was reached to utilize that system in this project. A complete throttle-body fuel-injection system was procured and adapted to the Chevrolet 350 CID heavy-duty engine.

Three-way and oxidation catalysts were obtained from Engelhard Industries. The monolithic catalyst substrates were nominally 15 centimeters (six inches) long, with nominally 47 cells per square centimeter (300 cells per square inch). These units were identified by Engelhard as Exhaust Gas Purifier PTX 616 Mod 3, Cat. No. 112834 101 and 112833 101, E.I. Ser. No. 8260001, 8260004, 8260005, and 8260006. Two additional 112384 units (Serial No. 8260002 and 8260003) were provided as spares. Both the three-way and the oxidation catalysts utilized noble metals.

B. System Assembly and Emissions Testing

The system consisted of a 1975 Chevrolet 350 CID heavy-duty basic engine, a throttle-body fuel-injection (TBI) system with feedback fuel control, and three-way and oxidation catalysts obtained from Engelhard. All components of the TBI system used in this project were the standard components used on the 1982 Corvette 350 engine. A good general description of the TBI system has been provided by GM in SAE Paper 800164. No exhaust gas recirculation system was used. For these evaluations, dual exhaust systems were utilized. Due to installation interferences, and after it was determined that good mixture balance existed between the two exhaust banks on the engine, the exhausts were not combined and the single oxygen sensor was located in only one bank of the exhaust.

Each bank of the exhaust system consisted of an exhaust manifold with air injection, about three feet of exhaust tubing, a three-way catalytic converter (Engelhard 112834), a four inch section of exhaust tubing with air injection, and an oxidation catalytic converter (Engelhard 112833). The exhausts from the two banks were combined after the oxidation catalytic converters. In one of the exhaust banks, an oxygen sensor was installed in the pipe between the exhaust manifold and the three-way catalytic converter.

Following assembly and a significant amount of debugging, the throttle-body Electronic Fuel Injection system was fully functional, and engine operation was very good with this system. Maximum power output with this system and with the stock carburetor system are given in Table 2. These data were obtained prior to installation of the emissions controls. At an engine speed of 3800 rpm, the power output was essentially the same with the EFI system as it was with the engine in its standard configuration. At lower engine speeds, maximum power output was higher with the EFI system.

TABLE 2. POWER OUTPUT COMPARISON 1975 MODEL CHEVROLET 350 HEAVY-DUTY GASOLINE ENGINE

Engine Speed, rpm	Maximum Power Output: Std. Conf. kW	BHp	EFI Sys. kW	BHp
1600	55	74	61	82
2000	70	94	77	103
2400	86	115	92	124
2800	98	132	106	142
3200	107	144	115	154
3800	116	155	116	156

The relationship between carbon monoxide emissions and engine power output with the EFI system is shown in Figure 1. Based on these data, it appears that the fuel-to-air ratio is controlled from the output of the oxygen sensor (i.e., closed loop operation) up to approximately 60 percent of maximum torque. Between 60 and 90 percent of maximum torque, the CO emissions increased to a value of two to three percent. When the Throttle Position Switch (TPS) was left operable, the CO emissions increased to between six and eight percent at maximum torque. With the TPS disconnected (i.e., no WOT signal to the fuel control), the CO emissions decreased to approximately two percent at maximum attainable torque. Maximum attainable torque decreased by a couple percent with the TPS disconnected.

An effort was then made to determine the parameters associated with the system going off control by the oxygen sensor (i.e., open loop operation). It appears that the primary parameter is the intake manifold pressure as sensed by the Manifold Air Pressure Sensor (MAP). In addition to controlling when the system goes into open loop operation, however, the intake manifold pressure also is used to establish the basic fuel flow. Therefore, controlling the MAP signal to maintain closed loop operation is not applicable, since it limits the torque attainable to 60 percent of maximum.

Additional effort involved the interface between the programmable read only memory (PROM or engine calibration unit) and the electronic control module (ECM). It was determined that control modifications apparently have to come from within the PROM or the ECM, rather than at the interface between them. At this point is was decided to provide sufficient air injection and run some initial emissions evaluations prior to applying additional efforts toward modification of the fuel control parameters.

To provide sufficient air to maximize oxidation over the transient cycle, it was necessary to install a second air pump. Each pump had a displacement of 0.3 liters (19 cu. in.) and a maximum rated output flow of 0.85 cubic meters per minute (30 cfm). The resulting supplemental air system operated as follows: The output of one air pump was injected into both exhaust manifolds during cold engine operation; the output of the other air pump was supplied between the three-way and the oxidation catalytic converters on one exhaust bank. After the engine was "warmed-up," the output of the one air pump was switched from the exhaust manifolds to between the three-way and the oxidation catalytic converters on the exhaust bank opposite to that supplied by the other air pump. After "warm-up," the air was provided between the three-way and oxidation catalytic converters during all engine operation, including cut-throttle operation. During the limited operation with this system, no backfires were apparent in the exhaust.

The air injection was partially optimized during several hot-start tests and subsequently during a couple of cold-start tests. During these tests, the exhaust oxygen and carbon monoxide (CO) levels were continuously observed. Maximum throttle was restricted to the point at which the air supplied was sufficient to achieve post-catalyst CO levels "at WOT" of essentially

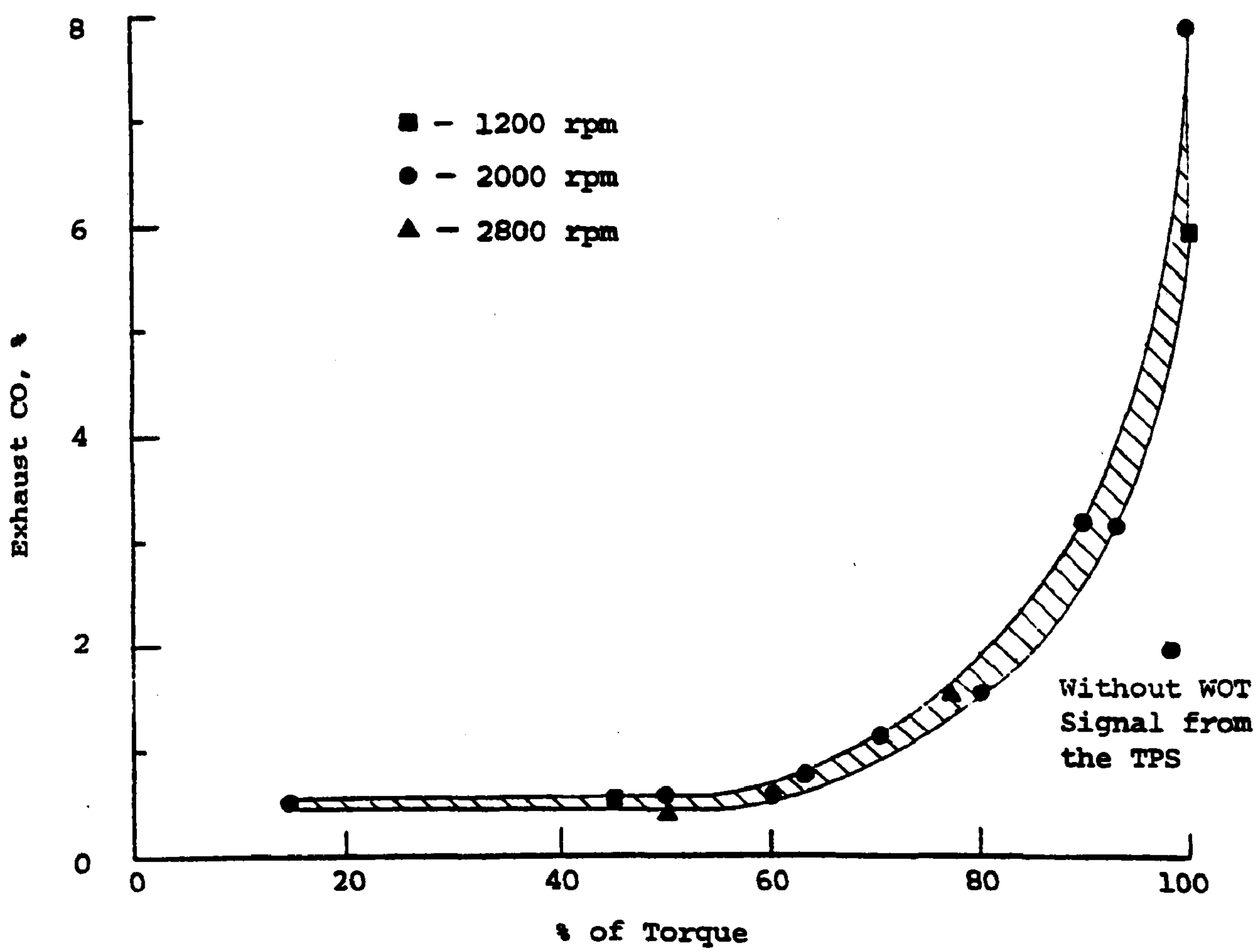

Figure 1. Exhaust CO vs percent of engine maximum torque

negligible concentrations. This resulted in a reduction in maximum torque of about two percent compared to EFI data in Table 2. Engine out CO levels were not measured during these evaluations, but from previous evaluations, the engine out CO levels are known to exceed several percent.

Difficulties encountered during these and subsequent emissions evaluations included malfunction of the idle reset system (engine did not return to the standard idle operation) and air leakage into the exhaust manifold after the air supply switched from the exhaust manifold to the locations between the three-way and oxidation catalysts. The malfunction in the idle reset system was uncovered and repaired prior to the last two cold-start emissions tests. The leaky air switching valve (the leak appeared to be intermittent and therefore, the extent of leakage at any specific time is not known) was discovered after completion of the initial emissions evaluations.

The results of the cold-start emissions evaluations, subsequent to installation of the second air pump, are included in Appendix A, and are summarized in Tables 3 and 4. In spite of the idle reset malfunction, and the apparent inconsistent leakage of the air switching valve, the results have reasonable repeatability. In some of the cold-start tests, minor failure of one or two of the statistical requirements occurred; these primarily resulted from the idle reset malfunction. It also appears that the repair of the idle reset resulted in some reduction in fuel consumption (i.e., BSFC in Tests 10 and 11).

Of interest is the percent contribution of the initial emissions sample bag from each cycle (hot-start and cold-start) to the composite HC and CO emissions values. Such results from Test 9, an apparently representative test, are as follows:

Sample Bag	Cycle Segment	Contribution to Total Composite Value, %			
		HC	CO	CO_2	NO_x
1	NYNF	59	62	10	12
1 & 2	NYNF & LANF	87	76	--	--

Based on these results for Test 9, the initial emissions sample bags for the cold- and hot-start cycles contributed about sixty percent of the total composite HC and CO emissions. The fourth emissions sample bags (Bags 1 and 4 involve the same NYNF operating cycle) contributed approximately five percent of the total composite HC and fifteen percent of the total composite CO. Therefore, the initial starts, until the catalytic emissions control systems reached maximum efficiency, accounted for approximately fifty-five percent of the total composite HC and forty-five percent of the total composite CO. Other major contributors to HC and CO emissions, appear to be the rapid acceleration and deceleration movements of the engine throttle; this is based on continuous visual observation of the HC and CO emission levels during the cycle.

TABLE 3. EPA TRANSIENT CYCLE TEST RESULTS
Metric Units

		Composite*					
	Work,	Emissions, g/kW-hr				SFC,	
Test	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr	Comments
5	7.81	0.55	6.80	1172	3.01	0.373	a,b
6	7.63	0.68	8.12	1206	3.03	0.385	a,b
7	7.63	0.49	6.19	1202	3.95	0.383	a,b
9	7.62	0.54	7.15	1177	3.61	0.375	a,b
10	8.02	0.33	6.81	1113	3.29	0.355	a,c
11	8.02	0.53	10.19	1142	3.31	0.366	a,c
Avg	7.8	0.52	7.5	1169	3.37	0.373	

		Cold Cycle					
	Work,	Emissions, g/kW-hr				SFC,	
Test	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr	Comments
5	7.99	1.97	20.87	1220	2.71	0.397	a,b
6	7.84	2.18	22.43	1234	2.84	0.402	a,b
7	7.78	1.66	24.52	1247	3.47	0.407	a,b
9	7.73	1.49	21.02	1219	3.16	0.396	a,b
10	8.23	0.60	11.15	1178	3.30	0.377	a,c
11	8.12	1.91	23.49	1210	3.27	0.395	a,c

		Hot Cycle					
	Work,	Emissions, g/kW-hr				SFC,	
Test	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr	Comments
5	7.78	0.31	4.46	1164	3.06	0.369	a,b
6	7.59	0.43	5.74	1201	3.06	0.382	a,b
7	7.60	0.30	3.14	1195	4.03	0.379	a,b
9	7.60	0.38	4.84	1170	3.69	0.371	a,b
10	7.99	0.28	6.09	1102	3.29	0.351	a,c
11	8.00	0.30	7.97	1131	3.32	0.361	a,c

*Composite = 1/7×Cold + 6/7×Hot

[a]Intermittant leakage of the air switching valve
[b]Malfunction of the idle reset system
[c]Idle reset system was repaired and was functioning properly

TABLE 4. EPA TRANSIENT CYCLE TEST RESULTS
English Units

Composite*

Test	Work, hp-hr	Emissions, g/hp-hr HC	CO	CO_2	NO_x	BSFC, lb/hp-hr	Comments
5	10.47	0.41	5.08	874	2.24	0.614	a,b
6	10.23	0.51	6.06	900	2.26	0.633	a,b
7	10.22	0.37	4.62	897	2.95	0.629	a,b
9	10.21	0.40	5.33	877	2.69	0.617	a,b
10	10.76	0.24	5.08	830	2.46	0.583	a,c
11	10.74	0.39	7.59	851	2.47	0.601	a,c
Avg.	10.4	0.39	5.6	872	2.51	0.613	

Cold Cycle

Test	Work, hp-hr	Emissions, g/hp-hr HC	CO	CO_2	NO_x	BSFC, lb/hp-hr	Comments
5	10.71	1.47	15.56	910	2.02	0.653	a,b
6	10.51	1.63	16.73	921	2.12	0.662	a,b
7	10.43	1.24	18.28	930	2.59	0.669	a,b
9	10.36	1.11	15.68	909	2.36	0.651	a,b
10	11.04	0.45	8.31	878	2.46	0.620	a,c
11	10.89	1.42	17.51	902	2.44	0.649	a,c

Hot Cycle

Test	Work, hp-hr	Emissions, g/hp-hr HC	CO	CO_2	NO_x	BSFC, lb/hp-hr	Comments
5	10.43	0.23	3.33	868	2.28	0.607	a,b
6	10.18	0.32	4.28	896	2.28	0.628	a,b
7	10.19	0.23	2.34	891	3.01	0.622	a,b
9	10.19	0.28	3.61	872	2.75	0.611	a,b
10	10.71	0.21	4.54	822	2.46	0.577	a,c
11	10.72	0.22	5.94	843	2.47	0.593	a,c

*Composite = 1/7×Cold + 6/7×Hot

[a]Intermittant leakage of the air switching valve
[b]Malfunction of the idle reset system
[c]Idle reset system was repaired and was functioning properly

The maximum exhaust temperature at the catalytic converters, during operation over the transient cycle, was 870°C (1600°F). This maximum temperature occurred at the entrance to the three-way catalytic converters during the Los Angeles Freeway (LAF) portion of the test cycle. The maximum temperature is below the maximum short-term safe operating temperature of 1800°F specified by Engelhard. No attempt was made to determine maximum temperature during stabilized operation at maximum power of the engine.

At the request of the EPA Project Officer, system optimization was discontinued and several evaluations were conducted over a transient cycle developed by the MVMA. The results of these evaluations are included in Appendix B and summarized in Tables 5 and 6. There was no significant difference between the results of the third test which met all statistical requirements for speed and load control, and the results of the first two tests which were slightly outside the statistical limits.

Average results for these MVMA transient cycle tests are compared with the previous results as follows:

	Composite Value Over the Transient Cycles						
		Emissions, g/kW-hr				SFC
Cycle	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr
MVMA	9.0	0.45	9.8	1103	3.1	0.35
EPA	7.8	0.52	7.5	1169	3.4	0.37

The MVMA cycle had a higher composite power output and produced lower HC and NO_x emissions and a reduction in BSFC.

With the exception of the very limited optimization of the system conducted during the application of the system to the engine, optimization evaluations were not conducted. Optimization would be expected to provide additional reductions in emissions, and possibly fuel consumption.

TABLE 5. MVMA TRANSIENT CYCLE TEST RESULTS
Metric Units

	Composite*					
	Work,	Emission, g/kW-hr				SFC,
Test	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr
21	9.02	0.46	9.86	1097	3.00	0.351
22	8.91	0.43	9.93	1115	3.14	0.357
23	8.96	0.46	9.68	1097	3.09	0.351
Avg.	8.96	0.45	9.8	1105	3.08	0.353

	Cold Cycle					
	Work,	Emissions, g/kW-hr				SFC,
Test	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr
21	9.15	1.66	21.44	1160	2.94	0.378
22	9.03	1.33	10.57	1177	2.86	0.382
23	9.15	1.39	10.94	1165	2.89	0.379

	Hot Cycle					
	Work,	Emissions, g/kW-hr				SFC,
Test	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr
21	9.00	0.26	7.93	1087	3.01	0.347
22	8.89	0.28	8.32	1105	3.19	0.353
23	8.93	0.31	7.97	1086	3.12	0.346

* Composite = 1/7×Cold + 6/7×Hot

TABLE 6. MVMA TRANSIENT CYCLE TEST RESULTS
English Units

Test	Composite*					
	Work,	Emissions, g/hp-hr				BSFC,
	hp-hr	HC	CO	CO_2	NO_x	lb/hp-hr
21	12.10	0.35	7.35	819	2.23	0.577
22	11.95	0.32	7.40	832	2.34	0.587
23	12.02	0.35	7.22	818	2.30	0.577
Avg.	12.02	0.34	7.3	823	2.29	0.580

Test	Cold Cycle					
	Work,	Emissions, g/kW-hr				SFC,
	kW-hr	HC	CO	CO_2	NO_x	kg/kW-hr
21	12.27	1.24	15.99	865	2.19	0.621
22	12.11	0.99	14.59	877	2.13	0.628
23	12.28	1.04	14.87	869	2.15	0.622

Test	Hot Cycle					
	Work,	Emission, g/hp-hr				BSFC,
	hp-hr	HC	CO	CO_2	NO_x	lb/hp-hr
21	12.07	0.20	5.91	811	2.24	0.570
22	11.92	0.21	6.20	824	2.38	0.580
23	11.98	0.23	5.94	810	2.33	0.570

* Composite = 1/7×Cold + 6/7×Hot

REFERENCES

1. Ingalls, M.N., and Mason, R.L., "Heavy-Duty Fuel Economy Program - Phase I, Specific Analysis of Certain Existing Data," Final Report to the Environmental Protection Agency under Contract No. 68-03-2220, Report No. EPA 460/3-77-001, January 1977.

2. Urban, C.M., amd Springer, K.J., "Heavy-Duty Fuel Economy Program Phase II - Evaluation of Emission Control Technology Approaches," Final Report to the Environmental Protection Agency under Contract No. 68-03-2220, Report No. EPA 460/3-77-010, July 1977.

3. Urban, C.M., "Heavy-Duty Fuel Economy Program Phase III - Transient Cycle Evaluations of the Advanced Emissions Control Technology Engine," Final Report to the Environmental Protection Agency under Contract No. 68-03-2220, Report No. 460/3-78-005, May 1978.

4. Code of Federal Regulations, Title 40, Part 86, Subpart N.

APPENDICES

A. Computer Printouts for the EPA Heavy-Duty Engine Transient Cycle Tests

B. Computer Printouts for the MVMA Transient Cycle Tests

APPENDIX A

Computer Printouts for the EPA Heavy-Duty Engine Transient Cycle Tests

Note: These data are summarized, along with comments, in Tables 3 and 4 of this report.

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.5 RUN1
DATE 1/10/83
TIME 12:45
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 744.22 MM HG(29.30 IN HG)
DRY BULB TEMP. 17.8 DEG C(64.0 DEG F)

RELATIVE HUMIDITY , ENGINE-48. PCT , CVS-25. PCT
ABSOLUTE HUMIDITY 6.2 GM/KG(43.4 GRAINS/LB) NOX HUMIDITY C.F. .8708

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	660.4 (26.0)	685.8 (27.0)	711.2 (28.0)	660.4 (26.0)
BLOWER INLET P MM. H2O(IN. H2O)	444.5 (17.5)	457.2 (18.0)	469.9 (18.5)	444.5 (17.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7168.	8088.	8319.	7160.
TIME SECONDS	272.1	307.1	316.1	272.0
TOTAL FLOW STD. CU. METRES(SCF)	189.4 (6691.)	212.7 (7512.)	217.3 (7674.)	189.2 (6684.)
HC SAMPLE METER/RANGE/PPM	14.0/ 3/ 140.	24.3/ 2/ 24.	15.6/ 2/ 16.	14.8/ 2/ 15.
HC BCKGRD METER/RANGE/PPM	1.4/ 3/ 14.	14.1/ 2/ 14.	13.9/ 2/ 14.	13.2/ 2/ 13.
CO SAMPLE METER/RANGE/PPM	24.9/ 3/ 577.	67.2/12/ 151.	27.5/13/ 25.	19.9/13/ 18.
CO BCKGRD METER/RANGE/PPM	.4/ 3/ 9.	3.9/12/ 7.	5.4/13/ 5.	3.5/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	89.5/12/ .40	70.3/11/ .62	75.9/ 3/ 1.38	77.1/12/ .33
CO2 BCKGRD METER/RANGE/PCT	11.9/12/ .04	7.5/11/ .04	3.8/ 3/ .06	15.4/12/ .05
NOX SAMPLE METER/RANGE/PPM	7.9/ 2/ 8.	16.3/ 2/ 16.	34.8/ 2/ 35.	6.3/ 2/ 6.
NOX BCKGRD METER/RANGE/PPM	.8/ 2/ 1.	1.0/ 2/ 1.	1.1/ 2/ 1.	.9/ 2/ 1.
DILUTION FACTOR	28.48	21.16	9.65	40.33
HC CONCENTRATION PPM	126.	11.	3.	2.
CO CONCENTRATION PPM	559.	141.	20.	15.
CO2 CONCENTRATION PCT	.36	.57	1.33	.28
NOX CONCENTRATION PPM	7.1	15.3	33.8	5.4
HC MASS GRAMS	13.82	1.33	.39	.21
CO MASS GRAMS	123.37	35.01	5.06	3.26
CO2 MASS GRAMS	1251.7	2232.3	5302.9	961.0
NOX MASS GRAMS	2.25	5.44	12.24	1.71
FUEL KG (LB)	.470 (1.04)	.722 (1.59)	1.675 (3.69)	.305 (.67)
KW HR (HP HR)	.67 (.90)	1.52 (2.04)	5.16 (6.92)	.64 (.85)
BSHC G/KW HR (G/HP HR)	20.53 (15.31)	.88 (.65)	.08 (.06)	.33 (.25)
BSCO G/KW HR (G/HP HR)	183.27 (136.67)	23.06 (17.19)	.98 (.73)	5.13 (3.83)
BSCO2 G/KW HR (G/HP HR)	1859.46 (1386.60)	1470.22 (1096.34)	1027.54 (766.23)	1511.63 (1127.22)
BSNOX G/KW HR (G/HP HR)	3.34 (2.49)	3.58 (2.67)	2.37 (1.77)	2.69 (2.00)
BSFC KG/KW HR (LB/HP HR)	.698 (1.147)	.476 (.782)	.324 (.533)	.479 (.788)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.99 (10.71)
BSHC G/KW HR (G/HP HR)	1.97 (1.47)
BSCO G/KW HR (G/HP HR)	20.87 (15.56)
BSCO2 G/KW HR (G/HP HR)	1220. (910.)
BSNOX G/KW HR (G/HP HR)	2.71 (2.02)
BSFC KG/KW HR (LB/HP HR)	.397 (.653)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.	TEST NO.5 RUN1
ENGINE MODEL 75 CHEV	DATE 1/10/83
ENGINE 5.7 L(350. CID) V-8	TIME 13:25 GASOLINE EM-338-F
CVS NO. 9	DYNO NO. 2 BAG CART NO. 1

BAROMETER 743.71 MM HG(29.28 IN HG)
DRY BULB TEMP. 20.0 DEG C(68.0 DEG F)

RELATIVE HUMIDITY , ENGINE-44. PCT , CVS-27. PCT
ABSOLUTE HUMIDITY 6.5 GM/KG(45.8 GRAINS/LB) NOX HUMIDITY C.F. .8794

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	660.4 (26.0)	685.8 (27.0)	711.2 (28.0)	660.4 (26.0)
BLOWER INLET P MM. H2O(IN. H2O)	444.5 (17.5)	457.2 (18.0)	469.9 (18.5)	444.5 (17.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7161.	8083.	8318.	7161.
TIME SECONDS	271.9	307.0	316.1	272.1
TOTAL FLOW STD. CU. METRES(SCF)	189.1 (6680.)	212.4 (7502.)	217.1 (7667.)	189.1 (6680.)
HC SAMPLE METER/RANGE/PPM	22.9/ 2/ 23.	20.9/ 2/ 21.	14.2/ 2/ 14.	12.1/ 2/ 12.
HC BCKGRD METER/RANGE/PPM	13.7/ 2/ 14.	14.3/ 2/ 14.	12.6/ 2/ 13.	11.5/ 2/ 12.
CO SAMPLE METER/RANGE/PPM	50.7/12/ 108.	18.2/13/ 17.	15.5/13/ 14.	27.8/13/ 25.
CO BCKGRD METER/RANGE/PPM	1.3/12/ 2.	2.3/13/ 2.	1.7/13/ 2.	1.5/13/ 1.
CO2 SAMPLE METER/RANGE/PCT	73.2/12/ .31	63.8/11/ .54	74.5/ 3/ 1.36	76.4/12/ .33
CO2 BCKGRD METER/RANGE/PCT	12.3/12/ .04	7.3/11/ .04	3.1/ 3/ .05	13.1/12/ .04
NOX SAMPLE METER/RANGE/PPM	9.6/ 2/ 10.	20.0/ 2/ 20.	33.4/ 2/ 33.	6.0/ 2/ 6.
NOX BCKGRD METER/RANGE/PPM	.4/ 2/ 0.	.5/ 2/ 1.	.4/ 2/ 0.	.3/ 2/ 0.
DILUTION FACTOR	41.75	24.72	9.86	40.74
HC CONCENTRATION PPM	10.	7.	3.	1.
CO CONCENTRATION PPM	104.	14.	12.	24.
CO2 CONCENTRATION PCT	.27	.50	1.31	.28
NOX CONCENTRATION PPM	9.2	19.5	33.0	5.7
HC MASS GRAMS	1.04	.88	.36	.10
CO MASS GRAMS	22.84	3.53	3.08	5.24
CO2 MASS GRAMS	925.9	1931.1	5222.2	975.4
NOX MASS GRAMS	2.93	6.97	12.07	1.82
FUEL KG (LB)	.304 (.67)	.611 (1.35)	1.648 (3.63)	.310 (.68)
KW HR (HP HR)	.57 (.76)	1.46 (1.96)	5.17 (6.93)	.58 (.78)
BSHC G/KW HR (G/HP HR)	1.83 (1.36)	.60 (.45)	.07 (.05)	.16 (.12)
BSCO G/KW HR (G/HP HR)	40.19 (29.97)	2.42 (1.80)	.60 (.45)	8.99 (6.70)
BSCO2 G/KW HR (G/HP HR)	1628.81 (1214.60)	1324.06 (987.35)	1010.43 (753.48)	1671.95 (1246.77)
BSNOX G/KW HR (G/HP HR)	5.15 (3.84)	4.78 (3.57)	2.33 (1.74)	3.11 (2.32)
BSFC KG/KW HR (LB/HP HR)	.535 (.880)	.419 (.689)	.319 (.524)	.532 (.874)

A-3

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.78 (10.43)
BSHC G/KW HR (G/HP HR)	.31 (.23)
BSCO G/KW HR (G/HP HR)	4.46 (3.33)
BSCO2 G/KW HR (G/HP HR)	1164. (868.)
BSNOX G/KW HR (G/HP HR)	3.06 (2.28)
BSFC KG/KW HR (LB/HP HR)	.369 (.607)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.	TEST NO.6 RUN1
ENGINE MODEL 75 CHEV	DATE 1/11/83
ENGINE 5.7 L(350. CID) V-8	TIME 8:35 GASOLINE EM-338-F
CVS NO. 9	DYNO NO. 2 BAG CART NO. 1
BAROMETER 747.52 MM HG(29.43 IN HG)	RELATIVE HUMIDITY , ENGINE-55. PCT , CVS-40. PCT
DRY BULB TEMP. 17.8 DEG C(64.0 DEG F)	ABSOLUTE HUMIDITY 7.1 GM/KG(49.6 GRAINS/LB) NOX HUMIDITY C.F. .8935

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	660.4 (26.0)	685.8 (27.0)	711.2 (28.0)	660.4 (26.0)
BLOWER INLET P MM. H2O(IN. H2O)	444.5 (17.5)	457.2 (18.0)	469.9 (18.5)	444.5 (17.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7170.	8090.	8324.	7163.
TIME SECONDS	272.1	307.1	316.1	272.1
TOTAL FLOW STD. CU. METRES(SCF)	190.4 (6724.)	213.7 (7549.)	218.4 (7715.)	190.2 (6718.)
HC SAMPLE METER/RANGE/PPM	15.1/ 3/ 151.	18.5/ 2/ 19.	11.0/ 2/ 11.	11.5/ 2/ 12.
HC BCKGRD METER/RANGE/PPM	1.0/ 3/ 10.	10.1/ 2/ 10.	9.8/ 2/ 10.	9.9/ 2/ 10.
CO SAMPLE METER/RANGE/PPM	27.1/ 3/ 630.	61.3/12/ 135.	25.0/13/ 23.	21.0/13/ 19.
CO BCKGRD METER/RANGE/PPM	.1/ 3/ 2.	2.7/12/ 5.	5.0/13/ 5.	4.5/13/ 4.
CO2 SAMPLE METER/RANGE/PCT	88.3/12/ .39	69.8/11/ .61	74.9/ 3/ 1.36	76.2/12/ .32
CO2 BCKGRD METER/RANGE/PCT	12.6/12/ .04	7.6/11/ .05	3.3/ 3/ .05	14.6/12/ .05
NOX SAMPLE METER/RANGE/PPM	6.6/ 2/ 7.	13.4/ 2/ 13.	37.7/ 2/ 38.	6.9/ 2/ 7.
NOX BCKGRD METER/RANGE/PPM	1.0/ 2/ 1.	.9/ 2/ 1.	.8/ 2/ 1.	.6/ 2/ 1.
DILUTION FACTOR	28.55	21.44	9.80	40.96
HC CONCENTRATION PPM	141.	9.	2.	2.
CO CONCENTRATION PPM	615.	127.	18.	15.
CO2 CONCENTRATION PCT	.35	.57	1.32	.28
NOX CONCENTRATION PPM	5.6	12.5	37.0	6.3
HC MASS GRAMS	15.52	1.09	.28	.20
CO MASS GRAMS	136.37	31.60	4.57	3.29
CO2 MASS GRAMS	1224.5	2216.7	5276.2	958.8
NOX MASS GRAMS	1.83	4.58	13.81	2.05
FUEL KG (LB)	.469 (1.03)	.716 (1.58)	1.666 (3.67)	.304 (.67)
KW HR (HP HR)	.65 (.87)	1.52 (2.04)	5.09 (6.82)	.58 (.78)
BSHC G/KW HR (G/HP HR)	23.85 (17.79)	.72 (.54)	.05 (.04)	.35 (.26)
BSCO G/KW HR (G/HP HR)	209.57 (156.28)	20.81 (15.52)	.90 (.67)	5.64 (4.21)
BSCO2 G/KW HR (G/HP HR)	1881.72 (1403.20)	1459.98 (1088.71)	1037.39 (773.58)	1643.45 (1225.52)
BSNOX G/KW HR (G/HP HR)	2.82 (2.10)	3.02 (2.25)	2.71 (2.02)	3.52 (2.62)
BSFC KG/KW HR (LB/HP HR)	.721 (1.185)	.471 (.775)	.328 (.538)	.521 (.857)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.84 (10.51)
BSHC G/KW HR (G/HP HR)	2.18 (1.63)
BSCO G/KW HR (G/HP HR)	22.43 (16.73)
BSCO2 G/KW HR (G/HP HR)	1234. (921.)
BSNOX G/KW HR (G/HP HR)	2.84 (2.12)
BSFC KG/KW HR (LB/HP HR)	.402 (.662)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.6 RUN1
DATE 1/11/83
TIME 9:15
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 747.78 MM HG(29.44 IN HG)
DRY BULB TEMP. 20.0 DEG C(68.0 DEG F)

RELATIVE HUMIDITY , ENGINE-46. PCT , CVS-32. PCT
ABSOLUTE HUMIDITY 6.8 GM/KG(47.7 GRAINS/LB) NOX HUMIDITY C.F. .8861

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	660.4 (26.0)	685.8 (27.0)	711.2 (28.0)	660.4 (26.0)
BLOWER INLET P MM. H2O(IN. H2O)	444.5 (17.5)	457.2 (18.0)	469.9 (18.5)	444.5 (17.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7164.	8085.	8319.	7162.
TIME SECONDS	272.1	307.1	316.1	272.1
TOTAL FLOW STD. CU. METRES(SCF)	190.3 (6721.)	213.7 (7547.)	218.4 (7713.)	190.2 (6719.)
HC SAMPLE METER/RANGE/PPM	29.9/ 2/ 30.	17.6/ 2/ 18.	12.4/ 2/ 12.	12.0/ 2/ 12.
HC BCKGRD METER/RANGE/PPM	11.3/ 2/ 11.	11.4/ 2/ 11.	11.3/ 2/ 11.	11.7/ 2/ 12.
CO SAMPLE METER/RANGE/PPM	66.9/12/ 150.	22.7/13/ 21.	16.0/13/ 15.	25.7/13/ 24.
CO BCKGRD METER/RANGE/PPM	1.9/12/ 4.	3.4/13/ 3.	3.3/13/ 3.	4.2/13/ 4.
CO2 SAMPLE METER/RANGE/PCT	74.1/12/ .31	64.0/11/ .54	75.2/ 3/ 1.37	77.7/12/ .33
CO2 BCKGRD METER/RANGE/PCT	14.4/12/ .05	8.2/11/ .05	3.7/ 3/ .06	14.6/12/ .05
NOX SAMPLE METER/RANGE/PPM	9.2/ 2/ 9.	18.2/ 2/ 18.	32.9/ 2/ 33.	6.8/ 2/ 7.
NOX BCKGRD METER/RANGE/PPM	.5/ 2/ 1.	.5/ 2/ 1.	.6/ 2/ 1.	.6/ 2/ 1.
DILUTION FACTOR	40.53	24.61	9.76	39.91
HC CONCENTRATION PPM	19.	7.	2.	1.
CO CONCENTRATION PPM	145.	17.	11.	19.
CO2 CONCENTRATION PCT	.26	.49	1.32	.28
NOX CONCENTRATION PPM	8.7	17.7	32.4	6.2
HC MASS GRAMS	2.07	.82	.28	07
CO MASS GRAMS	32.03	4.32	2.88	4.31
CO2 MASS GRAMS	922.6	1930.4	5277.4	987.4
NOX MASS GRAMS	2.81	6.42	11.98	2.00
FUEL KG (LB)	.309 (.68)	.612 (1.35)	1.665 (3.67)	.313 (.69)
KW HR (HP HR)	.56 (.75)	1.44 (1.94)	5.03 (6.74)	.56 (.75)
BSHC G/KW HR (G/HP HR)	3.69 (2.75)	.57 (.42)	.06 (.04)	.12 (.09)
BSCO G/KW HR (G/HP HR)	57.10 (42.58)	2.99 (2.23)	.57 (.43)	7.69 (5.74)
BSCO2 G/KW HR (G/HP HR)	1644.74 (1226.49)	1337.31 (997.23)	1049.98 (782.97)	1760.25 (1312.62)
BSNOX G/KW HR (G/HP HR)	5.01 (3.74)	4.45 (3.32)	2.38 (1.78)	3.57 (2.66)
BSFC KG/KW HR (LB/HP HR)	.550 (.905)	.424 (.696)	.331 (.545)	.559 (.919)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.59 (10.18)
BSHC G/KW HR (G/HP HR)	.43 (.32)
BSCO G/KW HR (G/HP HR)	5.74 (4.28)
BSCO2 G/KW HR (G/HP HR)	1201. (896.)
BSNOX G/KW HR (G/HP HR)	3.06 (2.28)
BSFC KG/KW HR (LB/HP HR)	.382 (.628)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.	TEST NO.7 RUN1		
ENGINE MODEL 75 CHEV	DATE 1/21/83		
ENGINE 5.7 L(350. CID) V-8	TIME 8:10	GASOLINE EM-338-F	
CVS NO. 9	DYNO NO. 2	BAG CART NO. 1	
BAROMETER 736.85 MM HG(29.01 IN HG)	RELATIVE HUMIDITY , ENGINE-56. PCT , CVS-27. PCT		
DRY BULB TEMP. 17.2 DEG C(63.0 DEG F)	ABSOLUTE HUMIDITY 7.1 GM/KG(49.5 GRAINS/LB)	NOX HUMIDITY C.F. .8930	

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	698.5 (27.5)	711.2 (28.0)	723.9 (28.5)	698.5 (27.5)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	431.8 (17.0)	457.2 (18.0)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.9 (111.0)
BLOWER REVOLUTIONS	7167.	8087.	8319.	7160.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	188.1 (6645.)	210.9 (7450.)	215.3 (7603.)	187.6 (6626.)
HC SAMPLE METER/RANGE/PPM	11.1/ 3/ 111.	21.9/ 2/ 22.	11.5/ 2/ 12.	13.0/ 2/ 13.
HC BCKGRD METER/RANGE/PPM	1.0/ 3/ 10.	10.7/ 2/ 11.	10.6/ 2/ 11.	11.2/ 2/ 11.
CO SAMPLE METER/RANGE/PPM	29.9/ 3/ 699.	65.6/12/ 147.	24.1/13/ 22.	18.3/13/ 17.
CO BCKGRD METER/RANGE/PPM	.3/ 3/ 7.	2.4/12/ 4.	5.1/13/ 5.	3.5/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	85.3/12/ .37	69.9/11/ .61	77.3/ 3/ 1.41	78.6/12/ .34
CO2 BCKGRD METER/RANGE/PCT	11.9/12/ .04	7.4/11/ .04	3.8/ 3/ .06	15.6/12/ .05
NOX SAMPLE METER/RANGE/PPM	6.3/ 2/ 6.	16.8/ 2/ 17.	45.9/ 2/ 46.	9.3/ 2/ 9.
NOX BCKGRD METER/RANGE/PPM	.4/ 2/ 0.	.5/ 2/ 1.	.9/ 2/ 1.	1.1/ 2/ 1.
DILUTION FACTOR	29.46	21.35	9.46	39.40
HC CONCENTRATION PPM	101.	12.	2.	2.
CO CONCENTRATION PPM	681.	140.	17.	13.
CO2 CONCENTRATION PCT	.34	.57	1.36	.28
NOX CONCENTRATION PPM	5.9	16.3	45.1	8 2
HC MASS GRAMS	11.00	1.42	.25	.23
CO MASS GRAMS	149.22	34.28	4.30	2.91
CO2 MASS GRAMS	1157.4	2197.3	5368.2	978.6
NOX MASS GRAMS	1.90	5.88	16 58	2.64
FUEL KG (LB)	.450 (.99)	.711 (1.57)	1.695 (3.74)	.310 (.68)
KW HR (HP HR)	.63 (.84)	1.49 (2.00)	5.10 (6.84)	.56 (.75)
BSHC G/KW HR (G/HP HR)	17.50 (13.05)	.96 (.71)	.05 (.04)	.40 (.30)
BSCO G/KW HR (G/HP HR)	237.50 (177.11)	23.03 (17.17)	.84 (.63)	5.19 (3.87)
BSCO2 G/KW HR (G/HP HR)	1842.16 (1373.70)	1476.26 (1100.85)	1052.38 (784.76)	1744.43 (1300.82)
BSNOX G/KW HR (G/HP HR)	3.02 (2.26)	3.95 (2.95)	3.25 (2.42)	4.70 (3.51)
BSFC KG/KW HR (LB/HP HR)	.716 (1.177)	.478 (.785)	.332 (.546)	.553 (.909)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.78 (10.43)
BSHC G/KW HR (G/HP HR)	1.66 (1.24)
BSCO G/KW HR (G/HP HR)	24.52 (18.28)
BSCO2 G/KW HR (G/HP HR)	1247. (930.)
BSNOX G/KW HR (G/HP HR)	3.47 (2.59)
BSFC KG/KW HR (LB/HP HR)	.407 (.669)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.7 RUN1
DATE 1/21/83
TIME 8:50
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 737.11 MM HG(29.02 IN HG)
DRY BULB TEMP. 20.6 DEG C(69.0 DEG F)

RELATIVE HUMIDITY , ENGINE-42. PCT , CVS-39. PCT
ABSOLUTE HUMIDITY 6.5 GM/KG(45.7 GRAINS/LB) NOX HUMIDITY C.F. .8788

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	698.5 (27.5)	711.2 (28.0)	723.9 (28.5)	698.5 (27.5)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	431.8 (17.0)	457.2 (18.0)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7163.	8087.	8318.	7160.
TIME SECONDS	272.1	307.1	316.1	272.1
TOTAL FLOW STD. CU. METRES(SCF)	188.1 (6643.)	211.0 (7453.)	215.3 (7605.)	188.0 (6640.)
HC SAMPLE METER/RANGE/PPM	20.1/ 2/ 20.	17.7/ 2/ 18.	13.4/ 2/ 13.	13.4/ 2/ 13.
HC BCKGRD METER/RANGE/PPM	11.2/ 2/ 11.	10.8/ 2/ 11.	12.5/ 2/ 13.	12.4/ 2/ 12.
CO SAMPLE METER/RANGE/PPM	58.2/13/ 56.	14.9/13/ 14.	19.2/13/ 17.	36.6/13/ 34.
CO BCKGRD METER/RANGE/PPM	3.0/13/ 3.	3.4/13/ 3.	4.2/13/ 4.	3.5/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	72.9/12/ .31	63.7/11/ .54	76.5/ 3/ 1.40	77.0/12/ .33
CO2 BCKGRD METER/RANGE/PCT	12.6/12/ .04	7.4/11/ .04	4.0/ 3/ .06	14.4/12/ .05
NOX SAMPLE METER/RANGE/PPM	13.4/ 2/ 13.	24.0/ 2/ 24.	45.6/ 2/ 46.	8.6/ 2/ 9.
NOX BCKGRD METER/RANGE/PPM	.7/ 2/ 1.	1.0/ 2/ 1.	1.3/ 2/ 1.	1.2/ 2/ 1.
DILUTION FACTOR	42.68	24.80	9.57	40.23
HC CONCENTRATION PPM	9.	7.	2.	1.
CO CONCENTRATION PPM	52.	10.	13.	30.
CO2 CONCENTRATION PCT	.26	.49	1.34	.28
NOX CONCENTRATION PPM	12.7	23.0	44.4	7.4
HC MASS GRAMS	.99	.89	.27	.14
CO MASS GRAMS	11.38	2.53	3.37	6.62
CO2 MASS GRAMS	911.7	1911.8	5293.1	965.1
NOX MASS GRAMS	4.02	8.17	16.08	2.35
FUEL KG (LB)	.294 (.65)	.605 (1.33)	1.671 (3.68)	.308 (.68)
KW HR (HP HR)	.55 (.73)	1.44 (1.94)	5.05 (6.77)	.56 (.75)
BSHC G/KW HR (G/HP HR)	1.82 (1.36)	.62 (.46)	.05 (.04)	.25 (.19)
BSCO G/KW HR (G/HP HR)	20.84 (15.54)	1.75 (1.31)	.67 (.50)	11.80 (8.80)
BSCO2 G/KW HR (G/HP HR)	1669.74 (1245.13)	1324.41 (987.61)	1048.43 (781.81)	1720.53 (1283.00)
BSNOX G/KW HR (G/HP HR)	7.36 (5.49)	5.66 (4.22)	3.19 (2.38)	4.19 (3.12)
BSFC KG/KW HR (LB/HP HR)	.539 (.885)	.419 (.689)	.331 (.544)	.548 (.902)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.60 (10.19)
BSHC G/KW HR (G/HP HR)	.30 (.23)
BSCO G/KW HR (G/HP HR)	3.14 (2.34)
BSCO2 G/KW HR (G/HP HR)	1195. (891.)
BSNOX G/KW HR (G/HP HR)	4.03 (3.01)
BSFC KG/KW HR (LB/HP HR)	.379 (.622)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.	TEST NO.9 RUN1		
ENGINE MODEL 75 CHEV	DATE 1/25/83		
ENGINE 5.7 L(350. CID) V-8	TIME 3:23	GASOLINE EM-338-F	
CVS NO. 9	DYNO NO. 2	BAG CART NO. 1	

BAROMETER 739.14 MM HG(29.10 IN HG)
DRY BULB TEMP. 19.4 DEG C(67.0 DEG F)

RELATIVE HUMIDITY , ENGINE-30. PCT , CVS-26. PCT
ABSOLUTE HUMIDITY 4.3 GM/KG(30.3 GRAINS/LB) NOX HUMIDITY C.F. .8262

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	698.5 (27.5)	711.2 (28.0)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	419.1 (16.5)	431.8 (17.0)	444.5 (17.5)	419.1 (16.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.9 (111.0)
BLOWER REVOLUTIONS	7165.	8086.	8317.	7159.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	188.5 (6656.)	211.6 (7475.)	216.2 (7637.)	188.0 (6639.)
HC SAMPLE METER/RANGE/PPM	10.0/ 3/ 100.	20.8/ 2/ 21.	14.3/ 2/ 14.	13.4/ 2/ 13.
HC BCKGRD METER/RANGE/PPM	1.1/ 3/ 11.	11.9/ 2/ 12.	11.8/ 2/ 12.	11.8/ 2/ 12.
CO SAMPLE METER/RANGE/PPM	25.6/ 3/ 594.	95.7/13/ 97.	31.0/13/ 29.	29.1/13/ 27.
CO BCKGRD METER/RANGE/PPM	.1/ 3/ 2.	2.3/13/ 2.	3.1/13/ 3.	2.3/13/ 2.
CO2 SAMPLE METER/RANGE/PCT	83.9/12/ .37	67.0/11/ .58	74.9/ 3/ 1.36	74.5/12/ .31
CO2 BCKGRD METER/RANGE/PCT	11.0/12/ .04	6.4/11/ .04	3.0/ 3/ .05	12.1/12/ .04
NOX SAMPLE METER/RANGE/PPM	7.8/ 2/ 8.	19.5/ 2/ 20.	41.0/ 2/ 41.	8.1/ 2/ 8.
NOX BCKGRD METER/RANGE/PPM	.5/ 2/ 1.	.5/ 2/ 1.	.9/ 2/ 1.	.8/ 2/ 1.
DILUTION FACTOR	30.78	22.81	9.79	42.01
HC CONCENTRATION PPM	89.	9.	4.	2.
CO CONCENTRATION PPM	582.	93.	25.	24.
CO2 CONCENTRATION PCT	.33	.54	1.32	.27
NOX CONCENTRATION PPM	7.3	19.0	40.2	7.3
HC MASS GRAMS	9.71	1.15	.46	.20
CO MASS GRAMS	127.82	22.98	6.31	5.33
CO2 MASS GRAMS	1142.0	2091.1	5239.7	946.3
NOX MASS GRAMS	2.18	6.36	13.74	2.17
FUEL KG (LB)	.433 (.95)	.672 (1.48)	1.655 (3.65)	.301 (.66)
KW HR (HP HR)	.64 (.86)	1.48 (1.99)	5.03 (6.75)	.57 (.76)
BSHC G/KW HR (G/HP HR)	15.10 (11.26)	.78 (.58)	.09 (.07)	.36 (.27)
BSCO G/KW HR (G/HP HR)	198.71 (148.18)	15.52 (11.57)	1.25 (.93)	9.37 (6.99)
BSCO2 G/KW HR (G/HP HR)	1775.45 (1323.95)	1411.99 (1052.92)	1040.93 (776.23)	1664.71 (1241.37)
BSNOX G/KW HR (G/HP HR)	3.39 (2.53)	4.30 (3.20)	2.73 (2.03)	3.83 (2.85)
BSFC KG/KW HR (LB/HP HR)	.673 (1.107)	.454 (.746)	.329 (.541)	.530 (.871)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.73 (10.36)
BSHC G/KW HR (G/HP HR)	1.49 (1.11)
BSCO G/KW HR (G/HP HR)	21.02 (15.68)
BSCO2 G/KW HR (G/HP HR)	1219. (909.)
BSNOX G/KW HR (G/HP HR)	3.16 (2.36)
BSFC KG/KW HR (LB/HP HR)	.396 (.651)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.9 RUN1
DATE 1/25/83
TIME 4:02
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 738.63 MM HG(29.08 IN HG)
DRY BULB TEMP. 22.8 DEG C(73.0 DEG F)

RELATIVE HUMIDITY , ENGINE-37. PCT , CVS-28. PCT
ABSOLUTE HUMIDITY 6.6 GM/KG(46.0 GRAINS/LB) NOX HUMIDITY C.F. .8800

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	698.5 (27.5)	711.2 (28.0)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	419.1 (16.5)	431.8 (17.0)	444.5 (17.5)	419.1 (16.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7165.	8085.	8318.	7159.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	188.3 (6652.)	211.4 (7468.)	216.1 (7633.)	188.2 (6646.)
HC SAMPLE METER/RANGE/PPM	23.1/ 2/ 23.	20.6/ 2/ 21.	13.6/ 2/ 14.	13.9/ 2/ 14.
HC BCKGRD METER/RANGE/PPM	12.0/ 2/ 12.	11.8/ 2/ 12.	12.1/ 2/ 12.	12.4/ 2/ 12.
CO SAMPLE METER/RANGE/PPM	85.6/13/ 85.	25.9/13/ 24.	23.8/13/ 22.	44.4/13/ 42.
CO BCKGRD METER/RANGE/PPM	1.6/13/ 1.	1.8/13/ 2.	2.7/13/ 2.	2.3/13/ 2.
CO2 SAMPLE METER/RANGE/PCT	71.8/12/ .30	62.7/11/ .53	73.7/ 3/ 1.34	74.9/12/ .32
CO2 BCKGRD METER/RANGE/PCT	11.4/12/ .04	6.7/11/ .04	3.0/ 3/ .05	12.1/12/ .04
NOX SAMPLE METER/RANGE/PPM	11.8/ 2/ 12.	22.7/ 2/ 23.	40.8/ 2/ 41.	7.5/ 2/ 8.
NOX BCKGRD METER/RANGE/PPM	.7/ 2/ 1.	.7/ 2/ 1.	.9/ 2/ 1.	.9/ 2/ 1.
DILUTION FACTOR	43.02	25.27	9.98	41.54
HC CONCENTRATION PPM	11.	9.	3.	2.
CO CONCENTRATION PPM	83.	22.	19.	39.
CO2 CONCENTRATION PCT	.26	.49	1.30	.28
NOX CONCENTRATION PPM	11.1	22.0	40.0	6.6
HC MASS GRAMS	1.24	1.13	.34	.20
CO MASS GRAMS	18.16	5.34	4.73	8.53
CO2 MASS GRAMS	907.3	1887.5	5138.7	954.7
NOX MASS GRAMS	3.52	7.84	14.55	2.10
FUEL KG (LB)	.296 (.65)	.599 (1.32)	1.623 (3.58)	.305 (.67)
KW HR (HP HR)	.58 (.77)	1.45 (1.95)	5.00 (6.71)	.57 (.76)
BSHC G/KW HR (G/HP HR)	2.15 (1.60)	.78 (.58)	.07 (.05)	.34 (.26)
BSCO G/KW HR (G/HP HR)	31.54 (23.52)	3.68 (2.75)	.95 (.71)	15.00 (11.19)
BSCO2 G/KW HR (G/HP HR)	1575.38 (1174.76)	1300.83 (970.03)	1026.98 (765.82)	1679.45 (1252.36)
BSNOX G/KW HR (G/HP HR)	6.12 (4.56)	5.40 (4.03)	2.91 (2.17)	3.69 (2.75)
BSFC KG/KW HR (LB/HP HR)	.514 (.846)	.413 (.678)	.324 (.533)	.537 (.883)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.60 (10.19)
BSHC G/KW HR (G/HP HR)	.38 (.28)
BSCO G/KW HR (G/HP HR)	4.84 (3.61)
BSCO2 G/KW HR (G/HP HR)	1170. (872.)
BSNOX G/KW HR (G/HP HR)	3.69 (2.75)
BSFC KG/KW HR (LB/HP HR)	.371 (.611)

Note: Intermittant leakage of the air switching valve and malfunction of the idle reset system

*‾LE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.10 RUN1
DATE 1/26/83
TIME 12:57
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 742.44 MM HG(29.23 IN HG)
DRY BULB TEMP. 19.4 DEG C(67.0 DEG F)

RELATIVE HUMIDITY , ENGINE-29. PCT , CVS-27. PCT
ABSOLUTE HUMIDITY 4.1 GM/KG(28.6 GRAINS/LB) NOX HUMIDITY C.F. .8210

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	698.5 (27.5)	711.2 (28.0)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	419.1 (16.5)	431.8 (17.0)	444.5 (17.5)	419.1 (16.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7163.	8083.	8317.	7160.
TIME SECONDS	271.9	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	189.3 (6686.)	212.5 (7507.)	217.2 (7673.)	189.2 (6683.)
HC SAMPLE METER/RANGE/PPM	39.8/ 2/ 40.	17.1/ 2/ 17.	11.4/ 2/ 11.	9.9/ 2/ 10.
HC BCKGRD METER/RANGE/PPM	9.8/ 2/ 10.	9.1/ 2/ 9.	8.7/ 2/ 9.	8.7/ 2/ 9.
CO SAMPLE METER/RANGE/PPM	72.8/11/ 313.	62.5/13/ 60.	20.8/13/ 19.	34.4/13/ 32.
CO BCKGRD METER/RANGE/PPM	.8/11/ 2.	2.3/13/ 2.	2.8/13/ 3.	2.8/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	92.3/12/ .42	67.6/11/ .58	74.7/ 3/ 1.36	78.7/12/ .34
CO2 BCKGRD METER/RANGE/PCT	11.3/12/ .04	6.7/11/ .04	3.0/ 3/ .05	13.8/12/ .05
NOX SAMPLE METER/RANGE/PPM	6.5/ 2/ 7.	21.6/ 2/ 22.	48.1/ 2/ 48.	8.1/ 2/ 8.
NOX BCKGRD METER/RANGE/PPM	.3/ 2/ 0.	.5/ 2/ 1.	.9/ 2/ 1.	.9/ 2/ 1.
DILUTION FACTOR	29.68	22.68	9.83	39.20
HC CONCENTRATION PPM	30.	8.	4.	1.
CO CONCENTRATION PPM	305.	57.	16.	29.
CO2 CONCENTRATION PCT	.38	.54	1.32	.29
NOX CONCENTRATION PPM	6.2	21.1	47.3	7.2
HC MASS GRAMS	3.31	1.03	.45	.16
CO MASS GRAMS	67.29	14.10	4.06	6.36
CO2 MASS GRAMS	1316.8	2121.1	5248.0	1010.9
NOX MASS GRAMS	1.85	7.05	16.13	2.15
FUEL KG (LB)	.452 (1.00)	.677 (1.49)	1.657 (3.65)	.322 (.71)
KW HR (HP HR)	.91 (1.21)	1.56 (2.09)	5.06 (6.79)	.71 (.95)
BSHC G/KW HR (G/HP HR)	3.66 (2.73)	.66 (.49)	.09 (.07)	.22 (.16)
BSCO G/KW HR (G/HP HR)	74.35 (55.45)	9.06 (6.76)	.80 (.60)	8.95 (6.68)
BSCO2 G/KW HR (G/HP HR)	1454.97 (1084.97)	1363.43 (1016.71)	1036.41 (772.85)	1422.70 (1060.91)
BSNOX G/KW HR (G/HP HR)	2.04 (1.52)	4.53 (3.38)	3.19 (2.38)	3.02 (2.25)
BSFC KG/KW HR (LB/HP HR)	.499 (.821)	.435 (.715)	.327 (.538)	.453 (.745)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	8.23 (11.04)
BSHC G/KW HR (G/HP HR)	.60 (.45)
BSCO G/KW HR (G/HP HR)	11.15 (8.31)
BSCO2 G/KW HR (G/HP HR)	1178. (878.)
BSNOX G/KW HR (G/HP HR)	3.30 (2.46)
BSFC KG/KW HR (LB/HP HR)	.377 (.620)

Note: Intermittant leakage of the air switching valve

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.10 RUN1
DATE 1/26/83
TIME 1:37
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 742.19 MM HG(29.22 IN HG)
DRY BULB TEMP. 20.0 DEG C(68.0 DEG F)

RELATIVE HUMIDITY , ENGINE-35. PCT , CVS-26. PCT
ABSOLUTE HUMIDITY 5.1 GM/KG(35.9 GRAINS/LB) NOX HUMIDITY C.F. .8448

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	698.5 (27.5)	711.2 (28.0)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	419.1 (16.5)	431.8 (17.0)	444.5 (17.5)	419.1 (16.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.9 (111.0)
BLOWER REVOLUTIONS	7162.	8083.	8317.	7158.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	189.2 (6682.)	212.5 (7504.)	217.2 (7670.)	188.8 (6667.)
HC SAMPLE METER/RANGE/PPM	16.6/ 2/ 17.	15.2/ 2/ 15.	10.8/ 2/ 11.	9.3/ 2/ 9.
HC BCKGRD METER/RANGE/PPM	8.9/ 2/ 9.	8.6/ 2/ 9.	8.4/ 2/ 8.	8.6/ 2/ 9.
CO SAMPLE METER/RANGE/PPM	60.5/12/ 133.	37.5/13/ 35.	23.9/13/ 22.	35.6/13/ 33.
CO BCKGRD METER/RANGE/PPM	.3/12/ 1.	1.3/13/ 1.	1.8/13/ 2.	2.1/13/ 2.
CO2 SAMPLE METER/RANGE/PCT	73.5/12/ .31	62.0/11/ .52	71.5/ 3/ 1.29	78.7/12/ .34
CO2 BCKGRD METER/RANGE/PCT	11.7/12/ .04	6.7/11/ .04	3.0/ 3/ .05	13.1/12/ .04
NOX SAMPLE METER/RANGE/PPM	10.5/ 2/ 11.	22.8/ 2/ 23.	39.8/ 2/ 40.	7.4/ 2/ 7.
NOX BCKGRD METER/RANGE/PPM	.6/ 2/ 1.	.6/ 2/ 1.	1.0/ 2/ 1.	.9/ 2/ 1.
DILUTION FACTOR	41.30	25.63	10.32	39.20
HC CONCENTRATION PPM	8.	7.	3.	1.
CO CONCENTRATION PPM	130.	33.	20.	31.
CO2 CONCENTRATION PCT	.27	.48	1.25	.29
NOX CONCENTRATION PPM	9.9	22.2	38.9	6.5
HC MASS GRAMS	.86	.85	.40	.10
CO MASS GRAMS	28.74	8.17	4.97	6.73
CO2 MASS GRAMS	939.0	1865.6	4984.5	1016.9
NOX MASS GRAMS	3.03	7.63	13.65	1.99
FUEL KG (LB)	.311 (.69)	.593 (1.31)	1.574 (3.47)	.324 (.71)
KW HR (HP HR)	.69 (.92)	1.53 (2.06)	5.06 (6.78)	.71 (.95)
BSHC G/KW HR (G/HP HR)	1.26 (.94)	.55 (.41)	.08 (.06)	.14 (.11)
BSCO G/KW HR (G/HP HR)	41.77 (31.14)	5.33 (3.97)	.98 (.73)	9.47 (7.06)
BSCO2 G/KW HR (G/HP HR)	1364.55 (1017.55)	1216.71 (907.30)	985.84 (735.14)	1431.21 (1067.25)
BSNOX G/KW HR (G/HP HR)	4.41 (3.29)	4.98 (3.71)	2.70 (2.01)	2.80 (2.09)
BSFC KG/KW HR (LB/HP HR)	.452 (.743)	.387 (.636)	.311 (.512)	.456 (.750)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	7.99 (10.71)
BSHC G/KW HR (G/HP HR)	.28 (.21)
BSCO G/KW HR (G/HP HR)	6.09 (4.54)
BSCO2 G/KW HR (G/HP HR)	1102. (822.)
BSNOX G/KW HR (G/HP HR)	3.29 (2.46)
BSFC KG/KW HR (LB/HP HR)	.351 (.577)

Note: Intermittant leakage of the air switching valve

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.11 RUN1
DATE 1/27/83
TIME 12:40
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 746.25 MM HG(29.38 IN HG)
DRY BULB TEMP. 20.0 DEG C(68.0 DEG F)

RELATIVE HUMIDITY , ENGINE-44. PCT , CVS-19. PCT
ABSOLUTE HUMIDITY 6.5 GM/KG(45.7 GRAINS/LB) NOX HUMIDITY C.F. .8788

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	698.5 (27.5)	711.2 (28.0)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	419.1 (16.5)	431.8 (17.0)	444.5 (17.5)	419.1 (16.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.9 (111.0)
BLOWER REVOLUTIONS	7166.	8087.	8320.	7161.
TIME SECONDS	272.1	307.2	316.2	272.1
TOTAL FLOW STD. CU. METRES(SCF)	190.4 (6725.)	213.8 (7551.)	218.5 (7717.)	189.9 (6708.)
HC SAMPLE METER/RANGE/PPM	13.7/ 3/ 137.	15.9/ 2/ 16.	10.4/ 2/ 10.	10.9/ 2/ 11.
HC BCKGRD METER/RANGE/PPM	.9/ 3/ 9.	9.4/ 2/ 9.	9.2/ 2/ 9.	8.7/ 2/ 9.
CO SAMPLE METER/RANGE/PPM	29.1/ 3/ 679.	55.3/12/ 119.	28.1/13/ 26.	49.5/13/ 47.
CO BCKGRD METER/RANGE/PPM	.3/ 3/ 7.	1.5/12/ 3.	3.1/13/ 3.	3.3/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	93.7/12/ .43	69.1/11/ .60	74.4/ 3/ 1.35	77.1/12/ .33
CO2 BCKGRD METER/RANGE/PCT	11.3/12/ .04	6.6/11/ .04	2.9/ 3/ .04	12.0/12/ .04
NOX SAMPLE METER/RANGE/PPM	6.6/ 2/ 7.	17.5/ 2/ 18.	44.2/ 2/ 44.	8.1/ 2/ 8.
NOX BCKGRD METER/RANGE/PPM	.3/ 2/ 0.	.5/ 2/ 1.	.6/ 2/ 1.	.7/ 2/ 1.
DILUTION FACTOR	26.48	21.80	9.87	40.04
HC CONCENTRATION PPM	128.	7.	2.	2.
CO CONCENTRATION PPM	663.	115.	22.	43.
CO2 CONCENTRATION PCT	.39	.56	1.31	.29
NOX CONCENTRATION PPM	6.3	17.0	43.7	7.4
HC MASS GRAMS	14.09	.85	.27	.26
CO MASS GRAMS	146.98	28.51	5.71	9.56
CO2 MASS GRAMS	1355.3	2207.2	5259.0	1006.1
NOX MASS GRAMS	2.02	6.12	16.04	2.37
FUEL KG (LB)	.514 (1.13)	.711 (1.57)	1.661 (3.66)	.322 (.71)
KW HR (HP HR)	.73 (.97)	1.61 (2.16)	5.07 (6.80)	.72 (.96)
BSHC G/KW HR (G/HP HR)	19.43 (14.49)	.53 (.40)	.05 (.04)	.37 (.27)
BSCO G/KW HR (G/HP HR)	202.60 (151.08)	17.73 (13.22)	1.13 (.84)	13.31 (9.93)
BSCO2 G/KW HR (G/HP HR)	1868.09 (1393.04)	1372.59 (1023.54)	1037.07 (773.34)	1401.18 (1044.86)
BSNOX G/KW HR (G/HP HR)	2.78 (2.08)	3.80 (2.84)	3.16 (2.36)	3.30 (2.46)
BSFC KG/KW HR (LB/HP HR)	.709 (1.165)	.442 (.727)	.328 (.538)	.449 (.738)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	8.12 (10.89)
BSHC G/KW HR (G/HP HR)	1.91 (1.42)
BSCO G/KW HR (G/HP HR)	23.49 (17.51)
BSCO2 G/KW HR (G/HP HR)	1210. (902.)
BSNOX G/KW HR (G/HP HR)	3.27 (2.44)
BSFC KG/KW HR (LB/HP HR)	.395 (.649)

Note: Intermittant leakage of the air switching valve

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.	TEST NO.11 RUN1		
ENGINE MODEL 75 CHEV	DATE 1/27/83		
ENGINE 5.7 L(350. CID) V-8	TIME 1:20	GASOLINE EM-338-F	
CVS NO. 9	DYNO NO. 2	BAG CART NO. 1	
BAROMETER 745.49 MM HG(29.35 IN HG)	RELATIVE HUMIDITY , ENGINE-41. PCT , CVS-21. PCT		
DRY BULB TEMP. 21.7 DEG C(71.0 DEG F)	ABSOLUTE HUMIDITY 6.7 GM/KG(46.6 GRAINS/LB)	NOX HUMIDITY C.F. .8823	

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	698.5 (27.5)	711.2 (28.0)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	419.1 (16.5)	431.8 (17.0)	444.5 (17.5)	419.1 (16.5)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	44.4 (112.0)	46.1 (115.0)	43.3 (110.0)
BLOWER REVOLUTIONS	7159.	8081.	8313.	7157.
TIME SECONDS	272.0	307.0	315.9	272.0
TOTAL FLOW STD. CU. METRES(SCF)	190.0 (6711.)	213.4 (7538.)	218.1 (7703.)	189.9 (6709.)
HC SAMPLE METER/RANGE/PPM	18.0/ 2/ 18.	15.5/ 2/ 16.	10.2/ 2/ 10.	9.2/ 2/ 9.
HC BCKGRD METER/RANGE/PPM	8.6/ 2/ 9.	8.4/ 2/ 8.	8.6/ 2/ 9.	8.6/ 2/ 9.
CO SAMPLE METER/RANGE/PPM	76.3/12/ 178.	48.1/13/ 45.	22.7/13/ 21.	52.0/13/ 49.
CO BCKGRD METER/RANGE/PPM	1.1/12/ 2.	2.4/13/ 2.	2.6/13/ 2.	2.7/13/ 2.
CO2 SAMPLE METER/RANGE/PCT	73.4/12/ .31	62.3/11/ .52	73.7/ 3/ 1.34	77.8/12/ .33
CO2 BCKGRD METER/RANGE/PCT	11.7/12/ .04	6.8/11/ .04	2.8/ 3/ .04	12.0/12/ .04
NOX SAMPLE METER/RANGE/PPM	9.2/ 2/ 9.	20.3/ 2/ 20.	41.0/ 2/ 41.	6.4/ 2/ 6.
NOX BCKGRD METER/RANGE/PPM	.5/ 2/ 1.	.6/ 2/ 1.	.8/ 2/ 1.	.8/ 2/ 1.
DILUTION FACTOR	40.79	25.41	9.98	39.58
HC CONCENTRATION PPM	10.	7.	2.	1.
CO CONCENTRATION PPM	174.	42.	18.	46.
CO2 CONCENTRATION PCT	.27	.48	1.30	.29
NOX CONCENTRATION PPM	8.7	19.7	40.3	5.6
HC MASS GRAMS	1.05	.91	.31	.09
CO MASS GRAMS	38.40	10.55	4.56	10.22
CO2 MASS GRAMS	941.2	1884.8	5196.9	1019.5
NOX MASS GRAMS	2.79	7.10	14.83	1.80
FUEL KG (LB)	.317 (.70)	.600 (1.32)	1.641 (3.62)	.327 (.72)
KW HR (HP HR)	.68 (.91)	1.55 (2.08)	5.06 (6.79)	.70 (.94)
BSHC G/KW HR (G/HP HR)	1.55 (1.15)	.59 (.44)	.06 (.05)	.13 (.09)
BSCO G/KW HR (G/HP HR)	56.41 (42.07)	6.81 (5.08)	.90 (.67)	14.54 (10.84)
BSCO2 G/KW HR (G/HP HR)	1382.77 (1031.13)	1217.40 (907.81)	1026.34 (765.34)	1450.09 (1081.33)
BSNOX G/KW HR (G/HP HR)	4.10 (3.06)	4.59 (3.42)	2.93 (2.18)	2.56 (1.91)
BSFC KG/KW HR (LB/HP HR)	.465 (.765)	.388 (.637)	.324 (.533)	.464 (.764)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	8.00 (10.72)
BSHC G/KW HR (G/HP HR)	.30 (.22)
BSCO G/KW HR (G/HP HR)	7.97 (5.94)
BSCO2 G/KW HR (G/HP HR)	1131. (843.)
BSNOX G/KW HR (G/HP HR)	3.32 (2.47)
BSFC KG/KW HR (LB/HP HR)	.361 (.593)

Note: Intermittant leakage of the air switching valve

APPENDIX B

Computer Printouts for the MVMA Transient Cycle Tests

Note: These data are summarized in Tables 5 and 6 of this report.

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.21 RUN1
DATE 1/ 8/83
TIME 8:26
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 742.70 MM HG(29.24 IN HG)
DRY BULB TEMP. 20.0 DEG C(68.0 DEG F)

RELATIVE HUMIDITY , ENGINE-52. PCT , CVS-39. PCT
ABSOLUTE HUMIDITY 7.7 GM/KG(53.8 GRAINS/LB) NOX HUMIDITY C.F. .9094

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	711.2 (28.0)	723.9 (28.5)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	431.8 (17.0)	469.9 (18.5)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	45.0 (113.0)	48.9 (120.0)	44.4 (112.0)
BLOWER REVOLUTIONS	7163.	8082.	8316.	7157.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	189.6 (6697.)	212.2 (7495.)	214.9 (7589.)	188.8 (6668.)
HC SAMPLE METER/RANGE/PPM	14.0/ 3/ 140.	16.0/ 2/ 16.	10.4/ 2/ 10.	11.5/ 2/ 12.
HC BCKGRD METER/RANGE/PPM	1.1/ 3/ 11.	10.9/ 2/ 11.	10.4/ 2/ 10.	10.2/ 2/ 10.
CO SAMPLE METER/RANGE/PPM	31.4/ 3/ 736.	51.8/12/ 110.	27.3/13/ 25.	39.9/13/ 37.
CO BCKGRD METER/RANGE/PPM	.1/ 3/ 2.	2.3/12/ 4.	4.6/13/ 4.	5.4/13/ 5.
CO2 SAMPLE METER/RANGE/PCT	58.2/11/ .48	77.7/11/ .71	76.4/ 3/ 1.40	87.6/12/ .39
CO2 BCKGRD METER/RANGE/PCT	7.0/11/ .04	7.2/11/ .04	3.3/ 3/ .05	14.0/12/ .05
NOX SAMPLE METER/RANGE/PPM	8.7/ 2/ 9.	17.8/ 2/ 18.	42.1/ 2/ 42.	8.4/ 2/ 8.
NOX BCKGRD METER/RANGE/PPM	.6/ 2/ 1.	.7/ 2/ 1.	.9/ 2/ 1.	1.0/ 2/ 1.
DILUTION FACTOR	23.86	18.52	9.58	34.08
HC CONCENTRATION PPM	129.	6.	1.	2.
CO CONCENTRATION PPM	718.	103.	20.	32.
CO2 CONCENTRATION PCT	.44	.67	1.35	.34
NOX CONCENTRATION PPM	8.1	17.1	41.3	7.4
HC MASS GRAMS	14.16	.70	.13	.17
CO MASS GRAMS	158.47	25.57	5.10	6.97
CO2 MASS GRAMS	1512.4	2604.8	5312.3	1182.1
NOX MASS GRAMS	2.68	6.33	15.43	2.44
FUEL KG (LB)	.569 (1.26)	.835 (1.84)	1.677 (3.70)	.376 (.83)
KW HR (HP HR)	.95 (1.27)	2.06 (2.77)	5.24 (7.02)	.90 (1.20)
BSHC G/KW HR (G/HP HR)	14.91 (11.11)	.34 (.25)	.03 (.02)	.19 (.14)
BSCO G/KW HR (G/HP HR)	166.83 (124.41)	12.39 (9.24)	.97 (.73)	7.77 (5.79)
BSCO2 G/KW HR (G/HP HR)	1592.17 (1187.28)	1261.82 (940.94)	1014.65 (756.62)	1317.01 (982.09)
BSNOX G/KW HR (G/HP HR)	2.82 (2.10)	3.06 (2.29)	2.95 (2.20)	2.72 (2.03)
BSFC KG/KW HR (LB/HP HR)	.599 (.986)	.404 (.665)	.320 (.527)	.419 (.689)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	9.15 (12.27)
BSHC G/KW HR (G/HP HR)	1.66 (1.24)
BSCO G/KW HR (G/HP HR)	21.44 (15.99)
BSCO2 G/KW HR (G/HP HR)	1160. (865.)
BSNOX G/KW HR (G/HP HR)	2.94 (2.19)
BSFC KG/KW HR (LB/HP HR)	.378 (.621)

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.21 RUN1
DATE 1/ 8/83
TIME 9:06
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 742.70 MM HG(29.24 IN HG)
DRY BULB TEMP. 21.7 DEG C(71.0 DEG F)

RELATIVE HUMIDITY , ENGINE-46. PCT , CVS-33. PCT
ABSOLUTE HUMIDITY 7.6 GM/KG(53.2 GRAINS/LB) NOX HUMIDITY C.F. .9072

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	711.2 (28.0)	723.9 (28.5)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	431.8 (17.0)	469.9 (18.5)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.9 (111.0)	45.6 (114.0)	48.9 (120.0)	44.4 (112.0)
BLOWER REVOLUTIONS	7163.	8084.	8317.	7158.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	189.3 (6685.)	211.9 (7484.)	214.9 (7590.)	188.8 (6669.)
HC SAMPLE METER/RANGE/PPM	22.8/ 2/ 23.	16.4/ 2/ 16.	10.9/ 2/ 11.	11.8/ 2/ 12.
HC BCKGRD METER/RANGE/PPM	11.0/ 2/ 11.	10.8/ 2/ 11.	10.5/ 2/ 11.	11.0/ 2/ 11.
CO SAMPLE METER/RANGE/PPM	88.3/12/ 216.	55.8/13/ 53.	26.3/13/ 24.	47.4/13/ 45.
CO BCKGRD METER/RANGE/PPM	2.0/12/ 4.	4.6/13/ 4.	4.6/13/ 4.	4.7/13/ 4.
CO2 SAMPLE METER/RANGE/PCT	83.4/12/ .36	71.0/11/ .62	75.2/ 3/ 1.37	87.8/12/ .39
CO2 BCKGRD METER/RANGE/PCT	13.5/12/ .05	7.3/11/ .04	3.2/ 3/ .05	13.5/12/ .05
NOX SAMPLE METER/RANGE/PPM	11.5/ 2/ 12.	21.1/ 2/ 21.	37.9/ 2/ 38.	8.6/ 2/ 9.
NOX BCKGRD METER/RANGE/PPM	1.0/ 2/ 1.	1.0/ 2/ 1.	1.2/ 2/ 1.	1.1/ 2/ 1.
DILUTION FACTOR	34.58	21.22	9.75	33.91
HC CONCENTRATION PPM	12.	6.	1.	1.
CO CONCENTRATION PPM	208.	48.	20.	40.
CO2 CONCENTRATION PCT	.32	.58	1.33	.34
NOX CONCENTRATION PPM	10.5	20.1	36.8	7.5
HC MASS GRAMS	1.32	.75	.18	.12
CO MASS GRAMS	45.91	11.84	4.88	8.72
CO2 MASS GRAMS	1106.6	2262.2	5220.8	1192.4
NOX MASS GRAMS	3.46	7.41	13.73	2.47
FUEL KG (LB)	.373 (.82)	.720 (1.59)	1.648 (3.63)	.380 (.84)
KW HR (HP HR)	.88 (1.17)	2.00 (2.69)	5.24 (7.02)	.88 (1.18)
BSHC G/KW HR (G/HP HR)	1.51 (1.13)	.37 (.28)	.03 (.03)	.14 (.10)
BSCO G/KW HR (G/HP HR)	52.46 (39.12)	5.91 (4.41)	.93 (.70)	9.89 (7.37)
BSCO2 G/KW HR (G/HP HR)	1264.55 (942.97)	1128.57 (841.58)	997.18 (743.60)	1351.04 (1007.47)
BSNOX G/KW HR (G/HP HR)	3.95 (2.95)	3.70 (2.76)	2.62 (1.96)	2.80 (2.09)
BSFC KG/KW HR (LB/HP HR)	.426 (.701)	.359 (.590)	.315 (.518)	.431 (.708)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	9.00 (12.07)
BSHC G/KW HR (G/HP HR)	.26 (.20)
BSCO G/KW HR (G/HP HR)	7.93 (5.91)
BSCO2 G/KW HR (G/HP HR)	1087. (811.)
BSNOX G/KW HR (G/HP HR)	3.01 (2.24)
BSFC KG/KW HR (LB/HP HR)	.347 (.570)

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.	TEST NO.22 RUN1		
ENGINE MODEL 75 CHEV	DATE 2/ 9/83		
ENGINE 5.7 L(350. CID) V-8	TIME 8:15	GASOLINE EM-338-F	
CVS NO. 9	DYNO NO. 2	BAG CART NO. 1	

BAROMETER 734.57 MM HG(28.92 IN HG)
DRY BULB TEMP. 20.6 DEG C(69.0 DEG F)

RELATIVE HUMIDITY , ENGINE-55. PCT , CVS-56. PCT
ABSOLUTE HUMIDITY 8.6 GM/KG(60.2 GRAINS/LB) NOX HUMIDITY C.F. .9350

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	711.2 (28.0)	723.9 (28.5)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	444.5 (17.5)	469.9 (18.5)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.9 (111.0)	45.0 (113.0)	47.8 (118.0)	44.4 (112.0)
BLOWER REVOLUTIONS	7164.	8084.	8317.	7159.
TIME SECONDS	271.9	307.0	315.9	271.9
TOTAL FLOW STD. CU. METRES(SCF)	187.1 (6609.)	209.5 (7400.)	213.1 (7528.)	186.7 (6593.)
HC SAMPLE METER/RANGE/PPM	11.5/ 3/ 115.	15.8/ 2/ 16.	11.3/ 2/ 11.	13.0/ 2/ 13.
HC BCKGRD METER/RANGE/PPM	1.3/ 3/ 13.	11.9/ 2/ 12.	11.4/ 2/ 11.	11.2/ 2/ 11.
CO SAMPLE METER/RANGE/PPM	29.9/ 3/ 699.	76.4/13/ 75.	26.5/13/ 24.	42.7/13/ 40.
CO BCKGRD METER/RANGE/PPM	.3/ 3/ 7.	2.9/13/ 3.	3.8/13/ 3.	3.5/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	58.7/11/ .48	77.0/11/ .70	77.4/ 3/ 1.42	89.1/12/ .40
CO2 BCKGRD METER/RANGE/PCT	6.9/11/ .04	6.9/11/ .04	3.2/ 3/ .05	13.1/12/ .04
NOX SAMPLE METER/RANGE/PPM	8.0/ 2/ 8.	17.8/ 2/ 18.	37.0/ 2/ 37.	9.2/ 2/ 9.
NOX BCKGRD METER/RANGE/PPM	.5/ 2/ 1.	.5/ 2/ 1.	.6/ 2/ 1.	.5/ 2/ 1.
DILUTION FACTOR	23.90	18.86	9.44	33.29
HC CONCENTRATION PPM	103.	5.	1.	2.
CO CONCENTRATION PPM	673.	70.	20.	36.
CO2 CONCENTRATION PCT	.44	.66	1.37	.35
NOX CONCENTRATION PPM	7.5	17.3	36.5	8.7
HC MASS GRAMS	11.07	.55	.14	.23
CO MASS GRAMS	146.71	17.17	5.00	7.79
CO2 MASS GRAMS	1513.4	2542.9	5355.4	1210.2
NOX MASS GRAMS	2.52	6.49	13.90	2.91
FUEL KG (LB)	.561 (1.24)	.811 (1.79)	1.691 (3.73)	.386 (.85)
KW HR (HP HR)	.93 (1.24)	2.02 (2.71)	5.20 (6.97)	.88 (1.18)
BSHC G/KW HR (G/HP HR)	11.93 (8.90)	.27 (.20)	.03 (.02)	.26 (.19)
BSCO G/KW HR (G/HP HR)	158.19 (117.96)	8.50 (6.34)	.96 (.72)	8.83 (6.58)
BSCO2 G/KW HR (G/HP HR)	1631.75 (1216.80)	1259.21 (938.99)	1030.24 (768.25)	1371.23 (1022.52)
BSNOX G/KW HR (G/HP HR)	2.71 (2.02)	3.22 (2.40)	2.67 (1.99)	3.30 (2.46)
BSFC KG/KW HR (LB/HP HR)	.605 (.994)	.401 (.660)	.325 (.535)	.437 (.718)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	9.03 (12.11)
BSHC G/KW HR (G/HP HR)	1.33 (.99)
BSCO G/KW HR (G/HP HR)	19.57 (14.59)
BSCO2 G/KW HR (G/HP HR)	1177. (877.)
BSNOX G/KW HR (G/HP HR)	2.86 (2.13)
BSFC KG/KW HR (LB/HP HR)	.382 (.628)

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.22 RUN1
DATE 2/ 9/83
TIME 8:55
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 734.82 MM HG(28.93 IN HG)
DRY BULB TEMP. 22.2 DEG C(72.0 DEG F)

RELATIVE HUMIDITY , ENGINE-49. PCT , CVS-53. PCT
ABSOLUTE HUMIDITY 8.4 GM/KG(58.8 GRAINS/LB) NOX HUMIDITY C.F. .9291

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	711.2 (28.0)	723.9 (28.5)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	444.5 (17.5)	469.9 (18.5)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.9 (111.0)	45.6 (114.0)	49.4 (121.0)	44.4 (112.0)
BLOWER REVOLUTIONS	7162.	8081.	8314.	7157.
TIME SECONDS	272.0	307.0	316.0	272.0
TOTAL FLOW STD. CU. METRES(SCF)	187.1 (6610.)	209.2 (7388.)	212.1 (7490.)	186.7 (6594.)
HC SAMPLE METER/RANGE/PPM	25.0/ 2/ 25.	17.4/ 2/ 17.	12.1/ 2/ 12.	14.2/ 2/ 14.
HC BCKGRD METER/RANGE/PPM	12.3/ 2/ 12.	12.2/ 2/ 12.	12.1/ 2/ 12.	12.3/ 2/ 12.
CO SAMPLE METER/RANGE/PPM	91.4/12/ 226.	57.4/13/ 55.	26.2/13/ 24.	49.3/13/ 46.
CO BCKGRD METER/RANGE/PPM	1.0/12/ 2.	2.6/13/ 2.	3.4/13/ 3.	5.5/13/ 5.
CO2 SAMPLE METER/RANGE/PCT	84.3/12/ .37	72.1/11/ .64	75.9/ 3/ 1.38	88.2/12/ .39
CO2 BCKGRD METER/RANGE/PCT	12.5/12/ .04	7.3/11/ .04	3.1/ 3/ .05	13.1/12/ .04
NOX SAMPLE METER/RANGE/PPM	10.4/ 2/ 10.	20.5/ 2/ 21.	39.5/ 2/ 40.	9.5/ 2/ 10.
NOX BCKGRD METER/RANGE/PPM	.5/ 2/ 1.	.5/ 2/ 1.	.7/ 2/ 1.	.6/ 2/ 1.
DILUTION FACTOR	34.04	20.76	9.65	33.68
HC CONCENTRATION PPM	13.	6.	1.	2.
CO CONCENTRATION PPM	219.	51.	20.	41.
CO2 CONCENTRATION PCT	.33	.60	1.34	.35
NOX CONCENTRATION PPM	9.9	20.0	38.9	8.9
HC MASS GRAMS	1.41	.70	.15	.24
CO MASS GRAMS	47.67	12.41	5.00	8.82
CO2 MASS GRAMS	1123.8	2286.0	5213.5	1191.9
NOX MASS GRAMS	3.30	7.44	14.65	2.96
FUEL KG (LB)	.379 (.84)	.727 (1.60)	1.646 (3.63)	.380 (.84)
KW HR (HP HR)	.86 (1.15)	1.98 (2.66)	5.17 (6.93)	.88 (1.17)
BSHC G/KW HR (G/HP HR)	1.64 (1.22)	.35 (.26)	.03 (.02)	.28 (.21)
BSCO G/KW HR (G/HP HR)	55.42 (41.33)	6.26 (4.67)	.97 (.72)	10.08 (7.52)
BSCO2 G/KW HR (G/HP HR)	1306.53 (974.28)	1153.36 (860.06)	1008.74 (752.22)	1362.00 (1015.64)
BSNOX G/KW HR (G/HP HR)	3.83 (2.86)	3.76 (2.80)	2.83 (2.11)	3.38 (2.52)
BSFC KG/KW HR (LB/HP HR)	.441 (.725)	.367 (.603)	.319 (.524)	.435 (.715)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	8.89 (11.92)
BSHC G/KW HR (G/HP HR)	.28 (.21)
BSCO G/KW HR (G/HP HR)	8.32 (6.20)
BSCO2 G/KW HR (G/HP HR)	1105. (824.)
BSNOX G/KW HR (G/HP HR)	3.19 (2.38)
BSFC KG/KW HR (LB/HP HR)	.353 (.580)

TABLE ENGINE EMISSION RESULTS
C-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.23 RUN1
DATE 2/10/83
TIME 8:18
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 737.11 MM HG(29.02 IN HG)
DRY BULB TEMP. 21.1 DEG C(70.0 DEG F)

RELATIVE HUMIDITY , ENGINE-45. PCT , CVS-28. PCT
ABSOLUTE HUMIDITY 7.2 GM/KG(50.7 GRAINS/LB) NOX HUMIDITY C.F. .8974

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	711.2 (28.0)	723.9 (28.5)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	431.8 (17.0)	457.2 (18.0)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.3 (110.0)	45.0 (113.0)	48.9 (120.0)	44.4 (112.0)
BLOWER REVOLUTIONS	7162.	8082.	8317.	7159.
TIME SECONDS	271.9	307.0	316.0	271.9
TOTAL FLOW STD. CU. METRES(SCF)	188.1 (6643.)	210.5 (7435.)	213.5 (7540.)	187.3 (6617.)
HC SAMPLE METER/RANGE/PPM	11.8/ 3/ 118.	17.0/ 2/ 17.	11.9/ 2/ 12.	13.5/ 2/ 14.
HC BCKGRD METER/RANGE/PPM	1.2/ 3/ 12.	12.2/ 2/ 12.	11.1/ 2/ 11.	11.2/ 2/ 11.
CO SAMPLE METER/RANGE/PPM	29.8/ 3/ 696.	88.7/13/ 89.	22.7/13/ 21.	47.2/13/ 44.
CO BCKGRD METER/RANGE/PPM	.1/ 3/ 2.	3.7/13/ 3.	3.7/13/ 3.	5.1/13/ 5.
CO2 SAMPLE METER/RANGE/PCT	58.7/11/ .48	77.5/11/ .71	77.5/ 3/ 1.42	88.7/12/ .39
CO2 BCKGRD METER/RANGE/PCT	7.1/11/ .04	7.1/11/ .04	3.2/ 3/ .05	13.6/12/ .05
NOX SAMPLE METER/RANGE/PPM	8.4/ 2/ 8.	18.4/ 2/ 18.	40.8/ 2/ 41.	9.3/ 2/ 9.
NOX BCKGRD METER/RANGE/PPM	.5/ 2/ 1.	.6/ 2/ 1.	.7/ 2/ 1.	.9/ 2/ 1.
DILUTION FACTOR	23.87	18.64	9.43	33.45
HC CONCENTRATION PPM	107.	5.	2.	3.
CO CONCENTRATION PPM	681.	84.	17.	39.
CO2 CONCENTRATION PCT	.44	.67	1.37	.35
NOX CONCENTRATION PPM	7.9	17.8	40.2	8.4
HC MASS GRAMS	11.55	.66	.24	.28
CO MASS GRAMS	149.24	20.56	4.23	8.55
CO2 MASS GRAMS	1517.0	2576.1	5372.2	1200.4
NOX MASS GRAMS	2.56	6.44	14.72	2.71
FUEL KG (LB)	.564 (1.24)	.823 (1.81)	1.696 (3.74)	.383 (.84)
KW HR (HP HR)	.95 (1.27)	2.05 (2.75)	5.27 (7.07)	.88 (1.18)
BSHC G/KW HR (G/HP HR)	12.16 (9.07)	.32 (.24)	.05 (.03)	.32 (.24)
BSCO G/KW HR (G/HP HR)	157.12 (117.16)	10.03 (7.48)	.80 (.60)	9.69 (7.22)
BSCO2 G/KW HR (G/HP HR)	1597.03 (1190.90)	1257.04 (937.37)	1018.82 (759.73)	1360.10 (1014.22)
BSNOX G/KW HR (G/HP HR)	2.69 (2.01)	3.14 (2.34)	2.79 (2.08)	3.07 (2.29)
BSFC KG/KW HR (LB/HP HR)	.593 (.976)	.402 (.660)	.322 (.529)	.434 (.713)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	9.15 (12.28)
BSHC G/KW HR (G/HP HR)	1.39 (1.04)
BSCO G/KW HR (G/HP HR)	19.94 (14.87)
BSCO2 G/KW HR (G/HP HR)	1165. (869.)
BSNOX G/KW HR (G/HP HR)	2.89 (2.15)
BSFC KG/KW HR (LB/HP HR)	.379 (.622)

TABLE ENGINE EMISSION RESULTS
H-TRANS.

PROJECT NO. 05-4311-005

ENGINE NO.
ENGINE MODEL 75 CHEV
ENGINE 5.7 L(350. CID) V-8
CVS NO. 9

TEST NO.23 RUN1
DATE 2/10/83
TIME 8:56
DYNO NO. 2

GASOLINE EM-338-F
BAG CART NO. 1

BAROMETER 737.87 MM HG(29.05 IN HG)
DRY BULB TEMP. 22.2 DEG C(72.0 DEG F)

RELATIVE HUMIDITY , ENGINE-44. PCT , CVS-38. PCT
ABSOLUTE HUMIDITY 7.6 GM/KG(53.0 GRAINS/LB) NOX HUMIDITY C.F. .9063

BAG RESULTS

BAG NUMBER	1	2	3	4
DESCRIPTION	NYNF	LANF	LAF	NYNF
BLOWER DIF P MM. H2O(IN. H2O)	685.8 (27.0)	711.2 (28.0)	723.9 (28.5)	685.8 (27.0)
BLOWER INLET P MM. H2O(IN. H2O)	406.4 (16.0)	431.8 (17.0)	457.2 (18.0)	406.4 (16.0)
BLOWER INLET TEMP. DEG. C(DEG. F)	43.9 (111.0)	45.0 (113.0)	48.3 (119.0)	44.4 (112.0)
BLOWER REVOLUTIONS	7161.	8082.	8316.	7159.
TIME SECONDS	272.0	307.0	316.0	271.9
TOTAL FLOW STD. CU. METRES(SCF)	187.9 (6638.)	210.7 (7444.)	214.0 (7560.)	187.5 (6624.)
HC SAMPLE METER/RANGE/PPM	23.9/ 2/ 24.	18.3/ 2/ 18.	12.4/ 2/ 12.	12.9/ 2/ 13.
HC BCKGRD METER/RANGE/PPM	11.8/ 2/ 12.	11.4/ 2/ 11.	11.2/ 2/ 11.	11.3/ 2/ 11.
CO SAMPLE METER/RANGE/PPM	83.6/12/ 200.	51.9/13/ 49.	22.0/13/ 20.	67.6/13/ 66.
CO BCKGRD METER/RANGE/PPM	1.3/12/ 2.	3.0/13/ 3.	3.2/13/ 3.	3.6/13/ 3.
CO2 SAMPLE METER/RANGE/PCT	85.4/12/ .38	72.0/11/ .64	72.7/ 3/ 1.32	89.2/12/ .40
CO2 BCKGRD METER/RANGE/PCT	12.8/12/ .04	7.2/11/ .04	2.6/ 3/ .04	13.2/12/ .04
NOX SAMPLE METER/RANGE/PPM	11.6/ 2/ 12.	21.5/ 2/ 22.	38.9/ 2/ 39.	10.0/ 2/ 10.
NOX BCKGRD METER/RANGE/PPM	.9/ 2/ 1.	.9/ 2/ 1.	1.2/ 2/ 1.	1.4/ 2/ 1.
DILUTION FACTOR	33.71	20.81	10.13	33.04
HC CONCENTRATION PPM	12.	7.	2.	2.
CO CONCENTRATION PPM	194.	45.	17.	61.
CO2 CONCENTRATION PCT	.33	.60	1.28	.35
NOX CONCENTRATION PPM	10.7	20.6	37.8	8.6
HC MASS GRAMS	1.35	.91	.28	.21
CO MASS GRAMS	42.50	11.13	4.17	13.35
CO2 MASS GRAMS	1146.8	2300.8	5030.9	1216.8
NOX MASS GRAMS	3.50	7.54	14.03	2.81
FUEL KG (LB)	.384 (.85)	.732 (1.61)	1.588 (3.50)	.390 (.86)
KW HR (HP HR)	.85 (1.14)	1.98 (2.66)	5.23 (7.01)	.87 (1.16)
BSHC G/KW HR (G/HP HR)	1.58 (1.18)	.46 (.34)	.05 (.04)	.24 (.18)
BSCO G/KW HR (G/HP HR)	49.84 (37.17)	5.62 (4.19)	.80 (.60)	15.39 (11.48)
BSCO2 G/KW HR (G/HP HR)	1345.03 (1002.99)	1160.81 (865.62)	962.28 (717.57)	1402.49 (1045.83)
BSNOX G/KW HR (G/HP HR)	4.10 (3.06)	3.81 (2.84)	2.68 (2.00)	3.24 (2.42)
BSFC KG/KW HR (LB/HP HR)	.450 (.740)	.369 (.607)	.304 (.499)	.450 (.740)

TOTAL TEST RESULTS 4 BAGS

TOTAL KW HR (HP HR)	8.93 (11.98)
BSHC G/KW HR (G/HP HR)	.31 (.23)
BSCO G/KW HR (G/HP HR)	7.97 (5.94)
BSCO2 G/KW HR (G/HP HR)	1086. (810.)
BSNOX G/KW HR (G/HP HR)	3.12 (2.33)
BSFC KG/KW HR (LB/HP HR)	.346 (.570)

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

This report describes the laboratory effort toward evaluation of a three-way catalyst and feedback fuel system with a heavy-duty gasoline engine. Described are the efforts toward obtaining a suitable feedback fuel system and the very limited test results obtained using the subsequently selected throttle-body fuel injection system. Average emissions values, with the system only partially optimized, were 0.52 HC, 7.5 CO, and 3.4 NO_x in grams per kilowatt-hour (0.39, 5.6, and 2.5 g/hp-hr).

17. KEY WORDS AND DOCUMENT ANALYSIS

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