1969 Heavy-Duty Engine Baseline Program and 1983 Emission Standards Development

U. S. ENVIRONMENTAL PROTECTION AGENCY

Technical Report

1969 Heavy-Duty Engine Baseline Program and 1983 Emission Standards Development

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I. Foreword

Under the Clean Air Act Amendments (CAAA) of 1977, the U.S. Environmental Protection Agency was tasked to develop revised hydrocarbon and carbon monoxide emission standards for heavy-duty engines for the 1983 model year. The Emission Control Technology Division (ECTD) of EPA's Office of Mobile Source Air Pollution Control was directed to determine these revised emission standards based on the criteria outlined in the Clean Air Act Amendments. Specifically, the Emission Control Technology Division was to measure the HC and CO emission levels of uncontrolled heavy-duty gasoline-fueled engines (model year 1969) and determine the emission standards based on at least a 90 percent reduction from the average of these actually measured emissions.

Consequently, ECTD began a baseline program to procure the engines prescribed by the CAAA (1969 MY) and test the emission levels of these engines to determine the baseline emission levels.

The primary purpose of the 1969 baseline program was to develop the baseline emission levels used to determine the 90 percent reduction. The 90 percent reduction directly represents the HC and CO emission standards which should then be proposed for heavy-duty engines beginning in MY 1983.

The purpose of this technical report is to present the results of the 1969 baseline program and explain the methodology by which the 1983 heavy-duty HC and CO emission standards were calculated.

It includes:

1. Engine procurement and preparation information.

2. Revised cycle statistical validation criteria.

3. Transient and idle test summaries for each engine tested.

4. Derivation of the 1983 standards.

While most of the information in this report has previously been placed in the public docket in various forms, this report provides a complete information base which should facilitate evaluation and comment on the baseline program by HD vehicle/engine manufacturers and other interested parties.

Contributors

The development of this baseline program and the ultimate determination of the baseline emission levels would not have been possible without the dedicated work of the personnel listed below:

Special recognition is due William B. Clemmens who was directly responsible for the success of the baseline program and the development of the transient test procedure. His technical skills and expertise greatly enhanced EPA's acquisition of transient testing capability and the ultimate success of this baseline program was in large part due to his efforts.

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Glossary of Acronyms

A/C	- Advisory Circular
BS	- Brake Specific
BSFC	- Brake Specific Fuel Consumption
CAAA	- Clean Air Act Amendments
CFV	- Constant Flow Venturi
CO	- Carbon Monoxide
CO_2	- Carbon Dioxide
CVS	- Constant Volume Sample
EG&G	- EG&G Automotive Research, San Antonio, Texas
ECTD	- Emission Control Technology Division
EPA	- U.S. Environmental Protection Agency
FTP	- Federal Test Procedure
GVWR	- Gross Vehicle Weight Rating
g/BHP-hr	- Grams per Brake Horsepower per Hour
HC	- Hydrocarbons
HD	- Heavy-Duty
HDV	- Heavy-Duty Vehicle
LDT	- Light-Duty Truck
MVEL	- Motor Vehicle Emissions Laboratory
MY	- Model Year
NOx	- Oxides of Nitrogen
NPRM	- Notice of Proposed Rulemaking
OEM	- Original Equipment Manufacturer
OMSAPC	- EPA Office of Mobile Source Air Pollution Control
ppmC	- Parts per million Carbon

SCI - Systems Control, Incorporated, Livonia, Michigan

SI - Spark Ignition

SwRI - Southwest Research Institute, San Antonio, Texas

II. Summary

The U.S. EPA was mandated by the 1977 Clean Air Act Amendments to determine revised HC and CO emission standards for 1983 model year heavy-duty engines. These revised emission standards were to be based on a 90 percent reduction from the average of actually measured emissions from uncontrolled (1969 model year) gasoline-fueled engines.

To comply with the provisions of the 1977 CAAA, ECTD began a baseline testing program. Under this program, in-use 1969 model year heavy-duty gasoline-fueled engines were procured, brought to manufacturer's specifications, and then were tested for emissions using the transient test proedure and idle test procedure. Twenty-three engines were tested on the transient procedure to determine the baseline emission levels. A total of 64 valid tests were conducted on the transient procedure.

Nineteen engines were tested on the idle test procedure to determine baseline. A total of 55 valid idle tests were achieved.

Based on the results of these emission tests, the average of the actually measured emissions is:

12.74	g/BHP-hr	HC
155.18	g/BHP-hr	CO
9706.7	ppmC	HC idle
4.6590	% (by volume)	CO idle

The CAAA of 1977 require that the 1983 HD emission standards for HC and CO be at least a 90% reduction from these emission levels. Based on this requirement, the 1983 HD emission standards proposed are:

1.3	g/BHP-hr	HC
15.5	g/BHP-hr	CO
970	ppmC	HC idle
0.47	% (by volume)	CO idle

This baseline program also served to gain experience using the transient test procedure, and tolerances for the test were revised from those proposed in Vol. 44, No. 31, Part II of the Federal Register on February 13, 1979 to allow more flexibility in conducting the test.

III. Introduction and Background

The 1977 Amendments to the Clean Air Act, Section 202(a)(3)(ii) require that beginning in model year 1983, both gasoline-fueled and diesel heavy-duty engines meet emission standards for hydrocarbons and carbon monoxide which represent at least a 90% reduction "from the average of the actually measured emissions from heavy-duty gasoline-fueled vehicles or engines, [emphasis added] or any class or category thereof, manufactured during the baseline model year." Part (v) of the same subsection goes on to define baseline model year as ". . . the model year immediately preceding the model in which Federal standards applicable to such vehicle or engine, or class or category thereof, first applied with respect to such pollutant." Using this criterion, EPA determined that 1969 was the baseline model year prescribed by law and established a 1969 baseline testing program.

The goal of this program was to measure the actual HC and CO emission levels for a predetermined sample of 1969 heavy-duty gasoline-fueled engines and then sales-weight the results of these tests to determine the average emissions for model year 1969. This technical report summarizes ECTD's efforts in procuring and testing the 1969 engines used to establish the proposed 1983 heavy-duty engine HC and CO emission standards.

Also included in this report is a summary of the methodology used to derive the HC and CO emission standards which are proposed for 1983 and later-model year heavy-duty engines. On February 13, 1979, EPA published an NPRM (Federal Register Vol. 44, No. 31, Part II) which included preliminary HC and CO emission standards of 1.4 g/BHP-hr (lower limit of .76 g/BHP-hr for HC) and 14.7 g/BHP-hr (lower limit of 11.4 g/BHP-hr for CO). In addition, preliminary idle standards of 1400 ppmC HC (lower limit of 530 ppmC) and 0.55% CO (lower limit of 0.30%) were also published. Preliminary levels and lower limits were proposed because the baseline testing program used to derive the final proposed standards was not yet completed. At the time the NPRM was published, only 12 baseline engines had been tested. The baseline testing program is now complete and the proposed final emission standards have been derived. These final emission and idle standards are not below the lower limits initially proposed and hence are acceptable in that respect.

Although these finalized standards were made public prior to the Heavy Duty Hearings of May 14 and 15, 1979, this report gives the engine manufacturers and all other interested parties the information necessary to allow them to comment on ECTD's selection, procurement, and testing techniques as well as the method by which the final proposed standards were derived.

This report is divided into two main parts: the text and the appendices. The text of the report discusses the vehicle/engine selection and procurement efforts of ECTD and its contractors, Systems Control Inc. and EG & G Automotive Research, as well as the engine preparation and testing programs at EPA/MVEL, and Southwest Research Institute. The last section of the text includes a presentation and discussion of the 1969 emissions data used in determining the 90% reduction which is used to determine the proposed emission standards for 1983.

The appendices to this report, available upon request, contain more detailed information on the procurement contracts and specific procurement, inspection, and preparation data for the baseline engines, as well as test by test data on the baseline engines.

IV. Discussion

A. Vehicle/Engine Selection and Procurement

1. 1969 Sales Data and Sampling Plan

To establish the HC and CO emission standards for 1983 heavy-duty engines, it was necessary to test the emission levels of 1969 heavy-duty engines.

To determine the average of actually measured emissions, ECTD first gathered the sales data by engine CID for each manufacturer's 1969 model year sales. This sales data, shown in Table IV-A-1, was supplied by the vehicle/engine manufacturers and MVMA at the request of ECTD, beginning in October 1977. The market shares for each of the manufacturer's engine lines were determined from this data.

Using this sales information, a sampling plan was constructed to determine which engines, and how many of each engine line, would be statistically desirable if between twenty and fifty engines were tested. A preliminary sample size of 25 engines was chosen to construct this sampling plan. However, the number of engines ultimately used in the baseline would be based primarily on the trend of the emission results with cost, time, and engine availability as other limiting factors. The sampling plan shown in Table IV-A-2 was constructed by multiplying the market percentage of each engine by twenty-five and then using the integer range around that number. For example, (0.059) x (25) = 1.475, or a (1-2) range for the sample. The desired sample was further constrained by not permitting more engines from any manufacturer than the number shown for each manufacturer in column 5 of Table IV-A-2.

Once the sampling plan was finalized, the next step was to determine the means by which the desired engines could be procured for testing.

In the fall of 1977, ECTD first considered testing manufacturer supplied 1969 heavy-duty gasoline-fueled engines. These engines would not have been production engines but would have been new engines built as near to 1969 specifications as possible. However, there was no guarantee that these engines would have been close enough to 1969 specifications to make them acceptable. Due to the non-availability of some original equipment carburetors and distributors it was very unlikely the 1969 specifications could have been met, especially by all four manufacturers on all engine lines. This alternative was rejected by OMSAPC for the reasons cited above and for another very important reason. EPA interpreted the provisions of the 1977 Clean Air Act Amendments to mean actual 1969 production engines and not new engines built to 1969 specifications.

Table IV-A-1

1969 Sales Data

Manufacturer	Engine	Sales	% of Market
Chrysler	318-3	10,850	3.1
9.3%	318-1	10,150	2.9
	361	7,000	2.0
	383	2,000	0.6
	413	1,500	0.4
	225	1,000	0.3
Ford	330	50,200	14.4
33.5%	360	21,300	6.1
	361	17,300	5.0
	300	14,200	4.1
	391	6,700	1.9
	477	2,600	0.7
	390	2,300	0.7
	534	2,000	0.6
GM	350-2	47,000	13.5
39.3%	366	22,000	6.3
	292	18,000	5.2
	351C	12,000	3.6
	250	10,000	2.9
	307	9,000	2.6
	305C	6,600	1.9
	477	6,300	1.8
	350-4	3,000	0.9
	396	2,000	0.6
IHC	V345	20,500	5.9
14.7%	V304	17,300	5.0
	V392	7,600	2.2
	RD450	3,350	1.0
	VS478	2,000	0.6
Others*		11,334	3.2
3.2%			
Total		347,584	100%

* Others as shown here represents sales of small volume engines whose individual percentages in the 1969 market were insignificant.

Table IV-A-2

Initial Sampling Plan

Manufacturer	Engine	Sales	% of Market	Sampling Target Range
Chrysler (9.3%)	318-3	10,850	3.1	0-1
	318-1	10,150	2.9	0-1
	361	7,000	2.0	0-1
	383	2,000	0.6	0-1
	413	1,500	0.4	0-1
	225	1,000	0.3	0-1
			Total	(2-3)
Ford (33.5%)	330	50,200	14.4	3-4
	360	21,300	6.1	1-2
	361	17,300	5.0	1-2
	300	14,200	4.1	1-2
	391	6,700	1.9	0-1
	477	2,600	0.7	0-1
	390	2,300	0.7	0-1
	534	2,000	0.6	0-1
			Total	(8-9)
GM (39.3%)	350-2	47,000	13.5	3-4
	366	22,000	6.3	1-2
	292	18,000	5.2	1-2
	351C	12,000	3.6	0-1
	250	10,000	2.9	0-1
	307	9,000	2.6	0-1
	305C	6,600	1.9	0-1
	477	6,300	1.8	0-1
	350-4	3,000	0.9	0-1
	396	2,000	0.6	0-1
			Total	(9-10)
IHC (14.7%)	V345	20,500	5.9	1-2
	V304	17,300	5.0	1-2
	V392	7,600	2.2	0-1
	RD450	3,350	1.0	0-1
	VS478	2,000	0.6	0-1
			Total	(3-4)

To comply with this interpretation of Congressional intent, a program was undertaken to procure actual in-use 1969 heavy-duty engines. The engines sought for the baseline were selected based on overall engine operating condition and closeness to OEM configuration but not on the vehicle body type, function, or usage pattern.

2. Selection Criteria

The following criteria were established to identify potential baseline engines:

(1) All engines must be 1969 Model Year and should be installed in a vehicle registered as a 1969 model year vehicle with a GVWR greater than 8,500 lb.

(2) The test engines must be in good operating condition, must be in their original configuration (i.e., must have original carburetor, distributor, and engine block), must not exhibit evidence of excessive oil consumption, and should not have been subjected to more than 80,000 miles of operation.

(3) The engine's original carburation and ignition system should not have been modified from OEM specifications.

(4) The engines shall not have received a major overhaul (i.e., valve grind, valve replacement, or compression rings replacement).

EPA realized that engine selection was a critical element in establishing a valid baseline of 1969 model year gasoline-fueled heavy-duty engines. The engines inspected were evaluated according to the selection criteria outlined above, and then placed into Class A, B, or C, depending upon how closely the selection criteria were met. Classes A, B, and C were defined as:

Class"A" - Engine is in its original configuration, meaning it has never been overhauled, rebuilt or modified, it has the original carburetor, distributor, cylinder head and intake manifold, and has never had the carburetor modified (i.e., rebuilt with different jet sizes, power valve, choke arrangement, governor, etc.). Engine does not currently need an overhaul or major repair and has not accumulated more than 80,000 miles;

Class"B" - Engine has been overhauled, but is in good operating condition, and has its original carburetor, distributor, heads, and intake manifold. Engine has not accumulated more than 80,000 miles since being overhauled;

Class"C" - Engine is in its original configuration, as in Class A, but needs major repairs, or has accumulated greater than 80,000 miles.

The engine selection process used by ECTD and its contractor, SCI, consisted of three main parts: initial screening, physical inspection, and diagnostic evaluation. Initial screening, usually by telephone, consisted of questioning the vehicle owners as to the vehicle make and GVWR, mileage, engine displacement, past maintenance history, and general operating condition of the engine. If maintenance records were available, the owners were requested to supply copies of these records, or at a minimum, allow inspection of these records.

Vehicles which passed the initial screening process were then inspected by a mechanic to verify the initial screening information and record any pertinent information. The engine was started and observed for proper operation in an attempt to eliminate engines with obvious problems. A compression check was done on many engines at this point. Finally, the distributor and carburetor found on the engine were verified as original and proper by using part numbers. This was accomplished either through direct communication with the manufacturer, or by using service manuals. If, at this point, all of the selection criteria were met, the vehicle was procured by lease, loan, or outright purchase.

The final step in the selection process was a major diagnostic evaluation and tune-up of the engine. During this final phase the engines were cleaned and given a compression check if this had not been done earlier. Included in the engine diagnosis was an evaluation of the ignition system, spark plug checks, fluid level check, compression check, etc. The engines also received a tune-up in which the ignition wires, spark plugs, PCV valve, belts, and hoses were replaced. The rotor, points, condensor and cap were replaced and the oil, oil filter, gas filter, and air filter were changed. In addition, any other non-emission-related part considered defective was replaced.

Manufacturers' service manuals were used to obtain engine tune-up specifications and in some cases the manufacturers provided these tune-up specifications. Initially, carburetors and distributors were removed from the engines to be checked for proper functioning and to determine if they met original specifications. The necessary equipment was not available at SCI or EPA/MVEL, so the manufacturers were requested to flow the carburetors and test the distributors. If a carburetor or distributor was found to be out of specifications, then the required overhaul or rebuild was done by the manufacturer when possible. This distributor and carburetor checking process was very time consuming due to tight scheduling at manufacturer's facilities. As a result of these delays, the carburetors and distributors of all baseline engines were not checked at the manufacturer facilities. It should be emphasized that the operation of all carburetors and distributors was inspected by EPA/MVEL and corrected if necessary. The carburetor flow curves and distributor curves for several baseline engines are shown in Appendix I.

3. Procurement Actions

Several procurement actions were instituted to obtain the initial 25 baseline engines. These consisted of actions by ECTD and ECTD's authorized contractors, SCI, and EG & G.

To expedite the procurement of baseline vehicles and get the 1969 baseline program underway, procurement actions were started by ECTD personnel in October 1977. ECTD contacted State and Federal agencies and the Armed Forces to determine the availability of 1969 model year vehicles. The first successful procurement action was completed on December 19, 1977, when baseline engine number one was procured (see Table IV-A-3).

In February 1978, SCI (formerly Olson Labs) was awarded EPA Contract No. 68-03-2412, Task Order 7, Location and Source Search for 1969 Model Year Heavy-Duty Vehicles. The purpose of this contract was to assess the availability of 1969 HD gasoline-fueled vehicles having a GVWR between 16,000 and 33,000 pounds. Availability was defined to mean that an arrangement (i.e., lease, borrow, etc.) could be made to remove the engine for performance testing on an engine dynamometer. The goal of Task Order 7 was to identify 100 HD engines which met the selection criteria outlined above. The scope of work for Contract No. 68-03-2412, Task Order 7, found in Appendix I, more fully outlines the provisions of this contract. This task order was successfully completed and the final report was accepted by ECTD on June 15, 1978. Included in Appendix I to this technical report is a copy of the final report for this contract and a copy of the contact and inspection sheets for the engines ultimately included in the baseline.

Also in February 1978, EPA Contract No. 68-03-2411, Task Order 10, Heavy-Duty Vehicle Engine Emissions Baseline Testing Program, was awarded to SCI. The purpose of this task order was to provide 15 qualified original equipment 1969 HD test engines, identified by ECTD, in the proper test configuration to the EPA/MVEL in Ann Arbor. The contractor was responsible for transporting the vehicle to SCI, removing the engine from

Table IV-A-3

Final 1969 Baseline Engines

Baseline Engine No.	Engine	Mileage	Model	Body Type	Selection Category	Source	Date Procured	Procurement Method
1	Dodge 225	16,271	D500	Stake Truck	A	MI National Guard Camp Grayling, MI	12-19-77	Loan to EPA
2	IHC 392	34,611	Loadstar 1800	Van	A	GSA Navy Yard Motor Pool, Wash. D.C.	2-17-78	Loan, Task 10
3	Ford 391	62,746	F750	Dump Truck	A	Mr. J.S. Wright Livonia, MI	4-14-78	Lease, Task 10
4	IHC 304	30,445	Loadstar 1600	Van	A	GSA Navy Yard Motor Pool, Wash. D.C.	4-12-78	Loan, Task 10
5	Ford 330	68,000	B700	School Bus	A	Mr. L. Patrias Westland, MI	5-08-78	Lease, Task 10
6	GM 351	53,627	5500	School Bus	A	Mr. L. Patrias Westland, MI	5-24-78	Lease, Task 10
7	Ford 330	78,849	B700	School Bus	A	Hamilton Com. Schls. Hamilton, MI	6-27-78	Loan, Task 10
8	Chev 350	54,721	C-50	School Bus	A	W. Central Schls. Anderson, IN	7-13-78	Loan, Task 10
9	Dodge 318-3	22,224	500	School Bus	A	Fairlane Com. Church W. Dearborn, MI	6-20-78	Lease, Task 10
10	IHC 345	45,000	C1800	Tractor	A	US Army Ft. Campbell, KY	6-5-78	Loan, Task 10
11	Chev 350	40,705	C-50	Van	A	GSA, Cleveland, OH	3-21-78	Loan, Task 10
12	Ford 300	16,117	B-600	School Bus	A	State of MI Lansing, MI	8-21-78	Loan, Task 10
13	IHC 345	88,000	Loadstar 1600	School Bus	C	Martin Schls. Martin, MI	10-6-78	Purchase, SCI C# 68-03-2715
14	Chev 366	98,000	C-50	School Bus	C	Plymouth Schls. Plymouth, MI	10-13-78	Purchase, SCI C# 68-03-2715

Table IV-A-3 (Cont'd)

Final 1969 Baseline Engines

Baseline Engine No.	Engine	Mileage	Model	Body Type	Selection Category	Source	Date Procured	Procurement Method
15	Ford 361	65,537	B700	School Bus	A	Taylor Cen. Baptist Church, Taylor, MI	10-27-78	Lease, SCI C# 68-03-2715
16	Ford 360	81,464	F250	Pick-up	B	Mr. D. Woolett San Antonio, TX	10-03-78	Lease, EG&G C# 68-03-2683
17	Chev 292	46,200	C-30	Pick-up	A	E & M Motor Sales Detroit, MI	12-06-78	Purchase, SCI C# 68-03-2683
18	Dodge 318-1	37,526	D200	Pick-up	A	Mr. J. Stanley San Antonio, TX	8-24-78	Lease, EG&G C# 68-03-2683
19	Ford 361	93,430	B750	School Bus	C	Southfield Pub Schls Southfield, MI	12-14-78	Purchase, SCI C# 68-03-2715
20	Ford 360	87,750	F250	Pick-up	C	Mr. R. Pfluger San Antonio, TX	11-16-78	Lease, EG&G C# 68-03-2683
21	Chev 350	57,000	C-50	School Bus	A	W. Central Schls. Anderson, IN	11-13-78	Purchase, SCI C# 68-03-2715
22	Dodge 361	85,000	C-700	Dump Truck	C	City of Huntington Woods, MI	1-05-79	Purchase, SCI C# 68-03-2715
23	Chev 366	109,000	C-50	School Bus	C	Plymouth Schls. Plymouth, MI	10-13-78	Purchase, SCI C# 68-03-2715

the chassis, supplying the engine to the EPA laboratory in the proper test configuration, reinstalling the engine into the chassis, and returning the vehicle to its owner. The scope of work for Task Order 10, found in Appendix I more fully outlines the provisions of this contract.

This task order was successfully completed and the final report accepted by ECTD on November 8, 1978. Included in Appendix I to this technical report is a copy of the final report on this contract and a copy of the inspection and tune-up sheets for the engines ultimately included in the baseline.

A third contract with SCI, EPA Contract No. 68-03-2715, Procurement of Heavy-Duty Vehicles and Preparation of Engines for Baseline Emissions Testing, was awarded on September 14, 1978 for procurement of additional baseline vehicles. The purpose of this contract, as regards the 1969 baseline, was generally similar to Task Order 10 outlined above, except that of the required 15 engines to be procured, prepared, and delivered, 10 would be delivered to EPA/ MVEL, and 5 to SwRI for testing at these facilities. The specifics of this contract are in the Scope of Work for Contract No. 68-03-2715, found in Appendix I. This contract is not yet closed out because it also includes procurement of 1973 engines for the HD NOx baseline program. The tune-up and inspection sheets for the engines procured under this contract and ultimately included in the baseline are found in Appendix I.

4. Problems Encountered

In the period beginning October 1977 and ending January 1979, ECTD and its contractor made every effort to procure engines which met all of the selection criteria outlined on page 7. However, due to time, budget, engine availability, and sampling plan constraints, all engines included in the baseline did not satisfy all of the selection criteria necessary to qualify as class "A" engines.

Specifically, of the twenty-three engines included in the baseline, seven had accumulated more than 80,000 miles (see Table IV-A-3). The carburetors and/or distributors on some engines either were replaced by new original equipment parts supplied by the manufacturers or rebuilt to bring their performance characteristics nearer to manufacturer's specifications.

Also, baseline engine 16, a Ford 360, had received a valve job at 75,000 miles. This vehicle odometer read 81,464 at the time of procurement. Although this valve job made this a class "B" engine, ECTD felt that it was important to include this engine due to its high sales. As will be shown later, this engine's emissions were not unrepresentative of this engine line.

Finally, when engines required by the sampling plan could not be procured by the previously described method, ECTD chose another procurement route. If a particular heavy-duty engine could not be procured from a heavy-duty vehicle, but the same engine, identical in all respects, was also sold in light-duty trucks, then the engine was procured from a light-duty truck under EPA Contract No. 68-03-2683 with EG & G Automotive Research of San Antonio, Texas. This method was used to procure three of the baseline engines which then underwent the normal inspection and tune-up procedures.

5. Result of Selection and Procurement Actions

The procurement efforts described above resulted in the twenty-three baseline engines shown in Table IV-A-3. Every effort was made to bring these engines to as close to original configuration as possible. Table IV-A-4 outlines the steps which were taken to prepare each baseline engine for testing. The condition of these baseline engines is attested to by the fact that none of the twenty-three engines experienced a mechanical breakdown or failure during engine testing. All were in good operating condition and tuned to manufacturer specifications.

In closing this section, it might be constructive to compare ECTD's procurement efforts to the sampling plan originally established to guide this effort. The original sampling plan called for ECTD to initially consider a sample of twenty-five engines which were sold in 1969 gasoline-fueled HD vehicles. Of the 25 engines initially desired, only 23 were included in this baseline program. As will be shown in section C, only 23 engines were necessary to establish dependable baseline results. The mileage criteria, less than 80,000 miles, was met by 70% of the sample used. Figure IV-A-1 shows the variation in the total miles accumulated on the 23 baseline engines. 87% of the engines used were actually taken from heavy-duty vehicles; 13% were heavy-duty engines taken from a light-duty truck chassis. Only one engine had undergone a major rebuild.

Finally, Table IV-A-5 compares the sampling plan (Table IV-A-2) to the final baseline (Table IV-A-3). Table IV-A-5 shows that the guidance of the initial sampling plan was followed closely. Small sales volume, large cubic inch displacement engines were not available for this baseline program. However, the sales-weighting used to determine the average emissions would have minimized the impact of these larger engines on the final baseline results. ECTD's procurement efforts were highly satisfactory in light of the goals established. Over 80% of the 1969 market was represented by the engines procured, and all engines were brought near to OEM specifications prior to testing.

Table IV-A-4

Baseline Engine Maintenance Summary

Engine#/Model	Pre-Testing Restorative Maintenance
1. Dodge 225-1	Major tune-up*; replaced intake manifold gasket and 2 broken studs on intake manifold.
2. IHC 392	Major tune-up; carburetor flow checked and adjusted at IHC-Fort Wayne. Distributor replaced with OEM part supplied by IHC-Fort Wayne.
3. Ford 391	Major tune-up; carburetor and distributor checked and adjusted by Ford.
4. IHC 304	Major tune-up; carburetor and distributor checked and adjusted by IHC.
5. Ford 330	Major tune-up; right cylinder head gasket and right intake manifold gasket replaced; carburetor flow checked and adjusted by Ford.
6. GM 351	Major tune-up; all hoses replaced; distributor replaced with OEM part supplied and adjusted by GMC; manual choke installed.
7. Ford 330	Major tune-up; carburetor and distributor checked and adjusted by Ford.
8. GM 350	Major tune-up; fuel pump replaced.
9. Chrysler 318-3	Major tune-up; distributor and carburetor checked and adjusted at Chrysler; Chrysler engineer assisted in pre-test adjustment of governor.
10. IHC 345	Major tune-up; carburetor and distributor checked and adjusted at IHC.
11. GM 350	Major tune-up; oil pan and gasket replaced; carburetor replaced with OEM model supplied by the manufacturer.
12. Ford 300	Major tune-up; accelerator pump replaced.

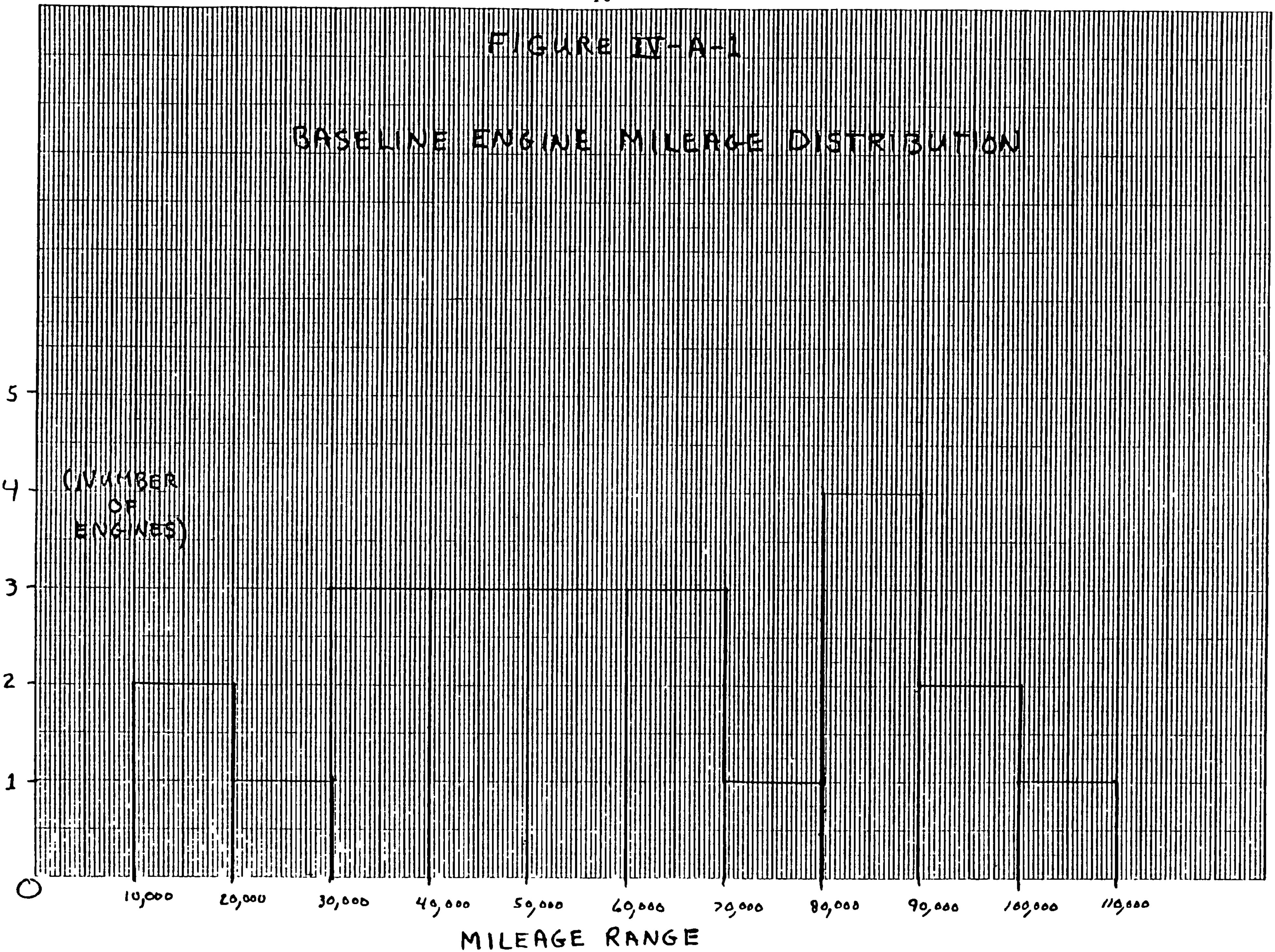


FIGURE IV-A-1
BASELINE ENGINE MILEAGE DISTRIBUTION
(NUMBER OF ENGINES)
5
4
3
2
1
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
MILEAGE RANGE

Table IV-A-5

Sampling Plan vs. Baseline Engines Procured

Manufacturer	Engine	Sampling Target Range	Actual Procurement
Chrysler	318-3	0-1	1
	318-1	0-1	1
	361	0-1	1
	383	0-1	0
	413	0-1	0
	225	0-1	1
Total		(2-3)	4
Ford	330	3-4	2
	360	1-2	2
	361	1-2	2
	300	1-2	1
	391	0-1	1
	477	0-1	0
	390	0-1	0
	534	0-1	0
Total		(8-9)	8
General Motors	350-2	3-4	3
	366	1-2	2
	292	1-2	1
	351C	0-1	1
	250	0-1	0
	307	0-1	0
	305C	0-1	0
	477	0-1	0
	350-4	0-1	0
	396	0-1	0
Total		(9-10)	7
IHC	V345	1-2	2
	V304	1-2	1
	V392	0-1	1
	RD450	0-1	0
	VS478	0-1	0
Total		(3-4)	4

B. Engine Testing

1. Test Sites

The 1969 Heavy Duty Baseline Testing Program was undertaken primarily at EPA's Motor Vehicle Emissions Laboratory in Ann Arbor, Michigan. Twenty-three engines were tested over the course of fifteen months; twenty-two were tested on one of ECTD's two transient dynamometers; the remaining engine was tested under contract by the Southwest Research Institute (SwRI) in San Antonio, Texas.

Baseline testing at EPA began in March 1978 upon the attainment of transient dynamometer testing capability in a single test cell (Cell 3). The second test cell (Cell 4) was upgraded for transient control in August, 1978; following correlation testing work, Cell 4 was brought on line into the program.

ECTD Test Cells 3 and 4 are adjacent, separated only by a twelve-foot-wide motor generator room. Each test cell utilized its own double-ended dynamometer, water coolant system, instrumentation, and ambient air handling/humidity conditioning systems. Both cells were controlled by a single computer, and emissions were measured using the same CFV-CVS unit.

Under contract by ECTD, SwRI developed both gasoline and diesel engine dynamometer test cells capable of transient operation. The purpose of the contract was two-fold: 1) to establish the fact that an independent laboratory could achieve transient capability with a minimum of ECTD guidance in a reasonable length of time, and 2) to provide a site for future transient baseline testing. Other engines were tested at SwRI upon achievment of transient capability; these were primarily current technology engines used for correlation attempts between EPA and SwRI. (Correlation testing between EPA and SwRI will be summarized in a separate technical report. However, correlation for transient and modal testing for the 1969 gasoline baseline has been satisfactorily established.

2. Test Procedure

Testing in the 1969 baseline program involved three separate test procedures, the transient test procedure (Reference Federal Register Vol. 44, No. 31, February 13, 1979), the 1979 9-mode FTP (Reference Federal Register Vol. 42, No. 174, September 8, 1977), and an idle test procedure (Reference Federal Register Vol. 44, No. 31, February 13, 1979). Time was also taken during the program for various emission sensitivity tests, to assess the impact on transient emissions of variations in the test cycle. In addition, several current technology engines were tested for correlation and technology assessment purposes

The transient procedure was identical to that described in the February 13, 1979 NPRM with two exceptions:

a) Four separate bag samples were taken during each hot and cold cycle (as opposed to the recommended one), this was done so that emission data could also be collected for the separate urban and highway segments within the total cycle.1/

b) The regression line tolerances specified as strict criteria for the validation of transient tests were judged too restrictive based upon the experience acquired in the baseline program, and were relaxed. (See Table IV B-1.)

The proposed criteria in the NPRM were derived prior to the accumulation of substantial transient testing data. Based upon a comprehensive review of the baseline data, use of the stricter NPRM criteria led to significantly higher void rates, with no apparent gain in emission repeatability or test quality.

These higher void rates were due primarily to control system limitations. The ECTD transient controller represented a first attempt, prototype system. Statistical reduction of tests performed at SwRI under a control system of different design (see Section 3), indicated a somewhat better control capability, especially for engines with a high degree of throttle performance nonlinearity. There is reason to believe that as future transient control systems are refined, no real difficulty should be experienced in meeting the statistical requirements of the February 13, 1979 NPRM. However, based upon the observation that emission sensitivity to the slightly relaxed criteria appeared to be minimal, it is recommended that the statistical criteria be relaxed prior to inclusion in the Final Rulemaking Action. The tolerances presented in Table IV B-1 are adequate to guarantee repeatable and representative emission results. These tolerances should be subject to future revision, however, if they prove inadequate due to the effects of advanced emission control technology on the repeatability of the test procedure.

1/ Brake specific emissions for each bag were combined to produce a composite brake specific emission number for the entire hot or cold cycle. This was mathematically and experimentally equivalent to a single bag result.

Table IV B-1

NPRM Regression Line Tolerances

	Speed	Torque	Brake Horsepower
Standard Error of Estimate (SE) of y on x	100 rpm	10% of max. engine torque (in ft-lbs)	5% of max. brake horsepower
Slope of the Regression Line, m	0.970-1.020	0.850-1.020	0.900-1.020
Coefficient of Determination, r^2	0.9700 1/	0.8800 1/	0.9200 1/
y Intercept of the Regression Line, b	± 50 rpm	± 10.0 ft-lbs	± 5.0 BHP

Revised Cycle Performance Regression Line Tolerances

	Speed	Torque 2/	Brake Horsepower
Standard Error of Estimate (SE) of y on x	100 rpm	13% of max. engine torque (in Ft-lbs.)	7% of max. brake horsepower
Slope of the Regression Line, m	0.970-1.030	0.83-1.03 (hot) 0.77-1.03 (cold)	0.89-1.03 (hot) 0.87-1.03 (cold)
Coefficient of Determination, r^2	0.9700 1/	0.8800 (hot) 1/ 0.8500 (cold) 1/	0.9100 1/
y Intercept of the Regression Line, b	± 50 rpm	± 15.0 ft-lbs	± 5.0 BHP

1/ Minimum

2/ In addition to the torque points not included in the regression per the February 13, 1979 NPRM, i.e., 1) all torque points measured during the initial 24 ±1 second idle period of the cold and hot start cycle, and 2) all torque points where the throttle is wide open and a negative torque error occurs, an additional exclusion of torque points is permitted. These additional points are. 3) all torque points measured when negative torque (motoring) is commanded and the throttle is completely closed.

The 9-mode test procedure used was identical to that specified in the Federal Register (Vol. 42, No. 174, September 1977) with the following exceptions:

a) Only a single 9-mode cycle was run; this was done with a warm engine (Engine oil temperature over 200°F).

b) Emission measurements were taken by the CVS-CFV bag technique, as opposed to raw exhaust analysis. In order to assure adequate sample volumes in the bags, sample modes of five minutes length were performed, as opposed to the one minute modes of the federal certification procedure.1/

Idle test data was taken in accordance with the February 13, 1979 NPRM, employing the CVS-CFV bag sampling technique, with the ratio of the concentrations of raw CO_2 to dilute sample CO_2 used for dilution factor determination. In addition to the idle mode, however, three other modes were tested for emissions. An overview of the test procedure is presented in Table IV B-2. These additional modes were sampled using the same procedure as the idle mode.

Table IV B-2

Idle Test Procedure

Mode	RPM	% Max Torque @RPM	Mode Length (minutes)
1	2,500	0	5
2	Idle	0	5
3	2,200	55% @ 2,200	5
4	1,700	43% @ 1,700	5

In addition to the three primary test procedures, various other tests were performed, primarily on current technology engines. These tests usually involved consecutive hot starts (hot start transient cycles with twenty-minute soak time between runs.) A single test parameter (e.g., total integrated brake horsepower-hour, engine temperature, throttle aggressiveness, ambient humidity, calibration settings, etc.) would be varied and its impact on engine emissions assessed. These tests were useful in assessing emission sensitivity to variations in the cycle

1/ Test results from current technology engines tested under this modified test procedure showed negligible variation from the manufacturers' test results, obtained using the raw exhaust, certification method.

performance regression statistics and to variations in other cycle parameters. Results of these test programs will appear in a separate technical report.

3. Transient Engine Dynamometer Control System

The transient control system used in the baseline program was a digital/analog hybrid, employing closed-loop analog speed control and open-loop analog torque control. (See Figure IV-B-1). A digital cassette recorder served as a source of continual command signals,, and also recorded speed/load feedback signals from the engine on a separate cassette tape. The digital command signals from the cassette keyboard were converted to analog control voltages within a Texas Instruments 960B Computer. The TI 960B was programmed for several tasks, the most important of which were transient engine control for emission testing (Task D), and manual steady-state engine control through the keyboard for system calibration (Task A). The analog control circuitry and the digital/analog interfacing were designed by LABECO, Inc. of Mooresville, Indiana.

Test cell hardware included General Electric motoring dynamometers and their associated G.E. control circuitry, which comprised the major portion of the speed loop of the control system. The speed control circuitry, was a simple closed-loop system employing proportional control (i.e., dynamometer speed was a linear function of command voltage), with a proportional feedback loop allowing for the generation of compensatory error voltages.

The torque control loop was somewhat more complex. Torque control was an open loop system in the sense that parts of the system were not electrical, i.e., the engine and its operational characteristics were integral components of the "circuit." Figure IV B-2 details the typical load vs. throttle position characteristics of an SI engine. (Throttle position is expressed in terms of the voltage applied to a throttle actuator servo motor; the clutch-driven actuator opened and closed the throttle linkage in proportion to the applied voltage.) Actual engine load was measured by a torquemeter (torsional strain gauge type with slip rings) mounted in line in the driveshaft between dynamometer and engine.

The ECTD control system controlled torque through three separate analog input voltages to the servo motor (See Figure IV B-1): 1) a "pre-position" throttle command voltage proportional to the commanded torque, 2) a speed correction voltage to allow for the variations in load vs. throttle position with engine speed (Figure IV B-2), and 3) a simple torque error (Command minus Feedback) voltage for fine tuning. In short, this linear "pre-position" system attempted to follow nonlinear engine load/throttle voltage characteristics with corrections for non-linearity provided by the limited error voltages and by additional circuitry (See Footnote 2/, Table IV B-3).

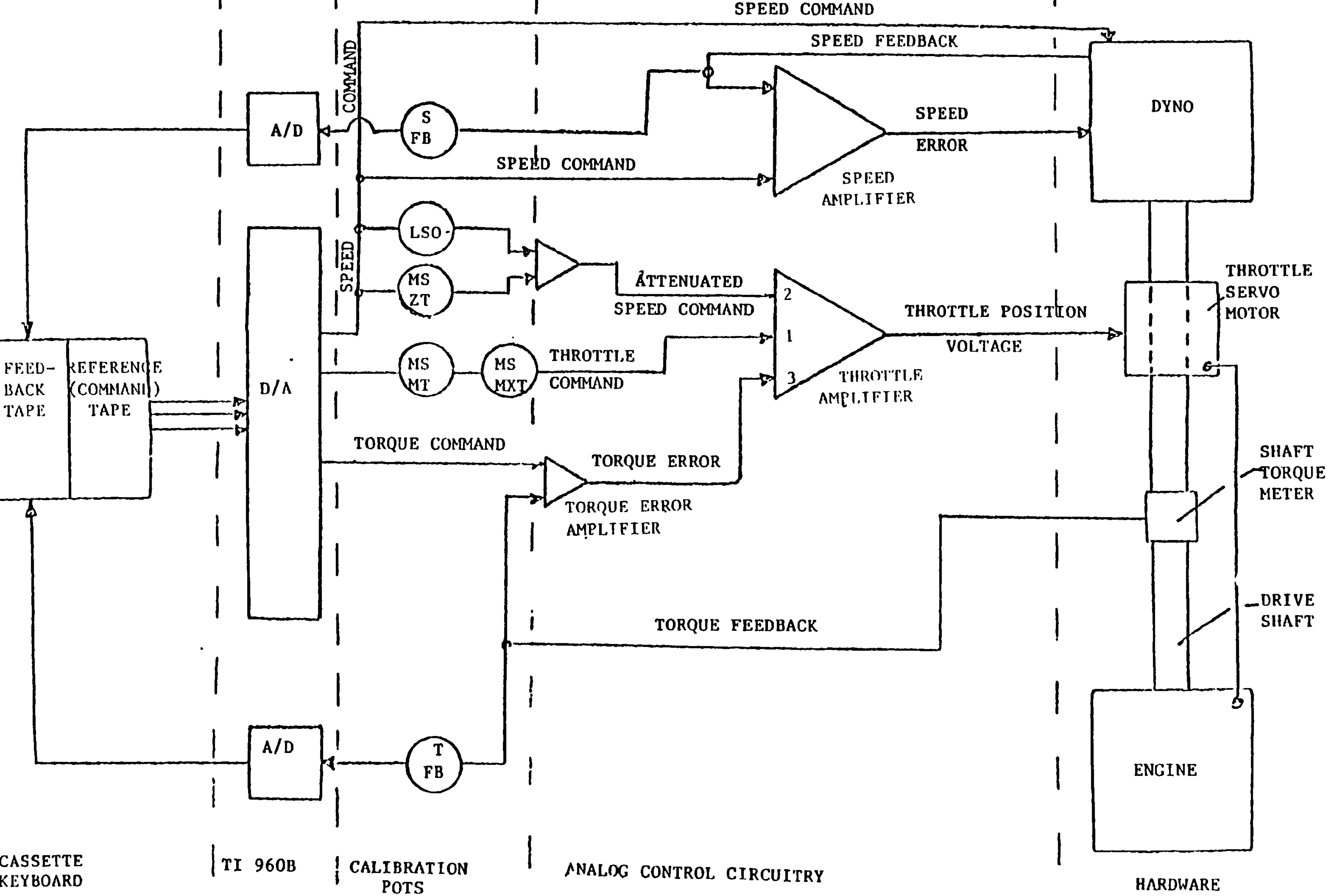


FIGURE IV.B.1: ECTD TRANSIENT DYNAMOMETER

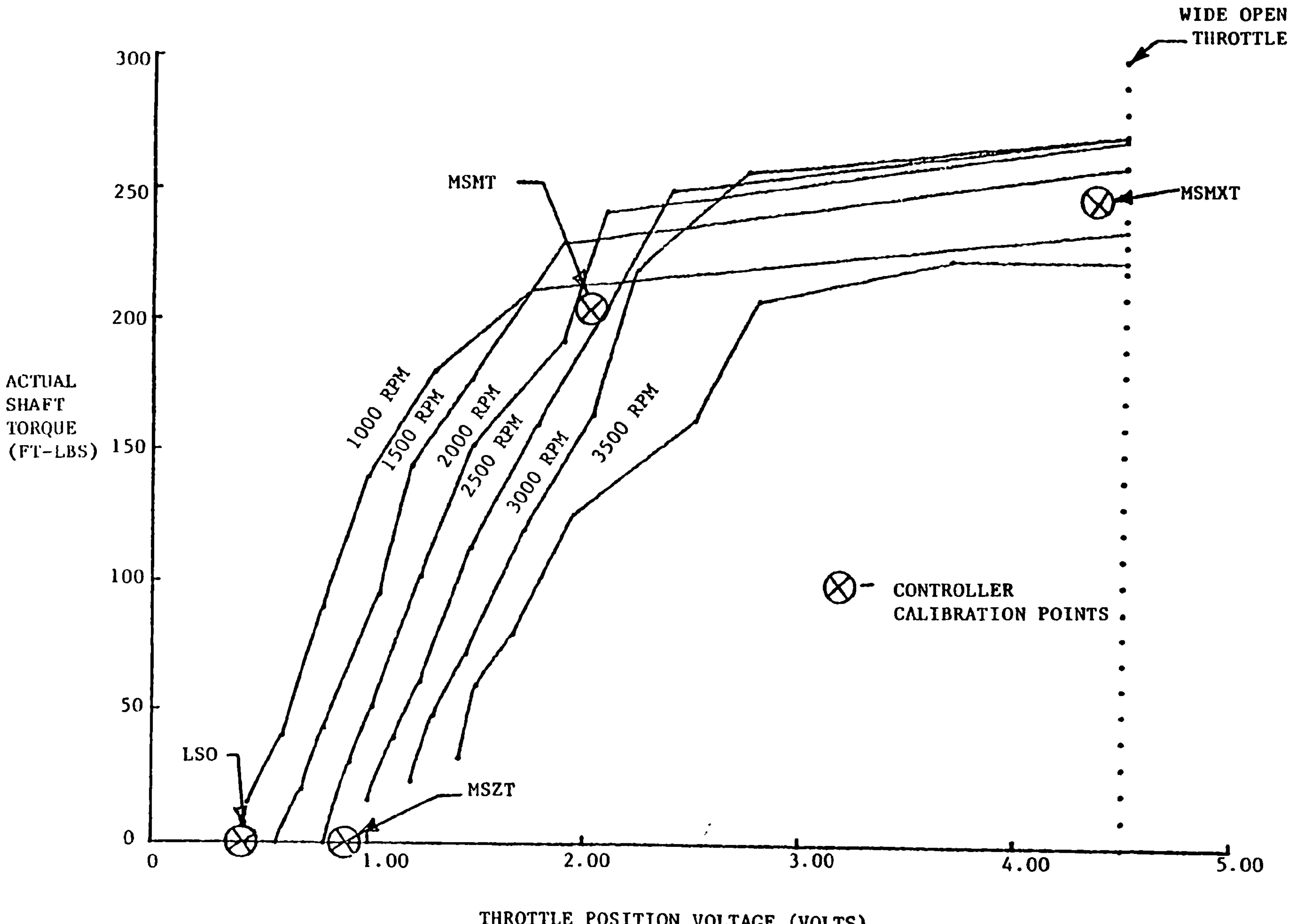


FIGURE IV B-2: TYPICAL THROTTLE VOLTAGE/LOAD CHARACTERISTICS OF AN SI ENGINE

Calibration of these three throttle input circuits was performed after engine preparation was completed. The calibration procedure is summarized in Table IV B-3. With the system operating in Task A mode, i.e., the engine running at chosen speeds and torques through typed-in commands at the keyboard, calibration was performed on the feedback and then the throttle input circuits. Specific calibration settings were unique to each engine (reflecting unique throttle/load characteristics and varying impedances between the test cells.) At any given time during production testing, one calibrated engine was present in each test cell, allowing two cold start transient tests per day. (The remaining space in each cell was reserved for engine buildup and preparation). Calibration settings for each engine were recorded to alleviate the need for recalibration when automatic control was switched from one cell to the other.

Following calibration, the engine was mapped under automatic control and a transient cycle command tape was generated. (See Section IV B-5 - Software Support.) This tape controlled the engine throughout the transient test; feedback data for cycle performance statistical validation were recorded on a separate tape and analyzed after the test.

The transient test began by manually cranking the engine with the starter motor (dynamometer off). Emission sampling began simultaneously with cranking. Upon ignition, the operator was permitted to manipulate the throttle as necessary to preclude stalling. (If stalling did occur, or the engine refused to start, the contingency procedure of the NPRM was followed. The few cases where this did occur are called out in Appendix II as comments on Individual Test Reports.) Between ignition and fifteen seconds into the test, the dynamometer, preset to run at engine idle speed, was engaged. Fifteen seconds into the test (referred to as "lag" time), the computer took control of the engine. The first non-idle point in the test occured at the twenty-four second mark and the transient portion of the cycle began. At the conclusion of the cold cycle the computer automatically returned control to the operator console, at which point the engine was shut down for the soak period. The hot cycle procedure was identical to the cold. (The emissions were sampled according to the schedule presented in Table IV B-8.)

During the analysis of the transient feedback tape, 9-mode and idle testing were performed under completely manual control. Following final validation of all test results, the engine was removed from the test cell.

Throughout the baseline program the engines were run in "speed control" mode, as described above. This was in contrast to "torque control" mode, in which the dynamometer directly controlled engine torque, while the throttle control equipment controlled engine speed. The ECTD system was capable of operating in either

Table IV B-3

Transient Controller Calibration Procedure

Task A

Step	Calibration Potentiometer 1/ (Figure 4 B-1)	Purpose (Figure 4 B-2)
A.	Torque and Speed Feedback Feedback (TFB and SFB)	Calibrates load and speed feedback signals so that the engine's performance may be accurately recorded.
B.	Midspeed/Zero Torque (MSZT)	Sets zero point for speed compensating voltage (Throttle Input 2)
C.	Midspeed/Mid Torque (MSMT)	Sets mid-span point for throttle command voltage (Throttle Input 1)
D.	Midspeed/Max Torque (MSMXT)2/	Sets maximum span point for additional Throttle voltage (Throttle Input 1)
E.	Low-Speed Offset (LSO)	Spans speed compensation voltage (Throttle Input 2).

1/ Named for speed/load at which calibration occurs. In general, midspeed is defined as $\frac{\text{Rated (or governed) RPM-Idle RPM}}{2}$ + Idle RPM, midtorque as $\frac{\text{Maximum torque @ Midspeed RPM.}}{2}$ These were not rigid parameters, however, and the calibrations occured wherever necessary to achieve satisfactory results.

2/ In reality, the Midspeed/Max Torque (MSMXT) is not only a potentiometer, but also additional circuitry located at (MS MXT) in Figure IV B 1. This circuitry was designed to provide on additional linear voltage boost at higher loads, so that the analog system could more closely approximate the load/throttle characteristics in the operating range between half and full throttle (See Figure IV B-2).

mode, and early in the baseline program, controller performance in each mode was analyzed. Based upon the high void rates associated with "torque control" mode due to the lack of cold engine driveability in the early moments of a cold start (resulting in stalled engines and voided tests) the decision was made to operate in "speed control" for the baseline program. The dynamometer controlled engine speed during momentary stumbles at the cold start, precluding stalling of the engine and substantially reducing the likelihood of a void test.

When compared with the ECTD control system, the control system at SwRI differed in support instrumentation, and in the case of the torque-control loop, in basic design. The torque control input to the throttle servo motor was entirely error-based, i.e., the torque command and feedback voltages were fed into a differencing amplifier; the amplifier output drove the servo motor. SwRI also ran in speed control mode, and in compliance with the revised regression statistics.

The ECTD "Pre-position" type system was originally selected to guarantee sufficiently rapid throttle response to widely varying torque commands. During the baseline program, however, frequent calibration difficulties resulted in regularly deficient controller performance, due to both the non-linearity of the engine's throttle-position function and the insufficient voltage achievable from the torque error amplifier. (Above a certain amplifier gain, considerable oscillatory motion of the throttle actuator was encountered. The point of excessive oscillation represented the maximum gain allowable; in some cases this gain was too low to overcome the non-linear characteristics.) Based upon the performance of the system at SwRI, a torque controller utilizing torque error as the major controlling input is equally responsive as a "pre-position" system, does not suffer from engine-to-engine variations in non-linear throttle operational characteristics, and is significantly easier to calibrate.

In general the ECTD control system produced repeatable results within the revised cycle performance criteria. Enough difficulty in calibration was experienced, however, to warrant modification of the controller to one whose primary torque controlling input is error-based. An alternative solution is to use a pre-position type control system with sufficient memory capacity to allow calibration through a comprehensive matrix mapping of the engine's throttle voltage characteristics, i.e., record the throttle voltage necessary for any combination of speed and torque. These matrix values could be stored into memory directly, or used to determine constants of higher-order polynomial algorithms (pre-programmed into the computer) to allow closer following of the non-linear throttle

11/ SwRI operated without ambient humidity controls,but this had no significant effect on HC and CO emission levels.

voltage curves. A small torque error compensatory voltage would then be sufficient to account for variation in engine performance (e.g., a cold engine vs. a hot engine). EPA plans to implement one of these alternatives in the near future. Furthermore, based upon testing experience to date, additional capabilities of a transient dynamometer controller are desirable. These include:

1) The engine should be capable of being "uncoupled" from the dynamometer, either electrically or mechanically, during idle portions of the transient test. This allows for a free idle, especially important during a cold start if the engine is equipped with an automatic choke.

2) The controller's data reduction capability should be sufficient to allow rapid calculation of a test's cycle performance statistics. This allows much prompter trouble-shooting of controller calibration settings, resulting in higher system reliability and lower void rates.

4. Engine Preparation and Instrumentation

Engines tested at MVEL arrived from two sources: private contractors and in-house procurements. Engines obtained through in-house procurements were removed from the vehicles and assembled upon test stands; those engines originating from contractors arrived in test-ready configuration. In both cases, the engines were set up for testing according to MSAPC Advisory Circular 22A (April 3, 1973).1/

The standard engine test configuration consisted of the engine's flywheel bolted to a torquemeter-equipped rubber-softened 2/ driveshaft (Dana-Spicer) coupled to the dynamometer. The engine was isolated from its mountings by shock-absorbing rubber mounts (usually OEM vehicle mounts). The throttle actuator stands were bolted to the dynamometer bed plate and to the engine itself by means of a rigid cross bar. (Accurate transient control of the throttle was difficult unless the actuator motor and the engine were rigidly fixed to one another.) The throttle servo motors were clutch driven with internal position feedback potentiometers. The actuator arms were connected to the throttle linkages by either ball chain or wire cable such that full travel of the actuator arm (approximately 60°) resulted in wide-open throttle.

1/ The only exception to A/C 22A procedure was that engines were not equipped with clutch assemblies, driveshafts were bolted directly to the flywheel by means of an adapter plate. A/C 22A is included in Appendix II.

2/ Driveshafts used at EPA were rubber-softened to alleviate the possibility of resonant torsional vibrations. SwRI used solid steel shafts with no apparent difficulties.

The engine coolant water was circulated through a heat-exchanging water cooling system; the system temperature control was set such that coolant water to the engine was a minimum of 20°F below engine thermostat temperature. Portable fans were directed at each side of the engine during the test, but were shut off during the hot soak.

Exact duplication of the in-vehicle exhaust system involved practical difficulties arising from the location of the dynamometer. Where necessary, the standard exhaust systems were bent to clear the dyno and other obstructions (e.g., the control instrumentation boom). Bends were kept to a minimum to eliminate back-pressure variations. Marmon flanges were welded to the end of the exhaust system for attacnment of flexible convoluted piping for transport of the raw exhaust to the CVS inlet, to which the piping was rigidly attached. Inlet depression at the CVS was kept within NPRM specifications.

In addition to the tune-ups performed by the procurement contractor, all engines were tuned and adjusted by ECTD personnel to manufacturer's recommended specifications prior to mapping and testing. The tune-up specifications used were those published in the manufacturer's applicable service manuals, obtained directly from the manufacturers. In the interest of accuracy, a number of carburetors and distributors were checked and adjusted by the manufacturers at their own facilities. Every attempt was made to meet the recommended specifications, and this was accomplished in the vast majority of cases. In a few cases (called out in Appendix II) both engineering judgment and manufacturer's advice, were used when specifications were unacnievable.

The tuneup procedure involved verification of engine performance. Distributor advance curves and dwell variation were checked on a Sun Model 500 distributor tester (distributor removed from the engine). With the engine running on the dynamometer, a Sun Model 947 engine performance tester was used to cneck mechanical and vacuum advance curves and dwell variations. The same instrument was used in the adjustment of idle HC and CO, along with the carburetor/cylinder balancing adjustment and the carburetor power valve check.

After all mechanical specifications were checked, calibration of the engine/control system was performed, and the engine mapping procedure began.

A summary of the equipment used is presented in Table IV B-4.

Table IV B-4

Instrumentation Summary

Instrument	Purpose/Specifications
General Electric Direct Current Dynamometer	Absorbing, 380 HP, 400 ft. lb. Motoring: 360 HP, 375 ft. lb. Base Speed: 5,000 RPM Frame Size: TLF 3644-F
Lebow Torquemeter	Model #1228H(5,000 in-lbs, 0 - 5,000 RPM)
Lebow Torque Signal Conditioner and Indicator	Model #7535
CVS Unit (Philco-Ford)	CFV Type, 1,500 SCFM Capacity
Texas Instrument 960B Computer with Silent 700 ASR Data Terminal	
LABECO Control Console, Control Equipment	

5. Software Support/Data Reduction

Considerable amounts of software support were utilized in the baseline program, both in evaluating the engine's performance over the cycle and in the actual emission calculations.

The vast computational and memory resources of the Michigan Terminal System's (MTS) AMDAHL V/7 Computer were made available to the TI Controller through a standard phone communications link (1200 BAUD). The MTS system served as a central processor (host computer) which stored the numerous support programs used in day-to-day baseline operations. These support programs and their functions are summarized below.

Cycle Support System Function List

GENCYC - Generate a normalized1/ cycle or mapping reference2/ file.
EDCYC - Edit opcodes3/ on normalized cycle or engine reference4/ file.
INPMFB - Input mapping feedback5/ cassette into a file.
MANIPCYC - Manipulate normalized cycles and unnormalize them
MAKECAS - Make a mapping or engine reference cassette (command tape).

Test Processing System Function List

INPEFC - Input engine feedback cassette into a file.
CYCPERF - Monitor performance of engine feedback file (perform statistical regression).
STOREDS - Store HD data sheets in the HD data base (emission data).
STOREEI - Store HD engine information.
PROCTEST - Process HD tests (perform emission calculations).
REPORT - Generate HD reports (output emission data).
RETRVDS - Retrieve HD data sheets to make changes.

1/ To normalize a cycle is to express each cycle parameter (RPM or ft lbs) as a percentage of the maximum achievable.
2/ A mapping reference file is used to control on engine during the automatic maximum load curve generation. It consists of incremental step speed commands and wide-open throttle commands.
3/ Opcodes (Operational Codes) are additional data recorded on the feedback tape, or present on the reference tape. They allow monitoring of certain conditions (e.g., closed or wide-open throttle), and can be used for additional control capabilities.
4/ Engine reference file is an engine-specific command tape used to run the engine through the entire transient test.
5/ Feedback is the recorded speed and torque performance of an engine, either during mapping or a transient test.

Table IV B-5

1969 Baseline Void Rates

Engine	Total Tests1/	Void Tests Statistical2/	Void Tests Experimental3/	Total Void Rate
(1) Chrysler 225	8	6		75%
(2) IHC 392	9	3	3	67%
(3) Ford 391	5	2	1	60%
(4) IHC 304	8		3	37%
(5) Ford 330	5			0%
(6) GM 351C	8	4	2	75%
(7) Ford 330	8	1	4	63%
(8) GM 350-2	3	1		33%
(9) Chrysler 318-3	4		1	25%
(10) IHC 345	4	2		50%
(11) GM 350-2	9	4	2	67%
(12) Ford 300	6	3		50%
(13) IHC 345	7	4		57%
(14) GM 366	3			0%
(15) Ford 361	8	6		75%
(16) Ford 360	6	3*		50%
(17) GM 292	11	9		82%
(18) Chrysler318-1	4	1		25%
(19) Ford 361	4		1	25%
(20) Ford 360	4	2*		50%
(21) GM 350-2	5	2		40%
(22) Chrysler 361	3	1		33%
(23) GM 366	4		1	25%
Total	136 (100%)	54 (40%)	18 (13%)	53%

*See Appendix II, Baseline Engines 16 and 20.

1/ Cold start transient tests intended for baseline data (excluding all correlation and parameter sensitivity tests).
2/ Statistically Void. exceeding the revised cycle performance regression tolerances given in this report.
3/ Experimentally Void engine or equipment malfunction, operator error, etc.

Table IV B-6

1969 Transient Baseline Repeatability

Engine	Valid Tests	Coefficients of Variation1/ (%) BSHC	BSCO
(1) Chrysler 225	2	7.4	3.2
(2) IHC 392	3	4.9	4.2
(3) Ford 391	2	0.5	0.2
(4) IHC 304	5	10.0	14.0
(5) Ford 330	5	4.4	2.5
(6) GM 351C	2	13.3	1.6
(7) Ford 330	3	5.9	9.1
(8) GM 350-2	2	0.2	0.2
(9) Chrysler 318-3	3	5.5	19.1
(10) IHC 345	2	1.3	3.6
(11) GM 350-2	3	18.4	12.0
(12) Ford 300	3	19.5	3.4
(13) IHC 345	3	4.8	12.1
(14) GM 366	3	.3	3.7
(15) Ford 361	2	5.5	7.8
(16) Ford 360	3	7.7	8.4
(17) GM 292	2	9.0	6.3
(18) Chrysler 318-1	3	1.1	6.7
(19) Ford 361	3	.4	3.7
(20) Ford 360	2	3.2	2.8
(21) GM 350-2	3	5.3	.7
(22) Chrysler 361	2	6.0	4.4
(23) GM 366	3	1.8	4.4
Mean Baseline Coefficient of Variation: (C. of V.)		5.9	5.8

1/ C. of V. = 100% x standard deviation of all valid tests/mean of all valid tests.

Following preparation and calibration of an engine, a mapping reference tape was created by the MAKECAS function. The mapping reference tape served as the command tape during the automatic mapping procedure. It consisted of wide open throttle commands at 100 RPM speed increments over the entire speed range of engine operation (i.e., approximately 200 RPM below idle to 300 RPM above rated or governed RPM). Each increment lasted fifteen seconds, torque feedback measured over the last five seconds of each increment were averaged to arrive at a maximum torque value. This feedback data was stored on a separate cassette tape.

The mapping feedback tape was then loaded into MTS data files by means of INPMFB, at which point GENCYC created a normalized cycle reference file, which was then recorded on a blank cassette by means of MAKECAS. This cassette became the command tape for controlling the engine during the entire transient cycle.

The feedback data from a transient test was recorded on a blank cassette during the test. The data from the feedback cassette was stored into MTS by INPEFC, at which time the regression analysis was performed by CYCPERF. Following the regression analysis, it was then possible to input the emission data into the master file (STOREDS), process the tests (PROCTEST), and generate a complete transient test report (see Appendix II).

During the baseline program, the actual process of loading data from the cassettes to the MTS files was time consuming; primarily because a time sharing system (MTS) was being used which was not under direct ECTD control. This delayed cycle performance results and tied up the keyboard terminal. EPA plans to substitute disc memory for the cassettes in a future transient test cell, in an effort to substantially reduce turnaround time.

6. Void Rates/Test Repeatability

A summary of the baseline program's void rates and the emission repeatability of valid transient tests is presented below in Tables IV B-5 and IV B-6. Statistical validation was accomplished using the revised statistics within this report.

Void rates during the baseline program were somewhat high. The voiding of tests due to experimental error (e.g., equipment malfunction, operator error) was initially high; as more experience with the test procedure and the equipment was gained, however, tests voided for this reason were virtually eliminated. Statistically-void tests were present throughout the program. In most cases, these high statistical void rates were a result of one of three causes:

a) the statistical criteria were not available (i.e., had not been developed) for calibration or validation when the engine was tested. A later application of the statistical criteria indicated that additional tests (as in engine No. 1) would not have been needed.

b) communication service with the host computer (MTS) was interrupted such that statistical validation of the test was not possible prior to the running of the next test. (Normally if the first test was void, the system would be recalibrated before the next test, however, many times the interruption was so long that the normal procedure was precluded.);

c) calibration difficulties with the EPA/MVEL system controller, which was highly engine dependent.

Once the statistical criteria were developed, the last two causes were the most prevalent. ECTD plans to improve both the communication and controlling capabilities of its sytem in the near future to reduce the incidence of statistically void tests.

Of those tests determined to be valid, however, the emission repeatability was good. The average coefficient of emission variation for the entire baseline program was less than 6%. When compared to the thirteen baseline engines for which data from more than a single 9-mode FTP is available, model emission variability over the baseline program was 5.0 percent for BSHC and 4.3 percent for BSCO. (See Table IV B-7.) The prototype ECTD Controller achieved comparable repeatability. It is anticipated that the closer future control systems come to achieving the ideal regression statistics, emission variability as measured over the transient test will be reduced.

Table IV B-7

Modal Baseline Emission Variability 1/

Engine	Valid Tests	Coefficients of Variation 2/(%) BSHC	BSCO
(4) IHC 304	3	4.0	6.0
(9) Chrysler 318-3	2	2.0	18.0
(11) GM 350-2	3	2.0	7.0
(12) Ford 300	2	1.0	1.0
(13) IHC 345	2	7.0	.10
(14) GM 366	2	1.0	2.0
(15) Ford 361	2	18.0	1.0
(16) Ford 360	3	5.0	7.0
(17) GM 292	2	10.0	5.0
(19) Ford 361	2	6.0	2.0
(20) Ford 360	2	2.7	1.7
(21) GM 350-2	2	5.2	2.1
(22) Chrysler 361	2	.50	3.0
(23) GM 366	3	1.8	4.4
Mean Modal C. of V.(%):		5.0	4.3

1/ Based upon the modified 9-mode test procedure.

2/ Modal data for engines 1-8 were voided due to a test procedure error. Engine #4 was retested. Remaining baseline engines not included here have only one valid 9-mode test.

7. Emission Sampling System

Emissions were sampled using the CFV-CVS bag technique. Dilution factors for the transient and 9-mode FTP's were determined using an average air/fuel ratio of 13.4, dilution factor for the idle test by using a raw CO_2 analyzer. (The calculations were performed according to the appropriate Federal Register).

Sample bags were analyzed at an analyzer site using the following equipment:

Gas	Instrument	EPA No.
HC	Beckman Model 400 (40% H_2/60% He Fuel)	086985
CO(0-1000 ppm)	Bendix Model 8501-5MB	109724
CO (0-50,000 ppm)	MSA Model 202	109961
CO_2	MSA Model 202	109952
NOx	TECO Serial #CT-M-1063-29	109723 Series 10
CH_4	Bendix Model 8205	038333

Raw CO_2 measurements for the idle test were taken on an MSA Model 202 (EPA #109949) analyzer (0-14%, with ice bath).

Maintenance and calibration checks of the equipment were performed regularly. Both propane injections and an Easttech Vortex shedding flowmeter were used on a weekly basis to check calibration on the CFV-CVS flow.

Emissions collected in the test cells were analyzed at EPA analyzer train A009, located 200 feet down the hall. The maximum delay between sample collection and sample analysis was twenty minutes.

The sampling timetable used during a transient test is presented in Table IV B-8.

Table IV B-8

Transient Emission Sampling Schedule (Cold Cycle) 1/

Time After Ignition (seconds) 2/	Event
	- Cranking of engine/Begin Bag 1 Sampling
0	- Ignition (Times Started)
1 - 14	- Dynamometer Engaged
15	- Automatic Control Engaged
25	- Just Non-Idle Cycle Command
272	- Bag 1 Ends/Bag 2 Begins
579	- Bag 2 Ends/Bag 3 Begins
895	- Bag 3 Ends/Bag 4 Begins
1167	- Bag 4 Ends
1169 ±2	- Twenty-Minute Soak Begins

1/ Hot cycle is identical, following twenty-minute soak.
2/ As denoted in the NPRM speed/Torque schedule.

C. Baseline Compilation and Standards Computation

The results of the testing efforts at EPA/MVEL and SwRI for all twenty-three of the baseline engines are summarized in the test results found in this section.

This section is divided into three main sub-sections:

1. Transient Cycle: Emission Test Summaries and Results

2. Idle Test: Emission Test Summaries and Results

3. Standards Computation and Discussion

1. Transient Cycle: Emission Test Summaries and Results

The data tabulations in this sub-section give a summary of all emission data for the 23 baseline engines tested on the transient test procedure. Data is included for valid and invalid tests. Appendix II contains more detailed information on each test conducted.

Before presenting the actual data, a discussion of the less obvious headings and codes used in the computer printout will aid in using this information:

a) Manufacturer Code (MFG)

20 Chrysler
30 Ford
40 General Motors
270 International Harvester

b) Actual BHP-hr: The integrated brake-horsepower-hour calculated from the actual speed and torque performance of an engine run over the transient cycle.

c) % Error: The percent deviation of the integrated brake-horsepower-hour over the actual transient test as compared to the reference cycle integrated brake-horsepower-hour. (Based on the sum of BHP from cold and hot cycle. Validation was determined based on the individual value for each cold cycle and hot cycle.)

d) Grams/mile: Weighted grams (cold and hot start) of each pollutant over the test cycle by miles instead of BHP-hr. The mileage represented by the cycle is 6.47 miles.

e) Disposition Code (DISP)

B = Valid baseline test

M = Marginally valid test

X = Invalid test

The test data on pages 49-70, summarize the test results for each of the 23 baseline engines tested. Using the descriptions above and basic engineering knowledge, the data should be self-explanatory.

The four tables following the test data sheets, (Computer Tables 1-4) summarize the results shown for each of the twenty-three baseline engines. Although the data in these tables should be easily understood using the short descriptions below, one important factor should be discussed.

The Clean Air Act Amendments prescribed that the 1983 HC and CO emission standards should be determined from the average of the actually measured emissions from heavy-duty gasoline-fueled vehicles or engines. ECTD interpreted average to mean the average of the entire 1969 fleet of HD gasoline-fueled vehicles and not just a simple average of the engine lines sold which would give equal weighting to each engine line sold. Thus, ECTD has sales-weighted the emission results according to the market share each engine line actually held corrected to 100 percent. This correction to 100 percent was necessary because not all engine lines are represented in the baseline. These market shares and their correction to 100 percent are shown in Computer Table 2. In the final analysis, using a simple average of the engine lines tested yielded only slightly more stringent emission standards.

For the reader's use, a short description of each table is provided below:

(1) Computer Table 1: Sales-Weighted Brake Specific Emissions. This table gives the average brake specific emissions g/BHP-hr) of HC, CO, and NOx for each baseline engine, sales-weighting fractions and sales-weighted emissions plus the number of valid tests on each engine ("Sample Size"). Figures representing a 90 percent reduction are also shown. The NOx data is not needed for any of the proposed standards and is included solely for informational purposes.

(2) Computer Table 2. Sales-Weighted Percentages Data. This table lists the percent of total 1969 sales represented by each baseline engine ("percent total"), as well as the percentage corresponding to the fraction of total sales represented by each engine using the combined sales of only the baseline engines as a base ("Corrected percent"). The latter figure yields the weighting factors.

(3) Table 3: Brake Specific Emissions. This table lists the

average brake specific HC, CO, and NOx emissions for each baseline engine, along with the sample size.

(4) Table 4: Sales-Weighted Transient Engine Emissions. This table is the same as Table 1, with the exception that all emission results are expressed in terms of grams per mile.

2. Idle Test: Emission Summaries and Results

EPA has also proposed idle emission standards for HC and CO. Idle test data to determine the 90 percent reduction is shown for 19 baseline engines which were tested. These 19 engines represent 79 percent of the 1969 sales of gasoline-fueled HD engines.

The results of the idle tests for these 19 engines are shown on pages 78 to 96. The four test modes listed on these individual summary sheets are:

Mode 1: 2500 rpm - no load.

Mode 2: Idle - no load (this mode used for standard setting).

Mode 3: 2200 rpm - 55 percent of maximum torque.

Mode 4. 1700 rpm - 43 percent of maximum torque.

Computer Tables 5, 6, and 7 summarize the idle emissions data for the 19 baseline engines. These tables are similar to Tables 1-3 shown earlier and are described briefly as:

(1) Computer Table 5. Sales-Weighted Idle Emissions. This table is the same as the Computer Table 1 listed above, except that it lists idle test data.

(2) Computer Table 6: Sales-Weighted Percentages Data. This table is the same as Computer Table 2 listed above, except that it is for engines having idle test data (19 engines instead of 23).

(3) Computer Table 7. Idle Emissions. This table is the same as Computer Table 3 listed above, except that it is for engines having idle test data.

Grams per mile data for the idle test is not included for obvious reasons. These tables are found on pages 98-100.

3. Standards Computation and Discussion

The 1969 heavy-duty baseline program began in the fall of 1977 with the first procurement actions and is concluded with this report.

During this program, ECTD procured and tested 23 heavy-duty gasoline-fueled engines representing 81.5 percent of the 1969 fleet. Of these 23 engines, 16 were class A, 1 was class B, 6 were class C (high mileage). One engine included in this baseline had undergone a major rebuild. No other engine needed one at the time of procurement.

To determine the emission levels, these engines were tested using the new transient test procedure. Of the 137 transient tests, 64 were considered valid and are included. No engine had less than two valid tests with the maximum per engine being five.

The fact that ECTD ceased baseline testing at 23 engines was based primarily on the fact that baseline emission levels were insensitive to further testing. This is shown in Figures IV-C-1 and IV-C-2 which demonstrate that as the number of engines tested approached 25, the effect of including more engines in the baseline was insignificant. This is true for both HC and CO.

Based on the fact that:

1) Only 1969 model year heavy-duty gasoline-fueled engines were tested;

2) Over 81 percent of the 1969 fleet is represented; and

3) 64 valid emission tests were accomplished on these engines;

ECTD concludes that the 1969 baseline shown here is representative of the HC and CO emission levels of 1969 HD gasoline-fueled engines. The following values are considered as a 90 percent reduction from the average of actually measured emissions based on the results of the test program:

HC 1.3 g/BHP-hr

CO 15.5 g/BHP-hr

The above values are the emissions standard which are proposed for heavy-duty engines beginning in 1983.

In addition, EPA has proposed idle emission standards based on Mode 2 of the four modes described above,

Mode 2: Idle - no load.

The 19 engines included in the idle test baseline give a representative depiction of the fleet-wide 1969 idle emissions. Figures IV-C-3 and IV-C-4 show the decreasing sensitivity of the HC and CO idle emissions as the number of baseline engines increased.

Each of the 19 engines included in the baseline received at least one valid idle test with a maximum of 6.

Based on the fact that:

1) Only 1969 model year heavy-duty gasoline-fueled engines were tested;

2) Over 79 percent of the 1969 fleet is represented; and

3) 55 valid idle emission tests were accomplished on these engines;

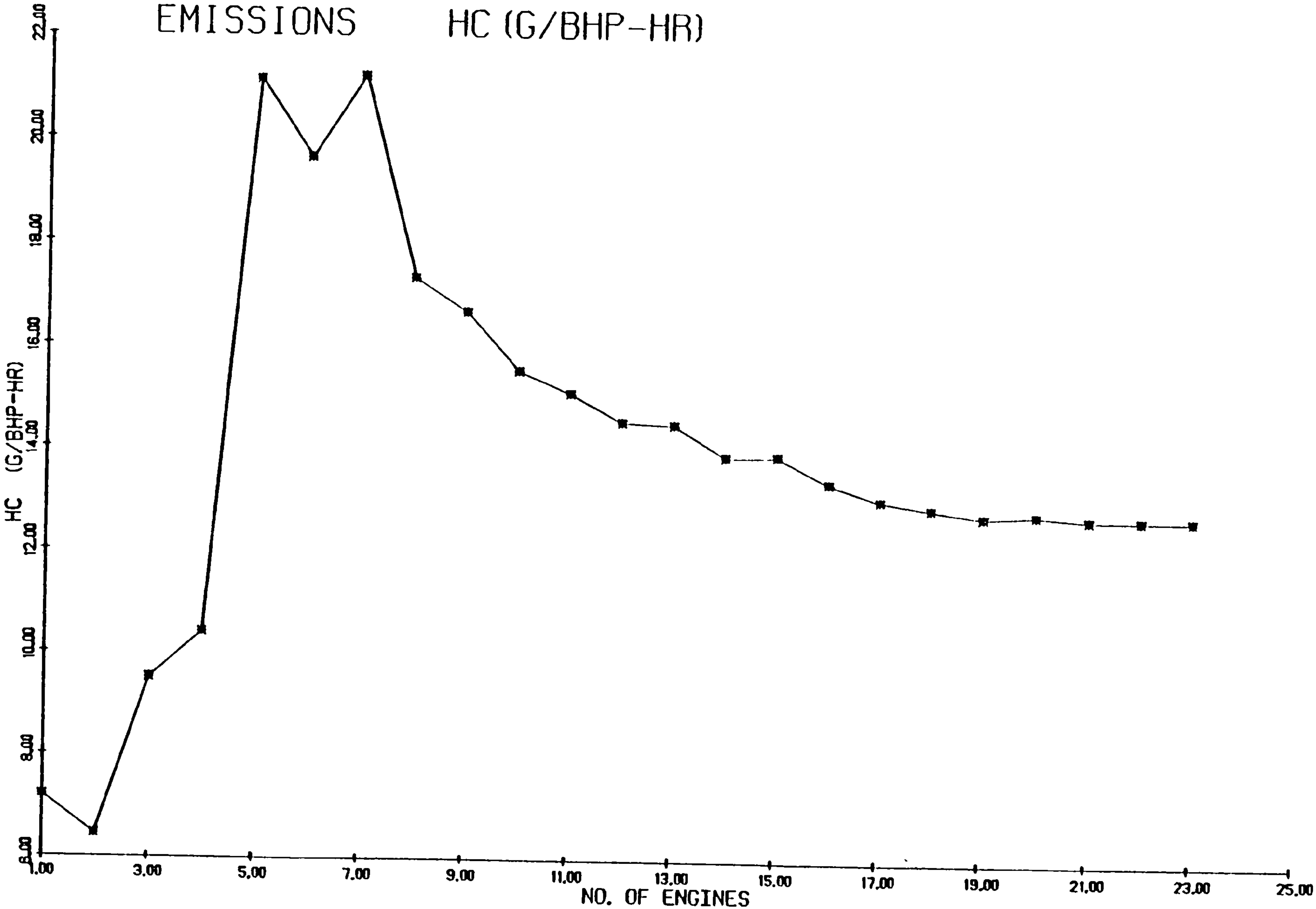
ECTD concludes that the 1969 baseline data for the idle emission standard is representative of the HC and CO emissions levels of 1969 gasoline-fueled HD engines. The following values are considered as a 90 percent reduction from actually measured emissions of 1969 HD gasoline-fueled engines and are the proposed 1983 heavy-duty idle emission standards:

HC 970 ppmC

CO .47%

Figure IV-C-1

SALES-WEIGHTED BASELINE TRANSIENT
EMISSIONS HC (G/BHP-HR)



SALES-WEIGHTED BASELINE TRANSIENT
EMISSIONS CO (G/BHP-HR)

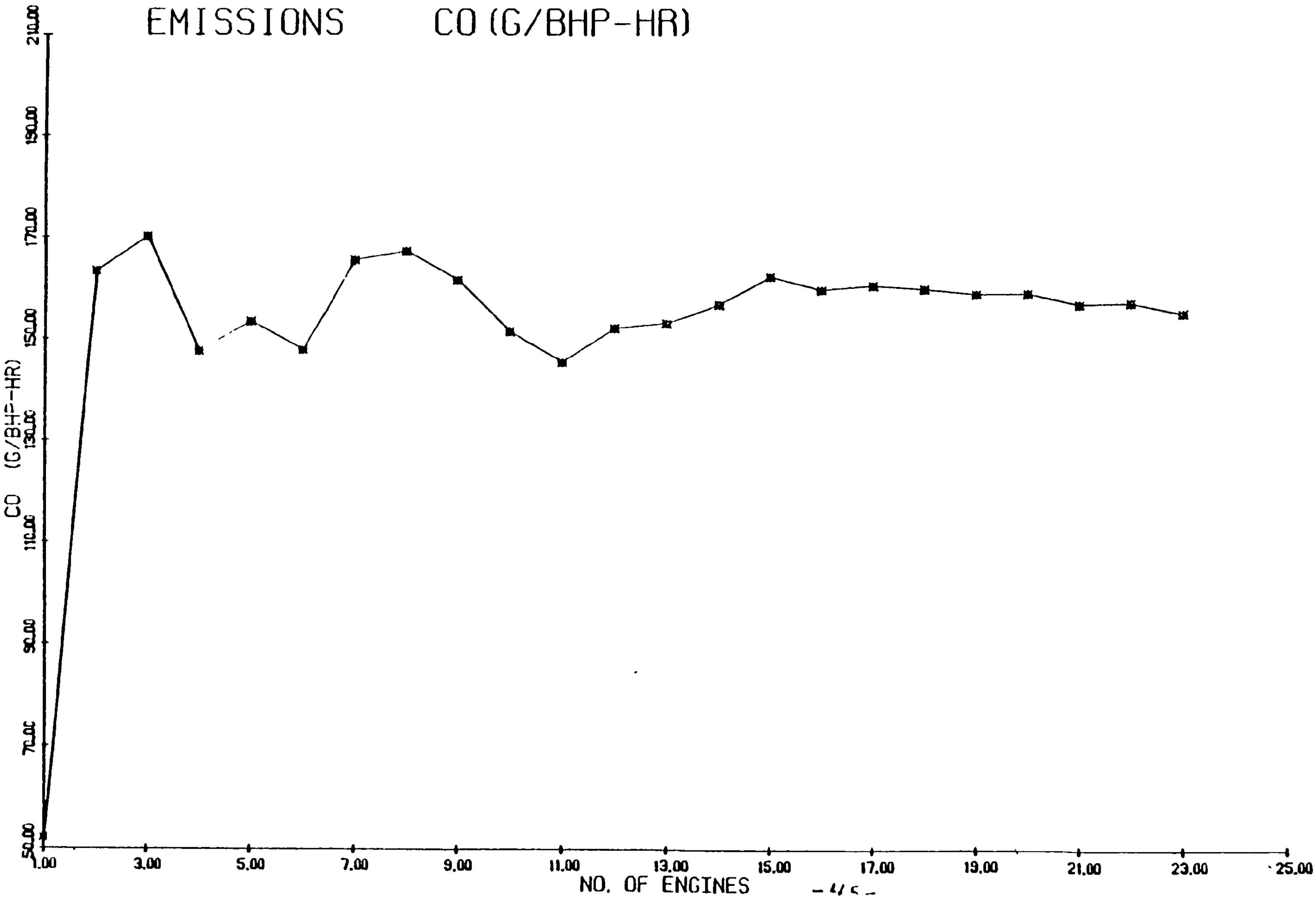
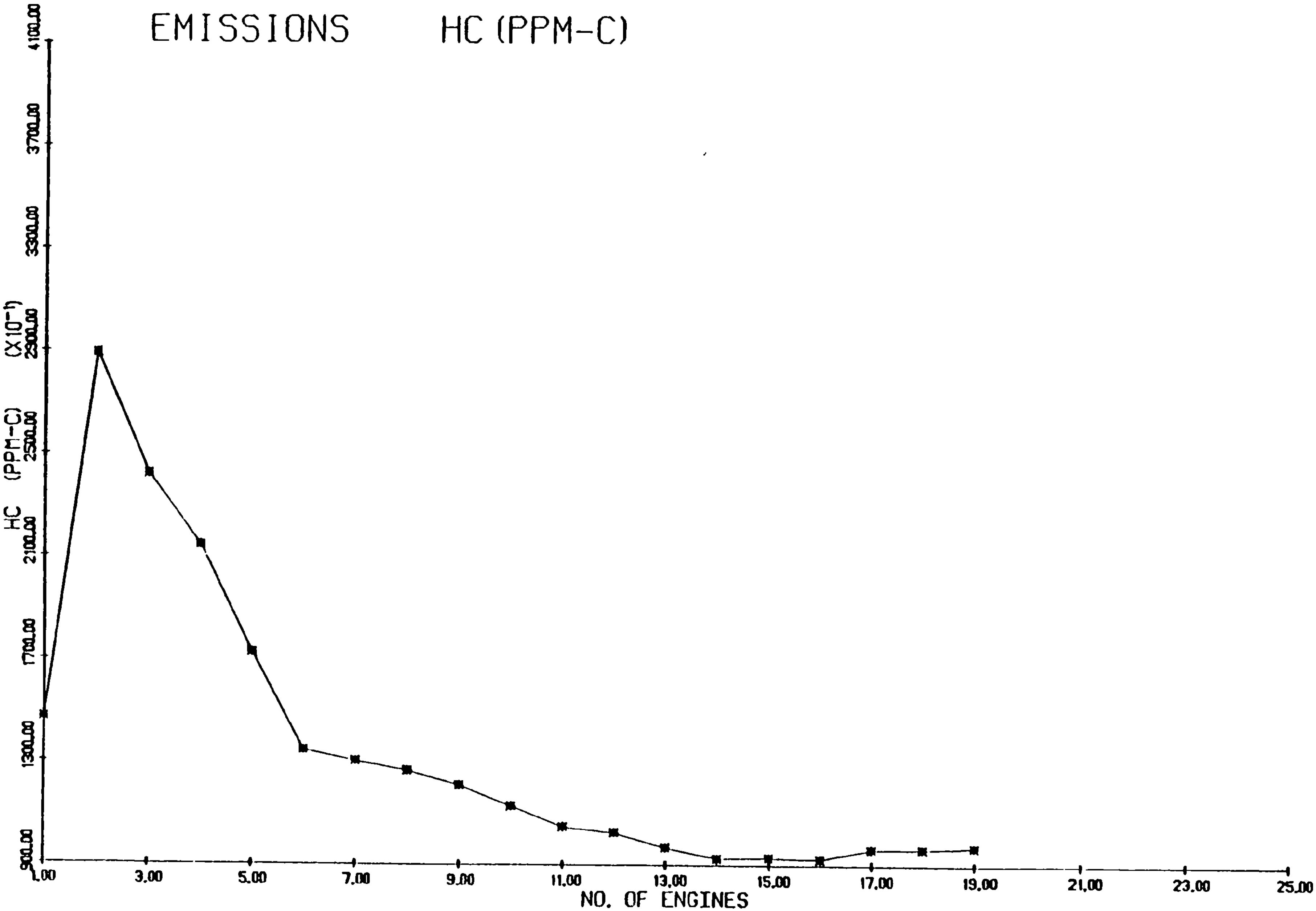
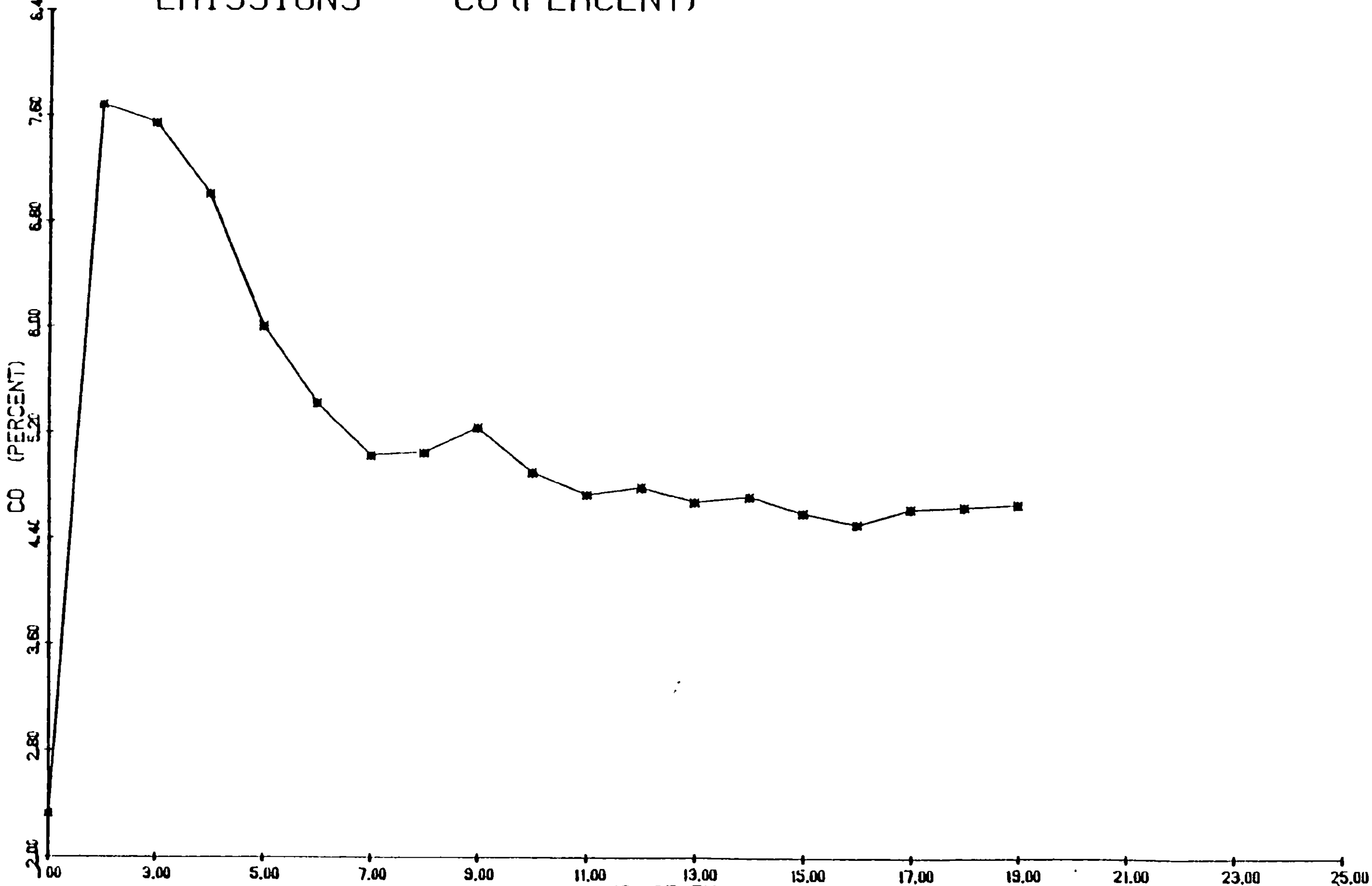


Figure IV-( )

SALES-WEIGHTED BASELINE IDLE EMISSIONS HC (PPM-C)



SALES-WEIGHTED BASELINE IDLE EMISSIONS CO (PERCENT)



BASELINE ENGINE TRANSIENT

EMISSION TEST DATA SHEETS

23 ENGINES

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 225 ENGID: FW 225H 2994 032 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #01

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE H= VALID M= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
790836	HL 0101	6.11	55.69	9.99	0.819	10.767	-15.0	5.11	46.53	8.35	7.46	67.99	12.20	X
790840	HL 0102	6.34	49.10	9.75	0.666	10.8[illegible]4	-14.0	5.36	41.52	8.24	9.52	73.73	14.64	X
791426	HL 0103	6.20	48.11	9.19	0.640	11.106	-12.3	5.35	41.47	7.92	9.69	75.17	14.36	X
791427	HL1 0104	6.82	51.01	9.24	0.651	10.967	-13.4	5.81	43.42	7.86	10.48	78.35	14.19	B
791452	HL 0105	7.57	53.40	7.68	0.627	11.154	-11.9	6.51	45.90	6.60	12.08	85.16	12.25	H
791455	HL 0106	6.87	51.78	9.36	0.618	11.110	-12.3	5.87	44.28	8.00	11.11	83.79	15.14	X
791497	HL 0108	3.76	46.35	9.00	0.575	14.488	14.4	4.17	51.35	9.97	6.54	80.61	15.65	X
791507	HL1 0107	5.15	50.07	9.10	0.600	13.551	7.0	5.41	52.58	9.56	8.58	83.44	15.17	X
791517	HL 0110	4.25	49.75	9.18	0.592	14.153	11.8	4.64	54.39	10.04	7.18	84.04	15.51	X
791520	HL1 0109	4.08	45.49	8.58	0.554	14.011	10.6	4.39	48.98	9.24	7.37	82.11	15.48	X
791528	HL1 0111	4.11	51.21	8.15	0.577	13.934	10.0	4.42	54.99	8.76	7.13	88.75	14.13	X
MEAN		7.20	52.20	8.46	0.639	11.060	-12.7	6.16	44.66	7.23	11.28	81.76	13.22	N= 2
STD.DEV. :		0.53	1.69	1.10	0.017	0.133	1.0	0.49	1.75	0.89	1.13	4.81	1.37	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 270 CID: 392 ENGID: V392 650417 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #02

N U M B E R		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	B= VALID H= VALID
791630	BL 0201	16.03	202.40	3.63	0.776	21.153	3.0	25.21	318.29	5.71	20.14	254.28	4.56	X
791631	BL 0202	9.06	172.59	4.03	0.758	19.805	-1.5	13.78	262.42	6.11	11.96	227.69	5.32	X
791632	BL 0203	3.93	78.74	1.95	0.353	19.193	-6.5	5.83	116.73	2.89	11.14	223.05	5.51	X
791633	BL 0204	8.57	265.44	4.39	0.888	17.480	-5.1	12.93	400.29	6.62	9.66	298.92	4.94	X
791634	BL 0205	12.15	192.02	4.20	0.826	18.941	-7.7	17.87	282.33	6.18	14.71	232.47	5.09	X
791635	BL 0206	8.44	194.04	4.29	0.818	19.098	-7.0	12.46	286.43	6.33	10.32	237.22	5.24	X
791636	BL 0207	9.00	204.13	4.04	0.820	18.958	-7.7	13.23	300.10	5.94	10.97	248.94	4.93	X
791637	BL 0208	10.31	228.88	3.90	0.869	18.506	-9.9	14.70	326.21	5.56	11.87	263.38	4.49	X
792301	BL 0210	6.69	186.44	3.71	0.802	18.912	-7.9	9.82	273.61	5.45	8.34	232.47	4.63	B
792302	BL 0211	6.07	171.47	4.78	0.758	18.998	-7.5	8.98	252.81	7.05	8.04	226.21	6.31	B
792303	BL 0212	6.28	177.50	4.21	0.773	18.800	-8.4	9.12	257.89	6.12	8.12	229.62	5.45	B
MEAN:		6.35	178.47	4.24	0.778	18.903	-7.9	9.31	261.44	6.21	8.17	229.44	5.46	N= 3
STD.DEV. :		0.31	7.54	0.54	0.022	0.099	0.5	0.45	10.85	0.80	0.16	3.14	0.84	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 391 ENGID: 391-JW RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #03

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
792304	BL1 0301	19.13	178.99	4.86	0.639	24.681	1.6	36.18	338.63	9.20	29.93	280.11	7.61	X
792471	BL 0303	13.50	178.88	5.74	0.641	24.608	1.3	26.12	346.18	11.10	21.06	279.07	8.95	B
792473	BL1 0304	12.98	177.55	5.79	0.633	24.868	2.3	24.85	339.94	11.08	20.51	280.49	9.14	X
792474	BL 0305	13.59	179.50	5.92	0.645	24.835	2.2	25.96	342.92	11.32	21.07	278.30	9.18	B
792637	BL1 0302	12.98	193.64	5.55	0.658	24.685	1.6	24.73	367.75	10.57	19.73	293.38	8.43	X
MEAN:		13.54	179.19	5.83	0.643	24.721	1.7	26.04	344.55	11.21	21.06	278.68	9.07	N= 2
STD.DEV. :		0.07	0.44	0.13	0.003	0.162	0.7	0.11	2.33	0.16	0.0	0.66	0.17	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 270   CID: 304   ENGID: V304 64H048   RATED BHP: N/A   RATED RPM: N/A

COMMENTS: 1969 BLT #04

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	
793002	BL1 0401	10.95	76.91	7.02	0.677	19.488	-1.4	16.64	116.85	10.67	16.18	113.61	10.38	X
793003	BL 0402	11.06	98.09	6.70	0.649	19.521	-1.2	16.82	149.18	10.19	17.04	151.13	10.32	B
793004	BL 0403	10.70	136.24	6.14	0.663	19.606	-0.8	16.40	208.79	9.41	16.14	205.49	9.26	B
793129	BL 0404	13.13	147.82	5.38	0.648	19.454	-1.5	19.75	222.25	8.09	20.27	228.12	8.30	B
796236	BL1 408	11.93	127.65	7.57	0.731	19.837	-4.0	17.11	199.85	11.85	14.95	174.63	10.35	B
790068	BL 410	10.37	125.45	7.66	0.719	20.051	-3.1	16.47	198.78	12.14	14.46	174.48	10.66	X
796235	BL 409	10.35	123.40	7.64	0.721	19.946	-3.6	16.33	194.54	12.05	14.37	171.15	10.60	X
796234	BL1 407	10.26	128.99	7.73	0.720	19.892	-3.8	16.11	202.40	12.13	14.25	179.15	10.74	B
MEAN:		11.22	127.76	6.70	0.682	19.662	-2.3	17.24	196.49	10.33	16.53	187.70	9.80	N= 5
STD.DEV.:		1.11	18.42	0.98	0.040	0.194	1.5	1.46	27.84	1.69	2.35	29.71	1.00	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 330 ENGID: F330 9A15055 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #05

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
793275	BL 0501	28.63	163.89	7.68	0.745	16.443	-7.8	36.52	209.03	9.79	38.44	219.99	10.31	B
793276	BLT 0502	29.26	156.13	8.15	0.724	16.398	-8.0	37.21	198.52	10.36	40.42	215.65	11.26	B
793277	BL 0503	27.40	155.26	7.77	0.724	16.422	-7.9	34.93	197.91	9.91	37.85	214.44	10.73	B
793278	BL 0504	26.29	153.69	8.10	0.715	16.554	-7.1	33.76	197.34	10.40	36.78	214.96	11.33	B
793279	BL 0505	29.05	156.77	7.75	0.728	16.513	-7.4	37.12	200.29	9.91	39.91	215.34	10.65	B
MEAN:		28.11	157.15	7.89	0.727	16.466	-7.6	35.91	200.62	10.07	38.68	216.08	10.86	N= 5
STD.DEV. %		1.25	3.95	0.22	0.011	0.065	0.4	1.51	4.84	0.28	1.49	2.25	0.43	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 351 ENGID: GM351 2483434 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #06

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE *= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	*= VALID
793500	HL 0602	14.30	101.09	6.67	0.631	18.336	5.4	20.69	146.29	9.65	22.66	160.21	10.57	*
793501	HL 0603	8.81	112.73	7.92	0.651	16.579	-4.7	11.68	149.47	10.50	13.49	172.64	12.13	*
793502	HL 0604	13.30	104.28	20.30	0.450	18.092	4.0	18.18	142.51	27.75	29.55	231.73	45.12	*
793503	HL 0605	8.19	113.77	9.45	0.650	16.721	-3.9	10.68	148.42	12.34	12.60	175.03	14.55	*
793504	HL 0606	9.00	78.56	9.88	0.609	16.685	-4.1	11.80	103.01	12.95	14.78	129.00	16.22	*
793505	HL 0607	10.35	82.78	8.68	0.643	16.655	-4.2	13.55	108.36	11.36	16.09	128.74	13.50	*
794345	HL 0608	10.64	110.28	9.68	0.651	15.872	-8.9	13.18	136.64	11.99	16.34	169.41	14.87	*
MEAN		9.72	111.51	8.80	0.652	16.225	-6.8	12.43	143.05	11.24	14.92	171.02	13.50	N= 7
STD.DEV. I		1.29	1.73	1.25	0.001	0.500	3.0	1.06	9.07	1.05	2.01	2.30	1.94	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 10 CID: 330 ENGID: F330 005055 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #07

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
794441	BLT 0708	37.77	240.67	5.50	0.767	18.039	-4.3	52.54	334.78	7.65	49.24	313.78	7.17	X
794444	BL 0705	36.46	239.67	6.04	0.773	17.945	-4.8	50.50	331.99	8.37	47.16	310.06	7.81	B
794445	BL 0706	33.30	201.26	6.73	0.716	18.174	-3.6	46.70	282.27	9.43	46.50	281.09	9.40	B
794446	BL 0707	32.76	232.17	6.00	0.762	18.080	-4.1	45.74	324.35	8.38	42.96	304.69	7.87	B
MEAN:		34.16	224.37	6.25	0.750	18.066	-4.2	47.65	312.87	8.73	45.54	298.61	8.36	N= 3
STD.DEV. :		2.01	20.36	0.41	0.030	0.117	0.6	2.52	26.77	0.61	2.26	15.41	0.90	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 350 ENGID: GM350 V0S1/X1 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #08

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL		GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID H= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	
794601	BLT 0803	9.90	167.42	5.06	0.640	22.405	2.4	17.26	291.68	8.82	15.48	261.59	7.91	X
794604	BL 0802	9.39	170.61	4.93	0.688	21.753	-5.2	16.02	291.10	8.41	13.64	247.98	7.16	B
794605	BL 0801	9.41	170.92	4.71	0.648	21.731	-5.3	15.94	289.58	7.98	14.52	263.77	7.27	B
MEAN:		9.40	170.77	4.82	0.668	21.742	-5.3	15.98	290.34	8.19	14.08	255.87	7.21	N= 2
STD.DEV.:		0.02	0.35	0.15	0.028	0.0	0.1	0.06	1.03	0.30	0.62	11.17	0.07	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 318 ENGID: D318 PH 318R RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #09

N U M B E R		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	M= VALID
795147	BLT 0904	7.70	68.56	8.23	0.593	16.758	-8.8	10.13	90.13	10.83	12.99	115.62	13.89	M
795149	BL 0902	7.70	100.91	7.69	0.612	18.351	-0.1	11.11	145.54	11.09	12.58	164.89	12.56	B
795150	BL 0901	8.46	91.45	6.87	0.593	17.524	-4.6	11.63	125.60	9.44	14.27	154.22	11.59	B
MEAN:		7.96	86.97	7.60	0.599	17.544	-4.5	10.96	120.42	10.45	13.28	144.91	12.68	N= 3
STD.DEV. :		0.44	16.63	0.69	0.011	0.797	4.3	0.76	28.07	0.89	0.88	25.92	1.15	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 270 CID: 345 ENG ID: V345 319806 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #10

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL		GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID H= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
795284	BL 1001	7.18	78.49	6.37	0.717	17.922	-11.3	10.00	109.27	8.87	10.02	109.47	8.89	B
795286	BL 1002	7.05	74.57	6.55	0.705	17.966	-11.1	10.02	105.91	9.31	10.01	105.78	9.30	B
795287	BL 1003	6.51	91.14	6.10	0.659	21.834	8.1	11.14	156.10	10.46	9.87	138.31	9.26	X
795332	BLT 1004	5.84	79.77	6.57	0.656	21.268	5.3	9.68	132.29	10.90	8.90	121.59	10.02	X
MEAN:		7.12	76.53	6.46	0.711	17.944	-11.2	10.01	107.59	9.09	10.01	107.62	9.09	N= 2
STD.DEV. :		0.09	2.77	0.13	0.008	0.035	0.2	0.02	2.38	0.31	0.01	2.61	0.29	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 350 ENGID: GM 350 2 1 JPN RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #11

NUMBER TEST	NUMBER CODING	GRAMS / BHP-HR HC	GRAMS / BHP-HR CO	GRAMS / BHP-HR NOX	#/BHP-HR BSFC	ACTUAL BHP-HR	% ERROR	GRAMS / MILE HC	GRAMS / MILE CO	GRAMS / MILE NOX	WEIGHTED GRAMS/LB FUEL HC	WEIGHTED GRAMS/LB FUEL CO	WEIGHTED GRAMS/LB FUEL NOX	DISP CODE B= VALID H= VALID
795441	BL1 1103	7.47	109.22	5.34	0.649	18.399	-10.4	10.74	156.95	7.68	11.51	168.29	8.23	B
795442	BL1 1102	8.55	109.22	5.85	0.626	17.276	-15.9	11.50	146.83	7.87	13.67	174.48	9.35	X
795443	BL 1101	4.47	121.30	4.93	0.621	20.222	-1.5	6.98	189.51	7.71	7.19	195.33	7.95	X
795544	BL 1104	5.22	93.68	6.93	0.616	19.431	-5.4	7.90	141.88	10.49	8.47	152.07	11.24	X
795545	BL1 1105	7.19	114.75	5.97	0.627	17.121	-16.6	9.61	153.36	7.98	11.47	183.01	9.53	X
795546	BL1 1106	5.26	131.01	5.45	0.601	19.874	-3.2	8.21	204.43	8.50	8.75	217.99	9.07	B
795547	BL1 1107	5.91	138.16	5.29	0.597	19.216	-6.4	8.81	205.86	7.88	9.90	231.43	8.86	B
795548	BL1 1108	9.55	107.29	7.08	0.658	17.374	-15.4	13.64	153.15	10.11	14.52	163.05	10.76	X
MEAN:		6.21	126.13	5.36	0.616	19.163	-6.7	9.25	189.08	8.02	10.06	205.90	8.72	N= 3
STD.DEV. :		1.14	15.08	0.08	0.029	0.739	3.6	1.32	27.84	0.43	1.39	33.26	0.44	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)
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MAY 24, 1979

MFG: 30 CID: 300 ENGID: F300 1 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #12

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID X= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
795553 BL	1201	8.75	230.81	5.39	0.681	17.176	-6.8	11.83	312.16	7.29	12.81	337.93	7.89	B
795552 BLT	1202	7.51	244.91	5.50	0.703	17.796	-1.8	10.47	341.12	7.66	10.69	348.37	7.82	X
795551 BL	1203	6.25	225.55	5.26	0.698	18.449	1.8	8.76	316.13	7.37	8.96	323.13	7.53	X
795554 BL	1204	8.64	242.32	4.81	0.718	16.420	-9.4	11.27	316.10	6.28	12.01	337.49	6.70	B
795555 BLT	1205	5.94	224.43	4.42	0.665	18.180	-1.3	8.52	321.61	6.33	8.94	337.49	6.64	X
795557 BLT	1206	6.06	227.02	4.52	0.681	18.244	0.6	8.61	322.53	6.43	8.90	333.37	6.64	B
MEAN:		7.81	233.38	4.91	0.696	17.280	-5.2	10.57	316.93	6.67	11.24	336.26	7.08	N= 3
STD.DEV. :		1.52	7.97	0.64	0.021	0.917	5.2	1.72	5.24	0.55	2.07	2.51	0.70	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 270 CID: 345 ENGID: V345 713456 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #13

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	
790071	HLT 1303	8.95	124.17	5.72	0.682	18.995	-13.4	13.50	187.28	8.63	13.12	182.06	8.79	X
796519	HLT 1301	6.09	111.61	6.20	0.685	20.325	-7.3	9.78	179.23	9.95	8.89	162.94	9.05	X
796520	HLT 1302	6.31	115.45	5.56	0.665	20.191	-8.0	10.14	185.75	8.94	9.48	173.61	8.36	X
796602	HLT 1305	6.75	81.01	5.49	0.620	20.603	-6.1	11.13	133.49	9.05	10.89	130.65	8.86	B
796603	HLT 1304	6.17	101.69	5.59	0.611	21.172	-3.5	10.37	170.71	9.39	10.10	166.43	9.15	B
796604	HLT 1306	6.29	99.35	5.68	0.609	21.119	-3.7	10.60	167.43	9.57	10.33	163.14	9.32	B
MEAN:		6.41	94.02	5.59	0.613	20.965	-4.4	10.70	157.21	9.34	10.44	153.41	9.11	N= 3
STD.DEV. :		0.31	11.33	0.09	0.006	0.314	1.4	0.39	20.61	0.26	0.40	19.78	0.23	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 366 ENGID: GM366 ARBUCKLE RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #14

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	N- VALID
A00106	BLT 1402	8.57	189.15	5.12	0.744	20.507	-8.8	13.79	304.35	8.24	11.52	254.24	6.83	B
A00105	BL 1401	8.61	194.08	5.37	0.736	20.936	-6.9	14.26	320.08	8.88	11.75	264.41	7.32	B
A00107	BL 1403	8.50	180.52	5.46	0.734	20.621	-9.3	13.98	291.87	8.90	11.70	245.93	7.45	B
MEAN:		8.59	187.92	5.32	0.737	20.688	-8.0	14.01	306.37	8.67	11.66	254.86	7.22	N= 3
STD.DEV. :		0.0	6.86	0.18	0.006	0.222	1.0	0.24	13.62	0.38	0.12	9.26	0.29	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 361 ENGID: F361 SHOE RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #15

NUMBER TEST	CODING	GRAMS / BHP-HR HC	CO	NOX	#/BHP-HR BSFC	ACTUAL BHP-HR	ERROR	GRAMS / MILE HC	CO	NOX	WEIGHTED GRAMS/LB FUEL HC	CO	NOX	DISP CODE B= VALID M= VALID
796609	HLT 1501	12.56	221.06	5.21	0.781	17.414	-17.0	17.12	301.67	7.10	16.06	283.05	6.67	X
796606	HL 1504	11.84	220.78	5.07	0.766	18.311	-12.8	17.07	318.24	7.31	15.46	288.23	6.62	X
796607	HL 1503	12.89	212.68	5.94	0.757	17.769	-15.1	17.83	296.06	8.27	16.92	280.95	7.85	X
796608	HLT 1502	11.51	211.95	5.60	0.754	16.985	-19.1	15.23	280.36	7.41	15.27	281.11	7.43	X
796605	HL 1505	14.01	219.75	4.81	0.729	22.121	5.4	24.55	384.90	8.43	19.22	301.44	6.60	X
800101	HLT 1508	14.23	243.36	4.86	0.776	17.961	-14.4	20.47	350.05	6.99	18.34	313.61	6.27	X
800102	HL 1507	14.67	240.93	5.24	0.793	18.733	-10.8	21.37	350.96	7.64	18.50	303.82	6.61	B
800101	HL 1506	13.59	215.85	5.61	0.766	18.899	-10.0	20.10	319.48	8.31	17.72	281.79	7.33	B
MEAN:		14.12	228.39	5.43	0.779	18.816	-10.4	20.73	335.22	7.97	18.11	292.81	6.97	N= 2
STD.DEV. :		0.79	17.73	0.20	0.019	0.119	0.6	0.90	22.26	0.47	0.55	15.58	0.51	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 360 ENGID: F360 E661 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #16

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
800111	HLT 1601	10.34	149.05	6.00	0.690	23.787	1.2	18.67	269.06	10.83	14.99	216.01	8.70	X
800110	HL 1602	7.46	134.89	6.19	0.654	23.588	2.4	13.73	248.29	11.30	11.41	206.26	9.39	M
800137	HL 1604	7.79	120.07	7.01	0.628	22.344	-3.0	13.71	211.29	12.34	12.40	191.11	11.16	M
800138	HL 1605	9.45	137.31	5.41	0.682	21.696	-5.8	14.34	233.10	9.18	12.38	201.33	7.93	X
800140	HLT 1606	8.64	141.64	6.71	0.684	23.335	1.3	15.81	259.12	12.32	12.64	207.08	9.85	M
MEAN:		7.96	132.19	6.63	0.655	23.089	0.2	14.42	239.57	11.99	12.15	201.48	10.13	N= 3
STD.DEV. :		0.61	11.07	0.44	0.028	0.658	2.9	1.21	25.08	0.59	0.65	9.00	0.92	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 292 ENGID: GM292 PAC ET RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #17

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	
800140	BLT 1701	10.81	209.46	7.60	0.859	15.588	-1.1	12.96	250.95	9.11	12.59	243.84	8.85	X
800141	BLT 1702	22.47	285.06	5.61	1.080	13.662	-13.3	23.36	296.45	5.84	20.80	263.94	5.20	X
800142	BLT 1703	9.82	217.57	4.96	0.861	16.851	6.9	12.79	283.56	6.46	11.40	252.70	5.76	X
800143	BLT 1704	8.65	197.05	5.77	0.864	14.678	-6.9	9.98	227.19	6.65	10.02	228.06	6.68	X
800145	BL 1705	8.21	221.73	5.56	0.905	14.853	-5.8	9.22	249.06	6.25	9.07	245.00	6.14	X
800169	BL 1706	5.24	153.35	3.99	0.655	17.945	13.8	7.27	212.97	5.54	7.99	234.13	6.10	X
800170	BLT 1707	7.14	161.00	14.63	0.578	13.845	-12.2	7.74	174.53	15.86	12.35	278.54	25.31	X
800171	BLT 1708	9.08	180.60	4.75	0.774	15.375	2.5	10.81	214.89	5.65	11.73	233.33	6.14	B
800188	BL 1710	8.60	179.43	4.46	0.784	15.029	-4.7	9.95	207.52	5.16	10.97	228.87	5.69	X
800172	BLT 1709	7.99	165.12	5.54	0.750	15.128	-4.0	9.39	193.93	6.50	10.66	220.15	7.38	B
800195	BL 1711	7.03	162.73	4.64	0.732	16.284	4.3	8.79	203.44	5.80	9.61	222.31	6.33	X
MEAN		8.54	172.86	5.14	0.762	15.251	-3.3	10.10	204.41	6.07	11.20	226.74	6.76	N= 2
STD.DEV. :		0.77	10.95	0.56	0.017	0.175	1.1	1.00	14.82	0.60	0.76	9.32	0.88	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 318 ENGID: D318 F002 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #18

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL		GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	
800186 HL	1801	7.87	164.66	6.09	0.658	21.920	19.3	13.36	279.47	10.34	11.96	250.25	9.26	X
800187 HLT	1802	8.91	145.90	7.05	0.660	17.854	2.9	12.36	202.34	9.78	13.51	221.05	10.68	B
800190 HL	1803	8.82	152.95	7.69	0.682	18.356	-0.1	12.41	215.17	10.82	12.94	224.26	11.28	B
800191 HL	1804	8.71	133.94	7.86	0.640	18.122	-1.4	12.23	188.09	11.04	13.61	209.28	12.29	B
MEAN:		8.82	144.26	7.54	0.661	18.111	-1.5	12.33	201.87	10.55	13.35	218.20	11.42	N= 3
STD.DEV. :		0.10	9.61	0.43	0.021	0.251	1.4	0.09	13.55	0.67	0.36	7.89	0.81	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)
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MAY 29, 1979

MFG: 30 CID: 361 ENGID: F361 BLT 1. RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #19

N U M B E R		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE
TEST	CODING	HC	CO	NOx	BSFC	BHP- HR	ERROR	HC	CO	NOX	HC	CO	NOX	B= VALID H= VALID
800118 BL	1901	9.82	203.50	4.46	0.680	21.073	-2.8	16.20	335.60	7.35	14.44	299.26	6.56	X
800128 BL	1902	9.54	204.97	4.61	0.681	20.587	-5.0	15.40	330.82	7.45	13.97	300.10	6.75	B
800129 BLT	1903	9.56	190.21	5.52	0.691	20.186	-6.9	15.10	300.31	8.72	13.84	275.26	7.99	B
800214 BL	1904	9.61	197.48	5.14	0.696	19.747	-8.9	14.83	304.73	7.94	13.81	283.74	7.39	B
MEAN:		9.57	197.55	5.09	0.690	20.173	-6.9	15.11	311.95	8.04	13.87	286.37	7.38	N= 3
STD.DEV. :		0.04	7.39	0.46	0.007	0.420	1.9	0.29	16.49	0.64	0.08	12.63	0.62	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 360 ENGID: F360 F663 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #29

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL		GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOx	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	
800201	BL 2001	5.78	73.83	6.97	0.635	21.624	1.2	9.81	125.26	11.81	9.10	116.27	10.98	M
800219	BL 2002	6.0	76.80	6.79	0.637	21.121	-1.2	10.03	127.28	11.26	9.50	120.56	10.67	M
MEAN:		5.92	75.32	6.88	0.636	21.372	0.0	9.92	126.27	11.54	9.30	118.42	10.82	N= 2
STD.DEV. :		0.19	2.10	0.13	0.002	0.356	1.7	0.16	1.43	0.40	0.28	3.03	0.22	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 350 ENGID: GM350 TENNIS RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #21

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL	%	GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP- HP	ERROR	HC	CO	NOX	HC	CO	NOX	H= VALID
800202	BL 2101	9.70	146.57	5.63	0.678	18.581	-12.0	14.03	211.94	8.15	14.31	216.19	8.31	X
800218	BLT 2102	9.50	141.07	5.65	0.679	18.296	-11.4	13.56	201.29	8.06	13.99	207.76	8.32	X
800224	BLT 2103	8.21	149.34	5.46	0.675	19.021	-9.9	12.17	221.33	8.09	12.17	221.24	8.09	H
800223	BL 2104	8.59	150.37	4.17	0.627	20.728	-1.8	13.82	241.93	6.70	13.70	239.82	6.65	H
800222	BL 2105	9.13	151.38	4.11	0.633	20.903	-1.0	14.89	246.92	6.70	14.42	239.15	6.49	B
MEAN:		8.64	150.36	4.58	0.645	20.217	-4.3	13.63	236.73	7.16	13.43	233.40	7.08	N= 3
STD.DEV. :		0.46	1.06	0.76	0.026	1.040	4.9	1.37	13.57	0.80	1.15	10.54	0.88	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 361 ENGID: D361-1 SLUG RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #22

NUMBER TEST	NUMBER CODING	GRAMS / BHP-HR HC	GRAMS / BHP-HR CO	GRAMS / BHP-HR NOX	#/BHP-HR BSFC	ACTUAL BHP-HR	% ERROR	GRAMS / MILE HC	GRAMS / MILE CO	GRAMS / MILE NOX	WEIGHTED GRAMS/LB FUEL HC	WEIGHTED GRAMS/LB FUEL CO	WEIGHTED GRAMS/LB FUEL NOX	DISP CODE B= VALID H= VALID
800220	HLT 2201	13.63	139.72	6.63	0.636	16.383	8.1	17.50	179.41	8.51	21.43	219.68	10.42	X
800221	HLT 2202	11.16	169.02	5.70	0.657	16.192	-9.2	16.64	213.68	7.21	20.04	257.27	8.68	B
800228	HLT 2203	12.10	168.34	6.32	0.713	16.058	-9.9	15.16	211.04	7.93	16.96	236.10	8.87	B
MEAN:		12.63	168.68	6.01	0.685	16.125	-9.5	15.90	212.36	7.57	18.50	246.69	8.78	N= 2
STD.DEV. :		0.76	0.50	0.44	0.040	0.096	0.5	1.05	1.87	0.51	2.17	14.96	0.13	

HEAVY DUTY ENGINE TRANSIENT EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 366 ENGID: GM366 S-FI RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #23

NUMBER		GRAMS / BHP-HR			#/BHP-HR	ACTUAL		GRAMS / MILE			WEIGHTED GRAMS/LB FUEL			DISP CODE B= VALID M= VALID
TEST	CODING	HC	CO	NOX	BSFC	BHP-HR	ERROR	HC	CO	NOX	HC	CO	NOX	
800236	BLT 2301	8.44	129.10	4.23	0.644	20.520	-5.0	13.60	205.13	6.72	13.11	200.47	6.57	B
800237	BL 2302	8.71	138.80	4.04	0.668	19.790	-8.4	0.0	0.0	0.0	13.04	207.78	6.05	X
800238	BL 2303	8.45	141.00	4.56	0.679	20.280	-6.1	13.24	220.53	7.13	12.44	207.66	6.72	B
800239	BLT 2304	8.71	134.50	5.19	0.673	21.100	-2.3	13.51	208.66	8.05	12.94	199.85	7.71	B
MEAN:		8.53	134.87	4.66	0.665	20.633	-4.5	13.45	211.44	7.30	12.83	202.66	7.00	N= 3
STD.DEV. :		0.15	5.96	0.49	0.019	0.422	2.0	0.19	8.07	0.68	0.34	4.34	0.62	

BASELINE ENGINE TRANSIENT

EMISSION TEST SUMMARY TABLES

4 TABLES

TABLE 1: SALES-WEIGHTED BRAKE SPECIFIC EMISSIONS(G/BHP-HR)

1979 BASELINE ENGINE(S)

MAY 24, 1979

	ENGINE		WEIGHTING FACTORS	SIZE	HC	WEIGHTED HC	CO	WEIGHTED CO	NOX	WEIGHTED NOX
01	FW 225R 2994 032	0	0.00368	2	7.20	0.026	52.20	0.192	8.46	0.031
02	V342 654417	0	0.02699	3	6.35	0.171	178.47	4.818	4.24	0.114
03	371-J	0	0.02331	2	13.54	0.316	179.19	4.178	5.83	0.136
04	V304 648048	0	0.06135	5	11.22	0.688	127.76	7.838	6.70	0.411
05	F 330 JAH5055	0	0.08834	5	28.13	2.485	157.15	13.883	7.89	0.697
06	GM351 2483434	0	0.04417	2	9.72	0.430	111.51	4.926	8.80	0.389
07	F 130 JHJ5055	0	0.08834	3	34.16	3.018	224.37	19.822	6.25	0.553
08	GM350 V0512XT	0	0.05521	2	9.40	0.519	170.77	9.429	4.82	0.266
09	D318 M 318R	0	0.03804	3	7.96	0.303	86.97	3.308	7.60	0.289
10	V345 119H0C	0	0.03620	2	7.12	0.258	76.53	2.770	6.46	0.234
11	GM 350 2 LJPN	0	0.05521	3	6.21	0.343	126.13	6.964	5.36	0.296
12	F 300 1	0	0.05031	3	7.81	0.393	233.38	11.741	4.91	0.247
13	V345 713456	0	0.03620	3	6.41	0.232	94.02	3.403	5.59	0.202
14	GM366 ARBUCKLE	0	0.03865	3	8.59	0.332	187.92	7.263	5.32	0.206
15	F361 HUF	0	0.03067	2	14.12	0.433	228.39	7.006	5.43	0.167
16	F360 FGG1	0	0.03742	3	7.96	0.298	132.19	4.947	6.63	0.248
17	GM292 RACKET	0	0.06380	2	8.54	0.545	172.86	11.029	5.14	0.328
18	D318 FGG2	0	0.03558	3	8.82	0.314	144.26	5.133	7.54	0.268
19	F361 MTF 19	0	0.03067	3	9.57	0.294	197.55	6.060	5.09	0.156
20	F360 FGG3	0	0.03742	2	5.92	0.221	75.32	2.819	6.88	0.258
21	GM350 TENNIS	0	0.05521	3	8.64	0.477	150.36	8.302	4.58	0.253
22	D361-3 SLUG	0	0.02454	2	12.63	0.310	168.68	4.139	6.01	0.148
23	GM366 SURI	0	0.03865	3	8.53	0.330	134.87	5.213	4.66	0.180
	SALES-WEIGHTED GAS BAG TOTALS:					12.74		155.18		6.08
	90% REDUCTION FROM BASELINE:					1.27		15.52		0.608

TABLE 2: SALES-WEIGHTED PERCENTAGES DATA
1969 BASELINE ENGINE(S)

MAY 24, 1979

	ENGINE		PERCENT TOTAL	CORRECTED PERCENT	WEIGHTING FACTOR
01	FW 225R 2994 032	0	0.300	0.368	0.00368
02	V392 CSH417	0	2.200	2.699	0.02699
03	351-J	0	1.900	2.331	0.02331
04	V304 648048	0	5.000	6.135	0.06135
05	F130 9AJ5055	0	7.200	8.834	0.08834
06	GM351 2483436	0	3.600	4.417	0.04417
07	F130 9HJ5055	0	7.200	8.834	0.08834
08	GM350 V0512XI	0	4.500	5.521	0.05521
09	D318 M 318R	0	3.100	3.804	0.03804
10	V345 119R0C	0	2.950	3.620	0.03620
11	GM 350 2 LJPN	0	4.500	5.521	0.05521
12	F300 1	0	4.100	5.031	0.05031
13	V345 719456	0	2.950	3.620	0.03620
14	GM366 ARBUCKLE	0	3.150	3.865	0.03865
15	F361 HOF	0	2.500	3.067	0.03067
16	F360 EGO1	0	3.050	3.742	0.03742
17	GM292 RACKET	0	5.200	6.380	0.06380
18	D318 EGO2	0	2.900	3.558	0.03558
19	F361 HF 19	0	2.500	3.067	0.03067
20	F360 EGO3	0	3.050	3.742	0.03742
21	GM350 TENNIS	0	4.500	5.521	0.05521
22	D361-1 SLUG	0	2.000	2.454	0.02454
23	GM366 SPI	0	3.150	3.865	0.03865
	SUM TOTALS:		81.500	100.00	1.000

1969 BASELINE ENGINE(S)

MAY 24, 1979

	ENGINE		BSHC	BSCO	BSNOX	SIZE
01	F 225R 2994 032	0	7.20	52.20	8.46	2
02	V392 658417	0	6.35	178.47	4.74	3
03	391-J	0	13.54	179.19	5.83	2
04	V304 48048	0	11.22	127.76	6.70	5
05	F 330 JA85055	0	28.13	157.15	7.89	5
06	GM351 2483434	0	9.72	111.51	8.80	2
07	F 330 9P35055	0	34.16	224.37	6.25	3
08	GM350 V0512X1	0	9.40	170.77	4.82	2
09	D318 M 318H	0	7.96	86.97	7.60	3
10	V345 119806	0	7.12	76.53	6.46	2
11	GM 350 2 LJPN	0	6.21	126.13	5.36	3
12	F 300 1	0	7.81	233.38	4.91	3
13	V345 71 456	0	6.41	94.02	5.59	3
14	GM366 A7HUCKLF	0	8.59	187.92	5.32	3
15	F 361 HUH	0	14.12	228.39	5.43	2
16	F 360 FG61	0	7.46	132.19	6.63	3
17	GM292 RACKLT	0	8.54	172.86	5.14	2
18	D316 FG62	0	8.82	144.26	7.54	3
19	F 361 LF 19	0	9.57	197.55	5.09	3
20	F 360 FG63	0	5.92	75.32	6.88	2
21	GM350 TENNIS	0	8.64	150.36	4.58	3
22	D361-3 SLUG	0	12.63	168.68	6.01	2
23	GM366 SARI	0	8.53	134.87	4.66	3

TABLE 4: SALES-WEIGHTED TRANSIENT ENGINE EMISSIONS(GRAMS/MI) PAGE NO. 4
1969 BASELINE ENGINE(S)

MAY 24, 1979

	ENGINE	WEIGHTING FACTORS	SIZE	HC	SALES WEIGHTED HC	CO	SALES WEIGHTED CO	NOX	SALES WEIGHTED NOX
01	FW 225P 2994 012	0 0.00368	2	6.16	0.023	44.66	0.164	7.23	0.027
02	V392 658417	0 0.02699	3	9.31	0.251	261.44	7.057	6.21	0.168
03	391-J	0 0.02331	2	26.04	0.607	344.55	8.032	11.21	0.261
04	V304 648048	0 0.06135	5	17.24	1.058	196.49	12.055	10.33	0.634
05	F330 9A 5055	0 0.08834	5	35.91	3.172	200.62	17.723	10.07	0.890
06	GM351 2683434	0 0.04417	2	12.43	0.549	143.05	6.319	11.24	0.497
07	F330 9885055	0 0.08834	3	47.65	4.209	312.87	27.640	8.73	0.771
08	GM350 V0512X1	0 0.05521	2	15.98	0.882	290.34	16.031	8.19	0.452
09	D318 CM 318R	0 0.03804	3	10.96	0.417	120.42	4.581	10.45	0.398
10	V345 3128OC	0 0.03620	2	10.01	0.362	107.59	3.894	9.09	0.329
11	GM 350 2 LJPN	0 0.05521	3	9.25	0.511	189.08	10.440	8.02	0.443
12	F309 1	0 0.05031	3	10.57	0.532	316.93	15.944	6.67	0.335
13	V345 714656	0 0.03620	3	10.70	0.387	157.21	5.690	9.34	0.338
14	GM366 ARBUCKLE	0 0.03865	3	14.01	0.541	306.37	11.841	8.67	0.335
15	F361 JHOF	0 0.03077	2	20.73	0.636	335.22	10.283	7.97	0.245
16	F360 EGG1	0 0.03742	3	14.42	0.540	239.57	8.965	11.99	0.449
17	GM292 RACKET	0 0.06380	2	10.10	0.644	204.41	13.042	6.07	0.388
18	D318 FG 2	0 0.03558	3	12.33	0.439	201.87	7.183	10.55	0.375
19	F361 HLF 19	0 0.03067	3	15.11	0.463	311.95	9.569	8.04	0.247
20	F360 EGG3	0 0.03742	2	9.92	0.371	126.27	4.725	11.54	0.432
21	GM350 TENNIS	0 0.05521	3	13.63	0.752	236.73	13.071	7.16	0.396
22	D361-3 SLUG	0 0.02454	2	15.90	0.390	212.36	5.211	7.57	0.186
23	GM366 SPRI	0 0.03865	3	13.45	0.520	211.44	8.172	7.30	0.282
	SALES-WEIGHTED GAS BAG TOTALS:				18.26		227.63		8.88
	90% REDUCTION FROM BASELINE:				1.83		22.76		0.888

BASELINE ENGINE IDLE

TEST DATA SHEETS

19 ENGINES

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 391 ENGID: 391-JW RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #03

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790017	IHB 0301	2548.	31951.	168.	15008.	15884.	69.	1867.	14271.	1088.	2484.	21563.	1681.	B
790018	IHB 0302	2687.	29603.	188.	15594.	10168.	66.	1679.	12297.	2624.	2286.	17741.	1962.	B
790019	IHB 0303	2704.	29603.	188.	15594.	10168.	66.	1679.	12297.	2624.	2286.	17741.	1962.	B
790020	IHB 0304	2992.	33593.	171.	16302.	12993.	71.	1548.	11546.	5100.	2156.	17204.	1888.	B
790021	IHB 0305	3776.	54968.	120.	10968.	67172.	1.	2260.	20654.	1136.	3003.	36375.	1232.	B
MEAN:		2941.	35944.	167.	14693.	23277.	54.	1807.	14213.	2514.	2443.	22125.	1745.	N= 5
STD.DEV. :		493.6	10768.0	27.7	2132.3	24651.9	30.2	278.0	3733.8	1631.3	334.4	8155.3	308.9	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 270 CID: 304 ENGID: V304 648048 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #04

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790001	IHB 0401	2209.	27182.	146.	39935.	93432.	30.	2045.	7826.	1767.	2374.	17865.	898.	B
790002	IHB 0402	1846.	23826.	143.	44825.	110558.	72.	1382.	8036.	814.	2269.	17349.	985.	B
790367	LHB 0403	1843.	24855.	184.	18160.	87365.	41.	1936.	6658.	2100.	2377.	14796.	1386.	B
MEAN:		1966.	25288.	158.	34307.	97118.	48.	1787.	7507.	1560.	2340.	16670.	1089.	N= 3
STD.DEV. :		210.3	1719.6	23.3	14195.6	12028.2	21.7	355.8	742.5	667.2	61.6	1643.3	260.2	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 330 ENGID: F330 9AH5055 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #05

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790022	IMR 0501	3228.	15366.	197.	17733.	68544.	18.	1517.	3308.	1719.	2272.	7948.	1637.	B
790024	IMR 0503	3024.	16626.	212.	29995.	81823.	35.	2132.	3900.	2255.	2714.	8473.	1837.	B
790028	IMR 0502	3048.	16128.	251.	18102.	73[illegible]7.	106.	2055.	3793.	2621.	2550.	8364.	1929.	B
MEAN:		3100.	16107.	220.	21943.	74755.	51.	1901.	3667.	2198.	2512.	8262.	1801.	N= 3
STD.DEV. :		111.4	659.5	27.6	6975.3	6681.5	46.8	335.3	315.5	453.9	223.6	277.2	149.3	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 351 ENGID: GM351 2483434 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #06

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790030	IMH 0601	2532.	19598.	201.	4556.	31751.	35.	1053.	2060.	1976.	1670.	7444.	1420.	B
790031	IMH 0602	1690.	23334.	168.	4261.	36710.	34.	1055.	1457.	1747.	1744.	7316.	1117.	B
790032	IMH 0603	2171.	26020.	236.	4920.	23504.	62.	1249.	1679.	2487.	2061.	8610.	1730.	B
790033	IMH 0604	1557.	20029.	258.	5685.	48505.	0.	1376.	2493.	2483.	2239.	9527.	1645.	B
790034	IMH 0605	2569.	20987.	246.	5632.	50653.	55.	1480.	2054.	2546.	1912.	6619.	1500.	B
MEAN:		2104.	21994.	222.	5011.	38226.	37.	1243.	1949.	2248.	1925.	7903.	1482.	N= 5
STD.DEV. :		467.7	2675.0	36.8	635.9	11413.1	24.1	190.7	398.2	362.6	231.9	1155.6	237.5	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 10 CID: 330 ENGID: F330 9BNS0S RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #07

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790023	1HB 0701	1644.	19575.	100.	7604.	44372.	32.	1537.	23755.	464.	1866.	23619.	502.	B
790025	1HB 0702	1901.	20631.	103.	7726.	39262.	31.	1874.	27775.	572.	1742.	24132.	548.	B
790026	1HB 0703	713.	9204.	65.	6902.	42443.	36.	1674.	19317.	936.	1840.	19235.	772.	B
790027	1HB 0704	1338.	11016.	113.	8820.	34616.	21.	1562.	23098.	1008.	1771.	14409.	760.	B
790029	1HB 0705	1514.	19921.	114.	8956.	46801.	21.	1637.	24650.	526.	1887.	24365.	516.	B
790039	1HB 0706	2108.	29655.	124.	5118.	34050.	20.	2599.	38158.	965.	2311.	27695.	557.	B
MEAN:		1536.	18334.	103.	7521.	40257.	27.	1814.	26126.	745.	1936.	22243.	609.	N= 6
STD.DEV. :		487.7	7408.3	20.5	1411.0	5212.8	6.8	402.7	6491.3	249.5	192.3	4692.7	123.1	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 350 ENGID: GM350 V0512X1 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #08

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790014	1MH 0801	929.	10561.	97.	5792.	41719.	34.	1028.	9886.	858.	1319.	18260.	492.	B
790015	1MH 0802	911.	10372.	84.	3749.	39271.	27.	1053.	9940.	885.	1276.	17230.	470.	B
790016	1 H 0803	748.	9015.	76.	9800.	49143.	25.	1019.	9780.	911.	1299.	16746.	520.	B
MEAN:		863.	9983.	85.	6447.	43378.	28.	1033.	9869.	885.	1298.	17412.	494.	N= 3
STD.DEV. :		99.6	843.4	10.6	3078.5	5141.0	4.7	17.4	81.6	26.4	21.5	173.1	25.0	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 318 ENGID: 0318 PM 1100 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #09

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790046	TMH 0901	912.	4400.	351.	7844.	1304.	46.	190.	3175.	2684.	1927.	5201.	2578.	B
MEAN:		912.	4400.	351.	7844.	1304.	46.	190.	3175.	2684.	1927.	5201.	2578.	N= 1

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 350 ENGID: GM 350 2 (JPN RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #11

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790040	1 B 1101	995.	14109.	170.	3231.	38961.	54.	1164.	9989.	1637.	1464.	20498.	848.	B
790043	1 B 1102	906.	13564.	156.	5674.	53913.	46.	1341.	14157.	1406.	1413.	21671.	841.	B
790042	1 B 1103	954.	13068.	175.	3412.	41018.	51.	1105.	9087.	169.	1446.	20011.	960.	B
MEAN:		952.	13580.	167.	4106.	44631.	50.	1203.	11078.	1071.	1441.	20727.	883.	N= 3
STD.DEV. :		44.3	520.7	10.0	1361.3	8104.3	3.6	122.8	2704.7	789.7	25.9	853.3	66.9	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 300 ENGID: F300 1 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #12

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
790041	IHB 1201	5391.	57717.	127.	5529.	72660.	20.	2519.	56615.	828.	2861.	59419.	417.	B
790044	IHB 1202	5486.	64707.	107.	9577.	79364.	29.	2845.	63333.	720.	3162.	63972.	360.	B
790045	IHB 1203	4684.	62411.	131.	4042.	63220.	39.	2726.	60859.	821.	2928.	60816.	395.	B
MEAN:		5187.	61612.	121.	6383.	71748.	29.	2697.	60269.	790.	2983.	61402.	391.	N= 3
STD.DEV. :		438.5	3563.1	12.9	2864.4	8110.5	9.9	164.8	3397.4	60.2	158.3	2332.7	28.7	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 270 CID: 345 ENGID: V345 719456 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #13

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
796539	1HB 1301	866.	8759.	200.	5627.	20925.	63.	2333.	14204.	1783.	2073.	10392.	1320.	B
796540	1HB 1302	885.	9474.	191.	2702.	24262.	75.	2418.	14956.	1696.	2356.	14936.	1693.	B
796584	1HB 1303	931.	9423.	203.	6586.	23580.	61.	2306.	14467.	1587.	2079.	10140.	1069.	B
MEAN:		894.	9085.	198.	4972.	22922.	66.	2352.	14542.	1689.	2169.	11823.	1360.	N= 3
STD.DEV. :		33.7	629.6	6.1	2023.2	1763.2	7.6	58.5	381.7	98.3	161.9	2699.2	313.9	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)
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MAY 24, 1979

MFG: 40 CID: 366 ENGID: GM366 ARBUCKLE RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #14

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
800117	IMR 1402	1268.	21394.	172.	3991.	34830.	51.	1840.	16467.	1407.	2049.	22251.	941.	B
800115	IMR 1405	1061.	18126.	188.	706.	27268.	297.	1626.	10341.	1708.	1875.	20245.	1020.	X
800116	I R	1216.	19936.	174.	3806.	32246.	59.	1603.	11127.	1517.	1787.	19170.	963.	B
MEAN:		1242.	20665.	173.	3898.	33538.	55.	1721.	13797.	1462.	1918.	20711.	952.	N= 2
STD.DEV. :		36.6	1031.0	1.0	131.0	1827.1	5.6	167.7	3775.9	78.1	185.3	2178.5	14.9	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 361 ENGID: F361 SHOE RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #15

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID H= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
796638	IMB 1501	3382.	35920.	143.	8483.	56731.	36.	2686.	27890.	1470.	2915.	30466.	1137.	B
796639	IMB 1502	3462.	33065.	156.	6111.	46772.	59.	2610.	27039.	1434.	2819.	30823.	1098.	B
796645	IMB 1503	3457.	35699.	162.	8347.	58464.	32.	2528.	26142.	1574.	2759.	29585.	1096.	B
MEAN:		3433.	34895.	154.	7647.	53989.	42.	2608.	27024.	1492.	2831.	30291.	1110.	N= 3
STD.DEV.:		45.0	1588.8	9.6	1332.2	6309.8	14.4	79.2	874.5	73.1	78.6	638.0	23.3	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 360 ENGID: F360 FOG1 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #16

N U M B E R		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
800112	IMH 1601	7558.	29247.	194.	4942.	45611.	65.	492.	7517.	2101.	2555.	13917.	1174.	B
800139	IMH 1604	442.	2159.	21.	505.	5047.	1.	274.	915.	234.	300.	1489.	157.	B
800113	IMH 1602	6504.	24204.	184.	5127.	45692.	51.	2434.	7982.	2062.	2681.	14208.	1353.	B
800184	IMH 1603	2357.	16290.	195.	4350.	46262.	45.	2358.	7995.	2164.	2482.	13767.	1380.	B
MEAN:		4215.	17975.	148.	3731.	35659.	40.	1389.	6102.	1640.	2005.	10845.	1016.	N= 4
STD.DEV. :		3273.3	11815.9	85.4	2175.8	20410.1	27.6	1165.9	3465.3	938.4	1139.3	6240.2	579.7	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 292 ENGID: GM292 RACKET RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #17

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
800144	I-H 1701	3460.	1525.	306.	2885.	49618.	66.	492.	4838.	1179.	167.	1042.	444.	B
800189	I H 1702	3971.	4624.	303.	4819.	54161.	55.	279.	2169.	982.	416.	1196.	832.	B
MEAN:		3716.	3075.	304.	3852.	51890.	60.	385.	3504.	1080.	292.	1119.	638.	N= 2
STD.DEV. :		361.5	2191.3	1.8	1367.1	3212.1	7.4	150.5	1887.3	139.7	176.3	108.9	274.4	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 318 ENGID: D318 E062 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #18

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
800191	1-H 1801	1938.	24373.	231.	15486.	20544.	45.	2330.	11540.	2108.	2686.	13528.	2166.	B
800192	1-H 1802	1049.	25262.	240.	4222.	7737.	23.	2414.	12459.	1940.	2762.	14299.	1977.	B
MEAN:		1493.	24818.	236.	9854.	14141.	34.	2372.	12000.	2024.	2724.	13914.	2072.	N= 2
STD.DEV. :		628.7	628.5	6.1	7965.5	9055.9	15.6	59.5	649.7	118.7	54.0	545.2	133.5	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 361 ENGID: F361 BLE 1[illegible] RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #19

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
800213	IDL 1901	2790.	28419.	228.	5321.	27598.	59.	2603.	22120.	1744.	2750.	28418.	1261.	B
800215	IDL 1902	3059.	30442.	220.	7055.	28428.	52.	2704.	22579.	1688.	2887.	31321.	1140.	B
MEAN		2924.	29431.	224.	6188.	28013.	55.	2654.	22350.	1716.	2818.	29870.	1200.	N= 2
STD.DEV. :		190.3	1430.5	5.9	1226.5	586.8	5.1	71.6	324.8	39.7	96.9	2052.7	85.6	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 30 CID: 360 ENGID: F360 F6G3 RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 HLT #20

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
800205	1MH 2001	49.	726.	148.	4027.	41727.	48.	164.	979.	1012.	251.	1494.	665.	B
800194	1MR 2002	177.	936.	153.	4372.	38324.	41.	166.	934.	1054.	287.	1548.	678.	B
MEAN:		113.	831.	150.	4199.	40026.	44.	165.	957.	1033.	269.	1521.	671.	N= 2
STD.DEV. :		91.0	148.5	3.6	244.6	2406.3	4.8	1.9	31.8	29.9	25.2	38.2	8.7	

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 40 CID: 350 ENGID: CM350 TENNIS RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #21

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	B= VALID M= VALID
800227 196	2101	995.	11639.	145.	11784.	63769.	32.	1841.	17782.	1318.	2376.	22689.	1019.	B
MEAN:		995.	11639.	145.	11784.	63769.	32.	1841.	17782.	1318.	2376.	22689.	1019.	N= 1

HEAVY DUTY ENGINE IDLE TEST EMISSIONS SUMMARY -- 1969 BASELINE ENGINE(S)

MAY 24, 1979

MFG: 20 CID: 361 ENGID: D361-3 SLUG RATED BHP: N/A RATED RPM: N/A

COMMENTS: 1969 BLT #22

NUMBER		MODE NO. 1			MODE NO. 2			MODE NO. 3			MODE NO. 4			DISP CODE B= VALID M= VALID
TEST	CODE	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX	
B00206	IMB 2201	3169.	19763.	164.	12667.	54556.	35.	2044.	17172.	1916.	2201.	11233.	1644.	B
B00207	I B 2202	4131.	19011.	176.	12257.	56149.	36.	2062.	17304.	2000.	2149.	11173.	1717.	B
MEAN:		3750.	19387.	170.	12462.	55353.	35.	2053.	17238.	1958.	2175.	11203.	1681.	N= 2
STD.DEV. :		519.2	531.6	8.6	290.7	1126.8	0.7	12.7	93.3	59.3	37.1	42.3	51.4	

BASELINE ENGINE IDLE

EMISSION TEST SUMMARY TABLES

3 TABLES

TABLE 5: SALES-WEIGHTED IDLE EMISSIONS PAGE NO. 1

1969 BASELINE ENGINE(S)

MAY 24, 1979

	ENGINE	WEIGHTING FACTORS	SIZE	HC PPM-C	WEIGHTED HC	CO (PPM)	WEIGHTED CO	NOX (PPM)	WEIGHTED NOX
01	371-J	0 0.02405	5	14693.	353.38	23277.	559.93	54.3	1.307
04	V304 348048	0 0.06329	3	34307.	2171.30	97118.	6146.73	47.6	3.011
05	F330 7A15055	0 0.09114	3	21943.	1999.89	74755.	6813.08	53.2	4.846
06	GM351 2483434	0 0.04557	5	5011.	228.34	38226.	1741.94	37.3	1.700
07	F330 HC5055	0 0.09114	6	7521.	685.45	40257.	3669.03	26.7	2.436
08	GM350 V0512XI	0 0.05696	1	6447.	367.24	43378.	2470.88	28.4	1.620
09	D318 M 318P	0 0.03924	1	7844.	307.80	1304.	51.17	45.9	1.801
11	GM 351 2 LJPN	0 0.05696	3	4106.	233.87	44631.	2542.26	50.3	2.863
12	F300 1	0 0.05190	3	6383.	331.25	71748.	3723.63	29.4	1.524
13	V345 719456	0 0.07468	3	4972.	371.30	22922.	1711.92	66.0	4.932
14	GM366 A/BUCKLI	0 0.07975	2	3898.	310.86	33538.	2674.55	55.2	4.406
15	F361 HOF	0 0.03165	3	7647.	241.99	53989.	1708.51	42.1	1.332
16	F360 FG61	0 0.03861	4	3731.	144.04	35657.	1376.72	40.5	1.563
17	GM292 RACKET	0 0.06582	2	3852.	253.56	51890.	3415.51	60.5	3.982
18	D318 FG62	0 0.03671	2	9854.	361.73	14141.	519.08	34.1	1.254
19	F361 HLF 19	0 0.03165	2	6188.	195.82	28013.	886.49	55.1	1.744
20	F360 FG63	0 0.03861	2	4199.	162.13	40026.	1545.29	44.5	1.718
21	GM350 TENNIS	0 0.05696	1	11786.	671.31	63769.	3632.41	31.6	1.800
22	D361-1 SLUG	0 0.02532	2	12462.	315.49	55353.	1401.37	35.3	0.894
	SALES-WEIGHTED IDLE TESTS TOTAL:				9706.7		46590.3		44.73
	90% REDUCTION FROM BASELINE:				970.7		4659.0		4.47

TABLE 6: SALES-WEIGHTED PERCENTAGES DATA
1969 BASELINE ENGINE(S)

MAY 24, 1979

ENGINE		PERCENT TOTAL	CORRECTED PERCENT	WEIGHTING FACTOR
03 391-J	0	1.900	2.405	0.02405
04 V304 669048	0	5.000	6.329	0.06329
05 F330 7A3505S	0	7.200	9.114	0.09114
06 GL351 2483434	0	3.600	4.557	0.04557
07 F330 A005055	0	7.200	9.114	0.09114
08 GM350 V0512X1	0	4.500	5.696	0.05696
09 D318 M 318R	0	3.100	3.924	0.03924
11 GM 350 2 LJPN	0	4.500	5.696	0.05696
12 F300 1	0	4.100	5.190	0.05190
13 V345 719456	0	5.900	7.468	0.07468
14 GM306 ARBUCKLE	0	6.300	7.975	0.07975
15 F361 HOF	0	2.500	3.165	0.03165
16 F360 EGG1	0	3.050	3.861	0.03861
17 GM292 RECKET	0	5.200	6.582	0.06582
18 D318 EG12	0	2.900	3.671	0.03671
19 F361 LE 19	0	2.500	3.165	0.03165
20 F360 EGG3	0	3.050	3.861	0.03861
21 GM350 TENNIS	0	4.500	5.696	0.05696
22 D361-3 SLUG	0	2.000	2.532	0.02532
SUM TOTALS:		79.00	100.00	1.000

TABLE 7: IDLE EMISSIONS PAGE NO.

1969 BASELINE ENGINE(S)

MAY 24, 1979

	ENGINE		HC	CO	NOX	SIZE
03	391-J	0	14623.	23277.	54.34	5
04	V304 643048	0	34307.	97118.	47.57	3
05	F330 2A35055	0	21963.	74755.	53.17	3
06	GM351 2683434	0	5011.	38226.	37.30	5
07	F330 4N5055	0	7521.	40257.	26.73	6
08	GM350 V0512X1	0	6447.	43378.	28.43	3
09	D318 PM 318R	0	7844.	1304.	45.90	1
11	GM 350 2 LJPN	0	4106.	44631.	50.27	3
12	F100 1	0	6383.	71748.	29.37	3
13	V345 713456	0	4972.	22922.	66.03	3
14	GM366 ARBUCKLE	0	3898.	33538.	55.25	2
15	F161 JOE	0	7647.	53999.	42.10	3
16	F160 GG1	0	3711.	35659.	40.47	4
17	GM292 RACKET	0	3852.	51890.	60.50	2
18	D318 FGG2	0	9854.	14141.	34.15	2
19	F161 CLE 19	0	6188.	28013.	55.10	2
20	F360 FGG3	0	4199.	40026.	44.50	2
21	GM350 TENNIS	0	11784.	63769.	31.60	1
22	D361-3 SLUG	0	12462.	55353.	35.10	2

V. References

These publications will aid the reader in obtaining a greater understanding of the transient test procedure and the 1983 HD NPRM which this report supports.

Report Number and Date	Report Title and Author	NTIS Number
HDV 76-03 Oct. 1976	Engine Horsepower Modeling for Diesel Engines, C. France	
HDV 76-04 Dec. 1976	Engine Horsepower Modeling for Gasoline Engines, L. Higdon	
HDV 77-01 Nov. 1977	Selection of Transient Cycles for Heavy-Duty Engines, T. Wysor & C. France	
HDV 78-01 May 1978	Category Selection for Transient Heavy-Duty Chassis and Engine Cycles, C. France	PB 294 088
HDV 78-02 June 1978	Selection of Transient Cycles for Heavy-Duty Vehicles, T. Wysor & C. France	PM 294 221
HDV 78-03 May 1978	Truck Driving Patterns and Use Survey, Phase II, Final Report, Part II Los Angeles, L. Higdon	PB 293 843
HDV 78-04 July 1978	Transient Cycle Arrangement for Heavy-Duty Engine and Chassis Emission Testing, C. France	PB 293 764
HDV 78-05 July 1978	Analysis of Hot/Cold Cycle Requirements for Heavy-Duty Vehicles, C. France	PB 293 842
HDV 78-06 June 1978	A Preliminary Examination of the Repeatability of the Heavy-Duty Transient Dynamometer Emission Test, W. Clemmens	PB 293-830
EPA 460/3-78-008 July 1978	Heavy-Duty Vehicle Cycle Development, Malcolm Smith	PB 288 805
Federal Register Vol. 44, No. 31 Part II February 13, 1979	Proposed Gaseous Emission Regulations for 1983 and Later Model Year Heavy-Duty Engines	