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CHARACTERIZATION AND CONTROL OF EMISSIONS FROM HEAVY DUTY DIESEL AND GASOLINE FUELED ENGINES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

Description and code identification of engines

Engine code number	Engine manufacturer	Engine model	Engine type
	DIESEL ENGINES		
15	Caterpillar Tractor Company	1160	Open chamber, naturally aspirated
16	Caterpillar Tractor Company	1673C	Precombustion chamber, turbocharged
17	General Motors Corp., Detroit Diesel Allison Div.	8V-71N	Open chamber, 2-cycle, Roots blown
18	Mack Truck, Inc.	ENDT-675	Open chamber, turbocharged
19	International Harvester Company	DV-550B	Open chamber, MAN, naturally aspirated
20	Mack Trucks, Inc.	ENDT-865	Open chamber, turbocharged
21	Cummins Engine Company	N-927	Open chamber, naturally aspirated
	GASOLINE ENGINES		
22	International Harvester Company	V-345	No 9 mode data
23	Chrysler Corporation	318-1	

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by

Fuels Combustion Research Group
Bartlesville Energy Research Center
Bureau of Mines

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Prepared for

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FOREWORD

This report presents a summary of work performed by the Fuels Combustion Research Group, Bartlesville Energy Research Center, Bureau of Mines, for the Environmental Protection Agency (EPA), Mobile Source Pollution Control Program, Characterization and Control Development Branch, Division of Emission Control Technology under Interagency agreement number EPA-IAG-0129 (D).

Dr. Jose L. Bascunana was Chief of the Highway Vehicles Section in EPA and John J. McFadden was the Project Officer. The program at Bartlesville was directed by R. W. Hurn, Research Supervisor; Dr. R. D. Fleming, Assistant Research Supervisor, was responsible for the experimental work. Others who contributed to the experimental work were W. F. Marshall, Jr., as Project Leader for the diesel engine work, J. R. Allsup as Project Leader for the gasoline engine work, F. W. Penn, Mechanical Engineer, and D. P. Hinman, P. E. Palmer, G. D. Garrison, T. R. Owens, G. E. Davis, E. J. Boettcher, C. C. Barnes, and L. R. Wilson as Mechanical Engineering Technicians. J. M. Clingenpeel, Chemical Engineer, and R. E. Stevens, Mechanical Engineering Technician, assisted in the aldehyde measurements.

CHARACTERIZATION AND CONTROL OF EMISSIONS FROM HEAVY DUTY DIESEL AND GASOLINE FUELED ENGINES

I. SUBJECT

This report covers results from experimental work in measurement of emissions from heavy duty diesel and gasoline fueled engines and an investigation of the effectiveness of engine modifications and/or auxiliary devices for reducing emissions.

II. OBJECTIVE

The objective of the study was to characterize emissions from some of the more prominent diesel and gasoline fueled heavy duty engines and to provide data to assess the effectiveness of emission control parameters, engine modifications, and auxiliary devices in controlling emissions.

III. SUMMARY AND CONCLUSIONS

Definitive engineering information was obtained on the characteristics of seven diesel and two gasoline engines: the diesel engines were operated on a 13-mode procedure and a 23-mode procedure; the gasoline engines were operated on a 9-mode procedure and a 23-mode procedure for the baseline tests and the 23-mode procedure was used in the parametric study.

In the case of diesel engines, the control parameters, engine modification, and auxiliary devices investigated for emission control were: injection timing; injector type; fuel pump and nozzle modifications; exhaust gas recirculation (EGR); aftercooling; turbocharging; and oxidation type catalytic converters.

In the case of the gasoline engines, the control parameters, engine modifications, and auxiliary devices studied were: manifold air injection; air-fuel ratio; exhaust gas recirculation; spark timing schedules; and oxidation type catalytic converters. The following were observed and conclusions were drawn as follows:

A. Applicable to Diesel Engines

The following observation and conclusions concerning emissions of carbon monoxide (CO), hydrocarbon (HC), and oxides of nitrogen (NO_x) as well as specific fuel consumption are based on composite results from the 23-mode procedure. All references to smoke emission are based on peak smoke (i.e., the smoke value from the mode which produced the maximum smoke reading).

1. Baseline Emissions for the Standard Engines

Carbon monoxide emissions from the seven engines ranged from a low of 1.1 g/bhp-hr to a high of 5.5 g/bhp-hr. The range of HC emissions was from 0.3 to 4.4 g/bhp-hr. The NO_x emissions varied from 5.2 to 16.5 g/bhp-hr.

2. Effectiveness of Emission Control Parameters

A parametric study which involved the use of various emission control parameters, engine modifications and/or auxiliary control devices was conducted using one parameter at a time. From the results of this study, certain combinations of parameters were selected and further tests were conducted. The following is based on the combination of parameter tests.

For two naturally aspirated diesel engines the combination of retarded injection timing and EGR resulted in about a 50 pct reduction in NO_x with about a 5 to 6 pct increase in brake specific fuel consumption (bsfc). For this 50 pct reduction in NO_x, peak smoke increased from 15 to 18 pct opacity for one engine and from 12 to 20 pct opacity for the other engine.

A 50 pct reduction in NO_x was achieved by use of modified injectors and retarded timing (engine 17) but peak smoke was increased from about 3 to 20 pct opacity while bsfc increased about 2 pct.

Oxides of nitrogen from one turbocharged engine (engine 16) was reduced about 50 pct by combining retarded injection timing, EGR, and aftercooling with about a 2 pct penalty in fuel consumption and peak smoke increased from 2 to 8 pct opacity. About a 46 pct reduction in NO_x from a second turbocharged engine (engine 20) was achieved by the use of retarded injection timing and aftercooling with a 1 pct increase in bsfc and no change in peak smoke.

The use of catalytic converters on two of the engines was quite effective in reducing CO and HC emissions. Conversion efficiencies for CO emissions were from 56 to 83 pct and for HC emissions from 36 to 85 pct. These were fresh catalysts, however, and further testing would be necessary to evaluate conversion efficiencies for a long term period.

Based on the 23-mode procedure and the test parameters used in this experimental program, one of the six engines used in the parametric study could meet 2 g/bhp-hr level in CO emissions without the use of emission control systems. One other engine could meet a 2 g/bhp-hr level with the use of

catalytic converters (this however is based on fresh catalyst). A third engine could meet a 2 g/bhp-hr limit on CO with turbocharging and the other three engines could meet a 4 g/bhp-hr level based on the best combination of parameters used in the test program. All six engines could meet a 2 g/bhp-hr level on HC, but, two of the engines required the use of catalytic converters. It appeared that one engine could meet a 3 g/bhp-hr level in NO_x, two engines a 6 g/bhp-hr level, and the other three a 10 g/bhp-hr level. Exhaust gas recirculation as a control parameter was not used in any of the three engines meeting the 10 g/bhp-hr level. The increase in fuel consumption for the engines to meet the above levels ranged from 2 to 6 pct. For four of the engines, peak smoke increased from 3 to 17 pct opacity; one engine showed no significant change in peak smoke; and one engine showed that peak smoke was reduced by 8 pct opacity.

3. Comparison of Results from the 13-Mode and 23-Mode Procedures

Because of the significant difference in weighting factors between the 13-mode and 23-mode procedures, the composite cycle emissions can be significantly different between the two procedures. For example, if an engine emits large quantities of CO at full power, the composite CO emissions for the 13-mode procedure will be greater than that for the 23-mode procedure because the full power modes are weighted heavier for the 13-mode procedure than for the 23-mode procedure. This can also be the case for EGR cutoff at full power as was used for engines 15 and 19.

The largest difference was found for CO emissions for engine 17 where CO levels increased greatly at the full power modes. For this particular case, the CO values were from 135 to 173 pct higher for the 13-mode procedure than for the 23-mode procedure.

For the two engines where EGR cutoff was used at full power, the 13-mode NO_x emissions were from 6 to 50 pct higher than the 23-mode NO_x emissions.

The composite HC values from the two procedures compared within ± 25 pct with the large deviations being associated with the tests where HC values were less than 1 g/bhp-hr.

In general, the two procedures gave NO_x emissions which agreed within ± 8 pct and in most cases the agreement was within 4 to 6 pct.

4. Odor and Aldehyde Emissions

Since odor and aldehyde measurements were taken using the 13-mode procedure, the following is based on the 13-mode results.

In general, the odor levels were not significantly affected by the emission control parameters except for engine 19 where a catalyst was used. In this case, odor intensity was reduced from 4.5 for the standard engine to 2.3 for the best combination of parameters which included a catalyst.

Aldehyde emissions were reduced by the same control parameters that reduced hydrocarbon. The catalysts were quite effective in reducing aldehydes in the exhaust.

B. Applicable to Gasoline Engines

The following observations and conclusions are based on results obtained using the 23-mode procedure.

1. Baseline Emissions for Standard Engines

Carbon monoxide emissions from the two engines were from 33 to 41 g/bhp-hr. Hydrocarbon levels were 2.3 to 2.8 g/bhp-hr. Note, however, the tests were run without the motored modes (due to the use of dynamometers with power absorption capability only). It is estimated that the HC emission would be on the order of 6 to 9 g/bhp-hr if the motored modes were included. Oxides of nitrogen emission for both engines was about 9.5 g/bhp-hr.

2. Effectiveness of Control Parameters

The use of air injection alone resulted in about a 55 to 60 pct reduction in CO and about a 47 to 56 pct reduction in HC emissions. The use of combined air injection and oxidation (noble metal) catalysts resulted in about a 95 pct reduction in both CO and HC emissions. Note, however, this is with a fresh catalyst and does not account for any deterioration effect with mileage accumulation. Using EGR combined with retarded spark timing, air-injection and oxidation catalyst, NO_x reduction was about 40 to 60 pct. The loss of fuel economy based on the composite cycle average was from 6 to 8 pct.

Based on the 23-mode procedure (without closed-throttle modes) it appeared that CO levels could be reduced to about 2 to 3 g/bhp-hr and NO_x to about 5.5 to 6 g/bhp-hr. To reach these levels of NO_x, fuel consumption was increased from 5 to 8 pct. Due to the lack of data for the closed-throttle motored modes, it is difficult to draw any conclusions regarding the absolute level of HC emissions. The closed-throttle modes could also have some effect on the absolute level of CO emission.

Based on the 13-mode procedure, aldehydes were reduced by about 90 pct by the use of catalysts.

3. Comparison Between the 9-Mode and 23-Mode Procedures

Baseline tests were run using both the 9-mode and 23-mode procedures.

Results indicate that the CO emission for engine 22 was about 40 pct higher for the 9-mode procedure than for the 23-mode procedure. For engine 23, CO emission was about 14 pct lower for the 9-mode procedure.

Hydrocarbon emissions were 19 to 27 pct higher for the 9-mode procedure and NO_x emission was from 4 to 6 pct higher for the 9-mode cycle when compared to the 23-mode procedure.

IV. DESCRIPTION OF TEST EQUIPMENT AND FUELS

A. Engines and Accessory Equipment

A total of nine engines were supplied by six manufacturers who cooperated in the program. In addition, two catalyst manufacturers furnished accessory hardware.

Seven diesel engines ranging from medium to heavy duty were used to generate emissions data in the experimental program. The engines are coded and described as follows:

Engine code No.	Combustion chamber type	Duty class	Turbocharged	Rated power output, bhp
15	open	medium	no	225
16	divided	heavy	yes	245
17	open	heavy	no	280
18	open	heavy	yes	235
19	open	medium	no	200
20	open	heavy	yes	325
21	open	heavy	no	260

Two gasoline engines in the medium to heavy duty class were used in the program and are coded and described as follows:

Engine code No.	Rated power output [SAE-J245 (1)*], bhp @ rpm
22	158 @ 4,000
23	150 @ 4,000

Standard hardware was not available for the study of exhaust gas recirculation (EGR) or aftercooling parameters in the diesel engine tests. Therefore, it was necessary to install piping for EGR and aftercooling tests. For the EGR tests, a

*Underlined numbers in parentheses designate references at the end of the report.

4-inch flexible pipe was used to recycle exhaust gas from the exhaust to the intake airstream. A typical example of this setup is shown in figure 1. Exhaust was taken upstream of the muffler, passed through a liquid/gas heat exchanger (cooling the exhaust to about 200° F), and then delivered to the air intake stream. Control of the EGR flow-rate was accomplished by means of an adjustable butterfly valve in the 4-inch line.

For the aftercooling tests, a laboratory aftercooler (liquid/gas heat exchanger) was provided by one of the engine manufacturers. The system was connected between the turbocharger and intake manifold as shown in figure 2. Temperature of the air entering the intake manifold was controlled by adjusting the flow of coolant (tap water) through the aftercooler.

For the gasoline engines, EGR was accomplished by using an intake manifold with EGR passages cast into the manifold. EGR rate was controlled in engine No. 22 by means of an automatic vacuum controlled valve. Different EGR rates could be obtained by changing the shape and/or size of the valve pintle. Engine No. 23 used a similar manifold but EGR rate was controlled by a manually adjustable valve. The valve was adjusted to the appropriate EGR rate for each individual mode of the cycle.

The air injection systems used on the gasoline engines were the same systems that have been used on light duty passenger car engines.

Catalytic converters were used in tests involving two diesel engines and the two gasoline engines. For the diesel engines, a pair of Engelhard noble metal catalysts were used with engine No. 15 and a pair of Universal Oil Products (UOP) noble metal catalysts were used with engine No. 19. For the two gasoline engines, a pair of UOP noble metal catalysts were used. In each case the converters were sized for the particular engine. Also, the converters were mounted as close to the engine exhaust manifold as possible.

B. Fuels

The diesel fuel used throughout the test program was obtained from a single source. Periodic inspections of the diesel fuel have shown the fuel properties and composition to remain relatively constant. A single batch of unleaded gasoline (Indolene Motor Fuel HO Gasoline III*) was used for all tests involving the gasoline engines. Inspection data for these fuels are as follows:

*Procured from American Oil Company.

	Diesel fuel	Gasoline
Gravity, °API	33.4	60.5
Reid vapor pressure, psi	-	8.7
Research octane number	-	97.7
Cetane index	44	-
Lead content, g/gal	0	NIL
Sulfur, wt pct	0.25	-
Distillation		
Temp °F:		
IBP	351	94
10 pct evaporated	430	138
20 " "	460	166
30 " "	478	192
50 " "	510	226
70 " "	542	250
90 " "	586	328
End point	618	400
Composition, vol pct, FIA:		
Saturates	61	67
Olefins	3	5
Aromatics	36	28

C. Dynamometer Equipment

All engine tests were conducted using eddy current dynamometers of the absorption type only. The dynamometers ranged in size from 250 to 350 horsepower. The lack of motoring capability in the dynamometer equipment necessitated the omission of closed-throttle motored modes in the test cycle used for the determination of gaseous emissions. The omission of motored modes in the diesel engine tests is probably unimportant because during motoring the emissions would be small because of fuel shut-off during the closed throttle operation. The gasoline engine, however, would probably emit relatively large quantities of hydrocarbon during closed throttle motored modes and omitting this part of the cycle is a definite limitation in obtaining a representative composite hydrocarbon emission value. The acceleration modes of the diesel Federal Smoke Test were also omitted because of the inability of applying a representative load during the acceleration modes.

V. EXPERIMENTAL PROCEDURES

A. Exhaust Sampling and Analysis

Engine exhaust was sampled from both diesel and gasoline engines about 10 feet downstream of the exhaust manifold and passed through a heated stainless steel line and delivered to instruments for continuous analysis. A schematic of the sampling and analytical systems for the diesel engine tests is shown in figure 3. The system for the gasoline engine tests was similar except the heated line was maintained at 160° F and the hydrocarbon

analyzer was a pressure type system rather than a vacuum type as shown in figure 3. In addition to the instruments shown, an oxygen analyzer was used in the gasoline engine tests.

The analytical methods were: carbon monoxide, carbon dioxide (CO_2), and nitric oxide (NO) by nondispersive infrared (NDIR); total oxides of nitrogen by chemiluminescence; oxygen (O_2) by a polarographic instrument; and total hydrocarbon by flame ionization detection (FID).

For some of the initial tests, a chemiluminescent analyzer was not available for the measurement of NO_x and the NDIR and nondispersive ultraviolet (NDUV) analyzers were used for NO_x. For these initial tests where NDIR and NDUV instruments were used, it is noted on the tables of data. For all other tests, the chemiluminescent analyzer was used for NO_x measurements.

B. Smoke Measurements for Diesel Engines

An EPA smokemeter of the type described in the Federal Register (2) was used in all tests to measure smoke. Smoke was measured during steady-state modes of the engine cycles and a lugging mode of a modified Federal Smoke Test. Due to limitations on the size of dynamometer equipment, it was impractical to run the complete Federal Smoke Test. For this program, the test was modified to include only the lugging mode. The lugging mode was essentially the same as that described in the Federal Register (2) except each of the three lugging modes of the test were preceded by 2 minutes of engine operation at full load and rated speed to precondition the engine. Also, due to the dynamometer test cell configuration, it was impractical to maintain the exhaust line length between the engine exhaust manifold and the smokemeter within the 15 ± 5 feet as specified in the latest Federal Register (5). The approximate distances between the exhaust manifold and the smokemeter in the actual exhaust system were as follows:

Engine No.	Muffler used	Exhaust line length between exhaust manifold and smokemeter, feet
15	yes	22
16	no	23
17	yes	20
18	no	23
19	yes	22
20	no	20
21	yes	23

The engines that were used without mufflers are turbocharged engines for which a silencing device is not specified by the engine manufacturer for use in the actual vehicle application.

C. Odor Measurement for Diesel Engines

Odor measurements were made using a human panel of six odor judges in accordance with the Turk method (3).

Exhaust was sampled through a 1-inch stainless steel line, diluted with fresh air, and delivered to the odor panel. Typical flow rates were: 300 standard cubic feet per minute (SCFM) of air and 3 SCFM of exhaust.

Exhaust sample flow was regulated by back pressure in the exhaust system and using an appropriately sized orifice. A dilution ratio of 100:1 was used for all engines except Nos. 15 and 19, where a dilution ratio of 400:1 was used due to the high odor intensity levels.

D. Aldehyde Measurement

Samples for measurement for total aldehyde (RCHO) were collected using the scheme depicted in figure 3 and analyzed using the MBTH method (4).

Because of the prohibitive time required for the analysis, it was impractical to obtain samples for every mode of the test cycle. Therefore, a method of sampling was devised to obtain a composite value for aldehydes corresponding to the 13-mode cycle.

In the case of naturally aspirated diesel engines, the procedure was to collect a separate sample for each of the three idle modes of the cycle. In addition, a single composite sample representing each speed was collected for each of the two speeds of the cycle. For example, the intermediate speed sample contained equal volumes of sample from each of the intermediate speed modes of the 13-mode cycle. Similarly, the sample for the rated speed contained equal volumes of sample from each of the 5 rated speed modes of the 13-mode cycle. The results from the three idle modes were then averaged and weighted 20 pct. The average results from each of the two composite samples (intermediate and rated speed cases) were then weighted 40 pct each. This gives a value equivalent to taking samples from each of the modes for the intermediate and rated speeds and weighting each of them 8 pct.

Samples for aldehyde measurements in the gasoline and turbocharged diesel engine tests were similar except the volume of sample from each mode for composite samples were varied in direct proportion to the exhaust flow-rate. This was necessary

for the gasoline and turbocharged diesel engines because exhaust flow-rate varies with load at a given speed, whereas for the naturally aspirated diesel engines, exhaust flow-rate is relatively constant for a given speed and independent of loads.

E. Engine Cycle Procedures

Four different engine cycles were used in the test program. A 23-mode procedure was used for the bulk of the gasoline engine work and most of the work involving the diesel engines. A 9-mode procedure (5) was used for baseline tests involving the two gasoline engines. A 13-mode procedure (5) was also used in the diesel engine tests for the purpose of measuring aldehydes and odor. Composite values for emissions were calculated for the 13-mode procedure from data generated in the 23-mode procedure. This was possible because the 23-mode procedure contained all of the engine modes that are used in the 13-mode procedure. Because the 23-mode and 13-mode procedures consumed a large amount of test time, it was necessary to develop a simpler cycle to study a large number of emission control parameters. A simplified 7-mode cycle was used to study the effects of parameters on emissions in diesel engine tests. The simplified 7-mode cycle was used to determine the combinations of parameters which yielded low emissions. The 23-mode procedure was then used to study those combinations of parameters that yielded lowest emissions. The 23-mode procedure is described as follows:

Mode	Engine speed	Percent load	Weighting factor, pct.
1	idle	0	7.0
2	intermediate	2	6.0
3	"	8	6.0
4	"	18	5.0
5	"	25	3.0
6	"	50	6.0
7	"	75	0
8	"	82	4.0
9	"	92	0
10	"	100	0
11	idle	0	7.0
12	intermediate	closed throttle	12.0
13	high	100	2.5
14	"	92	5.5
15	"	82	3.5
16	"	75	6.0
17	"	50	6.0
18	"	25	0
19	"	18	6.5
20	"	8	0
21	"	2	0
22	idle	0	8.0
23	high	closed throttle	6.0

The engine speed is defined as follows:

	Engine type	
	Gasoline	Diesel
Intermediate	1,200 rpm	peak torque speed or 60 pct rated, whichever is greatest
High	2,300 rpm	Rated speed

The emission data were read during the third minute after the beginning of each mode. A maximum of 10 minutes is allowed in each mode to take all necessary data.

The origin of the 23-mode test schedule operating speeds, loads, and weighting factors was from a computer analysis of truck and bus survey data taken by Ethyl Corporation in 1963. The computer analysis and subsequent formulation of the test schedule was performed by EPA's Procedure Development Branch, Division of Emission Control Technology.

The simplified 7-mode cycle uses modes of the 23-mode procedure, but weighting factors are different. The weighting factors for the simplified 7-mode cycle were developed to give composite cycle emissions similar to that of the 23-mode procedure. The simplified 7-mode cycle is as follows:

Mode No. of the 23-mode cycle	Engine speed	Percent load	Weighting factor, pct.
1	idle	0	40
2	intermediate	2	10
6	"	50	10
10	"	100	10
13	high	100	10
17	"	50	10
21	"	2	10

The speeds for the 7-mode cycle are defined the same as for the 23-mode procedure.

F. Experimental Design

The experimental work was divided into essentially four parts: (1) Initial baseline tests--the engines were operated with the parameters adjusted to the standard settings as recommended by the engine manufacturer; (2) parametric study--a study to investigate the influence of engine parameters and/or auxiliary devices on emissions, fuel consumption, and engine performance; (3) combination of parameter tests--tests were conducted using several different combinations of parameters which would result in reduced emissions (selection of the

combination of parameters was based on results from the parametric study); and (4) final baseline tests--similar to the initial baseline tests, except the tests were conducted at the end of the test program after the engines were restored to the normal design configuration.

In the diesel engine study, two replicate initial baseline tests were made for each engine with the exception of engine No. 18. Three replicate initial baseline tests were made on engine No. 18 and no other tests were conducted using this engine.

In the parametric study the following parameters were investigated for the diesel engines:

Engine code No.	Parameters investigated
15	Injection timing, EGR, and catalysts
16	Injection timing, EGR, and aftercooling
17	Injector type and injection timing
18	NONE (baseline tests only)
19	Injection timing, EGR, and catalysts
20	Special fuel pump and nozzle kit, injection timing and aftercooling
21	Turbocharger kit and injection timing

In the combination of parameters tests the particular combinations are indicated in the data tables in the experimental results section of this report. For the combination of parameters tests, one test was made for each combination of parameters. The combination of parameters which appeared to yield the lowest emissions with a minimum of penality was replicated. (These are referred to as the best combination.) One final baseline test was made with each engine used in the parametric study with the exception of engine No. 17 where two final baseline tests were conducted.

In the gasoline engine study, three replicate initial baseline (23-mode cycle) tests were made with each engine. Two replicate tests were made using the 9-mode cycle that corresponds to the initial baseline tests.

The parameters investigated for the two gasoline engines were: (1) manifold air injection, (2) air-fuel ratio, (3) EGR, (4) spark timing schedules, and (5) the application of an oxidation catalyst.

In the combination of parameters tests with the gasoline engines the particular combinations are shown in the data tables in the experimental results section of this report.

Two replicate tests each for the 23-mode cycle and 9-mode cycle were made corresponding to final baseline tests on the two gasoline engines.

VI. EXPERIMENTAL RESULTS

A. Applicable to Diesel Engines

1. Baseline Data

Two replicate initial baseline tests were run on each engine with the engine parameters adjusted in accordance with the engine manufacturer's recommendations. One final baseline test was run at the end of the test program for each engine after restoring the engine to its standard condition.

The purpose of replicate experiments in the initial baseline tests was to establish some measure of confidence in the repeatability of the data. The final baseline test was run to check on drift in the engine which might have occurred during the course of testing in the parameter study.

Emissions as a function of power output for the seven diesel engines for all the baseline tests are shown in figures 4-10. Note the emissions levels for different engines vary over a wide range, thus, the ordinate scale in figures 4-10 varies from engine to engine. The primary purpose of the figures is to show repeatability between baseline tests for a given engine rather than to compare emissions between the various engines. If the reader chooses to compare emission between the different engines it must be borne in mind that the emission scales are different for different engines.

Detailed results from baseline tests for all seven diesel engines are shown in appendix A. The results of each of the seven engines will be discussed separately.

The results obtained from engine No. 15 (figure 4) show considerable variability in NO_x emission between initial baseline No. 1 and the other two baselines. This is in part due to a slightly different adjustment in injection timing between these baseline tests. Following the initial baseline No. 1, several tests were conducted using varied timing before the second baseline was run. Thus, initial baselines Nos. 1 and 2 for engine No. 15 are not true replicates. It was ascertained that the injection timing for

initial baseline No. 1 was advanced about one degree when compared with the other two baseline tests. One other difference was that NO_x for initial baseline No. 1 was measured by NDIR and NDUV instruments, whereas, a chemiluminescent analyzer was used for NO_x in all other tests. These two differences do not appear to account for the discrepancy in NO_x between the baselines. Perhaps some of the difference was due to engine variability.

Results from engine No. 16 (figure 5) show fairly good repeatability except for CO emission for the final baseline test, where CO increased significantly at full load and the intermediate speed. The final baseline was run after tests in which EGR was used. The higher CO was due to turbocharger fouling caused by the use of EGR in previous tests in the parametric study. The turbocharger fouling effectively caused lower boost pressure in the intake manifold, thus reducing intake airflow and in turn caused reduced exhaust mass flow (see tables A-4, A-5, and A-6).

Engine No. 17 showed a consistent increase in hydrocarbon emission between initial baselines 1 and 2 and between final baselines 1 and 2 (figure 6). This may have been due to drift in injector performance, however, there was no clear evidence to prove this. The repeatability for CO and NO_x for the various baselines was reasonably good for this engine.

The emissions from engine No. 18 (figure 7) were fairly repeatable with the exception of hydrocarbon emission. This engine was used in the baseline study only, therefore, the three initial baselines shown are true replicates.

The results obtained from engine No. 19 (figure 8) repeated well between the two initial baselines, but, the hydrocarbon emission was significantly lower for the final baseline. The low hydrocarbon emission for the final baseline may have been due to changes in injection characteristics (i.e., variations in spray patterns due to deterioration in nozzle performance, etc.). Note the high hydrocarbon spike at about 25 pct load at rated speed. Engine No. 19 employs an injection pump with a 4-cylinder idle feature which causes the engine to operate on four cylinders at idle and low power modes. The high hydrocarbon spike occurs during the transition period when the fuel pump starts delivering fuel to all eight cylinders.

Results from engine No. 20 (figure 9) showed reasonably good repeatability for the different baselines with the exception of hydrocarbon during the rated speed modes. There is no consistent pattern in these hydrocarbon differences, since there was a larger variation between the

two initial baseline tests (which were true replicate experiments) than there was between the second initial baseline and the final baseline.

The results from baseline tests involving engine No. 21 (figure 10) show good repeatability except, NO_x was higher on the second initial baseline and the final baseline than it was for the first initial baseline. Differences in NO_x levels between the initial and final baseline tests might possibly be explained by slight difference in timing adjustments because for this particular engine, the timing adjustments were difficult, and were performed by the engine manufacturers' local service representative. The timing adjustment was reset as near as possible to the original setting, however, it was not possible to have a definite check on the setting other than the usual procedure that the service representative follows.

Composite cycle emission data for all of the baseline tests (including initial and final baselines) for the seven diesel engines were averaged and shown in table 1. The detailed data for each of these tests are given in appendix A. The results from the 23-mode and 13-mode cycles are compared in table 1 and also the peak smoke value for the cycle is given. The peak smoke refers to the mode in the cycle which yielded the highest smoke density.

Since the composite emissions from the 23-mode procedure can be different than those from the 13-mode procedure, the following discussion will be based on the 23-mode procedure results. Results from the two procedures will be discussed in detail in the next section of this report (Section VI(A)-2).

Results from the 23-mode procedure baselines show that CO emission from the seven engines (table 1) varied from about 1.1 g/bhp-hr for engine 16 to about 5.5 g/bhp-hr for engine 17. Carbon monoxide emission from most of the engines was from 4-6 g/bhp-hr. Hydrocarbons varied from about 0.3 g/bhp-hr for engine 16 to about 4.4 g/bhp-hr for engine 19. Engine 21 was a low hydrocarbon emitter with about 0.5 g/bhp-hr and the other engines emitted from about 1.7 to 3.1 g/bhp-hr. Oxides of nitrogen emission ranged from about 5 g/bhp-hr for engine 16 to about 15-16 g/bhp-hr for engines 17 and 20. Engine 18 was a high NO_x emitter with about 13 g/bhp-hr, while the other three engines emitted from 7 to 8.5 g/bhp-hr of NO_x.

2. Comparison Between 13- and 23-Mode Procedures

Large differences were found between results from the 13- and 23-mode cycles for certain engines. The greatest difference was found for CO emission (figure 11) for engine

17. This is caused by the very significant increase in CO emission as full load is approached (figure 6). The weighting factor used in the 23-mode cycle for one of the highest CO modes (mode 10) was actually zero (see tables A-7, A-8, A-9, and A-10). Other differences are not as large but are certainly significant. The HC and NO_x emissions showed better agreements between the 13- and 23-mode cycles than the CO emissions, but there were significant discrepancies for NO_x emission for engines 15 and 19 at about the 5 g/bhp-hr level. These discrepancies were primarily related to EGR cutoff during mode 10 of the 23-mode cycle. (Note figure 11 contains data for all engines for both the baseline and combination of parameter tests.)

3. Parametric Evaluation

In order to evaluate emission control parameters, a simplified 7-mode cycle was developed. The cycle was described in section V(E). The purpose of the cycle was to study one parameter at a time to determine which adjustments and/or accessory hardware to use in the combination of parameters tests which would involve the complete cycle test. The use of this short cycle (7-mode) allowed a much more rapid evaluation of parameters than if the complete 23-mode procedure were used for each test.

A summary of results from the simplified 7-mode cycle for engine 15 is given in table 2. More detailed data are shown in table D-1. Results (table 2 and figure 12) show that retarded injection timing reduced NO_x significantly but with some increase in HC emission and fuel consumption. Retarding injection timing 3° resulted in about 40 pct reduction in NO_x while fuel consumption was increased about 9 pct. Further retarded timing resulted in large penalty in HC emission without much gain in reducing NO_x. Thus, injection timings of standard and 3° retard appeared to be the best choices for use in the combination of parameters tests. Retarded injection timing by 3° increased peak smoke from 15 to 17 pct opacity.

The application of a pair of Engelhard catalysts to engine 15 resulted in about a 70 pct reduction in CO emission and about a 45 pct reduction in HC emission while fuel consumption, peak smoke, and NO_x emissions were essentially unchanged (table 2). Thus, the catalysts were chosen for use in the combination of parameters tests for control of HC.

The use of EGR reduced NO_x significantly, but, also increased peak smoke beyond acceptable limits (table 2 and figure 13). Five pct and 10 pct EGR, reduced NO_x by 33 and 49 pct, respectively. Since peak smoke at full load was increased to unacceptable levels, it was decided for

the combination of parameters tests to use EGR cutoff during the full load modes in order to limit peak smoke.

From results of the simplified 7-mode cycle for engine 15, the following adjustments were selected for use in the combination of parameters study; injection timing at standard and 3° retarded; Engelhard catalysts for HC control; and EGR adjusted to 5 and 10 pct respectively, with EGR cutoff at full load modes for smoke control.

For engine 16, emissions were determined during selected modes rather than the simplified 7-mode cycle because at the time that these experiments were performed, the simplified 7-mode cycle had not been developed. The effects of aftercooling, injection timing, and EGR on emissions are shown in tables 3, 4, and 5, respectively.

It is clear from these data (tables 3-5) that it is very difficult to select the best adjustment of parameters for use in the cycle test. Therefore, the simplified 7-mode cycle was developed for use in subsequent tests.

The parametric adjustments selected for use in the combination of parameters tests for engine 16 were: standard and 5° retarded injection timing; 10 pct EGR; and no aftercooling and 150° F aftercooling.

The parameters studied for engine 17 were a set of experimental injectors and injection timing. The experimental injectors were designed with low sac volume, high injection rate, and timing characteristics that provide for variable beginning and constant ending of injection. A summary of results from the simplified 7-mode cycle is given in table 6 and detailed data are in table D-2.

Carbon monoxide, HC, and NO_x emissions were significantly reduced (table 6 and figure 14) when the experimental injectors were substituted for the standard injectors. Peak smoke increased from 2 to 6 pct opacity when the experimental injectors were installed. Retarding injection timing further decreased NO_x emission without much penalty in fuel consumption but with a significant penalty in smoke emission. For example, NO_x was reduced from 16.3 g/bhp-hr for the standard injectors to 8.2 g/bhp-hr for the experimental injectors with 3.4° retarded injection timing while peak smoke increased from 6 to 20 pct opacity.

The injection timing adjustments selected for use in the combination of parameters tests for engine 17 were standard and 3.4° retarded timing with the experimental injectors.

Engine 18 was used in baseline tests only and will not be discussed in this section of the report.

The results from the simplified 7-mode cycle for engine 19 are shown in table 7 and the more detailed results are given in tables D-3 and D-4. The results from the simplified 7-mode cycle tests are plotted in figures 15 and 16. The trade-off between peak smoke emission and fuel consumption (figure 15) clearly occurs at about standard timing (34° before top center). NO_x can be further reduced by using a more retarded timing but with heavy penalties in fuel consumption. Thus, standard and 2° retarded timing settings were chosen for use in the combination of parameters study. The use of EGR decreased NO_x emission but resulted in heavy penalties in terms of increased smoke (figure 16). Since a catalyst was already selected for use with this engine for HC and CO control, the selection of an EGR rate would be determined by the trade-off between NO_x reduction and increased fuel consumption since smoke is limited by using an EGR cutoff at full load modes. Ten and 15 pct EGR, respectively, were selected for use in the combination of parameters study.

The parameters selected for use in combination of parameters tests for engine 19 were: standard and 2° retarded injection timing; 10 and 15 pct EGR with EGR cutoff during full load modes; and the application of a pair of UOP noble metal catalysts for HC and CO control.

Engine 20 was tested using the simplified 7-mode cycle and with injection timing, aftercooling, and a special fuel pump and nozzle kit as test parameters. A summary of the results are in table 8, and detailed data are shown in tables D-5, D-6, and D-7. Results show that the composite NO_x was reduced from 14.5 g/bhp-hr to 11.3 g/bhp-hr with 3° retarded injection timing. The use of aftercooling (150° F) reduced the NO_x further to 8.7 g/bhp-hr with no penalty in fuel consumption or peak smoke (figure 17). The use of the special fuel pump and nozzle kit had little or no effect on NO_x emission, peak smoke, or fuel consumption, but it did significantly reduce HC and CO emissions.

The parameter adjustments and/or accessory hardware selected for use in the combination of parameters test for engine 20 were: 3° retarded injection timing; aftercooling at 200° F and 150° F maximum inlet air temperature levels; and the use of the special fuel pump and nozzle kit and the standard fuel pump and nozzles.

Engine 21 was used in the combination of parameters tests but there were no tests made using the simplified 7-mode cycle because of the limitation of parametric adjustments. This work with engine 21 will be discussed in section VI(A)-4 of this report.

4. Effectiveness of Control Technology

The results of baseline and combination of parameters tests for all the diesel engines are summarized in table 9. The detailed data for baseline tests are in appendix A and detailed data for combination of parameters tests are in appendix E. Results for the 23-mode cycle and the 13-mode cycles are both shown in table 9. The following discussion is based on composite results from the 23-mode procedure.

Results from engine 15 show that NO_x can be reduced from about 8.5 g/bhp-hr for the standard engine to about 3.6 g/bhp-hr by using 3^o retarded injection timing and 10 pct EGR (table 9). This is about a 57 pct reduction in NO_x with about a 6 pct increase in fuel consumption. About a 45 pct reduction in NO_x was achieved with 5 pct EGR with only a 2 pct penalty in fuel consumption. A pair of Engelhard noble metal catalysts were also used in these combinations and reduced CO from 56 to 63 pct and HC from 36 to 56 pct. Emissions as a function of power output (for engine 15) for the baseline and combination of parameters tests are shown in figure 18. Note the loss of NO_x control at full power. This is caused by EGR cutoff at full load. Aldehydes, odor intensity, and smoke were essentially unchanged with any of the combinations of parameters (table 9).

It appears that for engine 15 by using 5 pct EGR, injection timing retarded 3^o, and catalysts the following emission levels can be reached: CO - 3 g/bhp-hr; HC - 2 g/bhp-hr, and NO_x - 5 g/bhp-hr. Fuel economy loss would be on the order of 2 pct. Peak smoke increased from 15 to 17 pct opacity.

Experiments with engine 16 showed that NO_x could be lower by combining EGR, aftercooling, and injection timing retard. Results (table 9) show that NO_x was reduced to about 2.5 g/bhp-hr with the use of 5^o retarded timing, 10 pct EGR, and 150^o aftercooling (note the 150^o aftercooling means that coolant water to the aftercooler was adjusted so that the intake air temperature was 150^o F for the full load and rated speed modes, coolant flow was maintained constant for all other modes of the cycle). Since NO_x for the standard engine was 5.2 g/bhp-hr, this was about a 52 pct reduction in NO_x with about a 2 pct penalty in fuel consumption. The 150^o aftercooling probably could not be achieved in practice due to limitation in having coolant at a low temperature in the real vehicle. Oxides of nitrogen for the same combination of parameters but without aftercooling yielded about 3.0 g/bhp-hr, but fuel consumption penalty was about 4 pct as compared to the standard engine. Emissions as a function of power output (engine 16) for the baseline and combination of parameters tests are shown in figure 19.

Aldehydes and odor intensity were not significantly changed with these combinations of parameters (table 9).

Results based on the 23-mode procedure indicate that with the use of 5° retarded injection timing, 10 pct EGR, and aftercooling, engine 16 could reach the following emission levels: CO - 2 g/bhp-hr, HC - 1 g/bhp-hr, and NO_x - 3 g/bhp-hr. Fuel economy loss would be estimated from 2 to 5 pct. Peak smoke would be increased from about 2 to 8 pct opacity.

About 8 g/bhp-hr of NO_x was possible with engine 17 (table 9) by using experimental injectors and retarded timing, but with a severe penalty in smoke. The more practical level of NO_x (based on combinations of parameters tested in this program) for this engine appears to be about 10 g/bhp-hr. Emissions as a function of power output (engine 17) are plotted in figure 20.

Aldehyde emission increased with retarded injection timing and odor intensity was not appreciably affected (table 9).

Results from this study based on the 23-mode procedure, indicate that for engine 17 the following emission levels could be reached: CO - 6 g/bhp-hr; HC - 1 g/bhp-hr, and NO_x - 10 g/bhp-hr. Fuel economy loss was about 3-4 pct. Peak smoke increased from about 3 to 6 pct opacity.

Engine 18 was not used in the combination of parameters study and was discussed earlier in the section on baseline data. This engine will not be discussed further.

Test results showed that for engine 19, NO_x emission was reduced about 50 pct with the use of EGR. The lowest level of NO_x was achieved by the use of 15 pct EGR (table 9). With 15 pct EGR, and 2° retarded timing, NO_x was reduced to 3.5 g/bhp-hr as compared to 7.3 g/bhp-hr for the standard engine. This is roughly a 52 pct reduction in NO_x. (Note that for this combination of parameters, and if the results were based on the 13-mode procedure, NO_x would be reduced by 28 pct instead of the 52 pct reduction shown by the 23-mode procedure. This difference is primarily due to difference in weighting factors for the full load modes between the two procedures. See figure 21 and note the loss of NO_x control at full load because of EGR cutoff at full power.) The use of a pair of UOP noble metal catalysts reduced CO and HC by about 84 pct. However, it should be borne in mind that these were fresh catalysts and durability testing would be required to determine the activity of the catalyst over a long period. The particular catalysts used on this engine increased exhaust back pressure to a value about double that used in the tests without catalysts (see tables E-13 through E-20). Aldehydes and odor intensity

were also decreased significantly with the catalysts.

Based on experiments with engine 19 it appears that the following levels of emissions can be reached by using 10 pct EGR (with EGR cutoff at full load modes), standard timing, and the UOP catalysts: CO - 1 g/bhp-hr, HC -1 g/bhp-hr, and NO_x - 6 g/bhp-hr. Fuel economy loss would be about 3-5 pct. Peak smoke increased from 12 to 15 pct opacity.

Engine parameters that were studied with engine 20 (turbocharged engine) were injection timing, aftercooling, and a special pump and nozzle kit. The special pump was equipped with a built-in puff limiter (acceleration smoke control) and an experimental 4-cylinder idle feature. The special nozzles had a wider spray angle than the standard nozzles. Results (table 9) showed that NO_x could be reduced from about 15 g/bhp-hr for the standard engine to about 8.2 g/bhp-hr with 3° retarded timing and 150° F aftercooling. Fuel consumption penalty for these changes was roughly 1 pct. No significant change was found for peak smoke density and aldehydes emission. Odor intensity increased slightly.

The use of the special fuel pump and nozzle kit reduced both CO and HC emissions (table 9). Oxides of nitrogen, however, increased slightly from about 8.2 to 9.7 g/bhp-hr when the special pump and nozzles were used. Emissions as a function of power output (engine 20) for baseline and combination of parameters test are shown in figure 22.

It appears that for engine 20, the following emission levels could be achieved with the use of retarded timing, the special pump and nozzle kit, and aftercooling; CO - 4 g/bhp-hr, HC - 2 g/bhp-hr; and NO_x - 10 g/bhp-hr. There would be an estimated 3 to 4 pct loss in fuel economy. No significant change was noted in peak smoke for the combination of parameters tests when compared to the baselines.

Experiments involving engine 21 did not result in reduced NO_x emissions when compared to the standard engine. The parameters investigated were addition of a turbocharger, injection timing, and increased fuel rate. Results show (table 9) that adding the turbocharger increased NO_x from 8 g/bhp-hr to 11.4 g/bhp-hr. Retarding injection timing decreased NO_x to about 10 g/bhp-hr. Further reductions in NO_x could be achieved by retarding injection timing further, but this was not practical in these experiments. Aldehydes were reduced with the addition of the turbocharger, and odor intensity was not changed. Peak smoke was reduced from 12 pct opacity for the standard engine to 4 pct opacity for the combination of parameters tests and fuel consumption was unchanged. The standard engine had the lowest emissions and they were: CO - 3.3 g/bhp-hr, HC - 0.50 g/bhp-hr, and NO_x - 7.98 g/bhp-hr. Emissions as

a function of power output (engine 21) for baseline and combination of parameters tests are shown in figure 23.

B. Applicable to Gasoline Engines

1. Baseline Data

Three replicate initial baselines were run on each of the two gasoline engines using the 23-mode procedure. The gasoline engines were tested using the 9-mode procedure with two replicate tests at the beginning of the program and two replicate tests at the end of the program. Two final baselines were run on each engine at the end of the program using the 23-mode procedure.

Results from the 23-mode cycle tests are summarized in table 10 and detailed results are in appendix B. Results show that the composite CO emission for engine 23 was about 23 pct higher than for engine 22. This was primarily caused by mixture enrichment (power jet operation) which occurred at high power modes for engine 23. The mixture enrichment at higher power mode did not occur with engine 22. This effect can clearly be seen by examining modal CO values in the tables of appendix B. Normally, for engines of this type, the air-fuel mixture will go rich at high power. There may have been a carburetor malfunction with engine 22. However, in this test program, there was no way to determine if a malfunction had occurred with engine 22. Hydrocarbon and NO_x emissions were similar for the two engines. Specific fuel consumption (when based on the 23-mode procedure) appeared to be significantly different for the two engines.

Since in this program it was impossible to motor the engines for closed throttle modes (due to unavailability of motoring type dynamometers), the HC values in the baseline tests are low. Also shown in table 10 are values computed for the same cycle, but with assumed emission values for the motored modes. Results show that the inclusion of the motored modes can double or even triple the composite cycle HC emission. Thus, actual HC emissions for these two engines are probably in the range of 6 to 9 g/bhp-hr.

Results from the 9-mode cycle tests are summarized in table 11 and detailed data are given in appendix C. The data are expressed in terms of the California weighting factors [now adopted for use in the Federal test (5)]. Since the Federal test now uses the California weighting factors the following discussion will be limited to the results that were calculated on the basis of the California weighting factors.

Results show that on the basis of the 9-mode cycle, the composite cycle CO emission is about 33 pct higher for

engine 22 than for engine 23. This result is different than that observed for the 23-mode cycle where the CO emission was about 23 pct higher for engine 23. This illustrates that different conclusions can be reached depending on the type of cycle and the weighting factors that are used. By using estimated values for emissions during the motored mode, the composite-emission of HC was increased by factors of 2.3 and 2.6 for engines 22 and 23, respectively. This clearly illustrates the need for considering the closed throttle modes when testing gasoline engines. The HC emission for the two gasoline engines are estimated to be about 6-9 g/bhp-hr for the 9-mode cycle when the closed throttle motored mode is included in the test.

2. Parametric Evaluation

For the purpose of evaluating individual emission control parameters in the gasoline engine tests, the complete 23-mode cycle test was employed.

Results from the investigation of the effects of emission control parameters are summarized in tables 12 and 13. The detailed data for the complete cycle are given in appendices F through J. It should be borne in mind that the HC emission does not reflect the contribution from motored modes.

In studies involving exhaust manifold air injection, the rate of airflow injected into the manifold was varied by changing the air pump pulley to drive pulley ratio. The air pump used was the same as that used with light-duty vehicles. Results (table 12 and figure 24) show that for engine 22, the CO and HC emission reached a minimum at an air pump pulley/drive pulley ratio of 1.25. Further increases in air pump speed did not decrease CO and HC emissions. The pump employs a pressure relief valve, thus, the increase in speed may not have resulted in increased airflow. At any rate, the air injection rate corresponding to the 1.25 air pump/drive pulley ratio was chosen for use in the combination of parameters study.

The application of a pair of UOP noble metal catalysts to engine 22 resulted in about an 88 pct reduction in CO and 91 pct reduction in HC when compared with air injection alone (table 12 and figure 25). Thus, the catalysts were selected for use in the combination of parameters tests.

Results from the air-fuel ratio study (table 12 and figure 24) with engine 22 showed significant decrease in CO and HC emissions with a slight decrease in NO_x with no measurable loss in maximum power (see appendices B and H) or fuel economy when the air-fuel ratio was adjusted one step leaner than standard. Further leaning of air-fuel mixture

decreased CO and NO_x but markedly increased HC and fuel consumption. Also, maximum power was decreased by about 25 pct (tables B-1 and H-1). When the air-fuel was adjusted richer than standard (0.058 jets), CO and HC emissions increased, NO_x decreased and there was about an 8 pct increase in maximum power (tables B-1 and H-3) and fuel consumption was improved. Going one-step richer (0.060 jets) resulted in a significant penalty in CO emission.

The air-fuel ratio settings chosen for the combination of parameters tests were: standard (0.056 jets); one-step lean (0.054 jets); and one step rich (0.058 jets). Although the CO increased with the one step rich setting, if used in conjunction with the catalysts, it might be acceptable.

Engine 22 used an EGR system that was built into the intake manifold and the amount of EGR was controlled by an automatic vacuum operated valve. The EGR rate was changed by changing the shape and/or size of the valve pintle. The EGR (percent) value indicated in table 12 and figure 25 are nominal values of different pintles that were furnished by the engine manufacturer. There was no method for checking EGR rate for the different modes in the cycle.

Results for the EGR tests on engine 22 (table 12 and figure 25) show the best compromise between CO, HC, and NO_x emission with the 15 pct pintle. Fuel consumption was increased about 3 to 4 pct with the use of the 15 pct pintle. The 15 pct EGR was selected for use in the combination of parameter tests.

Tests with engine 22 using different modified vacuum advance units did not show any improvement in terms of emissions over the standard unit (table 12). Therefore, the standard vacuum advance unit was used in tests involving combinations of parameters.

The experimental work with the second gasoline engine (engine 23) was similar to that for engine 22, except the ignition parameter used was basic timing and the EGR rate was controlled manually.

The EGR system was built into the intake manifold, but the EGR rate was controlled by a manually adjustable valve. This necessitated a means to observe the EGR rate for each mode. Sampling taps were placed in the intake passages just upstream of the intake valves. The eight sampling tubes were connected to a common manifold and a sample of the intake mixture was fed to a CO_2 analyzer. By monitoring CO_2 levels in both the exhaust stream and the intake stream, it was possible to calculate the percent of EGR.

This procedure allowed for programming the EGR rate as indicated in the tables.

Results from the air injection study for engine 23 (table 13) indicated the 2.5 air pump/engine speed ratio to be optimum for this engine. The air pump was similar to that used with engine 22 and is normally used with light-duty vehicles. The 2.5 air pump/engine speed ratio was used for the catalysts tests and the combination of parameters tests.

The use of a pair of UOP noble metal catalysts with engine 23 reduced CO by about 92 pct and HC 90 pct when compared to air injection alone (table 13 and figure 26). The catalysts were used in two out of the three combinations of parameters.

Results from the air-fuel ratio study for engine 23 showed the standard air-fuel ratio to be about optimum with respect to emissions (table 13).

The results from the EGR study with engine 23 indicated that programming the EGR rate from 5 pct EGR at 8 pct load to 7.5 pct EGR at 92 pct load and with EGR cutoff at other modes was about the best compromise between emissions and fuel consumption (table 13 and figure 26).

The results from the ignition timing study (engine 23, table 13 and figure 27) showed some advantage in retarding ignition timing with respect to NO_x and HC emissions, but did result in significant increases in fuel consumption. Ignition timing settings selected for the combination of parameters tests were standard and 5° retarded.

3. Effectiveness of Emission Control Parameters

The results of the baseline and the combination of parameters tests for the two gasoline engines are summarized in table 14. Aldehydes were analyzed for the modes corresponding to the 13-mode diesel cycle. Aldehyde emissions were calculated on the basis of the 13-mode procedure weighting factors [see section V(D)]. Detailed data for the baseline tests are in appendix B and detailed data for the combination of parameters tests are in appendix K.

The results showed that for the second combination of parameters for engine 22 (table 14), the NO_x was reduced to 3.93 g/bhp-hr, a reduction of about 59 pct when compared with the baseline. The CO emission, however, was high (19 g/bhp-hr) due to the rich operation. Even if the 19 g/bhp-hr of CO was considered acceptable, the thermal stress on the catalyst would (due to the rich operation) probably shorten the life of the catalysts. The combination Nos. 1 or 3 then would be considered more realistic.

This would indicate that a level of about 6 g/bhp-hr of NO_x could be achieved with about a 6 to 8 pct loss in fuel economy. The CO was reduced below 2 g/bhp-hr with the use of the catalysts. The HC level is not well established because of the lack of data for the closed throttle modes. The catalyst reduced the aldehyde emission by about 90 pct based on the 13-mode cycle. A comparison of emissions between the baseline and the combination of parameters tests for engine No. 22 is shown in figure 28.

Results from tests with engine 23 (table 14) indicate that NO_x can be reduced to 5-6 g/bhp-hr. This is about a 40 to 50 pct reduction in NO_x when compared to the baseline. It appears that 6 g/bhp-hr of NO_x could be reached without a penalty in fuel consumption with the proper programming of EGR rate. Carbon monoxide was reduced below 3 g/bhp-hr with the use of the catalysts. HC emissions were reduced 90 pct by the catalysts, but again the actual cycle composite HC could not be determined without data from the motored modes. Based on the 13-mode cycle, aldehyde emission was reduced from 75 to 88 pct. A comparison of emissions between the baseline and combination of parameters tests for engine No. 23 is shown in figure 29.

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TABLE 1. - Baseline emissions and fuel consumption for diesel engines used in the heavy duty engine project

(Averages include both initial and final baseline values)

Engine number	23-mode procedure				Peak smoke, pct opacity	13-mode procedure				Comments
	grams/bhp-hr			lb/bhp-hr		grams/bhp-hr			lb/bhp-hr	
	CO	HC	NO_2	BSFC		CO	HC	NO_2	BSFC	
15.....	5.54	2.82	8.46	0.446	15.2	5.93	2.90	8.27	0.445	Average of 3 tests
16.....	1.06	.32	5.20	.428	2.2	.93	.26	4.93	.422	Average of 2 tests 1/
17.....	3.37	1.70	16.5	.472	2.7	7.94	1.62	15.9	.476	Average of 4 tests
18.....	3.79	2.60	13.2	.424	9.0	4.53	2.32	14.0	.421	Average of 3 tests
19.....	5.29	4.37	7.26	.510	11.5	5.93	4.41	7.41	.504	Average of 3 tests
20.....	4.20	3.05	15.0	.504	8.5	4.48	2.62	15.1	.490	Average of 3 tests
21.....	3.29	.50	7.98	.452	11.7	4.39	.48	8.50	.452	Average of 3 tests

1/ The final baseline test was not included in the average because it was not representative due to the fouling of the turbocharger caused by using EGR in the parametric study.

TABLE 2. - Summary of results from engine No. 15 using a simplified 7-mode cycle

Description of engine adjustment and/or accessory hardware	Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Peak smoke 1/, pct opacity
	CO	HC	NO_x		
Standard engine.....	8.0	3.1	8.5	0.46	15
3° retarded timing.....	7.0	3.6	4.9	.50	17
6° retarded timing.....	9.1	6.5	4.3	.51	18
Engelhard catalysts.....	2.3	1.7	9.3	.46	14
5 percent EGR.....	7.9	3.1	5.7	.47	22
10 percent EGR.....	10.3	2.8	4.3	.47	32
15 percent EGR.....	14.5	2.9	3.4	.49	48

1/ Corresponds to smoke during the intermediate speed and full load mode.

TABLE 3. - The effect of aftercooling on emissions and fuel consumption for selected engine modes (engine No. 16)

Mode	Speed, rpm	Power, bhp	Inlet air temperature, °F	Fuel consumption, lb/bhp-hr	Emissions, g/bhp-hr			Smoke, pct opacity
					CO	HC 1/	NO_x	
6	1,600	95	138	0.368	0.38	0.064	4.77	7.0
		95	135	.395	.41	-	5.42	1.1
		96	130	.354	.45	-	5.57	3.3
		94	114	.387	.40	.18	4.63	1.5
10	1,600	189	203	0.391	0.25	0.060	3.60	2.0
		190	190	.371	.34	-	3.11	1.1
		189	155	.370	.35	.041	3.59	7.0
		192	150	.365	.28	-	2.55	4.4
13	2,200	245	273	0.399	0.23	0.073	4.56	2.0
		244	239	.395	.27	-	5.09	1.1
		251	188	.384	.29	-	4.63	3.3
		254	154	.380	.27	-	4.36	2.2
		256	150	.379	.42	.050	4.01	3.5
17	2,200	123	161	0.406	0.45	0.12	4.89	2.0
		122	155	.406	.44	-	5.68	1.1
		127	150	.390	.45	-	5.65	2.2
		128	145	.391	.43	.059	5.13	4.5

1/ Missing hydrocarbon values correspond to runs in which the hydrocarbon instrument malfunctioned.

TABLE 4. - The effect of injection timing on emissions and fuel consumption for selected engine modes (engine No. 16)

Mode	Speed, rpm	Power, bhp	Degrees of injection timing retard from standard	Fuel consumption, lb/bhp-hr	Emissions, g/bhp-hr			Smoke, % opacity
					CO	HC	NO_x	
6	1,600	94	0	0.387	0.40	0.18	4.63	1.5
		101	5	.400	.36	.12	3.93	.5
10	1,600	189	0	0.391	0.25	0.060	3.60	2.0
		203	5	.385	.31	.050	3.70	2.0
13	2,200	245	0	0.399	0.23	0.073	4.56	2.0
		250	5	.411	.30	.065	4.71	1.0
17	2,200	123	0	0.406	0.45	0.12	4.89	2.0
		125	5	.409	.61	.11	4.80	1.5

TABLE 5. - The effect of exhaust gas recirculation (EGR) on emissions and fuel consumption for selected engine modes (engine No. 16)

Mode	Speed, rpm	Power, bhp	% EGR	Fuel consumption, lb/bhp-hr	Emissions g/bhp-hr			Smoke, % opacity
					CO	HC 1/	NO_x	
6	1,600	94	0	0.387	0.40	0.18	4.63	1.5
		92	6.7	.370	.42	-	4.23	8.0
		86	25.0	.384	.46	-	2.03	11.0
10	1,600	189	0	0.391	0.25	0.060	3.60	2.0
		184	9.1	.380	.76	-	2.14	12.0
		183	10.4	.382	1.02	.062	1.96	11.0
		172	20.4	.412	4.81	-	.81	34.0
13	2,200	245	0	0.399	0.23	0.073	4.56	2.0
		237	8.2	.401	.43	.046	2.70	4.5
		234	12.6	.404	.50	.043	1.84	4.5
		231	17.1	.411	.72	.049	1.53	7.0
		228	21.0	.417	1.02	.054	1.17	11.0
17	2,200	123	0	0.406	0.45	0.12	4.89	2.0
		119	8.1	.420	.38	.066	3.50	4.5
		111	24.5	.405	.48	-	2.31	6.0

1/Missing hydrocarbon values correspond to runs in which the hydrocarbon instrument malfunctioned.

TABLE 6. - Summary of results from engine No. 17 using a simplified 7-mode cycle

Description of engine adjustment and/or accessory hardware	Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Peak smoke 1/, pct opacity
	CO	HC	NO_x		
Standard engine 2/.....	12.1	1.5	16.3	0.51	2
Experimental injectors:					
Standard timing.....	8.1	.80	11.0	.52	6
1.7° retarded timing.....	13.7	.77	9.9	.52	15
3.4° retarded timing.....	15.2	1.2	8.2	.51	20
5.1° retarded timing.....	15.2	2.0	7.5	.53	24

1/ Corresponds to smoke during the intermediate speed and full load mode.
2/ Average of two tests.

TABLE 7. - Summary of results from engine No. 19 using a simplified 7-mode cycle

Injection timing, °BTC	EGR, pct	Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Peak smoke 1/, pct opacity
		CO	HC	NO_x		
26	0	7.8	6.3	4.2	0.55	9
28	0	7.2	5.3	5.4	.53	8
30	0	6.4	4.7	6.4	.52	8
32	0	6.3	4.2	7.6	.51	8
34 (Std.)	0	6.7	3.7	7.8	.52	9
Do.	5	7.3	3.8	7.2	.51	12
Do.	10	8.1	3.5	5.2	.52	16
Do.	15	10.5	3.2	3.5	.52	31
36	0	7.8	3.7	10.4	.50	14
Do.	5	9.1	3.6	8.2	.51	17
Do.	10	10.4	3.3	6.2	.52	25
Do.	15	12.9	3.2	4.2	.52	39
38	0	10.4	3.8	10.5	.52	18
40	0	13.0	4.1	12.2	.53	24
42	0	17.2	5.1	12.2	.54	28
44	0	22.5	5.5	13.8	.56	32

1/ Corresponds to smoke during the intermediate speed and full load mode.

TABLE 8. - Summary of results from engine No. 20 using a simplified 7-mode cycle

Description of engine adjustment and/or accessory hardware	Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Peak smoke 1/, pct opacity
	CO	HC	NO_x		
ENGINE WITH STANDARD PUMP AND NOZZLES					
Standard timing.....	6.3	3.2	14.5	0.51	9
3° retarded timing.....	6.2	2.7	11.3	.53	12
Aftercooling with 3° retarded timing:					
250° F maximum inlet air temperature.....	5.7	2.7	10.2	.52	13
200° F maximum inlet air temperature.....	5.7	2.8	9.8	.51	13
150° F maximum inlet air temperature.....	5.0	3.0	8.7	.51	10
ENGINE WITH SPECIAL PUMP AND NOZZLES					
Standard timing.....	4.0	1.7	14.5	0.51	7
3° retarded timing.....	3.8	1.7	11.9	.52	8

1/ Corresponds to smoke during the intermediate speed and full load mode.

TABLE 9. - Summary of emissions and fuel consumption for baselines and combination of parameters tests for diesel engines

Combination of parameters Nos.	Description of engine adjustment and/or accessory hardware	23-mode cycle					13-mode cycle						Lug-down smoke, % opacity
		Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Peak smoke, % opacity	Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Aldehydes, g/bhp-hr	Odor intensity, DI units	
		CO	HC	NO_2			CO	HC	NO_2				
	ENGINE NO. 15												
	Baseline	5.54	2.82	8.46	0.446	15.2	5.93	2.90	8.27	0.445	0.23	4.3 1/	13.3
1	Standard timing, 10 pct EGR, Engelhard catalyst, (EGR cut off during modes 10 and 13 of the 23-mode cycle)	2.06	1.24	5.36	.453	15.0	1.73	1.22	6.24	.454	.16	3.6 1/	16.6
2	3° retarded timing, 5 pct EGR, Engelhard catalysts, (EGR cut off during modes 10 and 13 of the 23-mode cycle)	2.28	1.59	4.69	.461	16.5	1.89	1.78	4.97	.453	.29	3.8 1/	17.5
3	3° retarded timing, 10 pct EGR, Engelhard catalysts, (EGR cut off during modes 10 and 13 of the 23-mode cycle).	2.43	1.80	3.65	.472	18.2	1.93	1.79	4.18	.476	.20	4.0 1/	14.0
	ENGINE NO. 16												
	Baseline	1.06	0.32	5.20	0.428	2.2	0.90	0.26	4.93	0.422	0.082	4.6	6.9
1	Standard timing, 10 pct EGR, no aftercooling	1.09	.37	3.33	.421	17.5	1.20	.28	3.13	.421	.028	1.9	17.5
2	Standard timing, 10 pct EGR, 150° F aftercooling	.99	.23	3.07	.414	13.0	1.02	.20	2.98	.414	.021	2.8	20.9
3	5° retarded timing, 10 pct EGR, no aftercooling	1.51	.34	3.04	.447	12.0	1.58	.29	2.78	.443	.058	4.5	10.0
4	5° retarded timing, 10 pct EGR, 150° F aftercooling	1.88	.76	2.54	.436	8.2	1.68	.64	2.44	.430	.107	5.9	6.5
	ENGINE NO. 17												
	Baseline	3.37	1.70	16.5	0.472	2.7	7.94	1.62	15.9	0.476	0.088	4.2	2.8
1	Experimental injectors, standard timing.	1.99	.81	10.4	.490	5.5	5.45	.72	10.5	.492	.059	3.4	4.5
2	Experimental injectors, 3.4° retarded timing	3.74	.96	8.04	.482	20.4	9.78	.88	7.91	.491	.125	4.3	18.2
	ENGINE NO. 18												
	Baseline	3.79	2.60	13.2	0.424	9.0	4.53	2.32	14.0	0.421	0.12	7.7	6.4
	ENGINE NO. 19												
	Baseline	5.29	4.37	7.26	0.510	11.5	5.93	4.41	7.41	0.504	0.23	4.5 1/	12.5
1	Standard timing, 10 pct EGR (EGR cut off during modes 10 and 13 of the 23-mode cycle)	5.41	2.86	5.25	.509	12.7	5.71	3.22	6.41	.498	.17	4.8 1/	11.7
2	Standard timing, 15 pct EGR (EGR cut off during modes 10 and 13 of the 23-mode cycle)	6.32	2.85	4.47	.531	20.9	6.01	2.85	6.00	.512	.23	5.1 1/	11.7
3	2° retarded timing, 10 pct EGR (EGR cut off during modes 10 and 13 of the 23-mode cycle)	5.59	3.62	4.49	.516	8.8	5.68	4.12	5.95	.510	.33	4.7 1/	10.1
4	2° retarded timing, 15 pct EGR (EGR cut off during modes 10 and 13 of the 23-mode cycle)	6.60	3.81	3.53	.539	19.8	6.05	3.79	5.30	.520	.33	5.4 1/	10.1
5	Standard timing, UOP catalysts	.94	.67	8.10	.523	13.8	.68	.53	8.47	.514	.046	2.6 1/	14.0
7	Standard timing, 10 pct EGR, UOP catalysts, (EGR cut off during modes 10 and 13 of the 23-mode cycle)	.91	.69	5.43	.532	15.4	.68	.55	6.80	.520	.065	2.3 1/	13.4
	ENGINE NO. 20												
	Baseline	4.20	3.05	15.0	0.504	8.5	4.48	2.62	15.1	0.490	0.14	5.9	7.6
1	3° retarded timing, special pump and nozzle kit, 200° F aftercooling	3.67	2.12	10.1	.520	7.0	3.70	1.87	10.4	.502	.12	5.1	7.7
2	3° retarded timing, special pump and nozzle kit, 150° F aftercooling	3.57	1.95	9.86	.524	6.6	3.45	1.76	10.3	.507	.13	5.0	6.6
3	3° retarded timing, standard pump and nozzles, 150° F aftercooling	3.77	2.86	8.15	.508	9.2	3.76	2.60	8.82	.495	.18	7.4	7.4
	ENGINE NO. 21												
	Baseline	3.29	0.50	7.98	0.452	11.7	4.39	0.48	8.5	0.452	0.082	4.4	15.9
1	Standard timing, turbocharger, and standard fuel pump	1.46	.63	11.44	.448	3.3	1.51	.60	12.09	.441	.070	5.6	1.6
2	2° retarded timing, turbocharger, and special fuel pump	1.28	.59	10.59	.449	3.6	1.37	.53	11.28	.438	.042	4.6	3.6
3	2° retarded timing, turbocharger, and standard fuel pump	1.34	.72	10.08	.458	3.6	1.35	.61	10.50	.446	.057	5.4	3.0

1/NOTE.- Odor intensity determined with samples diluted 400:1 for engines 15 and 19, and 100:1 for all other engines

TABLE 10. - Summary of baseline emissions (23-mode cycle) and fuel consumption for gasoline engines (also comparison of composite cycle emissions with and without a value for the motored mode

	Engine No. 22				Engine No. 23			
	Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Emissions, g/bhp-hr			BSFC, lb/bhp-hr
	CO	HC	NO_2		CO	HC 1/	NO_2	
Data as generated in this test program 2/--average of initial and final baselines.....	33.1	2.29	9.52	0.649	40.6	2.85	9.59	0.567
Data computed using an estimated value 2/ for emissions during motored modes..	33.4	7.66	9.60	-	41.6	8.30	9.58	-

1/ Note due to limitation in dynamometer capability (i.e., power absorption only), data do not reflect emissions during closed throttle motored modes.

2/ Estimated values for motored modes were: Engine No. 22 -- intermediate speed - 45, 760, and 10 g/hr for CO, HC, and NO_2, respectively; high speed - 60, 540, and 12 g/hr for CO, HC, and NO_2, respectively; Engine No. 23 -- intermediate speed - 160, 840, and 10 g/hr for CO, HC, and NO_2, respectively; high speed - 160, 760, and 12 g/hr for CO, HC, and NO_2, respectively.

TABLE 11. - Summary of baseline emissions (9-mode cycle) for gasoline engines (also comparison of composite cycle emissions with and without a value for the motored mode

	Emissions, g/bhp-hr					
	Engine No. 22			Engine No. 23		
	CO	HC	NO_2	CO	HC	NO_2
Data as generated in this test program 1/ -- average of initial and final baselines.....	46.4	2.90	8.12	35.0	3.40	9.95
Data computed using estimated values 2/ for emissions during the motored mode.....	50.4	6.58	8.12	40.0	8.72	10.02

1/ Note due to limitation of dynamometer capability (i.e., power absorption only), data do not reflect emissions during the closed throttle mode.

2/ Estimated emission values for the motored mode were: Engine No. 22 -- 660, 540, and 10 g/hr for CO, HC, and NO_2, respectively; and engine No. 23 -- 280, 780, and 12 g/hr for CO, HC, and NO_2, respectively.

TABLE 12. - The effect of emission control parameters on emissions and specific fuel consumption (23-mode cycle, engine No. 22)

	Emissions, grams/bhp-hr			BSFC, lb/bhp-hr
	CO	HC	NO_x	
STANDARD BASELINE DATA				
Initial baselines, average of 3 tests.....	32.1	2.28	9.6	0.645
EFFECT OF AIR INJECTION				
Air pump pulley/drive pulley ratio				
1.00	16.2	1.05	10.6	0.634
1.25	13.0	1.00	9.2	.643
1.50	14.7	1.11	10.8	.655
1.75	14.6	.98	10.6	.655
2.00	12.8	1.02	8.9	.648
EFFECT OF CATALYST				
Standard without catalyst with air injection.....	13.0	1.00	9.2	0.643
Standard with catalyst with air injection.	1.6	.09	8.2	.662
EFFECT OF AIR-FUEL RATIO				
Main jet size, inches				
0.052 (lean)	8.1	4.70	7.2	0.744
.054 Do.	14.9	1.31	8.5	.644
.056 (initial baselines)	32.1	2.28	9.6	.645
.058 (rich)	61.8	2.83	7.7	.638
.060 Do.	151.3	4.31	4.4	.663
EFFECT OF EGR				
EGR, percent				
0 (initial baselines)	32.1	2.28	9.6	0.645
5	34.6	3.29	5.9	.643
8	37.3	2.97	5.1	.650
10	42.2	3.45	4.1	.657
12	34.3	3.43	4.2	.664
15	32.8	2.87	4.3	.668
EFFECT OF IGNITION TIMING				
Vacuum advance unit:				
Initial baselines.....	32.1	2.28	9.6	0.645
Modified unit No. 1.....	34.3	2.76	10.1	.632
Modified unit No. 2.....	34.4	2.92	10.2	.626

TABLE 13. - The effect of emission control parameters on emissions and specific fuel consumption (23-mode cycle, engine No.23)

	Emissions, grams/bhp-hr			BSFC, lb/bhp-hr
	CO	HC	NO_x	
STANDARD BASELINE DATA				
Initial baselines, average of 3 tests.....	40.8	2.77	10.3	0.582
EFFECT OF AIR INJECTION				
Air pump pulley/drive pulley ratio				
2.0	19.3	1.54	11.4	0.597
2.5	18.2	1.48	10.8	.596
3.0	18.8	1.46	11.1	.602
EFFECT OF CATALYST				
Standard without catalyst with air injection.....	18.2	1.48	10.8	0.596
Standard with catalyst and air injection..	1.5	.15	9.5	.562
EFFECT OF AIR-FUEL RATIO				
Main jet number				
299 (lean) 1/	64.9	3.80	9.0	0.583
300 (initial baselines)	40.8	2.77	10.3	.582
309 (rich)	112.0	4.40	5.8	.611
EFFECT OF EGR				
EGR, percent				
0 (initial baselines)	40.8	2.77	10.3	0.582
5	35.8	2.84	9.0	.574
5-7.5 2/	59.5	3.44	5.9	.586
5-10 or maximum EGR 3/	52.6	3.03	5.9	.576
15 percent or maximum EGR 4/	57.0	4.74	4.7	.608
EFFECT OF IGNITION TIMING				
Basic timing, ° BTC				
5 (initial baselines)	40.8	2.77	10.3	0.582
2.5	47.7	2.95	8.9	.606
0	48.7	2.41	7.3	.635
-2.5	50.2	2.32	7.3	.662

1/Although the carburetor jets were sized to give a leaner than standard air-fuel ratio in this test, the CO emission indicates that the air-fuel ratio was richer than standard. This is caused by interaction of power enrichment jets at the high power modes.

2/EGR was programmed to increase linearly with engine load starting with 5 pct EGR at 8 pct load and increasing to 7.5 pct at 82 pct load. EGR was cut off during the following modes: Idle and 2, 92, and 100 pct load modes for both speeds.

3/EGR was programmed from 5 to 10 pct similar to that described in footnote 2/, but at some modes the EGR valve would not deliver the required amount of EGR. For those modes, the EGR valve was maintained wide open. The actual percents of EGR for these modes are indicated in the 23-mode tables.

4/Fifteen pct EGR was used in all modes from 8 to 82 pct load except where 15 pct was not attainable due to limitation of flow through the EGR valve. For modes with less than 15 pct EGR indicated, the EGR valve was wide open.

TABLE 14. - Summary of emissions and fuel consumption for baselines and combination of parameter tests for gasoline engines

Combination of parameter No.	Description of engine adjustment and/or accessory hardware	23-mode cycle				13-mode cycle
		Emissions, g/bhp-hr			BSFC, lb/bhp-hr	Aldehydes, g/bhp-hr
		CO	HC 1/	NO_x		
	ENGINE NO. 22					
	Baselines, average of 5 tests	33.1	2.29	9.52	0.649	0.22
1	Standard timing, air injection, A/F--one step lean, 15 pct EGR, and UOP catalysts	1.20	.14	6.15	.700	.023
2	Standard timing, air injection, A/F--one step rich, 15 pct EGR, and UOP catalysts	19.2	.25	3.93	.689	.014
3	Standard timing, air injection, A/F--standard, 15 pct EGR, and UOP catalysts	1.32	.09	5.70	.688	.012
	ENGINE NO. 23					
	Baseline, average of 5 tests	40.6	2.85	9.59	0.567	0.26
1	5° retarded timing, air injection, A/F--standard, and 5.0-7.5 pct EGR 2/	16.6	.75	4.76	.571	.26
2	Standard timing, air injection, A/F--standard, 5.0-7.5 pct EGR 2/, and UOP catalysts	2.57	.12	5.79	.555	.030
3	5° retarded timing, air injection, A/F--standard, 5.0-7.5 pct EGR 2/, and UOP catalysts	2.97	.14	5.42	.604	.065

1/ Note composite hydrocarbon values in the table do not include any contribution from the motored modes.

2/ EGR was programmed to increase linearly with engine load starting with 5 pct EGR at 8 pct load and increasing to 7.5 pct at 82 pct load. EGR was cut off during the following modes: Idle and 2, 92, and 100 pct load modes for both speeds.

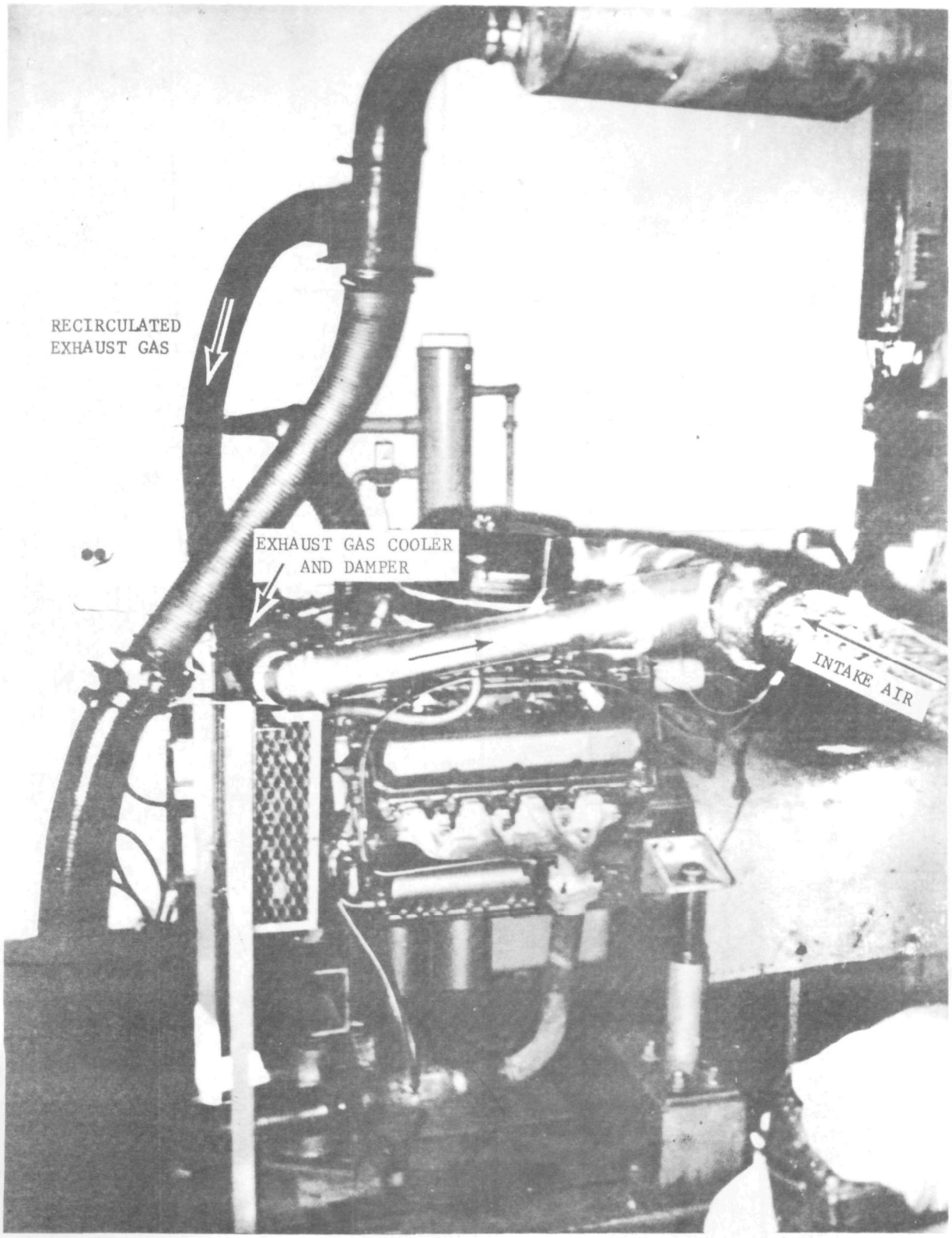


FIGURE 1. - Typical Exhaust Gas Recirculation System Used for Diesel Engine Tests

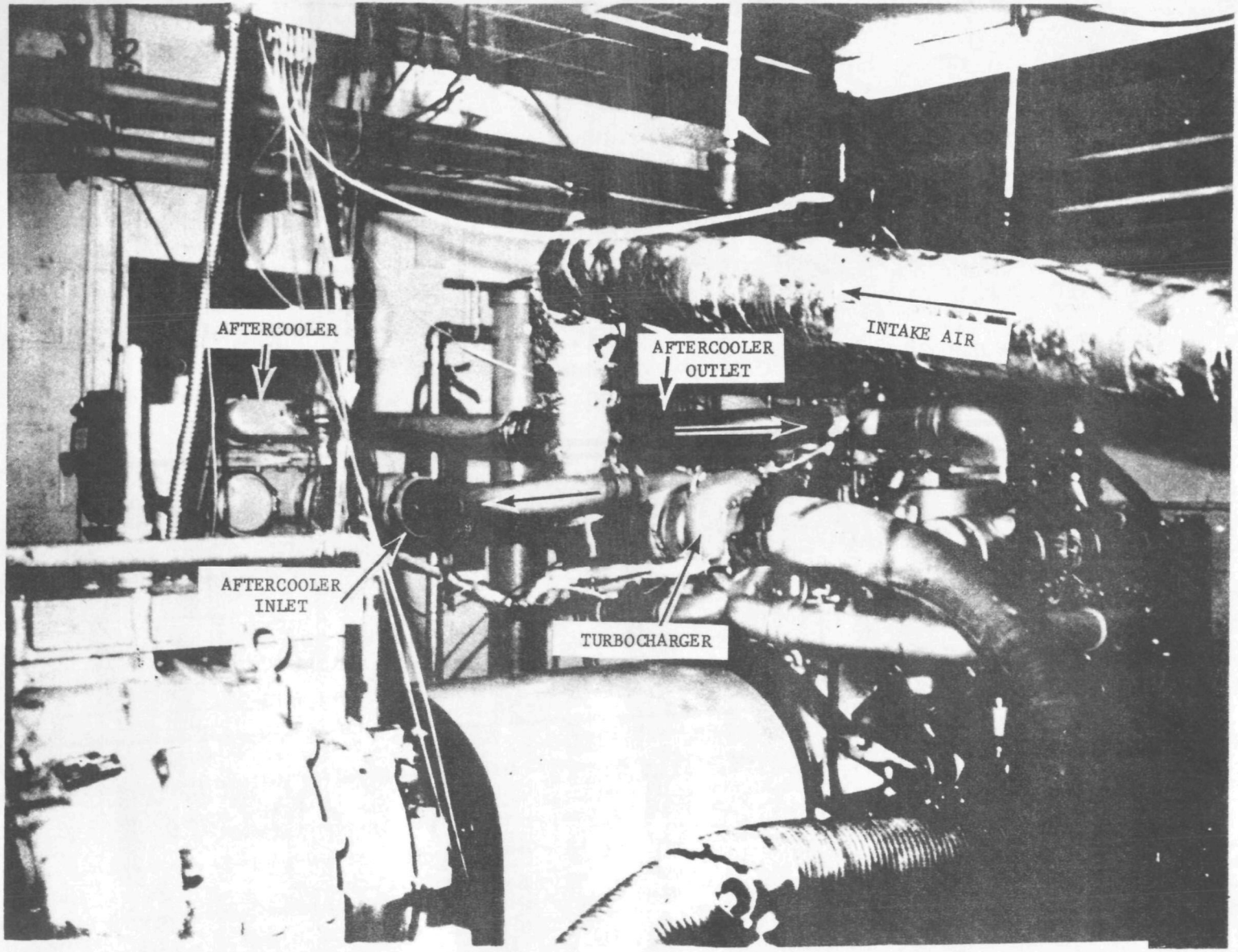
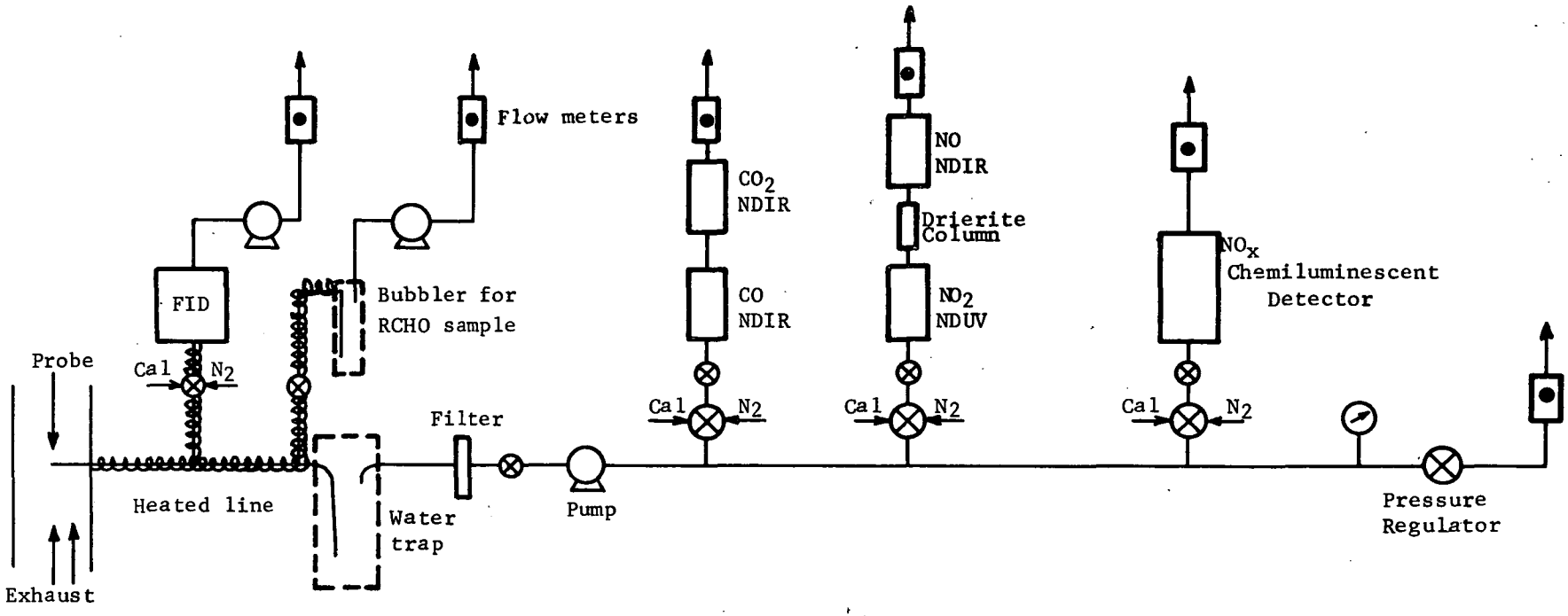


FIGURE 2. - Typical Aftercooling Setup Used in Diesel Engine Tests



1. Water trap maintained at 32° F
2. Sample line:
   a. Heated portion - Stainless steel at 350°F -- total length of stainless steel ≈ 20 feet
   b. Unheated portion - Teflon
3. Probe: 1/4" O.D. stainless steel
4. Total sample flow ≈ 30 cfh
5. FID - heated (oven temperature ≈ 400°F), vacuum type

FIGURE 3. - Schematic of Exhaust Sampling and Analytical System Used in Diesel Engine Tests

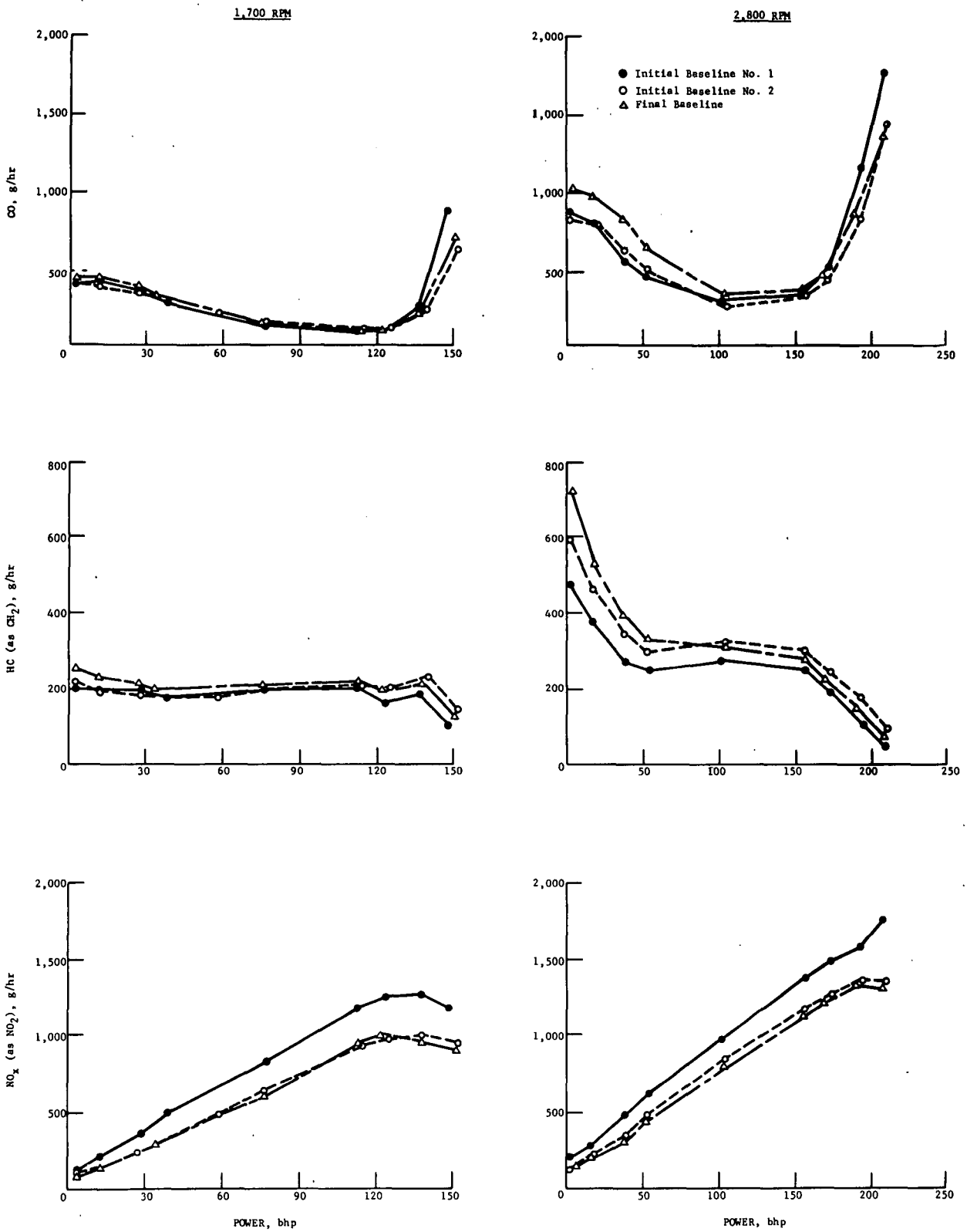


FIGURE 4. - Emissions as a Function of Power Output for Engine No. 15 (Baseline Tests)

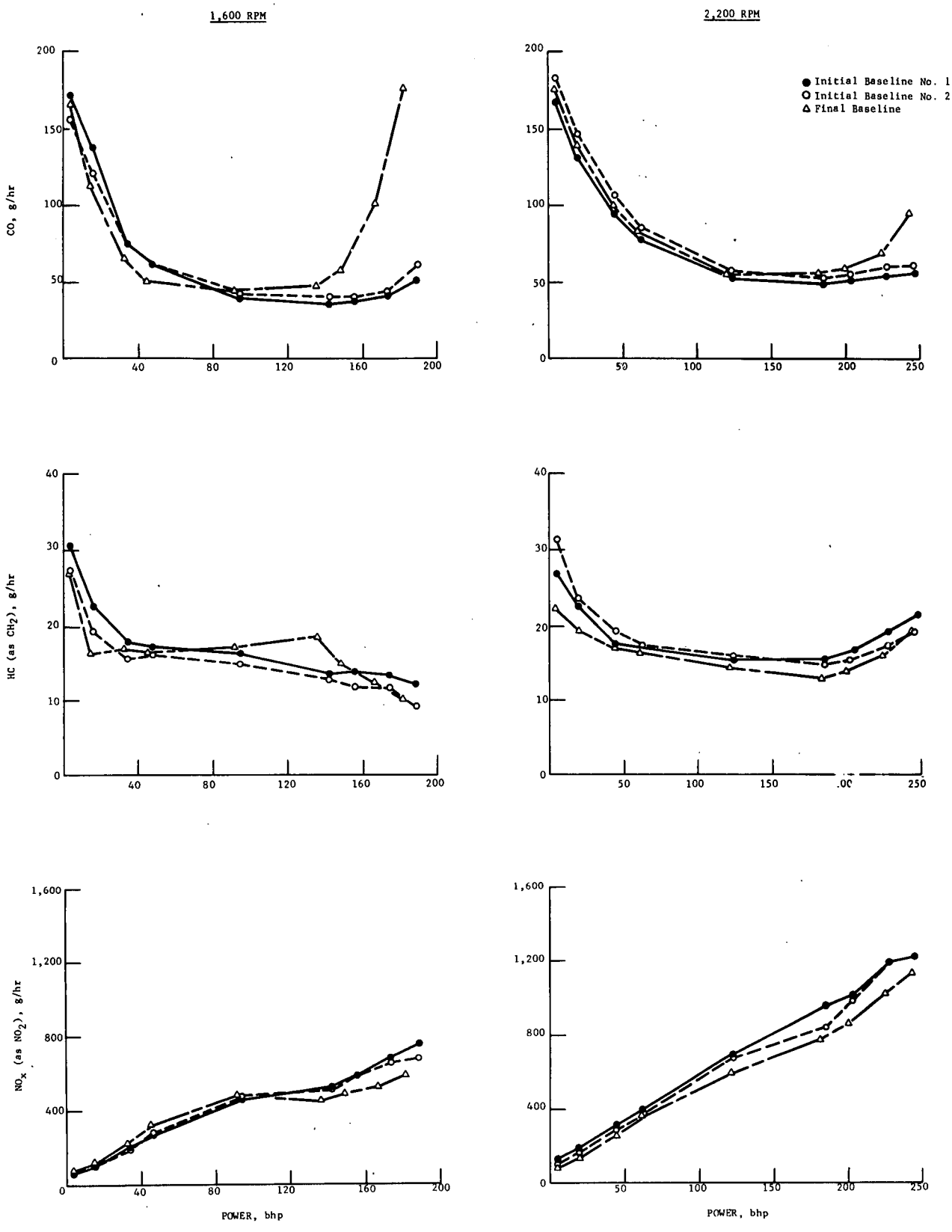


FIGURE 5. - Emissions as a Function of Power Output for Engine No. 16 (Baseline Tests)

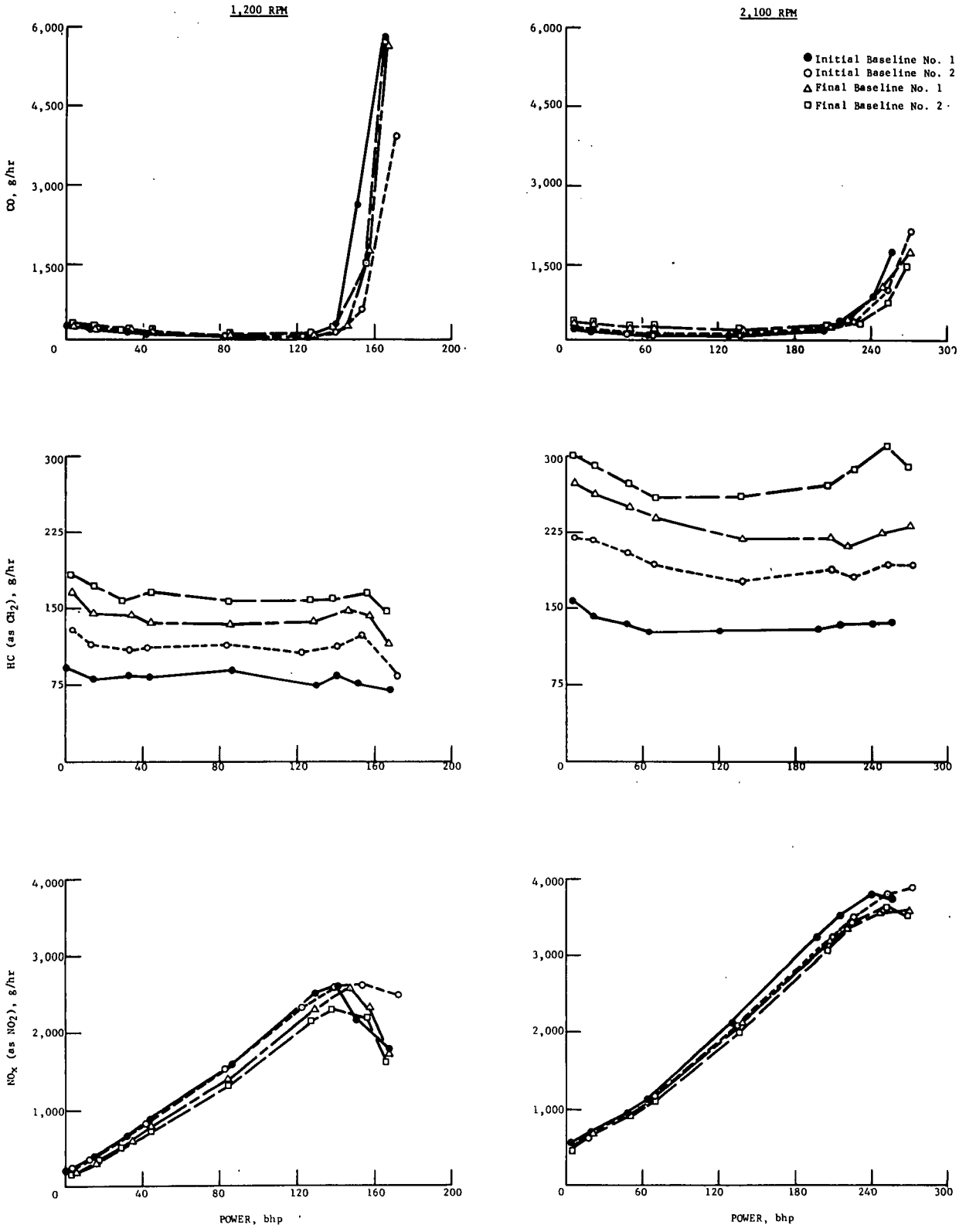


FIGURE 6. - Emissions as a Function of Power Output for Engine No. 17 (Baseline Tests)

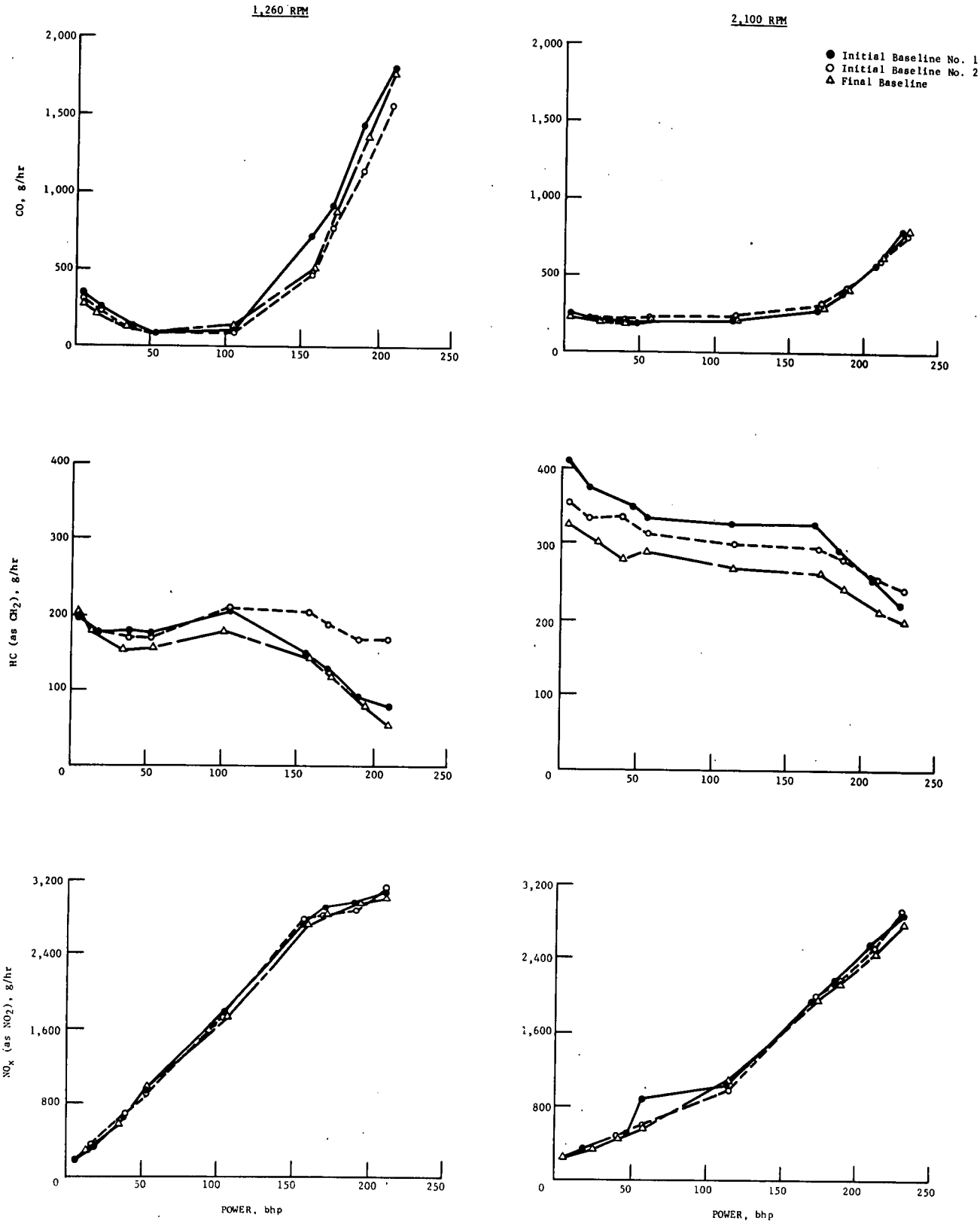


FIGURE 7. - Emissions as a Function of Power Output for Engine No. 18 (Baseline Tests)

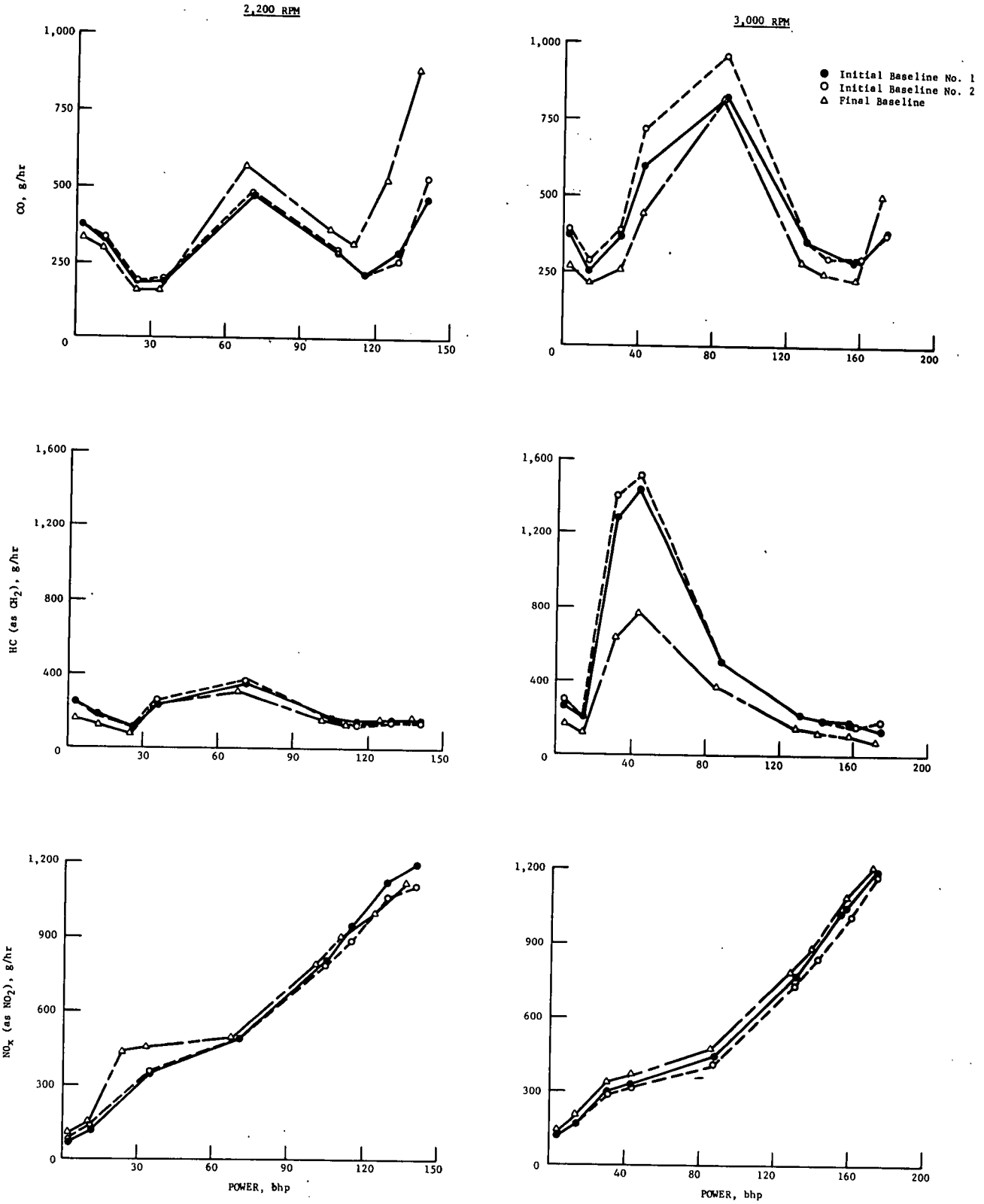


FIGURE 8. - Emissions as a Function of Power Output for Engine No. 19 (Baseline Tests)

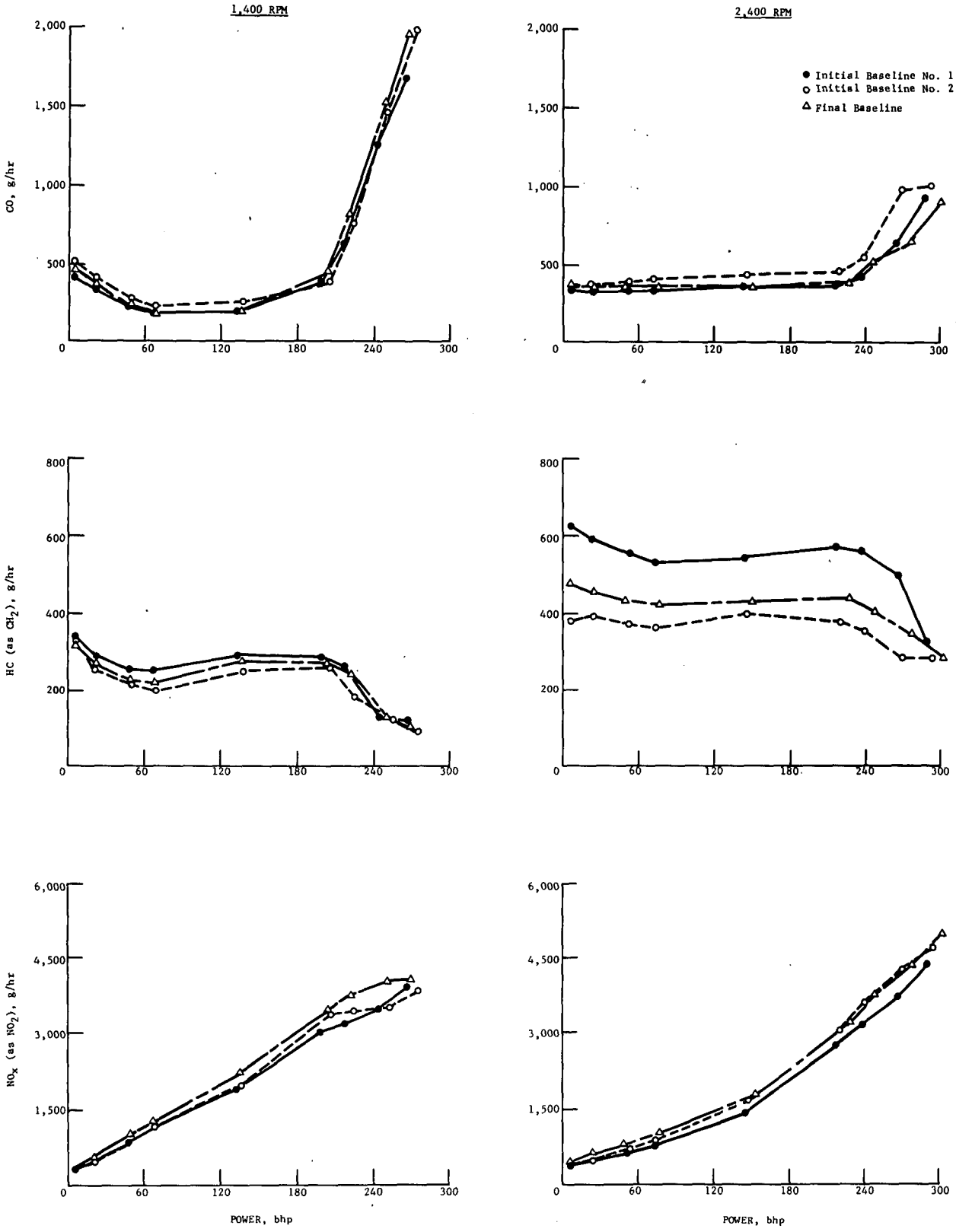


FIGURE 9. - Emissions as a Function of Power Output for Engine No. 20 (Baseline Tests)

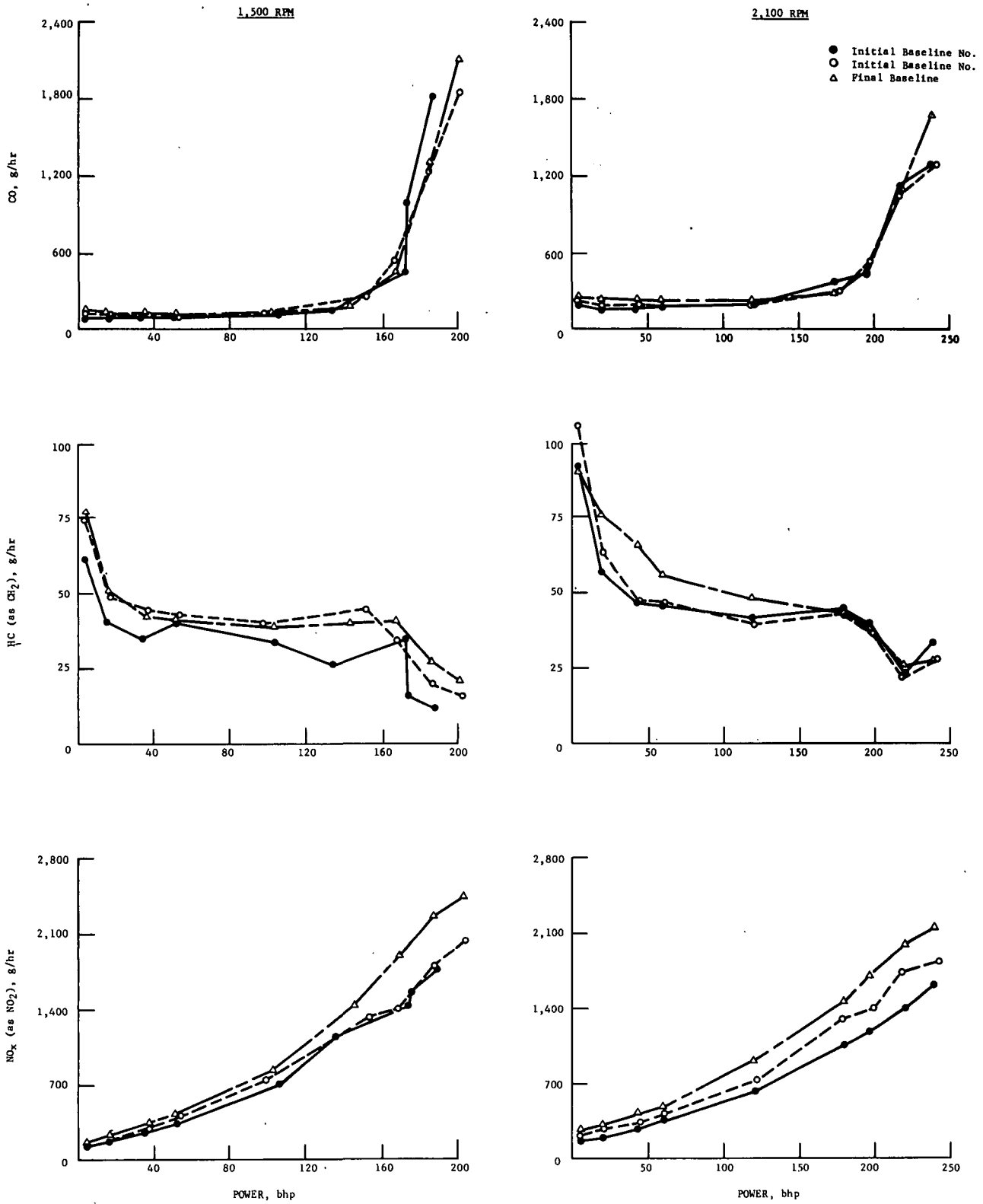


FIGURE 10. - Emissions as a Function of Power Output for Engine No. 21 (Baseline Tests)

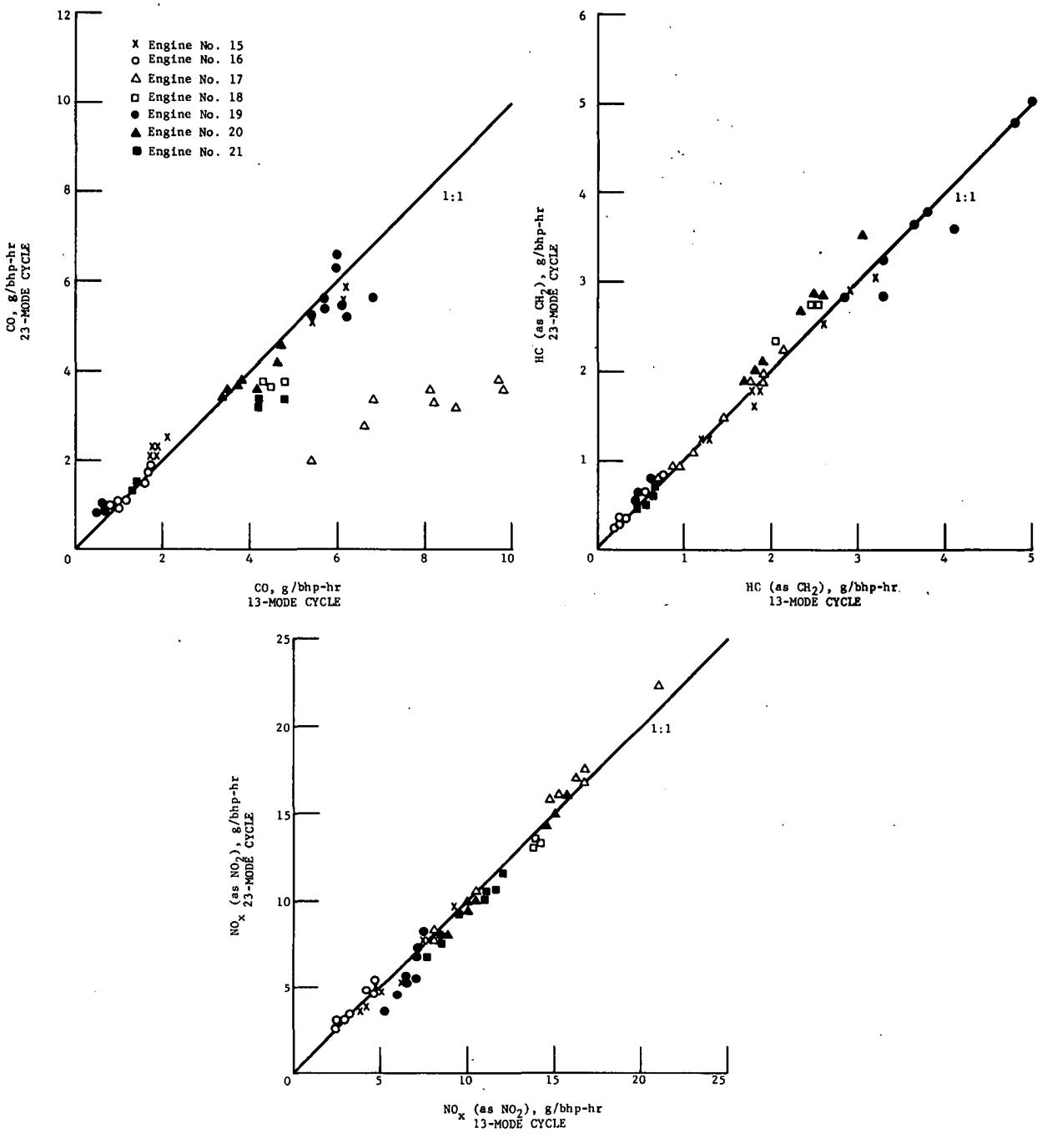


FIGURE 11. - Comparison of Emission Between the 13-Mode and 23-Mode Cycle Procedures (Data from Baseline and Combination of Parameter Tests)

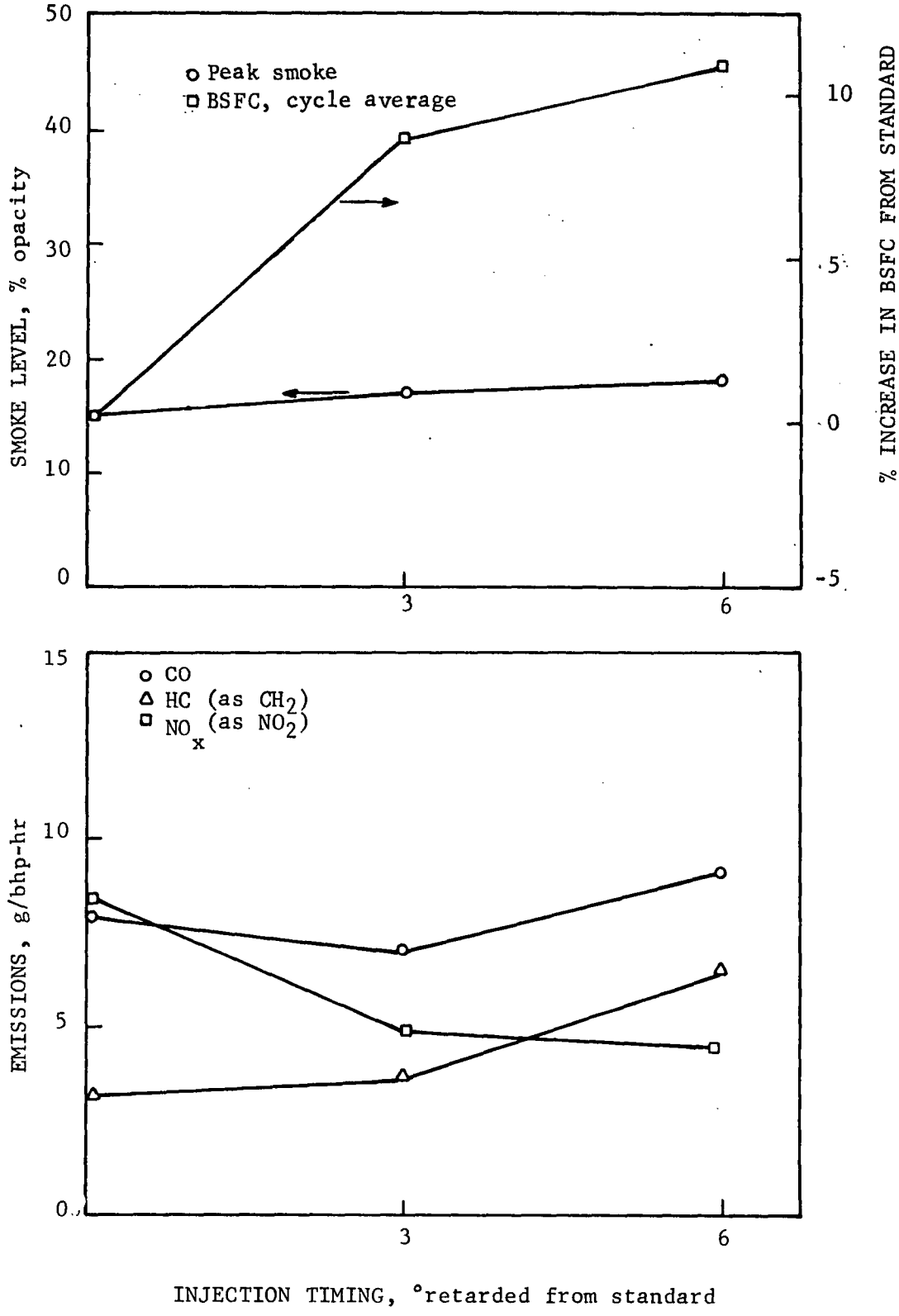


FIGURE 12. - Emissions, Smoke, and Fuel Consumption as a Function of Injection Timing Retard (Composite Results from a Simplified 7-Mode Cycle for Engine No. 15)

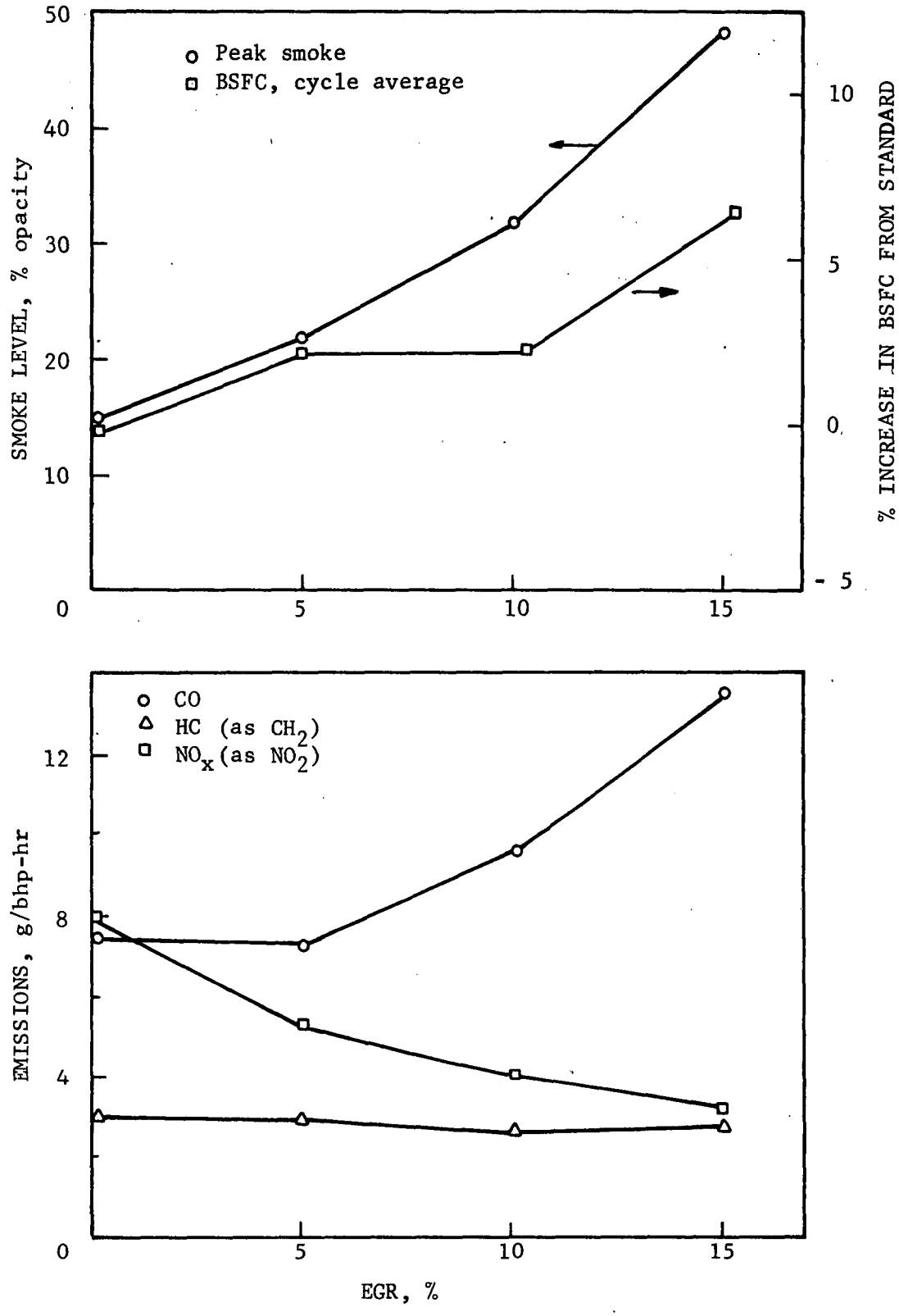


FIGURE 13. - Emissions, Smoke, and Fuel Consumption as a Function of EGR (Composite Results from a Simplified 7-Mode Cycle for Engine No. 15)

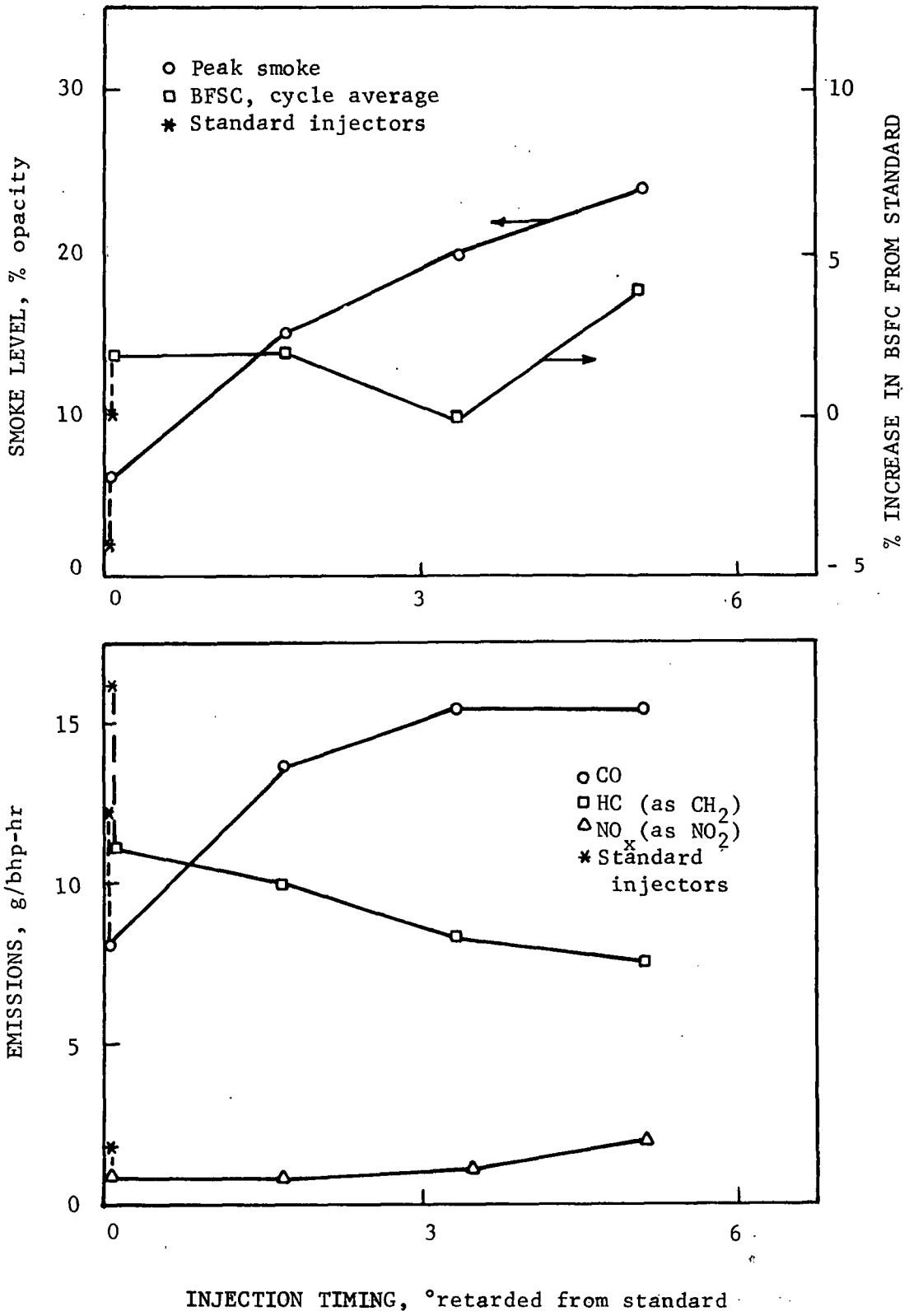


FIGURE 14. - Emissions, Smoke, and Fuel Consumption as a Function of Injection Timing Retard (Composite Results from a Simplified 7-Mode Cycle for Engine No. 17 using Experimental Injectors)

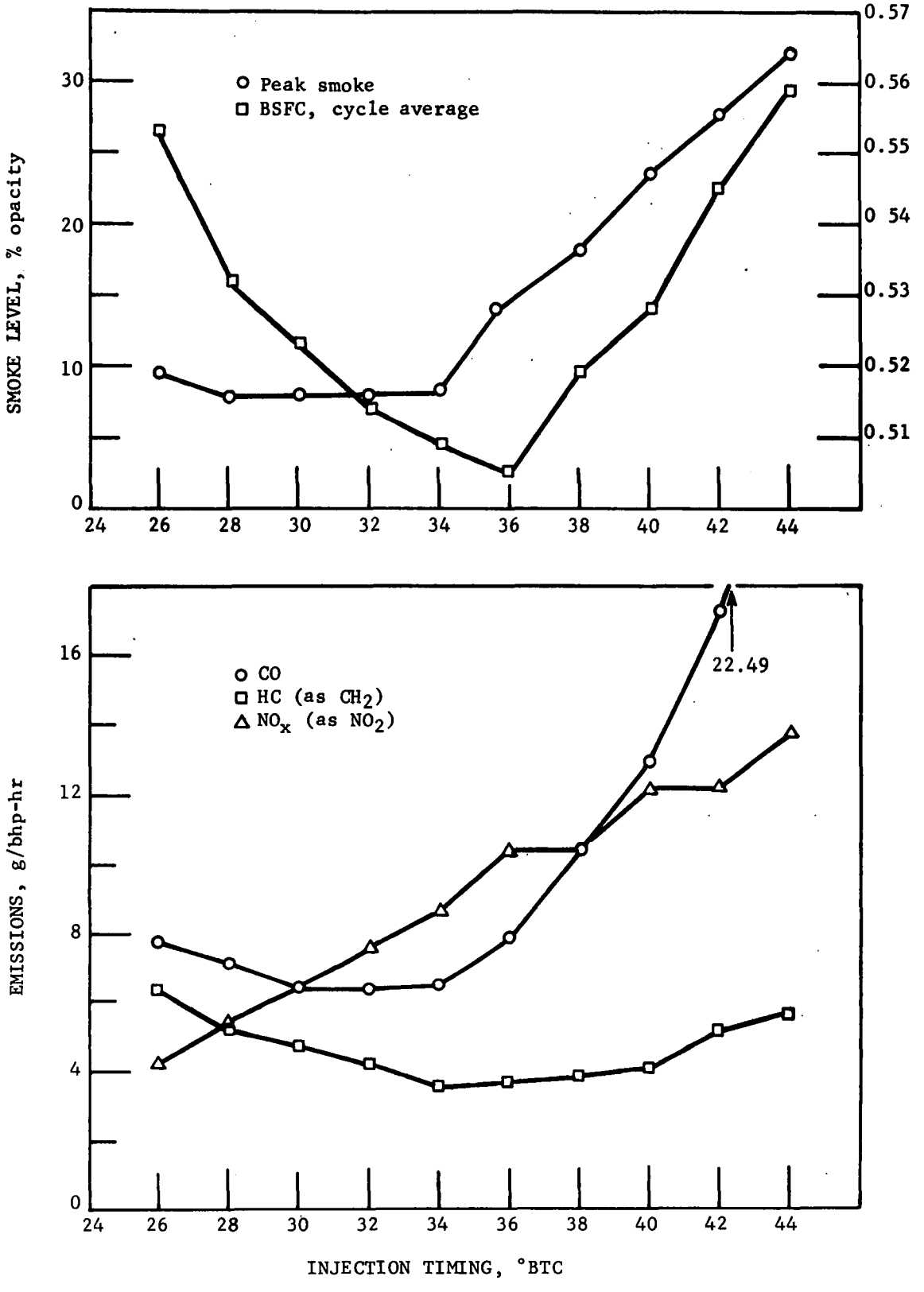


FIGURE 15. - Emissions, Smoke, and Fuel Consumption as a Function of Injection Timing Retard (Composite Results from a Simplified 7-Mode Cycle for Engine No. 19)

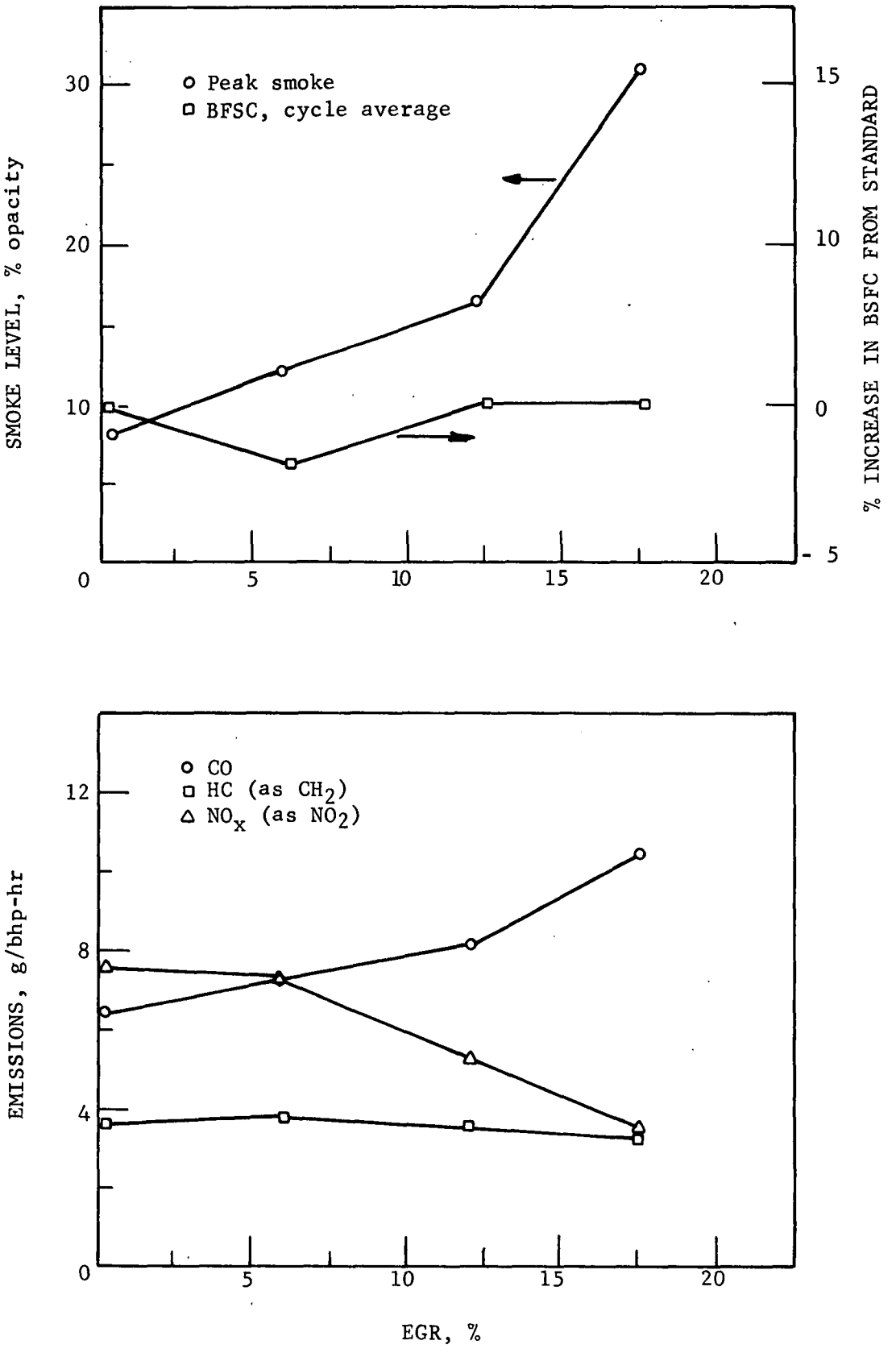


FIGURE 16. - Emissions, Smoke, and Fuel Consumption as a Function of EGR (Composite Results from a Simplified 7-Mode Cycle for Engine No. 19 with Standard Injection Timing)

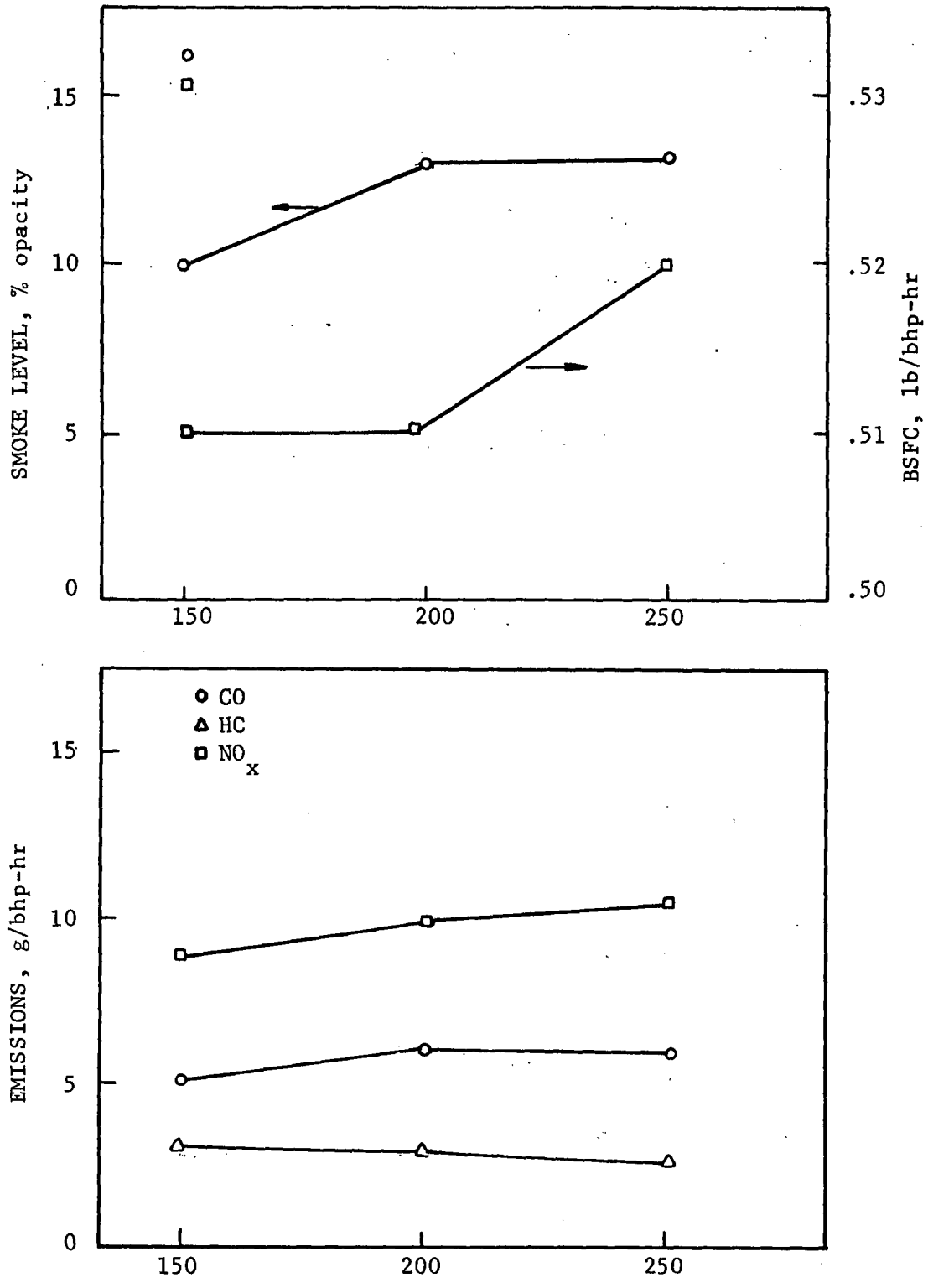


FIGURE 17. - Emissions, Smoke, and Fuel Consumption as a Function of Aftercooling Temperature (Composite Results from a Simplified 7-Mode Cycle for Engine No. 20 with Injection Timing Retarded 3° from Standard)

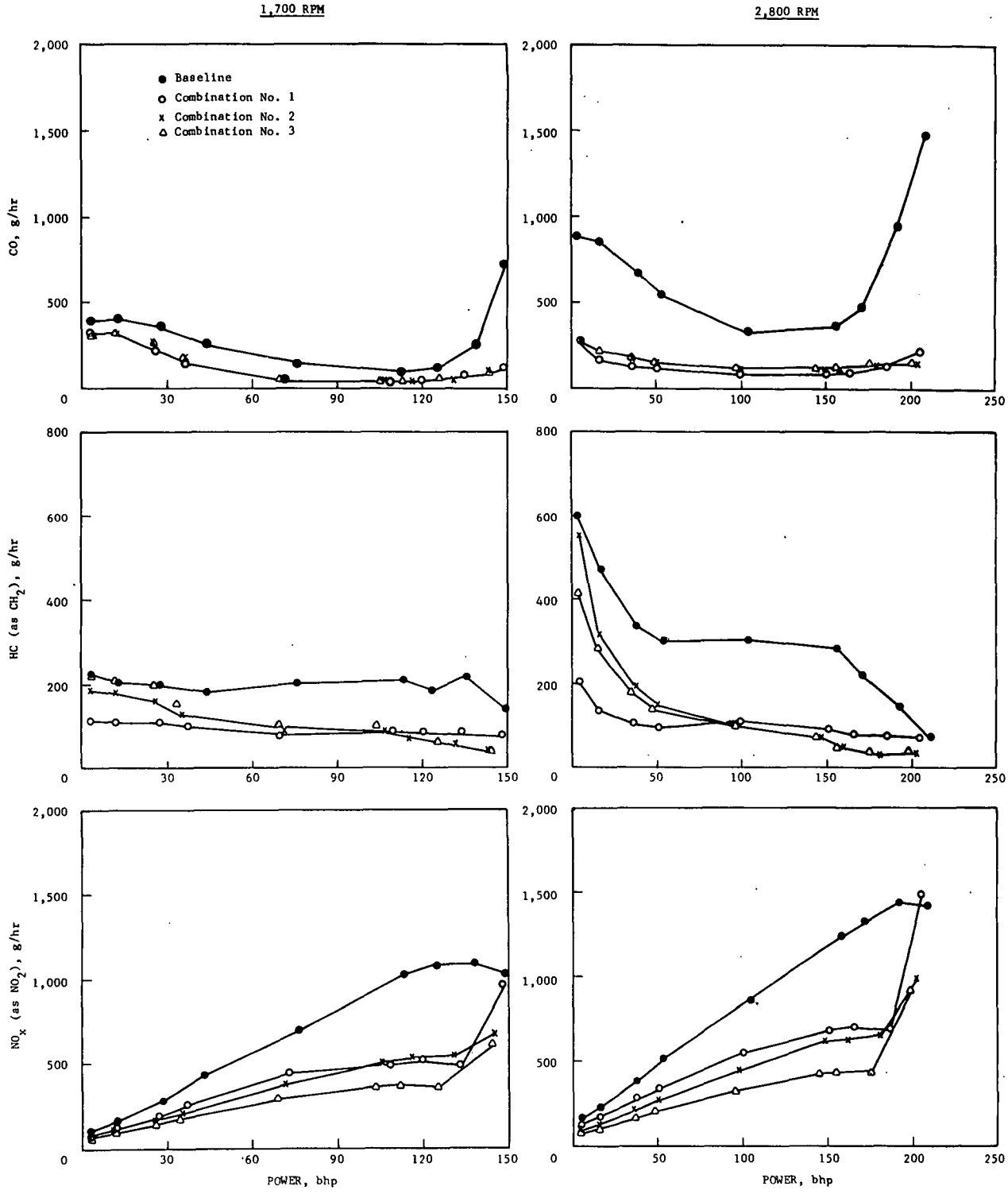


FIGURE 18. - Comparing Emissions from Baseline and Combination of Parameter Tests for Engine No. 15 (Emissions as a Function of Power Output)

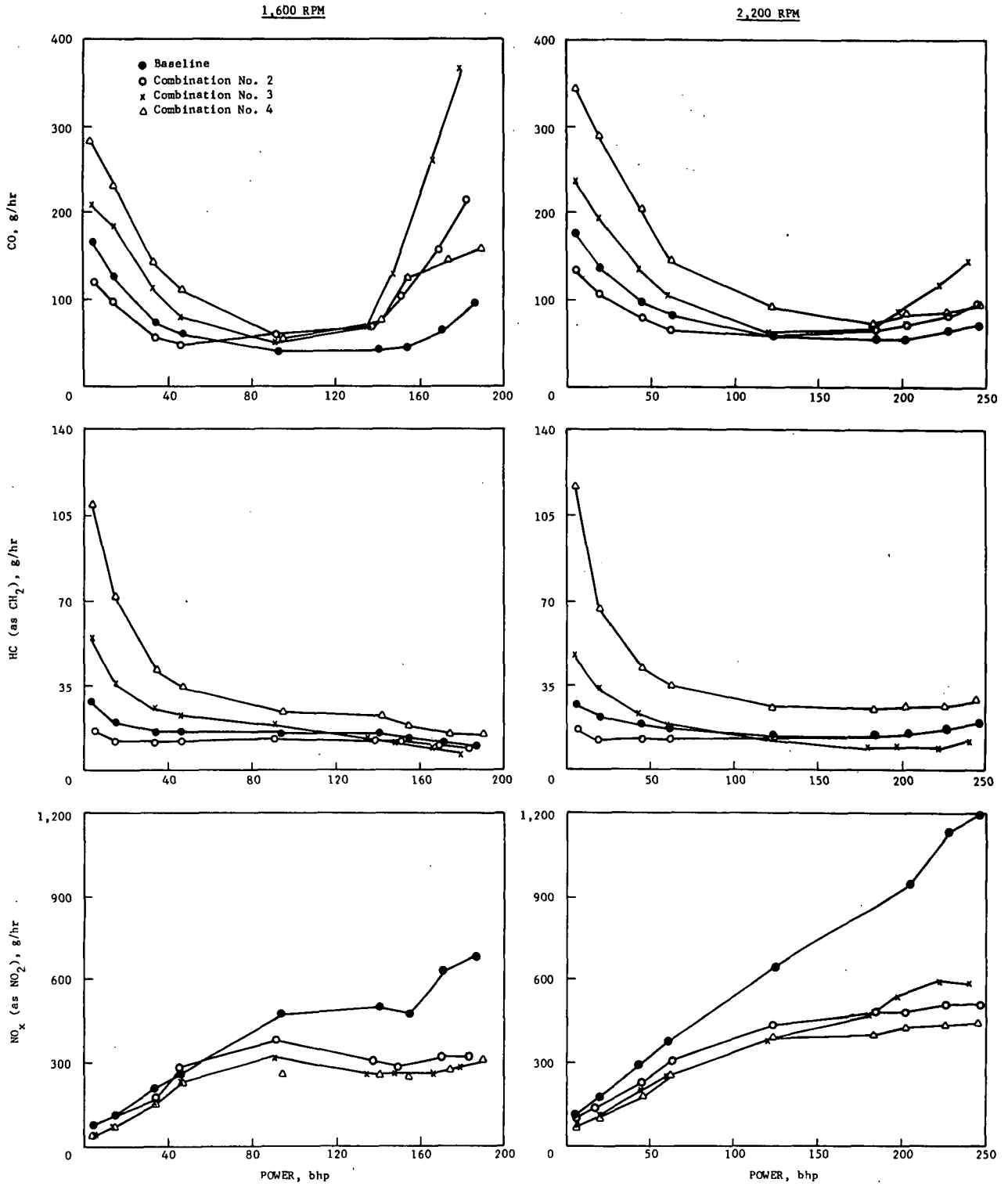


FIGURE 19. - Comparing Emissions from Baseline and Combination of Parameter Tests for Engine No. 16 (Emissions as a Function of Power Output)

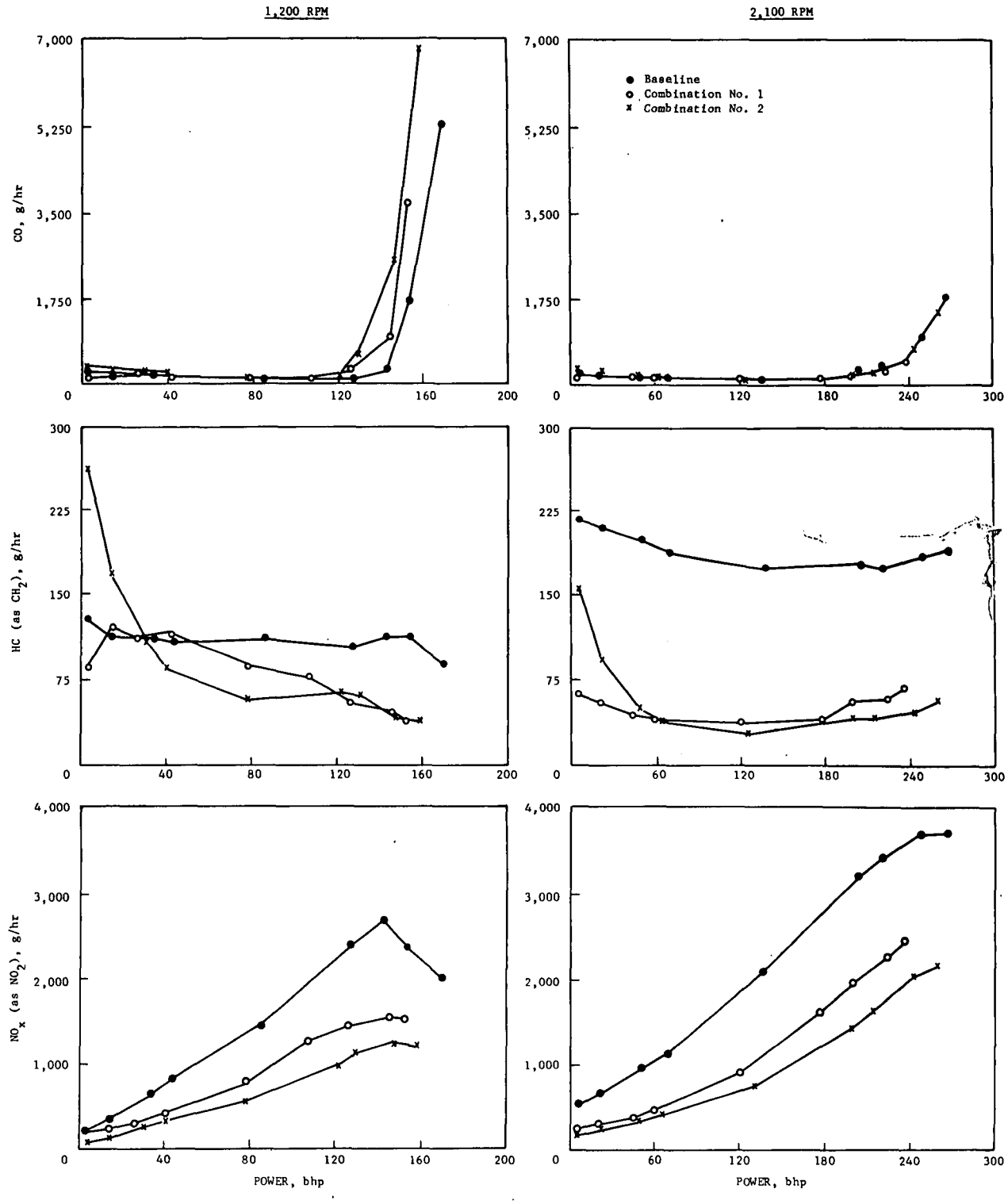


FIGURE 20. - Comparing Emissions from Baseline and Combination of Parameter Tests for Engine No. 17 (Emissions as a Function of Power Output)

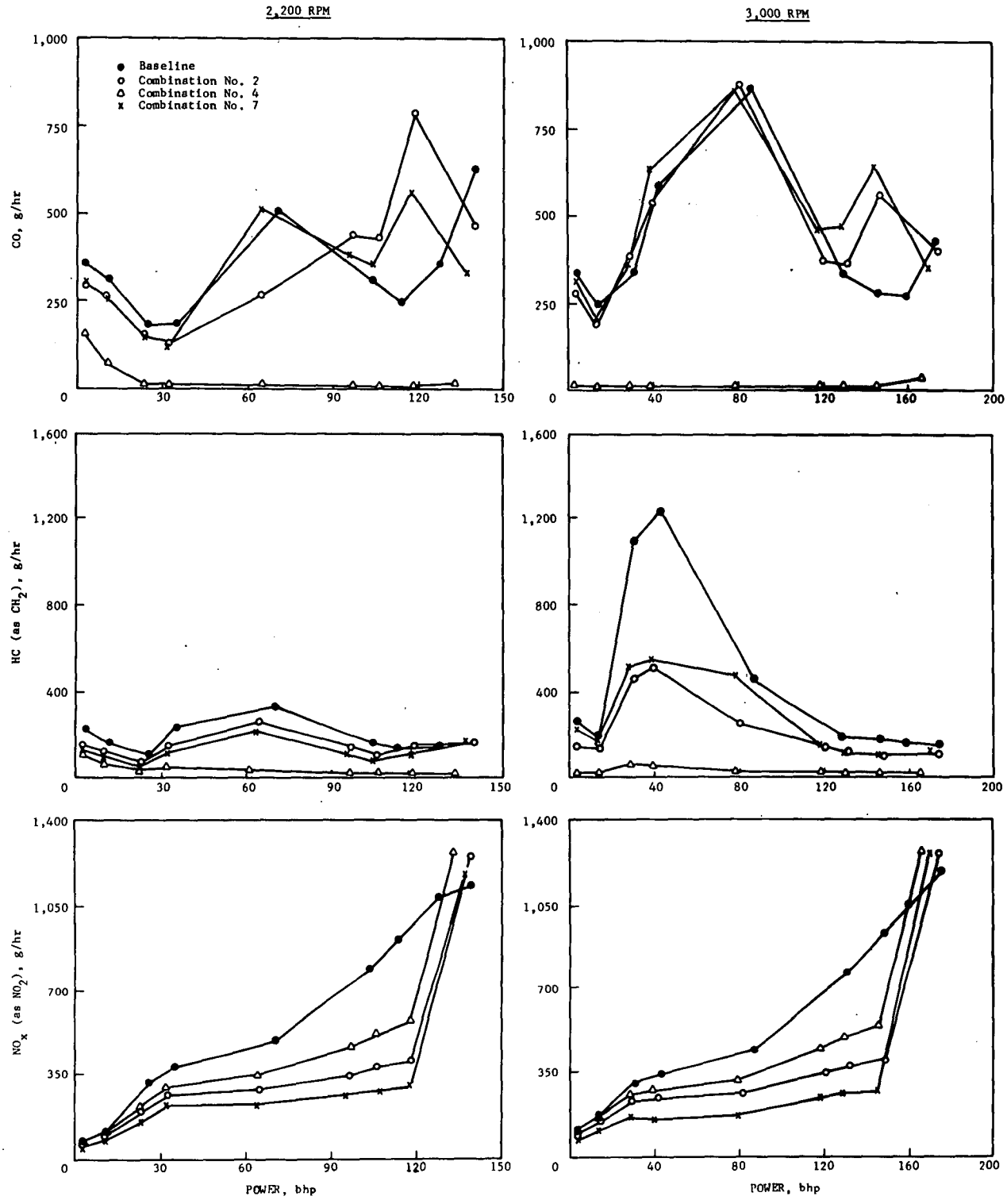


FIGURE 21. - Comparing Emissions from Baseline and Combination of Parameter Tests for Engine No. 19 (Emissions as a Function of Power Output)

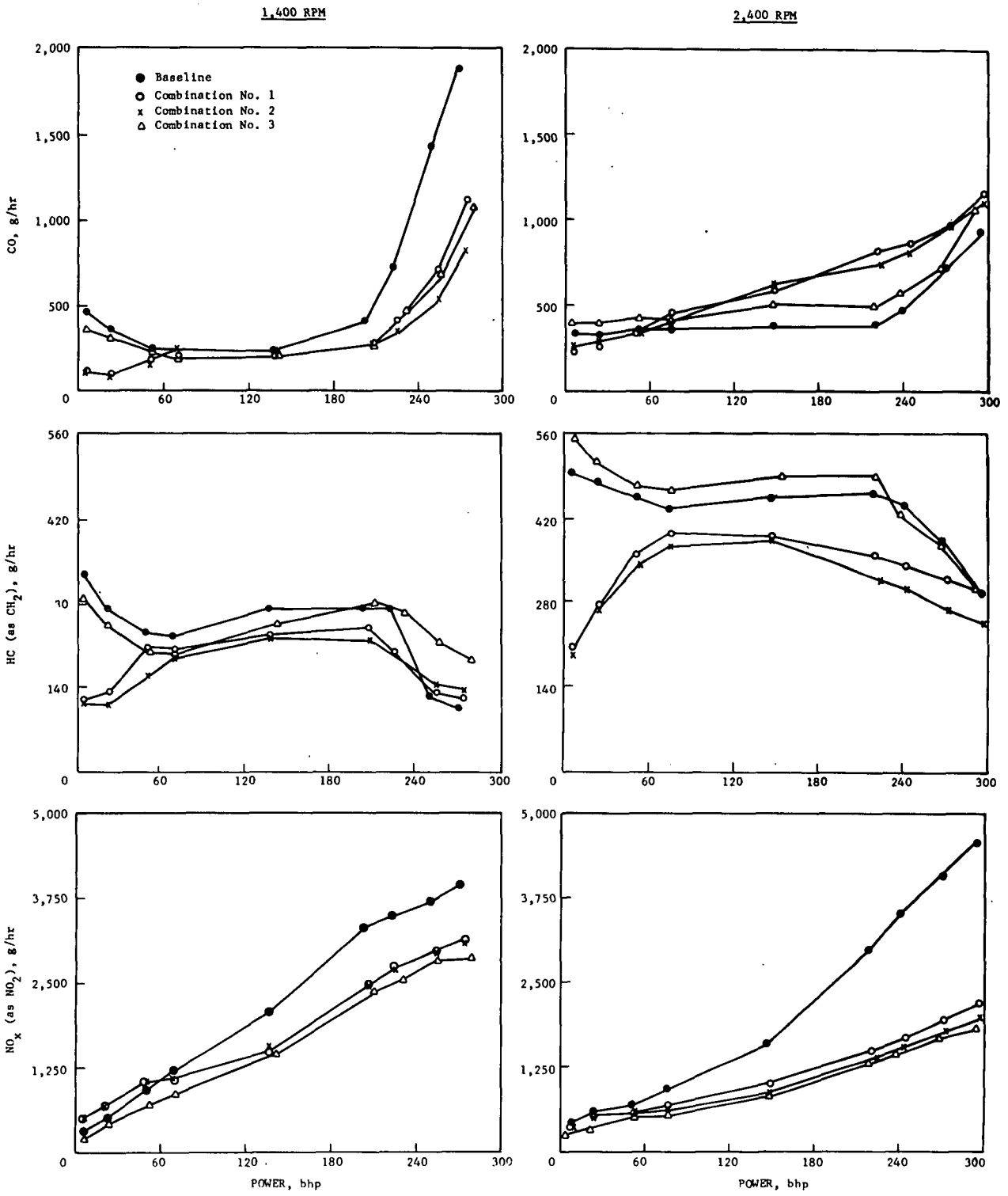


FIGURE 22. - Comparing Emissions from Baseline and Combination of Parameter Tests for Engine No. 20 (Emissions as a Function of Power Output)

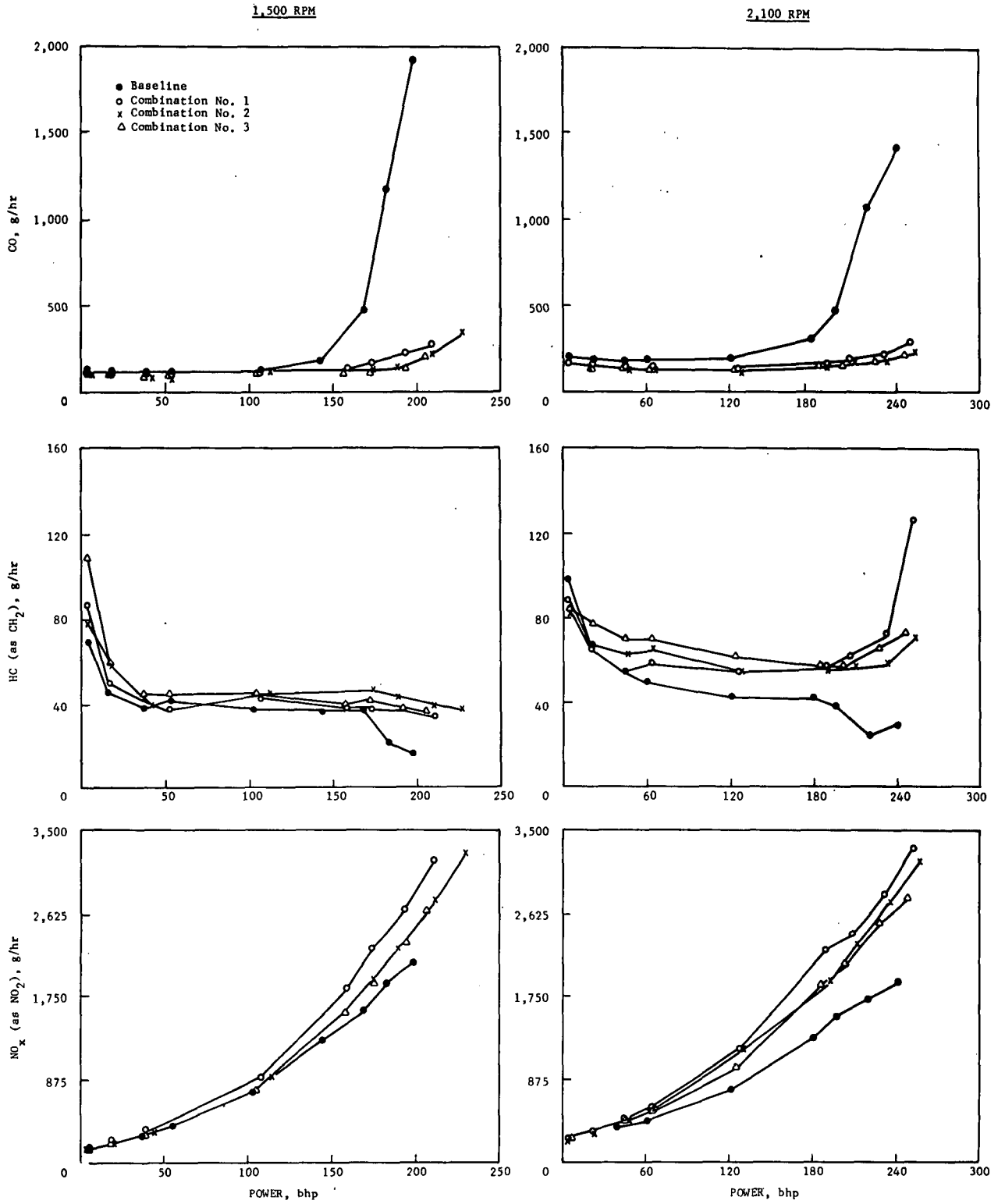


FIGURE 23. - Comparing Emissions from Baseline and Combination of Parameter Tests for Engine No. 21 (Emissions as a Function of Power Output)

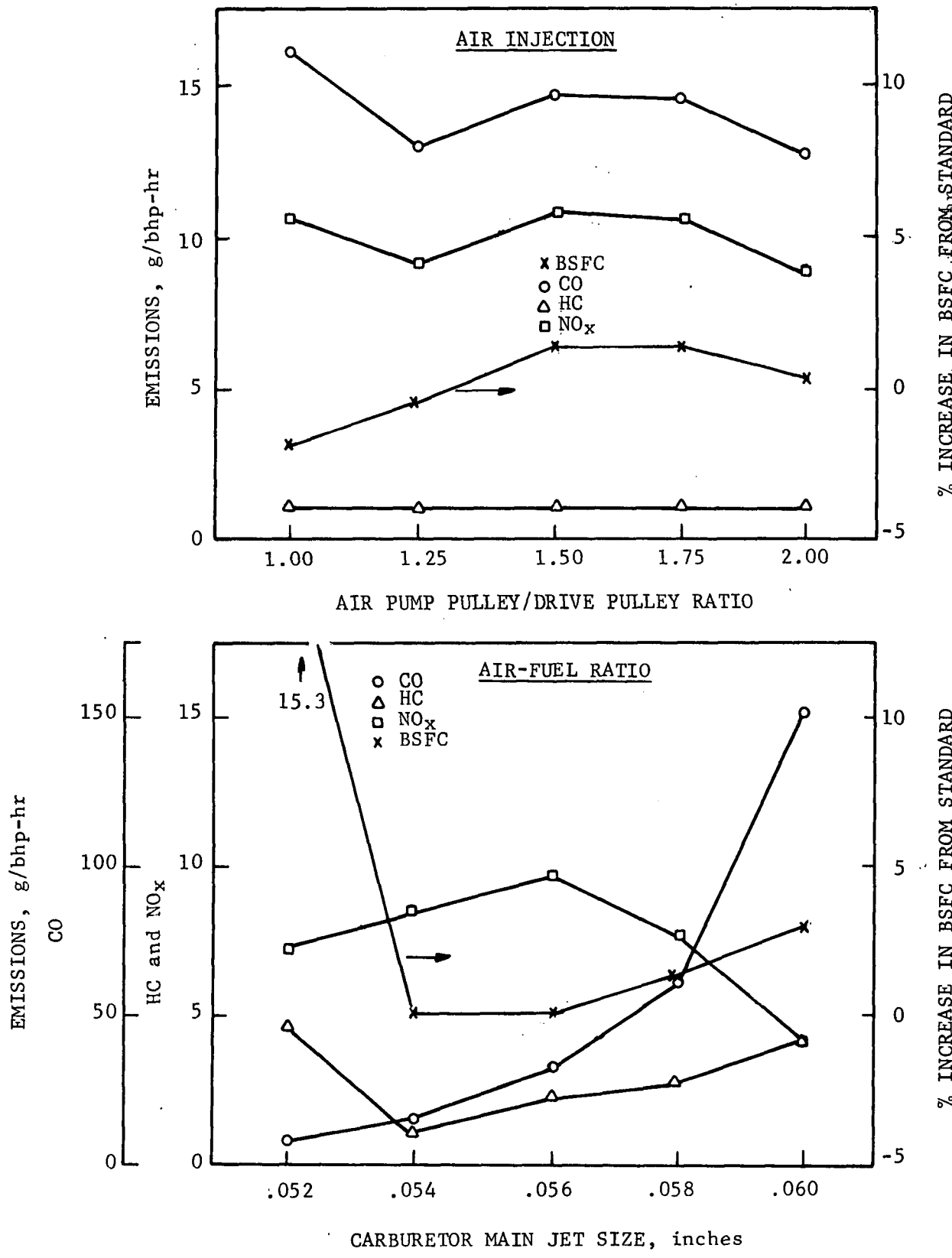


FIGURE 24. - The Effect of Air Injection and Air-Fuel Ratio on Fuel Consumption (Engine No. 22, 23-Mode Procedure)

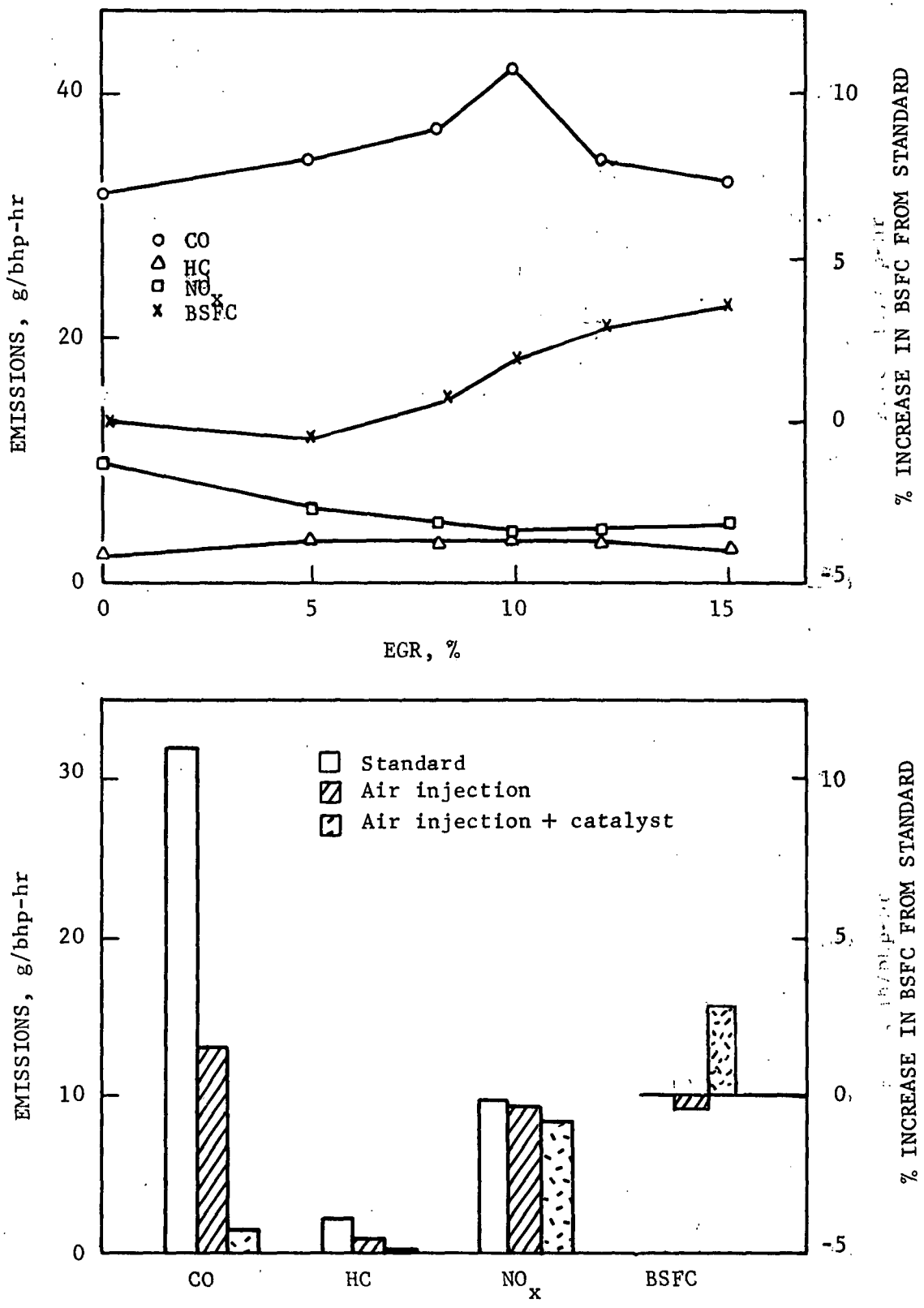


FIGURE 25. - The Effect of EGR and Catalysts on Emissions and Fuel Consumption (Engine No. 22, 23-Mode Procedure)

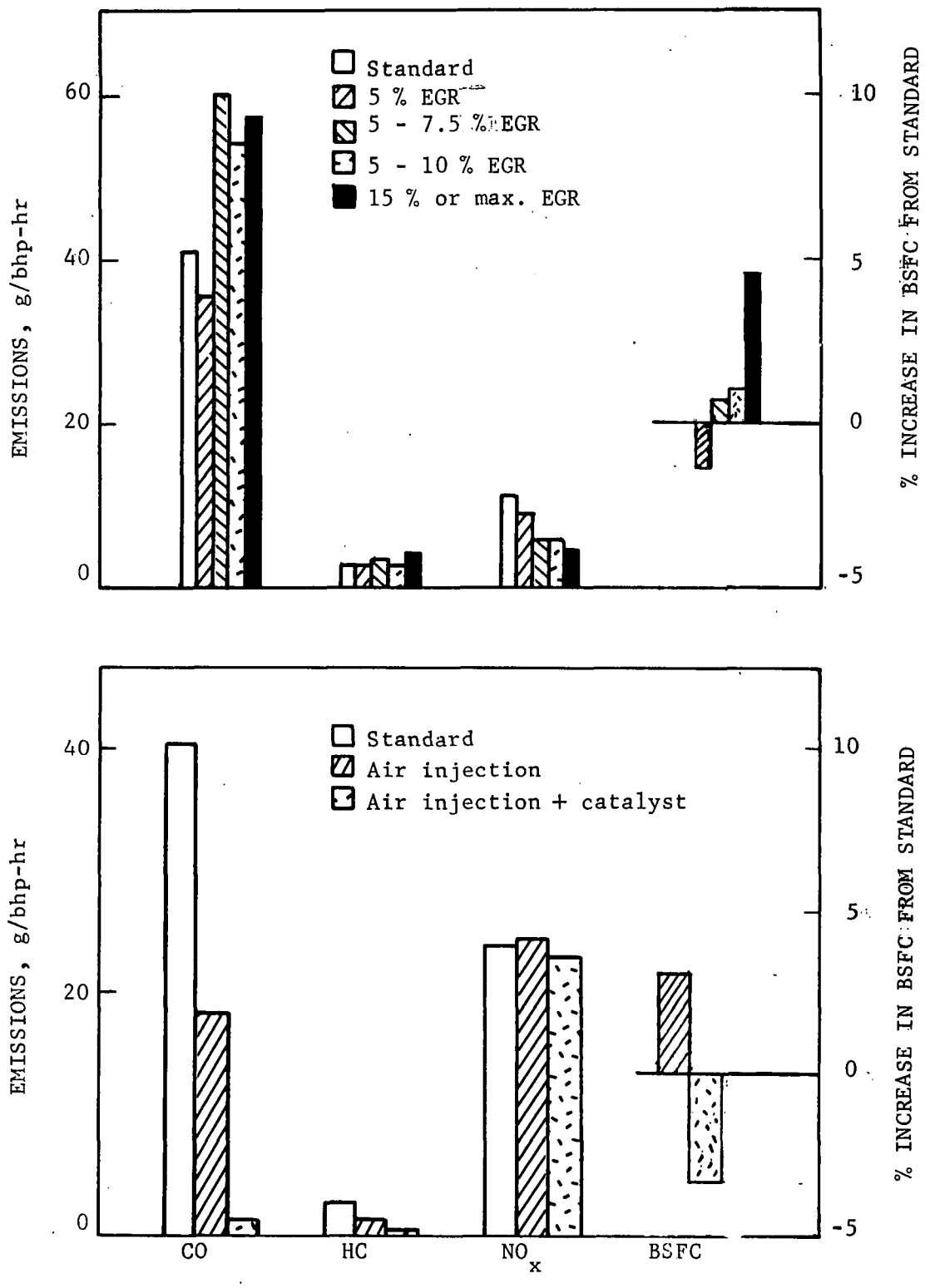


FIGURE 26. - The Effect of EGR and Catalysts on Emissions and Fuel Consumption (Engine No. 23, 23-Mode Procedure)

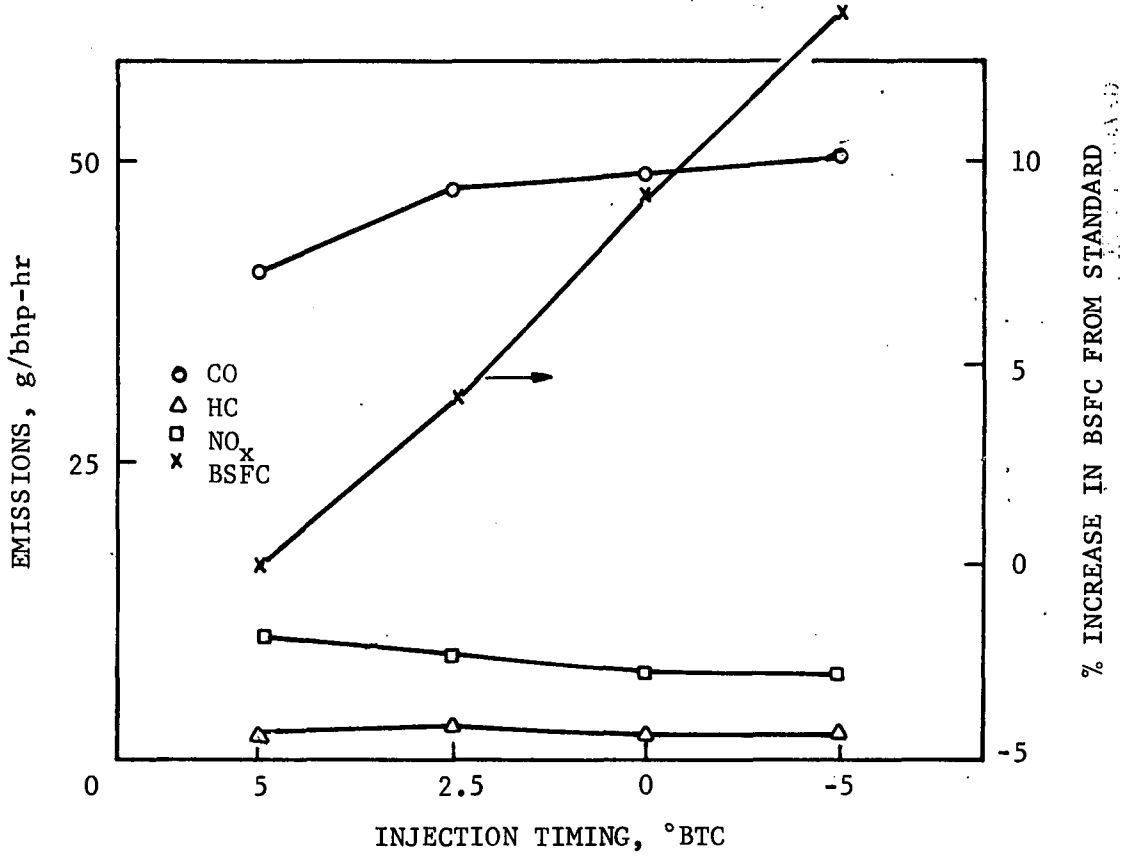


FIGURE 27. - The Effect of Basic Ignition Timing on Emissions and Fuel Consumption (Engine No. 23, 23-Mode Procedure)

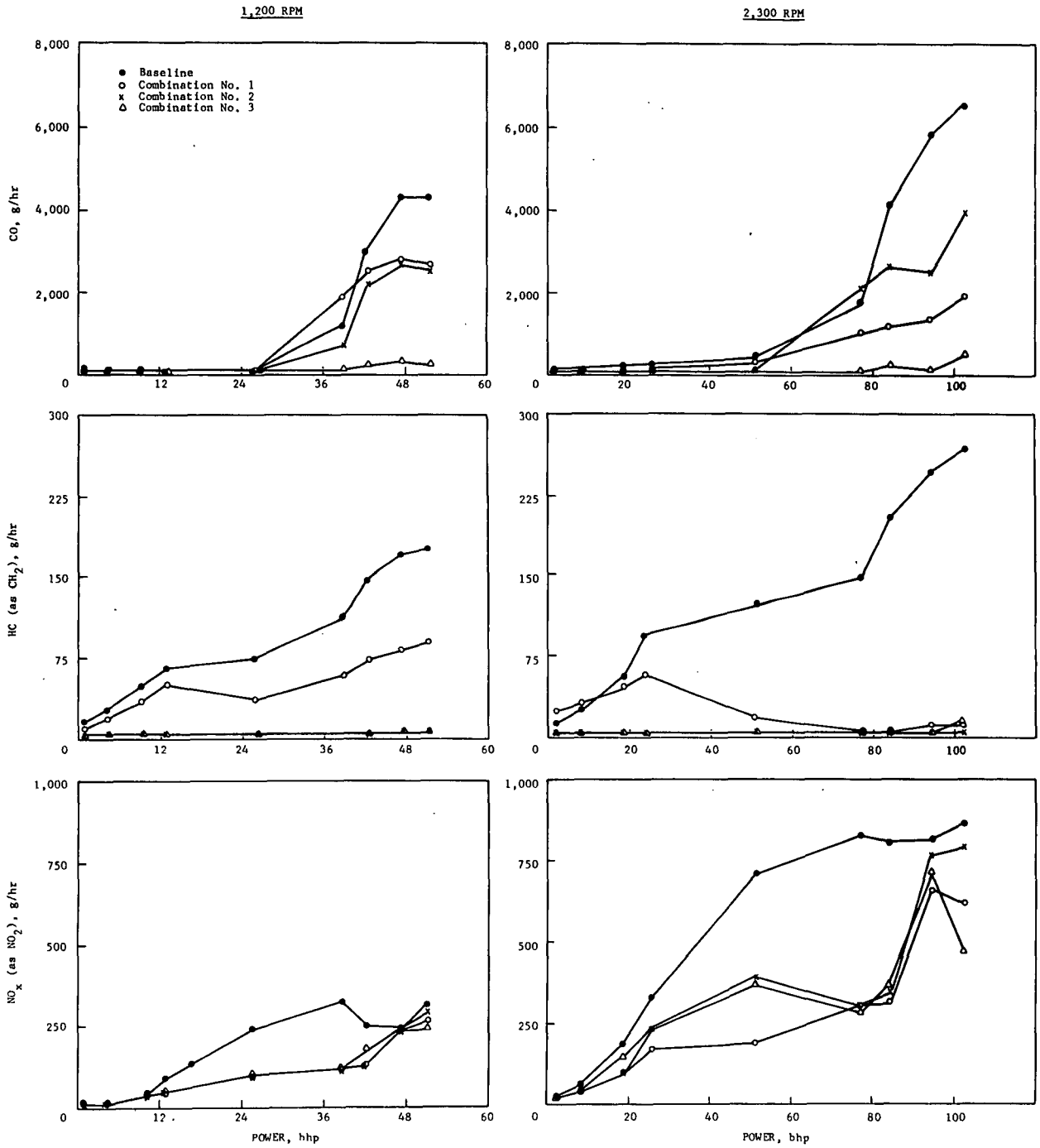


FIGURE 28. - Comparing Emissions from Baseline and Combinations of Parameter Tests for Engine No. 22 (Emissions as a Function of Power Output)

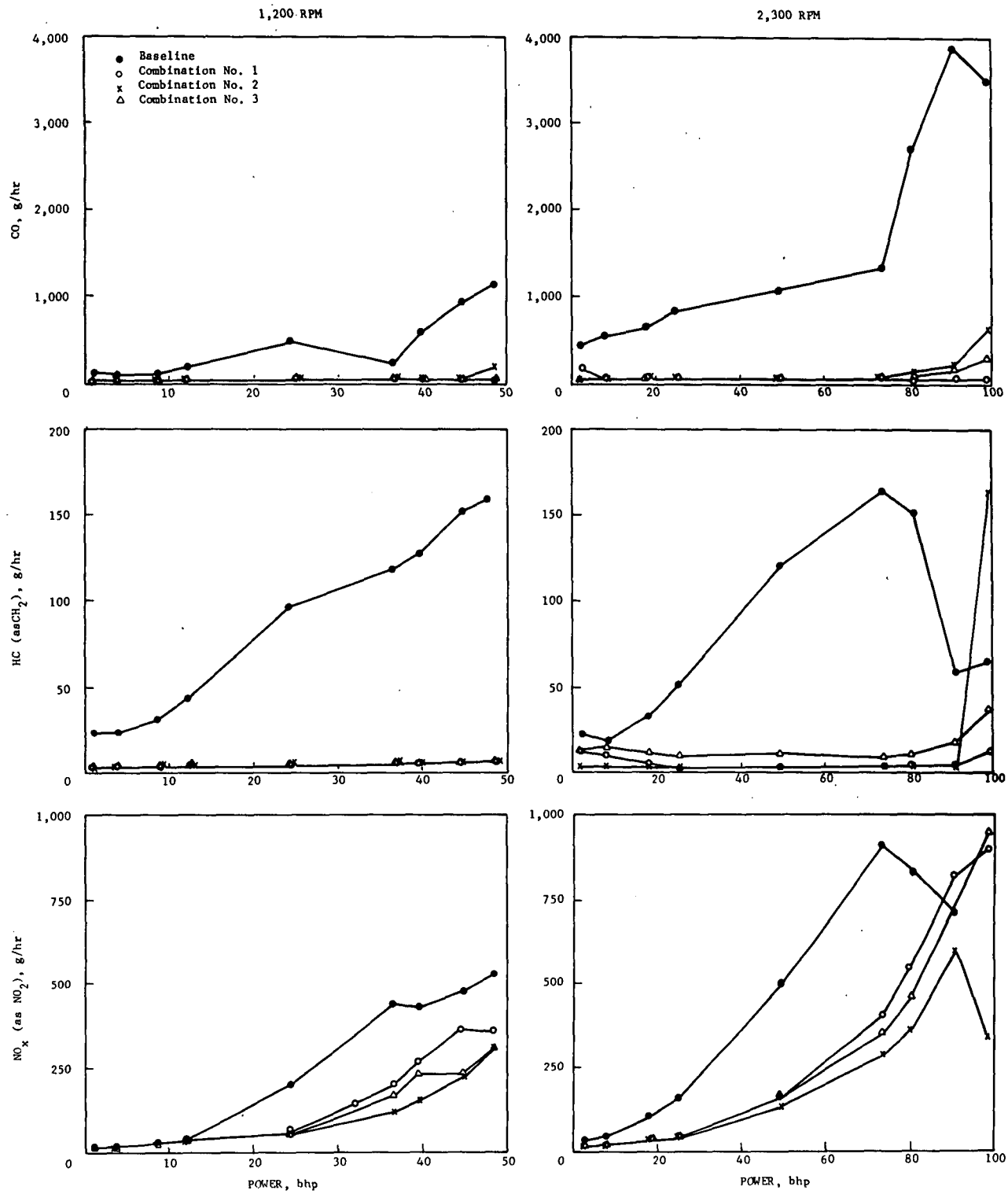


FIGURE 29. - Comparing Emissions from Baseline and Combinations of Parameter Tests for Engine No. 23 (Emissions as a Function of Power Output)

APPENDIX A. -- BASELINE DATA FOR HEAVY DUTY DIESEL ENGINES WITH PARAMETERS ADJUSTED TO MANUFACTURERS' SPECIFICATIONS (23-MODE CYCLE)

TABLE A-1 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 15.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	525	0.4	399	1.4	0.5	536	740	210	93.7	64.9	60.4
2	1700	2.8	1082	7.1	0.0	829	845	161	393.3	201.2	125.8
3	1700	12.3	1160	9.9	0.5	826	770	256	419.9	196.5	213.7
4	1700	28.2	1161	15.6	0.5	681	760	445	346.4	194.1	371.7
5	1700	38.5	1157	18.2	0.5	532	690	589	270.0	175.6	491.0
6	1700	77.0	1122	28.0	1.0	242	800	1025	119.0	197.5	828.0
7	1700	112.6	1123	39.3	1.5	181	820	1452	89.0	202.5	1173.5
8	1700	123.3	1121	45.1	1.5	202	650	1550	99.1	160.4	1251.5
9	1700	137.2	1125	50.5	4.5	509	740	1560	251.1	183.1	1263.9
10	1700	148.2	1122	54.6	15.0	1759	410	1465	865.4	101.2	1183.7
11	525	0.3	371	1.7	0.5	458	760	235	74.5	62.1	62.8
12*											
13	2800	209.0	1685	86.0	14.0	2187	140	1282	1615.2	51.9	1555.2
14	2800	194.1	1669	80.4	9.0	1582	280	1317	1157.3	102.8	1582.3
15	2800	173.3	1647	69.0	6.0	730	540	1249	527.1	195.7	1481.9
16	2800	157.3	1642	63.3	3.0	487	700	1168	350.8	252.8	1380.3
17	2800	101.8	1618	44.5	1.0	415	780	838	294.3	277.6	976.4
18	2800	53.3	1611	27.9	0.5	644	700	526	455.2	248.1	610.7
19	2800	38.4	1613	24.5	0.5	780	770	417	551.7	273.3	484.5
20	2800	15.5	1612	23.1	0.5	1146	1060	244	809.4	375.9	282.8
21	2800	2.1	1618	19.1	0.5	1220	1340	179	865.6	477.1	208.3
22	525	0.1	373	0.8	0.5	431	820	194	70.5	67.3	52.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.65 GM/BHP-HR
BSHC 2.54 GM/BHP-HR
BSNO2 9.74 GM/BHP-HR
BSFC 0.436 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 738.5 MMHG
HUMIDITY 45 GRAINS/LB
MAX. INLET RESTRICTION 25.0 "H20
MAX. EXHAUST BACK PRESSURE 37.4 "H20
INLET AIR TEMP. RANGE 67F - 84F
MAX. EXHAUST TEMP. 1300F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR AND NDUV.

TABLE A-2 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 15.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT CAPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.5	382	2.5	1.1	436	667	165	73.1	56.1	45.5
2	1700	2.9	1096	9.8	1.1	813	915	128	390.5	220.6	100.7
3	1700	12.3	1097	11.5	1.1	776	798	185	373.4	192.7	146.1
4	1700	27.5	1106	16.0	1.1	714	755	309	346.2	183.6	245.7
5	1700	58.3	1107	24.5	1.1	427	733	603	207.0	178.5	480.3
6	1700	76.4	1102	30.0	1.1	310	805	803	149.5	195.1	637.2
7	1700	114.6	1124	45.0	1.7	209	827	1157	102.9	204.4	936.3
8	1700	125.3	1127	48.0	2.2	229	813	1206	112.9	201.5	978.1
9	1700	140.8	1127	52.0	5.5	462	928	1236	228.0	230.1	1003.0
10	1700	152.1	1132	57.0	15.4	1265	580	1162	627.7	144.5	947.4
11	550	0.5	380	2.5	1.1	426	755	155	71.0	63.1	42.4
12*											
13	2800	210.6	1677	86.0	14.3	1964	261	1118	1443.8	96.3	1349.8
14	2800	193.5	1651	75.0	8.8	1150	493	1142	832.0	179.0	1357.6
15	2800	172.7	1638	67.5	6.6	611	682	1069	439.0	245.7	1260.1
16	2800	157.8	1633	62.5	5.5	470	856	1001	336.6	307.5	1177.0
17	2800	105.0	1622	46.0	2.8	426	915	722	302.5	326.4	843.1
18	2800	52.8	1612	31.0	2.2	728	850	413	514.5	301.4	479.7
19	2800	37.9	1614	28.0	2.5	881	973	298	623.1	345.5	346.0
20	2800	17.1	1567	23.5	2.2	1163	1335	181	799.2	460.3	204.6
21	2800	1.3	1568	19.5	1.3	1193	1700	119	820.2	586.5	133.8
22	550	0.0	380	2.5	1.6	436	944	134	72.6	78.9	36.6
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.10 GM/BHP-HR
BSHC 2.88 GM/BHP-HR
BSNO2 7.87 GM/BHP-HR
BSFC 0.446 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.0 MMHG
HUMIDITY 47 GRAINS/LB
MAX. INLET RESTRICTION 23.5 "H20
MAX. EXHAUST BACK PRESSURE 30.5 "H20
INLET AIR TEMP. RANGE 68F - 79F
MAX. EXHAUST TEMP. 1358F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-3 FINAL BASELINE TEST FOR ENGINE NO. 15.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.4	386	2.5	0.5	496	745	158	84.0	63.3	43.9
2	1700	2.9	1099	10.0	0.5	889	1045	123	428.5	252.7	97.2
3	1700	12.0	1105	12.0	0.5	868	950	184	420.6	230.9	146.4
4	1700	27.2	1109	16.0	0.5	781	875	303	379.8	213.5	241.9
5	1700	33.7	1106	17.0	1.6	669	800	378	324.6	194.7	301.1
6	1700	75.7	1119	30.0	2.0	293	828	758	143.7	203.9	611.0
7	1700	113.3	1128	42.0	2.2	183	875	1161	90.3	217.1	942.9
8	1700	122.4	1131	45.0	2.7	202	780	1239	100.0	194.0	1008.4
9	1700	137.6	1137	51.0	6.0	410	865	1179	204.0	216.3	964.5
10	1700	151.2	1143	57.0	15.4	1396	495	1097	699.3	124.4	902.5
11	550	0.4	386	2.5	1.0	496	742	160	84.0	63.0	44.5
12*											
13	2800	209.0	1697	85.5	13.0	1834	181	1073	1364.7	67.6	1311.7
14	2800	190.3	1693	75.5	7.0	1174	418	1098	871.1	155.7	1337.8
15	2800	169.5	1679	67.5	5.5	623	608	1008	458.6	224.6	1219.4
16	2800	156.7	1675	63.0	4.4	500	760	945	366.8	280.0	1140.1
17	2800	104.5	1654	47.0	2.2	481	856	665	348.7	311.4	791.8
18	2800	52.2	1643	31.5	2.0	900	913	361	648.6	330.1	426.6
19	2800	37.6	1640	28.5	2.0	1226	1093	265	881.6	394.4	313.5
20	2800	16.5	1636	24.0	2.0	1373	1590	170	984.4	572.2	200.1
21	2800	4.0	1628	21.0	2.0	1425	2015	119	1016.4	721.5	139.3
22	550	0.2	383	2.5	2.0	436	970	148	73.3	81.8	40.9
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.87 GM/BHP-HR
BSHC 3.05 GM/BHP-HR
BSNO2 7.76 GM/BHP-HR
BSFC 0.455 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.3 MMHG
HUMIDITY 75 GRAINS/LB
MAX. INLET RESTRICTION 26.0 "H2O
MAX. EXHAUST BACK PRESSURE 27.2 "H2O
INLET AIR TEMP. RANGE 66F - 71F
MAX. EXHAUST TEMP. 1376F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-4 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 16.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.2	440	1.9	1.0	589	315	43	113.6	30.5	13.7
2	1600	3.7	1208	10.3	2.5	324	115	75	171.8	30.6	65.6
3	1600	15.2	1210	12.1	2.5	260	85	114	137.7	22.6	99.5
4	1600	33.8	1162	18.1	2.0	145	70	244	74.0	17.9	204.2
5	1600	47.2	1166	21.6	1.5	119	67	328	61.0	17.2	275.4
6	1600	94.4	1297	36.5	1.5	70	58	495	39.6	16.5	462.6
7	1600	141.7	1452	52.6	1.0	56	42	499	35.9	13.4	522.2
8	1600	155.4	1554	58.2	1.0	55	40	516	37.7	13.7	577.0
9	1600	173.6	1727	66.2	1.5	55	35	548	41.8	13.3	680.8
10	1600	188.9	1829	73.9	2.0	64	30	573	51.4	12.1	754.2
11	550	0.2	384	1.5	1.0	516	890	73	86.8	75.2	20.3
12*											
13	2200	247.1	2574	98.7	2.0	50	38	663	56.1	21.5	1228.2
14	2200	227.5	2494	94.1	1.5	50	35	664	54.4	19.2	1191.5
15	2200	202.7	2327	82.9	1.5	50	32	601	51.0	16.4	1007.2
16	2200	185.1	2217	76.4	1.5	50	32	594	48.7	15.6	948.1
17	2200	123.6	1824	51.9	1.5	66	38	522	52.7	15.3	685.4
18	2200	62.0	1603	31.9	2.0	110	50	341	77.5	17.6	393.3
19	2200	44.4	1594	28.2	2.0	135	50	275	94.3	17.5	315.5
20	2200	19.7	1534	19.8	2.0	195	67	170	130.9	22.6	187.5
21	2200	5.0	1530	16.4	2.5	249	80	121	167.3	26.9	132.8
22	550	0.3	372	1.1	1.0	559	600	70	91.2	49.1	18.7
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.07 GM/BHP-HR
BSHC 0.36 GM/BHP-HR
BSNO2 5.26 GM/BHP-HR
BSFC 0.439 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.3 MMHG
HUMIDITY 53 GRAINS/LB
MAX. INLET RESTRICTION 29.0 "H2O
MAX. EXHAUST BACK PRESSURE 36.0 "H2O
INLET AIR TEMP. RANGE 64F - 78F
MAX. EXHAUST TEMP. 1090F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-5 INITIAL TEST NO. 2 FOR ENGINE NO. 16.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.1	377	1.2	1.0	591	330	45	97.7	27.4	12.2
2	1600	3.7	1130	9.4	2.0	315	110	80	155.9	27.4	65.0
3	1600	15.2	1129	12.0	1.0	246	78	125	121.6	19.4	101.4
4	1600	33.8	1135	17.6	1.0	149	63	245	74.2	15.7	200.3
5	1600	47.2	1137	20.2	0.5	123	65	344	61.5	16.3	281.7
6	1600	94.4	1253	34.3	0.5	77	54	521	42.5	14.9	470.3
7	1600	141.7	1432	51.5	1.0	65	41	502	40.7	12.9	518.1
8	1600	155.4	1537	55.8	1.5	60	35	524	40.5	11.8	579.7
9	1600	173.6	1643	62.6	2.0	60	32	548	43.1	11.6	648.1
10	1600	188.9	1695	67.8	2.5	83	25	554	61.3	9.3	676.2
11	550	0.1	372	1.2	1.0	528	280	69	86.1	22.9	18.6
12*											
13	2200	245.0	2548	97.8	2.0	55	34	666	61.7	19.1	1222.7
14	2200	227.5	2473	90.0	2.0	55	32	670	60.1	17.4	1192.2
15	2200	202.7	2263	78.7	2.0	56	31	600	55.2	15.4	978.1
16	2200	185.1	2153	71.9	2.0	56	31	563	52.7	14.7	872.3
17	2200	123.6	1810	49.8	2.0	74	40	521	58.4	15.9	679.2
18	2200	62.0	1591	31.1	2.0	123	50	331	85.7	17.5	379.1
19	2200	44.4	1596	25.7	2.5	153	55	251	106.9	19.3	288.6
20	2200	19.7	1533	19.6	3.0	218	70	152	146.6	23.6	167.5
21	2200	5.0	1529	15.6	3.0	273	93	106	183.1	31.3	117.1
22	550	0.1	371	1.0	1.0	592	580	64	96.2	47.3	17.1
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.06 GM/BHP-HR
BSHC 0.28 GM/BHP-HR
BSNO2 5.14 GM/BHP-HR
BSFC 0.418 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.0 MMHG
HUMIDITY 51 GRAINS/LB
MAX. INLET RESTRICTION 28.0 "H2O
MAX. EXHAUST BACK PRESSURE 36.0 "H2O
INLET AIR TEMP. RANGE 72F - 80F
MAX. EXHAUST TEMP. 1050F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-6 FINAL BASELINE TEST FOR ENGINE NO. 16.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW ** LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.1	359	2.8	1.1	638	356	80	100.5	28.1	20.7
2	1600	3.7	978	9.5	2.0	387	126	111	166.0	27.1	78.4
3	1600	14.6	981	12.2	2.2	263	77	166	113.2	16.6	116.9
4	1600	32.6	1034	17.8	2.2	145	75	302	65.6	17.1	225.1
5	1600	45.4	1037	20.8	2.2	110	72	432	50.1	16.4	322.2
6	1600	90.8	1101	34.5	3.0	92	71	599	44.2	17.2	474.4
7	1600	135.9	1264	51.0	3.8	87	67	501	48.2	18.6	456.5
8	1600	148.7	1320	57.0	4.0	100	51	512	57.9	14.8	486.6
9	1600	166.6	1422	62.5	5.5	163	39	518	101.8	12.2	530.3
10	1600	181.3	1525	70.8	6.8	264	30	533	176.2	10.1	585.4
11	550	0.1	352	2.5	2.2	542	325	74	83.7	25.2	18.8
12*											
13	2200	242.9	2191	98.5	3.3	100	40	714	95.7	19.3	1126.9
14	2200	224.1	2076	88.5	4.4	82	35	682	74.6	16.0	1019.0
15	2200	199.4	1913	79.0	4.4	70	33	629	59.0	13.9	866.0
16	2200	182.2	1801	71.5	4.4	72	32	597	56.5	12.7	774.5
17	2200	121.5	1538	49.0	4.4	80	42	532	54.2	14.2	589.4
18	2200	60.7	1372	30.5	4.8	138	55	374	83.3	16.6	369.5
19	2200	43.6	1323	26.0	5.5	173	59	281	100.2	17.2	267.2
20	2200	19.3	1320	19.5	5.0	240	67	154	138.7	19.5	146.4
21	2200	4.6	1320	15.5	4.6	303	77	100	175.2	22.4	95.1
22	550	0.1	358	2.5	2.2	606	505	60	95.1	39.8	15.6
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.11 GM/BHP-HR
BSHC 0.28 GM/BHP-HR
BSNO2 4.82 GM/BHP-HR
BSFC 0.432 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 739.0 MMHG
HUMIDITY 77 GRAINS/LB
MAX. INLET RESTRICTION 32.0 "H20
MAX. EXHAUST BACK PRESSURE 21.5 "H20
INLET AIR TEMP. RANGE 85F - 94F
MAX. EXHAUST TEMP. 1191F

* ENGINE NOT TESTED IN MOTORED MODES

** THE REDUCED EXHAUST FLOW FOR THIS TEST WAS DUE TO TURBOCHARGER FOULING CAUSED BY THE USE OF EGR IN PREVIOUS TESTS.

TABLE A-7 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 17.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	864	4.5	0.5	236	182	186	89.2	34.6	115.8
2	1250	0.2	2224	10.0	0.5	285	187	138	278.2	91.5	221.0
3	1220	13.9	2172	14.5	0.5	226	168	255	215.1	80.3	398.2
4	1280	32.7	2277	20.0	0.5	158	168	411	157.8	84.1	674.4
5	1260	43.2	2280	23.5	0.5	118	164	534	118.4	82.3	876.8
6	1250	85.7	2221	35.5	0.5	121	183	990	117.7	89.4	1582.5
7	1250	129.7	2232	53.0	0.5	102	150	1564	99.6	73.6	2513.4
8	1250	140.4	2230	58.0	1.0	281	171	1618	274.8	83.9	2597.8
9	1200	150.8	2131	63.5	1.5	2825	164	1417	2638.5	76.9	2173.9
10	1250	167.8	2183	74.0	2.0	6509	145	1132	6228.8	69.6	1779.7
11	500	0.0	896	3.5	1.0	249	136	186	97.8	26.8	119.7
12*											
13	2100	255.9	3783	110.0	1.5	1021	164	1384	1692.8	136.5	3768.5
14	2150	241.5	3863	105.0	1.0	500	159	1368	847.2	135.1	3803.3
15	2150	214.9	3841	95.0	0.5	204	159	1271	343.6	134.4	3515.9
16	2150	196.5	3905	87.0	0.5	119	150	1151	204.2	128.9	3236.3
17	2150	131.0	3869	63.0	0.5	61	150	753	103.3	127.7	2099.0
18	2150	65.5	3823	41.0	0.5	66	150	410	109.8	126.2	1127.9
19	2150	47.1	3830	36.5	0.5	75	159	344	125.2	134.0	948.5
20	2150	20.5	3823	29.5	0.5	96	168	254	161.7	141.3	699.6
21	2150	4.9	3831	24.5	0.5	119	187	197	200.6	157.6	543.7
22	500	0.0	858	4.0	0.5	218	173	201	82.0	32.7	124.0
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.20 GM/BHP-HR
BSHC 1.12 GM/BHP-HR
BSNO2 17.54 GM/BHP-HR
BSFC 0.492 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 739.5 MMHG
HUMIDITY 64 GRAINS/LB
MAX. INLET RESTRICTION 12.0 "H2O
MAX. EXHAUST BACK PRESSURE 61.0 "H2O
INLET AIR TEMP. RANGE 87F - 96F
MAX. EXHAUST TEMP. 830F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-8 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 17.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	837	4.0	0.5	258	268	172	94.8	49.3	103.7
2	1250	2.9	2221	10.5	0.5	306	261	153	298.0	127.6	244.0
3	1200	13.3	2165	12.5	0.5	254	240	241	241.1	114.3	375.1
4	1250	32.8	2208	18.5	0.5	204	225	420	196.9	109.3	667.7
5	1250	41.6	2225	21.0	0.5	119	225	517	115.7	110.1	827.4
6	1250	83.3	2282	34.5	0.5	52	225	934	52.3	112.9	1534.7
7	1225	122.5	2193	47.5	0.5	64	218	1472	61.6	105.2	2324.4
8	1250	140.4	2230	55.0	0.5	158	225	1613	154.1	110.4	2590.3
9	1250	153.7	2200	61.0	0.5	620	254	1640	597.4	122.9	2597.0
10	1250	172.5	2257	75.0	2.0	3986	170	1527	3943.8	84.4	2481.3
11	475	0.0	842	3.5	0.5	249	225	167	91.8	41.7	101.5
12*											
13	2100	271.9	3800	112.0	1.5	1247	233	1400	2077.5	194.8	3829.6
14	2125	252.9	3881	105.0	1.0	591	225	1361	1005.6	192.1	3801.4
15	2125	225.8	3870	94.0	1.0	200	211	1256	340.1	179.6	3498.4
16	2150	208.8	3890	89.0	1.0	150	219	1155	255.2	187.4	3235.9
17	2125	137.6	3889	64.0	0.5	73	205	744	125.2	175.4	2084.2
18	2125	68.8	3867	42.0	0.5	83	225	413	140.9	191.4	1150.0
19	2125	48.6	3874	36.5	0.5	87	240	341	148.3	204.6	951.6
20	2125	20.2	3879	28.5	0.5	119	254	240	202.7	216.8	669.8
21	2125	6.1	3837	24.0	0.5	128	261	186	215.9	220.3	514.9
22	475	0.0	834	4.0	0.5	222	268	192	81.1	49.2	115.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.37 GM/BHP-HR
BSHC 1.52 GM/BHP-HR
BSNO2 16.76 GM/BHP-HR
BSFC 0.470 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 740.9 MMHG
HUMIDITY 72 GRAINS/LB
MAX. INLET RESTRICTION 12.0 "H2O
MAX. EXHAUST BACK PRESSURE 61.0 "H2O
INLET AIR TEMP. RANGE 78F - 88F
MAX. EXHAUST TEMP. 833F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-9 FINAL BASELINE TEST NO. 1 FOR ENGINE NO. 17.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	797	3.4	0.5	299	403	147	104.6	70.7	84.4
2	1200	3.4	2089	11.0	0.5	303	360	136	277.2	165.4	205.2
3	1250	13.8	1936	12.5	0.5	291	342	204	247.1	145.6	284.5
4	1250	33.8	2046	20.0	0.5	237	318	397	212.8	143.2	585.3
5	1200	43.9	2042	22.0	0.5	193	305	526	172.5	137.0	773.6
6	1200	85.0	2002	34.0	0.5	82	305	948	72.0	134.4	1366.7
7	1200	128.6	2003	47.5	0.5	107	311	1590	93.6	137.0	2293.3
8	1250	146.4	2060	53.0	0.5	290	324	1731	261.7	146.8	2567.5
9	1200	157.2	1961	63.0	0.5	2015	330	1658	1732.2	142.4	2341.2
10	1200	166.8	1946	72.5	2.8	6643	269	1243	5667.6	115.2	1742.3
11	500	0.0	775	3.9	0.5	271	366	157	92.1	62.4	87.7
12*											
13	2100	269.9	3331	105.0	2.0	1077	318	1499	1572.5	233.0	3595.0
14	2100	248.3	3304	99.0	1.5	761	311	1504	1102.0	226.1	3578.8
15	2100	221.5	3272	87.0	1.0	292	293	1432	418.9	210.9	3372.8
16	2150	207.1	3481	88.0	1.0	178	287	1273	272.0	219.8	3189.4
17	2150	139.2	3447	65.0	0.5	142	287	854	215.0	217.6	2118.8
18	2150	69.6	3458	43.0	0.5	153	318	461	232.0	241.9	1148.3
19	2150	49.9	3453	38.0	0.5	154	330	380	232.3	250.7	944.5
20	2150	22.1	3456	30.0	0.5	176	348	272	266.4	264.6	676.7
21	2150	6.1	3453	27.0	0.5	176	360	210	266.6	273.4	521.4
22	500	0.0	822	3.5	0.5	268	385	168	96.5	69.7	99.4
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.61 GM/BHP-HR
BSHC 1.89 GM/BHP-HR
BSNO2 15.95 GM/BHP-HR
BSFC 0.458 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.6 MMHG
HUMIDITY 92 GRAINS/LB
MAX. INLET RESTRICTION 28.5 "H2O
MAX. EXHAUST BACK PRESSURE 49.9 "H2O
INLET AIR TEMP. RANGE 77F - 92F
MAX. EXHAUST TEMP. 850F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-10 FINAL BASELINE TEST NO. 2 FOR ENGINE NO. 17.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	770	3.9	0.5	294	445	152	99.2	75.3	84.4
2	1250	2.1	1984	10.0	0.5	340	412	132	295.3	179.9	189.0
3	1250	14.5	2045	14.0	0.5	311	380	216	278.5	171.0	317.5
4	1150	28.5	1841	17.0	0.5	242	387	377	195.6	156.7	499.0
5	1250	44.0	2004	23.0	0.5	189	374	504	165.6	164.9	727.5
6	1200	84.5	1952	34.2	0.5	99	361	947	85.0	155.0	1331.0
7	1200	126.8	1967	49.0	0.5	123	361	1523	106.4	156.2	2156.3
8	1200	138.7	1914	52.0	1.0	307	380	1658	257.4	160.0	2285.2
9	1200	155.8	1931	63.0	1.5	1792	387	1577	1517.0	164.4	2191.8
10	1200	165.6	1915	71.0	4.0	6830	348	1177	5733.5	146.6	1623.3
11	500	0.0	767	3.5	0.5	299	425	160	100.6	71.7	88.6
12*											
13	2100	267.9	3299	104.0	1.5	996	400	1495	1439.7	290.3	3551.8
14	2150	251.8	3444	105.0	1.5	465	412	1466	701.7	312.2	3634.3
15	2150	225.1	3444	94.0	1.0	199	380	1381	300.6	287.9	3423.3
16	2150	205.9	3437	87.0	0.5	195	361	1248	294.2	272.9	3087.2
17	2150	137.1	3414	64.0	0.5	138	348	813	205.8	261.3	1998.2
18	2150	69.6	3404	44.0	0.5	162	348	449	241.2	260.6	1099.4
19	2150	49.5	3443	39.0	0.5	166	361	376	250.7	273.4	931.7
20	2150	22.1	3413	31.0	0.5	189	387	276	283.4	290.6	678.9
21	2150	5.3	3418	25.0	0.5	190	400	198	284.9	300.8	488.4
22	500	0.0	812	3.4	0.5	272	438	163	96.7	78.2	95.1
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.27 GM/BHP-HR
BSHC 2.26 GM/BHP-HR
BSNO2 15.65 GM/BHP-HR
BSFC 0.468 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.6 MMHG
HUMIDITY 80 GRAINS/LB
MAX. INLET RESTRICTION 29.0 "H2O
MAX. EXHAUST BACK PRESSURE 52.6 "H2O
INLET AIR TEMP. RANGE 87F - 96F
MAX. EXHAUST TEMP. 871F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-11 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 18.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	431	3.0	1.0	1113	1185	166	210.2	112.3	51.4
2	1260	4.1	908	7.8	1.0	879	990	260	349.5	197.7	169.9
3	1260	16.8	905	11.2	1.5	646	890	481	256.5	177.2	313.5
4	1260	37.7	957	17.5	2.0	333	850	950	139.8	179.0	654.9
5	1260	52.3	961	21.0	2.0	203	835	1354	85.7	176.5	936.7
6	1260	104.6	1077	36.6	2.2	239	870	2269	112.7	206.1	1758.7
7	1260	156.9	1250	55.3	4.5	1332	548	3001	729.7	150.7	2700.1
8	1260	170.3	1353	60.0	4.5	1549	440	2976	918.5	131.0	2899.5
9	1260	190.7	1460	69.0	7.5	2256	285	2813	1443.6	91.5	2957.5
10	1260	211.1	1621	77.0	9.5	2553	220	2646	1814.4	78.5	3088.9
11	600	0.0	422	3.0	2.0	881	1020	197	163.1	94.8	59.8
12*											
13	2100	226.7	2452	89.0	3.5	741	410	1602	796.1	221.2	2827.9
14	2100	208.7	2446	82.5	3.5	531	475	1426	569.4	255.6	2510.5
15	2100	185.9	2302	74.0	3.3	386	580	1299	389.1	293.7	2152.3
16	2100	169.9	2246	68.0	3.3	283	660	1181	278.7	326.1	1909.8
17	2100	113.6	1977	50.0	3.3	244	750	722	211.1	326.2	1027.0
18	2100	56.8	1929	46.0	3.3	244	785	632	206.6	333.1	877.6
19	2100	47.2	1716	30.0	2.8	248	925	417	186.5	349.3	515.4
20	2100	18.0	1610	20.0	1.0	316	1050	297	222.9	371.9	344.0
21	2100	4.4	1552	17.5	0.5	360	1200	226	244.6	409.7	252.1
22	600	0.0	418	3.0	0.5	926	1095	197	169.8	100.8	59.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.83 GM/BHP-HR
BSHC 2.74 GM/BHP-HR
BSNO2 13.29 GM/BHP-HR
BSFC 0.427 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 737.0 MMHG
HUMIDITY 94 GRAINS/LB
MAX. INLET RESTRICTION 11.0 "H2O
MAX. EXHAUST BACK PRESSURE 17.0 "H2O
INLET AIR TEMP. RANGE 72F - 86F
MAX. EXHAUST TEMP. 1190F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-12 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 18.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	432	3.0	0.5	1066	1200	163	201.8	114.0	50.8
2	1260	4.3	910	8.0	0.5	787	1035	282	314.0	207.3	185.0
3	1260	16.8	960	11.5	0.5	557	845	494	234.5	178.5	341.7
4	1260	37.7	966	17.0	0.5	312	805	963	132.2	171.0	669.4
5	1260	52.3	969	20.7	0.5	225	805	1295	95.5	171.7	903.9
6	1260	104.6	1087	37.0	1.0	218	870	2182	104.1	208.0	1707.4
7	1260	156.9	1310	56.0	2.0	814	710	2927	467.3	204.6	2760.2
8	1260	170.3	1313	59.0	3.0	1348	650	2956	775.5	187.7	2793.7
9	1260	190.7	1416	68.0	6.0	1845	540	2803	1145.3	168.2	2857.9
10	1260	210.4	1577	75.0	8.5	2276	490	2762	1574.0	170.0	3136.9
11	600	0.0	427	2.6	1.5	975	1360	178	182.6	127.8	54.8
12*											
13	2100	230.3	2507	90.0	3.5	698	435	1600	766.7	239.9	2888.1
14	2100	211.9	2426	83.0	3.5	573	475	1426	609.5	253.5	2489.6
15	2100	188.7	2307	73.0	4.0	408	550	1297	412.2	279.2	2155.4
16	2100	172.7	2251	66.5	4.0	325	595	1212	320.5	294.6	1964.1
17	2100	115.2	1988	50.0	4.8	265	685	730	230.6	299.7	1044.9
18	2100	57.6	1770	33.4	4.4	290	805	468	225.2	313.4	596.7
19	2100	41.6	1720	28.5	4.0	292	885	395	219.9	334.8	489.4
20	2100	18.4	1616	21.1	3.5	315	935	299	223.4	332.3	347.5
21	2100	4.8	1566	17.7	3.0	360	1030	228	246.9	354.9	257.6
22	600	0.0	422	2.7	2.0	952	1015	175	176.0	94.2	53.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.80 GM/BHP-HR
BSHC 2.73 GM/BHP-HR
BSNO2 13.19 GM/BHP-HR
BSFC 0.421 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.5 MMHG
HUMIDITY 64 GRAINS/LB
MAX. INLET RESTRICTION 11.0 "H20
MAX. EXHAUST BACK PRESSURE 17.0 "H20
INLET AIR TEMP. RANGE 73F - 85F
MAX. EXHAUST TEMP. 1165F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-13 INITIAL BASELINE TEST NO. 3 FOR ENGINE NO. 18.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	421	2.5	0.5	906	1050	188	167.3	97.3	57.0
2	1260	4.3	944	7.8	0.5	696	975	285	287.9	202.4	193.4
3	1260	13.0	943	10.2	0.5	559	860	420	230.8	178.4	285.2
4	1260	34.1	948	15.7	0.5	334	740	849	139.0	154.4	579.6
5	1260	52.8	999	21.0	0.5	204	715	1312	89.2	157.1	943.2
6	1260	105.3	1072	37.0	0.5	280	760	2241	131.8	179.3	1729.9
7	1260	158.3	1295	55.0	2.0	899	510	2903	510.8	145.4	2707.5
8	1260	172.7	1344	60.5	3.0	1502	400	2907	884.5	118.3	2812.3
9	1260	193.8	1450	69.2	6.0	2162	255	2822	1374.0	81.3	2946.1
10	1260	210.6	1552	75.4	9.0	2616	162	2708	1779.9	55.3	3027.3
11	600	0.0	416	2.7	1.0	859	910	200	156.6	83.3	59.9
12*											
13	2100	231.1	2496	88.7	2.0	721	360	1515	788.4	197.7	2723.2
14	2100	212.7	2409	83.0	1.5	594	400	1407	627.6	212.0	2440.7
15	2100	189.5	2301	75.0	1.5	407	475	1278	410.1	240.4	2117.3
16	2100	173.5	2246	70.0	1.5	303	530	1192	298.4	261.8	1927.3
17	2100	115.6	2025	50.0	1.5	244	600	724	216.6	267.3	1055.4
18	2100	58.0	1757	33.0	1.0	268	745	464	206.6	287.9	587.0
19	2100	41.6	1651	27.5	0.5	270	770	392	195.0	279.6	465.5
20	2100	24.8	1607	23.4	0.5	293	850	300	206.4	300.4	346.7
21	2100	4.8	1550	17.0	0.5	360	955	222	244.4	325.6	247.4
22	600	0.0	416	2.6	0.5	814	855	200	148.4	78.3	60.0
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.74 GM/BHP-HR
BSHC 2.34 GM/BHP-HR
BSNO2 12.58 GM/BHP-HR
BSFC 0.423 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.0 MMHG
HUMIDITY 61 GRAINS/LB
MAX. INLET RESTRICTION 11.5 "H2O
MAX. EXHAUST BACK PRESSURE 17.0 "H2O
INLET AIR TEMP. RANGE 80F - 86F
MAX. EXHAUST TEMP. 1190F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-14 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 19.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	347	3.2	1.0	434	501	190	65.9	38.2	47.3
2	2200	2.9	1212	13.0	1.0	698	925	81	370.4	246.6	70.6
3	2200	11.3	1214	15.0	1.0	600	680	132	319.0	181.6	115.7
4	2200	25.1	1217	18.5	1.5	345	398	290	184.1	106.6	254.1
5	2200	35.2	1221	22.0	1.5	356	863	394	190.7	231.7	345.8
6	2200	70.4	1230	31.5	1.7	882	1285	546	475.6	347.7	483.5
7	2200	105.1	1240	41.5	2.5	529	627	892	287.4	171.1	796.3
8	2200	115.2	1218	45.0	3.3	413	556	1073	220.3	149.0	940.6
9	2200	129.0	1224	51.0	6.0	532	588	1269	285.5	158.3	1118.3
10	2200	140.3	1201	54.5	10.0	882	596	1373	464.7	157.5	1187.8
11	600	0.5	346	3.2	1.5	448	501	198	68.0	38.1	49.2
12*											
13	3000	174.2	1596	72.0	7.7	547	413	1033	382.6	145.0	1186.9
14	3000	160.5	1590	66.0	6.6	413	505	926	287.7	176.6	1059.6
15	3000	157.1	1589	65.0	6.0	409	516	910	284.8	180.4	1041.5
16	3000	130.8	1575	56.5	4.5	502	620	673	346.4	214.9	763.2
17	3000	87.4	1563	44.5	3.3	1197	1470	390	820.0	505.6	438.5
18	3000	43.4	1555	36.0	3.5	870	4198	291	592.8	1436.1	325.9
19	3000	30.8	1526	32.5	3.3	538	3810	273	360.2	1279.0	300.0
20	3000	13.7	1522	24.0	3.0	372	596	154	248.0	199.6	168.9
21	3000	3.4	1520	22.0	2.7	556	800	105	370.6	267.6	115.0
22	600	0.2	346	3.2	1.5	439	604	193	66.5	45.9	47.9
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.17 GM/BHP-HR
BSHC 4.79 GM/BHP-HR
BSNO2 7.14 GM/BHP-HR
BSFC 0.513 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 737.1 MMHG
HUMIDITY 98 GRAINS/LB
MAX. INLET RESTRICTION 14.5 "H20
MAX. EXHAUST BACK PRESSURE 31.9 "H20
INLET AIR TEMP. RANGE 76F - 80F
MAX. EXHAUST TEMP. 1137F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-15 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 19.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	346	3.2	1.0	444	548	206	67.2	41.7	51.2
2	2200	2.9	1208	13.0	1.0	697	927	94	369.3	246.3	81.9
3	2200	11.3	1209	14.5	1.0	621	653	156	329.0	173.7	135.4
4	2200	25.1	1213	18.5	1.5	359	411	292	190.7	109.7	255.4
5	2200	35.2	1216	21.5	1.5	365	935	402	194.8	250.2	352.3
6	2200	70.4	1226	31.0	1.5	888	1330	553	477.3	358.7	488.0
7	2200	105.1	1236	41.5	2.7	543	588	876	294.0	159.9	779.9
8	2200	115.2	1210	44.5	2.7	404	495	1013	214.0	131.7	882.3
9	2200	129.0	1214	49.0	4.9	492	548	1210	261.8	146.4	1058.1
10	2200	140.3	1195	55.0	9.0	1020	552	1281	534.1	145.1	1101.7
11	600	0.5	346	3.2	1.0	457	524	188	69.3	39.9	46.8
12*											
13	3000	173.6	1591	71.5	7.1	538	532	1018	375.2	186.2	1165.6
14	3000	160.5	1581	66.5	5.5	430	475	883	297.7	165.2	1005.3
15	3000	142.8	1574	59.5	3.5	434	556	739	299.4	192.5	837.8
16	3000	130.8	1570	56.0	3.3	511	637	644	351.8	220.0	728.1
17	3000	87.4	1559	44.5	2.7	1401	1482	363	956.9	508.2	406.9
18	3000	43.4	1551	36.5	2.2	1052	4415	285	714.9	1506.2	318.4
19	3000	30.8	1521	32.0	2.0	573	4190	266	382.1	1401.8	291.5
20	3000	13.7	1512	23.5	1.5	428	612	153	283.7	203.6	167.0
21	3000	3.4	1511	22.0	1.1	576	870	114	381.7	289.2	124.2
22	600	0.2	347	3.2	1.0	482	660	189	73.3	50.4	47.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.50 GM/BHP-HR
BSHC 5.07 GM/BHP-HR
BSNO2 6.89 GM/BHP-HR
BSFC 0.512 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 737.2 MMHG
HUMIDITY 101 GRAINS/LB
MAX. INLET RESTRICTION 15.0 "H20
MAX. EXHAUST BACK PRESSURE 31.9 "H20
INLET AIR TEMP. RANGE 76F - 81F
MAX. EXHAUST TEMP. 1136F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-16 FINAL BASELINE TEST FOR ENGINE NO. 19.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	370	2.5	1.1	560	489	196	90.9	39.8	52.2
2	2200	2.5	1178	12.0	1.1	640	580	113	330.2	150.3	96.2
3	2200	10.9	1176	14.0	1.1	569	484	171	293.3	125.2	144.5
4	2200	24.3	1180	18.0	1.1	304	316	504	157.4	82.0	428.0
5	2200	33.9	1158	21.5	1.6	316	892	537	160.2	227.3	447.4
6	2200	67.9	1168	31.0	2.2	1112	1189	572	569.0	305.4	480.8
7	2200	101.4	1177	40.0	3.3	701	594	923	361.5	153.8	781.5
8	2200	111.0	1180	43.0	4.4	613	508	1048	316.9	131.8	890.4
9	2200	124.4	1159	48.0	8.8	1031	594	1187	524.0	151.5	990.8
10	2200	137.0	1165	54.0	15.4	1741	633	1333	888.8	162.2	1118.3
11	600	0.5	370	2.5	1.1	460	446	200	74.6	36.3	53.4
12*											
13	3000	171.4	1532	72.0	8.8	752	240	1086	504.6	80.9	1197.7
14	3000	157.7	1498	63.5	4.9	342	336	1012	224.4	110.7	1091.5
15	3000	140.5	1487	58.0	3.3	375	403	825	244.4	131.9	883.6
16	3000	128.5	1489	55.0	3.3	435	460	733	283.9	150.7	786.0
17	3000	85.7	1504	44.0	2.8	1239	1131	435	816.9	374.1	471.1
18	3000	42.8	1467	33.0	2.8	680	2378	347	437.4	767.5	366.7
19	3000	30.8	1464	29.5	2.2	396	1947	322	254.1	626.9	339.0
20	3000	13.7	1432	23.5	1.0	326	387	196	204.5	121.9	201.6
21	3000	3.4	1429	20.0	1.1	420	512	131	262.9	160.9	134.6
22	600	0.3	370	2.5	1.1	504	483	184	81.8	39.3	49.1
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.21 GM/BHP-HR
BSHC 3.26 GM/BHP-HR
BSNO2 7.74 GM/BHP-HR
BSFC C.505 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.5 MMHG
HUMIDITY 52 GRAINS/LB
MAX. INLET RESTRICTION 16.0 "H20
MAX. EXHAUST BACK PRESSURE 31.9 "H20
INLET AIR TEMP. RANGE 80F - 85F
MAX. EXHAUST TEMP. 1146F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-17 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 20.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	524	3.0	0.6	1357	1303	134	311.9	150.3	50.6
2	1400	5.3	1357	13.1	0.2	676	1134	337	401.9	338.6	329.3
3	1400	21.3	1356	16.5	0.5	546	971	517	324.7	289.7	505.0
4	1400	48.0	1410	24.3	0.6	354	821	858	218.9	254.8	870.9
5	1400	66.4	1468	30.5	0.5	280	782	1058	179.9	252.5	1117.7
6	1400	132.7	1643	53.5	2.3	260	808	1603	187.4	292.1	1896.1
7	1400	198.9	1868	75.2	3.3	467	697	2249	382.6	286.4	3024.8
8	1400	217.5	1926	82.4	5.0	741	619	2289	625.7	262.3	3174.3
9	1400	243.9	2082	93.0	7.4	1367	280	2314	1247.7	128.3	3469.9
10	1400	266.6	2288	104.0	8.8	1676	239	2381	1680.8	120.3	3923.2
11	600	0.0	517	2.8	0.6	1204	1088	146	273.0	123.8	54.3
12*											
13	2400	287.9	4166	137.0	2.5	503	358	1453	919.0	328.1	4359.1
14	2400	265.0	3913	121.4	2.6	334	580	1322	573.1	499.3	3723.4
15	2400	236.2	3753	112.0	2.4	253	678	1175	416.8	559.8	3175.1
16	2400	216.1	3634	104.8	2.7	224	717	1062	356.6	573.2	2779.4
17	2400	143.9	3048	78.4	6.1	260	808	637	346.7	541.8	1398.2
18	2400	72.2	2447	50.4	5.0	302	984	442	323.7	529.8	779.1
19	2400	51.6	2343	45.0	5.5	316	1075	377	324.7	554.1	636.7
20	2400	22.8	2152	36.0	3.3	328	1219	294	314.9	587.9	464.5
21	2400	5.9	2138	31.6	1.6	342	1325	252	320.9	623.3	388.6
22	600	0.0	513	3.0	0.6	1138	1173	175	255.8	132.3	64.5
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.73 GM/BHP-HR
BSHC 3.53 GM/BHP-HR
BSNO2 14.13 GM/BHP-HR
BSFC 0.502 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.0 MMHG
HUMIDITY 68 GRAINS/LB
MAX. INLET RESTRICTION 20.0 "H20
MAX. EXHAUST BACK PRESSURE 16.0 "H20
INLET AIR TEMP. RANGE 82F - 91F
MAX. EXHAUST TEMP. 1040F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-18 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 20.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.7	529	3.0	0.5	1603	1445	106	371.6	168.2	40.3
2	1400	5.6	1316	11.9	0.5	890	1140	311	513.8	330.1	294.4
3	1400	21.9	1321	16.5	0.5	676	880	498	391.7	255.7	473.8
4	1400	49.3	1385	24.9	0.5	449	712	863	272.6	217.0	860.8
5	1400	68.8	1386	29.5	0.7	364	651	1141	221.3	198.4	1138.0
6	1400	137.3	1616	53.5	3.3	346	702	1705	244.8	249.6	1984.1
7	1400	206.1	1950	78.0	4.0	441	621	2410	376.9	266.5	3383.7
8	1400	225.2	1956	83.2	5.5	873	421	2439	748.2	181.1	3434.6
9	1400	252.7	2010	92.5	7.5	1653	280	2419	1456.0	123.8	3501.0
10	1400	274.6	2173	101.5	8.5	2076	187	2459	1977.9	89.4	3847.4
11	600	0.7	527	3.0	0.6	1491	1119	125	344.5	129.8	47.5
12*											
13	2400	292.5	4284	138.7	3.0	532	305	1522	998.7	287.5	4693.4
14	2400	268.7	4201	134.0	4.0	528	310	1410	971.9	286.5	4263.8
15	2400	239.4	3954	116.6	3.5	309	407	1269	535.5	354.0	3612.9
16	2400	219.3	3843	109.2	3.5	263	445	1100	442.5	376.3	3043.9
17	2400	146.2	3355	84.0	6.6	290	539	682	426.9	397.9	1646.6
18	2400	73.1	2707	53.5	5.5	323	611	453	383.7	363.8	883.0
19	2400	52.6	2546	47.5	6.0	343	661	375	383.2	370.2	686.7
20	2400	23.3	2383	39.1	4.0	345	748	296	360.4	392.1	508.5
21	2400	5.9	2275	35.0	1.8	351	748	259	349.7	374.4	424.9
22	600	0.7	527	3.0	0.5	1313	1608	144	303.4	186.5	54.8
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 4.63 GM/BHP-HR
BSHC 2.72 GM/BHP-HR
BSNO2 15.05 GM/BHP-HR
BSFC 0.512 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.4 MMHG
HUMIDITY 64 GRAINS/LB
MAX. INLET RESTRICTION 20.5 "H20
MAX. EXHAUST BACK PRESSURE 17.0 "H20
INLET AIR TEMP. RANGE 78F - 80F
MAX. EXHAUST TEMP. 1084F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-19 FINAL BASELINE TEST FOR ENGINE NO. 20.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	525	3.2	0.5	1760	1436	86	405.4	166.0	32.4
2	1400	5.3	1364	13.5	0.5	765	1055	339	457.8	316.7	333.4
3	1400	21.3	1368	17.5	0.5	595	895	553	357.0	269.4	544.7
4	1400	49.3	1372	25.0	1.1	376	746	996	225.8	225.1	983.3
5	1400	68.0	1429	31.5	1.1	284	712	1236	177.7	223.9	1271.5
6	1400	135.9	1711	57.0	2.2	251	729	1814	188.6	274.5	2234.7
7	1400	203.9	1893	79.5	3.0	534	646	2528	442.9	269.1	3445.6
8	1400	222.6	1996	86.0	4.4	930	563	2626	813.8	247.3	3774.5
9	1400	250.6	2109	96.0	6.5	1655	271	2654	1529.3	125.7	4029.4
10	1400	269.2	2169	105.0	8.2	2068	221	2592	1965.7	105.4	4047.8
11	600	0.0	526	3.3	0.5	1782	1282	92	410.6	148.2	34.9
12*											
13	2400	301.6	4063	138.0	3.3	507	326	1699	902.3	291.4	4970.4
14	2400	276.5	3847	125.0	4.4	382	414	1570	643.4	350.4	4349.9
15	2400	246.8	3710	116.0	4.4	317	497	1404	515.7	405.6	3749.7
16	2400	226.2	3484	105.0	4.4	245	574	1286	373.8	440.0	3225.1
17	2400	150.8	2992	79.0	7.7	268	652	819	351.0	429.1	1763.7
18	2400	75.4	2570	54.5	7.0	315	740	552	354.6	418.4	1021.7
19	2400	49.8	2418	47.5	8.0	339	817	443	359.1	434.6	771.6
20	2400	24.2	2238	35.5	3.3	350	922	377	343.7	454.0	607.6
21	2400	5.9	2140	32.0	2.5	378	1011	311	354.7	476.0	478.6
22	600	0.0	526	3.3	0.5	1691	1149	100	389.6	132.9	37.7
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 4.23 GM/BHP-HR
BSHC 2.90 GM/BHP-HR
BSNO2 15.88 GM/BHP-HR
BSFC 0.499 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.0 MMHG
HUMIDITY 59 GRAINS/LB
MAX. INLET RESTRICTION 19.5 "H2O
MAX. EXHAUST BACK PRESSURE 22.0 "H2O
INLET AIR TEMP. RANGE 79F - 83F
MAX. EXHAUST TEMP. 1095F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-20 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 21.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.1	643	3.5	1.0	132	189	98	37.1	26.7	45.5
2	1500	4.0	1419	9.0	1.0	148	196	115	92.1	61.2	117.6
3	1500	15.7	1418	12.5	2.0	156	130	154	97.0	40.5	157.0
4	1450	34.0	1470	18.5	2.0	150	106	242	96.7	34.9	256.3
5	1550	51.4	1477	25.5	2.5	161	123	321	104.4	40.0	341.5
6	1600	105.4	1523	39.0	5.0	175	101	635	117.0	33.8	695.7
7	1450	134.2	1384	48.5	4.5	236	67	1150	143.5	26.5	1146.4
8	1600	172.7	1498	65.0	5.5	669	105	1326	439.5	34.6	1430.3
9	1450	173.7	1348	67.0	6.0	1660	53	1606	980.8	15.7	1558.1
10	1450	187.7	1408	76.0	10.0	2948	38	1780	1819.0	11.8	1803.9
11	700	0.5	687	3.5	1.0	125	152	98	37.5	23.0	48.6
12*											
13	2100	238.3	1981	104.0	19.8	1474	76	1138	1280.1	33.1	1623.4
14	2100	219.1	1915	88.0	12.0	1322	54	1020	1109.5	22.7	1406.2
15	2100	195.5	1897	76.0	9.0	523	94	873	435.1	39.2	1192.5
16	2100	178.7	1896	75.0	8.5	423	105	783	351.5	43.8	1068.9
17	2100	119.2	1916	51.0	6.5	216	98	460	181.0	41.3	633.9
18	2100	59.6	1955	34.0	5.0	204	105	260	174.4	45.2	366.7
19	2100	42.8	1949	28.0	4.5	187	108	210	160.1	46.3	294.3
20	2100	19.2	1924	15.5	2.5	182	134	149	153.5	56.7	206.1
21	2100	4.8	1983	18.0	2.0	224	217	122	194.5	94.7	174.1
22	700	0.4	682	3.5	1.0	106	173	86	31.7	26.0	42.0
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.20 GM/BHP-HR
BSHC 0.47 GM/BHP-HR
BSNO2 6.79 GM/BHP-HR
BSFC 0.445 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.4 MMHG
HUMIDITY 105 GRAINS/LB
MAX. INLET RESTRICTION 25.0 "H2O
MAX. EXHAUST BACK PRESSURE 41.0 "H2O
INLET AIR TEMP. RANGE 75F - 90F
MAX. EXHAUST TEMP. 1353F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-21 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 21.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.4	693	3.5	1.0	119	196	95	36.1	29.9	47.6
2	1550	4.1	1519	12.0	2.0	182	221	113	121.2	73.9	123.2
3	1550	17.1	1522	15.0	2.0	169	145	151	112.5	48.6	165.0
4	1550	36.9	1527	20.0	3.0	163	130	263	108.8	43.7	289.2
5	1550	53.1	1532	25.0	3.0	158	126	369	105.8	42.5	406.8
6	1500	97.7	1488	37.0	3.8	183	122	689	119.5	39.9	737.8
7	1550	152.0	1503	57.0	4.5	371	133	1220	244.6	44.0	1320.2
8	1550	167.6	1460	65.0	6.5	833	107	1393	533.3	34.4	1464.2
9	1550	186.2	1466	71.0	9.0	1910	61	1708	1227.7	19.7	1802.8
10	1550	202.5	1475	80.0	12.0	2853	48	1918	1844.9	15.6	2036.8
11	700	0.4	688	3.5	1.5	115	158	113	34.6	23.9	56.1
12*											
13	2100	241.9	1929	104.0	17.5	1512	65	1323	1279.2	27.6	1838.6
14	2050	217.4	1913	88.0	12.0	1235	52	1263	1036.0	21.9	1740.7
15	2100	198.3	1913	82.0	10.0	619	86	1022	519.2	36.2	1408.4
16	2100	178.3	1892	72.0	8.0	354	101	956	293.2	42.0	1302.0
17	2100	121.2	1927	51.0	6.5	220	92	531	186.1	39.0	736.5
18	2100	60.4	1961	35.0	4.0	203	107	306	174.8	46.2	432.4
19	2100	44.0	1957	25.0	3.0	201	109	248	172.2	46.9	349.0
20	2100	20.0	1949	23.0	2.0	197	148	207	168.4	63.5	290.2
21	2100	3.6	1996	20.0	2.0	228	240	156	199.7	105.4	223.8
22	700	0.8	688	3.5	1.5	102	183	108	30.8	27.7	53.5
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.26 GM/BHP-HR
BSHC 0.50 GM/BHP-HR
BSNO2 7.82 GM/BHP-HR
BSFC 0.448 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.5 MMHG
HUMIDITY 97 GRAINS/LB
MAX. INLET RESTRICTION 25.5 "H2O
MAX. EXHAUST BACK PRESSURE 35.0 "H2O
INLET AIR TEMP. RANGE 75F - 87F
MAX. EXHAUST TEMP. 1330F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE A-22 FINAL BASELINE TEST FOR ENGINE NO. 21.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.3	637	3.5	0.8	128	204	120	35.6	28.6	55.2
2	1550	4.1	1470	12.0	1.0	199	236	150	128.0	76.3	158.2
3	1550	16.2	1474	16.0	1.0	181	157	220	116.9	50.9	233.5
4	1550	36.3	1479	21.0	1.0	171	129	315	110.8	42.0	335.4
5	1550	51.4	1482	24.0	1.0	170	126	385	110.5	41.1	411.0
6	1550	102.1	1452	41.0	2.0	190	121	792	121.1	38.6	828.3
7	1550	143.4	1465	54.0	3.2	260	123	1357	167.2	39.6	1431.3
8	1550	167.3	1474	63.5	5.0	680	123	1799	439.3	39.9	1909.1
9	1550	185.6	1478	72.0	8.5	1976	84	2124	1280.6	27.3	2260.9
10	1550	201.6	1486	80.0	13.2	3228	62	2291	2103.0	20.3	2451.0
11	700	0.3	637	3.5	1.0	128	202	130	35.6	28.3	59.8
12*											
13	2100	237.9	1960	102.0	15.5	1938	63	1534	1664.9	27.2	2164.6
14	2100	219.1	1943	91.0	11.0	1254	60	1430	1068.2	25.6	2000.9
15	2100	195.5	1938	80.0	9.0	533	89	1227	452.6	37.9	1712.6
16	2100	178.7	1930	72.0	8.0	320	101	1061	270.8	42.9	1474.7
17	2100	119.2	1963	54.0	6.5	245	111	650	211.1	47.9	919.1
18	2100	59.6	1931	34.0	3.5	246	132	352	208.1	56.1	489.1
19	2100	42.8	1985	31.0	2.5	252	150	304	219.0	65.5	434.8
20	2100	19.2	1984	24.0	2.0	254	173	222	220.6	75.5	317.8
21	2100	4.8	1980	20.0	2.0	259	208	184	224.5	90.6	261.9
22	700	0.3	637	3.5	1.0	128	199	130	35.6	27.9	59.8
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.42 GM/BHP-HR
BSHC 0.54 GM/BHP-HR
BSNO2 9.33 GM/BHP-HR
BSFC 0.463 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.5 MMHG
HUMIDITY 80 GRAINS/LB
MAX. INLET RESTRICTION 27.5 "H2O
MAX. EXHAUST BACK PRESSURE 38.0 "H2O
INLET AIR TEMP. RANGE 77F - 83F
MAX. EXHAUST TEMP. 1320F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX B. -- BASELINE DATA FOR HEAVY DUTY GASOLINE ENGINES WITH PARAMETERS ADJUSTED TO MANUFACTURERS' SPECIFICATIONS (23-MODE CYCLE)

TABLE B-1 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.5	74	4.9	-1.0	1.72	2175	79	583.2	36.5	4.4
2	1200	1.5	18.5	135	7.9	11.5	0.17	650	99	109.0	20.4	10.3
3	1200	3.9	18.0	140	8.2	10.5	0.16	686	132	105.0	22.3	14.3
4	1200	8.7	16.2	172	9.8	11.5	0.14	800	215	108.7	31.8	28.3
5	1200	12.1	14.9	205	11.7	10.5	0.13	1000	380	124.5	48.3	60.8
6	1200	24.2	11.8	228	14.5	11.5	0.48	2000	1085	518.8	107.0	192.5
7	1200	36.4	8.0	299	18.4	9.5	0.16	1825	1832	234.5	129.5	431.4
8	1200	39.7	6.3	325	20.3	6.5	0.26	1750	1719	398.4	133.4	435.1
9	1200	44.6	4.9	341	21.9	7.0	0.53	2025	1726	864.4	163.4	462.1
10	1200	48.5	3.3	376	24.0	7.0	0.57	2000	1832	1036.2	178.8	543.6
11	700	0.0	17.9	73	4.9	-1.0	1.99	2250	86	673.4	37.7	4.8
12*												
13	2300	98.4	1.7	778	49.1	13.5	0.81	170	1463	2998.0	31.0	886.6
14	2300	90.6	4.6	708	45.9	13.5	1.19	380	1298	3981.7	63.1	715.2
15	2300	80.7	7.0	625	39.4	10.5	0.53	950	1823	1590.6	142.1	905.4
16	2300	73.8	8.5	582	36.8	17.0	0.53	1250	1889	1510.2	174.7	876.7
17	2300	49.2	12.7	445	28.3	19.0	0.52	1200	1342	1125.6	129.1	479.3
18	2300	24.6	16.5	319	20.2	19.5	0.50	650	583	784.8	50.2	149.4
19	2300	17.7	17.5	288	18.1	18.5	0.46	450	422	645.5	31.1	96.6
20	2300	7.9	19.0	241	15.2	18.5	0.47	330	227	547.6	19.2	43.8
21	2300	2.8	19.9	219	13.8	18.5	0.12	520	170	131.8	28.1	30.3
22	700	0.0	18.1	78	4.9	-1.0	0.21	2150	79	80.7	41.3	5.0
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 31.05 GM/BHP-HR
BSHC 2.41 GM/BHP-HR
BSNO2 9.38 GM/BHP-HR
BSFC 0.643 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.8 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 78F - 86F
MAX. EXHAUST TEMP. 1475F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE B-2 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.6	74	4.9	-1.0	1.77	1900	89	573.6	30.5	4.7
2	1200	1.0	17.9	127	7.5	11.5	0.19	675	108	108.2	19.0	10.0
3	1200	3.9	17.8	140	8.2	10.5	0.16	675	158	102.3	21.1	16.3
4	1200	8.7	16.1	170	9.7	11.5	0.13	725	240	101.4	27.5	30.2
5	1200	12.1	14.9	188	11.5	10.5	0.65	1325	477	561.8	56.6	67.5
6	1200	24.2	12.4	228	14.4	11.5	0.39	1700	1172	407.4	88.7	203.2
7	1200	36.4	7.6	298	18.3	9.5	0.15	1625	1920	206.5	112.4	441.0
8	1200	39.7	6.2	319	20.2	6.5	0.34	1625	1771	509.7	119.7	433.0
9	1200	44.6	4.9	344	22.0	7.0	0.46	1725	1874	743.7	137.0	494.3
10	1200	48.5	3.1	364	23.3	7.0	0.57	1750	1959	970.0	147.3	547.4
11	700	0.0	17.7	75	5.0	-1.0	1.94	1975	88	634.9	31.9	4.7
12*												
13	2300	98.4	1.6	781	49.3	13.5	0.85	225	1583	3156.4	41.1	959.4
14	2300	90.6	3.8	716	46.1	13.5	1.01	250	1302	3381.7	41.4	715.4
15	2300	80.7	6.8	639	41.1	10.5	0.84	900	1784	2564.2	135.8	893.2
16	2300	73.8	8.3	585	36.9	17.0	0.52	1075	2031	1448.6	146.8	920.5
17	2300	49.2	12.5	445	28.2	19.0	0.47	1075	1511	998.5	112.7	525.6
18	2300	24.6	16.3	321	20.3	19.5	0.50	635	675	767.8	47.9	168.9
19	2300	17.7	17.1	298	18.7	18.5	0.46	475	495	654.7	33.4	115.3
20	2300	7.9	18.6	245	15.4	18.5	0.46	310	277	539.9	17.9	53.1
21	2300	2.0	19.7	212	13.5	18.5	0.62	350	187	622.9	17.4	30.9
22	700	0.0	17.8	73	4.8	-1.0	1.64	1825	80	544.6	30.0	4.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 32.77 GM/BHP-HR
BSHC 2.10 GM/BHP-HR
BSNO2 9.79 GM/BHP-HR
BSFC 0.647 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 739.9 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 78F - 82F
MAX. EXHAUST TEMP. 1494F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE B-3 INITIAL BASELINE TEST NO. 3 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.3	18.4	76	5.0	-1.0	1.82	2160	80	606.7	35.7	4.3
2	1200	1.0	19.4	133	7.9	11.5	0.23	875	98	139.6	26.7	9.9
3	1200	3.9	18.5	139	8.2	10.5	0.17	825	144	108.6	26.2	15.1
4	1200	8.7	16.5	168	9.7	11.5	0.13	900	238	103.8	34.6	30.3
5	1200	12.1	15.3	189	10.7	10.5	0.13	930	304	108.7	38.5	41.7
6	1200	24.2	12.9	226	14.4	11.5	0.53	1980	1087	563.9	103.3	188.3
7	1200	36.4	8.3	300	18.4	9.5	0.14	1710	1894	200.9	119.3	438.4
8	1200	39.7	6.6	326	20.1	6.5	0.16	1560	1839	240.3	117.2	458.9
9	1200	44.6	5.3	349	22.3	7.0	0.45	1920	1825	738.6	156.4	493.8
10	1200	48.5	3.7	369	23.5	7.0	0.43	1890	1994	741.1	161.4	565.6
11	700	0.0	18.3	76	5.1	-1.0	2.02	2085	86	690.2	35.3	4.8
12*												
13	2300	98.4	1.9	790	50.0	13.5	0.97	305	1474	3581.5	55.9	897.2
14	2300	90.6	4.6	711	46.2	13.5	1.26	430	1275	4196.7	70.8	696.9
15	2300	80.7	7.2	628	39.6	10.5	0.49	960	1885	1463.7	141.5	922.2
16	2300	73.8	8.6	578	36.5	17.0	0.47	1170	1986	1291.4	158.9	895.7
17	2300	49.2	12.9	455	28.8	19.0	0.41	1065	1441	895.0	113.7	511.0
18	2300	24.6	16.7	325	20.4	19.5	0.46	630	658	710.7	48.4	167.7
19	2300	17.7	17.7	293	18.3	18.5	0.42	460	479	585.7	31.7	109.6
20	2300	7.9	19.2	246	15.4	18.5	0.43	320	274	504.3	18.5	52.7
21	2300	2.0	20.2	218	13.8	18.5	0.55	310	194	570.1	15.9	32.8
22	700	0.0	18.5	77	5.1	-1.0	1.67	1850	87	588.0	32.2	5.0
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 32.47 GM/BHP-HR
BSHC 2.32 GM/BHP-HR
BSNO2 9.56 GM/BHP-HR
BSFC 0.646 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 752.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 77F - 79F
MAX. EXHAUST TEMP. 1462F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE B-4 FINAL BASELINE TEST NO. 1 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	16.6	82	5.3	0.0	0.73	1350	80	267.3	24.5	4.8
2	1200	1.0	18.1	120	7.3	12.0	0.27	850	97	146.0	22.6	8.5
3	1200	3.9	17.0	137	8.1	12.0	0.17	725	130	103.3	22.0	13.1
4	1200	8.7	15.1	172	9.8	12.0	0.13	740	196	98.1	28.5	25.0
5	1200	12.1	14.0	186	10.6	12.0	0.12	830	287	100.8	34.4	39.3
6	1200	24.2	11.4	223	14.3	12.0	0.57	1800	1080	589.8	91.7	182.6
7	1200	36.4	6.8	292	18.2	12.0	0.17	1670	1898	224.5	111.7	421.7
8	1200	39.7	5.1	309	20.1	7.5	0.64	1810	1524	939.1	130.5	364.7
9	1200	44.6	3.7	341	22.2	7.5	0.72	1900	1598	1145.9	149.4	417.0
10	1200	48.5	2.4	360	23.4	7.5	0.72	1850	1720	1220.8	154.9	478.1
11	715	0.0	16.3	79	5.1	0.0	0.75	1350	86	269.0	24.1	5.1
12*												
13	2300	98.4	1.0	766	49.1	15.0	1.01	450	1581	3633.9	80.3	935.8
14	2300	90.6	2.6	713	46.3	15.0	1.14	400	1343	3834.8	66.3	739.1
15	2300	80.7	5.1	638	42.1	15.0	1.27	1100	1445	3776.4	162.1	707.3
16	2300	73.8	6.9	587	37.3	20.0	0.42	1200	1984	1169.7	164.9	904.7
17	2300	49.2	11.3	437	27.9	20.0	0.53	1150	1360	1094.7	118.6	465.7
18	2300	24.6	15.4	326	20.7	20.0	0.55	650	565	855.8	50.2	144.6
19	2300	17.7	16.3	291	18.3	20.0	0.48	450	416	665.3	30.8	94.2
20	2300	7.9	17.9	245	15.4	20.0	0.45	300	235	526.1	17.3	44.9
21	2300	2.0	18.9	207	13.2	20.0	0.30	160	162	310.5	8.1	27.4
22	715	0.0	16.4	80	5.1	0.0	0.52	1250	75	192.0	22.9	4.6
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 33.21 GM/BHP-HR
BSHC 2.24 GM/BHP-HR
BSNO2 9.05 GM/BHP-HR
BSFC 0.649 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.4 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 78F
MAX. EXHAUST TEMP. 1472F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE B-5 FINAL BASELINE TEST NO. 2 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	730	0.0	16.6	84	5.5	1.0	1.08	1540	59	447.7	31.7	4.0
2	1200	1.0	18.1	122	7.2	11.0	0.17	880	85	106.5	26.6	8.4
3	1200	3.9	16.7	146	8.5	12.0	0.14	650	122	102.6	22.9	14.2
4	1200	8.7	14.8	179	10.1	12.5	0.13	710	190	116.9	31.1	27.5
5	1200	12.1	13.8	195	11.0	11.0	0.13	790	286	121.3	37.5	45.0
6	1200	24.2	10.9	234	14.8	11.0	0.35	1500	1149	421.9	89.0	226.3
7	1200	36.4	6.5	305	18.9	11.0	0.15	1530	1930	239.8	118.0	494.1
8	1200	39.7	4.9	329	21.2	7.5	0.51	1650	1617	856.9	136.7	444.8
9	1200	44.6	3.1	354	22.9	7.5	0.63	1700	1716	1141.3	153.1	512.8
10	1200	48.5	1.3	369	23.9	8.0	0.92	1650	1680	1719.1	152.6	515.8
11	720	0.0	16.5	80	5.2	0.0	0.85	1425	73	341.7	28.2	4.7
12*												
13	2300	98.4	1.0	778	50.1	15.0	1.01	560	1623	4060.5	111.4	1072.0
14	2300	90.6	2.3	716	46.6	15.0	1.10	600	1196	4021.7	54.4	720.6
15	2300	80.7	5.1	643	42.5	15.0	1.22	1030	1374	4097.6	170.6	755.2
16	2300	73.8	6.9	600	38.1	20.0	0.41	1085	1902	1288.7	168.2	978.4
17	2300	49.2	11.3	455	29.1	20.0	0.51	1050	1295	1214.6	123.2	504.5
18	2300	24.6	15.3	333	21.2	20.0	0.55	680	564	961.3	58.3	160.7
19	2300	17.7	16.4	292	18.4	20.0	0.46	460	395	712.1	34.8	99.4
20	2300	7.9	17.9	246	15.5	20.0	0.44	330	235	570.2	21.1	49.9
21	2300	2.0	18.8	212	13.6	19.0	0.44	650	153	496.0	36.6	28.5
22	715	0.0	16.5	78	5.0	0.0	0.68	1250	74	266.9	24.2	4.7
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 35.79 GM/BHP-HR
BSHC 2.36 GM/BHP-HR
BSNO2 9.80 GM/BHP-HR
BSFC 0.662 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.2 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 71F - 75F
MAX. EXHAUST TEMP. 1451F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE B-6 INITIAL BASELINE TEST NO. 1 FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.7	76	4.7	4.0	0.65	1375	40	223.5	23.2	2.2
2	1200	1.0	19.2	102	6.6	13.0	0.53	725	57	267.0	18.1	4.7
3	1200	4.1	18.6	112	6.9	18.0	0.53	1200	102	283.2	32.0	9.0
4	1200	9.2	17.4	129	7.8	30.0	0.23	1920	439	146.0	59.9	45.4
5	1200	12.8	16.0	145	8.7	30.0	0.12	1980	880	83.8	67.3	99.3
6	1200	25.7	10.1	229	13.5	18.0	0.10	1670	1484	99.3	86.0	253.7
7	1200	38.5	5.2	303	19.5	11.0	0.78	1975	1485	1091.7	136.4	340.3
8	1200	42.1	4.4	309	21.5	11.0	2.57	2500	947	3650.1	175.5	220.8
9	1200	47.3	2.5	336	23.5	11.0	2.78	2550	1045	4312.4	195.6	265.9
10	1200	51.4	1.5	349	24.4	11.0	2.79	2480	1248	4580.3	201.7	336.8
11	755	0.0	18.1	77	4.8	5.0	0.81	1225	45	288.4	21.6	2.6
12*												
13	2300	102.3	2.0	709	48.1	20.0	2.00	1750	1807	6674.7	289.3	991.5
14	2300	94.1	3.6	652	44.0	20.0	1.92	1700	1832	5881.4	258.1	923.8
15	2300	83.9	4.8	614	41.0	20.0	1.70	1200	1813	4899.0	171.1	858.2
16	2300	76.7	5.4	606	38.1	19.5	0.77	1065	1864	2198.7	151.2	878.9
17	2300	51.2	10.4	452	27.2	29.5	0.26	1150	2078	557.0	122.7	736.2
18	2300	25.6	16.0	296	18.0	39.5	0.22	1500	1570	305.4	104.5	362.9
19	2300	18.4	17.7	254	15.9	40.0	0.19	930	1034	242.9	57.9	213.8
20	2300	8.2	19.0	215	12.8	39.0	0.18	520	425	186.6	26.0	70.5
21	2300	2.0	20.2	185	10.9	38.0	0.16	325	214	133.6	13.8	30.0
22	760	0.0	18.4	75	4.6	5.5	0.30	990	35	104.7	16.9	1.9
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 45.23 GM/BHP-HR
BSHC 3.02 GM/BHP-HR
BSNO2 10.33 GM/BHP-HR
BSFC 0.593 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.9 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 78F
MAX. EXHAUST TEMP. 1415F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE 8-7 INITIAL BASELINE TEST NO. 2 FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.3	71	4.4	5.0	0.41	1350	48	130.9	21.1	2.5
2	1200	1.0	19.4	107	6.6	9.5	0.39	600	70	188.9	14.4	5.6
3	1200	4.1	18.9	112	6.9	19.0	0.34	1085	146	170.9	27.3	12.2
4	1200	9.2	17.9	127	7.8	29.0	0.29	1785	581	169.8	50.9	55.0
5	1200	12.8	16.5	147	8.9	29.5	0.21	1800	990	137.8	59.3	108.3
6	1200	25.7	10.3	234	13.5	19.5	0.10	1375	1498	100.8	71.9	260.1
7	1200	38.5	5.7	308	18.9	11.0	0.30	1370	1753	415.4	95.3	404.6
8	1200	42.1	4.9	312	20.4	11.0	1.23	1800	1580	1722.8	124.6	363.2
9	1200	47.3	3.6	334	23.3	11.0	2.87	2240	982	4290.2	165.6	240.9
10	1200	51.4	2.2	352	24.3	11.0	2.66	2250	1264	4155.4	174.2	324.7
11	745	0.0	18.4	71	4.4	5.0	0.33	1175	50	101.9	18.2	2.5
12*												
13	2300	102.3	2.8	703	47.1	18.0	1.86	1525	1832	5962.6	242.0	965.4
14	2300	94.1	4.4	647	43.3	18.0	1.79	1575	1823	5281.0	229.7	882.6
15	2300	83.9	5.2	627	39.8	19.0	0.82	1200	2013	2397.3	173.0	964.0
16	2300	76.7	6.0	598	36.5	19.0	0.40	980	1985	1114.1	133.6	897.9
17	2300	51.2	11.1	445	26.4	30.5	0.20	1100	2194	415.4	112.9	747.7
18	2300	25.6	16.1	301	18.0	39.5	0.19	1095	1562	265.1	75.8	359.1
19	2300	18.4	17.6	265	15.7	38.5	0.17	800	1018	213.7	48.4	204.2
20	2300	8.2	19.5	217	12.9	38.5	0.17	510	487	165.7	25.1	79.6
21	2300	2.0	20.6	187	10.9	39.0	0.15	281	237	126.9	12.0	33.5
22	750	0.0	18.7	70	4.3	5.0	0.28	1080	49	88.4	17.0	2.6
23*												

==23 MODE CYCLE COMPOSITE==
BSCO 31.84 GM/BHP-HR
BSHC 2.63 GM/BHP-HR
BSNO2 10.71 GM/BHP-HR
BSFC 0.577 LB/BHP-HR

==TEST CONDITIONS==
BAROMETER 753.4 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 69F - 77F
MAX. EXHAUST TEMP. 1424F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE B-8 INITIAL BASELINE TEST NO. 3 FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.2	72	4.4	5.0	0.26	1180	47	84.3	19.0	2.5
2	1200	1.0	19.4	106	6.5	9.5	0.36	540	69	171.2	12.6	5.4
3	1200	4.1	19.0	111	6.8	18.5	0.35	1075	140	172.4	26.4	11.4
4	1200	9.2	17.9	129	7.9	30.0	0.28	1800	582	163.1	52.1	55.9
5	1200	12.8	16.5	146	8.9	30.0	0.21	1900	988	140.5	61.7	106.6
6	1200	25.7	10.6	231	13.5	20.5	0.10	1500	1661	98.0	76.3	280.5
7	1200	38.5	5.6	299	18.5	10.5	0.35	1500	1779	479.0	100.1	394.1
8	1200	42.1	4.9	309	20.6	10.5	1.58	1975	1414	2176.5	134.7	320.3
9	1200	47.3	3.3	332	23.4	10.5	3.12	2350	910	4612.4	171.6	220.7
10	1200	51.4	2.1	347	24.3	11.0	3.00	2350	1141	4631.8	179.5	289.5
11	755	0.0	18.5	70	4.3	5.0	0.31	1175	50	93.4	17.6	2.4
12*												
13	2300	102.3	2.6	696	46.6	18.5	1.78	1655	1761	5531.2	254.2	898.3
14	2300	94.1	4.0	648	43.5	18.5	1.87	1675	1704	5431.5	240.5	812.5
15	2300	83.9	5.0	610	39.7	18.5	1.22	1400	1811	3362.5	190.4	817.9
16	2300	76.7	5.9	597	36.9	18.5	0.53	910	1844	1419.7	121.1	814.7
17	2300	51.2	10.9	445	26.6	30.0	0.20	1110	2071	401.2	110.1	682.1
18	2300	25.6	16.2	294	17.7	38.0	0.18	1100	1418	243.5	72.1	308.6
19	2300	18.4	17.6	259	15.5	38.0	0.17	850	958	199.6	48.6	182.0
20	2300	8.2	19.5	213	12.7	38.0	0.16	525	456	155.6	24.8	71.2
21	2300	2.0	20.6	184	10.8	37.0	0.15	320	220	124.0	13.0	29.6
22	770	0.0	18.7	70	4.3	5.0	0.26	1100	48	78.6	16.7	2.4
23*												

==23 MODE CYCLE COMPOSITE==
BSCO 34.35 GM/BHP-HR
BSHC 2.67 GM/BHP-HR
BSNO2 9.81 GM/BHP-HR
BSFC 0.577 LB/BHP-HR

==TEST CONDITIONS==
BAROMETER 753.6 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 70F - 77F
MAX. EXHAUST TEMP. 1418F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE B-9 FINAL BASELINE TEST NO. 1 FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.7	72	4.5	5.0	0.36	1125	49	117.4	18.1	2.6
2	1200	1.0	18.5	105	6.5	11.0	0.38	1025	65	179.9	24.2	5.1
3	1200	4.1	18.0	109	6.7	15.0	0.32	1325	1	157.6	32.5	0.1
4	1200	9.2	17.2	120	7.3	23.0	0.20	1500	352	109.8	40.6	31.5
5	1200	12.8	16.0	133	8.0	25.0	0.14	1675	717	83.8	51.0	72.4
6	1200	25.7	9.8	214	12.7	15.0	0.10	1325	1180	103.7	64.9	191.7
7	1200	38.5	4.9	273	18.0	9.5	1.31	1750	1306	1658.9	109.9	272.3
8	1200	42.1	3.7	283	19.8	9.5	2.87	2175	849	3716.1	139.4	180.7
9	1200	47.3	1.7	311	21.7	9.5	2.86	2175	1047	4123.9	155.3	248.3
10	1200	51.4	1.0	334	22.9	9.5	2.70	2000	1227	4206.0	154.3	314.2
11	770	0.0	18.0	72	4.5	5.0	0.37	1100	62	124.9	18.2	3.4
12*												
13	2300	102.3	1.8	641	44.1	19.0	2.30	1750	1426	7074.2	266.0	719.8
14	2300	94.1	3.0	596	40.8	19.0	2.26	1770	1426	6506.2	252.2	674.4
15	2300	83.9	4.5	563	38.1	19.0	1.91	1770	1468	5282.3	241.8	665.5
16	2300	76.7	5.2	541	34.3	18.0	0.74	1250	1680	1959.9	164.8	735.3
17	2300	51.2	10.8	400	24.4	29.0	0.24	1400	2039	479.2	135.8	657.0
18	2300	25.6	16.1	259	15.9	37.0	0.24	1390	1375	312.3	88.0	289.1
19	2300	18.4	17.5	230	14.1	37.0	0.23	1075	920	263.0	60.4	171.4
20	2300	8.2	19.3	185	11.1	37.0	0.18	600	378	158.7	26.6	55.6
21	2300	2.0	20.3	165	9.8	38.0	0.17	370	193	132.7	14.6	25.1
22	770	0.0	18.2	75	4.6	5.0	0.30	1350	54	107.6	23.7	3.1
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 45.64 GM/BHP-HR
BSHC 3.00 GM/BHP-HR
BSNO2 8.22 GM/BHP-HR
BSFC 0.546 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.4 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 76F - 79F
MAX. EXHAUST TEMP. 1394F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE B-10 FINAL BASELINE TEST NO. 2 FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.6	72	4.5	5.0	0.35	1100	41	115.0	18.0	2.2
2	1200	1.0	18.4	101	6.3	8.0	0.45	550	67	203.0	12.2	4.9
3	1200	4.1	18.0	107	6.6	12.0	0.38	850	109	186.4	20.5	8.6
4	1200	9.2	17.2	115	7.1	22.0	0.26	1575	347	139.1	41.3	30.3
5	1200	12.8	16.0	131	8.0	25.0	0.17	1825	745	101.1	54.9	74.3
6	1200	25.7	9.7	212	12.8	13.0	0.11	1450	1300	112.6	70.8	210.5
7	1200	38.5	4.8	269	18.7	8.0	1.85	1975	1037	2305.5	122.0	212.6
8	1200	42.1	3.5	285	20.1	8.0	3.04	2250	785	4055.8	148.3	171.6
9	1200	47.3	1.4	314	22.1	8.0	3.04	2225	1004	4460.0	161.6	241.9
10	1200	51.4	1.0	332	22.8	8.0	2.61	2125	1207	4075.1	164.1	309.6
11	760	0.0	18.2	69	4.3	5.0	0.35	1050	5	111.8	16.8	0.3
12*												
13	2300	102.3	1.5	651	45.0	19.0	2.33	1775	1418	7401.6	278.6	739.1
14	2300	94.1	2.8	596	40.6	19.0	2.08	1750	1585	6058.1	251.9	757.2
15	2300	83.9	4.4	557	37.7	18.0	1.83	1825	1588	4970.0	245.8	709.8
16	2300	76.7	5.2	531	33.8	18.0	0.86	1250	1882	2230.1	160.8	803.7
17	2300	51.2	10.6	397	24.1	29.0	0.24	1400	2270	466.6	135.0	726.9
18	2300	25.6	16.2	257	15.8	37.0	0.25	1450	1545	318.4	89.9	318.1
19	2300	18.4	17.6	228	13.9	37.0	0.22	1100	958	236.7	59.4	171.7
20	2300	8.2	19.5	181	10.9	37.0	0.19	575	389	167.1	24.8	55.5
21	2300	2.0	20.3	161	9.6	38.0	0.20	400	192	152.1	15.2	24.2
22	750	0.0	18.4	71	4.4	5.0	0.27	875	49	93.0	14.7	2.7
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 45.78 GM/BHP-HR
BSHC 2.95 GM/BHP-HR
BSNO2 8.88 GM/BHP-HR
BSFC 0.542 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.9 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 77F - 82F
MAX. EXHAUST TEMP. 1400F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX C. -- BASELINE DATA FOR HEAVY DUTY GASOLINE ENGINES WITH PARAMETERS ADJUSTED TO MANUFACTURERS' SPECIFICATIONS (9-MODE CYCLE)

TABLE C-1. - Initial baseline test No. 1 for engine No. 22 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO *	CO	HC	NO_x **
1	1	0	18	78	5.2	14.0	2.06	11.05	0.3150	0.0064	732	55.4	3.74
	2	29	16	347	21.0	15.5	.22	11.62	.1400	.0514	354	111	136
	3	54	10	509	32.0	14.9	.31	11.88	.1800	.0259	736	211	101
	4	26	16	329	20.9	14.7	.44	11.93	.1600	.0805	674	121	202
	5	4	19	211	13.7	14.4	.92	11.88	.1100	.0247	1,023	53.0	39.5
	6	23	16	330	20.5	15.1	.32	11.88	.1050	.0712	489	79.4	179
	7	82	3	636	41.0	14.5	1.93	10.79	.1600	.1060	5,640	231	509
	8	26	16	310	19.5	14.9	.41	11.93	.1075	.0817	590	76.5	193
	9												
2	1	0	18	78	5.2	14.0	2.06	11.05	0.3150	0.0064	732	55.4	3.74
	2	24	16	311	19.5	15.0	.41	11.88	.0950	.0744	593	67.9	176.6
	3	57	10	483	30.1	15.0	.26	11.88	.1325	.1723	585	148	637
	4	24	16	304	19.0	15.0	.41	11.88	.0850	.0769	578	59.2	178
	5	6	19	209	13.6	14.4	.92	11.84	.0800	.0287	895	38.5	45.8
	6	21	16	272	18.1	15.0	.44	11.80	.0775	.0696	594	51.7	154
	7	82	3	669	42.5	14.7	1.47	10.96	.0875	.1088	4,311	127	524
	8	24	16	315	18.8	14.9	.47	11.71	.0775	.0781	662	54.0	181
	9												
3	1	0	18	72	5.0	13.5	2.75	10.96	0.1825	0.0089	909	29.8	4.8
	2	24	16	295	18.5	15.0	.45	11.71	.0775	.0805	624	53.2	184
	3	57	10	468	29.3	15.0	.32	11.71	.1250	.1796	708	137	653
	4	24	16	296	18.6	14.9	.49	11.62	.0800	.0805	686	55.4	185
	5	6	19	199	13.0	14.3	1.08	11.80	.0875	.0267	794	39.8	40.4
	6	23	16	289	18.0	15.0	.45	11.71	.0750	.0712	608	50.1	158
	7	84	3	674	43.0	14.7	1.36	10.96	.1075	.1177	4,320	169	614
	8	26	16	298	18.8	14.9	.48	11.84	.0800	.0845	668	55.1	193
	9												

* Measured by NDIR.

** NO_x as NO_2.

TABLE C-1. - Initial baseline test No. 1 for engine No. 22 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO *	CO	HC	NO_x**
4	1	0	18	72	5.0	13.5	2.75	10.96	0.1825	0.0089	909	29.8	4.8
	2	26	16	294	18.5	14.9	.48	11.80	.0825	.0829	659	56.1	187
	3	56	10	467	29.4	14.9	.38	11.84	.1300	.1796	830	141	645
	4	26	16	295	18.6	14.9	.48	11.80	.0825	.0870	663	56.4	197
	5	9	19	209	13.6	14.4	.96	11.80	.0800	.0336	933	38.5	53.7
	6	25	16	295	18.5	14.9	.48	11.80	.0825	.0793	659	56.1	179
	7	82	3	655	42.0	14.6	1.53	11.05	.1050	.1149	4,650	158	574
	8	26	16	284	18.0	14.8	.53	11.84	.0850	.0870	703	55.8	190
	9												

* Measured by NDIR.
** NO_x as NO_2.

Cycle emission rates, Federal weighting Factors (5)

CO, gm/bhp-hr	42.0
HC, gm/bhp-hr	2.82
NO_x as NO_2, gm/bhp-hr	7.96

TABLE C-2. - Initial baseline test No. 2 for engine No. 22 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO *	CO	HC	NO_x**
1	1	0	18	78	5.2	13.9	2.18	11.05	0.3400	0.0065	767	59.2	3.8
	2	26	16	394	24	15.4	.26	11.80	.1400	.0235	470	125	69.7
	3	56	10	501	31.5	14.9	.22	12.15	.1750	.1505	498	200	570
	4	26	16	302	19.3	14.7	.57	12.01	.1300	.0639	795	89.6	146
	5	6	19	222	14.4	14.5	.88	12.01	.1000	.0247	896	50.3	41.3
	6	26	16	311	19.4	15	.38	11.97	.0900	.0591	544	63.7	139
	7	82	3	627	40	14.7	1.53	11.84	.1500	.1278	4,155	201	570
	8	26	16	288	18.1	14.9	.48	11.97	.0825	.0615	636	54.1	134
	9												
2	1	0	18	78	5.2	13.9	2.18	11.93	0.3400	0.0065	767	59.2	3.8
	2	26	16	292	18.3	15.0	.44	11.93	.0800	.0615	594	53.3	136
	3	56	10	486	30.4	15.0	.37	11.93	.1225	.1650	831	136	608
	4	26	16	293	18.4	14.9	.44	11.93	.0800	.0712	597	53.7	159
	5	6	19	202	13.1	14.4	.86	12.32	.0700	.0247	781	31.4	37
	6	26	16	296	18.5	15.0	.44	12.15	.0750	.0720	590	49.7	159
	7	82	3	610	41.5	14.7	1.46	11.14	.0850	.1116	4,384	126	550
	8	26	16	294	18.5	14.9	.49	11.93	.0675	.0781	666	45.4	174
	9												
3	1	0	18	73	5.0	13.6	2.52	11.14	0.1750	0.0097	836	28.7	5.3
	2	26	16	280	18.3	14.3	.46	11.93	.0675	.0781	620	45.0	173
	3	56	10	470	29.5	14.9	.38	11.93	.1175	.1816	814	124	639
	4	26	16	279	18.3	14.3	.53	12.15	.0700	.0769	711	46.4	169
	5	6	19	190	12.9	13.7	.97	11.93	.0750	.0275	885	33.8	41.2
	6	26	16	276	18.0	14.3	.48	11.93	.0700	.0744	636	45.8	162
	7	82	3	613	41.5	13.8	1.36	11.30	.0975	.1391	4,061	144	682
	8	26	16	282	18.4	14.3	.53	11.93	.0650	.0769	715	43.4	170
	9												

* Measured by NDIR.

** NO_x as NO_2.

TABLE C-2. - Initial baseline test No. 2 for engine No. 22 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO *	CO	HC	NO_x**
4	1	0	18	73	5.0	13.6	2.52	11.14	0.1750	0.0097	836	28.7	5.3
	2	26	16	277	18.0	14.3	.49	11.93	.0700	.0756	648	45.8	164
	3	56	10	469	29.5	14.9	.44	11.93	.1175	.1853	954	126	660
	4	26	16	275	18.0	14.3	.49	12.15	.0725	.0805	637	46.6	172
	5	6	19	179	12.2	13.7	1.04	11.93	.0775	.0267	893	32.9	37.6
	6	26	16	274	17.8	14.4	.48	11.93	.0675	.0732	629	43.7	157
	7	82	3	615	41.5	13.8	1.45	11.30	.0925	.1391	4,301	136	678
	8	26	16	277	18.2	14.2	.53	11.93	.0700	.0829	707	46.2	182
	9												

* Measured by NDIR.
** NO_x as NO_2.

Cycle emission rates, Federal weighting Factors (5)

CO, gm/bhp-hr 39.9

HC, gm/bhp-hr 2.51

NO_x as NO_2, gm/bhp-hr 8.39

TABLE C-3. - Final baseline No. 1 for engine No. 22 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
				Exhaust flow	Fuel flow		volume percent				grams/hr		
							CO	CO_2	HC	NO_x*	CO	HC	NO_x**
1	1	0	18	82	5.5	13.9	1.53	11.30	0.297	0.0059	588	56.5	3.7
	2	21	16	267	18.2	13.7	4.39	9.23	.169	.0200	5,319	101.3	39.8
	3	52	10	473	29.8	14.9	.35	11.62	.190	.0830	787	101.6	306.7
	4	21	16	311	19.9	14.6	.79	11.62	.134	.0520	1,151	96.5	124.4
	5	5	19	224	14.7	14.3	1.10	11.62	.120	.0200	1,156	62.4	34.5
	6	21	16	298	18.7	15.0	.48	11.62	.110	.0440	675	76.5	101.6
	7	79	3	686	43.4	14.8	1.40	10.66	.140	.0960	4,572	226.1	514.9
	8	21	16	312	19.9	14.7	.70	11.44	.110	.0460	1,044	81.1	112.7
	9												
2	1	0	18	82	5.5	13.9	1.53	11.30	0.297	0.0059	588	56.5	3.7
	2	21	16	277	17.5	14.8	.61	11.62	.100	.0530	795	64.4	113.4
	3	52	10	454	28.6	14.9	.44	11.62	.137	.1420	947	145.8	501.9
	4	21	16	294	18.6	14.8	.61	11.62	.095	.0620	845	65.1	141.0
	5	5	19	212	14.1	14.0	1.40	11.62	.120	.0230	1,379	58.5	37.2
	6	21	16	287	18.1	14.9	.48	11.62	.100	.0630	654	67.4	140.9
	7	79	3	656	42.5	14.4	1.58	11.14	.120	.1190	4,801	180.3	593.9
	8	21	16	302	19.2	14.7	.66	11.62	.097	.0680	940	68.3	159.0
	9												
3	1	0	18	84	5.8	13.5	2.24	10.96	0.170	0.0080	892	33.5	5.2
	2	21	16	294	18.6	14.8	.61	11.62	.095	.0650	845	65.1	147.8
	3	52	10	452	28.6	14.8	.44	11.62	.150	.1520	946	159.5	536.8
	4	21	16	293	18.5	14.8	.61	11.62	.085	.0630	841	57.9	142.6
	5	5	19	199	13.2	14.1	1.40	11.62	.115	.0210	1,292	52.5	31.8
	6	21	16	280	17.7	14.8	.61	11.62	.090	.0600	805	58.7	130.0
	7	79	3	643	40.9	14.7	1.36	10.96	.120	.1170	4,105	181.6	580.0
	8	21	16	296	18.7	14.8	.57	11.62	.080	.0610	797	55.4	140.2
	9												

* Measured by chemiluminescence.
** NO_x as NO_2.

TABLE C-3. - Final baseline No. 1 for engine No. 22 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
				Exhaust flow	Fuel flow		volume percent				grams/hr		
							CO	CO_2	HC	NO_x*	CO	HC	NO_x**
4	1	0	18	84	5.8	13.5	2.24	10.96	0.170	0.0080	892	33.5	5.2
	2	21	16	295	18.7	14.8	.61	11.62	.085	.0610	850	58.6	139.6
	3	52	10	448	28.4	14.8	.48	11.62	.128	.1540	1,023	134.4	539.2
	4	21	16	297	18.9	14.7	.70	11.62	.080	.0610	979	55.4	140.2
	5	5	19	205	13.6	14.1	1.31	11.44	.100	.0230	1,273	48.0	36.7
	6	21	16	276	17.5	14.8	.66	11.62	.088	.0570	857	56.2	121.6
	7	79	3	624	40.2	14.5	1.49	10.96	.100	.1190	4,381	145.4	574.7
	8	21	16	301	19.2	14.7	.70	11.62	.085	.0590	995	59.7	137.6
	9												

* Measured by chemiluminescence.
** NO_x as NO_2.

Cycle emission rates, Federal Weighting Factors (5)

CO, gm/bhp-hr	53.2
HC, gm/bhp-hr	3.1
NO_x as NO_2, gm/bhp-hr	7.8

TABLE C-4. - Final baseline No. 2 for engine No. 22 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO_x*	CO	HC	NO_x**
1	1	0	18	80	5.2	14.3	0.96	11.30	0.165	0.007	369	31.3	4.4
	2	21	16	278	17.7	14.9	.66	11.30	.125	.010	887	83.1	22.1
	3	52	10	462	29.0	14.9	.39	11.30	.160	.140	876	177.8	516.6
	4	21	16	300	19.0	14.8	.70	11.14	.108	.060	1,022	77.6	143.8
	5	5	19	213	14.1	14.1	1.27	11.14	.115	.020	1,312	58.8	33.9
	6	21	16	289	18.2	14.9	.61	11.14	.108	.050	859	87.2	115.7
	7	79	3	662	42.4	14.6	1.45	10.96	.140	.120	4,497	214.7	611.3
	8	21	16	298	19.0	14.7	.70	11.30	.102	.061	1,009	72.7	144.4
	9												
2	1	0	18	80	5.2	14.3	0.96	11.30	0.165	0.007	369	31.3	4.4
	2	21	16	287	18.2	14.8	.66	11.30	.097	.059	927	67.4	136.1
	3	52	10	467	29.5	14.8	.44	11.14	.137	.150	1,017	156.6	569.3
	4	21	16	296	18.8	14.7	.75	11.14	.093	.061	1,080	66.3	144.3
	5	5	19	200	13.3	14.1	1.32	11.14	.112	.020	1,282	53.8	31.9
	6	21	16	284	18.0	14.8	.66	11.14	.095	.060	939	66.8	140.1
	7	79	3	636	40.9	14.6	1.49	10.96	.105	.120	4,337	151.1	573.6
	8	21	16	305	19.4	14.7	.70	11.30	.090	.063	1,031	65.6	152.4
	9												
3	1	0	18	80	5.5	13.5	2.17	10.66	0.170	0.008	843	32.7	5.1
	2	21	16	283	17.9	14.8	.61	11.14	.090	.062	847	61.8	141.3
	3	52	10	457	29.0	14.8	.53	11.14	.132	.150	1,196	146.7	555.8
	4	21	16	296	18.8	14.8	.66	11.14	.087	.062	958	62.5	147.8
	5	5	19	206	13.7	14.0	1.34	11.14	.107	.022	1,339	52.9	36.1
	6	21	16	275	17.4	14.8	.66	11.14	.091	.059	887	60.5	130.2
	7	79	3	643	41.4	14.5	1.40	10.66	.115	.120	4,368	177.5	615.0
	8	21	16	297	18.9	14.7	.70	11.14	.085	.061	1,018	61.1	145.7
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

TABLE C-4. - Final baseline No. 2 for engine No. 22 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO_x*	CO	HC	NO_x**
4	1	0	18	80	5.5	13.5	2.17	10.66	0.170	0.008	843	32.7	5.1
	2	21	16	281	17.9	14.7	.70	11.30	.090	.061	951	60.5	136.2
	3	52	10	447	28.4	14.8	.53	11.14	.130	.150	1,171	142.0	544.3
	4	21	16	287	18.2	14.7	.70	11.14	.084	.061	981	58.6	140.4
	5	5	19	208	13.7	14.2	1.14	11.30	.095	.022	1,143	47.1	36.2
	6	21	16	282	17.9	14.8	.66	11.14	.090	.059	912	61.5	133.9
	7	79	3	617	40.0	14.4	1.47	10.66	.115	.130	4,406	170.5	639.9
	8	21	16	294	18.8	14.7	.73	11.30	.085	.062	1,040	59.5	145.0
	9												

* Measured by chemiluminescence.
** NO_x as NO_2.

Cycle emission rates, Federal weighting Factors (5)

CO, gm/bhp-hr	50.7
HC, gm/bhp-hr	3.2
NO_x as NO_2, gm/bhp-hr	3.3

TABLE C-5. - Initial baseline No. 1 for engine No. 23 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
				Exhaust flow	Fuel flow		volume percent				grams/hr		
							CO	CO_2	HC	NO_x*	CO	HC	NO_x**
1	1	0	18	86	5.4	15.0	0.61	10.66	0.270	0.0042	262	57.4	3.0
	2	20	16	230	14.8	14.6	.15	10.66	.160	.1035	185	98.0	210.5
	3	46	10	400	26.1	14.3	.21	10.96	.180	.1315	449	187.9	455.9
	4	20	16	251	15.4	15.3	.21	10.96	.130	.0789	270	80.4	162.0
	5	5	19	192	11.3	16.0	.15	10.96	.066	.0202	144	30.3	30.8
	6	20	16	268	15.5	16.4	.15	10.96	.132	.0840	193	82.9	174.5
	7	81	3	607	38.6	14.7	1.93	10.66	.200	.1193	5,347	274.0	542.9
	8	20	16	245	15.5	14.8	.21	11.30	.120	.0951	267	72.5	190.9
	9												
2	1	0	18	86	5.4	15.0	0.61	10.66	0.270	0.0042	262	57.4	3.0
	2	20	16	233	14.7	14.0	.22	10.96	.116	.0948	262	68.1	185.9
	3	46	10	403	24.4	15.5	.31	11.14	.150	.1557	598	143.2	493.8
	4	20	16	242	15.1	15.0	.45	11.62	.160	.1031	511	90.0	191.9
	5	5	19	177	10.6	15.7	.14	10.96	.041	.0222	128	17.9	31.8
	6	20	16	248	14.9	15.6	.17	10.96	.122	.0991	215	73.6	197.7
	7	81	3	604	38.7	14.6	1.93	10.96	.192	.1294	5,242	258.6	577.2
	8	20	16	253	16.0	14.8	.26	10.96	.113	.1062	340	72.4	225.9
	9												
3	1	0	18	75	4.7	15.1	0.72	11.14	0.144	0.0035	261	25.7	2.1
	2	20	16	234	14.8	14.8	.21	10.96	.115	.1031	263	68.4	203.8
	3	46	10	408	24.9	15.4	.35	11.62	.157	.1598	593	147.8	494.6
	4	20	16	238	14.8	15.1	.26	11.30	.121	.1072	305	69.6	204.8
	5	5	19	172	10.6	15.2	.21	10.96	.042	.0242	182	18.2	34.5
	6	20	16	249	15.1	15.5	.21	11.14	.125	.1052	264	74.6	208.6
	7	81	3	630	38.1	15.5	1.97	10.66	.200	.1274	5,378	269.6	570.4
	8	20	16	244	15.5	14.8	.26	10.96	.120	.1153	340	74.5	237.6
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

TABLE C-5. - Initial baseline No. 1 for engine No. 23 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
				Exhaust flow	Fuel flow		volume percent				grams/hr		
							CO	CO_2	HC	NO_x*	CO	HC	NO_x**
4	1	0	18	75	4.7	15.1	0.72	11.14	0.144	0.0035	261	25.7	2.1
	2	20	16	234	14.9	14.8	.26	10.96	.122	.1123	316	72.7	222.3
	3	46	10	395	24.1	15.4	.35	10.96	.160	.1719	677	152.6	544.6
	4	20	16	237	14.6	15.3	.26	10.96	.121	.1112	310	71.0	215.9
	5	5	19	170	10.4	15.4	.17	11.14	.037	.0243	147	15.4	33.6
	6	20	16	245	14.9	15.5	.21	10.96	.150	.1072	253	89.6	212.7
	7	81	3	589	38.1	14.6	1.89	10.79	.205	.1274	5,128	275.1	567.8
	8	20	16	236	15.0	14.8	.26	10.96	.119	.1133	319	71.5	226.0
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

Cycle emission rates, Federal weighting factors (5)

CO, gm/bhp-hr	37.6
HC, gm/bhp-hr	3.9
NO_x as NO_2, gm/bhp-hr	9.1

TABLE C-6. - Initial baseline No. 2 for engine No. 23 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
				Exhaust flow	Fuel flow		volume percent				grams/hr		
							CO	CO_2	HC	NO_x*	CO	HC	NO_x**
1	1	0	18	68	4.3	14.7	0.57	12.50	0.165	0.0042	170	24.3	2.1
	2	23	16	279	16.5	15.9	.13	11.93	.145	.1204	161	89.0	245.3
	3	48	10	419	25.1	15.7	.18	11.80	.155	.1877	341	145.5	585.1
	4	23	16	265	15.8	15.8	.18	11.80	.132	.1335	215	78.5	262.6
	5	9	19	188	11.1	15.9	.18	11.93	.076	.0324	150	31.4	44.5
	6	23	16	262	15.6	15.8	.18	11.93	.130	.1234	210	75.2	237.1
	7	85	3	605	40.3	14.0	1.80	11.80	.203	.1679	4,825	269.8	739.3
	8	23	16	264	15.7	15.8	.18	11.93	.120	.1355	212	69.9	262.3
	9												
2	1	0	18	68	4.3	14.7	0.57	12.50	0.165	0.0042	170	24.3	2.1
	2	23	16	252	15.0	15.8	.18	11.93	.125	.1341	202	69.5	247.8
	3	48	10	406	24.6	15.5	.22	11.93	.150	.2023	404	136.2	610.0
	4	23	16	256	15.3	15.7	.18	11.93	.130	.1456	206	73.8	274.4
	5	9	19	190	11.3	15.8	.18	11.93	.075	.0485	153	31.6	67.8
	6	23	16	256	15.3	15.7	.18	11.93	.138	.1359	206	78.5	255.9
	7	85	3	642	40.1	14.0	1.80	11.62	.208	.1618	4,861	277.8	717.8
	8	23	16	261	15.6	15.7	.18	11.93	.128	.1456	210	74.1	279.8
	9												
3	1	0	18	66	4.2	14.6	0.92	11.93	0.188	0.0040	276	28.0	2.0
	2	23	16	259	15.5	15.7	.18	11.80	.138	.1529	211	80.1	294.8
	3	48	10	408	24.9	15.4	.26	11.80	.159	.2023	486	147.5	621.5
	4	23	16	256	15.4	15.6	.18	11.80	.138	.1456	210	79.6	278.9
	5	9	19	183	11.0	15.6	.18	11.80	.077	.0460	150	32.1	63.3
	6	23	16	261	15.7	15.6	.18	11.62	.150	.1416	217	89.5	280.5
	7	85	3	595	40.2	13.8	2.02	11.44	.213	.1537	5,453	285.0	681.5
	8	23	16	256	15.5	15.5	.18	11.80	.136	.1456	211	79.3	280.7
	9												

* Measured by chemiluminescence.

**NO_x as NO_2.

TABLE C-6. - Initial baseline No. 2 for engine No. 23 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
				Exhaust flow	Fuel flow		volume percent				grams/hr		
							CO	CO_2	HC	NO_x*	CO	HC	NO_x**
4	1	0	18	66	4.2	14.6	0.92	11.93	0.188	0.0040	276	28.0	2.0
	2	23	16	257	15.5	15.6	.18	11.62	.145	.1416	212	84.4	273.7
	3	48	10	400	24.4	15.4	.28	11.62	.163	.1934	520	149.7	589.9
	4	23	16	253	15.4	15.4	.22	11.62	.147	.1456	259	85.7	282.0
	5	9	19	183	11.0	15.6	.18	11.62	.080	.0445	153	33.6	62.1
	6	23	16	257	15.6	15.5	.18	11.62	.155	.1375	215	91.5	269.5
	7	85	3	589	40.1	13.7	2.06	11.30	.215	.1456	5,584	288.2	648.3
	8	23	16	251	15.2	15.5	.22	11.62	.143	.1340	256	82.7	256.3
	9												

* Measured by chemiluminescence.
** NO_x as NO_2.

Cycle emission rates, Federal weighting factors (5).

CO, gm/bhp-hr	32.1
HC, gm/bhp-hr	3.6
NO_x as NO_2, gm/bhp-hr	10.4

TABLE C-7. - Final baseline No. 1 for engine No. 23 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO_x*	CO	HC	NO_x**
1	1	0	18	70	4.5	14.7	0.88	11.68	0.330	0.0037	283	46.2	2.1
	2	24	16	243	14.5	15.8	.13	11.77	.175	.0934	146	84.1	179.6
	3	48	10	393	23.8	15.5	.18	11.77	.170	.1453	318	133.7	457.1
	4	24	16	232	14.2	15.4	.18	11.85	.162	.1515	198	75.5	282.3
	5	9	19	168	10.4	15.1	.23	12.30	.130	.0374	173	42.7	49.1
	6	24	16	238	14.4	15.6	.14	11.94	.155	.1079	152	73.0	203.3
	7	84	3	525	35.0	14.0	1.85	11.42	.192	.1212	4,418	199.8	504.6
	8	24	16	223	14.1	14.9	.31	12.03	.158	.1204	320	71.3	217.5
	9												
2	1	0	18	70	4.5	14.7	0.88	11.68	0.330	0.0037	283	46.2	2.1
	2	24	16	226	13.9	15.3	.22	11.94	.150	.1370	228	66.8	247.6
	3	48	10	354	21.5	15.5	.22	11.77	.147	.1806	358	104.2	512.5
	4	24	16	227	13.8	15.5	.18	11.77	.140	.1203	194	63.9	219.8
	5	9	19	160	9.8	15.3	.31	11.85	.100	.0415	226	31.9	53.1
	6	24	16	229	13.9	15.5	.18	11.77	.146	.1289	195	67.1	237.2
	7	84	3	525	35.3	13.9	2.02	11.42	.190	.1421	4,800	197.0	589.5
	8	24	16	222	13.7	15.2	.22	11.94	.145	.1453	225	64.6	258.9
	9												
3	1	0	18	70	4.6	14.2	1.23	11.85	0.140	0.0083	394	19.5	4.7
	2	24	16	225	13.7	15.4	.18	11.94	.145	.1394	190	64.8	249.3
	3	48	10	355	21.7	15.4	.22	11.85	.150	.1847	359	106.5	524.9
	4	24	16	225	13.7	15.4	.19	11.94	.145	.1307	199	64.7	233.5
	5	9	19	158	9.6	15.5	.31	11.94	.095	.0415	220	29.5	51.6
	6	24	16	230	14.2	15.2	.18	11.85	.147	.1370	198	68.5	255.5
	7	84	3	526	35.5	13.8	2.09	11.42	.187	.1432	4,926	193.9	594.0
	8	24	16	224	13.7	15.3	.22	11.77	.145	.1457	228	65.5	263.4
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

TABLE C-7. - Final baseline No. 1 for engine No. 23 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO_x*	CO	HC	NO_x**
4	1	0	18	70	4.6	14.2	1.23	11.85	0.140	0.0083	394	19.5	4.7
	2	24	16	225	13.7	15.4	.18	11.85	.144	.1441	191	64.8	259.4
	3	48	10	356	21.8	15.3	.23	11.77	.149	.1942	378	107.0	558.3
	4	24	16	223	13.6	15.4	.19	11.85	.145	.1453	199	64.7	259.4
	5	9	19	154	9.5	15.3	.32	11.94	.097	.0457	224	29.8	56.2
	6	24	16	228	13.9	15.4	.18	11.94	.151	.1422	192	68.4	257.7
	7	84	3	516	34.7	13.9	2.13	11.42	.192	.1443	4,944	194.0	583.3
	8	24	16	224	13.8	15.3	.22	11.94	.150	.1577	227	67.3	283.0
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

Cycle emission rates, Federal weighting factors (5)

CO, gm/bhp-hr 33.8

HC, gm/bhp-hr 3.1

NO_x as NO_2, gm/bhp-hr 10.1

TABLE C-8. - Final baseline No. 2 for engine No. 23 (9-mode cycle)

Cycle No.	Mode	Observed power, bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO_x*	CO	HC	NO_x**
1	1	0	18	71	4.6	14.5	1.04	12.30	0.165	0.0045	325	22.5	2.4
	2	24	16	243	14.7	15.5	.18	12.13	.150	.1121	191	70.8	211.8
	3	48	10	391	23.9	15.4	.20	12.13	.152	.1712	356	116.5	525.0
	4	24	16	232	14.2	15.3	.18	12.30	.150	.1349	182	67.4	242.8
	5	9	19	176	10.9	15.2	.39	12.21	.100	.0384	306	34.3	52.8
	6	24	16	240	14.6	15.4	.18	12.13	.146	.1287	190	68.5	241.6
	7	84	3	527	35.5	13.8	2.09	11.77	.182	.1370	4,868	184.1	554.4
	8	24	16	224	13.9	15.1	.26	12.13	.145	.1453	269	64.3	257.9
	9												
2	1	0	18	71	4.6	14.5	1.04	12.30	0.165	0.0045	325	22.5	2.4
	2	24	16	227	13.9	15.3	.20	12.13	.144	.1411	207	64.2	251.8
	3	48	10	350	21.5	15.3	.26	12.13	.145	.1931	416	99.5	530.1
	4	24	16	226	13.8	15.4	.20	11.94	.141	.1453	209	63.4	261.2
	5	9	19	164	10.1	15.2	.34	12.03	.095	.0447	256	30.8	57.9
	6	24	16	230	14.0	15.4	.20	12.13	.145	.1401	209	65.1	251.8
	7	84	3	528	35.6	13.8	2.12	11.60	.187	.1432	4,992	191.6	597.0
	8	24	16	226	13.9	15.2	.26	12.13	.143	.1453	269	63.4	257.9
	9												
3	1	0	18	73	4.8	14.1	1.41	12.13	0.135	0.0083	454	18.9	4.7
	2	24	16	225	13.8	15.3	.22	12.13	.150	.1483	223	66.3	262.3
	3	48	10	354	21.7	15.3	.23	12.13	.152	.2024	365	104.1	412.1
	4	24	16	225	13.8	15.3	.22	12.13	.152	.1474	223	67.1	260.6
	5	9	19	156	9.6	15.2	.32	12.13	.100	.0498	223	30.6	61.0
	6	24	16	233	14.3	15.3	.20	12.13	.155	.1422	213	71.0	260.8
	7	84	3	528	35.7	13.8	2.16	11.68	.192	.1418	5,064	195.4	577.5
	8	24	16	225	13.9	15.2	.26	12.13	.147	.1504	269	65.2	267.0
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

TABLE C-8. - Final baseline No. 2 for engine No. 23 (9-mode cycle) (Cont'd)

Cycle No.	Mode	Observed power bhp	Manifold vacuum, in. Hg	lb/hr		A/F	Emissions						
							volume percent				grams/hr		
				Exhaust flow	Fuel flow		CO	CO_2	HC	NO_x*	CO	HC	NO_x**
4	1	0	18	73	4.8	14.1	1.41	12.13	0.135	0.0083	454	18.9	4.7
	2	24	16	226	13.9	15.3	.23	12.13	.150	.1475	234	66.7	262.5
	3	48	10	356	21.9	15.3	.26	12.13	.155	.2075	424	108.3	580.0
	4	24	16	222	13.7	15.2	.22	12.13	.155	.1536	222	68.0	269.4
	5	9	19	155	9.6	15.2	.33	12.13	.100	.0508	235	30.6	62.1
	6	24	16	228	14.0	15.3	.22	12.13	.157	.1473	227	70.3	264.2
	7	84	3	515	34.9	13.8	2.20	11.60	.193	.1473	5,046	192.7	588.5
	8	24	16	227	14.0	15.2	.28	12.13	.150	.1536	289	66.9	274.1
	9												

* Measured by chemiluminescence.

** NO_x as NO_2.

Cycle emission rates, Federal weighting factor (5)

CO, gm/bhp-hr 36.5

HC, gm/bhp-hr 3.0

NO_x as NO_2, gm/bhp-hr 10.2

APPENDIX D. -- RESULTS FROM THE INVESTIGATION OF THE EFFECT OF ENGINE AND EMISSION CONTROL PARAMETERS ON EXHAUST EMISSIONS FROM HEAVY DUTY DIESEL ENGINES (7-MODE CYCLE)

TABLE D-1. - The effect of various engine parameters on exhaust emissions using a simplified 7-mode cycle

[Engine No. 15]

STANDARD ENGINE (Average of two tests)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	525	0.4	82.8	60.2	50.8	2.0	0.8
2	1,700	2.6	392	212	109	8.4	.8
6	1,700	76.7	134	196	718	29.0	1.0
10	1,700	150.2	744	122	1,045	55.8	15.2
13	2,800	209.8	1,587	76	1,486	86.0	12.9
17	2,800	103.4	308	310	926	45.2	1.9
21	2,800	1.7	872	548	174	19.3	.9

7-mode cycle emission rates

CO (g/bhp-hr)	8.00
HC (g/bhp-hr)	3.12
NO_x (g/bhp-hr)	8.54
BSFC (lb/bhp-hr)	.461
Smoke (% opacity)	3.6

STANDARD ENGINE WITH ENGELHARD CATALYST (Average of two tests)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	525	0.3	59.2	44.4	29.4	1.7	1.0
2	1,700	.7	429	232	88	8.0	.5
6	1,700	75.2	24	95	842	30.2	.5
10	1,700	148.2	66	28	1,124	56.8	13.5
13	2,800	207.9	138	32	1,603	84.2	13.0
17	2,800	104.0	53	114	1,042	46.8	1.5
21	2,800	3.0	291	236	184	18.4	1.0

7-mode cycle emission rates

CO (g/bhp-hr)	2.29
HC (g/bhp-hr)	1.69
NO_x (g/bhp-hr)	9.26
BSFC (lb/bhp-hr)	.465
Smoke (% opacity)	3.4

TABLE D-1. - The effect of various engine parameters on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 15]

3° RETARDED INJECTION TIMING

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	525	0	59.9	60.7	26.0	3.0	3.3
2	1,700	3.9	318	249	63	10.0	2.7
6	1,700	71.2	197	227	399	30.0	2.5
10	1,700	142.4	723	88	593	58.5	17.0
13	2,800	202.1	902	54	824	85.0	13.5
17	2,800	100.2	416	274	485	46.0	3.0
21	2,800	3.7	877	743	89	22.0	2.0

7-mode cycle emission rates

CO (g/bhp-hr)	7.02
HC (g/bhp-hr)	3.59
NO_x (g/bhp-hr)	4.88
BSFC (lb/bhp-hr)	.503
Smoke (% opacity)	5.4

6° RETARDED INJECTION TIMING (Average of three tests)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	525	0	60.8	79.8	20.4	1.3	1.0
2	1,700	1	405	371	52	8.1	1.0
6	1,700	70	282	229	335	27.4	.5
10	1,700	139	828	50	499	56.4	17.5
13	2,800	190	679	36	717	85.0	7.0
17	2,800	95	760	288	394	46.3	2.0
21	2,800	1	1,328	1,913	72	25.5	1.0

7-mode cycle emission rates

CO (g/bhp-hr)	9.12
HC (g/bhp-hr)	6.46
NO_x (g/bhp-hr)	4.34
BSFC (lb/bhp-hr)	.512
Smoke (% opacity)	3.3

TABLE D-1. The effect of various engine parameters on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 15]

STANDARD ENGINE WITH 5 PERCENT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	% EGR
1	550	0	71.5	53.7	38.0	2.0	0.6	6.7
2	1,700	0	405	254	78	8.2	.6	5.9
6	1,700	74	150	198	504	28.4	.6	5.1
10	1,700	148	603	85	670	56.0	22.0	5.1
13	2,800	206	1,599	42	882	86.0	21.5	5.5
17	2,800	103	303	279	635	44.6	1.1	6.0
21	2,800	1	843	554	132	19.0	.6	5.9

7-mode cycle emission rates

CO (g/bhp-hr)	7.87
HC (g/bhp-hr)	3.06
NO_x (g/bhp-hr)	5.74
BSFC (lb/bhp-hr)	.470
Smoke (% opacity)	4.9

STANDARD ENGINE WITH 10 PERCENT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	% EGR
1	550	0	72.6	48.4	35.7	2.0	0.6	11.4
2	1,700	0	380	250	69	8.0	.6	10.2
6	1,700	73	154	185	424	28.2	1.1	10.5
10	1,700	146	1,267	106	410	56.0	32.4	10.6
13	2,800	203	2,302	35	548	85.2	31.4	11.0
17	2,800	101	296	249	517	43.6	1.1	10.2
21	2,800	1	714	429	140	18.0	.6	9.8

7-mode cycle emission rates

CO (g/bhp-hr)	10.31
HC (g/bhp-hr)	2.76
NO_x (g/bhp-hr)	4.30
BSFC (lb/bhp-hr)	.471
Smoke (% opacity)	7.0

TABLE D-1. - The effect of various engine parameters on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 15]

STANDARD ENGINE WITH 15 PERCENT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	% EGR
1	550	0	75.3	48.4	33.8	2.0	1.1	15.5
2	1,700	1	386	218	74	7.9	1.1	13.2
Note--5	1,700	36	225	165	220	17.1	.6	12.5
10	1,700	144	2,045	105	311	56.1	47.8	13.4
13	2,800	197	3,166	43	394	84.6	38.0	14.2
17	2,800	99	327	230	390	43.5	1.1	13.8
21	2,800	2	477	430	117	17.5	.6	13.2

NOTE. - Mode 5 was run instead of mode 6 by mistake, but the emissions are weighted accordingly.

7-mode cycle emission rates

CO (g/bhp-hr)	14.46
HC (g/bhp-hr)	2.89
NO_x (g/bhp-hr)	3.43
BSFC (lb/bhp-hr)	.490
Smoke (% opacity)	9.4

TABLE D-2. - The effect of fuel injection characteristics on exhaust emissions using a simplified 7-mode cycle

[Engine No. 17]

STANDARD ENGINE WITH STANDARD INJECTORS (Average of two tests)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	500	0	91.0	41.6	108.6	4.2	0.5
2	1,250	2	288	110	233	10.2	.5
6	1,250	84	84	101	1,554	35.0	.5
10	1,250	170	5,060	77	2,118	74.5	2.0
13	2,100	264	1,891	166	3,806	111.0	1.5
17	2,140	134	114	152	2,095	63.5	.5
21	2,140	6	208	190	531	24.2	.5

7-mode cycle emission rates

CO (g/bhp-hr)	12.13
HC (g/bhp-hr)	1.46
NO_x (g/bhp-hr)	16.32
BSFC (lb/bhp-hr)	.508
Smoke (% opacity)	.8

EXPERIMENTAL INJECTORS - STANDARD TIMING

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	500	0	27.6	22.0	96.8	4.5	0.6
2	1,200	2	138	86	200	10.0	.6
6	1,225	78	100	89	762	31.0	1.0
10	1,200	152	3,648	40	1,514	66.0	5.5
13	2,100	236	501	69	2,482	98.0	1.6
17	2,100	120	110	38	930	59.0	1.4
21	2,125	5	183	63	266	25.7	.6

7-mode cycle emission rates

CO (g/bhp-hr)	8.08
HC (g/bhp-hr)	.80
NO_x (g/bhp-hr)	11.03
BSFC (lb/bhp-hr)	.519
Smoke (% opacity)	1.3

TABLE D-2. - The effect of fuel injection characteristics on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 17]

EXPERIMENTAL INJECTORS - TIMING RETARDED 1.7 DEGREES

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	500	0	62.7	24.4	73.4	4.0	0
2	1,250	1	268	116	114	10.0	0
6	1,250	83	90	35	690	32.0	.5
10	1,200	160	6,326	39	1,354	74.0	15.4
13	2,100	264	1,429	67	2,662	111.7	1.6
17	2,100	132	108	41	984	63.2	.7
21	2,100	0	277	100	212	23.2	.6

7-mode cycle emission rates

CO (g/bhp-hr)	13.67
HC (g/bhp-hr)	.77
NO_x (g/bhp-hr)	9.86
BSFC (lb/bhp-hr)	.516
Smoke (% opacity)	1.9

EXPERIMENTAL INJECTORS - TIMING RETARDED 3.4 DEGREES
(Average of two tests)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	500	0	82.7	34.7	53.6	3.2	0.3
2	1,175	3	400	264	88	9.8	.2
6	1,175	78	106	59	580	32.0	0
10	1,200	159	6,806	41	1,194	74.0	20.4
13	2,100	260	1,555	60	2,184	110.0	3.0
17	2,100	130	108	30	782	62.5	.9
21	2,100	6	376	158	190	25.2	.2

7-mode cycle emission rates

CO (g/bhp-hr)	15.22
HC (g/bhp-hr)	1.18
NO_x (g/bhp-hr)	8.23
BSFC (lb/bhp-hr)	.513
Smoke (% opacity)	2.6

TABLE D-2. - The effect of fuel injection characteristics on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 17]

EXPERIMENTAL INJECTORS - TIMING RETARDED 5.1 DEGREES

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	500	0	106.0	37.9	46.6	3.3	0.5
2	1,200	0	529	456	60	10.9	1.2
6	1,250	83	130	69	506	35.0	1.0
10	1,200	160	6,640	95	1,123	73.3	23.7
13	2,100	250	1,275	126	1,925	110.6	3.8
17	2,125	127	120	73	695	63.2	2.4
21	2,125	0	278	293	170	25.3	1.6

7-mode cycle emission rates

CO (g/bhp-hr)	15.15
HC (g/bhp-hr)	2.01
NO_x (g/bhp-hr)	7.53
BSFC (lb/bhp-hr)	.534
Smoke (% opacity)	3.6

TABLE D-3. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle

[Engine No. 19]

INJECTION TIMING 26° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	78.7	64.5	19.1	2.3	1.6
2	2,200	1	472	596	37	13.8	.9
6	2,200	68	564	486	173	31.5	2.8
10	2,200	136	269	120	681	54.0	9.4
13	3,000	165	485	109	637	71.0	6.9
17	3,000	82	933	774	229	47.0	3.0
21	3,000	1	508	506	61	24.0	2.1

7-mode cycle emission rates

CO (g/bhp-hr)	7.83
HC (g/bhp-hr)	6.29
NO_x (g/bhp-hr)	4.18
BSFC (lb/bhp-hr)	.553
Smoke (% opacity)	3.2

INJECTION TIMING 28° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	76.9	58.4	28.6	2.0	1.4
2	2,200	1	432	443	37	12.5	.8
6	2,200	68	562	417	311	31.0	1.8
10	2,200	137	226	152	802	53.5	7.7
13	3,000	167	412	132	862	70.0	7.1
17	3,000	83	879	633	270	45.5	3.0
21	3,000	1	452	410	70	22.5	2.1

7-mode cycle emission rates

CO (g/bhp-hr)	7.16
HC (g/bhp-hr)	5.30
NO_x (g/bhp-hr)	5.40
BSFC (lb/bhp-hr)	.532
Smoke (% opacity)	2.8

TABLE D-3. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle (Cont'd)

[Engine No. 19]

INJECTION TIMING 30° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	87.2	62.1	35.8	2.3	1.5
2	2,200	0	383	306	48	12.0	.3
6	2,200	69	473	397	395	30.6	1.6
10	2,200	137	238	152	955	53.6	7.9
13	3,000	169	303	158	951	69.6	6.5
17	3,000	84	793	567	352	44.2	1.8
21	3,000	1	388	345	89	21.5	.6

7-mode cycle emission rates

CO (g/bhp-hr)	6.36
HC (g/bhp-hr)	4.72
NO_x (g/bhp-hr)	6.38
BSFC (lb/bhp-hr)	.523
Smoke (% opacity)	2.5

INJECTION TIMING 32° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	86.0	56.6	43.1	2.1	1.5
2	2,200	0	357	259	67	11.4	.6
6	2,200	69	456	353	476	31.0	1.1
10	2,200	137	312	168	1,095	53.5	7.7
13	3,000	169	326	156	1,160	69.7	7.7
17	3,000	85	762	469	437	43.0	2.8
21	3,000	1	356	302	108	19.8	.3

7-mode cycle emission rates

CO (g/bhp-hr)	6.32
HC (g/bhp-hr)	4.19
NO_x (g/bhp-hr)	7.63
BSFC (lb/bhp-hr)	.514
Smoke (% opacity)	2.6

TABLE D-3. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle (Cont'd)

[Engine No. 19]

INJECTION TIMING 34° BEFORE TOP CENTER (BTC)
Manufacturer's recommended setting (Average of three tests)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	63.1	37.5	50.1	2.9	1.0
2	2,200	2	352	225	81	12.5	.8
6	2,200	70	458	339	493	31.0	1.4
10	2,200	139	521	157	1,145	54.6	9.1
13	3,000	174	350	160	1,194	71.3	7.1
17	3,000	87	892	465	452	44.2	2.7
21	3,000	2	351	254	123	21.1	1.9

7-mode cycle emission rates

CO (g/bhp-hr)	6.68
HC (g/bhp-hr)	3.69
NO_x (g/bhp-hr)	7.78
BSFC (lb/bhp-hr)	.519
Smoke (% opacity)	2.7

INJECTION TIMING 36° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	87.5	52.9	64.7	2.2	1.7
2	2,200	1	344	188	115	10.6	.8
6	2,200	67	605	370	591	30.4	2.2
10	2,200	135	885	203	1,546	53.0	14.1
13	3,000	172	406	169	1,494	69.6	6.6
17	3,000	86	745	393	634	42.3	1.8
21	3,000	1	291	181	168	18.4	.9

7-mode cycle emission rates

CO (g/bhp-hr)	7.85
HC (g/bhp-hr)	3.71
NO_x (g/bhp-hr)	10.40
BSFC (lb/bhp-hr)	.505
Smoke (% opacity)	3.3

TABLE D-3. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle (Cont'd)

[Engine No. 19]

INJECTION TIMING 38° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	82.3	42.5	69.1	2.6	1.9
2	2,200	1	379	183	120	11.4	.4
6	2,200	67	753	368	578	31.0	3.9
10	2,200	134	1,415	301	1,356	54.5	18.2
13	3,000	172	839	204	1,631	71.0	9.9
17	3,000	86	768	370	663	42.4	2.8
21	3,000	1	316	161	199	18.5	1.6

7-mode cycle emission rates

CO (g/bhp-hr)	10.41
HC (g/bhp-hr)	3.81
NO_x (g/bhp-hr)	10.46
BSFC (lb/bhp-hr)	.519
Smoke (% opacity)	4.4

INJECTION TIMING 40° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	91.7	41.8	72.9	2.5	2.8
2	2,200	1	377	172	148	11.4	1.1
6	2,200	65	914	400	647	30.7	5.5
10	2,200	131	1,901	343	1,640	54.5	23.6
13	3,000	169	1,254	229	1,808	70.5	13.8
17	3,000	85	734	383	739	43.0	3.8
21	3,000	1	313	161	239	18.5	2.3

7-mode cycle emission rates

CO (g/bhp-hr)	12.96
HC (g/bhp-hr)	4.10
NO_x (g/bhp-hr)	12.20
BSFC (lb/bhp-hr)	.528
Smoke (% opacity)	6.1

TABLE D-3. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle (Cont'd)

[Engine No. 19]

INJECTION TIMING 42° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	93.9	43.3	82.5	2.5	5.5
2	2,200	1	433	177	169	11.5	.5
6	2,200	63	1,124	467	674	30.2	9.4
10	2,200	126	2,515	501	1,487	55.5	27.5
13	3,000	163	1,922	306	1,904	70.5	19.3
17	3,000	82	821	446	808	41.5	5.1
21	3,000	1	325	152	268	18.4	3.2

7-mode cycle emission rates

CO (g/bhp-hr)	17.24
HC (g/bhp-hr)	5.10
NO_x (g/bhp-hr)	12.18
BSFC (lb/bhp-hr)	.545
Smoke (% opacity)	8.7

INJECTION TIMING 44° BEFORE TOP CENTER (BTC)

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	98.5	40.8	89.9	2.4	6.6
2	2,200	1	378	163	189	11.0	2.5
6	2,200	61	1,306	516	710	29.6	9.9
10	2,200	121	3,311	584	1,468	54.5	31.9
13	3,000	159	2,787	357	1,929	70.5	24.8
17	3,000	79	982	407	875	42.4	7.2
21	3,000	1	334	146	303	18.5	2.6

7-mode cycle emission rates

CO (g/bhp-hr)	22.49
HC (g/bhp-hr)	5.54
NO_x (g/bhp-hr)	13.82
BSFC (lb/bhp-hr)	.559
Smoke (% opacity)	10.5

TABLE D-4. - The effect of exhaust gas recirculation (EGR) and injection timing on exhaust emissions using a simplified 7-mode cycle

[Engine No. 19]

STANDARD INJECTION TIMING 34° BEFORE TOP CENTER (BTC) WITH 5 PCT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	EGR, pct
1	600	0	77.5	46.1	53.9	2.4	0.8	6.7
2	2,200	1	360	223	82	11.5	.7	7.3
6	2,200	68	564	314	475	31.1	2.9	4.8
10	2,200	137	710	225	1,024	54.5	12.1	4.3
13	3,000	174	363	145	1,035	70.1	9.9	5.1
17	3,000	87	773	426	429	43.4	3.7	5.4
21	3,000	1	351	241	115	18.9	1.8	5.5

7-mode cycle emission rates

CO (g/bhp-hr)	7.33
HC (g/bhp-hr)	3.76
NO_x (g/bhp-hr)	7.21
BSFC (lb/bhp-hr)	.511
Smoke (% opacity)	3.4

STANDARD INJECTION TIMING 34° BEFORE TOP CENTER (BTC) WITH 10 PCT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	EGR, pct
1	600	0	78.9	45.8	38.8	2.3	1.3	13.6
2	2,200	0	335	196	71	11.3	1.0	12.0
6	2,200	67	422	291	369	30.6	2.8	9.7
10	2,200	135	846	173	710	54.6	16.5	10.1
13	3,000	173	696	131	684	71.0	13.8	11.0
17	3,000	86	807	434	335	43.4	2.6	12.0
21	3,000	1	336	222	102	19.2	1.9	13.2

7-mode cycle emission rates

CO (g/bhp-hr)	8.13
HC (g/bhp-hr)	3.53
NO_x (g/bhp-hr)	5.25
BSFC (lb/bhp-hr)	.518
Smoke (% opacity)	4.4

TABLE D-4. - The effect of exhaust gas recirculation (EGR) and injection timing on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 19]

STANDARD INJECTION TIMING 34° BEFORE TOP CENTER (BTC) WITH 15 PCT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	EGR, pct
1	600	0	66.6	33.4	32.1	2.2	0.4	19.0
2	2,200	0	317	159	62	11.3	.3	18.2
6	2,200	66	481	266	268	30.1	3.1	16.8
10	2,200	133	1,451	188	394	53.5	30.8	15.8
13	3,000	166	1,115	120	386	70.2	19.9	15.8
17	3,000	83	770	393	241	42.1	3.0	16.8
21	3,000	1	326	193	81	19.0	.7	17.0

7-mode cycle emission rates

CO (g/bhp-hr)	10.53
HC (g/bhp-hr)	3.24
NO_x (g/bhp-hr)	3.48
BSFC (lb/bhp-hr)	.523
Smoke (% opacity)	5.9

ADVANCED INJECTION TIMING 36° BEFORE TOP CENTER (BTC) WITH 5 PCT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	EGR, pct
1	600	0	86.6	44.9	53.9	2.4	0.6	7.0
2	2,200	0	352	193	101	11.0	.4	6.6
6	2,200	67	576	323	500	30.6	1.7	4.5
10	2,200	134	1,157	205	1,152	54.6	16.6	4.0
13	3,000	174	699	159	1,199	70.1	9.9	5.0
17	3,000	87	744	422	505	42.5	2.8	5.5
21	3,000	1	320	186	140	18.8	.9	5.5

7-mode cycle emission rates

CO (g/bhp-hr)	9.06
HC (g/bhp-hr)	3.60
NO_x (g/bhp-hr)	8.23
BSFC (lb/bhp-hr)	.512
Smoke (% opacity)	3.5

TABLE D-4. - The effect of exhaust gas recirculation (EGR) and injection timing on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 19]

ADVANCED INJECTION TIMING 36° BEFORE TOP CENTER (BTC) WITH 10 PCT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	EGR, pct
1	600	0	88.6	46.2	47.5	2.2	2.2	15.2
2	2,200	0	348	178	92	11.0	1.6	15.0
6	2,200	67	638	311	412	30.3	5.0	9.9
10	2,200	134	1,412	200	807	54.0	24.8	9.9
13	3,000	171	920	133	824	71.0	16.0	10.7
17	3,000	86	776	342	397	43.4	4.4	11.4
21	3,000	1	329	181	123	18.5	2.4	12.0

7-mode cycle emission rates

CO (g/bhp-hr)	10.41
HC (g/bhp-hr)	3.33
NO_x (g/bhp-hr)	6.20
BSFC (lb/bhp-hr)	.516
Smoke (% opacity)	6.3

ADVANCED INJECTION TIMING 36° BEFORE TOP CENTER (BTC) WITH 15 PCT EGR

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity	EGR, pct
1	600	1	75.5	33.1	45.8	2.3	1.5	18.7
2	2,200	1	325	157	81	10.7	.4	17.7
6	2,200	65	630	281	298	29.4	4.5	16.5
10	2,200	130	2,014	258	458	53.6	38.5	15.4
13	3,000	166	1,521	123	474	70.5	24.1	15.7
17	3,000	83	711	332	291	42.4	3.4	16.6
21	3,000	1	290	154	103	18.3	.8	16.6

7-mode cycle emission rates

CO (g/bhp-hr)	12.87
HC (g/bhp-hr)	3.19
NO_x (g/bhp-hr)	4.20
BSFC (lb/bhp-hr)	.520
Smoke (% opacity)	7.0

TABLE D-5. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle (standard pump and nozzles)

[Engine No. 20]

STANDARD TIMING

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	328	153	43.6	3.0	0.6
2	1,400	5	442	324	302	12.5	.4
6	1,400	135	209	262	1,875	53.5	2.8
10	1,400	271	1,770	102	3,761	102.8	8.6
13	2,400	290	935	300	4,440	137.8	2.8
17	2,400	145	376	458	1,482	81.2	6.4
21	2,400	6	325	693	300	33.3	1.7

7-mode cycle emission rates

CO (g/bhp-hr)	6.30
HC (g/bhp-hr)	3.23
NO_x (g/bhp-hr)	14.48
BSFC (lb/bhp-hr)	.508
Smoke (% opacity)	2.5

TIMING RETARDED 3 DEGREES

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	205	117	79.1	3.8	1.0
2	1,400	5	323	305	241	12.5	1.0
6	1,400	134	190	257	1,382	54.7	4.2
10	1,400	267	1,765	116	2,981	105.5	12.2
13	2,400	287	1,336	195	3,194	139.0	5.5
17	2,400	142	428	435	1,078	81.0	7.7
21	2,400	7	336	551	302	35.0	5.0

7-mode cycle emission rates

CO (g/bhp-hr)	6.17
HC (g/bhp-hr)	2.73
NO_x (g/bhp-hr)	11.28
BSFC (lb/bhp-hr)	.526
Smoke (% opacity)	4.0

TABLE D-6. - The effect of aftercooling on exhaust emissions using a simplified 7-mode cycle

[Engine No. 20]

TIMING RETARDED 3 DEGREES
Maximum inlet air temperature = 250° F

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	208	112	83.7	3.7	0.5
2	1,400	5	355	287	260	13.7	.5
6	1,400	137	203	245	1,423	55.5	3.9
10	1,400	275	1,819	138	3,166	105.5	13.2
13	2,400	292	941	301	2.327	138.6	8.0
17	2,400	148	452	452	996	85.3	8.8
21	2,400	6	315	481	326	33.0	4.4

7-mode cycle emission rates

CO (g/bhp-hr)	5.70
HC (g/bhp-hr)	2.73
NO_x (g/bhp-hr)	10.23
BSFC (lb/bhp-hr)	.517
Smoke (% opacity)	4.1

TIMING RETARDED 3 DEGREES
Maximum inlet air temperature = 200° F

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	208	112	83.7	3.7	0.5
2	1,400	5	355	287	260	13.7	.5
6	1,400	138	203	245	1,423	55.5	3.9
10	1,400	275	1,819	138	3,166	105.5	13.2
13	2,400	295	933	355	1,966	138.0	6.6
17	2,400	148	452	452	996	85.3	8.8
21	2,400	6	315	481	326	33.0	4.4

7-mode cycle emission rates

CO (g/bhp-hr)	5.66
HC (g/bhp-hr)	2.78
NO_x (g/bhp-hr)	9.77
BSFC (lb/bhp-hr)	.514
Smoke (% opacity)	3.9

TABLE D-6. - The effect of aftercooling on exhaust emissions using a simplified 7-mode cycle (Cont'd)

[Engine No. 20]

TIMING RETARDED 3 DEGREES Maximum inlet air temperature = 150° F							
Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	600	0	208	112	83.7	3.7	0.5
2	1,400	5	355	287	260	13.7	.5
6	1,400	138	203	245	1,423	55.5	3.9
10	1,400	276	1,171	142	2,648	105.0	10.2
13	2,400	295	1,001	340	1,797	140.0	6.8
17	2,400	148	460	528	792	84.0	8.8
21	2,400	5	336	593	280	31.0	3.3

7-mode cycle emission rates

CO (g/bhp-hr)	5.03
HC (g/bhp-hr)	2.98
NO_x (g/bhp-hr)	8.69
BSFC (lb/bhp-hr)	.512
Smoke (% opacity)	3.6

TABLE D-7. - The effect of injection timing on exhaust emission using a simplified 7-mode cycle (special pump and nozzle kit)

[Aftercooler installed - no cooling water]

[Engine No. 20]

STANDARD TIMING

Mode	Speed, rpm	Power bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel, lb/hr	Smoke, % opacity
1	700	0	92.0	73.8	203	4.3	0.3
2	1,400	5	93	109	524	13.7	.6
6	1,400	136	306	212	1,889	54.7	2.9
10	1,400	271	1,333	116	3,771	103	6.6
13	2,400	311	800	239	3,543	140	5.5
17	2,400	155	420	362	1,675	86	3.5
21	2,400	5	167	180	606	36	2.6

7-mode cycle emission rates

CO (g/bhp-hr)	3.95
HC (g/bhp-hr)	1.71
NO_x (g/bhp-hr)	14.51
BSFC (lb/bhp-hr)	.510
Smoke (% opacity)	2.3

TIMING RETARDED 3 DEGREES

Mode	Speed, rpm	Power, bhp	CO, g/hr	HC, g/hr	NO_x, g/hr	Fuel lb/hr	Smoke, % opacity
1	700	0	69.1	55.3	225	3.8	0.3
2	1,400	5	101	98	455	13.0	.3
6	1,400	137	264	215	1,469	58.0	4.4
10	1,400	271	1,019	138	3,154	103.5	7.7
13	2,400	302	950	234	2,619	140.5	6.7
17	2,400	151	513	370	1,282	84.1	7.9
21	2,400	5	210	197	455	37.5	7.2

7-mode cycle emission rates

CO (g/bhp-hr)	3.83
HC (g/bhp-hr)	1.69
NO_x (g/bhp-hr)	11.86
BSFC (lb/bhp-hr)	.519
Smoke (% opacity)	3.5

APPENDIX E. -- RESULTS FROM TESTS USING COMBINATIONS OF PARAMETERS FOR REDUCED EMISSIONS FOR HEAVY DUTY DIESEL ENGINES (23-MODE CYCLE)

TABLE E-1 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 15 -- STD. TIMING, 10% EGR, AND ENGELHARD CATALYST (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.4	337	2.8	1.0	464	323	129	68.6	24.0	31.3
2	1700	2.9	993	9.0	1.0	802	528	103	349.0	115.3	73.7
3	1700	11.7	995	11.0	1.0	758	500	177	330.3	109.4	126.8
4	1700	26.2	999	15.0	1.0	538	481	262	235.5	105.7	188.1
5	1700	36.6	1001	17.5	1.0	317	447	353	139.2	98.4	254.6
6	1700	73.2	1012	28.5	1.5	74	361	581	33.0	80.4	423.4
7	1700	109.4	1025	41.0	3.5	55	366	671	24.7	82.5	495.3
8	1700	119.8	1029	45.0	5.0	63	352	700	28.3	79.7	518.7
9	1700	134.3	1035	51.0	14.0	108	352	665	49.2	80.1	495.5
10	1700	149.9	1199	56.4	15.0	149	265	1151	78.1	69.9	993.1
11	550	0.4	334	2.5	2.0	481	419	136	70.3	30.7	32.6
12*											
13	2800	205.3	1815	86.4	16.0	272	177	1128	216.2	70.7	1473.2
14	2800	185.0	1465	72.5	11.0	168	228	656	108.2	73.5	692.3
15	2800	164.7	1459	66.0	9.0	127	243	667	81.0	78.0	701.0
16	2800	150.9	1454	61.0	6.0	109	285	655	69.8	91.1	685.7
17	2800	100.2	1433	45.0	2.0	103	304	532	64.6	95.8	548.7
18	2800	50.1	1418	30.0	1.5	172	304	337	107.1	94.8	343.6
19	2800	36.3	1416	27.5	1.5	206	328	268	127.5	102.2	273.6
20	2800	16.0	1410	22.0	1.5	281	438	175	173.6	135.9	178.1
21	2800	4.3	1413	20.0	1.5	449	656	135	277.9	203.9	137.1
22	550	0.2	334	2.2	1.0	432	524	141	63.3	38.5	33.9
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 2.06 GM/BHP-HR
BSHC 1.24 GM/BHP-HR
BSNO2 5.36 GM/BHP-HR
BSFC 0.453 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.6 MMHG
HUMIDITY 60 GRAINS/LB
MAX. INLET RESTRICTION 21.0 "H2O
MAX. EXHAUST BACK PRESSURE 34.6 "H2O
INLET AIR TEMP. RANGE 63F - 72F
MAX. EXHAUST TEMP. 1322F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-2 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 15 -- TIMING RETARDED 3 DEGREES, 5% EGR, AND ENGELHARD CATALYST (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.1	392	2.0	1.0	371	471	103	63.8	40.7	29.1
2	1700	2.9	1095	8.7	1.0	680	780	98	326.4	188.0	77.2
3	1700	11.3	1094	10.5	1.0	688	722	139	330.0	173.7	109.7
4	1700	25.6	1094	15.0	1.0	552	660	212	264.9	160.4	166.9
5	1700	35.6	1097	17.5	1.0	395	520	264	189.8	125.5	208.5
6	1700	71.5	1108	28.5	1.0	94	381	476	45.5	92.9	379.4
7	1700	107.1	1110	31.0	1.0	66	331	628	32.1	80.9	501.9
8	1700	115.6	1123	43.5	2.0	64	272	649	31.7	67.2	524.6
9	1700	131.4	1131	52.0	9.0	108	213	638	53.8	53.0	519.6
10	1700	144.7	1136	57.0	16.5	169	150	813	84.2	37.5	665.6
11	550	0.4	391	2.0	1.0	352	471	108	60.4	40.5	30.4
12*											
13	2800	202.6	1672	85.0	11.5	196	90	821	144.0	33.1	987.7
14	2800	181.3	1552	74.5	10.0	190	83	578	129.0	28.3	645.2
15	2800	161.5	1553	66.0	8.0	160	135	557	109.2	46.1	622.6
16	2800	148.2	1548	61.0	6.5	153	216	548	104.0	73.6	610.6
17	2800	98.6	1532	45.0	2.5	162	290	405	108.5	97.7	446.7
18	2800	49.6	1514	32.0	2.0	223	428	240	147.9	142.6	261.9
19	2800	35.7	1515	28.5	1.0	250	578	184	166.1	192.7	200.8
20	2800	16.0	1516	24.0	1.0	300	935	115	199.3	311.8	125.1
21	2800	3.7	1513	21.5	1.0	444	1650	83	294.4	549.3	90.2
22	550	0.3	386	2.0	1.0	371	761	103	63.2	65.0	28.8
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 2.28 GM/BHP-HR
BSHC 1.59 GM/BHP-HR
BSNO2 4.69 GM/BHP-HR
BSFC 0.461 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.0 MMHG
HUMIDITY 53 GRAINS/LB
MAX. INLET RESTRICTION 25.0 "H20
MAX. EXHAUST BACK PRESSURE 41.6 "H20
INLET AIR TEMP. RANGE 63F - 76F
MAX. EXHAUST TEMP. 1430F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-3 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 15 -- TIMING RETARDED 3 DEGREES, 10%EGR, AND ENGELHARD CATALYST (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT CPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.4	337	2.0	1.0	384	565	108	56.8	41.9	26.2
2	1700	2.8	995	8.5	1.0	684	1015	93	298.2	222.1	66.7
3	1700	11.0	1051	11.0	1.0	737	985	130	339.7	227.8	98.4
4	1700	24.9	1059	15.0	1.0	577	870	187	267.8	202.7	142.5
5	1700	34.3	1061	17.5	1.0	344	705	226	160.1	164.6	173.0
6	1700	68.9	1017	27.5	1.5	101	477	392	45.0	106.7	287.2
7	1700	103.6	1028	39.0	2.8	72	415	493	32.4	93.9	365.4
8	1700	111.7	1032	42.5	4.5	71	336	477	32.2	76.3	354.2
9	1700	125.6	1039	50.0	10.0	101	228	463	45.9	52.1	346.3
10	1700	144.4	1150	58.5	17.6	157	140	786	79.2	35.4	650.1
11	550	0.4	337	2.0	3.0	408	611	106	60.3	45.3	25.7
12*											
13	2800	203.1	1700	86.0	12.5	189	103	773	140.5	38.5	946.9
14	2800	175.4	1472	71.5	13.2	221	135	438	142.6	43.7	464.8
15	2800	155.7	1466	65.0	9.0	183	155	439	117.8	50.0	463.0
16	2800	144.5	1458	62.0	8.0	172	228	428	110.1	73.2	449.0
17	2800	96.5	1441	45.0	5.0	181	290	328	114.1	92.0	340.6
18	2800	48.5	1428	31.5	2.2	226	425	217	141.6	133.5	223.4
19	2800	34.7	1478	28.5	1.6	262	550	169	169.9	178.8	179.3
20	2800	15.5	1479	24.5	1.5	322	896	105	208.6	291.5	112.2
21	2800	3.7	1476	21.5	1.5	410	1270	83	264.9	412.4	88.0
22	550	0.2	337	2.0	2.0	403	725	104	59.6	53.8	25.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 2.33 GM/BHP-HR
BSHC 1.82 GM/BHP-HR
BSNO2 3.78 GM/BHP-HR
BSFC 0.470 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 748.0 MMHG
HUMIDITY 53 GRAINS/LB
MAX. INLET RESTRICTION 25.0 "H20
MAX. EXHAUST BACK PRESSURE 41.6 "H20
INLET AIR TEMP. RANGE 64F - 72F
MAX. EXHAUST TEMP. 1430F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-4 COMBINATION OF PARAMETERS NO. 3 (REPLICATE OF TEST IN TABLE E-3) FOR ENGINE NO. 15 -- TIMING RETARDED 3 DEGREES, 10% EGR, AND ENGELHARD CATALYST (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.4	336	2.0	1.7	408	570	105	60.1	42.1	25.4
2	1700	2.8	992	9.0	1.0	744	988	90	323.5	215.5	64.3
3	1700	11.0	990	10.5	1.0	776	913	123	336.7	198.8	87.5
4	1700	24.9	1048	14.5	1.0	672	846	178	308.5	195.0	134.4
5	1700	34.3	1050	17.0	1.0	446	599	217	205.3	138.4	164.4
6	1700	68.9	1061	27.5	1.0	110	466	384	51.1	108.8	293.1
7	1700	103.6	1073	40.0	2.0	76	438	467	35.6	103.4	361.2
8	1700	112.0	1076	42.5	3.3	75	361	483	35.5	85.4	373.8
9	1700	125.9	1079	49.0	8.0	101	285	480	47.9	67.6	373.0
10	1700	143.7	1129	56.5	18.7	173	162	718	85.5	40.2	584.0
11	550	0.4	335	2.0	2.0	398	551	105	58.5	40.6	25.3
12*											
13	2800	191.9	1680	87.0	12.0	216	171	731	158.7	63.2	883.7
14	2800	174.3	1456	74.0	12.0	244	109	379	155.6	34.9	397.5
15	2800	155.7	1448	65.5	8.5	206	143	384	131.0	45.5	400.6
16	2800	143.9	1496	61.5	6.5	193	233	379	126.5	76.7	408.7
17	2800	96.0	1475	44.5	3.3	198	304	294	127.9	98.6	312.3
18	2800	48.0	1467	32.0	3.0	252	447	184	162.2	144.3	194.7
19	2800	34.7	1463	28.0	3.0	280	570	147	179.3	183.5	154.3
20	2800	15.5	1459	24.0	2.8	335	856	96	214.5	274.8	100.9
21	2800	3.7	1456	21.0	2.5	467	1350	75	298.0	432.4	78.6
22	550	0.2	332	2.0	3.0	413	707	95	60.0	51.6	22.8
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 2.54 GM/BHP-HR
BSHC 1.79 GM/BHP-HR
BSNO2 3.52 GM/BHP-HR
BSFC 0.475 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.4 MMHG
HUMIDITY 60 GRAINS/LB
MAX. INLET RESTRICTION 25.0 "H2O
MAX. EXHAUST BACK PRESSURE 41.6 "H2O
INLET AIR TEMP. RANGE 64F - 75F
MAX. EXHAUST TEMP. 1455F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-5 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 16 -- STD. TIMING, 10% EGR, AND NO AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.2	295	1.4	3.8	458	123	98	59.2	8.0	20.8
2	1600	3.7	847	9.0	5.5	303	70	116	112.6	13.0	70.7
3	1600	14.3	846	11.0	5.5	214	50	163	79.5	9.3	99.6
4	1600	32.3	906	16.0	5.5	135	53	290	53.6	10.6	189.4
5	1600	44.5	905	18.5	5.5	134	63	421	53.2	12.6	274.5
6	1600	89.3	971	32.6	7.7	140	80	542	59.4	17.1	379.2
7	1600	134.0	1131	49.0	10.0	127	62	355	63.1	15.4	288.9
8	1600	146.5	1181	53.4	12.2	190	46	322	98.4	11.9	273.6
9	1600	164.5	1282	61.0	17.6	329	37	302	185.0	10.4	278.8
10	1600	178.5	1379	70.0	17.5	530	30	317	320.1	9.1	315.2
11	550	0.2	291	1.4	4.5	401	116	127	51.2	7.4	26.7
12*											
13	2200	245.9	2044	99.0	6.6	150	30	399	134.4	13.5	587.3
14	2200	226.2	1866	89.0	6.6	119	23	440	97.2	9.4	591.0
15	2200	201.5	1757	80.5	7.5	104	28	451	80.1	10.8	570.3
16	2200	184.3	1654	72.0	7.5	90	33	444	65.2	12.0	529.0
17	2200	123.2	1363	50.4	3.3	91	47	438	54.6	14.1	429.6
18	2200	61.6	1195	30.0	5.5	133	53	365	69.5	13.9	314.2
19	2200	44.4	1194	25.5	6.5	174	65	288	91.1	17.1	247.6
20	2200	19.7	1139	19.3	5.5	220	55	167	110.0	13.8	136.9
21	2200	5.0	1136	15.5	5.5	265	62	125	132.1	15.5	102.1
22	550	0.2	294	2.5	2.2	1209	2769	107	156.0	179.4	22.6
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.09 GM/BHP-HR
BSHC 0.37 GM/BHP-HR
BSNO2 3.33 GM/BHP-HR
BSFC 0.421 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 730.2 MMHG
HUMIDITY 70 GRAINS/LB
MAX. INLET RESTRICTION 26.5 "H20
MAX. EXHAUST BACK PRESSURE 18.5 "H20
INLET AIR TEMP. RANGE 91F -101F
MAX. EXHAUST TEMP. 1139F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-6 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 16 -- STD. TIMING, 10% EGR, AND 15CF AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.1	283	1.9	0.5	565	545	87	70.2	34.0	17.7
2	1600	5.2	816	9.0	2.5	337	91	111	120.7	16.3	65.3
3	1600	14.6	872	12.0	3.3	253	62	154	96.6	11.9	96.4
4	1600	32.9	885	17.0	3.3	144	60	278	55.9	11.7	177.1
5	1600	45.7	930	20.0	3.8	120	77	417	48.7	15.8	279.1
6	1600	91.4	1000	34.0	5.5	139	77	528	61.1	16.9	380.5
7	1600	137.1	1156	50.0	7.5	136	60	364	69.2	15.3	302.8
8	1600	149.9	1206	55.0	9.5	194	55	332	102.7	14.6	287.9
9	1600	168.2	1314	64.5	12.0	271	48	336	156.0	13.9	318.2
10	1600	182.8	1398	70.0	13.0	353	41	319	216.5	12.6	320.9
11	550	0.1	286	1.5	1.5	485	177	97	60.9	11.1	20.0
12*											
13	2200	246.7	2048	98.0	4.4	108	41	344	96.9	18.5	507.1
14	2200	227.0	1926	88.0	4.4	99	37	369	84.0	15.7	511.8
15	2200	201.9	1775	77.0	4.4	91	36	376	70.8	14.1	480.3
16	2200	184.7	1680	70.0	4.0	91	37	396	67.2	13.7	479.1
17	2200	123.2	1419	48.0	3.5	93	41	428	57.8	12.8	436.7
18	2200	61.6	1217	30.0	4.0	118	46	348	62.8	12.3	305.1
19	2200	44.4	1172	25.0	4.5	151	53	272	77.6	13.7	229.3
20	2200	19.7	1165	18.5	5.5	203	51	170	103.8	13.1	142.6
21	2200	5.0	1162	15.0	5.5	267	65	121	135.9	16.6	101.0
22	550	0.1	291	1.5	2.0	556	560	97	70.9	35.8	20.3
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 0.99 GM/BHP-HR
BSHC 0.23 GM/BHP-HR
BSNO2 3.07 GM/BHP-HR
BSFC 0.414 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 737.5 MMHG
HUMIDITY 88 GRAINS/LB
MAX. INLET RESTRICTION 28.0 "H20
MAX. EXHAUST BACK PRESSURE 19.0 "H20
INLET AIR TEMP. RANGE101F -114F
MAX. EXHAUST TEMP. 1195F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-7 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 16 -- TIMING RETARDED 5 DEGREES, 10% EGR, AND NO AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CC PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.2	299	2.0	1.0	807	575	80	105.6	37.8	17.3
2	1600	3.7	856	10.0	1.0	610	286	80	229.0	53.9	49.1
3	1600	14.3	860	11.0	1.0	492	190	126	185.4	35.9	78.1
4	1600	32.3	865	16.5	1.0	298	133	258	113.0	25.3	160.9
5	1600	45.1	867	21.0	1.0	209	116	369	79.5	22.1	230.6
6	1600	89.9	1029	35.0	2.0	112	80	433	50.3	18.1	320.6
7	1600	134.7	1153	53.0	3.5	155	54	308	78.5	13.7	255.5
8	1600	147.4	1201	59.0	5.5	246	41	306	129.3	10.8	264.1
9	1600	165.4	1299	67.0	10.0	459	34	282	261.4	9.7	264.0
10	1600	179.7	1392	74.5	12.0	603	20	281	367.9	6.1	281.5
11	550	0.2	293	2.0	1.0	653	368	114	83.8	23.7	24.0
12*											
13	2200	240.0	1971	99.5	2.2	165	26	407	142.9	11.3	578.3
14	2200	221.2	1893	93.0	2.2	142	22	439	117.5	9.2	598.2
15	2200	196.9	1740	84.5	2.4	115	26	431	87.6	10.0	539.8
16	2200	180.1	1629	75.0	3.3	104	27	403	74.2	9.7	472.9
17	2200	120.2	1364	51.0	3.3	101	44	381	60.7	13.2	373.8
18	2200	59.9	1143	30.0	3.0	208	77	304	104.3	19.4	250.3
19	2200	43.1	1149	25.5	3.0	270	92	243	136.1	23.3	200.9
20	2200	19.3	1094	18.5	2.5	409	143	144	196.3	34.4	113.1
21	2200	5.0	1094	15.0	2.0	496	196	98	237.7	47.2	77.1
22	2200	0.0	299	2.0	1.0	789	708	76	103.3	46.5	16.3
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.51 GM/BHP-HR
BSHC 0.34 GM/BHP-HR
BSNO2 3.05 GM/BHP-HR
BSFC 0.447 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 732.4 MMHG
HUMIDITY 58 GRAINS/LB
MAX. INLET RESTRICTION 24.5 "H2O
MAX. EXHAUST BACK PRESSURE 18.5 "H2O
INLET AIR TEMP. RANGE 88F -101F
MAX. EXHAUST TEMP. 1280F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-8 COMBINATION OF PARAMETERS NO. 4 FOR ENGINE NO. 16 -- TIMING RETARDED 5 DEGREES, 10% EGR, AND 150F AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.2	317	3.0	3.0	1393	2890	48	193.7	201.7	10.9
2	1600	3.7	901	9.5	2.5	754	638	57	297.5	126.4	36.9
3	1600	14.9	907	12.6	2.4	607	414	104	241.4	82.6	67.7
4	1600	34.1	909	17.5	2.0	370	243	224	147.3	48.6	146.4
5	1600	47.2	965	21.6	2.0	271	183	324	114.6	38.8	225.1
6	1600	94.4	1027	35.5	2.2	126	116	374	56.8	26.2	276.5
7	1600	141.7	1252	53.4	3.3	124	91	283	68.0	25.1	254.9
8	1600	154.8	1305	59.1	5.0	158	80	281	90.6	23.0	264.1
9	1600	173.6	1406	66.3	6.6	162	58	280	100.0	17.9	283.3
10	1600	188.9	1511	73.6	7.7	201	56	261	133.2	18.6	284.3
11	550	0.2	326	2.5	2.2	1049	1465	48	149.9	105.1	11.2
12*											
13	2200	245.5	2126	98.6	3.3	96	67	285	89.2	31.3	435.7
14	2200	226.2	2127	93.1	4.4	90	58	291	83.8	27.1	445.5
15	2200	201.1	2007	80.0	5.0	94	56	303	82.3	24.7	437.1
16	2200	183.9	1843	73.1	5.5	94	62	294	75.6	25.1	389.8
17	2200	122.7	1778	52.5	4.4	124	72	328	96.6	28.2	420.0
18	2200	61.2	1455	31.6	5.5	244	116	278	155.4	37.1	291.4
19	2200	44.4	1252	26.5	4.4	401	166	200	220.1	45.7	180.0
20	2200	19.7	1203	19.7	4.4	554	248	117	292.0	65.6	101.5
21	2200	4.6	1199	16.0	4.4	652	494	76	342.5	130.3	65.2
22	550	0.2	313	2.7	2.2	1135	1000	48	155.7	68.8	10.7
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.92 GM/BHP-HR
BSHC 0.67 GM/BHP-HR
BSNO2 2.55 GM/BHP-HR
BSFC 0.438 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 737.0 MMHG
HUMIDITY 63 GRAINS/LB
MAX. INLET RESTRICTION 29.0 "H20
MAX. EXHAUST BACK PRESSURE 21.0 "H20
INLET AIR TEMP. RANGE 70F - 85F
MAX. EXHAUST TEMP. 1121F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-9 COMBINATION OF PARAMETERS NO. 4 (REPLICATE OF TEST IN TABLE E-8) FOR ENGINE NO. 16 -- TIMING RETARDED 5 DEGREES, 10% EGR, AND 150F AFTER-COOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	550	0.2	309	2.5	1.1	1235	1055	49	167.4	71.8	10.9
2	1600	3.7	885	10.0	2.2	713	465	68	276.8	90.6	43.2
3	1600	14.9	888	12.5	2.2	577	313	116	224.6	61.1	73.9
4	1600	33.5	896	17.5	1.5	352	182	238	138.4	35.9	153.5
5	1600	47.2	950	21.0	2.2	258	147	341	107.4	30.7	233.2
6	1600	94.1	1016	35.5	2.0	122	99	386	54.5	22.1	282.6
7	1600	141.4	1236	55.0	4.4	159	73	283	86.0	19.9	252.1
8	1600	154.1	1237	60.0	6.6	296	54	254	160.7	14.7	226.1
9	1600	173.0	1391	70.0	8.8	319	41	253	194.6	12.5	253.0
10	1600	188.3	1436	74.0	8.8	294	37	263	185.2	11.7	272.4
11	550	0.2	304	2.5	2.2	862	1520	73	115.1	101.8	16.0
12*											
13	2200	244.6	2117	99.0	2.2	112	58	295	103.8	27.0	449.8
14	2200	224.9	2002	90.0	1.1	100	60	301	87.4	26.4	433.6
15	2200	200.6	1921	82.0	3.3	97	64	303	82.0	27.0	418.3
16	2200	183.5	1771	72.0	3.3	92	66	318	71.1	25.7	405.0
17	2200	122.3	1481	50.0	3.3	130	79	343	84.5	25.7	365.8
18	2200	62.0	1255	30.0	3.3	247	120	269	136.0	33.1	242.8
19	2200	45.2	1252	27.0	3.3	341	147	209	187.3	40.5	187.9
20	2200	19.7	1197	21.0	2.5	553	257	115	289.9	67.7	98.9
21	2200	5.0	1196	16.0	2.5	671	397	72	351.9	104.4	62.3
22	550	0.2	326	2.5	1.1	1183	970	49	169.0	69.5	11.4
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.83 GM/BHP-HR
BSHC 0.64 GM/BHP-HR
BSNO2 2.52 GM/BHP-HR
BSFC 0.434 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 736.0 MMHG
HUMIDITY 72 GRAINS/LB
MAX. INLET RESTRICTION 28.5 "H2O
MAX. EXHAUST BACK PRESSURE 21.0 "H2O
INLET AIR TEMP. RANGE 68F - 91F
MAX. EXHAUST TEMP. 0F

* ENGINE NOT TESTED IN MOTORED MODES
EXHAUST TEMPERATURE NOT MONITORED FOR THIS TEST.

TABLE E-10 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 17 -- STD. TIMING WITH EXPERIMENTAL INJECTORS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	843	4.5	0.6	75	119	160	27.8	22.1	97.3
2	1200	2.3	1973	10.0	0.6	159	199	140	137.8	86.4	199.5
3	1200	13.7	1970	13.0	0.6	212	279	170	183.2	120.9	241.1
4	1175	25.5	1915	15.8	1.0	229	273	227	192.4	115.0	313.3
5	1225	40.8	2036	21.0	1.0	193	262	298	172.1	117.3	436.2
6	1225	78.1	2032	31.0	1.0	112	199	520	100.1	89.0	761.5
7	1150	107.7	1992	41.6	1.5	137	182	902	119.5	79.8	1294.0
8	1200	125.7	1987	49.2	1.8	273	131	1020	238.1	57.3	1458.7
9	1250	145.2	1988	56.0	3.3	1085	108	1083	945.5	47.2	1550.5
10	1200	151.9	1991	66.0	5.5	4191	91	1059	3658.8	39.9	1518.4
11	500	0.0	775	4.0	0.6	88	44	155	29.9	7.5	86.8
12*											
13	2100	235.9	3276	98.0	1.6	348	95	1051	499.9	68.5	2478.2
14	2150	222.3	3287	94.0	1.6	219	82	954	315.9	59.3	2256.7
15	2150	198.1	3274	87.0	1.6	127	76	827	181.8	54.7	1948.6
16	2100	177.1	3236	78.0	1.6	89	57	704	126.7	40.6	1640.3
17	2100	120.0	3206	59.0	1.4	78	54	402	109.6	38.1	927.7
18	2100	59.2	3208	40.0	1.0	104	59	212	146.7	41.6	490.5
19	2125	42.9	3253	35.5	1.0	113	63	168	161.8	45.1	394.6
20	2125	19.0	3232	29.3	0.8	132	78	131	186.4	55.5	305.6
21	2125	4.9	3254	25.7	0.6	128	88	114	182.5	63.0	266.3
22	500	0.0	825	5.0	0.4	88	104	168	31.8	18.9	99.8
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.99 GM/BHP-HR
BSHC 0.81 GM/BHP-HR
BSNO2 10.44 GM/BHP-HR
BSFC 0.490 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.7 MMHG
HUMIDITY 80 GRAINS/LB
MAX. INLET RESTRICTION 26.0 "H2O
MAX. EXHAUST BACK PRESSURE 55.4 "H2O
INLET AIR TEMP. RANGE 79F - 91F
MAX. EXHAUST TEMP. 791F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-11 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 17 -- TIMING RETARDED 3.4 DEGREES WITH EXPERIMENTAL INJECTORS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	808	2.5	0.0	232	226	90	82.0	40.2	52.2
2	1150	3.1	2086	10.0	0.0	462	614	58	422.0	281.8	86.5
3	1150	13.1	1930	12.0	0.5	404	396	103	341.6	168.1	143.1
4	1250	30.9	2088	18.5	0.6	356	264	188	325.3	121.3	282.9
5	1200	41.1	2044	20.7	0.0	277	175	246	248.4	78.7	361.5
6	1150	74.9	1996	32.0	0.0	121	132	398	105.8	58.0	571.8
7	1200	121.1	1998	46.5	1.5	196	157	678	171.8	69.0	975.5
8	1175	129.8	2004	52.8	3.8	661	163	783	580.7	71.9	1129.4
9	1150	141.2	1945	58.8	10.0	3052	96	847	2602.2	41.1	1185.6
10	1200	159.9	2005	73.0	21.5	7950	96	807	6986.7	42.3	1164.6
11	500	0.0	795	3.0	0.0	231	133	91	80.6	23.3	51.9
12*											
13	2100	259.9	3369	110.0	2.7	993	66	879	1466.6	48.9	2133.0
14	2150	245.6	3368	105.0	1.5	478	60	817	705.9	44.5	1980.5
15	2150	217.0	3324	92.0	1.0	174	54	672	252.8	39.5	1607.4
16	2150	200.6	3330	88.0	0.8	114	54	593	167.0	39.6	1421.7
17	2100	131.9	3305	63.0	0.8	73	36	328	105.8	26.2	780.1
18	2125	62.7	3320	42.0	0.8	122	48	169	177.3	35.1	404.3
19	2100	48.0	3300	36.5	0.5	162	60	143	234.7	43.6	340.2
20	2100	22.0	3326	30.0	0.5	229	126	103	333.5	92.2	247.6
21	2100	4.8	3300	25.5	0.5	266	221	76	384.4	160.4	180.7
22	500	0.0	848	3.5	0.5	231	276	90	85.9	51.5	54.7
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.64 GM/BHP-HR
BSHC 0.97 GM/BHP-HR
BSNO2 7.84 GM/BHP-HR
BSFC 0.480 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.5 MMHG
HUMIDITY 76 GRAINS/LB
MAX. INLET RESTRICTION 27.0 "H2O
MAX. EXHAUST BACK PRESSURE 55.4 "H2O
INLET AIR TEMP. RANGE 73F - 83F
MAX. EXHAUST TEMP. 895F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-12 COMBINATION OF PARAMETERS NO. 2 (REPLICATE OF TEST IN TABLE E-11) FOR ENGINE NO. 17 -- TIMING RETARDED 3.4 DEGREES WITH EXPERIMENTAL INJECTORS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	500	0.0	845	4.0	0.6	227	159	92	84.1	29.6	56.3
2	1200	3.2	1986	9.5	0.5	433	558	63	376.8	243.9	90.1
3	1250	14.3	2101	14.0	0.6	394	364	99	362.5	168.2	150.0
4	1200	29.7	1994	17.5	0.5	309	228	193	270.5	100.0	277.8
5	1200	38.8	2049	21.0	0.2	282	205	238	253.4	92.4	351.3
6	1200	80.0	2002	32.0	0.0	121	137	407	106.2	60.4	586.7
7	1200	121.1	2019	48.5	1.6	239	137	683	211.2	60.9	992.5
8	1200	132.5	2030	53.0	3.3	632	125	772	562.5	55.8	1128.0
9	1250	154.2	2079	64.0	10.1	2769	104	845	2523.9	47.6	1265.6
10	1200	158.1	2071	75.0	19.2	7306	89	825	6631.6	40.5	1230.6
11	500	0.0	829	4.0	1.1	218	118	87	79.2	21.5	52.2
12*											
13	2100	259.9	3331	110.0	3.3	1114	95	927	1626.9	69.6	2223.3
14	2100	239.9	3283	104.0	2.5	606	69	887	871.6	49.8	2096.4
15	2100	212.7	3262	93.0	2.3	194	64	734	277.3	45.9	1723.7
16	2100	196.7	3255	86.0	2.2	123	61	640	175.4	43.7	1500.7
17	2100	128.7	3241	62.0	1.0	78	46	335	110.6	32.8	782.2
18	2100	64.0	3256	41.5	0.0	131	58	183	186.3	41.5	428.8
19	2100	48.0	3272	36.5	0.0	175	75	156	250.9	54.0	368.5
20	2100	20.8	3254	29.0	0.0	234	127	106	333.4	90.9	247.8
21	2100	6.0	3271	25.0	0.0	266	215	84	381.2	154.7	197.4
22	500	0.0	840	4.0	0.0	218	261	98	80.2	48.2	59.0
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.84 GM/BHP-HR
BSHC 0.94 GM/BHP-HR
BSNO2 8.24 GM/BHP-HR
BSFC 0.485 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.4 MMHG
HUMIDITY 85 GRAINS/LB
MAX. INLET RESTRICTION 27.0 "H2O
MAX. EXHAUST BACK PRESSURE 55.4 "H2O
INLET AIR TEMP. RANGE 79F - 89F
MAX. EXHAUST TEMP. 925F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-13 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 19 -- STD. TIMING AND 10% EGR (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	296	2.5	1.1	719	669	197	93.2	43.6	42.0
2	2200	2.5	1064	12.0	0.5	737	711	111	343.6	166.4	85.1
3	2200	10.9	1039	13.5	0.5	667	572	169	303.8	130.8	126.3
4	2200	24.3	1070	18.0	1.0	330	356	314	154.9	83.8	241.7
5	2200	33.9	1073	21.0	1.5	298	669	416	140.0	157.9	321.3
6	2200	67.4	1072	30.5	2.2	1130	1168	471	530.8	275.4	363.6
7	2200	101.4	1081	40.0	5.5	847	584	630	401.3	138.9	490.5
8	2200	110.6	1085	43.5	6.1	734	525	715	349.1	125.3	558.2
9	2200	124.0	1089	48.0	12.7	1285	593	801	613.4	142.1	628.5
10	2200	140.3	1211	54.5	10.0	883	596	1403	468.6	158.7	1222.6
11	600	0.5	295	2.5	1.5	563	533	218	72.8	34.6	46.4
12*											
13	3000	174.2	1613	72.0	7.7	548	413	1055	387.2	146.6	1225.9
14	3000	155.4	1370	66.0	8.8	631	435	574	378.8	131.1	566.3
15	3000	138.8	1362	58.0	6.1	503	508	513	300.2	152.2	503.0
16	3000	126.8	1362	54.5	5.5	559	563	462	333.9	168.8	452.9
17	3000	84.5	1348	44.0	4.5	1388	643	323	819.7	190.6	313.6
18	3000	42.3	1341	33.5	3.3	892	2719	298	524.4	802.4	287.8
19	3000	30.3	1321	29.0	3.0	358	1631	279	207.5	474.2	265.7
20	3000	13.7	1319	22.5	1.7	403	571	178	233.3	165.7	168.8
21	3000	3.4	1317	20.0	1.1	506	684	115	292.0	198.1	109.5
22	600	0.5	295	2.0	1.5	607	653	222	78.3	42.3	47.1
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.41 GM/BHP-HR
BSHC 2.86 GM/BHP-HR
BSNO2 5.25 GM/BHP-HR
BSFC 0.509 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.0 MMHG
HUMIDITY 106 GRAINS/LB
MAX. INLET RESTRICTION 14.5 "H2O
MAX. EXHAUST BACK PRESSURE 31.9 "H2O
INLET AIR TEMP. RANGE 76F - 79F
MAX. EXHAUST TEMP. 1180F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-14 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 19 -- STD. TIMING AND 15% EGR (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	296	2.5	1.7	673	620	169	87.3	40.3	35.9
2	2200	2.5	988	12.0	1.1	685	696	109	296.5	151.2	77.6
3	2200	10.5	987	14.0	1.3	608	562	160	262.9	122.0	113.8
4	2200	23.0	991	18.0	2.2	348	375	277	150.9	81.7	197.7
5	2200	32.3	994	21.0	3.0	297	642	371	129.2	140.3	265.3
6	2200	64.5	1003	30.0	5.0	1238	1222	395	543.9	269.5	285.0
7	2200	96.3	1013	40.0	8.8	992	611	478	440.3	136.1	348.2
8	2200	105.6	993	43.0	11.0	983	526	529	427.7	114.9	377.8
9	2200	118.1	994	48.0	20.9	1799	678	559	784.2	148.3	400.4
10	2200	140.3	1213	54.5	10.0	883	596	1434	469.7	159.1	1252.9
11	600	0.5	295	2.5	2.2	625	553	196	80.8	35.9	41.6
12*											
13	3000	174.2	1616	72.0	7.7	548	413	1079	388.1	146.9	1256.2
14	3000	147.9	1268	65.0	16.5	1007	344	437	559.6	96.0	398.5
15	3000	131.4	1257	58.5	11.0	664	397	415	366.1	109.8	375.4
16	3000	120.5	1283	54.0	9.4	660	460	374	371.3	129.8	345.1
17	3000	80.5	1272	43.0	5.5	1564	937	283	872.0	262.2	259.3
18	3000	40.0	1262	33.5	5.5	978	1892	267	540.9	525.4	242.6
19	3000	29.1	1233	30.0	4.9	710	1678	264	383.5	455.1	234.4
20	3000	12.6	1230	23.0	3.3	351	468	168	189.3	126.6	149.0
21	3000	3.4	1227	20.5	2.4	514	518	118	276.5	139.9	104.0
22	600	0.0	296	2.5	2.8	647	584	185	83.8	38.0	39.4
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 6.32 GM/BHP-HR
BSHC 2.85 GM/BHP-HR
BSNO2 4.47 GM/BHP-HR
BSFC 0.531 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.6 MMHG
HUMIDITY 114 GRAINS/LB
MAX. INLET RESTRICTION 14.5 "H20
MAX. EXHAUST BACK PRESSURE 31.9 "H20
INLET AIR TEMP. RANGE 77F - 80F
MAX. EXHAUST TEMP. 1180F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-15 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 19 -- TIMING RETARDED 2 DEGREES AND 10% EGR (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	295	2.0	2.2	549	562	174	71.0	36.4	37.0
2	2200	2.5	1061	12.0	1.1	724	810	81	336.8	189.1	61.9
3	2200	11.3	1059	13.5	1.5	599	594	140	278.2	138.4	106.8
4	2200	24.3	1063	17.5	1.5	362	423	246	168.9	98.9	188.2
5	2200	33.5	1067	21.5	2.0	341	994	350	159.7	233.4	268.8
6	2200	67.0	1076	30.5	2.0	1063	1261	396	501.5	298.6	306.6
7	2200	100.9	1086	40.5	3.9	637	617	551	303.5	147.4	430.8
8	2200	110.2	1089	43.0	4.2	464	497	617	221.6	119.0	483.6
9	2200	123.6	1095	49.5	8.8	636	465	671	305.1	112.0	528.9
10	2200	137.4	1229	53.5	7.7	613	654	1345	330.0	176.8	1189.6
11	600	0.5	295	2.0	2.0	544	534	167	70.3	34.6	35.4
12*											
13	3000	169.1	1576	69.7	7.7	501	474	1116	346.1	164.4	1266.1
14	3000	151.4	1360	63.5	9.9	723	405	444	430.6	121.1	434.4
15	3000	134.8	1359	58.5	6.6	584	460	413	348.0	137.5	403.6
16	3000	123.4	1355	55.0	6.0	627	534	374	372.5	159.2	365.4
17	3000	82.3	1345	44.5	4.5	1477	1491	247	870.4	441.1	239.4
18	3000	41.1	1335	35.0	3.3	1068	3462	230	625.3	1017.1	221.3
19	3000	29.7	1330	30.0	2.2	449	2210	226	262.0	646.8	216.2
20	3000	13.1	1324	23.5	1.5	375	700	149	217.6	203.9	142.2
21	3000	3.4	1321	21.0	1.2	524	755	94	303.8	219.5	89.6
22	600	0.5	295	2.0	1.8	560	598	180	72.4	38.8	38.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.59 GM/BHP-HR
BSHC 3.62 GM/BHP-HR
BSNO2 4.49 GM/BHP-HR
BSFC 0.516 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.1 MMHG
HUMIDITY 113 GRAINS/LB
MAX. INLET RESTRICTION 14.5 "H2O
MAX. EXHAUST BACK PRESSURE 34.6 "H2O
INLET AIR TEMP. RANGE 76F - 80F
MAX. EXHAUST TEMP. 1214F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-16 COMBINATION OF PARAMETERS NO. 4 FOR ENGINE NO. 19 -- TIMING RETARDED 2 DEGREES AND 15% EGR (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	295	2.3	1.1	669	481	134	86.7	31.3	28.5
2	2200	2.5	984	12.0	0.5	695	621	80	300.0	134.5	56.5
3	2200	10.1	983	14.0	0.5	587	472	127	252.8	102.1	89.9
4	2200	23.0	986	17.3	1.1	370	340	221	160.1	73.8	156.8
5	2200	31.8	990	21.0	2.8	278	522	300	120.8	113.7	214.1
6	2200	63.7	999	30.0	3.8	1170	994	307	512.3	218.5	220.7
7	2200	95.5	983	39.5	7.7	883	497	370	380.4	107.4	261.5
8	2200	104.3	985	42.0	9.9	835	431	397	360.7	93.4	281.7
9	2200	117.3	991	48.0	19.8	1293	481	411	561.5	104.9	293.5
10	2200	137.4	1234	53.5	7.7	613	654	1326	331.5	177.5	1178.4
11	600	0.5	295	2.3	1.1	653	598	145	84.5	38.9	30.8
12*											
13	3000	169.1	1583	69.7	7.7	501	474	1101	347.7	165.1	1254.2
14	3000	144.5	1241	64.5	17.1	1174	350	301	638.9	95.6	268.9
15	3000	128.5	1260	57.5	11.0	850	414	294	469.5	114.8	266.5
16	3000	117.7	1259	53.0	8.8	836	534	268	461.8	148.0	243.5
17	3000	78.3	1250	43.5	6.0	1561	1712	195	855.1	470.8	175.7
18	3000	38.8	1241	34.5	4.9	1176	3498	179	639.5	955.0	159.8
19	3000	28.0	1238	31.5	3.3	671	3351	186	364.1	912.7	165.8
20	3000	12.6	1230	23.5	0.0	397	690	126	214.0	186.7	111.3
21	3000	3.4	1228	21.5	0.0	573	773	84	308.3	208.8	74.4
22	600	0.0	295	2.3	0.5	653	755	129	84.5	49.1	27.4
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 6.60 GM/BHP-HR
BSHC 3.81 GM/BHP-HR
BSNO2 3.53 GM/BHP-HR
BSFC 0.539 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.4 MMHG
HUMIDITY 108 GRAINS/LB
MAX. INLET RESTRICTION 14.5 "H20
MAX. EXHAUST BACK PRESSURE 34.6 "H20
INLET AIR TEMP. RANGE 77F - 79F
MAX. EXHAUST TEMP. 1214F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-17 COMBINATION OF PARAMETERS NO. 5 FOR ENGINE NO. 19 -- STD. TIMING AND UOP CATALYST.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	346	2.0	2.0	582	307	200	88.4	23.4	49.6
2	2200	2.5	1187	12.0	1.1	286	454	112	148.9	118.6	96.0
3	2200	10.9	1186	14.0	1.1	139	267	176	72.0	69.6	150.1
4	2200	24.3	1164	18.0	1.5	64	118	338	32.6	30.2	283.5
5	2200	33.9	1167	21.0	2.0	47	202	463	24.1	51.9	388.8
6	2200	67.4	1174	32.0	2.8	26	93	649	13.6	24.0	548.8
7	2200	101.4	1183	41.0	3.9	26	65	1039	13.5	16.9	884.7
8	2200	110.6	1186	44.0	5.5	30	67	1134	15.4	17.5	968.0
9	2200	124.0	1192	49.5	9.5	33	83	1346	17.2	21.8	1154.8
10	2200	134.9	1196	54.0	13.8	33	93	1532	17.1	24.5	1319.4
11	600	0.5	346	2.0	1.8	516	325	194	78.3	24.8	48.4
12*											
13	3000	165.6	1492	71.5	7.7	67	28	1168	43.5	9.2	1254.8
14	3000	152.5	1486	65.5	5.5	59	49	1053	38.4	16.0	1126.8
15	3000	135.9	1480	59.5	4.4	26	45	890	16.6	14.6	948.4
16	3000	124.5	1475	55.0	3.5	22	45	770	14.3	14.6	818.3
17	3000	82.8	1465	44.5	3.3	19	54	460	12.0	17.4	485.6
18	3000	41.7	1454	34.0	3.0	23	145	353	14.6	46.4	370.0
19	3000	29.7	1451	30.5	3.0	19	184	334	12.2	58.7	349.2
20	3000	13.1	1444	24.0	2.0	12	44	227	7.3	14.0	235.8
21	3000	3.4	1441	20.5	1.1	19	78	138	12.3	24.7	143.0
22	600	0.2	345	2.0	1.5	475	273	194	72.0	20.7	48.3
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 0.94 GM/BHP-HR
BSHC 0.67 GM/BHP-HR
BSNO2 8.10 GM/BHP-HR
BSFC 0.523 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.1 MMHG
HUMIDITY 109 GRAINS/LB
MAX. INLET RESTRICTION 15.5 "H20
MAX. EXHAUST BACK PRESSURE 74.8 "H20
INLET AIR TEMP. RANGE 79F - 83F
MAX. EXHAUST TEMP. 1285F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-18 COMBINATION OF PARAMETERS NO. 6 FOR ENGINE NO. 19 -- STD. TIMING WITH EXHAUST FLOW THROTTLED TO SIMULATE THE EXHAUST BACK-PRESSURE OF TEST IN TABLE E-17 (NOTE NO CATALYST WAS USED IN THIS TEST).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	5.1	373	3.0	1.0	528	508	181	86.5	41.7	48.7
2	2200	2.9	1165	13.0	1.0	628	657	121	320.6	168.5	101.6
3	2200	10.9	1167	14.5	1.0	579	541	173	296.2	138.9	145.1
4	2200	24.7	1171	19.0	1.0	278	348	345	142.5	89.7	290.6
5	2200	33.9	1175	22.5	1.5	387	1431	430	199.5	369.9	363.6
6	2200	68.3	1180	31.5	2.2	1201	1276	567	621.5	331.3	482.1
7	2200	102.2	1164	41.0	3.4	677	638	920	345.2	163.4	770.8
8	2200	111.8	1167	44.5	4.5	646	580	1070	330.7	149.0	899.1
9	2200	125.2	1173	50.0	10.0	1245	667	1239	640.2	172.1	1046.4
10	2200	136.1	1177	54.5	14.4	1853	706	1333	956.2	182.9	1130.1
11	600	0.5	373	2.5	1.0	545	522	181	89.0	42.8	48.7
12*											
13	3000	169.1	1531	72.5	8.2	1017	232	1112	682.5	78.2	1225.8
14	3000	155.4	1520	66.0	4.0	419	338	986	279.3	113.0	1079.1
15	3000	138.8	1514	60.0	3.0	396	406	822	263.1	135.2	895.8
16	3000	126.8	1511	56.5	2.2	453	425	723	299.9	141.2	786.7
17	3000	84.5	1499	44.5	2.2	1216	1044	436	798.6	344.2	470.8
18	3000	42.3	1463	35.0	2.2	833	2436	341	534.4	784.3	358.9
19	3000	30.3	1464	31.0	2.2	528	2397	320	338.9	772.1	336.9
20	3000	13.7	1456	23.0	1.4	345	416	211	219.9	133.3	221.0
21	3000	3.4	1454	21.0	1.1	424	512	144	270.4	163.8	150.5
22	600	0.2	373	2.5	1.0	545	541	180	89.0	44.4	48.2
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 5.63 GM/BHP-HR
BSHC 3.64 GM/BHP-HR
BSNO2 7.54 GM/BHP-HR
BSFC 0.522 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 748.0 MMHG
HUMIDITY 62 GRAINS/LB
MAX. INLET RESTRICTION 15.5 "H20
MAX. EXHAUST BACK PRESSURE 77.6 "H20
INLET AIR TEMP. RANGE 80F - 82F
MAX. EXHAUST TEMP. 1162F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-19 COMBINATION OF PARAMETERS NO. 7 FOR ENGINE NO. 19 -- STD. TIMING, 10% EGR, AND UOP CATALYST (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	318	2.0	1.1	525	266	190	73.3	18.6	43.6
2	2200	2.5	1051	11.0	1.1	316	406	100	145.6	93.8	75.5
3	2200	10.1	1053	13.5	0.5	146	231	160	67.4	53.5	121.4
4	2200	23.0	1053	17.0	1.1	31	90	307	14.3	20.9	232.8
5	2200	32.3	1056	20.0	1.6	23	148	409	10.7	34.4	310.8
6	2200	64.5	1066	30.0	3.3	23	92	481	10.6	21.6	368.9
7	2200	96.8	1050	39.5	6.6	18	57	664	8.5	13.2	501.7
8	2200	106.0	1053	42.5	7.7	18	57	722	8.5	13.2	547.1
9	2200	118.5	1059	48.0	15.4	22	87	790	10.1	20.3	602.1
10	2200	134.9	1193	54.0	13.8	33	93	1591	17.0	24.4	1366.0
11	600	0.5	318	2.0	2.2	475	235	207	66.2	16.5	47.4
12*											
13	3000	165.6	1488	71.5	7.7	67	28	1213	43.4	9.2	1299.1
14	3000	145.7	1349	65.0	9.9	25	43	591	14.9	12.8	574.1
15	3000	129.7	1338	58.0	6.6	22	42	541	12.8	12.4	521.5
16	3000	118.8	1334	54.0	5.5	18	38	493	10.7	11.2	473.6
17	3000	79.4	1327	43.0	3.3	19	55	333	10.9	16.1	318.4
18	3000	39.4	1318	33.5	3.3	27	171	290	15.3	49.6	275.3
19	3000	28.6	1289	30.0	2.8	27	218	286	15.1	61.8	265.5
20	3000	12.6	1286	23.0	1.6	12	46	202	6.5	13.0	187.1
21	3000	2.9	1283	20.0	1.1	19	66	121	10.9	18.6	111.5
22	600	0.5	317	2.0	1.6	535	255	207	74.4	17.8	47.3
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 0.85 GM/BHP-HR
BSHC 0.57 GM/BHP-HR
BSNO2 5.63 GM/BHP-HR
BSFC 0.530 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.0 MMHG
HUMIDITY 122 GRAINS/LB
MAX. INLET RESTRICTION 15.5 "H2O
MAX. EXHAUST BACK PRESSURE 74.8 "H2O
INLET AIR TEMP. RANGE 80F - 85F
MAX. EXHAUST TEMP. 1285F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-20 COMBINATION OF PARAMETERS NO. 7 (REPLICATE OF TEST IN TABLE E-19) FOR ENGINE NO. 19 -- STD. TIMING, 10% EGR, AND UCP CATALYST (NOTE EGR WAS CUTOFF DURING MODES 10 AND 13 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.5	317	2.5	1.0	621	490	188	86.3	34.2	42.9
2	2200	2.5	1046	12.0	1.0	348	530	100	159.4	122.0	75.1
3	2200	10.5	1044	13.0	1.0	184	330	146	84.3	75.8	109.4
4	2200	23.0	1045	17.5	1.7	43	200	289	19.9	46.0	217.0
5	2200	32.3	1048	21.0	1.7	38	250	397	17.6	57.7	299.9
6	2200	64.5	1032	30.0	3.3	38	205	448	17.0	46.5	333.1
7	2200	96.3	1041	39.0	5.5	30	120	595	13.5	27.5	446.1
8	2200	105.6	1044	42.0	7.2	29	120	649	13.4	27.6	487.6
9	2200	118.1	1053	47.5	15.4	33	125	724	15.0	28.9	548.8
10	2200	131.1	1183	54.0	12.1	44	85	1372	23.0	22.1	1169.0
11	600	0.5	317	2.5	1.1	524	255	197	72.8	17.8	45.0
12*											
13	3000	165.1	1475	71.5	8.3	48	50	1168	30.8	16.2	1241.1
14	3000	144.5	1316	64.0	10.5	40	60	545	23.3	17.4	516.4
15	3000	129.1	1310	58.0	8.3	33	65	503	18.8	18.7	474.2
16	3000	117.7	1306	54.0	6.6	29	60	453	16.7	17.2	426.4
17	3000	78.8	1295	42.5	4.4	30	90	323	16.9	25.6	301.4
18	3000	39.4	1286	33.5	3.3	38	190	292	21.3	53.7	270.1
19	3000	28.6	1282	30.0	3.3	34	215	275	19.3	60.6	254.0
20	3000	12.6	1275	23.0	1.1	23	60	193	12.9	16.8	177.2
21	3000	3.4	1272	20.0	1.1	31	75	126	17.3	21.0	115.3
22	600	0.2	317	2.5	1.7	524	255	190	72.8	17.8	43.3
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 0.98 GM/BHP-HR
BSHC 0.81 GM/BHP-HR
BSNO2 5.23 GM/BHP-HR
BSFC 0.535 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 740.0 MMHG
HUMIDITY 60 GRAINS/LB
MAX. INLET RESTRICTION 15.5 "H20
MAX. EXHAUST BACK PRESSURE 77.6 "H20
INLET AIR TEMP. RANGE 80F - 84F
MAX. EXHAUST TEMP. 1260F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-21 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 20 -- TIMING RETARDED 3 DEGREES, SPECIAL FUEL PUMP AND NOZZLE KIT, AND 200F AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	581	3.8	0.5	293	488	473	74.6	62.4	197.8
2	1400	5.3	1367	13.0	0.5	193	400	489	115.7	120.3	481.2
3	1400	21.3	1476	19.5	0.5	153	395	639	98.9	128.3	679.4
4	1400	49.3	1590	30.0	1.5	263	596	885	183.6	208.5	1013.2
5	1400	69.3	1594	34.0	2.2	328	579	963	229.2	203.0	1105.0
6	1400	137.3	1713	55.0	2.7	282	602	1186	211.7	226.8	1462.5
7	1400	206.6	2098	81.0	2.9	273	520	1631	251.2	240.0	2463.8
8	1400	225.2	2155	87.0	3.2	423	415	1747	399.7	196.7	2711.3
9	1400	253.2	2275	97.0	5.5	701	269	1812	699.3	134.6	2967.8
10	1400	274.6	2331	102.0	7.0	1087	240	1860	1110.1	123.1	3121.0
11	600	0.0	577	3.7	0.5	293	412	502	74.1	52.3	208.4
12*											
13	2400	297.0	4176	141.0	7.1	631	324	731	1154.4	297.7	2198.9
14	2400	274.2	3984	128.0	8.8	551	360	680	962.0	315.5	1951.5
15	2400	244.5	3806	115.0	9.0	511	406	616	852.6	340.0	1687.7
16	2400	221.6	3659	108.5	8.8	507	438	581	813.1	352.6	1529.5
17	2400	148.5	3276	82.5	8.2	411	541	439	589.6	389.9	1035.7
18	2400	75.4	2947	60.0	8.2	347	608	317	448.1	394.1	672.6
19	2400	52.6	2838	54.0	7.7	294	573	295	365.9	357.8	602.7
20	2400	23.8	2571	42.5	6.6	234	476	283	263.6	269.3	523.2
21	2400	5.9	2464	37.5	6.6	208	371	232	225.0	201.1	412.1
22	600	0.0	577	3.7	0.5	311	438	492	78.6	55.6	204.4
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.67 GM/BHP-HR
BSHC 2.12 GM/BHP-HR
BSNO2 10.10 GM/BHP-HR
BSFC 0.520 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.5 MMHG
HUMIDITY 58 GRAINS/LB
MAX. INLET RESTRICTION 20.0 "H20
MAX. EXHAUST BACK PRESSURE 22.5 "H20
INLET AIR TEMP. RANGE 79F - 82F
MAX. EXHAUST TEMP. 1015F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-22 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 20 -- TIMING RETARDED 3 DEGREES, SPECIAL FUEL PUMP AND NOZZLE KIT, AND 150F AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	585	4.0	0.5	261	548	547	67.1	70.6	230.6
2	1400	5.3	1378	14.5	0.5	171	376	477	103.5	114.0	473.9
3	1400	21.9	1435	19.5	0.5	139	371	642	87.5	117.2	663.3
4	1400	49.3	1496	28.0	2.3	286	494	911	187.3	162.6	981.0
5	1400	68.8	1603	36.1	3.6	363	553	1004	255.3	195.0	1158.3
6	1400	137.3	1728	57.5	3.0	329	580	1269	248.9	220.5	1578.8
7	1400	206.1	2053	79.5	3.3	273	478	1759	245.8	215.9	2600.5
8	1400	225.2	2111	85.5	4.4	405	419	1817	374.4	194.6	2761.9
9	1400	252.7	2177	93.0	6.0	542	279	1786	517.0	133.6	2798.7
10	1400	274.6	2393	102.6	6.8	815	252	1785	854.6	132.7	3075.4
11	600	0.0	580	4.0	0.5	239	440	646	60.6	56.1	269.7
12*											
13	2400	297.0	4130	142.0	6.6	620	279	675	1123.2	253.5	2007.8
14	2400	272.3	4017	132.0	7.7	583	285	615	1027.4	251.9	1779.3
15	2400	243.1	3797	117.1	6.6	478	360	573	794.8	300.7	1567.1
16	2400	222.1	3727	110.0	7.7	456	387	530	745.6	317.3	1422.2
17	2400	148.1	3238	82.5	8.5	433	494	381	614.7	351.9	887.6
18	2400	74.0	2950	60.0	7.7	320	553	298	413.9	358.8	632.8
19	2400	53.5	2842	54.5	6.6	290	526	276	361.5	328.8	564.2
20	2400	23.8	2627	44.5	6.6	252	462	245	290.2	267.0	462.9
21	2400	5.9	2579	39.3	6.6	226	317	211	255.2	179.9	392.4
22	600	0.0	582	4.0	0.5	217	365	627	55.3	46.7	262.7
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.62 GM/BHP-HR
BSHC 1.92 GM/BHP-HR
BSNO2 9.89 GM/BHP-HR
BSFC 0.528 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.7 MMHG
HUMIDITY 57 GRAINS/LB
MAX. INLET RESTRICTION 20.0 "H2O
MAX. EXHAUST BACK PRESSURE 22.5 "H2O
INLET AIR TEMP. RANGE 79F - 82F
MAX. EXHAUST TEMP. 965F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-23 COMBINATION OF PARAMETERS NO. 2 (REPLICATE OF TEST IN TABLE E-22) FOR ENGINE NO. 20 -- TIMING RETARDED 3 DEGREES, SPECIAL FUEL PUMP AND NOZZLE KIT, AND 150F AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	582	4.0	0.5	266	468	546	67.9	59.9	228.6
2	1400	5.3	1369	13.6	0.5	189	385	480	113.5	116.0	472.8
3	1400	21.3	1369	18.0	0.5	144	374	622	86.4	112.6	613.4
4	1400	49.3	1482	27.5	2.2	268	468	891	174.3	152.5	950.0
5	1400	69.3	1539	33.0	2.8	373	569	994	251.5	192.6	1101.6
6	1400	137.3	1725	54.0	2.8	339	597	1276	256.0	226.5	1584.9
7	1400	206.6	2007	78.0	3.3	260	491	1688	228.9	216.8	2440.0
8	1400	225.2	2103	84.0	4.4	349	446	1750	322.1	206.4	2649.7
9	1400	253.2	2476	98.0	5.0	528	284	1738	572.7	154.7	3098.8
10	1400	274.6	2438	103.5	6.5	739	262	1748	789.9	140.5	3068.5
11	600	0.0	580	4.0	0.5	221	402	630	56.2	51.3	263.2
12*											
13	2400	297.0	4130	141.0	7.7	601	262	683	1088.6	238.1	2030.5
14	2400	274.2	3989	128.0	8.8	518	318	650	906.2	279.1	1868.0
15	2400	244.5	3827	119.0	8.8	491	362	576	824.2	304.8	1587.0
16	2400	223.9	3718	112.0	8.8	465	390	537	758.1	319.0	1437.4
17	2400	148.5	3386	86.0	9.0	451	558	380	669.6	415.6	925.9
18	2400	75.4	2879	58.0	7.7	298	602	311	376.3	381.3	644.8
19	2400	54.8	2720	52.0	6.5	277	580	289	330.0	347.1	565.7
20	2400	23.8	2627	43.5	7.7	243	496	244	279.3	286.6	462.1
21	2400	5.9	2571	38.5	7.7	226	357	213	254.6	201.9	393.8
22	600	0.0	578	4.0	0.5	226	390	618	57.2	49.6	257.3
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.52 GM/BHP-HR
BSHC 1.98 GM/BHP-HR
BSNO2 9.82 GM/BHP-HR
BSFC 0.515 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.5 MMHG
HUMIDITY 56 GRAINS/LB
MAX. INLET RESTRICTION 20.0 "H20
MAX. EXHAUST BACK PRESSURE 22.5 "H20
INLET AIR TEMP. RANGE 79F - 83F
MAX. EXHAUST TEMP. 965F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-24 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 20 -- TIMING RETARDED 3 DEGREES, STANDARD FUEL PUMP AND NOZZLES, AND 150F AFTERCOOLING.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	600	0.0	526	3.2	0.5	925	923	199	213.2	106.8	75.2
2	1400	5.3	1361	13.0	0.5	604	959	263	360.5	287.2	257.6
3	1400	22.1	1370	17.0	0.5	512	817	399	307.3	246.2	393.9
4	1400	50.4	1378	25.0	0.5	371	680	668	223.9	206.1	663.0
5	1400	70.1	1483	31.5	0.5	311	627	801	202.0	204.5	855.3
6	1400	139.9	1711	55.0	3.3	264	633	1162	198.2	238.3	1431.5
7	1400	210.0	2103	81.0	3.5	299	604	1541	275.6	279.4	2333.1
8	1400	229.5	2160	87.0	5.0	486	556	1622	459.8	264.3	2523.2
9	1400	257.5	2376	97.0	6.5	667	408	1642	694.5	213.2	2808.6
10	1400	279.9	2428	106.0	9.2	1007	349	1635	1071.8	186.5	2859.3
11	600	0.0	523	3.1	0.5	833	846	236	190.8	97.3	89.0
12*											
13	2400	292.5	4108	140.0	6.6	586	346	608	1056.1	312.7	1797.4
14	2400	268.7	3927	124.5	6.6	418	438	590	719.1	378.4	1669.3
15	2400	239.4	3764	114.0	6.0	344	518	538	567.6	428.9	1459.1
16	2400	219.3	3643	107.0	6.0	309	609	504	493.6	488.1	1321.0
17	2400	146.2	3317	86.0	10.0	351	669	340	510.8	488.2	811.7
18	2400	73.1	2571	52.5	8.5	360	822	294	406.1	465.0	543.4
19	2400	52.6	2405	47.0	8.8	383	888	257	403.9	469.9	445.6
20	2400	23.3	2309	38.0	7.7	390	1018	204	395.3	517.2	338.4
21	2400	5.9	2195	33.5	4.4	396	1136	178	381.4	548.7	281.5
22	600	0.0	524	3.2	0.5	654	781	284	150.3	90.1	107.1
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 3.77 GM/BHP-HR
BSHC 2.86 GM/BHP-HR
BSNO2 8.15 GM/BHP-HR
BSFC 0.508 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.0 MMHG
HUMIDITY 57 GRAINS/LB
MAX. INLET RESTRICTION 20.0 "H2O
MAX. EXHAUST BACK PRESSURE 22.5 "H2O
INLET AIR TEMP. RANGE 80F - 83F
MAX. EXHAUST TEMP. 970F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-25 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 21 -- STD. TIMING, TURBOCHARGER, AND STD. FUEL PUMP.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.3	635	3.0	0.3	111	229	110	30.9	32.0	50.2
2	1555	4.1	1373	12.5	0.5	211	289	141	127.0	87.3	139.7
3	1555	16.9	1424	16.0	0.5	185	157	200	115.3	49.2	205.2
4	1555	37.9	1481	22.0	0.7	167	120	317	108.3	39.1	337.9
5	1555	52.7	1536	25.0	1.0	161	111	343	108.7	37.5	378.9
6	1555	106.6	1652	43.0	1.0	163	117	746	117.9	42.5	887.7
7	1555	158.1	1770	58.0	0.5	176	94	1440	136.7	36.6	1835.1
8	1555	172.9	1822	65.0	0.5	207	92	1697	165.7	36.9	2227.0
9	1555	193.9	1878	69.0	1.0	273	85	1974	225.0	35.1	2669.0
10	1550	210.1	1936	76.0	1.2	322	78	2278	273.5	33.2	3174.9
11	700	0.3	636	3.5	1.0	132	220	113	36.6	30.8	51.6
12*											
13	2100	251.9	2727	100.0	2.0	244	208	1678	291.5	124.8	3294.1
14	2100	231.9	2605	89.0	2.0	188	127	1499	214.4	72.8	2812.6
15	2100	206.7	2545	80.0	2.0	165	111	1300	183.6	62.2	2381.8
16	2100	188.7	2490	76.0	2.5	153	106	1240	166.7	58.1	2223.7
17	2100	125.9	2276	58.5	3.0	138	110	722	138.0	55.1	1183.0
18	2100	63.2	2049	36.0	3.3	157	129	395	141.2	58.2	583.0
19	2100	42.8	1940	29.0	3.0	158	127	311	134.4	54.2	435.0
20	2100	20.0	1885	25.0	2.2	188	159	239	155.2	65.9	324.7
21	2100	2.0	1829	20.0	2.0	210	220	184	168.5	88.5	242.4
22	700	0.3	636	3.5	1.0	115	210	110	32.0	29.4	50.1
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.46 GM/BHP-HR
BSHC 0.63 GM/BHP-HR
BSNO2 11.44 GM/BHP-HR
BSFC 0.448 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 736.0 MMHG
HUMIDITY 114 GRAINS/LB
MAX. INLET RESTRICTION 27.0 "H20
MAX. EXHAUST BACK PRESSURE 40.0 "H20
INLET AIR TEMP. RANGE 75F - 79F
MAX. EXHAUST TEMP. 1004F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-26 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 21 -- TIMING RETARDED 2 DEGREES, TURBOCHARGER, AND SPECIAL FUEL PUMP.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	650	0.1	645	4.0	1.5	119	210	110	33.5	29.8	51.1
2	1550	4.4	1429	15.0	1.1	181	247	153	113.4	77.6	157.1
3	1550	18.3	1434	16.0	1.1	163	188	175	102.6	59.3	180.6
4	1550	42.5	1498	23.0	1.5	137	119	286	89.7	39.2	308.8
5	1550	53.4	1495	25.0	2.2	128	111	348	84.2	36.5	374.4
6	1550	112.4	1665	43.5	2.2	154	122	738	112.5	44.7	884.9
7	1550	173.8	1793	62.5	1.5	167	119	1477	131.2	46.9	1906.3
8	1550	188.0	1843	67.0	2.0	178	100	1683	144.2	40.6	2234.3
9	1550	209.8	1913	79.0	2.9	274	90	2001	229.9	37.9	2756.9
10	1550	228.4	1961	81.0	3.6	404	83	2296	347.2	35.8	3241.8
11	650	0.2	645	4.0	1.5	115	208	112	32.4	29.5	52.0
12*											
13	2100	253.9	2789	100.0	2.5	195	115	1570	238.6	70.6	3152.2
14	2100	233.5	2679	92.0	2.8	163	100	1421	191.9	58.9	2739.7
15	2100	209.9	2611	84.0	3.3	140	99	1209	160.3	56.9	2273.2
16	2100	190.3	2494	77.0	3.8	132	102	1054	144.3	56.0	1892.5
17	2100	127.1	2278	58.0	4.0	122	108	710	122.1	54.1	1164.5
18	2100	63.6	2054	39.0	4.4	140	144	370	126.4	65.1	547.3
19	2100	45.6	1994	30.0	3.8	158	144	282	138.1	63.2	405.5
20	2100	20.4	1907	27.0	3.3	175	161	232	146.1	67.5	319.1
21	2100	5.2	1848	20.0	2.2	201	202	173	163.2	82.1	230.2
22	650	0.2	645	4.0	1.5	115	220	113	32.4	31.2	52.5
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.28 GM/BHP-HR
BSHC 0.59 GM/BHP-HR
BSNO2 10.59 GM/BHP-HR
BSFC 0.449 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.0 MMHG
HUMIDITY 91 GRAINS/LB
MAX. INLET RESTRICTION 24.0 "H20
MAX. EXHAUST BACK PRESSURE 40.0 "H20
INLET AIR TEMP. RANGE 74F - 82F
MAX. EXHAUST TEMP. 1013F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-27 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 21 -- TIMING RETARDED 2 DEGREES, TURBOCHARGER, AND STD. FUEL PUMP.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.3	643	3.5	1.0	123	249	103	34.6	35.2	47.6
2	1550	4.1	1376	12.5	1.0	211	386	132	127.3	116.8	130.8
3	1550	14.8	1380	17.0	1.0	172	214	184	103.8	65.0	182.6
4	1550	36.3	1488	21.0	1.5	142	150	258	92.5	49.1	276.7
5	1550	50.5	1488	25.0	1.5	145	148	323	94.5	48.4	345.6
6	1550	104.2	1656	43.0	2.0	154	134	655	112.0	48.8	780.4
7	1550	154.1	1772	56.0	2.6	152	109	1209	118.3	42.5	1542.3
8	1550	171.5	1772	62.0	2.0	127	113	1445	98.7	44.1	1844.1
9	1550	191.5	1882	69.0	3.0	171	99	1708	141.0	41.0	2314.0
10	1500	201.3	1933	75.0	3.8	251	85	1957	212.6	36.1	2723.5
11	700	0.3	643	3.5	1.3	165	213	109	46.6	30.1	50.4
12*											
13	2100	245.1	2687	97.0	2.5	191	118	1454	224.5	69.8	2813.1
14	2100	223.9	2578	88.0	3.3	164	109	1332	184.8	61.8	2471.6
15	2100	200.3	2468	79.0	4.5	148	104	1137	160.6	56.5	2019.6
16	2100	183.9	2472	75.0	5.0	157	107	1022	169.6	58.2	1818.0
17	2100	122.4	2248	54.0	5.5	139	125	591	136.8	61.8	956.3
18	2100	61.2	1986	38.0	5.5	160	166	367	139.7	72.5	524.7
19	2100	44.0	1934	31.0	4.8	166	162	286	141.1	68.9	397.9
20	2100	19.6	1884	26.0	4.5	180	182	228	148.5	75.4	308.9
21	2100	4.8	1829	22.0	3.0	193	206	197	154.9	82.9	259.1
22	700	0.3	639	3.5	1.3	102	218	108	28.5	30.7	49.6
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.38 GM/BHP-HR
BSHC 0.70 GM/BHP-HR
BSNO2 10.01 GM/BHP-HR
BSFC 0.454 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.0 MMHG
HUMIDITY 82 GRAINS/LB
MAX. INLET RESTRICTION 27.0 "H2O
MAX. EXHAUST BACK PRESSURE 350.0 "H2O
INLET AIR TEMP. RANGE 75F - 86F
MAX. EXHAUST TEMP. 990F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE E-28 COMBINATION OF PARAMETERS NO. 3 (REPLICATE OF TEST IN TABLE E-27) FOR ENGINE NO. 21 -- TIMING RETARDED 2 DEGREES, TURBOCHARGER, AND STD FUEL PUMP.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	SMOKE PERCENT OPACITY	CO PPM	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.3	645	3.0	1.0	123	223	103	34.7	31.7	47.7
2	1550	4.1	1386	12.5	1.0	194	332	131	118.1	101.2	130.6
3	1550	16.8	1443	18.0	1.8	155	170	195	98.1	54.0	202.7
4	1550	37.5	1501	23.0	2.5	141	123	266	93.0	40.6	287.9
5	1550	52.2	1559	29.0	2.8	144	121	381	98.6	41.5	427.7
6	1550	104.2	1625	43.0	3.0	142	113	640	101.1	40.4	749.4
7	1550	156.4	1740	59.0	3.3	139	91	1259	106.4	34.8	1578.0
8	1550	170.9	1796	63.0	3.3	151	95	1456	119.0	37.5	1882.8
9	1550	191.8	1843	69.0	3.5	183	83	1717	147.5	33.6	2278.6
10	1550	208.4	1893	74.0	3.5	239	85	1899	198.2	35.4	2589.4
11	700	0.4	646	3.5	1.0	111	212	108	31.4	30.1	50.0
12*											
13	2100	246.3	2722	97.0	3.3	183	125	1397	218.8	74.9	2737.9
14	2100	226.7	2672	89.0	3.8	155	117	1314	182.1	68.8	2526.8
15	2100	201.9	2561	81.0	4.0	136	104	1134	153.2	58.6	2090.4
16	2100	184.7	2505	76.0	4.5	132	101	1018	145.1	55.7	1835.4
17	2100	123.2	2281	57.0	5.5	126	122	613	126.2	61.2	1007.2
18	2100	61.6	2060	35.0	4.9	154	147	337	138.6	66.6	499.7
19	2100	44.4	2008	34.0	5.0	157	161	312	138.5	71.1	451.2
20	2100	19.6	1906	29.0	3.9	174	172	239	145.7	72.1	327.5
21	2100	4.8	1845	20.0	2.8	198	212	176	159.8	86.1	233.4
22	700	0.4	642	3.5	2.0	111	224	110	31.1	31.6	50.6
23*											

==23 MODE CYCLE COMPOSITE==

BSCO 1.30 GM/BHP-HR
BSHC 0.66 GM/BHP-HR
BSNO2 10.15 GM/BHP-HR
BSFC 0.463 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.3 MMHG
HUMIDITY 85 GRAINS/LB
MAX. INLET RESTRICTION 24.0 "H20
MAX. EXHAUST BACK PRESSURE 40.0 "H20
INLET AIR TEMP. RANGE 74F - 82F
MAX. EXHAUST TEMP. 980F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX F. -- RESULTS FROM TESTS USING MANIFOLD AIR INJECTION WITH HEAVY DUTY GASOLINE ENGINES (23-MODE CYCLE)

TABLE F-1 AIR INJECTION FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 1.00).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	18.0	91	4.9	-1.0	1.28	2250	30	531.1	46.2	2.0
2	1200	1.0	18.7	166	7.3	11.5	0.14	650	59	107.9	25.1	7.6
3	1200	3.9	17.8	183	8.3	10.5	0.13	540	118	108.3	23.0	16.7
4	1200	8.7	16.1	213	9.8	11.5	0.12	635	160	118.0	31.8	26.6
5	1200	12.1	14.9	243	11.4	10.5	0.11	780	297	127.1	45.9	58.0
6	1200	24.2	12.4	265	14.3	11.5	0.41	1272	850	536.8	82.7	183.6
7	1200	36.4	7.8	337	18.4	9.5	0.19	1250	1488	301.5	99.5	393.3
8	1200	39.7	6.2	359	20.5	6.5	0.43	1175	1317	788.1	105.6	393.2
9	1200	44.6	4.6	382	22.0	7.0	0.47	1175	1432	873.0	108.4	438.5
10	1200	48.5	2.8	412	23.9	7.0	0.57	1150	1524	1172.9	116.0	510.4
11	700	0.0	18.0	94	4.9	-1.0	0.83	680	38	377.7	15.3	2.8
12*												
13	2300	98.4	1.6	852	49.8	13.5	0.26	35	1422	1109.9	7.5	1009.0
14	2300	90.6	3.9	794	46.9	13.5	0.14	75	1169	569.1	14.7	762.3
15	2300	80.7	6.7	677	41.3	10.5	0.26	32	1380	902.6	5.5	786.0
16	2300	73.8	8.2	653	36.8	17.0	0.30	165	1650	967.7	26.0	864.2
17	2300	49.2	12.6	530	28.8	19.0	0.24	125	1098	618.8	15.9	464.6
18	2300	24.6	16.4	405	20.3	18.5	0.18	85	467	338.5	8.1	147.6
19	2300	26.9	17.4	371	18.1	18.5	0.16	75	318	289.2	6.6	92.0
20	2300	7.9	18.7	325	15.2	18.5	0.15	68	168	231.3	5.1	41.6
21	2300	2.0	19.7	303	13.9	18.5	0.16	70	109	225.4	4.8	24.4
22	700	0.0	18.0	95	4.9	-1.0	0.75	760	38	327.4	16.4	2.7
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 16.18 GM/BHP-HR
BSHC 1.05 GM/BHP-HR
BSNO2 9.02 GM/BHP-HR
BSFC 0.634 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.2 MMHG
HUMICITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 82F - 88F
MAX. EXHAUST TEMP. 1478F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE F-2 AIR INJECTION FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 1.25).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	18.2	103	4.9	-1.0	0.52	710	38	242.9	16.5	2.9
2	1200	1.0	18.9	183	7.6	11.5	0.12	650	51	100.3	26.6	6.9
3	1200	3.9	17.9	194	8.3	10.5	0.11	570	81	93.9	25.0	11.6
4	1200	8.7	16.4	224	9.7	11.5	0.10	669	140	106.7	34.4	23.7
5	1200	12.1	15.0	243	11.4	10.5	0.42	885	349	453.4	47.4	62.1
6	1200	24.2	12.5	278	14.4	11.5	0.30	1290	948	376.1	80.5	196.3
7	1200	36.4	7.9	344	18.2	9.5	0.15	1347	1619	231.7	104.7	418.0
8	1200	39.7	6.3	366	20.2	6.5	0.28	1176	1514	469.2	98.3	420.2
9	1200	44.6	5.0	392	22.4	7.0	0.54	1200	1530	983.3	107.5	454.8
10	1200	48.5	3.1	419	23.9	7.0	0.49	1215	1623	948.7	116.7	517.7
11	700	0.0	16.0	101	4.9	-1.0	0.58	680	38	262.0	15.2	2.8
12*												
13	2300	98.4	1.6	847	49.3	13.5	0.20	90	1515	772.3	17.1	957.5
14	2300	90.6	4.0	773	45.4	13.5	0.13	35	1262	466.8	6.0	729.3
15	2300	80.7	6.9	695	39.5	10.5	0.24	62	1584	773.9	9.6	823.6
16	2300	73.8	8.4	670	37.2	17.0	0.27	195	1653	826.0	29.5	829.8
17	2300	49.2	12.7	530	28.2	19.0	0.23	162	1147	553.4	19.4	455.9
18	2300	24.6	16.6	416	20.1	19.5	0.17	127	469	312.9	11.7	143.5
19	2300	17.7	17.5	390	18.2	18.5	0.16	116	327	274.9	10.2	95.1
20	2300	7.9	19.0	343	15.2	18.5	0.14	99	177	218.7	7.6	45.2
21	2300	3.0	19.7	323	13.9	18.5	0.14	90	119	205.3	6.5	28.2
22	700	0.0	18.2	103	4.9	-1.0	0.49	650	51	228.6	14.9	3.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 13.00 GM/BHP-HR
BSHC 1.01 GM/BHP-HR
BSNO2 9.14 GM/BHP-HR
BSFC 0.643 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.0 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 87F - 90F
MAX. EXHAUST TEMP. 1520F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE F-3 AIR INJECTION FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 1.50).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.7	110	5.1	-1.0	0.72	800	30	357.5	19.6	2.4
2	1200	1.0	17.9	209	8.2	11.5	0.13	520	56	123.3	24.3	8.5
3	1200	3.9	17.7	207	8.5	10.5	0.12	575	90	111.6	26.9	13.8
4	1200	8.7	15.9	233	9.8	11.5	0.10	715	162	106.6	37.6	28.1
5	1200	12.1	14.7	255	11.8	10.5	0.45	875	279	538.3	51.3	54.2
6	1200	24.2	12.4	292	14.6	11.5	0.37	1200	768	509.8	81.9	174.2
7	1200	36.4	7.9	359	18.5	9.5	0.17	1325	1380	285.2	110.6	382.5
8	1200	39.7	6.1	388	20.7	6.5	0.32	1175	1309	576.0	105.9	391.5
9	1200	44.6	4.7	403	22.0	7.0	0.44	1150	1410	829.3	106.9	435.2
10	1200	48.5	2.7	443	24.4	7.0	0.51	1075	2241	1064.7	110.9	767.7
11	700	0.0	17.9	110	5.1	-1.0	0.68	630	38	341.1	15.7	3.1
12*												
13	2300	98.4	1.5	835	47.7	13.5	0.19	35	1455	730.7	6.8	931.6
14	2300	90.6	3.8	809	46.5	13.5	0.13	13	1126	468.2	2.4	685.6
15	2300	80.7	6.6	733	41.6	10.5	0.23	69	1387	771.5	11.6	775.0
16	2300	73.8	8.2	681	37.1	17.0	0.27	330	1662	835.6	50.9	851.5
17	2300	49.2	12.5	560	28.9	19.0	0.22	225	1115	580.0	28.7	472.2
18	2300	24.6	16.4	398	20.5	19.5	0.23	160	458	420.0	14.4	136.7
19	2300	17.7	17.3	408	18.4	18.5	0.16	153	320	318.3	14.6	101.4
20	2300	7.9	18.6	358	15.4	18.5	0.16	125	166	256.0	10.1	44.2
21	2300	2.0	19.8	327	13.7	18.5	0.15	108	111	224.6	8.0	26.9
22	700	0.0	18.0	112	5.0	-1.0	0.56	430	38	287.0	10.9	3.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 14.72 GM/BHP-HR
BSHC 1.11 GM/BHP-HR
BSNO2 8.95 GM/BHP-HR
BSFC 0.655 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.4 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 81F - 87F
MAX. EXHAUST TEMP. 1504F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE F-4 AIR INJECTION FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 1.75).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.7	115	4.9	-1.0	0.48	825	39	247.1	20.9	3.2
2	1200	1.0	18.0	205	7.6	11.5	0.13	186	36	124.6	9.0	5.8
3	1200	3.5	17.9	214	8.2	10.5	0.10	640	69	95.2	30.7	10.8
4	1200	8.7	16.0	244	9.7	11.5	0.09	740	137	96.4	40.6	24.8
5	1200	12.1	15.6	258	11.4	10.5	0.40	900	275	473.8	52.6	53.2
6	1200	24.2	12.3	303	14.5	11.5	0.32	1245	823	449.7	86.4	189.7
7	1200	36.4	7.7	371	18.5	9.5	0.16	1380	1467	281.4	118.2	416.9
8	1200	39.7	6.2	397	20.7	6.5	0.37	1140	998	690.0	104.6	303.8
9	1200	44.6	4.6	417	22.3	7.0	0.46	1155	1393	902.9	112.0	448.6
10	1200	48.5	2.8	459	24.7	7.0	0.53	1110	1447	1155.6	119.1	515.5
11	700	0.0	17.9	115	4.9	-1.0	0.54	630	30	290.4	16.6	2.6
12*												
13	2300	98.4	1.5	869	49.6	13.5	0.21	66	1407	887.8	13.6	965.0
14	2300	90.6	3.4	829	47.3	13.5	0.13	39	1085	514.2	7.7	710.5
15	2300	80.7	6.6	734	41.5	10.5	0.23	53	1326	794.7	9.1	754.6
16	2300	73.8	8.2	691	37.2	17.0	0.30	16	1591	980.6	2.6	864.9
17	2300	49.2	12.5	571	29.2	19.0	0.24	180	1041	653.8	24.4	467.4
18	2300	24.6	16.4	448	20.6	19.5	0.18	159	430	382.9	16.5	148.2
19	2300	17.7	17.3	415	18.4	18.5	0.17	152	309	337.3	14.6	98.3
20	2300	7.9	18.6	367	15.3	18.5	0.16	125	149	273.2	10.5	41.7
21	2300	2.0	19.7	325	13.1	18.5	0.16	128	103	240.6	9.5	25.0
22	700	0.0	18.1	117	4.8	-1.0	0.27	405	30	144.2	10.8	2.7
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 14.57 GM/BHP-HR
BSHC 0.98 GM/BHP-HR
BSNO2 8.89 GM/BHP-HR
BSFC 0.655 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 740.7 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 86F - 90F
MAX. EXHAUST TEMP. 1520F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE F-5 AIR INJECTION FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 2.00).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	18.1	122	4.9	-1.0	0.39	660	21	214.2	18.0	1.9
2	1200	1.0	18.6	200	7.5	11.5	0.10	520	39	87.4	21.4	5.2
3	1200	3.9	17.7	223	8.3	10.5	0.09	580	69	91.6	28.2	11.0
4	1200	8.7	16.0	255	9.8	11.5	0.08	665	137	95.5	37.3	25.5
5	1200	12.1	14.6	270	10.7	10.5	0.08	735	188	94.6	43.7	37.1
6	1200	24.2	12.4	307	14.4	11.5	0.29	1075	838	405.4	73.6	190.3
7	1200	36.4	7.6	380	18.5	9.5	0.11	1175	1466	195.8	99.2	411.0
8	1200	39.7	6.3	404	20.6	6.5	0.28	975	1364	507.9	87.6	406.9
9	1200	44.6	4.5	422	22.1	7.0	0.37	975	1432	696.4	90.4	440.5
10	1200	48.5	3.2	437	23.1	7.0	0.40	1000	1553	771.9	96.4	497.0
11	700	0.0	17.7	119	4.9	-1.0	0.46	565	39	240.3	14.7	3.3
12*												
13	2300	98.4	1.5	861	48.8	13.5	0.22	60	1456	853.0	11.6	935.9
14	2300	90.6	3.4	837	47.1	13.5	0.16	11	1073	587.1	2.0	660.2
15	2300	80.7	6.7	736	40.5	10.5	0.24	114	1451	812.2	18.8	793.3
16	2300	73.8	8.3	679	36.3	17.0	0.25	243	1643	772.7	36.7	825.1
17	2300	49.2	12.4	569	28.8	19.0	0.22	217	1149	578.0	27.6	484.6
18	2300	24.6	16.4	443	20.6	19.5	0.17	177	480	351.6	17.8	160.1
19	2300	17.7	17.2	427	18.8	18.5	0.16	166	333	303.1	15.8	105.0
20	2300	7.9	18.5	377	15.7	18.5	0.14	144	187	239.5	12.0	51.6
21	2300	2.0	19.7	324	12.8	18.5	0.15	150	107	221.9	10.7	25.1
22	700	0.0	18.3	120	4.8	-1.0	0.38	560	35	202.1	14.6	3.0
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 12.81 GM/BHP-HR
BSHC 1.02 GM/BHP-HR
BSNO2 8.92 GM/BHP-HR
BSFC 0.648 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.4 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 81F - 82F
MAX. EXHAUST TEMP. 1500F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE F-6 AIR INJECTION FOR ENGINE NO. 23 (AIR PUMP/ENGINE SPEED RATIO = 2.0).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.4	96	4.3	5.0	0.15	710	35	61.2	14.7	2.4
2	1200	1.0	19.4	152	6.6	12.0	0.13	330	54	87.6	11.1	5.9
3	1200	4.1	18.8	157	6.9	20.0	0.14	680	110	102.7	23.9	12.8
4	1200	9.2	17.6	176	7.9	31.0	0.10	1330	496	81.2	52.9	65.3
5	1200	12.8	16.2	196	9.0	31.0	0.08	1430	798	72.1	62.9	116.6
6	1200	25.7	10.2	279	13.7	21.0	0.08	1390	1280	102.2	86.9	265.6
7	1200	38.5	5.9	347	18.9	12.0	0.28	1325	1624	432.9	102.8	418.5
8	1200	42.1	4.9	355	20.9	12.0	1.16	1600	1378	1876.5	128.2	366.8
9	1200	47.3	3.3	388	23.7	12.0	1.63	1900	1020	2964.4	170.5	303.7
10	1200	51.4	2.0	394	24.6	12.0	2.25	1900	1286	4033.2	168.2	377.8
11	770	0.0	18.9	94	4.2	5.0	0.14	630	45	58.9	13.2	3.1
12*												
13	2300	102.3	2.4	798	48.4	20.0	0.80	300	1720	2974.0	55.3	1052.4
14	2300	94.1	3.7	754	45.3	20.0	0.62	155	1660	2191.4	27.2	966.0
15	2300	83.9	4.8	717	41.6	20.0	0.48	240	1748	1628.7	40.0	966.9
16	2300	76.7	5.5	707	38.9	20.0	0.28	335	1753	933.4	54.5	946.0
17	2300	51.2	10.6	549	27.6	31.0	0.19	770	1898	481.2	97.1	794.5
18	2300	25.6	16.1	401	18.6	39.0	0.15	740	1258	273.5	68.5	386.6
19	2300	18.4	17.4	361	16.2	39.0	0.13	640	876	215.7	53.0	240.8
20	2300	8.2	19.2	318	13.3	39.0	0.11	485	327	164.0	35.1	78.4
21	2300	2.0	20.3	280	11.1	39.0	0.10	370	188	132.6	23.4	39.3
22	775	0.0	18.9	99	4.3	5.0	0.12	570	43	53.9	12.6	3.1
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 19.33 GM/BHP-HR
BSHC 1.54 GM/BHP-HR
BSNO2 11.39 GM/BHP-HR
BSFC 0.597 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 72F - 74F
MAX. EXHAUST TEMP. 1429F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE F-7 AIR INJECTION FOR ENGINE NO. 23 (AIR PUMP/ENGINE SPEED RATIO = 2.5).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.4	100	4.2	6.0	0.12	700	34	55.8	15.7	2.5
2	1200	1.0	19.4	161	6.6	10.5	0.12	300	50	89.6	10.9	6.0
3	1200	4.1	18.8	166	6.9	18.0	0.13	613	102	100.7	22.8	12.6
4	1200	9.2	17.7	181	7.8	30.0	0.13	1250	473	106.2	51.3	64.4
5	1200	12.8	16.3	200	8.9	30.0	0.10	1375	785	93.8	62.8	119.2
6	1200	25.7	10.3	286	13.7	20.0	0.08	1300	1236	104.8	85.3	269.4
7	1200	38.5	5.5	357	19.3	11.0	0.41	1275	1435	675.6	103.7	387.5
8	1200	42.1	4.8	361	20.7	11.5	1.21	1425	1175	2073.7	121.2	331.7
9	1200	47.3	3.1	380	23.4	12.0	2.39	1675	817	4172.0	144.7	234.3
10	1200	51.4	1.9	398	24.4	12.0	2.35	1725	1105	4237.6	153.8	327.3
11	770	0.0	18.6	103	4.3	5.5	0.13	585	46	58.3	13.4	3.5
12*												
13	2300	102.3	2.4	816	48.4	21.0	0.66	210	1637	2508.2	39.2	1014.2
14	2300	94.1	3.7	769	45.3	21.0	0.52	125	1562	1855.5	22.0	913.5
15	2300	83.9	4.8	737	42.2	21.0	0.45	185	1586	1536.1	31.3	891.4
16	2300	76.7	5.4	712	38.5	21.0	0.27	320	1658	900.8	52.6	904.5
17	2300	51.2	10.5	560	27.5	30.0	0.18	750	1754	455.5	95.8	743.6
18	2300	25.6	15.9	412	18.5	39.0	0.15	746	1179	280.4	70.4	369.7
19	2300	18.4	17.2	376	16.3	39.0	0.13	665	837	218.1	56.7	236.6
20	2300	8.2	19.2	331	13.2	39.0	0.11	495	351	159.1	36.8	86.6
21	2300	2.0	20.2	295	11.1	38.0	0.09	400	176	126.1	26.4	38.3
22	7700	0.0	18.8	102	4.2	5.5	0.10	590	39	47.5	13.3	2.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 18.17 GM/BHP-HR
BSHC 1.48 GM/BHP-HR
BSNO2 10.83 GM/BHP-HR
BSFC 0.596 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.8 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 71F - 76F
MAX. EXHAUST TEMP. 1434F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE F-8 AIR INJECTION FOR ENGINE NO. 23 (AIR PUMP/ENGINE SPEED RATIO = 3.0).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.3	108	4.2	5.0	0.18	700	38	90.3	17.1	3.0
2	1200	1.0	19.1	174	6.6	10.0	0.14	334	49	116.7	13.4	6.4
3	1200	4.1	18.6	181	6.9	19.0	0.15	669	103	126.8	28.0	14.2
4	1200	9.2	17.3	199	7.8	30.0	0.08	1175	471	78.4	54.1	71.8
5	1200	12.8	16.1	219	8.9	30.0	0.07	1260	766	75.5	64.7	130.5
6	1200	25.7	10.1	298	13.6	19.0	0.07	1180	1158	105.5	83.4	271.8
7	1200	38.5	5.2	368	19.2	12.0	0.42	1150	1416	736.4	99.7	407.9
8	1200	42.1	4.5	376	21.6	12.0	1.56	1300	907	2821.9	116.3	269.1
9	1200	47.3	2.6	404	24.0	12.0	2.04	1490	897	3983.8	144.1	287.7
10	1200	51.4	1.2	423	24.8	12.0	1.91	1475	1131	3942.0	150.3	382.8
11	770	0.0	18.5	112	4.3	5.0	0.11	600	44	60.4	15.6	3.7
12*												
13	2300	102.3	2.0	835	49.0	22.0	0.46	65	1436	1890.1	13.2	970.1
14	2300	94.1	3.1	798	45.8	22.0	0.40	70	1489	1573.5	13.6	957.5
15	2300	83.9	4.4	761	43.0	21.0	0.39	90	1385	1466.1	16.6	848.9
16	2300	76.7	5.2	738	38.7	21.0	0.28	265	1617	1010.4	47.5	961.7
17	2300	51.2	10.3	599	28.1	30.0	0.18	680	1680	539.7	98.9	811.0
18	2300	25.6	16.0	433	18.0	39.0	0.13	755	1127	279.7	78.3	387.9
19	2300	18.4	17.0	404	16.3	39.0	0.13	676	811	241.5	64.3	256.1
20	2300	8.2	18.9	361	13.2	39.0	0.11	510	318	181.3	42.7	88.5
21	2300	2.0	20.1	326	11.2	38.0	0.10	420	164	148.4	32.1	41.3
22	775	0.0	18.8	112	4.2	5.0	0.11	600	39	54.9	15.3	3.2
23*												

==23 MODE CYCLE COMPOSITE==
BSCO 18.76 GM/BHP-HR
BSHC 1.46 GM/BHP-HR
BSNO2 11.13 GM/BHP-HR
BSFC 0.602 LB/BHP-HR

==TEST CONDITIONS==
BAROMETER 743.7 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 68F - 77F
MAX. EXHAUST TEMP. 1440F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX G. -- RESULTS FROM TESTS USING A CATALYST WITH HEAVY DUTY GASOLINE ENGINES (23-MODE CYCLE)

TABLE C-1 UOP CATALYST WITH AIR INJECTION FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 1.25).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	625	0.0	16.6	95	4.4	0.0	0.01	160	35	3.2	3.4	2.4
2	1200	1.0	18.4	176	7.3	10.0	0.01	83	63	5.8	3.2	8.2
3	1200	3.9	17.3	196	8.4	13.0	0.01	40	98	6.5	1.8	14.2
4	1200	8.7	15.6	228	10.0	13.0	0.01	50	156	7.6	2.6	26.6
5	1200	12.1	14.2	244	10.9	13.0	0.01	51	219	8.1	2.8	40.2
6	1200	24.2	12.0	281	14.7	13.0	0.01	93	786	11.7	6.0	168.7
7	1200	36.4	7.5	349	18.7	13.0	0.01	98	1419	14.5	7.9	379.9
8	1200	39.7	6.4	365	19.7	13.0	0.01	98	1574	15.3	8.3	444.0
9	1200	44.6	4.1	391	22.5	8.0	0.02	73	1225	39.5	6.7	375.1
10	1200	48.5	1.6	434	25.1	8.0	0.04	68	1252	72.2	6.9	421.6
11	700	0.0	17.1	101	4.9	0.0	0.07	48	49	33.9	1.1	3.7
12*												
13	2300	98.4	1.2	839	50.9	15.0	0.07	19	1287	274.7	3.6	800.8
14	2300	90.6	2.6	790	48.1	15.0	0.05	12	877	196.6	2.1	517.2
15	2300	80.7	4.9	713	43.5	15.0	0.05	10	897	172.1	1.6	478.6
16	2300	73.8	7.0	649	37.5	20.0	0.04	30	1486	110.3	4.4	723.0
17	2300	49.2	11.5	546	30.0	20.0	0.02	19	883	38.9	2.3	352.9
18	2300	24.6	15.7	415	20.7	20.0	0.01	15	386	27.2	1.4	119.4
19	2300	17.7	16.6	392	19.0	20.0	0.01	13	282	24.1	1.1	82.1
20	2300	7.9	18.3	342	15.6	20.0	0.01	11	160	16.8	0.8	40.2
21	2300	2.0	19.2	319	13.9	20.0	0.01	10	110	15.8	0.7	25.7
22	710	0.0	17.4	103	5.0	0.0	0.01	55	38	5.1	1.3	2.9
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.74 GM/BHP-HR
BSHC 0.10 GM/BHP-HR
BSNO2 7.30 GM/BHP-HR
BSFC 0.663 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.7 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 82F - 86F
MAX. EXHAUST TEMP. 1534F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE G-2 UOP CATALYST WITH AIR INJECTION (REPLICATE OF TEST IN TABLE G-1) FOR ENGINE NO. 22 (AIR PUMP/ENGINE SPEED RATIO = 1.25).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.2	106	5.1	0.0	0.01	65	68	5.0	1.5	5.0
2	1200	1.0	18.3	182	7.5	11.0	0.01	75	82	8.8	2.9	10.6
3	1200	3.9	17.3	198	8.4	12.5	0.01	35	116	9.6	1.5	16.5
4	1200	8.7	15.6	226	9.9	12.5	0.01	35	186	10.8	1.7	30.0
5	1200	12.1	14.1	246	11.0	12.5	0.01	64	283	11.8	3.4	50.2
6	1200	24.2	12.1	274	14.3	12.5	0.01	69	980	16.4	4.1	195.5
7	1200	36.4	7.6	359	19.3	12.5	0.01	78	1856	21.5	6.0	474.5
8	1200	39.7	6.4	362	19.7	12.5	0.01	78	1952	21.6	6.3	520.3
9	1200	44.6	4.2	403	23.3	8.0	0.02	67	1491	41.8	6.1	448.1
10	1200	48.5	2.3	426	24.7	8.0	0.03	72	1583	61.3	6.9	504.3
11	700	0.0	17.2	103	5.0	0.0	0.01	50	73	5.3	1.1	5.3
12*												
13	2300	98.4	1.0	813	49.9	14.0	0.08	8	1588	285.4	1.4	920.8
14	2300	90.6	2.6	785	48.1	15.0	0.05	5	1149	181.9	0.9	659.0
15	2300	80.7	5.0	702	42.8	15.0	0.05	6	1206	153.7	0.8	615.9
16	2300	73.8	6.9	654	37.9	20.0	0.02	25	1871	56.1	3.6	885.5
17	2300	49.2	11.6	538	29.6	20.0	0.01	15	1214	29.5	1.8	472.8
18	2300	24.6	15.8	405	20.4	20.0	0.01	10	605	19.0	0.9	175.1
19	2300	17.7	16.8	380	18.4	20.0	0.01	9	375	17.8	0.7	101.2
20	2300	7.9	18.4	321	14.8	20.0	0.01	7	198	15.2	0.5	45.2
21	2300	2.0	19.5	288	12.9	18.0	0.01	8	137	13.7	0.5	28.0
22	650	0.0	16.6	95	4.5	0.0	0.01	125	49	4.5	2.5	3.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.47 GM/BHP-HR
BSHC 0.08 GM/BHP-HR
BSNO2 9.03 GM/BHP-HR
BSFC 0.660 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 742.7 MMHG
HUMIDITY 94 GRAINS/LB
INLET AIR TEMP. RANGE 84F - 98F
MAX. EXHAUST TEMP. 1553F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE C-3 UOP CATALYST WITH AIR INJECTION FOR ENGINE NO. 23 (AIR PUMP/ENGINE SPEED RATIO = 2.5).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	760	0.0	18.4	100	4.1	5.0	0.01	150	20	5.9	3.3	1.4
2	1200	1.0	19.2	157	6.3	10.5	0.01	46	42	9.3	1.6	5.0
3	1200	4.1	18.5	163	6.7	15.0	0.01	74	83	9.6	2.7	10.1
4	1200	9.2	17.5	174	7.4	28.0	0.01	103	337	10.1	4.0	43.8
5	1200	12.8	16.2	193	8.4	29.0	0.01	170	624	11.3	7.4	90.5
6	1200	25.7	10.3	273	12.9	18.0	0.01	125	1091	16.1	7.8	227.0
7	1200	38.5	5.2	329	17.6	11.0	0.02	93	1450	24.8	7.1	365.1
8	1200	42.1	4.5	348	20.3	11.0	0.03	85	1062	42.7	7.0	290.1
9	1200	47.3	2.4	367	22.2	11.0	0.08	108	1015	141.6	9.4	294.9
10	1200	51.4	1.6	376	22.9	11.0	0.15	120	1044	272.8	10.8	311.4
11	790	0.0	18.6	102	4.1	7.5	0.01	75	26	6.8	1.7	1.9
12*												
13	2300	102.3	2.2	756	44.9	20.0	0.07	32	1634	261.6	5.6	955.4
14	2300	94.1	3.4	727	42.6	20.0	0.06	31	1639	206.6	5.3	934.7
15	2300	83.9	4.6	683	39.6	20.0	0.04	36	1559	134.0	5.8	838.7
16	2300	76.7	5.7	673	36.3	20.0	0.02	47	1733	57.6	7.5	916.9
17	2300	51.2	10.5	528	25.6	30.0	0.01	76	1753	24.8	9.4	718.0
18	2300	25.6	16.0	390	17.3	39.0	0.01	71	1220	15.0	6.4	365.9
19	2300	18.4	17.3	359	15.2	39.0	0.01	64	781	13.8	5.3	214.3
20	2300	8.2	19.3	310	12.0	39.0	0.01	52	820	9.2	3.7	192.5
21	2300	2.0	20.3	284	10.4	39.0	0.01	65	176	8.5	4.2	37.5
22	780	0.0	18.6	106	4.2	7.5	0.01	65	30	4.0	1.5	2.4
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.43 GM/BHP-HR
BSHC 0.16 GM/BHP-HR
BSNO2 10.37 GM/BHP-HR
BSFC 0.562 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 749.0 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 80F
MAX. EXHAUST TEMP. 1449F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE G-4 UOP CATALYST WITH AIR INJECTION (REPLICATE OF TEST IN TABLE G-3) FOR ENGINE NO. 23 (AIR PUMP/ENGINE SPEED RATIO = 2.5).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	775	0.0	18.4	95	4.0	7.5	0.01	105	21	4.2	2.1	1.4
2	1200	1.0	19.4	157	6.4	12.0	0.01	40	49	5.7	1.4	5.5
3	1200	4.1	18.5	160	6.7	15.0	0.01	58	82	5.8	2.0	9.6
4	1200	9.2	17.6	172	7.4	28.0	0.01	148	342	6.3	5.6	43.1
5	1200	12.8	16.3	189	8.3	29.0	0.01	168	644	6.9	6.9	88.5
6	1200	25.7	10.3	269	13.0	18.0	0.01	125	1214	9.9	7.5	240.9
7	1200	38.5	5.2	329	17.9	12.0	0.01	98	1467	16.0	7.2	358.5
8	1200	42.1	4.4	340	20.4	12.0	0.04	108	857	60.3	8.3	217.9
9	1200	47.3	2.0	364	22.2	12.0	0.11	135	924	189.6	11.2	255.4
10	1200	51.4	1.1	380	22.8	12.0	0.14	130	1183	242.5	11.2	337.3
11	770	0.0	18.5	97	4.0	7.5	0.01	83	25	3.6	1.8	1.7
12*												
13	2300	102.3	1.9	754	45.8	19.0	0.13	20	1333	443.1	3.4	752.4
14	2300	94.1	3.1	722	42.9	20.0	0.07	22	1494	241.3	3.6	804.2
15	2300	83.9	4.2	678	40.1	20.0	0.05	24	1433	168.5	3.7	732.7
16	2300	76.7	5.1	655	36.3	20.0	0.02	38	1696	58.5	5.6	825.7
17	2300	51.2	10.2	512	25.4	30.0	0.01	69	1815	23.3	8.0	696.8
18	2300	25.6	15.9	382	17.2	39.0	0.01	68	1242	14.1	5.8	350.2
19	2300	18.4	17.3	346	15.0	39.0	0.01	61	845	12.8	4.7	215.7
20	2300	8.2	19.2	306	12.2	39.0	0.01	50	340	11.3	3.4	76.0
21	2300	2.0	20.3	273	10.3	39.0	0.01	43	180	10.2	2.6	35.9
22	765	0.0	18.7	98	4.0	5.0	0.01	72	26	3.6	1.5	1.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.72 GM/BHP-HR
BSHC 0.14 GM/BHP-HR
BSNO2 9.33 GM/BHP-HR
BSFC 0.563 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 748.8 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 76F - 79F
MAX. EXHAUST TEMP. 1463F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX H. -- RESULTS FROM TESTS USING VARIED AIR-FUEL RATIO WITH HEAVY DUTY GASOLINE ENGINES (23-MODE CYCLE)

TABLE H-1 AIR-FUEL RATIO LEANER THAN STANDARD FOR ENGINE NO. 22 (0.052 CARBURETOR JETS).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	660	0.0	17.4	74	4.6	1.0	0.42	3275	65	139.4	53.5	3.5
2	1200	0.7	18.3	133	7.6	10.5	0.16	3975	67	94.4	118.1	6.6
3	1200	2.7	17.8	143	8.1	12.0	0.15	4300	81	95.2	138.6	8.7
4	1200	6.1	16.3	168	9.1	12.0	0.14	260	109	106.9	9.7	13.4
5	1200	8.4	15.7	170	9.8	12.0	0.23	4025	207	175.6	151.3	25.7
6	1200	16.8	13.9	197	11.9	13.0	0.13	3800	573	111.4	167.4	83.8
7	1200	25.2	10.5	256	14.9	13.0	0.11	3875	802	121.1	218.9	150.5
8	1200	27.6	8.3	294	16.9	13.0	0.10	3875	1029	136.8	251.5	221.8
9	1200	31.0	7.4	301	17.3	12.0	0.10	3950	1052	139.0	259.8	229.7
10	1200	33.7	7.0	313	18.1	11.0	0.11	4050	1113	151.7	276.9	252.5
11	690	0.0	17.5	76	4.7	0.0	0.05	3650	74	16.9	60.6	4.0
12*												
13	2300	73.6	4.7	716	41.6	16.0	0.03	850	1085	112.9	137.3	581.4
14	2300	67.7	6.9	619	35.4	18.0	0.14	800	1244	388.7	109.4	564.4
15	2300	60.4	9.0	547	31.1	20.0	0.14	735	1237	334.9	88.6	494.7
16	2300	55.2	10.1	537	30.5	20.0	0.14	750	1065	335.0	88.7	418.2
17	2300	36.8	13.3	429	24.4	20.0	0.15	780	706	282.6	73.3	220.2
18	2300	18.4	16.4	327	18.7	20.0	0.11	890	357	164.1	63.6	84.4
19	2300	13.2	17.2	299	17.1	20.0	0.11	915	262	138.5	59.5	56.3
20	2300	5.9	18.4	258	14.8	20.0	0.09	935	175	105.9	52.7	32.7
21	2300	1.5	19.2	233	13.5	19.0	0.10	428	147	98.1	21.6	24.5
22	675	0.0	17.8	75	4.7	0.0	0.39	3900	69	124.0	61.9	3.6
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 8.09 GM/BHP-HR
BSHC 4.70 GM/BHP-HR
BSNO2 7.20 GM/BHP-HR
BSFC 0.744 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 85F - 88F
MAX. EXHAUST TEMP. 1433F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE H-2 AIR-FUEL RATIO LEANER THAN STANDARD FOR ENGINE NO. 22 (0.054 CARBURETOR JETS).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.9	73	4.6	0.0	0.60	1250	67	192.3	19.9	3.5
2	1200	1.0	18.6	131	7.5	12.5	0.15	550	78	88.2	15.9	7.5
3	1200	3.9	18.0	145	8.2	12.5	0.14	600	103	87.9	19.2	10.9
4	1200	8.7	15.6	176	9.7	12.5	0.13	700	148	101.4	26.8	18.8
5	1200	12.1	15.2	178	10.5	12.5	0.31	1050	338	250.7	41.4	44.2
6	1200	24.2	12.1	233	14.1	12.0	0.14	1275	961	143.3	66.2	165.7
7	1200	36.4	6.7	316	18.9	9.0	0.23	1225	1431	330.4	85.8	333.0
8	1200	39.7	5.7	327	20.2	8.0	0.28	1300	1632	417.6	95.8	399.3
9	1200	44.6	3.9	352	21.8	8.0	0.31	1375	1722	487.4	108.2	449.7
10	1200	48.5	3.3	364	22.5	8.0	0.19	1400	1974	310.1	113.0	529.0
11	690	0.0	17.8	72	4.6	0.0	0.96	1363	72	299.3	21.0	3.6
12*												
13	2300	98.4	1.3	803	49.6	15.0	0.57	200	1556	2064.9	36.1	932.4
14	2300	90.6	2.0	760	46.4	15.0	0.33	375	1146	1118.8	63.8	646.9
15	2300	80.7	5.6	670	41.9	15.0	0.58	275	1332	1782.4	41.6	668.6
16	2300	73.8	7.2	627	37.9	18.0	0.20	450	1746	582.6	63.8	822.0
17	2300	49.2	12.1	465	28.2	19.5	0.17	450	1316	364.3	47.3	458.7
18	2300	24.6	16.3	334	20.1	19.5	0.18	210	528	276.6	15.8	132.2
19	2300	17.7	17.2	298	17.9	19.5	0.18	150	367	246.4	10.1	81.5
20	2300	7.9	18.6	251	15.0	20.0	0.14	146	208	155.5	8.3	38.9
21	2300	2.0	19.7	216	13.1	19.5	0.15	150	155	152.5	7.3	25.0
22	690	0.0	17.7	71	4.4	0.0	0.43	1150	68	135.0	17.8	3.4
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 14.91 GM/BHP-HR
BSHC 1.31 GM/BHP-HR
BSNO2 8.48 GM/BHP-HR
BSFC 0.644 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.8 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 81F - 85F
MAX. EXHAUST TEMP. 1484F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE H-3 AIR-FUEL RATIO RICHER THAN STANDARD FOR ENGINE NO. 22 (0.058 CARBURETOR JETS).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	640	0.0	16.5	75	4.6	1.0	0.33	1350	77	109.1	21.8	4.1
2	1200	1.0	19.2	117	7.1	11.5	0.30	800	89	157.2	20.8	7.7
3	1200	3.9	18.3	134	8.0	13.0	0.17	1200	127	105.3	36.4	12.7
4	1200	8.7	16.7	163	9.5	13.0	0.15	850	229	109.3	31.0	27.7
5	1200	12.1	15.5	181	10.5	13.0	0.13	900	317	109.1	36.5	42.6
6	1200	24.2	12.8	221	14.6	12.5	1.15	2000	886	1170.6	100.5	147.8
7	1200	36.4	8.5	287	18.6	12.5	0.79	1950	1536	1042.8	127.6	333.7
8	1200	39.7	6.8	311	20.3	10.0	1.01	1850	1476	1440.8	130.8	346.6
9	1200	44.6	5.1	336	22.9	8.0	2.00	2050	1115	3060.2	155.0	279.8
10	1200	48.5	3.6	349	23.7	8.0	1.87	2050	1210	2991.2	162.0	317.6
11	690	0.0	17.6	74	4.7	0.0	0.74	1375	73	244.2	22.5	4.0
12*												
13	2300	106.3	1.3	800	53.7	15.0	1.97	1125	1604	7167.0	202.2	957.0
14	2300	97.8	2.7	770	51.6	15.0	1.94	675	1214	6805.4	117.2	700.1
15	2300	87.1	6.0	669	46.0	15.0	2.38	1500	1196	7263.3	226.9	600.2
16	2300	79.7	7.9	595	39.8	20.0	1.49	1700	1693	4046.5	227.9	753.7
17	2300	53.1	12.3	451	30.2	20.0	1.49	1700	1261	3070.5	173.0	426.2
18	2300	26.6	16.6	317	20.9	20.0	1.20	1200	600	1761.4	87.4	145.1
19	2300	19.1	17.7	279	18.2	20.0	0.96	875	452	1240.6	56.1	96.2
20	2300	8.5	19.2	232	15.0	20.0	0.76	500	237	823.9	26.8	41.9
21	2300	2.1	20.1	206	13.7	20.0	1.30	925	228	1251.8	44.0	36.0
22	700	0.0	17.7	75	4.7	0.0	0.65	1225	66	220.0	20.6	3.6
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 61.81 GM/BHP-HR
BSHC 2.83 GM/BHP-HR
BSNO2 7.69 GM/BHP-HR
BSFC 0.638 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 748.5 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 83F - 86F
MAX. EXHAUST TEMP. 1483F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE H-4 AIR-FUEL RATIO RICHER THAN STANDARD FOR ENGINE NO. 22 (0.060 CARBURETOR JETS).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.4	72	5.1	1.0	3.33	2500	52	1118.2	41.5	2.9
2	1200	1.1	19.8	115	7.6	12.5	1.59	1575	82	878.7	43.1	7.4
3	1200	4.3	18.5	127	8.2	12.5	1.19	1350	118	725.1	40.6	11.8
4	1200	9.6	16.7	155	9.5	12.5	0.40	1175	254	299.1	43.7	31.3
5	1200	13.3	15.9	171	10.6	12.5	0.42	1375	401	342.9	56.0	54.1
6	1200	26.7	12.8	219	15.6	12.5	3.20	2425	423	3354.7	125.7	72.8
7	1200	40.0	7.4	302	21.2	12.5	2.77	2375	820	4020.8	170.5	195.3
8	1200	43.8	5.5	333	24.3	8.0	3.95	2375	476	6260.1	186.3	123.7
9	1200	49.1	3.2	363	26.4	8.0	3.96	2400	497	6800.1	204.1	140.1
10	1200	53.4	1.0	397	29.1	8.0	4.08	2475	953	7831.5	234.7	300.1
11	740	0.0	18.0	73	5.0	0.0	2.42	2125	62	816.5	35.5	3.4
12*												
13	2300	110.4	1.1	817	65.6	15.0	6.54	2400	26526367.1		478.5	175.5
14	2300	101.6	2.4	752	53.8	15.0	3.46	1550	116312588.2		278.9	694.4
15	2300	90.5	5.5	676	49.6	15.0	3.99	2000	76313030.9		323.3	409.1
16	2300	82.8	7.3	617	44.3	18.0	3.31	2025	853	9846.9	298.3	416.8
17	2300	55.2	12.2	454	33.0	20.0	3.66	2150	624	8016.8	232.9	224.5
18	2300	27.6	16.5	315	22.5	20.0	3.18	2000	358	4792.3	148.9	88.3
19	2300	19.9	17.8	276	19.6	20.0	3.02	1975	275	4000.1	129.3	59.8
20	2300	8.8	19.4	224	15.8	20.0	2.85	1825	200	3053.5	96.6	35.0
21	2300	2.2	20.3	195	13.2	19.0	1.92	900	123	1842.8	42.8	19.4
22	710	0.0	18.1	74	4.8	0.0	1.14	1750	63	384.2	29.3	3.5
23*												

==23 MODE CYCLE COMPOSITE==
BSCO 151.29 GM/BHP-HR
BSHC 4.31 GM/BHP-HR
BSNO2 4.43 GM/BHP-HR
BSFC 0.663 LB/BHP-HR

==TEST CONDITIONS==
BAROMETER 745.7 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 84F - 87F
MAX. EXHAUST TEMP. 1411F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE H-5 AIR-FUEL RATIO LEANER THAN STANDARD FOR ENGINE NO. 23**(299 CARBURETOR JETS).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.0	65	4.2	5.0	0.69	1775	47	205.3	26.2	2.3
2	1200	1.0	19.3	101	6.5	11.0	0.65	825	65	306.1	19.2	5.0
3	1200	4.1	18.5	107	6.8	17.0	0.51	1140	114	252.5	28.0	9.2
4	1200	9.2	17.6	121	7.6	29.0	0.36	1925	501	202.5	53.1	45.9
5	1200	12.8	16.3	139	8.7	29.0	0.29	2075	959	186.2	66.3	101.7
6	1200	25.7	10.9	212	13.1	21.5	0.16	1960	1850	159.6	94.7	296.7
7	1200	38.5	5.6	284	18.9	11.0	1.37	2100	1369	1786.7	135.7	293.5
8	1200	42.1	4.6	305	22.1	12.0	3.69	2700	613	5201.7	188.2	141.9
9	1200	47.3	2.8	333	24.4	12.0	4.02	2800	601	6278.7	216.2	153.9
10	1200	51.4	1.6	348	25.2	12.0	3.65	2725	915	5950.3	219.9	245.2
11	770	0.0	18.3	67	4.3	5.0	0.59	1525	50	181.2	23.3	2.5
12*												
13	2300	102.3	2.2	687	48.5	20.0	2.98	2100	1261	9686.6	337.4	672.3
14	2300	94.1	3.9	623	43.8	20.0	2.80	2090	1298	8346.5	307.7	634.6
15	2300	83.9	4.8	593	40.5	20.0	2.08	1900	1557	5896.4	266.1	724.1
16	2300	76.7	6.0	570	37.1	20.0	1.13	1525	1876	3081.5	205.2	837.9
17	2300	51.2	11.2	421	27.1	32.0	0.81	1925	2217	1647.4	193.7	740.8
18	2300	25.6	16.3	274	17.8	39.0	0.87	2000	1477	1143.3	129.4	317.2
19	2300	18.4	17.7	241	15.5	39.0	0.67	1750	1053	773.1	100.4	200.4
20	2300	8.2	19.5	194	12.2	39.0	0.37	950	457	345.3	44.0	70.1
21	2300	2.0	20.4	171	10.6	39.0	0.29	475	229	241.6	19.3	30.7
22	770	0.0	18.2	68	4.3	5.0	0.65	1300	45	207.5	20.6	2.4
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 64.89 GM/BHP-HR
BSHC 3.80 GM/BHP-HR
BSNO2 8.99 GM/BHP-HR
BSFC 0.583 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 739.1 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 77F - 79F
MAX. EXHAUST TEMP. 1392F

* ENGINE NOT TESTED IN MOTORED MODES

** ALTHOUGH THE CARBURETOR JETS WERE SIZED TO GIVE A LEANER THAN STD. AIR FUEL RATIO IN THIS TEST, THE CO CONCENTRATIONS INDICATE THAT THE AIR FUEL WAS RICHER THAN STD.. THIS IS CAUSED BY INTERACTION OF POWER ENRICHMENT JETS AT THE HIGH POWER MODES.

TABLE H-6 AIR-FUEL RATIO RICHER THAN STANDARD FOR ENGINE NO. 23 (309 CARBURETOR JETS).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.9	67	4.3	5.0	0.80	1725	45	236.6	25.2	2.1
2	1200	1.0	19.4	105	6.8	10.0	0.97	930	61	463.4	22.0	4.7
3	1200	4.1	18.7	108	7.0	15.5	0.88	1250	99	431.5	30.2	7.9
4	1200	9.2	17.8	121	7.8	29.0	0.75	1975	385	414.4	53.8	34.7
5	1200	12.8	16.5	138	8.9	29.0	0.60	2125	726	373.7	65.8	74.6
6	1200	25.7	11.2	210	13.6	20.5	0.71	2150	1447	681.4	102.7	229.6
7	1200	38.5	5.9	293	20.4	12.0	2.66	2250	838	3564.9	149.0	184.0
8	1200	42.1	4.5	309	23.5	12.0	5.27	2715	330	7485.3	190.8	76.8
9	1200	47.3	2.6	345	26.2	12.0	5.30	2795	411	8385.2	218.6	106.5
10	1200	51.4	1.1	354	26.5	11.0	4.82	2750	653	7881.4	222.2	175.0
11	770	0.0	18.4	68	4.4	5.0	0.71	1575	48	221.5	24.2	2.4
12*												
13	2300	110.2	1.2	740	56.0	21.0	5.08	2405	568	17639.5	412.7	323.1
14	2300	101.3	2.7	689	51.4	20.5	4.60	2400	766	15031.3	387.7	410.4
15	2300	90.3	4.3	645	47.8	20.5	4.43	2405	795	13455.3	361.5	396.4
16	2300	82.6	5.4	602	42.0	20.5	2.68	2075	1281	7635.4	291.9	598.0
17	2300	55.1	10.6	448	30.4	30.0	1.86	2260	1638	4020.1	241.8	582.0
18	2300	27.6	16.3	285	19.5	39.5	2.08	2500	1102	2826.1	167.9	245.8
19	2300	19.8	17.7	247	16.8	39.0	1.87	2325	843	2191.3	135.0	162.3
20	2300	8.8	19.8	193	12.8	39.0	1.23	1700	401	1135.5	77.9	60.9
21	2300	2.2	20.8	163	10.6	38.0	0.92	1100	186	717.6	42.4	23.8
22	760	0.0	18.5	66	4.2	5.0	0.50	1500	41	151.4	22.5	2.0
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 119.99 GM/BHP-HR
BSHC 4.40 GM/BHP-HR
BSNO2 5.82 GM/BHP-HR
BSFC 0.611 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 744.0 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 77F
MAX. EXHAUST TEMP. 1392F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX I. -- RESULTS FROM TESTS USING EXHAUST GAS RECIRCULATION (EGR) WITH HEAVY DUTY GASOLINE ENGINES (23-MODE CYCLE)

TABLE I-1 STANDARD ADJUSTMENTS WITH 5% EGR FOR ENGINE NO. 22 (THIS ENGINE USED A VACUUM MODULATED EGR VALVE AND THE 5% EGR IS A NOMINAL VALUE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	675	0.0	18.3	74	4.9	1.5	1.86	2900	49	606.3	46.8	2.6
2	1200	1.0	19.3	116	6.9	12.5	0.22	2100	63	111.9	53.5	5.2
3	1200	3.9	18.7	131	7.9	12.5	0.25	1290	98	146.8	37.6	9.5
4	1200	8.7	16.9	164	9.4	13.0	0.14	990	134	99.1	35.9	16.1
5	1200	12.1	15.0	183	10.5	13.0	0.13	1020	156	109.2	41.1	20.8
6	1200	24.2	11.8	222	14.1	13.0	0.41	2010	425	416.4	101.8	71.4
7	1200	36.4	7.2	294	18.2	13.0	0.21	1815	897	285.1	121.4	199.3
8	1200	39.7	5.4	319	20.4	9.0	0.47	1896	933	700.0	139.7	228.3
9	1200	44.6	4.2	337	21.8	8.0	0.55	2013	1166	861.9	157.3	302.7
10	1200	48.5	3.0	371	23.8	8.0	0.45	1810	1479	791.7	158.2	429.4
11	700	0.0	18.1	74	5.0	0.0	1.94	3400	52	671.7	58.4	3.0
12*												
13	2300	98.4	2.5	733	46.8	15.0	0.69	1380	1694	2408.2	237.3	966.9
14	2300	90.6	3.7	701	45.8	15.0	1.13	1281	1202	3806.3	212.7	662.7
15	2300	80.7	5.2	607	40.0	15.0	1.10	1470	973	3137.2	208.2	457.6
16	2300	73.8	6.4	596	37.8	19.0	0.47	1170	1039	1365.9	166.6	491.5
17	2300	49.2	10.7	460	29.2	20.0	0.55	1005	508	1216.5	109.1	182.8
18	2300	24.6	14.7	319	20.2	20.0	0.49	660	182	748.5	49.4	45.3
19	2300	17.7	16.0	297	18.7	20.0	0.41	510	146	585.1	35.8	33.8
20	2300	7.9	17.9	250	15.7	20.0	0.35	350	101	420.7	20.8	19.9
21	2300	2.0	19.8	205	13.0	20.0	0.44	420	89	434.6	20.5	14.4
22	695	0.0	18.2	73	4.9	0.0	2.03	3100	51	680.8	51.4	2.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 34.57 GM/BHP-HR
BSHC 3.29 GM/BHP-HR
BSNO2 5.91 GM/BHP-HR
BSFC 0.643 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.9 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 73F - 75F
MAX. EXHAUST TEMP. 1436F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE I-2 STANDARD ADJUSTMENTS WITH 8% EGR FOR ENGINE NO. 22 (THIS ENGINE USED A VACUUM MODULATED EGR VALVE AND THE 8% EGR IS A NOMINAL VALUE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	675	0.0	17.7	76	5.0	1.0	1.95	2700	48	643.7	44.0	2.5
2	1200	1.0	19.5	118	7.1	13.0	0.31	1575	74	162.7	40.5	6.3
3	1200	3.9	19.0	130	7.9	13.0	0.33	1140	102	190.7	32.3	9.6
4	1200	8.7	16.9	163	9.4	13.0	0.13	840	153	94.6	30.6	18.4
5	1200	12.1	14.9	179	10.3	12.5	0.12	918	133	99.4	36.3	17.5
6	1200	24.2	13.5	229	14.6	12.5	0.46	1860	392	482.9	95.6	66.9
7	1200	36.4	5.9	313	19.6	9.5	0.28	1620	699	398.3	114.2	163.7
8	1200	39.7	5.0	314	20.2	8.0	0.51	1842	848	730.1	129.6	198.1
9	1200	44.6	3.8	339	21.9	8.0	0.51	1941	1159	790.9	148.6	294.8
10	1200	48.5	2.9	373	24.0	8.0	0.49	1950	1530	840.9	166.1	432.8
11	700	0.0	18.1	79	5.1	0.0	2.00	2640	55	694.3	45.3	3.1
12*												
13	2300	98.4	2.4	746	47.7	15.0	0.79	1272	1645	2688.6	214.0	919.3
14	2300	90.6	3.6	684	44.5	15.0	1.05	1200	1174	3278.8	185.3	602.0
15	2300	80.7	4.9	626	41.1	15.0	1.09	1365	873	3140.0	194.2	412.0
16	2300	73.8	5.7	598	39.1	15.0	0.92	1320	786	2543.9	181.5	358.8
17	2300	49.2	9.4	469	29.7	20.0	0.49	885	375	1071.5	95.6	134.1
18	2300	24.6	14.0	338	21.4	20.0	0.47	600	156	741.9	46.9	40.5
19	2300	17.7	15.5	309	19.5	20.0	0.40	450	125	583.0	32.2	29.7
20	2300	7.9	17.6	257	16.1	20.0	0.32	370	91	384.1	21.6	17.5
21	2300	2.0	19.1	218	13.8	20.0	0.44	400	83	450.0	20.3	13.8
22	625	0.0	16.5	66	4.5	0.0	2.63	2500	49	777.4	36.5	2.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 37.28 GM/BHP-HR
BSHC 2.97 GM/BHP-HR
BSNO2 5.10 GM/BHP-HR
BSFC 0.650 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.2 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 76F
MAX. EXHAUST TEMP. 1442F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE I-3 STANDARD ADJUSTMENTS WITH 10% EGR FOR ENGINE NO. 22 (THIS ENGINE USED A VACUUM MODULATED EGR VALVE AND THE 10% EGR IS A NOMINAL VALUE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	18.4	70	4.9	1.0	3.03	2730	48	974.3	43.4	2.5
2	1200	1.0	19.8	112	6.8	12.5	0.36	1500	59	195.0	40.2	5.3
3	1200	3.9	18.5	133	7.9	12.5	0.18	840	90	116.2	26.6	9.3
4	1200	8.7	16.8	163	9.4	12.5	0.14	780	132	107.1	30.0	16.8
5	1200	12.1	16.0	163	10.2	12.5	0.81	1470	142	620.8	55.4	17.8
6	1200	24.2	10.1	234	14.8	12.5	0.41	1650	220	467.9	93.5	41.2
7	1200	36.4	5.4	306	19.7	8.0	0.50	1752	459	780.1	134.0	116.6
8	1200	39.7	4.6	314	20.4	8.0	0.62	1890	540	981.6	148.4	140.8
9	1200	44.6	3.8	344	22.3	8.0	0.51	1908	725	899.4	166.2	209.8
10	1200	48.5	2.3	355	22.9	8.0	0.54	1890	1095	961.5	167.8	322.5
11	680	0.0	17.9	73	4.8	1.0	1.87	5000	49	647.1	85.5	2.7
12*												
13	2300	98.4	2.4	739	47.1	15.0	0.62	1050	1258	2344.1	196.7	782.6
14	2300	90.6	3.6	678	44.0	15.0	0.84	1020	853	2900.8	175.2	486.0
15	2300	80.7	4.8	634	42.1	15.0	1.22	1260	666	3947.5	201.0	352.3
16	2300	73.8	5.4	608	40.3	15.0	1.13	1500	534	3439.0	225.0	266.0
17	2300	49.2	9.3	478	30.4	20.0	0.50	840	296	1231.9	102.2	119.6
18	2300	24.6	13.3	370	23.5	20.0	0.48	570	109	902.3	53.2	33.8
19	2300	17.7	14.6	319	20.2	20.0	0.41	470	96	668.6	37.7	25.3
20	2300	7.9	16.7	274	17.2	20.0	0.36	800	69	496.3	54.7	15.4
21	2300	2.0	18.3	238	15.1	20.0	0.41	990	61	497.5	59.0	11.9
22	675	0.0	18.0	74	5.0	0.0	2.29	5600	47	803.9	97.1	2.7
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 42.19 GM/BHP-HR
BSHC 3.45 GM/BHP-HR
BSNO2 4.11 GM/BHP-HR
BSFC 0.657 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 72F - 78F
MAX. EXHAUST TEMP. 1447F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE I-4 STANDARD ADJUSTMENTS WITH 12% EGR FOR ENGINE NO. 22 (THIS ENGINE USED A VACUUM MODULATED EGR VALVE AND THE 12% EGR IS A NOMINAL VALUE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.9	87	5.3	2.0	1.04	5000	46	393.6	93.2	2.8
2	1200	1.0	19.4	118	7.1	12.0	0.51	3000	65	253.1	74.1	5.3
3	1200	3.9	18.7	134	7.9	13.0	0.17	1110	94	100.5	32.4	9.1
4	1200	8.7	16.7	164	9.4	14.0	0.13	900	141	96.5	32.5	16.9
5	1200	12.1	16.2	186	11.1	14.0	0.18	1290	172	152.0	54.8	24.1
6	1200	24.2	10.1	241	15.1	14.0	0.21	1710	237	231.8	92.6	42.6
7	1200	36.4	5.4	313	20.0	9.0	0.48	1770	503	689.7	125.3	118.0
8	1200	39.7	4.6	328	21.1	9.0	0.51	1830	680	773.1	136.5	168.2
9	1200	44.6	3.3	355	22.8	9.0	0.45	1860	1005	737.3	151.5	271.9
10	1200	48.5	2.6	362	23.1	9.0	0.45	1905	1458	759.9	158.8	403.4
11	700	0.0	18.2	81	5.0	1.0	1.04	5700	78	374.5	101.7	4.6
12*												
13	2300	98.4	2.1	771	48.9	15.0	0.60	990	1497	2171.2	175.8	883.0
14	2300	90.6	3.1	696	44.8	15.0	0.83	960	971	2639.2	151.4	508.0
15	2300	80.7	4.4	637	41.8	15.0	1.16	1155	667	3430.4	169.6	324.8
16	2300	73.8	4.9	598	39.4	15.0	1.16	1260	586	3166.5	170.7	263.6
17	2300	49.2	8.7	486	30.8	20.0	0.48	822	283	1088.8	92.2	105.1
18	2300	24.6	12.8	375	23.8	20.0	0.48	579	107	843.0	50.5	30.7
19	2300	17.7	14.0	320	20.2	20.0	0.43	540	88	624.2	38.6	20.6
20	2300	7.9	16.4	277	17.4	20.0	0.39	570	67	488.1	35.7	13.9
21	2300	2.0	18.2	235	14.8	20.0	0.39	720	63	409.0	37.6	10.9
22	660	0.0	17.2	77	4.7	0.0	1.64	6000	54	518.8	93.9	2.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 34.27 GM/BHP-HR
BSHC 3.43 GM/BHP-HR
BSNO2 4.24 GM/BHP-HR
BSFC 0.664 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 72F - 75F
MAX. EXHAUST TEMP. 1468F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE I-5 STANDARD ADJUSTMENTS WITH 15% EGR FOR ENGINE NO. 22 (THIS ENGINE USED A VACUUM MODULATED EGR VALVE AND THE 15% EGR IS A NOMINAL VALUE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	700	0.0	17.2	83	4.9	2.0	0.19	5100	56	76.3	100.8	3.6
2	1200	1.0	19.8	119	7.0	12.0	0.28	1000	68	150.2	26.9	6.0
3	1200	3.9	19.1	132	7.7	13.0	0.18	850	96	107.7	25.7	9.5
4	1200	8.7	17.0	161	9.2	13.0	0.13	770	156	100.8	28.9	19.3
5	1200	12.1	16.1	168	10.1	14.0	0.35	1000	207	277.9	39.2	27.0
6	1200	24.2	9.3	247	15.4	14.0	0.31	1400	217	372.3	82.5	42.3
7	1200	36.4	4.9	311	20.0	9.0	0.53	1450	505	794.1	108.4	125.4
8	1200	39.7	4.1	325	20.9	9.0	0.53	1500	659	855.9	119.0	173.7
9	1200	44.6	3.1	336	21.6	9.0	0.50	1550	992	832.8	127.1	270.1
10	1200	48.5	2.4	357	22.9	9.0	0.46	1650	1413	802.6	142.0	403.9
11	710	0.0	17.6	86	5.1	0.0	0.33	5200	64	128.8	101.4	4.1
12*												
13	2300	98.4	2.1	756	48.1	15.0	0.63	900	1509	2196.5	155.1	863.0
14	2300	90.6	2.9	697	44.9	15.0	0.81	800	983	2603.6	126.7	517.0
15	2300	80.7	3.9	639	41.8	15.0	1.05	900	720	3087.0	130.5	346.2
16	2300	73.8	4.7	610	40.1	15.0	1.09	1000	590	3072.1	139.0	271.9
17	2300	49.2	7.9	485	30.8	20.0	0.48	660	270	1090.3	73.9	100.1
18	2300	24.6	11.5	373	23.8	20.0	0.53	560	99	932.8	48.4	28.4
19	2300	17.7	12.9	340	21.6	20.0	0.50	530	79	797.5	41.7	20.4
20	2300	7.9	15.2	286	18.1	20.0	0.48	850	55	639.7	55.8	11.8
21	2300	2.0	16.7	248	15.6	20.0	0.46	1000	48	516.9	56.1	8.8
22	720	0.0	17.4	80	5.2	0.0	1.58	3800	44	549.1	65.3	2.5
23*												

==23 MODE CYCLE COMPOSITE==
BSCO 32.76 GM/BHP-HR
BSHC 2.87 GM/BHP-HR
BSNO2 4.30 GM/BHP-HR
BSFC 0.668 LB/BHP-HR

==TEST CONDITIONS==
BAROMETER 746.5 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 78F
MAX. EXHAUST TEMP. 1454F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE I-6 STANDARD ADJUSTMENTS WITH 5% EGR FOR ENGINE NO. 23 (EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	745	0.0	18.0	66	4.2	5.0	0.51	1620	41	137.1	21.7	1.8
2	1200	1.0	19.2	108	6.7	11.0	0.40	720	71	183.6	16.2	5.2
3	1200	4.1	18.2	111	6.9	19.0	0.33	1050	116	155.5	24.8	9.0
4	1200	9.2	17.1	124	7.6	30.0	0.22	1750	459	118.3	46.1	40.1
5	1200	12.8	15.8	142	8.6	30.0	0.13	1850	807	81.0	55.9	81.0
6	1200	25.7	9.4	231	13.7	16.0	0.09	1550	1449	88.1	76.1	236.2
7	1200	38.5	4.7	310	19.5	11.0	0.42	1675	1628	567.0	110.8	357.7
8	1200	42.1	3.5	318	21.2	12.0	1.62	2050	1313	2202.2	138.0	293.4
9	1200	47.3	3.0	331	23.0	12.0	2.82	2300	1083	4005.7	161.5	252.5
10	1200	51.4	1.4	344	23.9	12.0	2.84	2300	1252	4249.8	170.2	307.5
11	750	0.0	18.2	66	4.2	5.0	0.59	1450	47	163.6	19.8	2.1
12*												
13	2300	102.3	2.7	679	45.8	20.0	1.96	1775	1587	5796.9	260.1	771.9
14	2300	94.1	4.0	621	41.9	20.0	2.05	1800	1572	5589.6	242.8	703.6
15	2300	83.9	3.8	618	40.4	20.0	1.35	1550	1724	3686.6	210.1	775.9
16	2300	76.7	4.9	602	37.2	20.0	0.50	1025	1792	1344.5	136.5	792.3
17	2300	51.2	10.0	441	26.5	27.5	0.22	1300	1988	427.3	127.2	645.4
18	2300	25.6	15.8	287	17.5	39.0	0.22	1300	1423	277.2	82.3	299.3
19	2300	18.4	17.0	255	15.5	39.0	0.20	1050	957	228.0	58.2	176.0
20	2300	8.2	18.6	212	12.7	39.0	0.16	525	410	152.9	24.2	62.6
21	2300	2.0	20.6	179	10.6	39.0	0.15	315	221	118.3	12.2	28.3
22	770	0.0	18.5	67	4.2	5.0	0.42	1435	51	120.4	20.2	2.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 35.75 GM/BHP-HR
BSHC 2.84 GM/BHP-HR
BSNO2 8.97 GM/BHP-HR
BSFC 0.574 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.7 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 73F - 75F
MAX. EXHAUST TEMP. 1414F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE I-7 STANDARD ADJUSTMENTS WITH 5 TO 7.5% EGR** FOR ENGINE NO. 23 (EGR WAS CUT-OFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.0	68	4.3	5.0	0.51	1500	49	164.7	23.7	2.5
2	1200	1.0	18.9	108	6.7	9.0	0.37	550	65	185.4	13.6	5.3
3	1200	4.1	18.1	111	6.8	19.0	0.28	1150	93	148.8	29.8	8.0
4	1200	9.2	17.0	127	7.7	30.0	0.18	1750	272	107.4	51.6	26.5
5	1200	12.8	15.4	146	8.7	30.0	0.10	1750	408	67.9	60.5	46.7
6	1200	25.7	7.0	239	14.7	11.0	0.25	1350	435	284.5	77.2	82.6
7	1200	38.5	3.8	282	19.7	11.0	2.89	1150	404	3863.8	76.1	88.8
8	1200	42.1	2.5	300	21.2	11.0	2.92	2375	556	4223.5	169.9	131.8
9	1200	47.3	2.6	319	22.6	11.0	2.96	2500	965	4610.0	192.7	246.7
10	1200	51.4	1.2	340	23.8	11.0	2.83	2420	1305	4689.4	198.7	355.8
11	750	0.0	18.4	67	4.2	5.0	0.45	1375	42	144.2	21.8	2.2
12*												
13	2300	102.3	2.6	675	45.6	20.0	1.88	1750	1733	6201.0	286.2	941.2
14	2300	94.1	3.9	632	42.8	20.0	1.96	1800	1648	6046.6	275.1	835.9
15	2300	83.9	2.0	592	41.0	20.0	2.39	1900	742	6908.4	271.9	352.6
16	2300	76.7	3.0	565	38.8	20.0	2.21	1800	682	6149.1	247.1	311.0
17	2300	51.2	9.0	437	27.3	25.0	0.48	1250	868	1042.0	134.3	309.4
18	2300	25.6	15.5	288	17.5	39.0	0.22	1325	874	311.0	94.2	206.1
19	2300	18.4	17.0	254	15.4	39.0	0.22	1050	519	286.5	66.6	109.1
20	2300	8.2	18.9	207	12.4	39.0	0.17	565	225	178.7	29.0	38.1
21	2300	2.0	20.5	182	10.7	39.0	0.16	340	197	143.6	15.0	28.9
22	760	0.0	18.5	69	4.3	5.0	0.30	1300	44	100.5	21.2	2.4
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 59.47 GM/BHP-HR
BSHC 3.44 GM/BHP-HR
BSNO2 5.87 GM/BHP-HR
BSFC 0.586 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.2 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 77F
MAX. EXHAUST TEMP. 1409F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE.

TABLE I-8 STANDARD ADJUSTMENTS WITH 5 TO 10% EGR**FOR ENGINE NO. 23 (EGR WAS CUT-OFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHALST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	18.1	69	4.3	5.0	0.30	1360	43	91.2	20.3	2.1
2	1200	1.0	19.3	105	6.6	10.5	0.46	670	65	217.1	15.6	5.0
3	1200	4.1	18.4	110	6.9	17.5	0.41	1050	88	202.8	25.7	7.1
4	1200	9.2	17.3	120	7.5	28.0	0.37	1850	259	198.6	49.4	23.0
5	1200	12.8	15.9	139	8.6	30.0	0.25	1950	481	159.0	61.1	50.0
6	1200	25.7	6.8	232	14.3	11.0	0.26	1350	412	280.6	71.6	72.6
7	1200	38.5	2.2	289	20.2	11.0	2.74	2225	362	3669.1	147.1	79.5
8	1200	42.1	1.0	305	21.0	11.0	2.67	2125	596	3719.6	146.5	136.5
9	1200	47.3	2.5	315	22.1	11.0	2.87	2450	1005	4159.4	175.5	239.0
10	1200	51.4	1.0	334	23.2	11.0	2.74	2350	1285	4263.7	181.0	328.6
11	760	0.0	18.3	68	4.3	5.0	0.41	1350	48	126.3	20.7	2.4
12*												
13	2300	102.3	2.7	672	45.1	20.0	1.73	1675	1836	5488.2	263.1	957.8
14	2300	94.1	3.9	615	41.3	20.0	1.81	1700	1815	5177.3	240.8	853.9
15	2300	83.9	2.2	575	39.3	20.0	2.09	1825	927	5725.5	246.7	416.1
16	2300	76.7	3.0	566	38.5	20.0	2.03	1700	800	5515.0	227.9	355.8
17	2300	51.2	7.4	444	27.5	20.0	0.45	870	600	960.8	91.3	209.2
18	2300	25.6	15.7	279	17.0	39.0	0.44	1250	956	573.2	81.0	205.6
19	2300	18.4	17.2	247	14.9	39.0	0.26	950	652	306.5	54.8	124.8
20	2300	8.2	18.8	201	11.9	39.0	0.25	500	279	238.5	23.3	43.1
21	2300	2.0	20.4	174	10.1	39.0	0.25	300	214	203.1	12.0	28.4
22	770	0.0	18.4	68	4.2	5.0	0.25	1200	51	78.1	18.3	2.5
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 52.58 GM/BHP-HR
BSHC 3.03 GM/BHP-HR
BSNO2 5.90 GM/BHP-HR
BSFC 0.576 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.7 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 79F
MAX. EXHAUST TEMP. 1417F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 10% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE.

TABLE I-9 STANDARD ADJUSTMENTS WITH 15% OR MAXIMUM EGR FOR ENGINE NO. 23**(EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE).

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.9	67	4.3	5.0	0.59	1775	40	179.3	26.6	2.0
2	1200	1.0	19.2	107	6.7	10.5	0.58	370	56	286.1	9.0	4.5
3	1200	4.1	17.5	133	7.4	25.0	0.39	3700	48	233.7	109.8	4.7
4	1200	9.2	11.9	175	9.9	25.0	0.20	4300	69	165.4	173.7	9.3
5	1200	12.8	9.2	184	11.7	11.0	1.35	4000	81	1130.0	165.6	11.1
6	1200	25.7	3.6	243	16.5	11.0	1.85	2050	149	2142.5	117.4	28.1
7	1200	38.5	1.0	294	20.4	11.0	2.72	2100	364	3744.5	143.1	82.4
8	1200	42.1	1.0	306	21.1	11.0	2.76	2100	534	3922.7	147.8	124.6
9	1200	47.3	2.3	324	22.1	11.0	1.74	2430	915	2839.0	196.1	244.9
10	1200	51.4	1.2	344	23.2	11.0	1.56	2350	1204	2722.1	202.2	344.1
11	760	0.0	18.3	66	4.2	5.0	0.55	1415	47	169.5	21.6	2.4
12*												
13	2300	102.3	2.8	670	45.2	20.0	1.87	1730	1726	6084.3	278.6	923.1
14	2300	94.1	4.0	623	42.0	20.0	1.87	1725	1687	5653.9	258.0	837.4
15	2300	83.9	2.3	589	40.2	20.0	2.12	1825	741	6099.2	259.1	349.3
16	2300	76.7	3.1	591	37.9	20.0	0.87	1025	381	2515.6	146.8	181.2
17	2300	51.2	5.8	457	29.1	20.0	0.79	975	404	1777.8	109.0	149.6
18	2300	25.6	9.8	332	20.7	25.0	0.56	3100	165	908.7	248.5	43.9
19	2300	18.4	11.0	308	18.6	30.0	0.38	6000	137	567.0	444.0	33.7
20	2300	8.2	14.6	245	14.1	39.0	0.30	8800	111	348.8	498.3	20.9
21	2300	2.0	20.4	169	10.0	39.0	0.17	450	182	140.3	18.1	24.3
22	775	0.0	18.4	69	4.3	5.0	0.38	1450	42	124.4	23.6	2.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 57.03 GM/BHP-HR
BSHC 4.74 GM/BHP-HR
BSNO2 4.68 GM/BHP-HR
BSFC 0.608 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 78F
MAX. EXHAUST TEMP. 1410F

* ENGINE NOT TESTED IN MOTORED MODES

** 15% EGR WAS USED IN ALL MODES OF THE CYCLE FROM 8% TO 82% LOAD EXCEPT WHERE 15% EGR WAS NOT ATTAINABLE DUE TO LIMITATION OF FLOW THROUGH THE EGR VALVE. FOR THOSE MODES WITH LESS THAN 15% EGR INDICATED, THE EGR VALVE WAS WIDE OPEN.

APPENDIX J. -- RESULTS FROM TESTS USING VARIED IGNITION TIMING WITH HEAVY DUTY GASOLINE ENGINES (23-MODE CYCLE)

TABLE J-1 MODIFIED VACUUM ADVANCE UNIT NO. 1 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	710	0.0	18.0	72	5.0	1.0	3.34	2220	87	998.3	32.9	4.3
2	1200	1.0	19.8	125	7.4	18.0	0.21	1020	107	121.5	28.7	9.9
3	1200	3.9	18.4	132	7.8	16.0	0.19	1110	169	111.2	32.9	16.6
4	1200	8.7	16.7	159	9.2	16.0	0.13	1170	293	96.2	41.6	34.5
5	1200	12.1	15.5	182	10.4	16.0	0.12	1860	370	101.0	76.8	50.6
6	1200	24.2	12.9	220	14.1	16.0	0.53	2220	1296	545.4	112.0	217.1
7	1200	36.4	8.0	294	18.2	14.0	0.16	1860	1961	217.1	126.0	441.2
8	1200	39.7	6.2	327	20.6	9.0	0.28	1800	1725	434.6	135.9	432.1
9	1200	44.6	4.9	348	22.4	9.0	0.50	2040	1754	825.3	165.2	471.5
10	1200	48.5	3.0	362	23.2	9.0	0.59	2025	1819	1016.0	171.7	512.2
11	720	0.0	18.0	74	5.0	1.0	2.25	2340	87	751.3	38.6	4.8
12*												
13	2300	98.4	1.6	778	49.5	15.5	1.02	440	1470	3767.1	80.2	889.0
14	2300	90.6	4.1	697	45.4	15.5	1.32	575	1297	4323.7	93.5	700.1
15	2300	80.7	6.9	621	39.3	18.0	0.55	1020	1855	1622.6	149.9	905.1
16	2300	73.8	8.9	566	35.9	22.0	0.38	1500	2333	1042.8	201.8	1042.1
17	2300	49.2	13.1	431	27.3	25.0	0.42	1485	1759	866.4	151.6	595.9
18	2300	24.6	16.7	306	19.2	25.0	0.48	930	805	702.8	67.3	193.2
19	2300	17.7	17.9	272	16.9	25.0	0.45	680	534	578.6	43.7	113.8
20	2300	7.9	19.4	225	14.1	25.0	0.54	540	289	574.9	28.6	50.8
21	2300	2.0	20.3	195	12.6	24.0	0.82	720	186	781.0	33.9	28.9
22	720	0.0	18.1	71	4.7	1.0	1.66	2070	81	534.2	33.0	4.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 33.92 GM/BHP-HR
BSHC 2.80 GM/BHP-HR
BSNO2 10.21 GM/BHP-HR
BSFC 0.629 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.0 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 78F - 81F
MAX. EXHAUST TEMP. 1451F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE J-2 MODIFIED VACUUM ADVANCE UNIT NO. 2 FOR ENGINE NO. 22.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX** PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	740	0.0	18.2	76	5.1	1.0	1.95	2235	58	660.9	37.5	3.2
2	1200	1.0	20.0	112	7.0	20.0	0.51	1575	99	262.8	40.2	8.4
3	1200	3.9	18.7	124	7.5	20.0	0.23	1440	167	129.7	40.9	15.7
4	1200	8.7	17.3	147	8.7	20.0	0.15	1530	342	97.8	50.6	37.6
5	1200	12.1	16.2	167	9.7	20.0	0.11	1530	468	84.2	58.3	59.1
6	1200	24.2	13.2	212	13.8	20.0	0.78	2475	1231	780.2	123.0	203.0
7	1200	36.4	8.1	292	18.1	14.5	0.18	1920	1888	253.7	131.1	428.2
8	1200	39.7	6.4	317	19.8	9.5	0.20	1710	1765	304.1	127.9	438.2
9	1200	44.6	4.8	335	21.6	8.5	0.55	1995	1675	875.3	157.8	439.8
10	1200	48.5	3.8	364	23.3	8.0	0.62	1920	1722	1076.7	165.6	493.2
11	730	0.0	17.8	88	5.9	0.0	2.07	2340	61	864.5	48.3	4.1
12*												
13	2300	98.4	1.6	744	47.1	16.0	0.92	395	1523	3312.0	70.1	897.2
14	2300	90.6	3.7	716	46.3	16.0	1.10	400	1205	3744.5	67.6	676.4
15	2300	80.7	6.9	623	39.5	18.5	0.61	1020	1862	1851.5	152.3	923.2
16	2300	73.8	8.7	573	36.3	23.0	0.59	1410	2102	1626.9	193.6	957.9
17	2300	49.5	13.2	426	27.1	29.0	0.47	1710	1977	971.9	175.3	672.9
18	2300	24.6	16.9	300	18.9	28.0	0.51	1125	880	739.5	80.4	208.7
19	2300	17.7	18.0	270	16.9	28.0	0.46	870	588	610.2	57.6	129.4
20	2300	7.9	19.7	222	14.0	28.0	0.62	730	315	661.8	38.2	54.8
21	2300	2.0	20.4	188	12.3	28.0	1.13	1080	182	1023.8	48.3	27.0
22	715	0.0	18.1	73	4.8	0.0	1.66	2040	61	552.3	33.6	3.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 34.41 GM/BHP-HR
BSHC 2.92 GM/BHP-HR
BSNO2 10.18 GM/BHP-HR
BSFC 0.626 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.2 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 82F - 87F
MAX. EXHAUST TEMP. 1473F

* ENGINE NOT TESTED IN MOTORED MODES
** NOX FOR THIS TEST WAS MEASURED BY NDIR.

TABLE J-3 IGNITION TIMING RETARDED 2.5 DEGREES FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	755	0.0	17.6	87	4.7	2.5	0.24	830	37	93.3	16.2	2.4
2	1200	1.0	19.2	119	6.8	10.0	0.34	520	62	181.8	13.9	5.5
3	1200	4.1	18.7	124	7.1	19.5	0.32	1000	273	179.7	28.0	25.3
4	1200	9.2	17.6	138	8.0	27.0	0.26	1650	453	169.5	52.7	47.9
5	1200	12.8	16.3	156	9.1	26.5	0.18	1690	758	132.5	61.0	90.7
6	1200	25.7	10.1	246	14.1	17.5	0.11	1350	1223	124.5	76.5	230.2
7	1200	38.5	5.0	313	19.8	9.0	1.06	1650	1238	1527.4	118.1	294.3
8	1200	42.1	4.2	330	22.5	9.0	2.95	2110	697	4485.2	158.7	173.9
9	1200	47.3	2.5	355	24.3	9.0	3.04	2225	841	5014.3	181.7	227.9
10	1200	51.4	1.0	378	25.1	9.0	2.56	2000	1111	4533.4	174.9	322.7
11	750	0.0	18.0	87	4.7	2.5	0.28	850	48	110.9	16.6	3.1
12*												
13	2300	102.3	2.2	718	48.9	16.0	2.06	1685	1428	6955.1	281.0	790.8
14	2300	94.1	3.5	666	44.9	16.0	1.98	1590	1430	6237.5	247.9	739.8
15	2300	83.9	4.9	632	42.1	16.0	1.72	1500	1446	5191.7	224.3	718.1
16	2300	76.7	5.4	620	39.1	16.5	0.83	1035	1518	2463.8	152.0	739.9
17	2300	51.2	10.6	466	27.3	26.5	0.26	975	1730	572.3	107.3	632.2
18	2300	25.6	16.0	309	18.0	36.0	0.24	1000	1252	354.7	72.4	300.9
19	2300	18.4	17.3	275	15.8	35.0	0.18	750	832	233.7	48.6	178.9
20	2300	8.2	19.1	228	12.9	36.0	0.15	400	366	167.4	21.5	65.2
21	2300	2.0	20.3	201	11.1	35.0	0.14	250	190	127.9	11.7	29.3
22	760	0.0	18.0	98	4.6	2.5	0.19	600	40	87.9	13.7	3.0
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 47.59 GM/BHP-HR
BSHC 2.86 GM/BHP-HR
BSNO2 8.69 GM/BHP-HR
BSFC 0.604 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 748.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 72F - 76F
MAX. EXHAUST TEMP. 1446F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE J-4 IGNITION TIMING RETARDED 5 DEGREES FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHALST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CC PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.0	80	5.0	0.0	0.23	795	57	80.7	13.5	3.2
2	1200	1.0	19.5	109	6.8	9.5	0.34	525	71	150.9	11.6	5.2
3	1200	4.1	18.7	114	7.1	12.0	0.38	985	132	172.5	22.3	9.9
4	1200	9.2	17.8	129	8.1	24.0	0.35	1600	432	186.8	42.1	37.6
5	1200	12.8	16.4	147	9.2	24.0	0.26	1700	731	161.8	51.5	73.6
6	1200	25.7	10.3	236	14.2	14.0	0.12	1250	1266	114.8	60.8	204.2
7	1200	38.5	4.9	310	20.5	7.0	1.41	1650	1238	1824.6	105.8	263.4
8	1200	42.1	3.8	322	22.8	7.0	3.09	2100	772	4453.0	149.5	182.5
9	1200	47.3	1.7	357	24.8	7.0	2.78	1950	1124	4365.2	151.2	289.2
10	1200	51.4	1.0	387	26.1	7.0	2.31	1800	1244	3572.4	137.9	316.6
11	780	0.0	17.5	78	4.9	0.0	0.32	690	61	98.0	10.3	3.0
12*												
13	2300	102.3	1.7	754	51.1	13.5	2.08	1550	1377	6344.4	234.2	691.1
14	2300	94.1	2.6	713	47.9	13.5	1.87	1450	1420	5486.3	209.9	682.1
15	2300	83.9	4.1	664	44.8	13.5	2.00	1420	1286	5506.3	193.0	580.4
16	2300	76.7	4.8	639	41.9	15.0	1.36	1100	1332	3682.4	147.8	593.8
17	2300	51.2	10.3	474	29.0	24.0	0.32	780	1489	630.6	75.8	480.2
18	2300	25.6	16.0	310	19.0	33.0	0.25	910	1138	323.7	58.2	241.7
19	2300	18.4	17.2	275	16.7	33.0	0.20	650	775	223.8	36.7	145.0
20	2300	8.2	18.9	222	13.4	33.0	0.17	350	352	153.5	15.8	52.9
21	2300	2.0	20.2	195	11.6	33.0	0.13	200	189	101.6	8.0	24.8
22	780	0.0	17.6	80	5.0	0.0	0.27	650	53	87.2	10.4	2.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 48.68 GM/BHP-HR
BSHC 2.41 GM/BHP-HR
BSNO2 7.28 GM/BHP-HR
BSFC 0.635 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 749.8 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 71F - 75F
MAX. EXHAUST TEMP. 1494F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE J-5 IGNITION TIMING RETARDED 7.5 DEGREES FOR ENGINE NO. 23.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	16.4	83	5.2	2.5	0.31	630	59	106.5	10.8	3.4
2	1200	0.9	19.0	109	6.7	10.0	0.31	435	66	145.1	10.0	5.0
3	1200	3.5	18.6	115	7.0	15.0	0.24	730	96	115.3	17.2	7.5
4	1200	7.8	17.8	123	7.5	23.0	0.18	1350	304	91.5	34.4	25.7
5	1200	10.9	16.7	136	8.3	24.0	0.14	1500	489	82.5	42.5	45.9
6	1200	21.7	11.8	221	13.0	16.0	0.11	1200	883	105.0	57.4	140.2
7	1200	32.6	5.6	292	18.3	4.5	0.49	1050	1022	618.8	66.0	213.1
8	1200	35.6	5.0	294	19.2	4.5	1.10	1500	1034	1422.8	96.1	219.9
9	1200	40.0	4.0	313	21.7	4.5	2.82	2100	728	3516.9	129.6	149.2
10	1200	43.4	2.7	329	23.0	4.5	2.82	2120	782	4094.5	152.0	186.2
11	750	0.0	16.5	83	5.2	2.5	0.32	630	58	120.1	11.7	3.5
12*												
13	2300	98.4	1.7	744	50.7	10.0	2.22	1400	1063	7269.6	227.2	572.3
14	2300	90.6	2.5	720	48.1	10.0	1.74	1200	1205	5518.6	188.2	627.2
15	2300	80.7	4.0	660	44.1	10.5	1.79	1150	1106	5253.8	167.4	534.1
16	2300	73.8	4.8	630	40.9	10.5	1.22	800	1110	3479.9	112.5	517.9
17	2300	49.2	10.1	468	28.2	19.0	0.27	530	1217	566.7	55.2	421.1
18	2300	24.6	15.9	301	18.1	29.0	0.23	680	875	306.2	45.5	194.1
19	2300	17.7	17.1	272	16.2	30.0	0.15	460	622	180.5	27.1	121.5
20	2300	7.9	18.8	227	13.5	30.0	0.15	265	319	149.0	13.3	52.9
21	2300	2.0	20.0	194	11.4	30.0	0.12	160	167	101.5	6.8	23.6
22	790	0.0	17.1	86	5.3	2.5	0.25	470	57	96.0	8.8	3.5
23*												

==23 MODE CYCLE COMPOSITE==
BSCO 45.90 GM/BHP-HR
BSHC 2.13 GM/BHP-HR
BSNO2 6.80 GM/BHP-HR
BSFC 0.658 LB/BHP-HR

==TEST CONDITIONS==
BAROMETER 748.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 76F
MAX. EXHAUST TEMP. 1530F

* ENGINE NOT TESTED IN MOTORED MODES

APPENDIX K. -- RESULTS FROM TESTS USING COMBINATIONS OF PARAMETERS FOR REDUCED EMISSIONS FROM HEAVY DUTY GASOLINE ENGINES (23-MODE CYCLE)

TABLE K-1 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 22 -- STD. TIMING, AIR INJECTION (AIR PUMP/ENGINE SPEED RATIO = 1.25), AIR-FUEL RATIO LEANER THAN STANDARD (0.054 CARB. JETS), 15% EGR, AND UCP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	650	0.0	15.0	99	4.5	0.0	0.01	250	55	5.0	5.4	3.9
2	1200	1.0	16.9	208	8.5	12.5	0.01	100	50	10.5	4.7	7.8
3	1200	3.9	15.9	213	8.9	12.5	0.01	95	65	10.7	4.5	10.2
4	1200	8.7	15.9	221	10.1	12.5	0.01	42	137	13.0	2.1	22.9
5	1200	12.1	14.3	229	11.1	12.5	0.01	43	220	13.3	2.2	37.4
6	1200	24.2	7.2	322	16.2	12.5	0.01	43	275	18.6	3.1	66.6
7	1200	36.4	3.4	385	20.8	12.5	0.01	38	668	21.9	3.3	194.0
8	1200	39.7	2.8	379	20.5	8.0	0.01	41	910	21.6	3.5	258.0
9	1200	44.6	1.9	424	23.2	8.0	0.01	52	1209	27.6	5.0	386.9
10	1200	48.5	1.4	447	24.3	8.0	0.01	53	1203	29.3	5.4	410.2
11	710	0.0	16.0	110	5.1	0.0	0.01	195	77	5.3	4.6	6.0
12*												
13	2300	98.4	1.0	810	48.6	15.0	0.05	45	1689	194.6	8.2	1027.4
14	2300	90.6	1.2	798	45.4	15.0	0.02	19	1384	78.5	3.4	832.6
15	2300	80.7	1.8	753	42.5	15.0	0.02	12	973	68.5	2.1	555.4
16	2300	73.8	2.3	739	41.6	15.0	0.02	9	762	60.9	1.5	427.9
17	2300	49.2	5.6	618	33.5	15.0	0.01	7	339	40.9	1.0	158.9
18	2300	24.6	9.5	466	23.2	20.0	0.02	27	143	38.6	2.8	49.7
19	2300	17.7	10.7	463	22.5	20.0	0.02	44	109	39.1	4.7	38.5
20	2300	7.9	13.4	395	18.3	20.0	0.02	100	82	36.6	9.1	24.7
21	2300	2.0	15.1	364	16.2	20.0	0.02	160	68	30.7	13.3	18.5
22	655	0.0	14.8	94	4.2	0.0	0.01	240	66	5.6	5.0	4.5
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.12 GM/BHP-HR
BSHC 0.13 GM/BHP-HR
BSNO2 6.42 GM/BHP-HR
BSFC 0.691 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.7 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 78F
MAX. EXHAUST TEMP. 1528F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE K-2 COMBINATION OF PARAMETERS NO. 1 (REPLICATE OF TEST IN TABLE K-1) FOR ENGINE NO. 22 -- STD. TIMING, AIR INJECTION, AIR-FUEL RATIO LEANER THAN STANDARD, 15% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	650	0.0	15.7	107	4.9	0.0	0.01	210	51	5.1	5.1	4.0
2	1200	1.0	16.7	215	8.6	11.0	0.01	48	50	10.2	2.4	8.1
3	1200	3.9	15.9	226	9.2	12.0	0.01	44	67	10.8	2.3	11.8
4	1200	8.7	14.0	243	11.0	12.0	0.01	95	177	12.7	5.5	33.7
5	1200	12.1	12.9	240	11.4	12.0	0.01	45	186	12.6	2.6	34.9
6	1200	24.2	5.6	348	17.6	8.0	0.01	29	240	18.1	2.4	66.3
7	1200	36.4	3.3	376	19.9	8.0	0.01	38	651	19.3	3.4	192.7
8	1200	39.7	2.7	401	21.4	8.0	0.01	45	865	21.1	4.4	280.3
9	1200	44.6	1.7	426	22.9	8.0	0.01	56	1028	29.5	5.8	350.7
10	1200	48.5	1.4	438	23.9	8.0	0.02	50	883	34.2	5.3	310.5
11	700	0.0	16.1	111	5.1	0.0	0.01	215	68	5.7	5.4	5.6
12*												
13	2300	98.4	1.0	819	50.7	15.0	0.05	65	1125	207.3	13.5	772.8
14	2300	90.6	1.1	807	46.2	15.0	0.03	18	1196	103.9	3.5	788.5
15	2300	80.7	1.8	771	43.7	15.0	0.02	11	806	84.7	2.0	502.0
16	2300	73.8	2.1	751	42.5	15.0	0.02	9	647	79.1	1.6	392.8
17	2300	49.2	5.6	620	33.8	15.0	0.01	8	289	43.1	1.2	143.1
18	2300	24.6	9.4	494	24.5	20.0	0.02	30	127	38.4	3.5	49.3
19	2300	17.7	10.8	441	21.2	20.0	0.02	49	101	38.6	5.2	34.9
20	2300	7.9	13.6	415	18.8	20.0	0.02	85	75	32.9	8.5	24.5
21	2300	2.0	15.4	377	16.3	20.0	0.01	130	65	26.8	11.8	19.6
22	650	0.0	15.9	104	4.6	0.0	0.01	300	52	5.5	7.2	4.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.27 GM/BHP-HR
BSHC 0.15 GM/BHP-HR
BSNO2 5.88 GM/BHP-HR
BSFC 0.708 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 741.9 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 72F - 78F
MAX. EXHAUST TEMP. 1543F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE K-3 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 22 -- STD. TIMING, AIR INJECTION (AIR PUMP/ENGINE SPEED RATIO = 1.25), AIR-FUEL RATIO RICHER THAN STANDARD (0.058 CARB. JETS), 15% EGR, AND UCP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	645	0.0	15.9	108	5.1	1.0	0.01	250	60	4.8	5.7	4.4
2	1200	1.0	18.3	194	8.2	13.0	0.01	37	70	7.1	1.6	5.7
3	1200	3.9	17.5	197	8.5	12.5	0.01	38	106	8.9	1.7	15.2
4	1200	8.7	16.1	226	10.2	12.5	0.01	46	204	10.3	2.4	34.5
5	1200	12.1	13.8	240	11.4	12.5	0.01	47	213	10.9	2.5	38.3
6	1200	24.2	9.2	294	16.0	12.5	0.01	53	288	14.5	3.6	63.8
7	1200	36.4	4.5	362	21.2	8.0	0.03	54	467	43.7	4.6	131.3
8	1200	39.7	3.6	369	21.8	8.0	0.04	58	578	61.1	5.0	164.5
9	1200	44.6	2.6	390	23.2	8.0	0.04	67	814	70.4	6.0	242.5
10	1200	48.5	1.7	400	24.1	8.0	0.08	80	1073	150.7	7.4	329.9
11	645	0.0	16.0	106	5.2	0.0	0.01	200	60	5.3	4.7	4.6
12*												
13	2300	106.3	1.0	856	62.3	15.0	3.93	830	551	1600	2.9	167.1	368.3
14	2300	97.7	1.1	791	49.9	15.0	0.16	11	949	601.0	2.0	586.1
15	2300	87.1	2.0	736	46.1	15.0	0.07	7	645	244.2	1.2	370.1
16	2300	79.7	2.9	714	44.6	15.0	0.06	7	540	188.6	1.2	301.2
17	2300	53.1	7.0	549	32.1	19.0	0.02	12	333	57.0	1.6	140.1
18	2300	26.6	11.4	448	24.1	19.0	0.01	12	135	25.8	1.2	45.7
19	2300	19.1	13.3	406	21.0	20.0	0.01	12	115	20.1	1.1	34.9
20	2300	8.5	15.7	352	17.1	20.0	0.01	15	88	17.3	1.2	22.8
21	2300	2.1	17.1	323	15.2	20.0	0.01	20	75	14.6	1.4	18.0
22	690	0.0	16.2	109	5.1	0.0	0.01	165	57	5.0	3.9	4.5
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 18.99 GM/BHP-HR
BSHC 0.26 GM/BHP-HR
BSNO2 4.05 GM/BHP-HR
BSFC 0.683 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.2 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 79F
MAX. EXHAUST TEMP. 1558F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE K-4 COMBINATION OF PARAMETERS NO. 2 (REPLICATE OF TEST IN TABLE K-3) FOR ENGINE NO. 22 -- STD. TIMING, AIR INJECTION, AIR-FUEL RATIO RICHER THAN STANDARD, 15% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	690	0.0	16.4	110	5.2	1.0	0.01	160	51	4.2	3.9	4.2
2	1200	1.0	18.0	173	7.3	12.5	0.01	36	67	6.6	1.4	8.6
3	1200	3.9	17.1	200	8.7	12.5	0.01	34	135	7.6	1.6	20.6
4	1200	8.7	15.9	219	10.0	12.0	0.01	45	172	8.3	2.3	28.6
5	1200	12.1	13.6	241	11.5	12.0	0.01	46	184	9.3	2.6	34.4
6	1200	24.2	9.1	288	15.7	12.0	0.01	48	252	13.4	3.2	56.3
7	1200	36.4	4.4	354	20.8	8.0	0.03	48	391	44.1	4.1	110.9
8	1200	39.7	3.5	386	22.9	7.5	0.03	49	462	61.0	4.6	142.5
9	1200	44.6	2.5	398	23.8	7.5	0.03	59	659	65.9	5.6	207.6
10	1200	48.5	1.6	421	25.4	7.5	0.12	60	937	236.2	6.0	312.4
11	710	0.0	17.5	99	5.3	0.0	0.01	28	36	4.6	0.6	2.7
12*												
13	2300	106.3	1.0	819	60.3	15.0	4.14	870	4671	6216.1	168.6	300.5
14	2300	97.8	1.1	801	50.7	15.0	0.18	10	956	683.8	1.9	600.9
15	2300	87.1	2.1	756	47.3	15.0	0.07	3	578	237.9	0.5	343.5
16	2300	79.7	2.9	724	45.2	15.0	0.05	3	476	182.1	0.5	270.9
17	2300	53.1	6.9	582	34.0	20.0	0.02	7	282	60.4	0.9	126.3
18	2300	26.6	11.5	445	24.1	20.0	0.01	8	124	26.2	0.8	42.3
19	2300	19.1	12.9	429	22.5	20.0	0.01	10	107	21.5	0.9	35.3
20	2300	8.5	15.3	363	17.6	20.0	0.01	17	86	17.8	1.3	23.2
21	2300	2.1	17.0	326	15.3	19.0	0.01	17	72	15.1	1.3	17.9
22	660	0.0	16.0	105	4.9	0.0	0.01	115	54	4.8	2.7	4.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 19.36 GM/BHP-HR
BSHC 0.24 GM/BHP-HR
BSNO2 3.80 GM/BHP-HR
BSFC 0.694 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.5 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 77F
MAX. EXHAUST TEMP. 1565F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE K-5 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 22 -- STD. TIMING, AIR INJECTION (AIR PUMP/ENGINE SPEED RATIO = 1.25) STANDARD AIR-FUEL RATIO, 15% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	725	0.0	16.9	105	5.2	0.0	0.01	73	47	3.9	1.7	3.6
2	1200	1.0	18.8	168	7.3	12.5	0.01	33	72	7.8	1.3	9.1
3	1200	3.9	17.6	191	8.4	13.0	0.01	33	102	7.2	1.4	14.4
4	1200	8.7	15.7	227	10.2	12.5	0.01	40	149	8.5	2.0	25.2
5	1200	12.1	14.5	222	10.8	12.5	0.01	51	201	10.2	2.6	33.6
6	1200	24.2	8.2	302	15.8	12.5	0.01	47	199	13.8	3.3	45.7
7	1200	36.4	4.1	379	21.0	8.0	0.01	40	620	19.0	3.5	182.4
8	1200	39.7	3.2	384	21.4	8.0	0.01	42	802	19.4	3.8	239.6
9	1200	44.6	2.4	404	22.8	8.0	0.01	48	1135	20.4	4.6	357.3
10	1200	48.5	1.7	425	24.3	8.0	0.01	49	1308	28.5	4.9	431.9
11	695	0.0	16.6	102	5.0	0.0	0.01	70	57	4.7	1.6	4.3
12*												
13	2300	98.4	1.1	819	49.3	15.0	0.05	31	1552	209.6	6.1	1007.2
14	2300	90.6	1.6	785	46.8	15.0	0.03	15	1106	122.7	2.7	679.3
15	2300	80.7	2.4	729	43.3	15.0	0.03	10	763	95.2	1.7	433.1
16	2300	73.8	3.2	703	41.6	15.0	0.02	10	630	73.9	1.6	345.1
17	2300	49.2	6.7	588	32.2	20.0	0.01	13	337	27.0	1.8	152.5
18	2300	24.6	10.9	483	24.8	20.0	0.01	16	136	18.0	1.7	50.1
19	2300	17.7	12.3	428	21.3	20.0	0.01	19	110	16.2	1.9	36.1
20	2300	7.9	14.7	368	17.4	20.0	0.01	33	81	13.9	2.8	22.3
21	2300	2.0	16.7	324	14.8	20.0	0.01	30	69	12.3	2.2	16.9
22	675	0.0	16.9	102	4.9	0.0	0.01	82	46	3.0	1.9	3.4
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.16 GM/BHP-HR
BSHC 0.08 GM/BHP-HR
BSNO2 5.53 GM/BHP-HR
BSFC 0.690 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.7 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 79F
MAX. EXHAUST TEMP. 1549F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE K-6 COMBINATION OF PARAMETERS NO. 3 (REPLICATE OF TEST IN TABLE K-5) FOR ENGINE NO. 22 -- STD. TIMING, AIR INJECTION, STANDARD AIR-FUEL RATIO, 15% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	680	0.0	16.8	101	4.9	1.0	0.01	73	46	3.7	1.6	3.3
2	1200	1.0	18.7	167	7.3	12.0	0.01	33	71	6.1	1.2	8.7
3	1200	3.9	17.5	192	8.4	13.0	0.01	33	100	7.1	1.4	13.9
4	1200	8.7	15.5	223	10.0	13.0	0.01	40	154	8.2	2.0	25.2
5	1200	12.1	13.9	238	11.7	12.5	0.01	45	195	8.7	2.4	33.9
6	1200	24.2	8.1	290	15.1	12.5	0.01	48	270	10.6	3.1	57.6
7	1200	36.4	4.1	361	20.2	8.0	0.01	45	624	16.0	3.6	167.8
8	1200	39.7	3.2	379	21.4	8.0	0.01	46	820	16.7	3.9	230.8
9	1200	44.6	2.4	395	22.4	8.0	0.01	54	1189	19.4	4.8	355.5
10	1200	48.5	1.6	417	23.8	8.0	0.01	56	1363	27.5	5.4	432.8
11	700	0.0	16.7	100	4.9	0.0	0.01	90	70	3.7	2.0	5.1
12*												
13	2300	98.4	1.0	818	49.6	15.0	0.10	45	1552	388.5	8.8	1008.9
14	2300	90.6	1.6	772	45.7	15.0	0.04	20	1191	147.0	3.7	734.7
15	2300	80.7	2.5	723	42.7	15.0	0.03	12	821	109.3	2.1	474.0
16	2300	73.8	3.3	708	41.7	15.0	0.03	10	654	88.5	1.7	370.5
17	2300	49.2	6.8	587	31.7	20.0	0.01	14	358	30.7	2.0	168.8
18	2300	24.6	11.0	460	23.2	20.0	0.01	15	141	22.2	1.7	52.0
19	2300	17.7	12.2	439	21.7	20.0	0.01	20	112	21.4	2.1	39.9
20	2300	7.9	15.0	377	17.5	20.0	0.01	30	87	18.3	2.7	26.2
21	2300	2.0	16.5	346	15.4	20.0	0.01	36	72	13.5	2.9	19.5
22	750	0.0	17.0	114	5.3	0.0	0.01	80	60	4.5	2.2	5.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 1.47 GM/BHP-HR
BSHC 0.09 GM/BHP-HR
BSNO2 5.86 GM/BHP-HR
BSFC 0.686 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.2 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 78F
MAX. EXHAUST TEMP. 1539F

* ENGINE NOT TESTED IN MOTORED MODES

TABLE K-7 COMBINATION OF PARAMETERS NO. 1 FOR ENGINE NO. 23**-- TIMING RETARDED 5 DEGREES, AIR INJECTION (AIR PUMP/ENGINE SPEED RATIO = 2.5) STANDARD AIR-FUEL RATIO, AND 5 TO 7.5% EGR.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.3	98	4.1	0.0	0.11	590	38	47.2	13.0	2.8
2	1200	1.0	18.4	159	6.4	6.5	0.10	270	52	70.7	9.7	6.2
3	1200	4.1	17.7	165	6.9	14.0	0.11	600	80	80.8	22.6	10.0
4	1200	9.2	16.7	176	7.5	24.0	0.09	830	229	77.4	33.6	30.8
5	1200	12.8	15.3	188	8.3	24.0	0.08	1200	382	71.7	52.1	54.9
6	1200	25.7	6.2	308	15.6	6.0	0.13	550	451	192.6	38.9	105.7
7	1200	38.5	2.3	328	19.5	6.0	1.38	810	444	2132.2	61.9	112.5
8	1200	42.1	1.0	358	21.6	6.0	1.55	850	450	2833.3	76.9	134.9
9	1200	47.3	1.0	380	22.8	6.0	1.59	950	919	3098.6	91.4	293.7
10	1200	51.4	1.0	385	23.3	6.0	1.64	1000	919	3239.7	98.0	298.7
11	750	0.0	17.6	104	4.3	0.0	0.14	600	39	71.6	15.0	3.1
12*												
13	2300	102.3	1.8	768	46.1	14.0	0.49	60	1084	2007.0	12.2	733.5
14	2300	94.1	2.5	709	41.7	14.0	0.44	42	1232	1635.2	7.6	743.8
15	2300	83.9	1.6	684	40.9	14.0	0.32	28	705	1141.6	4.9	411.1
16	2300	76.7	2.0	652	38.3	14.0	0.32	31	649	1088.7	5.2	364.2
17	2300	51.2	8.0	570	28.7	14.0	0.13	130	399	399.2	19.7	200.3
18	2300	25.6	15.4	381	16.4	34.0	0.13	680	592	246.5	64.7	186.7
19	2300	18.4	16.7	352	14.6	34.0	0.12	580	415	210.2	50.6	119.9
20	2300	8.2	18.3	304	11.8	34.0	0.10	440	175	159.4	33.2	43.9
21	2300	2.0	20.0	280	10.0	34.0	0.10	390	129	137.7	26.7	29.1
22	770	0.0	17.9	103	4.1	0.0	0.11	580	40	56.5	14.6	3.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 18.22 GM/BHP-HR
BSHC 0.81 GM/BHP-HR
BSNO2 5.51 GM/BHP-HR
BSFC 0.585 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.3 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 78F
MAX. EXHAUST TEMP. 1553F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE. EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE.

TABLE K-8 COMBINATION OF PARAMETERS NO. 1 (REPLICATE OF TEST IN TABLE K-7) FOR ENGINE NO. 23** TIMING RETARDED 5 DEGREES, AIR INJECTION, STANDARD AIR-FUEL RATIO, AND 5 TO 7.5% EGR.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	760	0.0	17.3	104	4.4	0.0	0.10	560	22	45.9	12.7	1.6
2	1200	1.0	18.4	162	6.8	5.0	0.09	240	33	67.9	8.7	4.0
3	1200	4.1	17.6	161	6.9	14.0	0.11	520	43	74.1	18.0	4.8
4	1200	9.2	16.5	171	7.4	21.0	0.08	1000	59	64.3	38.0	7.5
5	1200	12.8	15.3	188	8.3	21.0	0.07	1125	261	59.5	47.2	36.2
6	1200	25.7	7.7	309	15.6	5.0	0.12	480	385	166.6	33.1	88.1
7	1200	38.5	2.3	332	19.6	5.0	1.11	725	476	1624.6	52.4	114.3
8	1200	42.1	1.0	353	21.5	5.0	1.41	775	441	2305.0	62.5	117.8
9	1200	47.3	1.0	377	23.0	5.0	1.46	840	570	2504.9	71.5	161.2
10	1200	51.4	1.0	384	22.9	5.0	1.24	900	816	2153.9	77.5	233.3
11	775	0.0	18.0	101	4.4	0.0	0.12	450	97	51.0	9.6	6.8
12*												
13	2300	102.3	1.5	744	45.8	14.0	0.54	45	940	1747.3	7.2	499.4
14	2300	94.1	2.4	702	41.9	14.0	0.36	55	1110	1121.5	8.4	561.4
15	2300	83.9	1.2	682	42.2	14.0	0.34	22	509	1097.7	3.6	272.9
16	2300	76.7	1.8	641	38.4	14.0	0.34	31	502	959.5	4.4	234.1
17	2300	51.2	6.6	555	28.7	14.0	0.13	145	441	310.4	17.5	176.6
18	2300	25.6	15.4	366	16.7	34.0	0.12	670	598	194.3	53.4	158.4
19	2300	18.4	16.5	338	14.9	34.0	0.11	550	338	168.4	40.6	83.0
20	2300	8.2	18.4	10912	12.1	34.0	0.10	430	145	125.3	27.5	30.6
21	2300	2.0	20.0	267	10.5	35.0	0.09	360	109	99.7	20.2	20.3
22	770	0.0	18.1	108	4.5	0.0	0.10	480	31	43.1	10.4	2.2
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 14.92 GM/BHP-HR
BSHC 0.69 GM/BHP-HR
BSNO2 4.00 GM/BHP-HR
BSFC 0.591 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 747.0 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 79F
MAX. EXHAUST TEMP. 1497F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE. EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE.

TABLE K-9 COMBINATION OF PARAMETERS NO. 2 FOR ENGINE NO. 23**-- STD. TIMING, AIR INJECTION (AIR PUMP/ENGINE SPEED RATIO = 2.5) STANDARD AIR-FUEL RATIO, 5 TO 7.5% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.5	105	4.5	5.0	0.01	115	45	6.7	2.7	3.5
2	1200	1.0	18.4	159	6.6	10.0	0.01	72	71	10.1	2.6	8.4
3	1200	4.1	17.6	162	6.8	18.0	0.01	68	86	10.4	3.2	10.4
4	1200	9.2	16.5	175	7.5	26.0	0.01	125	276	11.2	5.0	36.9
5	1200	12.8	15.4	191	8.2	26.0	0.01	133	428	12.5	6.0	63.7
6	1200	25.7	6.3	288	14.2	8.0	0.01	57	441	18.5	3.9	99.8
7	1200	38.5	2.9	322	18.6	9.0	0.03	68	531	51.8	5.3	137.8
8	1200	42.1	1.0	343	20.3	9.0	0.14	87	498	250.4	7.6	143.8
9	1200	47.3	1.3	354	21.5	9.0	0.18	115	814	326.1	10.4	244.6
10	1200	51.4	1.0	380	22.8	9.0	0.22	125	915	432.9	12.0	290.5
11	760	0.0	18.0	103	4.2	5.0	0.02	75	27	8.0	1.8	2.0
12*												
13	2300	102.3	1.7	736	44.1	20.0	0.12	20	1224	451.1	3.6	727.0
14	2300	94.1	3.0	693	40.5	20.0	0.08	19	1313	276.5	3.2	745.1
15	2300	83.9	1.2	649	39.6	19.0	0.11	11	546	368.1	1.8	291.9
16	2300	76.7	2.0	621	36.2	19.0	0.06	16	664	193.7	2.4	334.7
17	2300	51.2	9.5	507	25.1	25.0	0.02	47	999	40.5	5.8	409.4
18	2300	25.6	15.6	379	16.3	39.0	0.01	69	843	24.9	6.2	251.1
19	2300	18.4	16.8	349	14.5	39.0	0.01	60	508	23.1	5.0	140.2
20	2300	8.2	18.6	310	11.8	39.0	0.01	49	213	20.6	3.6	52.1
21	2300	2.0	20.2	278	9.7	38.0	0.01	47	135	18.5	3.1	29.5
22	760	0.0	18.5	105	4.1	5.0	0.01	78	21	7.2	2.0	1.7
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 2.92 GM/BHP-HR
BSHC 0.12 GM/BHP-HR
BSNO2 5.86 GM/BHP-HR
BSFC 0.559 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 748.5 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 77F
MAX. EXHAUST TEMP. 1445F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE. EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE.

TABLE K-10 COMBINATION OF PARAMETERS NO. 2 (REPLICATE OF TEST IN TABLE K-9) FOR ENGINE NO. 23**-- STD. TIMING, AIR INJECTION, STANDARD AIR-FUEL RATIO, 5 TO 7.5% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.7	97	4.0	5.0	0.01	78	21	4.5	1.7	1.4
2	1200	1.0	18.8	157	6.4	12.0	0.01	70	38	7.2	2.5	4.3
3	1200	4.1	17.7	163	6.8	15.0	0.01	68	68	8.4	2.6	8.5
4	1200	9.2	16.7	169	7.2	25.0	0.01	130	212	8.5	5.0	26.9
5	1200	12.8	15.5	183	8.0	26.5	0.01	155	413	9.3	6.5	57.8
6	1200	25.7	6.8	275	13.6	9.0	0.01	53	402	14.0	3.4	84.6
7	1200	38.5	2.5	318	18.6	9.0	0.05	67	433	78.8	5.0	107.4
8	1200	42.1	1.0	332	20.0	10.0	0.12	75	564	191.4	6.0	149.4
9	1200	47.3	1.7	346	21.1	10.0	0.13	100	855	219.7	8.3	236.3
10	1200	51.4	1.0	368	22.0	10.0	0.15	100	1018	274.0	8.8	296.8
11	750	0.0	18.4	100	4.1	5.0	0.01	58	24	5.1	1.3	1.7
12*												
13	2300	102.3	1.8	736	43.7	20.0	0.10	28	1484	336.3	4.9	853.6
14	2300	94.1	3.0	684	40.2	20.0	0.07	21	1497	219.1	3.3	787.3
15	2300	83.9	1.7	648	37.8	20.0	0.05	17	777	162.8	2.6	397.3
16	2300	76.7	1.5	622	37.2	20.0	0.07	12	542	225.0	1.8	273.3
17	2300	51.2	8.7	496	24.9	24.0	0.01	43	977	26.0	5.1	386.3
18	2300	25.6	15.5	366	15.8	39.0	0.01	72	845	14.2	6.2	239.7
19	2300	18.4	16.7	339	14.1	38.0	0.01	63	203	13.3	5.0	53.7
20	2300	8.2	18.6	296	11.4	38.0	0.01	52	205	10.3	3.6	46.8
21	2300	2.0	20.1	269	9.7	38.0	0.01	50	123	9.5	3.1	25.5
22	750	0.0	18.4	103	4.1	5.0	0.01	65	23	3.6	1.6	1.8
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 2.22 GM/BHP-HR
BSHC 0.11 GM/BHP-HR
BSNO2 5.72 GM/BHP-HR
BSFC 0.551 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 746.8 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 73F - 77F
MAX. EXHAUST TEMP. 1436F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE. EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE.

TABLE K-11 COMBINATION OF PARAMETERS NO. 3 FOR ENGINE NO. 23** -- TIMING RETARDED 5 DEGREES, AIR INJECTION (AIR PUMP/ENGINE SPEED RATIO = 2.5), STANDARD AIR-FUEL RATIO, 5 TO 7.5% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	750	0.0	17.5	99	4.4	0.0	0.02	77	29	6.7	1.7	2.0
2	1200	1.0	18.4	156	6.7	6.0	0.01	34	54	10.4	1.2	6.1
3	1200	4.1	17.8	157	6.8	17.0	0.01	72	70	10.6	2.6	8.1
4	1200	9.2	16.4	177	7.8	24.0	0.02	121	199	13.1	4.7	25.9
5	1200	12.8	14.8	192	8.8	24.0	0.02	125	283	14.2	5.3	40.0
6	1200	25.7	5.0	295	16.2	6.0	0.02	42	265	25.7	2.7	56.5
7	1200	38.5	1.1	350	20.9	6.0	0.10	63	382	157.8	4.9	97.8
8	1200	42.1	1.0	369	22.1	6.0	0.15	80	510	249.9	6.7	140.9
9	1200	47.3	1.0	387	23.3	6.0	0.15	100	936	260.5	8.7	270.6
10	1200	51.4	1.0	400	24.1	6.0	0.11	19	926	206.1	1.7	278.0
11	780	0.0	17.9	103	4.4	0.0	0.01	59	28	5.1	1.3	2.0
12*												
13	2300	102.3	1.6	760	48.2	16.0	0.17	125	734	610.1	22.0	429.1
14	2300	94.1	2.6	754	44.7	16.0	0.05	12	1309	186.0	2.0	728.5
15	2300	83.9	1.6	686	42.0	16.0	0.08	8	605	270.0	1.3	315.7
16	2300	76.7	1.3	665	41.5	16.0	0.14	40	366	418.4	6.1	185.3
17	2300	51.2	9.0	525	27.8	21.0	0.01	29	934	26.6	3.5	377.8
18	2300	25.6	15.8	363	16.7	35.0	0.01	55	781	14.0	4.6	219.1
19	2300	18.4	16.8	338	14.9	35.0	0.01	45	529	13.1	3.5	137.5
20	2300	8.2	18.7	298	12.1	35.0	0.01	42	221	11.6	2.9	51.0
21	2300	2.0	20.0	268	10.2	35.0	0.01	40	133	10.5	2.5	27.4
22	750	0.0	18.0	102	4.3	0.0	0.01	60	30	4.9	1.4	2.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 3.24 GM/BHP-HR
BSHC 0.12 GM/BHP-HR
BSNO2 4.91 GM/BHP-HR
BSFC 0.608 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 745.2 MMHG
HUMIDITY 54 GRAINS/LB
INLET AIR TEMP. RANGE 74F - 79F
MAX. EXHAUST TEMP. 1541F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE. EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE.

TABLE K-12 COMBINATION OF PARAMETERS NO. 3 (REPLICATE OF TEST IN TABLE K-11) FOR ENGINE NO. 23** - TIMING RETARDED 5 DEGREES, AIR INJECTION, STANDARD AIR-FUEL RATIO, 5 TO 7.5% EGR, AND UOP CATALYSTS.

MODE	ENGINE SPEED RPM	OBSERVED POWER BHP	MANIFOLD VACUUM "HG	EXHAUST FLOW LB/HR	FUEL FLOW LB/HR	IGNITION TIMING DEG BTC	CO PCT	HC PPMC	NOX PPM	CO GM/HR	HC GM/HR	NO2 GM/HR
1	760	0.0	17.3	115	4.5	0.0	0.02	90	30	9.6	2.6	2.7
2	1200	1.0	18.5	175	6.6	8.0	0.01	46	54	12.9	2.0	7.6
3	1200	4.1	18.4	191	7.2	21.0	0.01	87	93	14.2	4.2	14.6
4	1200	9.2	16.9	196	7.7	24.5	0.01	125	249	14.5	6.1	40.7
5	1200	12.8	15.4	204	8.3	24.0	0.01	135	369	15.2	6.9	62.7
6	1200	25.7	6.4	328	15.8	7.0	0.02	49	441	28.6	4.3	127.8
7	1200	38.5	2.1	342	20.3	7.0	0.08	67	430	168.6	6.7	142.7
8	1200	42.1	2.0	354	21.4	7.0	0.17	87	612	359.4	9.0	210.8
9	1200	47.3	1.0	367	22.1	7.0	0.20	95	598	423.6	10.1	211.3
10	1200	51.4	1.0	389	23.5	7.0	0.18	100	572	400.6	11.2	212.6
11	780	0.0	17.7	118	4.5	0.0	0.02	50	23	10.0	1.5	2.3
12*												
13	2300	102.3	1.2	842	46.6	15.0	0.13	125	871	453.3	21.3	493.1
14	2300	94.1	2.3	726	43.6	15.0	0.06	58	1270	199.3	9.6	700.2
15	2300	83.9	1.8	700	42.5	15.0	0.08	10	792	263.5	1.6	428.4
16	2300	76.7	2.6	660	39.3	15.0	0.05	10	737	166.0	1.5	372.1
17	2300	51.2	8.7	541	27.9	20.0	0.01	25	870	24.7	3.1	358.7
18	2300	25.6	15.6	379	17.2	34.0	0.01	55	863	14.3	4.7	246.5
19	2300	18.4	17.0	348	15.3	34.0	0.01	49	591	13.1	3.9	154.2
20	2300	8.2	19.0	303	12.1	34.0	0.01	41	256	11.5	2.8	57.9
21	2300	2.0	19.9	279	10.6	34.0	0.01	36	154	10.5	2.2	31.8
22	790	0.0	18.0	106	4.4	0.0	0.01	50	43	4.0	1.2	3.3
23*												

==23 MODE CYCLE COMPOSITE==

BSCO 2.69 GM/BHP-HR
BSHC 0.15 GM/BHP-HR
BSNO2 5.92 GM/BHP-HR
BSFC 0.599 LB/BHP-HR

==TEST CONDITIONS==

BAROMETER 743.5 MMHG
HUMIDITY 55 GRAINS/LB
INLET AIR TEMP. RANGE 75F - 80F
MAX. EXHAUST TEMP. 1527F

* ENGINE NOT TESTED IN MOTORED MODES

** EGR WAS PROGRAMMED TO INCREASE LINEARLY WITH ENGINE LOAD STARTING WITH 5% EGR AT 8% LOAD AND INCREASING TO 7.5% EGR AT 82% LOAD. THIS PROCEDURE WAS USED FOR BOTH SPEEDS IN THE CYCLE. EGR WAS CUTOFF DURING MODES 1, 2, 9, 10, 11, 13, 14, 21, AND 22 OF THE CYCLE.

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1. REPORT NO. APTD-1513	2.	3. RECIPIENT'S ACCESSION NO. PB-219 052
4. TITLE AND SUBTITLE: Characterization and Control of Emissions from Heavy Duty Diesel and Gasoline Fueled Engines		5. REPORT DATE: December 1972 6. PERFORMING ORGANIZATION CODE
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16. ABSTRACT

The report covers results from experimental work in measurement of emissions from heavy duty diesel and gasoline fueled engines and an investigation of the effectiveness of engine modifications and/or auxiliary devices for reducing emissions. Definitive engineering information was obtained on the characteristics of seven diesel and two gasoline engines: the diesel engines were operated on a 13-mode procedure and a 23-mode procedure; the gasoline engines were operated on a 9-mode procedure and a 23-mode procedure for the baseline tests and the 23-mode procedure was used in the parametric study for the diesel engines, the control parameters, engine modification, and auxiliary devices investigated for emission control were: injection timing; injector type; fuel pump and nozzle modifications; exhaust gas recirculation (EGR); aftercooling; turbocharging; and oxidation type catalytic converters for the gasoline engines, the control parameters, engine modifications, and auxiliary devices studied were: manifold air injection; air-fuel ratio exhaust gas recirculation; spark timing schedules; and oxidation type catalytic converters. The report describes the test equipment and fuels, and outlines the experimental procedures for analysis and measurement. The experimental results are presented in detail.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution	Odors	Heavy duty diesel engines	13B
Emission	Smoke	Engine modifications	
Measurement	Aldehydes	Air pollution control	
Sampling	Catalytic converters	Turbocharging	
Diesel engines	Fuel injectors		
Engines	Circulation		
Exhaust emissions	Carbon monoxide		
	Hydrocarbons		
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