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MILITARY STANDARD

ENGINES, GASOLINE AND DIESEL,

METHODS OF TEST

FSC 2805

DEPARTMENT OF DEFENSE

WASHINGTON, DC 20301

Engines, Gasoline and Diesel, Methods of Test.

MIL-STD-1400B

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletions should be addressed to Commander, U.S. Army Mobility Equipment Research and Development Center, ATTN: AMXFB-DS, Fort Belvoir, VA 22060.

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APPENDIXES

TABLES

1. SCOPE

1.1 Purpose and scope. This standard establishes the test methods to be used for evaluation, preproduction, and production testing of spark ignition and compression ignition industrial engines of the reciprocating type. It applies to 4-stroke and 2-stroke cycle engines, liquid or air cooled, naturally aspirated, supercharged or turbocharged.

1.2 Application of methods. The methods established in this standard apply to engine evaluation, preproduction model performance, production control and production tests under Government procurement contracts.

Gasoline

Group I - Air cooled, 2- and 4-stroke cycle under 10 net continuous bhp.
Group II - Air or liquid cooled, 2- and 4-stroke cycle, 10 net continuous bhp and above.

Diesel — Medium and high speed industrial engines air or liquid cooled, 2- or 4-stroke cycle.

1.3 Method numbers. Numbers are employed to designate test methods of this standard. The methods included in this standard are numbered in the 1000, 2000, 3000, and 4000 series.

1.4 Method of reference. Methods of test contained in this standard shall be referenced, when applicable, in the individual procurement documents by specifying this standard and the applicable method.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on date of invitation for bids, or at the start of the evaluation test, whichever is applicable, form a part of this standard to the extent specified herein:

SPECIFICATIONS

Federal

VV-F-800 - Fuel Oil, Diesel.
VV-G-1690 - Gasoline, Automotive, Low Leaded or Unleaded.

Military

MIL-L-2104	- Lubricating Oil, Internal Combustion Engine, Tactical Service.
MIL-G-46015	- Gasoline, Automotive, Combat; Referee Grade.
MIL-F-46162	- Fuel, Diesel, Referee Grade.
MIL-L-46167	- Lubricating Oil, Internal Combustion Engine, Arctic.
MIL-A-62181	- Analyzer, Gasoline Exhaust Emission, Portable.

STANDARD

Military

MIL-STD-1410	- Methods for Selection of Industrial Engines for End Item Application.

(Copies of specifications and standard required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

U.S. DEPARTMENT OF COMMERCE

Publication W. B. No. 235	- U.S. Department of Commerce Weather Bureau Psychometric Tables.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402.)

3. DEFINITIONS

3.1 Tests.

3.1.1 Evaluation tests. Evaluation tests are tests conducted to determine suitability of an engine for military use primarily where similar commercial experience is not available.

3.1.2 Preproduction model performance tests. Preproduction model performance tests are tests performed on the engine when the end-item specification or contract requires preproduction tests. The conduct of these tests is the responsibility of the end-item supplier. They are tests conducted on the engine as installed in the end-item and prior to the end-item preproduction model test to assure that engines produced for a particular end-item application conform to the characteristics and performance data of the manufacturer's specification and meet the requirements of the specific end-item. These tests will indicate such characteristics as power characteristics, fuel pump settings, fuel consumption data, torque curves, ignition timing, intake manifold vacuum, cooling system capability and fan horsepower consumption prior to preproduction testing of the end-item. Diesel engine fuel pumps or injector racks will be sealed to preclude the engine from developing more horsepower than specified by the end-item specification.

3.1.3 Production control tests. Production control tests are tests performed on engines selected at random from the supplier's production line to insure continued compliance with the pertinent end-item procurement specification and this standard.

3.1.4 Production tests. Production tests are tests performed on each engine leaving the production line, except those selected for production control tests, to insure continued compliance with the pertinent end-item procurement specification and this standard.

3.2 Engines.

3.2.1 Naturally aspirated engines. A naturally aspirated engine is defined as either a 2- or 4-stroke cycle engine which obtains air for combustion at ambient atmospheric pressures. Included also under this definition is a 2-stroke cycle engine that utilizes a mechanically connected, engine-driven blower, to provide both combustion and scavenging air but which develops no higher brake mean effective pressure (bmep) than normal for a naturally aspirated engine.

3.2.2 Supercharged engine. A supercharged engine is defined as a 4-stroke cycle engine which employs a mechanically connected, engine-driven, positive-displacement or centrifugal compressor to provide combustion air at higher than ambient atmospheric pressure.

3.2.3 Turbocharged engine. A turbocharged engine is an engine which employs an exhaust-driven turbine driving a centrifugal compressor to provide combustion air or combustion and scavenging air at higher than ambient atmospheric pressure.

3.3 Power output.

3.3.1 Observed power. Observed power is the power actually developed by an engine fully equipped with all accessories and components as installed in the end-item under the existing or simulated atmospheric conditions.

3.3.2 Corrected power. Corrected power is the observed power adjusted to atmospheric conditions stated herein (see 3.5) in accordance with 6.3.2.

3.3.3 Rated horsepower. Rated horsepower is the power output established by test as defined in Test Method 1000 but must be further identified as maximum, intermittent, or continuous at a specific speed, and as defined in subsequent paragraphs.

3.3.4 Maximum brake horsepower. The maximum brake horsepower rating at a specified speed is the maximum power output developed by an engine for 10 minutes of continuous operation without exceeding the manufacturer's temperature, observed bmep or other limits, or limitations set forth in this standard, corrected to specified atmospheric conditions where allowable (see 3.5). Maximum power attainable with fixed accessories, adjustments, and settings referred to a "Maximum Power Test" is determined at normal test site conditions, in accordance with Test Method 1310 or 1311 (see Appendix A). The power attainable under these conditions shall be the basis for the maximum bhp rating. Observed maximum brake horsepower for naturally aspirated engines is corrected to atmospheric conditions stated herein (see 3.5) in accordance with 6.3.2.

3.3.5 Intermittent brake hosepower. Intermittent brake horsepower ratings are intended to be the maximum allowable outputs for periods of continuous operation up to 1 hour, with alternate hourly periods of

decreased power output. For the purpose of this standard, intermittent brake horsepower at any speed is defined as the maximum power developed by an engine continuously for 1 hour at that speed without exceeding the manufacturer's recommended temperature, observed bmep, or other limits, or limitations set forth in this standard. For military applications, the intermittent brake horsepower rating at any speed shall not exceed 90 percent of the maximum brake horsepower rating of the engine at each speed in the "Maximum Power Test", Test Method 1310 or 1311 (see Appendix A), and will be an observed value (see 6.3.3).

3.3.6 Continuous brake horsepower. The continuous brake horsepower rating at any specified speed is the maximum allowable output for unlimited periods of continuous operation at sustained load and speed. For military applications, the continuous brake horsepower rating at any speed shall not exceed the observed output developed at that speed under altitude conditions during the maximum power test at 5,000 feet, Test Method 1410 (see Appendix A). This rating shall be not more than 85 percent of the maximum bhp rating of the engine at each speed (see Test Methods 1310 or 1311, Appendix A).

3.4 Engine test (speed).

3.4.1 Rated speed. Rated speed is the speed output associated with the maximum, intermittent, or continuous brake horsepower as defined in 3.3.4 through 3.3.6.

3.4.2 Long-term idle. Long-term idle is the lowest idle rpm recommended by the manufacturer to conserve fuel, remain within smoke limitations (compression - ignition engines, see 6.2.3), and have minimum recommended oil pressure but still maintain the engine clear of fouling and deposits of carbon for periods of 2 hours or more.

3.5 Standard atmospheric conditions. Specified standard atmospheric conditions will be as follows:

Barometric pressure (Corresponding to 500-foot altitude, wet barometer)	29.38 inches Hg
Temperature	85°F
Vapor pressure	0.38 inches Hg
Dry barometric pressure	29.00 inches Hg
Dry air density	0.0705 lb/cu ft

4. GENERAL REQUIREMENTS

4.1 Location of tests. The tests shall be conducted at facilities of the engine manufacturer, a Government laboratory, or a Government approved laboratory, as specified by the contracting officer.

4.2 Repairs or replacements. No repairs or replacement of critical engine parts or accessories will be permitted subsequent to completion of the check test and run-in, Test Methods 1200, 2200, 3200, and 4200 without the approval of the contracting officer.

4.3 Modifications during tests. No engine parts or accessory changes or modifications will be permitted during tests without prior approval of the contracting officer. Any modifications permitted may require rerunning of all preceding tests.

4.4 Criteria for failure. Operating characteristics, mechanical failure, excessive engine wear, or final engine condition at the conclusion of testing, not as specified herein, are all causes for rejection of the test engine. The contracting officer shall have the sole authority to determine when an engine has failed. If retest is permitted, rerunning of all preceding tests will be required.

4.4.1 Operating characteristics. The engine shall have failed the entire test series in the event of failure or malfunction of any engine component which is a direct cause of any of the following:

(a) During conduct of the periodic maximum bhp tests or final performance test, a decrease of more than 10 percent in maximum power output at maximum continuous speed from that developed in the "Maximum Power Test", (Test Method 1310 or 1311).
(b) Exceeding the average maximum allowable oil consumption rate for the particular test sequence or endurance test period, except for gasoline engines of less than 10 continuous hp rating (see Table II of Test Method 1500).
(c) Leakage of oil past the crankshaft and oil seals will not be permitted. This will be defined as "oil droplets" from the crankshaft which have gone past the seals. A wet seal bearing surface and adjacent crankshaft area only is allowable. Leakage past machine screwbolt threads, etc., shall be corrected. Oil line fittings, plugs, coolers, connections, etc., will be judged in the same manner.

(d) Exceeding the average maximum allowable fuel consumption rate for the particular test sequence or endurance test period, except for gasoline engines of less than 10 continuous hp rating (see Table I of Test Method 1500).
(e) Exceeding a 5 percent increase in governor regulation from the initial test to the final test.

4.4.2 Mechanical failure. The engine shall have failed the entire test series in the event of failure or malfunction of any critical part which causes the engine to become inoperative. Repeated failures of a system or noncritical component shall also be cause for rejection of the test engine.

4.4.3 Engine wear. The engine shall have failed the evaluation test if at any time during the test or at final inspection the wear of any high mortality engine component exceeds the limits specified in the manufacturer's Maximum Wear Replacements Limits (MWRL) (see 6.1 and Appendix D), or if the combined working clearance, backlash, or assembly fit of any mating components exceeds the maximum limits specified in the latest edition of the manufacturer's maintenance manual. Wear of these parts will be assessed by the contracting officer as to cause of wear (see 4.4.4).

4.4.4 Engine condition. Successful completion of the evaluation test shall be based not only upon the acceptable performance of the engine during the entire test series, but also on the final condition of engine parts and components. The contracting officer shall have the authority to define and interpret the significance of the condition of all parts in question.

4.5 Justification for retest. In the event of a failure as specified in 4.4, retest may be permitted upon request to the contracting officer by the engine manufacturer and his furnishing data indicating that the cause of the failure has been corrected. To justify a rerun, it shall be necessary for the manufacturer to demonstrate with engineering data, test results, or calculations that the condition initiating failure has been corrected.

4.6 Number of test engines. Unless otherwise specified by the procuring agency, the number of engines to be used in any test method shall be as follows:

(a) Evaluation test: One engine.
(b) Preproduction model performance test: One engine.
(c) Production control tests: One engine will be tested for each lot of 50 engines or any portion thereof.
(d) Production test: All engines produced under the contract except those selected for production control tests.

4.7 Fuels and lubricants. Fuels and lubricants for all tests shall be as specified in 4.7.1 and 4.7.2. For 2-cycle engines requiring a gasoline-oil mixture, the mixture ratio shall be as specified by the engine manufacturer, but the fuel and lubricants shall conform to the specification listed in 4.7.1 and 4.7.2. Certified chemical analysis shall be furnished for each initial batch and each new batch of fuel and lubricating oil used during a test program. Samples of fuel and new and used lubricating oil will be obtained by a representative of the contracting officer at intervals during the test program.

4.7.1 Fuels. Fuels shall be as specified in Table I.

Table I. Test Fuels

Test method series	Specification	
	Gasoline engines	Diesel engines
1000	* MIL-G-46015	MIL-F-46162
2000	* MIL-G-46015	MIL-F-46162
3000	VV-G-1690	VV-F-800
4000	VV-G-1690	VV-F-800

* If test requires the use of low-lead or unleaded fuels, use gasoline meeting specification VV-G-1690.

4.7.2 Lubricants. Lubricants for use in 1000 and 2000 series tests at temperatures of minus 10°F and above shall conform to the following MIL-L-2104 referee grade oils:

Grade	Manufacturers Designation	Temperature Range
10	EXXON 2257 MIL-C Motor Oil	minus 10°F to 32°F
30	EXXON 2257 MIL-C Motor Oil	32°F and above

5. INSTRUMENTATION

5.1 Speed.

5.1.1 Engine crankshaft. Engine crankshaft speed shall be determined by any of the following methods provided accuracy limits are within plus or minus 1/2 percent of the observed reading or plus or minus 10 revolutions, whichever may be more.

(a) Mechanical counter and stopwatch.
(b) Automatic electric revolution counter with synchronized timer.
(c) Electronic decade counter and magnetic pickup or pulse generator on the engine crankshaft or dynamometer shaft.

5.1.2 Turbocharger. The turbocharger speed shall be measured with an accuracy of plus or minus 1/4 percent of the true reading. This can be accomplished by means of a magnetic pickup on the turbocharger and a suitable counting or indicating device. The pickup may consist of a magnetized nut or other ferrous part attached to the turbocharger shaft and a sensitive coil positioned in the peripheral plane of the rotating element. Appendix G outlines two suggested methods.

5.2 Temperatures. Laboratory thermometers, or thermocouples connected through a selector switch to a calibrated potentiometer shall be used to measure temperatures, in degrees Fahreheit. Instrumentation accuracy shall be within 2° F or plus or minus 1 percent of the true reading, whichever is greater.

5.2.1 Ambient air. Ambient air temperature shall be measured at four points around the engine, approximately midway of its maximum vertical dimension and not less than 4 feet from the engine. Thermometers or thermocouples shall be shielded to avoid the effects of heat radiation from the engine and shall be positioned so as not to be affected by abnormal heat radiations, drafts, or rapid or erratic variations in temperature of the surrounding air. For test purposes, the ambient air temperature shall be the average of the measurements at the four points.

5.2.2 Intake air. Intake air temperature shall be measured in the intake air stream in the air cleaner or as close as possible to the air stream at the air cleaner inlet. The intake air temperature obtained shall be used in correcting the observed data to the

specified atmospheric conditions when applicable. When a turbocharger or an aftercooler is used, the outlet air temperature of the turbocharger and the aftercooler shall also be obtained. Thermometers or thermocouples shall be shielded to avoid the effects of heat radiation from the engine.

5.2.3 Exhaust. The common exhaust temperature shall be measured in the exhaust line approximately 2 inches downstream from the exhaust manifold outlet flange or as close as practicable to the turbine inlet if a turbocharger is employed. On turbocharged engines, turbocharger outlet temperature shall also be recorded as close as practicable to the turbocharger. Gas temperatures in the exhaust outlet of each cylinder of a diesel engine shall be measured during the low temperature test (Test Method 1450). Individual cylinder exhaust temperature may be measured during other tests at the option of the manufacturer.

5.2.4 Fuel. Fuel temperatures shall be measured at the inlet to the carburetor for gasoline engines and at the outlet of the final filter or the inlet to the injection pump for diesel engines.

5.2.5 Coolant. Liquid coolant temperatures shall be measured at the engine coolant inlet and outlet.

5.2.6 Lubricating oil. For force feed and splash systems, the lubricating oil temperature shall be measured in the sump, away from the sump wall at a location such that the temperature is representative of the greater mass of the lubricant and is not unduly influenced by localized hot or cool spots on the sump wall. For full force feed lubrication system, the temperature shall be measured in the oil gallery. If the engine is equipped with an oil cooler, the temperature drop across the cooler shall also be measured.

5.2.7 Cylinder head (air cooled gasoline engines only). Cylinder head temperatures for each cylinder air cooled gasoline engines shall be measured by means of a thermocouple in the spark plug gasket.

5.3 Pressures. Pressures shall be measured by barometer, manometer, or pressure gage in inches of mercury, inches of water, or pounds per square inch as indicated. Typical pressure taps are illustrated in Appendix G. The accuracy of all manometers shall be plus or minus 0.05 inch of indicated readings, and the accuracy of all pressure gages shall be plus or minus 2.0 percent of indicated readings unless otherwise specified herein.

5.3.1 Barometric. Atmospheric pressure at the test site shall be measured by a mercury barometer of the Weather Bureau type, in inches of mercury, within plus or minus 0.02 inch. An aneroid barometer shall not be used.

5.3.2 Atmospheric vapor. Atmospheric vapor pressure shall be determined in inches of mercury using the U.S. Department of Commerce Publication No. 235, or the carrier equation, from wet and dry bulb temperatures measured as near as possible to the ambient air thermometers or thermocouples. Sling, hand aspirated, laboratory or motor psychrometers having thermometer accuracies within plus or minus 0.5° F shall be used.

5.3.3 Intake air. Intake manifold pressure for gasoline engines shall be measured by a manometer connected to a pressure tap in the manifold as near as possible to the carburetor flange. For naturally aspirated diesel engines, the tap shall be located as near as possible to the manifold inlet flange. On engines equipped with blowers, mechanical superchargers, or turbochargers, the air pressure shall be measured by manometers connected to pressure taps located on the inlet and discharge sides of the blower or supercharger, on the inlet and discharge sides of the compressor of the turbocharger, and on the inlet and discharge sides of the intercooler or aftercooler, if applicable. Pressure shall be measured in inches of mercury or may be measured in inches of water if necessary for very low pressures. At the discretion of the contracting officer, measurements may be omitted for small gasoline engines of less than 20 hp if carburetion is affected adversely.

5.3.4 Exhaust. Exhaust gas pressure shall be measured by a manometer connected to a pressure tap located as near as possible to the outlet flange of the exhaust manifold for naturally aspirated or supercharged engines or the outlet flange of the turbine for turbocharged engines. If a diffuser is used on the turbine exhaust, the tap shall be located 10 to 12 inches downstream from the diffuser. Turbine inlet pressure shall be measured from a tap located as close as possible to the turbine inlet. Pressure shall be measured in inches of mercury. Turbine outlet pressure shall be measured in inches of water.

5.3.5 Fuel. Fuel supply pressure for gasoline engines using a fuel pump shall be measured at a gage connected to a pressure tap in the discharge line of the pump; for diesel engines, the tap shall be located at the outlet of the final filter.

5.3.6 Lubricating oil. Lubricating oil pressure for full force-feed lubricating systems shall be measured by a gage connected to a pressure tap located in the main oil header as close as practicable to the discharge side of the lubricating oil pump. Pressure shall be measured in pounds per square inch.

5.3.7 Blowby volume. For information purposes, and at the manufacturer's option, engine blowby may be measured by means of a gas meter or equivalent in cubic feet per minute at a minimum of 1 minute per reading.

5.4 Fuel and lubricating oil consumption and exhaust smoke.

5.4.1 Fuel consumption. Rate of fuel consumption shall be measured by equipment capable of 1 percent accuracy, or if the time-weight procedure described in Figures G-1 and G-2, Appendix G, is utilized, repeatability shall be within plus or minus 1 percent for three readings for each fuel consumption point.

5.4.2 Lubricating oil consumption. The lubricating oil consumption shall be measured during the entire endurance test. A suggested method is to record weight of oil and oil filters installed in the engine, the weight of all oil additions or oil samples taken, and the weight of oil and filters removed from the engine for each oil change period. Other methods may be used provided approval is given by the contracting officer before the start of the endurance test.

5.4.3 Exhaust smoke. Exhaust smoke conditions for diesel engines during performance and altitude testing shall be measured by the use of a Robert Bosch EFAW 65 sampling pump and analyzed on an EFAW 68 analyzing instrument at room temperature (65° F to 80° F). The smoke sampling tube shall be located in the exhaust pipe, positioned midway of and parallel to the pipe walls and between 12 and 60 inches of the exhaust manifold. Tubing between the sampling pump and exhaust probe shall not exceed 24 inches in length and shall have an inside diameter of not more than 1/4 inch. At that location, the exhaust pipe inside area shall not be larger than 125 percent of the exhaust manifold outlet area. Alternate smoke analyzers may be utilized provided comparative data is obtained during initial portions of the test program, and the engine manufacturer and contracting officer mutually establish an official table indicating comparative readings. For this study, the Bosch meters shall be Government-furnished equipment.

5.4.4 Exhaust emission. When required, gasoline engine exhaust emissions during performance, endurance, and environmental testing, shall be measured by a meter meeting requirements of MIL-A-62181.

6. LIMITING TEST CONDITIONS AND CORRECTIONS

6.1 Wear. The manufacturer shall indicate the acceptable wear limits to be listed on a MWRL table as shown in Appendix D, and this data shall be furnished to the contracting officer prior to initiation of endurance testing. These limits shall be identical to those listed in his current commercial overhaul and repair service manual. In the absence of such information within the applicable commercial manual, the manufacturer shall prepare an MWRL listing for the evaluation test program which shall form the criteria for failure due to engine wear (see 4.4.3).

6.2 Operating limits. Operating limits or limiting conditions specified in this section or as specified in specific test methods shall not be exceeded. Prior to the beginning of testing, the manufacturer shall determine the maximum observed bmep, minimum oil pressure, maximum exhaust temperature, turbocharger rpm and exhaust back pressure limits. Maximum fuel flows may be specified at the manufacturer's option. These limits shall not be exceeded throughout the test program.

6.2.1 Engine temperatures. Maximum or minimum engine temperatures shall not exceed those specified by the engine manufacturer, the applicable engine specification or the following Table II.

Table II. Engine Temperatures

Item	Temperatures (° F)	
	Minimum 1/	Maximum
Lubricating Oil 2/	130	230
Coolant, Out	175	210

1/ Minimum temperatures do not apply for no load, low temperature tests (Test Method 1450).

2/ Lubricating oil temperature limits apply to engines having a continuous rating of 20 bhp or higher. The limits indicated are for the oil gallery with the engine operating at continuous or intermittent duty load. When an oil cooler is used, the oil gallery temperature limit remains 230° F, and the temperature of the oil entering the oil cooler shall not exceed 250° F.

6.2.2 Pressures. For naturally aspirated and supercharged engines, the exhaust back pressure shall be set for at least 75 percent of the maximum recommended by the engine manufacturer. For turbocharged engines, the back pressure shall in no case be less than 3 inches of water back pressure. For simulated altitude conditions, the exhaust shall be evacuated to the absolute barometric pressure of that altitude plus the above specified back pressure. These required back pressures shall be determined when the engine is developing maximum bhp at the maximum speed and except for altitude testing, the adjustments and settings made to the exhaust shall remain unchanged for the entire test program.

6.2.3 Smoke limits. All diesel engines shall operate under all conditions specified herein with a smoke reading of not more than 4.5 when analyzed with a Robert Bosch EFAW 68 analyzing instrument as specified in 5.4.3, except for those engines that fall under the clean air act.

6.3 Corrections.

6.3.1 Barometric pressure. Observed barometric pressure shall be corrected for temperature.

6.3.2 Horsepower, torque, bmep. These observed values shall be corrected to specified conditions according to the following formula when allowable (see 6.3.3).

$$\text{Correction factor} = \frac{29.00}{B-e}\sqrt{\frac{460 + t}{545}}$$

Corrected bhp = observed bhp x correction factor

Example:

Where

B = test barometric pressure, inch Hg. corrected for temperature.
e = water vapor pressure, inch Hg.
t = intake air temperature, $^{\circ}$ F (see 5.2.2).

6.3.3 Application. Correction to the observed output, as above, of more than plus or minus 5 percent of observed results for performance testing will not be permitted. Corrections to the observed data will not be made when the engine is operated at less than the maximum bhp for the observed conditions and are not applicable to simulated altitude tests since results of these tests are corrected to standard altitude conditions by the test method. Supercharged or turbocharged engines will not be corrected in accordance with 3.3.4.

7. TEST METHODS

7.1 General. The test methods in this section shall be employed according to the outline in Table III. Tests shall be conducted in numerical sequence, and the provisions and requirements of this standard shall be observed.

Table III. Test Method Outline

	Test Method Series Appendix A			
Type of Test	Evaluation 1000	Preproduction 2000	Production Control 3000	Production 4000
Initial inspection	1100	2100	3100	4100
Check test and run-in	1200	2200	3200	4200
Initial performance	1300	2300	3300	-
Environmental	1400	2400	-	-
Endurance	1500	-	-	-
Final performance	1600	-	-	-
Final inspection	1700	2500	3400	-

Custodians:

Army - ME
Navy - YD
Air Force - 82

Preparing activity:

Army - ME

Project No. 2805-0507

Review activities:

Army - MU, AT
Navy - SH

User activity:

Navy - MC

APPENDIX A

TEST METHOD SERIES

ENGINES, GASOLINE OR DIESEL, INDUSTRIAL

2 OR 4 STROKE CYCLE

CONTENTS

Series 1000, Evaluation

APPENDIX A
Series 1000, (continued)

Series 2000, Preproduction Model Performance Test

Series 3000, Production Control Tests

APPENDIX A (continued)

Series 4000, Production Test

TEST METHOD 1000

EVALUATION TEST

1. SCOPE. This test method is used to determine conformance of an engine to MIL-STD-1410 and the applicable end item specification. This test method includes all testing in the 1000 series.

2. TEST EQUIPMENT AND DATA

2.1 Test equipment. A cradle type dynamometer shall be used for performance and environmental tests; a calibrated generator may be used for endurance testing only. Prior to starting tests, the power-absorption device shall be calibrated, shall be in balance, and its accuracy shall be certified to as being within plus or minus 1 percent of the full-scale deflection at maximum engine horsepower rating. This accuracy shall be checked at any time upon request of the contracting officer. In the event that power-absorption equipment is changed during any portion of a test program, the new equipment will be calibrated and its accuracy certified to the above tolerance.

2.2 Test data. Test data shall be obtained for the applicable test method, indicated in Table I of this test method, during the individual tests. Data requirements for the low-temperature test are indicated in Test Method 1450. During both endurance and cycling portions of the endurance test, all data shall be recorded hourly, except that barometric and vapor pressure shall be calculated at 8-hour intervals, and fuel consumption shall be determined as specified in Test Method 1500. Comments and observations made by the operator shall be recorded on the log sheets. In those instances where data might be identical, such as oil cooler inlet and oil sump temperatures or combined exhaust and turbine inlet temperatures, the contracting officer shall determine those data items which may be deleted.

TEST METHOD 1000 (cont'd)

Table I. Test Data to be Recorded

Data Items	Test Method Numbers*				
	4200	3200 3300	1200 1430 1300 1600 1410 2200 1420 2300		1400 (except 1450) 1500 2400
1	2	3	4		5
MISCELLANEOUS					
**Engine Speed	X	X	X		X
**Load	X	X	X		X
Turbocharger Speed 1/	-	-	X		X
Starting Time	X	X	X		X
Finish Time	X	X	X		X
**Accum. Time	X	X	X		X
Ignition or Timing 1/	-	X	X		-
Hour Meter Reading (oil pressure actuated)	-	-	-		X (1500 only)
PRESSURES					
Intake Manifold	-	X	X		X
Air Cleaner Restriction	-	X	X		X
Air Box 1/	-	X	X		X
Air to Compressor 1/	-	X	X		X
**Air from Compressor 1/	-	X	X		X
Exhaust Combined	-	X	X		X
Exhaust to Turbine 1/	-	X	X		X
Exhaust from Turbine 1/	-	X	X		X
**Lube Oil	X	X	X		X
**Fuel	-	X	X		X
**Barometer	-	-	X		X
Crankcase Blowby (cfm) 4/	-	-	-		X
Air Flow (lbs./hr.)	-	-	X		-

TEST METHOD 1000 (cont'd)

Table I. Test Data to be Recorded (continued)

1	2	3	4	5
PRESSURES				
**Fuel Weight	-	-	X	X
**Fuel Cons. Time	-	-	X	X
**Smoke Grade 1/ 2/	-	-	X	-
**Lube Oil Weight	-	-	-	X (except 1440)
**Lube Oil Cons. Time	-	-	-	X (except 1440)
TEMPERATURES				
**Ambient Air, D.B.	X	X	X	X
**Ambient Air, W.B.	-	-	X	X
**Intake Air, Cleaner	-	X	X	X
Intake Air, Manifold	-	X	X	X
Air to Compressor 1/	-	X	X	X
Air from Compressor 1/	-	X	X	X
**Exhaust, Comb.	-	X	X	X
Exhaust, Individual, Diesel 3/	-	-	X	X
Exhaust to Turbine 1/	-	X	X	X
Exhaust from Turbine 1/	-	X	X	X
**Spark Plugs 1/	-	X	X	X
**Coolant to Engine	-	X	X	X
**Coolant from Engine	-	X	X	X
**Oil Sump	-	X	X	X
**Oil Gallery	-	X	X	X
**Oil to Cooler 1/	-	X	X	X
**Oil from Cooler 1/	-	X	X	X
Fuel	-	-	X	X
Air Box 1/	-	-	X	X

NOTES, Table I:

* The test method numbers refer to paragraph 3 (Test Sequence) of Test Methods Series 1000, 2000, 3000 and 4000.

1/ If applicable to engine model.

2/ Test Method 1500, para. 2-3, periodic max. power checks, required.

3/ Manufacturer's option except required for Test Method 1450.

4/ Manufacturer's option.

** MIL-STD-1410 Essential Data - Those not marked are desirable but not essential.

3. TEST SEQUENCE. Unless otherwise specified by the procuring agency, this test series shall consist of the following tests and inspections and shall be conducted in the numerical sequence indicated:

Initial Inspection	1100
Check Test and Run-In	1200
Initial Performance Tests	1300
Maximum Power Test (Gasoline Engines)	1310
Maximum Power Test (Diesel Engines)	1311
Intermittent BHP Test	1320
Part Throttle Test	1330
Governor Test	1340
Environmental Tests	1400
Maximum Power Test at 5000 Feet	1410
Maximum Continuous BHP Test at 5000 Feet	1420
Maximum Power Test at 8000 Feet	1430
High Temperature Test	1440
Low Temperature Test	1450
Endurance Test	1500
Final Performance Test	1600
Final Inspection	1700

4. TEST ENGINE. The evaluation test engine shall be an engine built by production tooling. The engine shall be complete with the following accessories and parts as required or excepted:

(a) Complete fuel system, except fuel tank.
(b) Lubrication system, including oil cooler if required.
(c) Air induction system, including air cleaner(s).
(d) Air or liquid cooling system, with fan and radiator optional for liquid-cooled engines. If a fan is used, the fan horsepower shall be obtained and adjustments made for the fan load. An engine fan and radiator shall be used for the low-temperature test (Test Method 1450). An external heat exchanger may be used to bypass the radiator for all other tests provided that

coolant outlet temperature can be maintained at 205° F, plus or minus 5° F, for high temperature and altitude testing; and 180° F, plus or minus 5° F, for all other tests.

(e) Exhaust system.
(f) Governing system.
(g) Flywheel and flywheel housing.
(h) Electric ignition system, if applicable.

Metal housing, skid base, clutches, and instrument panel are not required.

5. TEST FUELS. All testing shall be conducted with fuel conforming to 4.7.1 and lubricating oil conforming to 4.7.2 of this standard as applicable.

6. TEST TEMPERATURES.

6.1 Fuel temperatures.

(a) Performance and endurance test, minimum 85° F.
(b) Simulated 5000 feet altitude, minimum 107° F.
(c) Simulated 8000 feet altitude, minimum 95° F.
(d) High temperature test, minimum 120° F.
(e) Low temperature test, not higher than minus 10° F or minus 25° F, as applicable.

6.2 Coolant temperatures. The coolant temperature from the engine shall be maintained at 180° F, plus or minus 5° F, for all tests except for simulated altitude, high temperature and low temperature tests. For the simulated altitude and high temperature tests the coolant temperature from the engine shall be maintained at 205° F, plus or minus 5° F. For the low temperature tests the coolant temperature shall not be higher than the ambient temperature required for the test. See 6.2, Table II of this standard.

6.3 Oil temperatures. See 6.2, Table II of this standard.

6.4 Air temperatures. Both ambient and intake air temperatures should be representative of the immediate environment of the location in which the engine is being tested or as given in the applicable test method, Appendix A.

7. REPORTS. When specified by the procuring agency, a single laboratory report covering the evaluation tests shall be prepared by the engine manufacturer for each engine tested. The arrangement and content of the report shall be as indicated in Outline of Report Form, Appendix E. One copy of the report shall be prepared in a manner to permit economical reproduction. An unretouched negative of each photograph contained in the report shall be furnished. The reproducible copy and the number of reproductions of the report as specified shall be furnished to the contracting officer. The report shall include the following:

(a) Evaluation test model engine, physical description, Appendix C, and Maximum Wear Replacement Limits (MWRL), Appendix D.

(b) Engine log. A log of observations by personnel maintained throughout the evaluation test. Every event connected with the test including the date of receipt of the engine, the date each test was started and finished, and all maintenance work performed shall be recorded. Each engine adjustment made after the start of the test shall be recorded, giving the reason for the adjustment and the amount of the adjustment. A complete record of engine oil consumption shall be maintained throughout the test.

(c) Laboratory data sheets for each test. Two copies of performance and environmental test and one copy of the endurance test. All copies shall be legible.

(d) Performance curves: (see Appendix F). (For Test Methods 1310, 1311, 1320, 1410, 1430 and 1600).

(1) Corrected or observed maximum bhp as applicable vs engine rpm.
(2) Maximum corrected or observed engine torque as applicable vs engine rpm.
(3) Corrected or observed maximum bmep as applicable vs engine rpm.
(4) Observed fuel consumption at maximum bhp (bsfc) vs engine rpm.

TEST METHOD 1000 (cont'd)

(For Test Method 1330 only).

(5) Observed fuel consumption at part throttle (bsfc) vs observed bhp.
(6) Exhaust temperatures at part throttle vs observed bhp.
(7) Smoke meter readings at part throttle vs observed bhp.

(e) Graphic log of endurance test (for Test Method 1500).

(1) Observed bhp vs endurance test hours.
(2) Engine rpm vs endurance test hours.
(3) Observed fuel consumption at continuous duty speed and load (bsfc) vs endurance test hours.
(4) Observed oil consumption based on continuous duty speed and load (bsoc) vs endurance test hours.
(5) Exhaust outlet temperature vs endurance test hours.
(6) Oil sump (or gallery) temperature vs endurance test hours.
(7) Periodic 50 hour maximum power checks, bhp (corr. where applicable) vs endurance test hours.

8. PHOTOGRAPHS. The engine complete with the accessories shall be photographed and its weight and major dimensions recorded, (Appendix C, Paragraphs 9 and 10). At least two three-quarter views of the engine against a white background shall be made in such a manner as to show all exposed parts; close-ups shall be included to illustrate any unusual features of the engine. Upon completion of the run-in (Test Method 1200) and prior to further testing, photographs shall be made of the completed installation to clearly show the relative arrangement of engine, accessories, equipment and installation. Additional photographs shall be taken to show any changes made in the test installation during subsequent testing. Photographs shall be taken of the engine parts at final inspection (Test Method 1700) as requested by the contracting officer. These may be representative photographs, if all pistons, for example, appear similar. Photographs shall not be retouched. An identification card clearly showing engine manufacturer, engine model and date of test shall be placed so that it will appear in the photographic negative. Other techniques may be used provided the full information appears on the individual positive prints.

TEST METHOD 1100

INITIAL INSPECTION

1. SCOPE. This test method is for the purpose of determining conformance of the engine to MIL-STD-1410 or the applicable end item specification.

2. TEST. The engine shall be examined visually for conformance to MIL-STD-1410 or the applicable end item specification. One copy of the assembly bill of materials which shall include all parts required for the test engine shall be furnished to the contracting officer.

TEST METHOD 1200

CHECK TEST AND RUN-IN

1. SCOPE. This test method is for the purpose of determining that the engine is in suitable condition for operation and to check all instrumentation.

2. SERVICING AND ADJUSTMENTS. Prior to the check test and run-in, servicing and adjustments shall be performed as specified for items marked X in before test column of "Servicing and Adjustment Schedule for Evaluation Tests", Appendix B.

3. CHECK TEST AND RUN-IN. A check test and manufacturer's run-in of at least 4 hours but not longer than 20 hours shall be conducted concurrently. After the test installation is complete, the engine shall be started and run while operation and instrumentation are checked. During this period, the engine shall be attended at all times and observed for evidence of excessive temperatures or unusual conditions that may cause damage to the engine. In the event of malfunction, the engine shall be shut down until the trouble is corrected. Upon completion of the run-in, photographs shall be made of the completed installation to clearly show the arrangement of engine, accessories, equipment, and instrumentation. Additional photographs shall be taken to show any changes made in the test installation during subsequent testing. Before further testing, seals shall be placed to prevent separation of the oil pan and cylinder heads from the engine block.

TEST METHOD 1300

INITIAL PERFORMANCE TESTS

1. SCOPE. This test method is for the purpose of determining the various power ratings of an engine at the start of testing.

2. GENERAL. Initial performance tests consist of a maximum power test, an intermittent brake horsepower test, a part throttle test, and a governor test. The engine shall be operated and data shall be taken at not less than five approximately equal rpm increments (six data points) throughout the engine manufacturer's recommended speed range for the engine. Performance tests shall be conducted in descending speed increments throughout the speed range. At each rpm and load point, the engine shall be brought to a condition of stabilized operation and operated for not less than 20 minutes under that condition while data is taken. Engine rpm during the stabilized data observation period shall be held as constant as possible by means of the applied dynamometer load and shall be permitted to vary not more than 1 percent or 10 rpm, whichever is greater. If practicable the governor shall remain operative as a maximum rpm control but shall be adjusted so as not to interfere with throttle setting. At the manufacturer's option, the intermittent bhp test, Test Method 1320, and the part throttle test, Test Method 1330, may be performed concurrently.

3. TESTS. The following tests comprise Test Method 1300, initial performance tests:

(a) Test Method 1310 - Maximum Power Test (Gasoline Engines).
(b) Test Method 1311 - Maximum Power Test (Diesel Engines).
(c) Test Method 1320 - Intermittent BHP Test.
(d) Test Method 1330 - Part Throttle Test.
(e) Test Method 1340 - Governor Test.

TEST METHOD 1310

MAXIMUM POWER TEST (GASOLINE ENGINES)

1. SCOPE. This test will determine the maximum brake horsepower rating of a spark ignition engine throughout the manufacturer's recommended operating speed range.

2. TEST PROCEDURE. The engine shall be equipped and adjusted for operation at the proposed maximum continuous duty speed. The test shall be conducted in descending order only. The throttle lever shall be fully opened; speed will be controlled by adjustment of applied dynamometer load. The gasoline used shall conform to MIL-G-46015. Any evidence of excessive vibration or temperatures, unstable operation, malfunctioning, or exceeding the limits specified in 6.2 of this standard or the maximum bhp (see 3.3.4 of this standard) shall be noted and recorded. If any or all of these conditions are noted, the test will be conducted at a lower load where the conditions are not present, and the maximum power ratings shall be reduced accordingly. The curve established will serve as the comparison curve for subsequent testing and checks and shall be included in the Final Report.

TEST METHOD 1311

MAXIMUM POWER TEST (DIESEL ENGINES)

1. SCOPE. This test will determine the maximum bhp rating of a compression ignition engine throughout the manufacturer's recommended operating speed range.

2. TEST PROCEDURE. The engine shall be equipped and adjusted for operation at the proposed maximum continuous duty speed. The engine shall be run on diesel fuel conforming to MIL-F-46162. The test shall be conducted in descending order only, throughout its operating speed range. The throttle lever shall be fully opened against the fuel flow control stop; speed will be controlled by adjustment of the applied dynamometer load. Any evidence of excessive vibration or temperatures, unstable operation, malfunctioning, or exceeding the operating limits specified in 6.2 of this standard shall be noted and recordad. If any or all of these conditions are noted, the test will be conducted at a lower load where the conditions are not present, and the maximum power ratings shall be reduced accordingly. The curve established will serve as the comparison curve for subsequent testing and checks and shall be included in the Final Report.

TEST METHOD 1320

INTERMITTENT BHP TEST

1. TEST PROCEDURE. The intermittent bhp test shall consist of 1 hour of operation at each speed used during the maximum power test at an observed load not to exceed 90 percent of the corrected maximum power output (as determined by Test Method 1310 or 1311) at the applicable speed. The engine components and adjustments used during the maximum power test shall be utilized for the intermittent test. Test conditions and engine temperatures will be stabilized prior to beginning the hour of operation at intermittent loading. Data shall be recorded at the start of the hour, after 30 minutes of operation and at the end of the hour. Any evidence of excessive vibration or temperatures, unstable operation, malfunctioning, or exceeding the operational limits in 6.2 of this standard shall be noted and recorded. If any or all of these conditions are noted or the manufacturer does not desire rating the engine at 90 percent of maximum corrected power output, the test may be conducted at a load where these conditions are not encountered, or at the desired rating, and the engine shall be rated for intermittent duty at whatever percentage of maximum power is obtained for each speed. At the manufacturer's option, the intermittent bhp test and the part throttle test may be performed concurrently.

TEST METHOD 1330

PART THROTTLE TEST

1. TEST PROCEDURE. The part throttle test shall be conducted on engines of 100 cubic inches or more total displacement. The engine shall be operated at the same speed increments as in the maximum power test (Test Method 1310 or 1311) and at loads of 100 percent, 90 percent, 80 percent, 60 percent and 40 percent of the maximum power output at each speed. The equipment and adjustments used during the maximum power test except throttle setting will be utilized during the part throttle test. The required loads shall be observed power output. The part throttle tests may be conducted concurrently with the intermittent bhp test at the option of the manufacturer. If the tests are not combined in one series of runs at each speed, it is required to repeat the 90 percent points for the part throttle tests. A graphic record of brake specific fuel consumption, smoke density and exhaust temperature shall be made from this test, consisting of a family of curves as shown in Figures F-5, F-6, and F-7, Appendix F.

TEST METHOD 1340

GOVERNOR TEST

1. SCOPE. This test will determine the speed regulation of the governor.

2. TEST PROCEDURE. To determine speed regulation, the engine shall be operated at the maximum continuous duty load and speed. The load shall be entirely removed and the speed measured at no load without making adjustments to the throttle or governor. Three trails shall be made to show consistent results. Regulation shall be calculated by the following formula:

$$R = \frac{(Snl - Srl) \times 100}{Srl}$$

R = regulation in percent
Snl = engine speed at no load
Srl = engine speed at rated load

Data recorded during the governor tests may be limited to engine speed, load and fuel rate. Information from the initial governor tests will be used for comparison to the final test to be conducted after completion of the endurance test.

Governor regulation shall not exceed the conditions as specified in 4.4.1 (e) of this standard.

TEST METHOD 1400

ENVIRONMENTAL TESTS

1. SCOPE. These test methods are for the purpose of determining engine operation and power output under specified environmental conditions.

2. GENERAL. Environmental tests consist of maximum power tests at 5000 and 8000 foot altitudes, a 2-hour continuous test at 5000 foot altitude, high temperature test and low temperature tests. The order of these tests may be varied at the manufacturer's option; however, they are to be conducted after the initial performance tests and before the endurance test.

3. TESTS.

(a) Test Method 1410 - Maximum Power Test at 5000 Foot Altitude.
(b) Test Method 1420 - Maximum Continuous BHP Test at 5000 Feet.
(c) Test Method 1430 - Maximum Power Test at 8000 Foot Altitude.
(d) Test Method 1440 - High Temperature Test.
(e) Test Method 1450 - Low Temperature Test.

TEST METHOD 1410

MAXIMUM POWER TEST AT 5000 FOOT ALTITUDE

1. SCOPE. This test will determine the maximum brake horsepower output of an engine at conditions corresponding to 5000 foot altitude as follows:

Barometric Pressure, inches Hg, 24.9 plus or minus 0.2.
Minimum Ambient and Intake Air Temperature, 107° F.
Water Outlet Temperature, 205° F plus or minus 5° F.

2. TEST PROCEDURE. The tests may be conducted at an actual test site or in a laboratory under simulated altitude conditions. The altitude conditions are to be simulated by controlling the temperatures as specified, restricting the engine inlet air with a restriction chamber and evacuating the exhaust gases. Provisions shall be made on the exhaust evacuation for back pressure requirements specified in 6.2.2 of this standard. A maximum power test, Test Method 1310 or 1311 as applicable, will be conducted at the specified altitude. The test will be conducted using MIL-G-46015 or MIL-F-46162 fuel, as applicable. Ambient air and engine coolant temperatures must be maintained throughout the test within the limits as specified above. The engine parts used for the altitude tests shall be the same as used during the maximum power test. The observed horsepower during the test shall be corrected for barometric pressure and water vapor pressure only by the following formula:

$$\text{BHP, corr.} - \text{BHP, obs.} \times \frac{P}{Pt - E}$$

P = Specified altitude barometric pressure
Pt = Absolute pressure at the air cleaner inlet
(Barometric Pressure - Intake Air Restriction)
E = Water vapor pressure
All units are in inches Hg.

The manufacturer's proposed continuous brake horsepower ratings at any speed shall not exceed the corrected power attained at that speed during this test. The limiting factors specified in 3.3.6 and 6.2 of this standard shall apply at each speed. Continuous power ratings listed for fuels conforming to MIL-G-46015 or MIL-F-46162 will not exceed the power output during the test at 5000 foot altitude.

TEST METHOD 1420

MAXIMUM CONTINUOUS BHP TEST AT 5000 FEET

1. SCOPE. This test will determine the operating characteristics of an engine under continuous operation at 5000 foot altitude conditions.

2. TEST PROCEDURE. The engine shall be operated for a period of 2 hours at the maximum continuous duty load and speed under the ambient conditions specified in Test Method 1410. The engine parts and accessories used for the continuous test shall be the same as used during the maximum power test. Ambient and intake air and engine water outlet temperatures must be maintained throughout the test within the limits of Test Method 1410. Instrument readings shall be taken at the start of the test and at 30-minute intervals during the test. The 2 hours of operation shall be conducted without engine shutdown. The limitations specified in 6.2 of this standard shall apply. Inability of the engine to operate for 2 hours at the continuous duty speed and load or exceeding limitations shall result in derating the engine for all speeds.

TEST METHOD 1430

MAXIMUM POWER TEST AT 8000 FOOT ALTITUDE

1. SCOPE. This test will determine the maximum bhp output of an engine at conditions corresponding to 8000 foot altitude as follows:

Barometric Pressure, Inches Hg. 22.2 plus or minus 0.2.
Minimum Ambient and Intake Air Temperature, 95° F.
Water Outlet Temperature, 205° F plus or minus 5° F.

2. TEST PROCEDURE. The test shall be conducted in the same manner as the maximum power test at 5000 foot altitude, Test Method 1410, except for the specified ambient conditions. The limiting factors specified in 6.2 of this standard shall apply at each speed. Ambient air and engine water outlet temperatures shall be maintained as specified above throughout the test. The power obtained during the test will be used for application purposes.

TEST METHOD 1440

HIGH TEMPERATURE TEST

1. SCOPE. This test will determine the operating characteristics of an engine when operating in a minimum ambient and intake air temperature of 120° F.

2. TEST PROCEDURE. The engine shall be operated according to the following schedule:

(a) Operate at maximum torque speed and intermittent horsepower at that speed for 1 hour.
(b) Operate at maximum continuous load and speed for 1 hour.
(c) Operate at maximum intermittent load and speed for 1 hour.
(d) Shut engine down for 5 minutes.
(e) Restart and operate at maximum continuous load and speed for 30 minutes.

The ambient and intake air temperatures shall be maintained at a minimum of 120° F, except during steps (d) and (e) where variations of plus or minus 10° F will be permitted during these two steps. The engine water outlet temperature shall be maintained at 205° F plus or minus 5° F except during step (d). The required loads shall be observed power with no corrections applied. Testing shall not begin until temperatures throughout the engine have stabilized. The test shall be conducted in a consecutive series without any shutdowns or operation other than as specified. Complete data will be recorded at the start of each step and at 30-minutes intervals except during step (d) data will be recorded after the 5-minute shutdown. The limitations of 6.2 in this standard shall apply.

TEST METHOD 1450

LOW TEMPERATURE TEST

1. SCOPE. This test will determine engine starting characteristics at ambient temperatures not higher than minus 10° F and starting and operating characteristics at minus 25° F.

2. FUELS AND LUBRICANTS. Fuels and lubricants shall conform to the following specifications:

Fuel, gasoline engines	VV-G-1690, unleaded.
Fuel, diesel engines	VV-F-800, DF-1.
Lubricant at minus 10° F	MIL-L-2104, Grade 10.
Lubricant at minus 25° F	MIL-L-46167, OEA

3. INSTRUMENTATION. Instrumentation shall be provided for obtaining the following data as a minimum:

Miscellaneous

Battery voltage before start
Battery specific gravity
Engine cranking speed, rpm
Engine running speed, rpm
Time

Cold soak, hours
Cranking, minutes, if no start
To combustion detection, minutes
To start, minutes
To smooth running without aids, all cylinders firing, minutes

Cranking voltage and current
Starting procedure

Type, method, etc., in detail

Temperatures, ° F

Ambient air
Coolant
Cylinder head (air-cooled engines only)
Lube oil (gallery and sump)
Fuel
Battery electrolyte
Exhaust, individual (diesel engines only)

Pressures, psi

Fuel
Lube oil

4. *TEST PROCEDURE.* The test may be conducted at a site where natural ambient conditions meet these requirements or in a cold chamber having the necessary capabilities. Prior to the low temperature tests, the manufacturer may attempt practice starts using external heat and power if desired. For the tests, batteries and starting aids conforming to the applicable end item specification shall be used. Preparation of the engine will include draining the lubricating oil and thoroughly flushing the system when changing grades of lubricating oil, changing the lubricating oil filter elements, and refilling the engine with the required lubricant, see Section 2 of this test method. When applicable, the gasoline and lubricating oil mixture ratio shall be the same as that used for the endurance test, Test Method 1500. Engine accessories shall be serviced if they require low temperature servicing. The complete engine, including batteries, coolant, lubricant, fuel and starting aids shall be cold soaked until all temperatures are stabilized at the test temperature prior to each start attempt. The engine shall be started twice at each temperature and shall be operated long enough to demonstrate steady operation.

Steady operation is defined as all cylinders firing without the use of the starting aids. This will be determined by the use of thermocouples in exhaust ports of the diesel engines to indicate temperatures. The exhaust manifold may be changed after completion of the test. The temperature difference between cylinders shall not exceed 100° F. After obtaining steady operation during the second start at minus 25° F, the

engine shall be operated for 30-minutes at the maximum continuous duty speed. The chamber temperature will be permitted to rise to not higher than 0° F by the end of the 30-minutes of operation; however, the engine starting shall begin at a chamber temperature not higher than minus 25° F. The total time from initiating starting until obtaining the various engine operating conditions shall not exceed the following:

Engine operation	5 minutes
Steady engine operation	15 minutes
Operation at maximum continuous duty speed	20 minutes

The operation at maximum continuous duty speed time limitation applies to the second start at minus 25° F only. Initiating starting is defined as the first action taken during a start attempt, turning on glow plugs, discharging ether unit, engaging cranking motor or whatever else is the first action. The two starts at each temperature shall be consecutive starts with steady operation achieved after each start.

TEST METHOD 1500

ENDURANCE TEST

1. SCOPE. This test method is for the purpose of determining the wear characteristics of an engine over an extended period of operation at various loads and speeds. The manufacturer's maximum wear replacement limits, Appendix D, will be furnished to the contracting officer prior to the start of the endurance test.

2. TEST PROCEDURE.

2.1 Pre-endurance inspection. At the manufacturer's option, a pre-endurance inspection to include disassembly of the engine may be made following completion of the environmental tests. Prior to reassembly, combustion deposits may be removed from the cylinder head, piston heads, and valve seats. If the pre-endurance disassembly is performed, the contracting officer or his representative shall be present. If the engine is unsuitable for endurance testing or parts changes (other than gaskets) are necessary, rerunning of all previous tests may be required.

2.2 Pre-endurance servicing. Before the endurance test the engine should be serviced in accordance with the before test servicing of the "Servicing and Adjustment Schedule for Evaluation Tests", Appendix B, or as otherwise specified in this test method. After the servicing is completed and before the start of the endurance test, the engine shall be sealed by a representative of the contracting officer. Seals shall be placed on the adjustable components and settings, and to prevent separation of the cylinder block and oil pan, side covers, cylinder head, removal of the rocker arm covers and accessories; fuel injection pump nozzles or injectors, turbocharger if applicable or carburetor. A representative of the contracting officer shall be present when removal of the seals is necessary for engine servicing or inspection. Maximum horsepower output, fuel consumption and lubricating oil consumption shall be determined periodically during the test.

2.3 Endurance time record. Only the time when the engine is at test load and speed will be logged as endurance test time. An engine oil pressure actuated hourmeter shall be installed and readings recorded at approximately 24-hour intervals. The readings taken from the hourmeter will include warmup and idling time however, shall be used to verify engine endurance test hours.

2.4 Endurance procedure. The endurance test shall consist of operation at various speeds and loads according to the schedule indicated in Tables III and IV of this method for the appropriate engine type and size. The loads specified in each schedule represent the observed power output at which the engine shall be operated. The loading used shall not exceed the engine ratings as previously established. The engine accessories and adjustments (except for throttle lever position) shall be the same for the endurance test as for the maximum power test, Test Method 1310 or 1311, Appendix A. The governor shall be adjusted to maintain the required engine speed during the constant speed operation and shall remain operative as a maximum speed control during the remainder of the test if practicable. Horsepower and speed tolerance during all endurance testing shall be held to plus or minus 1-1/2 percent of Schedules I, II, and III in Table IV of this test method.

2.5 Periodic maximum power checks. Maximum power output shall be determined at the start of the endurance test and at approximately 50-hour intervals thereafter. The maximum power checks shall be taken at the maximum continuous duty speed with a complete set of readings recorded including smoke meter readings. Any evidence of excessive vibration or temperatures, unstable operation, malfunctioning or exceeding the limitations of 3.3.4 or 6.2 of this standard shall be noted and recorded. If these conditions are noted, they shall be brought to the immediate attention of the contracting officer for directives on continuing the endurance test. If the "Servicing and Adjustment Schedule for Evaluation Test", Appendix B, permits servicing at the power check intervals, the maximum power check shall be performed after servicing.

2.6 Fuel consumption limits. The fuel consumption shall be determined at maximum continuous power output every 8-hours during Schedule I, Table IV of this test method, during Test Sequences 4 and 9 of Schedule II and during Test Sequences 2 and 6 of Schedule III. At least three readings shall be made at each determination. The difference between three consecutive readings shall not be more than plus or minus 1 percent with the average of the three readings representing the fuel consumption for that determination. The maximum allowable fuel consumption rates are shown in Table I of this test method. There are

no fuel consumption limits for gasoline engines having a maximum continuous power rating of less than 10 bhp.

2.7 Lubricating oil consumption limits. The lubricating oil consumption shall be determined for the period between oil changes. The brake specific oil consumption shall be calculated, based on the maximum continuous bhp, for all endurance test schedules. The maximum allowable lubricating oil consumption limits are shown in Table II of this test method. There are no oil consumption limits for gasoline engines having a maximum continuous power rating of less than 10 bhp.

3. TABLES

Table I. Average Maximum Allowable Fuel Consumption Rates, BSFC

Engine Type and Size	Limits
Gasoline (10 bhp 1/ up to 500 cu. in.)	0.700 lb/bhp-hr.
Gasoline (over 500 cu. in.)	0.650 lb/bhp-hr.
Diesel (under 20 bhp 1/)	0.575 lb/bhp-hr.
Diesel (over 20 bhp 1/)	0.490 lb/bhp-hr.

Notes, Table I
1/ Continuous bhp.

TEST METHOD 1500 (cont'd)

Table II. Average Maximum Allowable Crankcase Oil Consumption Limits, BSOC, LBS/BHP-HR., Based on Continuous Duty BHP Rating.

Engine Type and Size	Schedule		
	I	II	III
Gasoline (over 10 bhp 1/ up to 500 cu. in.) 2/	0.0025	0.0025	0.0025
Gasoline (over 500 cu. in.)	0.0022	0.0030	0.0030
Diesel (over 10 bhp 1/)	0.0035	0.0035	0.0035
Diesel (under 10 bhp 1/)	0.0050	0.0050	0.0050

Notes, Table II
1/ Continuous bhp.
2/ Air cooled engines may not exceed 0.004 lb/bhp-hr.

Note: Crankshaft oil seal; seal leakage (see 4.1.4, criteria for failure in basic standard).

Table III. Endurance Operation

Engine Type and Size	Time (hrs.)	Test Schedule
Group I and II - Gasoline (up to 500 cu. in.)	300	I
	200	II
	250	III
Group II - Gasoline (over 500 cu. in.)	400	I
	250	II
	350	III
Diesel (All)	400	I
	250	II
	350	III

Notes, Table III

Gasoline Engines: Endurance operation and final performance tests will be run on gasoline conforming to MIL-G-46015 (see 4.3.1 of this standard).

Diesel Engines: Endurance operation and final performance tests will be run on diesel fuel conforming to MIL-F-46162 (see 4.3.1 of this standard).

Table IV. Endurance Test Schedules

Schedule No.	Test Sequence	Hours Duration	Horsepower 1/	Speed at	Fuel Consumption
I	-	Table III	Cont. Duty Rating	Cont. Duty	Every 8 Hours
II	1	1	No Load 2/	Cont. Duty	
	2	1	Int. Duty	Cont. Duty	
	3	1	60% Cont. Duty	Cont. Duty	
	4	1	Cont. Duty	Cont. Duty	X
	5	1	80% Cont. Duty	Cont. Duty	
	6	1	No Load	Cont. Duty	
	7	1	Int. Duty	Cont. Duty	
	8	1	90% Cont. Duty	Cont. Duty	
	9	1	Cont. Duty	Cont. Duty	X
	10	1	70% Cont. Duty	Cont. Duty	
III	1	1	Int. Duty	Int. Duty 3/	
	2	2	Cont. Duty	Cont. Duty	X
	3	1	Int. Duty	Lowest Tested	
	4	2	Cont. Duty	Cont. Duty	
	5	2	No Load	Min. Idle	
	6	2	Cont. Duty	Cont. Duty	X
	7	1	Int. Duty	Max. Torque	
	8	2	Cont. Duty	Lowest Tested	

TEST METHOD 1500 (cont'd)

Table IV. Endurance Test Schedules (cont'd)

Schedule No.	Test Sequence	Hours Duration	Horsepower 1/	Speed at	Fuel Consumption
III	9	1	Int. Duty	Int. Duty	
	10	1	No Load	Cont. Duty	
	11	2	Cont. Duty	Max. Torque	
	12	1	No Load	Cont. Duty	
	13	1	Int. Duty	Lowest Tested	
	14	2	Cont. Duty	Max. Torque	
	15	1	Int. Duty	Int. Duty	
	16	1	Cont. Duty	Cont. Duty	
	17	1	Int. Duty	Int. Duty	
	18	1	No Load	Cont. Duty	

Notes, Table IV

1/ Horsepower loads are observed power based on percent of corrected power output obtained during Test Method 1310 or 1311, Appendix A. However, intermittent and continuous duty loads as developed under Test Method 1320 and 1410 must be achieved.

2/ No load is defined as the minimum possible load to overcome equipment friction and maintain required speed. When testing is interrupted for servicing, etc., engine starting and stopping shall be performed at the "No Load" points.

3/ The applicable speeds for Test Schedule III are based upon performance data of Test Method 1310 or 1311. However, the lowest test speed and intermittent duty speed as developed under Test Method 1320 must be achieved.

TEST METHOD 1600

FINAL PERFORMANCE TEST

1. SCOPE. This test method is for the purpose of determining the power output of the engine at the completion of the endurance test.

2. TEST PROCEDURE. The final performance test shall consist of a rerun of the maximum power test (Test Method 1310 or 1311) and a governor test, Test Method 1340. Prior to performance of these tests, and before test servicing of the "Servicing and Adjustment Schedule for Evaluation Test" (Appendix B) may be performed. A decrease in maximum power output in excess of 5 percent from the initial maximum power test shall be cause for derating the engine. The engine shall be derated on the maximum ratings by the percentage of power loss in excess of the 5 percent at each speed. The intermittent and continuous ratings shall also be derated if necessary to be within the 90 percent and 85 percent of maximum limitations. Refer to Appendix H.

TEST METHOD 1700

FINAL INSPECTION

1. SCOPE. The purpose of this test is to determine the final condition of the engine at the completion of the evaluation test.

2. PROCEDURE. The engine shall be completely disassembled for visual inspection of the component parts. All high mortality parts shall be in condition to permit extended continued service. Engines of less than four cylinders will be permitted no stuck or broken rings. Engines of four cylinders or more will be permitted no more than one ring stuck or broken. Seized, broken or scored piston rings, scored piston(s), stuck valves and other engine parts in such condition to be detrimental to engine reliability shall be cause for rejection. All parts shall be functioning in a normal manner, injector nozzles, turbochargers and similar parts shall be in satisfactory condition. All parts shall be in agreement with the assembly bill of material. Photographs shall be taken of the high mortality parts or, provided the appearance of the parts is sufficiently similar, in the judgement of the contracting officer, typical photographs of individual parts will suffice. Any excessively worn or damaged parts including crankshaft oil seals or excessive accumulations of deposits shall also be photographed. Any part appearing heavily worn shall be measured for comparison to the manufacturer's maximum wear replacement limits. The photographs and measurements to be taken shall be at the discretion of the contracting officer. A complete description of the condition of the component parts shall be recorded including: Severity of deposits, condition of metal wear surfaces, port plugging, nozzles and pump condition, misalinement, etc. See 4.4, criteria for failure in this standard.

TEST METHOD - SERIES 2000

PREPRODUCTION MODEL PERFORMANCE TEST

1. SCOPE. This test method is used to determine conformance of an engine to the applicable drawing and to determine the suitability of an engine for a specified end item application.

2. TEST EQUIPMENT AND DATA. The necessary test equipment and data are as specified in Test Method 1000.

3. TEST SEQUENCE. This test series shall consist of the following tests and inspections and shall be conducted in the numerical sequence indicated:

Initial Inspection	2100
Check Test and Run-In	2200
Performance Test	2300
Environmental Test	2400
Final Inspection	2500

4. PHYSICAL DESCRIPTION. A physical description shall be prepared according to format of Appendix C, Evaluation Test Model Engine, Physical Description, except that the title shall be Preproduction Test Model Engine, Physical Description.

5. REPORTS. Unless otherwise specified in the end item specification, a single laboratory report shall be prepared by the manufacturer and shall include the following:

(a) Description and identification of the engine (see Appendix C).
(b) Engine log. A log of observations of test personnel maintained throughout the preproduction tests. Every event connected with the test, including the date of receipt of the engine, the date each test was started and finished, and all maintenance work accomplished shall be recorded. Each engine adjustment after the start of the test shall be recorded, giving the reason for the adjustment and the instrument readings before and after the adjustment and the amount of the adjustment.

(c) Laboratory data sheets for each test.
(d) Performance curves, data indicated vs engine rpm:
  (1) Corrected brake horsepower
  (2) Engine torque
  (3) Corrected maximum bmep
  (4) Observed fuel consumption at maximum bhp
  (5) Exhaust smoke readings (diesel engines)
  (6) Turbine speed*
  (7) Exhaust temperature into and out of the turbine*
  (8) Turbine inlet pressure*
  (9) Intake manifold pressure (gasoline engines)

*Turbocharged engines only

6. FUELS. The fuels to be used for the conduct of these tests shall conform to the fuels specified in 4.7.1 of this standard.

TEST METHOD 2100

INITIAL INSPECTION

1. SCOPE. This test method is used to determine conformance of the engine with the applicable end item specification and, when applicable, drawings.

2. TEST PROCEDURE. The engine with all accessories will be examined visually. The manufacturer shall certify that it is a production engine. At the option of the contracting officer, the engine may be disassembled sufficiently to determine conformance to the requirements of the end item specifications. For all tests, the engine shall be fully equipped with all accessories and components and shall be adjusted as it will be installed in the end item. In addition to the equipment indicated in Test Method 1000, the engine shall have other equipment such as governor, fan, radiator, and complete cranking and charging system as will be provided for the end item.

TEST METHOD 2200

CHECK TEST AND RUN-IN

1. SCOPE. This test method is for the purpose of determining that the engine is suitable for operation and to check all instrumentation.

2. SERVICING AND ADJUSTMENT. Servicing and adjustment shall be performed prior to the check test and run-in as specified for before test of the "Servicing and Adjustment Schedule for Evaluation Tests", Appendix B.

3. TEST PROCEDURE. A check test shall be conducted to determine that the engine is in suitable condition for test and to check all instrumentation. After the test installation is complete, the engine shall be started and run while operation and instrumentation are checked. The manufacturer's run-in, of at least 4 hours but not longer than 20 hours, shall be performed concurrently with this test. All adjustments necessary for the maximum power test (Test Method 2300) shall be performed during this period.

TEST METHOD 2300

PERFORMANCE TEST

1. SCOPE. This test method is for the purpose of determining the ability of the engine to meet specific end item power requirements.

2. TEST CONDITIONS. For data observations, the engine shall be brought to a condition of stabilized operation at each speed and load condition and operated not less than 10 minutes under those conditions while data observations are made. Engine speed during the stabilized 10 minute data observation period shall be held as constant as possible by means of the applied dynamometer load and shall be permitted to vary not more than 1 percent or 20 rpm, whichever is greater. The governor shall be set and adjusted as required by the end item and remain operative as a maximum speed control. Any evidence of excessive vibration or temperatures, unstable operation, or other malfunctioning which may occur at any of the conditions under which the engine is tested shall be noted and recorded. The manufacturer shall furnish horsepower consumption curves for all parasitic loads over the operating range of the engine (i.e., fan, battery charging system, torque converter, etc.). The curves will be certified to by the manufacturer, and these parasitic loads will be considered toward meeting the power ratings and determining the required loading during the preproduction model performance and environmental tests.

3. TEST PROCEDURES. The engine shall be subjected to a maximum brake horsepower test conducted in the same manner as Test Method 1310 or 1311, except that the tests will be run only at the applicable end item power and speed ranges. On diesel engines, horsepower and speed output will be limited to either maximum, intermittent, or continuous ratings as listed by the engine manufacturer or the requirements of the end item specification whichever is lower. Further, the fuel pump or injection rack setting shall be set and sealed in such a manner as to insure that the horsepower and speed output will not exceed the maximum, intermittent, or continuous ratings as listed by the engine manufacturer or the requirements of the end item specification, whichever is lower. A tolerance of plus or minus 1 percent will be permitted. Both gasoline and diesel engines shall be equipped with accessories and systems as required for the preproduction end item. Adjustments shall be as set in Test Method 2200 for the end item application. Operational limits recommended by the engine manufacturer, limitations specified in

6.2 of this standard, or maximum data points (of graphic record data) established in evaluation tests shall not be exceeded. For gasoline engines, intake manifold vaccum shall be determined at the maximum, intermittent and continuous bhp output conditions for the applicable operating speeds or governed speeds, or both, of the end item. The graphic record produced by this test (intake manifold vaccum, in. Hg vs corrected bhp at the applicable speed) and all data obtained by this maximum power test can be utilized by the contracting officer during preproduction end item testing to determine whether the required horsepower limitations are being exceeded.

The final report shall include a graphic record of corrected brake horsepower, torque, bmep, fuel rate, and exhaust smoke condition for diesel engines; ignition or injection timing shall also be indicated. For turbocharged engines, the graphic record shall also include turbine speed, exhaust temperature into and out of the turbine, and turbine inlet pressure.

TEST METHOD 2400

ENVIRONMENTAL TEST

1. SCOPE. This test method is to determine engine operation under high temperature conditions and the adequacy of accessories being installed on the engine as equipped for end item installation. In the event that the entire engine equipped end item is to be high temperature tested, this test may be waived at the option of the contracting officer.

2. TEST CONDITIONS. Unless otherwise specified in the end item procurement document, the high temperature test shall be conducted at 120° F.

3. TEST PROCEDURE. This test shall be conducted in the same manner as the corresponding evaluation test (Test Method 1440) except that the engine shall be equipped with all accessories and systems such as fan, radiator, and oil cooler, as required for the production model end item, and adjustments shall be as set in Test Method 2300.

The engine shall be operated according to the following schedule:

(a) Operate at maximum torque speed and intermittent horsepower at that speed for 1 hour.
(b) Operate at rated application speed and horsepower for 1 hour.
(c) Operate at maximum intermittent load and maximum speed for which engine is applied for 1 hour.
(d) Shut down engine for 5 minutes.
(e) Restart and operate at rated application speed and horsepower for 30 minutes.
(f) Idle at no load for 1 hour at idle speed recommended by engine manufacturer.

TEST METHOD 2500

FINAL INSPECTION

1. SCOPE. The purpose of this test is to determine the final condition of the engine after the completion of the preproduction model tests.

2. TEST PROCEDURE. The assembled engine will be visually examined at the completion of test. At the option of the contracting officer, it may be disassembled sufficiently to determine conformance to the requirements of the end item specifications. Upon completion of the inspection, the contracting officer or his representative shall insure that all components and adjustments are sealed and shall remain sealed until completion of all preproduction-model end item testing. Performance curves may be rerun at the option of the contracting officer to determine correct assembly and verify adjustment of the engines and sealing to preclude the engine from developing more than the required horsepower. All engine components which would permit access to the internal engine parts shall also be sealed.

TEST METHOD - SERIES 3000

PRODUCTION CONTROL TESTS

1. SCOPE. This test method is used to determine continued compliance of production engines with the applicable end item specification and, when applicable, drawings.

2. TEST EQUIPMENT AND DATA. The necessary test equipment and data are as specified in Test Method 1000.

3. TEST SEQUENCE. This test series shall consist of the following test and shall be conducted in the sequence listed:

Initial Examination	3100
Check Test and Run-In	3200
Performance Tests	3300
Maximum Power Test	3310
Rated Load Test	3320
Final Inspection	3400

4. TEST ENGINE. The production control test engine shall be equipped to the extent required by the end item manufacturer.

5. TEST FUELS. The fuels to be used in conducting these tests shall conform to the fuels specified in 4.7.1 of this standard.

6. REPORTS. Unless otherwise specified in the end item specification, a single laboratory report shall be prepared by the engine manufacturer and shall include the following:

(a) Identification of the engine (including manufacturer's model and serial number, contract number and production control test number) preproduction model performance test, and production control tests.
(b) Engine log. A log of observations by test personnel maintained throughout the production control tests. Every event connected with the test, including date each test was started and finished, and all maintenance work accomplished shall be recorded. Each engine adjustment of the test shall be recorded, and all pertinent settings and limitations shall be indicated.

TEST METHOD - SERIES 3000 (cont'd)

(c) Laboratory data sheets for each test.
(d) Performance curves, data indicated vs engine rpm. (Test Method 3310):

(1) Corrected brake horsepower
(2) Engine torque
(3) Corrected maximum bmep
(4) Observed fuel consumption at maximum bhp

TEST METHOD 3100

INITIAL EXAMINATION

1. SCOPE. This test method is used to determine that the engine is a production engine.

2. TEST PROCEDURE. The engine with all accessories shall be visually examined and compared with the production engine.

TEST METHOD 3200

CHECK TEST AND RUN-IN

1. SCOPE. This test method is to determine that the engine is suitable for operation and to check instrumentation.

2. SERVICING AND ADJUSTMENTS. Servicing and adjustments shall be performed prior to the check test and run-in, as specified for before test of the "Servicing and Adjustment Schedule for Evaluation Test", Appendix B.

3. TEST PROCEDURE. A check test shall be conducted to determine that the engine is in suitable condition for test and to check all instrumentation. After the test installation is complete, the engine shall be started and run while operation and instrumentation are checked. The manufacturer's run-in, of at least 4 hours but not longer than 20 hours shall be performed concurrently with this test. All adjustments necessary for the maximum power test (Test Method 3310) shall be performed during this period.

TEST METHOD 3300

PERFORMANCE TESTS

1. SCOPE. This test method is used to determine the ability of an engine to meet specified end item performance requirements.

2. TEST CONDITIONS. Operational limits recommended by the engine manufacturer or limitations specified in 6.2 of this standard shall not be exceeded.

3. TEST SEQUENCE. This test series shall consist of the following tests and shall be conducted in the sequence listed:

Maximum Power Test	3310
Rated Load Test	3320

TEST METHOD 3310

MAXIMUM POWER TEST

TEST PROCEDURE. This test shall be conducted in the same manner as the maximum power test (Test Method 1310 or 1311), and the engine shall be equipped to the extent required by the end item manufacturer. Engine adjustments including governor shall be set as they will be for end item use. The governor shall remain operating as the maximum speed control for all production control tests. If the speed and horsepower capability of the engine is not to exceed the applicable speed and horsepower determined by Test Method 2300, this test shall be performed to meet the power and speed criteria of Test Method 2300 within the same tolerances.

TEST METHOD 3320

RATED LOAD TEST

TEST PROCEDURE. The rated load test shall consist of 10 hours of operation following the load sequence of Schedule II, Table IV (Test Method 1500) for one cycle. The applicable speed shall be either the continuous duty speed as tested or the required speed for the end item application. The load cycle shall be either the continuous duty rating of the engine or shall be based on percentages of rated load required for the end item. In no case shall loading be greater than the intermittent duty horsepower at any applicable speed. Parasitic loads shall be considered in determining the exact cycle.

TEST METHOD 3400

FINAL INSPECTION

1. SCOPE. This method is used to determine the condition of the engine following the completion of production control tests.

2. TEST PROCEDURE. The engine shall be disassembled sufficiently for a visual inspection of the cylinder head, valves and cylinder, one main bearing and journal, and one connecting rod and journal. Measurements may be made at the option of the contracting officer to determine conformance to the engine manufacturer's drawings. Performance curves also may be rerun to determine correct assembly and adjustment of the engine.

TEST METHOD - SERIES 4000

PRODUCTION TEST

1. SCOPE. This test method is used to determine continued compliance of each production engine, except those engines selected for production control tests (Test Method 3000) with the applicable procurement specification.

2. TEST EQUIPMENT AND DATA. Engine manufacturer's standard production test equipment shall be used, and it shall be adequate to obtain the test data specified in Table I, Test Method 1000.

3. TEST SEQUENCE. This test series shall consist of the following test and shall be conducted in the sequence listed:

Initial Examination	4100
Check Test and Run-In	4200

4. TEST ENGINE. The production test engine shall be equipped to the extent required for the performance of these tests.

5. TEST FUELS. The fuels to be used in conducting these tests shall be as specified in 4.7.1 of this standard.

6. REPORTS. Unless otherwise specified in the end item specification, a single laboratory report covering the production test on each engine delivered under the contract, except those engines selected for production control test, shall be prepared by the engine manufacturer and shall include the following:

(a) Identification of the engine (including manufacturer's model and serial number and contract number) and preproduction test.
(b) Laboratory data sheets for test conducted.

7. TOLERANCES. Engines furnished to comply with a given end item horsepower requirement shall have the following tolerances:

TEST METHOD - SERIES 4000 (cont'd)

(a)	Maximum bhp requirement	92 percent minimum
(b)	Intermittent bhp requirement	Plus or minus 5 percent
(c)	Continuous bhp requirement	100 percent minimum
(d)	All speeds	Plus or minus 10 percent

All tolerances are based on the observed output of the engine as published by the engine manufacturer at the applicable speed.

8. RUN-IN SCHEDULE

Table I. Run-In Schedule

(Series 4000)

Run No.	Load Fraction	Speed Fraction	Duration (min)
1	0	Idle	5
2	1/4	3/4	10
3	1/2	3/4	15
4	3/4	3/4	15
5	Maximum Continuous Load and Speed as follows:		
	Engine Size		
	Gasoline (up to 100 cu. in.)		15
	Gasoline (100-500 cu. in.)		30
	Gasoline (over 500 cu. in.)		45
	Diesel (up to 400 cu. in.)		45
	Diesel (over 400 cu. in.)		75

TEST METHOD 4100

INITIAL EXAMINATION

1. SCOPE. This test method is used to determine that the engine is a production engine.

2. TEST. The engine shall be visually examined and compared with the preproduction engine.

TEST METHOD 4200

CHECK TEST AND RUN-IN

1. SCOPE. This test method is to determine that the engine is suitable for operation and to check instrumentation.

2. SERVICING AND ADJUSTMENTS. Servicing and adjustments shall be performed prior to the check test and run-in as specified for before test of the "Servicing and Adjustment Schedule for Evaluation Tests", Appendix B.

3. TEST PROCEDURE. A check test shall be conducted to determine that the engine is in suitable condition for test and to check all instrumentation. After the test installation is complete, the engine shall be started and run while operation and instrumentation are checked. The manufacturer's run-in shall be performed with this test. The manufacturer's recommended run-in schedule shall be followed if the total run-in hours equal or exceed the total hours as listed in Table I, Test Method 4000; otherwise Table I shall be used. At the option of the manufacturer, gasoline engines up to 500 cu. in. total displacement need not be loaded. However, the minimum required speed fractions and run duration shall be adhered to for all engines.

APPENDIX B

SERVICING AND ADJUSTMENT SCHEDULE FOR EVALUATION TESTS ENGINES, GASOLINE OR DIESEL, INDUSTRIAL, 2 - OR 4 - CYCLE

SERVICING AND ADJUSTMENT SCHEDULE FOR EVALUATION TESTS

ENGINES, GASOLINE OR DIESEL, INDUSTRIAL, 2 - OR 4 - CYCLE

No.	Before Test	Gasoline: Less Than 10 bhp Hours	Gasoline: 10 bhp and above Hours	Diesel Hours	
					Engine Engine Mfg. _____ Engine Model _____ Serial No. _____ Rated _____ HP at _____ RPM
					General:
1	X	8	8	8	Inspection. Check engine for loose connection, leaks in oil, fuel and water systems, cracks, and free action of all moving parts. Correct as necessary and record.
2	X	100	200	500	Valve clearance (where applicable). Check valve tappet clearance and reset if necessary.
3	X	200	200	500	Compression pressures. Take compression pressures at the same speed, using the same procedure for all check periods.
					Exhaust ports, intake ports and combustion chamber:
4	X	300	500	1000	1. Clean exhaust ports and intake ports (2-cycle engines).
	X	300	500	1000	2. Clean combustion chamber and manifold.
					General:
5	X	300	500	500	Governor and throttle. Adjust governor and throttle linkage (except normal speed adjustments on the engine).

SERVICING AND ADJUSTMENT SCHEDULE FOR EVALUATION TESTS (cont'd)

ENGINES, GASOLINE OR DIESEL, INDUSTRIAL, 2 - OR 4 - CYCLE

No.	Before Test	Gasoline: Less Than 10 bhp Hours	Gasoline: 10 bhp and above Hours	Diesel Hours	Engine
					Engine Mfg. _____
					Engine Model _____ Serial No. _____
					Rated _____ HP at _____ RPM
6	X	100	100	100	Air Induction System:
					1. Clean air filter.
					Fuel System:
7	X	300	500	—	1. Clean and adjust carburetor.
	X	*	*	*	2. Clean fuel strainer and case, fuel pump, sediment bowl, tank, lines.
	X	*	*	*	3. Replace filter element.
	X	—	—	500	4. Clean injector nozzles, adjust fuel setting.
		—	—	500	5. Drain and refuel lube oil in fuel injector pump.
					Ignition System:
8	X	—	100	—	1. Clean and regap spark plugs.
	X	100	200	—	2. Replace spark plugs.
	X	200	300	—	3. Adjust and dress breaker points.
	X	300	500	—	4. Replace breaker points and condenser.
	X	300	300	—	5. Adjust ignition timing.
					Lubrication System:
9	X	*	*	*	1. Lubricate grease fittings and oil cups.
	X	8	15	15	2. Add lubricating oil.

SERVICING AND ADJUSTMENT SCHEDULE FOR EVALUSTION TESTS (cont'd)

ENGINES, GASOLINE OR DIESEL, INDUSTRIAL, 2 - OR 4 - CYCLE

No.	Before Test	Gasoline Less Than 10 bhp Hours	Gasoline 10 bhp and above Hours	Diesel Hours	Engine
					Engine Mfg. _____
					Engine Model _____ Serial No. _____
					Rated _____ HP at _____ RPM
		50	100	100	3. Change lubricating oil.
	X	--	100	100	4. Change filter elements.
	X	100	100	100	5. Clean crankcase breather.
	X	--	500	500	6. Service crankcase emission control system.
					Cooling System:
10.	X	--	24	24	1. Add coolant.
					Electrical System:
11.	X	*	*	*	1. Fill batteries, clean and grease battery cables.
					Belt Drives:
12.	X	--	200	500	1. Adjust belt tension.
	X	--	500	1000	2. Replace belts.

*As required.

Note: If the manufacturer does not desire to perform the servicing at any specified interval the service may be omitted. However, it shall not be performed until the next specified interval.

APPENDIX C

EVALUATION TEST MODEL ENGINE

PHYSICAL DESCRIPTION

APPENDIX C

EVALUATION TEST MODEL ENGINE

PHYSICAL DESCRIPTION

DATED _____

1. Date of Test _____ Rept. No. _____
2. Mfr. _____ Model _____ Type _____
3. Ser. No. _____ Cycle _____ No. of cyls _____
4. Bore _____ in., Stroke _____ in., Displ per cyl _____ cu. in.
5. Total Displ. _____ cu. in., Cyl arrange _____
6. Combust, Chamber, describe _____
7. Nom. Compress. ratio _____. Compress. press _____
   at cranking _____rpm.
8. Rotation, flywhl. end. _____, Firing Order _____
9. 1/ Weight, dry _____lbs.
10. 1/ Overall dimensions
    lgth _____in. hght _____ in.
    wdth _____in.
11. Horsepower*
    Max. power _____ bhp at _____ max. rpm _____ Bmep.
    Max. Inter. (1 hour) _____ bhp at _____ rpm _____ Bmep.
    Net Con't _____ bhp at _____ rpm _____ Bmep.

*For definition of power rating, see 3.3.3.

1/ The engine weight and dimensions to be furnished in accordance with Test Method 1000 shall include the following items: Coolant fan, water pump, thermostat, spark plugs or injectors, fuel filters, carburetor or fuel injection pump, ignition harness or injection lines, flywheel housing, lube oil pumps and filters, complete manifolding, magneto or distributor, crankcase (oil pan), oil cooler (if required), and turbo-charger or supercharger (if utilized). The following items should not be included in the engine weight and dimension tabulations: Batteries and box, radiator, external governor, instrument panel, fuel tank, skids or mounts, clutch, power take-off, coolant and lubricating oil. If the following items are contained on the test engine, they should be included in the weight and this information noted: Starter, muffler, air cleaner, generator and regulator.

12. Piston speed at con't rpm _____ ft/min.

Max. torque _____ lb. ft. at _____ rpm.

13. Engine balanced? _____ Method _____

Mechanical

14. Cylinder head, type _____ Number _____

Material _____. Size and number of head studs _____

Bolt torque _____lb/ft.

15. Cylinder Block (single, enbloc) _____

Material _____

16. Crankcase Ventilation System _____

17. Cyl. Liners (Yes, No) _____ Wet, Dry _____

Material _____

18. Piston, type _____ Material _____ Length _____ in.

Plating or surface treat _____

Piston cooling, method _____

Insert, if used _____, Taper, inches _____

Cam Degree _____.

19. Piston Rings, Compress. No. per piston _____

Type _____ Plating _____

Expander _____, Piston ring locating pins used? _____,

Tension lbs _____, Material _____ End Gap _____,

Face Width _____ Radial Thickness _____

20. Piston Rings, Oil No. per piston _____ Type _____

Plating _____ Expander _____ Location _____

Piston ring locating pins used? _____

Tension _____ Material _____

End Gap _____ Face Width _____

Radial Thickness _____

21. Piston Pin, Diameter _____ in. lgth _____ in. fixed

or floating _____

Method of reatining _____

Material _____

22. Piston Pin Bushing, type _____ Material _____

I.D. _____ in total lgth _____ in. lubrication _____

Method _____

a. Con Rod Bushing (if used) Type _____

Material _____ I.D. _____ Total Length _____

Lubrication Method _____

23. Connecting Rod, type _____ Drilled? _____

Material _____ lgth c to c _____ in.

24. Connecting Rod Bearings, Type _____ Material _____

I.D. _____ in. lgth _____ in. lubrication method _____

_____

Bearing bolt torque _____ lb/ft Connecting rod cap method of fastening _____

25. Crankshaft, material _____ forged or cast _____

Balanced? _____ How? _____ No. of c'wts _____

Method of hardening _____

26. Main bearings, No. _____ Material _____

Bolt torque _____ lb/ft lubrication method _____

I.D. _____ in. lgth _____

27. Camshaft, material _____ forged or cast _____

No. _____ Method of hardening _____

Location _____ Driven by _____

Type of valve lifters _____

28. Camshaft bearings, No. _____ Material _____

Lubrication method _____ Dia. _____

Length _____.

29. Valve arrangement and operating mechanism _____

Lash adjustment method _____

30. Valve or port timing: Inlet opens _____ degs. _____

closes _____ degs. _____ Exhaust opens _____

degs. _____ closes _____ degs. _____

31. Intake ports, No. per cyl. _____ size _____ in.

32. Exhaust ports, No. per cyl. _____ size _____ in.

33. Valve, intake No. per cyl. _____ Head diam. _____ in.

lgth _____ in. port diam. _____ in. Max lift _____

_____ in. Lash cold _____ in. Face angle _____

_____ degs. Material, head _____ Stem _____

Facing material _____ No. springs per valve _____

Valve spring load, valve open _____ lb., closed _____ lb.

Rotators? _____ Type _____ Valve stem dia. _____

Valve spring material _____ Valve spring free length _____

34. Valve, exhaust, No. per cyl. _____ Head diam. _____ in. lgth _____ in. Port diam. _____ in. Max. Lift _____ in. Lash cold _____ in. Face angle _____ degs. Material, head _____ stem _____ Facing material _____ No. springs per valve _____ Valve stem dia. _____ Valve spring material _____ Valve spring free length _____ Valve spring load, valve open _____ lb., closed _____ lb. Rotators? _____ Type _____

35. Valve seat inserts, intake _____ Seat angle _____ degs. Material _____ how installed _____ Exhaust _____ Seat angle _____ degs. Material _____ how installed _____

36. Valve guide, type _____ Material _____ Valve guide dia. _____

37. Flywheel O.D. _____ in. Weight _____ lbs. Material _____ Moment of Inertia, WR^2 _____ (lb. $in.^2$) (lb $ft.^2$) Balanced? _____ Flywheel housing SAE No. _____

38. Vibration damper, type _____

Fuel Injection System (Diesel engines)

39. Fuel Injection Pump, make _____ Model _____ Type _____ Enbloc _____

Individual pumps _____ Bore _____ in. Total stroke _____ in. Nominal pump timing _____

Timing control, fixed _____ Manual _____

Timing automatically variable, with load _____

with speed _____ Max. Delivery c.c. per stroke _____

_____

40. Injector nozzle, make _____ type _____

Valve opening press. _____ psi. Spray angle _____ degs. No. of holes _____

Hole size _____ in. Holder, make _____

type _____ torque _____

41. Fuel lines, high press. I.D. _____ in. O.D. _____ in. Material _____ Type of fittings _____ Low press. I.D. _____ in.

Material _____ Type of fittings _____

42. Fuel transfer pump; make _____ type _____

Method of drive _____ Integral _____

Separate _____ By pass _____

Suction lift _____ ft. Max. pump output _____ gal/hr.

at _____ rpm at pressure _____ psi.

Nominal fuel pressure _____ psi.

43. Fuel filters, primary stage, make _____ model _____

Type _____ Secondary stage, make _____

Model _____ Type _____ Number of primary and

secondary filters used _____

44. Manual fuel primer, type _____

Fuel System (Gasoline Engines)

45. Carburetor, Make _____ Model _____ Nominal Size _____ in.

Venturi size _____ in. nom. Fuel feed, up draft, down draft or

horizontal _____ Fuel Pressure _____ psi.

Float level _____ in.

How measured _____

Method of adjustment _____

46. Fuel pump, type _____ make _____ model _____

capacity _____ Suction lift _____ ft. Bowl material _____

47. Fuel filters, strainer, make _____ model _____

type _____

48. Fuel lines I.D. _____ in. Material _____

Type of fittings _____

49. Fuel tank, capacity _____ Material _____

Baffled _____ Filler strainer provided _____

Fuel shut-off provided _____ Stand pipe hght _____ in.

Means provided for measuring oil for gas-oil mixture (2-cycle)____

_____ how? _____

Ignition System (Gasoline Engines)

50. Distributor, make _____ model _____ Advance;

Centrifugal _____ deg. Vac. _____ deg. _____

man _____deg. RPM at max. centrifugal, advance _____

_____ Basic setting _____ deg at TDC. Breaker point gap ___

_____ in.

51. Magneto, type _____ make _____ model _____

Crest voltage _____ breaker gap _____

Type drive _____ Impulse cplg. type _____

Lag angle _____ Shielded _____ Timing fixed or

variable _____

52. Spark plug, make _____ model _____thread size _____

Gap _____in. Shielded_____Torque _____ Thread size of

shield _____ Torque _____

53. Ignition system waterproofed? _____

54. Ignition timing, crankshaft angle, cyl. No. _____

fires _____BTDC. Automatic advance _____ degs.

begins _____ rpm ends _____ rpm

55. Ignition cable, type _____ make _____

56. Other data _____

_____

Lubrication System

57. Type and description (splash, force feed or combination)

Press. Lubricated parts _____

Sump type, (automotive, industrial) _____

Wet or dry _____ Baffled? _____ Capacity _____ qts.

Size drain _____ in. Location of drain in line _____

58. Oil pump type _____ capacity _____ gal/min at _____ psi

at _____ rpm. Pressure relief valve opens _____ psi

Nominal oil pressure _____ psi at _____ rated cont. rpm.

Minimum oil pressure _____ psi at _____ rated cont. rpm.

Oil strainer and intake, type _____

59. Oil cooler, make _____ model _____ type _____

60. Oil filter, make _____ model _____ type _____

No. used _____ Filter element area, total sq. in. _____

Cooling System

61. Type, air or liquid? _____ Radiator type _____

Recommended water out (engine) temp. _____ degs.

Radiator frontal area _____ sq. in.

Pressure? _____ psi. Capacity, radiator _____ gal.

Complete system? _____ gal. Thermostat, type _____

Range, open full _____ deg. Closed _____ degs.

62. Water pump, type _____ capacity _____ gal/min.

at _____ rpm Drive ? _____

63. Fan, type _____ diam. _____ in. No. of blades _____

Projected blade width, pitch? _____ Ratio fan to engine

speed _____ Drive _____ No. belts _____

Air Induction System

64. Air cleaner, make _____ model _____ type _____

Precleaner (if used) _____

65. Induction, natural _____ forced _____ superchge _____

66. Manifolds, No. _____ Header I.D. _____ in.

67. Air heating device _____ type _____ location _____

68. Ether priming device _____ No. _____ location _____

69. Blower, description _____

Capacity _____ cfm at _____ rpm. Nominal charge pressure

_____ psi at _____ rpm. Ratio to engine speed _____

Method of drive _____

Exhaust System

70. Exhaust manifold, No. _____ Header I.D. _____ in. Header

outlet, flange _____ threaded _____

71. Exhaust muffler, type _____ lgth _____ diam. _____ Max. recommended back pressure _____ in. Hg., water

Governor

72. Make _____ model _____ type _____ Governed speed _____ rpm. Speed characteristics, (variable constant, vehicle) _____

73. Control range, speed, maximum _____ rpm, minimum _____ rpm. idle _____ rpm; percent regulation (constant speed only) _____% Overspeed Control _____ Type _____ Maximum overspeed _____% Method of adjustment _____

_____

Cranking System

74. Type, electric, rope, automatic rewind _____ Electric make _____ Voltage _____ Starter make _____ Model _____ Drive _____ Engagement, automatic, manual _____ Generator, make _____ Model _____ Rating _____ watts. Speed ratio _____ Drive _____ Voltage regulator, make _____ Model _____

75. Type: Gasoline or auxiliary engine (diesel engines) _____ _____ Hand or electric starting _____

Voltage _____ starter, make _____

Model _____ Drive _____ Engagement, automatic,

manual _____ Generator, make _____

Model _____ Rating _____ watts. Speed ratio _____

Drive _____ Magneto, make _____ Model _____

Breaker gap, inches _____ Firing order _____

Sparkplug size (thread) _____ Gap _____ in.

Carburetor, make _____ model _____ type _____

Method of adjustment _____ nominal size _____

Starter gas fuel tank capacity _____ gal.

76. Engine provided with lifting eyes? _____

77. Cylinder head and/or block adaptable for winterization? _____

78. Radio-interference suppression provided? _____

79. Special accessories attached during test _____

80. Special features - Describe _____

_____

_____

81. Military standard accessories used _____

_____

82. Turbocharger, manufacturer _____

Model _____

Turbine nozzle ring size (sq. in.) (inches) _____

Turbine housing "A/R" ratio designation _____

Turbine speed limits, maximum _____

Intermittent operation _____ _____

Continuous operation _____

Turbocharger bearing type _____

Type of cooling _____

Turbo inlet temperature limit _____

Pressure ratio control _____

Copy of Turbocharger compressor map (see curve No. P8) shall be included.

83. Turbocharger Control Device or Pressure/Fuel Control:

Manufacturer _____ Model _____

Type of control _____

84. Aftercooler or intercooler; Manufacturer _____

Model _____ Type _____ Location _____

_____ _____

_____

APPENDIX D

MAXIMUM WEAR REPLACEMENT LIMITS (MWRL)

APPENDIX D

MAXIMUM WEAR REPLACEMENT LIMITS (MWRL)

Maximum Permissible Dimensions and Clearances Which Can be Tolerated Prior to Replacement

PART	WEAR LIMIT DIMENSION (Inches)
Liner, Bore	Max. I.D. _____
	Where Measured _____
	Max. Out of Round _____
	Max. Taper _____
Piston	Min. Diameter _____
	Where Measured _____
	Max. Ring Groove Width Ring No. 1_____, 2_____, 3_____ 4_____, 5_____, 6_____
Piston Ring, Comp.	Max. Gap, Ring No. 1_____, 2_____, 3_____, 4_____
	Min. Width, Ring No. 1_____, 2_____, 3_____, 4_____
	Min. Radial Thickness No. 1_____, 2_____, 3_____, 4_____
Piston Ring, Oil	Max. Gap, Ring No. 1_____, 2_____
	Min. Width, Ring No. 1_____, 2_____
	Min. Radial Thickness 1_____, 2_____

Piston Pin	Min. Diameter _____
Piston Pin Bushing	Max. I.D., In. Piston _____,
	In. Rod _____
Connecting Rod Bearing	Min. Width _____
	Where Measured _____
	Min. Thickness _____
	Where Measured _____
Crankshaft	Main Journal
	Min. Diameter _____
	Max. Out of Round _____
	Max. Taper _____
	Connecting Rod Journal
	Min. Diameter _____
	Max. Out of Round _____
	Max. Taper _____
Main Bearing	Min. Width _____
	Where Measured _____
	Min. Thickness _____
	Where Measured _____
Camshaft	Min. Journal Diameter _____
Valve	Min. Stem Diameter; Intake _____
	Exhaust _____

Valve Guide Max. I.D., Intake _____ Exhaust _____

Valve Seat Max. Width, Intake _____ Exhaust _____

MAXIMUM CLEARANCES (Inches)

Piston-Bore _____ Where Measured _____

Piston Ring, Comp., Side: Ring No. 1____, 2____, 3____, 4 _____

Piston Ring, Oil, Side: Ring No. 1____, 2____, 3____, 4 _____

Piston Ring, End Gap 1____, 2____, 3____, 4 _____

Piston Pin-Bushing; Rod _____, Piston _____

Crankshaft End Play _____

Main Bearing _____

Connecting Rod Bearing _____

Camshaft End Play _____

Valve-Stem-Guide Intake _____, Exhaust _____

APPENDIX E

OUTLINE OF REPORT FORM

TESTS OF INDUSTRIAL ENGINES

EVALUATION AND PREPRODUCTION

APPENDIX E

OUTLINE OF REPORT FORM

TESTS OF INDUSTRIAL ENGINES

EVALUATION AND PREPRODUCTION

TEXT:

The report shall consist of the following parts, in order specified, except in those instances where it is more advantageous to place test data and illustrations after the main body of the text, in the form of appendices.

TABLE OF CONTENTS:

There shall be a list of page numbers in the report for all section titles, paragraph titles and appendices.

I. SUMMARY:

In the test report there shall be a statement of scope of test, work performed and conclusions reached as a result of tests.

A proposed rating sheet shall be included as part of the summary.

II. INTRODUCTION.

A. Purpose: This section shall contain a statement of the purpose of the tests conducted.

B. Date and Place of Test: The test report shall contain the date the tests were started, the date of completion of the last test or inspection and the location of the test laboratory.

III. INVESTIGATION:

A. Description: This section shall include a brief physical description of the engine, including a list of high mortality parts and accessories used, with reference to the complete description in the

appendix of the report, test installation and the instrumentation and equipment used, including the date of latest calibration of each.

B. Method of Test: This section shall contain a brief description of the tests conducted, referenced to this standard. When sketches and drawings are used, they shall be presented on separate sheets following the test data. Reference shall preferably be made to specifications and drawings, or other generally available documents, as applicable in lieu of detailed written descriptions.

C. Fuels and Lubricants: Certified chemical analysis for each batch of fuel and for the lubricating oil used are required and shall be included in the report.

D. Results of Tests: This section shall contain detailed results of the test in addition to the engine log. Test results shall be keyed to the test procedure and to specification requirements to assure identification or relation between requirements, procedure and results.

Test data compiled in the performance of the required tests may be included under results of tests or as an appendix. Sketches, graphs, charts, photographs, and other exhibits shall be included as part of the test data as applicable. All exhibits shall be correctly titled to identify the specific test.

IV. ANALYSIS:

This section of the report shall include pertinent discussion of design features, operating characteristics, engine casualties or malfunctioning and probable reasons for them, and difficulties encountered. A statement of the engine manufacturer's proposed action regarding each instance wherein the engine did not fulfill the specified requirements shall be included.

V. CONCLUSIONS:

This section shall contain a statement of conclusions reached as a result of tests, including any major deficiencies found in the engine, and whether the engine is considered to have passed or failed to pass the test.

SAMPLE TABLE OF CONTENTS

(EVALUATION TEST)

APPENDIX F

SAMPLE CURVES

CURVE NO. F1

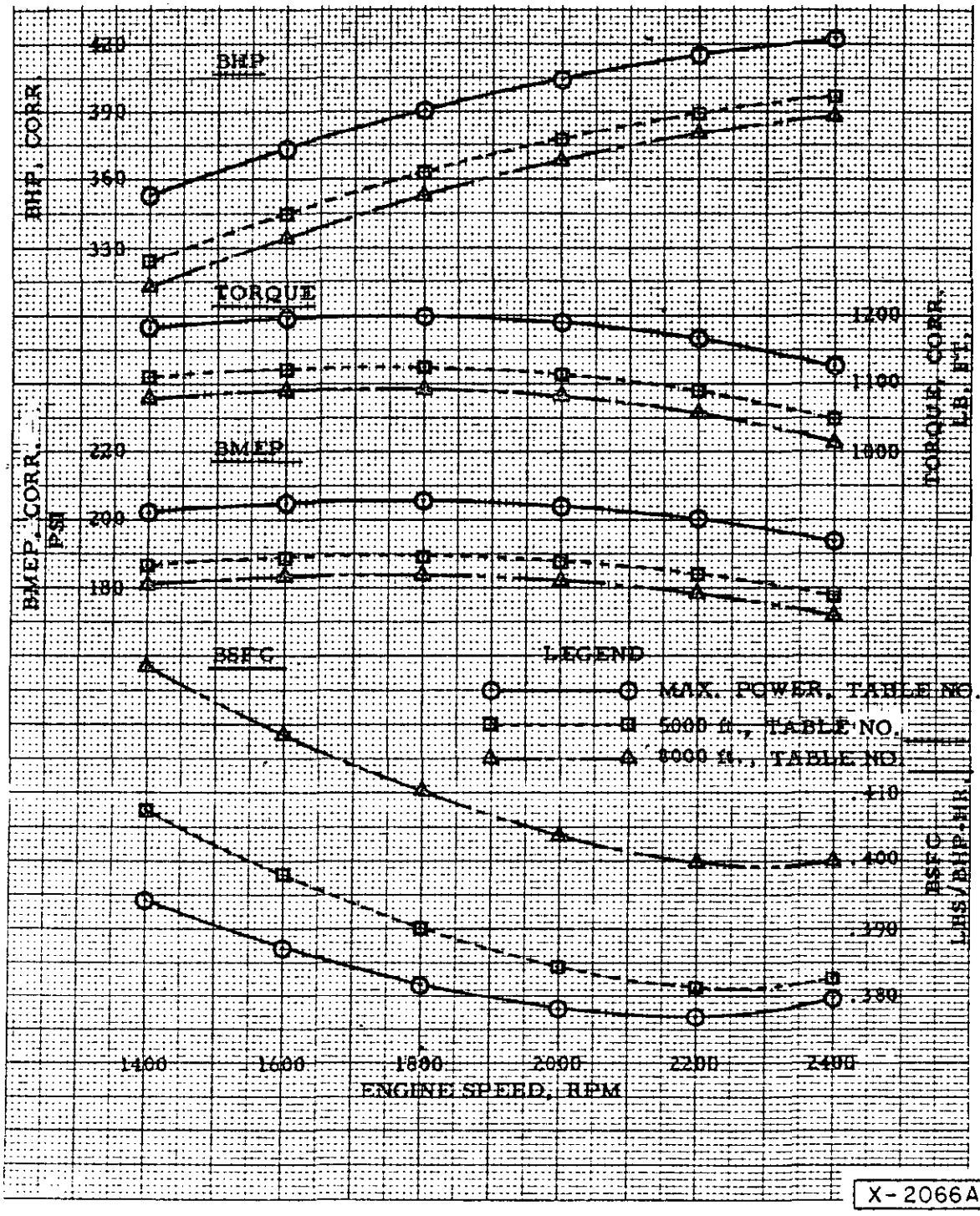
COMPARISON OF:

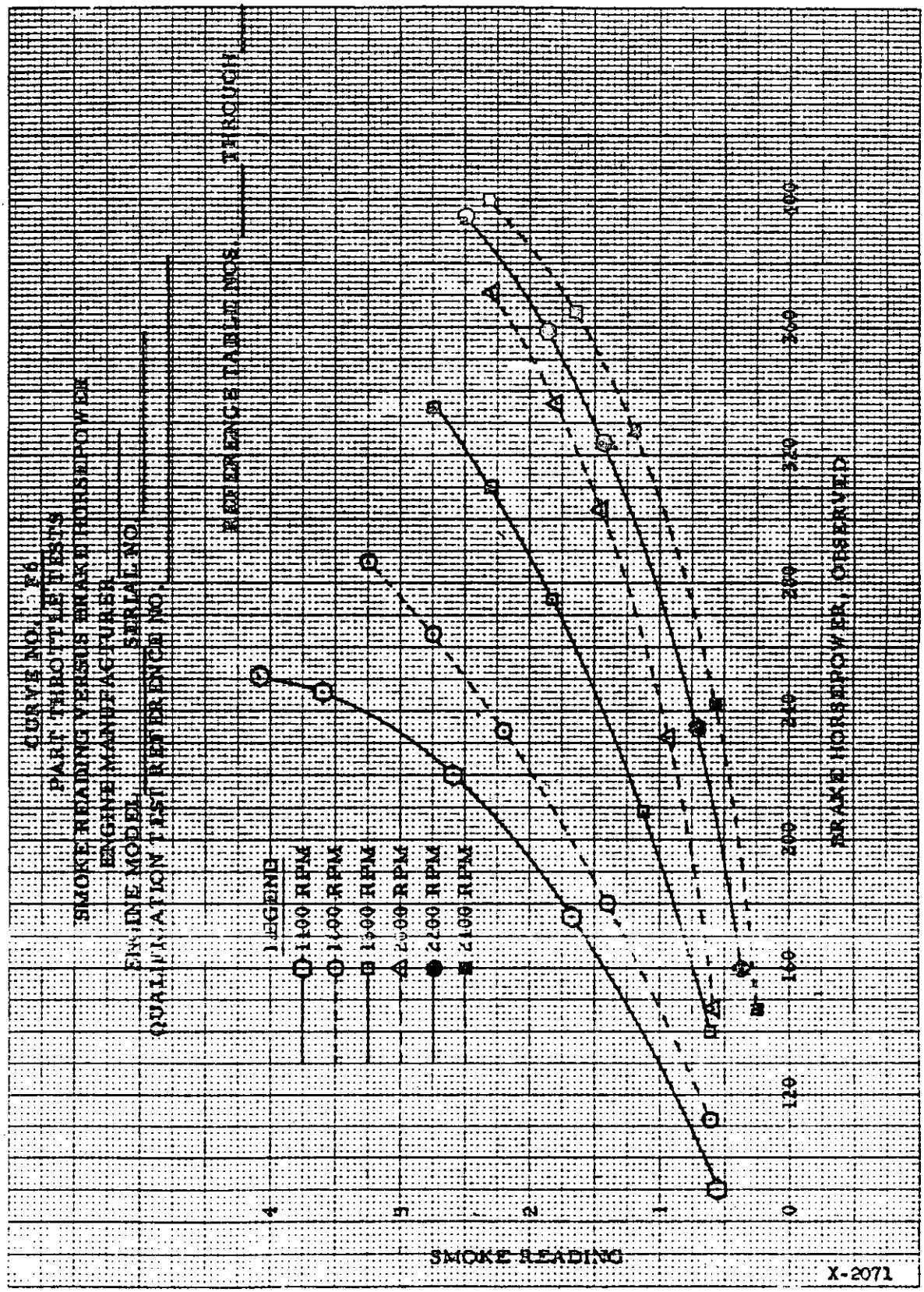
MAXIMUM POWER, 5000 FOOT & 8000 FOOT ALTITUDE TESTS

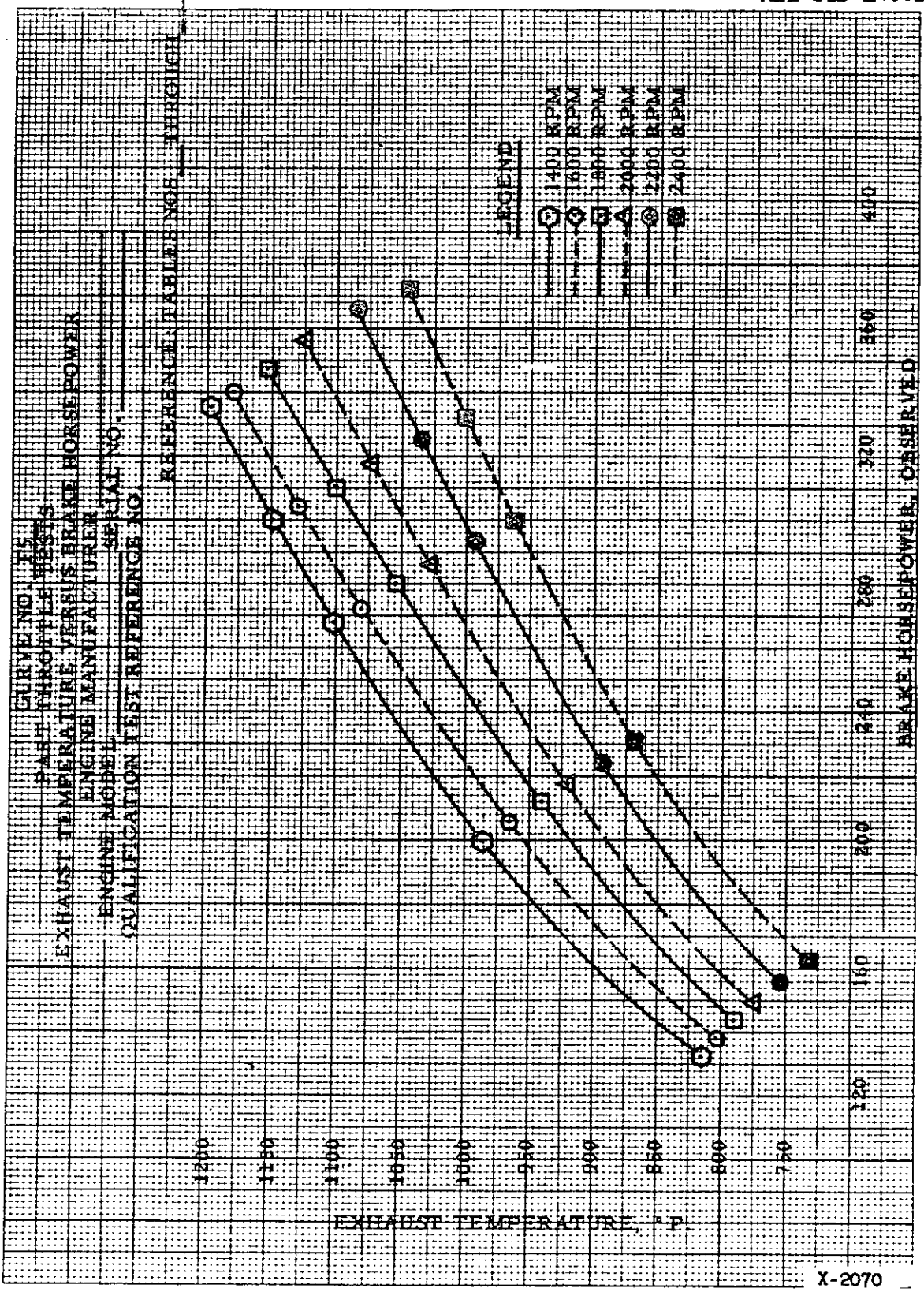
ENGINE MANUFACTURER _____

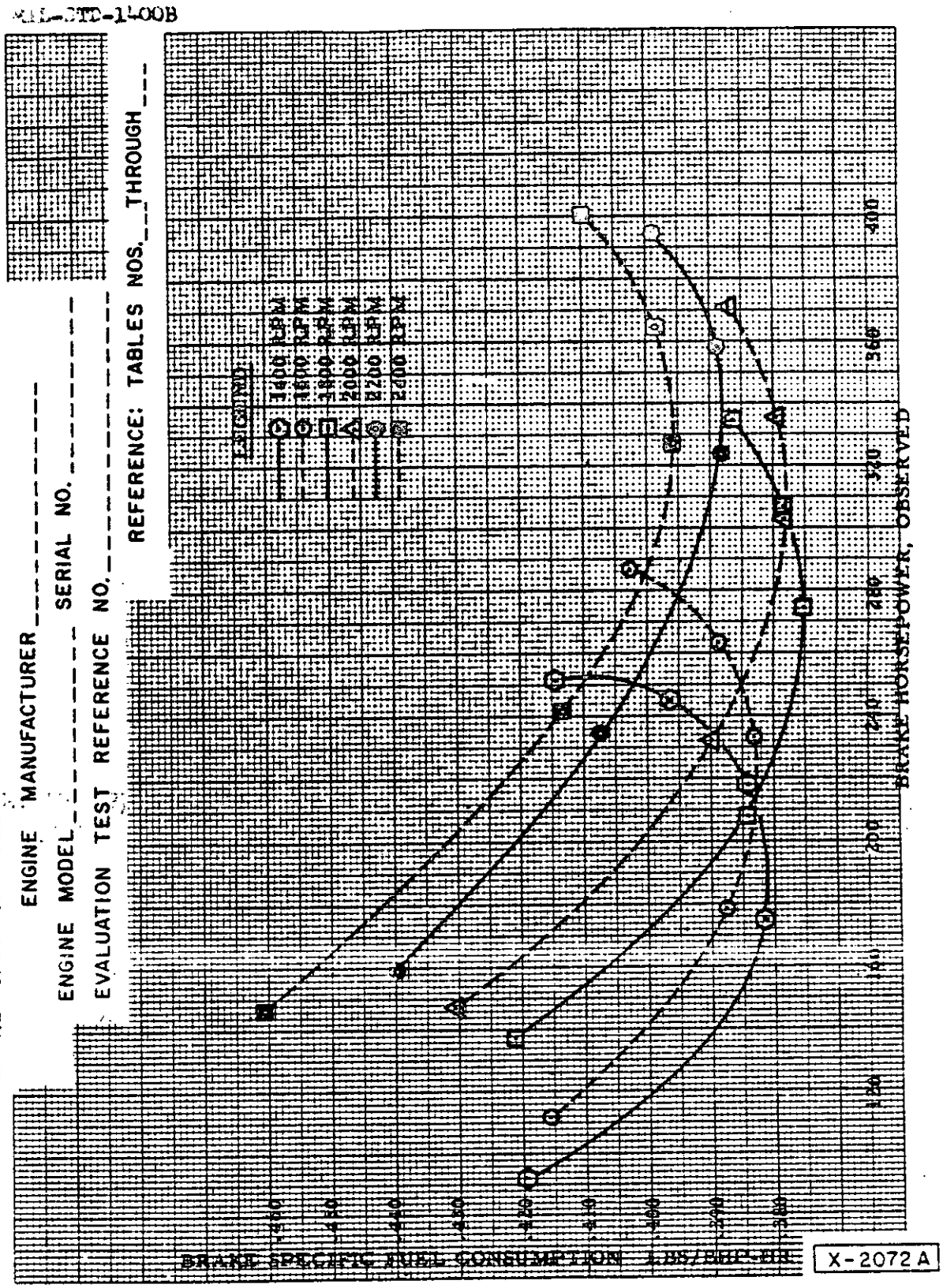
ENGINE MODEL _____ SERIAL NO. _____

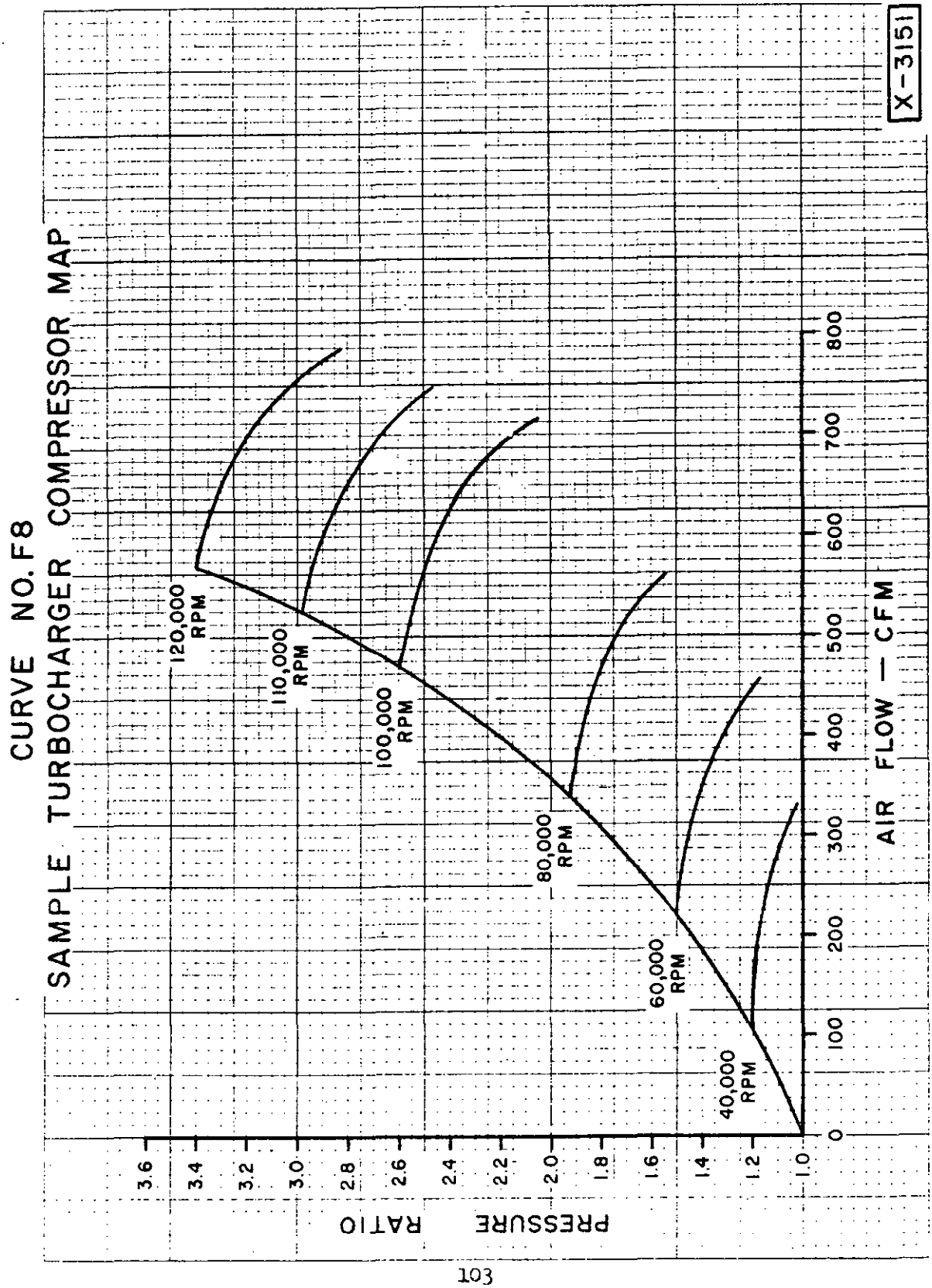
EVALUATION TEST REFERENCE NO. _____



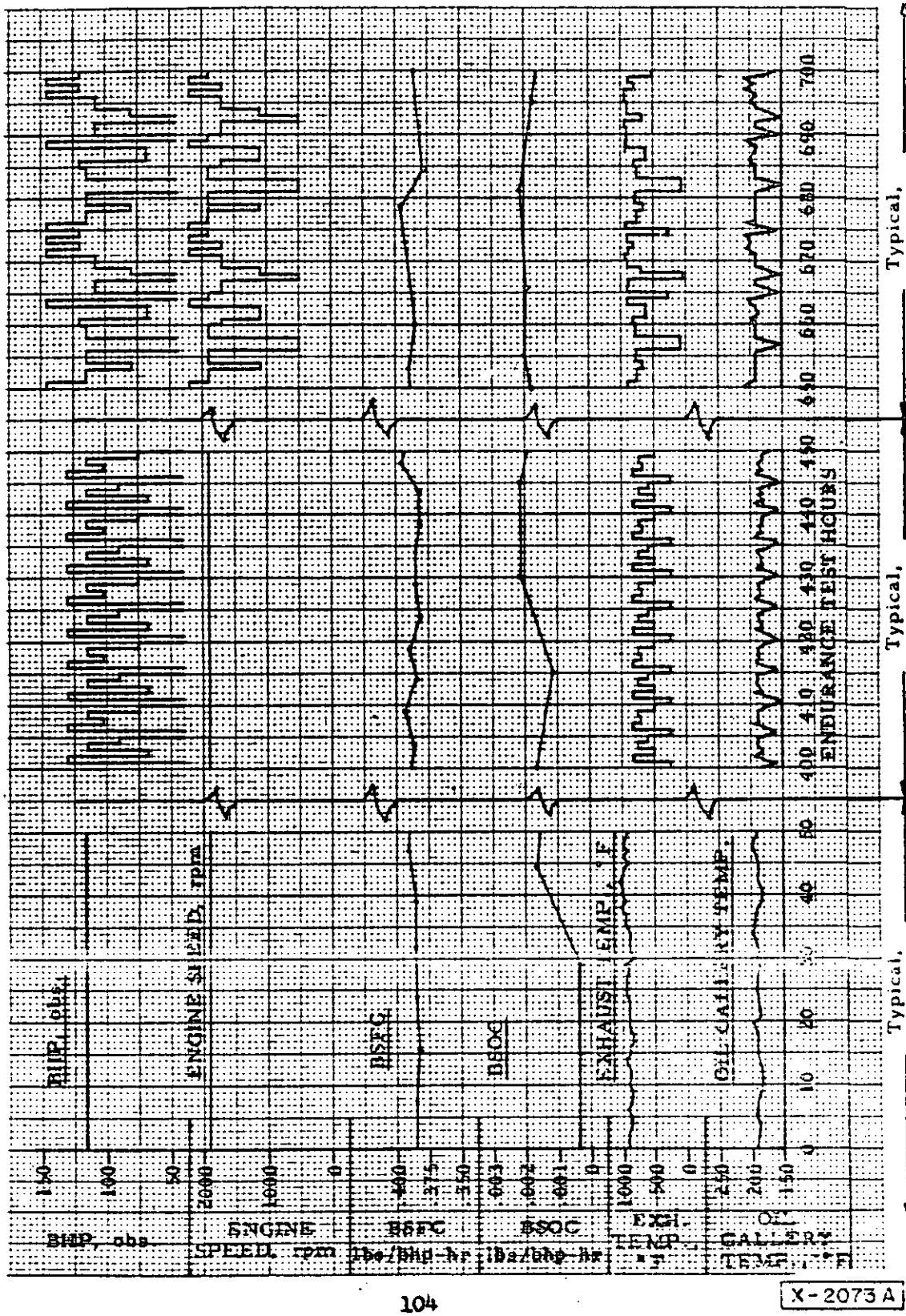








(Sample) GRAPHIC LOG OF ENDURANCE TEST ENGINE MODEL_____(#)_____ Page No.(#)___
(ENGINE MANUFACTURER) EVALUATION TEST REFERENCE NO.___(#)_____



X-2073 A

APPENDIX G

TEST TECHNIQUES

This appendix contains techniques which are for informational purposes only and are not to be considered as test requirements.

FUEL TIME-WEIGHT METHOD

Basically, this method makes use of a scale or balance, a timer and laboratory fuel system plumbing so arranged that the weight of fuel consumed by the engine during a fuel consumption determination and the consumption time may be measured. A mechanical arrangement is indicated schematically in Figure G-1 and an automatic system in Figure G-2 of this section.

With the engine operating and fuel in the measuring tank (a beaker is usually adequate), fuel suction is transferred quickly from the day tank to the measuring tank. By means of the scale or balance on which the tank rests, the weight of fuel withdrawn is determined while the time required for withdrawal of the measured amount is also determined. Fuel suction is then transferred to the day tank. For diesel engines with return fuel lines, a 3-way valve is required in the return line to transfer bypassed fuel to the measuring tank during fuel consumption determinations. As indicated, the return line to the measuring tank must be vented continuously to the atmosphere.

One successful method employs a two-pan balance for weighing the fuel consumed and a laboratory beaker as a measuring tank. With the beaker filled slightly in excess of the predetermined weight of fuel to be consumed and a weight on the other pan precisely equal to the predetermined fuel weight, fuel suction is transferred to the beaker and timing is started at the instant of null balance as fuel is withdrawn. The weight on the other pan is then removed and the timing completed at the instant null balance is again reached.

Convenience and accuracy may be furthered in several ways. A fuel weight should be selected such that consumption will require approximately 1 minute. Engine rpm fluctuations during suction transfer from the day tank to the beaker and back may be minimized by positioning the beaker at approximately the level of the fuel in the day tank.

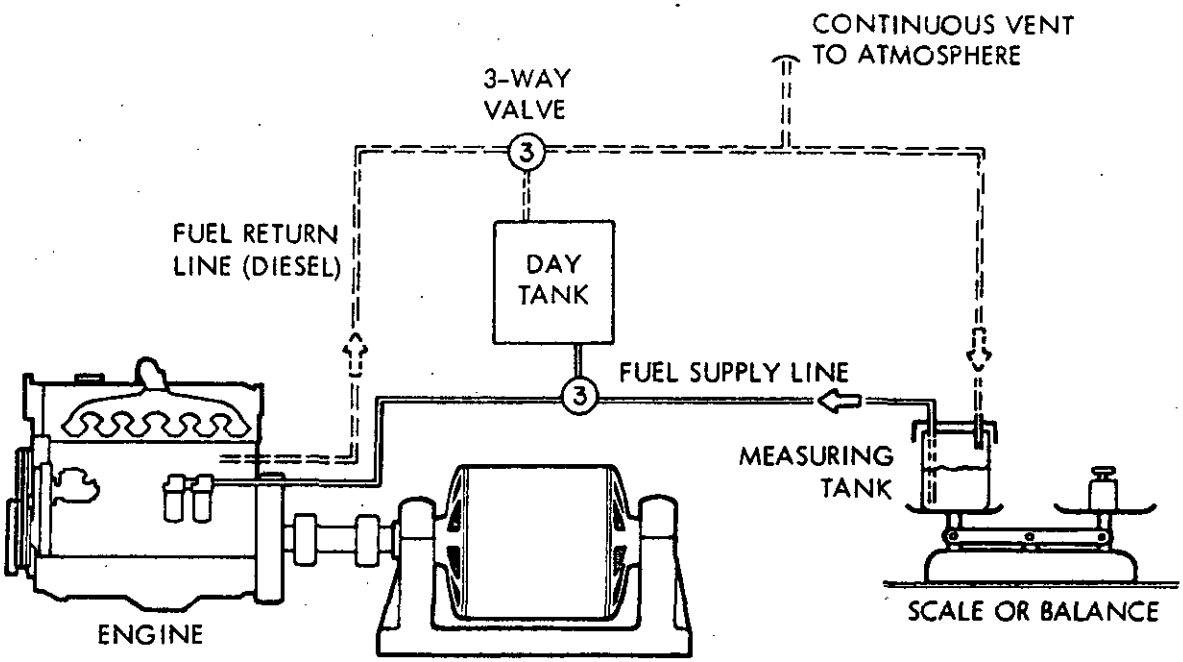


FIGURE G-1 FUEL LINE SCHEMATIC

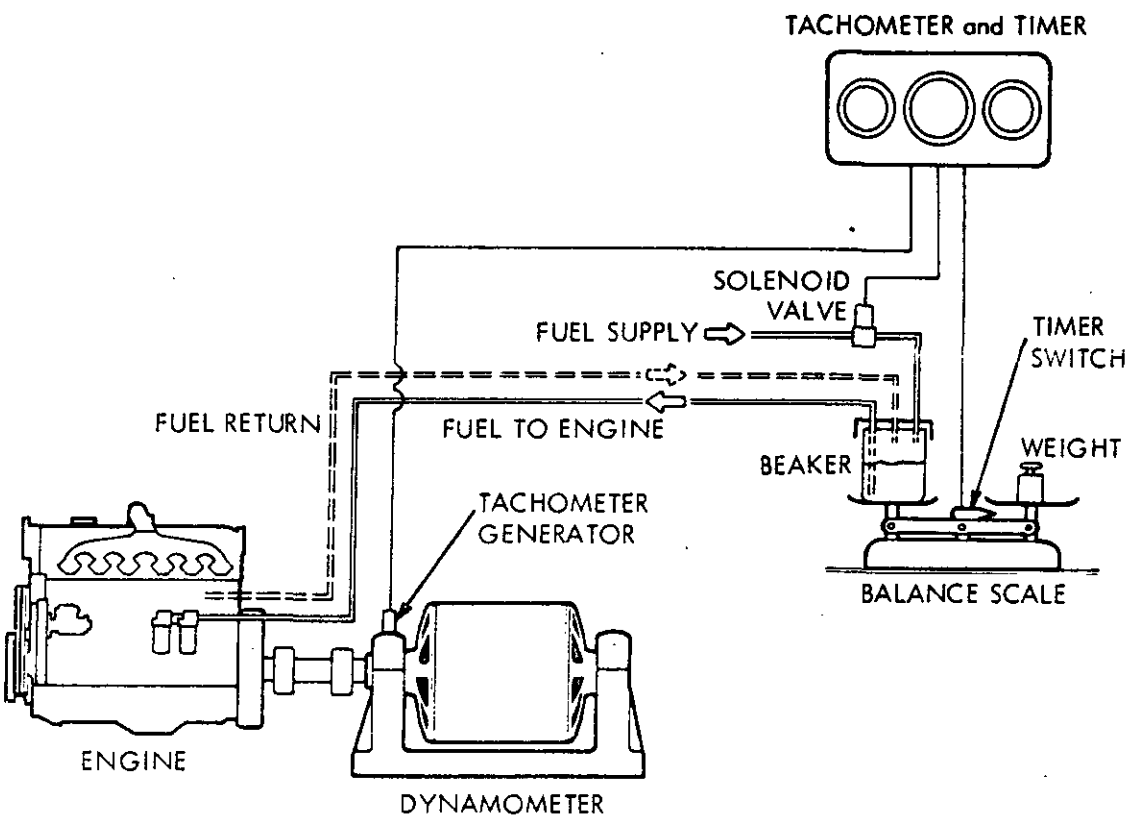


FIGURE G-2 FUEL SYSTEM SCHEMATIC X-2074

TURBOCHARGER RPM MEASUREMENT

The tachometer pickup for the turbocharger consists of a magnetized nut on the impeller shaft and a pickup coil mounted on the outside of the turbocharger housing as close as possible to the nut. A laminated iron core long enough to form a semicircle around the housing increases the effectiveness of the coil.

When the impeller shaft rotates, the magnetized nut generates an alternating voltage in the coil at the frequency of rotation, which can be measured by any of several methods. If the signal is relatively clear (free from electrical noise), an electronic counter (decade counter) or frequency meter may be used to indicate frequency directly. If the installation is noisy (electrically), an indirect method such as using Lissajous figures on an oscilloscope gives good results. This system involves applying the tachometer signal to the vertical deflection axis of the oscilloscope and the output of a precision signal generator to the horizontal deflection axis. The signal generator is adjusted until a 1:1 Lissajous - figure is observed on the oscilloscope, and the frequency is read directly from the signal generator. See Figure G-3 of this section.

An alternate means of measuring turbocharger speed is by use of a calibrated stroboscopic light source. A sealed window must be installed at the inlet side of the turbocharger to permit direct viewing of the compressor wheel. Speed measurements may be made which are beyond the range of the measuring instrument by obtaining a reading at a known or reasonably known fraction of the turbocharger speed, however this must be verified by checking at the next smaller fraction of turbocharger speed. See Figure G-4 of this section.

Example:

Measuring unit indicates 23,000 rpm and it is believed this reading was made at every fourth revolution of the turbocharger. Turbocharger speed would be 23,000 rpm x 4 = 92,000 rpm. The next smaller fraction of turbocharger speed would be one-fifth. Verifying speed would be 92,000 rpm ÷ 5 = 18,400 rpm on the stroboscope.

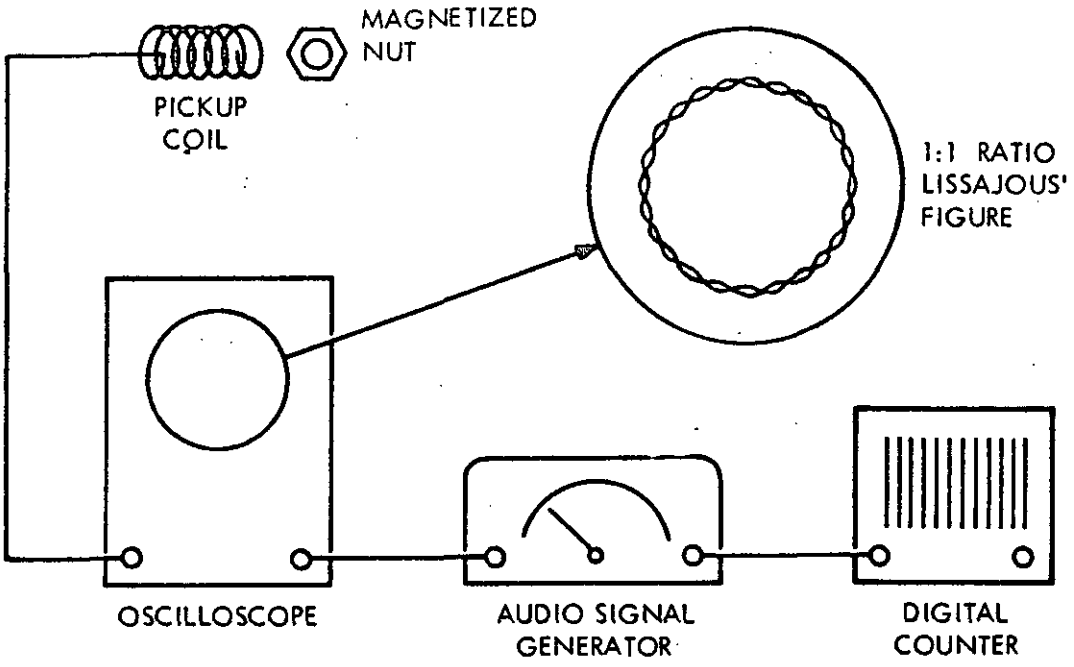


FIGURE G-3 SCHEMATIC FOR METHOD OF MEASURING TURBOCHARGER RPM

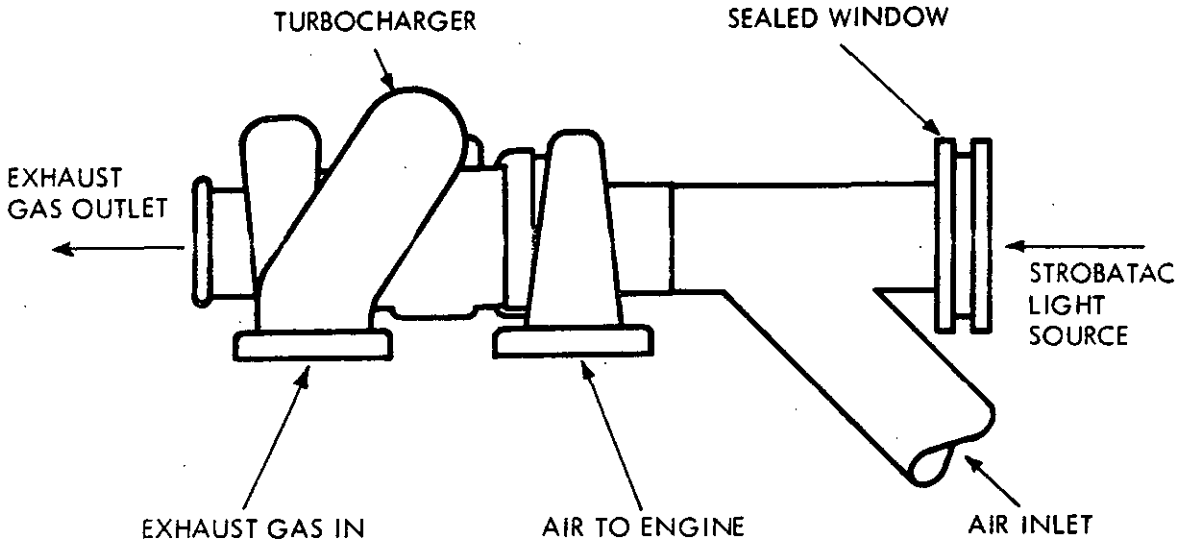
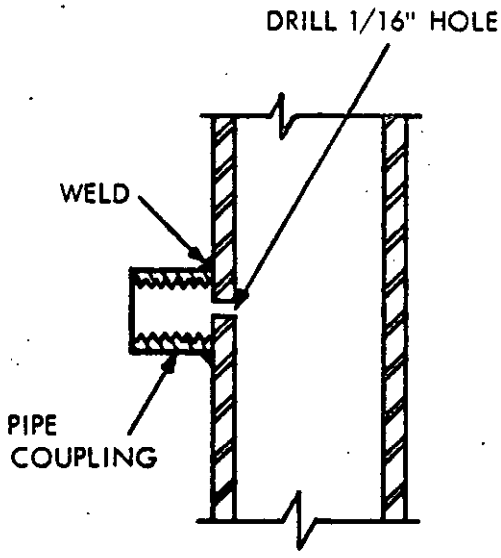
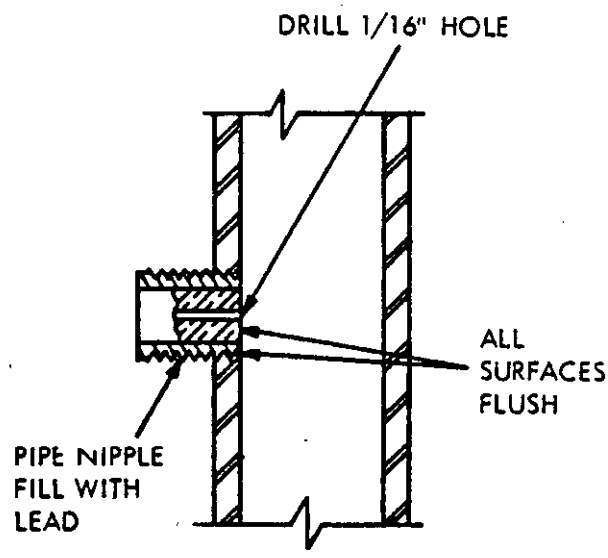


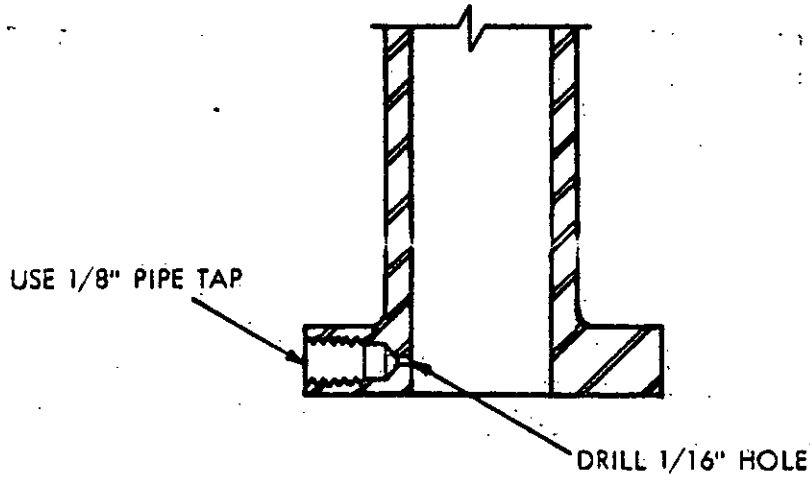
FIGURE G-4 SCHEMATIC FOR STROBATIC METHOD OF MEASURING TURBOCHARGER RPM



A. WELDABLE MATERIAL



B. NON-WELDABLE MATERIAL



C. FLANGE

FIGURE G-5 PRESSURE TAPS

X-2076

APPENDIX H

METHOD OF DETERMINING ENGINE RATING

MILITARY STANDARD, METHODS OF TEST

TEST SERIES 1000, MIL-STD-1400B

PRIMARY FUEL

APPENDIX H

METHOD OF DETERMINING ENGINE RATING

MILITARY STANDARD, METHODS OF TEST

TEST SERIES 1000, MIL-STD-1400B

PRIMARY FUEL

Diesel: MIL-F-46162 Gasoline: MIL-G-46015

MAXIMUM RATING: Determined from the maximum power test (Test Method 1310 or 1311) and subject to derating dependent on the results of the final performance test (Test Method 1600). Final performance test data showing a loss of power in excess of 5% shall be cause for derating by 1 percent for each 1 percent power loss in excess of 5% at that speed.

INTERMITTENT RATING: Not to exceed 90% of maximum bhp rating.

Limited by:
1. Intermittent test (Test Method 1320).
2. By 90% points in cycling schedule of the endurance test (Test Method 1500).
3. By 90% sequence of high temperature test (Test Method 1440, sequence (c)).

CONTINUOUS DUTY RATING: Not to exceed 85% of maximum bhp rating.

Limited by:
1. Altitude test at 5000 feet (Test Method 1410 and 1420).
2. The endurance test power at continuous speed and load, and at the lower speeds by that power run during Schedule III of the endurance test.

NOTE 1: Maximum ratings will be corrected to specified conditions when allowable (see 6.3.2).

NOTE 2: Horsepower figures shall be rounded off to 3 significant figures.

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INDEX (cont'd)

INDEX (cont'd)

INDEX (cont'd)

INDEX (cont'd)

INDEX (cont'd)

INDEX (cont'd)

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