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# MILITARY STANDARD

# ENGINES, GASOLINE AND DIESEL,

# METHODS OF TEST

AMSC N/A FSC 2805

DEPARTMENT OF DEFENSE
Washington, DC 20301

Engines, Gasoline and Diesel, Methods of Test

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

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: USA Belvoir Research, Development, and Engineering Center, ATTN: STRBE-TSE, Fort Belvoir, VA 22060-5606, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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## TABLES



## APPENDIXES

# 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. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

Federal

| | |
|---|---|
| VV-F-800 | - Fuel Oil, Diesel. |

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.
MIL-T-83133 - Turbine Fuel, Aviation, Kerosene Type, Grade JP-8.

STANDARD

Military

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

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government publications. The following documents form a part of this standard to the extent specified herein. The issues of the documents which are indicated as DOD adopted shall be the issues listed in the issue of the DODISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DODISS.

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, U.S. Government Printing Office, Washington, DC 20402.)

2.2 Other publications. The following document forms a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the document which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of the documents not listed in the DODISS shall be the issue of the non-Government documents which is current on the date of the solicitation.

American Society for Testing and Materials (ASTM)

ASTM D 4814 - Automotive Spark-Ignition Engine Fuel.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Nongovernment standards are generally available for reference from libraries. They are also distributed among nongovernment standards bodies and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

# 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 End item suitability tests. End item suitability tests are tests performed on the engine when the end item specification or contract requires first article 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 first article 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 end item suitability 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 ensure 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 ensure 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. Also included 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 engines. 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 engines. 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 6.2.3.2.

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 as 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 engine is corrected to atmospheric conditions stated herein (see 3.5) in accordance with 6.2.3.2.

3.3.5 Intermittent brake horsepower. 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 6.2.3.3).

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 6.2.2.3), 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 shall 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 shall 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 shall 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 shall 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 shall not be permitted. This shall 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., shall 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 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 6.2.1 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 retest, 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, 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 shall 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 and MIL-T-83133 |
| 2000 | * MIL-G-46015 | MIL-F-46162 and MIL-T-83133 |
| 3000 | ASTM D 4814 | VV-F-800 |
| 4000 | ASTM D 4814 | VV-F-800 |

*If test requires the use of unleaded fuels, use gasoline meeting specification ASTM D 4814.

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

| Grade | Manufacturers designation | Temperature range |
|---|---|---|
| 10 | The latest manufacturer's designation and qualification number can be procured from the "Fuels and Lubricants Division, STRBE-VF, Belvoir RD&E Center, Fort Belvoir, VA 22060-5606." | - 10 to 32 °F |
| 15/W40 | | 32 °F and above |

## 5. DETAILED REQUIREMENTS

5.1 Instrumentation.

5.1.1 Speed.

5.1.1.1 Engine crankshaft. Engine crankshaft speed shall be determined by any of the following methods, provided accuracy limits are within ±0.5 percent of the observed reading or ±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.

5.1.1.2 Turbocharger. The turbocharger speed shall be measured with an accuracy of ±0.25 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.

5.1.2 Temperatures. Laboratory thermometers or thermocouples connected through a selector switch to a calibrated potentiometer shall be used to measure temperatures in degrees Fahrenheit. Instrumentation accuracy shall be within 2 °F or ±1.0 percent of the true reading, whichever is greater.

5.1.2.1 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.

5.1.2.2 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.

5.1.2.3 Exhaust. The common exhaust temperature shall be measured in the exhaust line approximately 2.0 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.

5.1.2.4 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.

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

5.1.2.6 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.

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

5.1.3 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 ±0.05 inch of indicated readings, and the accuracy of all pressure gages shall be ±2.0 percent of indicated readings unless otherwise specified herein.

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

5.1.3.2 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 ±0.5 °F shall be used.

5.1.3.3 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.

5.1.3.4 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.

5.1.3.5 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.

5.1.3.6 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.

5.1.3.7 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.

5.1.4 Fuel and lubricating oil consumption and exhaust smoke.

5.1.4.1 Fuel consumption. Rate of fuel consumption shall be measured by equipment capable of 1.0 percent accuracy, or if the time-weight procedure described in figures G-1 and G-2, appendix G, is utilized, repeatability shall be within ±1.0 percent for three readings for each fuel consumption point.

5.1.4.2 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.

5.1.4.3 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, or its equivalent, and analyzed on an EFAW 68 analyzing instrument, or its equivalent, at room temperature (65 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 from 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 0.25 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.

5.1.4.4 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.

5.2 Test methods.

5.2.1 General. The test methods in this standard shall be employed according to the outline in table II. Tests shall be conducted in numerical sequence, and the provisions and requirements of this standard shall be observed.

TABLE II. Test method outline.

| Type of test | Test method series Appendix A | | | |
|---|---|---|---|---|
| | Evaluation 1000 | End Item suitability 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 | ---- |

## 6. NOTES

6.1 Intended use. This standard contains the test methods established for evaluation, end item suitability, production control, and production testing of spark-ignition and compression-ignition, reciprocating-type industrial engines under Government procurement contracts.

6.2 Limiting test conditions and corrections.

6.2.1 Wear. The manufacturer shall indicate the acceptable wear limits to be listed on an 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).

6.2.2 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.

6.2.2.1 Engine temperatures. Maximum or minimum engine temperatures shall not exceed those specified by the engine manufacturer, the applicable engine specification, or the following table III.

TABLE III. Engine temperatures.

| Item | Temperatures (°F) Minimum 1/ | Maximum |
|---|---|---|
| Lubricating Oil 2/ | 130 | 230 |
| Cooland, 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.

6.2.2.2 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 3.0 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.

6.2.2.3 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, or its equivalent, as specified in 5.1.4.3, except for those engines that fall under the Clean Air Act.

6.2.3 Corrections.

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

6.2.3.2 Horsepower, torque, bmep. These observed values shall be corrected to specified conditions (see 3.5) according to the following formula when allowable (see 6.2.3.3).

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

Corrected brake horsepower (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, °F (see 5.1.2.2).

6.2.3.3 Application. Correction to the observed output, as above, of more than ±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 simulated altitude conditions by the test method. Supercharged or turbocharged engines will not be corrected in accordance with 3.3.4.

6.3 Government-furnished property. The contracting officer should arrange to furnish the property listed in 5.1.4.3.

6.4 Subject term (key word) listing.

Compression-ignition
Engines
Engines, diesel
Engines, gasoline
Engines, methods of test
Engines, naturally aspirated
Engines, reciprocating type
Engines, supercharged
Engines, turbocharged
Spark-ignition
Test
Test, diesel engine
Test, gasoline engine
Test, methods of
Tests
Tests, evaluation
Tests, preproduction model performance
Tests, production
Tests, production control

6.5 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

APPENDIX A

TEST METHOD SERIES

ENGINES, GASOLINE OR DIESEL, INDUSTRIAL

2- OR 4-STROKE-CYCLE

This appendix is a mandatory part of the standard.

CONTENTS

10. SERIES 1000, EVALUATION TESTS

APPENDIX A

20. SERIES 2000, END ITEM SUITABILITY MODEL PERFORMANCE TESTS



30. SERIES 3000, PRODUCTION CONTROL TESTS



40. SERIES 4000, PRODUCTION TESTS

10. SERIES 1000, EVALUATION TESTS

10.1 Test method 1000, evaluation tests.

10.1.1 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.

10.1.2 Test equipment and data.

10.1.2.1 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 as being within $\pm$1.0 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.

10.1.2.2 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.

TABLE I. Test data to be recorded.

| Data Items | Test method numbers* | | | | |
|---|---|---|---|---|---|
| | 4200 | 3200<br>3300 | 1200<br>1300<br>1410<br>1420 | 1430<br>1600<br>2200<br>2300 | 1400<br>(except<br>1450)<br>1500<br>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 |
| **Accumulated 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 | | - |
| **Fuel weight | - | - | X | | X |
| **Fuel cons. time | - | - | X | | X |

TABLE I. Test data to be recorded - Continued

| Data Items | Test method numbers* | | | |
|---|---|---|---|---|
| | 4200 | 3200<br>3300 | 1200 1430<br>1300 1600<br>1410 2200<br>1420 2300 | 1400<br>(except<br>1450)<br>1500<br>2400 |
| 1 | 2 | 3 | 4 | 5 |
| **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, combined | - | 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 __.1.3 (test sequence) of test method series 1000, 2000, 3000 and 4000.
1/If applicable to engine model.

2/Test method 1500, 10.16.2.3, 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.

10.1.3 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 |

10.1.4 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 $\pm$5 °F for high-temperature and altitude testing; and 180, $\pm$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.

10.1.5 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.

10.1.6 Test temperatures.

10.1.6.1 Fuel temperatures.

a. Performance and endurance test, minimum 85 °F.

b. Simulated 5000-foot altitude, minimum 107 °F.

c. Simulated 8000-foot altitude, minimum 95 °F.

d. High-temperature test, minimum 120 °F.

e. Low-temperature test, not higher than -10 °F or -25 °F, as applicable.

10.1.6.2 Coolant temperatures. The coolant temperature from the engine shall be maintained at 180 ±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 250 ±5 °F. For the low-temperature tests the coolant temperature shall be not higher than the ambient temperature required for the test. See 6.2, table III, of this standard.

10.1.6.3 Oil temperatures. See 6.2, table III, of this standard.

10.1.6.4 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.

10.1.7 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. (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 (corrected where applicable) vs endurance test hours.

10.1.8 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.

10.2 Test method 1100, initial inspection.

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

10.2.2 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.

10.3 Test method 1200, check test and run-in.

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

10.3.2 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.

10.3.3 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.

10.4 Test method 1300, initial performance tests.

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

10.4.2 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 1.0 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.

10.4.3 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.

10.5 Test method 1310, maximum power test (gasoline engine).

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

10.5.2 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 6.2.2 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.

10.6 Test method 1311, maximum power test (diesel engines).

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

10.6.2 Test procedures. The engine shall be equipped and adjusted for operation at the proposed maximum continuous duty speed. The engine shall be run on fuels conforming to MIL-F-46162 and MIL-T-83133. 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 6.2.2 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.

10.7 Test method 1320, intermittent bhp test.

10.7.1 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 used for the intermittent test. Test conditions and engine temperatures shall 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 tempera- tures, unstable operation, malfunctioning, or exceeding the operational limits in 6.2.2 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.

10.8 Test method 1330, part-throttle test.

10.8.1 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 used during the part-throttle test. The required loads shall be observed power output. The part-throttle tests may be conducted concur-rently 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.

10.9 Test method 1340, governor test.

10.9.1 Scope. This test will determine the speed regulation of the governor.

10.9.2 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 trials 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 4.4.1a of this standard.

10.10 Test method 1400, environmental tests.

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

10.10.2 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.

10.10.3 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.

10.11 Test method 1410, maximum power test at 5000-foot altitude.

10.11.1 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 $\pm$0.2.
Minimum ambient and intake air temperature, 107 °F.
Water outlet temperature, 205 $\pm$5 °F.

10.11.2 Test procedure. The tests may be conducted at an actual test site or in a laboratory under simulated altitude conditions. The altitude condi-tions 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 6.2.2.2 of this standard. A maximum power test, test method 1310 or 1311 as applicable, will be conducted at the speci-fied altitude. The test will be conducted using MIL-G-46015 or MIL-F-46162 and MIL-T-83133 fuels, as applicable. Ambient air and engine coolant tempera-tures 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 6.2.2 of this standard shall apply at each speed. Continuous power ratings listed for fuels conforming to MIL-G-46015 or MIL-F-46162 and MIL-T-83133 shall not exceed the power output during the test at 5000-foot altitude.

10.12 Test method 1420, maximum continuous bhp test at 5000 feet.

10.12.1 Scope. This test will determine the operating characteristics of an engine under continuous operation at 5000-foot altitude conditions.

10.12.2 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 with-out engine shutdown. The limitations specified in 6.2.2 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.

10.13 Test method 1430, maximum power test at 8000-foot altitude.

10.13.1 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 $\pm$0.2.
Minimum ambient and intake air temperature, 95 °F.
Water outlet temperature, 205 $\pm$5 °F.

10.13.2 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 6.2.2 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.

10.14 Test method 1440, high-temperature test.

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

10.14.2 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 ±10 °F will be permitted during these two steps. The engine water outlet temperature shall be maintained at 205 ±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 con-ducted in a consecutive series without any shutdowns or operation other than as specified. Complete data shall be recorded at the start of each step and at 30-minute intervals, except during step d data will be recorded after the 5-minute shutdown. The limitations of 6.2.2 in this standard shall apply.

10.15 Test method 1450, low-temperature test.

10.15.1 Scope. This test will determine engine starting characteristics at ambient temperatures not higher than -10 °F and starting and operating characteristics at -25 °F.

10.15.2 Fuels and lubricants. Fuels and lubricants shall conform to the following specifications:

| | |
|---|---|
| Fuel, gasoline engines | ASTM D 4814, unleaded. |
| Fuel, diesel engines | VV-F-800, DF-1. |
| Lubricant at -10 °F | MIL-L-2104, grade 10. |
| Lubricant at -25 °F | MIL-L-46167, OEA. |

10.15.3 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.

10.15.4 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 operating during the second

start at -25 °F, the engine shall be operated for 30 minutes at the maximum continuous duty speed. The chamber temperatures shall 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 -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 -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 and similar first actions. The two starts at each temperature shall be consecutive starts with steady operation achieved after each start.

10.16 Test method 1500, endurance test.

10.16.1 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.

10.16.2 Test procedure.

10.16.2.1 Preendurance inspection. At the manufacturer's option, a preendurance 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 preendurance 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.

10.16.2.2 Preendurance servicing. Before the endurance test the engine should be serviced in accordance with the pretest 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.

10.16.2.3 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 hour meter shall be installed and readings recorded at approximately 24-hour

intervals. The readings taken from the hour meter, which will include warmup and idling time, shall be used to verify engine endurance test hours.

10.16.2.4 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 $\pm$1.5 percent of schedules I, II, and III in table IV of this test method.

10.16.2.5 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 6.2.2 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 direction 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.

10.16.2.6 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 be not more than $\pm$1.0 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.

10.16.2.7 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.

10.16.3 Tables.

TABLE I. Average maximum allowable fuel consumption rates, BSFC.

| Engine type and size | Limits |
|---|---|
| Gasoline (10 bhp 1/ up to 50 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 02 bhp 1/) | 0.490 lb/bhp-hr. |

Notes, TABLE I
1/ Continuous bhp.

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 bph 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 50 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 4.7.1 of this standard).

Diesel engines: Endurance operation and final performance tests will be run on fuels conforming to MIL-F-46162 and MIL-T-83133 (see 4.7.1 of this standard).

TABLE IV. Endurance test schedules.

| Schedule No. | Test Sequence | Hours Duration | Horsepower 1/ | Speed at | Fuel consump-tion |
|---|---|---|---|---|---|
| I | - | Table III | Cont. duty Rating | Cont. duty<br>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 | X |
| | 4 | 1 | Cont. duty | Cont. duty | |
| | 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 | |
| | 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 | |
| | 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.

10.17 Test method 1600, final performance test.

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

10.17.2 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 50 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 50 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.

10.18 Test method 1700, final inspection.

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

10.18.2 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 shall be permitted no stuck or broken rings. Engines of four cylinders or more shall 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 judgment 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, misalignment, etc. See 4.4, criteria for failure, in this standard.

20. SERIES 2000, END ITEM SUITABILITY MODEL PERFORMANCE TESTS

20.1 Test method 2000, end item suitability model performance test.

20.1.1 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.

20.1.2 Test equipment and data. The necessary test equipment and data are as specified in Test method 1000.

20.1.3 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 |

20.1.4 Physical description. A physical description shall be prepared according to the format of appendix C, evaluation test model engine, physical description, except that the title shall be end item suitability test model engine, physical description.

20.1.5 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

20.1.6 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.

20.2 Test method 2100, initial inspection.

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

20.2.2 Test procedure. The engine with all accessories shall 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.

20.3 Test method 2200, check test and run-in.

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

20.3.2 Servicing and adjustment. Servicing and adjustment shall be performed prior to the check test and run-in as specified for pretest of the servicing and adjustment schedule for evaluation tests, appendix B.

20.3.3 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.

20.4 Test method 2300, performance test.

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

20.4.2 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 1.0 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 shall be certified by the manufacturer, and these parasitic loads will be considered toward meeting the power ratings and determining the required loading during the end item suitability model performance and environmental tests.

20.4.3 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 test shall 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 ensure 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 ±1.0 percent shall 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 6.2.2 of this standard, or maximum data points (of graphic record data) established in evaluation tests shall not be exceeded. For gasoline engines, intake manifold vacuum 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 vacuum, in. Hg vs corrected bhp at the applicable speed) and all data obtained by this maximum power test may 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.

20.5 Test method 2400, environmental test.

20.5.1 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.

20.5.2 Test conditions. Unless otherwise specified in the end item procurement document, the high-temperature test shall be conducted at 120 °F.

20.5.3 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 3 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.

20.6 Test method 2500, final inspection.

20.6.1 Scope. The purpose of this test is to determine the final condition of the engine after the completion of the end item suitability model tests.

20.6.2 Test procedure. The assembled engine shall 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 ensure 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 engine 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.

30. SERIES 3000, PRODUCTION CONTROL TESTS

30.1 Test method 3000, production control tests.

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

30.1.2 Test equipment and data. The necessary test equipment and data are as specified in test method 1000.

30.1.3 Test sequence. This test series shall consist of the following tests 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 |

30.1.4 Test engine. The production control test engine shall be equipped to the extent required by the end item manufacturer.

30.1.5 Test fuels. The fuels to be used in conducting these tests shall conform to the fuels specified in 4.7.1 of this standard.

30.1.6 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.

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.

30.2 Test method 3100, initial examination.

30.2.1 Scope. This test method is used to determine that the engine is a production engine.

30.2.2 Test procedure. The engine, with all accessories, shall be visually examined and compared with the production engine.

30.3 Test method 3200, check test and run-in.

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

30.3.2 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.

30.3.3 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.

30.4 Test method 3300, performance tests.

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

30.4.2 Test conditions. Operational limits recommended by the engine manufacturer or limitations specified in 6.2.2 of this standard shall not be exceeded.

30.4.3 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 |

30.5 Test method 3310, maximum power test.

30.5.1 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.

30.6 Test method 3320, rated load test.

30.6.1 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.

30.7 Test method 3400, final inspection.

30.7.1 Scope. This method is used to determine the condition of the engine following the completion of production tests.

30.7.2 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.

40. SERIES 4000, PRODUCTION TESTS

40.1 Test method 4000, production test.

40.1.1 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.

40.1.2 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.

40.1.3 Test sequence. This test series shall consist of the following tests and shall be conducted in the sequence listed:

| | |
|---|---|
| Initial examination | 4100 |
| Check test and run-in | 4200 |

40.1.4 Test engine. The production test engine shall be equipped to the extent required for the performance of these tests.

40.1.5 Test fuels. The fuels to be used in conducting these tests shall be as specified in 4.7.1 of this standard.

40.1.6 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.

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

| | | |
|---|---|---|
| a. | Maximum bhp requirement | 92 percent minimum |
| b. | Intermittent bhp requirement | ±5 percent |
| c. | Continuous bhp requirement | 100 percent minimum |
| d. | All speeds | ±10 percent |

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

40.1.8 Run-in schedule.

TABLE I. Run-in schedule (series 4000).

| Run No. | Load fraction | Speed fraction | Duration (min) |
|---|---|---|---|
| 1 | 0 | Idle | 5 |
| 2 | 0.25 | 0.75 | 10 |
| 3 | 0.5 | 0.75 | 15 |
| 4 | 0.75 | 0.75 | 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 |

40.2 Test method 4100, initial examination.

40.2.1 Scope. This test method is used to determine that the engine is a production engine.

40.2.2 Test. The engine shall be visually examined and compared with the end item suitability engine.

40.3 Test method 4200, check test and run-in.

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

40.3.2 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.

40.3.3 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

This appendix is a mandatory part of this standard.

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

| No. | Before test | Gasoline | | Diesel | Engine<br>Engine Mfg. _____<br>Engine Model _____<br>Serial No. _____<br>Rated _____ HP at _____ RPM |
|---|---|---|---|---|---|
| | | Less than 10 bhp | 10 bhp and above | | |
| | | Hours | Hours | Hours | |
| | | | | | General: |
| 1 | X | 8 | 8 | 8 | Inspection. Check engine for loose connections, 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. |

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

| No. | Before test | Gasoline | | | Engine<br>Engine Mfg. _____<br>Engine Model _____<br>Serial No. _____<br>Rated _____ HP at _____ RPM |
|---|---|---|---|---|---|
| | | Less than 10 bhp | 10 bhp and above | Diesel | |
| | | Hours | Hours | Hours | |
| | | | | | General: |
| 5 | X | 300 | 500 | 500 | Governor and throttle. Adjust governor and throttle linkage (except normal speed adjustments on the engine). |
| 6 | X | 100 | 100 | 100 | Air induction system:<br>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 refill lube oil in fuel injector pump. |

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

| No. | Before test | Gasoline | | Diesel | Engine<br>Engine Mfg. _____<br>Engine Model _____<br>Serial No. _____<br>Rated _____ HP at _____ RPM |
|---|---|---|---|---|---|
| | | Less than 10 bhp | 10 bhp and above | | |
| | | Hours | Hours | Hours | |
| | | | | | 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. |
| | | 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. |

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

| No. | Before test | Gasoline | | Diesel | Engine<br>Engine Mfg. _____<br>Engine Model _____<br>Serial No. _____<br>Rated _____ HP at _____ RPM |
|---|---|---|---|---|---|
| | | Less than 10 bhp | 10 bhp and above | | |
| | | Hours | Hours | Hours | |
| 11 | X | * | * | * | Electrical system:<br>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.

# EVALUATION TEST MODEL ENGINE PHYSICAL DESCRIPTION

This appendix is a mandatory part of this standard.

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 arrangement _____

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

    length _____ in., height _____ in.

    width _____ in.

11. Horsepower*

    Max. power _____ bhp at _____ max. rpm _____ Bmep.

    Max. inter. (1 hour) _____ bhp at _____ rpm _____ Bmep.

    Net continuous _____ 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 turbocharger or supercharger (if used). 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 takeoff, 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 continuous 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 treatment _____

    Piston cooling, method _____

    Insert, if used _____, Taper, inches _____

    Cam Degree _____.

19. Piston rings, compression, No. per piston _____

    Type _____ Plating _____

    Expander _____, Piston ring locating pins used? _____,
    Tension lbs _____, Material _____ End cap _____,

    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., length _____ in.

Fixed or floating _____

Method of retaining _____

Material _____

22. Piston pin bushing, type _____ Material _____

I.D. _____ in. Total length _____ in. Lubrication _____

Method _____

a. Connecting rod bushing (if used) type _____

Material _____ I.D. _____ Total length _____

Lubrication method _____

23. Connecting rod, type _____ Drilled? _____

Material _____, length c to c _____ in.

24. Connecting rod bearings, Type _____ Material _____

I.D. _____ in. Length _____ 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. Length _____in.

27. Camshaft, material _____ Forged or cast _____

No. _____ Method of hardening _____

Location _____ Driven by _____

Type of valve lifters _____

28. Camshaft bearings, No. _____ Material _____

Lubrication method _____ Diameter _____

Length _____

29. Valve arrangement and operating mechanism _____

Lash adjustment method _____

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

closes _____ degrees _____ Exhaust opens _____

degrees _____ closes _____ degrees _____

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

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

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

Length _____ in. Port diameter _____ in. Max lift _____ in.

Lash cold _____ in. Face angle _____ degrees

Material, head _____ stem _____

Facing material _____ No. springs per valve _____

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

Rotators? _____ Type _____ Valve stem diameter _____

Valve spring material _____ Valve spring free length ___

34. Valve, exhaust, No. per cyl. _____ Head diameter _____ in.

Length _____ in. Port diameter _____ in. Max. lift _____ in.

Lash cold _____ in. Face angle _____ degrees. Material,

head _____ stem _____ Facing material _____

No. springs per valve _____ Valve stem diameter _____

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 _____ degrees

Material _____ How installed _____

36. Valve guide, type _____ Material _____

Valve guide diameter _____

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 _____

degrees. 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 _____ Bypass _____

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 height _____ in.
Means provided for measuring oil for gas-oil mixture
(2-cycle) _____ how? _____

Ignition system (gasoline engines)

50. Distributor, make _____ model _____; Advance,
centrifugal _____ degrees, vacuum_____ degrees
man _____ degrees rpm at max. centrifugal, advance _____
Basic setting _____ degrees at TDC. Breaker
point gap _____ in.

51. Magneto, type _____ make _____ model _____
Crest voltage _____ Breaker gap _____
Type drive _____ Impulse coupling 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 _____ degrees

begins _____ rpm, ends _____ rpm.

55. Ignition cable, type _____ make _____

56. Other data _____

_____

Lubrication system

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

Pressure-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. _____ degrees

Radiator frontal area _____ sq. in.

Pressure? _____ psi. Capacity, radiator _____ gal.

Complete system? _____ gal. Thermostat, type _____

Range, open full _____degrees, closed _____ degrees

62. Water pump, type _____ capacity _____ gal/min. at _____ rpm. Drive? _____

63. Fan, type _____ diameter _____ 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 _____ supercharged _____

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 _____ length _____ diameter _____ 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. F8) shall be included.

83. Turbocharger control device or pressure/fuel control:

manufacturer _____ model _____

type of control _____

84. Aftercooler or intercooler; manufacturer _____

model _____ type _____ location _____

_____

_____

# MAXIMUM WEAR REPLACEMENT LIMITS (MWRL)

This appendix is a mandatory part of this standard.

# 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<br>Ring No. 1_____, 2_____, 3_____<br>4_____, 5_____, 6_____ |
| Piston ring, compression | Max. gap _____ |
| | Ring No. 1_____, 2_____, 3_____<br>4_____ |
| | Min. width<br>Ring No. 1_____, 2_____, 3_____,<br>4_____ |
| | Min. radial thickness<br>Ring No. 1_____, 2_____, 3_____,<br>4_____ |
| Piston ring, oil | Max. gap, Ring No. 1_____, 2_____ |
| | Min. width, Ring No. 1_____, 2_____ |
| | Min. radial thickness, Ring No. 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: Ring No. 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 _____

# OUTLINE OF REPORT FORM:

# TESTS OF INDUSTRIAL ENGINES,

# EVALUATION AND END ITEM SUITABILITY

This appendix is a mandatory part of this standard.

# OUTLINE OF REPORT FORM

TEXT:

The report shall consist of the following parts, in the 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. Data 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 the test.

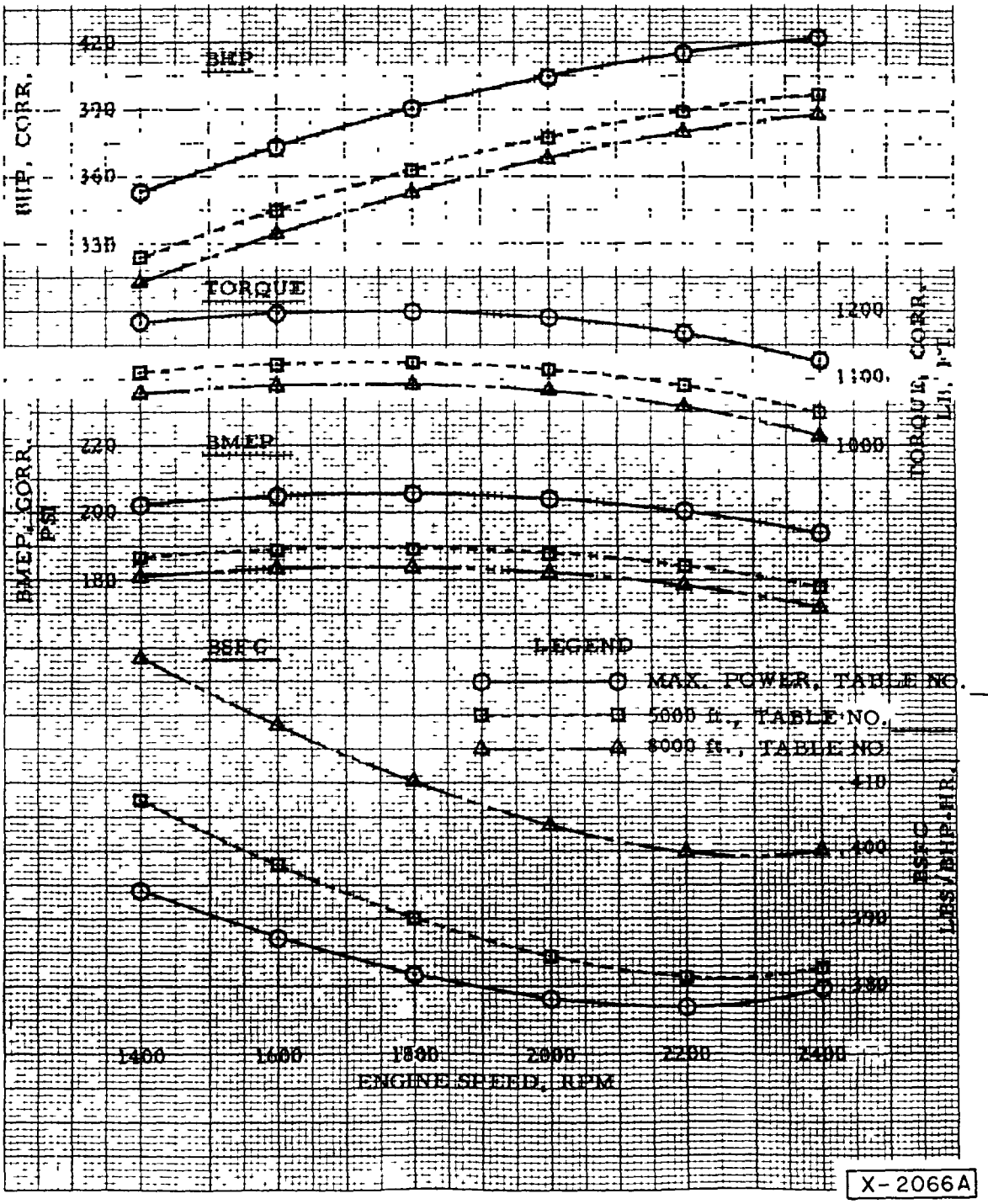
# SAMPLE TABLE OF CONTENTS

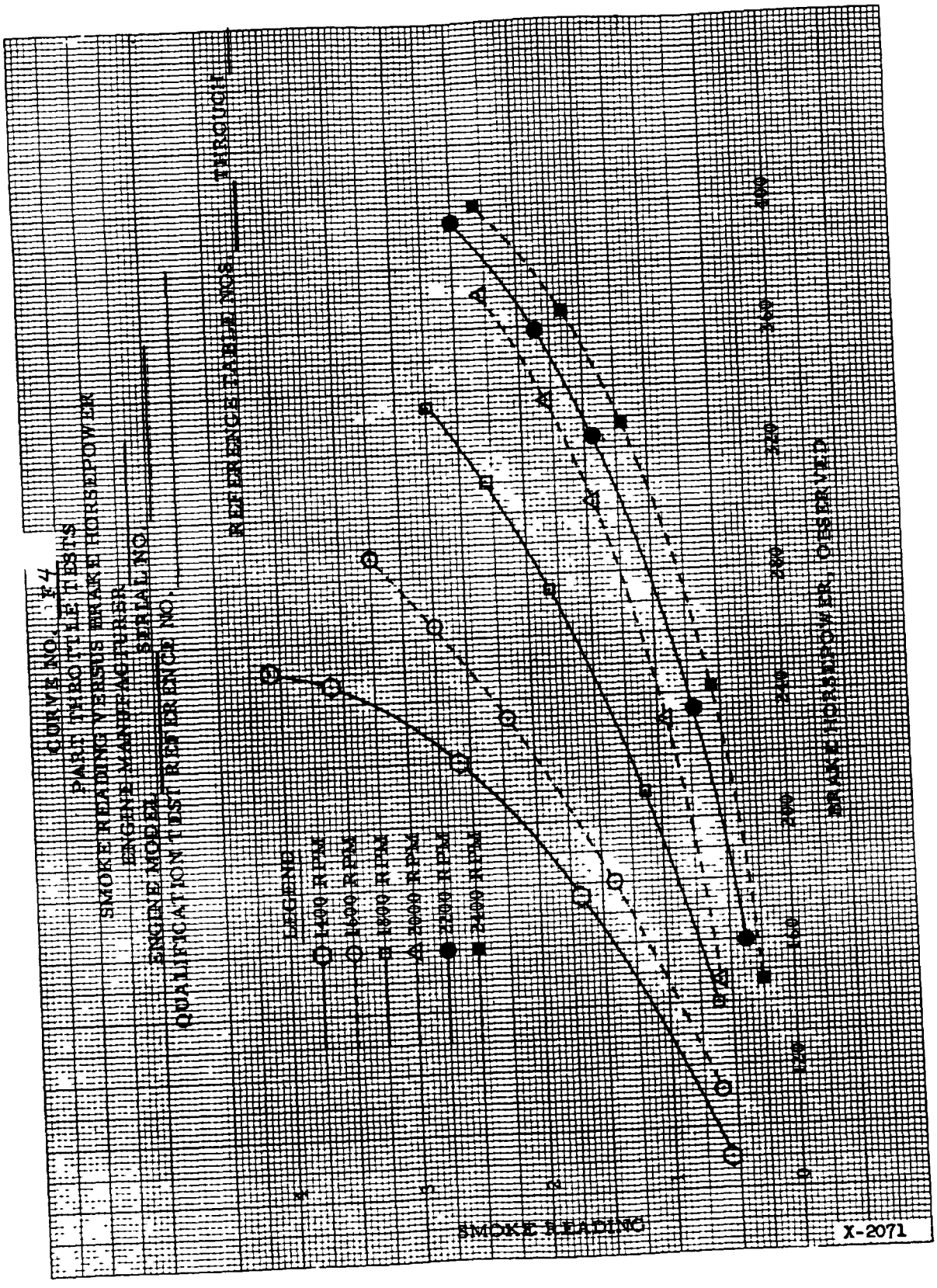
## (EVALUATION TEST)

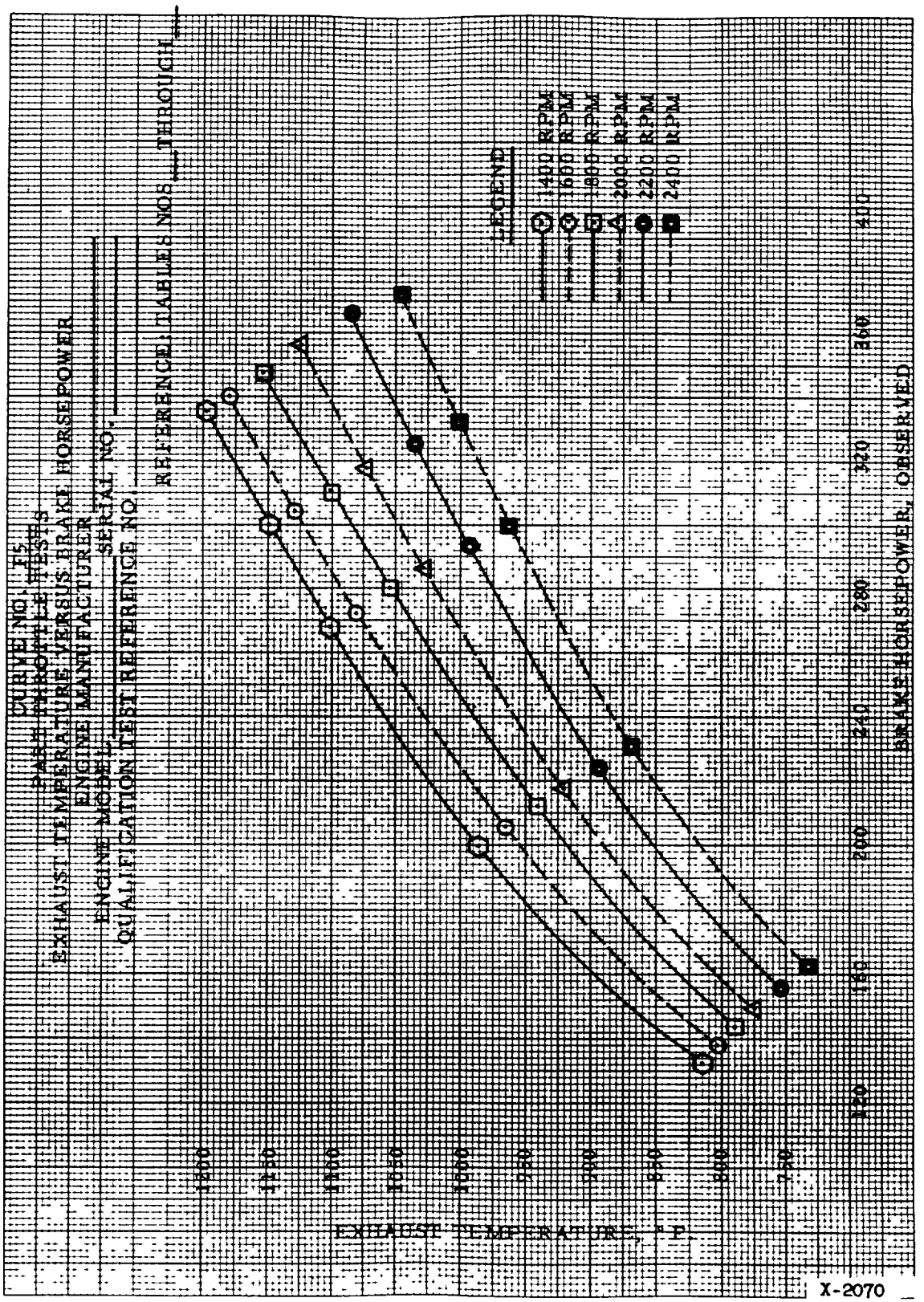
# SAMPLE CURVES

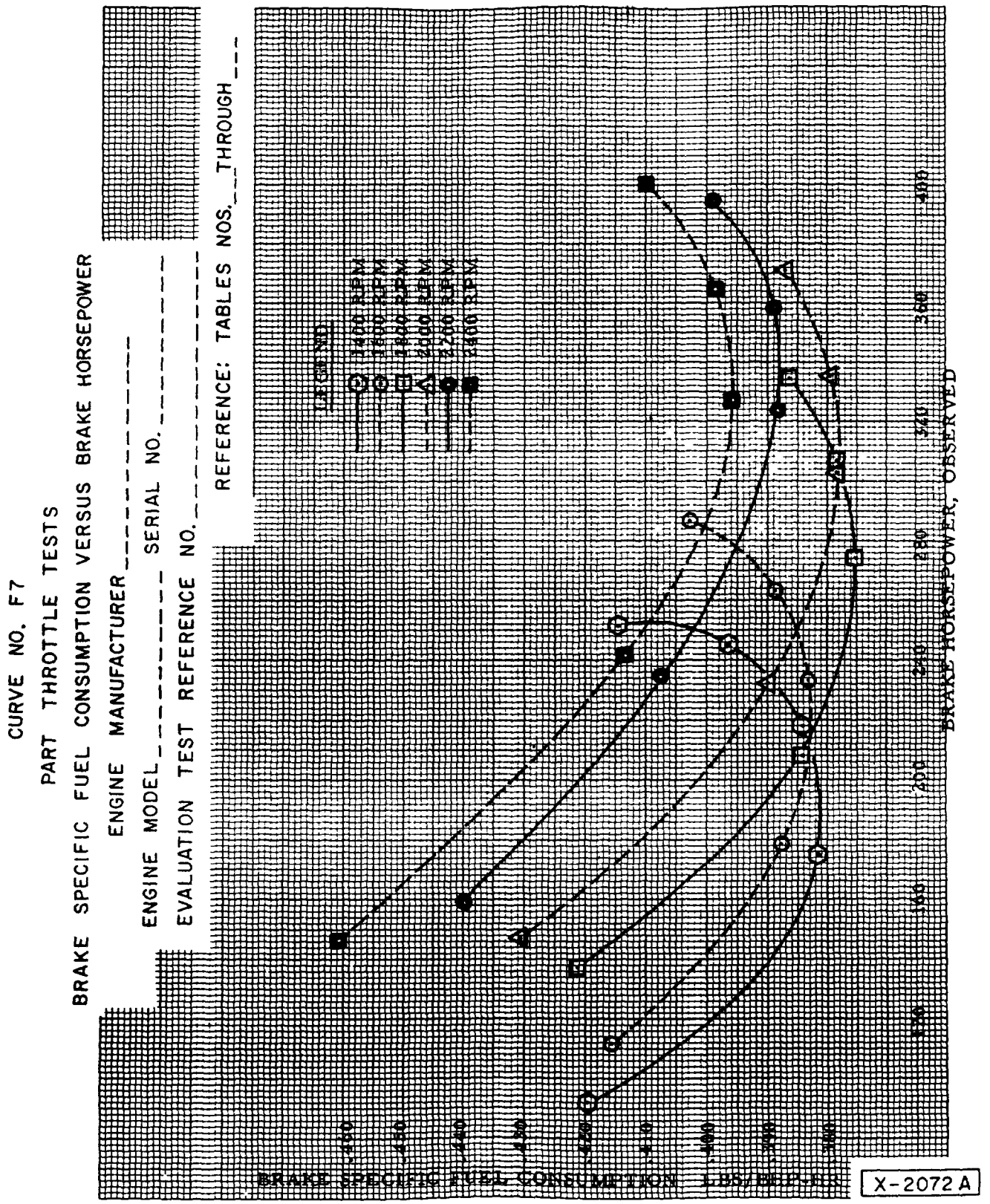
This appendix is a mandatory part of this standard.

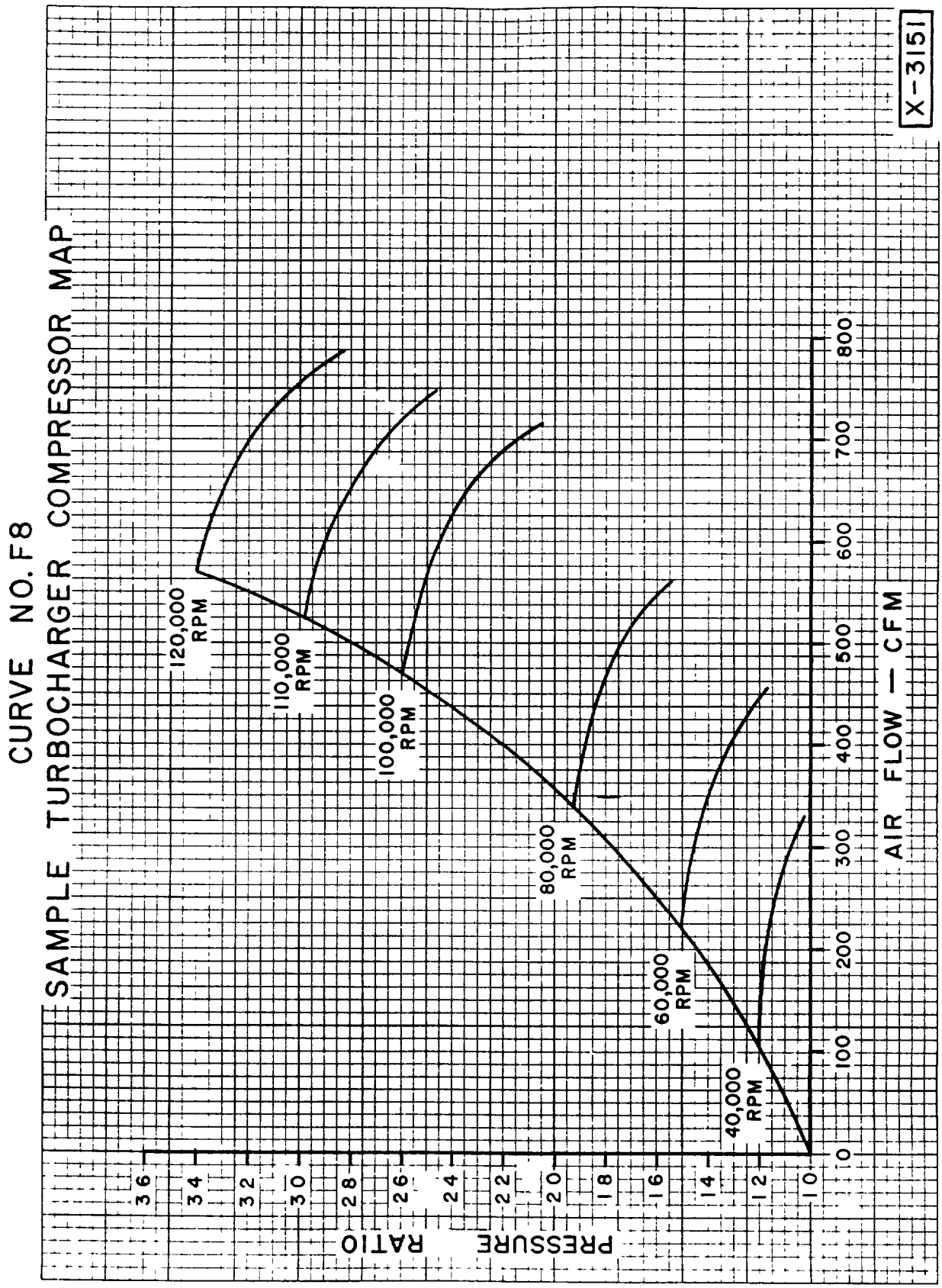
MIL-STD-1400C
APPENDIX F
CURVE NO. F1
COMPARISON OF:
MAXIMUM POWER, 5000 FOOT & 8000 FOOT ALTITUDE TESTS
ENGINE MANUFACTURER _____
ENGINE MODEL _____ SERIAL NO. _____
EVALUATION TEST REFERENCE NO. _____



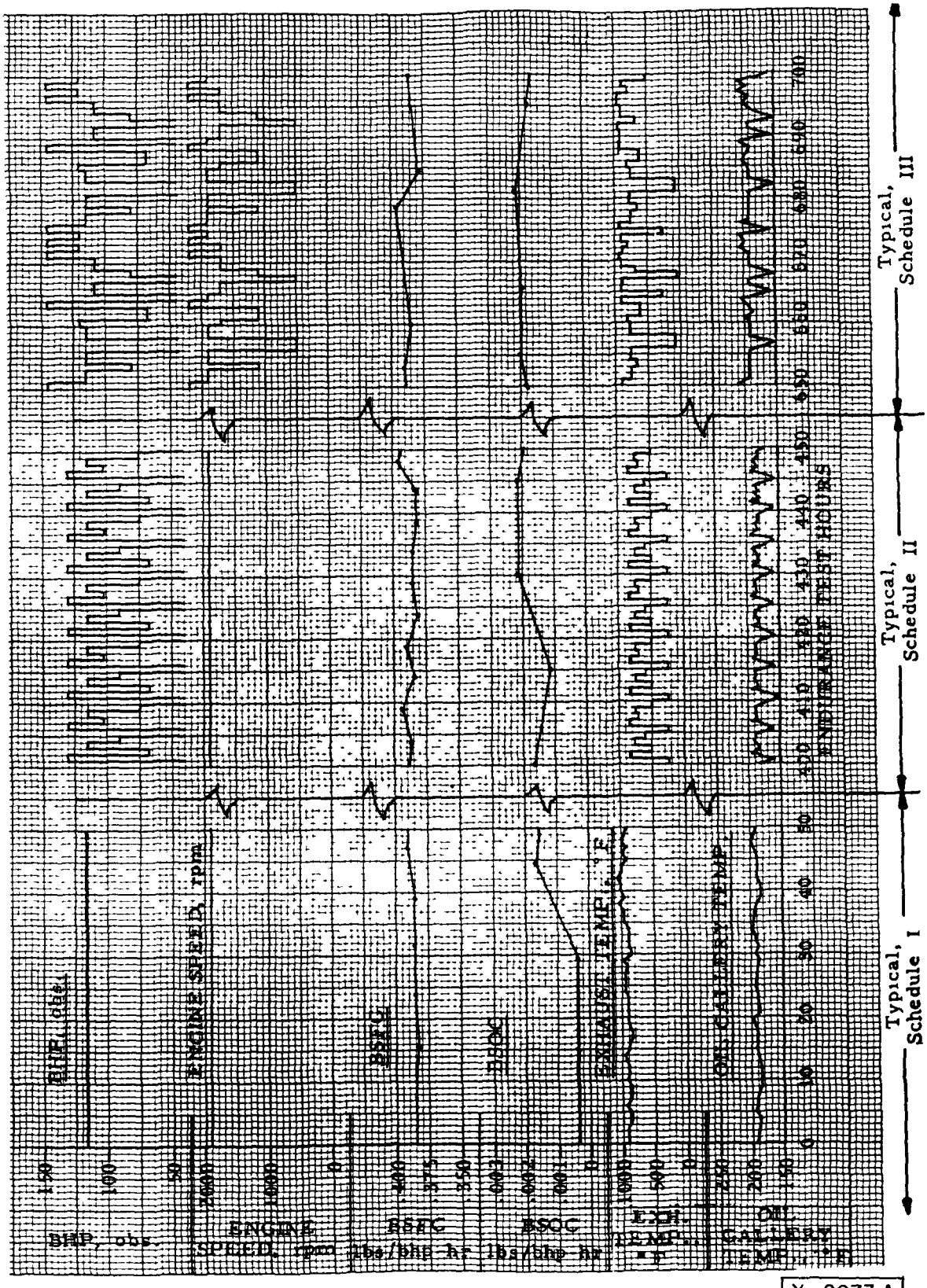








(Sample) GRAPHIC LOG OF ENDURANCE TEST ENGINE MODEL_____(#)_____ Page No._(#)__
(ENGINE MANUFACTURER) EVALUATION TEST REFERENCE NO.___(#)_____



# TEST TECHNIQUES

This appendix is not a mandatory part of this standard. The information contained herein is for information purposes only.

## 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.

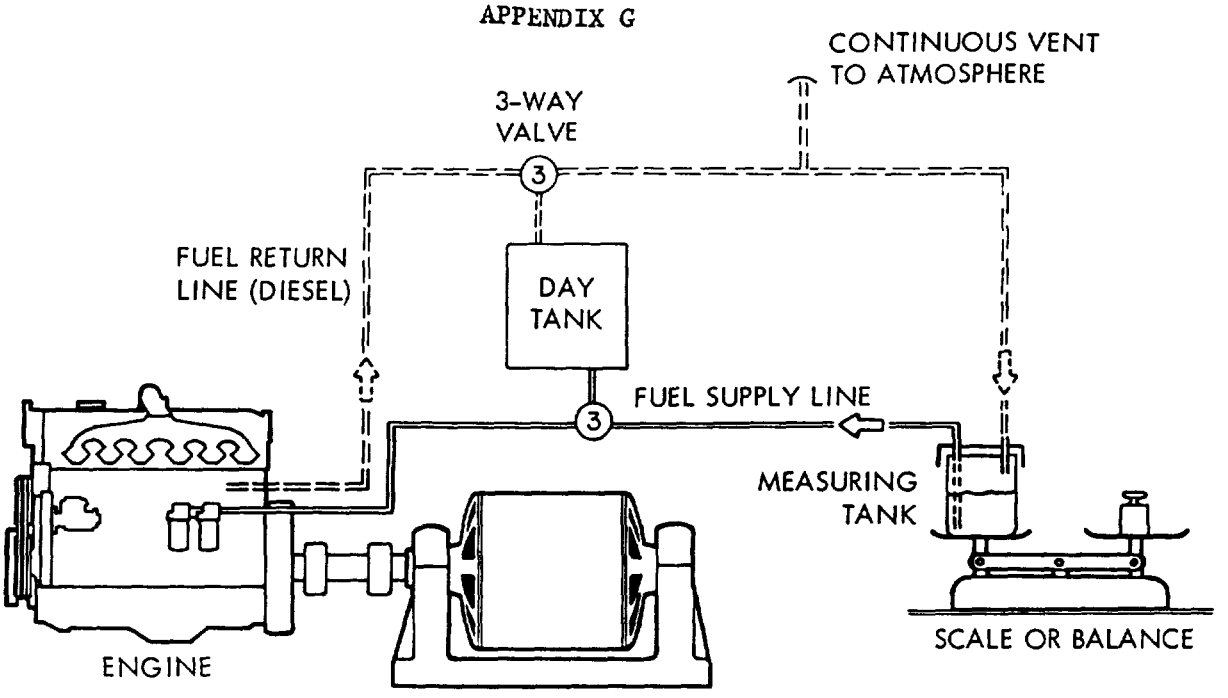



FIGURE G-1 FUEL LINE SCHEMATIC

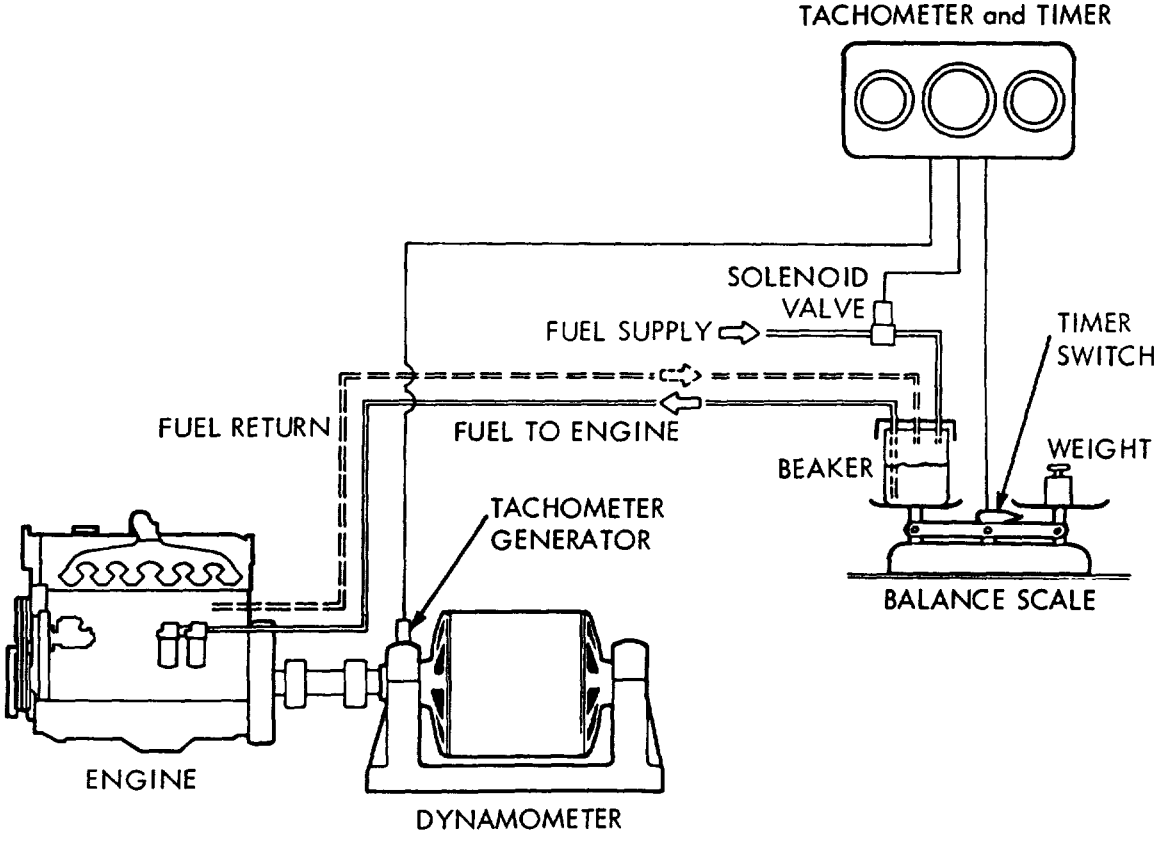



FIGURE G-2 FUEL SYSTEM SCHEMATIC X-2074

# 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. The turbocharger speed would be 23,000 multiplied by 4, which equals 92,000 rpm. The next smaller fraction of turbocharger speed would be one-fifth. Verifying speed would be 92,000 rpm divided by 5, which equals 18,400 rpm on the stroboscope.

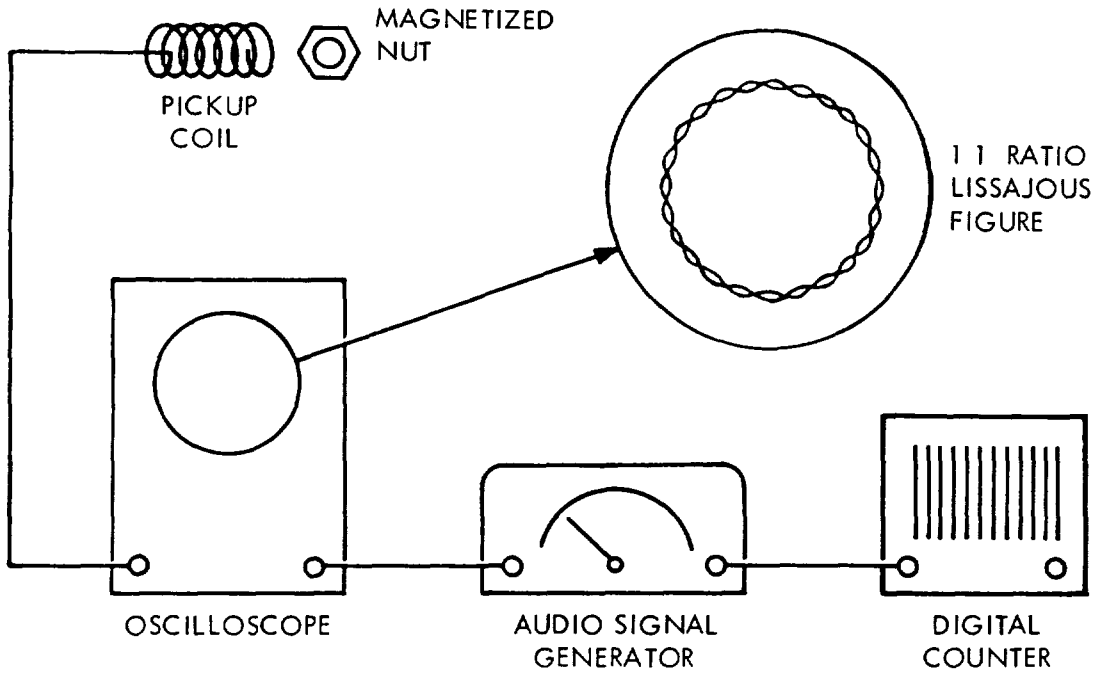



FIGURE G-3 SCHEMATIC FOR METHOD OF MEASURING TURBOCHARGER RPM

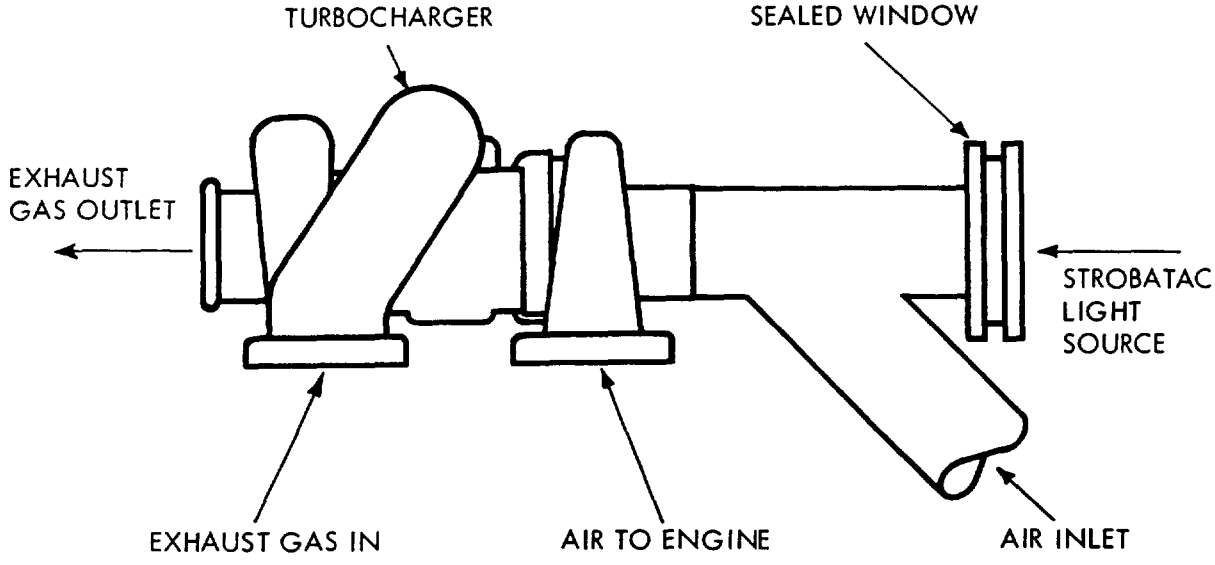
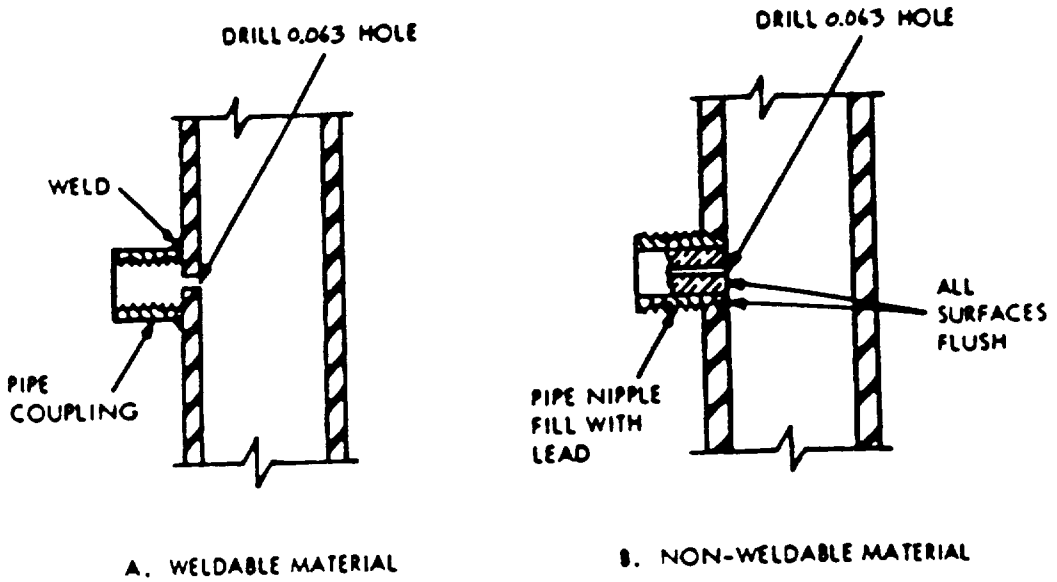
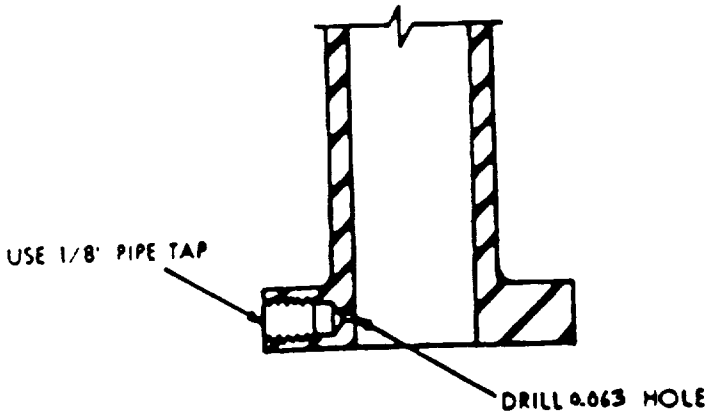



FIGURE G-4 SCHEMATIC FOR STROBATIC METHOD OF MEASURING TURBOCHARGER RPM



x-2075




X-2076A

FIGURE G-5. Pressure taps.

# METHOD OF DETERMINING ENGINE RATING

## MILITARY STANDARD, METHODS OF TEST

## TEST SERIES 1000, MIL-STD-1400C

This appendix is a mandatory part of this standard.

### Primary Fuel

| | | | |
|---|---|---|---|
| Diesel: | MIL-F-46162 | Gasoline: | MIL-G-46015 |
| and Turbine: | MIL-T-83133 | | |

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 5.0 percent shall be cause for derating by 1.0 percent for each 1.0 percent power loss in excess of 5.0 percent at that speed.

Intermittent rating: Not to exceed 90 percent of maximum bhp rating.

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

Continuous duty rating: Not to exceed 85 percent 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 6.2.3.2).

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

Custodians:
Army - ME
Air Force - 99

Review activity:
Army - AR
Navy - YD
Air Force - 82

User activity:
Navy - MC

Preparing activity:
Army - ME Navy - YD
Project No. 2805-0551

# STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

## INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

| I RECOMMEND A CHANGE: | 1. DOCUMENT NUMBER | 2. DOCUMENT DATE (YYMMDD) |
|---|---|---|
| | MIL-STD-1400C | 900730 |

**3. DOCUMENT TITLE**

Engines, Gasoline and Diesel, Methods of Test

**4. NATURE OF CHANGE** *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

**5. REASON FOR RECOMMENDATION**

**6. SUBMITTER**

| a. NAME (Last, First, Middle Initial) | b. ORGANIZATION | |
|---|---|---|
| c. ADDRESS (Include Zip Code) | d. TELEPHONE (Include Area Code)<br>(1) Commercial<br>(2) AUTOVON (If applicable) | e. DATE SUBMITTED (YYMMDD) |

**8. PREPARING ACTIVITY**

| a. NAME | b. TELEPHONE (Include Area Code)<br>(1) Commercial | (2) AUTOVON |
|---|---|---|
| | (703) 664-5717 | 354-5717 |
| c. ADDRESS (Include Zip Code)<br>US Army Belvoir RDE Center<br>ATTN: STRBE-TSE<br>Ft. Belvoir, VA 22060-5606 | IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:<br>Defense Quality and Standardization Office<br>5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466<br>Telephone (703) 756-2340 AUTOVON 289-2340 | |