Specification for Internal-Combustion Reciprocating Engines for Oil-Field Service

API SPECIFICATION 7B-11C
NINTH EDITION, NOVEMBER 1, 1994

American Petroleum Institute
1220 L Street, Northwest
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Exploration and Production Department

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CONTENTS

FOREWORD

This specification is under the jurisdiction of the API Committee on Standardization of Production Equipment.

The use of the API monogram under this standard is not permitted, since the specification defines rating procedures only, and does not provide minimum requirements on quality or standardized dimensions.

The following standard, issued by the API Production Department, is related to this specification:

RP 7C-11F: *Recommended Practice for Installation, Maintenance, and Operation of Internal Combustion Engines.*

Covers recommendations and information of a general nature pertaining to installation; daily, weekly, and monthly maintenance check-off lists; and operating troubles and their causes for all types of internal combustion engines in all types of service.

This standard shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

Specification for Internal-Combustion Reciprocating Engines for Oil-Field Service

1 Scope

This specification covers internal-combustion reciprocating engines for oil-field service, including methods of testing and rating for application to specific oilfield duties.

The methods of test stipulated herein are intended to afford the purchaser a uniform basis for comparing similar equipment with respect to capacity, energy requirements, and recommended speed range. Since maintenance and durability factors have not been included in the test procedure, it is assumed that comparisons between engines will be made advisedly. The ratings for bare eingines are intended for use only in cases where engines are supplied without cooling systems.

2 Testing and Rating of Internal-Combustion Reciprocating Engines

DEFINITIONS

2.1 bare engine: A bare engine shall be an engine less all accessories except those (built in or attached) absolutely required for running. All accessories normally required for operation of the engine, such as ignition, water pump, air cleaner, oil pump, governor, etc. shall be included.

2.2 power unit: A power unit shall consist of a bare engine, plus other equipment such as a fan for air cooling, special water pumps and so forth. When included, specific information must be given as to design factors such as ambient temperature and power consumption.

2.3 maximum standard brake horsepower: At any rotational speed, maximum standard brake horsepower shall be the greatest horsepower, corrected to standard conditions[1], that can be sustained continuously under the conditions as outlined under test procedure.

2.4 maximum standard torque: The maximum standard torque at any given rotational speed shall be that corresponding to the maximum standard brake horsepower at that speed.

TEST REQUIREMENTS

2.5 TEST ENGINE

Test engines shall be of exactly the same design and equipped with the same components and accessories as engines delivered to the purchaser. They shall be tested with all their regularly included component parts in place and operating normally.

[1]Standard conditions of temperature and pressure are 85°F (29.4°C) and 29.38 in. of mercury (99kPa).

2.6 ADJUSTMENTS

Immediately prior to testing, the engine or power unit shall be given a preliminary run of not less than 2 hr to determine optimum adjustment and to effect uniform operating conditions applicable to the tests stipulated herein. These conditions shall be maintained as nearly constant as possible throughout the subsequent testing. All performance tests shall be made without change of engine adjustments.

2.7 TEST PROCEDURE

Tests shall start at the lower end of the speed range over which data are required and shall be continuous. Each data point shall be determined by a minimum of three readings taken at 5-min intervals during the test run. Variations from the average rotational speed shall not be greater than ±1¼ per cent, based upon observations at 5-min intervals. Averages of the readings obtained shall be reported as the values for the test.

2.8 COOLING-WATER, OIL, AND AIR TEMPERATURE VARIATIONS

The maximum allowable variation from the average outlet cooling-water and average oil temperature during any run shall be ±5°F. The variation between maximum and minimum air-intake temperature shall not exceed 6°F during any run.

2.9 MAXIMUM BRAKE HORSEPOWER

The maximum brake horsepower shall be determined at a minimum of four speeds spaced with approximate uniformity in the range between the minimum and maximum speeds recommended for oil-field service. Manifold vacuum and/or pressure reading will be recorded at each point where horsepower is observed.

2.10 FUEL CONSUMPTION

Fuel consumption curves shall be determined at a minimum of four speeds spaced with approximate uniformity between the minimum and maximum recommended speeds for oil-field service. Measurements of fuel consumption rates shall be made in accordance with accepted good engineering practice. Fuel consumption rates shall be expressed as follows:

a. Natural gas engines—BTU/BHP Hr.—LHV
b. Diesel engines—Lb/BHP Hr.—LHV
c. Gasoline engines—Lb/BHP Hr.—LHV.

For diesel engines, tests should be conducted using fuel

oil conforming to ASTM D 396-63T. For gasoline engines, tests should be conducted using gasoline conforming to ASTM D 439-60T. For natural gas engines use fuel of 1000 Btu/ft³ H.H.V. (approx. 905 Btu/ft³ L.H.V.). If natural gas fuel of this specification is not available report heat value specification of actual fuel used.

COMPUTATIONS

2.11 STANDARD BRAKE HORSEPOWER

Observed horsepower determinations as required under 2.9 shall be converted to standard conditions by use of the following formula:

$$H_s = H_o \quad \frac{29.38}{P_o - E} \quad \sqrt{\frac{460 + T_o}{520}}$$

Where:

H_s = standard brake horsepower.
H_o = observed brake horsepower.
P_o = observed barometric pressure, inches of mercury.
E = pressure of water vapor in air (from relative humidity data), inches of mercury.
T_o = observed air temperature, degrees Fahrenheit.

Note: Standard brake horsepower values may be converted to non-standard conditions by use of the following formula and factors, which are included for the convenience of users. Such conversion applies only to curves 1, 2, 3e, 3f, and 3g of Fig. 2 and to curves 1, 6e, 6f, and 6g of Fig. 1. Fuel-consumption rates are relatively unaffected by temperature and pressure changes.

a. Conversions of Standard Brake Horsepower. Conversions of standard brake horsepower, for barometric pressures (altitude) or atmospheric temperatures other than standard, should be made in accordance with the following formula.

$$H = \frac{H_s (P_o - E)}{29.38} \quad \sqrt{\frac{520}{T_o + 460}}$$

Where:

H = brake horsepower at T_o temperature and P_o barometric pressure (other than standard).
H_s = standard brake horsepower.
P_o = observed barometric pressure, inches of mercury.
T_o = observed temperature, deg. F.
E = pressure of water vapor in air (from relative humidity data), inches of mercury.

b. Altitude and Temperature Conversions. Information concerning these conversions for turbocharged engines should be secured from the manufacturer. Approximate conversions for altitude and temperature for naturally aspirated engines may be made as follows:

1. Deduct 3 per cent of the standard brake horsepower for each 1000-ft rise in altitude above sea level.
2. Deduct 1 per cent of the standard brake horsepower for each 10-deg rise in temperature above 85°F, or add 1 per cent for each 10-deg fall in temperature below 85°F.

2.12 MAXIMUM STANDARD TORQUE

The maximum standard torque at any given rotational speed shall be computed from the maximum standard brake horsepower at that speed.

TEST REPORTS

2.13 TEST DATA

If so requested by the purchaser, the manufacturer shall furnish the purchaser a report giving results of test conducted as specified herein. Such reports shall include the following data:

a. Engine Description. Model and serial number, number of cycles, number of cylinders, compression ratio, piston displacement, bore, stroke, etc.
b. Accessories. Type, make, and model number.
c. Fuel. Type, heating value, octane or cetane rating, temperature at intake, and pressure (for gas fuel) at intake.
d. Air, Cooling Water, and Crankcase Oil. Barometric pressure, air temperature at intake, wet and dry bulb temperature of air source furnishing the intake-air stream, inlet and outlet temperature of cooling water, and temperature of crankcase oil.
e. Speed
   1. Recommended minimum speed for continuous operation.
   2. Recommended maximum speed for continuous operation.
   3. Recommended maximum speed for intermittent operation.
f. Horsepower
   1. Bare-engine maximum standard brake horsepower. (This curve shall be shown on reports for bare engines.)
   2. Power-unit maximum standard brake horsepower. (This curve shall be shown on reports for power units only.)
g. Torque
   1. Bare-engine maximum standard torque. (This curve shall be shown on reports for bare engines.)
   2. Power-unit maximum standard torque. (This curve shall be shown on reports for power units only.)
h. Fuel Consumption
   1. Fuel-consumption rate at the recommended minimum speed for continuous operation.
   2. Fuel-consumption rate at an intermediate speed approximately midway between the minimum and maximum speeds for continuous operations.
   3. Fuel-consumption rate at the recommended maximum speed for continuous operation.

2.14 RECOMMENDED SERVICE APPLICATIONS

If so requested by the purchaser, the manufacturer shall supply the purchaser, on the standard test report form, the recommended service applications, together with curves showing the recommended maximum standard brake horsepower within the recommended speed range for each of such services.

2.15 REPORT FORMS

The test data shall be supplied on report forms of the type, or similar to, those shown in Fig. 1 (for bare engines) or Fig. 2 (for power units).

2.16 MARKING

The engine manufacturer shall affix to each engine, a nameplate of his own design, on which shall be included the information shown below, and on which no horsepower rating shall be shown.

Name of manufacturer _____

Address _____

Manufacturer's serial no. _____

Manufacturer's designation* _____

_____ cycle. Bore _____ in.

Stroke (2 or 4) _____ in. No. of cylinders _____

Piston displacement: _____ cu. in.

Tested and rated in accordance with API Specification 7B-11C.

2.17 OUT-OF-STOCK ENGINES

Bare engines and power units delivered out of stock, after a run to reduce friction, shall develop at least 95 per cent of the horsepower shown on their respective maximum brake-horsepower curves, when tested in accordance with the procedure specified herein.

2.18 COMPLIANCE

The manufacturer is responsible for complying with all of the provisions of this specification. The purchaser may make any investigation necessary to satisfy himself of compliance by the manufacturer and may reject any material that does not comply with this specification.

*Model number, trade name, etc., as used on the test form.

TEST REPORT ON INTERNAL-COMBUSTION BARE ENGINE FOR OIL-FIELD SERVICE

All values shown in this test report were determined by the procedures stipulated in API Specification 7B-11C, Ninth Edition.

ENGINE:

Manufacturer _____ Date of test _____

Engine model designation _____ Engine number _____

Cycle _____ Compression ratio _____

No. of cylinders _____ Bore _____ in.

Stroke _____ in. Piston displacement _____ cu. in.

BARE ENGINE ACCESSORIES (Make and Model):

Air Cleaner _____ _____

Oil filter _____ _____

Carburetor (fuel pump) _____ _____

Water pump _____ _____

Oil pump _____ _____

Magneto _____ _____

Generator _____ _____

Distributor and coil _____ _____

Governor _____ _____

Clutch _____ _____

Other _____ _____

_____ _____

_____ _____

_____ _____

FUEL:

Type _____

Low heating value: Gas _____ Btu per cu ft Liquid _____ Btu per lb

Rating: Gasoline _____ octane (ASTM D 357, motor method) Oil _____ cetane

Temperature at intake _____ F Pressure at intake _____ oz per sq in.

AIR, COOLING WATER, AND CRANKCASE OIL: (OBSERVATION AT MAX. B.H.P. TEST POINT)

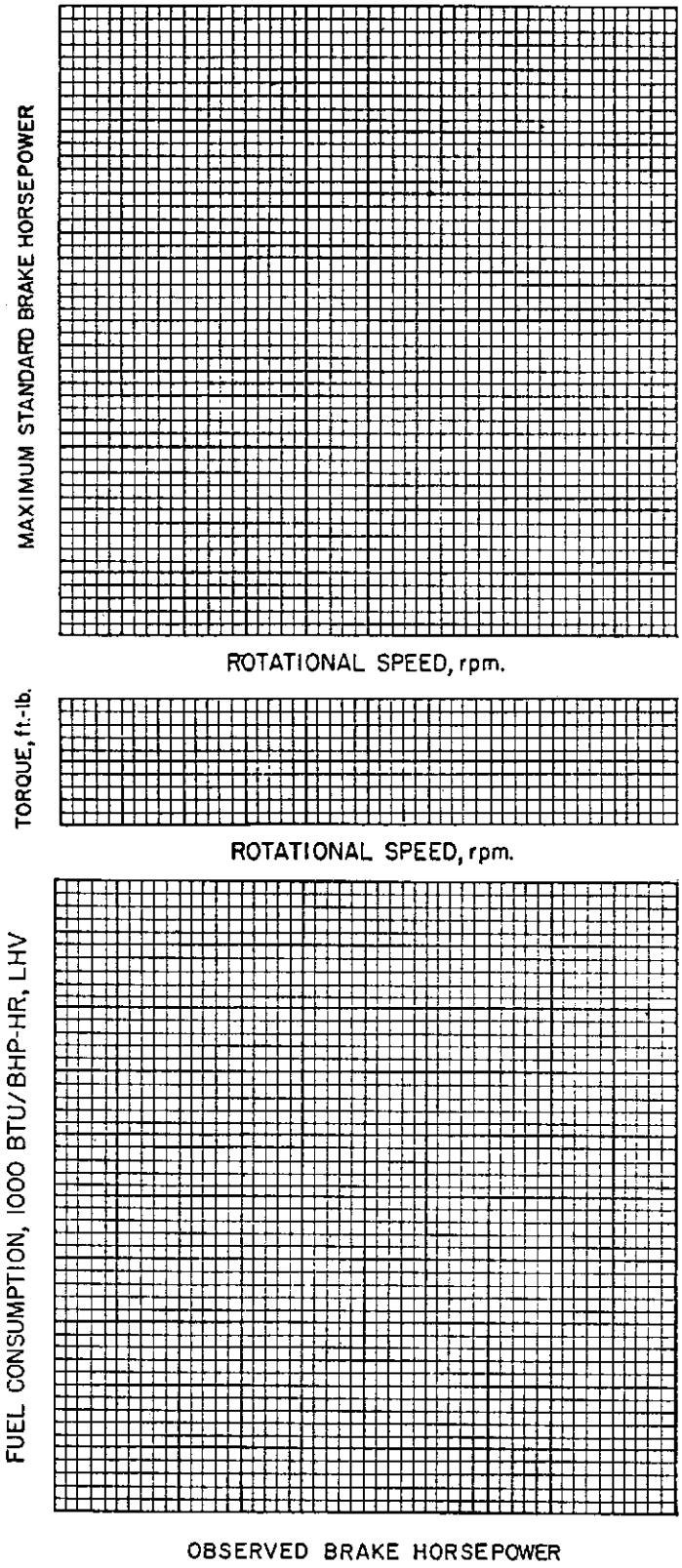
Air temperature: At intake _____ F Wet bulb _____ F Dry bulb _____ F

Barometric pressure _____ in. of Hg Crankcase oil temperature _____ F

Water temperature: Inlet _____ F Outlet _____ F

Intercooler water temperature: Inlet _____ F

Figure 1—Test Report Form for Internal-Combustion Bare Engines



RECOMMENDED SPEEDS

A._____min rpm, continuous operation.
C._____max rpm, continuous operation.
D._____max rpm, intermittent operation.

MAXIMUM STANDARD BRAKE HORSEPOWER CURVES

1. Bare engine for speed range A to D.
6e. As recommended for intermittent service.
6f. As recommended for continuous service.
6g. As recommended for_____ _____service.

MAXIMUM STANDARD TORQUE CURVES

4. Bare engine for speed range A to D.

BARE-ENGINE FUEL-CONSUMPTION CURVES

A_2. For speed A.
b_2. For speed_____(Speed B, approximately midway between speeds A and C).
C_2. For speed C.
D_2. For speed D where maximum intermittent rpm is not the same as speed C.

Figure 1—Test Report Form for Internal-Combustion Bare Engines (Continued)
(See Figure 3 for examples of test-data curves)

TEST REPORT ON INTERNAL-COMBUSTION POWER UNIT FOR OIL-FIELD SERVICE

All values shown in this test report were determined by the procedures stipulated in API Specification 7B-11C, Ninth Edition.

ENGINE:

Manufacturer _____ Date of test _____

Engine model designation _____ Engine number _____

Cycle _____ Compression ratio _____

No. of cylinders _____ Bore _____ in.

Stroke _____ in. Piston displacement _____ cu. in.

POWER UNIT ACCESSORIES (Make and Model):

Radiator _____ _____

Fan _____ _____

Air Cleaner _____ _____

Oil Filter _____ _____

Carburetor (fuel pump) _____ _____

Water pump _____ _____

Magneto _____ _____

Generator _____ _____

Distributor and coil _____ _____

Governor _____ _____

Clutch _____ _____

Other _____ _____

_____ _____

_____ _____

FUEL:

Type _____

Low heating value: Gas _____ Btu per cu ft Liquid _____ Btu per lb

Rating: Gasoline _____ octane (ASTM D 357, motor method) Oil _____ cetane

Temperature at intake _____ F Pressure at intake _____ oz per sq in.

AIR, COOLING WATER, AND CRANKCASE OIL: (OBSERVATIONS AT MAX. B.H.P. TEST POINT)

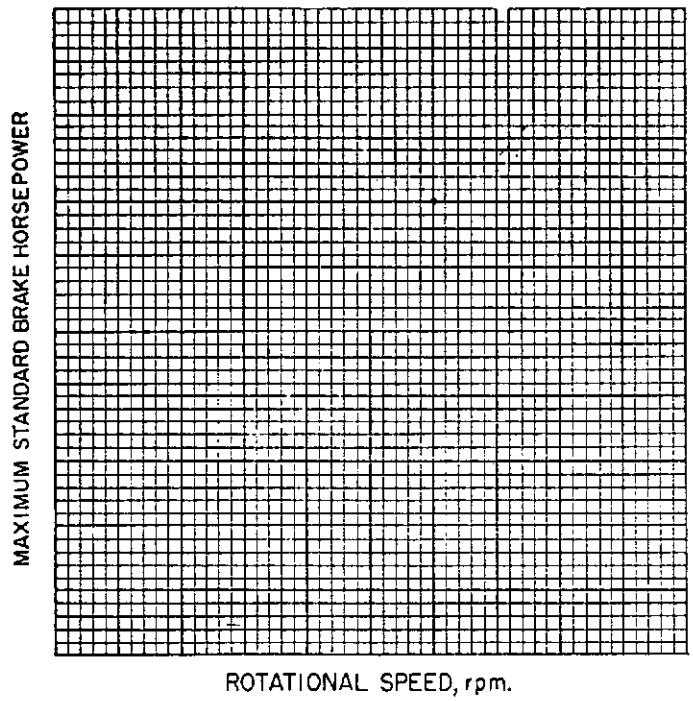
Air temperature: At intake _____ F Wet bulb _____ F Dry bulb _____ F

Barometric pressure _____ in. of Hg Crankcase oil temperature _____ F

Water temperature: Inlet _____ F Outlet _____ F

Intercooler water temperature: Inlet _____ F

Figure 2—Test Report Form for Internal-Combustion Power Units



RECOMMENDED SPEEDS

A._____min rpm, continuous operation.
C._____max rpm, continuous operation.
D._____max rpm, intermittent operation.

MAXIMUM STANDARD BRAKE HORSEPOWER CURVES

1. Bare engine for speed range A to D.
2 Power unit for speed range A to D.
3e. As recommended for intermittent service.
3f. As recommended for continuous service.
3g. As recommended for_____ _____service.

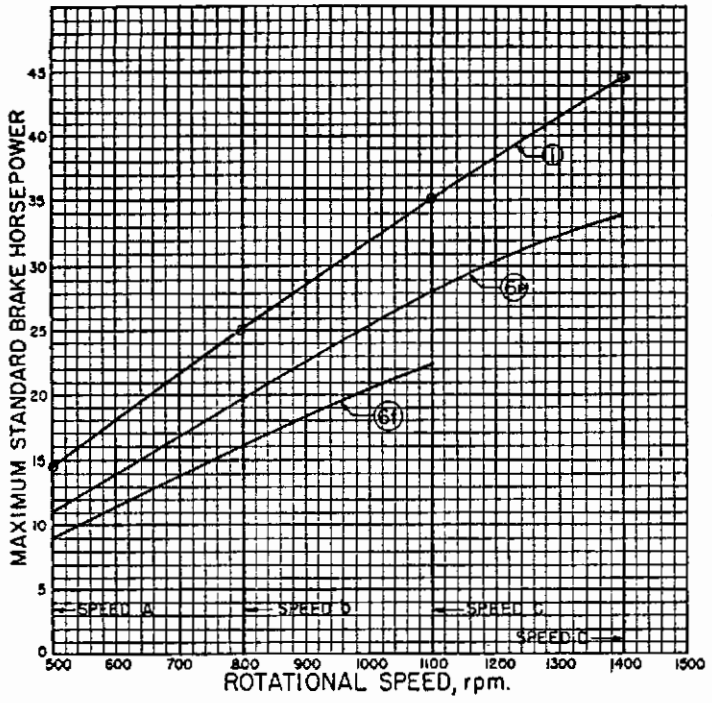
MAXIMUM STANDARD TORQUE CURVES

4. Bare engine for speed range A to D.
5. Power unit for speed range A to D.

POWER-UNIT FUEL-CONSUMPTION CURVES

A_1. For speed A.
b_1. For speed_____(Speed B, approximately midway between speeds A and C).
C_1. For speed C.
D_1. For speed D where maximum intermittent rpm is not the same as speed C.

Figure 2—Test Report Form for Internal-Combustion Power Units (Continued)
(See Figure 4 for examples of test-data curves)



RECOMMENDED SPEEDS

A_____ 500___min rpm, continuous operation.

C_____1100___max rpm, continuous operation.

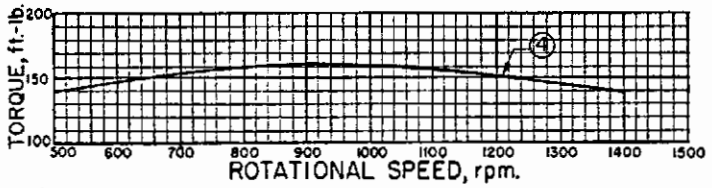
D_____1400___max rpm, intermittent operation.

MAXIMUM STANDARD BRAKE HORSEPOWER CURVES

1. Bare engine for speed range A to D.

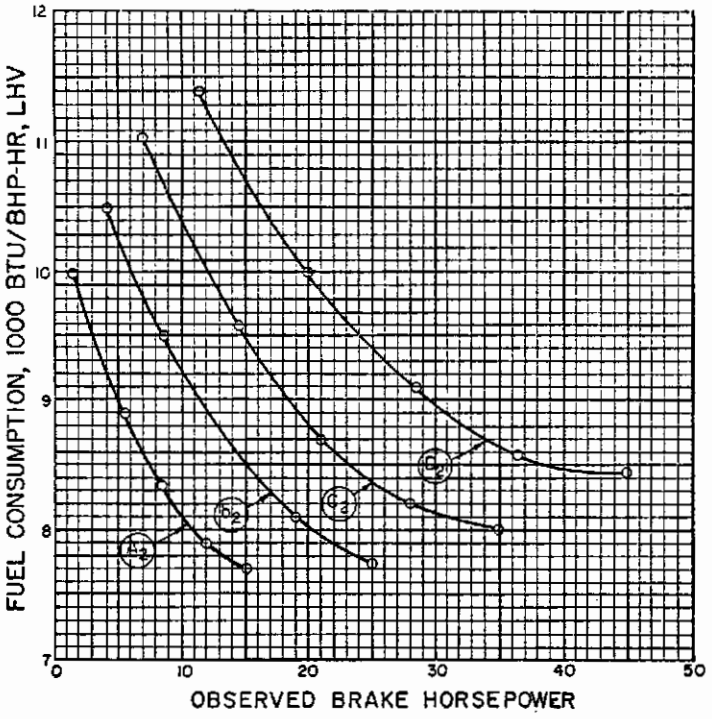
6e. As recommended for intermittent service.

6f. As recommended for continuous service.



MAXIMUM STANDARD TORQUE CURVES

4. Bare engine for speed range A to D.



BARE-ENGINE FUEL-CONSUMPTION CURVES

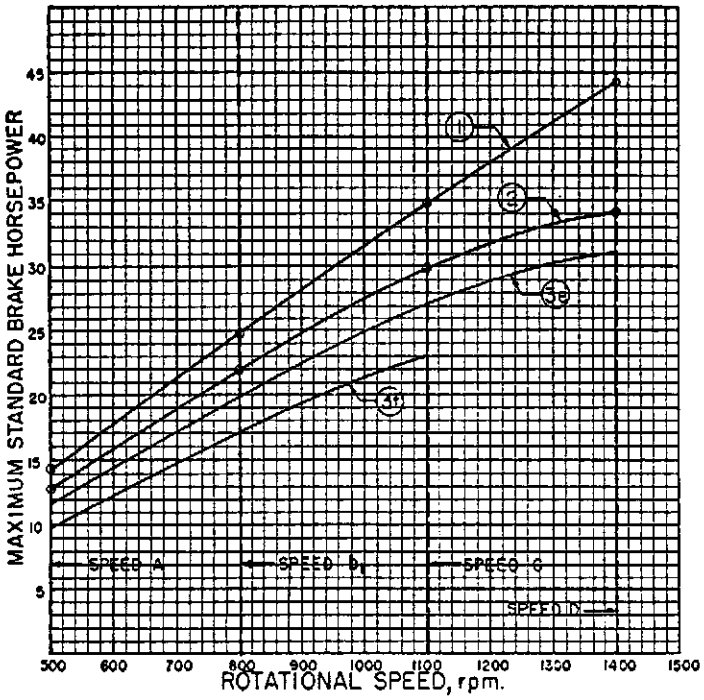
A_2. For speed A.

b_2. For speed_____800_____(Speed B, approximately midway between speeds A and C)

C_2. For speed C.

D_2. For speed D where maximum intermittent rpm is not the same as speed C.

Figure 3—Example of Test Data Curves for Internal-Combustion Bare Engines
(See Figure 1)



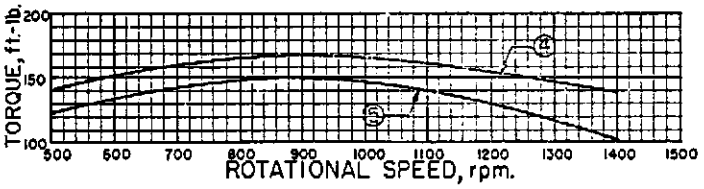
RECOMMENDED SPEEDS

A_____ 500___min rpm, continuous operation.
C_____1100___max rpm, continuous operation.
D_____1400___max rpm, intermittent operation.

MAXIMUM STANDARD BRAKE HORSEPOWER CURVES

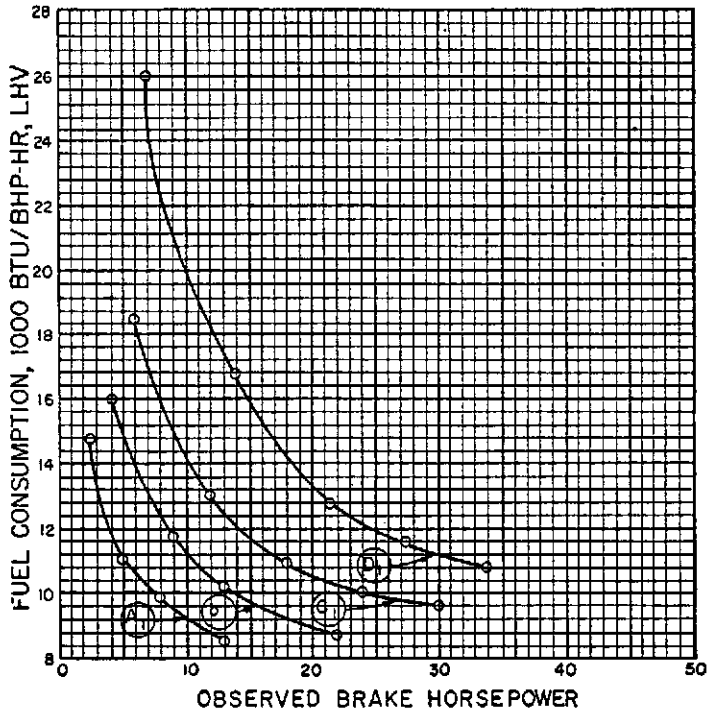
1. Bare engine for speed range A to D.
2. Power unit for speed range A to D.

3e. As recommended for intermittent service.
3f. As recommended for continuous service.



MAXIMUM STANDARD TORQUE CURVES

4. Bare engine for speed range A to D.
5. Power unit for speed range A to D.



POWER-UNIT FUEL-CONSUMPTION CURVES

A_1. For speed A.
b_1. For speed_____800_____(Speed B, approximately midway between speeds A and C.
C_1. For speed C.
D_1. For speed D where maximum intermittent rpm is not the same as speed C.

Figure 4—Example of Test Data Curves for Internal-Combustion Power Units
(See Figure 2)

APPENDIX A—EXHAUST AND AIR-INTAKE OPENING CONNECTIONS

A.1 Flanges

When exhaust and air-intake openings of internal-combustion engines are provided with flanges for the purpose of furnishing a pipe connection, the flanges shall conform to USASI* specifications, series 15, flat face.

A.2 Threading in Flanges

Threading in flanges, when used, shall conform to API Standard 5B: Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads, whenever practical. API reference master thread gauges are recommended, but are not mandatory.

A.3

If standard flange or screwed connections are not provided, the manufacturer should provide mating fittings.

*American National Standards Institute.

APPENDIX B—RECOMMENDED PRACTICE FOR USE OF INTAKE VACUUM VS. LOAD CURVES FOR NATURALLY ASPIRATED INTERNAL-COMBUSTION ENGINES

B.1

The recommendations given herein are for use on four cycle engines of two or more cylinders equipped with carburetors for liquid or gaseous fuels.

B.2

The vacuum-load curves shown in Fig. B.1 are an index of the approximate percentage of maximum brake horsepower (within 3 per cent on new engines), that an average engine in proper adjustment will develop at a given location. These curves cannot be used on super-charged engines.

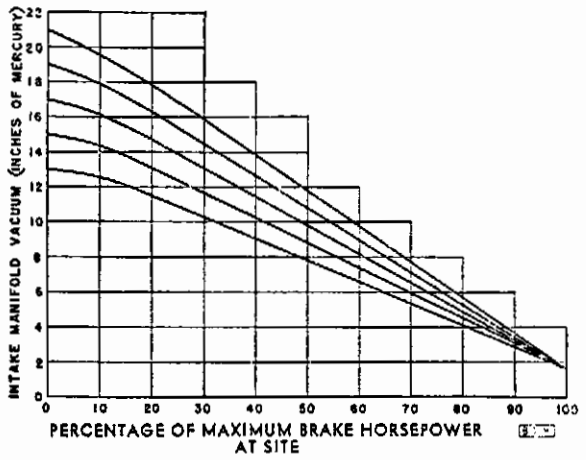


Figure B.1—Intake Vacuum vs. Load Curves

Note: The curves shown in Fig. B.1 are the average of curves obtained from six representative engine manufacturers covering many models having cylinder bores varying from 2½ to 8 in.

INSTRUCTIONS FOR USE

B.3

The engine to be tested should be checked to make certain that it is properly adjusted before any vacuum readings are taken. The spark, gas supply, gas pressure, and carburetor should particularly be checked and any necessary adjustments made.

B.4

A conventional vacuum gage with a dial graduated in inches of mercury should be used.

B.5

The engine should be run at its normal operating speed with no load and a reading taken of the intake manifold vacuum.

B.6

The engine should then be run at a normal operating speed with its normal loading and a reading of the intake manifold vacuum.

B.7

The curve should then be selected (see Fig. B.1) whose ordinate at no load most nearly corresponds to the intake manifold vacuum reading taken at no load for the engine being tested. From the intake manifold vacuum reading taken at normal loading, a point on this curve is located whose abscissa indicates the percentage of maximum brake horsepower at which the engine is operating.

Note: 100% maximum brake horsepower on abscissa of Fig. B.1 is the rating at site conditions of altitude and ambient temperature. The horsepower developed by a naturally aspirated engine decreases about 3 percent with each 1,000 ft. increase in altitude, and around 1% with each 10°F increase in temperature, above the base altitude and ambient temperature at which the manufacturer tested and rated the engine.
Likewise, the no load intake manifold vacuum decreases about 5% for each 1,000 ft. increase in altitude. For example, an engine that develops 20 inch vacuum at no load at sea level, will develop about 14 inch vacuum at 6,000 ft. altitude.

EXAMPLE:

TEST CONDITIONS:

a. Intake manifold vacuum at no load: 17 in. of mercury.
b. Intake manifold vacuum at normal loading: 10 in. of mercury.

SOLUTION:

a. From Fig. B.1 select the curve which shows 17-in. vacuum at no load.
b. Follow down this curve to a point whose ordinate is 10-in. vacuum. Determine that the engine is developing 48 per cent of maximum brake horsepower.

B.8

Failure to duplicate former readings at no load and normal speed indicates poor engine condition due to poor gas supply, loss of compression, ignition timing, etc.

B.9

Failure to duplicate former readings at normal load and speed indicates either a change in engine efficiency or a change in load.

B.10

Field men should become familiar with the vacuum-curve readings taken when their engines are properly adjusted and in good operating condition in order to enable them to detect variations in either load or engine condition.

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