Engine Power Test Code–
Spark Ignition and Diesel–
SAE J1349 DEC80

SAE Standard
Approved December 1980

THIS IS A PREPRINT WHICH IS SUBJECT TO REVISIONS AND CORRECTIONS. THE FINAL VERSION WILL APPEAR IN THE 1982 EDITION OF THE SAE HANDBOOK.

PREPRINT

ENGINE POWER TEST CODE—SPARK IGNITION AND DIESEL—SAE J1349 DEC80

SAE Standard

Report of the Engine Committee, approved December 1980.

1. Scope—This standard test code has been adopted by SAE to specify:

(a) A laboratory engine dynamometer test procedure.

(b) A basis for engine power rating.

(c) A method for correcting observed power to standard inlet air conditions.

The pressure and temperature correction formulas contained herein should be used only within the specified range of conditions (see paragraph 8.4.1) and are not intended for altitude derating.

2. Field of Application—This standard test code is applicable to four-stroke and two-stroke cycle spark ignition and diesel engines, naturally aspirated and pressure charged, with and without charge air cooling.

3. References—ISO 1585, Revised – This SAE Standard is in agreement with SAE J916c. This test code supersedes:

(a) J816b Engine Test Code—Spark Ignition and Diesel (last issued in 1981 Handbook).

(b) J245 Engine Rating Code—Spark Ignition (last issued in 1981 Handbook).

(c) J270 Engine Rating Code—Diesel (last issued in 1981 Handbook).

4. Terminology

4.1 **Engine**

4.1.1 Basic Engine is an engine equipped only with built-in accessories essential to its operation, such as: fuel pump, oil pump, coolant pump, and built-in emission control equipment.

4.1.2 Fully Equipped Engine is an engine equipped with all the accessories necessary to perform its intended functions unaided. This includes, but is not restricted to, the basic engine of paragraph 4.1.1 plus intake air system, exhaust system, cooling system, generator or alternator, starter, and emission, noise and RFI control equipment (see paragraph 6.5.1).

4.2 **Engine Power**—Engine Power is defined as the product of engine dynamometer speed and torque obtained at wide-open throttle and is expressed in kW units.

4.2.1 Observed Brake Power is the power developed by an engine under the actual inlet air conditions existing during the test.

4.2.2 Corrected Brake Power is the observed power adjusted to standard inlet air conditions using the correction methods specified in paragraph 8.4.

4.2.3 Net Brake Power is the power output of a "fully equipped" engine as defined in paragraphs 4.1.2 and 6.5.1.

4.2.4 Gross Brake Power is the power output of a "basic" engine as defined in paragraphs 4.1.1 and 6.5.2.

4.2.5 Rated Brake Power is the power established for an application at a rated speed chosen by the manufacturer. It shall be the net of all accessory losses and inlet and exhaust restriction effects associated with that application.

4.2.6 Friction Power is the power required to drive the engine as equipped during the power test. Friction may be approximated by one of the following methods with sufficient accuracy for the purposes of this code:

(a) Hot motoring method (preferred method).

(b) Assumed 85% mechanical efficiency (see paragraph 8.4.2).

4.2.7 Indicated Power is the power developed in the cylinders. It is defined as the sum of the brake power and friction power for the purposes of this standard.

5. Test Measurement and Accuracy—The test measurements listed below are required in engine power determination. The measurement accuracies specified do not include human or other probable errors involved in the reading.

5.1 Torque—±0.5% of the observed full load reading.

5.2 Engine Speed—±0.5% of the observed reading.

5.3 Temperatures—±1°C.

5.4 Inlet Air Pressure

5.4.1 Total Pressure—±0.100 kPa.

5.4.2 Water Vapor Pressure—±0.100 kPa.

6. Test Procedures—This section contains the required test procedures for determining engine power.

6.1 **Engine Installation**—The test engine shall be representative of the manufacturer's production units. All auxiliary equipment such as fan, fan coupling, air cleaner, inlet system, exhaust system, and pumps shall be listed and described in the documentation supporting the test results.

6.2 **Fuels and Lubricants**

6.2.1 Fuel used shall conform to the manufacturer's specifications.

6.2.1.1 Spark Ignition Engines

(a) Record Research and Motor Octane Numbers, lower heating value (LHV) in kJ/g, and API gravity of liquid fuel.

(b) Record lower heating value (LHV) in kJ/m^3 at 16°C and 101 kPa, and the composition of gaseous fuels.

6.2.1.2 Diesel Engines—Record ASTM or other fuel specifications, Cetane Number, and API gravity.

6.2.2 Lubricating oil used shall conform with the manufacturer's recommendations. Record oil API Engine Service Classification, SAE Viscosity Grade, and brand name of the lubricant.

6.3 **Instrumentation**

6.3.1 Temperature and pressure of the inlet air to the engine shall be measured in a manner to obtain a mass average temperature and pressure. Measurements shall be taken in the engine inlet air stream or within 150 mm before the air cleaner. Temperature sensors shall be shielded from radiant heat sources.

6.3.2 Coolant temperatures in liquid-cooled engines shall be measured at the inlet and outlet of the engine. Temperatures in air-cooled engines should be measured at point(s) specified by the manufacturer such as spark plug gasket(s) and cylinder head fin(s).

6.3.3 Oil temperatures shall be measured in the main oil gallery.

6.3.4 Fuel temperature shall be measured at the outlet of the volumetric fuel measuring device, if used. Fuel supply temperature should be measured at the inlet to the fuel injection pump for fuel injection engines.

6.3.5 Exhaust system pressure shall be measured within 150 mm downstream of the exhaust manifold or turbocharger exhaust outlet.

6.4 **Adjustment and Run In**

6.4.1 If the engine exhaust is connected to a laboratory exhaust system, that system shall not cause a back pressure exceeding the value specified by the manufacturer or produce a vacuum of more than 0.750 kPa. If the engine air inlet is connected to a laboratory air system, that system should not deviate from the prevailing atmospheric pressure by more than 0.500 kPa.

6.4.2 The generator (alternator) shall be disconnected electrically if an external power source is used for ignition and/or starting unless certain accessories such as the fuel pump are electrically driven, in which case the generator or alternator shall operate at a load sufficient to power them.

6.4.3 Adjustments shall be made before the test in accordance with the manufacturer's instructions. No changes or adjustments shall be made during the test.

6.4.4 The engine shall be run-in according to the manufacturer's recommendations. If no such recommendation is available, the engine shall be run-in until corrected full throttle power and fuel consumption are repeatable within 1% over a 4 h period.

6.5 **Engine Equipment**

6.5.1 Net Brake Power—A fully equipped engine is used for this test (see paragraph 4.1.2).

(a) Air preheat (if applicable)—on.

(b) Air cleaner—on.

(c) Inlet system—on, or a system providing equivalent restriction.

(d) Radiator—not used.[1]

(e) Fan—not used, but losses accounted for[2]—liquid-cooled.

(f) Fan or blower—on, air control mechanism operating normally—air-cooled.

(g) Exhaust system—on, or system providing equivalent restriction.

(h) Heat valve—open.

(i) Timing—manufacturer's specification.

(j) Spark advance—manufacturer's specification.

(k) Fuel pump setting—manufacturer's specification.

(l) Carburetor or fuel metering control setting—manufacturer's specification.

(m) Boost pressure control setting—manufacturer's specification.

(n) Emission, noise, and RFI control equipment—manufacturer's specification.

(o) Governor—on, if integral part of engine.

6.5.2 Gross Brake Power—A basic engine is used for this test (see paragraph 4.1.1) using the same equipment and settings as for Net Brake Power, with the following exceptions:

(a) Air cleaner—not used.

(b) Air preheat—not used.

(c) Inlet system—laboratory system.

(d) Radiator—not used—liquid-cooled.

(e) Fan—not used—liquid-cooled.

(f) Exhaust system—laboratory system.

(g) Emission, noise, and RFI controls integral with engine—manufac-

turer's specification.

6.6 Test Operating Conditions

6.6.1 No data shall be taken until torque and speed have been maintained within 1% and temperatures have been maintained within 2°C for at least 2 min. An optional procedure for spark ignited engines may be used in place of the steady-state test. This procedure consists of stabilizing speed and temperature for 2 min at 50% of wide-open throttle, then rapidly opening the throttle to wide-open position. The torque is then recorded 5 s after opening the throttle. Power measurements made in accordance with this optional procedure shall be defined as "instantaneous."

6.6.2 Engine speed shall not deviate from the nominal speed by more than ±1% or ±10 r/min, whichever is greater.

6.6.3 Coolant outlet temperature for a liquid-cooled engine shall be controlled to within ±3°C of the nominal thermostat value specified by the manufacturer.

6.6.4 Fuel temperature at the inlet of the diesel fuel injection pump shall be controlled to 40 ± 3°C.

7. Data Acquisition

7.1 Gross and Net Brake Power—Record data for at least five approximately evenly spaced operating speeds to define the power curve between 600 r/min (or the lowest stable speed) and the maximum engine speed recommended by the manufacturer. On spark ignition engines, where hot motoring friction is used, the hot motoring friction measurement shall be taken with coolant inlet and oil gallery temperatures within 3°C of those observed during the power test.

7.2 Data to be Recorded for Test Documentation

(a) Speed (see paragraph 6.6.2).
(b) Brake torque or beam load (labeled "instantaneous," if applicable) (see paragraph 6.6.1).
(c) Friction torque or beam load (if measured) (see paragraphs 4.2.6 and 7.1).
(d) Ambient air temperature, pressure, humidity (see paragraphs 5.3 and 5.4).
(e) Inlet air pressure and temperature (see paragraphs 6.3.1 and 6.4.1).
(f) Exhaust system pressure (see paragraphs 6.3.5 and 6.4.1).
(g) Fuel supply temperature (see paragraph 6.3.4).
(h) Oil and coolant temperature (see paragraphs 6.3.2 and 6.3.3).
(i) All auxiliary equipment (see paragraph 4.1.2).

7.3 *The following data should also be recorded where applicable and for safety of operation:*

(a) Oil pressure.
(b) Intake manifold air (mixture) temperature and pressure.
(c) Exhaust manifold temperature.
(d) Exhaust manifold pressure.
(e) Air cleaner and piping restriction.
(f) Ignition or injection timing.
(g) Fuel supply pressure.
(h) Exhaust smoke (diesel only).

8. Computations

8.1 Symbols

Symbol	Definition	Units
B	Inlet air pressure (see paragraph 6.3.1)	kPa
D	Engine displacement	L
F	Fuel rate	g/s
N	Engine speed	r/min
P	Inlet manifold pressure	kPa
fa	Atmospheric factor	
fm	Engine factor	
t	Inlet air temperature (see paragraph 6.3.1)	°C
bp	Brake power	kW
fp	Friction power	kW
ip	Indicated power	kW

Subscripts

c	Corrected to standard conditions
d	Dry air condition
o	Observed at test conditions

8.2 Useful Equivalents

1 kg = 2.2046 lb mass
1 N = 0.2248 lb force
1 N·m = 0.7376 lbf·ft
1 kPa = 0.1450 lbf/in^2
1 kPa = 0.2961 in Hg
1 hp = 33 000 ft·lbf/min
1 kW = 1000 N·m/s
1 kW = 1.341 hp

8.3 Standard Inlet Air Conditions

Pressure, total	B	100 kPa
Temperature	t	25°C
Vapor pressure		1.0 kPa
Dry barometric pressure	B_d	99 kPa
Dry air density		1.1572 kg/m^3

8.4 Power Corrections

8.4.1 Atmospheric Test Conditions—The performance of diesel and spark ignition engines is affected by the pressure, temperature, and humidity of the inlet air. Therefore, in order to provide a common basis of comparison, it is necessary to apply a correction factor to account for the difference between standard inlet air conditions and those at which the test data were observed.

It is recommended that only test data obtained within the range of 95–101 kPa dry inlet air pressure and 15–43°C inlet air temperature be used for correction by this standard. If test data obtained outside this range are used as a basis for correction, the inlet air conditions under which the test was performed shall be shown with the corrected results (see Section 9).

8.4.2 Spark Ignition Engines—Corrected Brake Power at Wide-Open Throttle[3]—Engine friction for correcting engine power should be established by the hot motoring method at wide-open throttle.

$$ip_o = fp_o + bp_o$$

$$ip_c = ip_o\left(\frac{99}{B_{do}}\right)\left(\frac{t+273}{298}\right)^{0.5}$$

$$bp_c = ip_c - fp_o$$

If friction power is not measured,

$$bp_c = bp_o\left[1.18\left(\frac{99}{B_{do}}\right)\left(\frac{t+273}{298}\right)^{0.5} - 0.18\right]$$

8.4.3 Diesel Engines—Corrected Brake Power at Constant Fuel Rate[3]

$$bp_c = bp_o\,(fa)^{fm}$$

Where: $fa = \left(\frac{99}{B_{do}}\right)^{1.1}\left(\frac{t+273}{298}\right)^{1.2}$ for naturally aspirated and mechanical supercharged engines,

or: $fa = \left(\frac{99}{B_{do}}\right)^{0.6}\left(\frac{t+273}{298}\right)^{0.6}$ for turbocharged and turbocharged aftercooled engines, and

where: fm = 0.036 x q/r - 1.14 for values of q/r between 40 and 65 mg/L cycle. For values of q/r less than 40, fm = 0.3. For values of q/r greater than 65, fm = 1.2,

where: q = 120 000 F/DN mg/L cycle for four-stroke cycle engines.

or: q = 60 000 F/DN mg/L cycle for two-stroke cycle engines, and

where the pressure ratio: