

Marine Engine Rating Code — SAE J1228 MAR80

SAE Recommended Practice
Approved March 1980

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MARINE ENGINE RATING CODE—SAE J1228 MAR80

SAE Recommended Practice

Report of the Marine Technical Committee, approved March 1980.

Purpose—The purpose of this code is to provide a standard for documenting the declared (rated) performance of a marine engine and a standard procedure for determining this performance in an engine dynamometer laboratory.

Scope—This recommended practice specifies the conditions of testing marine engine configuration for the determination of the rated power (single point) or power curve, when declaring *crankshaft power* or *propeller shaft power*. This code is not intended as a complete laboratory test manual or for derating engines for site conditions. (The rated power should give satisfactory expected life in the intended application.) This code is composed of the following Sections:

1. Definitions of Terminology
2. Test Equipment Requirements
3. Test Procedures
4. Computations and Results
5. Presentation of Results

References—ISO 3046/I—Reciprocating Internal Combustion Engines: Performance—Part I: Standard Reference Conditions and Declarations of Power, Fuel Consumption, and Lubricating Oil Consumption.

ISO 3046/II—Reciprocating Internal Combustion Engines: Performance—Part II: Test Methods.

ISO 3046/III—Reciprocating Internal Combustion Engines: Performance—Part III: Test Measurements.

ISO 2710—Reciprocating Internal Combustion Engines: Part I: General Definitions.

1. Definitions of Terminology

1.1 Power Output—Engine power output shall be expressed in units of *kilowatts* equivalent to 1000 J/s or *horsepower*, equivalent to 550 ft-lb/s.

1.1.1 Observed power is the power actually developed by an engine under the atmospheric conditions existing during the test.

1.1.2 Corrected power is the observed power adjusted to standard atmospheric conditions, using the correction methods specified in paragraph 4.5.

1.2 Crankshaft power (CSP) is the usable power available from the crankshaft of an engine equipped only with those auxiliaries necessary for the continued or repeated operation of the engine at its declared power such as oil pumps, coolant circulating pump, cooling fan (air cooled engines), fuel pump, fuel injection equipment, scavenge air blower, etc. which are fitted to the engine. Crankshaft power is a power the manufacturer declares the engine is capable of delivering continuously between normal maintenance intervals with acceptable durability for the application.

1.3 Propeller shaft power (PSP) is the usable power available at the final output shaft of a propulsion system including an engine equipped with all the auxiliaries necessary to perform its intended function. This includes all auxiliaries fitted to the engine including complete air intake system, exhaust system, electrical system, cooling system, and power transmission equipment. Propeller shaft power is a power the manufacturer declares the engine is capable of delivering continuously between normal maintenance intervals with acceptable durability for the application.

1.4 The rated power is that power declared at a given speed (the rated speed). The rated crankshaft power determined according to the code is the ISO standard power.

1.5 Rated speed shall be the mid-point of the full throttle speed range recommended by the manufacturer for propeller selection, if a range is specified. Governed engines shall be rated at the governed speed.

2. Test Equipment Requirements—The required limits of accuracy concern the instrument precision specified by the manufacturer of the instruments used and do not include human or other probable errors involved in the reading.

2.1 Torque

2.1.1 Dynamometer and scale capacity shall be compatible with engine size. Dynamometer shall be capable of maintaining load and speed conditions as defined in Section 3.

2.1.2 Dynamometer coupling drive between engine and dynamometer shall be suitable for operation through the test engine speed range.

2.1.3 Dynamometer Balance, Calibration, and Sensitivity

2.1.3.1 Scales shall be checked for zero scale reading with the dynamometer frame in the neutral position.

2.1.3.2 Calibration of the dynamometer with the engine running at some fixed (beam) load, for example 50 daN or 100 lb, shall be checked by the addition of a 50 daN or 100 lb weight to the opposite side which should bring the scale back to zero. This shall be done for several different loads within the range of expected operation and shall be repeated under

static conditions. This resulting calibration shall be accurate within $\pm 1/2\%$ of the observed full load reading.

2.1.3.3 Sensitivity of the dynamometer and scales shall be checked by adding small increments of weight until the pointer moves a readable amount. The magnitude of this weight, which is the sensitivity, shall not exceed 1/4% of the observed full load reading. Several points shall be checked within the operating range.

2.2 Speed

2.2.1 Revolution counter shall be accurate within $\pm 1/4\%$ of the observed reading or ± 10 revolutions, whichever may be less.

2.2.2 Tachometer shall be accurate within $\pm 1/2\%$ of the observed value if the reading is used for computations.

2.3 Time—The time measuring instruments shall be accurate within $\pm 1/4\%$ of the observed reading.

2.4 Fuel Systems—The engine fuel system used in the test shall be in accordance with the manufacturer's specifications.

2.5 Temperatures

2.5.1 Temperatures shall be measured in degrees Celsius using metric units or degrees Fahrenheit using English units.

2.5.2 Accuracy of instrumentation for measuring temperatures of 204°C (400°F) or less shall be $\pm 1^\circ\text{C}$ ($\pm 2^\circ\text{F}$), and at temperatures above 204°C (400°F) shall be $\pm 5.5^\circ\text{C}$ ($\pm 10^\circ\text{F}$).

2.5.3 The necessary temperature measurements and corresponding locations are as follows:

2.5.3.1 Temperature of the inlet air to the engine (ambient air) shall be measured in a manner to get a mass average temperature. The temperature shall be taken in the engine inlet air stream or within 152 mm (6 in) of the air inlet horn or inlet cleaner. Care should be taken to shield the thermometer or thermocouple from radiant heat sources, and a sufficient number of locations shall be checked to assure a representative average inlet temperature.

2.5.3.2 *Coolant Temperatures*—Water jacket temperatures in liquid-cooled engines shall be measured at the outlet of the engine. Temperatures in air-cooled engines should be measured at point(s) specified by the manufacturer, such as spark plug(s) and cylinder head fin(s).

2.5.3.3 Oil temperatures shall be measured in the oil gallery, if feasible.

2.6 Pressures

2.6.1 Pressures shall be measured in kilopascals (pounds per square inch), millimeters (inches) of mercury, or millimeters (inches) of water either above or below atmospheric pressure.

2.6.2 Required instrument accuracies are as follows:

2.6.2.1 Air cleaner and piping restriction ± 2.5 mm H₂O (± 0.1 in H₂O).

2.6.2.2 Exhaust pressure measurements ± 2.5 mm Hg (± 0.1 in Hg).

2.7 Atmospheric Conditions

2.7.1 All measurements shall be made in a location representative of the engine's test environment.

2.7.2 Barometric pressure shall be measured with an aneroid or mercury barometer corrected for temperature and accurate within ± 0.50 mm Hg (± 0.02 in Hg).

2.7.3 Wet and dry bulb temperatures shall be measured with a sling-psychrometer or equivalent. The thermometers used shall be accurate within $\pm 0.28^\circ\text{C}$ ($\pm 0.5^\circ\text{F}$).

3. Test Procedures—This Section contains the required test procedures for determining the following engine performance characteristics—crankshaft power and propeller shaft power.

3.1 Description of Tests

3.1.1 Crankshaft power tests consist of a run at full throttle (or full load) to determine power output versus speed of the engine as defined in paragraph 1.2.

3.1.2 Propeller shaft power tests consist of a run at full throttle (or full load) to determine power output versus speed of the propulsion system as defined in paragraph 1.3.

3.2 Engine Installation and Adjustments—The test engine shall be a representative unit within the manufacturer's specifications. All auxiliary equipment fitted to the test engine shall be listed and described.

The engine shall be mounted on the dynamometer stand at an installation angle typical for its application. If it is necessary because of test bed conditions to utilize auxiliary equipment, such as exhaust piping, not furnished with the propulsion system, the specific conditions must be within the manufacturer's recommended operating recommendations and shall be so declared. If engine exhaust is connected to a laboratory exhaust system, that system shall not cause a vacuum of more than 76 mm (3 in) of water or a back pressure exceeding the value specified by the manufacturer at the

point specified by the manufacturer. If the engine air inlet is connected to a laboratory air system, the system shall neither supply air to the engine above atmospheric pressure nor at a vacuum.

The generator or alternator, hydraulic systems, and similar systems intended for intermittent operation shall be operated under no-load conditions.

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

3.3 Run-In—The engine shall be run-in until power stabilizes according to the manufacturer's recommendations. If no such recommendation is available, the engine shall be run-in until power is repeatable within 1% over a 4 h period.

3.4 Fuels and Lubricants

3.4.1 Fuel used shall conform to the manufacturer's specifications:

3.4.1.1 For spark ignition engines, record research and motor octane numbers and API gravity of liquid fuel.

3.4.1.2 For compression ignition engines, record cetane number, API gravity and J/kg (Btu/lb), ASTM or other fuel specifications.

3.4.2 Lubricating oil used shall conform with the manufacturer's recommendations. Record oil performance level and SAE viscosity number of the lubricant.

3.5 Test Conditions—Performance data shall be obtained under stabilized normal operating conditions, with an adequate fresh air supply to the engine. Combustion chambers shall be free of deposits. Test conditions, such as inlet air temperature, should be selected as near to standard as possible (paragraph 4.3) in order to minimize the magnitude of the correction factor.

3.5.1 No data shall be taken until torque, speed, and engine temperature have been maintained within 1% for at least 2 min.

3.5.2 Engine speed should be held as nearly constant as possible during a run or reading and shall not deviate from the nominal speed by more than $\pm 1\%$ or ± 10 rpm, whichever is greater.

3.5.3 Observed dynamometer load, rpm, ambient air temperature, ambient air pressure, wet and dry bulb readings, and fuel consumption data if recorded shall be taken simultaneously and shall be the average of at least two stabilized sustained values which do not vary more than 1%. A measuring interval of not less than 30 s shall be used when measuring speed and fuel consumption with an automatically synchronized counter timer combination; for hand operation, the time interval shall be not less than 120 s.

3.5.4 Coolant outlet temperature in liquid-cooled engines shall be controlled at 71°C (160°F) $\pm 5^\circ\text{C}$ unless otherwise specified by the manufacturer.

3.5.4.1 Sea water inlet temperature shall be 27°C (80.6°F) $\pm 2^\circ\text{C}$.

3.5.5 Fuel temperature at the inlet of compression ignition engine fuel pump shall be controlled to 37.8°C (100°F) $\pm 5.5^\circ\text{C}$.

3.6 Procedures

3.6.1 Crankshaft Power Test

3.6.1.1 *Engine Equipment and Settings*—(See paragraph 1.2.)

3.6.1.2 *Procedure*—Record data at rating speed, or to develop a curve, record data for at least five (approximately equal spaced) operating speeds to define completely the power curve between 600 rpm (or the lowest stable speed) and the maximum engine speed recommended by the manufacturer, or 200 rpm past peak power.

3.6.1.3 *Data to be Recorded for Test Documentation*—(See Fig. 1.)—To be recorded simultaneously (within 1 min):

Speed
Torque or Beam Load
Barometric Pressure
Barometer Temperature
Wet and Dry Bulb Temperature
Fuel Temperature (Diesel Only)
Inlet Air Temperature

Also record:

Laboratory Exhaust System Pressure
Oil Temperature
Coolant Temperature

The following data should be recorded where applicable or for safety of operation:

Fuel Consumption
Oil Pressure
Intake Manifold Temperature and Pressure
Exhaust Temperature
Exhaust Back Pressure (See paragraph 3.2)
Air Inlet Restriction
Ignition Timing
Injection Timing

Fuel Supply Pressure

3.6.2 Propeller Shaft Power Test

3.6.2.1 *Engine Equipment and Settings*—(See paragraph 1.3.)

3.6.2.2 *Procedure*—Same as Crankshaft Power Test—(See paragraph 3.6.1.2).

3.6.2.3 *Data to be Recorded for Test Documentation* (See Fig. 1)—Same as Crankshaft Power Test.

4. Computations and Results

4.1 Definition of Symbols (See Fig. 2)

4.2 Useful Equivalents

1 kg = 2.2046 lb mass
1 KN = 2.247 lb force

1 $\frac{\text{KN}}{\text{cm}^2}$ = 14.499 lb/in²

1 hp = 33 000 ft/lb/min

1 kW = 6000 KNm/min

1 kW = 1.341 hp

4.3 Standard Ambient Conditions

Total barometric pressure 100 kPa, 100 KN/m², 750 mm Hg, 29.53 in Hg
Temperature 300°K, 27°C, 80.6°F

Relative humidity 60% (2.133 kPa (16 mm Hg) (0.63 in Hg))

4.4 Computations from Test Data

4.4.1 Observed Power—The general formula for observed power is:

$$P_o = \frac{NL}{K}$$

In the designated SI units, the observed power in kilowatts is:

$$P_o = 1.047 \cdot 10^{-3} \cdot L \cdot N \text{ (dynamometer) } \cdot R$$

4.4.2 Observed Torque—The general formula for observed torque is:

$$T_o = L \cdot R$$

4.5 Corrected Power—The performance of engines is affected by barometric pressure, temperature, and humidity of the ambient atmosphere. Therefore, in order to provide a common basis of comparison, it is necessary to apply a correction factor to convert the observed data to specified standard atmospheric conditions.

$$P_c = P_o \cdot C$$

4.5.1 Spark Ignition Engines—The general formula for the power correction factor for spark ignition engines is:

$$C = \frac{B^*}{B_o} \cdot \left(\frac{t_o + A}{t_* + A} \right)^{0.5}$$

In the designated SI units, the correction factor is:

$$C = \frac{734}{B-c} \cdot \left(\frac{t_o + 273}{300} \right)^{0.5}$$

4.5.2 Compression Ignition Engines—The general formula for the power correction factor for compression ignition engines is:

$$C = \left(\frac{f_a}{f_m} \right) f_m$$

where f_a is the atmospheric factor and
where f_m is the engine characteristic factor

4.5.2.1 *Atmospheric Factor*—This factor indicates effect of environmental condition (pressure, temperature, and humidity) on the air drawn in by the engine. The atmospheric factor formula differs according to the types of engines.

4.5.2.1.1 Naturally Aspirated and Mechanically Supercharged Engines

$$f_a = \frac{734}{B-c} \cdot \left(\frac{t_o + 273}{300} \right)^{0.7}$$

REQUIRED DATA—(CRANKSHAFT OR PROPELLER SHAFT POWER)		
1. Speed	rpm	
2. Torque or Beam Load	Torque Beam Load	KNm (lb-ft) KN (lb)
3. Intake Air Temperature		°C (°F)
4. Fuel Temperature (Diesel Only)		°C (°F)
5. Barometric Air Temperature		°C (°F)
6. Barometric Air Pressure		mm Hg (in Hg)
7. Wet and Dry Bulb Temperature		C (°F)
8. Laboratory Exhaust System Pressure		kPa (mm H ₂ O) (in H ₂ O)
9. Oil Temperature		°C (°F)
10. Coolant Temperature		°C (°F)
11. Fuel per Cycle (Compression Ignition Engines)		mg/L/cycle
OPTIONAL DATA		
1. Air Inlet Restriction		kPa (mm H ₂ O) (in H ₂ O)
2. Oil Pressure		kPa (lb/in ²)
3. Intake Manifold Temperature		C (°F)
4. Intake Manifold Pressure		kPa (mm Hg) (in Hg)
5. Exhaust Temperature		C (°F)
6. Ignition or Injection Timing		deg
7. Fuel Supply Pressure		kPa (mm Hg) (lb/in ²)
8. Temperature of Coolant to Sea Water Pump		C (°F)

FIG. 1

SYMBOL	DEFINITION	UNITS	
		SI	ENGLISH
A	Absolute Temperature Constant	273	460
B	Barometric Pressure	mm Hg	in Hg
C	Correction Factor		
D	Engine Displacement	L	in ³
F	Fuel Consumption	g/h	lb/h
G	Power Constant	955	5252
K	Dynamometer Constant	G/R	G/R
L	Dynamometer Scale Reading	KN	lb
M	Time of Fuel Measurement	min	min
N	Dynamometer Speed	rpm	rpm
P	Power	kW	hp
R	Dynamometer Torque Arm	m	ft
T	Torque	KNm	lb-ft
V	Volume of Fuel Measured	cm ³	cm ³
W	Mass of Fuel	g	lb
d	Air Density	kg/m ³	lb/ft ³
e	Water Vapor Pressure in Atmosphere	mm Hg	in Hg
t	Ambient Temperature	°C	°F
(sp. gr.)	Specific Gravity of Fuel at Tank or Burette Temperature		
Subscripts			
c	Corrected to Standard Conditions		
o	Observed at Test Conditions		
Subscript*	To Denote Standard Ambient Conditions		

FIG. 2

4.5.2.1.2 Turbosupercharged Engines With or Without Cooling of Inlet Air

$$f_a = \left(\frac{734}{B-e} \right)^{0.7} \left(\frac{t_o + 273}{300} \right)^{1.5}$$

4.5.2.2 Engine Factor— f_m is a function of corrected fuel flow.

$$f_m = 0.0356 q_c - 1.14 \text{ (this engine factor is valid only for } 0.9 \leq C \leq 1.1 \text{)}$$

where:

$$q_c = q/r$$

q = fuel flow in mg/L/cycle

r = pressure ratio (r equal to unity is taken for naturally aspirated engines)

This formula is valid for a value interval of q_c included between 40 mg/L/cycle and 65 mg/L/cycle.

$$40 \text{ mg/L/cycle} \leq q_c \leq 65 \text{ mg/L/cycle}$$

For q_c values lower than 40 mg/L/cycle, a constant value of f_m equal to 0.3 ($f_m = 0.3$) shall be used.

For q_c values higher than 65 mg/L/cycle, a constant value of f_m equal to 1.2 ($f_m = 1.2$) shall be used (see Fig. 3).

5. **Presentation of Results**—The computed values may be presented graphically. Data shall be corrected per paragraph 4.5. Reported corrected curves shall carry the notation: *Performance obtained and corrected in accordance with SAE J1228*. (See Fig. 4 for typical presentation.)

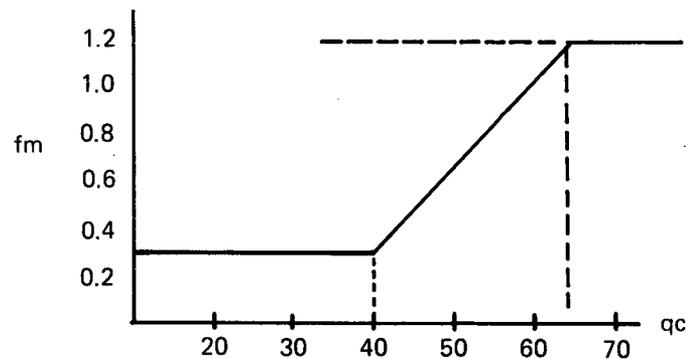


FIG. 3