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SAE J1228 MAR86

Marine Engine Rating Code

SAE Recommended Practice
Revised March 1986

Submitted for Recognition as
an American National Standard

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Comparable to ISO 3046.

REFERENCE SECTION:

ISO 3046

ISO 1000, SI Units

ISO 2710, Reciprocating Internal Combustion Engines: Vocabulary

ISO 3046/1, Reciprocating Internal Combustion Engines: Performance-Part I: Standard Reference Conditions and Declarations of Power, Fuel Consumption, and Lubricating Oil Consumption

ISO 3046/2, Reciprocating Internal Combustion Engines: Performance-Part II: Test Methods

ISO 3046/3, Reciprocating Internal Combustion Engines: Performance-Part III: Test Measurements

APPLICATION:

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

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SPECIALIZED VEHICLE PRACTICE

Submitted for recognition as an American National Standard

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Supersedes J1228 JUN84

MARINE ENGINE RATING CODE

Comparable to ISO 3046

CONTENTS: This code is composed of the following sections:

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

SCOPE: This recommended practice specifies requirements in addition to those given in ISO 3046 for testing a high speed reciprocating internal combustion marine propulsion engine or propulsion system for recreational and small commercial craft, for the determination of the rated power (single point) or power curve. This code is not intended as a complete laboratory test manual or for derating engines for site conditions.

REFERENCES:

ISO 3046/1 - Reciprocating Internal Combustion Engines: Performance-Part I: Standard Reference Conditions and Declarations of Power, Fuel Consumption, and Lubricating Oil Consumption.

ISO 3046/2 - Reciprocating Internal Combustion Engines: Performance-Part II: Test Methods.

REFERENCES (Cont'd.):

ISO 3046/3 - Reciprocating Internal Combustion Engines: Performance-Part III: Test Measurements.

ISO 2710 - Reciprocating Internal Combustion Engines: Vocabulary.

ISO 1000 - SI Units.

1. TERMINOLOGY AND POWER DECLARATIONS:

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

1.2 Corrected power is the observed power adjusted to the standard atmospheric conditions specified in ISO 3046/1 using the correction methods specified in ISO 3046/2.

1.3 Power shall be declared (rated) at the final output shaft of the engine or propulsion unit as offered for sale by the manufacturer and according to the following principles:

1.3.1 The rated power is that power declared at a given crankshaft speed (the rated speed).

1.3.1.1 In the case of ungoverned engines, if any power within the manufacturer's recommended speed range exceeds the rated power by more than 6%, it shall be stated additionally.

1.3.2 Propeller Shaft Power shall be declared at the propeller shaft of engines sold with complete propulsion units, and at the coupling to the propeller shaft of inboard engines sold with reduction or reversing gear.

1.3.3 Crankshaft Power shall be declared at the crankshaft (flywheel) of engines sold without reduction gears, stern drive, or sail drive units. Declaration of rated power shall contain a statement that usable power will be reduced by transmission or gear box losses.

1.3.4 In the case of ungoverned engines, the rated speed shall be the midpoint of the full throttle speed range recommended by the manufacturer for propeller selection.

1.3.5 In the case of governed engines, the rated speed shall be that speed declared by the manufacturer.

2. TEST MEASUREMENTS: Test measurements and their degree of accuracy shall be as specified in ISO 3046/3.

2.1 Temperatures:

2.1.1 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 150 mm of the air inlet horn to the air cleaner. (Inside the engine cowl, if furnished.)

2.1.2 Temperature of coolant medium shall be measured within 150 mm of sea water inlet. Water jacket temperatures in liquid-cooled engines shall be measured at the inter-cooler inlet if applicable, or at an outlet point of the engine specified by the manufacturer. Temperatures in air-cooled engines should be measured at point(s) specified by the manufacturer, such as spark plug(s) or cylinder heads.

2.1.3 Oil temperatures shall be measured at point(s) specified by the manufacturer.

3. TEST PROCEDURES: This section contains the required test procedures for determining propeller shaft power and crankshaft power.

3.1 Description of Tests:

3.1.1 Power tests consists of runs at full throttle to determine power output as defined in paragraph 1.3.

3.2 Engine Installation: The test engine or propulsion system shall be representative of the manufacturer's production units, and shall be fitted with the exhaust system and all auxiliary equipment delivered with the unit except the propeller. Auxiliary equipment shall be listed and described.

3.2.1 Carburetor wedges may be removed or added to maintain carburetors in a normal running angle if the engine is run in a horizontal position.

3.2.2 If it is necessary to utilize auxiliary equipment, such as an exhaust piping, not furnished with the propulsion system, the exhaust back pressure at rated speed shall be within 0.75 kPa of the maximum back pressure specified by the manufacturer at which rated power can be achieved. If the exhaust system as delivered is not complete, and no back pressure is specified by the manufacturer, the unit will be operated at 10 kPa ± 0.75 kPa back pressure measured at the exit of the engine exhaust manifold or turbocharger. If the exhaust system as delivered, is complete, the laboratory exhaust system shall maintain exhaust pressure at the unit outlet within ±0.75 kPa of barometric pressure at the test bed.

3.2.3 If the engine air inlet is connected to a laboratory air system, the system shall supply air to the engine within ±0.75 kPa of barometric pressure at the test bed.

3.2.4 For liquid cooled engines, the temperature of the coolant at the sea water inlet shall be maintained at 20 ± 15°C, except that for inter-cooled engines the temperature shall be maintained at 20 ± 5°C. The coolant supply pressure shall not exceed 50 kPa. The coolant outlet temperature shall be within the range specified by the manufacturer if a range is specified.

3.2.5 Fuel temperature at the inlet of the compression ignition engine fuel injection pump shall be controlled to 40°C ± 3°C.

3.3 Run-In: The engine shall be run-in according to the manufacturer's recommendations.

3.4 Fuels/Lubricants:

3.4.1 Fuels used shall conform to the manufacturer's specifications.

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

3.4.1.2 For compression ignition engines, record cetane number API gravity and heat content. Use ASTM D975-2D or equivalent fuel if compatible with the engine.

3.4.2 Lubricating oil used shall conform with the manufacturer's recommendations. Record oil performance level designation and SAE viscosity number (if applicable), 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. Test conditions, such as inlet air temperature, should be controlled as near to standard as possible (see paragraph 1.2) in order to minimize the magnitude of the correction factor. 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.

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

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

3.5.3 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 ±1% or ±10 rpm, whichever is greater.

3.5.4 All fluid levels shall be within the range specified by the manufacturer.

3.5.5 Wet exhaust systems shall be operated with normal water flow.

3.6 Data Acquisition:

3.6.1 Observed dynamometer load, speed, 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.

3.6.2 Power Test Data to be Recorded for Test Documentation: See Fig. 1. To be recorded simultaneously (within 1 min):

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

Also record:

Laboratory Exhaust System Pressure
Oil Temperature (see paragraph 2.1.3)
Coolant Temperature at Sea Water Inlet and Engine Outlet (see paragraphs 2.1.2 and 3.2.4)
Coolant Supply Pressure (see paragraph 3.2.4)
Fuel per Cycle (Diesel Only)
Exhaust Back Pressure (see paragraph 3.2.2)
All Auxiliary Equipment

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

Oil Pressure
Intake Manifold Temperature and Pressure
Exhaust Temperature
Ignition of Injection Timing
Fuel Supply Pressure
Fuel Consumption

4. PRESENTATION OF RESULTS: The corrected power value shall be used to determine rated power (single point) together with the rated speed, or may be presented graphically. Data shall be corrected per paragraph 1.2. Reported corrected curves shall carry the notation: Performance obtained and corrected in accordance with SAE J1228 Propshaft Power, or SAE J1228 Crankshaft Power. Power shall be expressed in units of kilowatts. In addition, power may be expressed in English units of horsepower, equivalent to 0.746 kW.

5. POWER TOLERANCE: The corrected power at the rated speed of any marine propulsion engine or propulsion system shall not deviate from the declared (rated) power by more than ±10% or 0.45 kW, whichever is greater, except that governed propulsion engines and systems rated above 100 kW shall not deviate from the rated power by more than ±5%.

REQUIRED DATA--(CRANKSHAFT OR PROPELLER SHAFT POWER)		
1. Speed	rpm	
2. Torque or Beam Load	Torque	KNm (lb-ft)
	Beam Load	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_2O) (in H_2O)
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_2O) (in H_2O)
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

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APPENDIX A

For the convenience of the user, this appendix contains information contained in the applicable parts of the latest ISO 3046 standards, as of March 1, 1986.

A.1 STANDARD REFERENCE CONDITIONS: (Ref. ISO 3046/1, Third Edition)

The standard reference conditions are:

Total Barometric Pressure 100 kPa
Air Temperature 298 K
Relative Humidity 30% - equivalent to 1.0 kPa

A.2 CORRECTION METHODS: (Ref. ISO 3046/2, Second Edition)

Corrected power is equal to observed power times the correction factor. The correction methods are:

A.2.1 Spark Ignition Engines: The formula for the power correction factor for spark ignition engines in SI units is:

$$\alpha_a = \left(\frac{99}{P_y - \phi P_{sy}}\right)^{1.2} \left(\frac{T_y + 273}{298}\right)^{0.6}$$

Where: P_y is the barometric pressure in the test cell in kPa
ϕP_{sy} is the water vapor pressure in the test cell in kPa at applicable temperature and humidity
T_y is the intake air temperature in °C

A.2.2 Compression Ignition Engines: The general formula for the power correction factor for compression ignition engines:

$$\alpha_d = (f_a)^{fm}$$

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

A.2.2.1 The atmospheric factor indicates the effect of environmental conditions (pressure, temperature, and humidity) on the air drawn in by the engine. The atmospheric factor formula differs according to the types of engines. Naturally Aspirated and Mechanically Supercharged engines:

$$f_a = \left(\frac{99}{P_y - \phi P_{sy}}\right) \left(\frac{T_y + 273}{298}\right)^{0.7}$$

A.2.2.1 Continued:

Turbosupercharged Engines With or Without Cooling of Inlet Air:

$$f_a = \left(\frac{99}{P_y - \varnothing P_{sy}}\right)^{0.7} \left(\frac{T_y + 273}{298}\right)^{1.5}$$

A.2.2.2 Engine factor (f_m) is a function of corrected fuel flow.

$f_m = 0.036\ q_c - 1.14$ where: $q_c = q/r$ and:

q = fuel delivery per cycle measured in milligrams per liter of total swept volume.

r = rate of absolute pressure at compressor outlet to that at compressor inlet. (r is equal to one for naturally aspirated engines.)

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

$$40 \leq q_c \leq 65$$

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

For q_c values higher than 65, a constant value of f_m equal to 1.2 ($f_m = 1.2$) shall be used. (See Fig. A-1.)

A.2.2.3 Limitation in Use of the Correction Formula: This correction formula is only applicable where the correction factor α_d is between 0.9 and 1.1, the ambient temperature of the air inlet of the engine is $T_r \pm 15°C$ and the dry barometric pressure is 80 - 110 kPa. If these limits are exceeded, the correction value obtained shall be given, and test ambient conditions (temperature and pressure) precisely stated in the test report.

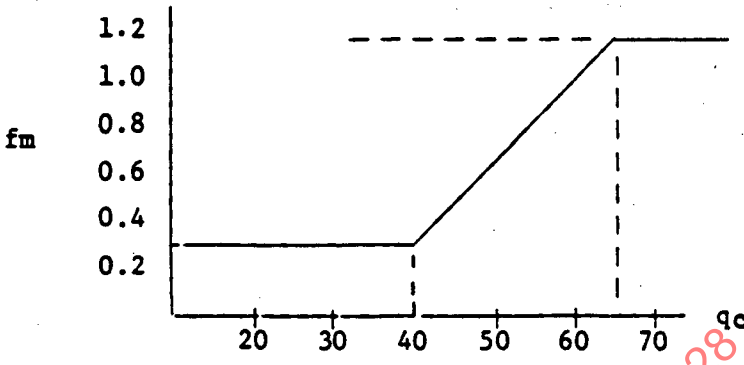

FIGURE A - 1

A.3 MEASUREMENT CONDITIONS AND DEFINITIONS OF DEGREES OF ACCURACY: (Ref. ISO 3046/2, First Edition.)

A.3.1 Operating Conditions:

A.3.1.1 Before a set of measurements is commenced, the engine shall have operated at the particular conditions of load and speed for a sufficient length of time to ensure that the operating temperatures have reached stable conditions as laid down by the manufacturer.

A.3.1.2 During the period in which a set of measurements is being made, the load, speed and all fluid temperatures and pressure shall be maintained constant within the limits of accuracy of measurement given in Section A.4.

A.3.2 Methods of Measurement:

A.3.2.1 Methods of measurement are selected by the manufacturer and, if necessary, may be subject to contractual agreement between the manufacturer, customer and/or inspecting authority.

A.3.2.2 The location of points of measurement is selected by the manufacturer.

A.3.3 Accuracy of Measurement:

A.3.3.1 The accuracy of measurement indicated in Section A.4 applies to the power declared and not only includes the accuracy of the instrument being used but also involves the correctness of its location, the conditions under which it is being used, and the interpretation of the results obtained.