SAE International™ SURFACE VEHICLE STANDARD

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Small Craft—Marine Propulsion Engine and Systems—Power Measurements and Declarations

This document is technically equivalent to ISO 8665.

1. ***Scope—***This SAE Standard specifies the test requirements in addition to those given in ISO 3046-1 for determining the power, at a single point or as a power curve, of marine propulsion engines or systems for recreational craft and other small craft using similar propulsion equipment of less than 24 m length of the hull.

It also provides the means for documenting and checking the declared (rated) power published by the manufacturer.

2. ***References***

2.1 **Applicable Publications—**The following standards contain provisions which, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards listed as follows. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1.1 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO3046-1:2002—Reciprocating internal combustion engines—Performance—Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods—Additional requirements for engines for general use
ISO3046-3:1989—Reciprocating internal combustion engines—Performance—Part 3: Test measurements
ISO 3675:1998—Crude petroleum and liquid petroleum products—Laboratory determination of density—Hydrometer method
ISO 5163:1990—Motor and aviation-type fuels—Determination of knock characteristics—Motor method
ISO 5164:1990—Motor fuels—Determination of knock characteristics—Research method
ISO 5165:1998—Petroleum Products—Determination of ignition quality of diesel fuels—Cetane engine method
ISO 8217:1996—Petroleum Products—Fuels (class F)—Specifications of marine fuels

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3. Definitions and Declarations

3.1 Declared Engine Speed (Crankshaft Speed)

3.1.1 In the case of spark-ignition engines without speed governor, the declared engine speed shall be the midpoint of the full throttle speed range recommended by the manufacturer for propeller selection.

3.1.2 In the case of engines with speed governors, the declared engine speed shall be the governed speed chosen by the manufacturer.

3.2 Declared Power—The corrected net brake power declared for a given engine or propulsion system at its final output shaft when all the auxiliaries which affect the power output are fitted. The declared power shall be determined and corrected according to ISO 3046-1.

3.2.1 The declared power shall be "*propeller shaft power*" and so named at the propeller shaft of engines sold with complete propulsion units, and at the coupling to the propeller shaft of engines sold with reduction or reversing gears.

3.2.2 The declared power shall be "*crankshaft power*" and so named at the engine output shaft of engines sold without reduction or reversing gears or stem drives or sail drive units. In such cases, the power declaration shall be accompanied by a statement that usable power will be reduced by gear losses.

4. Test Equipment

4.1 Engine or Propulsion System

4.1.1 The test engine or propulsion system shall be representative of the manufacturer's production units. It shall be run-in according to the manufacturer's recommendations and shall be fitted with an exhaust system. All auxiliaries fitted shall be listed and described.

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

4.1.3 If the exhaust system as delivered is not complete, the back-pressure at the declared engine speed shall be within ±0.75 kPa of the maximum back-pressure specified by the manufacturer at which the declared power can be achieved.

If the exhaust system as delivered is complete, the laboratory exhaust system shall maintain the exhaust pressure at the unit outlet within ±0.75 kPa of the barometric pressure at the test bed.

NOTE—The maximum permissible back-pressure declaration is required by ISO 3046-1.

4.1.4 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 the barometric pressure at the test bed.

4.1.5 For liquid-cooled engines, the temperature of the coolant at the raw-water inlet shall be maintained at 298 K ± 15 K (25 °C ± 15 °C) except that for engines with charge air cooler the temperature shall be maintained at 298 K ± 5 K (25 °C ± 5 °C).

The coolant pressure shall not exceed 50 kPa. The coolant outlet temperature shall be within the range specified by the manufacturer if such a range is specified.

4.1.6 Fuel temperature at the inlet of the compression-ignition engine fuel-injection pump shall be maintained at 313 K ± 3 K (40 °C ± 3 °C).

NOTE—These requirements are not applicable for compression ignition engines running on intermediate or heavy fuels.

4.2 Fuels and Lubricants

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

4.2.2 For spark-ignition engines, record the octane number determined in accordance with ISO 5163 (motor method) and ISO 5164 (research method), and density determined in accordance with ISO 3675.

4.2.3 For compression-ignition (diesel) engines, record the cetane number determined in accordance with ISO 5165, the density determined in accordance with ISO 3675 or API gravity, and lower calorific value. Use ISO-F-DMX (see ISO 8217) or equivalent fuel if compatible with the engine.

4.2.4 Lubricating oil used shall conform to the manufacturer's recommendations. Record lubricating oil type, grade and, if applicable, viscosity of the lubricant.

5. Test Conditions

5.1 Test conditions should be maintained as near to standard reference conditions as possible (see 3.2) 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.

5.2 Generator and Hydraulic Systems—The generator or alternator, hydraulic systems and similar systems intended for intermittent load only shall be operated under no-load conditions.

5.3 Engine Stabilization—No data shall be taken until the engine has reached stable operating conditions maintained for at least 2 min within the permissible deviations prescribed in ISO 3046-3 clause 4.2.

5.4 Engine Speed—During a run or reading the engine speed shall not deviate from the nominal speed by more than ±1% or ±10 r/min, whichever is greater.

5.5 Fluid Levels—All fluid levels shall be within the range specified by the manufacturer.

5.6 Wet Exhaust System—Wet exhaust systems shall be operated with the water flow necessary for normal installations.

6. Data Acquisition

6.1 Accuracy—Test measurements and their degree of accuracy shall be as specified in ISO 3046-3.

6.2 Air Temperature—The temperature of the inlet air to the engine (ambient air) shall be measured so as to obtain a mass average temperature. The temperature shall be taken in the engine inlet air stream or within 150mm of the air inlet to the air cleaner, silencer, or flame arrester.

On outboard engines the cowl, if supplied, shall be regarded as a part of the air inlet system.

6.3 Temperature of Coolant—The temperature of the coolant medium shall be measured not further than 150mm from the raw-water inlet. Water jacket temperatures in liquid-cooled engines and engine temperatures in air-cooled engines shall be measured at point(s) specified by the manufacturer.

6.4 Lubricating Oil Temperature—Lubricating oil temperatures shall be measured at point(s) specified by the manufacturer.

6.5 Readings—Observed dynamometer load, engine 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 the permissible deviations prescribed in ISO 3046-3 clause 4.2, except that engine speed shall not vary more than ±1% or ±10 r/min, whichever is greater.

A measuring interval of not less than 30 s shall be used when measuring engine speed and fuel consumption.

6.6 Recording of Results—Power test data given in 6.6.1 to 6.6.3 should be recorded.

6.6.1 The following data shall be recorded simultaneously, within 1 min:

a. Engine speed
b. Torque or beam load
c. Intake air temperature and pressure at the point located and specified in 6.2
d. Fuel temperature (for compression-ignition [diesel] engines only)
e. Ambient air temperature of the atmosphere
f. Barometric pressure at the test bed
g. Wet and dry bulb temperature

6.6.2 The following data shall also be recorded:

a. Laboratory exhaust system pressure (see 4.1.3)
b. Lubricating oil temperature (see 6.4)
c. Coolant temperature at raw-water inlet and engine outlet (see 4.1.5 and 6.3)
d. Coolant supply pressure (see 4.1.5)
e. Fuel delivery per injection cycle (for compression ignition [diesel] engines only and if the engine has no acceptance test)
f. Exhaust back-pressure (see 4.1.3)

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

a. Lubricating oil pressure
b. Intake air temperature and pressure inside the air intake manifold
c. Exhaust gas temperature
d. Ignition or injection timing
e. Fuel supply pressure at supply-pump outlet
f. Fuel consumption per unit of time

7. Presentation of Data

7.1 Declaration of Power and Speed—A single value of the declared power shall be accompanied by a statement of the declared engine speed.

Power and engine speed may alternatively be presented as a power curve. Declarations shall indicate whether the power is propeller shaft power (see 3.2.1) or crankshaft power (see 3.2.2).

7.2 Engine Speed Range and Declared Power—It is recommended to choose the full throttle engine speed range quoted in 3.1.1 so that the highest power within this range does not exceed the declared power by more than 6%. If the highest power exceeds declared power by more than 6%, both powers shall be stated.

8. ***Manufacturing Tolerance—*** The declared (rated) power at declared (rated) engine speed of any individual marine propulsion engine or propulsion system shall not deviate from its measured value by more than:

a. ±5% for engines or propulsion systems with speed governors of more than 100 kW declared power, or
b. ±10% or ±0.45 kW, whichever is greater, for all other engines and propulsion systems.

9. ***Notes***

9.1 **Marginal Indicia—** The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE MARINE TECHNICAL COMMITTEE

APPENDIX A

For the convenience of the user, this appendix contains applicable portions of the information contained in the latest ISO 3046-1 and ISO 3046-3 Standards.

A.1 Standard Reference Conditions—(Reference ISO 3046-1, 4th Edition)

The standard reference conditions are:

a. Total Barometric Pressure—100 kPa
b. Air Temperature—298 K
c. Relative Humidity—30% (equivalent to 1.0 kPa)
d. Charge Air Coolant Temperature—300 K

A.2 Correction Methods—(Reference ISO 3046-1, 4th 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 naturally aspirated and pressure charged spark ignition engines in SI units is:

$$\alpha_a = \left(\frac{99}{P_y - \Phi P_{sy}}\right)^{1.2}\left(\frac{T_y + 273}{298}\right)^{0.6} \quad \text{(Eq. A1)}$$

where:

P_y is the barometric pressure in the test cell (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

This formula applies to carburetted engines and to other engines where the fuel management system is designed to maintain a relatively constant fuel/air ratio as ambient conditions change.

A.2.1.1 LIMITATION IN USE OF CORRECTION FORMULA—This formula is only applicable if the correction factor $_a$ is between 0.93 and 1.07, the ambient temperature at the air inlet to the engine is ±10 °C, and the dry barometric pressure is 80 to 100 kPa. If these limits are exceeded the corrected value obtained shall be given, and the test ambient conditions (temperature and pressure) precisely stated in the test report.

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

$$\alpha_d = (f_a)^{fm} \quad \text{(Eq. A2)}$$

f_a is the atmospheric factor
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 engines, mechanically pressure charged engines, and turbocharged engines with waste gates operating:

$$f_a = \left(\frac{99}{P_y - \Phi P_{sy}}\right)\left(\frac{T_y + 273}{298}\right)^{0.7} \quad \text{(Eq. A3)}$$

Turbocharged engines without charge air cooling or with charge cooling by air/air cooler:

$$f_a = \left(\frac{99}{P_y - \Phi P_{sy}}\right)^{0.7}\left(\frac{T_y + 273}{298}\right)^{1.2} \quad \text{(Eq. A4)}$$

Turbocharged engines with charge air cooling by engine coolant:

$$f_a = \left(\frac{99}{P_y - \Phi P_{sy}}\right)^{0.7}\left(\frac{T_y + 273}{298}\right)^{0.7} \quad \text{(Eq. A5)}$$

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

$$f_m = \frac{0.036q}{r} - 1.14 \quad \text{(Eq. A6)}$$

where:

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 = 1.0 for naturally aspirated engines)

This formula is valid for a value interval of q/r included between 37.2 mg/L and 65 mg/L. For q/r values lower than 37.2, a constant value of f_m = 0.2 shall be used. For q/r values higher than 65, a constant value of f_m = 1.2 shall be used. (See Figure A1.)

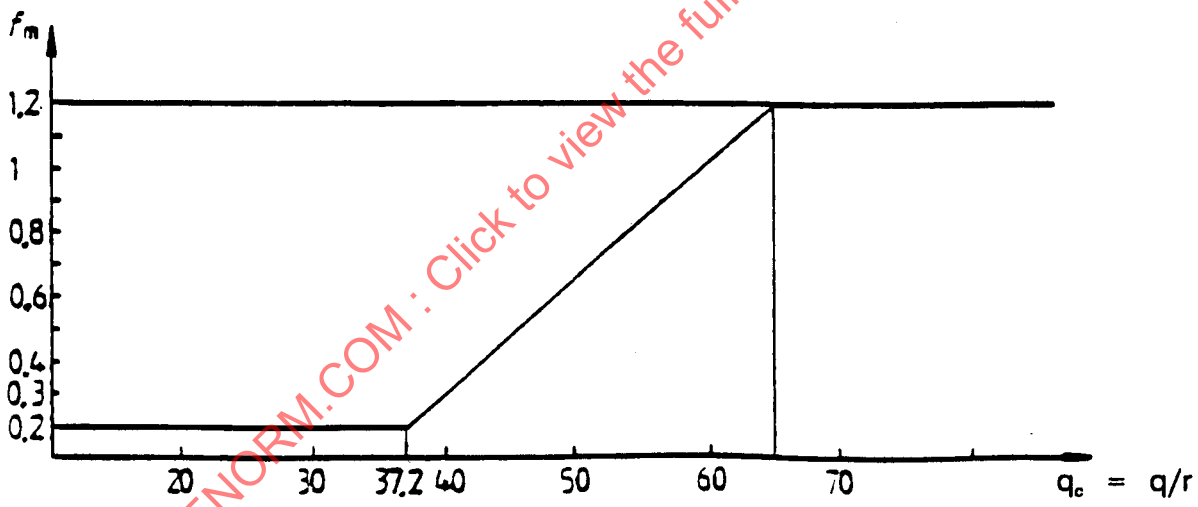

FIGURE A1—ENGINE FACTOR OF CORRECTED FUEL FLOW

A.2.2.3 LIMITATION IN USE OF CORRECTION FORMULA—This correction formula is only applicable where the correction factor α_d is between 0.9 and 1.1, the ambient temperature at the air inlet of the engine is ±15 °C and the dry barometric pressure is 80 to 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.

A.3 Measurements and Accuracy—(Reference ISO 3046-3, 2nd Edition)

A.3.1 Accuracy of Measurement—The accuracy of measurement depends on a number of factors. Therefore, for all parameters measured it is necessary to specify permissible deviations to cover the following factors which result in measurement uncertainty.

a. Error of the measuring instrument
b. Correctness of the location of the measuring instrument
c. Conditions under which the measuring instrument is used
d. Accuracy of the readings
e. Scatter of the instrument reading during the measuring period

The permissible deviations define the allowable range between the extreme values of the measurement.

A.3.2 Operating Conditions

A.3.2.1 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 it has reached stable operating conditions as specified by the engine manufacturer.

A.3.2.2 During the period in which a set of measurements is being made, the load, speed, and all fluid temperatures and pressures shall be maintained constant within the permissible deviations given in Table A1.

A.3.3 Methods of Measurement

A.3.3.1 Methods of measurement shall be selected by the manufacturer and, if necessary, may be subject to contractual agreement between the manufacturer and customer and/or inspecting authority.

A.3.3.2 The location of points of measurement shall be selected by the manufacturer.

A.3.4 Permissible Deviation of Parameters:

A.3.4.1 The permissible deviation quoted is that considered adequate for most acceptance test purposes. Manufacturers may adopt reduced permissible deviations.

a. For type tests
b. For special contractual or legislative requirements.

A.3.4.2 All measuring instruments and apparatus used during tests shall be checked and calibrated periodically over the range of the expected readings at time intervals specified by the engine manufacturer unless otherwise agreed.

A.3.4.3 Where the total measurement uncertainty involves measurements of a number of quantities, each with its own measurement uncertainty, or where an individual measurement is dependent on several parameters, each with its own measurement uncertainty, the overall measurement uncertainty is taken as the square root of the sum of the squares of the separate measurement uncertainties, each multiplied by an appropriate factor equal to the exponent of its parameter in the formulae.

A.4 See Figure A2 for typical engine performance curves and data required.