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Superseding J3046-1 NOV1994

**Reciprocating Internal Combustion Engines—Performance—
Part 1: Standard Reference Conditions, Declarations
of Power, Fuel and Lubricating Oil Consumptions, and Test Methods**

Foreword—ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and nongovernmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

International Standard ISO 3046-1 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 2, *Performance and tests*.

This fourth edition cancels and replaces the third edition (ISO 3046-1:1986), ISO 3046-2:1987, and ISO 3046-1:1986/Amd. 1:1987. A method of power correction (see clause 14) has been added.

ISO 3046 consists of the following parts, under the general title *Reciprocating internal combustion engines—Performance*:

- Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods*
- Part 3: Test measurements*
- Part 4: Speed governing*
- Part 5: Torsional vibrations*
- Part 6: Overspeed protection*
- Part 7: Codes for engine power*

Appendices A, B, C, D, E, and F of this part of ISO 3046 are for information only.

The standard reference conditions defined in this edition of ISO 3046-1 were first introduced in the third edition (ISO 3046-1:1986). The 5-year transition period, which permitted the use of ISO 3046-1:1981 conditions, expired at the end of 1991. Users of this part of ISO 3046 are therefore now required to adopt the values quoted in clause 6.

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- 1. Scope**—This part of ISO 3046 specifies standard reference conditions and methods of declaring the power, fuel consumption, lubricating oil consumption, and test methods for reciprocating internal combustion (RIC) engines in commercial production using liquid or gaseous fuels. Where necessary, individual requirements are given for particular engine applications.

This part of ISO 3046 covers RIC engines for land, rail-traction, and marine use, excluding engines used to propel agricultural tractors, road vehicles, and aircraft.

This part of ISO 3046 may be applied to engines used to propel road construction and earthmoving machines, industrial trucks, and for other applications where no suitable International Standard for these engines exists.

This part of ISO 3046 may be applied to tests on a test bed at the manufacturer's works and to tests on site (see 15.4.4).

- 1.1 Rationale**—J3046-1 is now an obsolete recreational power rating standard and should be cancelled as an SAE standard.

The ISO document J3046-1 was based on; ISO 3046-1, has been revised and is now a satellite standard applicable to commercial and recreational boats over 24 meters which have no other specific satellite standard available for engine power rating.

The current applicable International power rating standards for small craft are:

CORE STANDARD—ISO 15550—Reciprocating Internal Combustion Engines—Determination and Method for the Measurement of Engine Power

SATELLITE STANDARD—ISO 8665—Small Craft-Marine Propulsion Reciprocating Internal Combustion Engines—Power Measurements and Declarations

2. References

- 2.1 Applicable Publications**—The following publications form a part of this specification to the extent specified herein. The latest issue of the publications shall apply.

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

ISO 1204—Reciprocating internal combustion engines—Designation of the direction of rotation and of cylinders and valves in cylinder heads, and definition of right-hand and left-hand in-line engines and locations on an engine

ISO 1585—Road vehicles—Engine test code—Net power

ISO 2710:1978—Reciprocating internal combustion engines—Vocabulary

ISO 2710/Add. 1—Addendum 1: Symbols

ISO 3046-3—Reciprocating internal combustion engines—Performance—Part 3: Test measurements
 ISO 3046-4—Reciprocating internal combustion engines—Performance—Part 4: Speed governing
 ISO 3046-5—Reciprocating internal combustion engines—Performance—Part 5: Torsional vibrations
 ISO 3046-6—Reciprocating internal combustion engines—Performance—Part 6: Overspeed protection
 ISO 3046-7—Reciprocating internal combustion engines—Performance—Part 7: Codes for engine power
 ISO 7876-1:1990—Fuel injection equipment—Vocabulary—Part 1: Fuel injection pumps
 ISO 8528-1—Reciprocating internal combustion engine driven alternating current generating sets—Part 1: Application, ratings and performance

- 3. Definitions**—For the purposes of this part of ISO 3046, the following definitions apply. For the convenience of users of this part of ISO 3046, some definitions are quoted from ISO 2710 and ISO 7876-1.

3.1 Auxiliary

- 3.1.1 **DEPENDENT AUXILIARY**—Item of equipment, the presence or absence of which affects the final shaft output of the engine.
- 3.1.2 **INDEPENDENT AUXILIARY**—Item of equipment which uses power supplied from a source other than the engine.
- 3.1.3 **ESSENTIAL AUXILIARY**—Item of equipment which is essential for the continued or repeated operation of the engine.
- 3.1.4 **NONESSENTIAL AUXILIARY**—Item of equipment which is not essential for the continued or repeated operation of the engine.

3.2 Engine

- 3.2.1 **ENGINE ADJUSTMENT**—Physical procedure of modifying an engine for the purpose of adapting it to a different set of ambient conditions, such as by moving limiting fuel stop, rematching the turbocharger, changing the fuel injection timing or other mechanical changes. In that case the engine is an adjusted engine (see 3.3.11).
- 3.2.2 **NONADJUSTED ENGINE**—Engine which is preset so that no physical procedure of modifying the engine for the purpose of adapting it to a different set of ambient conditions is carried out.
- 3.2.3 **ENGINE SPEED**—The number of revolutions of the crankshaft in a given period of time. [ISO 2710:1978, 10.2.1]
- 3.2.4 **DECLARED ENGINE SPEED**—The engine speed corresponding to the declared power.

NOTE 1—In some applications, the declared engine speed is named "rated speed."

3.3 Power and Load

- 3.3.1 **DECLARED POWER**—The value of the power, declared by the manufacturer, which an engine will deliver under a given set of circumstances.
- NOTE 2—In some applications, the declared power is named "rated power."
- 3.3.2 **INDICATED POWER**—The total power developed in the working cylinders as a result of the pressure of the working medium acting on the pistons. [ISO 2710:1978, 10.3.1]
- 3.3.3 **BRAKE POWER**—The power or the sum of the powers measured at the driving shaft or shafts. [ISO 2710:1978, 10.3.2]

- 3.3.4 **CONTINUOUS POWER**—The power which an engine is capable of delivering continuously, between the normal maintenance intervals stated by the manufacturer, at the stated speed and under stated ambient conditions, the maintenance prescribed by the manufacturer being carried out.
- 3.3.5 **OVERLOAD POWER**—The power which an engine may be permitted to deliver, with a duration and frequency of use depending on the service application, at stated ambient conditions, immediately after operating at the continuous power.
- 3.3.6 **FUEL STOP POWER**—The power which an engine is capable of delivering during a stated period corresponding to its application, and stated speed and under stated ambient conditions, with the fuel limited so that this power cannot be exceeded.
- 3.3.7 **ISO POWER**—The power determined under the operating conditions of the manufacturer's test bed and adjusted or corrected as determined by the manufacturer to the standard reference conditions specified in Section 6.
- 3.3.8 **ISO STANDARD POWER**—The continuous brake power which the engine manufacturer declares that an engine is capable of delivering using only the essential dependent auxiliaries, between the normal maintenance intervals stated by the manufacturer, and under the following conditions.
- At a stated speed at the operating conditions of the engine manufacturer's test bed
 - With the declared power adjusted or corrected as determined by the manufacturer to the standard reference conditions specified in Section 6
 - With the maintenance prescribed by the engine manufacturer being carried out
- 3.3.9 **SERVICE POWER**—The power delivered under the ambient and operating conditions of an engine application.
- 3.3.10 **SERVICE STANDARD POWER**—The name given to the continuous brake power which the engine manufacturer declares that an engine is capable of delivering, using only the essential dependent auxiliaries, between the normal maintenance intervals stated by the manufacturer and under the following conditions:
- At a stated speed at the ambient and operating conditions of the engine application
 - With the declared power adjusted or corrected as determined by the manufacturer to the stated ambient and operating conditions of the engine application
 - With the maintenance prescribed by the engine manufacturer being carried out
- 3.3.11 **POWER ADJUSTMENT**—Calculation procedure by which a power value under one set of ambient conditions is modified to represent the power value expected under another set of ambient conditions, to maintain approximately constant thermal and/or mechanical load in critical engine components (see Section 13).
- 3.3.12 **POWER CORRECTION**—Calculation procedure by which a power value determined under engine test conditions is modified so that it represents the power value expected under other operating or reference conditions without any engine adjustment. In that case, the power and performance parameters may vary as a function of ambient conditions (see Section 14).
- 3.3.13 **LOAD**—A general term describing the magnitude of the "power" or "torque" demanded from the engine by its driven machinery and usually expressed relative to a declared power or torque.

NOTE 3—For quantitative purposes, the terms "power" or "torque" should be used, instead of "load," together with a statement of speed.

[ISO 2710:1978, 10.3.4]

3.4 Consumption and Delivery

- 3.4.1 FUEL CONSUMPTION—The quantity of fuel consumed by an engine per unit of time at a stated power and under stated ambient conditions.
- 3.4.2 SPECIFIC FUEL CONSUMPTION—The quantity of fuel consumed by an engine per unit of power and time.
- 3.4.3 ISO SPECIFIC FUEL CONSUMPTION—The name given to the specific fuel consumption at the ISO standard power.
- 3.4.4 FUEL DELIVERY—Metered volume (mass) of fuel delivered by a fuel injection system during one working cycle.

[ISO 7876-1:1990, 10.24]
- 3.4.5 SPECIFIC FUEL DELIVERY—Metered volume (mass) of fuel delivered by a fuel-injection system during one working cycle per liter of engine swept volume.
- 3.4.6 LUBRICATING OIL CONSUMPTION—The quantity of lubricating oil consumed by an engine per unit of time.

[ISO 2710:1978, 10.4.3]

3.5 Tests

- 3.5.1 ACCEPTANCE TEST—Test carried out as an overall check on the manufacturing quality, and to establish that the contractual commitments have been fulfilled.
- 3.5.2 TYPE TEST—Test carried out on a representative engine of a certain engine type to establish the main performance data of the engine and, as far as possible, to enable their reliability and durability in service to be assessed.
- 3.5.3 SPECIAL TEST—Test additional to acceptance or type tests carried out to meet the requirements of inspecting and legislative authorities, classification societies, or customers.

4. Symbols—The symbols used in this part of ISO 3046 are given in Table 1. Subscripts are given in Table 2.

5. Other Regulations and Additional Requirements

- 5.1** For engines used on board ships and offshore installations which have to comply with rules of a classification society, the additional requirements of the classification society shall be observed. The classification society shall be stated by the customer prior to placing the order.

TABLE 1—SYMBOLS

Symbols Common Use	Symbols EDP ⁽¹⁾ Representation	Definition	Unit
a	A	Humidity factor	dimensionless
b _r	BR	Specific fuel consumption under standard reference conditions	kg/(kW-h)
b _x	BX	Specific fuel consumption under site ambient conditions	kg/(kW-h)
b _y	BY	Specific fuel consumption under test ambient conditions	kg/(kW-h)
f _a	FA	Atmospheric factor	dimensionless
f _m	FM	Engine factor (characteristic parameter for each type of engine)	dimensionless
k	K	Ratio of indicated power	dimensionless
m	M	Exponent of the dry air pressure ratio or total barometric pressure ratio	dimensionless
n	N	Exponent of the ambient air thermodynamic temperature ratio	dimensionless
p _r	PR	Standard reference total barometric pressure	kPa
p _{ra}	PRA	Substitute reference total barometric pressure	kPa
p _{sr}	PSR	Standard reference saturated water vapor pressure	kPa
p _{sx}	PSX	Ambient saturated water vapor pressure on site	kPa
p _{sy}	PSY	Ambient saturated water vapor pressure during test	kPa
p _x	PX	Ambient total barometric pressure on site	kPa
p _y	PY	Ambient total barometric pressure during test	kPa
P _r	PPR	Brake power or net brake power under standard reference conditions	kW
P _{ra}	PPRA	Brake power or net brake power under substitute reference conditions	kW
P _x	PPX	Brake power or net brake power under ambient conditions on site	kW
P _y	PPY	Brake power or net brake power under ambient conditions during test	kW
q	Q	Fuel mass per cycle per liter of engine swept volume	mg/(cycle-l)
q _c	QC	Fuel mass per cycle per liter of air available for combustion	mg/(cycle-l)
r	R	Boost pressure ratio (ratio of absolute air pressure at the compressor outlet to that at the compressor inlet)	dimensionless
r _r	RR	Boost pressure ratio under standard reference conditions	dimensionless
T _{r, max}	RRMAX	Maximum allowable boost pressure ratio under standard reference conditions	dimensionless
s	S	Exponent of the charge air coolant thermodynamic temperature ratio	dimensionless
t _{cr}	TCR	Standard reference charge air coolant temperature	°C
t _{cx}	TCX	Ambient charge air coolant temperature on site	°C
t _r	TR	Standard reference ambient air temperature	°C
t _x	TX	Ambient air temperature on site	°C
T _{cr}	TTCR	Standard reference charge air coolant thermodynamic temperature	K
T _{cra}	TTCRA	Substitute reference charge air coolant thermodynamic temperature	K
T _{cx}	TTCX	Ambient charge air coolant thermodynamic temperature on site	K
T _{cy}	TTCY	Ambient charge air coolant thermodynamic temperature during test	K
T _r	TTR	Standard reference ambient air thermodynamic temperature	K
T _{ra}	TTRA	Substitute reference ambient air thermodynamic temperature	K
T _x	TTX	Ambient air thermodynamic temperature on site	K
T _y	TTY	Ambient air thermodynamic temperature during test	K
α	ALP	Power adjustment factor	dimensionless
α _a	ALPA	Power correction factor for spark-ignition engines	dimensionless
α _c	ALPC	Power correction factor for compression-ignition engines	dimensionless
β	BET	Fuel consumption recalculation factor	dimensionless
η _m	ETAM	Mechanical efficiency	dimensionless
φ _r	PPHIR	Standard reference relative humidity	%
φ _x	PPHIX	Ambient relative humidity on site	%
φ _y	PPHIY	Ambient relative humidity during test	%

1. EDP = Electronic data processing if using uppercase letters only

TABLE 2—SUBSCRIPTS

Subscript	Meaning
a	Atmospheric
c	Compression ignition engine ⁽¹⁾
	Coolant ⁽¹⁾
	Corrected ⁽¹⁾
m	Mechanical
max	Maximum
r	Standard reference conditions
ra	Substitute reference conditions
s	Saturated
x	Site conditions
y	Test conditions

1. Depending on the application.

For nonclassified engines, such additional requirements are in each case subject to agreement between the manufacturer and customer.

- 5.2** If special requirements from regulations of any other authority (e.g., inspecting and/or legislative authorities) have to be met, the authority shall be stated by the customer prior to placing the order.
- 5.3** Any further additional requirements shall be subject to agreement between the manufacturer and customer.
- 6. *Standard Reference Conditions***—For the purpose of determining the power and fuel consumption of engines, the following standard reference conditions shall be used.
- Total barometric pressure— $p_r = 100$ kPa
 - Air temperature— $T_r = 298$ K ($t_r = 25$ °C)
 - Relative humidity— $\phi_r = 30\%$
 - Charge air coolant temperature— $T_{cr} = 298$ K ($t_{cr} = 25$ °C)

NOTE 4—Relative humidity of 30% at a temperature of 298 K corresponds to a water-vapor pressure of 1 kPa. Hence the corresponding dry barometric pressure is 99 kPa.

- 7. *Auxiliaries***—In order to show clearly the conditions under which the power output is determined, it is necessary to distinguish those auxiliaries which affect the final shaft output of the engine and also those which are necessary for the continuous or repeated use of the engine. For examples, see Appendix A.

Items of equipment fitted to the engine and without which the engine could not under any circumstances operate at its declared power are considered to be engine components and are not, therefore, classed as auxiliaries.

NOTE—Items such as fuel injection pump, exhaust turbocharger and charge air cooler are in this category of engine components.

8. Declarations of Power

8.1 General

8.1.1 PURPOSE OF STATEMENT OF POWER—Statements of power are required for two main purposes, as follows.

- The declaration of the value of the power
- The verification by measurement that the engine delivers the power which has been declared in (a), under the same set of circumstances or after proper allowance has been made for any difference in circumstances.

To specify the set of circumstances under which the declared value of a power would be achieved, the declaration shall state:

- The type of statement of power (see 8.4, standard or service power) and, if necessary, the ambient and operating conditions (see 8.4)
- The type of power application (see 8.3, continuous power with overload power and/or fuel stop power)
- The type of power (see 8.2, indicated or brake power)
- The declared engine speed (see 3.2.4)

For the methodology of expressing the engine power according to a, b, and c, see Figure 1. For appropriate codes, where necessary, refer to ISO 3046-7.

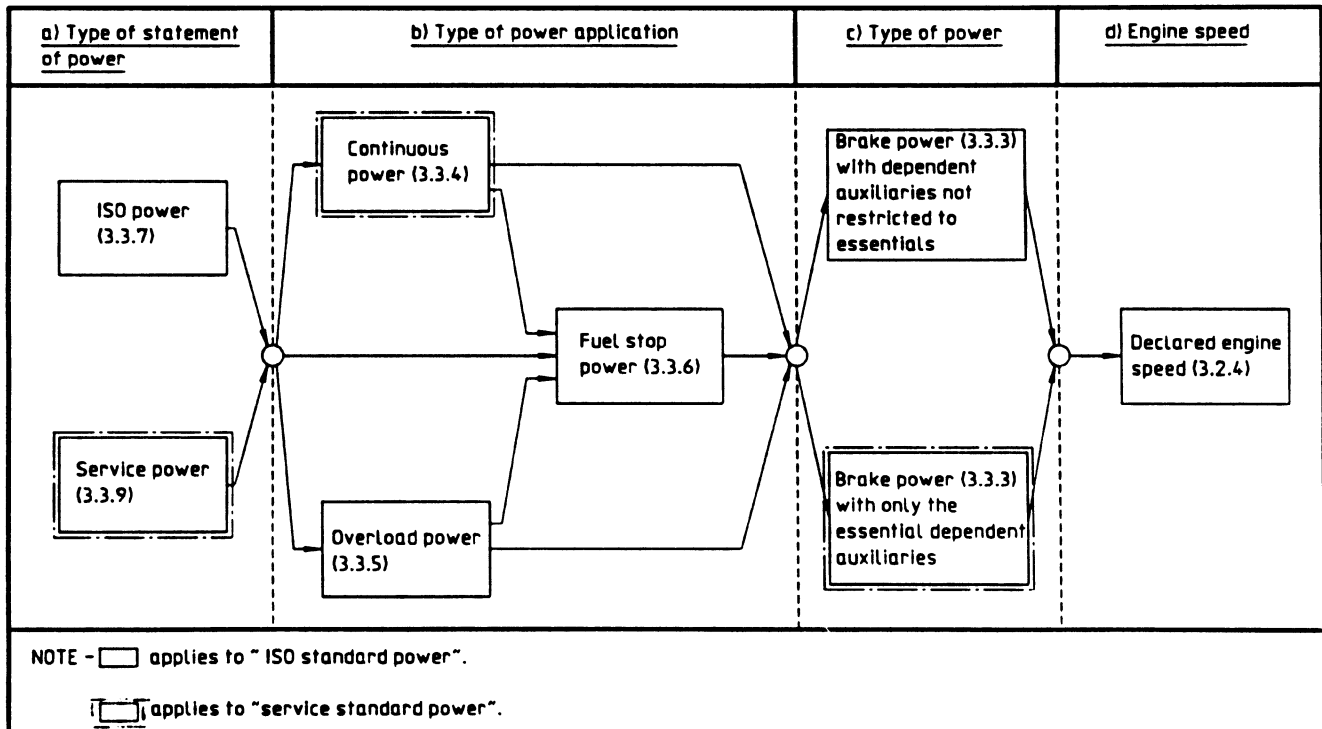


FIGURE 1—DIAGRAM SHOWING THE METHODOLOGY TO BE USED IN POWER STATEMENTS

NOTE 6—The terms used in a to c may be combined, for example, continuous brake fuel stop power.

NOTE 7—Where appropriate to the engine application and the method of manufacture, the power achieved may be subject to a tolerance on the declared power. The existence of such a tolerance and its magnitude should be stated by the manufacturer.

- 8.1.2 POWER AND TORQUE—For engines delivering power by a shaft or shafts, for the purposes of this part of ISO 3046, any power is a quantity proportional to the mean torque, calculated or measured, and to the mean rotational speed of the shaft or shafts transmitting this torque.

For engines delivering power other than by a shaft or shafts, reference shall be made to the appropriate International Standard for the driven machine.

- 8.1.3 ENGINE WITH INTEGRAL GEARING—When stating the power of an engine fitted with an integral (built-in) speed increasing or reducing device, the speed of the driving-shaft extremity shall also be given at the declared engine speed.

8.2 Types of Power

- 8.2.1 Indicated power and brake power are types of power.

- 8.2.2 Except in the cases of ISO standard power and service standard power, any statement of brake power shall be supported by the following list of auxiliaries:

- a. Essential dependent auxiliaries as defined in 3.1.1 and 3.1.3
- b. Essential independent auxiliaries as defined in 3.1.2 and 3.1.3
- c. Nonessential dependent auxiliaries as defined in 3.1.1 and 3.1.4

The power absorbed by the auxiliaries listed in b and c may be significant. In such cases, their power requirement shall be declared.

NOTE 8—Examples of typical auxiliaries are listed in Appendix A for guidance purposes.

- 8.3 Types of Power Application—Continuous power, overload power, and fuel stop power are types of power application.

The duration and frequency of use of the overload power which is permitted will depend on the service application, but adequate allowance shall be made in setting the engine fuel stop to permit the overload power to be delivered satisfactorily. The overload power shall be expressed as a percentage of the continuous power, together with the duration and frequency permitted and the appropriate engine speed.

Unless otherwise stated, an overload power of 110% of the continuous power at a speed corresponding to the engine application is permitted for a period of 1 h, with or without interruptions, within a period of 12 h of operation. This period also applies to any overload power up to 110% of the continuous power.

NOTE 9—The power of marine main-propulsion engines is normally limited to the continuous power, so that the overload power cannot be given in service. However, for special applications, marine main-propulsion engines may develop overload power in service.

For engines for electrical power generation, the specifications given in ISO 8528-1 apply.

8.4 Types of Statement of Power—ISO power and service power are types of statement of power.

To establish service power, the following conditions shall be taken into account:

- a. The ambient conditions, or any nominal ambient conditions according to the special requirements of inspecting and/or legislative authorities and/or classification societies, as specified by the customer (see Section 11).

NOTE 10—For example, the following nominal ambient conditions apply to main and auxiliary RIC engines on ships for International Association of Classification Societies (IACS) unrestricted service:

Total barometric pressure: $p_x = 100 \text{ kPa}$

Air temperature: $T_x = 318 \text{ K}$ ($t_x = 45 \text{ °C}$)

Relative humidity: $\phi_x = 60\%$

Sea or raw temperature (change air coolant inlet): $T_{cx} = 305 \text{ K}$ ($t_{cx} = 32 \text{ °C}$)

- b. The normal duty of the engine
- c. The expected interval between maintenance periods
- d. The nature and amount of supervision required
- e. Any information relevant to the operation of the engine in service (see Sections 11 and 12)

9. Declarations of Fuel Consumption**9.1 Fuel Consumption**—The quantity of liquid fuels shall be expressed in mass units (kg) or in energy units (J).

The quantity of gaseous fuels shall be expressed in energy units (J).

If not otherwise specified by the manufacturer, a declared specific fuel consumption shall be considered to be the ISO specific fuel consumption.

9.2 Calorific Value of Fuels**9.2.1 LIQUID-FUEL ENGINES**—Where a distillate type of fuel is specified, any declared specific fuel consumption of a liquid-fuel engine given in mass units shall be related to a lower calorific value of 42 700 kJ/kg.

Where any other type of fuel is specified, the declared specific fuel consumption shall either be expressed in energy units, or both the specific fuel consumption in mass units and the associated lower calorific value shall be stated.

9.2.2 GAS ENGINES—Any declared specific fuel consumption of a gas engine shall be related to a stated lower calorific value of the gas. The type of gas shall be declared.**9.3 Specific Fuel Consumption Declarations**—The specific fuel consumption of an engine shall be declared at:

- a. The ISO standard power
- b. (If required by special agreement) any other declared power and at specified engine speeds appropriate to the particular engine application

Unless otherwise stated, a deviation of +5% is permitted for the specific fuel consumption for the declared power.

10. Declarations of Lubricating Oil Consumption

- 10.1** The value of the lubricating oil consumption is used for guidance. It shall be expressed in liters or kilograms per engine operating hour at the declared power and engine speed.
- 10.2** The lubricating oil consumption after a stated period of running-in shall be declared.
- 10.3** The oil discarded during an engine oil change shall not be included in the lubricating oil consumption declaration.
- 10.4** The lubricating oil used shall be declared.

11. Information to be Supplied by the Customer—The customer shall supply the following information.

- a. The application and the power required from the engine and details arising from these
- b. The expected frequency and duration of the required powers and the corresponding engine speeds, preferably as a load profile
- c. Site conditions
 1. Site barometric pressure: highest and lowest readings available; if no pressure data are available, the altitude above sea level
 2. The monthly mean minimum and maximum ambient air temperatures on site during the hottest and coldest months of the year
 3. The highest and lowest ambient air temperatures on site around the engine
 4. The relative air humidity (or alternatively, the water vapor pressure or the wet and dry bulb temperature) at the maximum ambient air temperature on site
 5. The maximum and minimum temperatures of the cooling water available
- d. The specification and lower calorific value of the fuel available
- e. Whether the engine is to comply with the requirements of any classification society or with special requirements
- f. Characteristics of the essential dependent auxiliaries supplied by the customer
- g. Any other information appropriate to the particular engine application

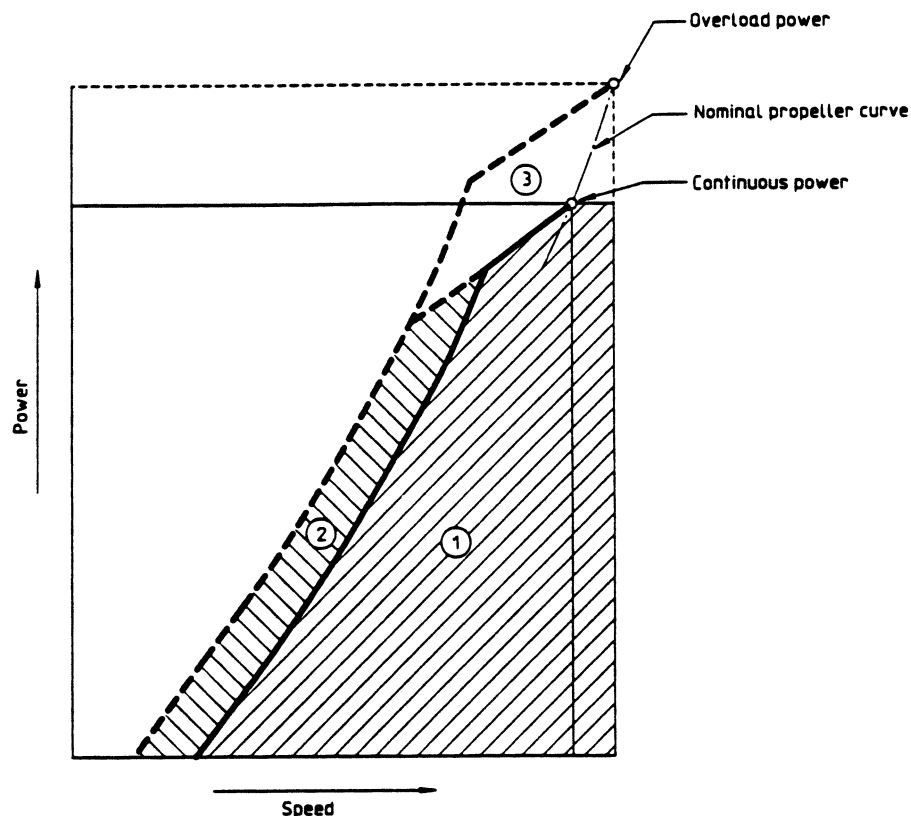
12. Information to be Supplied by the Engine Manufacturer—The engine manufacturer shall supply the following information.

- a. The declared brake powers and, where appropriate, their tolerances
- b. The corresponding engine speed

NOTE 11—For certain applications of variable-speed engines, it is common practice to supply a power speed diagram covering the ranges of power over which the engine may be used in continuous and in short-period operation.

A typical example for a marine main-propulsion engine with a fixed-pitch propeller is given in Figure 2. For the preparation of such a diagram, the customer should supply the required information according to Section 11.

- c. The direction of rotation (see ISO 1204).



- 1 Range of continuous power
- 2 Range of intermittent operation
- 3 Range of short-time overload operation for special applications

FIGURE 2—EXAMPLE OF A POWER/SPEED DIAGRAM

- d. The number and arrangement of cylinders (see ISO 1204).
- e. Whether the engine is two-stroke or four-stroke, naturally aspirated, mechanically pressure-charged or turbocharged, and whether with or without a charge air cooler.
- f. The air flow required for the operation of the engine for:
 1. Combustion and scavenging
 2. Cooling and ventilation
- g. The method of starting apparatus supplied and additional apparatus required
- h. The type and grade of lubricating oil recommended