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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

Moteurs alternatifs à combustion interne — Performances —

Partie 1: Déclaration de la puissance et de la consommation de carburant et d'huile de lubrification, et méthodes d'essai — Exigences supplémentaires pour les moteurs d'usage général

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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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 non-governmental, 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this part of ISO 3046 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 3046-1 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*.

This part of ISO 3046 cancels and replaces ISO 3046-1:1995, ISO 3046-2:1987 and ISO 3046-7:1995, which have been technically revised and their technical content combined.

ISO 3046 consists of the following parts, under the general title *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*

— *Part 3: Test measurements*

— *Part 4: Speed governing*

— *Part 5: Torsional vibrations*

— *Part 6: Overspeed protection*

Annex A forms a normative part of this part of ISO 3046. Annexes B, C and D are for information only.

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Introduction

This part of ISO 3046 establishes one “Satellite” standard of the ISO engine power measurement standards, the use of which enables one to avoid the disadvantages due to the existance of many similar, but different, ISO standards for the definition and determination of engine power. It uses the “Core” and “Satellite” approach.

The “Core” standard, ISO 15550, contains the requirements that are common to all engine applications whereas this part of ISO 3046 contains as a “Satellite” standard those requirements that are necessary to tailor power measurement and declaration to suit the particular engine application as defined in clause 1.

This part of ISO 3046 is intended to be applied in conjunction with the “Core” standard ISO 15550 in order to completely specify the requirements for the particular engine application. The “Satellite” standard therefore is not a document that can stand alone standard but is intended to be accomplished by the requirements laid down in the “Core” standard ISO 15550 in order to become a complete standard.

The structures of both, the “Core” and the “Satellite” standard have been drafted in a very similar way in order to ensure easy use.

The advantage of this approach is that the use of standards for the same or similar engines used in different applications will be rationalized and the harmonization of standards in the course of revision or development will be ensured.

For engines used on board ships and offshore installations which have to comply with the rules of a classification society, it is recommended that the additional requirements of the classification society be observed. It is recommended that the relevant classification society be stated by the customer prior to placing the order.

For non-classed engines, any additional requirements are subject to agreement between the manufacturer and customer.

If requirements from the regulations of any other authority (e. g. inspecting and/or legislative authority) have to be met, it is recommended that the relevant authority be stated by the customer prior to placing the order.

It is recommended that any further requirements be subject to agreement between the manufacturer and customer.

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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

1 Scope

This part of ISO 3046 specifies the requirements for the declaration of power, fuel consumption, lubricating oil consumption and the test method in addition to the basic requirements defined in “Core” standard ISO 15550.

This part of ISO 3046 defines codes for engine brake power in accordance with “Core” standard ISO 15550, in order, where necessary, to simplify the application of the statements of power and to facilitate communication. This applies, e.g., to statements of power used on engine data plates.

It applies to Reciprocating Internal Combustion (RIC) engines for land, rail-traction and marine use.

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

It is a “Satellite” standard and is intended to be applied in conjunction with “Core” standard ISO 15550 only, in order to completely specifiy the requirements for the particular engine application.

NOTE In addition to the terms used in the three official ISO languages (English, French and Russian), this International Standard gives, in Table 3, the equivalent terms in German; these have been included at the request of Technical Committee ISO/TC 70 and are published under the responsibility of the member body for Germany (DIN). However, only the terms given in the official languages can be considered as ISO terms.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 3046. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 3046 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1204:1990, *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 3046-4:1997, *Reciprocating internal combustion engines — Performance — Part 4: Speed governing*

ISO 3046-6:1990, *Reciprocating internal combustion engines — Performance — Part 6: Overspeed protection*

ISO 15550:2002, *Internal combustion engines — Determination and method for the measurement of engine power — General requirements*

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3 Terms and definitions

For the purposes of this part of ISO 3046 the terms and definitions given in ISO 15550, listed in Table 1, apply.

Table 1 — Terms and definitions

Term (listed alpahbetically)	**Definition** see ISO 15550 subclause No.
brake power	3.3.3
continuous power	3.3.4
declared engine speed dependent auxiliary	3.2.4 3.1.1
engine adjustment engine speed essential auxiliary	3.2.1 3.2.3 3.1.3
fuel consumption fuel stop power	3.4.1 3.3.6
indicated power independent auxiliary	3.3.2 3.1.2
ISO power ISO specific fuel consumption ISO standard power	3.3.7 3.4.1.2 3.3.7.1
low idle engine speed (idling speed)	3.2.6
lubricating oil consumption	3.4.3
non-adjusted engine non-essential auxiliary	3.2.2 3.1.4
overload power	3.3.5
power adjustment	3.3.9
service power service standard power specific fuel consumption	3.3.8 3.3.8.1 3.4.1.1

4 Symbols

For the symbols used in this part of ISO 3046 see Table 2 of ISO 15550:2002; for the meanings of subscripts see Table 3 of ISO 15550:2002.

5 Standard reference conditions

The requirements of ISO 15550:2002 clause 5 apply.

6 Test method

6.1 General

Test method 1 in accordance with 6.2 of ISO 15550:2002 applies.

The manufacturer shall specify which of the following procedures is applicable to the engine for this test method:

a) power adjustment;

b) power correction.

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6.2 Adjusted engines

6.2.1 The test power may be determined, where necessary, using equations (1) to (6) (see 10.3) in one or more of the following ways:

a) by adjusting the ISO power from the standard reference conditions to the test ambient conditions;

b) by adjusting the declared service power from the site ambient conditions to the power under the test ambient conditions;

c) by making the test power equal to the declared service power and testing under conditions altered artificially in accordance with 6.2.5 in order to simulate the site ambient conditions;

d) by testing under conditions simulating some of the site ambient conditions in accordance with 6.2.5 and adjusting the declared service power to allow for the remaining differences.

NOTE Power adjustment by using equations (1) to (6) is only permissible if the turbocharging equipment or timing of the engine is not changed or modified for site ambient conditions.

6.2.2 When adjusting the power, the engine manufacturer shall state which of the formula references given in Table 2 shall be used.

If there is no suitable formula reference for power adjustment shown in Table 2, the method of adjustment shall be agreed in writing by the manufacturer and customer.

6.2.3 If a turbocharged engine at the declared power and under the standard reference conditions attains neither the turbocharger speed limit nor the exhaust gas temperature limit at the turbine inlet, nor the maximum combustion pressure, the manufacturer may declare substitute reference conditions as specified in 10.3.2 for the power adjustment.

6.2.4 When adjusting the declared power on site for the test ambient conditions, results may be attained where, e.g., the maximum combustion pressure in the engine cylinder exceeds the permitted value. In this case, the engine test shall be carried out at a power considered safe by the manufacturer, at which the permitted value is not exceeded.

The values of the engine parameters corresponding to the required power may be extrapolated from the measured values by a method agreed upon between the manufacturer and customer.

6.2.5 Engine tests may be carried out under ambient conditions created artificially to simulate site ambient conditions by one of the following:

a) altering the air temperature at the engine inlet by artificial heating;

b) altering the coolant temperature at the inlet of the charge air cooler, etc.;

c) other appropriate methods considered safe by the manufacturer.

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Table 2 — Numerical values for power adjustment

Engine type	Fuel type	Conditions		Formula reference	Factor a	Exponents m	n	s
Diesel engines and dual fuel compression-ignition engines operating on liquid fuel	Diesel fuel oils	Non-turbocharged	Power limited by air to fuel ratio	A	1	1	0,75	0
			Power limited by thermal loading	B	0	1	1	0
		Turbocharged without charge air cooling	Low and medium speed four-stroke engines	C	0	0,7	2	0
		Turbocharged with charge air cooling		D	0	0,7	1,2	1
Compression ignition (diesel) engines	Diesel fuel oils	Turbocharged with charge air cooling	Low speed two stroke	E	0	nr	nr	nr
Pilot injection gas engines (dual fuel or gas-diesel)	Gaseous fuels with pilot fuel oil	Turbocharged with charge air cooling	Low and medium speed four-stroke engines	F	0	0,57	0,55	1,75
High pressure gas injection dual fuel engines	Gaseous fuels with pilot fuel oil	Turbocharged with charge air cooling	Low and medium speed four-stroke engines	G	0	0,7	1,2	1
High pressure gas injection dual fuel engines	Gaseous fuels with pilot fuel oil	Turbocharged with charge air cooling	Low speed two stroke	H	0	nr	nr	nr
Spark-ignition (Otto) engines	Gasoline, LPG and gaseous fuels	Non-turbocharged	High speed four-stroke engines	I	1	0,86	0,55	0
	Gaseous fuels	Turbocharged with charge air cooling	Low and medium speed four-stroke engines	J	0	0,57	0,55	1,75

NOTES

1 The formula references and exponents have been derived by CIMAC (International Council on Combustion Engines).

2 The factors and exponents have been established by tests on a number of engines to be representative of the types of engines specified. They may be considered as a guideline.
Engine manufacturers may alternatively declare their own values appropriate to their individual engine design.

3 The values of exponent s applies to power adjustment from a reference charge air coolant temperature.
Where the charge air is cooled by engine jacket water at nominally constant temperature the value of ‘s’ could be taken as zero.

4 The formulae reference A and D are applied in the examples given in annexes C and D.

5 High speed four-stroke engines subject to power adjustment are not covered in this table. The correction factors and exponents shall be specified by engine manufacturer.

6 nr = There are no values recommended. It is up to the engine manufacturers to use their own values appropriate to their individual engine design.

6.3 Non-adjusted engines (pre-set engines)

Where the test conditions differ from the standard reference conditions, the method given in clause 7 of ISO 15550:2002, may be used for power correction of the measured power to standard reference conditions (correction by calculation).

The test may be carried out in air-conditioned test rooms where the atmospheric conditions are controlled in order to maintain the correction factor as close to unity (1) as possible.

Where an influencing parameter is controlled by an automatic device, no power correction for that parameter shall be applied, provided that the parameter is within the relevant range of the device. This applies in particular to:

a) automatic air temperature controls where the device is operating at 298 K (25 °C);

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b) automatic boost control independent of atmospheric pressure when the atmospheric pressure is such that the boost control is working;

c) automatic fuel control where the governor adjusts the fuel delivery for constant power output (by compensating for the influence of ambient pressure and temperature).

However, in the case of a), if the automatic air temperature device is fully closed at full load at 298 K (25 °C) (no heated air added to the inlet air), the test shall be carried out with the device fully closed, and the normal correction factor applied. In the case of c), the fuel consumption for compression-ignition (diesel) engines shall be corrected by the reciprocal of the power correction factor.

6.4 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 its continuous or repeated use. For examples, see annex A.

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

NOTE Items such as the fuel injection pump, exhaust turbocharger and charge air cooler are in this category.

7 Method of power correction

The requirements given in clause 7 of ISO 15550:2002 apply.

8 Measurement of exhaust emission

For the measurement of the gaseous and particulate exhaust emissions after the measurement of engine power has been completed, the measurement methods shown in ISO 8178 apply.

9 Test report

The test report in accordance with 9.1 of ISO 15550:2002 applies.

10 Methods of calculating power adjustment and recalculating specific fuel consumption

10.1 General

The engine manufacturer shall indicate the amounts by which the test or site ambient conditions may differ from the standard reference conditions without having to adjust the power and recalculate the specific fuel consumption.

10.2 Application

The procedures given in this part of ISO 3046 shall be applied to calculate:

a) the expected power and specific fuel consumption for site ambient conditions from values known for standard reference conditions (see 10.3 and 10.4);

b) whether the values of power and fuel consumption attained under engine test ambient conditions correspond to the declared values (see 10.3 and 10.4).

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10.3 Power adjustment for ambient conditions

10.3.1 When it is required that the engine be operated under conditions different from the standard reference conditions given in clause 5 of ISO 15550:2002, and if it is required that the power output be adjusted to or from the standard reference conditions, the following equations shall be used if other methods are not stated by the manufacturer (see note 2 in 10.3.2 and also 10.3.4):

$$P_{\mathrm{x}} = \alpha \times P_{\mathrm{r}} \tag{1}$$

NOTE In equation (1), the mathematical approach is inverse of that of equations (1) and (2) of ISO 15550:—, clause 7.

where the power adjustment factor, α, is given by:

$$\alpha = k - 0{,}7\left(1 - k\right)\left(\frac{1}{\eta_{\mathrm{m}}} - 1\right) \tag{2}$$

where the ratio of indicated power is:

$$k = \left(\frac{p_{\mathrm{x}} - a\phi_{\mathrm{x}} p_{\mathrm{sx}}}{p_{\mathrm{r}} - a\phi_{\mathrm{r}} p_{\mathrm{sr}}}\right)^{m}\left(\frac{T_{\mathrm{r}}}{T_{\mathrm{x}}}\right)^{n}\left(\frac{T_{\mathrm{cr}}}{T_{\mathrm{cx}}}\right)^{s} \tag{3}$$

For examples, see C.1 and annex D.

10.3.2 In the case of turbocharged engines where the limits of turbocharger speed, turbo-charger turbine inlet temperature and maximum combustion pressure have not been reached at the declared power under standard reference conditions, the manufacturer may declare substitute reference condtions to or from which power adjustment shall be made (for an example, see C.2).

In this case:

$$P_{\mathrm{x}} = \alpha \times P_{\mathrm{ra}} \tag{4}$$

Equations (5) and (6) shall then be used instead of equation (3).

Replacing the dry air pressure ratio in equation (3) by the total barometric pressure ratio, the ratio of the indicated power is given by:

$$k = \left(\frac{P_{\mathrm{x}}}{P_{\mathrm{ra}}}\right)^{m}\left(\frac{T_{\mathrm{ra}}}{T_{\mathrm{x}}}\right)^{n}\left(\frac{T_{\mathrm{cra}}}{T_{\mathrm{cx}}}\right)^{s} \tag{5}$$

where the substitute reference total barometric pressure is:

$$p_{\mathrm{ra}} = p_{\mathrm{r}}\left(\frac{r_{\mathrm{r}}}{r_{\mathrm{r,max}}}\right) \tag{6}$$

The factor a and exponents m, n and s have the numerical values given in Table 2 (see 10.4).

NOTE 1 See also the tables in annex B, and the numerical examples in annexes C and D.

NOTE 2 When the test or site ambient conditions are more favourable than the standard reference or substitute reference conditions (see 10.3.2), the declared power under the test or site ambient conditions may be limited, by the manufacturer, to the declared power under the standard reference conditions or substitute reference conditions.

NOTE 3 If the relative humidity is not known, a value of 30 % should be assumed for formula references A, E and G in Table 2. For all other formula references, the power adjustment is independent of humidity (a = 0).

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