INTERNATIONAL STANDARD

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Reciprocating internal combustion engines — Performance —

Part 1:

Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods

Moteurs alternatifs à combustion interne — Performances —

Partie 1: Conditions normales de référence, déclaration de la puissance et de la consommation de carburant et d'huile de lubrification, méthodes d'essai

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Contents

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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.

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) and test methods (see clause 15) have 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*

Annex A forms an integral part of this part of ISO 3046. Annexes B, C, D, E and F are for information only.

Introduction

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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Reciprocating internal combustion engines — Performance —

Part 1:
Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods

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 earth-moving 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).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 3046. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3046 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO 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 3046-3:1989, *Reciprocating internal combustion engines — Performance — Part 3: Test measurements.*

ISO 3046-4:—[1)], *Reciprocating internal combustion engines — Performance — Part 4: Speed governing.*

ISO 3046-5:1978, *Reciprocating internal combustion engines — Performance — Part 5: Torsional vibrations.*

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

ISO 3046-7:1995, *Reciprocating internal combustion engines — Performance — Part 7: Codes for engine power.*

ISO 8528-1:1993, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance.*

1) To be published. (Revision of ISO 3046-4:1978)

3 Definitions

For the purposes of this part of ISO 3046, the following definitions apply.

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 non-essential 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, re-matching 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 non-adjusted 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 clause 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:

a) at a stated speed at the operating conditions of the engine manufacturer's test bed;

b) with the declared power adjusted or corrected as determined by the manufacturer to the standard reference conditions specified in clause 6;

c) 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 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:

a) at a stated speed at the ambient and operating conditions of the engine application;

b) with the declared power adjusted or corrected as determined by the manufacturer to the stated ambient and operating conditions of the engine application;

c) with the maintenance prescribed by the engine manufactuer 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 clause 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 clause 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. [ISO 2710:1978, 10.3.4]

NOTE 3 The term "load" is physically imprecise and should be avoided. For quantitative purposes terms "power" or "torque" should be used, instead of "load", together with a statement of speed.

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 litre 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.

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

Table 1 — Symbols

Symbols		Definition	Unit
common use	EDP[1] representation		
a	A	Humidity factor	1
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	1
f_m	FM	Engine factor (characteristic parameter for each type of engine)	1
k	K	Ratio of indicated power	1
m	M	Exponent of the dry air pressure ratio or total barometric pressure ratio	1
n	N	Exponent of the ambient air thermodynamic temperature ratio	1
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 vapour pressure	kPa
p_{sx}	PSX	Ambient saturated water vapour pressure on site	kPa
p_{sy}	PSY	Ambient saturated water vapour 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 under standard reference conditions	kW
P_{ra}	PPRA	Brake power under substitute reference conditions	kW
P_x	PPX	Brake power under ambient conditions on site	kW
P_y	PPY	Brake power under ambient conditions during test	kW
q	Q	Fuel mass per cycle per litre of engine swept volume	mg/(cycle·l)
q_c	QC	Fuel mass per cycle per litre 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)	1
r_r	RR	Boost pressure ratio under standard reference conditions	1
$r_{r,max}$	RRMAX	Maximum allowable boost pressure ratio under standard reference conditions	1
s	S	Exponent of the charge air coolant thermodynamic temperature ratio	1
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
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

Symbols		Definition	Unit
common use	EDP[1] representation		
α	ALP	Power adjustment factor	1
α_a	ALPA	Power correction factor for spark-ignition engines	1
α_c	ALPC	Power correction factor for compression-ignition engines	1
β	BET	Fuel consumption recalculation factor	1
η_m	ETAM	Mechanical efficiency	1
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 upper-case 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.

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 vapour 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 annex 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 5 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.

a) The declaration of the value of the power.

b) 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:

a) the type of statement of power (see 8.4, standard or service power) and, if necessary, the ambient and operating conditions (see 8.4);

b) the type of power application (see 8.3, continuous power with overload power and/or fuel stop power);

c) the type of power (see 8.2, indicated or brake power);

d) 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.

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

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 shall be stated by the manufacturer.

8.1.2 Power and torque

For engines delivering power by a shaft or shafts, any power according to this part of ISO 3046 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.

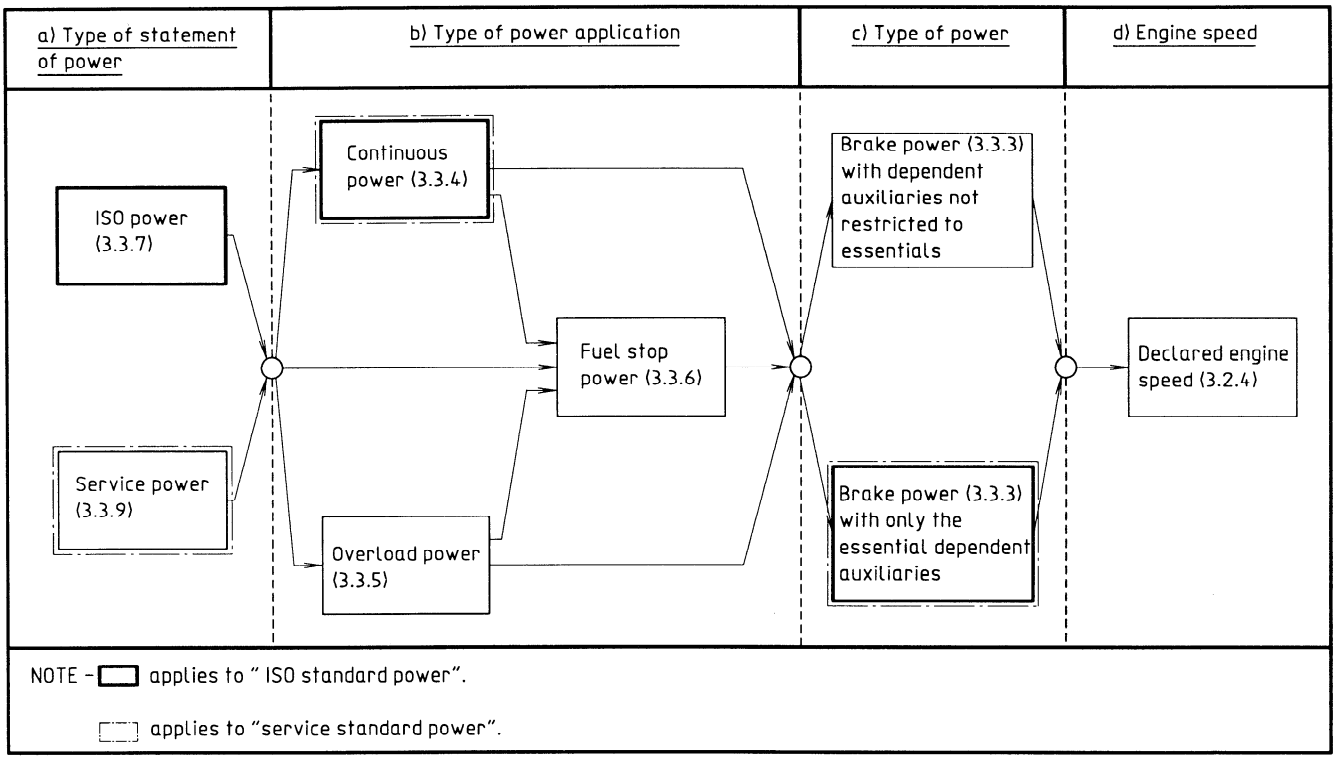

Figure 1 — Diagram showing the methodology to be used in power statements

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) non-essential 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.

Examples of typical auxiliaries are listed in annex A.

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