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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

Reference number
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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.

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.

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*

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.

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.

Table 2 — Numerical values for power adjustment

Engine type	Fuel type	Conditions		Formula reference	Factor	Exponents		
					a	*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);

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).

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:

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

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).

10.3.3 The value of the mechanical efficiency shall be stated by the engine manufacturer. In the absence of any such statement, the value of η_m = 0,8 shall be assumed.

10.3.4 When declaring the ISO standard power, the engine manufacturer shall state which of the formula references in Table 2 is applicable.

10.4 Recalculation of fuel consumption at test or site ambient conditions for adjusted engines

When it is required that the engine be operated under test or site ambient conditions different from the standard reference conditions given in clause 5 of ISO 15550:2002 the specific fuel consumption will differ from that declared for the standard reference conditions and shall be recalculated for or from the standard reference conditions.

The following equations shall be used if other methods are not declared by the manufacturer:

$$b_x = \beta \, b_r \tag{7}$$

where $\beta = \frac{k}{\alpha}$ (8)

NOTE See also the tables in annex B, and the numerical example C.1.

11 Declarations of power

11.1 General

11.1.1 Purpose of the statement of power

Statements of power are required for two main purposes:

— the declaration of the value of the power;

— the verification by measurement that the engine delivers the power that has been declared in a), under the same set of circumstance or after proper allowance has been made for any difference in circumstances.

In order to specify the set of circumstances under which the declared value of power should be achieved, the declaration shall state:

a) the type of statement of power and, if necessary, the ambient and operating conditions (see 11.4);

b) the type of power application (see 11.3);

c) the type of power (see 11.2);

d) the declared engine speed (see Table 1).

For the methodology of expressing the engine power in accordance with a), 2) and 3), see Figure 1. For the appropriate codes, where necessary, see clause 12.

NOTE The terms used in 1) to 3) may be combined (e.g., 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 value shall be stated by the manufacturer.

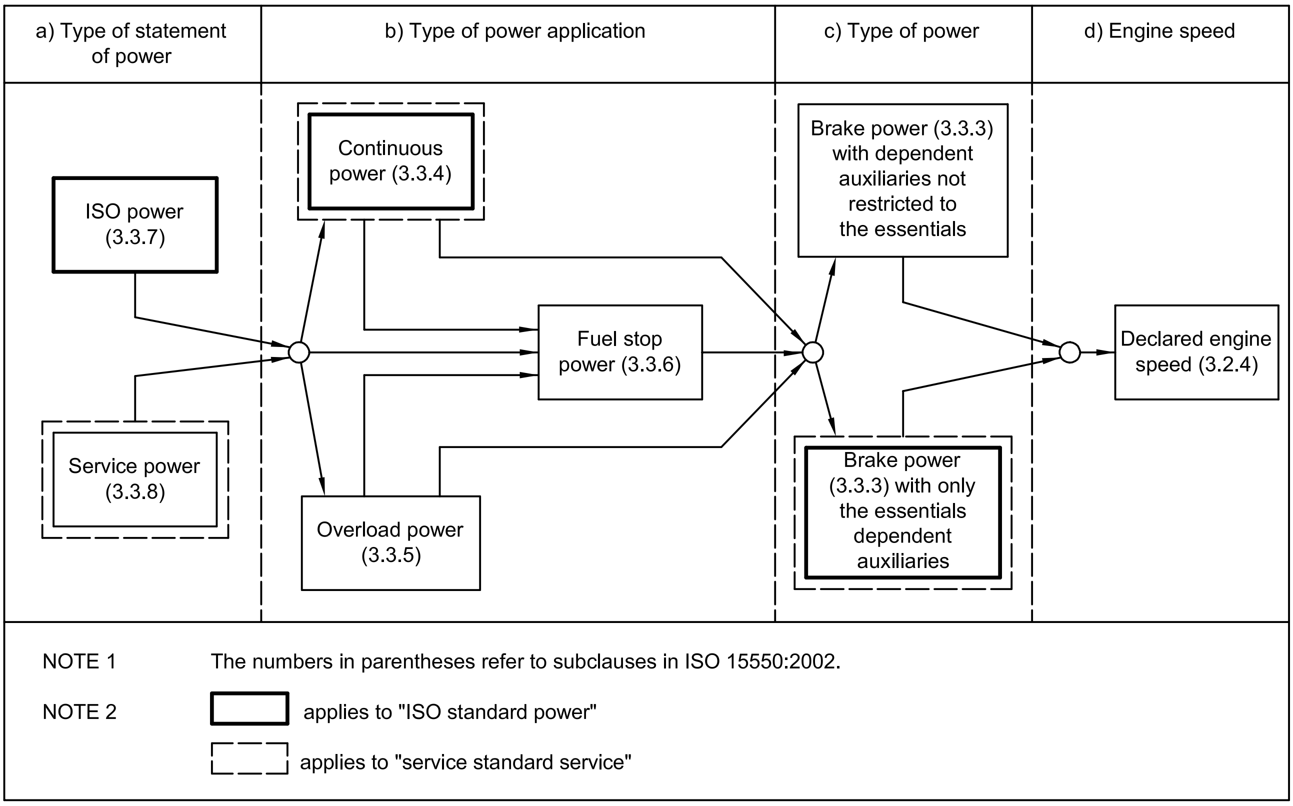


Figure 1 — Diagram showing the methodology to be used in power statements

11.1.2 Power and torque

For engines delivering power through a shaft or shafts, any power in accordance with the requirements of this part of ISO 3046 is 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.

11.1.3 Engines 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.

11.2 Types of power

11.2.1 Indicated power and brake power are types of power.

11.2.2 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 in accordance with clause 6.3 and annex A:

a) essential dependent auxiliaries as defined in ISO 15550:2002 (3.1.1 and 3.1.3);

b) essential independent auxiliaries as defined in ISO 15550:2002 (3.1.2 and 3.1.3);

c) non-essential dependent auxiliaries as defined in ISO 15550:2002 (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 requirements shall be declared.

For guidance purposes, examples of typical auxiliaries are listed in annex A.

11.3 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 permitted overload power 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 12 h of operation. These periods also apply to any overload power up to 110 % of the continuous power.

NOTE 1 The power of marine propulsion engines is normally limited to the continuous power, so that the overload power cannot be given in service. However, for special applications, marine propulsion engines may develop overload power in service.

NOTE 2 For engines used for electrical power generation, the specifications given in 13.3 of ISO 8528-1:1993 apply.

11.4 Types of power statements

ISO power and service power are types of statement of power.

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

a) The atmospheric ambient conditions, or any nominal ambient conditions required by the inspecting and/or legislative authorities and/or classification societies, as specified by the customer (see clause 15).

   NOTE e.g., the following nominal ambient conditions apply to marine propulsion and auxiliary RIC engines on ships as required by the International Association of Classification Societies (IACS) unrestricted service:

   — total barometric pressure: p_x = 100 kPa;

   — air temperature: T_x = 318 K (t_x = 45 °C);

   — relative humidity: ϕ_x = 60 %;

   — sea or raw water temperature (charge air coolant inlet): T_{cx} = 305 K (t_{cx} = 32 °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 clauses 15 and 16).

12 Designation of power

12.1 Relation of codes to power

As a result of the requirements given in 11.1.1, the statement of power by means of codes in accordance with this part of ISO 3046 requires the combination of letters from three different groups of letters, supplemented by a statement of the engine speed.

The sequence of the letters making up the coding is shown diagrammatically in Figure 2.

In addition, the letter C may be followed by an indication of the numerical percentage value by which a continuous power may be exceeded (see Table 3, No. 3). Where the continuous power can be exceeded by the standard amount of 10 %, the numerical indication is replaced by the letter X (see Table 3, No. 4).

12.2 Designation of power by means of codes

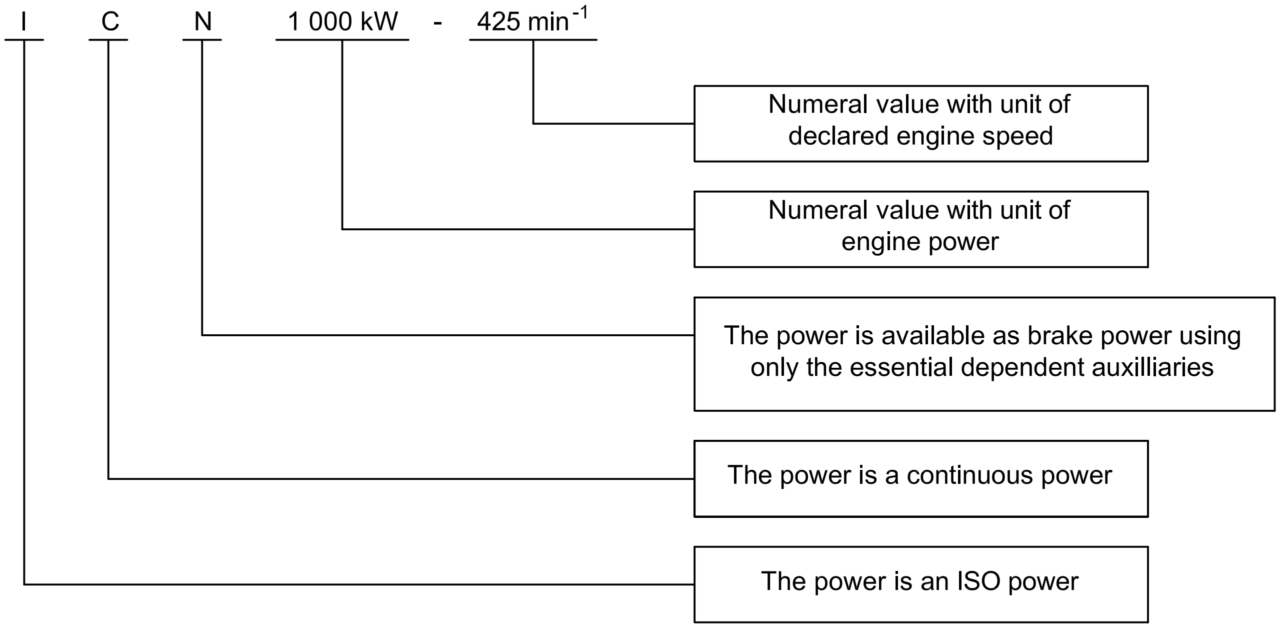
An engine power statement by use of codes comprises the following:

a) the letters indicated in Figure 2;

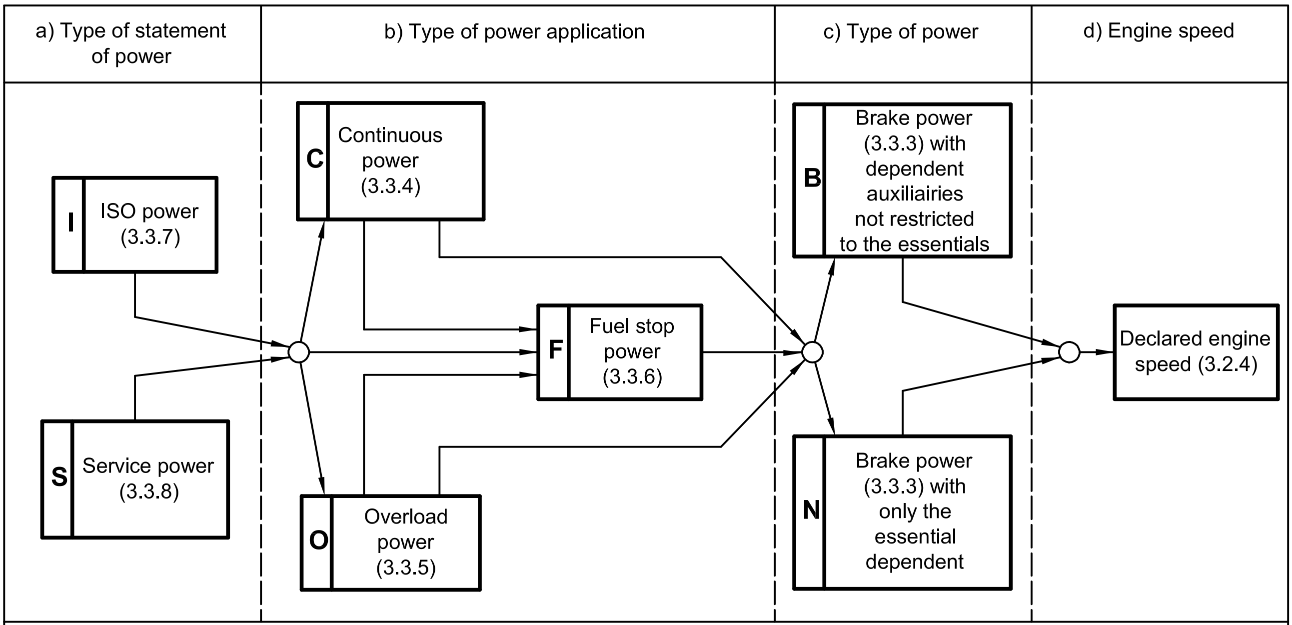
b) the numerical value with the unit of power;

c) the numerical value with the unit of the declared engine speed.

EXAMPLE



This statement does not define whether the engine power may be exceeded. However, if the engine power can be exceeded, the indication of the numerical percentage value shall be given, for example as ICXN.



NOTE 1 The numbers in parentheses refer to subclauses in ISO 15550:2002.

NOTE 2 In the case of engines wich are used on board ships for International Association of Classification Societies (IACS) unrestricted service and to which the nominal ambient conditions specified in subclause 11.4 a) apply, the code M may be used instead of S to designate the service power. When the code M is used, it is not necessary to give any additional information on the particular ambient and operating conditions at site.

Figure 2 — Diagram showing the sequence of letters to be used in codified power statements

12.3 Examples of power designation by the use of codes

Table 3 contains examples of codes used for common power designations.

Table 3 — Examples of codes used for common power designations

No.	Power designation [a]	ISO 15550 subclause No.	Code [b]
1	en ISO standard power fr Puissance normale ISO ru Стандртная мощность ИСО de ISO-Standard-Leistung	3.3.8	ICN
2	en ISO standard fuel stop power fr Puissance en butée normale ISO ru Стандартная мощность ИСО на упоре рейки de Blockierte ISO-Standard-Leistung	3.3.6 3.3.8	ICFN
3	en ISO standard power exceedable by *x* % fr Puissance normale ISO pouvant être dépassée de *x* % ru Стандартная мощность ИСО с перегрузкой на *x* % de ISO-Standard-Leistung überschreitbar um *x* %	3.3.8 (and 11.3 of this International Standard)	ICxN [c]
4	en ISO standard power exceedable by 10 % fr Puissance normale ISO pouvant être dépassée de 10 % ru Стандартная мощность ИСО с перегрузкой на 10 % de ISO-Standard-Leistung überschreitbar um 10 %	3.3.8 (and 11.3 of this International Standard)	ICXN
5	en ISO overload brake power using only the essential dependent auxiliaries fr Puissance de surcharge au frein ISO en utilisant seulement les auxiliaires dépendants essentiels ru Тормозная мощность ИСО с перегрузкой с существенным зависимым вспомогательным оборудованием de ISO-Überleistung als Nutzleistung	3.3.3 3.3.5 3.3.7	ION
6	en ISO overload brake fuel stop power using only the essential dependent auxiliaries fr Puissance de surcharge au frein en butée ISO en utilisant seulement les auxiliaires dépendants essentiels ru Тормозная мощность ИСО с перегрузкой на упоре рейки с существенным зависимым вспомогательным оборудо-ванием de Blockierte ISO-Überleistung als Nutzleistung	3.3.3 3.3.5 3.3.6 3.3.7	IOFN
7	en ISO brake fuel stop power using only the essential dependent auxiliaries fr Puissance au frein en butée ISO en utilisant seulement les auxiliaires dépendants essentiels ru Тормозная мощность ИСО на упоре рейки с существенным зависимым вспомогательным оборудованием de Blockierte ISO-Nutzleistung	3.3.3 3.3.6 3.3.7	IFN

[a] en: English; fr: French; ru: Russian; de: German.

[b] The prominence given to the code letters in the “Code” column of this table and in Figure 2 is not necessarily required in practical use.

The codes indicated may also be applied to service power, in which case the letter I shall be replaced by S or M (see footnote 1) to Figure 2). They may also be used to designate brake power with auxiliaries not restricted to the essential auxiliaries and listed, in which case the letter N shall be replaced by B. See the examples below.

[c] The appropriate numerical value of x shall be indicated.

EXAMPLES

— Service standard power exceedable by 10 % will be coded SCXN

— Service standard fuel stop power will be coded SCFN

— ISO overload brake power using auxiliaries not restricted to the essential and listed will be coded IOB

13 Declaration of fuel consumption

13.1 Fuel consumption

The quantity of liquid fuel used shall be expressed in mass units (kg) or in energy units (J).

The quantity of gaseous fuel used 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.

13.2 Calorific value of fuels

13.2.1 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.

13.2.2 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.

13.3 Declaration of specific fuel consumption

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 higher consumption of $+$ 5 % is permitted for the specific fuel consumption declared at the declared power.

14 Declarations of lubricating oil consumption

14.1 The value of the lubricating oil consumption is used for guidance. It shall be expressed in litres or kilograms per engine operating hour at the declared power and engine speed.

14.2 The lubricating oil consumption after a stated period of running-in shall be declared.

14.3 The oil discarded during an engine oil change shall not be included in the lubricating oil consumption declaration.

14.4 The lubricating oil used shall be declared.

15 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 other related details;

b) the expected frequency and duration of the required powers and 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 average of 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 vapour 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 any other special requirements;

f) characteristics of the essential dependent auxiliaries supplied by the customer;

g) any other information appropriate to the particular engine application.

16 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 speeds.

NOTE For certain variable-speed engine applications, 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 short-period operation.

A typical example of power/speed diagram for a marine propulsion engine with a fixed-pitch propeller is given in Figure 3. For the preparation of such a diagram, the customer should supply the required information in accordance with clause 15.

c) the direction of rotation (see ISO 1204);

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 working of any starting apparatus supplied and additional apparatus required;

h) the type and grade of lubricating oil recommended;

i) the type of governing, with speed droop if required (see ISO 3046-4 and ISO 3046-6). For variable speed duties, the working engine speed range and the low idle engine speed (idling speed). If necessary, the critical engine speed range shall be indicated;

j) the method of cooling and the capacity of the cooling system with the rates of cooling fluid circulation;

k) whether hot air discharge ducting can be fitted (for air-cooled engines only);

l) a schedule of the recommended maintenance and overhaul periods;

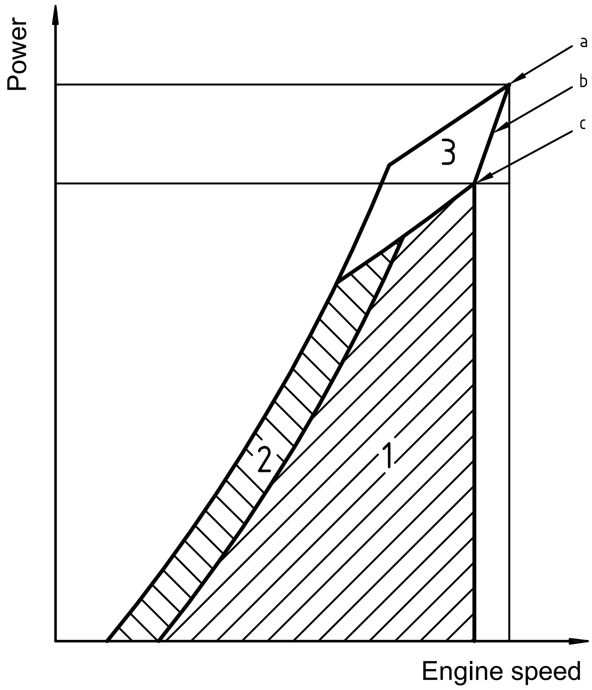
m) specifications and lower calorific values of the fuels recommended;

n) engine fuel supply temperature and/or viscosity;

o) maximum permissible back-pressure in the exhaust system and maximum permissible air-inlet depression;

p) characteristics of the essential independent auxiliaries supplied by the manufacturer;

q) any other information appropriate to the particular engine application.



Key

1 Continuous operation range
2 Intermittent operation range
3 Short-time overload operation range for special applications

a Overload power
b Nominal propellor curve
c Continuous power

Figure 3 — Example of a power/speed diagram

Annex A
(normative)

Examples of auxiliaries which may be fitted

A.1 List F — Essential dependent auxiliaries

a) engine-driven lubricating oil pressure pump;

b) engine-driven lubricating oil scavenge pump for dry-sump engines;

c) engine-driven engine-cooling water pump;

d) engine-driven raw-water pump;

e) engine-driven radiator-cooling fan;

f) engine-driven engine-cooling fan for air-cooled engines;

g) engine-driven gaseous fuel compressor;

h) engine-driven fuel-feed pump;

i) engine-driven fuel-pressure pump for common rail or servo-injection system;

j) engine-driven scavenge-air blower and/or charge-air blower;

k) engine-driven generator, air compressor or hydraulic pump when supplying power to items in list G;

l) engine-driven cylinder lubricating pump;

m) air cleaner or air silencer (normal or special);

n) exhaust silencer (normal or special).

A.2 List G — Essential independent auxiliaries

a) separately driven lubricating oil pressure pump;

b) separately driven lubricating oil scavenge pump for dry-sump engines;

c) separately driven engine-cooling water pump;

d) separately driven raw-water pump;

e) separately driven radiator-cooling fan;

f) separately driven engine-cooling fan for air-cooled engines;

g) separately driven gaseous fuel compressor;

h) separately driven fuel-feed pump;

i) separately driven fuel-pressure pump for common-rail or servo-injection system;

j) separately driven scavenge-air blower and/or charge-air blower;

k) separately driven crankcase extractor fan;

l) separately driven cylinder-lubricating pump;

m) governing or control system using power from an external source.

A.3 List H — Non-essential dependent auxiliaries

a) engine-driven starting air compressor;

b) engine-driven generator, air compressor or hydraulic pump when supplying power to items not shown in list G;

c) engine-driven bilge pump;

d) engine-driven fire pump;

e) engine-driven ventilation fan;

f) engine-driven fuel-transfer pump;

g) engine-integral thrust bearing.

Annex B
(informative)

Tables for determination of water vapour pressure, ratios and factors

B.1 Determination of water vapour pressure

The water vapour pressure ($\phi_x\ p_{sx}$) values are given in Table B.1, in kilopascals, for different values of air temperature t_x, in degrees Celsius, and relative humidity ϕ_x.

Table B.1 — Water vapour pressure values

t_x °C	**Water vapour pressure** ($\phi_x\ p_{sx}$), kPa								
	Relative humidity (ϕ_x) %								
	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2
− 10	0,30	0,27	0,24	0,21	0,18	0,15	0,12	0,09	0,06
− 9	0,30	0,29	0,26	0,23	0,20	0,16	0,13	0,10	0,07
− 8	0,35	0,32	0,28	0,25	0,21	0,18	0,14	0,11	0,07
− 7	0,38	0,34	0,30	0,27	0,23	0,19	0,15	0,11	0,08
− 6	0,41	0,36	0,32	0,28	0,24	0,20	0,16	0,12	0,08
− 5	0,43	0,39	0,35	0,30	0,26	0,22	0,17	0,13	0,09
− 4	0,46	0,41	0,37	0,32	0,28	0,23	0,18	0,14	0,09
− 3	0,49	0,44	0,39	0,34	0,30	0,25	0,20	0,15	0,10
− 2	0,53	0,47	0,42	0,37	0,32	0,26	0,21	0,16	0,10
− 1	0,50	0,50	0,45	0,39	0,34	0,28	0,22	0,17	0,11
0	0,60	0,54	0,48	0,42	0,36	0,30	0,24	0,18	0,12
1	0,60	0,58	0,51	0,45	0,39	0,32	0,26	0,19	0,13
2	0,69	0,62	0,55	0,48	0,41	0,34	0,28	0,21	0,14
3	0,74	0,66	0,59	0,52	0,44	0,37	0,30	0,22	0,15
4	0,79	0,71	0,63	0,55	0,47	0,40	0,32	0,24	0,16
5	0,85	0,76	0,68	0,59	0,51	0,42	0,34	0.25	0.17
6	0,91	0,82	0,73	0,64	0,55	0,46	0,36	0,27	0,18
7	0,98	0,88	0,78	0,68	0,59	0,49	0,39	0,29	0,20
8	1,05	0,94	0,84	0,73	0,63	0,52	0,42	0,31	0,21
9	1,12	1,01	0,90	0,78	0,67	0,56	0,45	0,34	0,22
10	1,20	1,08	0,96	0,84	0,72	0,60	0,48	0,36	0,24
11	1,28	1,16	1,03	0,90	0,77	0,64	0,51	0,39	0,26
12	1,37	1,24	1,10	0,96	0,82	0,69	0,55	0,41	0,27
13	1,47	1,32	1,17	1,03	0,88	0,73	0,59	0,44	0,29
14	1,57	1,41	1,25	1,10	0,94	0,78	0,63	0,47	0,31
15	1,67	1,51	1,34	1,17	1,00	0,84	0,67	0,50	0,33

Table B.1 *(continued)*

t_x °C	Water vapour pressure ($\phi_x p_{sx}$), kPa								
	Relative humidity (ϕ_x) %								
	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2
16	1,79	1,61	1,43	1,25	1,07	0,89	0,71	0,54	0,36
17	1,90	1,71	1,52	1,33	1,14	0,95	0,76	0,57	0,38
18	2,03	1,83	1,62	1,42	1,22	1,01	0,81	0,61	0,41
19	2,16	1,94	1,73	1,51	1,30	1,08	0,86	0,65	0,43
20	2,30	2,07	1,84	1,61	1,38	1,15	0,92	0,69	0,46
21	2,45	2,20	1,96	1,71	1,47	1,22	0,98	0,73	0,49
22	2,60	2,34	2,08	1,82	1,56	1,30	1,04	0,78	0,52
23	2,77	2,49	2,21	1,94	1,66	1,38	1,11	0,83	0,55
24	2,94	2,65	2,35	2,06	1,76	1,47	1,18	0,88	0,59
25	3,12	2,81	2,50	2,19	1,87	1,56	1,25	0,94	0,62
26	3,32	2,98	2,65	2,32	1,99	1,66	1,33	0,99	0,66
27	3,52	3,17	2,82	2,46	2,11	1,76	1,41	1,06	0,70
28	3,73	3,36	2,99	2,61	2,24	1,87	1,49	1,12	0,75
29	3,96	3,56	3,17	2,77	2,38	1,98	1,58	1,19	0,79
30	4,20	3,78	3,36	2,94	2,52	2,10	1,68	1,26	0,84
31	4,45	4,01	3,56	3,12	2,67	2,23	1,78	1,34	0,89
32	4,72	4,25	3,78	3,30	2,83	2,36	1,89	1,42	0,94
33	5,00	4,50	4,00	3,50	3,00	2,50	2,00	1,50	1,00
34	5,29	4,76	4,24	3,71	3,18	2,65	2,12	1,59	1,06
35	5,60	5,04	4,48	3,92	3,36	2,80	2,24	1,68	1,12
36	5,93	5,34	4,74	4,15	3,56	2,97	2,37	1,78	1,19
37	6,27	5,64	5,02	4,39	3,76	3,14	2,51	1,88	1,25
38	6,63	5,97	5,30	4,64	3,98	3,32	2,65	1,99	1,33
39	7,01	6,31	5,61	4,90	4,20	3,50	2,80	2,10	1,40
40	7,40	6,66	5,92	5,18	4,44	3,70	2,96	2,22	1,48
41	7,81	7,03	6,25	5,47	4,69	3,91	3,12	2,34	1,56
42	8,24	7,42	6,59	5,77	4,94	4,12	3,30	2,47	1,65
43	8,69	7,82	6,95	6,08	5,21	4,34	3,47	2,61	1,74
44	9,15	8,24	7,32	6,41	5,49	4,58	3,66	2,75	1,83
45	9,63	8,67	7,71	6,74	5,78	4,82	3,85	2,89	1,93
46	10,13	9,12	8,11	7,09	6,08	5,07	4,05	3,04	2,03
47	10,65	9,58	8,52	7,45	6,39	5,33	4,26	3,20	2,13
48	11,18	10,07	8,95	7,83	6,71	5,59	4,47	3,36	2,24
49	11,73	10,56	9,39	8,21	7,04	5,87	4,69	3,52	2,35
50	12,30	11,07	9,84	8,61	7,38	6,15	4,92	3,69	2,46

B.2 Determination of dry air pressure ratio

The dry air pressure ratio $\left(\frac{p_x - a\phi_x p_{sx}}{p_r - a\phi_r p_{sr}}\right)$ used in equation (3) is given in Table B.2 for the value of a = 1 of formula references A, E and G (see Table 3) and for different values of total barometric pressure, p_x, and water vapour pressure, $\phi_x p_{sx}$. If the water vapour pressure is not known, it can be obtained from the air temperature and relative humidity by the use of Table B.1.

NOTE For easier calculation see 2.7 of ISO 2533:1975.

Table B.2 — Dry air pressure ratio values

Altitude	Total barometric pressure p_x	Dry air pressure ratio $\left(\frac{p_x - a\phi_x p_{sx}}{p_r - a\phi_r p_{sr}}\right)$													
m	kPa	Water vapour pressure $\phi_x p_{sx}$, (kPa)													
		0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	101,3	1,02	1,01	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89
100	100,0	1,01	1,00	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87
200	98,9	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86
400	96,7	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,85	0,84
600	94,4	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82
800	92,1	0,93	0,92	0,91	0,90	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,79
1 000	89,9	0,90	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,77
1 200	87,7	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,75
1 400	85,6	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,73
1 600	83,5	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,73	0,72	0,71
1 800	81,5	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,73	0,72	0,71	0,70	0,69
2 000	79,5	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,73	0,72	0,71	0,70	0,69	0,68	0,67
2 200	77,6	0,78	0,77	0,76	0,75	0,74	0,73	0,72	0,71	0,70	0,69	0,68	0,67	0,66	0,65
2 400	75,6	0,76	0,75	0,74	0,73	0,72	0,71	0,70	0,69	0,68	0,67	0,66	0,65	0,64	0,63
2 600	73,7	0,74	0,73	0,72	0,71	0,70	0,69	0,68	0,67	0,66	0,65	0,64	0,63	0,62	0,61
2 800	71,9	0,72	0,71	0,70	0,69	0,68	0,67	0,66	0,65	0,64	0,63	0,62	0,61	0,60	0,59
3 000	70,1	0,70	0,69	0,68	0,67	0,66	0,65	0,64	0,63	0,62	0,61	0,60	0,59	0,58	0,57
3 200	68,4	0,69	0,68	0,67	0,66	0,65	0,64	0,63	0,62	0,61	0,60	0,58	0,57	0,56	0,55
3 400	66,7	0,67	0,66	0,65	0,64	0,63	0,62	0,61	0,60	0,59	0,58	0,57	0,56	0,55	0,54
3 600	64,9	0,65	0,64	0,63	0,62	0,61	0,60	0,59	0,58	0,57	0,56	0,55	0,54	0,53	0,52
3 800	63,2	0,63	0,62	0,61	0,60	0,59	0,58	0,57	0,56	0,55	0,54	0,53	0,52	0,51	0,50
4 000	61,5	0,62	0,61	0,60	0,59	0,58	0,57	0,56	0,55	0,54	0,53	0,52	0,51	0,50	0,48
4 200	60,1	0,60	0,59	0,58	0,57	0,56	0,55	0,54	0,53	0,52	0,51	0,50	0,49	0,48	0,47
4 400	58,5	0,59	0,58	0,57	0,56	0,55	0,54	0,53	0,52	0,51	0,50	0,48	0,47	0,46	0,45
4 600	56,9	0,57	0,56	0,55	0,54	0,53	0,52	0,51	0,50	0,49	0,48	0,47	0,46	0,45	0,44
4 800	55,3	0,55	0,54	0,53	0,52	0,51	0,50	0,49	0,48	0,47	0,46	0,45	0,44	0,43	0,42
5 000	54,1	0,54	0,53	0,52	0,51	0,50	0,49	0,48	0,47	0,46	0,45	0,44	0,43	0,42	0,41

B.3 Determination of the ratio of indicated power, k

Equation (3) or (5) can be written as:

$$k = (R_1)^{y1} (R_2)^{y2} (R_3)^{y3}$$

where

$$R_1 = \frac{p_x \times a\phi_x p_{sx}}{p_r \times a\phi_r p_{sr}} \quad \text{or} \quad \frac{p_x}{p_{ra}}$$

$$R_2 = \frac{T_r}{T_x} \quad \text{or} \quad \frac{T_{ra}}{T_x}$$

$$R_3 = \frac{T_{cr}}{T_{cx}} \quad \text{or} \quad \frac{T_{cra}}{T_{cx}}$$

and

$$y_1 = m; y_2 = n; y_3 = s.$$

The value of R_1 can be obtained from Table B.2 and other values of R can be calculated.

The values of m, n, s, are obtained from Table B.3.

Table B.3 then gives values of R^y for known ratios R and known factors y.The value of k is then obtained by multiplying together the appropriate values of R^y.

Table B.3 — Values of R^y for determination of the ratio of indicated power, k

R	R^y								
	y								
	0,5	0,55	0,57	0,7	0,75	0,86	1,2	1,7	2,0
0,60	0,775	0,755	0,747	0,699	0,682	0,645	0,542	0,409	0,360
0,62	0,787	0,769	0,762	0,716	0,699	0,663	0,564	0,433	0,384
0,64	0,800	0,782	0,775	0,732	0,716	0,681	0,585	0,458	0,410
0,66	0,812	0,796	0,789	0,748	0,732	0,700	0,607	0,483	0,436
0,68	0,825	0,809	0,803	0,763	0,749	0,718	0,630	0,509	0,462
0,70	0,837	0,822	0,816	0,779	0,765	0,736	0,652	0,536	0,490
0,72	0,849	0,835	0,829	0,795	0,782	0,754	0,674	0,563	0,518
0,74	0,860	0,847	0,842	0,810	0,798	0,772	0,697	0,590	0,548
0,76	0,872	0,860	0,855	0,825	0,814	0,790	0,719	0,619	0,578
0,78	0,883	0,872	0,868	0,840	0,830	0,808	0,742	0,647	0,608
0,80	0,894	0,885	0,881	0,855	0,846	0,825	0,765	0,677	0,640
0,82	0,906	0,897	0,893	0,870	0,862	0,843	0,788	0,707	0,672
0,84	0,917	0,909	0,905	0,885	0,877	0,861	0,811	0,737	0,706
0,86	0,927	0,920	0,918	0,900	0,893	0,878	0,834	0,768	0,740
0,88	0,938	0,932	0,930	0,914	0,909	0,896	0,858	0,800	0,774
0,90	0,949	0,944	0,942	0,929	0,924	0,913	0,881	0,832	0,810
0,92	0,959	0,955	0,954	0,943	0,939	0,931	0,905	0,864	0,846
0,94	0,970	0,967	0,965	0,958	0,955	0,948	0,928	0,897	0,884
0,96	0,980	0,978	0,977	0,972	0,970	0,966	0,952	0,931	0,922
0,98	0,990	0,989	0,989	0,986	0,985	0,963	0,976	0,965	0,960
1,00	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
1,02	1,010	1,011	1,011	1,014	1,015	1,017	1,024	1,035	1,040
1,04	1,020	1,022	1,023	1,028	1,030	1,034	1,048	1,071	1,082
1,06	1,030	1,033	1,034	1,042	1,045	1,051	1,072	1,107	1,124
1,08	1,038	1,043	1,045	1,055	1,059	1,068	1,097	1,144	1,166
1,10	1,049	1,054	1,056	1,069	1,074	1,085	1,121	1,182	1,210
1,12	1,058	1,064	1,067	1,083	1,089	1,102	1,146	1,219	1,254
1,14	1,068	1,075	1,078	1,096	1,103	1,119	1,170	1,258	1,300
1,16	1,077	1,085	1,088	1,110	1,118	1,136	1,195	1,297	1,346
1,18	1,086	1,095	1,099	1,123	1,132	1,153	1,220	1,336	1,392
1,20	1,095	1,106	1,110	1,135	1,147	1,170	1,245	1,376	1,440

B.4 Determination of the fuel consumption recalculation factor, β

Table B.4 gives values of the fuel consumption recalculation factor, β [see equation (8)], for known values of the ratio of indicated power k and mechanical efficiency η_m.

The value of k can [see equations (3) and (5)] be determined for B.3.

The value of η_m is stated by the manufacturer.

Table B.4 — Fuel consumption recalculation factor, β, values

k	β					
	Mechanical efficiency η_m					
	0,7	0,75	0,8	0,85	0,9	0,95
0,50	1,429	1,304	1,212	1,141	1,084	1,083
0,52	1,383	1,275	1,193	1,129	1,077	1,035
0,54	1,343	1,248	1,175	1,118	1,071	1,032
0,56	1,308	1,225	1,159	1,108	1,065	1,030
0,58	1,278	1,203	1,145	1,098	1,060	1,027
0,60	1,250	1,184	1,132	1,090	1,055	1,025
0,62	1,225	1,167	1,120	1,082	1,050	1,023
0,64	1,203	1,151	1,109	1,075	1,046	1,021
0,66	1,183	1,137	1,099	1,068	1,042	1,019
0,68	1,164	1,123	1,090	1,062	1,038	1,018
0,70	1,148	1,111	1,081	1,056	1,035	1,016
0,72	1,132	1,100	1,073	1,051	1,031	1,015
0,74	1,118	1,089	1,066	1,045	1,028	1,013
0,76	1,105	1,080	1,059	1,041	1,025	1,012
0,78	1,092	1,070	1,052	1,036	1,022	1,011
0,80	1,081	1,062	1,046	1,032	1,020	1,009
0,82	1,071	1,054	1,040	1,028	1,017	1,008
0,84	1,061	1,047	1,035	1,024	1,015	1,007
0,86	1,051	1,040	1,029	1,021	1,013	1,006
0,88	1,043	1,033	1,024	1,017	1,011	1,005
0,90	1,035	1,027	1,020	1,014	1,009	1,004
0,92	1,027	1,021	1,016	1,011	1,007	1,003
0,94	1,020	1,015	1,011	1,008	1,005	1,002
0,96	1,013	1,010	1,007	1,005	1,003	1,002
0,98	1,006	1,005	1,004	1,003	1,002	1,001
1,00	1,000	1,000	1,000	1,000	1,000	1,000
1,02	0,994	0,995	0,997	0,998	0,999	0,999
1,04	0,989	0,991	0,993	0,995	0,997	0,999
1,06	0,983	0,987	0,990	0,993	0,996	0,998
1,08	0,978	0,983	0,987	0,991	0,994	0,997
1,10	0,974	0,979	0,984	0,989	0,993	0,997
1,12	0,969	0,976	0,982	0,987	0,992	0,996
1,14	0,965	0,972	0,979	0,985	0,991	0,996
1,16	0,960	0,969	0,976	0,983	0,989	0,995
1,18	0,956	0,966	0,974	0,982	0,988	0,994
1,20	0,952	0,963	0,972	0,980	0,987	0,994

B.5 Determination of the power adjustment factor, α

Table B.5 gives values of the power adjustment factor, α [see equation (2)], for known values of the ratio of indicated power k and mechanical efficiency η_m.

The value of k [see equations (3) and (5)] can be determined from B.3.

The value of η_m is stated by the manufacturer (see 10.3.3).

Table B.5 — Power adjustment factor, α

k	α					
	Mechanical efficiency η_m					
	0,70	0,75	0,80	0,85	0,90	0,95
0,50	0,350	0,383	0,413	0,438	0,461	0,482
0,52	0,376	0,408	0,436	0,461	0,483	0,502
0,54	0,402	0,433	0,460	0,483	0,504	0,523
0,56	0,428	0,457	0,483	0,506	0,526	0,544
0,58	0,454	0,482	0,507	0,528	0,547	0,565
0,60	0,480	0,507	0,530	0,551	0,569	0,585
0,62	0,506	0,531	0,554	0,573	0,590	0,606
0,64	0,532	0,556	0,577	0,596	0,612	0,627
0,66	0,558	0,581	0,601	0,618	0,634	0,648
0,68	0,584	0,605	0,624	0,641	0,655	0,668
0,70	0,610	0,630	0,648	0,663	0,677	0,689
0,72	0,636	0,655	0,671	0,685	0,698	0,710
0,74	0,662	0,679	0,695	0,708	0,720	0,730
0,76	0,688	0,704	0,718	0,730	0,741	0,751
0,78	0,714	0,729	0,742	0,753	0,763	0,772
0,80	0,740	0,753	0,765	0,775	0,784	0,793
0,82	0,766	0,778	0,789	0,798	0,806	0,813
0,84	0,792	0,803	0,812	0,820	0,828	0,834
0,86	0,818	0,827	0,836	0,843	0,849	0,855
0,88	0,844	0,852	0,859	0,865	0,871	0,876
0,90	0,870	0,877	0,883	0,888	0,892	0,896
0,92	0,896	0,901	0,906	0,910	0,914	0,917
0,94	0,922	0,926	0,930	0,933	0,935	0,938
0,96	0,948	0,951	0,953	0,955	0,957	0,959
0,98	0,974	0,975	0,977	0,978	0,978	0,979
1,00	1,000	1,000	1,000	1,000	1,000	1,000
1,02	1,026	1,025	1,024	1,023	1,022	1,021
1,04	1,052	1,049	1,047	1,045	1,043	1,042
1,06	1,078	1,074	1,071	1,067	1,065	1,062
1,08	1,104	1,099	1,094	1,090	1,086	1,083
1,10	1,130	1,123	1,118	1,112	1,108	1,104
1,12	1,156	1,148	1,141	1,135	1,129	1,124
1,14	1,182	1,173	1,165	1,157	1,151	1,145
1,16	1,208	1,197	1,188	1,180	1,172	1,166
1,18	1,234	1,222	1,212	1,202	1,194	1,187
1,20	1,260	1,247	1,235	1,225	1,216	1,207

Annex C
(informative)

Example of calculating power adjustment and recalculating specific fuel consumption from standard reference conditions or substitute reference conditions to site ambient conditions

C.1 Example 1

A non-turbocharged compression-ignition (diesel) engine with its power limited by insufficient excess air has an ISO standard power of 500 kW with a mechanical efficiency of 85 % and an ISO specific fuel consumption of 220 g/kW h.

What is the expected service standard power and specific fuel consumption at a site with a total barometric pressure of 87 kPa, air temperature 45 °C and relative humidity 80 %?

From Table 2, formula reference A gives a = 1, m = 1, n = 0,75 and s = 0

Standard reference conditions	Site ambient conditions
p_r = 100 kPa	p_x = 87 kPa
T_r = 298 K	T_x = 318 K
ϕ_r = 0,3	ϕ_x = 0,8

and η_m = 0,85.

From B.1, at t_x = 45 °C and ϕ_x = 0,8:

$$\phi_x p_{sx} = 7{,}71 \text{ kPa}$$

From B.2, at p_x = 87 kPa and $\phi_x p_{sx}$ = 7,71 kPa, by interpolation:

$$\frac{p_x - a\phi_x p_{sx}}{p_r - a\phi_r p_{sr}} = 0{,}801$$

From B.3, at $\frac{T_r}{T_x} = \frac{298}{318}$ = 0,937 and n = 0,75, by interpolation:

$$\left(\frac{T_r}{T_x}\right)^n = 0{,}952$$

From formula (3), k = 0,801 × 0,952 = 0,763.

From B.4, at k = 0,763 and η_m = 0,85, by interpolation β = 1,040.

From B.5, at k = 0,763 and η_m = 0,85, by interpolation α = 0,733 6.

Hence:

site continuous brake power = 500 × 0,733 6 = 366,8 kW

site specific fuel consumption = 220 × 1,040 = 228,8 g/kW·h

C.2 Example 2

A turbocharged and charge-cooled medium-speed four-stroke compression-ignition (diesel) engine has a declared power of 1 000 kW at standard reference conditions, with a mechanical efficiency of 90 % and a boost pressure ratio of 2. The manufacturer declares that the limits of temperature and turbocharger speed have not been reached under standard reference conditions and gives a substitute reference temperature of 313 K and a maximum available boost pressure ratio of 2,36.

What power will be available at an altitude of 4 000 m with an ambient temperature of 323 K and a charge air coolant temperature of 310 K?

From Table 2, formula reference D is applicable with a = 0, m = 0,7, n =1,2 and s = 1.

From equation (6), at p_r = 100 kPa, r_r = 2 and r_{max} = 2,36:

$$p_{ra} = \left(\frac{100 \times 2{,}0}{2{,}36} \right) = 84{,}7 \text{ kPa}$$

From B.2, at 4 000 m altitude, p_x = 61,5 kPa.

Standard reference conditions	**Site ambient conditions**
p_{ra} = 84,7 kPa	p_x = 61,5 kPa
T_{ra} = 313 K	T_x = 323 K
T_{cr} = 298 K	T_{cx} = 310 K

and η_m = 0,90.

Hence:

$$\frac{p_x}{p_{ra}} = \frac{61{,}5}{84{,}7} = 0{,}726$$

$$\frac{T_{ra}}{T_x} = \frac{313}{323} = 0{,}969$$

$$\frac{T_{cr}}{T_{cx}} = \frac{298}{310} = 0{,}961$$

From equation (5):

$$k = \left(\frac{p_x}{p_{ra}} \right)^{0{,}7} \left(\frac{T_{ra}}{T_x} \right)^{1{,}2} \left(\frac{T_{cr}}{T_{cx}} \right)^{1{,}0}$$

From B.3, by interpolation :

$(0{,}726)^{0{,}7} = 0{,}799$

$(0{,}969)^{1{,}2} = 0{,}963$

and

$k = 0{,}799 \times 0{,}963 \times 0{,}961 = 0{,}741$

From B.5, at $k = 0{,}740$ and $\eta_m = 0{,}90$, $\alpha = 0{,}720$.

Hence:

site power = 0,720 × 1 000 = 720 kW at 2,36 boost pressure ratio.

Annex D
(informative)

Examples of power adjustment from site ambient conditions to test ambient conditions and simulation of site ambient conditions for adjusted engines

A four-stroke turbocharged compression-ignition(diesel) engine with charge air cooling will develop 640 kW brake power, P_x, under site ambient conditions.

What brake power would be developed at test ambient conditions?

Standard reference conditions	**Site ambient conditions**
p_x = 70 kPa	p_y = 100 kPa
T_x = 330 K	T_y = 300 K
T_{cx} = 300 K	T_{cy} = 280 K

The mechanical efficiency η_m refers to standard reference conditions and is 85 %.

Adjust the initial engine power required at the site ambient conditions to the standard reference conditions, and then adjust the results obtained to test ambient conditions.

The first step in solving the example is to determine what the brake power output is under standard reference conditions.

The general equations and symbols needed to adjust the power are equations (1), (2) and (5) in 10.3. Redefine the general equations so the brake power under site ambient conditions can be adjusted to standard reference conditions.

To adjust the brake power, P_x, under site ambient conditions to the brake power under standard reference conditions, P_r, the general equation (1) in 10.3 is applied and adapted as follows:

$$P_r = \frac{P_x}{\alpha}$$

The power adjustment factor α for adjusting brake power from site ambient conditions to standard reference conditions is:

$$\alpha = k - 0{,}7(1-k)\left(\frac{1}{\eta_m} - 1\right)$$

The power ratio k needed for brake power adjustment from site ambient conditions to standard reference conditions is given by:

$$k = \left(\frac{p_x}{p_r}\right)^m \left(\frac{T_r}{T_x}\right)^n \left(\frac{T_{cr}}{T_{cx}}\right)^s$$

where m, n and s are exponents found in table 2, formula reference D:

m = 0,7; n = 1,2; s = 1,0

Using the equations that have been developed, and substituting the values given in the example:

$$k = \left(\frac{70}{100}\right)^{0,7} \left(\frac{298}{330}\right)^{1,2} \left(\frac{298}{300}\right)^{1,0} = 0,685$$

$$\alpha = 0,685 - 0,7(1 - 0,685)\left(\frac{1}{0,85} - 1\right)$$

$$= 0,685 - (0,7 \times 0,315 \times 0,176)$$

$$= 0,646$$

Therefore the brake power under standard reference conditions is:

$$P_\mathrm{r} = \frac{640}{0,646} = 991 \quad \mathrm{kW}$$

This is the power output under standard reference conditions.

The next step is to adjust the brake power from the standard reference conditions to test ambient conditions.

The equations for adjusting the brake power from standard reference conditions to test ambient conditions are:

$$P_\mathrm{y} = \alpha P_\mathrm{r}$$

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

$$k = \left(\frac{P_\mathrm{y}}{P_\mathrm{r}}\right)^{m} \left(\frac{T_\mathrm{r}}{T_\mathrm{y}}\right)^{n} \left(\frac{T_\mathrm{cr}}{T_\mathrm{cy}}\right)^{s}$$

Substituting the values given above:

$$k = \left(\frac{100}{100}\right)^{0,7} \left(\frac{298}{300}\right)^{1,2} \left(\frac{298}{280}\right)^{1,0} = 1,056$$

$$\alpha = 1,056 - 0,7(1 - 1,056)\left(\frac{1}{0,85} - 1\right)$$

$$= 1,056 + (0,7 \times 0,056 \times 0,176) = 1,063$$

Therefore the brake power under test ambient conditions is:

$$P_\mathrm{y} = 1,063 \times 991 = 1\,053 \ \mathrm{kW}$$

If there is a limitation in the maximum permissible combustion pressure, say, at 808 kW, and the manufacturer so decides, the engine should be tested under loads up to but not exceeding 808 kW. For this purpose a method of simulating site ambient conditions on the test bed in accordance with 6.2.5 may be applied.

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