INTERNATIONAL STANDARD

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Reciprocating internal combustion engines — Performance —

Part 3 : Test measurements

Moteurs alternatifs à combustion interne — Performances —

Partie 3 : Mesures pour les essais

Reference number
ISO 3046-3 : 1989 (E)

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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 3046-3 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines.*

This second edition cancels and replace the first edition (ISO 3046-3 : 1979), of which it constitutes a technical revision.

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

— *Part 1: Standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption*

— *Part 2: Test methods*

— *Part 3: Test measurements*

— *Part 4: Speed governing*

— *Part 5: Torsional vibrations*

— *Part 6: Overspeed protection*

— *Part 7: Codes for engine power*

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Reciprocating internal combustion engines — Performance —

Part 3 : Test measurements

1 Scope

This part of ISO 3046 summarizes the common measurement techniques of the main performance parameters of reciprocating internal combustion engines to ensure that the required accuracy of measurement is achieved for comparison of the measured values with those values specified by the engine manufacturer. Where necessary, individual requirements may be given for particular engine applications.

It applies to reciprocating internal combustion engines for land, rail-traction and marine use, excluding engines used to propel agricultural tractors, road vehicles and aircraft.

It may be applied to engines used to propel road construction and earth-moving machines, industrial trucks and for other applications where no suitable International Standards for these engines exist.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 3046. At the time of publication, the edition indicated was 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 edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2710:1978, *Reciprocating internal combustion engines — Vocabulary.*

3 Other regulations and requirements

3.1 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. If this applies, the classification society shall be stated by the customer before placing the order.

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

3.2 If special requirements from regulations of any other authority, for example inspecting and/or legislative authorities, have to be met, the authority shall be stated by the customer before placing the order.

Any further additional requirements shall be subject to agreement between the manufacturer and customer.

4 Requirements

4.1 Accuracy of measurement

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

— error of the measuring instrument;

— correctness of the location of the measuring instrument;

— conditions under which the measuring instrument is used;

— accuracy of the readings;

— scatter of the readings of the measuring instrument during the measuring period.

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

4.2 Operating conditions

4.2.1 Before a set of measurements is commenced, the engine shall have operated at the particular conditions of load and speed for a sufficient period of time to ensure that it has reached stable operating conditions as specified by the engine manufacturer.

4.2.2 During the period in which a set of measurements is being made, the load, speed and all fluid temperatures and pressures shall be maintained constant within the permissible deviations given in column 6 of table 1 which gives the list of parameters (see clause 5).

4.3 Measurement methods

4.3.1 Measurement methods shall be selected by the engine manufacturer and, if necessary, may be subject to contractual agreement between the engine manufacturer and customer and/or inspecting authority.

4.3.2 The location of measurement points shall be selected by the engine manufacturer.

4.4 Permissible deviation of parameters

4.4.1 The permissible deviations given in column 6 of table 1 apply only to the declared power.

4.4.2 The permissible deviation quoted is that considered adequate for most acceptance test purposes. Engine manufacturers may adopt reduced permissible deviations

a) for type tests;

b) for special contractual or legislative requirements.

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

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

Where measurements are used in subsequent calculations, measurement uncertainties on the measured parameters shall be selected so that the deviation of the final calculated parameter complies with the corresponding permissible deviation.

5 List of parameters

The parameters of engine performance for test measurements are given in table 1.

NOTE — All footnotes appear at the end of the table.

Table 1 — List of parameters

No.	Parameter	Definition	Symbol	Unit	Permissible deviation
1	2	3	4	5	6
5.1	**General parameters**				
5.1.1	Engine brake torque[1]	Mean torque delivered by the engine, measured at the engine driving shaft extremity.	T_{tq}	kN·m	± 2 %
5.1.2	Engine speed[2]	Number of revolutions of the crankshaft in a given period of time.	n	s^{-1} min^{-1} r/min	± 2 %
5.1.3	Engine driving shaft speed	Number of revolutions of the engine driving shaft in a given period of time.	n_d	s^{-1} min^{-1} r/min	± 2 %
5.1.4	Turbocharger speed	Number of revolutions of the turbocharger shaft in a given period of time.	n_t	s^{-1} min^{-1} r/min	± 2 %
5.1.5	Brake power[3]	Power or sum of the powers measured at the driving shaft or shafts.	P[4]	kW	± 3 %
5.2	**Pressures**[5),6]				
5.2.1	Ambient pressure[7]	Pressure level of the atmosphere in the vicinity from where the engine takes its air.	p_a	kPa	± 0,5 %
5.2.2	Compression pressure in a cylinder[8]	Maximum pressure of the working medium present in a cylinder at momentary fuel cut-off.	p_{co}	MPa	± 5 %
5.2.3	Maximum cylinder pressure[8]	Maximum pressure of the working medium present in a cylinder attained during a working cycle.	p_{max}	MPa	± 5 %
5.2.4	Intake depression	Arithmetic mean intake depression at engine or pressure-charger inlet.	Δp_d	kPa	± 5 %
5.2.5	Intake pressure	Arithmetic mean absolute intake pressure at engine or pressure-charger inlet.	p_d	kPa	± 1 %
5.2.6	Boost pressure	Arithmetic mean charge air pressure after a pressure-charger.	p_b	kPa	± 2 %
5.2.7	Boost pressure before cylinder inlet	Arithmetic mean of the air pressure before the cylinder inlet.	p_{ba}	kPa	± 2 %

Table 1 (*continued*)

No.	Parameter	Definition	Symbol	Unit	Permissible deviation
1	2	3	4	5	6
5.2.8	Boost pressure drop through the air cooler	—	Δp_{ba}	kPa	± 10 %
5.2.9	Exhaust gas pressure at the turbine inlet or inlet of other exhaust gas-assisted pressure charger (valid only for engines with a constant-pressure system)	Arithmetic mean of the pressure in the exhaust pipe before the turbine.	p_{g1}	kPa	± 5 %
5.2.10	Exhaust back pressure	Arithmetic mean of the pressure in the exhaust manifold or after the turbine.	p_{g2}	kPa	± 5 %
5.2.11	Coolant pressure	Pressure(s) at given point(s) of the fluid cooling systems(s).	p_{cl}	kPa	± 5 %
5.2.12	Lubricating oil pressure	Oil pressure(s) at given point(s) of the lubricating system(s) (in individual circuits before and after filters, coolers, etc.).	p_o	kPa	± 5 %
5.2.13	Fuel supply pressure	Arithmetic mean of the fuel pressure at the inlet of the injection pump.	p_f	kPa	± 10 %
5.3	**Temperatures**[9),10)]				
5.3.1	Ambient temperature	Temperature level of the atmosphere in the environment of the engine installation at a given point or location.	T_a	K	± 2 K
5.3.2	Intake temperature	Air temperature at the engine or pressure-charger inlet.	T_d	K	± 2 K
5.3.3	Charge air temperature after the pressure-charger	—	T_b	K	± 4 K
5.3.4	Charge air temperature after the air cooler	Air temperature before the cylinder inlet.	T_{ba}	K	± 4 K
5.3.5	Exhaust gas temperature at the cylinder outlet	Mean temperature of the exhaust gas measured by the thermal pick-up at a given cylinder.	$T_{g,cyl}$	K	± 25 K
5.3.6	Exhaust gas temperature at the turbine inlet or inlet of other exhaust gas-assisted pressure-charger	Mean temperature of the exhaust gas measured by the thermal pick-up before the turbine.	T_{g1}	K	± 25 K
5.3.7	Exhaust gas temperature in the exhaust pipe or after the turbine or other exhaust gas-assisted pressure-charger	Mean temperature of the exhaust gas measured by the thermal pick-up in the exhaust manifold or after the turbine.	T_{g2}	K	± 15 K
5.3.8	Coolant temperature	Temperature(s) at given point(s) of the fluid cooling system(s).	T_{cl}	K	± 2 K
5.3.9	Lubricating oil temperature	Oil temperature(s) at given point(s) of the lubricating system(s).	T_o	K	± 2 K
5.3.10	Fuel temperature	Fuel temperature at a given point of the fuel system.	T_f	K	± 5 K
5.4	**Consumptions**[11)]				
5.4.1	Fuel consumption	Mass of fuel consumed by the engine per unit of time.	B	g/s kg/s kg/h	± 3 %
5.4.2	Specific fuel consumption	Fuel consumption per unit of power.	b	g/(kW·h) g/MJ	± 3 %
5.4.3	Cylinder lubricating oil consumption	Mass of cylinder oil supplied by the lubricator per unit of time.	C_{cyl}	g/s kg/s kg/h	± 10 %
5.4.4	Specific consumption of cylinder oil	Cylinder lubricating oil consumption per unit of power.	c_{cyl}	g/(kW·h) g/MJ	± 13 %
5.4.5	Air consumption	Mass of air drawn into the engine from the atmosphere per unit of time.	A	kg/s kg/h	± 5 %
5.4.6	Specific air consumption	Air consumption per unit of power.	a	kg/(kW·h) kg/MJ	± 5 %

Table 1 (*concluded*)

No.	Parameter	Definition	Symbol	Unit	Permissible deviation
1	2	3	4	5	6
5.5	**Flows**				
5.5.1	Cooling fluid flow	Mass of fluid flowing through the engine cooling system per unit of time.	m_{cl}	kg/s kg/h	± 10 %
5.5.2	Lubricating oil flow	Mass of oil flowing through the engine lubricating system per unit of time.	m_o	kg/s kg/h	± 10 %
5.6	**Exhaust gas emission characteristics**				
5.6.1	Smoke index[12]	Filter soiling (expressed as function of light reflectivity) by undiluted gas.[13]	r	Smoke number	± 0,3 on a scale of 10 units[14]
5.6.2	Smoke opacity[12]	a) Light obscuration by undiluted gas.[15] b) Coefficient of light absorption.[16]	N k	% m^{-1}	± 5 % ± 5 %
5.6.3	Soot content[12]	Gravimetric carbon concentration.[17]	C_c	g/m^3	± 10 %
5.6.4	Gaseous emission composition[18]	Volumetric concentration of gaseous components.	c_B[19]	% or ppm	AMC[20]
5.6.5	Emission rate[21]	Mass of each component emitted per unit of time.	E_B[19]	g/h	AMC[20]
5.6.6	Specific emission	Emission rate per unit of power.	e_B[19]	g/(kW·h)	AMC[20]

1) Measured by hydraulic brake, electric dynamometer or other similar arrangements.

2) Measured by a tachometer, revolution counter, tachoscope or similar means.

3) Calculated from measured values of torque and speed of engine driving shaft.

4) Where necessary the suffix "e" shall be used in accordance with ISO 2710:1978 to distinguish brake power from another power.

5) The permissible deviation of each pressure (except the pressure in 5.2.1 and 5.2.5) is given as a percentage of the gauge pressure.

6) The unit bar may be used instead of kPa or MPa.

7) Measured by spring-loaded, fluid-type barometers or similar means.

8) Measured by a recording maximum pressure gauge, mechanical indicator, from an indicator diagram or similar means.

9) Measured by electrical methods (resistance thermometers or a thermocouple with measuring apparatus) or fluid-type thermometers.

10) The unit °C may be used instead of K.

11) Consumptions are measured by mass or volume methods (the unit assumes by mass in this part of ISO 3046), by determining the time during which a given quantity of fluid is consumed, or alternatively by using normal pressure differential systems or other types of flowmeter.

12) The engine manufacturer may select either parameter indicated in 5.6.1 or 5.6.3 for non-opacity measurement or 5.6.2 for opacity measurement according to the facilities available.

13) Measured by passing a known volume of gas through a specified area of (white) filter paper and determining the reduction in light reflected from the filter.

14) For automatic continuous measurement, the permissible deviation in 5.6.1 may be ± 0,6 on a scale of 10 units.

15) Measured over the entire cross-section of the exhaust plume close to the point of exit from the exhaust pipe or over a defined length of the smoke column, the linear dimension in each case being denoted by L, expressed in metres.

16) The value k is given by the equation

$$k = -\frac{1}{L}\log_e\left(1 - \frac{N}{100}\right)$$

where N is the reading of smoke opacity on a linear scale from 0 to 100 units.

17) Measured by the increase in mass of a filter through which a known volume of undiluted exhaust gas has been passed and corrected to standard reference temperature and pressure.

18) Measured by chemical or physical methods appropriate to each component (and/or its concentration).

19) "B" is the suffix of an individual component of the exhaust gas.

20) By Agreement between engine Manufacturer and Customer.

21) Calculated from the emission concentration measurement and calculated rate of exhaust gas flow.

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