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Internal combustion engines — Determination and method for the measurement of engine power — General requirements

Moteurs à combustion interne — Détermination et méthode de mesure de la puissance du moteur — Exigences générales

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 70, *Internal combustion engines*.

This second edition cancels and replaces the first edition (ISO 15550:2002), of which it constitutes a minor revision.

Introduction

This document establishes the framework for ISO engine power measurement standards. By applying this framework, the disadvantages of the existence of many similar, but different, ISO standards for the definition and determination of engine power can be avoided.

This framework uses the "Core" and "Satellite" approach. The "Core" standard contains the requirements that are common to all engine applications described in the scope and the "Satellite" standard contains those requirements that are necessary to tailor power measurement and declaration to suit a particular engine application.

This document is only applicable in conjunction with a particular "Satellite" standard in order to completely specify the requirements for the particular engine application. The "Core" standard, therefore, is not a document that can stand alone, but only represents addenda to a particular "Satellite" standard used to create a complete standard together with the said "Satellite" standard.

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.

This document is the "Core" standard.

This document was prepared in order to serve as the "Core" standard for making engine power measurements. It was drafted in close co-operation with technical committees ISO/TC 22 *Road vehicles*, ISO/TC 23 *Machinery for forestry and agriculture*, ISO/TC 127 *Earth moving machinery* and ISO/TC 188 *Small craft*. The prerequisite for any future modification of this document will be the formal approval of all the above technical committees. Together with the "Satellite" standard for each engine application, the "Core" standard serves as the basis for engine power declaration and measurement. Each technical committee is fully responsible for the administration of its own "Satellite" standard(s).

Any further requirements are subject to agreement between the manufacturer and customer.

Internal combustion engines — Determination and method for the measurement of engine power — General requirements

1 Scope

1.1 This document specifies standard reference conditions and methods of declaring the power, fuel consumption, lubricating oil consumption and test methods for internal combustion engines in commercial production using liquid or gaseous fuels. It is applicable to the following:

a) reciprocating internal combustion (RIC) engines (spark-ignition or compression-ignition engines) but excluding free piston engines;

b) rotary piston engines.

These engines can be naturally aspirated or pressure-charged either using a mechanical pressure-charger or turbocharger.

1.2 This document is applicable to engines used for the following:

a) land, rail-traction and marine use as defined in ISO 3046-1;

b) the propulsion of automotive vehicles as defined in ISO 1585 and ISO 2534;

c) motorcycles as defined in ISO 4106;

d) the propulsion of agricultural tractors and machines

e) the propulsion of earth-moving machinery as defined in ISO 9249;

f) the propulsion of recreational craft or other small marine craft up to 24 m hull length as defined in ISO 8665.

This document can be applied to engines used to propel road construction machines, industrial trucks and for other applications where no suitable International Standard for these engines exists.

It also can be applied to tests performed both on a test bed at a manufacturer's works as well as on site.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2710-1, *Reciprocating internal combustion engines — Vocabulary — Part 1: Terms for engine design and operation*

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

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

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

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

ISO 5163, *Petroleum products — Determination of knock characteristics of motor and aviation fuels — Motor method*

ISO 5164, *Petroleum products — Determination of knock characteristics of motor fuels — Research method*

ISO 5165, *Petroleum products — Determination of the ignition quality of diesel fuels — Cetane engine method*

ISO 11614, *Reciprocating internal combustion compression-ignition engines — Apparatus for measurement of the opacity and for determination of the light absorption coefficient of exhaust gas*

ASTM D 240, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter*

ASTM D 3338/D 3338M, *Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2710-1, ISO 3046-4, ISO 7876-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Auxiliaries and equipment

3.1.1
dependant auxiliary
item of equipment, the presence or absence of which affects the final shaft power output of the engine

3.1.2
independent auxiliary
item of equipment that uses power supplied from a source other than the engine

3.1.3
essential auxiliary
item of equipment that is essential for the continued or repeated operation of the engine

3.1.4
non-essential auxiliary
item of equipment that is not essential for the continued or repeated operation of the engine

3.1.5
standard production equipment
SPE
equipment specified by the manufacturer for a particular engine application that is fitted as standard to the engine

3.2 Engine

3.2.1
engine adjustment
physical procedure of modifying an engine for the purpose of adapting it to deliver a power adjusted to a different set of ambient conditions, such as by moving the limiting fuel stop, re-matching the turbocharger, changing the fuel injection timing or other physical changes

Note 1 to entry: Once the modifications have been completed, the engine is an adjusted engine.

3.2.2
non-adjusted engine
engine which is pre-set 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
number of revolutions of the crankshaft in a given period of time

[SOURCE: ISO 2710-1:2000, 11.1]

3.2.4
declared engine speed
engine speed corresponding to the *declared power* (3.3.1)

[SOURCE: ISO 2710-1:2000, 11.1.2 — modified]

Note 1 to entry: In some applications, the declared engine speed is named “rated speed”.

3.2.5
declared intermediate engine speed
engine speed less than 100 % of the declared speed, declared by the manufacturer taking into account the specific requirement defined in the relevant “Satellite” standard

3.2.6
low idle engine speed
idling speed
lowest steady-state engine speed without load

[SOURCE: ISO 2710-1:2000, 11.1.4 — modified]

3.2.7
engine speed at maximum torque
engine speed at maximum torque on maximum fuel stop, including additional torque fuel setting, if applicable

[SOURCE: ISO 3046-4:2009, 2.3.13 — modified]

3.3 Power and load

3.3.1
declared power
value of the power, declared by the manufacturer, which an engine will deliver under a given set of circumstances

Note 1 to entry: In some applications, the declared power is named “rated power”.

3.3.1.1
declared propeller shaft power
value of the power, declared by the manufacturer, at the propeller shaft of an engine sold with complete propulsion units or at the coupling to the propeller shaft of an engine sold with reduction and/or reversing gears

3.3.1.2
declared crankshaft power
value of the power, declared by the manufacturer, at the engine power output shaft of an engine sold without reduction or reversing gears, stern drives or sail drive units

3.3.2
indicated power
total power developed in the working cylinders as a result of the pressure of the working medium acting on the pistons

[SOURCE: ISO 2710-1:2000, 13.1]

3.3.3
brake power
power or the sum of the powers delivered at the end of the crankshaft or its equivalent, with the equipment and auxiliaries fitted as required by the relevant "Satellite" standard

Note 1 to entry: See Table 1.

Table 1 — Equipment and auxiliaries to be installed for the test to determine engine power

1	2	3	4	5
No.	Equipment and auxiliaries	Fitted for engine net power test in accordance with ISO 1585 ISO 8665 ISO 9249 ISO 4106	Fitted for engine gross power test in accordance with ISO 2534	Fitted for engine power test in accordance with ISO 14396
1	Inlet system: Inlet manifold	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Crankcase emission control system	Yes, if SPE	Optional	Yes, if SPE
	Control devices for dual induction	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Inlet manifold system: Air flow meter	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Air inlet ductwork	Yes, if SPE[a]	Optional[a]	Yes[a]
	Air filter	Yes, if SPE[a]	Optional[a]	Yes[a]
	Inlet silencer	Yes, if SPE[a]	Optional[a]	Yes[a]
	Speed-limiting device	Yes, if SPE[a]	No	Yes[a]
2	Induction-heating device of inlet manifold	Yes, if SPE. If possible, to be set in the most favourable condition.		
3	Exhaust system: Exhaust purifier	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Exhaust manifold	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Pressure-charging device	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Connecting pipes	Yes, if SPE[b]	Optional, may use minimum loss test bed system[b]	Yes[b]
	Silencer	Yes, if SPE[b]		Yes[b]
	Tail pipe	Yes, if SPE[b]		Yes[b]
	Exhaust brake	Yes, if SPE[c]	No[c]	No[c]
4	Fuel supply pump	Yes, if SPE[d]	Yes, if SPE[d]	Yes, if SPE[d]
5	Carburation equipment: Carburettor	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Electronic control system, air flow meter, etc.	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Equipment for gas engines: Pressure reducer	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Evaporator	Yes, if SPE	Yes, if SPE	Yes, if SPE

Table 1 *(continued)*

	Mixer	Yes, if SPE	Yes, if SPE	Yes, if SPE
6	Fuel injection equipment [spark-ignition (petrol) and compression-ignition (diesel)]: Prefilter	Yes, if SPE	Optional	Yes, if SPE or test bed equipment
	Filter	Yes, if SPE	Optional	Yes, if SPE
	Fuel injection pump	Yes, if SPE	Yes, if SPE	Yes, if SPE
	High-pressure pipes	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Injector	Yes, if SPE	Yes, if SPE	Yes, if SPE[e]
	Air inlet valve	Yes, if SPE[e]	Yes, if SPE[e]	Yes, if SPE
	Electronic control system, air flow meter, etc.	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Governor/control system	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Automatic full-load stop for the control rack depending on atmospheric conditions	Yes, if SPE	Yes, if SPE	Yes, if SPE
7	Liquid-cooling equipment: Radiator	Yes, if SPE[f]	No	No
	Fan	Yes, if SPE[f,g]	No[f]	No
	Fan cowl	Yes, if SPE[f]	No	No
	Water pump	Yes, if SPE[f]	Yes, if SPE	Yes, if SPE[f]
	Thermostat	Yes, if SPE[f,h]	Optional[h]	Yes, if SPE[h]
8	Air cooling: Cowl	Yes, if SPE[f]	No	No
	Fan or blower	Yes, if SPE[f,g]	No[f]	No[i]
	Temperature-regulating device	Yes, if SPE	No	No
9	Electrical equipment: Generator	Yes, if SPE[j]	Yes, if SPE[j]	Yes, if SPE[j]
	Spark distribution system	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Coil or coils	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Wiring	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Spark-plugs	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Electronic control system including knock sensor/ spark-retard system	Yes, if SPE[k]	Yes, if SPE[k]	Yes, if SPE[k]
10	Pressure-charging equipment: Compressor driven either directly by the engine and/or by the exhaust gases:	Yes, if SPE	Yes, if SPE	Yes, if SPE
	Boost control	Yes, if SPE[l]	Yes, if SPE[l]	Yes, if SPE[l]
	Charge air cooler	Yes, if SPE[f,g,m]	Yes, if SPE[f,g,m]	Yes, if SPE, or test bed equipment[i,m]
	Coolant pump or fan (engine-driven)	Yes, if SPE	Yes, if SPE	No[i]
	Coolant flow control device	Yes, if SPE	Yes, if SPE	Yes, if SPE
11	Auxiliary test-bed fan	Yes, if necessary	Yes, if necessary	Yes, if necessary
12	Anti-pollution device	Yes, if SPE[n]	Yes, if SPE[n]	Yes, if SPE[n]
13	Lubricating oil pump	Yes, if SPE	Yes, if SPE	Yes, if SPE

Table 1 *(continued)*

NOTE "Yes, if SPE" means that this equipment shall be fitted for the engine power determination if it is Standard Production Equipment (SPE).

[a] — For net power/gross power test:

If used (for gross power test) and except in the case where there is a risk of the system having a noticeable influence upon engine power, an equivalent may be used. In this case, a check shall be made to ascertain that inlet depression does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

— For engine power test for ISO 8178:

The complete inlet system for the intended application shall be fitted

— where there is a risk of an appreciable effect on the engine power;

— in the case of naturally aspirated spark ignition engines;

— when the manufacturer requests that this should be done.

In other cases, an equivalent system may be used and a check shall be made to ascertain that the inlet pressure does not differ by more than 100 Pa from the upper limit specified by the manufacturer for a clean air filter.

[b] — For net power test:

Except in the case where there is a risk of the system having a noticeable influence upon engine power, an equivalent system may be used. In this case, a check shall be made to ascertain that the back-pressure in the engine exhaust system does not differ by more than 1 000 Pa from the upper limit specified by the manufacturer.

— For gross power test:

If used and except in the case where there is a risk of the system having a noticeable influence upon engine power, an equivalent system may be used. In this case, a check shall be made to ascertain that the back-pressure in the engine exhaust system does not differ by more than 1 000 Pa from that specified by the manufacturer. However, a minimum loss system may be used.

— For engine power test for ISO 8178:

The complete exhaust system for the intended application shall be fitted:

— where there is a risk of an appreciable effect on the engine power;

— in the case of naturally aspirated spark ignition engines;

— when the manufacturer requests that this should be done.

In other cases an equivalent system may be installed provided that the pressure measured does not differ by more than 1 000 Pa from the upper limit specified by the manufacturer.

[c] If an exhaust brake is incorporated in the engine, the throttle valve shall be fixed in the fully open position.

[d] If necessary, the fuel feed pressure may be adjusted to reproduce the fuel pressures existing in the particular engine application (particularly when a "fuel return" system, e.g. to tank or filter, is used).

[e] The air inlet valve is the control valve for the pneumatic governor of the injection pump. The governor or the fuel injection equipment may contain other devices which may affect the amount of fuel injected.

Table 1 *(continued)*

[f] — For net power test:

The radiator, fan, fan cowl, water pump and thermostat shall be located on the test bed in the same relative positions that they are to occupy on the vehicle or machine. The cooling liquid circulation shall only be operated by the engine water pump.

Cooling of the liquid may be provided either by the engine radiator or by an external circuit, provided that the pressure loss of this circuit and the pressure at the pump inlet remains substantially the same as those of the engine cooling system. The radiator shutter, if incorporated, shall be set in the open position.

Where the fan, radiator and cowl system cannot conveniently be fitted to the engine, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cowl (if used), shall be determined at the speeds corresponding to the engine speeds used for measurement of the engine power either by calculation from standard characteristics or by practical tests. This power, corrected to the standard atmospheric conditions defined in Clause 5, shall be deducted from the corrected power.

— For gross power test:

When the engine cooling fan or blower is of the fixed type, that is neither disconnectable nor progressive, and it is fitted for the test, then the power absorbed shall be added to the test results. The fan or blower power shall be determined at the speeds corresponding to the engine speeds used for the measurement of engine power either by calculation from standard characteristics or by practical tests.

— For engine power test for ISO 8178:

The cooling-liquid circulation shall only be operated by the engine pump. Cooling of the liquid may be produced by an external circuit, such that the pressure loss in this circuit and the pressure at the pump inlet remain substantially the same as those of the engine cooling system.

[g] — For net power test:

Where a disconnectable or progressive fan or blower is incorporated, the test shall be performed with the fan or blower disconnected or with the progressive fan running at maximum slip.

— For gross power test:

Where a separate disconnectable or progressive fan or blower is incorporated for the charge air cooler, the test shall be performed with the disconnectable fan or blower disconnected or with the progressive fan running at maximum slip.

Table 1 *(continued)*

[h] The thermostat may be fixed in the fully open position.
[l] When the cooling fan or blower is fitted for the test, the power absorbed shall be added to the test results. The power absorbed by the fan or blower shall be determined at the speeds used for the test either by calculation from standard characteristics or by practical tests.
[j] The electrical power of the generator shall be the minimum. It shall be limited to that necessary for operation of accessories which are indispensable for engine operation. If the connection of a battery is necessary, a fully charged battery in good condition shall be used.
[k] The spark advance shall be representative of in-use conditions established with the minimum octane fuel recommended by the manufacturer.
[l] For engines equipped with variable boost as a function of charge or inlet air temperature, octane rating and/or engine speed, the boost pressure shall be representative of in-vehicle or in-machine conditions established with the minimum octane fuel as recommended by the manufacturer.
[m] — For net power test/gross power test: Charge air-cooled engines shall be tested with the charge air-cooling system operating, whether this system is liquid- or air-cooled. If the engine manufacturer prefers, a test bed system may replace an air-cooled cooler. In either case the measurement of power at each speed shall be made with the pressure drop and temperature drop of the engine air across the charge air cooler in the test bed the same as those specified by the manufacturer for the system on the complete vehicle or machine. — For engine power test for ISO 8178: Charge air-cooled engines shall be tested with the charge air-cooling system operating, whether this system is liquid- or air-cooled. If the manufacturer prefers, a test bed system may replace an air-cooled cooler. In either case, the measurement of power at each speed shall be made with the maximum pressure drop and the minimum temperature drop of the engine air across the charge air-cooler in the test bed system the same as those specified by the manufacturer.
[n] These may include, e.g. Exhaust Gas Recirculation (EGR), catalytic converter, thermal reactor, secondary air-supply and fuel evaporation protection systems.

3.3.3.1
net power
power obtained on a test bed at the end of the crankshaft or its equivalent at the corresponding engine speed with the equipment and auxiliaries specified by ISO 1585, ISO 8665, ISO 9249 or ISO 4106

Note 1 to entry: If the power measurement can only be carried out with a mounted gear-box, the losses in the gear-box should be added to the measured power to give the net engine power.

3.3.3.2
gross power
power obtained on a test bed at the end of the crankshaft or its equivalent at the corresponding engine speed with the equipment and auxiliaries specified by ISO 2534

Note 1 to entry: If the power measurement can only be carried out with a mounted gear-box, the losses in the gear-box should be added to the measured power to give the gross engine power.

3.3.3.3
engine power for ISO 8178
power obtained on a test-bed at the end of the crank-shaft or its equivalent, at the *declared engine speed* (3.2.4) specified by the manufacturer at the *declared power* (3.3.1) with the engine being fitted only with the equipment and auxiliaries specified in ISO 14396

3.3.4
continuous power
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 having been carried out