TECHNICAL REPORT

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Reciprocating internal combustion engines — Determination and method for the measurement of engine power

Moteurs à combustion interne — Détermination et méthode de mesure de la puissance

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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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 14396, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 2, *Performance and tests*.

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INTRODUCTION

In comparison with engines for on-road applications, engines for off-road use are made in a much wider range of power output and configuration and are used in a great number of different applications.

The objective of ISO 8178 is to rationalise the gaseous and particulate emissions test procedures for off-road engines in order to simplify and make more cost effective the drafting of legislation, the development of engine specifications and the certification of engines.

One of the concepts that has been adopted to achieve these objectives is to calculate the specific emissions, g/kWh, on the basis of the engine power when only the essential dependent auxiliaries are fitted.

ISO 8178 has been used for legislation and the authorities have set limit values that vary according to the power of the engine. This Technical Report defines the procedure to be used to determine the power of the engine for ISO 8178 testing.

The calculation of specific emissions according to ISO 8178 is based upon uncorrected power measurement values since the emissions also vary with ambient conditions but cannot be corrected. The allowable range of variation of ambient conditions in this Technical Report is therefore very small in order to minimize ambient effects.

In comparison to ISO 3046-1 which also defines the power measurement including the power correction procedures this Technical Report defines the specific auxiliaries and equipment to meet the needs of supporting the emissions legislation. Due to the fact that ISO 3046 is intended to suit the needs of all engines for all kinds of applications there are 15 definitions of power contained in ISO 3046, so that it is not sufficiently specific to meet the needs of supporting the emissions legislation.

This Technical Report, which is to be used to determine the engine power prior to an emissions test so that the correct limit values can be applied, employs power correction procedures so that a wider range of ambient conditions can be used.

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Reciprocating internal combustion engines — Determination and method for the measurement of engine power

1 SCOPE

This Technical Report specifies the method of determining the power of RIC engines as equipped when presented for an exhaust emssions test according to ISO 8178.

It also specifies the power correction method for the confirmation of engine power for preset engines under variable atmospheric conditions. These corrections do not apply to the definition of the exhaust emission values which are in all cases related to the uncorrected engine power only.

This Technical Report is applicable to RIC engines for land, rail traction and marine use excluding engines for motor vehicles primarily designed for road use. It may be applied to engines used to propel e.g. road construction and earth-moving machines, industrial trucks and for other applications.

2 REFERENCES

ISO 2710-1:—[1]	Reciprocating internal combustion engines - Vocabulary Part 1: Terms for engine design and operation
ISO 3046-1: 1995	Reciprocating internal combustion engines- Performance Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods
ISO 3104:1994	Petroleum products - Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity.
ISO 3675: 1993	Crude petroleum and liquid petroleum products - Laboratory determination of density or relative density - Hydrometer method.
ISO 5163: 1990	Motor and aviation type fuels - Determination of knock characteristics - Motor method.
ISO 5164: 1990	Motor fuels - Determination of knock characteristics - Research method.
ISO 5165:—[2]	Diesel fuels - Determination of ignition quality - Cetane engine method.
ISO 7876-1: 1990	Fuel injection equipment - Vocabulary - Part 1: Fuel injection pumps.
ISO 7967-1: 1987	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 1: Structure and external covers.
ISO 7967-2: 1987	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 2: Main running gear.
ISO 7967-3: 1987	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 3: Valves, camshaft drive and actuating mechanisms.
ISO 7967-4: 1988	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 4: Pressure charging and air/exhaust gas ducting systems.

1) To be published. (Revision of ISO 2710-1:1978 and of its addendum 1:1982)

2) To be published. (Revision of ISO 5165:1992)

ISO 7967-5: 1982	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 5: Cooling systems.
ISO 7967-8: 1994	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 8 : Starting systems.
ISO 8178-1:1996	Reciprocating internal combustion engines - Exhaust emission measurement - Part 1: Test bed measurement of gaseous and particulate emissions.
ISO 8178-2:1996	Reciprocating internal combustion engines - Exhaust emission measurement - Part 2: Measurement of gaseous and particulate exhaust emissions at site.
ISO 8178-4:1996	Reciprocating internal combustion engines - Exhaust emission measurement - Part 4: Test cycles for different engine applications.
ISO 8178-5:—[3)]	Reciprocating internal combustion engines - Exhaust emission measurement - Part 5: Specification of test fuels.
ISO 8178-6:—[3)]	Reciprocating internal combustion engines - Exhaust emissions measurement - Part 6: Test report.
ISO 8178-7:1996	Reciprocating internal combustion engines - Exhaust emission measurement - Part 7: Engine Family determination.
ISO 8178-8:1996	Reciprocating internal combustion engines - Exhaust emission measurement - Part 9: Engine Group determination.
ASTM D 240-87	Standard test method for heat of combustion of liquid hydrocarbon fuels by bomb calorimeter.
ASTM 3338-88	Standard test method for estimation of heat of combustion of aviation fuels.

3) To be published.

3 DEFINITIONS

For the purposes of this Technical Report, the definitions given in ISO 2710-1, ISO 7876-1, ISO 7967-1, ISO 7967-2, ISO 7967-3, ISO 7967-4, ISO 7967-5 and ISO 7967-8, and the following definitions apply.

3.1 Engine Power for ISO 8178: Power obtained on a test-bed at the end of the crankshaft or its equivalent, at the declared engine speed specified by the manufacturer at the declared power with the engine being fitted only with equipment and auxiliaries as listed in Table 1.

All equipment and auxiliaries not required by Table 1 should be removed.

Where accessories cannot be removed, the power absorbed by them in the unloaded condition shall be determined and added to the measured engine power. If this value is greater than 3% of the maximum power at the test speed it may be verified by the test authority.

Where equipment and auxiliaries required by Table 1 are not fitted for the test, the power absorbed by them in the loaded condition shall be determined and subtracted from the measured power. If this value is less than 3% of the maximum power at the test speed it may be verified by the test authority.

3.2 Standard Production Equipment: Equipment specified by the manufacturer for a particular engine application and that is fitted as standard to the engine.

3.3 Declared Engine Speed: The engine speed declared by the engine manufacturer corresponding to the declared power.

3.4 Intermediate Engine Speed

The intermediate engine speed shall be declared by the manufacturer taking into account the following requirements.

a) For engines which are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be the declared maximum torque speed if it occurs between 60% and 75% of declared speed.

If the declared maximum torque speed is less than 60% of declared speed, then the intermediate speed shall be 60% of the declared speed.

If the declared maximum torque speed is greater than 75% of the declared speed, then the intermediate speed shall be 75% of the declared speed.

b) For engines which are not designed to operate over a speed range on the full load torque curve at steady state conditions, the intermediate speed will typically be between 60% and 70% of the maximum declared speed.

4 ACCURACY OF THE MEASURING EQUIPMENT AND INSTRUMENTS

4.1 **Torque:** The dynamometer torque measuring system shall have an accuracy within ± 1 % in the range of scale values required for the test[1)]

4.2 **Engine speed**

The engine speed measuring system shall have an accuracy of ± 0,5%

4.3 **Fuel flow:** The fuel flow measuring system shall have an accuracy of ± 1%.

4.4 **Fuel temperature:** The fuel temperature measuring system shall have an accuracy of ± 2 K.

4.5 **Engine inlet air temperature:** The air temperature measuring system shall have an accuracy of ± 2 K.

4.6 **Barometric pressure:** The barometric pressure measuring system shall have an accuracy of ± 100 Pa

4.7 **Back pressure in exhaust system:** The system used to measure the back pressure in the exhaust system shall have an accuracy of ± 200 Pa.

4.8 **Depression in inlet system:** Subject to footnote 1a) in table 1, this pressure shall be measured to ± 50 Pa.

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1) The torque measuring system shall be calibrated to take friction losses into account. The accuracy in the lower half of the measuring range of the dynamometer bench may be ± 2 % of measured torque.

5 TEST FOR MEASURING ENGINE POWER FOR ISO 8178

5.1 Equipment and auxiliaries

5.1.1 *Equipment and auxiliaries to be fitted*

During the test, the equipment and auxiliaries as listed in Table 1 shall be installed on the test bed.

5.1.2 *Equipment and auxiliaries to be removed*

Certain machine accessories necessary only for the operation of the machine and which may be mounted on the engine should be removed for the test.

The following non-exhaustive list is given as a sample:

- air compressor for brakes,
- power-steering pump
- suspension compressor,
- air-conditioning system compressor.
- mounted gearbox.

TABLE 1

Equipment and auxiliaries to be installed for the test to determine engine power for ISO 8178

No.	Equipment and Auxiliaries	Fitted for Engine Power Test
1	Inlet system	
	Inlet manifold	Yes, standard production equipment.
	Crankcase emission control system	Yes, standard production equipment
	Control devices for dual induction inlet manifold system	Yes, standard production equipment
	Air flow meter	Yes, standard production equipment
	Air inlet duct work	Yes [1)]
	Air filter	Yes [1)]
	Inlet silencer	Yes [1)]
	Speed-limiting device	Yes [1)]
2	Induction-heating device of inlet manifold	Yes, standard production equipment. If possible to be set in the most favourable condition.
3	Exhaust system	
	Exhaust purifier	Yes, standard production equipment
	Exhaust manifold	Yes, standard production equipment
	Pressure charging device	Yes, standard production equipment
	Connection pipes	Yes [2)]
	Silencer	Yes [2)]
	Tail pipe	Yes [2)]
	Exhaust brake	No [3)]
4	Fuel supply pump	Yes, standard production equipment [4)]
5	Carburation Equipment	
	Carburettor	Yes, standard production equipment
	Electronic control system, air flow meter, etc.	Yes, standard production equipment
	Equipment for gas engines	
	Pressure reducer	Yes, standard production equipment
	Evaporator	Yes, standard production equipment
	Mixer	Yes, standard production equipment

TABLE 1 - CONT/D

No.	Equipment and Auxiliaries	Fitted for engine power test
6	Fuel injection equipment (petrol and diesel)	
	Prefilter	Yes, standard production or test bed equipment
	Filter	Yes, standard production or test bed equipment
	Pump	Yes, standard production equipment
	High pressure pipe	Yes, standard production equipment
	Injector	Yes, standard production equipment
	Air inlet valve	Yes, standard production equipment [5]
	Electronic control system, air flow meter, etc.	Yes, standard production equipment
	Governor/control system	Yes, standard production equipment
	Automatic full-load stop for the control rack depending on atmospheric conditions	Yes, standard production equipment
7	Liquid-cooling equipment	
	Radiator	No
	Fan	No
	Fan cowl	No
	Water pump	Yes, standard production equipment [6]
	Thermostat	Yes, standard production equipment [7]
8	Air cooling	
	Cowl	No
	Fan or Blower	No [8]
	Temperature-regulating device	No

TABLE 1 -CONT/D

No.	Equipment and Auxiliaries	Fitted For Engine Power Test
9	Electrical Equipment	
	Generator	Yes, standard production equipment [9)]
	Spark distribution system	Yes, standard production equipment
	Coil or coils	Yes, standard production equipment
	Wiring	Yes, standard production equipment
	Spark plugs	Yes, standard production equipment
	Electronic control system including knock sensor/spark retard system	Yes, standard production equipment [12)]
10	Pressure charging equipment	
	Compressor driven either directly by the engine and/or by the exhaust gases	Yes, standard production equipment
	Boost control	Yes, standard production equipment [13)]
	Charge air cooler	Yes, standard production or test bed equipment [8, 10)]
	Coolant pump or fan (engine-driven)	No [8)]
	Coolant flow control device	Yes, standard production equipment
11	Auxiliary test-bed fan	Yes, if necessary
12	Anti-pollution device	Yes, standard production equipment [11)]
13	Lubricating Oil Pump	Yes, standard production equipment

1) The complete inlet system shall for the intended application 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 should 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.