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Road vehicles — Engine test code — Net power

Véhicules routiers — Code d'essai des moteurs — Puissance nette

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

This fourth edition cancels and replaces the third edition (ISO 1585:1992), which has been technically revised. The main changes compared to the previous edition are as follows:

— the air induction system definition has been updated to clarify included components;

— a requirement for exhaust particulate filter restriction has been added;

— a requirement for engine cooling active thermal management system settings has been added;

— a power correction factor for turbocharged engines with a system compensating the ambient conditions has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Road vehicles — Engine test code — Net power

1 Scope

This document specifies a method for testing engines designed for automotive vehicles. It applies to the evaluation of their performance with a view, in particular to presenting curves of power and specific fuel consumption at full load as a function of engine speed.

It applies only to net power assessment.

This document concerns internal combustion engines used for propulsion of passenger cars, trucks and other motor vehicles, excluding motorcycles, mopeds and agricultural tractors, normally travelling on roads, and included in one of the following categories:

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

— rotary piston engines.

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

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 7876-1, *Fuel injection equipment — Vocabulary — Part 1: Fuel injection pumps*

ISO 7967-1, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 1: Structure and external covers*

ISO 7967-2, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 2: Main running gear*

ISO 7967-3, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 3: Valves, camshaft drives and actuating mechanisms*

ISO 7967-4, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 4: Pressure charging and air/exhaust gas ducting systems*

ISO 7967-5, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 5: Cooling systems*

ISO 7967-8, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 8: Starting systems*

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*

3 Terms and definitions

For the purposes of this document, the terms and 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.

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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 listed in Table 1

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

3.2
standard production equipment
any equipment provided by the manufacturer for a particular engine application

4 Accuracy of 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.

4.2 Engine speed (rotational frequency)

The engine speed (rotational frequency) 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 Air temperature

The air temperature measuring system shall have an accuracy of ±1 K.

4.6 Barometric pressure

The barometric pressure measuring system shall have an accuracy of ±100 Pa.

NOTE 1 Pa = 1 N/m^2.

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. The measurement shall be made subject to footnote b of Table 1.

4.8 Depression in inlet system

The system used to measure the depression in the inlet system shall have an accuracy of ±50 Pa. The measurement shall be made subject to footnote a of Table 1.

4.9 Absolute pressure in inlet duct

The system used to measure the absolute pressure in the inlet duct shall have an accuracy of ±2 % of the measured pressure.

Table 1 — Installation of equipment and auxiliaries during test

No.	Equipment and auxiliaries	Fitted for net power test
1	Inlet system Inlet manifold Crankcase emission control system Control devices for dual induction inlet manifold system Air flow meter Air inlet ductwork[a] Air filter[a] Inlet silencer[a] Speed-limiting device[a]	Yes, standard production equipment
2	Induction heating device of inlet manifold	Yes, standard production equipment If possible, to be set in the most favourable position.
3	Exhaust system Exhaust purifier(s)[b] Exhaust manifold Pressure-charging devices Connecting pipes[c] Silencer[c] Tail pipe[c] Exhaust brake[d]	Yes, standard production equipment
4	Fuel supply pump[e]	Yes, standard production equipment
5	Carburation equipment Carburettor Electronic control system, air-flow meter, etc. (if fitted) Equipment for gaseous fuel engines Pressure reducer Evaporator Mixer	Yes, standard production equipment

Table 1 *(continued)*

No.	Equipment and auxiliaries	Fitted for net power test
6	Fuel injection equipment [spark-ignition and compression ignition (diesel)]	
	Prefilter	Yes, standard production equipment
	Filter	
	Pump	
	High-pressure pipe	
	Injector	
	Air inlet valve (if fitted)[f]	
	Electronic control system, etc. (if fitted)	
	Governor/control system: automatic full-load stop for the control depending on atmospheric conditions	
7	Liquid cooling equipment	
	Radiator	Yes, standard production equipment
	Fan[g,h]	
	Fan cowl	
	Water pump	
	Thermostat or thermal management system[i]	
8	Air cooling	
	Cowl	Yes, standard production equipment
	Fan or blower[g,h]	
	Temperature regulating device	
9	Electrical or electronic equipment	
	Generator/alternator[j]	Yes, standard production equipment
	Spark distribution system	
	Coil(s)	
	Wiring	
	Spark-plugs	
	Electronic control system including knock sensor/spark retard system[m]	
10	Pressure-charging equipment (if fitted)	
	Compressor driven either directly by the engine, and/or by the exhaust gases	Yes, standard production equipment
	Boost control[n]	
	Charge-air-cooler[g,h,k]	
	Coolant pump or fan(engine-driven)	
	Coolant flow control devices (if fitted)	
11	Auxiliary test bed fan	Yes, if necessary
12	Anti-pollution devices[l]	Yes, standard production equipment

Table 1 *(continued)*

No.	Equipment and auxiliaries	Fitted for net power test
[a] The air induction system begins where the air enters the system from atmosphere. Except when 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 should 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. [b] For the case of an exhaust particulate filter, the filter or equivalent restriction shall represent the clean state. [c] Except when 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 should be made to ascertain that the backpressure in the engine exhaust system does not differ by more than 1 000 Pa from that specified by the manufacturer. [d] If an exhaust brake is incorporated in the engine, the throttle valve shall be fixed fully open. [e] The fuel feed pressure may be adjusted, if necessary, to reproduce the inlet pump pressure conditions consistent with the particular engine application (particularly where a "fuel return" system, e.g. to tank or filter, is used). [f] The air inlet valve is the control valve for the pneumatic governor of the injection pump. The governor of the fuel injection equipment may contain other devices which may affect the amount of fuel injected. [g] The radiator, fan, fan cowl, water pump and thermostat shall be located on the test bed in the same relative positions that they will occupy on the vehicle. The cooling liquid circulation shall be operated by the engine water pump only. Cooling of the liquid may be produced 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 remain substantially the same as those of the engine cooling system. The radiator shutter, if incorporated, shall be 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 6.2 shall be deducted from the corrected power. [h] Where a separate disconnectable or progressive fan or blower is incorporated, the test shall be made with the disconnectable fan or blower disconnected or with the progressive fan running at the maximum slip. [i] The thermostat may be fixed in the fully open position. For the case of an active thermal management system, control settings shall be representative of full load operation. [j] Minimum power of the generator/alternator: the power of the generator/alternator shall be limited to that necessary for the operation of accessories which are indispensable for engine operation. If the connection of a battery is necessary, a fully charged battery in good order shall be used. [k] Charge-air-cooled engines shall be tested complete with charge-air-cooling whether liquid or air-cooled but if the engine manufacturer prefers, a test bed system may replace the 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. If a test bed system is used on a compression-ignition engine without a wastegate, or with the wastegate not operating, the correction factor given in 6.3.2.1 b) is to be used. If a wastegate is both fitted and operating, then the correction factor in 6.3.2.1 a) is to be used. [l] They may include for example EGR system, catalytic converter, particulate filter, thermal reactor, secondary air supply system and fuel evaporating protecting system. [m] The spark advance shall be representative of in-use conditions established with the minimum octane fuel recommended by the manufacturer. [n] 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 conditions established with the minimum octane fuel as recommended by the manufacturer.		

5 Tests

5.1 Auxiliaries

5.1.1 Auxiliaries to be fitted

During the test, auxiliaries necessary to make an engine acceptable for service in the intended application (as listed in Table 1) shall be installed on the test bed as far as possible in the same position as in the intended application.

5.1.2 Auxiliaries to be removed

Certain vehicle accessories necessary only for the operation of the vehicle, and which may be mounted on the engine, shall be removed for the test. The following non-exhaustive list is given as an example:

— air compressor for brakes;

— power steering pump;

— suspension compressor;

— air-conditioning system compressor.

Where accessories cannot be removed, the power absorbed by them in the unloaded condition may be determined and added to the measured engine power.

5.1.3 Compression-ignition engine starting auxiliaries

For auxiliaries used to start compression-ignition engines, the two following cases shall be considered:

a) electrical starting: the generator/alternator is fitted and supplies, where necessary, electricity to the accessories indispensable to the operation of the engine;

b) starting other than electrical: if there are any electrically operated accessories indispensable to the operation of the engine, the generator/alternator is fitted to supply these accessories; otherwise, it is removed.

In either case, the system for producing and accumulating the energy necessary for starting is fitted and operates in the unloaded condition.

5.2 Setting conditions

The setting conditions for the test for determination of net power are indicated in Table 2.

Table 2 — Setting conditions

1	Setting of fuel delivery system	In accordance with the manufacturer's production specifications and used without further alteration for the particular application.
2	Setting of injection pump delivery system	
3	Ignition or injection timing (timing curve)	
4	Governor setting	
5	Anti-pollution devices	
6	Boost control	

5.3 Test conditions

5.3.1 The net power test shall consist of a run at full throttle for spark-ignition engines and at the fixed full-load fuel injection pump setting for compression-ignition engines, the engine being equipped as specified in Table 1.

5.3.2 Performance data shall be obtained under stabilized operating conditions, with an adequate fresh air supply to the engine.

Engines shall have been run-in, started and warmed up in accordance with the manufacturer's recommendations. Combustion chambers may contain deposits, but in limited quantity. Test conditions such as inlet air temperature shall be selected as near to reference conditions (see 6.2) as possible in order to minimise the correction factor.

5.3.3 The temperature of the inlet air to the engine (ambient air), shall be measured within 0,15 m upstream of the air inlet duct work.

The thermometer or thermocouple shall be shielded from radiant heat and located directly in the airstream. It shall also be shielded from fuel spray back. A sufficient number of locations shall be used to give a representative average inlet temperature.

5.3.4 The inlet depression shall be measured downstream of the entry ducts, air filter, inlet silencer, speed-limiting device (if they are fitted) or their equivalents.

5.3.5 The absolute pressure at the entry to the engine, downstream of the compressor and heat exchanger, if they are fitted, shall be measured in the inlet manifold and at any other point where pressure has to be measured to calculate correction factors.

5.3.6 The exhaust back pressure shall be measured at a point at least three pipe diameters from the outlet flange(s) of the exhaust manifold(s) and downstream of the turbocharger(s), if fitted. The location shall be specified.

5.3.7 No data shall be taken until torque, speed and temperature have been maintained substantially constant for at least 1 min.

5.3.8 The engine speed during a run or reading shall not deviate from the selected speed by more than ±1 % or ±10 min^{-1}, whichever is greater.

5.3.9 Observed brake load, fuel flow and inlet air temperature data shall be taken virtually simultaneously and shall, in each case, be the average of two stabilized consecutive readings which do not vary more than 2 % for the brake load and fuel consumption. The second reading shall be determined without any adjustment of the engine, approximately 1 min after the first.

5.3.10 The coolant temperature at the engine outlet shall be kept within ±5 K of the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified, the temperature shall be 353 K ± 5 K.

For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within $^{0}_{-20}$ K of the maximum value specified by the manufacturer in the reference conditions.

5.3.11 Fuel temperature shall be as follows:

a) For spark-ignition engines, the fuel temperature shall be measured as near as possible to the inlet of the carburettor or assembly of fuel injectors. Fuel temperature shall be maintained within ±5 K of the temperature specified by the manufacturer. However, the minimum test fuel temperature

allowed shall be the ambient air temperature. If the test fuel temperature is not specified by the manufacturer, it shall be 298 K ± 5 K;

b) For compression-ignition engines, the fuel temperature shall be measured at the inlet to the fuel-injection pump. At the manufacturer's request the fuel temperature measurement can be made at another point in the pump representative of the engine operating condition. Fuel temperature shall be maintained within ±3 K of the temperature specified by the manufacturer. In all cases, the minimum allowable fuel temperature at the pump entrance is 303 K. If the test fuel temperature is not specified by the manufacturer, it shall be 313 K ± 3 K.

5.3.12 The lubricant temperature shall be measured at the oil gallery inlet or the cooler outlet if fitted, unless some other measuring location is specified by the manufacturer. The temperature shall be maintained within the limits specified by the manufacturer.

5.3.13 An auxiliary regulation system may be used if necessary to maintain temperature within limits specified in 5.3.10, 5.3.11 and 5.3.12.

5.3.14 It is recommended that a reference fuel is used; for example a non-exhaustive list of such fuel includes the following:

— CEC RF-01-A-80;

— CEC RF-08-A-85;

— CEC RF-03-A-84;

NOTE Coordinating European Council for the Development of Performance Tests for Lubricants and Engines Fuels.

— JIS K 2202;

— JIS K 2204;

NOTE Japan Industrial Standards.

— 40 CFR, Part 86.113-04 or the latest edition for spark-ignition engines;

— 40 CFR, Part 86.1313-04 or the latest edition for compression-ignition engines.

NOTE Title 40, Code of Federal Regulations, USA.

A commercially available fuel may be used, providing its characteristics are specified in 8.3 and that is does not contain any supplementary smoke-suppressant or additive.

5.4 Test procedure

Measurements shall be taken at a sufficient number of engine speeds to define the power curve completely between the lowest and the highest engine speeds recommended by the manufacturer. This range of speeds shall include the revolution speed at which the engine produces its maximum power.

5.5 Data to be recorded

Data to be recorded shall be those indicated in Clause 8.

6 Power correction factors

6.1 Definition of factor α for power correction

This is the factor by which the observed power shall be multiplied to determine the engine power at the reference atmospheric conditions specified in 6.2. The corrected power (i.e. power at reference conditions), P_{ref}, is given in Formula (1):

$$P_{ref} = \alpha \cdot P_y \tag{1}$$

where

α is the correction factor (α_a being the correction factor for spark-ignition engines and α_c the correction factor for compression-ignition engines);

P_y is the measured (observed) power.

6.2 Atmospheric conditions

6.2.1 Reference atmospheric conditions

For the purposes of determining the power and fuel consumption of engines, the reference atmospheric conditions given in 6.2.1.1 and 6.2.1.2 shall be used.

6.2.1.1 Temperature

The reference temperature, T_{ref}, is 298 K (25 °C).

6.2.1.2 Dry pressure

The reference dry barometric pressure, $p_{d,\,ref}$, is 99 kPa.

NOTE The dry barometric pressure is based on a total pressure of 100 kPa and a vapour pressure of 1 kPa.

6.2.2 Test atmospheric conditions

The test atmospheric conditions shall be within the values given in 6.2.2.1 and 6.2.2.2 during the test.

6.2.2.1 Temperature, T

For spark-ignition engines:

$288\ K \leq T \leq 308\ K$

For compression-ignition engines:

$283\ K \leq T \leq 313\ K$

6.2.2.2 Dry pressure, p_d

For all engines:

$80\ kPa \leq p_d \leq 110\ kPa$

6.3 Determination of power correction factors

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 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 relevant parameter is within the relevant range of the device. This applies in particular to:

a) automatic air temperature controls where the device is still operating at 298 K;

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 flow 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 (no heated air added to the intake 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 flow for compression-ignition engines shall be corrected by the reciprocal of the power correction factor.

6.3.1 Naturally aspirated and pressure-charged spark-ignition engines — Factor α_a

The correction factor, α_a, for spark-ignition engines shall be calculated following Formula (2):

$$\alpha_a = \left(\frac{99}{p_d}\right)^{1,2} \left(\frac{T}{298}\right)^{0,6} \tag{2}$$

where

T is the absolute temperature, in kelvins, at the engine air inlet;

p_d is the dry atmospheric pressure, in kilopascals, i.e. the total barometric pressure minus the water vapor pressure.

Formula (2) applies to carburettor-equipped engines and to other engines where the management system is designed to maintain a relatively constant fuel/air ratio as ambient conditions change. For other engine types see 6.3.3.

Formula (2) only applies if

$0,93 \leq \alpha_a \leq 1,07$

If these limits are exceeded, the corrected value obtained shall be given, and the test conditions (temperature and pressure) precisely stated in the test report.

6.3.2 Compression-ignition engines — Factor α_c

The power correction factor, α_c, for compression-ignition engines at constant fuel delivery setting is obtained by applying Formula (3):

$$\alpha_c = (f_a)^{f_m} \tag{3}$$

where

f_a is the atmospheric factor (see 6.3.2.1);

f_m is the characteristic parameter for each type of engine and adjustment (see 6.3.2.2).

6.3.2.1 Atmospheric factor, f_a

The atmospheric factor, f_a, which indicates the effect of environmental conditions (pressure, temperature and humidity) on the air drawn in by the engine shall be calculated with Formulae (4), (5) or (6):

a) naturally aspirated engines, mechanically pressure-charged engines and turbocharged engines with wastegates operating:

NOTE For engine speeds when the wastegate of a turbocharged engine is not operating, Formulae (5) or (6) is used, depending on the type of charge air cooling, if any.

$$f_a = \left(\frac{99}{p_d}\right)\left(\frac{T}{298}\right)^{0,7} \tag{4}$$

b) turbocharged engines without charge air cooling or with charge cooling by air/air cooler:

$$f_a = \left(\frac{99}{p_d}\right)^{0,7}\left(\frac{T}{298}\right)^{1,2} \tag{5}$$

c) turbocharged engines with charge air cooling by engine coolant:

$$f_a = \left(\frac{99}{p_d}\right)^{0,7}\left(\frac{T}{298}\right)^{0,7} \tag{6}$$

where T and p_d are as defined in 6.3.1.

6.3.2.2 Engine factor, f_m

Within the limits established for α_c in 6.3.2, the engine factor, f_m, is a function of the corrected fuel delivery parameter, q_c, and is calculated following Formulae (7) to (9):

$$f_m = 0,036 q_c - 1,14 \tag{7}$$

where

$$q_c = \frac{q}{r} \tag{8}$$

in which q is the fuel delivery parameter, in milligrams per cycle per litre of engine swept volume [mg/(l cycle)]:

$$q = \frac{(Z)\times[\text{fuel flow (g/s)}]}{[\text{displacement (l)}]\times\left[\text{engine speed }\left(\text{min}^{-1}\right)\right]} \tag{9}$$

where

Z equals 120 000 for 4-stroke cycle engines and Z= 60 000 for 2-stroke cycle engines;

r is the ratio between the absolute static pressure at the outlet of the pressure charger, or charge air cooler if fitted, and the ambient pressure (r = 1 for naturally aspirated engines).

The formula for the engine factor, f_m [Formula (7)], is only valid for a 37,2 mg/(l·cycle) ≤ q_c ≤ 65 mg/(l cycle). For values less than 37,2 mg/(l·cycle), a constant value of f_m equal to 0,2 shall be taken; for values greater than 65 mg/(l·cycle), a constant value of f_m equal to 1,2 shall be taken (see Figure 1).

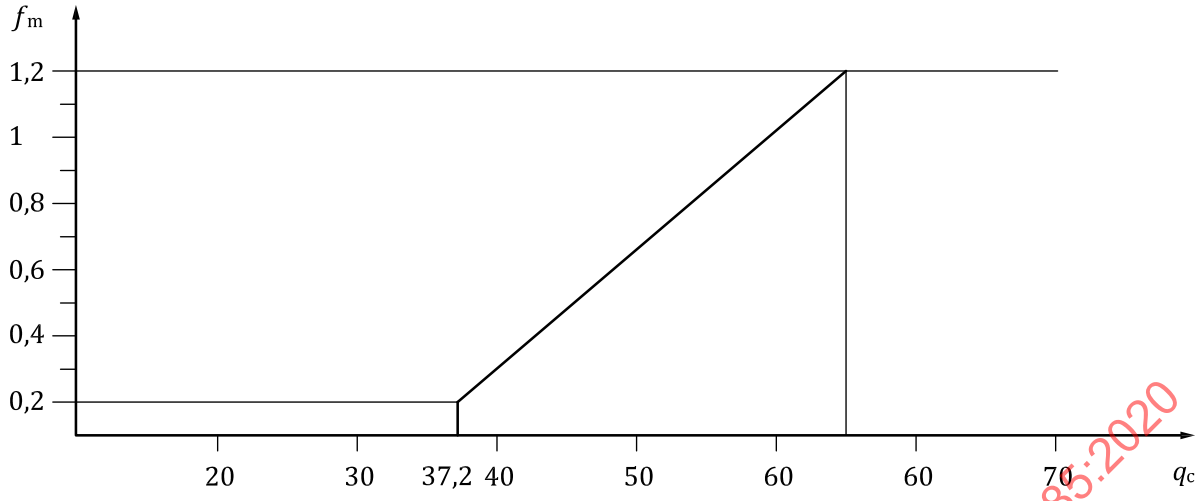

Figure 1 — Engine factor, f_m, as a function of corrected fuel delivery parameter, q_c

6.3.2.3 Limitation in use of correction formula

This correction formula only applies if:

$$0{,}9 \leq \alpha_c \leq 1{,}1$$

If these limits are exceeded, the corrected value obtained shall be given, and the test conditions (temperature and pressure) precisely stated in the test report.

6.3.3 Turbocharged engine with a system compensating the ambient conditions

When a turbocharged engine is fitted with a system which allows compensating the ambient conditions temperature and altitude the correction factor α_a or α_c shall be set to the value of "1".

6.3.4 Other types of engine

For engines not covered by 6.3.1 and 6.3.2, a correction factor of 1 shall be applied when the ambient air density does not vary by more than ±2 % from the density at the reference conditions (298 K and 99 kPa). When the ambient air density is beyond these limits, no correction shall be applied, but the test conditions shall be stated in the test report.

7 Measurement of and correction for smoke value for compression-ignition engines

The smoke value shall be measured and recorded at every test point. The opacimeter used, and its installation, shall meet the requirements of ISO 11614.

7.1 Correction factor for light absorption coefficient of smoke

This is the factor by which the light absorption coefficient of smoke, S_r, expressed in absolute units of meters to the power minus one, shall be multiplied to determine the engine light absorption coefficient of smoke at the reference atmospheric conditions specified in 6.2.1 [see Formula (10)]:

$$S_r = \alpha_s \cdot S \tag{10}$$

where

α_s is the correction factor (see 7.2);

S is the measured light absorption coefficient of smoke, in reciprocal metres (observed smoke).

7.2 Determination of correction factor for light absorption coefficient of smoke

The correction factor α_s for compression-ignition engines under a constant fuel delivery setting is obtained from Formula (11):

$$\alpha_s = 1 - 5(f_a - 1) \tag{11}$$

where f_a is the atmospheric factor (see 6.3.2.1).

7.3 Limits of application

This correction factor only applies when, for approval purposes:

$0{,}92 \leq f_a \leq 1{,}08$

$283\ \text{K} \leq T \leq 313\ \text{K}$

$80\ \text{kPa} \leq p_d \leq 110\ \text{kPa}$

8 Test report

(State "none" where inapplicable or delete.)

8.1 Compression-ignition engines — Essential characteristics

In the case of non-conventional engines and systems, particulars equivalent to those referred to in this document shall be supplied by the manufacturer.

8.1.1 Description of engine

a) make

b) type

c) cycle (four-stroke/two-stroke) (delete where inapplicable)

d) bore (expressed in mm)

e) stroke (expressed in mm)

f) number of cylinders

g) layout of cylinders

h) firing order

i) engines swept volume (expressed in l)

j) compression ratio (specify tolerance)

8.1.2 Cooling system

a) liquid
   i. nature of liquid
   ii. circulating pumps (yes/no) (delete where inapplicable)
      1. characteristics or make(s)
      2. type(s)
      3. drive ratio
   i. thermostat setting
   ii. radiator
      1. drawing(s) or make(s)
      2. type(s)
   iii. relief valve pressure setting
   iv. fan (yes/no)
      1. characteristics or make(s)
      2. type(s)
      3. fan drive system
      4. drive ratio
   v. fan cowl

b) air
   i. blower(yes/no)
      1. characteristics or make(s)
      2. type(s)
      3. drive ratio
   ii. air ducting (standard production)
   iii. temperature regulation system (yes/no) (delete where inapplicable)
      1. brief description

8.1.3 Temperatures specified by the manufacturer

a) liquid cooling
   i. maximum temperature at outlet (expressed in K)

b) air cooling
   i. reference point (description)
   ii. maximum temperature at reference point (expressed in K)

c) maximum exhaust temperature (expressed in K)

d) fuel temperature

   i. minimum (expressed in K)

   ii. maximum (expressed in K)

e) lubricant temperature

   i. minimum (expressed in K)

   ii. maximum (expressed in K)

8.1.4 Pressure charger (with/without) (delete where inapplicable)

a) description of the system

   i. make

   ii. type

b) compressor system

   i. make

   ii. type

c) charge-air-cooling system

   i. make

   ii. type

8.1.5 Inlet system

a) description and diagrams of air inlets and their accessories (heating device, inlet silencer, etc.)

b) inlet manifold

   i. description

c) air filter

   i. make

   ii. type

d) inlet silencer

   i. make

   ii. type

8.1.6 Additional smoke control devices (if any, and if not covered by another heading)

Description and diagrams

8.1.7 Fuel feed system

a) fuel feed

   i. feed pump

      1. pressure (expressed in kPa, specify tolerance) or characteristic diagram (delete where inapplicable)

   ii. injection system

b) pump

   i. make(s)

   ii. type(s)

   iii. delivery at full injection (expressed in mm^3 per stroke, specify tolerance)

      1. at pump speed of (expressed in min^{-1}, specify tolerance) or characteristic diagram (delete where inapplicable)

   iv. quote the method used: on engine/on pump bench (delete where inapplicable)

c) injection advance (specify tolerance)

   i. injection advance curve

   ii. timing

d) injection piping

   i. length (expressed in mm)

   ii. internal diameter (expressed in mm)

e) injector(s)

   i. make(s)

   ii. type(s)

   iii. opening pressure (expressed in kPa, specify tolerance) or characteristic diagram (delete where inapplicable)

f) governor

   i. make(s)

   ii. type(s)

   iii. speed at which cut-off starts under full load (expressed in min^{-1})

   iv. maximum no-load speed (expressed in min^{-1})

   v. idling speed (expressed in min^{-1})

g) cold-start system

   i. make(s)

   ii. type(s)

   iii. description

8.1.8 Valve timing

a) maximum lift of valves and angles of opening and closing in relation to dead centres

b) reference and/or setting ranges (delete where inapplicable)

8.1.9 Exhaust system

a) description of exhaust manifold

b) description of other parts of the exhaust equipment if the test is made with the complete exhaust equipment provided by the manufacturer, or indication of the maximum back pressure at maximum power specified by the manufacturer (delete where inapplicable)

8.1.10 Lubrication system

a) description of system

   i. position of lubricant reservoir

   ii. feed system (circulation by pump, injection inlet mixing with fuel, etc.)

   iii. circulating pump (yes/no)

      1. make

      2. type

   iv. mixture with fuel

      1. percentage

   v. oil cooler (with/without) (delete where inapplicable)

      1. drawing(s) or make(s)

      2. type(s)

8.1.11 Electrical equipment

Generator/alternator (delete where inapplicable)

a) characteristics or make(s)

b) type(s)

8.1.12 Other engine-driven equipment

List and brief description if necessary

8.2 Spark-ignition engines — Essential characteristics

In the case of non-conventional engines and systems, particulars equivalent to those referred to in this document shall be supplied by the manufacturer.

8.2.1 Description of engine

a) make

b) type

c) cycle (four-stroke/two-stroke) (delete where inapplicable)

d) bore (expressed in mm)

e) stroke (expressed in mm)

f) number of cylinders

g) layout of cylinders

h) firing order

i) engine swept volume (expressed in l)

j) compression ratio (specify tolerance)

8.2.2 Cooling system

a) liquid

  i. nature of liquid

  ii. circulating pumps (yes/no) (delete where inapplicable)

    1. characteristics or make(s)

    2. type(s)

    3. drive ratio

  iii. thermostat setting

  iv. radiator

    1. drawing(s) or make(s)

    2. type(s)

  v. relief valve pressure setting

  vi. fan (yes/no)

    1. characteristics or make(s)

    2. type(s)

    3. fan drive system

    4. drive ratio

  vii. fan cowl

b) air

  i. blower (yes/no)

    1. characteristics or make(s)

    2. type(s)

  ii. drive ratio

  iii. air ducting (standard production)

  iv. temperature regulating system (yes/no) (delete where inapplicable)

  v. brief description

8.2.3 Temperature specified by the manufacturer

a) liquid cooling

   i. maximum temperature at outlet (expressed in K)

b) air cooling

   i. reference point (description)

   ii. maximum temperature at reference point (expressed in K)

c) fuel temperature

   i. minimum (expressed in K)

   ii. maximum (expressed in K)

d) lubricant temperature

   i. minimum (expressed in K)

   ii. maximum (expressed in K)

8.2.4 **Pressure charger** (with/without) (delete where inapplicable)

a) description of the system

   i. make

   ii. type

b) compressor system

   i. make

   ii. type

c) charge-air-cooling system

   i. make

   ii. type

8.2.5 Inlet system

a) description and diagrams of air inlets and their accessories (heating device, inlet silencer, etc.)

b) inlet manifold

   i. description

c) air filter

   i. make

   ii. type

d) inlet silencer

   i. make

   ii. type

8.2.6 Additional anti-pollution devices (if any, and if not covered by another heading)

Description and diagrams

8.2.7 Fuel feed system

Fuel feed

a) by carburettor(s) (delete where inapplicable)

i. number(s)

ii. make

iii. type

iv. adjustments

1. jets
2. venturis
3. float-chamber level
4. mass of float
5. float needle

} or { Curve of fuel delivery plotted against air flow and settings required to keep to the curve

v. manual/automatic choke (delete where inapplicable)

1. closure setting (specify tolerance)

vi. feed pump

1. pressure (expressed in kPa, specify tolerance) or characteristic diagram (delete where inapplicable)

b) by fuel injection (delete where inapplicable)

i. make(s)

ii. type(s)

iii. description (general)

iv. calibration (expressed in kPa, specify tolerance) or characteristic diagram (delete where inapplicable)

8.2.8 Valve timing

a) maximum lift of valves and angles of opening and closing in relation to dead centres

b) reference and/or setting ranges (delete where inapplicable)

8.2.9 Ignition system

a) ignition distributor

i. knock sensor (yes/no) (delete where inapplicable)

1. strategy (retard only or advance/retard) (delete where inapplicable)

2. make
3. type
4. ignition advance curve (specify tolerance)
5. ignition timing (specify tolerance)
6. contact-point gap (specify tolerance)
7. dwell-angle (expressed in degrees) (delete where inapplicable)

b) spark-plugs
   i. make
   ii. type
   iii. spark-gap setting

c) ignition coil
   i. make
   ii. type

d) ignition condenser
   i. make
   ii. type

e) radio interference suppression equipment
   i. make
   ii. type

8.2.10 Exhaust system

Description and diagrams

8.2.11 Lubrication system

a) description of system

b) position of lubricant reservoir

c) feed system (circulation by pump, injection into inlet, mixing with fuel, etc.)

d) circulation pump (yes/no) (delete where inapplicable)
   i. make
   ii. type

e) mixture with fuel
   i. percentage

e) oil cooler (with/without) (delete where inapplicable)
   i. drawing(s) or make(s)
   ii. type(s)

8.2.12 Electrical equipment

a) generator/alternator (delete where inapplicable)

   i. characteristics or make(s)

   ii. type(s)

8.2.13 Other auxiliaries fitted to engine

List and brief description if necessary

8.3 Test conditions for measuring engine net power

a) trade-name or make of the engine

b) type and identification number of engine

c) test conditions

   i. pressure measured at maximum power

      1. total barometric pressure (expressed in kPa)
      2. water vapour pressure (expressed in kPa)
      3. exhaust back-pressure (expressed in kPa)
      4. location of exhaust back-pressure measurement point
      5. inlet depression (expressed in Pa)
      6. absolute pressure in the inlet ductwork (expressed in Pa)

   ii. temperatures measured at maximum power

      1. inlet air (expressed in K)
      2. engine intercooler outlet (expressed in K)
      3. cooling fluid at the engine cooling fluid outlet (expressed in K)
      4. cooling fluid at the reference point in the case of air cooling (expressed in K)
      5. lubricating oil (expressed in K)
      6. location of lubrication oil measurement point
      7. fuel at the carburettor inlet/fuel injection system inlet (expressed in K) (delete where inapplicable)
      8. fuel in the fuel flow-measuring device (expressed in K)

d) characteristics of the dynamometer

   i. make

   ii. model

   iii. type

iv. rating

e) characteristics of the opacimeter

i. make

ii. model

iii. type

f) fuel flow-measuring apparatus (gravimetric/volumetric) (delete where inapplicable)

i. fuel for spark-ignition engines operating on liquid fuel

1. make and type
2. specification
3. Research Octane Number (RON) (according to ISO 5164)

NOTE ASTM standard also exists.

4. Motor Octane Number (MON) (according to ISO 5163)

NOTE ASTM standard also exists.

5. percentage and type of oxygenates
6. density (expressed in g/cm^3 at 288 K) (according to ISO 3675)

NOTE ASTM standard also exists.

7. lower calorific value, measured (expressed in kJ/kg) (according to ASTM D 240) (delete where inapplicable)
8. or lower calorific value, estimated (expressed in kJ/kg) (according to ASTM D 3338) (delete where inapplicable)
9. fuel temperature (expressed in K)

ii. fuel for spark-ignition engines operating on gaseous fuel

1. make
2. Specification
3. storage pressure (expressed in kPa)
4. utilization pressure (expressed in kPa)
5. lower calorific value (expressed in kJ/kg)

iii. fuel for compression-ignition engines operating on gaseous fuel

1. gas feed systems
2. specification of gas used
3. fuel oil/gas proportion
4. lower calorific value (expressed in kJ/kg)

iv. fuel for compression-ignition engines operating on liquid fuel

1. make

2. specification of fuel used
3. cetane number (according to ISO 5165)

NOTE ASTM standard also exists.

4. viscosity (expressed in mm^2/s at 40 °C) (according to ISO 3104)

NOTE ASTM standard also exists.

5. density (expressed in g/cm^3 at 288 K) (according to ISO 3675)

NOTE ASTM standard also exists.

6. lower calorific value, measured (expressed in kJ/kg) (in accordance with ASTM D 240) (delete where inapplicable)
7. or lower calorific value, estimated (expressed in kJ/kg) (in accordance with ASTM D 3338) (delete where inapplicable)

g) lubricant

i. make
ii. specification
iii. SAE viscosity

8.4 Statement of results as function of engine speed

The statement of results as function of engine speed is indicated in Table 3. The characteristic curves of the net power and net torque, of the specific net fuel consumption and of the exhaust smoke values shall be drawn as a function of the engine speed.

Table 3 — Statement of results as function of engine speed

Characteristics		Results	
			Engine Speed (min^{-1})
Measured torque, N·m			
Measured power, kW			
Measured fuel flow[a], g/s			
Measured smoke, m^{-1}			
Barometric pressure, kPa			
Water vapor pressure, kPa			
Inlet depression, Pa			
Exhaust back pressure, kPa			
Inlet air temperature, K			
Power to be added for auxiliaries in excess of Table 1 (see 8.1.12 and 8.2.13), kW	No. 1		
	No. 2		
	No. 3		

[a] For spark-ignition engines, the corrected fuel flow is the measured fuel flow multiplied by the power correction factor. The concept of corrected fuel flow is added only for calculation purposes. For compression-ignition engines, the corrected fuel flow is equal to the measured fuel flow, except for constant power engines [see 6.3 c)].

[b] Delete where inapplicable.

[c] Calculated with corrected net power and corrected fuel flow (see 9.3.4).

Table 3 *(continued)*

Characteristics	Results	
		Engine Speed (min^{-1})
Power correction factor		
Corrected fuel flow[a], g/s		
Corrected brake power, kW (with/without[b] fan or blower)		
Corrected brake torque, Nm (with/without[b] fan or blower)		
Power of fan or blower, kW (to be added if fan or blower is fitted)		
Net power, kW		
Net torque, N·m		
Specific net fuel consumption[c], g/(kW·h)		
Smoke correction factor		
Corrected smoke, m^{-1}		
Cooling liquid temperature at outlet, K		
Lubricating oil temperature at measuring point, K		
Air temperature after pressure-charger, K[b]		
Fuel temperature at injection pump inlet, K		
Air temperature after charge air cooler, K[b]		
Pressure after pressure charged, kPa		
Pressure after charge air cooler, kPa		

[a] For spark-ignition engines, the corrected fuel flow is the measured fuel flow multiplied by the power correction factor. The concept of corrected fuel flow is added only for calculation purposes. For compression-ignition engines, the corrected fuel flow is equal to the measured fuel flow, except for constant power engines [see 6.3 c)].

[b] Delete where inapplicable.

[c] Calculated with corrected net power and corrected fuel flow (see 9.3.4).

9 Verification of engine performance

9.1 Designation

When the performance (power curves, torque and specific fuel consumption) of an engine are determined according to this document, reference shall be made to the method used by stating "determined in accordance with ISO 1585".

9.2 Notation

9.2.1 Declared net power and corresponding engine speed (range)

The declared net power and corresponding engine speed (range) are the power and corresponding engine speed (range) which the manufacturer indicates in their sales literature for an engine type.

Qualify the net power and engine speed (range) by the word "ISO".

EXAMPLE

ISO net power: ..... kW at ..... min^{-1}

(in accordance with ISO 1585)

9.2.2 Declared net torque and corresponding engine speed (range)

The declared net torque and corresponding engine speed (range) are the torque and corresponding engine speed (range) which the manufacturer indicates in their sales literature for an engine type.

Qualify the net torque and engine speed (range) by the word "ISO".

EXAMPLE

ISO net torque: ..... N·m at ..... min^{-1}

(in accordance with ISO 1585)

9.2.3 Declared specific net fuel consumption and corresponding engine speed (range)

The declared specific net fuel consumption and the corresponding engine speed (range) are the specific net fuel consumption and corresponding engine speed (range) which the manufacturer indicates in their sales literature for an engine type.

Qualify the specific net fuel consumption and engine speed (range) by the word "ISO".

EXAMPLE

ISO specific net fuel consumption: ..... g/(kW·h) at ..... min^{-1}

(in accordance with ISO 1585)

9.3 Tolerances — Declared values

9.3.1 Power

9.3.1.1 Declared single maximum power engine speed, n_p

At least at one engine speed which is in the range of n_p ±2 %, the corrected power shall be not less than (100 – a) % (see Figure 2) of the declared power.

At no engine speed shall the corrected power be more than (100 + a) % (see Figure 2) of the declared power. In normal cases near the declared maximum power engine speed, it is recommended that measurements be made in steps no smaller than 3 % of the declared maximum power engine speed or 3 % of the maximum engine speed, n_{p2}, of the power range as appropriate.

In no case shall the corrected power differ from the declared power at a given engine speed by more than d %.

NOTE See 9.3.4 for numerical tolerances.

9.3.1.2 Declared maximum power engine speed range, (n_{p1} – n_{p2})

Within the engine speed range (n_{p1} + 2 %) to (n_{p2} – 2 %), the corrected power shall be not less than

(100 – a) % of the declared power (see Figure 3).

At no engine speed shall the corrected power be more than (100 + a) % (see Figure 3) of the declared power. In normal cases near the declared maximum power engine speed, it is recommended that measurements be made in steps no smaller than 3 % of the declared maximum power engine speed or 3 % of the maximum engine speed, n_{p2}, of the power range as appropriate.

In no case shall the corrected power differ from the declared power at a given engine speed by more than d %.

NOTE See 9.3.4 for numerical tolerances.