INTERNATIONAL STANDARD

ISO 2534

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Road vehicles — Engine test code — Gross power

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

Reference number
ISO 2534:1998(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 voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 2534 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 5, *Engine tests*.

This second edition cancels and replaces the first edition (ISO 2534:1974), of which it constitutes a technical revision.

NOTE — This International Standard is consistent with ISO 1585:1992, *Road vehicles — Engine test code — Net power*.

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Road vehicles — Engine test code — Gross power

1 Scope

This International Standard specifies a method for testing internal combustion engines for propulsion of road vehicles as defined in ISO 3833. It applicable 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.

This International Standard is applicable to gross power assessment.

This International Standard 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 may be naturally aspirated or pressure-charged, either using a mechanical supercharger or turbocharger.

This International Standard is primarily intended for the communication between the engine manufacturer and the manufacturer of the vehicle. If used for advertising purposes, the ratings must clearly state that they are gross power in accordance with 9.2.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of the publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on the International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

ISO 3104:1994, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*.

ISO 3173:1974, *Road vehicles — Apparatus for measurement of the opacity of exhaust gas from diesel engines operating under steady state conditions*.

ISO 3675:1998, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*.

1) To be published. (Revision of ISO 2710:1978)

ISO 3833:1977, *Road vehicles — Types — Terms and definitions*.

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 5165:1998, *Petroleum products — Determination of the ignition quality of diesel fuels — 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*.

ISO 7967-5:1992, *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 11614:—[2)], *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 240-92e1, *Standard test method for heat of combustion of liquid hydrocarbon fuels by bomb calorimeter*.

ASTM D 3338-95, *Standard test method for estimation of net heat of combustion of aviation fuels*.

3 Definitions

For the purposes of this International Standard, 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
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 listed in table 1

NOTE — 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 engine power.

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

2) To be published. (Revision of ISO 3173:1974 and ISO/TR 4011:1976)

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 ± 2 K.

4.6 Barometric pressure

The barometric pressure measuring system shall have an accuracy of ± 100 Pa[3)].

4.7 Back pressure in exhaust system

Subject to footnote 1b) of table 1, 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) of table 1, the system used to measure the depression in the inlet system shall have an accuracy of ± 50 Pa.

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 gross power test
1	Inlet system	
	Inlet manifold	Yes, standard production equipment
	Crankcase emission control system	Optional
	Control devices for dual induction inlet manifold system	Yes, standard production equipment
	Air flow meter	Yes, standard production equipment
	Air inlet ductwork[1a)] } Air filter[1a)] } Inlet silencer[1a)]	Optional
	Speed-limiting device[1a)]	No

3) 1 Pa = 1 N/m²

Table 1 — Installation of equipment and auxiliaries during test *(continued)*

No.	Equipment and auxiliaries	Fitted for gross power test
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 Exhaust manifold Pressure-charging devices	Yes, standard production equipment
	Connecting pipes[1b)] Silencer[1b)] Tail pipe[1b)]	Optional, may use minimum loss bench system
	Exhaust brake[2)]	No
4	Fuel supply pump[3)]	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
6	Fuel injection equipment [Spark-ignition and compression-ignition (diesel)]	
	Prefilter	Optional
	Filter	Optional
	Pump High-pressure pipe Injector Air inlet valve (if fitted)[4)] Electronic control system, etc. (if fitted) Governor/control system: automatic full-load stop for the control depending on atmospheric conditions	Yes, standard production equipment
7	Liquid cooling equipment	
	Radiator Fan[5)] Fan cowl	No
	Water pump	Yes, standard production equipment
	Thermostat[7)]	Optional
8	Air cooling	
	Cowl Fan or blower[5)] Temperature regulating device	No
9	Electrical or electronic equipment	
	Generator[8)] Spark distribution system Coil(s) Wiring Spark-plugs Electronic control system including knock sensor/spark retard system[11)]	Yes, standard production equipment

Table 1 — Installation of equipment and auxiliaries during test *(concluded)*

No.	Equipment and auxiliaries	Fitted for gross power test
10	Pressure-charging equipment (if fitted) Compressor driven either directly by the engine, and/or by the exhaust gases Boost control[12)] Charge-air-cooler[5) 6) 9)] Coolant pump of ran (engine-driven) Coolant flow control devices (if fitted)	Yes, standard production equipment
11	Auxiliary test bed fan	Yes, if necessary
12	Anti-pollution devices[10)]	Yes, standard production equipment

1a) 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

1b) 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 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.

2) If an exhaust brake is incorporated in the engine, the throttle valve shall be fixed fully open.

3) 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)

4) 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.

5) When the cooling fan or blower is a fixed type, that is neither disconnectable nor progressive, and 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.

6) Where a separate disconnectable or progressive fan or blower, the test shall be made with the disconnectable fan or blower disconnected or with the progressive fan running at the maximum slip.

7) The thermostat may be fixed in the fully open position.

8) Minimum power of the generator: the power of the generator shall be limited to that necessary for the operation of accessories which are indispensable for engine operation. If the connection of a battery if necessary, a fully charged battery in good order shall be used.

9) 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 for a compression-ignition engine without a 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 is 6.3.2.1 a) is to be used .

10) They may include for example EGR system, catalytic converter, thermal reactor, secondary air supply system and fuel evaporating protecting system.

11) The spark advance shall be representative of in-use conditions established with the minimum octane fuel recommended by the manufacturer.

12) 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 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 is fitted and supplies, where necessary, the auxiliaries 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 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 gross power are indicated in table 2.

Table 2 — Setting conditions

1	Setting of carburettor(s)	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 gross 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 equipment used.

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 so 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; a non exhaustive list of such fuel includes the following:

— CEC RF-01-A-80[4)];

— CEC RF-08-A-85;

— CEC RF-03-A-84;

— JIS K 2202[5)];

— JIS K 220440 CFR, Part 86.113-94 or the latest edition[6)] for spark-ignition engines;

— 40 CFR, Part 86.1313-94 or the latest edition for compression-ignition engines.

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 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 by:

$$P_{ref} = \alpha P_y$$

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.

4) Co-ordinating European Council for the Development of Performance Tests for Lubricants and Engines Fuels.

5) Japan Industrial Standard.

6) Title 40, Code of Federal Regulations, USA.

6.2 Atmospheric conditions

6.2.1 Reference atmospheric conditions

For the purposes for 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:

$$298\ \text{K} \leq T \leq 308\ \text{K}$$

For compression-ignition engines:

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

6.2.2.2 Dry pressure, p_d

For all engines:

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

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 as calculated from the formula:

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

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 vapour pressure.

This formula 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.

This formula 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 the formula:

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

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 as calculated from the formula in a), b) or c):

a) naturally aspirated engines, mechanically pressure-charged engine:

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

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

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

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

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

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 from the formula:

$$f_m = 0,036 q_c - 1,14$$

where

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

in which

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

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

with Z = 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, 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).

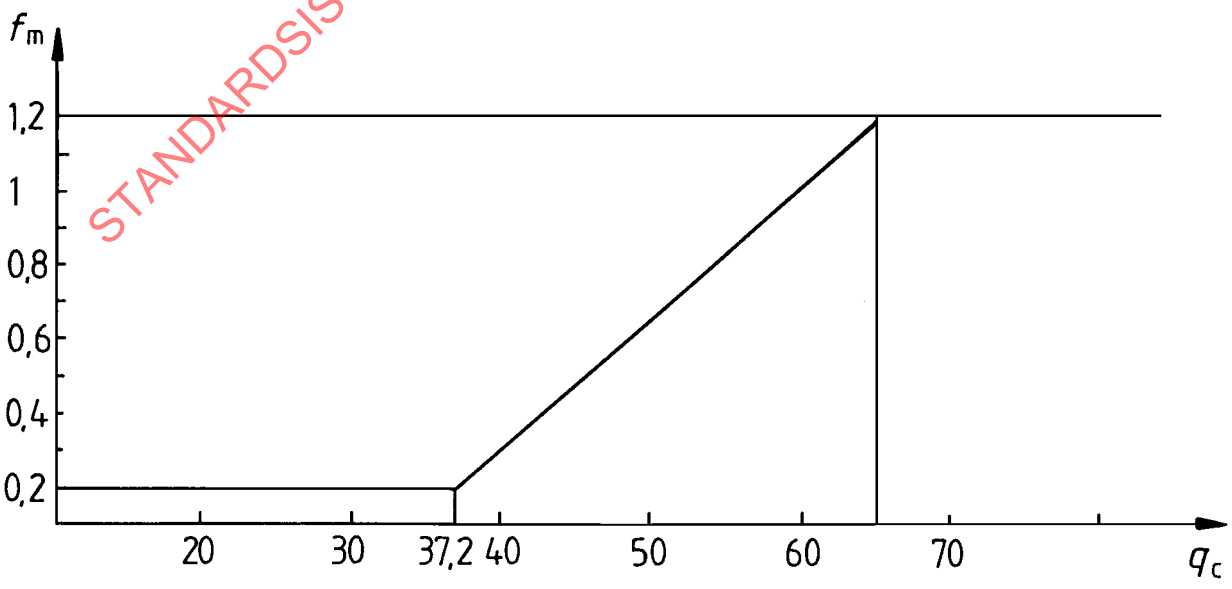

Figure 1 — Engine factor, f_m, as a function of corrected fuel delivery parameter, q_c

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 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:

$$S_r = \alpha_s S$$

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 the following formula:

$$\alpha_s = 1 - 5\,(f_a - 1)$$

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[7)]

8.1.1 Description of engine

Make: .....

Type: .....

Cycle: four-stroke/two-stroke[8)]

Bore: ..... mm

Stroke: ..... mm

Number of cylinders: .....

Layout of cylinders: ..... Firing order: .....

Engines swept volume: l

Compression ratio[9)]: .....

8.1.2 Cooling system

a) Liquid

Nature of liquid: .....

Circulating pumps: yes/no[8)]

Characteristics or make(s): ..... Type(s): .....

Drive ratio: .....

Thermostat setting: .....

Radiator: drawing(s) or make(s): ..... Type(s): .....

Relief valve: .....

Fan: Characteristics or make(s): ..... Type(s): .....

Fan drive system: .....

Drive ratio: .....

Fan cowl: .....

b) Air

Blower: Characteristics or make(s): ..... Type(s): .....

Drive ratio: .....

Air ducting (standard production): .....

7) In the case of non-conventional engines and systems, particulars equivalent to those referred to here shall be supplied by the manufacturer.

8) Delete where inapplicable.

9) Specify the tolerance.

Temperature regulation system: yes/no[10)]

Brief description: .....

8.1.3 Temperatures specified by the manufacturer

Liquid cooling

Maximum temperature at outlet: ..... K

Air cooling

Reference point (description): .....

Maximum temperature at reference point: ..... K

Maximum exhaust temperature: ..... K

Fuel temperature: minimum: ..... K maximum: ..... K

Lubricant temperature: minimum: ..... K maximum: ..... K

8.1.4 Pressure charger: with/without[10)]

Description of the system: .....

Make: ..... Type: .....

Compressor system: Make: ..... Type: .....

Charge-air-cooling system: Make: ..... Type: .....

8.1.5 Inlet system

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

.....

Inlet manifold: ..... Description: .....

Air filter: Make: ..... Type: .....

Inlet silencer: Make: ..... 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

Fuel feed: .....

Feed pump

Pressure: ..... kPa [11)]

or characteristic diagram[10)]: .....

Injection system: .....

10) Delete where inapplicable.

11) Specify the tolerance.

Pump

Make(s):.....

Type(s): .....

Delivery:..... mm^3 per stroke at pump speed of ....
..... min^{-1} 12)13) ..... at full injection, or characteristic diagram14)
.....

Quote the method used: on engine/on pump bench14)

Injection advance13):.....

Injection advance curve:.....

Timing:.....

Injection piping

Length:..... mm

Internal diameter:..... mm

Injector(s)

Make(s):.....

Type(s): .....

Opening pressure:.....kPa 13)
or characteristic diagram14):.....

Governor

Make(s):.....

Type(s): .....

Speed at which cut-off starts under full load:..... min^{-1} 12)

Maximum no-load speed:..... min^{-1} 12)

Idling speed: ..... min^{-1} 12)

Cold-start system

Make(s):.....

Type(s):.....

Description:.....

8.1.8 Valve timing

Maximum lift of valves and angles of opening and closing in relation to dead centres: .....

.....

12) 1 min^{-1} = 1 r/min

13) Specify the tolerance.

14) Delete where inapplicable.

Reference and/or setting ranges[15]: .....

8.1.9 Exhaust system

Description of exhaust manifold: .....

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[16]: .....

.....

8.1.10 Lubrication system

Description of system: .....

Position of lubricant reservoir: .....

Feed system (circulation by pump, injection inlet mixing with fuel, etc.): .....

Circulating pump: yes/no[15]

Make: .....

Type: .....

Mixture with fuel

Percentage: .....

Oil cooler: with/without[15]

Drawing(s) or make(s): ..... Type(s): .....

8.1.11 Electrical equipment

Generator/Alternator[15]

Characteristics or make(s): ..... Type(s): .....

8.1.12 Other engine-driven equipment

List and brief description if necessary: .....

.....

.....

8.2 Spark-ignition engines — Essential characteristics[17]

8.2.1 Description of engine

Make: .....

Type: .....

15) Delete where inapplicable.

16) Minimum loss lab system may be used.

17) In the case of non-conventional engines and systems, particulars equivalent to those referred to here shall be supplied by the manufacturer.

Cycle: four-stroke/two-stroke[18)]

Bore: ..... mm

Stroke: ..... mm

Number of cylinders: .....

Layout of cylinders: ..... Firing order: .....

Engine swept volume: l

Compression ratio[19)]: .....

8.2.2 Cooling system

a) Liquid

Nature of liquid: .....

Circulating pumps: yes/no[18)]

Characteristics or make(s): ..... Type(s): .....

Drive ratio: .....

Thermostat setting: .....

Radiator: Drawing(s) or make(s): ..... Type(s): .....

Relief valve pressure setting: .....

Fan: Characteristics or make(s): ..... Type(s): .....

Fan drive system: .....

Drive ratio: .....

Fan cowl: .....

b) Air

Blower: Characteristics or make(s): ..... Type(s): .....

Drive ratio: .....

Air ducting (standard production): .....

Temperature regulating system: yes/no[18)]

Brief description: .....

8.2.3 Temperature specified by the manufacturer

Liquid cooling

Maximum temperature at outlet: ..... K

Air cooling

Reference point (description): .....

Maximum temperature at reference point: ..... K

18) Delete where inapplicable.

19) Specify the tolerance.

Fuel temperature: minimum: ..... K maximum: ..... K

Lubricant temperature: minimum: ..... K maximum: .....K

8.2.4 Pressure charger: with/without[20)]

Description of the system:.....

Make: ..... Type:.....

Compressor system: Make: ..... Type:.....

Charge-air-cooling system: Make: ..... Type:.....

8.2.5 Inlet system

Description and diagrams of air inlets and their accessories (dash-pot, heating device, additional air inlets, etc.):

.....

Inlet manifold:..... Description:.....

Air filter: Make: ..... Type:.....

Inlet silencer: Make: ..... 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

By carburettor(s)[20)]:..... Number(s):.....

Make: .....

Type:.....

Adjustments

Jets: .....
Venturis: .....
Float-chamber level: ..... } or { Curve of fuel delivery plotted against air flow and settings required to keep to the curve[20)]
Mass of float: .....
Float needle: .....

Manual/automatic choke[20)]

Closure setting[21)]:.....

Feed pump

Pressure: .....kPa[21)] .....or characteristic diagram[20)]:.....

20) Delete where inapplicable.

21) Specify the tolerance.

By fuel injection[22)]

Make(s):.....

Type(s): .....

Description (general): .....

Calibration: ..... kPa [23)] ..... or characteristic diagram[22)]:.....

8.2.8 Valve timing

Maximum lift of valves and angles of opening and closing in relation to dead centres: .....

.....

Reference and/or setting ranges[22)]: .....

8.2.9 Ignition system

Ignition distributor

Knock sensor: yes/no[22)]

Strategy: retard only or advance/retard[22)]

Make:.....

Type:.....

Ignition advance curve[23)]: .....

Ignition timing[23)]: .....

Contact-point gap[23)] and dwell-angle[22)]:.....°

Spark-plugs

Make:.....

Type:.....

Spark-gap setting: .....

Ignition coil

Make:.....

Type:.....

Ignition condenser

Make:.....

Type:.....

Radio interference suppression equipment

Make:.....

Type:.....

22) Delete where inapplicable.

23) Specify the tolerance.

8.2.10 Exhaust system

Description and diagrams (or minimum loss lab system)[24)]

8.2.11 Lubrication system

Description of system

Position of lubricant reservoir: .....

Feed system (circulation by pump, injection into inlet, mixing with fuel, etc.): .....

Circulation pump:yes/no[24)]

Make: .....

Type: .....

Mixture with fuel

Percentage: .....

Oil cooler: with/without[24)]

Drawing(s) or make(s): ..... Type(s): .....

8.2.12 Electrical equipment

Generator/alternator[24)]

Characteristics or make(s): ..... Type(s): .....

8.2.13 Other auxiliaries fitted to engine

List and brief description if necessary: .....

.....

.....

8.3 Test conditions for measuring engine gross power

Trade-name or make of the engine: .....

Type and identification number of engine: .....

Test conditions

Pressure measured at maximum power: .....

Total barometric pressure: ..... kPa

Water vapour pressure: ..... kPa

Exhaust back-pressure: ..... kPa

Location of exhaust back-pressure measurement point: .....

Inlet depression: .....Pa

Absolute pressure in the inlet ductwork: .....Pa

Temperature measured at maximum power

24) Delete where inapplicable.

a) of the inlet air: ..... K

b) at the engine intercooler outlet: ..... K

c) of the cooling fluid

— at the engine cooling fluid outlet: ..... K[25)]

— at the reference point in the case of air cooling: ..... K[25)]

d) of the lubricating oil: ..... K at measurement point: .....

e) of the fuel

— at the carburettor inlet/fuel injection system inlet[25)]: ..... K

— in the fuel flow-measuring device: ..... K

Characteristics of the dynamometer

Make: ..... Model: .....

Type: .....

Rating: .....

Characteristics of the opacimeter

Make: ..... Model .....

Type: .....

Fuel flow-measuring apparatus: gravimetric/volumetric[25)]

Fuel for spark-ignition engines operating on liquid fuel

Make and type: .....

Specification: .....

Research Octane Number (RON): .....(according to ISO 5164)[26)]

Motor Octane Number (MON): .....(according to ISO 5163)[26)]

Percentage and type of oxygenates: .....

Density: .....g/cm^3 at 288 K (according to ISO 3675)[26)]

Lower calorific value, measured[25)]: .....kJ/kg (according to ASTM D 240)

or lower calorific value, estimated[25)]: .....kJ/kg (according to ASTM D3338)

Fuel temperature: ..... K

Fuel for spark-ignition engines operating on gaseous fuel

Make: .....

Specification: .....

Storage pressure: .....kPa

Utilization pressure: .....kPa

25) Delete where inapplicable.

26) ASTM standards also exist.

Lower calorific value: ..... kJ/kg

Fuel for compression-ignition engines operating on gaseous fuel

Gas feed systems: .....

Specification of gas used: .....

Fuel oil/gas proportion: .....

Lower calorific value: ..... kJ/kg

Fuel for compression-ignition engines operating on liquid fuel

Make: .....

Specification of fuel used: .....

Cetane number: ..... (according to ISO 5165)[27)]

Viscosity: ..... mm^2/s at 40 °C (according to ISO 3104)[27)]

Density: ..... g/cm^3 at 288 K (according to ISO 3675)[27)]

Lower calorific value, measured[28)]: ..... kJ/kg (in accordance with ASTM D 240)

or lower calorific value, estimated[28)]: ..... kJ/kg (in accordance with ASTM D 3338)

Lubricant

Make: .....

Specification: .....

SAE viscosity: .....

27) ASTM standards also exist.

28) Delete where inapplicable.

8.4 Statement of results as function of engine speed[29)]

Characteristic		Results	
		Engine speed	
		..... min^{-1}	..... min^{-1}
Measured torque, N·m			
Measured power, kW			
Measured fuel flow [1)], g/s			
Measured smoke, m^{-1}			
Barometric pressure, kPa			
Water vapour 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		
Power correction factor			
Corrected fuel flow [1)], g/s			
Corrected brake power, kW (with/without[2)] fan or blower)			
Power of fan or blower, kW (to be added if fan or blower is fitted)			
Gross power, kW			
Gross torque, N·m			
Specific fuel consumption (gross)[3)], 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 [2)]			
Fuel temperature at injection pump inlet, K			
Air temperature after charge air cooler, K [2)]			
Pressure after pressure-charged, kPa			
Pressure after charge air cooler, kPa			

1) 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)].

2) Delete where inapplicable.

3) Calculated with corrected gross power and corrected fuel flow (see 9.3.1.4).

29) The characteristic curves of the gross power and gross torque, of the specific fuel consumption and of the exhaust smoke values shall be drawn as a function of the engine speed.