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Motorcycles — Engine test code — Net power

Motocycles — Code d'essai des moteurs — Puissance nette

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 4106 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

This fourth edition cancels and replaces the third edition (ISO 4106:2004), which has been technically revised.

Introduction

The third edition of ISO 4106 (ISO 4106:2004) has many cross-references to ISO 15550, which contains the requirements that are common to all engine applications. Consequently, users of ISO 4106:2004 always have to refer to ISO 4106 and ISO 15550 simultaneously in order to comprehend the full test procedures for motorcycles. In this fourth edition, all the necessary components are described in the text rather than referring to ISO 15550 in order to avoid such inconveniences, and some technical and editorial modifications have also been made for refinement.

ISO 4106 can now be used as a stand-alone International Standard for engine net power measurement of motorcycles.

Motorcycles — Engine test code — Net power

1 Scope

This International Standard specifies methods for evaluating the performance of engines designed for motorcycles as defined in ISO 3833, in particular with a view to the presentation of power curves and specific fuel consumption at full load as a function of engine speed, for net power assessment. It is applicable to reciprocating internal combustion engines (spark-ignition or compression-ignition) — excluding free-piston engines — and rotary piston engines, either naturally aspirated or pressure-charged and equipped with either mechanical pressure-charger or turbocharger. Particular specifications for the test of compression-ignition engines are specified in Annex A.

2 Normative references

The following referenced documents are indispensable for the application 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 3833, *Road vehicles — Types — Terms and definitions*

ISO 15550, *Internal combustion engines — Determination and method for the measurement of engine power — General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2710-1, ISO 15550 and the following apply.

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 6.3.1

3.2
corrected net power
net power corrected under the standard reference conditions

3.3
net torque
torque transmitted 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 6.3.1

3.4
corrected net torque
net torque corrected under the standard reference conditions

3.5
specific fuel consumption
amount of fuel consumed by an engine per unit of power and time

NOTE The amount of the lubricants for two-stroke cycle engines is excluded.

3.6
auxiliaries
equipment and devices necessary to make the engine acceptable for service in the intended application

4 Symbols

For the purposes of this document, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbol	Designation	Unit
b_e	Specific fuel consumption	g/(kW·h)
p_d	Ambient dry air barometric pressure during the test	kPa
p_r	Standard reference total barometric pressure	kPa
p_{sr}	Standard reference saturated water vapour pressure	kPa
p_{sy}	Ambient saturated water vapour pressure during the test	kPa
p_y	Ambient total barometric pressure during the test	kPa
P	Measured power	kW
P_o	Corrected net power	kW
P_y	Net power	kW
T	Measured torque	N·m
T_o	Corrected net torque	N·m
T_y	Net torque	N·m
t_r	Standard reference ambient air temperature	K
t_y	Engine inlet air temperature during the test	K
α_a	Correction factor for ambient test conditions	—
α_m	Correction factor for efficiency of the transmission	—
η_i	Efficiency of each element constituting the transmission	—
η_t	Efficiency of the transmission which is located between the crankshaft and the measurement point	—
ϕ_r	Standard reference relative humidity	%
ϕ_y	Ambient relative humidity during the test	%

5 Standard reference conditions

For the purpose of determining the power and fuel consumption of an engine, the following standard reference conditions shall be used:

— standard reference total barometric pressure: $p_r = 100$ kPa;

— standard reference air temperature: $t_r = 298$ K;

— standard reference relative humidity: $\phi_r = 30$ %.

NOTE A relative humidity of 30 % at a temperature of 298 K corresponds to a water pressure of 1 kPa. The corresponding dry barometric pressure is 99 kPa.

6 Tests

6.1 General

This test method is used for verifying the net power of an engine type with the declared values. It presents engine performance at full power/torque as a function of engine speed by generating curves of corrected net torque, corrected net power and specific fuel consumption.

6.2 Measuring equipment and instrument accuracy

6.2.1 Torque

The dynamometer torque-measuring system shall have an accuracy of ± 1 % in the range of scale values required for the test. The torque-measuring system shall be calibrated to take into account friction losses. The accuracy may be ± 2 % for measurements carried out at a power less than 50 % of maximum power.

6.2.2 Engine speed

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

6.2.3 Fuel flow

The fuel-flow measuring system shall have an accuracy of ± 1 %.

6.2.4 Fuel temperature

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

6.2.5 Engine inlet air temperature

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

6.2.6 Barometric pressure

The barometric-pressure measuring system shall have an accuracy of ± 70 Pa.

6.2.7 Back pressure in exhaust system

The system used to measure the back pressure (differential pressure) in the exhaust system shall have an accuracy of ± 25 Pa.

6.2.8 Test room humidity

The test-room-humidity measuring system shall have an accuracy of ± 5% in relative humidity.

NOTE In the test atmospheric conditions specified in 6.3.3, the worst relative humidity measurement accuracy of ± 5 % corresponds to a wet and dry bulb thermometer measurement accuracy of ± 0,5 K. In the worst case, it is estimated that an accuracy of ± 0,5 K in a wet and dry bulb thermometer measurement would have an effect of approximately ± 0,3 % on the net power measuring result.

6.3 Setting and test conditions

6.3.1 Equipment and auxiliaries

During the test, if the equipment and auxiliaries specified in Table 2 are the standard productions, they shall be installed on the test bench as far as possible in the same position and in the same condition as in the intended application. The equipment and auxiliaries for the test of compression-ignition engines are listed in Annex A.

Table 2 — Equipment and auxiliaries to be installed for the test to determine engine power

No.	Equipment and auxiliaries	
1	Inlet system	Inlet manifold
		Crankcase emission control system
		Control devices for dual induction
		Electronic control system
		Air flow meter
		Air inlet ductwork[a]
		Air filter[a]
		Inlet silencer[a]
		Speed-limiting device[a]
2	Induction-heating device of inlet manifold	
3	Exhaust system	Exhaust purifier
		Exhaust manifold
		Pressure-charging device
		Connecting pipes[b]
		Silencer[b]
		Tail pipe[b]
		Electronic control system
4	Fuel supply system	Fuel supply pump[c]
		Carburettor
		Electronic control system
		Gaseous fuel pressure reducer
		Gaseous fuel evaporator
		Gaseous fuel mixer
5	Fuel injection equipment	Prefilter
		Filter
		Fuel injection pump
		High-pressure pipes
		Injector
		Air inlet valve
		Electronic control system
6	Liquid-cooling equipment	Radiator[d]
		Fan[de]
		Fan cowl[d]
		Water pump[d]
		Thermostat[df]
7	Air-cooling equipment	Cowl[d]
		Fan or blower[de]
		Temperature-regulating device

Table 2 *(continued)*

No.	Equipment and auxiliaries	
8	Electrical equipment	Generator[g]
		Battery[g]
		Spark distribution system
		Coil or coils
		Wiring
		Spark-plugs
		Electronic control system[h]
9	Pressure-charging equipment	Compressor driven directly by the engine and/or by the exhaust gases
		Boost control[i]
		Charge air cooler[dej]
		Coolant pump or fan (engine-driven)
10	Anti-pollution device[k]	
11	Lubricating oil pump	
12	Oil cooler	

[a] Except in the case where there is a risk of the system having a noticeable influence upon engine power, where the equivalents may be used. In this case, a check shall be made to ascertain that inlet depression does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

[b] If it is impracticable to fit the standard exhaust system, a system permitting the normal engine running characteristics in accordance with the manufacturer's specification shall be fitted for the test. In particular, in the test laboratory, the exhaust extraction system at the point where the test bench exhaust system is connected shall not create a pressure differing from the atmospheric pressure by more than $\pm$ 740 Pa at the exhaust extraction duct, with the engine in operation, unless the manufacturer has specifically prescribed the back pressure prior to the test, in which case the lower of the two pressures shall be used.

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

[d] The radiator, fan, fan cowl, water pump, thermostat and cowl shall be located on the test bed in the same relative positions that they are to occupy on the vehicle or machine. The cooling liquid circulation shall only be operated by the engine water pump. Cooling of the liquid may be provided either by the engine radiator or by an external circuit, provided that the pressure loss of this circuit and the pressure at the pump inlet remain substantially the same as those of the engine cooling system. The radiator shutter, if incorporated, shall be set in the open position.

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

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

[f] The thermostat may be fixed in the fully open position.

[g] The electrical power of the generator shall be the minimum. It shall be limited to that necessary for operation of accessories which are indispensable for engine operation. If the connection of a battery is necessary, a fully charged battery in good condition shall be used.

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

[i] 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.

[j] Charge air-cooled engines shall be tested with the charge air-cooling system operating, whether this system is liquid- or air-cooled. If the engine manufacturer prefers, a test bed system may replace an air-cooled cooler. In either case the measurement of power at each speed shall be made with the pressure drop and temperature drop of the engine air across the charge air cooler in the test bed the same as those specified by the manufacturer for the system on the complete vehicle.

[k] These may include, for example, Exhaust Gas Recirculation (EGR) system, catalytic converter, secondary air-supply, fuel evaporation protection systems and crankcase emission control system.

6.3.2 Test conditions

The test conditions shall be as follows. The particular test conditions for test of compression-ignition engines shall be as specified in Annex A.

a) The power test shall consist of a run at full throttle, the engine being equipped with equipment and auxiliaries as specified in 6.3.1.

b) The engine speed during a test run shall not deviate from the selected speed by more than ± 1 %.

c) Performance data shall be obtained under stabilized operating conditions in accordance with the manufacturer's specifications, with an adequate fresh-air supply to the engine.

   Before the test, the engine shall have been run-in in accordance with the manufacturer's recommendations. Test conditions such as inlet air temperature shall be selected to be as near to the standard reference conditions (see Clause 5) as possible in order to minimize the magnitude of the correction factor.

d) No data shall be taken until torque, engine speed and temperatures have been maintained substantially constant as specified by the manufacturer.

   If the constant operating conditions (torque, engine speed and temperatures) are not specified by the manufacturer, no data shall be taken until the engine speed has been maintained within the limits specified in 6.3.2 b). Each measurement period shall be equal for every measurement.

e) Data on the observed brake load, the fuel consumption and the engine inlet air temperature shall be taken virtually simultaneously and shall, in each case, be the average of two consecutive stabilized readings for which the brake load and fuel consumption do not vary by more than 2 %.

   No adjustment shall be made to the engine between these readings.

f) A measurement time of not less than 10 s shall be used when measuring engine speed and fuel consumption with an automatically synchronized counter-timer combination.

g) For liquid-cooled engines, the temperature of the coolant at the outlet from the engine shall be kept within ± 5 K from the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer, 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 for the reference conditions.

   If no temperature is specified by the manufacturer, the temperature of the ignition spark-plug washer shall be 523 K or less. For multi-cylinder engines, it is permissible to measure the ignition spark-plug washer temperature at only one representative cylinder.

h) The fuel temperature shall be measured as near as possible to the inlet of the carburettor or fuel injector manifold assembly. 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 ± 20 K.

i) The lubricating oil temperature measured in the oil sump or at the oil cooler outlet, if fitted, shall be maintained within the limits established by the engine manufacturer.

j) Engine inlet air temperature shall be measured within 0,15 m of the point of entry to the air cleaner, or, if no air cleaner is used, within 0,15 m of the air inlet horn. The inlet depression measurement shall be made at the same point.

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

k) The exhaust temperature shall be measured at a point in the exhaust pipe(s) adjacent to the outlet flange(s) of the exhaust manifold(s) or ports.

l) In cases of type approval (certification) or acceptance test, the selection of fuel for power test shall be agreed by the parties involved and be selected in accordance with the requirements of Table 3. In the case of other tests, an appropriate fuel for the test can be used.

Unleaded gasoline shall be used for the engine equipped with the catalyst. Specifications for test fuels in 8.2.2 e) shall be reported in cases of type approval (certification) or acceptance test. For other types of test, at least the following fuel information shall be reported.

1) make and name;

2) octane number RON or MON;

3) relative density at 288 K, in g/cm^3;

4) lower calorific value, in kJ/kg;

5) applicable fuel standard(s).

In case of using commercial fuels, it is permitted to only report the following information:

— make and name;

— grade;

— applicable fuel standard(s).

m) Data to be recorded shall be those indicated in 8.3.

Table 3 — Test fuels

Test purpose	Interested parties	Fuel selection
Type approval (certification)	Certification body, manufacturer or supplier	Reference fuel, if one is defined Commercial fuel if no reference fuel is defined
Acceptance test	Manufacturer or supplier Customer or inspector	Commercial fuel as specified by the manufacturer

6.3.3 Test atmospheric conditions

The atmospheric conditions during the test shall be within the range given below.

a) Engine inlet air temperature, in kelvin, $288 \leq t_y \leq 308$.

b) Dry pressure, in kilopascal, $90 \leq p_d \leq 110$.

NOTE $p_d = p_y - \phi_y p_{sy}$.

6.4 Test procedure

Measurements shall be taken at a sufficient number of engine speeds to completely define the torque and power curve between the lowest and the highest engine speeds recommended by the manufacturer. The speed range shall include the point at which the engine produces its maximum torque and power. Data shall be taken incrementally from the lowest to the highest engine speeds recommended by the manufacturer. When the temperature exceeds the value specified in 6.3.2 g), the measurements shall be made intermittently.

7 Torque, power and specific fuel consumption

7.1 Calculation of measured torque, measured power and specific fuel consumption

The measured torque and measured power shall be calculated by Equations (1) and (2), respectively:

$$T = WL \tag{1}$$

$$P = \frac{2\pi WLN}{60k} = cWN \tag{2}$$

where

c is the coefficient of the dynamometer $\left(c = \frac{2\pi L}{60k} \right)$;

k is the conversion factor ($k = 1\ 000$);

L is the arm length of the dynamometer, in metres;

N is the dynamometer rotation speed, in min^{-1};

W is the dynamometer braking load, in newtons.

When the power take-off shaft rotation speed is different from the crankshaft rotation speed, the measured torque shall be defined as the quotient of the torque, T, divided by the reduction gear ratio defined in Equation (3):

$$r_{\text{g}} = \frac{n_{\text{c}}}{n_{\text{p}}} \tag{3}$$

where

n_{c} is the crankshaft rotation speed, in min^{-1};

n_{p} is the power take-off shaft rotation speed, in min^{-1};

r_{g} is the reduction gear ratio.

The specific fuel consumption shall be calculated by Equation (4):

$$b_{\text{e}} = \frac{B}{P} \tag{4}$$

where

B is the amount of fuel consumed by an engine per unit of time, in grams per hour.

7.2 Net torque and net power

The net torque and net power shall be determined by multiplying the measured torque and measured power by the correction factor (α_{m} factor), which is defined by the efficiency of the transmission used during the test.

7.2.1 Determination of correction factor α_{m}

Where the measurement point is at the crankshaft, this factor is equal to 1.

Where the measurement point is not at the crankshaft, this factor is calculated using Equation (5):

$$\alpha_{\mathrm{m}} = \frac{1}{\eta_{\mathrm{t}}} \tag{5}$$

where η_{t} is the efficiency of the transmission which is located between the crankshaft and the measurement point.

This efficiency of the transmission, η_{t}, is determined from the product of the efficiency η_i of each element constituting the transmission and calculated by Equation (6):

$$\eta_{\mathrm{t}} = \eta_1 \times \eta_2 \times \ldots \times \eta_i \tag{6}$$

The efficiency η_i of each element constituting the transmission shall be in accordance with Table 4.

Table 4 — Transmission component efficiencies

Component	Type	Efficiency η_i
Gear	Spur gear	0,98
	Helical gear	0,98
	Bevel gear	0,98
Chain	Roller	0,95
	Silent	0,98
Belt	Toothed	0,95
	V-belt	0,94
Hydraulic coupler or converter	Hydraulic coupler	0,92
	Non-locked hydraulic converter	0,92

7.2.2 Calculation of net torque and net power

The net torque and net power shall be calculated by Equations (7) and (8), respectively:

$$T_{\mathrm{y}} = \alpha_{\mathrm{m}} T \tag{7}$$

$$P_{\mathrm{y}} = \alpha_{\mathrm{m}} P \tag{8}$$

7.3 Corrected net torque and corrected net power

The corrected net torque and corrected net power shall be determined by multiplying the net torque and net power by the correction factor (α_{a} factor). This factor is to determine the corrected net torque and power, taking into account the standard reference conditions given in Clause 5.

7.3.1 Determination of correction factor α_a

The correction factor α_a for naturally aspirated and pressure-charged spark-ignition engines, with or without charge air cooling, shall be calculated by Equation (9):

$$\alpha_a = \left(\frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right)^{1,2} \left(\frac{t_y}{t_r} \right)^{0,6} \quad (9)$$

Equation (9) is only applicable if:

$$0,96 \leq \alpha_a \leq 1,06$$

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

The correction factor α_a for the test of compression-ignition engines is specified in Annex A.

7.3.2 Calculation of corrected net torque and corrected net power

The corrected net torque and corrected net power shall be calculated by Equations (10) and (11), respectively:

$$T_o = \alpha_a T_y = \alpha_a \alpha_m T \quad (10)$$

$$P_o = \alpha_a P_y = \alpha_a \alpha_m P \quad (11)$$

8 Test report

8.1 General

The requirements for the test report shall be as follows. The particular requirements for the test report of compression-ignition engines are specified in Annex A.

8.2 The description of test report

The test report shall include the following engine identification and test information.

8.2.1 Essential characteristics of spark-ignition engines

8.2.1.1 Engine description

a) Reciprocating engines:

1) make;

2) type;

3) identification number;

4) cycle;

5) engine swept volume (total displacement volume);

6) bore and stroke;

7) number and layout of cylinders;

8) firing order;

9) compression ratio;

10) cooling system.

b) Rotary piston engines:

1) make;

2) type;

3) identification number;

4) engine swept volume (total displacement volume);

5) eccentricity (ratio);

6) operating width;

7) number of rotors;

8) compression ratio;

9) cooling system.

8.2.1.2 Equipment and auxiliaries

For the following equipment and auxiliaries, the make, type, specifications, setting conditions, etc. shall be described when the standard production equipment is not used.

a) cooling system;

EXAMPLE Nature of liquid, radiator, fan, blower, etc.

b) pressure charger;

EXAMPLE Compressor system, charge air cooling system, etc.

c) inlet system;

EXAMPLE Inlet manifold, air filter, inlet silencer, etc.

d) emission control devices;

EXAMPLE Exhaust Gas Recirculation (EGR) system, catalytic converter, secondary air-supply, fuel evaporation protection systems and crankcase emission control system, etc.

e) fuel feed system;

EXAMPLE Carburetor, fuel feed pump, fuel injection system, etc.

f) ignition systems;

EXAMPLE Ignition timing control system, spark-plug, ignition coil, ignition condenser, radio interference suppression equipment, etc.

g) exhaust system;

EXAMPLE Exhaust pipe, silencer (muffler), etc.

h) lubrication system;

EXAMPLE Feed system, oil cooler, etc.

i) electric equipment;

EXAMPLE Generator/alternator, etc.

j) transmission;

k) auxiliaries which are driven by engine and not able to be removed from engine during the test.

8.2.2 Test conditions during net power measurement

The following test conditions shall be reported in the test report.

a) Pressure measurements:
   1) total barometric pressure, kPa;
   2) ambient relative humidity, %;
   3) ambient saturated water vapour pressure, kPa;
   4) back pressure in exhaust system, kPa;
   5) back pressure measurement point;
   6) inlet depression, Pa;
   7) absolute pressure in inlet manifold, Pa.

b) Temperature measurements:
   1) engine inlet air temperature, K;
   2) temperature of air at the outlet from the charge air cooling system, K;
   3) engine coolant temperature, K;
   4) temperature at specific point of air-cooled engines, K;
   5) lubricating oil temperature, K;
   6) fuel temperatures, K:
      i) fuel temperature measured at the inlet of the carburettor or fuel injector manifold assembly, K;
      ii) fuel temperature measured inside the fuel flow meter, K.

c) Characteristics of dynamometer:
   1) make;
   2) type;
   3) constant.

d) Type of fuel flow measurement system.

e) Specifications of test fuel; [see 6.3.2 l) for the items to be reported]:
   1) liquid fuel:
      i) make and name;
      ii) research octane number (RON) or motor octane number (MON);
      iii) relative density at 288 K, g/cm^3;
      iv) Reid vapour pressure, kPa;

v) distillation:

— initial boiling point, K;

— 10 % (volume), K;

— 50 % (volume), K;

— 90 % (volume), K;

— final boiling point, K;

— residue, volume %;

vi) hydrocarbon analysis:

— olefins, volume %;

— aromatics, volume %;

— saturates, volume %;

vii) oxidation stability, minute;

viii) existent gum, mg/100 ml;

ix) sulfur content, mass %;

x) lead content, mg/l;

xi) carbon/hydrogen mole ratio or carbon/hydrogen mass ratio;

xii) benzene, volume %;

xiii) ETBE, volume %;

xiv) ethanol, volume %;

xv) MTBE, volume %;

xvi) methanol, volume %;

xvii) phosphorus content, mg/l;

xviii) mixture-ratio of fuels to lubricants, volume %;

xix) lower calorific value (measured or calculated value), kJ/kg;

xx) others;

2) gaseous fuel:

i) make and name;

ii) storage pressure, kPa;

iii) utilization pressure and measurement point, kPa;

iv) lower calorific value (measured or calculated value), kJ/kg;

v) others.

f) Lubrication oil:

1) make and name;

2) grade;

3) SAE viscosity.

8.3 Statement of results

The following items shall be included in the test results report:

a) maximum corrected net torque, N·m;

b) engine speed at maximum corrected net torque, min^{-1};

c) specific fuel consumption at maximum corrected net torque, g/kW·h;

d) maximum corrected net power, kW;

e) engine speed at corrected maximum net power, min^{-1};

f) specific fuel consumption at maximum corrected net power, g/kW·h.

The characteristic curves of the corrected net torque, corrected net power and the specific fuel consumption shall be drawn as a function of the engine speed. An example of a test results report is given in Table 5. The results shall be reported by Table 6.

Table 5 — Example of test results for the characteristic curves

Date:								Time of test start:						Time of test end:						
No.		n min^{-1}		N min^{-1}	W N	T N·m	P kW	**Temperatures** K						ϕ_y %	p_y kPa	α_a	T_o N·m	P_o kW	B g/s or ml/s[b]	b_e[c] g/(kW·h)
		Target	**Measured**					**Inlet air**	**Cooling[a]**	**Oil**	**Exhaust gas**	**Fuel**	**Ambient air**							
1	1																			
	2																			
	Mean																			
2	1																			
	2																			
	Mean																			
3	1																			
	2																			
	Mean																			
4	1																			
	2																			
	Mean																			
5	1																			
	2																			
	Mean																			

[a] Specify the measurement point (delete where inapplicable):
— at the cooling liquid outlet;
— at the spark-plug gasket;
— at other points (specify these).

[b] Delete as applicable.

[c] Without correction of power.

n engine speed
N dynamometer rotation speed
W dynamometer braking load
T measured torque
P measured power
ϕ_y ambient relative humidity during the test

p_y ambient total barometric pressure during the test
α_a correction factor
T_o corrected net torque
P_o corrected net power
B measured fuel consumption
b_e specific fuel consumption

Table 6 — Test results

Items	Value	Engine speed at measurement	Specific fuel consumption at measurement
Maximum corrected net torque	N·m	min^{-1}	g/(kW·h)
Maximum corrected net power	kW	min^{-1}	g/(kW·h)

Annex A
(normative)

Test method for compression-ignition engines

A.1 General

This annex specifies particular specifications on equipment and auxiliaries, test conditions, power correction method and test report, for the test of compression-ignition engines.

A.2 Equipment and auxiliaries

During the test, the standard production equipment and auxiliaries specified in Table A.1 shall be installed on the test bench as far as possible in the same position and in the same condition as in the intended application.

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

No.	Equipment and auxiliaries	
1	Inlet system	Inlet manifold
		Crankcase emission control system
		Control devices for dual induction
		Electronic control system
		Air flow meter
		Air inlet ductwork[a]
		Air filter[a]
		Inlet silencer[a]
		Speed-limiting device[a]
2	Exhaust system	Exhaust purifier
		Exhaust manifold
		Pressure-charging device
		Connecting pipes[b]
		Silencer[b]
		Tail pipe[b]
		Exhaust brake[c]
		Electronic control system
3	Fuel supply system	Fuel supply pump[d]
		Delivery system
4	Fuel injection equipment	Prefilter
		Filter
		Fuel injection pump
		High-pressure pipes
		Injector
		Air inlet valve
		Electronic control system
		Governor/control system
5	Liquid-cooling equipment	Radiator[e]
		Fan[ef]
		Fan cowl[e]
		Water pump[e]
		Thermostat[eg]
6	Air cooling equipment	Cowl[e]
		Fan or blower[ef]
		Temperature-regulating device
7	Electrical equipment	Generator[h]
		Battery[h]
		Wiring
		Electronic control system[i]
8	Pressure-charging equipment	Compressor driven directly by the engine and/or by the exhaust gases
		Boost control[j]
		Charge air cooler[efk]
		Coolant pump or fan (engine-driven)

Table A.1 *(continued)*

No.	Equipment and auxiliaries
9	Anti-pollution device[l]
10	Lubricating oil pump
11	Oil cooler

[a] Except in the case where there is a risk of the system having a noticeable influence upon engine power, where the equivalents may be used. In this case, a check shall be made to ascertain that inlet depression does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

[b] If it is impracticable to fit the standard exhaust system, a system permitting the normal engine running characteristics in accordance with the manufacturer's specification shall be fitted for the test. In particular, in the test laboratory, the exhaust extraction system at the point where the test bench exhaust system is connected shall not create a pressure differing from the atmospheric pressure by more than $\pm$ 740 Pa at the exhaust extraction duct, with the engine in operation, unless the manufacturer has specifically prescribed the back pressure prior to the test, in which case the lower of the two pressures shall be used.

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

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

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

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

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

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

[g] The thermostat may be fixed in the fully open position.

[h] The electrical power of the generator shall be the minimum. It shall be limited to that necessary for operation of accessories which are indispensable for engine operation. If the connection of a battery is necessary, a fully charged battery in good condition shall be used.

[i] The fuel injection timing shall be representative of in-use conditions established with the minimum cetane fuel recommended by the manufacturer.

[j] For engines equipped with variable boost as a function of charge or inlet air temperature, cetane rating and/or engine speed, the boost pressure shall be representative of in-vehicle conditions established with the minimum cetane fuel as recommended by the manufacturer.

[k] Charge air-cooled engines shall be tested with the charge air-cooling system operating, whether this system is liquid- or air-cooled. If the engine manufacturer prefers, a test bed system may replace an air-cooled cooler. In either case the measurement of power at each speed shall be made with the pressure drop and temperature drop of the engine air across the charge air cooler in the test bed the same as those specified by the manufacturer for the system on the complete vehicle or machine.

[l] These may include, for example, Exhaust Gas Recirculation (EGR) system, catalytic converter, secondary air-supply, fuel evaporation protection systems and crankcase emission control system.

A.3 Test conditions

The particular test conditions for test of compression-ignition engines are as follows.

a) The power test shall consist of a run at fixed full load fuel injection pump setting, the engine being equipped with equipment and auxiliaries as specified in A.2.

b) 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 or in the fuel supply pipe between the filter and the fuel injection pump, upstream of the entry point for any backflow fuel. Fuel temperature shall be maintained to within $\pm$ 3 K of the temperature specified by the manufacturer. In all cases, the minimum permissible fuel temperature at the pump inlet is 303 K. If the test fuel temperature is not specified by the manufacturer, it shall be 313 K $\pm$ 3 K for distillate fuels.

c) The temperature of the air inducted into the engine during the test shall be within the range given below:

$283\ \text{K} \leq t_y \leq 313\ \text{K}$.

A.4 Correction factor α_a

A.4.1 Determination of correction factor α_a

The power correction factor (α_a) for compression-ignition engines at constant fuel delivery setting (pre-set fuel delivery) is obtained by applying Equation (A.1):

$$\alpha_a = (f_a)^{f_m} \tag{A.1}$$

where

f_a is the atmospheric factor (see A.4.2);

f_m is the characteristic parameter for each type of engine and fuel setting (see A.4.3).

A.4.2 Determination of atmospheric factor f_a

This factor, which indicates the effects of environmental conditions (pressure, temperature and humidity) on the air drawn in by the engine and differs according to the type of engine, shall be as calculated from Equation (A.2), (A.3) or (A.4):

— for naturally aspirated engines and mechanically pressure-changed engines:

$$f_a = \left(\frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right) \left(\frac{t_y}{t_r} \right)^{0,7} \tag{A.2}$$

— for turbocharged engines without charge air cooling or with charge air cooling by air-to-air cooler:

$$f_a = \left(\frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right)^{0,7} \left(\frac{t_y}{t_r} \right)^{1,2} \tag{A.3}$$

— for turbocharged engines with charge air cooling by air-to-liquid charge air cooler:

$$f_a = \left(\frac{p_r - \phi_r p_{sr}}{p_y - \phi_y p_{sy}} \right)^{0,7} \left(\frac{t_y}{t_r} \right)^{0,7} \tag{A.4}$$

A.4.3 Determination of engine factor f_m

Factor f_m is dependent on the type of engine and the trapped air/fuel ratio corresponding to the fuel setting. The engine factor f_m is a function of the corrected specific fuel delivery q_c and shall be calculated from Equation (A.5):

$$f_m = 0,036 q_c - 1,14 \tag{A.5}$$

$$q_c = \frac{q}{r_r} \tag{A.6}$$

where

r_r is the ratio between the absolute static pressure at the compressor outlet and compressor inlet under standard reference conditions ($r_r = 1$ for naturally aspirated engines). For two-stage turbo charging, r_r is the overall pressure ratio;

q is the fuel delivery parameter in mg/l·cycle and is equal to Equation (A.7):

$$q = \frac{z \times V}{v_H \times n} \tag{A.7}$$

where

n is the engine speed, in min^{-1};

V is the fuel flow, in grams per second;

z is the unit conversion factor to obtain q, $z = 120\,000$ for four-stroke cycle engines and $z = 60\,000$ for two-stroke cycle engines;

v_H is the engine swept volume, in litres.

Equation (A.5) is valid for the following range of q_c, in mg/l·cycle:

$37{,}2 \leq q_c \leq 65$

For q_c values lower than 37,2, a constant value of f_m equal to 0,2 ($f_m = 0{,}2$) shall be taken. For q_c values higher than 65, a constant value of f_m equal to 1,2 ($f_m = 1{,}2$) shall be taken (see Figure A.1).

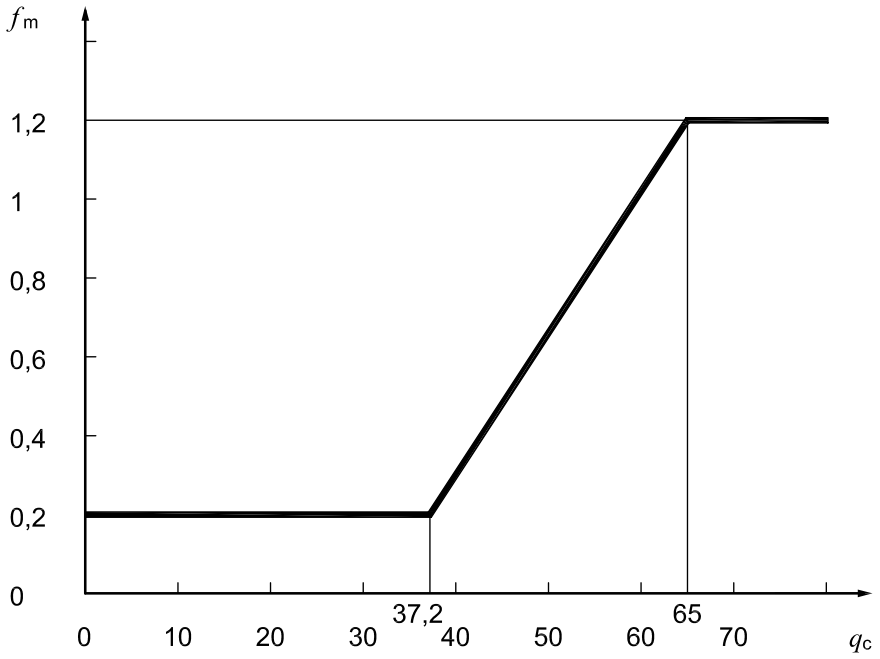

Figure A.1 — Engine factor, f_m, as a function of the corrected fuel delivery, q_c

A.4.4 Limitation in use of correction factor equation

The correction factor Equation (A.1) is only applicable if $0{,}96 \leq \alpha_a \leq 1{,}06$.

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

A.5 Test report

A.5.1 General

The particular requirements for the net power measurement test report for compression-ignition engines are as follows.

A.5.2 The description of test report

The test report shall include the following engine identification and test information.

A.5.2.1 Essential characteristics of compression-ignition engines

Appropriate items in 8.2.1.1 for engine description shall be selected and described.

A.5.2.1.1 Equipment and auxiliaries

For equipment and auxiliaries specified in 8.2.1.2, the make, type, specifications, setting conditions, etc. shall be described when the standard production equipment is not used. Subclause 8.2.1.2 e) shall be read as follows:

e) Fuel feed system;

EXAMPLE Governor, fuel feed pump, fuel injection system, fuel injection timing control system, etc.

A.5.2.2 Test conditions during net power measurement

The test conditions specified in 8.2.2 shall be reported in the test report. Subclause 8.2.2 e) shall be read as follows:

e) Specifications of test fuel:

1) liquid fuel:

i) make and name;

ii) relative density at 288 K, g/cm^3;

iii) cetane number;

iv) lower calorific value (measured or calculated value), kJ/kg;

v) distillation:

— initial boiling point, K;

— 10 % (volume), K;

— 50 % (volume), K;

— 90 % (volume), K;

— final boiling point, K;

— residue, volume %;

vi) hydrocarbon analysis;

— olefins, volume %;

— aromatics, volume %;

— saturates, volume %;

vii) sulfur content, mass %;

viii) kinetic viscosity at 30 °C, mm^2/s;

ix) carbon/hydrogen mole ratio or carbon/hydrogen mass ratio;

x) others.

A.5.3 Statement of results

The test results report shall be in accordance with 8.3.

Bibliography

[1] ISO 1585, *Road vehicles — Engine test code — Net power*

[2] ISO 3007, *Petroleum products and crude petroleum — Determination of vapour pressure — Reid method*

[3] ISO 3405, *Petroleum products — Determination of distillation characteristics at atmospheric pressure*

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

[5] ISO 3830, *Petroleum products — Determination of lead content of gasoline — Iodine monochloride method*

[6] ISO 3837, *Liquid petroleum products — Determination of hydrocarbon types — Fluorescent indicator adsorption method*

[7] ISO 4164, *Mopeds — Engine test code — Net power*

[8] ISO 4260, *Petroleum products and hydrocarbons — Determination of sulfur content — Wickbold combustion method*

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

[10] ISO 6246, *Petroleum products — Gum content of light and middle distillate fuels — Jet evaporation method*

[11] ISO 7536, *Petroleum products — Determination of oxidation stability of gasoline — Induction period method*

[12] ISO 8754, *Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence spectrometry*

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