



EAST AFRICAN STANDARD

The determination of performance (at net power) of internal combustion engines — Part 1: Road vehicle internal combustion engines at sea level

EAST AFRICAN COMMUNITY

Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

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The determination of performance (at net power) of internal combustion engines — Part 1: Road vehicle internal combustion engines at sea level

1 Scope

1.1 This part of CD/K/049 covers a method for testing engines designed for road vehicles. It is applicable to the evaluation of their performances with a view, in particular, to presenting curves of power, torque and specific fuel consumption at full load as a function of engine speed.

1.2 It does not apply to internal-combustion engines used for propulsion of motorcycles and agricultural tractors, or free piston engines.

2 Normative references

The following referenced documents are indispensable for the application of this East African Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASTM D 86, *Standard test method for distillation of petroleum products at atmospheric pressure*

ASTM D 93a, *Standard test methods for flash-point by Pensky-Martens closed cup tester*

ASTM D 95, *Standard test method for water in petroleum products and bituminous materials by distillation*

ASTM D 97, *Standard test method for pour point of petroleum products*

ASTM D 130, *Standard test method for corrosiveness to copper from petroleum products by copper strip test*

ASTM D 189, *Standard test method for Conradson carbon residue of petroleum products*

ASTM D 323a, *Standard test method for vapor pressure of petroleum products (Reid method)*

ASTM D 381, *Standard test method for gum content in fuels by jet evaporation*

ASTM D 445, *Standard test method for kinematic viscosity of transparent and opaque liquids (and the calculation of dynamic viscosity)*

ASTM D 482, *Standard test method for ash from petroleum products*

ASTM D 525, *Standard test method for oxidation stability of gasoline (induction period method)*

ASTM D 664, *Standard test method for acid number of petroleum products by potentiometric titration*

ASTM D 974, *Standard test method for acid and base number by color-indicator titration*

ASTM D 976, *Standard test method for calculated cetane index of distillate fuels*

ASTM D 1266, *Standard test method for sulfur in petroleum products (lamp method)*

ASTM D 1298, *Standard test method for density, relative density (specific gravity), or API gravity of crude petroleum and liquid petroleum products by hydrometer method*

ASTM D 1319, *Standard test method for hydrocarbon types in liquid petroleum products by fluorescent indicator adsorption*

ASTM 2270, *Standard practice for calculating viscosity index from kinematic viscosity at 40 and 100 °C*

ASTM D 2622, *Standard test method for sulfur in petroleum products by wavelength dispersive X-ray fluorescence spectrometry*

ASTM D 2699, *Standard test method for research octane number of spark-ignition engine fuel*

ASTM D 3341, *Standard test method for lead in gasoline-iodine monochloride method*

ASTM D 5293, *Standard test method for apparent viscosity of engine oils between -5 and -35 °C using the cold-cranking simulator*

EN 116, *Diesel and domestic heating fuels — Determination of cold filter plugging point*

IP 15, *Petroleum products — Determination of pour point*

IP 71 Section 1, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

IP 71 Section 2, *Petroleum products — Glass capillary kinematic viscometers — Specifications and operating instructions*

IP 160, *Crude petroleum and liquid petroleum products — Laboratory determination of density -Hydrometer method*

IP 177, *Determination of weak and strong acid number — Potentiometric titration method*

IP 226, *Petroleum products — Calculation of viscosity index from kinematic viscosity*

IP 276, *Petroleum products — Determination of base number — Perchloric acid potentiometric titration method.*

IP 309, *Diesel and domestic heating fuels — Determination of cold filter plugging point*

ISO 2719, *Determination of flash point — Pensky-Martens closed cup method*

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

CD/K/049-2:2008, *The determination of performance (at net power) of internal combustion engines — Part 2: Compression ignition engines at altitude*

3 Definitions

For the purposes of this part of CD/K/049, the following definitions apply:

3.1

ASTM method

test method published by the American Society for Testing and Materials

3.2

IP method

test method published by the Institute of Petroleum

3.3

net power

power obtained on a test bed at the end of a crankshaft or its equivalent at the corresponding engine speed with the auxiliaries listed in Table 1

NOTE If the power measurement can only be carried out with mounted gear, the efficiency of the gear should be taken into account.

3.4

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 accuracy of the measured torque shall be $\pm 1\%$.

NOTE Friction losses should be taken into account when the torque measuring system is to be calibrated.

4.2 Engine speed

The accuracy of the measured engine speed shall be $\pm 0.5\%$ of measured speed.

4.3 Fuel consumption

The accuracy of the measured fuel consumption shall be $\pm 1\%$ of measured consumption.

4.4 Fuel temperature

The accuracy of the measured fuel temperature shall be $\pm 2\text{ }^{\circ}\text{C}$.

4.5 Air temperature

The accuracy of the measured air temperature shall be $\pm 2\text{ }^{\circ}\text{C}$.

4.6 Barometric pressure

The accuracy of the measured barometric pressure shall be $\pm 100\text{ Pa}$.

4.7 Pressure in exhaust duct (see footnote b to table 1)

The accuracy of the measured pressure in exhaust duct shall be $\pm 25\text{ Pa}$.

4.8 Pressure in intake duct (see footnote a to Table 1)

The accuracy of the measured pressure in intake shall be $\pm 50\text{ Pa}$.

5 Tests

5.1 Auxiliaries

5.1.1 Auxiliaries to be fitted

During the test, the auxiliaries necessary to make the 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 auxiliaries 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:

- a) air compressor for brakes;
- b) power steering compressor;
- c) suspension compressor; and

d) air-conditioning system.

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

5.1.3 Diesel engine starting auxiliaries

For the auxiliaries used in the starting of diesel engines, the two following cases shall be considered:

- Electrical starting. The generator is fitted and supplies, where necessary, the auxiliaries indispensable to the operation of the engine.
- 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.

In either case, the system for producing and accumulating the energy necessary for starting shall be fitted and operated in the unloaded condition.

Table 1 — Installation of auxiliaries during test for determination of net power of engine

1	2	3
No.	Auxiliaries	Fitted for net power test
1	Intake system Intake manifold Crankcase emission control system Air filter Intake silencer Speed limiting device	Yes, standard production equipment Yes, standard production equipment ³
2	Induction heating device of intake 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 Connecting pipes Silencer ⁶ Tail pipe ³ Exhaust brake ⁰	Yes, standard production equipment
4	Fuel supply pump ⁴	Yes, standard production equipment
5	Carburettor Electronic control system, air-flow meter, etc. (if fitted) Pressure reducer Evaporator Mixer	Yes, standard production equipment Equipment for gas engines
6	Fuel injection equipment (petrol and diesel) Prefilter Filter Pump High-pressure pipe Injector Air-intake valve (if fitted) ⁶ Electronic control system, airflow meter, 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 Engine bonnet Bonnet air outlet Radiator Fan ^{f,9} Fan cowl Coolant pump Thermostat ^h	No Yes, standard production equipment ⁱ
8	Air cooling Cowl Fan ^{f,9} Temperature regulating device	Yes, standard production equipment Yes, standard production equipment
9	Electrical equipment	Yes, standard production equipment ^f

Table 1 — Installation of auxiliaries during test for determination of net power of engine (cont.)

1	2	3
No.	Auxiliaries	Fitted for net power test
10	Pressure charging equipment (if fitted) Compressor driven either directly by the engine, by the exhaust gases, or by both Charge air cooler* Coolant pump or fan (engine driven) Coolant flow control devices (if fitted)	Yes, standard production equipment
11	Auxiliary test bed fan	Yes, if necessary
12	Anti-pollution devices ^k	Yes, standard production equipment
<p>^a The complete intake systems should be fitted as provided for the intended application:</p> <ul style="list-style-type: none"> - where there is a risk of noticeable influence upon engine power; - in case of two-strokes and spark ignition engines; and - when the manufacturer requests that this be done. <p>In other cases an equivalent system may be used and a check should be made to ascertain that intake pressure does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.</p> <p>^b The complete exhaust system should be fitted as provided for the intended application:</p> <ul style="list-style-type: none"> - where there is a risk of noticeable influence upon engine power; - in case of two-strokes and spark ignition engines; and - when the manufacturer requests that this be done. <p>In other cases, an equivalent system may be installed provided that the pressure at the exit of the engine exhaust system does not differ by more than 1000 Pa from that specified by the manufacturer. The exit from the engine exhaust system is defined as a point 150 mm downstream from the termination of the part of the exhaust system mounted on the engine.</p> <p>^c If an exhaust brake is incorporated in the engine, the throttle valve should be fixed in a fully open position.</p> <p>^d The fuel feed pressure should be adjusted, as necessary, to reproduce pressures existing in the particular engine application (particularly where a "fuel return" system is used).</p> <p>^e The air-intake valve is the control valve for the pneumatic governor of the injection pump. The governor of the fuel equipment may contain other devices which may affect the amount of injected fuel.</p> <p>^f The radiator, the fan, the fan cowl, the coolant pump and the thermostat should be located on the test bed in the same relative positions that they will occupy in the vehicle. The cooling liquid circulation should be operated by the engine water pump only.</p> <p>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, should 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), should 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 should be deducted from the corrected power.</p> <p>^g Where a disconnectable or progressive fan is incorporated, the test should be made with the disconnectable fan disconnected or with the progressive fan running at maximum slip.</p> <p>^h The thermostat should be fixed in the fully open position.</p> <p>ⁱ Minimum power of the generator: The power of the generator should be limited to that necessary for the operation of accessories which are indispensable for the operation of the engine. If the connection of a battery is necessary, a fully charged battery in good order should be used.</p> <p>^j Charge air cooled engines should 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 should be made with the pressure drop and temperature drop of the engine air across the charge air cooler or test bed system the same as those specified by the engine manufacturer to the manufacturer for the system on the complete vehicle.</p> <p>^k They may include for example the exhaust gas recirculation (EGR) system, catalytic converter, thermal reactor, secondary air supply system and fuel evaporation protecting system.</p>		

5.2 Setting conditions

The setting conditions of setting of carburettors, injection pump delivery systems, ignition or injection timing (timing curve), governors and anti-pollution devices for the test for determination of net power shall be in

accordance with the manufacturer's production specifications and used without further alteration for the particular application.

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 fixed full load fuel injection pump setting for diesel engines, the engines being equipped as specified in Table 1.

5.3.2 Performance data shall be obtained under stabilized normal operating conditions, with an adequate fresh air supply to the engine. The engines shall have been run-in in accordance with the manufacturer's recommendations.

NOTE 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 minimize the magnitude of 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 point of entry to the air cleaner, or, if no air cleaner is used, within 0.15 m of the air inlet horn. The thermometer or thermocouple shall be shielded from radiant heat and located directly in the air stream. 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 No data shall be recorded until torque, speed and temperature have been maintained substantially constant for at least 1 min.

5.3.5 The engine speed during a run or reading shall not deviate from the selected speed by more than $\pm 1\%$ or ± 10 r/min, whichever is the greater.

5.3.6 Observed brake load, fuel consumption and inlet-air temperature data shall be taken simultaneously and shall in each case be the average of two stabilized consecutive values which do not vary by more than 2 % for brake load and fuel consumption.

5.3.7 The temperature of the coolant of the outlet from the engine shall be kept within ± 5 °C of the upper thermostatically controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer, the temperature shall be $80 \text{ °C} \pm 5 \text{ °C}$.

For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within $\begin{matrix} 0 \\ - 20 \end{matrix}$ °C of the maximum value specified by the manufacturer in the reference conditions.

5.3.8 The fuel temperature shall be measured at the inlet to the carburettor or the fuel injection system, and maintained within the limits established by the engine manufacturer.

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

5.3.10 An auxiliary regulation system may be used if necessary to maintain temperature within limits specified in 5.3.7, 5.3.8 and 5.3.9.

5.3.11 The fuel shall be one available on the market without any supplementary or smoke suppressant additives. In cases of dispute, the reference fuel shall be:

- a) spark ignition engines as defined by CEC RF-01-A-80 (see Annex A);
- b) diesel engines as defined by CEC RF-03-A-80 (see Annex B);
- c) two-stroke engines as defined by CEC standardization oils (RL-58/1) (see Annex C); and
- d) LPG engines defined by CEC.

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 (see also Annex E). This range of speed shall include the speed of revolution at which the engine produces its maximum power. The average of at least two stabilized measurements shall be determined.

NOTE Measurement of the parameters should be taken with suitable equipment and to the relevant accuracy given in Clause 4.

5.5 Data to be recorded

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

6 Correction factors

6.1 Definition of factor α for correction of the power

The observed power, P , shall be multiplied by a factor α to determine the engine power under the reference atmospheric conditions specified in 6.2:

$$P_0 = \alpha P$$

where

P_0 is the corrected power (i.e. power under reference conditions);

α is the correction factor (α_a or α_d);

P is the measured power (first power).

NOTE The correction factor α_a is for spark-ignition engines and the correction factor α_d is for diesel engines.

6.2 Atmospheric conditions

6.2.1 Reference atmospheric conditions

6.2.1.1 Temperature (T_0)

The reference atmospheric conditions for temperature, T_0 shall be 25 °C.

6.2.1.2 Dry pressure (p_{s0})

The reference atmospheric conditions for dry pressure, p_{s0} shall be 99 kPa.

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

6.2.2 Test atmospheric conditions

NOTE The test may be carried out in an air-conditioned test room when the atmospheric conditions may be controlled.

The atmospheric conditions shall be, during the test, within the following values:

a) Temperature (T)

— For spark ignition engines: $15\text{ °C} \leq T \leq 35\text{ °C}$

— For diesel engines: $10\text{ °C} \leq T \leq 40\text{ °C}$

where

T is the absolute temperature, in degrees Celsius, at the air-inlet to the engine.

b) Pressure (p_s)

— For all engines: $80 \text{ kPa} \leq p_s \leq 110 \text{ kPa}$.

where

p_s is the total dry atmospheric pressure, in kilopascals, i.e. the total barometric pressure minus the water vapour pressure.

6.3 Naturally aspirated and pressure charged spark ignition engines — Factor α_a

$$\alpha_a = \left(\frac{99}{p_s} \right)^{1.2} \left(\frac{T}{298} \right)^{0.6}$$

In the case of engines fitted with automatic air temperature control, if the device is fully closed at full load at 25 °C (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. If the device is still operating at 25 °C, the test is made with the device operating normally and the exponent of the temperature term in the correction factor shall be taken as zero (no temperature correction).

This formula is only applicable 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.

6.4 Diesel engines

6.4.1 Power correction factor α_d

The power correction factor for diesel engines at constant fuel delivery is obtained by applying the formula:

$$\alpha_d = f_a^{f_m}$$

where

f_a is the atmospheric factor;

f_m is the characteristic parameter for each type of engine and adjustment.

6.4.2 Atmospheric factor f_a

NOTE The atmospheric factor formula differs according to the types of engine.

This factor indicates effects of environmental conditions (pressure, temperature and humidity) on the air drawn in by the engine, and shall be as calculated from the following formulae:

a) naturally aspirated and mechanically pressure charged engines

$$f_a = \left(\frac{99}{p_s} \right) \left(\frac{T}{298} \right)^{0.7}$$

b) turbocharged engines with or without cooling of charge air

$$f_a = \left(\frac{99}{p_s}\right)^{0.7} \left(\frac{T}{298}\right)^{1.5}$$

6.4.3 Engine factor f_m

f_m is a function of q_c (fuel flow corrected) as follows:

$$f_m = 0.036q_c - 1.14$$

where

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

where

q is the fuel delivery, expressed in milligrams per litre, per cycle of engine swept volume (mg/L per cycle);

r is the ratio of the compressor outlet pressure to the compressor inlet pressure ($r = 1$ for naturally aspirated engines).

This formula is valid for a value interval of q_c included between $40 \text{ mg/L per cycle} \leq q_c \leq 65 \text{ mg/L per cycle}$. For q_c values lower than $40 \text{ mg/L per cycle}$, a constant value of f_m equal to 0.3 ($f_m = 0.3$) shall be taken. For q_c values higher than $65 \text{ mg/L per cycle}$, a constant value of f_m equal to 1.2 ($f_m = 1.2$) shall be taken (see Figure 1).

6.4.4 Limitation in use of correction formula

The correction formula is applicable only if:

$$0.9 \leq \alpha_d \leq 1.1$$

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.

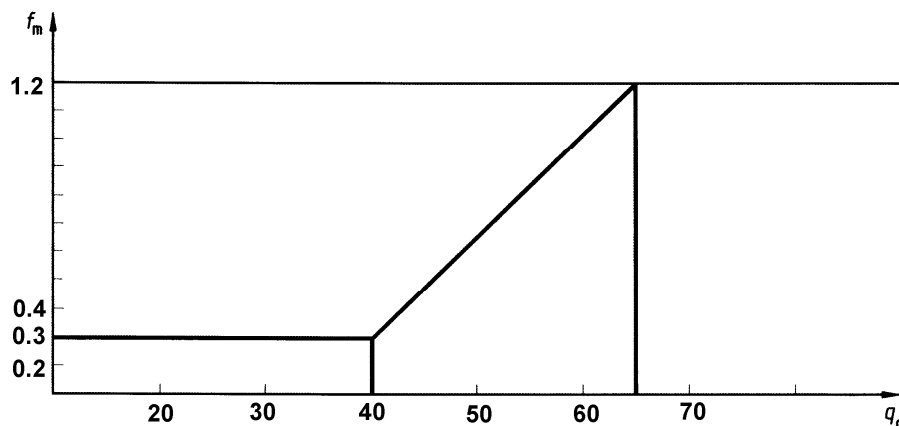


Figure 1 — Engine factor (f_m) as a function of the corrected fuel delivery (q_c)

7 Measurement of smoke value for diesel engines

7.1 The smoke value for the engine or vehicle shall be measured and recorded at every test point. The opacimeter used, and its installation, shall be designed in accordance with ISO 11614.

7.2 Equivalent measuring instrument shall be allowed. If an instrument other than that referred to in 7.1 is used, its equivalence for the engine considered shall be required to be proved.

7.3 The emission of pollutants by the engine shall be measured by the method given in Annex E.

7.4 Manufacturer's certification of an engine or vehicle in terms of ECE R24 or EEC/72/306 shall be deemed to meet the requirements of Annex E.

8 Test report

8.1 Diesel engines — Essential characteristics

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

8.1.1 Description of engine

Make:

Type:

Cycle: four-stroke/two stroke

Bore: mm

Stroke: mm

Number of cylinders

Layout of cylinders Firing order:

Engine swept volume: litres

Compression ratio (specify the tolerance):

System of cooling

a) Liquid
Nature of liquid:
Circulating pumps: yes/no
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):
Temperature regulation system: yes/no
Brief description:

c) Temperatures specified by the manufacturer
Liquid cooling
Maximum temperature at outlet: °C
Air cooling
Reference point (description):

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Maximum temperature at reference point: °C
 Maximum exhaust temperature: °C
 Fuel temperature: min.: °C max.: °C
 Lubricant temperature: min.: °C max.: °C

Pressure charger: with/without

Description of the system:
 Make: Type:
 Compressor system: Make: Type:
 Cooling system: Make: Type:

Intake system

Description and diagrams of air-intake systems and their accessories (heating device, intake silencer, etc.)

Intake manifold: Description:
 Air filter: Make: Type:
 Intake silencer: Make: Type:

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

Description and diagrams:

8.1.3 Fuel feed system

Fuel feed:
 Feed pump
 Pressure (specify the tolerance): kPa or characteristics diagram:

Injection system:

Pump
 Make(s):
 Type(s):
 Delivery (specify the tolerance): mm³ per stroke at pump speed (specify the tolerance) of r/min at full injection, or characteristics diagram:

Mention the method used: on engine/on pump bench
 Injection advance (specify the tolerance)
 Injection advance curve:
 Timing:

Injection piping
 Length: mm
 Internal diameter: mm

Injector(s)
 Make(s):
 Type(s):
 Opening pressure (specify the tolerance): kPa or characteristics diagram:

Governor
 Make(s):
 Type(s):
 Speed at which cut-off starts under full load: r/min
 Maximum no-load speed: r/min
 Idling speed: r/min

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Cold-start system

Make(s):

Type(s):

Description:

8.1.4 Valve timing

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

Reference or setting ranges (or both)

8.1.5 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:

8.1.6 Lubrication system

Description of system:

Position of lubricant reservoir:

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

Circulating pump

Make:

Type:

Mixture with fuel

Percentage:

Oil cooler: with/without

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

8.1.7 Electrical equipment

Generator/Alternator

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

8.1.8 Other engine-driven equipment (Enumeration and brief description if necessary)

8.2 Spark ignition engines — Essential characteristics

NOTE In the case of non-conventional engine and systems, particulars equivalent to those referred to here should be supplied by the manufacturer.

8.2.1 Description of engine

Make:

Type:

Draw

ward

Cycle: four-stroke/two stroke

Bore: mm

Stroke: mm

Number of cylinders

Layout of cylinders Firing order:

Engine swept volume: litres

Compression ratio (specify the tolerance):

System of cooling

a) Liquid

Nature of liquid:

Circulating pump: yes/no

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 regulation system: yes/no

Brief description:

c) Temperatures specified by the manufacturer

Liquid cooling

Maximum temperature at engine outlet: °C

Draft for

Air cooling

Reference point (description):

Maximum temperature at reference point: °C

Fuel temperature: min.: °C max.: °C

Lubricant temperature: min.: °C max.: °C

Pressure charger: with/without

Description of the system:

Make: Type:

Compressor system: make Type:

Cooling system: make Type:

Intake system

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

Intake manifold: Description:

Airfilter: Make: Type:

Intake silencer: Make: Type:

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

Description and diagrams:

8.2.3 Fuel feed system

Fuel feed:

By carburettor(s) Number:

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

Weight of float:

Float needle:

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Manual/automatic choke

Closure setting (specify the tolerance):

Feed pump

Pressure (specify the tolerance): kPa or characteristic diagram:

By fuel injection

Make(s):

Type(s):

Description:

Calibration (specify the tolerance):..... kPa or characteristic diagram:

8.2.4 Valve timing

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

Reference or setting ranges (or both)

8.2.5 Ignition systems

Ignition distributor

Make:

Type:

Ignition advance curve (specify the tolerance):

Ignition timing (specify the tolerance):

Contact-point gap (specify the tolerance) and dwell-angle: degrees

Spark plugs

Make:

Type:

Spark-gap setting:

Ignition coil

Make:

Type:

Ignition condenser

Make:

Type:.....

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Radio interference suppression equipment

Make:

Type:.....

8.2.6 Exhaust system

Description and diagrams:

8.2.7 Lubrication system

Description of system:

Position of lubricant reservoir:

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

Circulating pump

Make:

Type:

Mixture with fuel

Percentage:

Oil cooler: with/without

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

8.2.8 Electrical equipment

Generator/alternator

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

8.2.9 Other auxiliaries fitted on the engine (Enumeration and brief description if necessary)

8.3 Statement of the results of tests for measuring engine net power

Trade name or trademark of the engine:

Type and identification number of engine:

Test conditions

Pressures measured at maximum power:

Total barometric pressure: kPa

Water vapour pressure: kPa

Exhaust pressure measured at the point adjacent to the outlet flange(s) of the exhaust manifold(s):
..... kPa

Inlet depression:..... Pa, at engine intake system

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Temperatures measured at maximum power:

- a) of the intake air: °C
- b) at the outlet of the engine intercooler: °C
- c) of the cooling fluid
 - at the engine cooling fluid outlet: °C
 - at the reference point in the case of air cooling: °C
- d) of the lubricating oil: °C (indicate point of measurement)
- e) of the fuel
 - at the carburettor inlet/fuel injection system inlet: °C
 - in the fuel-consumption measuring device: °C

Characteristics of the dynamometer:

Make: Model:
 Type:
 Rating:

Characteristics of the opacimeter:

Make: Model:
 Type:

Fuel

For spark ignition engines operating on liquid fuel:

Make:
 Specification:
 Anti-knock additive (lead etc.):
 Type:
 Content: mg/L
 Octane number RON¹⁾: (ASTM D 2699)
 Density: g/cm³ at 15 °C
 Lower calorific value: kJ/kg

⚠ Fuel consumption measuring apparatus: gravimetric or volumetric

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¹⁾ RON: Research octane number.

For spark ignition engines operating on gaseous fuel:

Make:
 Specification:
 Storage pressure: kPa
 Utilization pressure: kPa
 Lower calorific value: kJ/kg

For diesel engines operating on gaseous fuels:

Feed systems: gas:
 Specification of gas used:
 Fuel oil/gas proportion:
 Lower calorific value: kJ/kg

For diesel engines operating on liquid fuel:

Make:
 Specification of fuel used:
 Cetane index (ASTM D 976):
 Density: g/cm³ at 15°C
 Lower calorific value: kJ/kg

Lubricant

Make:
 Specification:
 SAE viscosity:

8.4 Statement of results²⁾

Table 2 — Statement of results of net power measurement test

1	2	3
Engine speed, r/min		
Measured torque, N·m		
Measured power, kW		
Measured fuel flow, g/h		
Measured smoke, m-1 b		
Barometric pressure, kPa		
Water vapour pressure, kPa		
Inlet-air temperature, °C		
Power to be added for auxiliaries in excess of Table 1 (see 8.1.8 and 8.2.9), kW	No. 1	
	No. 2	
	No. 3	
Power correction factor		

²⁾ The characteristics curve of the net power and net torque, of the specific fuel consumption and of the exhaust smoke values should be drawn as a function of the engine.

Table 2 — Statement of results of net power measurement test (conc.)

1	2	3
Corrected brake power, kW (with/without ³ fan)		
Power of fan, kW (to be subtracted if fan not fitted)		
Net power, kW		
Net torque, N-m		
Corrected specific fuel consumption, g/kW-h ^o		
Cooling liquid temperature at outlet, °C		
Lubricating oil temperature at measuring point, °C		
Air temperature after pressure charger, °C ^a		
Fuel temperature at injection pump inlet, °C		
Air temperature after charge air cooler, °C ^d		
Pressure after pressure charger, kPa ^d		
Pressure after charge air cooler, kPa		
^a Strike out what does not apply. ^b Only for diesel engines. ^c Calculated with net power for diesel and spark ignition engines, in the latter case multiplied by the power correction factor. ^d Delete where inapplicable.		

8.5 Results summary

Maximum net power: kW at r/min

Maximum net torque: N-m at r/min

Specific fuel consumption

— at maximum net power: (kW-h)

— at maximum net torque: g/(kW-h)

Net efficiency³⁾

— at maximum net power:

— at maximum net torque:

9 Expression of the results

9.1 Designation

When the performances (power curves, torque and specific fuel consumption) of an engine are measured in accordance with this part of CD/K/049, reference shall be made to the method used by stating "measured in accordance with CD/K/049-1".

NOTE For information on declared power and power tolerances see annex D.

³⁾ Recommended additional statement to be calculated from data under "specific fuel consumption", where:

$$\text{Net efficiency} = \frac{\text{Net power} \times 100}{\text{Lower calorific value of fuel used}}$$

where power and calorific value are expressed in the same unit.

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9.2 Indication of net power

Qualify net power as in the example below:

Example:

Net power: kWat: r/min (measured in accordance with CD/K/049-1)

9.3 Indication of net torque

Qualify net torque as in the example below: Example:

Net torque: N-m at: r/min (measured in accordance with CD/K/049-1)

9.4 Indication of specific fuel consumption

"Net power" between parenthesis after "specific fuel consumption" shall be stated as in the example below:

Example:

Specific fuel consumption (net power — CD/K/049-1): g/(kW-h).

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Annex A
(normative)

CEC reference fuel RF-01-A-80 for spark ignition engines

Table A.1 — RF-01-A-80 for spark ignition engines (Type: premium gasoline, leaded)

1	2	3
Characteristic	Limits and units	Test method
Research octane number	min. 98.0	ASTM D 2699
Density at 15 °C	min. 0.741 kg/L max. 0.755 kg/L	ASTM D 1298
Reid vapour pressure	min. 56 kPa max. 64 kPa	ASTM D 323a
Distillation		ASTM D 86
Initial boiling point	min. 24 °C max. 40 °C	
10 % (volume fraction)	min. 42 °C max. 58 °C	
50 % (volume fraction)	min. 90 °C max. 110 °C	
90 % (volume fraction)	min. 150 °C max. 170 °C	
Final boiling point	min. 185 °C max. 205 °C	
Residue	max. 2 % (volume fraction)	
Hydrocarbon analysis		ASTM D 1319
Olefins	max. 20 % (volume fraction)	
Aromatics	max. 45 % (volume fraction)	
Saturates	balance	
Oxidation stability	min. 480 min	ASTM D 525
Existent gum	max. 4 mg/100 mL	ASTM D 381
Sulfur content	max. 0.04 % (mass fraction)	ASTM D 1266, ASTM D 2622
Lead content	min. 0.10g/L max. 0.40 g/L	ASTM D 3341
Nature of scavenger	motor mix	
Nature of lead alkyl	not specified	
Carbon/Hydrogen ratio	report	

Table A.2 — Reference fuel No. 2: CEC RF 08-A-85 (Type: premium petrol, lead-free)

	Limits and units		ASTM method
	min.	Max.	
Research octane number	95.0		D 2699
Motor octane number	85.0		D 2700
Density at 15/C	0.748	0.762	D 1298
Reid vapor pressure	0.56 bar	0.64 bar	D 323
Distillation			
Initial boiling point	24/C	40/C	D86
10 vol. % point	42/C	58/C	D86
50 vol. % point	90/C	110/C	D86
90 vol. % point	155/C	180/c	D86
Final boiling point	190/C	215/C	D86
Residue		2%	D86
Hydrocarbon analysis			
Alkenes		20 vol. %	D 1319
Aromatics	(included inq 5 vol. % max. benzol*)	45 vol. %	D 1319 *D 3606/D 2267
Alkanes	balance		D 1319
Ratio hydrocarbon/ hydrogen	ratio		
Oxidation stability	480 min.		D525
Existent gum		4 mg/100 ml	D 381
Sulphur content		0.04% mass	D 1266/D 2622/ D 2785
Copper corrosion at 50/C		1	D 130
Lead content		0.005 g/l	D 3237
Phosphorus content		0.0013 g/l	D 3231

Annex B
(normative)

CEC reference fuel RF-03-A-80 for diesel engines

Table B.1 — RF-03-A-80 for diesel engines

1	2	3
Characteristic	Limits and units	Test method
Density at 15 °C	min. 0.835 kg/L max. 0.845 kg/L	ASTM D 1298
Cetane index	min. 51 max. 57	ASTM D 976
Distillation		ASTM D 86
50 % (volume fraction)	min. 245 °C	
90 % (volume fraction)	min. 320 °C max. 340 °C	
Final boiling point	min. 370 °C	
Viscosity, 40 °C	min. 2.5 cSt (mm ² /s) max. 3.5 cSt (mm ² /s)	ASTM D 445
Sulfur content	min. 0.20 % (mass fraction) max. 0.50 % (mass fraction)	ASTM D 1266 or ASTM D 2622
Flash point	min. 55 °C	ASTM D 93a
Cold filter plugging point	max. -5 °C	EN 116 or IP 309
Conradson carbon residue on 10 % dist. residue	max. 0.20 % (mass fraction)	ASTM D 189
Ash content	max. 0.01 % (mass fraction)	ASTM D 482
Water content	max. 0.50 % (mass fraction)	ASTM D 95
Copper corrosion, 100 °C	max. 1	ASTM D 130
Neutralization (strong acid) number	max. 0.20 mg KOH/g	ASTM D 974

Annex C (normative)

CEC standardization oil RL-58/1 to be used with spark ignition two-stroke engines

C.1 Characteristics

SAE Grade	40 plus diluent
Density at 15 °C (ASTM D 1298/IP 160)	0.892
Flash point (ISO 2719)	68 °C
Pour point (ASTM D 97/IP 15)	not controlled
Viscosity at 99 °C (ASTM D 445/IP 71 Sections 1 and 2)	10.3 cSt ⁴⁾ (mm ² /s)
Viscosity at 38 °C (ASTM D 445/IP 71 Sections 1 and 2)	78.5 cSt (mm ² /s)
Viscosity at 50 °C (ASTM D 5293)	46.1 cSt (mm ² /s)
VI (ASTM D 2270/IP 226)	not controlled
TBN (Perchloric) (IP 276)	2.4 mg KOH/g
TAN (ASTM D 664/IP 177)	not controlled
Sulphated ash	0.4 % (mass fraction)
Element analysis	
Zinc	0 % (mass fraction)
Phosphorus	0 % (mass fraction)
Calcium	0.13 % (mass fraction)
Barium	0 % (mass fraction)
Magnesium	0 % (mass fraction)
Nitrogen	0 % (mass fraction)
Others	0 % (mass fraction)

C.2 Composition

SAE 40 mineral base stock containing bright stock, 20 % kerosene type diluent and Ca base additive package.

⁴⁾ Difficult to determine accurately owing to diluent.

Annex D
(informative)**Declared power and power tolerances**

Standard

D.1 Declared power

The declared power is that power which the manufacturer indicates in his sales literature for an engine type.

D.2 Power tolerances**D.2.1 Net power test**

The declared power is assumed to be verified if the maximum corrected net power measured during the test is within ± 2 % of the declared power for all engines. The tolerance would be ± 4 % of the declared power at the other points of the power curve.

D.2.2 Production conformity tests

The declared power is assumed to be verified if the maximum corrected net power measured during the test is within ± 5 % of the declared power of engines type. The tolerance would be ± 6 % of the declared power at other points of the power curve.

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Annex E
(normative)

Test for measuring the emission of pollutants at steady speeds over the full-load curve

E.1 Introduction

E.1.1 This annex describes the method of determining emissions of pollutants at different steady speeds over the full-load curve.

E.1.2 The test may be carried out either on an engine or on a vehicle.

E.2 Measurement principle

E.2.1 The opacity of the exhaust gases produced by the engine shall be measured with the engine running under full load and at steady speed. Six measurements shall be made at engine speeds spaced out uniformly between the maximum speed permitted by the governor of full load and the highest of the following three engine speeds:

- 45 % of the engine speed at maximum power;
- 1 000 r/min; or
- the minimum speed permitted by the idling control.

The extreme points of measurement shall be situated at the limits of the interval defined above and one of the intermediate speeds shall coincide with the speed at which maximum power is developed.

E.2.2 In the case of diesel engines fitted with an air supercharger which can be engaged at will, and where the entry into operation of the air supercharger automatically brings about an increase in the quantity of fuel injected, the measurements shall be made both with and without the supercharger working. For each engine speed, the higher of the two figures obtained shall be the result of the measurement.

E.3 Test conditions

E.3.1 Vehicle or engine

E.3.1.1 The engine or the vehicle shall be submitted in good mechanical condition. The engine shall have been run in.

E.3.1.2 The engine shall be tested with the equipment prescribed in Clause 5.

E.3.1.3 The settings of the engine shall be those prescribed by the manufacturer and shown in Clause 5.

The power of the engine measured at the test bench during the test at steady speeds over the full-load curve may differ from the power specified by the manufacturer as follows:

- a) maximum power ± 2 %; and
- b) at the other five measurement points ± 4 %.

E.3.1.4 The exhaust device shall not have any orifice through which the gases emitted by the engine might be diluted. In cases where an engine has several exhaust outlets, these shall be connected to a single outlet in which the opacity measurement shall be made.

E.3.1.5 The engine shall be in the normal working condition prescribed by the manufacturer. In particular, the cooling water and the oil shall each be at the normal temperature prescribed by the manufacturer.

E.3.2 Fuel

The fuel shall be the reference fuel whose specifications are given in Annex B.

E.3.3 Test laboratory

E.3.3.1 The absolute temperature T of the laboratory, expressed in degrees Celsius, and the atmospheric pressure p_s , expressed in kilopascals, shall be measured, and the parameter α shall be determined as follows for tests at sea level, but for tests at the reference altitude, in accordance with CD/K/049-2:2008:

- a) For naturally aspirated and mechanically supercharged engines:

$$\alpha = \frac{99}{p_s} \left(\frac{T}{298} \right)^{0.7}$$

- b) For turbo-supercharged engines with or without cooling of inlet air:

$$\alpha = \left(\frac{99}{p_s} \right)^{0.7} \left(\frac{T}{298} \right)^{1.5}$$

E.3.3.2 For a test to be recognized as valid, the parameter α shall be such that $0.98 \leq \alpha \leq 1.02$.

E.3.4 Sampling and measuring apparatus

The light-absorption coefficient of the exhaust gases shall be measured with an opacimeter that complies with the requirements in Clause 7.

E.4 Limit values

E.4.1 For each of six engine speeds at which the absorption coefficient is measured in accordance with E.2.1, the nominal gas flow G , expressed in litre per second, shall be calculated by means of the following formulae:

- a) for two-stroke engines

$$G = \frac{Vn}{60}$$

- b) for four-stroke engines

$$G = \frac{Vn}{120}$$

where

V is the cylinder capacity of the engine, expressed in litres;

n is the engine speed, expressed in revolutions per minute.

E.4.2 For each engine speed the absorption coefficient of the exhaust gases shall not exceed

- a) when tested at sea level, the limit value given in Table F.1, or
 b) when tested at the reference altitude, the limit value given in CD/K/049-2:2008.

Where the value of the nominal flow is not one of those given in the applicable table, the limit value applicable shall be obtained by the interpolation on the principle of proportional parts.

Annex F
(normative)

Limit values of absorption coefficient versus nominal flow applicable in the test at steady speeds

Table F.1 — Limit values

1	2
Nominal flow, G L/s	Absorption coefficient, K m^{-1}
≤42	2.26
45	2.19
50	2.08
55	1.985
60	1.90
65	1.84
70	1.775
75	1.72
80	1.665
85	1.62
90	1.575
95	1.535
100	1.495
105	1.465
110	1.425
115	1.395
120	1.37
125	1.345
130	1.32
135	1.30
140	1.27
145	1.25
150	1.225
155	1.205
160	1.19
165	1.17
170	1.155
175	1.14
180	1.125
185	1.11
190	1.095
195	1.08
≥200	1.065

NOTE Although the above values in column 2 are rounded to the nearest 0.01 or 0.005, this does not mean that the measurements need to be made to this degree of accuracy.

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ECE R24, *Uniform provisions concerning: I. the approval of compression ignition (C.I.) engines with regard to the emission of visible pollutants, II. the approval of motor vehicles with regard to the installation of C.I. III. engines of an approved type, IV. the approval of motor vehicles equipped with C.I. engines with regard to the emission of visible pollutants by the engine, V. the measurement of power of C.I. engine.*

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