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EAST AFRICAN STANDARD

The determination of performance (at net power) of internal combustion engines — Part 3: Agricultural vehicle internal combustion engines at sea level

EAST AFRICAN COMMUNITY

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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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Contents

1 Scope 1
2 Normative references 1
3 Definitions 2
4 Accuracy of measurements 2
5 Tests 4
5.1 Auxiliaries 4
5.2 Setting conditions 5
5.3 Test conditions 5
5.4 Test procedure 6
5.5 Data to be recorded 6
6 Correction factors 6
6.1 Definition of factor α 6
6.2 Reference atmospheric conditions 7
6.3 Limitations in the use of correction formulae 7
6.4 Determination of correction factors 7
7 Measurement of smoke value for diesel engines 9
8 Test report 9
8.1 Engine data 9
8.2 Fuel supply 9
8.3 Carburettor 9
8.4 Injection pumps or devices 10
8.5 Injection nozzles and nozzle holders 10
8.6 Governor 10
8.7 Ignition distributor 10
8.8 Spark plugs 10
8.9 Ignition coils 10
8.10 Glow plugs 10
8.11 Interference suppressor 10
8.12 Intake system 11
8.13 Valve gear 11
8.14 Crankcase emission control system 11
8.15 Induction heating device 11
8.16 Exhaust system 11
8.17 Cooling system 11
8.18 Oil cooler 12
8.19 Electrical equipment 12
8.20 Anti-pollution systems 12
8.21 Other test equipment 12
8.22 Specific test conditions 12
8.23 Fuels and lubricants 13
8.24 Results 13
8.25 Statement of results (net power) 13
9 Units and designation 14
9.1 Units 14
9.2 Designation 14
Annex A (normative) Reference fuel CEC RF-01-T-69 specifications 15
Annex B (normative) Reference fuel CEC RF-03-T-69 specifications 21
Annex C (normative) Test for measuring the emission of pollutants at steady speeds over the full-load curve 23
Annex D (normative) Limit values applicable in the test at steady speeds 26
Bibliography 27

The determination of performance (at net power) of internal combustion engines — Part 3: Agricultural vehicle internal combustion engines at sea level

1 Scope

This part of CD/K/049 covers a bench method for testing the following categories of engines, which are intended for use in agricultural tractors and machines and which may be fitted with a supercharging device using a mechanical supercharger or turbocharger.

a) spark-ignition engines; and

b) compression-ignition (diesel) engines.

In particular, it allows curves to be plotted of net power, torque, and specific fuel consumption at full load as functions of engine speed.

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

ASTM D 129, *Standard test method for sulfur in petroleum products (general bomb method)*

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

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 524, *Standard test method for ramsbottom carbon residue of petroleum products*

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

ASTM D 611, *Standard test methods for aniline point and mixed aniline point of petroleum products and hydrocarbon solvents*

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

ASTM E 11, *Standard specification for wire cloth and sieves for testing purposes*

ISO 789-1, *Agricultural tractors — Test procedures — Part 1: Power tests for power take-off*

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
auxiliaries
equipment and devices used in agricultural vehicle internal combustion engines

NOTE See Table 1.

3.2
net power
power obtained on a test bed at the crankshaft or its equivalent, at the engine speed specified by the manufacturer, the engine being equipped with the standard production auxiliaries necessary to its operation for the particular application

3.3
standard production equipment
any equipment normally provided or recommended by the manufacturer for the particular engine application

4 Accuracy of measurements

4.1 Torque

The dynamometer torque measuring system shall give an accuracy within ±1.0 % in the range of scale values required for the test.

4.2 Engine speed

Engine speed shall be measured preferably with a revolution counter and an automatically synchronized chronometer (or counter timer). The accuracy of the measured value shall be ±0.5 %.

4.3 Engine inlet-air temperature

The accuracy of the measured engine inlet-air temperature shall be ±2 °C.

4.4 Fuel consumption

The accuracy of the measured fuel consumption shall be ± 1 % overall for the apparatus used.

4.5 Barometric pressure

The accuracy of the measured barometric pressure shall be ± 100 Pa.

4.6 Pressure in exhaust extraction duct (see footnote a in table 1)

The accuracy of the measured pressure in exhaust extraction duct shall be ± 25 Pa.

Table 1 — Installation of auxiliaries during test

1	2	3
No.	**Auxiliaries**	**Fitted for net power test**
1	Intake system Intake manifold Air filter Intake silencer Crankcase emission control system Speed limiting device	Yes, standard production equipment
2	Induction heating device of intake manifold	Yes, standard production equipment. If possible, to be set in the most favourable condition
3	Exhaust system Exhaust purifier Manifold Connecting pipes[a] Silencer[a] Tail pipe[a] Exhaust brake[b]	Yes, standard production equipment
4	Fuel supply pump[c]	Yes, standard production equipment
5	Carburettor	Yes, standard production equipment
6	Fuel injection equipment (petrol and diesel) Prefilter Filter Pump High-pressure pipe Injector Air-intake valve (if fitted)[d] Governor (if fitted)	Yes, standard production equipment
7	Liquid cooling equipment Engine bonnet Bonnet air outlet Radiator Fan[f, g] Fan cowl Coolant pump Thermostat[h]	No Yes[e], standard production equipment
8	Air cooling Cowl Fan[f, g] Auxiliary test bed fan Temperature regulating device	 Yes, standard production equipment Yes, if necessary Yes, standard production equipment
9	Electrical equipment	Yes', standard production equipment
10	Supercharging equipment (if fitted) Compressor driven either directly or indirectly by the engine, the exhaust gases, or by both Intercooler[j] Coolant pump or fan (engine driven) Coolant flow control device (if fitted) Auxiliary test bed fan	Yes, standard production equipment Yes, if necessary
11	Anti-pollution devices	Yes, standard production equipment

1	2	3
No.	**Auxiliaries**	**Fitted for net power test**

[a] If it is impracticable to fit the standard exhaust system, a system of equivalent restriction may be fitted for the test, provided that this is acceptable to the manufacturer.

In the test laboratory, the exhaust extraction system at the point where the test bed exhaust system is connected should not, with the engine in operation, create at the exhaust extraction duct a pressure differing from the atmospheric pressure by more than ± 740 Pa, unless the manufacturer has accepted a higher back pressure before the test.

[b] If an exhaust brake is incorporated in the engine, the throttle valve may be removed or fixed in a fully open position.

[c] The fuel feed pressure should be adjusted, if necessary, to reproduce pressures existing in the particular engine application (particularly where a fuel return system is used).

[d] The air-intake valve is the control valve for the pneumatic governor of the injection pump.

[e] 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 on the vehicle. The cooling liquid circulation should be operated by the engine water pump only.

Cooling should be produced either by the engine radiator or by an external circuit, provided that the pressure loss of this circuit remains substantially the same as that of the engine cooling system. The radiator shutter, if incorporated, should be in the open position.

[f] Where a disconnectable fan is incorporated, the net power should be determined firstly with the fan disconnected, then with the fan connected.

[g] Where a fixed fan, electrically or mechanically operated, cannot be fitted on the test bed, the power absorbed by the fan should be determined at the same engine speeds as those used for the measurement of the engine power. This power should be deducted from the corrected power to obtain the net power.

[h] The thermostat should be fixed in the fully open position.

[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. There should be no charging of the battery during the test.

[j] The temperature of the air at the inlet manifold should be that specified by the engine manufacturer, if such a specification is given.

5 Tests

5.1 Auxiliaries

5.1.1 General

The engine auxiliaries to be considered for testing are those necessary for the use of the engine in an agricultural tractor or machine.

During the test, the auxiliaries specified below shall be installed on the bench as far as possible in the same position as in the intended application.

5.1.2 Auxiliaries to be fitted

The auxiliaries which shall be fitted during the test are listed in table 1. In addition, the all-speed governor of the fuel supply equipment shall be fitted.

5.1.3 Auxiliaries to be removed

All the auxiliaries except those detailed in 5.1.2 shall, where possible, be removed during the test, i.e. all except the auxiliaries necessary for the correct operation of the vehicle and usually fitted to the engine. The following partial list is given as an example:

a) air compressor for brakes;

b) power-steering pump;

c) hydraulic lift pump; and

d) air-conditioning system.

Where auxiliaries cannot be removed, the power absorbed by them in the unloaded condition shall be determined (if this cannot be determined, the manufacturer's estimate may be used) and added to the measured engine power.

5.1.4 Diesel engine starting auxiliaries

For the auxiliaries used in the starting of diesel 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.

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

5.2 Setting conditions

The setting conditions of carburettors, injection pump delivery systems, ignition or injection timing (timing curve), and governors 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 full-load 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 of spark-ignition engines 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 not more than 0.15 m upstream of the point of entry to the air cleaner, or, if no air cleaner is used, 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 ±1 % or ±10 r/min, whichever is the greater.

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

5.3.7 A time of measurement of not less than 30 s shall be used when measuring speed and fuel consumption with an automatically synchronized counter timer combination; for hand operation, the time of measurement shall be not less than 60 s.

5.3.8 The coolant outlet temperature in liquid-cooled engines shall be controlled at 80 °C ± 5 °C unless otherwise specified by the manufacturer.

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

5.3.9 The fuel temperature at the inlet of the fuel injection pump or carburettor shall be maintained within the limits established by the engine manufacturer.

5.3.10 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.

5.3.11 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). This temperature shall be maintained within the limits established by the engine manufacturer.

5.3.12 The fuel used shall comply with the specifications published by the manufacturer of the engine under test.

For spark-ignition engines, in cases of dispute, tests shall be carried out using CEC reference fuel CEC RF-01-T-69 (see Annex A). For diesel engines, the fuel shall be one supplied and delivered by the refinery to the customer without any supplementary smoke suppressant additives. In cases of dispute, tests shall be made with the CEC reference fuel CEC RF-03-T-69 (see Annex B).

5.4 Test procedure

Record data at a sufficient number of operating speeds to define completely the power curve between the lowest and the highest engine speeds recommended by the manufacturer (see also Annex C). For part load performance measurement, see ISO 789-1.

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

The observed power, P, shall be multiplied by 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);
P is the measured power (first power);
α is the correction factor (α_a or α_d).

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

6.2 Reference atmospheric conditions

6.2.1 Temperature

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

6.2.2 Dry pressure

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

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

6.3 Limitations in the use of correction formulae

6.3.1 General

The correction formulae given in 6.4.1 and 6.4.2 are applicable only where the correction factors, aa and ad, are within the limits indicated in 6.3.2 and 6.3.3.

When the formula in 6.4.1 is used, the air-inlet temperature shall be between 15 °C and 35 °C; for the formula in 6.4.2, the air-inlet temperature shall be between 10 °C and 40 °C.

6.3.2 **Spark-ignition engines** (normally aspirated and pressure-boosted)

The following limits for spark-ignition engines shall apply: $0.93 \leq \alpha_a \leq 1.07$

6.3.3 **Diesel engines** (compression-ignition)

The following limits for diesel engines shall apply. $0.9 \leq \alpha_d \leq 1.1$

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.

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

6.4 Determination of correction factors

6.4.1 Spark-ignition engines — Correction factor, α_a

The correction factor, α_a, for spark-ignition engines (carburettor or injection) shall be as calculated from the following formula:

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

where

T is the absolute temperature, expressed in degrees Celsius, at the air inlet to the engine;

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

Although the above formula is recommended at present, it shall be considered as provisional only. Studies are being made to establish a more accurate formula which will take turbocharged engines into account.

In the case of engines fitted with automatic inlet-air temperature control, the exponent of the temperature term in the correction factor shall be taken as zero, provided that the manufacturer can show that the automatic system is effective.

An automatic control system shall be deemed to be effective if, at the test ambient air-inlet temperature, the system controls the air temperature within the intake system to the same temperature, to ±5 °C, as it would produce at the reference air-inlet temperature.

6.4.2 Diesel engines (compression-ignition)

6.4.2.1 Correction factor, α_d

The correction factor, α_d, for diesel engines at constant fuel rate shall be as calculated from the following formula:

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

where

f_a is the atmospheric factor (see 6.4.2.2);

f_m is the engine factor, i.e. the characteristic parameter for each type of engine and adjustment (see 6.4.2.3).

6.4.2.2 Atmospheric factor

The atmospheric factor, fa, 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 relevant of the following formulae:

a) naturally aspirated and mechanically supercharged engines:

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

where

T and p_s are as defined in 6.4.1.

b) turbocharged engines, with or without cooling of inlet air:

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

where

T and p_s are as defined in 6.4.1.

6.4.2.3 Engine factor

Within the limits established for α_a in 6.3.3, the engine factor f_m is a function of the corrected fuel flow, q_c, and shall be as calculated from the following formula:

$$f_m = 0.036q_c - 1.14$$

where

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

where

q is the fuel flow, in milligrams per litre, per cycle of total swept volume;

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

The formula for the engine factor, f_m, is only valid for a qc value between 40 mg/L per cycle and 65 mg/L per cycle. For values less than 40 mg/L per cycle, a value of 0.3 shall be taken for fm whilst for values greater than 65 mg/L per cycle, a value of 1.2 shall be taken for fm.

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 comply with the requirements in ISO 11614.

7.2 Equivalent measuring instruments 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 vehicle or engine shall be measured by the method described in Annex C. The manufacturer may elect to carry out the tests at sea level or at the reference altitude in terms of CD/K/049-2:2008.

7.4 Manufacturer's certification of an engine or vehicle in terms of ECE R 24 shall be deemed to meet the requirements of 7.1 and 7.3.

8 Test report

8.1 Engine data

8.1.1 Reciprocating engines

Make: ..... Type: ..... Serial No. (in series of the type): .....
Bore: ..... Stroke: ..... Swept volume of one cylinder: .....
Number of cylinders : ..... Arrangement of cylinders: .....
Total swept volume of the cylinders: ..... Ignition: spark or compression firing or injection order: .....
Compression ratio: ..... Cycle: two-stroke or four stroke
Supercharging device: ..... Make: ..... Type: .....Serial No.: .....

8.1.2 Rotary trochoidal engines

Make: ..... Type: ..... Serial No. (in series of the type): .....

Epitrochoidal or hypotrochoidal Envelope: internal or external

Number of gas-tight chambers between the rotor and the stator, i.e. number of peripheral sealing devices per rotor or stator: .....

Eccentricity: ..... Generating radius: .....
Operating width: ..... Swept volume of one gas-tight chamber: ……
Number of rotors: ..... Ignition: spark or compression firing or injection order: .....
Compression ratio: ..... Cycle: two-stroke or four stroke: .....
Supercharging device: ..... Make: ..... Type: ..... Serial No.:……..

8.2 Fuel supply

Pump: ..... Make: ..... Type: ..... Serial No.

Prefilter: yes or no: Filter: yes or no:

8.3 Carburettor

Make: ..... Type: ..... Serial No.: .....
Number: ..... Detailed specifications: .....

8.4 Injection pumps or devices

Make: ..... Type: ..... Serial No.: .....

Static timing: ..... Advance device: .....

Manufacturer's code: .....

8.5 Injection nozzles and nozzle holders

Make: ..... Type: ..... Serial No.: .....

Setting pressure: ..... Injection high-pressure pipes Lengths: .....

Inside diameter:……..

8.6 Governor

Make: ..... Type: ..... Serial No.: .....

Cutting-in speed under load: ..... r/min

Maximum no-load speed: ..... r/min

8.7 Ignition distributor

Make: ..... Type:..... Serial No.: .....

Static timing: ..... Advance device: .....

Timing at..... r/min:..... (as specified by the manufacturer)
Maximum range of advance device: .....
Distributor contact breaker gap: .....

8.8 Spark plugs

Make: ..... Type or No.: .....

Number per cylinder: ..... Electrodes gap: .....

8.9 Ignition coils

Make: ..... Type: ..... Serial No.: .....

Number: .....

8.10 Glow plugs

Make: ..... Type: ..... Serial No.: .....

Number: .....

8.11 Interference suppressor

Make: ..... Type: ..... Serial No.: .....

8.12 Intake system

Intake manifold: ..... Description: .....

Airfilter: Make: ..... Type:..... Serial No.: .....

Intake silencer: Make: ..... Type: ..... Serial No.: .....

Inlet maximum depression at full flow recommended by the manufacturer: ..... kPa

8.13 Valve gear

Type of valve gear: ..... Brief description: .....

Valve timing: ..... Tappet clearances (hot or cold): .....

8.14 Crankcase emission control system

Brief description: .....

Make: ..... Type: ..... Serial No.: .....

8.15 Induction heating device

Type: ..... Brief description: .....

8.16 Exhaust system

Pipes and other components: standard or not Brief description if not: .....

Exhaust brake: Make: ..... Type: ..... Serial No.: .....

Silencer: Make: ..... Type: ..... Serial No.: .....

8.17 Cooling system

8.17.1 Liquid

Nature of the liquid: .....

Circulating pump: Make: ..... Type: ..... Serial No.: ..... Drive ratio: ……

Thermostat: Make: ..... Type: ..... Serial No.: ..... Setting: .....

Radiator: Make: ..... Type: ..... Serial No.: .....

Pressurizing valve: Make: ..... Type: ..... Pressure setting: .....

Fan: Make: ..... Type: ..... Serial No.: .....

Fan drive system: ..... Drive ratio: .....

Fan cowl: yes or no

8.17.2 Air

Fan: Make: ..... Type: ..... Serial No.: ..... Drive ratio: ……

Air ducting (standard production): yes or no

Auxiliary test bed fan: yes or no

Temperature regulating system: yes or no Brief description: .....

8.18 Oil cooler

Make: ..... Type: ..... Serial No.: .....

Oil cooler: yes or no

8.19 Electrical equipment

Generator or alternator: Make: ..... Type: ..... Serial No. :……..

8.20 Anti-pollution systems

Brief description: .....

8.21 Other test equipment

Enumerate, with brief description if necessary.

8.22 Specific test conditions

Barometric pressure: ..... kPa (mbar)

Relative humidity: ..... % (for information)

Temperature of the test laboratory: ..... °C (for information)

Cooling liquid outlet temperature specified by the manufacturer: ..... °C

Oil temperature range specified by the manufacturer: ..... °C min. ..... °C max.

Fuel temperature range specified by the manufacturer
at inlet of the carburettor or of the injection pump: ..... °C min. ..... °C max.

Maximum exhaust temperature: ..... °C

Idling speed: ..... r/min (for information)

Laboratory extraction system for the exhaust gases:

Over-pressure or maximum depression: ..... ± ..... Pa, at full load

Dynamometer: Make: ..... Type: ..... Serial No.: ..... Constant: .....

Fuel consumption measuring apparatus: gravimetric or volumetric

Smoke opacity measuring apparatus (diesel): Make: ..... Type: .....

Measuring point or installation: .....

8.23 Fuels and lubricants

Liquid fuel

Make:..... Type: ..... Octane RON[1)] No.: ..... Cetane No.: .....

Distillation: Temperature at which the distillate volume is equal to: 10% ..... 50% .....

90% ..... End point: .....

Density: ..... g/cm^3 at ..... °C

Lower calorific value ..... kJ/kg

Other fuels: Characteristics .....

Lubricant: Make: ..... Type: ..... SAE viscosity: .....

8.24 Results

Maximum net power, corrected: ..... kWat ..... r/min

Maximum net torque, corrected: ..... N-m at ..... r/min

Specific fuel consumption

— at maximum net power, corrected: ..... g/kWh

— at maximum net torque, corrected: ..... g/kWh

8.25 Statement of results (net power)

The characteristic curves of the corrected torque and power, of the specific fuel consumption and of the exhaust smoke emission shall be drawn as functions of the engine speed. The data in Table 2 can be used to draw these curves.

Table 2 — Results (net power)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Engine speed	Observed torque	Observed power	Test conditions		Correction factor	Corrected torque	Corrected power	Specific fuel consumption	Fuel delivery[a]	Temperature of engine cooling liquid at outlet	Temperature of oil at measuring point	Exhaust temperature	Smoke value observed (optional)
			Barometric pressure	Temperature of inlet air									
r/min	N-m	kW	kPa	°C		N-m	kW	g/kWh	mm^3/stroke	°C	°C	°C	

For pressure charged engines, add the following columns to Table 2:

15	16	17	18
Pressure charging			
Temperature		**Pressure**	
After pressure charger	**After intercooler**	**After pressure charger**	**After intercooler**
°C	°C	kPa	kPa

[1)] RON. Research octane number.

9 Units and designation

9.1 Units

Units used for the determination of performance of agricultural vehicle internal combustion engines at sea level shall be as follows:

a) Unit of mass: gram (g).

b) Unit of power: kilowatt (kW).

c) Unit of torque: newton metre (N m).

d) Unit of volume of injected fuel: cubic millimetre (mm3).

e) Barometric pressure: kilopascal (kPa).

9.2 Designation

When the performances (power curves, torque and specific fuel consumption) of a heat 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/049-3".

9.2.1 Indication of net power

Qualify net power as in the example below:

Example:

Net power: ..... kWat:..... r/min (measured in accordance with CD/K/049-3).

9.2.2 Indication of net torque

Qualify net power as in the example below

Example:

Net power: ..... N-m at:..... r/min (measured in accordance with CD/K/049-3).

9.2.3 Indication of specific fuel consumption

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

Example:

Specific fuel consumption (net power-CD/K/049-3): ..... g/kWh.

Annex A
(normative)

Reference fuel CEC RF-01-T-69 specifications

A.1 General

A.1.1 The specifications for reference fuel CEC RF-01-T-69 (see 5.3.12) are given in Table A.1.

Table A.1 — CEC RF-01-T-69 specifications

1	2	3
Characteristic	**Limits and units**	**Test method3**
Research octane number	99 ±1	ASTM D 2699
Relative density at 1 5/4 °C	0.742 ± 0.007	ASTM D 1298
Reid vapour pressure	60 kPa ± 4 kPa	ASTM D 323
Distillation		ASTM D 86
Initial boiling point		
10 % (volume fraction)	50 °C ± 5 °C	
50 % (volume fraction)	100°C±10°C	
90 % (volume fraction)	160°C±10°C	
Final boiling point	195°C±10°C	
— Residue (volume fraction)	2 % max.	
— Loss (volume fraction)	1 % max.	
Hydrocarbon analysis		ASTMD 1319
— Olefins (volume fraction)	18% ±4%	
— Aromatics (volume fraction)	35 % ± 5 %	
— Saturates (volume fraction)	balance	
Oxidation stability	480 min, min.	ASTM D 525
Existent gum	4 mg/100 mm^3 max.	ASTM D 381
Sulfur content (mass)	0.03% ±0.01 5%	ASTMD 1266
Lead content	0.57 g/dm3 ± 0.03 g/dm^3	[b]
— Nature of scavenger	motor mix	
— Nature of lead alkyl	not specified	
Other additives	nil	

NOTE The blending of CEC RF-01-T-69 should only use conventional European base materials, and exclude unconventional components such as pyrolysis gasoline, thermally cracked material and motor benzole.

[a] The references given in column 3 will be replaced by ISO references when the corresponding international standards, at present in preparation, have been adopted.

[b] See A.2.

A.1.2 Use the test method in A.2 for the gravimetric determination of the total lead of fuel.

A.2 Gravimetric method for the determination of lead in fuel

A.2.1 Introduction

This annex describes the gravimetric determination of the total lead content of gasoline and other volatile distillates blended with lead alkyls (tetraethyllead, tetramethyllead, dimethyldiethyllead, methyltriethyllead, or mixture thereof) within the concentration range of 0.05 g to 1.3 g of lead per litre.

A.2.2 Principle

The lead alkyl is converted to lead chloride and extracted from the gasoline by refluxing with concentrated hydrochloride acid. The acid extract is evaporated to dryness, any organic materials present is removed by oxidation with nitric acid, and the lead is determined gravimetrically as lead chromate.

A.3 Apparatus

A.3.1 Extraction apparatus, fabricated from borosilicate glass, conforming to the dimensions given in figure A.1, and consisting of the following component parts:

a) Boiling flask, of 500 mL capacity.

b) Hopkins reflux condenser, that has a vapour outlet connected by a rubber tube to an outside vent or to a suction hood.

c) Thistle tube, of approximately 70 mL capacity, with a line to indicate approximately 50 ml level.

d) Heating tube, that contains a chimney for increasing convention in the liquid.

e) Heating coil, of 250 W, that consists of 2.4 m of 0.25 mm No. 30 B and S gage or equivalent nichrome wire.

f) Rheostat, for regulating the heater.

   1) 110 V power supply:
      — resistance 25 Ω; and
      — minimum capacity 2 A.

   2) 240 V power supply:
      — resistance 250 Ω; and
      — minimum capacity 1 A.

A.3.2 Filtering crucible, of approximately 25 mL capacity No. 4 porosity sintered glass, or 25 mL porcelain crucibles, having porous bottoms equivalent to Selas No. 3001, or 25 mL gooch crucibles, capable of retaining a fine precipitate.

A.4 Reagents and materials

A.4.1 Purity of reagents, reagent grade chemicals shall be used in all tests.

NOTE Other grades may be used, provided that it is first ascertained whether the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

A.4.2 Purity of water, unless otherwise indicated, references to water shall be understood to mean lead-free distilled water or water of equal purity.

A.4.3 Acetic acid (1 + 1), mix one volume of glacial acetic acid with one volume of water.

A.4.4 Ammonium hydroxide (1 + 1), mix one volume of concentrated ammonium hydroxide (NH_4OH, sp gr 0.9) with one volume of water.

A.4.5 Asbestos, medium-fibre, acid-washed, and ignited for use with gooch crucibles.

NOTE The asbestos that is used under the conditions of the analysis should be tested to determine its weight loss due to solubility or to mechanical disintegration. If necessary, the asbestos should be picked over by hand to remove coarse material, and then acid-washed before use.

A.4.6 Heavy distillate, a straight-run, lead-free, petroleum distillate, of low bromine number, with approximately 10 % distilling at 205 °C and 90 % at 240 °C.

A.4.7 Hydrochloric acid (sp gr 1,19), concentrated hydrochloric acid (HC1).

A.4.8 Nitirc acid (1 + 20), mix one volume of HNO3 (sp gr 1.42) with 20 volumes of water.

A.4.9 p-Nitrophenol indicator solution, dissolve 0,5 g of p-nitrophenol in 100 ml of water, and filter if necessary to remove insoluble material.

A.4.10 Potassium chlorite-nitric acid solution, dissolve 78 g of potassium chlorate ($KClO_3$) in 550mLofHN03(spgr1,42).

B.4.11 Potassium dichromate solution (100 g/L), dissolve 100 g of potassium dichromate ($K_2Cr_2O_7$) in water, dilute to 1 L, and filter.

A.5 Procedure

A.5.1 Measure the temperature of the sample to the nearest 0.5 °C.

NOTE For gasolines having a Reid vapour pressure above 3.175 kg, the sealed sample container should be cooled to approximately 15 °C before removing the sample for analysis.

A.5.2 Using a pipet, transfer 50 mL ± 0,05 mL of the sample of the gasoline flask (see figure A.1) through the thistle tube, and add approximately 50 mL of heavy distillate.

A.5.3 Add 50 ml of HC1 and reflux the mixture for 30 min.

A.5.4 Use the full heat of the heater until boiling has begun (usually 0.5 min to 1.0 min); then adjust the rheostat to regulate the heat to maintain boiling at a vigorous rate, but not at such a rate to cause bumping in the flask (see note 1) or to cause the condenser to flood (see note 2).

NOTE 1 A new or a thoroughly cleaned extractor has a tendency to reduce super-heating and bumping of the solution may occur. This difficulty is reduced and boiling will continue at an even rate after the apparatus has been used for several analyses.

NOTE 2 During the heating, hydrochloric acid gas is volatilized and constant boiling hydrochloric acid is obtained. Continuous and vigorous boiling is necessary to obtain intimate mixing of the acid and sample to extract completely the decomposed lead alkyls from the gasoline phase.

A.5.5 After the 30 min reflux period, turn off the heat, allow the sample to cool a few minutes, and drain the acid layer into a 400 ml beaker.

A.5.6 Then add 50 mL of water and reflux the water and gasoline for 5 min, using the full heat of the heater. Drain the water into the 400 mL beaker, and repeat the water extraction.

A.5.7 Evaporate the aqueous extract to dryness.

NOTE To reduce the evaporation time it is permissible to employ an air jet under the following conditions:

a) substitute a 500 mL Erlenmeyer flask for the 400 mL beaker;

b) evaporate on a hot plate whose surface temperature is maintained between 230 °C and 260 °C, while impinging upon the surface of the liquid a stream of hot (about 75 °C) clean air at a rate of about 10 L/min;

c) the air steam should be led into the flask by means of a glass tube with an orifice about 5 mm in diameter, placed about 60 mm above the surface of the liquid. The air stream should not be used in the HNO_3 evaporation.

A.5.8 Add 3 mL of HNO_3 (sp gr 1.42) to the residue, cover the beaker with a watch glass, and heat to oxidize any organic material present.

NOTE If the residue flashes on being heated with HNO_3, the sample should be discarded and the acid extraction repeated on another sample of gasoline. Then evaporate the extraction until crystallization commences, bout not to complete dryness. Add 10 mL of the $KClO_3$-HNO_3 mixture, cover the beaker with a watch glass, and evaporate the mixture almost to dryness. Repeat this treatment, if necessary, to obtain a white residue.

A.5.9 Repeat the HNO_3 treatment. If a white residue is not obtained after two additions of HNO_3, oxidize the remaining organic matter with the $KClO_3$-HNO_3 mixture as described in the note to A.5.8, then add 4 mL of HNO_3 (1 + 20) and 25 mL of water; heat until all the lead salt is in solution.

A.5.10 Cool the sample, add six drops of p-nitrophenol indicator solution, and add NH4OH until the indicator changes colour; then add approximately 4 mL to 5 mL in excess.

A.5.11 Add acetic acid to neutralize the NH_4OH; then add 1 mL to 2 mL in excess.

A.5.12 Filter the solution through a coarse-texture paper and collect the filtrate in a 600 mL beaker.

A.5.13 Wash the paper with hot water, and dilute the filtrate to 350 mL to 400 mL with water.

A.5.14 Heat the solution to boiling on a hot plate and add 25 mL of the $K_2Cr_2O_7$ solution drop wise from a pipet.

A.5.15 Continue boiling until the precipitated lead chromate ($PbCrO_4$) is deep orange in colour (usually 5 min to 7 min).

A.5.16 Allow the precipitate to settle 3 h to 4 h, or overnight.

A.5.17 Filter the sample through a filtering crucible previously dried at 110°C to 120 °C and weighed to the nearest 0.1 mg.

A.5.18 Wash the beaker and precipitate with hot water. Dry the precipitate and crucible in an oven at 110 °C to 120 °C for 1 h, cool in a desiccator, and weigh the $PbCrO_4$ to the nearest 0.1 mg.

A.6 Calculations

Calculate the concentration of lead by means of the following equation:

$$\text{Lead} = 12.79G\,(1 + 0.0012(t_x - 15))$$

where:
G is the weight of $PbCrO_4$, expressed in grams;

t_x is the temperature of gasoline when pipetting the sample, expressed in degrees Celsius.

NOTE The constant 12.79 is obtained by dividing 48.41 by 3.7853.

A.7 Report

Results shall be reported to the nearest 0.01 g as grams of lead per litre at 15 °C.

A.8 Precision

A.8.1 The following principle should be used for evaluating the acceptability of results (95 % confidence) in the concentration 0.13 g to 1.3 g lead per litre:

a) Repeatability: Duplication of results by the same operator should be considered suspect if they differ by more than the following:

Litre: 0.019 + 0.014 *A*

where

A is the grams of lead per litre at 15.5 °C.

b) Reproducibility: The results submitted by each of the two laboratories should be considered suspect if they differ by more than the following:

Litre: 0.0485 + 0.034 A

where

A is grams of lead per litre at 15.5 °C.

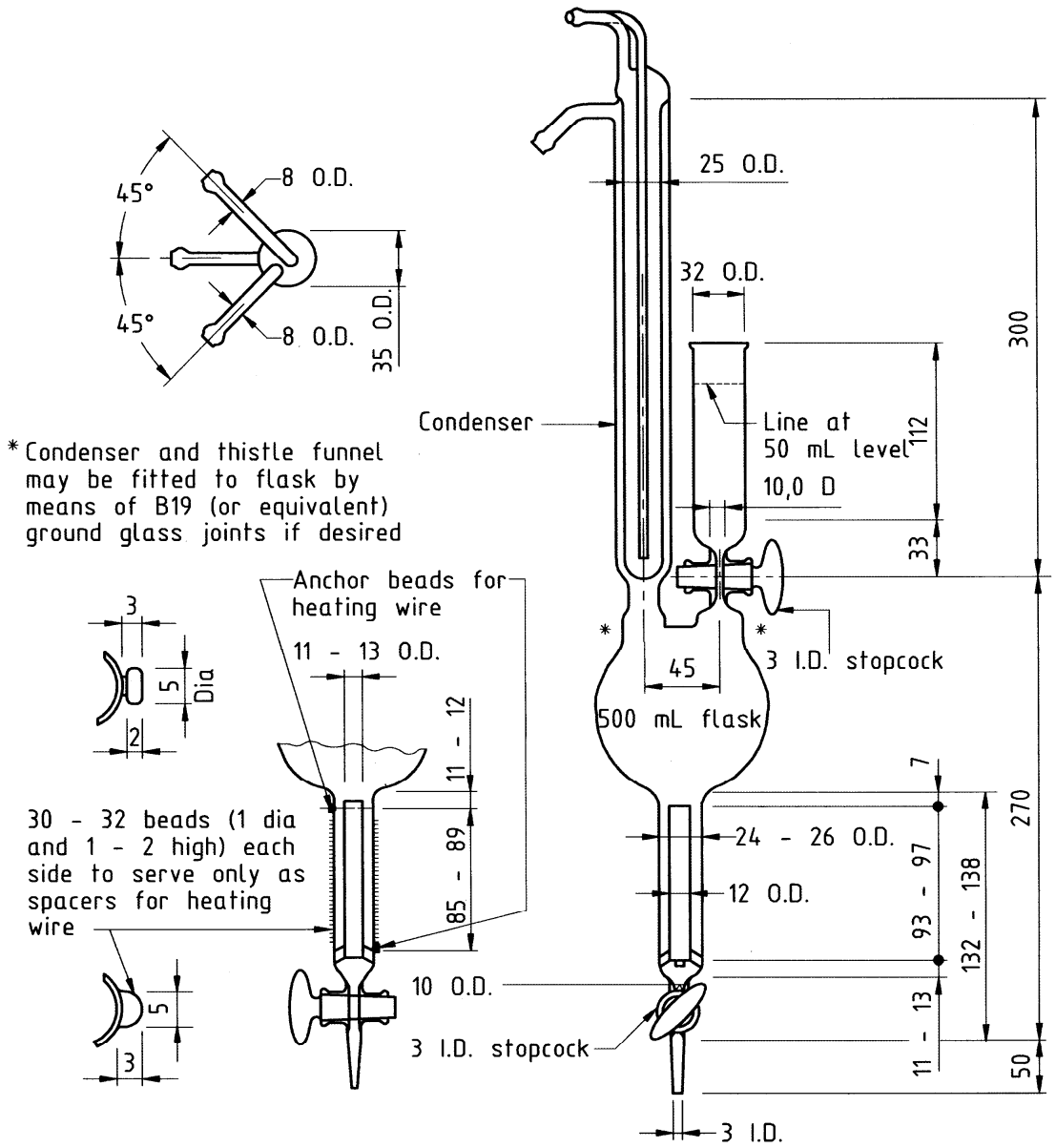
A.8.2 The following precision for gasolines containing 0.05 g to 0.13 g of lead per litre should be used:

a) Repeatability: Duplication of results by the same operator should be considered suspect if they differ by more than the following amount in grams:

Litre: 0.013

b) Reproducibility: The results submitted by each of the two laboratories should be considered suspect if they differ by more than the following amount in grams:

Litre: 0.024



NOTE A Hopkins type condenser is used.

Figure A.1 — Extraction apparatus

Annex B
(normative)

Reference fuel CEC RF-03-T-69 specifications

B.1 General

B.1.1 The specifications for reference fuel CEC RF-03-T-69 (see 5.3.12) are given in table B.1.

Table B.1 — CEC RF-03-T-69 specifications

1	2	3
Characteristic	**Limits and units**	**Test method** [a]
Relative density at 1 5/4 °C	0.830 ± 0.005	ASTMD1298
Distillation		ASTM D 86
50 % (volume fraction)	245 °C, min.	
90 % (volume fraction)	330°C±10°C	
Final boiling point	370 °C, max.	
Cetane index	54±3	ASTM D 976
Kinematic viscosity at 37,8 °C	(3 ± 0.5) cSt	ASTM D 445
Sulfur content (mass fraction)	(0.4 ± 0.1)%	ASTM D 129
Flash point	55 °C, min.	ASTM D 93a
Pour point	-7 °C, max.	ASTM D 97a
Aniline point	69 °C ± 5 °C	ASTM D 611
Carbon residue on 10 % bottoms (mass fraction)	0.2 %, max.	ASTM D 524
Ash content (mass fraction)	0.01 %, max.	ASTM D 482
Water content (mass fraction)	0.05 %, max.	ASTM D 95
Copper corrosion test at 1 00 °C	1 max. (10250 ± 100)kcal/kg	ASTM D 130
Lower calorific value		[b]
Strong acid number	nil mg KOH/g	ASTM D 974
NOTE The CEC RF-03-T-69 should be based only on straight run distillates, hydrodesulfurized or not, and contain no additives.		

[a] The references given in column 3 will be replaced by ISO references when the corresponding international standards, at present in preparation, have been adopted.

b See B.2.

B.1.2 Use the test method in B.2 for the determination of abrasion of rock by use of the Deval machine.

B.2 Test method for determining abrasion of rock by use of the Deval machine

B.2.1 Introduction

This annex describes the procedure for testing rock for resistance to abrasion in the Deval testing machine.

B.3 Apparatus

B.3.1 Deval machine, that consists of one or more hollow cast-iron cylinders closed at one end and furnished with a tightly fitting iron cover at the other end. The inside dimensions of the cylinders shall be 200 mm in diameter and 340 mm in depth. These cylinders shall be mounted on a shaft at an angle of 30 °C with the axis of rotation of the shaft.

B.3.2 Sieve (square hole), with nominal sieve openings of 1.68 mm (No. 12), and that complies with ASTM E 11.

B.4 Test sample

B.4.1 At least 13,608 kg of coarsely broken stone shall be available for a test. The rock to be tested shall be broken into pieces as nearly uniform in size as possible; and as nearly 50 cubical pieces as possible shall constitute a test sample.

B.4.2 The total weight of rock used, as the test sample shall be 5 kg weighed to the nearest 10 g.

B.4.3 All test pieces shall be washed and thoroughly dried before weighing.

B.5 Procedure

B.5.1 Place the test sample in the Deval abrasion machine and rotate the machine for 10 000 revolutions at a rate of from 30 rpm to 33 rpm.

B.5.2 At the completion of the test, remove the material from the machine and sieve on a No. 12 (1.68 mm) sieve.

B.5.3 The material passing the No. 12 sieve shall be expressed as a percentage of the original weight of the sample, or as the French coefficient of wear calculated as follows:

$$F = \frac{40}{W}$$

where

F is the French coefficient of wear;

W is the loss in the test expressed as a percentage of the original weight of the sample, expressed in kilograms (kg).

Annex C
(normative)

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

C.1 Introduction

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

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

C.2 Measurement principle

C.2.1 The opacity of the exhaust smoke produced by the engine shall be measured with the engine running under 80 % of the maximum load and at steady speed. Six measurements shall be made at engine speeds spaced out uniformly between

a) the speed corresponding to maximum power, and

b) the higher of the following two speeds:

— 55 % engine speed at maximum power,

— 1 000 r/min.

NOTE Maximum load should be interpreted as the maximum torque at each of six relevant engine speeds. The extreme points of measurement shall be situated at the limits of the interval defined above.

C.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.

C.3 Test conditions

C.3.1 Vehicle or engine

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

C.3.1.2 The engine shall be tested with the equipment prescribed in clause 5.

C.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:

Maximum power	+3% −1%
At the other five measurement points	+6% −2%

C.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.

C.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.

C.3.2 Fuel

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

C.3.3 Test laboratory

C.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) Naturally aspirated and mechanically supercharged engines:

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

b) Turbo-supercharged engine with or without cooling of inlet air:

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

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

C.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.

C.4 Limit values

C.4.1 For each of the six engine speeds at which the absorption coefficient is measured in accordance with to C.2.1, the nominal gas flow G, expressed in litres 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.

C.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 D.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 Table D.1, the limit value applicable shall be obtained by interpolation on the principle of proportional parts.

Annex D
(normative)

Limit values applicable in the test at steady speeds

Table D.1 — Limit values

1 Nominal flow, G L/s	2 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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