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(Acts whose publication is obligatory)

**Regulation No 24 of the Economic Commission for Europe of the United Nations (UN/ECE) —
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. engines of an approved type

III. The approval of motor vehicles equipped with C.I. engines with regard to the emission of visible pollutants by the engine

IV. The measurement of power of C.I. engines

1. SCOPE

1.1 This Regulation applies to,

1.1.1 PART I: The emission of visible exhaust pollutants from C.I. engines which are intended for fitting to road vehicles.

1.1.2 PART II: The installation into road vehicles of C.I. engines that have been type approved to Part I of this Regulation.

1.1.3 PART III: The emission of visible exhaust pollutants from a motor vehicle that is fitted with an engine that has not been separately type approved to Part I of this Regulation.

1.2 The secondary scope of this Regulation is the ECE procedure to be applied when only the power output by C.I. engines is to be measured.

2. DEFINITIONS COMMON TO PARTS I, II AND III

2.1 For the purpose of this Regulation the following definitions are common to Parts I, II and III:

2.2 'Net power' means the power of a C.I. engine as defined in Annex 10 to this Regulation;

2.3 'Compression ignition (C.I.) engine' means an engine which operates on the compression-ignition principle (e.g. diesel engine);

2.4 'Cold-start device' means a device which by its operation temporarily increases the amount of fuel supplied to the engine and is intended to facilitate starting of the engine;

2.5 'Opacimeter' means an instrument for continuous measurement of the light absorption coefficients of the exhaust gases emitted by vehicles, as specified in Annex 8 to this Regulation;

2.6 'Maximum rated speed' means maximum speed permitted by the governor at full load;

- 2.7 'Minimum rated speed' means
- 2.7.1 either the highest of the following three engine speeds:
- 45 % of maximum net power speed
 - 1 000rpm
 - minimum speed permitted by the idling control
- 2.7.2 or such lower speed as the manufacturer may request.
- 2.8 Hybrid vehicles (HV)
- 2.8.1 'Hybrid vehicle (HV)' means a vehicle with at least two different energy converters and two different energy storage systems (on vehicle) for the purpose of vehicle propulsion.
- 2.8.2 'Hybrid electric vehicle (HEV)' means a vehicle that, for the purpose of mechanical propulsion, draws energy from both of the following on-vehicle sources of stored energy/power:
- a consumable fuel
 - an electrical energy/power storage device (e.g. battery, capacitor, flywheel/generator)

PART I — EMISSION OF VISIBLE EXHAUST POLLUTANTS FROM C.I. ENGINES

3. DEFINITIONS

For the purpose of Part I of this Regulation:

- 3.1 Approval of a C.I. engine means the approval with regard to the limitation of the emission of visible exhaust pollutants from the engine,
- 3.2 'Engine type' means a category of C.I. engine for installation in a motor vehicle which does not differ in such essential characteristics as those defined in Annex 1 to this Regulation except for modifications as permitted by paragraphs 7.2 and 7.3 of this Regulation,
- 3.3 'An engine representative of the type to be approved' means the engine which develops the highest net power within the engine type,
- 3.4 Other definitions applicable to this Part I are given in paragraph 2 of this Regulation.

4. APPLICATION FOR APPROVAL

4.1 Emission of visible pollutants

- 4.1.1 The application for approval of an engine type with regard to the limitation of the emission of visible pollutants from the engine shall be submitted by the engine manufacturer or by his duly accredited representative or a vehicle manufacturer.
- 4.1.2 It shall be accompanied by the following documents in triplicate: description of the engine comprising all the relevant particulars referred to in Annex 1 to this Regulation.
- 4.1.3 An engine representative of the engine type to be approved shall, with the equipment prescribed in Annex 1 to this Regulation, be submitted to the technical service conducting the approval tests defined in paragraph 6 of this Regulation.
- 4.1.4 When determining the emission of visible pollutants, the measurements shall be made by the two methods described in Annexes 4 and 5 to this Regulation relating respectively to tests at steady speeds and to tests under free acceleration.
- 4.1.5 When determining the emission of visible pollutants the power and fuel consumption of the same engine submitted for approval shall be measured according to Annex 10 to this Regulation.

- 4.2 **Engine power**
- 4.2.1 The manufacturer or his duly accredited representative may request that measurement only of engine power be performed. In this case:
- 4.2.1.1 The manufacturer shall complete Annex 1 to this Regulation with the information specially related to power measurement i.e. all points not preceded by the letter E.
- 4.2.1.2 An engine corresponding in all aspects to the description report in that Annex 1 shall be submitted to the technical service for tests described in Annex 10 to this Regulation. Such tests shall only be carried out on the test bench.
- 4.2.2 Where, at the request of the manufacturer or his duly accredited representatives, only engine power tests in accordance with Annex 10 are performed, these will not be considered as approval tests but an official statement of the test results according to the appendix of Annex 10 to this Regulation will be issued.
5. APPROVAL
- 5.1 If the engine submitted for approval pursuant to this Regulation meets the requirements of paragraph 6 below, approval of the engine type shall be granted.
- 5.2 An approval number shall be assigned to each engine type approved. Its first two digits (at present 03 corresponding to the 03 series of amendments which entered into force on 20 April 1986) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party may not assign the same number to another engine type.
- 5.3 Notice of approval or of extension or of refusal of approval of an engine type pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation by means of a form conforming to the model in Annex 2 to this Regulation.
- 5.4 There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every engine conforming to an engine type approved under this Regulation an international approval mark consisting of:
- 5.4.1 a circle surrounding the letter 'E' followed by the distinguishing number of the country which has granted approval ⁽¹⁾;
- 5.4.2 the number of this Regulation, followed by the letter 'R', a dash and the approval number to the right of the circle prescribed in paragraph 5.4.1;
- 5.4.3 the following additional symbol, a rectangle surrounding a figure expressing in m^{-1} the absorption coefficient obtained, at the time of approval, during the tests under free acceleration and determined by the procedure described in Annex 5 to this Regulation.
- 5.4.4 Alternatively, instead of affixing these approval marks and symbols to the engine, the manufacturer may decide that each engine type approved under this Regulation shall be accompanied by a document giving this information so that the approval marks and symbol can be attached to the vehicle in accordance with paragraph 14.4 of this Regulation.

⁽¹⁾ 1 for Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for the Russian Federation, 23 for Greece, 24 for Ireland, 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32 for Latvia, 33 (vacant), 34 for Bulgaria, 35 and 36 (vacant), 37 for Turkey, 38 and 39 (vacant), 40 for the former Yugoslav Republic of Macedonia, 41 (vacant), 42 for the European Community (Approvals are granted by its Member States using their respective ECE symbol), 43 for Japan, 44 (vacant), 45 for Australia, 46 for Ukraine and 47 for South Africa. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement Concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

- 5.5 If the engine conforms to a type approved, under one or more other Regulations Annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 5.4.1 need not be repeated: in such a case, the Regulation and approval numbers of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 5.4.1.
- 5.6 The approval mark shall be clearly legible and be indelible.
- 5.7 The approval mark shall be placed close to the engine identification figures provided by the manufacturer.
- 5.8 Annex 3 to this Regulation gives examples of the arrangements of the approval mark.
6. SPECIFICATIONS AND TESTS
- 6.1 **General**
- The components liable to affect the emission of visible pollutants shall be so designed, constructed and assembled as to enable the engine in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.
- 6.2 **Specifications concerning cold-start devices**
- 6.2.1 The cold-start device shall be so designed and constructed that it cannot be brought into or kept in action when the engine is running normally.
- 6.2.2 The provisions of paragraph 6.2.1 shall not apply if at least one of the following conditions is met:
- 6.2.2.1 The light absorption coefficient of the gases emitted by the engine at steady speeds when measured by the procedure prescribed in ANNEX 4 to this Regulation with the cold-start device operating, is within the limits prescribed in ANNEX 7 to this Regulation.
- 6.2.2.2 Keeping the cold-start device in operation causes the engine to stop within a reasonable time.
- 6.2.3 If necessary any vehicle related part of the system may be simulated for the approval test.
- 6.3 **Specifications concerning the emission of visible pollutants**
- 6.3.1 The emission of visible pollutants by the engine submitted for approval shall be measured by the methods described in Annexes 4 and 5 to this Regulation.
- 6.3.2 The power of the engine submitted for approval shall be within the tolerances specified under paragraph 3.1.5 of Annex 4 to this Regulation.
- 6.3.3 The emission of visible pollutants, as measured by the method described in Annex 4 to this Regulation, shall not exceed the limits prescribed in Annex 7 to this Regulation.
- 6.3.4 At the request of the manufacturer additional tests described in Annexes 4 and 5 shall be performed to obtain free acceleration values for derivatives of the approved engine permitted by paragraphs 7.2. and 7.3. of this Regulation.
- 6.3.4.1 If the engine manufacturer desires to have the visible pollutants measured over a smaller range of torque and/or speed than is allowed by paragraph 7.3. of this Regulation, then the approval of the engine type will be for the limited range of torque and speed.
- 6.3.4.2 If at a later stage it is desired to extend the approval of the engine to cover the whole of the torque/speed range allowed by paragraph 7.3. of this Regulation then a further engine would have to be submitted for test so that the visible pollutants can be established for that part of the load/speed range which has previously been omitted.

- 6.3.5 If in order to meet some parts of the torque and speed ranges it is necessary to have additional specifications then these shall be declared in the format of Annex 1 and attached to the documentation submitted.
- 6.3.6 The value of the free acceleration absorption coefficient allocated to the engine will be appropriately chosen in accordance with its rated speed and torque from the matrix of values established by the method in Annex 5 to this Regulation.
- 6.3.7 In the case of engines with an exhaust-driven supercharger the absorption coefficient measured under free acceleration shall not exceed the limit prescribed in Annex 7 for the nominal flow value corresponding to the maximum absorption coefficient measured during the tests at steady speeds, plus 0,5 m³.
- 6.4 Equivalent measuring instruments shall be allowed. If an instrument other than those described in Annex 8 to this Regulation is used, its equivalence for the engine considered shall be required to be proved.
7. MODIFICATION OF THE ENGINE TYPE AND EXTENSION OF APPROVAL
- 7.1 Every modification of an engine within an engine type with regard to the characteristics in Annex 1 shall be notified to the administrative department which approved the engine type. Details of these modifications shall be declared in the format of Annex 1. Within the constraints imposed by paragraphs 7.2 and 7.3, the department may then either:
- 7.1.1 consider that the modifications made are unlikely to have an appreciable adverse effect, and that in any case the engine still complies with the requirements, or
- 7.1.2 require a further test report from the technical service responsible for conducting the test.
- 7.2 For the purposes of this Regulation, with regard to the emission of visible pollutants the modifications may be classified as follows:
- (1) Modifications which require a new approval with tests.
 - (2) Modifications which require a new approval without tests.
 - (3) Modifications which may require new tests however without new approval.
 - (4) Modifications which do not require complementary tests or new approvals.
- The above classifications (1), (2), (3) and (4) are marked on each line of the corresponding characteristics in Annex 1.
- 7.3 Irrespective of these classifications in paragraph 7.2, a new approval, with tests, i.e. Classification (1), will automatically be required unless the engine also respects the following conditions:
- Maximum rated speed not greater than 100 % or less than 75 % of that of the engine in the approval test,
- Minimum rated speed not less than that of the engine in the approval test,
- Torque rating not greater than 100 %, nor less than 70 % of that of the engine at that speed in the approval test,
- Steady state absorption values are not greater than 1,1 times the values obtained in the approval test and do not exceed the prescribed limits in Annex 7,
- Exhaust back pressure not greater than that of the engine in the type approval test,
- Exhaust system volume does not differ by more than 40 %,
- Intake depression not greater than that of the engine in the type approval test,
- Moment of inertia of a new combined flywheel and transmission is within 15 % of the engine flywheel and transmission system approved.
- Note:* In all cases the engine in the approval test means 'an engine representative of the type to be approved' as defined in paragraph 3.3.

- 7.4 If the manufacturer asks to cover the range of de-rated and de-speeded engines allowed for in paragraph 7.3 of Part I of this Regulation, tests shall also be carried out over the speed range defined in paragraph 2.2 of Annex 5 with the engine reset to give 90 %, 80 % and 70 % of the full power. If the engine is de-speeded then the minimum speed defined in paragraph 2.2 of Annex 5 to this Regulation shall be calculated from the derivative with the lowest maximum power speed. If the engine manufacturer desires to have the visible pollutants measured over a smaller range of torque and/or speed than is allowed by paragraph 7.3 of Part I of the Regulation, then the approval of the engine type will be for the limited range of torque and/or speed.
- 7.5 For such modifications further tests must be carried out to establish free acceleration smoke values in accordance with paragraph 6.3.1 of this Regulation unless these values can be established from tests already carried out as allowed under paragraph 6.3.4.
- 7.6 Confirmation or refusal of approval, specifying the alterations, shall be communicated by the procedure specified in paragraph 5.3 above to the Parties to the Agreement which apply this Regulation.
- 7.7 The competent authority issuing the extension of approval shall assign a series number to each communication form drawn up for such an extension.
8. CONFORMITY OF PRODUCTION
- 8.1 Every engine identified by an approval mark and/or document as prescribed in paragraph 5.4 of this Regulation shall conform, with regard to components affecting the emission of visible pollutants, to the engine type approved.
- 8.2 In order to verify conformity as prescribed in paragraph 8.1, an engine shall be taken from the series.
- 8.3 Conformity of the engine with the type approved shall be verified on the basis of the description given in the approval form according to Annex 2 to this Regulation. In addition, verifying tests shall be carried out in the following conditions:
- 8.3.1 An engine which has not been run in shall be subjected to the test under free acceleration prescribed in Annex 5 to this Regulation. The engine shall be deemed to conform to the approved type if the absorption coefficient determined does not exceed by more than $0,5 \text{ m}^{-1}$ the figure shown in the approval mark or document for that engine (see paragraph 8.1). On the request of the manufacturer, commercially available fuel may be used rather than the reference fuel.
- 8.3.2 If the figure determined in the test referred to in paragraph 8.3.1 exceeds by more than $0,5 \text{ m}^{-1}$ the figure shown in the approval document for that engine, the engine shall be subjected to the test at steady speeds over the full load curve as prescribed in Annex 4 to this Regulation. The emission levels shall not exceed the limits prescribed in Annex 7 to this Regulation.
9. PENALTIES FOR NON-CONFORMITY OF PRODUCTION
- 9.1 The approval granted in respect of an engine type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 8.1 are not complied with or if the engine has failed to pass the test prescribed in paragraph 8.3.
- 9.2 If a Party to the Agreement which applies this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties to the Agreement which apply this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation 'APPROVAL WITHDRAWN'.
10. PRODUCTION DEFINITELY DISCONTINUED
- If the holder of the approval completely ceases production of the engine approved in accordance with this Regulation, he shall so inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Parties to the Agreement applying this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation 'PRODUCTION DISCONTINUED'.

11. NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the Agreement which apply this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and or the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

PART II — THE INSTALLATION ON ROAD VEHICLES OF TYPE-APPROVED C.I. ENGINES

12. DEFINITIONS

For the purpose of Part II of this Regulation:

- 12.1 'Approval of a vehicle' means the approval of a vehicle type with regard to the installation of type approved engines for the limitation of visible pollutants from the engine,
- 12.2 'Vehicle type' means a category of power-driven vehicles which do not differ in such essential respects as the vehicle and engine characteristics defined in Annex 1 to this Regulation,
- 12.3 Other definitions applicable to this Part II are contained in paragraph 2 of this Regulation.

13. APPLICATION FOR APPROVAL

- 13.1 **Emission of visible pollutants**

- 13.1.1 The application for approval of a vehicle type with regard to the installation of the C.I. engine for the limitation of the emission of visible pollutants from the engine shall be submitted by the vehicle manufacturer or by his duly accredited representative.
- 13.1.2 It shall be accompanied by the following documents in triplicate; description of the vehicle comprising all the relevant vehicle and engine particulars referred to in Annex 1 to the Regulation, and type-approval communication for the engine in Annex 2 together with those documents listed under item 19 of Annex 2. When filling in Annex 1 only the items which differ from those of the engine type approval need be completed.
- 13.1.3 A vehicle representative of the vehicle type to be approved, shall be submitted to the technical services conducting the approval test defined in paragraph 15 to this Regulation.

14. APPROVAL

- 14.1 If the vehicle submitted for approval pursuant to this Regulation meets the requirements of paragraph 15, approval for the vehicle type shall be granted.
- 14.2 An approval number shall be assigned to each vehicle type approved. Its first two digits (at present 03 corresponding to the 03 series of amendments which entered into force on 20 April 1986) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party may not assign the same number to another vehicle type.
- 14.3 Notice of approval or of extension or of refusal of approval of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a form conforming to the model in Annex 2 to this Regulation.

- 14.4 There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation an international approval mark consisting of:
- 14.4.1 a circle surrounding the letter 'E' followed by the distinguishing number of the country which has granted approval (*);
- 14.4.2 the number of this Regulation, followed by the letter 'R', a dash and the approval number to the right of the circle prescribed in paragraph 14.4.1;
- 14.4.3 the following additional symbol of a rectangle surrounding a figure expressing in m^{-1} the absorption coefficient determined during the test under free acceleration, in Annex 5 of this Regulation.
- 14.5 If the vehicle conforms to a type approved, pursuant to one or more other Regulations annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 14.4.1 need not be repeated. In such a case, the Regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 14.4.1.
- 14.6 The approval mark and the additional symbol shall be clearly legible and be indelible.
- 14.7 The approval mark shall be placed close to or on the vehicle data plate affixed by the manufacturer.
- 14.8 Annex 3 to this Regulation gives examples of the arrangements of the approval mark and of the additional symbol.
15. SPECIFICATIONS AND TESTS
- 15.1 **General**
- The diesel engine fitted on the vehicle shall be of a type approved under Part I of this Regulation. The components liable to affect the emission of visible pollutants shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.
- It shall be possible to inspect the vehicle for roadworthiness by determining its performance in relation to the data collected for type approval as reported in paragraph 11.1.2.2. of Annex 2 to this Regulation. If this inspection requires a special procedure, this shall be detailed in the service manual (or equivalent media). This special procedure shall not require the use of special equipment other than that provided with the vehicle.
- 15.2 **Specifications concerning cold-start devices**
- 15.2.1 The cold-start device shall be so designed and constructed that it cannot be brought into or kept in action when the engine is running normally.
- 15.2.2 The provisions of paragraph 15.2.1 shall not apply if at least one of the following conditions is met:
- 15.2.2.1 The light absorption coefficient of the gases emitted by the engine at steady speeds when measured by the procedure prescribed in Annex 4 to this Regulation with the cold-start device operating, is within the limits prescribed in Annex 7 to this Regulation.
- 15.2.2.2 Keeping the cold-start device in operation causes the engine to stop within a reasonable time.

(*) See footnote 1.

15.3 Installation

15.3.1 The installation of the engine shall respect in particular the following limitations with respect to the type approval of the engine:

- Intake depression shall not exceed that of the type approved engine
- Exhaust back pressure shall not exceed that of the type approved engine
- Exhaust system volume is within $\pm 40\%$ of the type approved engine
- Moment of inertia of the combined flywheel and transmission is within $\pm 15\%$ of the type approved engine.

16. MODIFICATION OF THE VEHICLE TYPE AND EXTENSION OF APPROVAL

16.1 Every modification of the vehicle type with regard to the characteristics in Annex 1 shall be notified to the administrative department which approved the vehicle type. The department may then either:

16.1.1 consider that the modifications made are unlikely to have an appreciable adverse effect, and that the vehicle still complies with the requirements; or

16.1.2 require a further test report from the technical service responsible for conducting the tests.

16.2 Confirmation or refusal of approval, specifying the alterations, shall be communicated by the procedure specified in paragraph 14.3 to the Parties to the Agreement which apply this Regulation.

16.3 The competent authority issuing the extension of approval shall assign a series number to each communication form drawn up for such an extension.

17. CONFORMITY OF PRODUCTION

17.1 Every vehicle identified by an approval mark and/or document in the case of the engine type installed as prescribed under paragraphs 5.4 and 14.4 of this Regulation shall conform with regard to components affecting the emission of visible pollutants to the vehicle type approved.

17.2 In order to verify conformity as prescribed in paragraph 17.1, a vehicle shall be taken from the series.

17.3 Conformity of the vehicle with the type approved shall be verified on the basis of the description given in the approval form according to Annex 2 to this Regulation. In addition, verifying tests shall be carried out in the following conditions:

17.3.1 A vehicle with an engine which has not been run-in shall be subjected to the test under free acceleration prescribed in Annex 5 to this Regulation. The vehicle shall be deemed to conform to the vehicle type approved if the absorption coefficient determined does not exceed by more than $0,5 \text{ m}^{-1}$ the figure shown in the approval mark or document (see paragraph 17.1). On the request of the manufacturer commercially available fuel may be used rather than the reference fuel. In the case of dispute, reference fuel has to be used.

17.3.2 If the figure determined in the test referred to in paragraph 17.3.1 exceeds by more than $0,5 \text{ m}^{-1}$ the figure shown in the approval mark or document (see paragraph 17.1) the engine shall be subjected to the test at steady speeds over the full-load curve as prescribed in Annex 4 to this Regulation. The visible emission levels shall not exceed the limits prescribed in Annex 7 to this Regulation.

18. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

18.1 The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 17.1 are not complied with or if the vehicle has failed to pass the tests prescribed in paragraph 17.3.

- 18.2 If a Party to the Agreement which applies this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties to the Agreement which apply this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation 'APPROVAL WITHDRAWN'.

19. PRODUCTION DEFINITELY DISCONTINUED

If the holder of the approval completely ceases production of the vehicle approved in accordance with this Regulation, he shall so inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Parties to the Agreement applying this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation 'PRODUCTION DISCONTINUED'.

20. NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the Agreement which apply this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval, and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

PART III — EMISSION OF VISIBLE EXHAUST POLLUTANTS FROM A MOTOR VEHICLE WHOSE ENGINE HAS NOT BEEN SEPARATELY APPROVED

21. DEFINITIONS

For the purposes of Part III of this Regulation:

- 21.1 'Approval of a vehicle' means the approval of a vehicle type with regard to limitation of the emission of visible pollutants from the engine;
- 21.2 'Vehicle type' means a category of power-driven vehicles which do not differ in such essential respects as the vehicle and engine characteristics as defined in Annex 1 to the Regulation;
- 21.3 Other definitions applicable to this Part III are contained in paragraph 2 of this Regulation.

22. APPLICATION FOR APPROVAL

- 22.1 The application for approval of a vehicle type with regard to limitation of the emission of pollutants from the engine shall be submitted by the vehicle manufacturer or by his duly accredited representative.
- 22.2 It shall be accompanied by the under mentioned documents in triplicate and the following particulars:
- 22.2.1 A description of the vehicle and engine type comprising all the particulars referred to in Annex 1.
- 22.3 An engine and the equipment prescribed in Annex 1 to the Regulation for fitting it to the vehicle to be approved shall be submitted to the technical service conducting the approval tests defined in paragraph 24 of the Regulation. However, if the manufacturer so requests and the technical service conducting the approval tests agrees, a test may be carried out on a vehicle representative of the vehicle type to be approved.

23. APPROVAL

- 23.1 If the vehicle submitted for approval pursuant to this Regulation meets the requirements of paragraph 24, approval of that vehicle type shall be granted.

- 23.2 An approval number shall be assigned to each vehicle type approved. Its first two digits (at present 03 corresponding to the 03 series of amendments which entered into force on 20 April 1986) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party may not assign the same number to another vehicle type.
- 23.3 Notice of approval or of extension or of refusal of approval of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation by means of a form conforming to the model in Annex 2 to this Regulation.
- 23.4 There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation an international approval mark consisting of:
- 23.4.1 a circle surrounding the letter 'E' followed by the distinguishing number of the country which has granted approval ⁽²⁾;
- 23.4.2 the number of this Regulation, followed by the letter 'R', a dash and the approval number to the right of the circle prescribed in paragraph 5.4.1,
- 23.4.3 the following additional symbol of a rectangle surrounding a figure expressing in m^{-1} the corrected absorption coefficient obtained, at the time of approval, during the test under free acceleration, and determined at the time of approval by the procedure described in Annex 5(3.2) to this Regulation.
- 23.5 If the vehicle conforms to a vehicle type approved, under one or more other Regulations annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 23.4.1 need not be repeated; in such a case, the Regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 23.4.1.
- 23.6 The approval mark and the additional symbol shall be clearly legible and be indelible.
- 23.7 The approval mark shall be placed close to or on the vehicle data plate affixed by the manufacturer.
- 23.8 Annex 3 to this Regulation gives examples of the arrangements of the approval mark and of the additional symbol.
24. SPECIFICATIONS AND TESTS
- 24.1 **General**
- The components liable to affect the emission of pollutants shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.
- It shall be possible to inspect the vehicle for roadworthiness by determining its performance in relation to the data collected for type approval as reported in paragraph 11.1.2.2. of Annex 2 to this Regulation. If this inspection requires a special procedure, this shall be detailed in the service manual (or equivalent media). This special procedure shall not require the use of special equipment other than that provided with the vehicle.
- 24.2 **Specifications concerning cold-start devices**
- 24.2.1 The cold-start device shall be so designed and constructed that it cannot be brought into or kept in action when the engine is running normally.

⁽²⁾ See footnote 1.

24.2.2 The provisions of paragraph 24.2.1 above shall not apply if at least one of the following conditions is met:

24.2.2.1 The light absorption coefficient of the gases emitted by the engine at steady speeds when measured by the procedure prescribed in Annex 4 to this Regulation with the cold-start device in operation, is within the limits prescribed in Annex 7 to this Regulation.

24.2.2.2 Keeping the cold-start device in operation causes the engine to stop within a reasonable time.

24.3 **Specifications concerning the emission of visible pollutants**

24.3.1 The emission of visible pollutants by the vehicle type submitted for approval shall be measured by the two methods described in Annexes 4 and 5 to this Regulation, relating respectively to tests at steady speeds and to tests under free acceleration. If performing these tests on a hybrid electric vehicle requires a special procedure, this shall be detailed in the service manual (or equivalent media). This special procedure shall not require the use of special equipment other than that provided with the vehicle.

24.3.2 The emission of visible pollutants, as measured by the method described in Annex 4 to this Regulation, shall not exceed the limits prescribed in Annex 7 to this Regulation.

24.3.3 In the case of engines with an exhaust-driven supercharger the absorption coefficient measured under free acceleration shall not exceed the limit prescribed in Annex 7 for the nominal flow value corresponding to the maximum absorption coefficient measured during the tests at steady speeds, plus $0,5 \text{ m}^{-1}$.

24.3.4 Equivalent measuring instruments shall be allowed. If an instrument other than those described in Annex 8 to this Regulation is used, its equivalence for the engine considered shall be required to be proved.

25. MODIFICATION OF THE VEHICLE TYPE AND EXTENSION OF APPROVAL

25.1 Every modification of the vehicle or component type with regard to the characteristics in Annex 1 to this Regulation shall be notified to the administrative department which approved the vehicle type. The department may then either:

25.1.1 consider that the modifications made are unlikely to have an appreciable adverse effect, and that in any case the vehicle still complies with the requirements, or

25.1.2 require a further test report from the technical service responsible for conducting the test.

25.2 Confirmation or refusal of approval, specifying the alterations, shall be communicated by the procedure specified in paragraph 23.3 to the Parties to the Agreement which apply this Regulation.

25.3 The competent authority issuing the extension of approval shall assign a series number to each communication form drawn up for such an extension.

26. CONFORMITY OF PRODUCTION

26.1 Every vehicle bearing an approval mark as prescribed by this Regulation shall conform, with regard to components affecting the emission of visible pollutants by the engine, to the vehicle type approved.

26.2 In order to verify conformity as prescribed in paragraph 26.1, a vehicle bearing the approval mark required by this Regulation shall be taken from the series.

26.3 Conformity of the vehicle with the type approved shall be verified on the basis of the description given in the approval form. In addition, verifying tests shall be carried out in the following conditions:

- 26.3.1 A vehicle which has not been run in shall be subjected to the test under free acceleration prescribed in Annex 5 to this Regulation. The vehicle shall be deemed to conform to the type approved if the absorption coefficient determined does not exceed by more than 0,5 m⁻¹ the figure shown in the approval mark (see paragraph 26.1). On the request of the manufacturer, commercially available fuel may be used rather than the reference fuel. In the case of dispute, reference fuel has to be used.
- 26.3.2 If the figure determined in the test referred to in paragraph 26.3.1 above exceeds by more than 0,5 m⁻¹ the figure shown in the approval mark, the engine of the vehicle shall be subjected to the test at steady speeds over the full-load curve, as prescribed in Annex 4 to this Regulation. The visible emission levels shall not exceed the limits prescribed in Annex 7 to this Regulation.
27. PENALTIES FOR NON-CONFORMITY OF PRODUCTION
- 27.1 The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 26.1 are not complied with or if the vehicle or vehicles taken have failed to pass the tests prescribed in paragraph 26.3.
- 27.2 If a Party to the Agreement which applies this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties to the Agreement which apply this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation 'APPROVAL WITHDRAWN'.
28. PRODUCTION DEFINITELY DISCONTINUED
- If the holder of the approval completely ceases production of a vehicle approved in accordance with this Regulation, he shall so inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Parties to the Agreement applying this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation 'PRODUCTION DISCONTINUED'.
29. NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS
- The Parties to the Agreement which apply this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.
-

ANNEX 1

**ESSENTIAL CHARACTERISTICS OF THE VEHICLE AND THE C.I. ENGINE AND INFORMATION
CONCERNING THE CONDUCT OF TESTS ⁽¹⁾ ⁽⁵⁾**

Note: The letter 'E' preceding figures means: information to be supplied for emission approval. When no letter precedes the figures, it means: information to be supplied in any case.

For footnotes, see end of this Annex.

- 0. DESCRIPTION OF THE VEHICLE
 - 0.1 Make
 - 0.2 Type
 - 0.3 Name and address of manufacturer
 - 0.4 Engine type and approval no

- 1. DESCRIPTION OF ENGINE
 - 1.1. Make
 - 1.2. Trade mark
 - 1.3. Name and address of manufacturer
 - 1.4. Type(s)
 - 1.5. Cycle: four-stroke/two-stroke/others ⁽²⁾
 - 1.6. Bore: mm
 - 1.7. Stroke: mm
 - 1.8. Cylinder capacity cm ⁽²⁾
 - 1.9. Number and layout of cylinders and firing order:
 - 1.10. Combustion system: description:
 - 1.11. Drawings of combustion chamber and piston crown:
 - 1.12. Compression ratio ⁽³⁾:
 - 1.13. Minimum cross-section area of inlet and outlet ports ⁽²⁾:

- 2. COOLING SYSTEM: LIQUID/AIR COOLING ⁽⁵⁾
 - 2.1 **Characteristics of liquid-cooling system**
 - 2.1.1 Nature of liquid:
 - 2.1.2 Circulating pump ⁽⁵⁾: description or make(s) and type(s):
 - 2.1.3 Radiator/fan systems description:
 - 2.1.4 Drive ratio ⁽⁵⁾:
 - 2.1.5 Max. temperature at outlet ⁽⁵⁾: °C

 - 2.2 **Characteristics of air-cooling system:**
 - 2.2.1 Blower system: characteristics or make(s) and type(s):
 - 2.2.2 Drive ratio(s) ⁽⁵⁾:
 - 2.2.3 Temperature regulating systems Yes/No ⁽⁵⁾— Brief description:
 - 2.2.4 Air ducting: description:
 - 2.2.5 Max. temperature at a characteristic place ⁽⁴⁾: °C

3. AIR INTAKE SYSTEM AND FUEL FEED
- 3.1 **Air intake system**
- 3.1.1 Description and drawings of air intake system and its accessories (heating device, intake silencers, air filter, etc.) or make(s) and type(s) if the test is made with complete system as supplied by the vehicle manufacturer, in a vehicle or on a test bench:
- 3.1.2 Maximum permitted depression of air intake at a characteristic place (specify location of measurement) ⁽²⁾ ⁽³⁾:
..... kPa
- 3.2 **Pressure charger ⁽⁵⁾: Yes/No**
- 3.2.1 Description of the pressure charger system:
- 3.2.2 Characteristics or make(s) and type(s):
- 3.2.3 Max. temperature of the air at the outlet of the intake intercooler ⁽²⁾ ⁽³⁾ °C
- 3.3 **Injection system**
- 3.3.1 *Low pressure section*
- 3.3.1.1 Fuel feed
- 3.3.1.2 Characteristic pressure or make(s) and type(s):
- 3.3.2 *High pressure section*
- 3.3.2.1 Description of the injection system:
- 3.3.2.1.1 Pump: description or make(s) and type(s):
- 3.3.2.1.2 Delivery: mm³ per stroke at engine speed of rpm at full injection or characteristic diagram ⁽⁵⁾ ⁽²⁾ ⁽³⁾
Mention the method used on engine/on pump bench ⁽⁵⁾.
If boost control is supplied, state the characteristic fuel delivery and boost pressure versus engine speed.
- 3.3.2.1.3 Static injection timing ⁽²⁾ ⁽³⁾:
- 3.3.2.1.4 Automatic injection advance range ⁽²⁾:
- 3.3.3 *Injection piping*
- 3.3.3.1 Length ⁽²⁾ ⁽³⁾:
- 3.3.3.2 Internal diameter ⁽²⁾ ⁽³⁾:
- 3.3.4 *Injector(s)*
- 3.3.4.1 Make(s):
- 3.3.4.2 Type(s):
- 3.3.4.3 Opening pressure ⁽²⁾: Mpa
- 3.3.5 *Governor*
- 3.3.5.1 Description of the governor system or make(s) and type(s):
- 3.3.5.2 Speed at which cut-off starts under full-load ⁽²⁾ ⁽³⁾: rpm (maximum rated speed)
- 3.3.5.3 Maximum no-load speed ⁽²⁾ ⁽³⁾: rpm
- 3.3.5.4 Idling speed ⁽²⁾ ⁽³⁾: rpm
- E 3.4 **Cold start system**
- Description or make(s) and type(s):
- E 3.5 Additional anti-smoke devices (if any, and if not covered by another heading):
Description of characteristics:

4. VALVE TIMING
Maximum lift of valves and angles of opening and closing in relation to dead centres (nominal values) ⁽²⁾ ⁽³⁾: .
5. EXHAUST SYSTEM ⁽⁵⁾
 - 5.1 Description of exhaust equipment if the test is made with the complete exhaust equipment provided by the engine or vehicle manufacturer :
Specify the back pressure at maximum net power and the location of measurement: kPa
Indicate the effective volume of the exhaust ⁽²⁾ ⁽³⁾: cm³
 - 5.2 If the test bench equipment is used, specify the back pressure at maximum net power and the location of measurement:
..... kPa
Indicate the effective volume of the exhaust ⁽²⁾ ⁽³⁾: cm³
6. LUBRICATION SYSTEM
 - 6.1 Description of system:
 - 6.2 Circulating pumps ⁽⁵⁾: Yes/No
Description or make(s) and type(s):
 - 6.3 Oil cooler ⁽⁵⁾: Yes/No
Description or make(s) and type(s):
 - 6.4 Mixture with fuel ⁽⁵⁾: Yes/No
(Lubrication oil/fuel ratio)
7. OTHER ENGINE DRIVEN AUXILIARIES
 - 7.1 Auxiliaries necessary for the operation of the engine on test bench, other than the fan State characteristics, or make(s) and type(s):
 - 7.1.1 Generator/alternators ⁽⁵⁾: Yes/No ⁽⁵⁾
 - 7.1.2 Other ⁽⁵⁾:
- E 7.2 **Additional auxiliaries in operation when test is conducted in a vehicle**
State characteristics, or make(s) and type(s):
- E 7.3 **Transmission**
State moment of inertia of combined flywheel and transmission at condition when no gear is engaged ⁽³⁾:
or description, make(s) and type(s) (for torque converter):
8. ENGINE PERFORMANCE (declared by the manufacturer)
 - 8.1 Idling speed ⁽²⁾:
..... rpm
 - 8.2 Maximum rated speed ⁽²⁾:
..... rpm
 - 8.3 Minimum rated speed ⁽²⁾:
..... rpm
 - 8.4 Max. net torque of engine on bench ⁽²⁾: Nm atrpm
 - 8.5 Max. net power of engine on bench ⁽²⁾: kW at rpm
indicate power absorbed by fan kW

8.5.1 Test on bench

Declared powers at the points of measurement referred to in Annex 4(2.2) shall be stated in Table 1.

Table 1

Declared speeds and powers of the engine/vehicle ⁽²⁾ submitted for approval

(Speeds to be agreed with the test authority)

Measurement points (**)	Engine speed: n (rpm)	Power: P (*) kW
.....
.....
.....
.....
.....

(*) Net power according to Annex 10.

(**) See Annex 5(2.2).

⁽¹⁾ In the case of non-conventional engine types and systems, particulars equivalent to those referred to here shall be supplied by the manufacturer.

⁽²⁾ Strike out what does not apply.

⁽³⁾ Specify the tolerance.

⁽⁴⁾ Specify the range if applicable.

⁽⁵⁾ For the engine representative of the type to be approved, a complete data-set shall be supplied. For modified engines, only data which differ from this data-set need to be supplied.

ANNEX 2

(Maximum format: A4 (210 × 297 mm))



(¹)

Communication concerning:

either:
APPROVAL,
REFUSAL OF APPROVAL,
EXTENSION OF APPROVAL,
APPROVAL WITHDRAWN,
PRODUCTION DEFINITELY DISCONTINUED (²)
OF A VEHICLE/ENGINE TYPE (²) WITH REGARD TO EMISSIONS
or:
MEASUREMENT OF POWER OF THE ENGINE ONLY,
pursuant to Regulation No 24.

Approval No: Extension No:

- 1. Trade name or mark of the vehicle (³):
- 9. Trade name or mark of engine:
- 3. Vehicle type (³):
- 10. Engine type: Engine approval No (³):
- 11. Manufacturer's name and address:
- 12. If applicable, name and address of the manufacturer's representative:
- 13. Vehicle/engine submitted for approval on (²):
- 14. Technical service responsible for conducting approval tests:
- 15. Date of report issued by that service:
- 16. Number of report issued by that service:
- 17. Test results
- 17.1 Emissions (²)
- 17.1.1 Tests at steady speeds: Vehicle on roller dynamometer/engine on test bench (²)

Measurement points	Engine speed n (rpm)	Power P (kW)	Nominal flow G (litres/sec)	Measured absorption values (m ⁻¹)
1				
2				
3				
4				
5				
6				

For engine type approval, power absorbed by the fan during the tests (³): kW

For footnotes see end of this Annex

17.1.2. Free acceleration tests

17.1.2.1. Engine test in accordance with Annex 5 ⁽³⁾

Percentage of maximum rpm ⁽⁴⁾	Percentage of maximum torque at rpm stated m ⁻¹	Measured absorption value m ⁻¹	Corrected absorption value m ⁻¹
100	100		
90	100		
100	90		
90	90		
100	80		
90	80		

17.1.2.2. Engine test according to part 1 of this Regulation, or vehicle test according to part III ⁽³⁾Corrected absorption value: m⁻¹

Rpm at start: rpm

17.2 Stated net maximum power ⁽³⁾: kW at rpm

18. Make and type of opacimeter:

19. Principal characteristics of engine type

Engine working principle: four-stroke/two-stroke ⁽²⁾

Number and layout of cylinders:

Cylinder capacity: cm³Fuel feed: direct injection/indirect injection ⁽²⁾Supercharging equipment: YES/NO ⁽²⁾20. Approval granted/refused/extended/withdrawn ⁽²⁾

Reason(s) for extension of approval:

Place:

Date:

Signature:

A list of the documents contained in the approval file transmitted to the administrative service which has granted approval is annexed to this communication.

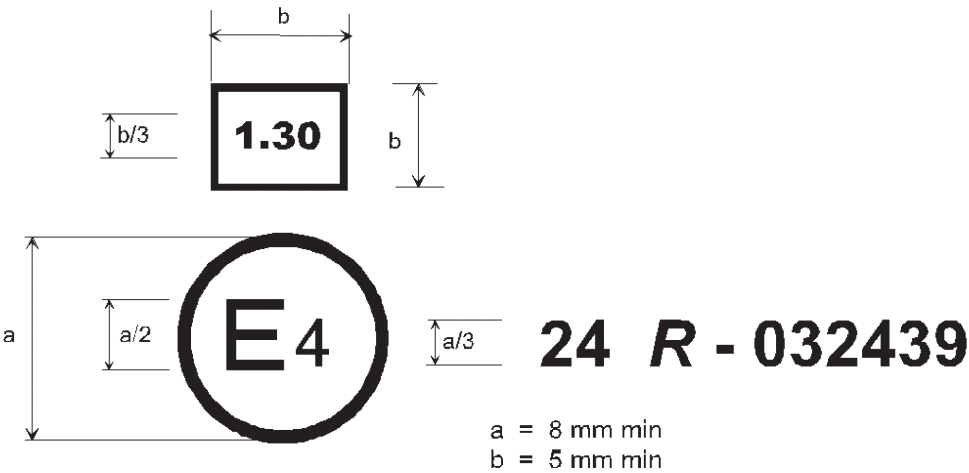
⁽¹⁾ Name of the administration.⁽²⁾ Strike out what does not apply.⁽³⁾ Complete or enter 'not applicable', according to type of approval requested.⁽⁴⁾ The lower limit may be that stated by the manufacturer in accordance with paragraph 6.3.4 of part 1 of this Regulation.

ANNEX 3

ARRANGEMENTS OF APPROVAL MARKS

Model A

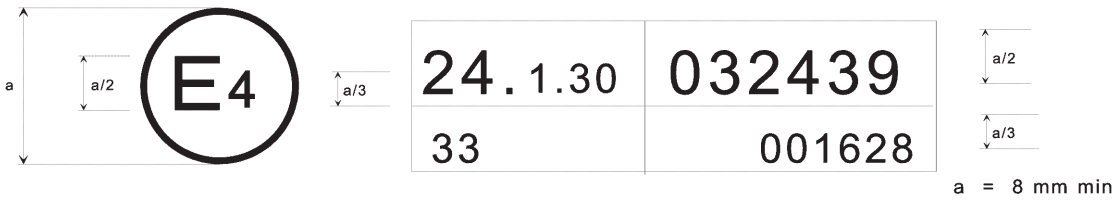
(See paragraphs 5.8, 14.8 and 23.8 of this Regulation)



The above approval mark affixed to an engine/vehicle shows that, pursuant to Regulation No 24, the engine/vehicle concerned has, with regard to the emission of visible pollutants by the engine, been approved in the Netherlands (E 4) under approval number 032439; the Regulation, at the time of approval, included already the 03 series of amendments. The corrected absorption coefficient is 1,30 m⁻¹ (in the case of a vehicle approval).

Model B

(See paragraphs 5.5, 14.5 and 23.5 of this Regulation)



The above approval mark affixed to an engine/vehicle shows that the type concerned has been approved in the Netherlands (E 4), pursuant to Regulations No 24 and No 33 (*). The approval numbers indicate that, at the dates when the respective approvals were given, Regulation No 24 included already the 03 series of amendments, but Regulation No 33 was in its original form.

(*) The latter number is given as an example only.

ANNEX 4

TEST AT STEADY SPEEDS OVER THE FULL-LOAD CURVE**1. INTRODUCTION**

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

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

2. MEASUREMENT PRINCIPLE

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.

2.2. A sufficient number of measurements will be carried out ranging between the maximum rated speed and the minimum rated speed. The extreme points of measurement shall be situated at the limits of the interval defined above and one point of measurement will coincide with the speed at which the engine develops its maximum power and the speed at which it develops maximum torque.

3. TEST CONDITIONS**3.1 Vehicle or engine**

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

3.1.2 The engine shall be tested with the equipment prescribed in Annex 1 to this Regulation.

3.1.3 The settings of the engine shall be those prescribed by the manufacturer and shown in Annex 1 to this Regulation.

3.1.4 In the case of a test on an engine the power of the engine shall be measured in accordance with Annex 10 to this Regulation, but the tolerances of paragraph 3.1.5 of this Annex shall apply. In the case of a test on a vehicle it should be established that the fuel flow is not less than that declared by the manufacturer.

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

Maximum power	± 2 %
at the other measurement points	+ 6 % - 2 %.

3.1.6 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.

3.1.7 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.

3.2 Fuel

The fuel shall be the reference fuel whose specifications are given in Annex 6 to this Regulation.

3.3 Test laboratory

3.3.1 The absolute temperature T of the air (°) at the inlet to the engine 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, expressed in degrees Kelvin, and the atmospheric pressure ps, expressed in Kilopascals, shall be measured, and the atmospheric factor fa shall be determined according to paragraph 6.4.2.1 of Annex 10 to this Regulation which corresponds to the following provisions:

(°) The test may be carried out in air-conditioned test rooms where the atmospheric conditions may be controlled.

3.3.1.1 Naturally aspirated and mechanically supercharged engines:

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

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

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

3.3.2 For a test to be recognised as valid, the parameter f_a shall be such that $0.98 \leq f_a \leq 1.02$.

3.4 Sampling and measuring apparatus

The light-absorption coefficient of the exhaust gases shall be measured with an opacimeter satisfying the conditions laid down in Annex 8 and installed in conformity with Annex 9 to this Regulation.

4. EVALUATION OF THE ABSORPTION COEFFICIENT

4.1 For each of the engine speeds at which the absorption coefficient is measured pursuant to paragraph 2.2, the nominal gas flow shall be calculated by means of the following formulae:

for two-stroke engines: $G = V.n/60$

for four-stroke engines: $G = V.n/120$

in which:

G = nominal gas flow, in litres per second (l/s)

V = cylinder capacity of the engine, in litres (l)

n = engine speed, in revolutions per minute (min^{-1})

4.2 Where the value of the nominal flow is not one of those given in that table in Annex 7 to this Regulation, the limit value applicable shall be obtained by interpolation on the principle of proportional parts.

	% of maximum rated speed	% of maximum torque at that speed
1	100	100
2	90	100
3	100	90
4	90	90
5	100	80
6	90	80

Each measuring point governs the power and speed area to the left of and below that point and is the measuring point for any engine rated in that area. For example the measuring point at 'A' which is for the 90 % full load line and 100 % rated speed applies to the rated power/speed area bounded by ABCD on the diagram.

- 2.3 If the test is a bench test the engine shall be disconnected from the brake, the latter being replaced either by the rotating parts driven when no gear is engaged or by an inertia substantially equivalent to that of the said parts (see paragraph 7.3 of Annex 1 to this Regulation).
- 2.4 If the test is carried out on a vehicle the gear-change control shall be set in the neutral position and the drive between engine and gear-box engaged.
- 2.5 With the engine idling, the accelerator control shall be operated quickly, but not violently, so as to obtain maximum delivery from the injection pump. This position shall be maintained until maximum engine speed is reached and the governor comes into action. As soon as this speed is reached the accelerator shall be released until the engine resumes its idling speed and the opacimeter reverts to the corresponding conditions.
- 2.6 The operation described in paragraph 2.5 shall be repeated not less than six times in order to clear the exhaust system and to allow for any necessary adjustment of the apparatus. The maximum opacity values read in each successive acceleration shall be noted until stabilised values are obtained. No account shall be taken of the values read while, after each acceleration, the engine is idling. The values read shall be regarded as stabilised when four of them consecutively are situated within a band width of 0,25 m⁻¹ and do not form a decreasing sequence. The absorption coefficient X_M to be recorded shall be the arithmetical mean of these four values.
- 2.7 Engines fitted with an air pressure-charger shall be subject, where appropriate, to the following special requirements:
- 2.7.1 In the case of engines with an air pressure-charger which is coupled or driven mechanically by the engine and is capable of being disengaged, two complete measurement cycles with preliminary accelerations shall be carried out, the air pressure-charger being engaged in one case and disengaged in the other. The measurement result recorded shall be the higher of the two results obtained; and
- 2.7.2 in cases where the engine has several exhaust outlets, the tests shall be carried out with all the outlets joined in an adequate device ensuring mixture of the gases and ending in a single orifice. Free acceleration tests, however, may be carried out on each outlet. In this case the value to be used for calculating the correction to the absorption coefficient shall be the arithmetical mean of the values recorded at each outlet, and the test shall be regarded as valid only if the extreme values measured do not differ by more than 0,15 m⁻¹.

3. DETERMINATION OF THE CORRECTED VALUE OF THE ABSORPTION COEFFICIENT

Applicable where steady speed absorption coefficient has been effectively established on the same engine derivative.

3.1 Notation

X_M = value of the absorption coefficient under free acceleration measured as prescribed in paragraph 2.4 of this Annex

X_L = corrected value of the absorption coefficient under free acceleration

S_M = value of the absorption coefficient measured at steady speed (Annex 4(2.1)) which is closest to the prescribed limit value corresponding to the same nominal flow

S_L = value of the absorption coefficient prescribed in Annex 4(4.2), for the nominal flow corresponding to the point of measurement which gave the value S_M.

- 3.2 The absorption coefficients being expressed in m⁻¹ the corrected value X_L is given by the smaller of the following two expressions:

$$X_L = \frac{S_L}{S_M} X_M \text{ or } X_L = X_M + 0,5$$

ANNEX 6

SPECIFICATIONS OF REFERENCE FUEL PRESCRIBED FOR APPROVAL TESTS AND TO VERIFY CONFORMITY OF PRODUCTION

Property	Limits and units	ASTM method ⁽¹⁾
Density at 15 °C	min. 0,835 kg/l max. 0,845 kg/l	D 1298
Cetane index	min. 51 max. 57	D 976 D 86
50 % Vol. point	min. 245 °C	
90 % Vol. point	min. 320 °C max. 340	
Final boiling point	max. 370 °C	
Viscosity at 40 °C	min. 2,5 mm ² /s max. 3,5 mm ² /s	D 445
Sulphur content	min. 0,20 % mass max. 0,50	D 1266, D 2622 or D 2785
Flash point	min. 55 °C	D 93
Cold filter plugging point	max. - 5 °C	CEN Draft Pr EN116 or IP309
Conradsor carbon residue	max. 0,20 % mass on 10 % dist. residue	D 189
Ash content	max. 0,01 % mass	D 482
Water content	max. 0,05 % mass	D 95 or D 1744
Copper corrosion 100 °C	max. 1	D 130
Neutralisation (Strong acid) number	max. 0,20 mg KOH/g	D 974

⁽¹⁾ Initials of the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pennsylvania 19103, United States of America.

Note 1: Equivalent ISO methods will be referred to when issued for all properties listed above.

Note 2: The figures quoted show the total evaporated quantities (% recovered + % loss).

Note 3: This fuel may be based on straight run and cracked distillates; desulphurisation is allowed. It must not contain any metallic additives.

Note 4: The values quoted in the specification are 'true values'. In establishment of their limit values the terms of ASTM D 3244 'Defining a Basis for Petroleum Product Quality Disputes' have been applied and, in fixing a maximum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = Reproducibility). Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of a fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ASTM D 3244 should be applied.

Note 5: If it is required to calculate the thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from: specific energy (calorific value) (net)

$$\text{MJ/kg} = (46,423 - 8,792 d^2 + 3,170 d)$$

$$(1 - (x + y + s)) + 9,420 s - 2,499 x \text{ where:}$$

d is the density at 15 °C

x is the proportion by mass of water (% divided by 100)

y is the proportion by mass of ash (% divided by 100)

s is the proportion by mass of sulphur (% divided by 100).

ANNEX 7

LIMIT VALUES APPLICABLE FOR THE TEST AT STEADY SPEEDS

Nominal flow G litres/second	Absorption coefficient k $\frac{\text{m}^{-1}}{\text{m}^2}$
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 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.

ANNEX 8

CHARACTERISTICS OF OPACIMETERS

1. SCOPE

This Annex defines the conditions to be met by opacimeters used in the tests described in Annexes 4 and 5 to this Regulation.

2. BASIC SPECIFICATION FOR OPACIMETERS

2.1 The gas to be measured shall be confined in an enclosure having a non-reflecting internal surface.

2.2 In determining the effective length of the light path through the gas, account shall be taken of the possible influence of devices protecting the light source and the photoelectric cell. This effective length shall be indicated on the instrument.

2.3 The indicating dial of the opacimeter shall have two measuring scales, one in absolute units of light absorption from 0 to ∞ (m^{-1}) and the other linear from 0 to 100; both scales shall range from 0 at total light flux to full scale at complete obscuration.

3. CONSTRUCTION SPECIFICATIONS

3.1 **General**

The design shall be such that under steady-speed operating conditions the smoke chamber is filled with smoke of uniform opacity.

3.2 **Smoke chamber and opacimeter casing**

3.2.1 The impingement on the photoelectric cell of stray light due to internal reflections or diffusion effects shall be reduced to a minimum (e.g. by finishing internal surfaces in matt black and by a suitable general layout).

3.2.2 The optical characteristics shall be such that the combined effect of diffusion and reflection does not exceed one unit on the linear scale when the smoke chamber is filled with smoke having an absorption coefficient near $1,7 \text{ m}^{-1}$.

3.3 **Light source**

The light source shall be an incandescent lamp with a colour temperature in the range of 2 800 to 3 250 K or a green light-emitting diode (LED) with a spectral peak between 550 and 570 nm.

The light source shall be protected against sooting by means that do not influence the optical path length beyond the manufacturer's specifications.

3.4 **Receiver**

3.4.1 The receiver shall consist of a photoelectric cell with a spectral response curve similar to the photopic curve of the human eye (maximum response in the range 550/570 nm; less than 4 % of that maximum response below 430 nm and above 680 nm).

3.4.2 The construction of the electrical circuit, including the indicating dial, shall be such that the current output from the photoelectric cell is a linear function of the intensity of the light received over the operating-temperature range of the photoelectric cell.

3.5 **Measuring scales**

3.5.1 The light-absorption coefficient k shall be calculated by the formula $\bar{\varnothing} = \bar{\varnothing}_0 e^{-kL}$, where L is the effective length of the light path through the gas to be measured, $\bar{\varnothing}_0$ the incident flux and $\bar{\varnothing}$ the emergent flux. When the effective length L of a type of opacimeter cannot be assessed directly from its geometry, the effective length L shall be determined

either by the method described in paragraph 4 of this Annex; or

through correlation with another type of opacimeter for which the effective length is known.

- 3.5.2 The relationship between the 0-100 linear scale and the light-absorption coefficient k is given by the formula

$$K = - \frac{1}{L} \operatorname{Log}_e \left(1 - \frac{N}{100} \right)$$

where N is a reading on the linear scale and k the corresponding value of the absorption coefficient.

- 3.5.3 The indicating dial of the opacimeter shall enable an absorption coefficient of $1,7 \text{ m}^{-1}$ to be read with an accuracy of $0,025 \text{ m}^{-1}$.

3.6 Adjustment and calibration of the measuring apparatus

- 3.6.1 The electrical circuit of the photoelectric cell and of the indicating dial shall be adjustable so that the pointer can be reset at zero when the light flux passes through the smoke chamber filled with clean air or through a chamber having identical characteristics.
- 3.6.2 With the lamp switched off and the electrical measuring circuit open or short-circuited, the reading on the absorption-coefficient scale shall be ∞ , and it shall remain at ∞ with the measuring circuit reconnected.
- 3.6.3 An intermediate check shall be carried out by placing in the smoke chamber a screen representing a gas whose known light-absorption coefficient k , measured as described in paragraph 3.5.1, is between $1,6 \text{ m}^{-1}$ and $1,8 \text{ m}^{-1}$. The value of k must be known to within $0,025 \text{ m}^{-1}$.

The check consists in verifying that this value does not differ by more than $0,05 \text{ m}^{-1}$ from that read on the opacimeter indicating dial when the screen is introduced between the source of light and the photoelectric cell.

3.7 Opacimeter response

- 3.7.1 The response time of the electrical measuring circuit, being the time necessary for the indicating dial to reach 90 % of full-scale deflection on insertion of a screen fully obscuring the photoelectric cell, shall be 0,9 to 1,1 seconds.
- 3.7.2 The damping of the electrical measuring circuit shall be such that the initial overswing beyond the final steady reading after any momentary variation in input (e.g. the calibration screen) does not exceed 4 % of that reading in linear scale units.
- 3.7.3 The response time of the opacimeter which is due to physical phenomena in the smoke chamber is the time taken from the start of the gas entering the chamber to complete filling of the smoke chamber; it shall not exceed 0,4 seconds.
- 3.7.4 These provisions shall apply solely to opacimeters used to measure opacity under free acceleration.

3.8 Pressure of the gas to be measured and of scavenging air

- 3.8.1 The pressure of the exhaust gas in the smoke chamber shall not differ by more than 75 mm (water gauge) from the atmospheric pressure.
- 3.8.2 The variations in the pressure of the gas to be measured and of the scavenging air shall not cause the absorption coefficient to vary by more than $0,05 \text{ m}^{-1}$ in the case of a gas having an absorption coefficient of $1,7 \text{ m}^{-1}$.
- 3.8.3 The opacimeter shall be equipped with appropriate devices for measuring the pressure in the smoke chamber.
- 3.8.4 The limits of pressure variation of gas and scavenging air in the smoke chamber shall be stated by the manufacturer of the apparatus.

3.9 Temperature of the gas to be measured

- 3.9.1 At every point in the smoke chamber the gas temperature at the instant of measurement shall be between 70°C and a maximum temperature specified by the opacimeter manufacturer such that the readings over the temperature range do not vary by more than $0,1 \text{ m}^{-1}$ when the chamber is filled with a gas having an absorption coefficient of $1,7 \text{ m}^{-1}$.
- 3.9.2 The opacimeter shall be equipped with appropriate devices for measuring the temperature in the smoke chamber.

4. EFFECTIVE LENGTH 'L' OF THE OPACIMETER

4.1 General

- 4.1.1 In some types of opacimeter the gas between the light source and the photoelectric cell, or between transparent parts protecting the source and the photoelectric cell, is not of constant opacity. In such cases the effective length L shall be that of a column of gas of uniform opacity which gives the same absorption of light as that obtained when the gas is normally admitted into the opacimeter.
- 4.1.2 The effective length of the light path is obtained by comparing the reading N of the opacimeter operating normally with the reading N_0 obtained with the opacimeter modified so that the test gas fills a well defined length L_0 .
- 4.1.3 It will be necessary to take comparative readings in quick succession to determine the correction to be made for shifts of zero.

4.2 Method of assessment of L

- 4.2.1 The test gas shall be exhaust gas of constant opacity or a light-absorptive gas of a gravimetric density similar to that of exhaust gas.
- 4.2.2 A column of length L_0 of the opacimeter, which can be filled uniformly with the test gas, and the ends of which are substantially at right angles to the light path, shall be accurately determined. This length L_0 shall be close to the effective length of the opacimeter.
- 4.2.3 The mean temperature of the test gas in the smoke chamber shall be measured.
- 4.2.4 If necessary, an expansion tank of sufficient capacity to damp the pulsations and of compact design may be incorporated in the sampling line as near to the probe as possible. A cooler may also be fitted. The addition of the expansion tank and of the cooler should not unduly disturb the composition of the exhaust gas.
- 4.2.5 The test for determining the effective length shall consist in passing a sample of test gas alternately through the opacimeter operating normally and through the same apparatus modified as indicated in paragraph 4.1.2.
- 4.2.5.1 The opacimeter readings shall be recorded continuously during the test with a recorder whose response time is equal to or shorter than that of the opacimeter.
- 4.2.5.2 With the opacimeter operating normally, the reading on the linear scale of opacity is N and that of the mean gas temperature expressed in Kelvin degrees is T .
- 4.2.5.3 With the known length L_0 filled with the same test gas, the reading on the linear scale of opacity is N_0 and that of the mean gas temperature expressed in Kelvin degrees is T_0 .
- 4.2.6 The effective length will be

$$L = L_0 \frac{T}{T_0} \frac{\text{Log} \left(1 - \frac{N}{100} \right)}{\text{Log} \left(1 - \frac{N_0}{100} \right)}$$

- 4.2.7 The test shall be repeated with at least four test gases giving readings evenly spaced between the readings 20 and 80 on the linear scale.
- 4.2.8 The effective length L of the opacimeter will be the arithmetic average of the effective lengths obtained as stated in paragraph 4.2.6. for each of the gases.

ANNEX 9

INSTALLATION AND USE OF THE OPACIMETER

1. SCOPE

This Annex specifies the installation and use of opacimeters for the tests described in Annexes 4 and 5 to this Regulation.

2. SAMPLING OPACIMETER

2.1 Installation for steady-speed tests

2.1.1 The ratio of the cross-sectional area of the probe to that of the exhaust pipe shall not be less than 0,05. The back pressure measured in the exhaust pipe at the opening of the probe shall not exceed 75 mm (water gauge).

2.1.2 The probe shall be a tube with an open end facing forwards in the axis of the exhaust pipe, or of the extension pipe if one is required. It shall be situated in a section where the distribution of smoke is approximately uniform. To achieve this, the probe shall be placed as far downstream in the exhaust pipe as possible, or, if necessary, in an extension pipe so that, if D is the diameter of the exhaust pipe at the opening, the end of the probe is situated in a straight portion at least $6 D$ in length upstream of the sampling point and $3 D$ in length downstream. If an extension pipe is used, no air shall be allowed to enter the joint.

2.1.3 The pressure in the exhaust pipe and the characteristics of the pressure drop in the sampling line shall be such that the probe collects a sample sensibly equivalent to that which would be obtained by isokinetic sampling.

2.1.4 If necessary, an expansion tank of compact design and of sufficient capacity to damp the pulsations may be incorporated in the sampling line as near to the probe as possible. A cooler may also be fitted. The design of the expansion tank and cooler shall not unduly disturb the composition of the exhaust gas.

2.1.5 A butterfly valve or other means of increasing the sampling pressure may be placed in the exhaust pipe at least three $3 D$ downstream from the sampling probe.

2.1.6 The connecting pipes between the probe, the cooling device, the expansion tank (if required) and the opacimeter shall be as short as is possible while satisfying the pressure and temperature requirements prescribed in Annex 8(3.8) and (3.9). The pipe shall be inclined upwards from the sampling point to the opacimeter, and sharp bends where soot might accumulate shall be avoided. If not embodied in the opacimeter, a by-pass valve shall be provided upstream.

2.1.7 A check shall be carried out during the test to ensure that the requirements of Annex 8(3.8), concerning pressure and those of Annex 8(3.9), concerning the temperature in the measuring chamber are observed.

2.2 Installation for tests under free acceleration

2.2.1 The ratio of the cross-sectional area of the probe to that of the exhaust pipe shall not be less than 0,05. The back pressure measured in the exhaust pipe at the opening of the probe shall not exceed 75 mm (water gauge).

2.2.2 The probe shall be a tube with an open end facing forwards in the axis of the exhaust pipe, or of the extension pipe if one is required. It shall be situated in a section where the distribution of smoke is approximately uniform. To achieve this, the probe shall be placed as far downstream in the exhaust pipe as possible or, if necessary, in an extension pipe so that, if D is the diameter of the exhaust pipe at the opening, the end of the probe is situated in a straight portion at least $6 D$ in length upstream of the sampling point and $3 D$ in length downstream. If an extension pipe is used, no air shall be allowed to enter the joint.

2.2.3 The sampling system shall be such that at all engine speeds the pressure of the sample at the opacimeter is within the limits specified in Annex 8(3.8.2). This may be checked by noting the sample pressure at engine idling and maximum no-load speeds. Depending on the characteristics of the opacimeter, control of sample pressure can be achieved by a fixed restriction or butterfly valve in the exhaust pipe or extension pipe.

Whichever method is used, the back pressure measured in the exhaust pipe at the opening of the probe shall not exceed 75 mm (water gauge).

2.2.4 The pipes connecting with the opacimeter shall also be as short as possible. The pipe shall be inclined upwards from the sampling point to the opacimeter, and sharp bends where soot might accumulate shall be avoided. A by-pass valve may be provided upstream of the opacimeter to isolate it from the exhaust-gas flow when no measurement is being made.

3. FULL-FLOW OPACIMETER

The only general precautions to be observed in steady-speed and free-acceleration tests are the following:

3.1 Joints in the connecting pipes between the exhaust pipe and the opacimeter shall not allow air to enter from outside.

3.2 The pipes connecting with the opacimeter shall be as short as possible, as prescribed in the case of sampling opacimeters. The pipe system shall be inclined upwards from the exhaust pipe to the opacimeter, and sharp bends where soot might accumulate shall be avoided. A by-pass valve may be provided upstream of the opacimeter to isolate it from the exhaust-gas flow when no measurement is being made.

3.3 A cooling system may also be required upstream of the opacimeter.

ANNEX 10

'ECE' METHOD OF MEASURING THE NET POWER OF C.I. ENGINES**1. PURPOSE**

These provisions apply to the method for representing the curve of the power at full load of an internal combustion engine as a function of engine speed.

2. SCOPE

This method applies to internal combustion engines used for the propulsion of the vehicles covered by this Regulation and Regulation No 15 (E/ECE/324-E/ECE/505/Rev.1/Add.14/Rev.3).

The engines belong to one of the following categories:

Reciprocating piston engines (positive ignition or compression ignition) excluding free piston engines;
Rotary piston engines.

These engines may be naturally aspirated or supercharged.

3. DEFINITIONS

For the purposes of these provisions,

'Net power' means the power obtained on a test bench at the end of the crankshaft or its equivalent ⁽¹⁾ at the corresponding engine speed with the auxiliaries listed in Table 1;

'Standard production equipment' means any equipment provided by the manufacturer for a particular engine application.

4. ACCURACY OF MEASUREMENTS**4.1 Torque**

± 1 % of measured torque ⁽²⁾.

4.2 Engine speed

± 0,5 % of measured speed.

4.3 Fuel consumption

± 1 % of measured consumption

4.4 Fuel temperature

± 2 K 4,5

4.5 Air temperature

± 2 K

4.6 Barometric pressure

± 100 Pa

4.7 Pressure in intake duct (see note 1a to Table 1)

± 50 Pa

4.8 Pressure in exhaust duct (see note 1b to Table 1)

± 200 Pa

⁽¹⁾ If power measurement can be carried out only on an engine with the gear-box mounted, the efficiency of the gear-box shall be taken into account.

⁽²⁾ The torque measuring system shall be calibrated to take friction losses into account. The accuracy in the lower half of the measuring range of the dynamometer bench may be ± 2 per cent of measured torque.

5. TEST FOR MEASURING NET ENGINE POWER

5.1 **Auxiliaries**5.1.1 *Auxiliaries to be fitted*

During the test, the auxiliaries necessary for the engine operation in the intended application (as listed in Table 1) shall be installed on the test bench as far as possible in the same position as in the intended application.

5.1.2 *Auxiliaries to be removed*

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

- Air compressor for brakes
- Power steering compressor
- Suspension compressor
- Air-conditioning system.

Where accessories cannot be removed, the power they absorb in the unloaded condition may be determined and added to the measured engine power.

Table 1

Auxiliaries to be fitted for the test to determine net power of engine

No	Auxiliaries	Fitted for net power test
1	Intake system <ul style="list-style-type: none"> — Intake manifold — Crankcase emission control system — Air filter — Intake silencer — Speed limiting device 	Yes, standard production equipment Yes, standard production equipment ^(1a)
2	Induction heating device of intake manifold	Yes, standard production equipment. If possible, to be set in the most favourable position
3	Exhaust system <ul style="list-style-type: none"> — Exhaust purifier — Exhaust manifold — Supercharging device — Connecting pipes ^(1b) — Silencer ^(1b) — Tail pipe ^(1b) — Exhaust brake ⁽²⁾ 	Yes, standard production equipment.
4	Fuel supply pump ⁽³⁾	Yes, standard production equipment.
5	Carburettor <ul style="list-style-type: none"> — Electronic control system, air flow meter, etc. (if fitted) — Pressure reducer — Evaporator — Mixer 	Yes, standard production equipment. Equipment for gas engines

No	Auxiliaries	Fitted for net power test
6	Fuel injection equipment (petrol and diesel) <ul style="list-style-type: none"> — Prefilter — Filter — Pump — High pressure pipe — Injector — Air intake valve ⁽⁴⁾, if fitted — Electronic control system, air flow meter, etc. ... (if fitted) — Governor/control system — Automatic full-load stop for the control rack depending on atmospheric conditions 	Yes, standard production equipment
7	Liquid cooling equipment <ul style="list-style-type: none"> — Engine bonnet — Bonnet air outlet — Radiator — Fan ⁽⁵⁾ ⁽⁶⁾ — Fan cowl — Water pump — Thermostat ⁽⁷⁾ 	No Yes ⁽⁵⁾ , standard production equipment
8	Air cooling <ul style="list-style-type: none"> — Cowl — Blower ⁽⁵⁾ ⁽⁶⁾ Temperature regulating device	Yes, standard production equipment Yes, standard production equipment
9	Electrical equipment	Yes ⁽⁸⁾ , standard production equipment
10	Supercharging equipment (if fitted) <ul style="list-style-type: none"> — Compressor driven either directly by the engine, and/or by the exhaust gases — Charge air cooler ⁽⁹⁾ — Coolant pump or fan (engine driven) — Coolant flow control devices (if fitted) 	Yes, standard production equipment

No	Auxiliaries	Fitted for net power test
11	Auxiliary test bench fan	Yes, if necessary
12	Anti-pollution devices ⁽¹⁰⁾	Yes, standard production equipment

^(1a) The complete intake system shall be fitted as provided for the intended application:

Where there is a risk of an appreciable effect on the engine power

In the case of two-stroke and positive-ignition engines

When the manufacturer requests that this should be done.

In other cases, an equivalent system may be used and a check should be made to ascertain that the intake pressure does not differ by more than 100 Pa from the limit specified by the manufacturer for a clean air filter.

^(1b) The complete exhaust system shall be fitted as provided for the intended application:

Where there is a risk of an appreciable effect on the engine power

In the case of two-stroke and positive ignition engines

When the manufacturer requests that this should be done.

In other cases, an equivalent system may be installed provided the pressure measured at the exit of the engine exhaust system does not differ by more than 1 000 Pa from that specified by the manufacturer.

⁽²⁾ 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

⁽³⁾ If an exhaust brake is incorporated in the engine, the throttle valve must be fixed in a fully open position. The fuel feed pressure may be adjusted, if necessary, to reproduce the pressures existing in the particular engine application (particularly when a 'fuel return' system is used).

⁽⁴⁾ The air intake valve is the control valve for the pneumatic governor of the injection pump. The governor of the fuel injection equipment may contain other devices which may affect the amount of injected fuel

⁽⁵⁾ The radiator, the fan, the fan cowl, the water pump and the thermostat shall be located on the test bench in the same relative positions as on the vehicle. The cooling liquid circulation shall be operated by the engine water pump only.

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

Where the fan, radiator and cowl system cannot conveniently be fitted to the engine, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cowl (if used), must 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 paragraph 6.2, should be deducted from the corrected power.

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

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

⁽⁸⁾ Minimum power of the generators the power of the generator shall 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 must be used

⁽⁹⁾ Charge air-cooled engines shall be tested with charge air cooling, whether liquid- or air-cooled, but if the engine manufacturer prefers, a test bench system may replace the air-cooled cooler. In either case, the measurement of power at each speed shall be made with the same pressure drop and temperature drop of the engine air across the charge air cooler on the test bench system as those specified by the manufacturer for the system on the complete vehicle

⁽¹⁰⁾ They may include, for example, EGR (exhaust gas recirculation) system, catalytic convertor, thermal reactor, secondary air supply system and fuel evaporation protecting system.

5.1.3 Compression ignition engine starting auxiliaries

For the auxiliaries used in starting compression ignition engines, the two following cases shall be considered:

(a) Electrical starting. The generator is fitted and supplies, where necessary, the auxiliaries indispensable to the operation of the engine;

(b) Starting other than electrical. If there are any electrically operated accessories indispensable to the operation of the engine, the generator is fitted to supply these accessories. Otherwise, it is removed.

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

5.2. Setting conditions

The setting conditions for the test to determine the net power are indicated in table 2.

Table 2

Setting conditions

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

5.3 Test conditions

- 5.3.1 The net power test shall consist of a run at full throttle for positive-ignition engines and at fixed full-load fuel injection pump setting for diesel engines, the engine being equipped as specified in table 1.
- 5.3.2 Performance data shall be obtained under stabilizing operating conditions with an adequate fresh air supply to the engine. The engines must have been run-in in accordance with the manufacturer's recommendations. Combustion chambers may contain deposits, but in limited quantity. Test conditions, such as inlet air temperature, shall be selected as near to reference conditions (see paragraph 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 placed directly in the air stream. It shall also be shielded from fuel sprayback. A sufficient number of locations shall be used to give a representative average inlet temperature.
- 5.3.4 No data shall be taken until torque, speed and temperatures 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 per cent or $\pm 10 \text{ min}^{-1}$, whichever is greater.
- 5.3.6 Observed brake load, fuel consumption and inlet air temperature data shall be taken simultaneously and shall be the average of two stabilised consecutive values which do not vary more than 2 % for the brake load and fuel consumption.
- 5.3.7 The temperature of the coolant at the outlet from the engine shall be kept within $\pm 5 \text{ K}$, from the upper thermostatically-controlled temperature specified by the manufacturer. If no temperature is specified by the manufacturer, the temperature shall be $353 \text{ K} \pm 5 \text{ K}$. For air-cooled engines, the temperature at a point indicated by the manufacturer shall be kept within -20 K 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 at 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 regulating system may be used if necessary to maintain the temperatures within the limits specified in paragraphs 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 smoke suppressant additives. In any case of dispute, the reference fuel shall be:
- (a) Diesel engines, as defined by CEC (*) in CEC-RF-03-A-80;
 - (b) Positive ignition engines, as defined by CEC-RF-01-A-80.

(*) European Coordinating Council for the Development of Performance Tests for Lubricants and Engine Fuels.

5.4 Test procedure

Measurements shall be taken at a sufficient number of engine speeds to define correctly the power curve between the lowest and the highest engine speeds recommended by the manufacturer. This range of speeds must include the speed of revolution at which the engine produces its maximum power. The average of at least two stabilised measurements is to be determined.

5.5 Data to be recorded

Data to be recorded are those indicated in the appendix to this Annex.

6. POWER CORRECTION FACTORS

6.1 Definition

The power correction factor is the coefficient α by which the measured power must be multiplied to determine the engine power under the reference atmospheric conditions specified in paragraph 6.2.

$$P_o = \alpha P$$

where

P_o is the corrected power (i.e. power under reference atmospheric conditions)

α is the correction factor (α_a or α_d)

P is the measured power (test power).

6.2 Reference atmospheric conditions

6.2.1 Temperature (T_o): 298 K (25 °C)

6.2.2 Dry pressure (P_{so}): 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 Test atmospheric conditions

The atmospheric conditions during the test shall be the following:

6.3.1 Temperature (T)

For positive-ignition engines $288 \text{ K} \leq T \leq 308 \text{ K}$

For diesel engines $283 \text{ K} \leq T \leq 313 \text{ K}$

6.3.2 Pressure (P_s)

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

6.4 Determination of correction factor α_a and α_d ⁽¹⁾

6.4.1 Naturally aspirated or supercharged positive-ignition engine — Factor α_a :

The correction factor α_a is obtained by applying the formula:

$$\alpha_a = \frac{(99)^{12}}{(P_s)} \cdot \frac{(T)^{0,6}}{(298)} \quad (2)$$

where:

P_s is the total dry atmospheric pressure in kilopascals (kPa); that is to say, the total barometric pressure minus water vapour pressure;

T is the absolute temperature in Kelvins (K) of the air drawn in by the engine.

Conditions to be complied with in the laboratory

For a test to be valid, the correction factor α_a must be such that $0,93 \leq \alpha_a \leq 1,07$.

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.

⁽¹⁾ The tests may be carried out in air-conditioned test rooms where the atmospheric conditions may be controlled.

⁽²⁾ In the case of engines fitted with automatic air temperature control, if the device is such that at full load at 25 °C no heated air is added, the test shall be carried out with the device fully closed. If the device is still operating at 25 °C then 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).

6.4.2 Diesel engines — Factor α_d :

The power correction factor (α_d) for diesel engines at constant fuel rate is obtained by applying the formula:

$$\alpha_d = (f_d)^{f_m}$$

where:

f_a is the atmospheric factor;

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

6.4.2.1 Atmospheric factor f_a

This factor indicates the effects of environmental conditions (pressure, temperature and humidity) on the air drawn in by the engine.

The atmospheric factor formula differs according to the type of engines.

6.4.2.1.1 Naturally aspirated and mechanically supercharged engines

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

6.4.2.1.2 Turbocharged engines with or without cooling of inlet air

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

6.4.2.2 Engine factor f_m

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

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

where:

$$q_c = q/r$$

where:

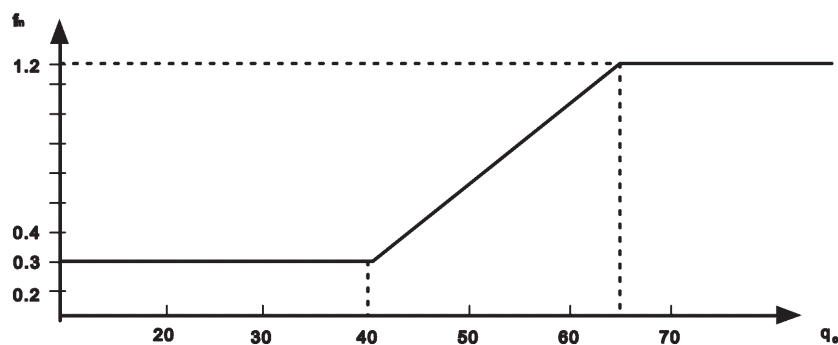
'q' is the fuel flow in milligramme per cycle per litre of total swept volume (mg/(l. cycle)).

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

This formula is valid for a value interval of q_c included between 40 mg/(l. cycle) and 65 mg/(l. cycle).

For q_c values lower than 40 mg/(l. cycle), a constant value of f_m equal to 0,3 ($f_m = 0,3$) will be taken.

For q_c values higher than 65 mg/(l. cycle), a constant value of f_m equal to 1,2 ($f_m = 1,2$) will be taken (see the figure below):



6.4.2.3 Conditions to be complied with in the laboratory

For a test to be valid, the correction factor α_d must be such that $0,9 \leq \alpha_d \leq 1,1$.

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.

7. TEST REPORT

The test report shall contain the results and all the calculations required to find the net power, as listed in the appendix to this Annex, together with the characteristics of the engine listed in Annex 1 to this Regulation

8. MODIFICATION OF ENGINE TYPE

Any modification of the engine with regard to the characteristics listed in Annex 1 to this Regulation must be reported to the competent administration. That administration may then either:

- 8.1 Consider that the modifications made are not liable to have any substantial effect on the power of the engine, or
- 8.2. Request a further determination of the engine power through the carrying-out of such tests as are deemed necessary.

9. TOLERANCES FOR MEASURING THE NET POWER

- 9.1 The net power of the engine measured by the technical service may differ by $\pm 2\%$ from the net power specified by the manufacturer, with a tolerance of 1,5 % for the engine speed.
 - 9.2 The net power of an engine at a production conformity test may differ by 5 % from the net power at a type approval test.
-

ANNEX 10

Appendix

STATEMENT OF THE RESULTS OF TESTS FOR MEASURING NET ENGINE POWER

This information is to be supplied by the manufacturer simultaneously with the identification sheet constituting Annex 1 to the Regulation. If the test under this Regulation is a bench test of the engine, this form shall be completed by the laboratory performing the test.

1. **Test conditions**1.1 *Pressures measured at maximum power*

1.1.1 Total barometric pressure: Pa

1.1.2 Water vapour pressure: Pa

1.1.3 Exhaust pressure: Pa

1.2 *Temperatures measured at maximum power*

1.2.1 of the intake air: K

1.2.2 at the outlet of the engine intercooler: K

1.2.3 of the cooling fluid:

1.2.3.1 at the engine cooling fluid outlet: K ⁽¹⁾1.2.3.2 at the reference point in the case of air cooling: K ⁽¹⁾

1.2.4 of the lubricating oil (indicate point of measurement): K

1.2.5 of the fuel

1.2.5.1 at the fuel pump inlet: K

1.2.5.2 in the fuel-consumption measuring device: K

1.3 *Characteristics of the dynamometer*

1.3.1 Make: Model:

1.3.2 Type:

2. **Fuel**2.1 *For positive-ignition engines operating on liquid fuel*

2.1.1 Make:

2.1.2 Specification:

2.1.3 Anti-knock additive (lead, etc.):

2.1.3.1 Type:

2.1.3.2 Contents: mg/l

2.1.4 Octane number RON: (ASTM D 26 99-70)

2.1.4.1 Specific density: g/cm³ at 288 K

2.1.4.2 Lower calorific value: kJ/kg

2.2 *For positive-ignition engines operating on gaseous fuel*

2.2.1 Make:

2.2.2 Specification:

2.2.3 Storage pressure: bar

2.2.4 Utilisation pressure: bar

2.2.5 Lower calorific value: kJ/kg

⁽¹⁾ Strike out what does not apply.

- 2.3 *For compression-ignition engines operating on gaseous fuels*
- 2.3.1 Feed system: gas
- 2.3.2 Specification of gas used:
- 2.3.3 Fuel oil/gas proportion:
- 2.3.4 Lower calorific value: kJ/kg
- 2.4 *For compression-ignition engines operating on liquid fuel*
- 2.4.1 Make:
- 2.4.2 Specification of fuel used:
- 2.4.3 Cetane index (ASTM D 976-71)
- 2.4.4 Specific density: g/cm³ at 288 K
- 2.4.5 Lower calorific value: kJ/kg
3. **Lubricant**
- 3.1 Make:
- 3.2 Specification:
- 3.3 SAE viscosity:
4. **Detailed results of measurements**
- 4.1 *Statements of results of net power measurement test (*)*

Engine speed, min ⁻¹			
Measured torque, Nm			
Measured power, kW			
Measured fuel flow, g/kWh			
Measured smoke index, m ⁻¹ (1)			
Barometric pressure, kPa			
Water vapour pressure, kPa			
Inlet air temperature, K			
Power to be added for auxiliaries in excess of Table 1, kW	No 1		
	No 2		
	No 3		
Power correction factor			
Corrected brake power, kW (with/without (2) fan)			
Power of fan, kW (to be subtracted if fan not fitted)			
Net power, kW			
Net torque, Nm			
Corrected specific fuel consumption g/kWh (3)			
Smoke index m ⁻¹			

(*) The characteristic curves of the net power and the net torque shall be drawn as a function of the engine speed.

Cooling liquid temperature at outlet, K		
Lubricating oil temperature at measuring point, K		
Air temperature after supercharger, K ⁽⁴⁾		
Fuel temperature at injection pump inlet, K		
Air temperature after charge air cooler, K ⁽⁴⁾		
Pressure after supercharger, kPa ⁽⁴⁾		
Pressure after charge air cooler, kPa		

⁽¹⁾ Only for diesel engines.
⁽²⁾ Strike out what does not apply
⁽³⁾ Calculated with the net power for compression-ignition and positive ignition engines, in the latter case multiplied by the power correction factor.
⁽⁴⁾ If applicable.

- 4.2 *Maximum net powers* kW at min⁻¹
- 4.3 *Maximum net torques* Nm at min⁻¹
5. **Engine submitted for testing on**
6. **Technical service conducting tests**
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