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Acts whose titles are printed in light type are those relating to day-to-day management of agricultural matters, and are generally valid for a limited period.

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I

(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.

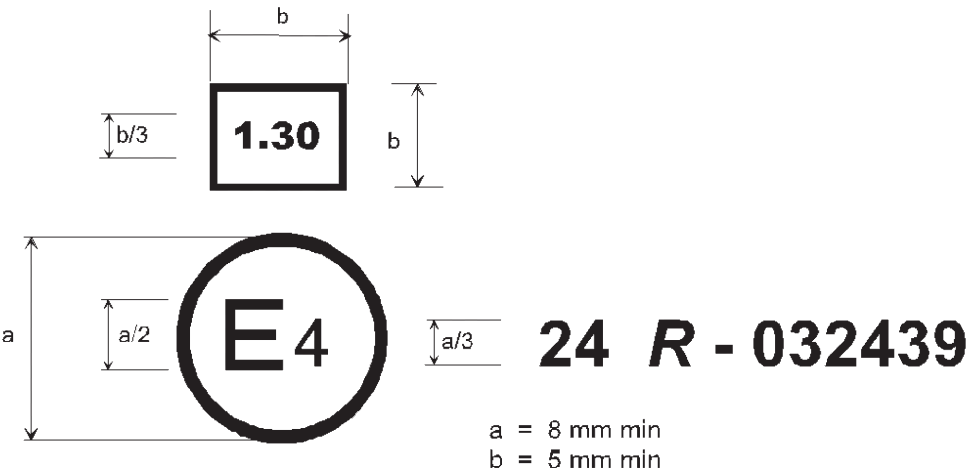
⁽¹⁾ Name of the administration.⁽²⁾ Strike out what does not apply.⁽³⁾ Complete or enter 'not applicable', according to type of approval requested.⁽⁴⁾ The lower limit may be that stated by the manufacturer in accordance with paragraph 6.3.4 of part 1 of this Regulation.

ANNEX 3

ARRANGEMENTS OF APPROVAL MARKS

Model A

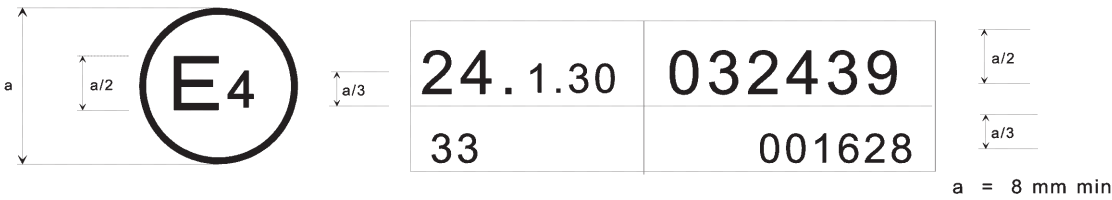
(See paragraphs 5.8, 14.8 and 23.8 of this Regulation)



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.

ANNEX 5

TEST UNDER FREE ACCELERATION

1. TEST CONDITIONS

1.1 The test shall be carried out on an engine installed on a test bench or on a vehicle.

1.1.1. If the engine test is a bench test it shall be carried out as soon as possible after the test for measurement of opacity under full load at steady speed. In particular, the cooling water and the oil shall be at the normal temperatures stated by the manufacturer.

1.1.2 If the test is carried out on a stationary vehicle the engine shall first be brought to normal operating conditions during a road run or on a dynamic test. The test shall be carried out as soon as possible after completion of this warming up period.

1.2 The combustion chamber shall not have been cooled or fouled by a prolonged period of idling preceding the test.

1.3 The test conditions prescribed in Annex 4(3.1), (3.2) and (3.3) shall apply.

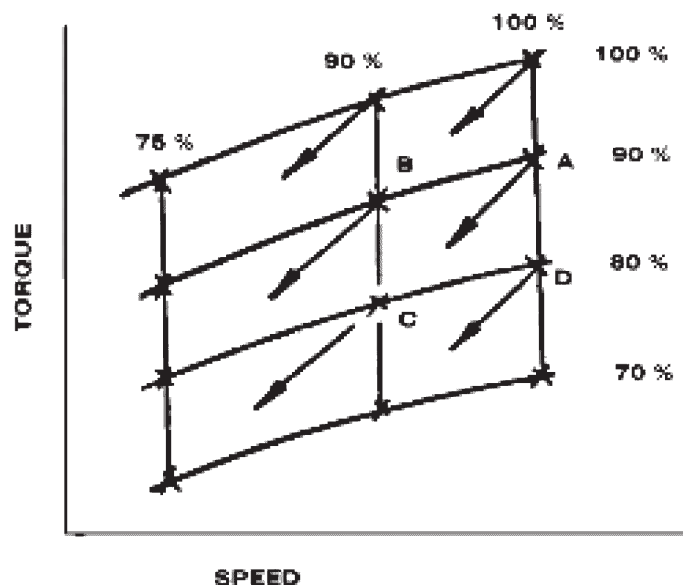
1.4 The conditions prescribed in Annex 4(3.4) with regard to the sampling and measuring apparatus shall apply.

2. TEST METHODS

2.1 The free acceleration visible pollutants shall be measured with the engine in the maximum rated speed and maximum power condition.

2.2 At the request of the manufacturer, measurements shall also be made over a matrix of up to five other power/speed combinations for the de-speeded and de-rated engine to cover the range of speed and power allowed for in paragraph 6.3.4. of part I of this Regulation covering the modification of an engine type. In this case the steady state visible pollutants will also be measured with the engine rated at these other points, by the method described in Annex 4 to this Regulation, to enable the free acceleration absorption coefficient to be corrected in accordance with paragraph 3 of this Annex. These values shall be recorded in Table 2 of Annex 2 to this Regulation.

The diagram below shows the six possible measuring points of the matrix and the range of power and speed governed by each point.



	% 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 $0,25 \text{ m}^{-1}$ 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 $0,15 \text{ m}^{-1}$.

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 — 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 — 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 — 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) — 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 — Engine bonnet — Bonnet air outlet — Radiator — Fan ⁽⁵⁾ ⁽⁶⁾ — Fan cowl — Water pump — Thermostat ⁽⁷⁾	No Yes ⁽⁵⁾ , standard production equipment
8	Air cooling — 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) — 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:

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

where:

f_a is the atmospheric factor;

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

6.4.2.1 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:

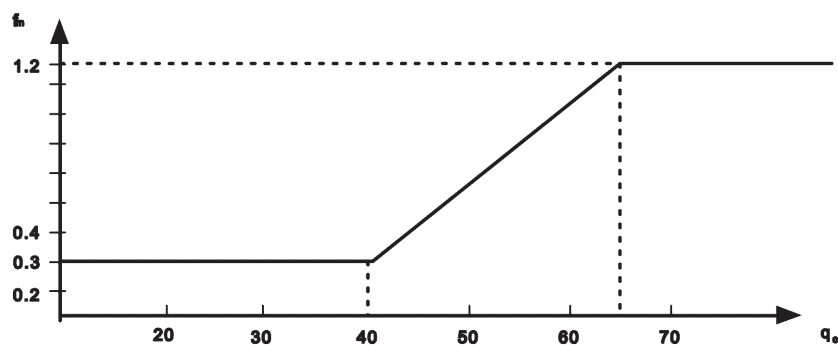
'q' is the fuel flow in milligramme per cycle per litre of total swept volume (mg/(l. cycle)).

'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**
-

Regulation No 59 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of replacement silencing systems

1. SCOPE

This Regulation contains provisions relating to the approval of silencing systems or components thereof to be fitted to one or more given types of motor vehicles in categories M₁ and N₁ ⁽¹⁾ as replacement parts.

2. DEFINITIONS

For the purpose of this Regulation,

- 2.1. 'Silencing system' means a complete set of components necessary for limiting the noise produced by the engine of a motor vehicle and its exhaust;
- 2.2. 'Silencing system component' means one of the separate components which together form the exhaust system (e.g. silencer proper, expansion chamber, resonator);
- 2.3. 'Silencing system of different types' means silencing systems which differ significantly in such respects as:
 - 2.3.1. that their components bear different trade names or marks,
 - 2.3.2. that the characteristics of the materials constituting a component are different or that the components differ in shape or size, a modification regarding the coating (zinc coating, aluminium coating, etc.) is not considered changing the type,
 - 2.3.3. that the operating principles of at least one component are different,
 - 2.3.4. that their components are combined differently;
- 2.4. 'Replacement silencing system or components of said system' means any part of the exhaust system defined in paragraph 2.1. above, intended for use on a vehicle, other than a part of the type fitted to this vehicle when submitted for type approval pursuant to this Regulation;
- 2.5. 'Approval of a replacement silencing system or components of said system' means the approval of the whole or part of a silencing system adaptable to one or several specified types of motor vehicles, as regards the limitation of their noise level;
- 2.6. 'Vehicle type' means a category of motor vehicles which do not differ significantly in such respects as:
 - 2.6.1. the lines and constituent materials of the body (more particularly the engine compartment and its soundproofing),
 - 2.6.2. the length and width of the vehicle,
 - 2.6.3. the type of engine (positive ignition, compression ignition, two stroke or four stroke, reciprocating or rotary), number and capacity of cylinders, number of carburetors, arrangement of valves, maximum horse-power and corresponding engine speed (r.p.m.), etc.
 - 2.6.4. number and ratios of gears, total ratio of the transmission,
 - 2.6.5. the number, type and arrangement of the exhaust systems, and
 - 2.6.6. the number, type and arrangement of the intake systems.

⁽¹⁾ Category M: Power-driven vehicles having at least four wheels or having three wheels when the maximum weight exceeds 1 metric ton, and used for the carriage of passengers. (articulated vehicles comprising two non-separable but articulated units shall be considered as single vehicles.)

Category M₁: Vehicles used for the carriage of passengers and comprising not more than eight seats in addition to the driver's seat.

Category N: Power-driven vehicles having at least four wheels or having three wheels when the maximum weight exceeds 1 metric ton and used for the carriage of goods.

Category N₁: Vehicles used for the carriage of goods and having a maximum weight not exceeding 3,5 metric tons. In conformity with 'Classification of vehicles' in Regulation No 13 (E/ECE/324 — E/ECE/TRANS/505/Rev.1/Add.12/Rev.2, paragraph 5.2.).

3. APPLICATION FOR APPROVAL

- 3.1. The application for approval of a replacement silencing system or components of said system shall be submitted by its manufacturer or by this duly accredited representative.
- 3.2. It shall be accompanied by the undermentioned documents in triplicate and the following particulars:
- 3.2.1. a description of the vehicle type(s) on which the system or components is intended to be mounted, with regard to the items mentioned in paragraph 2.6. above. The numbers and/or symbols identifying the engine type and the vehicle type shall be specified and the vehicle type approval number, if necessary;
- 3.2.2. a description of the assembled silencing system showing the relative position of each of its components, as well as mounting instructions;
- 3.2.3. detailed drawings of each component to enable it to be easily located and identified, and a specification of the material used.
- 3.3. On request of the technical service conducting the tests for approval, the manufacturer of the silencing system shall submit:
- 3.3.1. two samples of the system or components submitted for approval;
- 3.3.2. a sample of the original silencing system with which the vehicle was equipped when submitted for type approval;
- 3.3.3. a vehicle representative of the type to which the system is to be fitted; this vehicle, when measured for noise emission according to the methods described in paragraphs 3.1. and 3.2. of annex 3 to Regulation No 51, must satisfy the following conditions:
- 3.3.3.1. the noise level when the vehicle is in motion must not exceed the limit applicable to the category of vehicle concerned at the time when the type to which the vehicle belongs was approved; furthermore, it must not exceed by more than 3 dB(A) the noise level indicated in the approval of the type to which the vehicle belongs;
- 3.3.3.2. the noise level when the vehicle is stationary must not exceed by more than 3 dB (A) the reference value indicated in the approval of the type to which the vehicle belongs;
- 3.3.4. A separate engine, of at least the same cylinder capacity and power as that of the abovementioned vehicle.

4. MARKINGS

- 4.1. Each component of the replacement silencing system, excluding tubes and mounting accessories, shall bear:
- 4.1.1. the trade name or mark of the manufacturer of the system or its components,
- 4.1.2. the commercial description given by the manufacturer.
- 4.2. Such markings shall be clearly legible and indelible.

5. APPROVAL

- 5.1. If the type of replacement silencing system submitted for approval pursuant to this Regulation meets the requirements of paragraph 6. below, approval for that type shall be granted.
- 5.2. An approval number shall be assigned to each type approved. Its first two digits (at present 00 for the Regulation in its original form) 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 type of replacement silencing system or component designed for the same type(s) of vehicle.

- 5.3. Notice of approval or of refusal of approval of a replacement silencing system or components of said system pursuant to this Regulation shall be communicated to the Parties to the Agreement which apply this Regulation, by means of a form conforming to the model in annex 1 to the Regulation, and of drawings of the silencing system or components supplied by the applicant for approval, in a format not exceeding A4 (210 × 297 mm) or folded to that format and on an appropriate scale.
- 5.4. There shall be affixed to every component of silencing system conforming to a 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 approval number shall be mentioned in the approval form, as well as the method used for approval tests.
- 5.5. The approval mark shall be easily legible and indelible, when the silencing system is mounted on the vehicle.
- 5.6. A component may be marked with more than one approval number if it has been approved as a part of more than one replacement silencing system; in this case the circle need not be repeated. Annex 2 to this Regulation gives an example of the arrangement of the approval mark.
6. SPECIFICATIONS
- 6.1. **General specifications**
- 6.1.1. The replacement, exhaust system or components thereof must be designed, constructed and capable of being mounted so as to ensure that the vehicle complies with the provisions of this Regulation under normal conditions of use, notwithstanding any vibrations to which it may be subject.
- 6.1.2. The silencing system or components thereof must be designed, constructed and capable of being mounted so that reasonable resistance to the corrosion phenomenon to which it is exposed is obtained having regard to the conditions of use of the vehicle.
- 6.2. **Specifications regarding noise levels**
- 6.2.1. The acoustic efficiency of the replacement silencing system or components of said system shall be verified by means of the methods described in paragraphs 3.1. and 3.2. of annex 3 to Regulation No 51. When the replacement silencing system or components thereof is mounted on the vehicle described in paragraph 3.3.3. above, the noise levels obtained using the two methods (stationary and running vehicle) shall satisfy one of the following conditions:
- 6.2.1.1. they shall not exceed the values obtained with the type of vehicle concerned when submitted for type approval,
- 6.2.1.2. they shall not exceed the noise values measured on the vehicle referred to in paragraph 6.2.1. above when this is fitted with an exhaust silencing system corresponding to the type fitted to the vehicle when submitted for type approval.
- 6.3. **Measurement of the vehicle performances**
- 6.3.1. The replacement exhaust system or components thereof must be such as to ensure that vehicle performance is comparable with that achieved with the original equipment exhaust system or component thereof.

⁽¹⁾ 1 for the Federal Republic of Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden; 6 for Belgium, 7 for Hungary, 8 for Czechoslovakia, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 for the German Democratic Republic, 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland and 21 for Portugal. 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 Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

- 6.3.2. The replacement silencing system or, depending on the manufacturer's choice, the components of said system shall be compared with an original silencing system or components, which are also in new condition, successively mounted on the vehicle mentioned in paragraph 3.3.3. above.
- 6.3.3. The verification shall be carried out by measuring the back pressure pursuant to paragraph 6.3.4. below. The value measured with the replacement silencing system shall not exceed the value measured with the original standard silencing system by more than 25 per cent under the conditions mentioned below.
- 6.3.4. *Test method*
- 6.3.4.1. Test method with engine
- The measurements shall be conducted on the engine referred to in paragraph 3.3.4. above coupled to a dynamometer. With the throttle completely open, the bench shall be adjusted so as to obtain the engine speed(s) corresponding to the rated maximum power of the engine. For the measurement of back pressure, the distance at which the pressure tap shall be placed from the exhaust manifold is indicated in annex 4 to this Regulation.
- 6.3.4.2. Test method with vehicle
- The measurements shall be carried out on the vehicle referred to in paragraph 3.3.3. above.
- The test shall be conducted:
- either on the road,
- or on a roller dynamometer.
- With the throttle completely open, the engine must be loaded so as to obtain the engine speed corresponding to the rated maximum power of the engine (engine speed S).
- For the measurement of back pressure, the distance at which the pressure tap shall be placed from the exhaust manifold is indicated in annex 4 to this Regulation.
- 6.4. **Additional specifications regarding silencing systems or components filled with fibrous materials**
- Absorbing fibrous materials may be used in silencing systems or components only when it is established by appropriate means of design and manufacturing, that the efficiency of the system in traffic conditions is sufficient to comply with the existing regulations. Such a silencing system is deemed to be effective in traffic conditions if the exhaust gas is not in contact with the fibrous materials or if, the silencing system being emptied of its absorbing materials and tested on vehicle in conformity with the procedures described in Regulation No 51, Annex 3, paragraphs, 3.1 and 3.2., the acoustic pressure levels comply with the provisions laid down in paragraph 6.2. above.
- If that condition is not fulfilled, the complete silencing system shall be submitted to conventional conditioning using one of the three installations and procedures described below. When the procedure described in paragraph 6.2.1.2. above is employed, the applicant for approval may ask for the emptying or the conditioning of the original silencing system.
- 6.4.1. *Continuous road operation for 10 000 km*
- 6.4.1.1. About half this operation shall consist of town driving and the other half of long-distance runs at high speed: continuous road operation can be replaced by a corresponding test-track programme.
- 6.4.1.2. The two engine speeds must be alternated several times.
- 6.4.1.3. The complete test programme must include a minimum of 10 breaks of at least three-hour duration in order to reproduce the effects of cooling and any condensation which may occur.
- 6.4.2. *Conditioning on a test bench*
- 6.4.2.1. Using standard parts and observing the vehicle manufacturer's instructions, the silencer must be fitted to the engine, which is coupled to a dynamometer.

6.4.2.2. The test must be conducted in six six-hour periods with a break of at least 12 hours between each period in order to reproduce the effects of cooling and any condensation which may occur.

6.4.2.3. During each six-hour period, the engine shall be run under the following conditions in turn:

- (1) five minutes at idling speed;
- (2) one-hour sequence under $1/4$ load at $3/4$ of rated maximum speed (S);
- (3) one-hour sequence under $1/2$ load at $3/4$ of rated maximum speed (S);
- (4) 10-minute sequence under full load at $3/4$ of rated maximum speed (S);
- (5) 15-minute sequence under $1/2$ load at rated maximum speed (S);
- (6) 30-minute sequence under $1/4$ load at rated maximum speed (S) ;

Total duration of the six sequences: three hours.

Each period must comprise two sets of the six abovementioned sequences.

6.4.2.4. During the test, the silencer must not be cooled by a forced draught simulating normal airflow around the vehicle. Nevertheless, at the request of the manufacturer, the silencer may be cooled in order not to exceed the temperature recorded at its inlet when the vehicle is running at maximum speed.

6.4.3. *Conditioning by pulsation*

The exhaust system or components of said system is/are fitted to the vehicle referred to in paragraph 3.3.3. above or the engine referred to in paragraph 3.3.4. In the former case, the vehicle must be mounted on a roller dynamometer, and, in the second case, the engine must be mounted on a dynamometer. The test apparatus described below is fitted at the outlet of the silencing system.

6.4.3.1. *Test apparatus*

The test apparatus, a detailed diagram of which is shown in Annex 3 to this Regulation must be fitted at the outlet of the exhaust system. Any other apparatus providing equivalent results is acceptable.

6.4.3.2. *Test procedure*

6.4.3.2.1. The test apparatus shall be adjusted in such a way that the exhaust gas flow is alternately interrupted and re-established by the quick action valve for 2 500 cycles.

6.4.3.2.2. The valve is opened when the exhaust gas pressure, measured at 100 mm at least downstream from the intake flange, reaches a value between 0,35 and 0,40 bar. It is closed when this pressure does not differ by more than 10 per cent from its stabilised value, measured with the valve open.

6.4.3.2.3. The time delay switch shall be set for the duration of gas exhaust resulting from the provisions laid down in paragraph 6.4.2.2. above.

6.4.3.2.4. Engine speed shall be 75 per cent of the speed S at which, according to the manufacturer, the engine develops maximum power.

6.4.3.2.5. The power indicated by the dynamometer shall be 50 per cent of the full-throttle power measured at 75 per cent of engine speed (S).

6.4.3.2.6 Any drain holes shall be closed off during the test.

6.4.3.2.7. The entire test must be completed within 48 hours. If necessary, one cooling period will be observed after each hour.

6.4.3.2.8. After conditioning, the noise level is checked pursuant to paragraph 6.2. above.

7. EXTENSION OF APPROVAL

The silencing system manufacturer or his duly accredited representative may ask the administrative department which has granted the approval of the silencing system for one or several types of vehicles, for an extension of the approval to other types of vehicles. The procedure is that described in paragraph 3. above.

Notice of the extension of approval (or refusal of extension) shall be communicated to the Parties to the Agreement which apply this Regulation in accordance with the procedure specified in paragraph 5.3. above.

8. MODIFICATION OF THE TYPE OF SILENCING SYSTEM

8.1. Every modification of the type of replacement silencing system shall be notified to the administrative department which approved the type of silencing system. The said department may then either:

8.1.1. consider that the modifications made are unlikely to have an appreciable adverse effect, or

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

8.2. 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 applying this Regulation.

9. CONFORMITY OF PRODUCTION

9.1. Every replacement silencing system or component thereof bearing an approval mark as prescribed under this Regulation shall conform to the type of silencing system approved and satisfy the requirements of paragraph 6 above.

9.2. In order to verify conformity as prescribed in paragraph 9.1. above, adequate monitoring of the production shall be carried out.

9.3. The holder of the approval shall in particular:

9.3.1. ensure existence of procedures for the effective control of the quality of products;

9.3.2. have access to the control equipment necessary for checking the conformity of each approved type;

9.3.3. ensure that data of test results are recorded and that annexed documents shall remain available for a period to be determined in accordance with the administrative service;

9.3.4. analyze the results of each type of product in order to verify and ensure the stability of the product characteristics, making allowance for the variation of an industrial production;

9.3.5. ensure that for each type of product at least the tests prescribed in Annex 5, point 2, are carried out;

9.3.6. ensure that sampling or test pieces giving evidence of non-conformity with the type of test considered shall give rise to another sampling and another test. All the necessary steps shall be taken to re-establish the conformity of the corresponding production.

9.4. The competent authority which has granted type-approval may at any time verify the conformity control method applicable to each production unit.

9.4.1. At every inspection, the test books and production survey records shall be presented to the visiting inspector.

9.4.2. The inspector may take samples at random which will be tested in the manufacturer's laboratory. The minimum number of samples may be determined according to the results of the manufacturer's own verification.

- 9.4.3. When the quality level appears unsatisfactory or when it seems necessary to verify the validity of the tests carried out in application of paragraph 9.4.2. above, the inspector shall select samples to be sent to the technical service which has conducted the type approval tests.
- 9.4.4. The competent authority may carry out any test prescribed in this Regulation.
- 9.4.5. The normal frequency of inspections by the competent authority shall be one every two years. If unsatisfactory results are recorded during one of these visits, the competent authority shall ensure that all necessary steps are taken to re-establish the conformity of production as rapidly as possible.
10. PENALTIES FOR NON-CONFORMITY OF PRODUCTION
- 10.1. The approval granted in respect of a type of silencing system pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 9. above are not complied with, or if the silencing system or components fail to pass the tests provided for in paragraph 9.2. above.
- 10.2. 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 applying 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'.
11. PRODUCTION DEFINITELY DISCONTINUED
- If the holder of the approval completely ceases to manufacture a type of replacement silencing system or components of the said system 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'.
12. 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 refusal or withdrawal of approval, issued in other countries, are to be sent.
-

ANNEX 1

(Maximum format: A 4 (210 × 297 mm))



Name of administration

Communication concerning the approval (or extension or refusal or withdrawal of approval or production definitely discontinued) of a type of replacement silencing system or components of the said system pursuant to Regulation No 59.

Approval No:

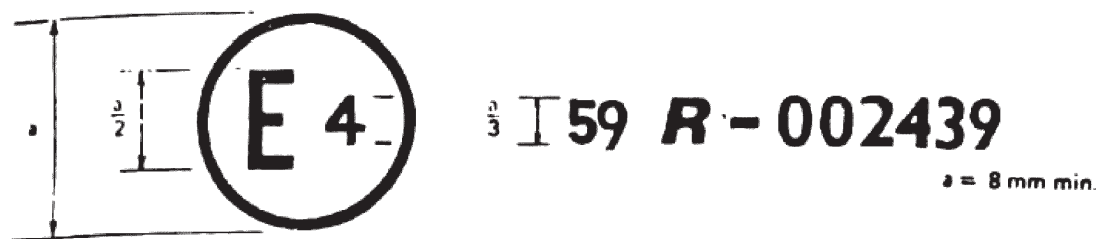
1. Trade name or mark of the silencing system:
2. Type of the silencing system:
3. Manufacturer's name and address:
4. If applicable, name and address of manufacturer's representative:
5. Brief description of the silencing system (with/without ⁽¹⁾ fibrous material, etc.):
6. Trade name or mark of the vehicle type for which the silencing system is intended:
7. Vehicle type, starting from serial number:
8. Kind of engine: positive-ignition, compression ignition:
9. Cycles: two-stroke or four-stroke:
10. Cylinder capacity:
11. Engine power (kW ECE):
12. Number of gears:
13. Gears used:
14. Final drive ratio(s):
15. Maximum power:
16. Load conditions of vehicles during test:
17. Sound levels:
 Vehicle in motion: dbA at steady speed before acceleration of km/h
 Vehicle stationary: dbA with engine running at r.p.m.
18. Value of the back pressure:
19. Silencing system submitted: For approval on
 For extension of approval on
20. Technical service responsible for conducting approval tests:
21. Date of report issued by that service:
22. Number of report issued by that service:
23. Approval granted/refused ⁽¹⁾:
24. Position of approval mark on the vehicle:
25. Place:
26. Date:
27. Signature:
28. The following documents, bearing the approval number shown above, are annexed to this communication:
 drawings, diagrams and plans of the silencing system
 photographs of the silencing system
 list of components, duly identified constituting the silencing system

⁽¹⁾ Strike out whatever does not apply.

ANNEX 2

ARRANGEMENT OF TEE APPROVAL MARK

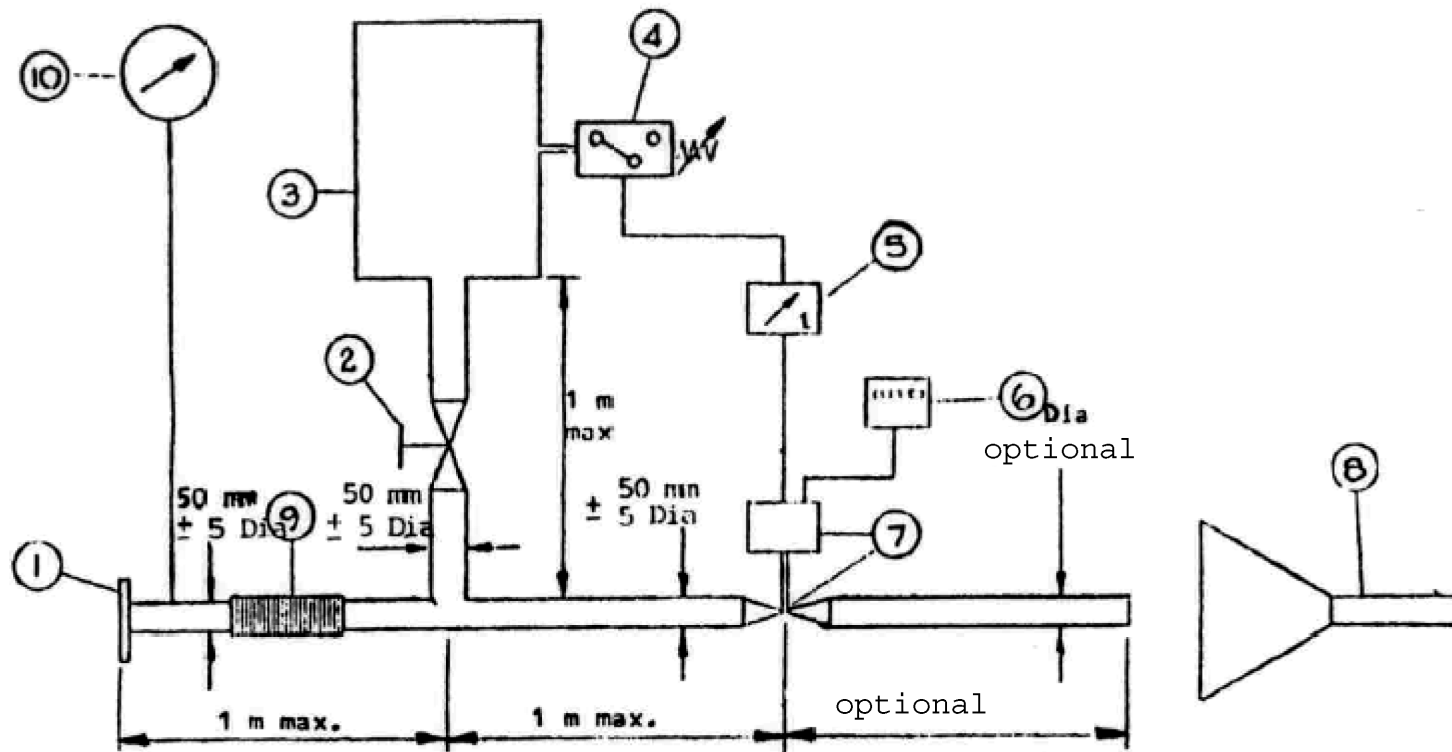
(see paragraph 5.4. of this Regulation)



The above approval mark affixed to a component of silencing system shows that the replacement silencing system type concerned has been approved in the Netherlands (E 4) pursuant to Regulation No 59 under approval number 002439. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No 59 in its original form.

ANNEX 3

TEST APPARATUS



- (1) Inlet flange or sleeve — connection to the rear of complete silencing system to be tested.
- (2) Regulation valve (hand operated).
- (3) Compensating reservoir from 35 to 40 l.
- (4) Pressure switch 0,05 to 2,5 bars — to open item 7.
- (5) Time delay switch — to close item 7.
- (6) Counter of impulses.
- (7) Quick response valve — such as the valve of an exhaust brake system of 60 mm in diameter, operated by a pneumatic cylinder with an output of 120 N at 4 bars. The response time, both when opening and closing, must not exceed 0,5 s.
- (8) Exhaust gas evacuation.
- (9) Flexible pipe.
- (10) Pressure gauge.

ANNEX 4

MEASURING POINTS — BACK PRESSURE

Examples of possible measuring points for loss-of-pressure tests. The exact measuring point shall be specified in the test report. It shall be in an area where gas flow is regular.

Fig. 1

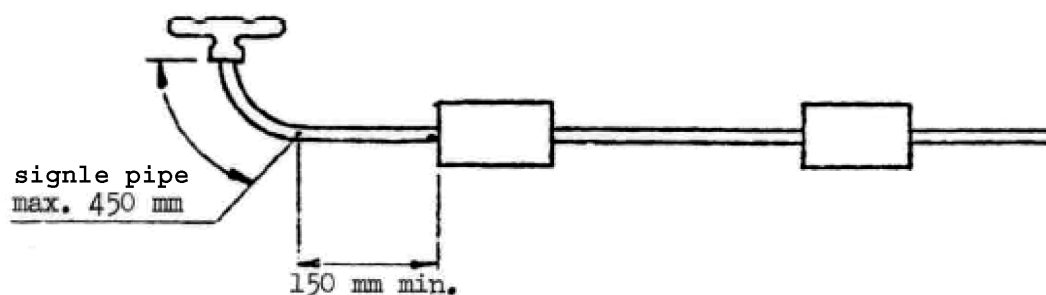


Fig. 2 (1)

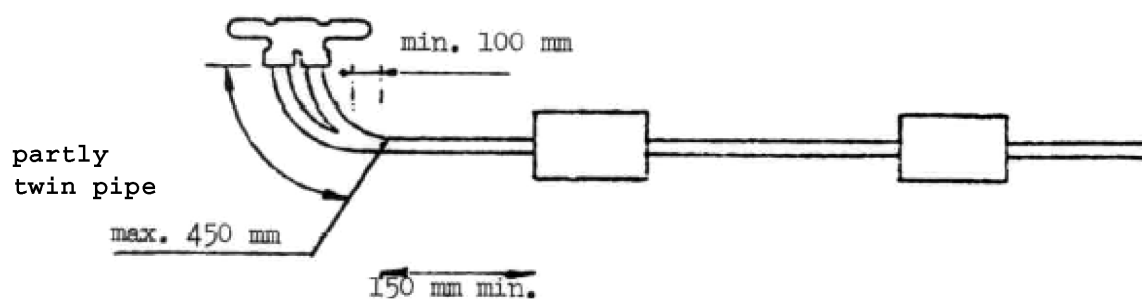
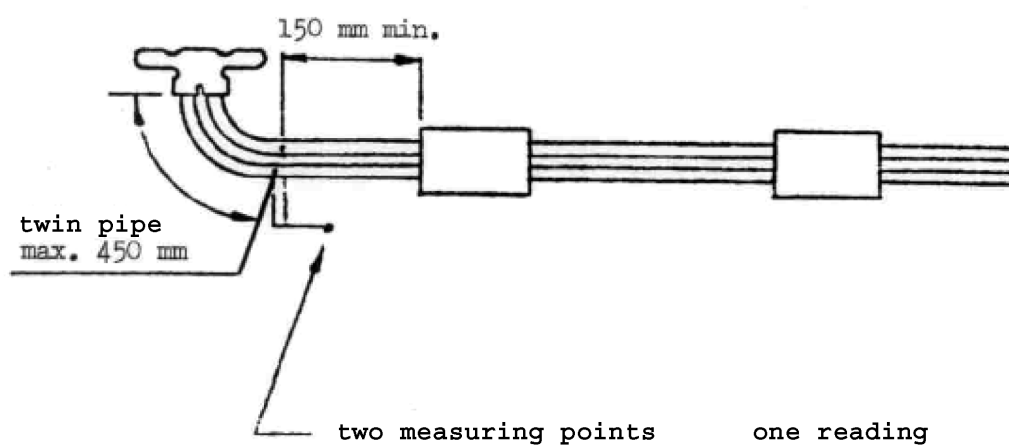


Fig. 3



(1) If not possible, refer to figure 3.

ANNEX 5

CHECKS ON CONFORMITY OF PRODUCTION**1. GENERAL**

These requirements are consistent with tests to be held to check conformity of production, according to paragraphs 9.3.5 and 9.4.3. of this Regulation.

2. TESTING PROCEDURES

The methods of testing, measuring instruments and interpretation of results shall be those described in paragraph 6 above. The exhaust system or component under test shall be subjected to the test as described in paragraphs 6.2., 6.3. and 6.4. above.

3. SAMPLING

An exhaust system or component has to be chosen. If after the test of paragraph 4.1. the sample is not considered to conform to the requirements of this Regulation two more samples have to be tested.

4. EVALUATION OF THE RESULTS

- 4.1. If the sound levels of the exhaust system or component tested pursuant to paragraphs 1 and 2, measured in accordance with paragraph 6.2. above, do not exceed by more than 1 dB(A) the level measured during the type-approval tests of this type of exhaust system or component, the exhaust system or component type shall be considered to conform to the requirements of this Regulation.
 - 4.2. If the exhaust system or component tested according to paragraph 4.1. does not satisfy the requirements laid down in that paragraph, two more exhaust systems or components of the same type must be tested pursuant to paragraphs 1 and 2 above.
 - 4.3. If the sound level of the second and/or third sample of paragraph 4.2. exceeds by more than 1 dB(A) the level measured during the type-approval tests of this type of exhaust system or component, the exhaust system or component type shall be considered not to conform to the requirements of this Regulation and the manufacturer shall take the necessary measures to re-establish the conformity.
-

Regulation No 85 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of internal combustion engines or electric drive trains intended for the propulsion of motor vehicles of categories M and N with regard to the measurement of net power and the maximum 30 minutes power of electric drive trains

1. SCOPE

1.1. This Regulation applies to the representation of the curve as a function of engine or motor speed of the power at full load indicated by the manufacturer for internal combustion engines or electric drive trains and the maximum 30 minutes power of electric drive trains intended for the propulsion of motor vehicles of categories M and N.

1.2. The internal combustion engines belong to one of the following categories:

Reciprocating piston engines (positive-ignition or compression-ignition), but excluding free piston engines;

Rotary piston engines (positive-ignition or compression-ignition).

1.3. The electric drive trains are composed of controllers and motors and are used for propulsion of vehicles as the sole mode of propulsion.

2. DEFINITIONS

2.1. 'Approval of a drive train' means the approval of a drive train type with regard to its net power measured in accordance with the procedure specified in Annexes 5 or 6 to this Regulation;

2.2. 'Drive train type' means a category of an internal combustion engine or an electric drive train for installation in a motor vehicle which does not differ in such essential characteristics as those defined in Annexes 1 or 2 to this Regulation;

2.3. 'Net power' means the power obtained on a test bench at the end of the crankshaft or its equivalent at the corresponding engine or motor speed with the auxiliaries listed in table 1 of Annexes 5 or 6 to this Regulation, and determined under reference atmospheric conditions.

2.4. 'Maximum 30 minutes power' means the maximum net power of an electric drive train at DC voltage as defined in paragraph 5.3.1, which a drive train can deliver over a period of 30 minutes as an average.

2.5. **'Hybrid vehicles (HV)'**

2.5.1. '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.

2.5.2. '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).

2.5.3. For a hybrid electric vehicle the 'power train' comprises a combination of two different drive train types:

— an internal combustion engine, and

— one (or several) electric drive train(s).

3. APPLICATION FOR APPROVAL

- 3.1. The application for approval of a drive train type with regard to the measurement of the net power and the maximum 30 minutes power of electric drive trains shall be submitted by the drive train manufacturer, the vehicle manufacturer, or by his duly accredited representative.
- 3.2. It shall be accompanied by the description, in triplicate, of the drive train comprising all the relevant particulars referred to:
- in Annex 1 for vehicles powered by an internal combustion engine only, or
 - in Annex 2 for pure electric vehicles, or
 - in Annexes 1 and 2 for **hybrid** electric vehicles.
- 3.3. For hybrid electric vehicles (HEV), the tests shall be carried out separately on the internal combustion engine (according to Annex 5) and on the electric drive train(s) (according to Annex 6).
- 3.4. A drive train (or set of drive trains), representative of the (set of) drive train type(s) to be approved, shall, with the equipment prescribed in Annexes 5 and 6 to this Regulation, be submitted to the technical service conducting the approval tests.

4. APPROVAL

- 4.1. If the power of the drive train submitted for approval pursuant to this Regulation has been measured according to the specifications of paragraph 5, approval of the drive train type shall be granted.
- 4.2. An approval number shall be assigned to each drive train type approved. Its first two digits (at present 00 for the Regulation in its original form) 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 shall not assign the same number to another drive train type.
- 4.3. Notice of approval or of extension or of refusal of approval of a drive train type pursuant to this Regulation shall be communicated to the Parties to the 1958 Agreement applying this Regulation by means of a form conforming to the model in Annex 3 to this Regulation.
- 4.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every drive train conforming to a drive train type approved under this Regulation an international approval mark consisting of:
- 4.4.1. a circle surrounding the letter 'E' followed by the distinguishing number of the country which has granted approval ⁽¹⁾;

⁽¹⁾ 1 for the Federal Republic of Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden; 6 for Belgium, 7 for Hungary, 8 for Czechoslovakia, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 for the German Democratic Republic, 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland and 21 for Portugal. 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 Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

- 4.4.2. 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 4.4.1.
- 4.4.3. Alternatively, instead of affixing these approval marks and symbols to the drive train, the manufacturer may decide that each drive train type approved pursuant to this Regulation shall be accompanied by a document giving this information so that the approval marks and symbol can be attached to the vehicle.
- 4.5. If the drive train 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 4.4.1 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 4.4.1.
- 4.6. The approval mark shall be clearly legible and be indelible.
- 4.7. The approval mark shall be placed close to the drive train identification figures provided by the manufacturer.
- 4.8. Annex 4 to this Regulation gives examples of the arrangements of the approval mark.

5. SPECIFICATIONS AND TESTS

5.1. **General**

The components liable to affect the power of the drive train shall be so designed, constructed and assembled as to enable the drive train in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.

5.2. **Description of tests for internal combustion engines**

5.2.1. 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 of Annex 5 to this Regulation.

5.2.2. 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 speeds of revolution at which the engine produces its maximum power and its maximum torque.

5.2.3. The fuel used shall be the following:

5.2.3.1. For positive ignition engines fuelled with petrol:

The fuel used shall be the one available on the market. In any case of dispute, the fuel shall be one of the reference fuels defined by CEC ⁽¹⁾ for petrol fuelled engines, in CEC documents RF-01-A-84 and RF-01-A-85.

5.2.3.2. For positive ignition engines fuelled with LPG:

5.2.3.2.1. In the case of an engine with self-adaptive fuelling:

The fuel used shall be the one available on the market. In any case of dispute the fuel shall be one of the reference fuels specified in Annex 8;

⁽¹⁾ European Coordinating Council

5.2.3.2.2. In the case of an engine without self-adaptive fuelling:

The fuel used shall be the reference fuel specified in Annex 8 with the lowest C_3 -content, or

5.2.3.2.3. In the case of an engine labelled for one specific fuel composition:

The fuel used shall be the fuel for which the engine is labelled.

5.2.3.2.4. The fuel used shall be specified in the test report.

5.2.3.3. For positive ignition engines fuelled with natural gas:

5.2.3.3.1. In the case of an engine with self-adaptive fuelling:

The fuel used shall be the one available on the market. In any case of dispute the fuel shall be one of the reference fuels specified in Annex 8;

5.2.3.3.2. In the case of an engine without self-adaptive fuelling:

The fuel used shall be the one available on the market with a Wobbe index at least $52,6 \text{ MJm}^{-3}$ (20°C , $101,3 \text{ kPa}$). In case of dispute the fuel used shall be the reference fuel G20 specified in Annex 8, i.e. the fuel with the highest Wobbe index, or

5.2.3.3.3. In the case of an engine labelled for a specific range of fuels:

The fuel used shall be the one available on the market with a Wobbe index at least $52,6 \text{ MJm}^{-3}$ (20°C , $101,3 \text{ kPa}$) if the engine is labelled for the H-range of gases, or at least $47,2 \text{ MJm}^{-3}$ (20°C , $101,3 \text{ kPa}$) if the engine is labelled for the L-range of gases. In case of dispute the fuel used shall be the reference fuel G20 specified in Annex 8 if the engine is labelled for the H-range of gases, or the reference fuel G23 if the engine is labelled for the L-range of gases, i.e. the fuel with the highest Wobbe index for the relevant range, or

5.2.3.3.4. In the case of an engine labelled for one specific fuel composition:

The fuel used shall be the fuel for which the engine is labelled.

5.2.3.3.5. The fuel used shall be specified in the test report.

5.2.3.4. For compression ignition engines

The fuel used shall be the one available on the market. In any case of dispute, the fuel shall be the reference fuel defined by CEC for compression ignition engines, in CEC document RF-03-A-84.

5.2.4. Measurements shall be carried out according to the provisions of Annex 5 to this Regulation.

5.2.5. The test report shall contain the results and all the calculations required to find the net power, as listed in the appendix to Annex 5 to this Regulation together with the characteristics of the engine listed in Annex 1 to this Regulation.

5.3. **Description of tests for measuring the net power and the maximum 30 minutes power of electric drive trains**

The electric drive train shall be equipped as specified in Annex 6 to this Regulation. The electric drive train shall be supplied from a DC voltage source with a maximum voltage drop of 5 per cent depending on time and current (periods of less than 10 seconds excluded). The supply voltage of the test shall be given by the vehicle manufacturer.

Note: If the battery limits the maximum 30 minutes power, the maximum 30 minutes power of an electric vehicle can be less than the maximum 30 minutes power of the drive train of the vehicle according to this test.

5.3.1. *Determination of the net power*

- 5.3.1.1. The motor and its entire equipment assembly must be conditioned at a temperature of $25\text{ °C} \pm 5\text{ °C}$ for a minimum of two hours.
- 5.3.1.2. The net power test shall consist of a run at full setting of the power controller.
- 5.3.1.3. Just before beginning the test, the motor shall be run on the bench for three minutes delivering a power equal to 80 % of the maximum power at the speed recommended by the manufacturer.
- 5.3.1.4. Measurements shall be taken at a sufficient number of motor speeds to define correctly the power curve between zero and the highest motor speed recommended by the manufacturer. The whole test shall be completed within five minutes.

5.3.2. *Determination of the maximum 30 minutes power*

- 5.3.2.1. The motor and its entire equipment assembly must be conditioned at a temperature of $25\text{ °C} \pm 5\text{ °C}$ for a minimum of four hours.
- 5.3.2.2. The electric drive train shall run at the bench at a power which is the best estimate of the manufacturer for the maximum 30 minutes power.

The speed must be in a speed range, which the net power is greater than 90 % of the maximum power as measured in paragraph 5.3.1. This speed shall be recommended by the manufacturer.
- 5.3.2.3. Speed and power shall be recorded. The power must be in a range of $\pm 5\%$ of the power value at the start of the test. The maximum 30 minutes power is the average of the power within the 30 minutes period.

5.4. **Interpretation of the results**

The net power and the maximum 30 minutes power for electric drive trains indicated by the manufacturer for the type of drive train shall be accepted if it does not differ by more than $\pm 2\%$ for maximum power and more than $\pm 4\%$ at the other measurement points on the curve with a tolerance of $\pm 2\%$ for engine or motor speed, or within the engine or motor speed range ($X_1 \text{ min}^{-1} + 2\%$) to ($X_2 \text{ min}^{-1} - 2\%$) ($X_1 < X_2$) from the values measured by the technical service on the drive train submitted for testing.

6. CONFORMITY OF PRODUCTION

The conformity of production procedures shall comply with those set out in Appendix 2 of the Agreement (E/ECE/324 — E/ECE/TRANS/505/Rev.2), with the following requirements:

- 6.1. Engines approved pursuant to this Regulation shall be so manufactured as to conform to the type approved.
- 6.2. The minimum requirements for conformity of production control procedures set forth in Annex 7 to this Regulation shall be complied with.

7. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

- 7.1. The approval granted in respect of a drive train type pursuant to this Regulation may be withdrawn if the requirements set forth above are not met or if a drive train bearing the approval mark does not conform to the type approved.
- 7.2. If a Contracting Party to the 1958 Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation, by means of a communication form conforming to the model in Annex 3 to this Regulation.

8. MODIFICATION AND EXTENSION OF APPROVAL OF THE DRIVE TRAIN TYPE
 - 8.1. Every modification of a drive train within a drive train type with regard to the characteristics in Annexes 1 or 2 shall be notified to the administrative department which approved the drive train type. The department may then either:
 - 8.1.1. consider that the modifications made are unlikely to have any appreciable adverse effect and that in any case the vehicle still complies with the requirements; or
 - 8.1.2. require a further test report from the technical service responsible for conducting the tests.
 - 8.2. Confirmation or refusal of approval, specifying the alterations shall be communicated by the procedure specified in paragraph 4.3 to the Parties to the Agreement applying this Regulation.
 - 8.3. The competent authority issuing the extension of approval shall assign a series number for such an extension and inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 3 to this Regulation.
 9. PRODUCTION DEFINITELY DISCONTINUED

If the holder of an approval completely ceases to manufacture a drive train 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 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 3 to this Regulation.
 10. 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 of approval, issued in other countries, are to be sent.
-

ANNEX 1

ESSENTIAL CHARACTERISTICS OF THE INTERNAL COMBUSTION ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TESTS ⁽¹⁾

1. Description of engine:
- 1.1. Make:
- 1.2. Type:
- 1.3. Working principle: positive-ignition/compression-ignition/four-stroke/two-stroke ⁽²⁾
- 1.4. Bore: mm
- 1.5. Stroke: mm
- 1.6. Number and layout of cylinders and firing order:
- 1.7. Cylinder capacity: cm³
- 1.8. Compression ratio ⁽³⁾:
- 1.9. Drawings of combustion chamber and piston crown
- 1.10. Minimum cross-sectional area of inlet and outlet ports
- 1.11. Fuel: leaded petrol/unleaded petrol/diesel oil/LPG/NG ⁽²⁾
- 1.12. Cooling system: liquid/air cooling ⁽²⁾
- 1.12.1. Characteristics of liquid-cooling system
 - Nature of liquid: Circulating pump: Yes/No ⁽²⁾
 - Characteristics of make(s) and type(s) of the pump:
 - Drive ratio:
 - Thermostat: setting:
 - Radiator: drawing(s) or make(s) and type(s):
 - Relief valve: pressure setting:
 - Fan: characteristics or make(s) and type(s):
 - Fan: drive system: Drive ratio:
 - Fan cowl:
- 1.12.2. Characteristics of air-cooling system
 - Blower: characteristics or make(s) and type(s): Drive ratio:
 - Air ducting (standard production):.....
 - Temperature regulating system: Yes/No ⁽²⁾ Brief description:
- 1.12.3. Temperatures permitted by the manufacturer
- 1.12.3.1. Liquid cooling: Maximum temperature at engine outlet
- 1.12.3.2. Air cooling:: Reference point:
 - Maximum temperature at reference point:
- 1.12.3.3. Maximum charge air temperature at intercooler outlet
- 1.12.3.4. Fuel temperature: min max
- 1.12.3.5. Lubricant temperature: min max
- 1.13. Supercharger: Yes/No ⁽²⁾ Description of the system:

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

⁽²⁾ Specify the tolerance.

⁽³⁾ Strike out what does not apply.

- 1.14. Intake system
 Intake manifold: Description:
 Air filter: Make: Type:
 Intake silencer: Make: Type:
2. Additional anti pollution devices (if any, and if not covered by another heading)
 Description and diagrams
3. Air intake and fuel feed
- 3.1. Description and diagrams of inlet pipes and their accessories (dash-pot, heating device, additional air intakes, etc.):
- 3.2. Fuel feed
- 3.2.1. By carburettor(s) ⁽²⁾: Number:
- 3.2.1.1. Make:
- 3.2.1.2. Type:
- 3.2.1.3. Adjustments ⁽³⁾
- 3.2.1.3.1. Jets
- 3.2.1.3.2. Venturis
- 3.2.1.3.3. Float-chamber level
- 3.2.1.3.4. Mass of float
- 3.2.1.3.5. Float needle
- or
- } Curve of fuel delivery plotted against air flow, and settings required to keep to the curve ⁽²⁾ ⁽³⁾
- 3.2.1.4. Manual/automatic choke ⁽²⁾
- 3.2.1.5. Feed pump
 Pressure ⁽³⁾: or characteristic diagram ⁽³⁾:
- 3.2.2. By fuel injection ⁽²⁾: system description
 Working principle: Intake manifold/direct injection
 injection prechamber/swirl chamber ⁽²⁾
- 3.2.2.1. Fuel pump:
- 3.2.2.1.1. Make:
- 3.2.2.1.2. Type:
- 3.2.2.1.3. Delivery: mm³ per stroke at a pump speed of rpm ⁽²⁾ ⁽³⁾:
 or, alternatively, a characteristic diagram ⁽²⁾ ⁽³⁾:
 calibration procedure: test bench/engine ⁽²⁾:
- 3.2.2.1.4. Injection timing:
- 3.2.2.1.5. Injection curve:
- 3.2.2.2. Injector nozzle:
- 3.2.2.3. Governor:
- 3.2.2.3.1. Make:
- 3.2.2.3.2. Type:
- 3.2.2.3.3. Cut-off point under load min⁻¹:
- 3.2.2.3.4. Maximum speed without load min⁻¹:
- 3.2.2.3.5. Idle speed:
- 3.2.2.4. Cold start device:

⁽²⁾ Specify the tolerance.

⁽³⁾ Strike out what does not apply.

- 3.2.2.4.1. Make:
- 3.2.2.4.2. Type:
- 3.2.2.4.3. System description:
- 3.2.2.5. Starting aid:
- 3.2.2.5.1. Make:
- 3.2.2.5.2. Type:
- 3.2.2.5.3. System description:
- 3.2.3. By LPG fuelling system: Yes/No ⁽²⁾
- 3.2.3.1. Approval number according to Regulation No 67 and documentation:
- 3.2.3.2. Electronic Engine Management Control Unit for LPG-fuelling:
- 3.2.3.3. Make(s):
- 3.2.3.4. Type:
- 3.2.3.5. Emission related adjustment possibilities:
- 3.2.3.6. Further documentation:
- 3.2.3.6.1. Description of the safeguarding of the catalyst at switch-over from petrol to LPG or back:
- 3.2.3.6.2. System lay-out (electrical connections, vacuum connections compensation hoses, etc):
- 3.2.3.6.3. Drawing of the symbol:
- 3.2.4. By NG fuelling system: Yes/No ⁽²⁾
- 3.2.4.1. Approval number according to Regulation No 67:
- 3.2.4.2. Electronic Engine Management Control Unit for NG-fuelling:
- 3.2.4.3. Make(s):
- 3.2.4.4. Type:
- 3.2.4.5. Emission-related adjustment possibilities:
- 3.2.4.6. Further documentation
- 3.2.4.6.1. Description of the safeguarding of the catalyst at switch-over from petrol to NG or back:
- 3.2.4.6.2. System lay-out (electrical connections, vacuum connections compensation hoses, etc.):
- 3.2.4.6.3. Drawing of the symbol:
- 4. Valve timing or equivalent data
- 4.1. Maximum lift of valves, angles of opening and closing, or timing details of alternative distribution systems, in relation to top dead centre
- 4.2. Reference and/or setting ranges ⁽²⁾:
- 5. Ignition
- 5.1. Ignition system type:
- 5.1.1. Make:
- 5.1.2. Type:
- 5.1.3. Ignition advance curve ⁽³⁾:
- 5.1.4. Ignition timing ⁽³⁾:
- 5.1.5. Contact-point gap ⁽³⁾ ⁽²⁾ and dwell-angle ⁽³⁾
- 6. Exhaust system
- Description and diagrams:

⁽²⁾ Specify the tolerance.

⁽³⁾ Strike out what does not apply.

7. Lubrication system
 - 7.1. Description of system:
 - 7.1.1. Position of lubricant reservoir:
 - 7.1.2. Feed system (pump, injection into intake, mixing with fuel, etc.):
 - 7.2. Lubricating pump ⁽²⁾
 - 7.2.1. Make:
 - 7.2.2. Type:
 - 7.3. Mixture with fuel ⁽²⁾
 - 7.3.1. Percentage
 - 7.4. Oil cooler: Yes/No ⁽²⁾
 - 7.4.1. Drawing(s) or make(s) and type(s)
8. Electrical equipment
 - Generator/alternator ⁽²⁾: characteristics or make(s) and type(s):
9. Other auxiliaries fitted on the engine
 - (Enumeration and brief description if necessary):
10. Additional information on test conditions
 - 10.1. Sparking plugs
 - 10.1.1. Make:
 - 10.1.2. Type:
 - 10.1.3. Spark-gap setting:
 - 10.2. Ignition coil
 - 10.2.1. Make:
 - 10.2.2. Type:
 - 10.3. Ignition condenser
 - 10.3.1. Make:
 - 10.3.2. Type:
 - 10.4. Radio interference suppression equipment
 - 10.4.1. Make:
 - 10.4.2. Type:
11. Engine performance (declared by manufacturer)
 - 11.1. Idle rpm ⁽³⁾: min⁻¹
 - 11.2. Rpm at maximum power ⁽³⁾: min⁻¹
 - 11.3. Maximum power — kW (according to paragraph 5.3. of this Regulation):
 - 11.4. Rpm at maximum torque ⁽³⁾: min⁻¹
 - 11.5. Maximum torque ⁽³⁾: Nm.

⁽²⁾ Specify the tolerance.

⁽³⁾ Strike out what does not apply.

ANNEX 2

ESSENTIAL CHARACTERISTICS OF THE ELECTRIC DRIVE TRAIN AND INFORMATION CONCERNING THE CONDUCT OF TESTS

1. General

- 1.1. Make:
- 1.2. Type:
- 1.3. Drive ⁽¹⁾: monomotor/multimotors/(number):
- 1.4. Transmission arrangement: parallel/transaxial/others, to precise:
- 1.5. Test voltage:
- 1.6. Basic motor rotation: min⁻¹
- 1.7. Motor crankshaft maximum speed: min⁻¹
(or by default): ... reducer/gearbox outlet shaft ⁽¹⁾: min⁻¹
gear engaged.
- 1.8. Maximum power speed ⁽²⁾ (specified by the manufacturer): min⁻¹
- 1.9. Maximum power (specified by the manufacturer): kW
- 1.10. Maximum 30 minutes power (specified by the manufacturer): kW
- 1.11. Flexible range (where P > 90 per cent of max. power):
speed at beginning of the range: min⁻¹
speed at the end of the range: min⁻¹

2. Motor

- 2.1. Working principle
- 2.1.1. Direct current (DC)/alternative current (AC) ⁽¹⁾ number of phases:
- 2.1.2. Excitation/separate/series/compound ⁽¹⁾:
- 2.1.3. Synchron/asynchron ⁽¹⁾:
- 2.1.4. Rotor coiled/with permanent magnets/with housing ⁽¹⁾
- 2.1.5. Number of poles of the motor:
- 2.2. Inertia mass:

3. Power controller

- 3.1. Make:
- 3.2. Type:
- 3.3. Control principle: vectorial/open loop/closed/other, to be specified:
- 3.4. Maximum effective current supplied to the motor ⁽²⁾: A
during seconds
- 3.5. Voltage range use: V to V

4. Cooling system:

- Motor: liquid/air ⁽¹⁾
- Controller: liquid/air ⁽¹⁾
- 4.1. Liquid-cooling equipment characteristics
- 4.1.1. Nature of the liquid circulating pumps: yes/no ⁽¹⁾
- 4.1.2. Characteristics or make(s) and type(s) of the pump:
- 4.1.3. Thermostat: setting:
- 4.1.4. Radiator: drawing(s) or make(s) and type(s):
- 4.1.5. Relief valve: pressure setting:
- 4.1.6. Fan: characteristics or make(s) and type(s):
- 4.1.7. Fan duct:

⁽¹⁾ Strike out what does not apply.

⁽²⁾ Specify the tolerance.

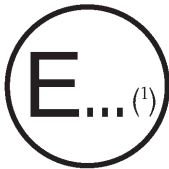
- 4.2. Air-cooling equipment characteristics
 - 4.2.1. Blower: characteristics or make(s) and type(s)
 - 4.2.2. Standard air ducting:
 - 4.2.3. Temperature regulating system: Yes/No ⁽¹⁾
 - 4.2.4. Brief description:
 - 4.2.5. Air filter: make(s): type(s):
- 4.3. Temperatures admitted by the manufacturer
 - 4.3.1. Motor outlet: (max.) °C
 - 4.3.2. Controller inlet: (max) °C
 - 4.3.3. At motor reference point(s): (max.) °C
 - 4.3.4. At controller reference point(s): (max.) °C
- 5. **Insulating category:**
- 6. **International protection (IP)-code:**
- 7. **Lubrication system principle: ⁽¹⁾:** Bearings: friction/ball
 Lubricant: grease/oil
 Seal: Yes/No
 Circulation: with/without

⁽¹⁾ Strike out what does not apply.

ANNEX 3

COMMUNICATION

(Maximum format: A4 (210 x 297 mm))



Issued by: Name of administration:

.....

.....

.....

Concerning ⁽²⁾:

APPROVAL GRANTED

APPROVAL EXTENDED

APPROVAL REFUSED

APPROVAL WITHDRAWN

PRODUCTION DEFINITELY DISCONTINUED

of a drive train pursuant to Regulation No 85.

Approval No Extension No

1. Trade name or mark of drive train or set of drive trains:
2. Internal combustion engine
 - 2.1. Make:
 - 2.2. Type:
 - 2.3. Manufacturer's name and address:
3. Electric drive train(s):
 - 3.1. Make:
 - 3.2. Type:
 - 3.3. Manufacturer's name and address:
5. Drive train or set of drive trains submitted for approval on:
6. Technical service responsible for conducting approval tests:
7. Date of report issued by that service:
8. Number of report issued by that service:
9. Location of the approval mark:
10. Reason(s) for extension of approval (if applicable) ⁽²⁾
11. Internal combustion engine
 - 11.1. Declared figures
 - 11.1.1. Maximum net power: kW, at min⁻¹
 - 11.1.2. Maximum net torque: N.m, at min⁻¹
 - 11.2. Essential characteristics of the engine type:

Operating principle: four stroke/two stroke ⁽²⁾

Number and layout of cylinders:

Cylinder capacity: cm³

Fuel feed: carburettor/indirect injection/direct injection ⁽²⁾

Pressure-charger device: Yes/No ⁽²⁾

Exhaust gas cleaning device: Yes/No ⁽²⁾
 - 11.3. Engine fuel requirements: leaded petrol/unleaded petrol/diesel fuel/NG/LPG ⁽²⁾:

⁽¹⁾ Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).⁽²⁾ Strike out what does not apply.

12. Electric drive train(s):.....
- 12.1. Declared figures
- 12.1.1. Maximum net power: kW, at min⁻¹
- 12.1.2. Maximum net torque: Nm, at min⁻¹
- 12.1.3. Maximum net torque at zero speed:..... Nm
- 12.1.4. Maximum 30 minutes power: kW
- 12.2. Essential characteristics of the electric drive train
- 12.2.1. Test DC voltage: V
- 12.2.2. Working principle:.....
- 12.2.3. Cooling system:
- Motor: liquid/air ⁽²⁾
- Variator:..... liquid/air ⁽²⁾
13. Approval granted/extended/refused/withdrawn ⁽²⁾
14. Place:
15. Date:
16. Signature:
17. The documents filed with the request for approval or extension may be obtained on request.

⁽²⁾ Strike out what does not apply.

ANNEX 4

ARRANGEMENTS OF APPROVAL MARKS

Model A

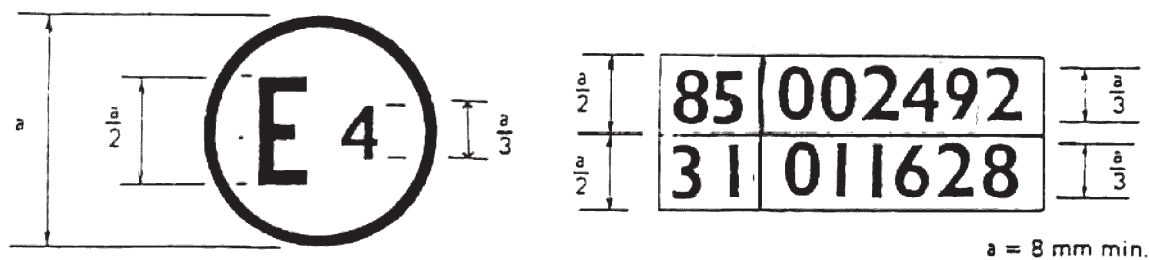
(see paragraph 4.4 of this Regulation)



The above approval mark affixed to a drive train shows that the drive train type concerned has been approved in the Netherlands (E 4) with regard to the measurement of the net power, pursuant to Regulation No. 85 and under the approval number 002492. The approval number indicates that the approval was granted in accordance with the requirements of Regulation No 85 in its original form.

Model B

(see paragraph 4.5 of this Regulation)



The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in the Netherlands (E 4) pursuant to Regulations No 85 and No 31 ⁽¹⁾. The first two digits of the approval numbers indicate that, at the dates when the respective approvals were granted, Regulation No 85 had not been modified and Regulation No 31 already included the 01 series of amendments.

⁽¹⁾ The second number is given merely as an example.

ANNEX 5

METHOD FOR MEASURING INTERNAL COMBUSTION ENGINE NET POWER

1. These provisions apply to the method for representing the power curve at full load of an internal combustion engine as a function of engine speed.
2. TEST CONDITIONS
 - 2.1. The engine shall have been run-in according to the manufacturer's recommendations.
 - 2.2. If the 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.
 - 2.3. **Auxiliaries**
 - 2.3.1. *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.
 - 2.3.2. *Auxiliaries to be removed*

Certain vehicle accessories necessary only for 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

('Standard-production equipment' means equipment provided by the manufacturer for a particular application)

No	Auxiliaries	Fitted for net power test
1	Intake system — Intake manifold — Crankcase emission control system — Air filter — Intake silencer — Speed limiting device	Yes, standard production equipment Yes, standard production equipment (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 — Exhaust purifier — Exhaust manifold — Supercharging device — Connecting pipes (1b) — Silencer (1b) — Tail pipe (1b) — Exhaust brake (2)	Yes, standard production equipment

No	Auxiliaries	Fitted for net power test
4	Fuel supply pump ⁽³⁾	Yes, standard production equipment
5	Carburettor — Electronic control system, air flow meter, etc. (if fitted) Pressure reducer Evaporator Mixer	Yes, standard production equipment
6	Fuel injection equipment (petrol and diesel) — Prefilter — Filter — Pump — High pressure pipe — Injector — Air intake valve if fitted ⁽⁴⁾ — 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 — Engine bonnet — Bonnet air outlet — Radiator — Fan ⁽⁵⁾ ⁽⁶⁾ — Fan cowl — Water pump — Thermostat ⁽⁷⁾	No Yes, standard production equipment ⁽⁵⁾
8	Air cooling Cowl Blower ⁽⁵⁾ ⁽⁶⁾ Temperature regulating device	Yes, standard production equipment Yes, standard production equipment
9	Electrical equipment	Yes, standard production equipment ⁽⁸⁾
10	Supercharging equipment (if fitted) — 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.
 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.
- (2) If an exhaust brake is incorporated in the engine, the throttle valve must be fixed in a fully open position.
- (3) 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 generator: 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.

2.3.3. Compression-ignition engine starting auxiliaries

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

- (a) electric starting. A generator is fitted and supplies, where necessary, the auxiliaries essential for engine operation;
- (b) starting other than by electrical means. If there are any electrically operated accessories essential for engine operation for which a generator is fitted. Otherwise, it is removed.

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

2.4. 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	Emission control devices	

3. DATA TO BE RECORDED

- 3.1. Data to be recorded are those indicated in paragraph 4 of the appendix to this Annex. Performance data shall be obtained under stabilised operating conditions with an adequate fresh air supply to the engine. 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 5.2 of this Annex) as possible in order to minimise the magnitude of the correction factor.
- 3.2. 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 spray-back. A sufficient number of locations shall be used to give a representative average inlet temperature.
- 3.3. No data shall be taken until torque, speed and temperatures have been maintained substantially constant for at least one minute.
- 3.4. The engine speed during a run or reading shall not deviate from the selected speed by more than ± 1 or $\pm 10 \text{ min}^{-1}$, whichever is greater.
- 3.5. 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.
- 3.6. The temperature of the coolant at the outlet from the engine shall be kept at the value 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 $\pm 0 \text{ K } 20$ of the maximum value specified by the manufacturer in the reference conditions.
- 3.7. 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.
- 3.8. The temperature of the lubricating oil measured in the oil pump or within the oil sump or at the outlet from the oil cooler, if fitted, shall be maintained within the limits specified in paragraphs 3.6., 3.7. and 3.8. of this Annex.
- 3.9. An auxiliary regulating system may be used if necessary to maintain the temperatures within the limits specified in paragraphs 3.6, 3.7 and 3.8 of this Annex.

4. ACCURACY OF MEASUREMENTS

- 4.1. **Torque:** $\pm 1 \%$ of measured torque.

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 $\pm 2 \%$ of measured torque.

- 4.2. **Engine speed:** 0,5 % of measured speed.
- 4.3. **Fuel consumption:** $\pm 1 \%$ of measured consumption.
- 4.4. **Fuel temperature:** $\pm 2 \text{ K}$.
- 4.5. **Engine inlet air temperature:** $\pm 1 \text{ K}$.
- 4.6. **Barometric pressure:** $\pm 100 \text{ Pa}$.
- 4.7. **Pressure in intake-duct:** $\pm 50 \text{ Pa}$
- 4.8. **Pressure in exhaust duct:** $\pm 200 \text{ Pa}$

5. POWER CORRECTION FACTORS

5.1. Definition

The power correction factor is the coefficient α to determine the engine power under the reference atmospheric conditions specified in paragraph 5.2.

where $P_o = \alpha \cdot P$

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)

5.2. Reference atmospheric conditions

5.2.1. Temperature (T_o): 298 K (25 °C)

5.2.2. 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.

5.3. Test atmospheric conditions

The atmospheric conditions during the test shall be the following:

5.3.1. Temperature (T)

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

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

5.3.2. Pressure (P_s)

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

5.4. Determination of correction factor α_a and α_d ⁽¹⁾

5.4.1. Naturally aspirated or pressure-charged positive-ignition engine factor α_a

The correction factor α_a is obtained by applying the formula:

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

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.

5.4.2. Diesel engines — Factor α_d

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

where $\alpha_d = (f_a) f_m$

f_a is the atmospheric factor

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

⁽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).

5.4.2.1. 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 engine.

5.4.2.1.1. Naturally aspirated and mechanically supercharged engines

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

5.4.2.1.2. Turbocharged engines with or without cooling of inlet air

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

5.4.2.2. 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:

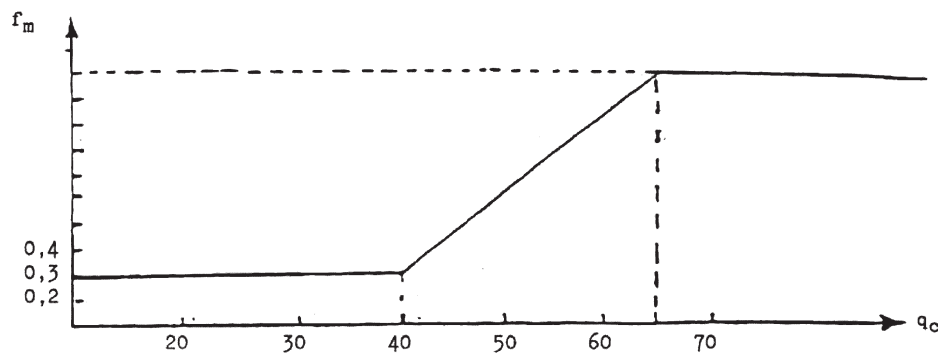
q is the fuel flow in milligram per cycle per litre of total swept volume (mg/(l. cycle))

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 figure):



5.4.2.3. 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.

ANNEX 5

Appendix

RESULTS OF TESTS FOR MEASURING NET ENGINE POWER

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 K

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: K (indicate point of measurement)

1.2.5. of the fuel: K

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. Content: 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

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:

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 number (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 (*)

Engine speed, min ⁻¹			
Measured torque, Nm			
Measured power, Kw			
Measured fuel flow, g/h			
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 fan ⁽¹⁾)			
Power of fan, kW (to be subtracted if fan not fitted)			
Net power, Kw			
Net torque, Nm			
Corrected specific fuel consumption g/(kWh) ⁽²⁾			
Cooling liquid temperature at outlet, K			
Lubricating oil temperature at measuring point, K			
Air temperature after pressure-charger, K ⁽³⁾			

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

Fuel temperature at injection pump inlet, K		
Air temperature after charge air cooler, K ⁽³⁾		
Pressure after pressure charger, kPa ⁽³⁾		
Pressure after charge air cooler, kPa		

⁽¹⁾ Delete as appropriate.

⁽²⁾ Calculated with the net power for compression-ignition and positive-ignition engines, in the latter case multiplied by the power correction factor.

⁽³⁾ Delete where inapplicable.

ANNEX 6

METHOD FOR MEASURING NET POWER AND THE MAXIMUM 30 MINUTES POWER OF ELECTRIC DRIVE TRAINS

1. These requirements apply for measuring the maximum net power and the maximum 30 minutes power of electric drive trains used for propelling pure electric road vehicles.

2. TEST CONDITIONS

2.1. The drive train shall have been run-in according to the manufacturer's recommendations.

2.2. If the power measurement can be carried out only on a drive train with the gear-box or a reducer mounted, the efficiency shall be taken into account.

2.3. **Auxiliaries**

2.3.1. *Auxiliaries to be fitted*

During the test, the auxiliaries necessary for the drive train operation in the intended application (as listed in Table 1 of this Annex) shall be installed in the same position as in the vehicle.

2.3.2. *Auxiliaries to be removed*

The auxiliaries necessary for the proper operation of the vehicle, and which may be mounted on the motor shall be removed when performing the test. The following non-exhaustive list is given as an example:

- Air compressor for brakes
- Power steering compressor
- Suspension system compressor
- Air conditioner system, etc.
- Where accessories cannot be removed, the power they absorb in the unloaded condition may be determined and added to the measured power.

Table 1

Auxiliaries to be fitted for the test to determine net power and the maximum 30 minutes power of electric drive trains

('Standard-production equipment' means equipment provided by the manufacturer for a particular application).

No	Auxiliaries	Fitted for net power and the maximum 30 minutes power test
1	DC voltage source	Voltage drop during test less than 5 %
2	Speed variator and control device	Yes: Standard-production equipment
3	LIQUID COOLING Motor bonnet Bonnet outlet Radiator ⁽¹⁾ ⁽²⁾ Fan Fan cowl Pump Thermostat ⁽³⁾	} No } Yes: Standard-production equipment
	AIR COOLING Air filter Cowl Blower Temperature adjustment system	Yes: Standard-production equipment

No	Auxiliaries	Fitted for net power and the maximum 30 minutes power test
4	Electric equipment	Yes: Standard-production equipment
5	Bench test auxiliary fan	Yes, if necessary

(¹) The radiator, the fan, the fan cowl, the water pump and the thermostat shall be located on the test bench in the same relative position as on the vehicle. The cooling-liquid circulation shall be activated by the drive train water pump only.

Cooling of the liquid may be produced either by the drive train 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 drive train cooling system. The radiator shutter, if any, shall be in the open position.

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

(²) Where a disconnectable or progressive fan or blower is incorporated, the test should be carried out with the disconnectable fan (or blower) disconnected or at maximum slip condition.

(³) The thermostat may be fixed in the fully open position.

2.4. Setting conditions

The setting conditions shall conform to the manufacturer's specifications for the production motor and be used without further alteration for the particular application.

2.5. Data to be recorded

2.5.1. The test for determining the net power shall be carried out with the accelerator control set at the maximum position.

2.5.2. The motor must have been run in accordance with the recommendations of the applicant for the approval.

2.5.3. Torque and speed data shall be recorded simultaneously.

2.5.4. If needed, the cooling liquid temperature recorded at the motor outlet must be maintained at ± 5 K of the thermostat temperature setting specified by the manufacturer.

For air cooling drive trains, the temperature at a point indicated by the manufacturer shall be kept within $+ 0/- 20$ K of the maximum value specified by the manufacturer.

2.5.5. The temperature of the lubricating oil measured in the oil sump or at the outlet from the oil temperature exchanger (if any) shall be maintained within the limits prescribed by the manufacturer.

2.5.6. An auxiliary regulating system may be used, if necessary, to maintain the temperature within the limits specified in paragraphs 2.5.4 and 2.5.5.

3. ACCURACY OF MEASUREMENTS

3.1. **Torque:** ± 1 per cent of measured torque.

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 % of measured torque.

3.2. **Motor speed:** 0,5 % of measured speed.

3.3. **Motor inlet air temperature:** ± 2 K.

ANNEX 7

CHECKS ON CONFORMITY OF PRODUCTION**1. GENERAL**

These requirements are consistent with tests to be held to check conformity of production, according to paragraph 6.3.6.

2. TEST PROCEDURES

The methods of testing and measuring instruments shall be those described in Annexes 5 or 6 to this Regulation.

3. COLLECTION OF SAMPLES

One drive train has to be chosen. If after the test of paragraph 5.1, the drive train is not considered as conforming to the requirements of this Regulation, two more drive trains have to be tested.

4. MEASUREMENT CRITERIA**4.1. Net power of internal combustion engine**

During the tests to verify conformity of production, the power shall be measured at two engine speeds S_1 and S_2 , corresponding respectively to the measurement points of maximum power and maximum torque accepted for type approval. At these two engine speeds, which are subject to a tolerance of $\pm 5\%$, the net power measured at least one point within the ranges $S_1 \pm 5\%$ and $S_2 \pm 5\%$ shall not differ by more than $\pm 5\%$ from the approval figure.

4.2. Net power and maximum 30 minutes power of electric drive trains

During the tests to verify conformity of production the power shall be measured at motor speed S_1 corresponding to the measurement point of maximum power accepted for type approval. At this speed, the net power shall not differ by more than $\pm 5\%$ from the approval figure.

5. EVALUATION OF RESULTS

- 5.1. If the net power and the maximum 30 minutes power of the drive train tested pursuant to paragraph 2 fulfils the requirement of paragraph 4, the production is considered to conform to the type approval.
 - 5.2. If the requirements of paragraph 4 are not fulfilled, two more drive trains are tested in the same way.
 - 5.3. If the net power figure or the maximum 30 minutes power of the second and/or third drive train of paragraph 5.2 does not fulfil the requirements of paragraph 4 above, the production shall be considered not to conform to the requirements of this Regulation and the provisions of paragraph 7.1 shall be put into effect.
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ANNEX 8

1. TECHNICAL DATA OF THE LPG REFERENCE FUELS

		Fuel A	Fuel B	Test method
Composition:				ISO 7941
C3	% vol.	30 ± 2	85 ± 2	
C4	% vol.	balance	balance	
<C3, >C4	% vol.	max. 2 %	max. 2 %	
Olefines	% vol.	9 ± 3	12 ± 3	
Evaporative residue	ppm	max. 50	max. 50	NFM 41-015
Water content		none	none	visual inspect.
Sulphur content	ppm mass (*)	max. 50	Max. 50	EN 24260
Hydrogen sulphide		none	None	
Copper corrosion	rating	Class 1	Class 1	ISO 625 1 (**)
Odour		characteristic	characteristic	
MON		Min. 89	Min. 89	EN 589 Annex B

(*) Value to be determined at standard conditions (293,2 K (20 °C) and 101,3 kPa).

(**) This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

2. TECHNICAL DATA OF NG REFERENCE FUELS

		G20	G23	G25
Composition:				
CH ₄	% vol.	100	92,5	86
N ₂	% vol.	0	7,5	14
Wobbe index (*)	MJ/m ³	53,6 ± 2 %	48,2 ± 2 %	43,9 ± 2 %

(*) Based on the gross calorific value and calculated for 0 °C.

The constituting gases of the mixtures shall have at least the following purities:

N₂: 99 %

CH₄: 95 % with a total content of hydrogen, carbon monoxide and oxygen below 1 % and a total content of nitrogen and carbon dioxide below 2 %.

The Wobbe index is the ratio of the calorific value of a gas per unit volume and the square root of its relative density under the same reference conditions:

$$Wobbe\ index = H_{gas} \frac{\sqrt{air}}{\sqrt{gas}}$$

with H_{gas} = calorific value of the fuel in MJ/m³ at 0 °C

air = density of air at 0 °C

gas = density of fuel at 0 °C

The Wobbe index is said to be gross or net according to whether the calorific value uses is the gross or net calorific value.