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COUNCIL DIRECTIVE

of 2 August 1972

on the approximation of the laws of the Member States relating to the measures to be taken against the emission of pollutants from diesel engines for use in vehicles

(72/306/EEC)

(OJ L 190, 20.8.1972, p. 1)

Amended by:

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► <u>M1</u> Commission Directive 89/491/EEC of 17 July 1989	L 238	43	15.8.1989
► <u>M2</u> Commission Directive 97/20/EC of 18 April 1997	L 125	21	16.5.1997
► <u>M3</u> Commission Directive 2005/21/EC of 7 March 2005	L 61	25	8.3.2005

Corrected by:

- **C1** Corrigendum, OJ L 215, 6.8.1974, p. 20 (72/306/EEC)
- **C2** Corrigendum, OJ L 299, 23.11.1977, p. 27 (72/306/EEC)

▼B**COUNCIL DIRECTIVE****of 2 August 1972****on the approximation of the laws of the Member States relating to the measures to be taken against the emission of pollutants from diesel engines for use in vehicles**

(72/306/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 100 thereof;

Having regard to the proposal from the Commission;

Having regard to the Opinion of the European Parliament;

Having regard to the Opinion of the Economic and Social Committee;

Whereas the technical requirements which motor vehicles must satisfy pursuant to national laws relate, *inter alia*, to the emission of pollutants from diesel engines for use in vehicles;Whereas those requirements differ from one Member State to another; whereas it is therefore necessary that all the Member States adopt the same requirements either in addition to or in place of their existing rules, in order, in particular, to allow the EEC type approval procedure which was the subject of the Council Directive ⁽¹⁾ of 6 February 1970 on the approximation of the laws of the Member States relating to the type approval of motor vehicles and their trailers to be applied in respect of each type of vehicle;Whereas, it is desirable to follow the technical requirements adopted by the UN Economic Commission for Europe in its Regulation No 24 (Uniform provisions concerning the approval of vehicles equipped with diesel engines with regard to the emission of pollutants by the engine), which is annexed to the Agreement of 20 March 1958 concerning the adoption of uniform conditions of approval and reciprocal recognition of approval for motor vehicle equipment and parts ⁽²⁾;

HAS ADOPTED THIS DIRECTIVE:

▼M2*Article 1*

For the purposes of this Directive 'vehicle' means any vehicle with a diesel engine, intended for use on the road, with or without bodywork, having at least four wheels and a maximum design speed exceeding 25 km/h, with the exception of vehicles which run on rails and of agricultural and forestry tractors and of all mobile machinery.

▼B*Article 2*

No Member State may refuse to grant a vehicle EEC type approval or national type approval on the ground that pollutants are emitted by the diesel engine which drives the vehicle, if the engine complies with ►M2 the requirements of the relevant Annexes to this Directive ◀.

Article 3

The Member State which has granted type approval shall take the necessary measures to ensure that it is informed of any modification of a part or characteristic referred to in ►M2 item 1.1 ◀ of Annex I. The competent authorities of that Member State shall decide whether fresh tests should be carried out on the ►C1 modified vehicle type ◀ and

⁽¹⁾ OJ No L 42, 23.2.1970, p. 1.⁽²⁾ Doc. E/EEC/324 — E/EEC/TRANS/505, Rev 1/add 23, 23.8.1971.

▼B

a fresh report drawn up. Where the tests reveal failure to comply with this Directive, the modification shall not be approved.

Article 4

The amendments necessary for adjusting the Annexes so as to take account of technical progress shall be adopted in accordance with the procedure laid down in Article 13 of the Council Directive of 6 February 1970 on the approximation of the laws of the Member States relating to the type approval of motor vehicles and their trailers.

Article 5

1. Member States shall put into force the provisions needed in order to comply with this Directive within eighteen months of its notification and shall forthwith inform the Commission thereof.
2. Furthermore, once notification of this directive has been effected the Member States shall ensure that the Commission is informed, in time for it to submit its comments, of the most important laws, regulations and administrative provisions which they envisage adopting in the field covered by this Directive.

Article 6

This Directive is addressed to the Member States.

▼M3

LIST OF ANNEXES

- Annex I: Definitions, application for EC type-approval, granting of EC type-approval, symbol of the corrected absorption coefficient, specifications and tests, modifications of the type, conformity of production
- Appendix 1:* Information document
- Appendix 2:* Type-approval certificate
- Annex II: Example of the symbol of the corrected absorption coefficient
- Annex III: Test at steady speeds over the full load curve
- Annex IV: Test under free acceleration
- Annex V: Limit values applicable in the test at steady speeds
- Annex VI: Characteristics of opacimeters
- Annex VII: Installation and use of the opacimeter

▼ BANNEX I ► M2 ————— ◀▼ M2**DEFINITIONS, APPLICATION FOR EC TYPE-APPROVAL, GRANTING OF EC TYPE-APPROVAL, SYMBOL OF THE CORRECTED ABSORPTION COEFFICIENT, SPECIFICATIONS AND TESTS, MODIFICATIONS OF THE TYPE, CONFORMITY OF PRODUCTION**▼ B► M2 1. ◀ DEFINITIONS

For the purposes of this Directive:

- M2 1.1. ◀ ‘Vehicle type as regards the limitation of the emission of pollutants from the engine’ means motor vehicles which do not differ in such essential respects as the vehicle and engine characteristics defined in ► M2 Appendix 1 ◀;
- M2 1.2. ◀ ‘Diesel engine’ means an engine which works on the compression-ignition principle;
- M2 1.3. ◀ ‘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 the starting of the engine;
- M2 1.4. ◀ ‘Opacimeter’ means an instrument for continuous measurement of the absorption coefficients of the light by the exhaust gases emitted by vehicles.

► M2 2. ◀ APPLICATION FOR EEC TYPE APPROVAL▼ M2

- 2.1. The application for EC type-approval pursuant to Article 3 (4) of Directive 70/156/EEC of a vehicle type with regard to its emission of pollutants from diesel engines shall be submitted by the manufacturer.
- 2.2. A model for the information document is given in Appendix 1.

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- M2 2.3. ◀ An engine and the equipment prescribed in ► M2 Appendix 1 ◀ for fitting to the vehicle to be approved shall be submitted to the technical service conducting the approval tests defined in item 5. 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.

▼ M2

3. GRANTING OF EC TYPE-APPROVAL

- 3.1. If the relevant requirements are satisfied, EC type-approval pursuant to Article 4 (3) and, if applicable, Article 4 (4) of Directive 70/156/EEC shall be granted.
- 3.2. A model for the EC type-approval certificate is given in Appendix 2.
- 3.3. An approval number in accordance with Annex VII to Directive 70/156/EEC shall be assigned to each type of vehicle approved. The same Member State shall not assign the same number to another type of vehicle.

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4. SYMBOL OF THE CORRECTED ABSORPTION COEFFICIENT

- M2 4.1. ◀ To every vehicle conforming to a vehicle type approved under this Regulation there shall be affixed, conspicuously and in a readily accessible place specified in the ► M2 Addendum to the type-approval certificate shown in Appendix 2 ◀, a symbol being 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 method described in item 3.2 of Annex IV.
- M2 4.2. ◀ The symbol must be clearly legible and indelible.
- M2 4.3. ◀ ► M2 Annex II ◀ gives an example of the symbol.

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5. SPECIFICATIONS AND TESTS

5.1. **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 Directive.

5.2. **Specifications concerning cold-start devices**

5.2.1. 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.

5.2.2. The provisions of item 5.2.1 above shall not apply if at least one of the following conditions is met:

5.2.2.1. The light absorption coefficient of the gases emitted by the engine at steady speeds when measured by the method described in Annex III with the cold-start device operating is within the limits prescribed in ►**M3** Annex V ◀.

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

5.3. **Specifications concerning the emission of pollutants**

5.3.1. The emission of pollutants by the vehicle type submitted for approval shall be measured by the two methods described in Annexes III and IV, relating respectively to tests at steady speeds and to tests under free acceleration.⁽⁴⁾

5.3.2. The emission of pollutants, as measured by the method described in Annex III, shall not exceed the limits prescribed in ►**M3** Annex V ◀.

5.3.3. 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 VI for the nominal flow value corresponding to the maximum absorption coefficient measured during the tests at steady speeds, plus 0.5 m^{-1} .

5.4. Equivalent measuring instruments shall be allowed. If an instrument other than those described in ►**M3** Annex VI ◀ is used, proof of its equivalence for the engine considered shall be required.

▼M2

6. MODIFICATIONS OF THE TYPE AND AMENDMENTS TO APPROVALS

6.1. In the case of modifications of the type approved pursuant to this Directive, the provisions of Article 5 of Directive 70/156/EEC shall apply.

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7. CONFORMITY OF PRODUCTION

▼M2

7.1. Measures to ensure the conformity of production shall be taken in accordance with the provisions laid down in Article 10 of Directive 70/156/EEC.

7.2. In particular, conformity of the vehicle with the approved type as regards the emission of pollutants from diesel engines shall be verified on the basis of the results listed in the Addendum to the type-approval certificate shown in Appendix 2. In addition:

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►**M2** 7.2.1. ◀Where a check is carried out on a vehicle taken from the series, the tests shall be carried out as follows:

►**M2** 7.2.1.1. ◀ A vehicle which has not been run in shall be subjected to the test under free acceleration described in Annex IV. The vehicle shall be deemed to conform to the approved type if the absorption coefficient determined does not exceed by more than 0.5 m^{-1} the figure shown in the approval mark.

⁽⁴⁾ A test under free acceleration shall be carried out, especially in order to provide a reference figure for administrations which use this method to check vehicles in use.

▼ B

- ▶ **M2** 7.2.1.2. ◀ If the figure determined in the test referred to in item ▶ **M2** 7.2.1.1 ◀ above exceeds by more than 0.5 m⁻¹ the figure shown in the approval mark, a vehicle of the type considered or its engine shall be subjected to the test at steady speeds over the full-load curve, as described in Annex III. The emission levels shall not exceed the limits prescribed in ▶ **M3** Annex V ◀.

▼ M2

▼ M2*Appendix 1***INFORMATION DOCUMENT NO ...**

pursuant to Annex I to Council Directive 70/156/EEC ⁽¹⁾ relating to EC type-approval of a vehicle with respect to the measures to be taken against the emission of pollutants from diesel engines

(Directive 72/306/EEC, as last amended by Directive .../.../EC)

The following information, if applicable, must be supplied in triplicate and include a list of contents. Any drawings must be supplied in appropriate scale and in sufficient detail on size A4 or on a folder of A4 format. Photographs, if any, must show sufficient detail.

If the systems, components or separate technical units have electronic controls, information concerning their performance must be supplied.

⁽¹⁾ The item numbers and footnotes used in this information document correspond to those set out in Annex I to Directive 70/156/EEC. Items not relevant for the purpose of this Directive are omitted.

▼ M2

- 0. GENERAL
 - 0.1. Make (trade name of manufacturer):
 - 0.2. Type and general commercial description(s):
 - 0.3. Means of identification of type, if marked on the vehicle^(b):
 - 0.3.1. Location of that marking:
 - 0.4. Category of vehicle^(c):
 - 0.5. Name and address of manufacturer:
 - 0.8. Address(es) of assembly plant(s):
- 1. GENERAL CONSTRUCTION CHARACTERISTICS OF THE VEHICLE
 - 1.1. Photographs and/or drawings of a representative vehicle:
- 3. POWER PLANT^(a)
 - 3.1. Manufacturer:
 - 3.1.1. Manufacturer's engine code (as marked on the engine, or other means of identification):
 - 3.2.1.1. Working principle: positive ignition/compression ignition, four stroke/two stroke⁽¹⁾
 - 3.2.1.2. Number and arrangement of cylinders:
 - 3.2.1.2.1. Bore⁽¹⁾: mm
 - 3.2.1.2.2. Stroke⁽¹⁾: mm
 - 3.2.1.2.3. Firing order:
 - 3.2.1.3. Engine capacity⁽¹⁾: cm³
 - 3.2.1.4. Volumetric compression ratio⁽²⁾
 - 3.2.1.5. Drawings of combustion chamber, piston crown and, in the case of positive ignition engines, piston rings:
 - 3.2.1.6. Idling speed⁽²⁾: min⁻¹
 - 3.2.1.8. Maximum net power⁽¹⁾: kW at min⁻¹ (manufacturer's declared value)
 - 3.2.1.9. Maximum permitted engine speed as prescribed by the manufacturer: min⁻¹
 - 3.2.4. Fuel feed
 - 3.2.4.2. By fuel injection (compression ignition only): yes/no⁽¹⁾
 - 3.2.4.2.1. System description:
 - 3.2.4.2.2. Working principle: direct injection/pre-chamber/swirl chamber⁽¹⁾
 - 3.2.4.2.3. Injection pump
 - 3.2.4.2.3.1. Make(s):
 - 3.2.4.2.3.2. Type(s):
 - 3.2.4.2.3.3. Maximum fuel delivery⁽¹⁾⁽²⁾: mm³/stroke or cycle at a pump speed of: min⁻¹ or, alternatively, a characteristic diagram:
 - 3.2.4.2.3.4. Injection timing⁽²⁾:
 - 3.2.4.2.3.5. Injection advance curve⁽²⁾:
 - 3.2.4.2.3.6. Calibration procedure: test bench/engine⁽¹⁾
 - 3.2.4.2.4. Governor
 - 3.2.4.2.4.1. Type:
 - 3.2.4.2.4.2. Cut-off point
 - 3.2.4.2.4.2.1. Cut-off point under load: min⁻¹
 - 3.2.4.2.4.2.2. Cut-off point without load: min⁻¹
 - 3.2.4.2.5. Injection piping

▼ M2

- 3.2.4.2.5.1. Length: mm
- 3.2.4.2.5.2. Internal diameter: mm
- 3.2.4.2.6. Injector(s)
- 3.2.4.2.6.1. Make(s):
- 3.2.4.2.6.2. Type(s):
- 3.2.4.2.6.3. Opening pressure⁽²⁾: kPa or characteristic diagram⁽²⁾:
- 3.2.4.2.7. Cold start system
- 3.2.4.2.7.1. Make(s):
- 3.2.4.2.7.2. Type(s):
- 3.2.4.2.7.3. Description:
- 3.2.4.2.9. Electronic control unit
- 3.2.4.2.9.1. Make(s):
- 3.2.4.2.9.2. Description of the system:
- 3.2.4.4. Feed pump
- 3.2.4.4.1. Pressure⁽²⁾: kPa or characteristic diagram⁽²⁾:
- 3.2.7. Cooling system (liquid/air)⁽¹⁾
- 3.2.8. Intake system
- 3.2.8.1. Pressure charger: yes/no⁽¹⁾
- 3.2.8.1.1. Make(s):
- 3.2.8.1.2. Type(s):
- 3.2.8.1.3. Description of the system (e.g. maximum charge pressure: Pa, wastegate if applicable):
- 3.2.8.2. Intercooler: yes/no⁽¹⁾
- 3.2.8.3. Intake depression at rated engine speed and at 100 % load
 minimum allowable: kPa
 maximum allowable: kPa
- 3.2.8.4. Description and drawings of inlet pipes and their accessories (plenum chamber, heating device, additional air intakes, etc.):
- 3.2.8.4.1. Intake manifold description (include drawings and/or photos):
- 3.2.8.4.2. Air filter, drawings:, or
- 3.2.8.4.2.1. Make(s):
- 3.2.8.4.2.2. Type(s):
- 3.2.8.4.3. Intake silencer, drawings:, or
- 3.2.8.4.3.1. Make(s):
- 3.2.8.4.3.2. Type(s):
- 3.2.9. Exhaust system
- 3.2.9.1. Description and/or drawing of the exhaust manifold:
- 3.2.9.2. Description and/or drawing of the exhaust system:
- 3.2.9.3. Maximum allowable exhaust back pressure at rated engine speed and at 100 % load: kPa
- 3.2.10. Minimum cross-sectional areas of inlet and outlet ports:
- 3.2.11. Valve timing or equivalent data
- 3.2.11.1. Maximum lift of valves, angles of opening and closing, or timing details of alternative distribution systems, in relation to dead-centres:
- 3.2.11.2. Reference and/or setting ranges⁽¹⁾:
- 3.2.12. Measures taken against air pollution
- 3.2.12.2. Additional anti-pollution devices (if any, and if not covered by another heading)
- 3.2.12.2.1. Catalytic converter: yes/no⁽¹⁾
- 3.2.12.2.1.1. Number of catalytic converters and elements:

▼ M2

- 3.2.12.2.1.2. Dimensions, shape and volume of the catalytic converter(s):
- 3.2.12.2.1.3. Type of catalytic action:
- 3.2.12.2.1.4. Total charge of precious metals:
- 3.2.12.2.1.5. Relative concentration:
- 3.2.12.2.1.6. Substrate (structure and material):
- 3.2.12.2.1.7. Cell density:
- 3.2.12.2.1.8. Type of casing for the catalytic converter(s):
- 3.2.12.2.1.9. Location of the catalytic converter(s) (place and reference distance in the exhaust line):
.....
- 3.2.12.2.4. Exhaust gas recirculation: yes/no⁽¹⁾
- 3.2.12.2.4.1. Characteristics (flow rate, etc.):
- 3.2.12.2.6. Particulate trap: yes/no⁽¹⁾
- 3.2.12.2.6.1. Dimensions, shape and capacity of the particulate trap:
- 3.2.12.2.6.2. Type and design of the particulate trap:
- 3.2.12.2.6.3. Location (reference distance in the exhaust line):
- 3.2.12.2.6.4. Method or system of regeneration, description and/or drawing:
-
- 3.2.12.2.7. Other systems (description and operation):
- 3.2.13. Location of the absorption coefficient symbol (compression ignition engines only):
-
4. TRANSMISSION^(v)
- 4.3. Moment of inertia of engine flywheel:
- 4.3.1. Additional moment of inertia with no gear engaged:

.....
(Date, file)

⁽¹⁾ Delete where not applicable.

⁽²⁾ If the means of identification of type contains characters not relevant to describe the vehicle, component or separate technical unit types covered by this type-approval certificate such characters shall be represented in the documentation by the symbol: '?' (e.g. ABC??123??).

▼ **M2***Addendum to Appendix I***INFORMATION ON TEST CONDITIONS**

1. LUBRICANT USED

1.1. Make:

1.2. Type:
(state percentage of oil in mixture if lubricant and fuel mixed)

2. ENGINE PERFORMANCES

2.1. Power at the six points of measurement referred to in 2.1 of Annex III:

2.1.1. Power of the engine measured on the test bench:

2.1.2. Power measured on the wheels of the vehicle:

Engine speed (min ⁻¹)	Measured power (kW)
1.
2.
3.
4.
5.
6.

▼ M2

Appendix 2

MODEL**(maximum format: A4 (210 × 297 mm))**

EC TYPE-APPROVAL CERTIFICATE

Stamp of administration

Communication concerning the:

- type-approval⁽¹⁾,
- extension of type-approval⁽¹⁾,
- refusal of type-approval⁽¹⁾,
- withdrawal of type-approval⁽¹⁾

of a type of a vehicle/component/separate technical unit⁽¹⁾ with regard to Directive . . . /EEC, as last amended by Directive . . . /EC.

Type-approval number:

Reason for extension:

SECTION I

0.1. Make (trade name of manufacturer):

0.2. Type and general commercial description(s):

▼ M2

- 0.3. Means of identification of type if marked on the vehicle/component/separate technical unit⁽¹⁾ ⁽²⁾:
- 0.3.1. Location of that marking:
- 0.4. Category of vehicle⁽¹⁾ ⁽³⁾:
- 0.5. Name and address of manufacturer:
- 0.7. In the case of components and separate technical units, location and method of affixing of the EC approval mark:
- 0.8. Address(es) of assembly plant(s):

SECTION II

1. Additional information (where applicable): see Addendum
2. Technical service responsible for carrying out the tests:
3. Date of test report:
4. Number of test report:
5. Remarks (if any): see Addendum
6. Place:
7. Date:
8. Signature:
9. The index to the information package lodged with the approval authority, which may be obtained on request, is attached.

⁽¹⁾ Delete where not applicable.

⁽²⁾ If the means of identification of type contains characters not relevant to describe the vehicle, component or separate technical unit types covered by this type-approval certificate such characters shall be represented in the documentation by the symbol: '?' (e.g. ABC??123??).

⁽³⁾ As defined in Annex II A to Directive 70/156/EEC.

▼ **M2**

Addendum to EC type-approval certificate No ...

concerning the type-approval of a vehicle with regard to Directive 72/306/EEC, as last amended by Directive .../.../EC

1. Additional information

1.1. Power plant

1.1.1. Manufacturer's engine code (as marked on the engine, or other means of identification):....

1.2. Test results

1.2.1. At steady speeds:

Engine speed (min ⁻¹)	Nominal flow G (litres/second)	Limit absorption values (m ⁻¹)	Measured absorption values (m ⁻¹)
1.
2.
3.
4.
5.
6.

1.2.2. Under free acceleration

1.2.2.1. Measured value of the absorption coefficient: m⁻¹

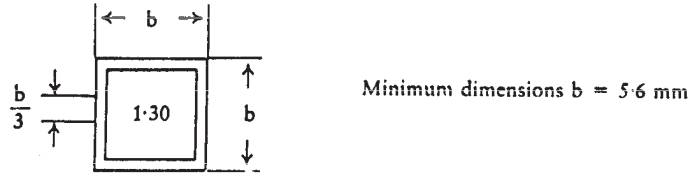
1.2.2.2. Corrected value of the absorption coefficient: m⁻¹

1.2.2.3. Location of the absorption coefficient symbol on the vehicle:

5. Remarks:

▼ M2

ANNEX II

EXAMPLE OF THE SYMBOL OF THE CORRECTED ABSORPTION
COEFFICIENT

The above symbol shows that the corrected absorption coefficient is 1.30 m^{-1} .

▼B*ANNEX III***TEST AT STEADY SPEEDS OVER THE FULL-LOAD CURVE****1. INTRODUCTION**

- 1.1. This annex describes the method of determining emissions of 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. Six measurements shall be made at engine speeds spaced out uniformly between that corresponding to maximum power and the higher of the following two engine speeds:
 - 45 per cent of the engine speed corresponding to maximum power; and
 - 1 000 rpm.

The extreme points of measurement shall be situated at the limits of the interval defined above.

- 2.2. In the case of diesel engines which are fitted with an air supercharger which can be engaged at will, and in which engines the entry into operation of the air supercharger automatically brings about an increase in the quantity of fuel injected, the measurements shall be made both with and without the supercharger working.

For each engine speed, the result of the measurement shall be the higher of the two figures obtained.

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 described in ►**M2** Appendix 1 to Annex I ◀.
- 3.1.3. The settings of the engine shall be those described by the manufacturer and by ►**M2** Appendix 1 to Annex I ◀.
- 3.1.4. The exhaust device shall not have any orifice through which the gases emitted by the engine might be diluted.
- 3.1.5. The engine shall be in the normal working condition prescribed by the manufacturer. In particular, the cooling water and the oil shall each be at the normal temperature indicated by the manufacturer.

▼M3**3.2. Fuel**

The reference fuel specified in Annex IV of Directive 88/77/EEC, as last amended, and which is appropriate to the emission limits against which the vehicle or engine is being type-approved, shall be used.

▼B**3.3. Test laboratory**

- 3.3.1. The absolute temperature T of the laboratory, expressed in degrees Kelvin, and the atmospheric pressure H, expressed in torr, shall be measured, and the factor F shall be determined by the formula

$$F = \left(\frac{750}{H}\right)^{0.65} \times \left(\frac{T}{298}\right)^{0.5}$$

- 3.3.2. For a test to be recognized as valid, the factor F shall be such that $0.98 \leq F \leq 1.02$.

▼B**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 ►**M3** Annex VI ◀ and installed in conformity with ►**M3** Annex VII ◀.

4. LIMIT VALUES

- 4.1. For each of the six engine speeds at which the absorption coefficient is measured pursuant to paragraph 2.1 above, the nominal gas flow G, expressed in litres per second, shall be calculated by means of the following formulae:

— for two-stroke engines $G = \frac{Vn}{60}$

— for four-stroke engines $G = \frac{Vn}{120}$

where:

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

n is the engine speed in revolutions per minute.

- 4.2. For each engine speed the absorption coefficient of the exhaust gases shall not exceed the limit value given in the table in ►**M3** Annex V ◀. Where the value of the nominal flow is not one of those given in that table, the limit value applicable shall be obtained by interpolation on the principle of proportional parts.



ANNEX IV

TEST UNDER FREE ACCELERATION

1. TEST CONDITIONS

- 1.1. The test shall be carried out on the vehicle or engine which has undergone the test at steady speeds described in Annex III.
 - 1.1.1. If the engine is tested on a bench the test 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 indicated 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 condition by a road run. The test shall be carried out as soon as possible after completion of the road run.
- 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 described in Annex III, items 3.1, 3.2 and 3.3, shall apply.
- 1.4. The conditions described in Annex III, item 3.4, with regard to the sampling and measuring apparatus shall apply.

2. TEST METHODS

- 2.1. 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 rotating parts.
- 2.2. If the test is carried out on a vehicle, the gear-change control shall be set in the neutral position and the engine in gear.
- 2.3. 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.
- 2.4. The operation described in item 2.3 above 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 at each successive acceleration shall be noted until stabilized values are obtained. No account shall be taken of the values read while the engine is idling after each acceleration. The values read shall be regarded as stabilized when four consecutive readings are situated within a band width of 0.25 m^{-1} and do not form a decreasing sequence. The absorption coefficient X_M to be recorded shall be the arithmetic mean of these four values.
- 2.5. Engines fitted with an air supercharger shall be subject, where appropriate, to the following special requirements:
 - 2.5.1. In the case of engines with an air supercharger which is coupled with 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 supercharger being engaged in one case and disengaged in the other. The measurement result recorded shall be the higher of the two results obtained;
 - 2.5.2. In the case of engines with an air supercharger which can be cut out by means of a driver-operated bypass, the test shall be carried out with and without the bypass. The measurement result recorded shall be the higher of the results obtained.

3. DETERMINATION OF THE CORRECTED VALUE OF THE ABSORPTION COEFFICIENT

3.1. **Notation**

X_M = value of the absorption coefficient under free acceleration measured as described in item 2.4 of this Annex;

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X_L = corrected value of the absorption coefficient under free acceleration;

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

S_L = value of the absorption coefficient (Annex III, item 4.2.) for the nominal flow corresponding to the point of measurement which gave the value S_M ;

L = effective length of the light path in the opacimeter.

- 3.2. When the absorption coefficients are expressed in m^{-1} and the effective length of the light path in metres, the corrected value X_L is given by the smaller of the following two expressions:

$$X'_L = \frac{S_L}{S_M} \cdot X_M \text{ or } X''_L = X_M + 0.5$$

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▼BANNEX ► M3 V ◀**LIMIT VALUES APPLICABLE IN THE TEST AT STEADY SPEEDS**

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

Note: Although the above values 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.

▼B*ANNEX ► **M3** VI ◀***CHARACTERISTICS OF OPACIMETERS****1. SCOPE**

This annex defines the conditions to be met by opacimeters used in the tests described in Annexes III and IV.

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 m^{-1} .

▼M3**3.3. Light source**

The light source shall be an incandescent lamp with a colour temperature in the range 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.

▼B**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 per cent 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 $\Phi = \Phi_0 \cdot e^{-kL}$, where L is the effective length of the light path through the gas to be measured, Φ_0 the incident flux and Φ 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 item 4 of this Annex; or
 - through correlation with another type of opacimeter for which the effective length is known.

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

$$k = -\frac{1}{L} \log_e \left(1 - \frac{N}{100} \right)$$

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 m^{-1} to be read with an accuracy of 0.025 m^{-1} .

3.6. Setting and testing 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 item 3.5.1. is between 1.6 m^{-1} and 1.8 m^{-1} . The value of k must be known to within 0.025 m^{-1} . The check consists in verifying that this value does not differ by more than 0.05 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 per cent of full-scale deflection ►C2 on insertion ◀ of a screen fully obscuring the photoelectric cell, shall be 0.9 to 1.1 second.
- 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 per cent 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 between the entry of the gas into the measuring apparatus and the complete filling of the smoke chamber; it shall not exceed 0.4 second.
- 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 m^{-1} in the case of a gas having an absorption coefficient of 1.7 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 indicated 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 $70 \text{ }^\circ\text{C}$ and a maximum temperature, specified by the opacimeter manufacturer, such that the readings over this temperature range do not vary by more than 0.1 m^{-1} if the chamber is filled with a gas having an absorption coefficient of 1.7 m^{-1} .
- 3.9.2. The opacimeter shall be equipped with appropriate devices for measuring the temperature in the smoke chamber.

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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 admitted in a normal way 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_o obtained with the opacimeter modified so that the test gas fills a well defined length L_o .
- 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 the exhaust gas.
- 4.2.2. A column of length L_o of the opacimeter, which can be filled uniformly with the test gases, and the ends of which are substantially at right angles to the light path, shall be accurately determined. This length L_o shall be close to the presumed 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 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 addition of the expansion tank and of the cooler must not unduly disturb the composition of the exhaust gas.
- 4.2.5. The test for determining the effective length shall consist of passing a sample of test gas alternately through the opacimeter operating normally and through the same apparatus modified as indicated in item 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_o filled with the same test gas, the reading on the linear scale of opacity is N_o and that of the mean gas temperature expressed in Kelvin degrees is T_o .
- 4.2.6. The effective length will be

$$L = L_o \frac{T}{T_o} \frac{\log \left(1 - \frac{N}{100} \right)}{\log \left(1 - \frac{N_o}{100} \right)}$$

- 4.2.7. The test shall be repeated with at least four test gases giving readings evenly spaced between the 20 and 80 on the linear scale.
- 4.2.8. The effective length L of the opacimeter will be the arithmetic mean of the effective lengths obtained as stated in item 4.6 with each of the gases.



ANNEX ►M3 VII ◀

INSTALLATION AND USE OF THE OPACIMETER

1. SCOPE

This annex specifies the installation and use of opacimeters for the tests described in Annexes III and IV.

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 intake 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 outlet, 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 substantially 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 possible while satisfying the pressure and temperature requirements described in ►M3 Annex VI ◀, items 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 bypass valve shall be provided upstream.
- 2.1.7. A check shall be carried out during the test to ensure that the requirements of ►M3 Annex VI ◀, item 3.8, concerning pressure and those of ►M3 Annex VI ◀, item 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 intake 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 outlet, 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 ►M3 Annex VI ◀, item 3.8.2. This may be checked by noting the sample pressure at engine idling and maximum no-load speeds. Depending on the character-

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istics of the opacimeter, control of sample pressure can be achieved by a fixed restriction or a butterfly valve in the exhaust pipe or extension pipe. Whichever method is used, the back pressure measured in the exhaust pipe at the intake of the probe shall not exceed 75 mm (water gauge).

- 2.2.4. The pipes connecting with the opacimeter shall 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 bypass 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 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 bypass 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.

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