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# COUNCIL DIRECTIVE

**of 28 June 1977**

**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 wheeled agricultural or forestry tractors**

(77/537/EEC)

(OJ L 220, 29.8.1977, p. 38)

Amended by:

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| ►**M1** Council Directive 82/890/EEC of 17 December 1982 | L 378 | 45 | 31.12.1982 |

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# COUNCIL DIRECTIVE

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(77/537/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 [1],

Having regard to the opinion of the Economic and Social Committee [2],

Whereas the technical requirements which tractors must satisfy pursuant to national laws relate *inter alia* to the emission of pollutants from diesel engines for use in tractors;

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 Council Directive 74/150/EEC of 4 March 1974 on the approximation of the laws of the Member States relating to the type-approval of wheeled agricultural or forestry tractors [3], to be applied in respect of each type of tractor;

Whereas the approximation of national laws relating to tractors entails reciprocal recognition by Member States of the tests carried out by each of them on the basis of common requirements,

HAS ADOPTED THIS DIRECTIVE:

*Article 1*

1. 'Agricultural or forestry tractor' means any motor vehicle, fitted with wheels or endless tracks, having at least two axles, the main function of which lies in its tractive power and which is specially designed to tow, push, carry or power certain tools, machinery or trailers intended for agricultural or forestry use. It may be equipped to carry a load and passengers.

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2. This Directive shall apply only to tractors defined in paragraph I which are equipped with pneumatic tyres and have at least two axles and a maximum design speed of between 6 and 30 km/h.

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*Article 2*

No Member State may refuse to grant a tractor EEC type-approval or national type-approval on the grounds that pollutants are emitted by the diesel engine which drives the tractor if the tractor satisfies the requirements laid down in Annexes I, II, III, IV and VI.

*Article 3*

No Member State may refuse the registration or may prohibit the sale, entry into service or use of any tractor on the grounds that pollutants are

[1] OJ No C 125, 8. 6. 1976, p. 51.
[2] OJ No C 197, 23. 8. 1976, p. 16.
[3] OJ No L 84, 28. 3. 1974, p. 10.

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emitted by the diesel engine which drives the tractor if the tractor satisfies the requirements laid down in Annexes I, II, III, IV and VI.

*Article 4*

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 2.2 of Annex I. The competent authorities of that State shall determine whether fresh tests should be carried out on the modified tractor and a fresh report drawn up. Where such tests reveal a failure to comply with the requirements of this Directive, the modification shall not be approved.

*Article 5*

The amendments necessary to adapt the provisions of Annexes I to X to this Directive to take account of technical progress shall be adopted in accordance with the procedure laid down in Article 13 of Directive 74/150/EEC.

*Article 6*

1. Member States shall bring into force provisions containing the provisions necessary in order to comply with this Directive within 18 months of its notification and shall forthwith inform the Commission thereof.

2. Member States shall ensure that the texts of the main provisions of national law which they adopt in the field covered by this Directive are communicated to the Commission.

*Article 7*

This Directive is addressed to the Member States.

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*ANNEX I ([1])*

**DEFINITIONS, APPLICATION FOR EEC TYPE-APPROVAL, SYMBOL OF THE CORRECTED ABSORPTION COEFFICIENT, SPECIFICATIONS AND TESTS AND CONFORMITY OF PRODUCTION**

(1.)

2. DEFINITIONS

For the purposes of this Directive:

(2.1.)

2.2. '*tractor type as regards the limitation of the emission of pollutants from the engine*' means tractors which do not differ in such essential respects as the tractor and engine characteristics defined in Annex II;

2.3. '*diesel engine*' means an engine which works on the compression-ignition principle;

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 the starting of the engine;

2.5. '*opacimeter*' means an instrument for continuous measurement of the absorption coefficients of the light by the exhaust gases emitted by tractors.

3. APPLICATION FOR EEC TYPE-APPROVAL

3.1. The application for approval must be submitted by the tractor manufacturer or by his duly accredited representative.

3.2. It must be accompanied by the undermentioned documents in triplicate and the following particulars:

3.2.1. a description of the engine type including all the particulars referred to in Annex II;

3.2.2. drawings of the combustion chamber and of the upper face of the piston.

3.3. An engine and the equipment prescribed in Annex II to this Regulation, for fitting to the tractor to be approved, shall be submitted to the technical service conducting the approval tests defined in 5. However, if the manufacturer so requests and the technical service conducting the approval tests agrees, a test may be carried out on a tractor representative of the tractor type to be approved.

3a. EEC TYPE-APPROVAL

A certificate conforming to that shown in Annex X shall be attached to the EEC type-approval certificate.

4. SYMBOL OF THE CORRECTED ABSORPTION COEFFICIENT

(4.1.)

(4.2.)

(4.3.)

4.4. To every tractor conforming to a tractor type approved under this Regulation there shall be affixed, conspicuously and in a readily accessible place specified in the Annex to the type-approval certificate shown in Annex X, 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 3.2 of Annex IV.

([1]) The text of the Annexes is similar to that of Regulation No 24 of the UN Economic Commission for Europe; in particular the breakdown into items is the same. For this reason, where an item of Regulation No 24 has no counterpart in this Directive, its number is given in brackets as a token entry.

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4.5. The symbol must be clearly legible and indelible.

4.6. Annex IX gives an example of the symbol.

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 tractor 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 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 Annex VI;

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 tractor 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 ([1]).

5.3.2. The emission of pollutants, as measured by the method described in Annex III, shall not exceed the limits prescribed in Annex VI.

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 Annex VII is used, proof of its equivalence for the engine considered shall be required.

(6.)

7. CONFORMITY OF PRODUCTION

7.1. Every tractor in the series must conform, with regard to components affecting the emission of pollutants by the engine, to the tractor type approved.)

(7.2.)

7.3. As a general rule conformity of the tractor with the approved type as regards the emission of pollutants from diesel motors shall be verified on the basis of the description given in the Annex to the EEC approval certificate shown in Annex X. In addition:

7.3.1. where a check is carried out on a vehicle taken from the series, the tests shall be carried out as follows:

7.3.1.1. a tractor 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 the figure shown in the approval mark by more than 0·5 $m^{-1}$;

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

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7.3.1.2. if the figure determined in the test referred to in 7.3.1.1 above exceeds the figure shown in the approval mark by more than 0·5 $m^{-1}$, a tractor of the type considered or its engine shall be subjected to the test at steady speeds as described in Annex III. The emission levels shall not exceed the limits prescribed in Annex VI.

(8.)

(9.)

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*ANNEX II*

## ESSENTIAL CHARACTERISTICS OF THE TRACTOR AND THE ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TESTS (1)

1. **Description of engine**

1.1. Make .....

1.2. Type .....

1.3. Cycle: four-stroke/two-stroke (2)

1.4. Bore ..... mm

1.5. Stroke ..... mm

1.6. Number of cylinders .....

1.7. Cylinder capacity ..... $cm^3$

1.8. Compression ratio (3) .....

1.9. System of cooling .....

1.10. Supercharger with/without (2) description of the system .....

.....

1.11. Air filter: drawings, or makes and types .....

2. **Additional anti-smoke 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 air intakes and their accessories (heating device, intake silencer, etc.)

.....

3.2. Fuel feed

3.2.1. Feed pump

Pressure (3) ..... or characteristic diagram (3) .....

.....

3.2.2. Injector .....

3.2.2.1. Pump

3.2.2.1.1. Make(s) .....

---

(1) In the case of non-conventional engines and systems, particulars equivalent to those referred to below shall be supplied by the manufacturer.
(2) Delete where inapplicable.
(3) Specify the tolerance.

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3.2.2.1.2. Type(s) .....

3.2.2.1.3. Delivery ..... $mm^3$ per stroke at pump speed of ..... rpm (1)

at full injection; or characteristic diagram (1) (2) .....

Mention the method used: On engine/on pump test bench (2)

3.2.2.1.4. Injection advance .....

3.2.2.1.4.1. Injection advance curve .....

3.2.2.1.4.2. Timing .....

3.2.2.2. Injection piping

3.2.2.2.1. Length .....

3.2.2.2.2. Internal diameter .....

3.2.2.3. Injector(s)

3.2.2.3.1. Make(s) .....

3.2.2.3.2. Type(s) .....

3.2.2.3.3. Starting pressure ..... bar (1)

or characteristic diagram (1) (2) .....

3.2.2.4. Governor

3.2.2.4.1. Make(s) .....

3.2.2.4.2. Type(s) .....

3.2.2.4.3. Speed at which cut-off starts under load: ..... rpm

3.2.2.4.4. Maximum no-load speed: ..... rpm

3.2.2.4.5. Idling speed: ..... rpm

3.3. Cold-start system

3.3.1. Make(s) .....

3.3.2. Type(s) .....

3.3.3. Description .....

**4. Valve timing**

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

.....

4.2. Reference and/or setting ranges (2) .....

(1) Specify the tolerance.
(2) Delete where inapplicable.

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5. **Exhaust device**

5.1. Description and diagrams .....

5.2. Mean back-pressure at maximum power: ..... mm water Pascal (Pa)

6. **Transmission**

6.1. Moment of inertia of engine flywheel .....

6.2. Additional moment of inertia with no gear engaged .....

.....

7. **Additional information on test conditions**

7.1. Lubricant used

7.1.1. Make(s) .....

7.1.2. Type(s) .....
(State percentage of oil in mixture if lubricant and fuel mixed)

8. **Engine performances**

8.1. Idling speed ..... rpm [1]

8.2. Engine speed at maximum power ..... rpm [1]

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

8.3.1. Power of the engine measured on the test bench: indicate the standard followed (BSI-CUNA-DIN-GOST-IGM-ISO-SAE, etc.)

8.3.2. Power measured on the wheels of the vehicle

| Engine speed (n) rpm | Measured power kW |
|---|---|
| 1. ..... | ..... |
| 2. ..... | ..... |
| 3. ..... | ..... |
| 4. ..... | ..... |
| 5. ..... | ..... |
| 6. ..... | ..... |

[1] Specify the tolerance.

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*ANNEX III*

**TEST AT STEADY SPEEDS**

1. INTRODUCTION

1.1. This Annex describes the method of determining emissions of pollutants at different steady speeds at 80% of the maximum load.

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

2. MEASUREMENT PRINCIPLE

2.1. The opacity of the exhaust gases produced by the engine shall be measured with the engine running under 80% of the maximum load and at steady speed. Six measurements shall be made at engine speeds spaced out uniformly between that corresponding to maximum power and the higher of the following two engine speeds:

— 55% 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. Tractor or engine

3.1.1. The engine or the tractor 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 Annex II.

3.1.3. The settings of the engine shall be those described by the manufacturer and by Annex II.

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.

3.2. Fuel

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

3.3. Test laboratory

3.3.1. The absolute temperature T of the laboratory, expressed in 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 $0{\cdot}98 \leq F \leq 1{\cdot}02$.

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 VII and installed in conformity with Annex VIII.

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,

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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 Annex VI. 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.

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*ANNEX IV*

**TEST UNDER FREE ACCELERATION**

1. TEST CONDITIONS

1.1. The test shall be carried out on the tractor 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 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 tractor, 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 3.1, 3.2 and 3.3 of Annex III shall apply.

1.4. The conditions described in 3.4 of Annex III, 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 tractor, 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 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 driveroperated 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 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 (2.1 of Annex III), which is closest to the prescribed limit value corresponding to the same nominal flow;

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$S_L$ =value of the absorption coefficient (4.2 of Annex III) 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 correcte value $X_L$ is given by the smaller of the following two expressions:

$$X'_L = \frac{S_L}{S_M} \cdot X_M \text{ ou } X''_L = X_M + 0{,}5$$

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*ANNEX V*

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

| | Limits and units | Method |
|---|---|---|
| Density 15/4 °C | 0·830 ± 0·005 | ASTM D 1298-67 |
| Distillation | | ASTM D 86-67 |
| 50 % | min. 245 °C | |
| 90 % | 330 ± 10 °C | |
| Final boiling point | max. 370 °C | |
| Cetane index | 54 ± 3 | ASTM D 976-66 |
| Kinematic viscosity at 100 °F | 3 ± 0·5 cSt | ASTM D 445-65 |
| Sulphur content | 0·4 ± 0·1 % by weight | ASTM D 129-64 |
| Flash-point | min. 55 °C | ASTM D 93-71 |
| Cloud point | max. − 7 °C | ASTM D 2500-66 |
| Aniline point | 69 ± 5 °C | ASTM D 611-64 |
| Carbon residue on 10 % bottoms | max. 0·2 % by weight | ASTM D 524-64 |
| Ash content | max. 0·01 % by weight | ASTM D 482-63 |
| Water content | max. 0·05 % by weight | ASTM D 95-70 |
| Copper — corrosion test at 100 °C | max. 1 | ASTM D 130-68 |
| Net calorific value | { 10 250 ± 100 kcal/kg<br>18 450 ± 180 BTU/lb } | ASTM D 2-68 (Ap. VI) |
| Strong acid number | nil mg KOH/g | ASTM D 974-64 |

*Note:* The fuel must be based only on straight-run distillates, hydrodesulphurized or not, and must contain no additives.

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*ANNEX VI*

**LIMIT VALUES APPLICABLE IN THE TEST AT STEADY SPEEDS**

| *Nominal flow G* litres/second | *Absorptions coefficient k* $m^{-1}$ |
|---|---|
| ≤ 42 | 2·26 |
| 45 | 2·19 |
| 50 | 2·08 |
| 55 | 1·985 |
| 60 | 1·90 |
| 65 | 1·84 |
| 70 | 1·775 |
| 75 | 1·72 |
| 80 | 1·665 |
| 85 | 1·62 |
| 90 | 1·575 |
| 95 | 1·535 |
| 100 | 1·495 |
| 105 | 1·465 |
| 110 | 1·425 |
| 115 | 1·395 |
| 120 | 1·37 |
| 125 | 1·345 |
| 130 | 1·32 |
| 135 | 1·30 |
| 140 | 1·27 |
| 145 | 1·25 |
| 150 | 1·225 |
| 155 | 1·205 |
| 160 | 1·19 |
| 165 | 1·17 |
| 170 | 1·155 |
| 175 | 1·14 |
| 180 | 1·125 |
| 185 | 1·11 |
| 190 | 1·095 |
| 195 | 1·08 |
| ≥ 200 | 1·065 |

*Note:* Although the above values are rounded to the nearest 0·01 or 0·005, this does not mean that the measurements need to be made to this degree of accuracy.

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*ANNEX VII*

## 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 $1{\cdot}7\ m^{-1}$.

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.

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 $\Phi = \Phi o \cdot e^{-kL}$, where L is the effective length of the light path through the gas to be measured, $\Phi_o$ the incident flux and $\Phi$ 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 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 to 100 linear scale and the light absorption coefficient k is given by the formula

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

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 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 % 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 between the beginning of 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 735 Pa 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 °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.

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

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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 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 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 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 4.2.6 with each of the gases.

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*ANNEX VIII*

## 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 735 Pa.

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 addition 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 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 3.8 and 3.9 of Annex VII. 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 3.8 of Annex VII, concerning pressure and those of 3.9 of Annex VII, 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 735 Pa.

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 3.8.2 of Annex VII. 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 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 735 Pa.

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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;

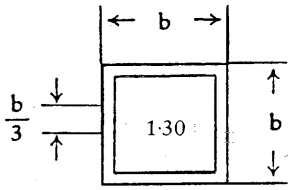
3.2. the pipes connecting with the opacimeter shall be as short as possible, as in the case of sampling opacimeters. The pipe system shall be inclined upwards from the exhaust pipe to the opacimeter, and sharp bends where soot might accumulate shall be avoided. A bypass valve may be provided upstream 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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*ANNEX IX*

**EXAMPLE OF THE SYMBOL OF THE CORRECTED ABSORPTION COEFFICIENT**




Minimum dimensions b = 5·6 mm

The above symbol shows that the corrected absorption coefficient is 1·30 $m^{-1}$.

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*ANNEX X*

Name of administration

## ANNEX TO THE EEC TYPE-APPROVAL CERTIFICATE ON THE EMISSION OF GASEOUS POLLUTANTS BY DIESEL ENGINES

(Articles 4 (2) and 10 of Council Directive 74/150/EEC of 4 March 1974 on the approximation of the laws of the Member States relating to the type-approval of agricultural tractors and machinery)

EEC type-approval No (1) .....

Registered No (1) .....

1. Trade name or mark of the vehicle .....

2. Vehicle type .....

3. Manufacturer's name and address .....

.....

4. If applicable, name and address of manufacturer's representative .....

.....

5. Emission levels

5.1. At steady speeds

| Engine speed (rpm) | Nominal flow G (litres/second) | Limit absorption values ($m^{-1}$) | Measured absorption values ($m^{-1}$) |
|---|---|---|---|
| 1. ..... | ..... | ..... | ..... |
| 2. ..... | ..... | ..... | ..... |
| 3. ..... | ..... | ..... | ..... |
| 4. ..... | ..... | ..... | ..... |
| 5. ..... | ..... | ..... | ..... |
| 6. ..... | ..... | ..... | ..... |

5.2. Under free acceleration

5.2.1. Measured absorption value..... $m^{-1}$

(1) Delete where inapplicable.

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5.2.2. Corrected absorption value..... $m^{-1}$

6. Make and type of the opacimeter .....

7. Engine submitted for approval tests on .....

8. Technical service conducting approval tests .....

.....

9. Date of test report issued by that service .....

10. Number of test report issued by that service .....

11. Approval granted/refused (1) .....

12. Site of approval mark on the vehicle .....

13. Place .....

14. Date .....

15. Signature .....

16. The following documents, bearing the approval number shown above, are annexed in communication:

one copy of Annex II duly completed together with the drawings and diagrams referred to

..... photograph(s) of the engine.

1) Delete where inapplicable.