No. 4789. AGREEMENT CONCERNING THE ADOPTION OF UNIFORM CONDITIONS OF APPROVAL AND RECIPROCAL RECOGNITION OF APPROVAL FOR MOTOR VEHICLE EQUIPMENT AND PARTS. DONE AT GENEVA ON 20 MARCH 1958[1]

ENTRY INTO FORCE OF REGULATION NO. 24 (UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES EQUIPPED WITH DIESEL ENGINES WITH REGARD TO THE EMISSION OF POLLUTANTS BY THE ENGINE) AS AN ANNEX TO THE ABOVE-MENTIONED AGREEMENT

The said Regulation came into force on 15 September 1972 in respect of France and Spain, in accordance with article 1 (5) of the Agreement.

Authentic texts of the Regulation: English and French.
Registered ex officio *on 15 September 1972.*

1. SCOPE
This Regulation applies to emissions from diesel engines used for driving motor vehicles.

2. DEFINITIONS
For the purposes of this Regulation,

2.1. " *Approval of a vehicle* " means the approval of a vehicle type with regard to limitation of the emission of pollutants from the engine;

2.2. " *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 this Regulation;

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 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 vehicles.

3. APPLICATION FOR APPROVAL

3.1. 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.

3.2. It shall be accompanied by the under-mentioned documents in triplicate and the following particulars :

3.2.1. a description of the engine type comprising all the particulars referred to in annex 1;

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

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[1] United Nations, *Treaty Series*, vol. 335, p. 211; for subsequent actions, see references in Cumulative Indexes Nos. 4 to 10, as well as annex A in volumes 723, 730, 740, 752, 754, 756, 759, 764, 768, 771, 772, 774, 777, 778, 779, 787, 788, 797, 801, 802, 808, 811, 814, 815, 818, 820, 825, 826, 829, 830 and 834.

3.3. An engine and the equipment prescribed in annex 1 to this Regulation for fitting it to the vehicle to be approved shall be submitted to the technical service conducting the approval tests defined in paragraph 5 of this 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.

4. APPROVAL

4.1. If the vehicle type submitted for approval pursuant to this Regulation meets the requirements of paragraph 5 below, approval of that vehicle type shall be granted.

4.2. An approval number shall be assigned to each type approved. The same Contracting Party may not assign the same number to another vehicle type.

4.3. Notice of approval or of refusal of approval of a vehicle type 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 2 to this Regulation and of drawings and diagrams supplied, by the applicant for approval, in a format not exceeding A 4 (210 × 297 mm) or folded to that format and on an appropriate scale.

4.4. 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,

4.4.1. an international approval mark consisting of:

4.4.1.1. a circle surrounding the letter " E " followed by the distinguishing number of the country which has granted approval*;

4.4.1.2. the number of this Regulation, followed by the letter " R ", a dash and the approval number, below the circle;

4.4.2. the following additional symbol: 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, paragraph 3.2, to this Regulation.

4.5. The approval mark and the additional symbol shall be clearly legible and be indelible.

4.6. Annex 3 to this Regulation gives an example of the arrangement of the approval mark and of the additional 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 vehicle, in normal use, despite the

* 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 and 12 for Austria. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify the Agreement concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, or in which they accede to that Agreement, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

vibration to which it may be subjected, to comply with the provisions of this Regulation.

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 paragraph 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 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.

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 4 and 5 to this Regulation, relating respectively to tests at steady speeds and to tests under free acceleration.*

5.3.2. The emission of 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.

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 7 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 8 to this Regulation is used, its equivalence for the engine considered shall be required to be proved.

6. MODIFICATION OF THE VEHICLE TYPE

6.1. Every modification of the vehicle type shall be notified to the administrative department which approved the vehicle type. The department may then either:

6.1.1. 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

6.1.2. require a further test report from the technical service conducting the tests.

6.2. Confirmation of approval, specifying the alterations, or refusal or approval shall be communicated by the procedure specified in paragraph 4.3 above to the Parties to the Agreement which apply this Regulation.

7. CONFORMITY OF PRODUCTION

7.1. Every vehicle bearing an approval mark as prescribed under this Regulation

* 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.

shall conform, with regard to components affecting the emission of pollutants by the engine, to the vehicle type approved.

7.2. In order to verify conformity as prescribed in paragraph 7.1, a vehicle bearing the approval mark required by this Regulation shall be taken from the series.

7.3. Conformity of the vehicle with the approved type 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:

7.3.1. 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 approved type if the absorption coefficient determined does not exceed by more than 0.5 m^{-1} the figure shown in the approval mark.

7.3.2. If the figure determined in the test referred to in paragraph 7.3.1 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 prescribed in annex 4 to this Regulation. The emission levels shall not exceed the limits prescribed in annex 7 to this Regulation.

8. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

8.1. The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 7.1 are not complied with or if the vehicle or vehicles taken fail to pass the tests prescribed in paragraph 7.3 above.

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

9. NAMES AND ADDRESSES OF TECHNICAL SERVICES CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the Agreement which apply this Regulation shall communicate to the Secretariat of the United Nations the names and addresses of the technical services 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

ESSENTIAL CHARACTERISTICS OF THE VEHICLE AND THE ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TESTS*

1. *Description of engine*

1.1. Make . . . . . .

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

1.2. Type . . . . . .
1.3. Cycle: four-stroke/two-stroke† .
1.4. Bore . . . . . mm
1.5. Stroke . . . . . mm
1.6. Number of cylinders . . . . . .
1.7. Cylinder capacity . . . . . cm^3
1.8. Compression ratio‡ . . . . . .
1.9. System of cooling . . . . . .
1.10. Supercharger with/without† 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‡. . . . . or characteristic diagram‡ . . . . . .
3.2.2. Injector . . . . . .
3.2.2.1. Pump
3.2.2.1.1. Make(s) . . . . . .
3.2.2.1.2. Type(s) . . . . . .
3.2.2.1.3. Delivery . . . mm^3 per stroke at pump speed of . . . r.p.m.‡ at full injection; or characteristic diagram†‡ . . . . . .
Mention the method used : On engine/on pump bench†
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 bars‡
or characteristic diagram†‡ . . . . . .
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: . . . . . r.p.m.
3.2.2.4.4. Maximum no-load speed:. . . . . r.p.m.
3.2.2.4.5. Idling speed: . . . . . r.p.m.
3.3. Cold-start system
3.3.1. Make(s) . . . . . .

† Strike out what does not apply.
‡ Specify the tolerance.

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† . . . . . .
5. *Exhaust device*
5.1. Description and diagrams . . . . . .
5.2. Mean back-pressure at maximum power: . . . . mm water
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 . . . . . .
7.1.2. Type . . . . . .
(State percentage of oil in mixture if lubricant and fuel mixed)

8. *Engine performances*
8.1. Idling speed . . . . . r.p.m.
8.2. Engine speed at maximum power . . . . . r.p.m.‡

8.3. Power at the six points of measurement referred to in paragraph 2.1. of annex 4 to this Regulation
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) r.p.m.	*Measured power HP*
1	. . . . .	. . . . .
2	. . . . .	. . . . .
3	. . . . .	. . . . .
4	. . . . .	. . . . .
5	. . . . .	. . . . .
6	. . . . .	. . . . .

ANNEX 2

(Maximum format : A 4 (210 × 297 mm))

NAME OF
ADMINISTRATION

Communication concerning the approval
(or refusal or withdrawal of approval) of a vehicle type
equipped with a diesel engine with regard to the emission of pollutants by the engine,
pursuant to Regulation No. 24

Approval No. . . . . .

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 (r.p.m.)	*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}

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*

* Strike out what does not apply.

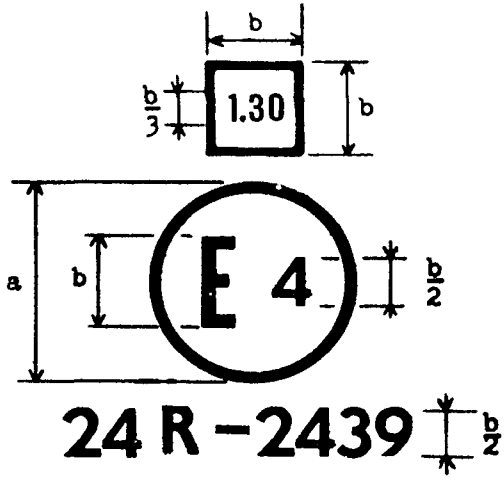
12. Site of approval mark on the vehicle . . . . . .
13. Place . . . . . .
14. Date . . . . . .
15. Signature . . . . . .
16. The following documents, bearing the approval number shown above, are annexed to this communication :

    1 copy of annex 1 to this Regulation, duly completed and with the drawings and diagrams referred to attached;

    . . . . photograph(s) of the engine and its compartment.

ANNEX 3

ARRANGEMENT OF THE APPROVAL MARK



	a	b
Minimum dimensions	12	5.6

(millimetres)

The above approval mark affixed to a vehicle shows that, pursuant to Regulation No. 24, the vehicle type concerned has, with regard to the emission of pollutants by the engine, been approved in the Netherlands (E 4) under approval number 2439. The corrected absorption coefficient is 1.30 m^{-1}.

ANNEX 4

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
—1000 r.p.m.

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

2.2. In the case of diesel engines fitted with an air supercharger which can be engaged at will, 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 conditions. 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. 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 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 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

$$F = \frac{(740)^{0.65}}{(H)} \times \frac{(T)^{0.5}}{(303)}$$

3.3.2. For a test to be recognized as valid, the factor F shall be such that

$$0.98 \leqslant F \leqslant 1.02.$$

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. 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 $G = \frac{Vn}{120}$

in which :

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 7. 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 5

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 4 to this Regulation.

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. 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 prescribed in annex 4, paragraphs 3.1, 3.2 and 3.3, shall apply.

1.4. The conditions prescribed in annex 4, paragraph 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 said 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 paragraph 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 in each successive acceleration shall be noted until stabilized 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 stabilized when four of them consecutively are situated within a band width of 0.25 m^{-1} and do not form a decreasing sequence. The absorption coefficient X_M to be recorded shall be the arithmetical mean of these four values.

2.5. 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 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; and

2.5.2. in the case of engines with an air supercharger which can be cut out by means of a driver-operated by-pass, the test shall be carried out with and without the by-pass. 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 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, paragraph 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, paragraph 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. The absorption coefficients being expressed in m^{-1} and the effective length of the light path being expressed in metres, the corrected value X_L is given by the smaller of the following two expressions:

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

ANNEX 6

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 99–66
Cloud point	max. −7°C	ASTM D 97–66
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 95–62
Copper—corrosion test at 100°C	max. 1	ASTM D 130–68
Net calorific value	(10,250 ± 100 kcal/kg (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.

* Initials of the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pennsylvania 19103, U.S.A. The figures after the dash denote the year when a standard was adopted or revised. Should any ASTM standards be amended, the standards adopted in the years quoted above will remain applicable unless all Parties to the 1958 Agreement which apply this Regulation agree to replace them by later standards.

ANNEX 7

LIMIT VALUES APPLICABLE IN THE TEST AT STEADY SPEEDS

Nominal flow G (*litres/second*)	*Absorption coefficient* K (m^{-1})	*Nominal flow* G (*litres/second*)	*Absorption coefficient* K (m^{-1})
⩽42	2.26	120	1.37
45	2.19	125	1.345
50	2.08	130	1.32
55	1.985	135	1.30
60	1.90	140	1.27
65	1.84	145	1.25
70	1.775	150	1.225
75	1.72	155	1.205
80	1.665	160	1.19
85	1.62	165	1.17
90	1.575	170	1.155
95	1.535	175	1.14
100	1.495	180	1.125
105	1.465	185	1.11
110	1.425	190	1.095
115	1.395	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 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 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 $\phi = \phi_0 . e^{-kL}$, 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 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

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

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. *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 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 on removal 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 taken by gas entering the chamber to the smoke chamber completely; 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 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 this temperature range do not vary by more than 0.1 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 photo-

electric 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.

4.3. The mean temperature of the test gas in the smoke chamber shall be measured.

4.4. 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.

4.5. 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.

4.5.1. 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.

4.5.2. 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.

4.5.3. 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.

4.6. The effective length will be

$$L = L_0 \frac{T}{T_0} \frac{\log [1 - (N/100)]}{\log [1 - (N_0/100)]}$$

4.7. 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.

4.8. The effective length L of the opacimeter will be the arithmetic average of the effective lengths obtained as stated in paragraph 4.6 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 $6D$ in length upstream of the sampling point and $3D$ 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 $3D$ 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, paragraphs 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, paragraph 3.8, concerning pressure and those of annex 8, paragraph 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, paragraph 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.

ENTRY INTO FORCE OF REGULATION NO. 27 (UNIFORM PROVISIONS FOR THE APPROVAL OF ADVANCE-WARNING TRIANGLES) AS AN ANNEX TO THE AGREEMENT OF 20 MARCH 1958[1] CONCERNING THE ADOPTION OF UNIFORM CONDITIONS OF APPROVAL AND RECIPROCAL RECOGNITION OF APPROVAL FOR MOTOR VEHICLE EQUIPMENT AND PARTS

The said Regulation came into force on 15 September 1972 in respect of France, the Netherlands and Sweden, in accordance with article 1 (5) of the Agreement.

Authentic texts of the Regulation: English and French.
Registered ex officio *on 15 September 1972.*

1. SCOPE
This Regulation applies to certain advance-warning devices intended to be on board vehicles and to be placed on the carriageway in order to signal, by day and at night, the presence of a halted vehicle.

2. DEFINITIONS
For the purposes of this Regulation,

2.1. " *advance-warning triangle* " means the device referred to in paragraph 1. above, in the form of an equilateral triangle;

2.2. " *type of triangle* " means advance-warning triangles which do not differ in such essential respects as

2.2.1. the trade name or mark;
2.2.2. the optical characteristics;
2.2.3. the distinctive geometrical and mechanical features of the design;

2.3. " *reflex reflecting device* " means an assembly, ready for use, comprising one or more reflex reflecting optical units;

2.4. " *front face of the triangle* " means the face carrying the optical units;

2.5. " *axis of the advance-warning triangle* " means the straight line which, perpendicular to the front face of the triangle, passes through its centre;

2.6. " *fluorescent material* " means a material which, either in the mass or at the surface, when excited by daylight, exhibits the phenomenon of photoluminescence ceasing rather shortly after excitation;

2.7. " *luminance factor* " means the rate of the luminance of the body considered, illuminated and observed in specified conditions, to the luminance of a perfect diffuser receiving the same illumination. The luminance of the body considered includes that produced by reflection and by fluorescence;

2.8. " *Coefficient of luminous intensity* (*CIL*) " means the amount of the luminous intensity reflected in the direction considered by illumination of the reflex reflecting device for given angles of illumination, divergence and rotation.*

* Translation from the French of the definition given in the *International Lighting Vocabulary*, third edition, CIE (International Commission on Illumination (ICI)), publication No. 17 (E.1.1.), 1970.

[1] See note 1 on p. 226 of this volume.

3. APPLICATION FOR APPROVAL

The application for approval shall be submitted by the holder of the trade name or mark or by his duly accredited representative, and shall be accompanied by:

3.1. dimensional drawings in triplicate in sufficient detail to permit identification of the type;

3.2. a brief description giving the technical specifications of the materials constituting the advance-warning triangle and instructions for use;

3.3. a copy of the instructions on its assembly for use;

3.4. three samples of the advance-warning triangle, each in its protective cover;

3.5. two samples of the complete reflex reflecting device;

3.6. two samples of the fluorescent material in which a 100 × 100 mm square can be inscribed and fully representative of the material and applied to the same base material as used for the triangle.

4. MARKINGS

4.1. Every advance-warning triangle and its protective cover shall, when submitted for approval, bear the trade name or mark of the applicant; such marking shall be clearly legible and be indelible.

4.2. Every advance-warning triangle and its protective cover shall provide adequate space for the approval mark; the space aforesaid shall be shown in the drawings referred to in paragraph 3.1 above.

5. APPROVAL

5.1. If all the samples of a type of advance-warning triangle which are submitted in conformity with the provisions of paragraph 3 above meet the requirements of this Regulation, approval shall be granted.

5.2. An approval number shall be assigned to each type approved; the number so assigned may not subsequently be assigned by the same Contracting Party to another type of advance-warning triangle covered by this Regulation.

5.3. Notice of approval or of refusal of approval of a type of advance-warning triangle pursuant to this Regulation shall be communicated to the countries Parties to the Agreement which apply this Regulation by means of a form conforming to the model in annex 1 to this Regulation accompanied by dimensional drawings (supplied by the applicant for approval) in a format not exceeding A 4 (210 × 297 mm), or folded to that format, and on an appropriate scale.

5.4. In addition to the markings prescribed in paragraph 4.1, there shall be affixed, in the space referred to in paragraph 4.2 above, to every advance-warning triangle and to its protective cover conforming to a type approved under this Regulation,

5.4.1. an international approval mark consisting of:

5.4.1.1. a circle surrounding the letter " E " followed by the distinguishing number of the country which has granted approval;*

5.4.1.2. the approval number placed close to the circle but in any position with respect to it. The figures of the approval number shall however face the same way as the letter " E ".

5.5. The trade name or mark on the protective cover shall be visible from the outside.

5.6. The approval mark shall be clearly legible and indelible.

5.7. Annex 2 to this Regulation gives an example of the arrangement of the approval mark

6. GENERAL SPECIFICATIONS

6.1. The advance-warning triangle shall be open at the centre and shall comprise a red border composed of an outer reflex reflecting strip and an inner fluorescent strip, the whole supported at a certain height above the surface of the carriageway. The open centre and the fluorescent and reflex reflecting strips shall be bounded by concentric equilateral triangular contours.

6.2. Advance-warning triangles shall be so made that in normal use (on the road and when carried in the vehicle) they retain the prescribed characteristics and their satisfactory functioning continues to be ensured.

6.3. The optical units of the advance-warning triangle shall not be easily disassembled. The various parts making up the advance-warning triangle shall provide good stability on the road. They shall not be easily disassembled. If a triangle has to be folded in order to be placed in its protective cover, the movable parts, including its supports, shall not be detachable.

6.4. When the advance-warning triangle is in the position of use on the road, the front face of the triangle must be vertical. This condition is deemed fulfilled if the axis of the triangle does not form an angle of more than 5° with the base plane.

6.5. The front face of the advance-warning triangle shall be easy to clean; in particular it shall not be rough, and such protuberances as it may exhibit shall not prevent such cleaning.

6.6. The advance-warning triangle and its support shall not present sharp edges or corners.

6.7. The advance-warning triangle shall be required to be accompanied by a protective cover in which it shall be placed when not in use, for protection against impact and external agents, especially during carriage.

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* 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 and 12 for Austria; and 13 for Luxembourg; subsequent numbers shall be assigned to other countries in the chronological order in which they ratify the Agreement concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, or in which they accede to that Agreement, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

6.8. Each triangle shall be required to be accompanied by a copy of the instructions referred to in paragraph 3.3 above.

7. PARTICULAR SPECIFICATIONS

7.1. *Requirements as to shape and dimensions*

7.1.1. *Shape and dimensions of the triangle* (see annex 3)

7.1.1.1. The theoretical sides of the triangle shall be 500 ± 50 mm long.

7.1.1.2. The reflex reflecting units shall be arranged along the edge within a strip of an unvarying width which shall be between 25 mm and 50 mm.

7.1.1.3. Between the outer edge of the triangle and the reflex reflecting strip there may be a red edging not more than 5 mm wide.

7.1.1.4. The reflex reflecting strip may be continuous or not. In the latter case the free area of the supporting material must be red (see also paragraph 7.3.1.2 of this Regulation).

7.1.1.5. The fluorescent surface shall be contiguous to the reflex reflecting units. It shall be arranged symmetrically along the three sides of the triangle. When in use, its surface area shall be not less than 315 cm^2. However, a red coloured edging, continuous or not, not more than 5 mm wide may be placed between the reflex reflecting surface and the fluorescent surface.

7.1.1.6. The side of the open centre of the triangle shall have a minimum length of 200 mm (fig. 1).

7.1.2. *Shape and dimensions of the support*

7.1.2.1. The distance between the supporting surface and the lower side of the advance-warning triangle shall not exceed 300 mm.

7.2. *Colorimetric specifications*

7.2.1. *Reflex reflecting devices*

7.2.1.1. Reflex reflecting devices shall be made of material coloured red in the mass.

7.2.1.2. When the reflex reflecting device is illuminated by the CIE standard illuminant *A*, with an angle of divergence of $\frac{1}{3}°$ and an illumination angle $V = H = 0°$, or, if this produces a colourless surface reflection, an angle $V = \pm 5°$, $H = 0°$, the trichromatic co-ordinates of the red reflected luminous flux shall be within the following limits:

limit towards yellow	$y \leqslant 0.335$
limit towards purple	$z \leqslant 0.008$

7.2.2. *Fluorescent materials*

7.2.2.1. The fluorescent materials shall either be coloured in the mass or take the form of separate coatings applied to the surface of the triangle.

7.2.2.2. When the fluorescent material is illuminated by the CIE standard illuminant *C*, the trichromatic co-ordinates of the light reflected and emitted by fluorescence shall be within the following limits:

limit towards yellow	$y \leqslant 0.335$
limit towards purple	$z \leqslant 0.08$*

* These figures will be modified, if necessary, to bring them into line with those to be adopted by CIE/E-1.3.3 " Fundamental Principles of Luminous Signals ", as appearing in the CIE Committee's report to the seventeenth session of CIE in September 1971.

7.3. *Photometric specifications*

7.3.1. *Reflex reflecting devices*

7.3.1.1. The values of the CIL of reflex reflecting optical units shall be not less than those given in the table below, expressed in millicandelas per lux, for the angles of divergence and the illumination angles shown :

		Illumination angles			
	V	0°	±20°	0°	0°
	H	0° or ±5°	0°	±30°	±40°
Angles of divergence	20′	8,000	4,000	1,750	600
	1°30′	600	200	100	50

7.3.1.2. The CIL measured on random slices of 30 mm of the reflex reflecting device shall all lie between extremes having a ratio not in excess of 2. These slices are taken between the perpendiculars to the side of the triangle and passing through the corresponding apexes of the central aperture. This requirement applies to an angle of divergence of 20′ and to illumination angles of $V = 0°$, $H = 0°$ or $\pm 5°$ and $V = \pm 20°$, $H = 0°$.

7.3.1.3. Diversity of luminance at angles of illumination of $V = 0°$, $H = \pm 30°$ and $V = 0°$, $H = \pm 40°$ shall be tolerated on condition that the triangular shape remains clearly discernible, for an angle of divergence of 20′ and an illumination of approx. 1 lux.

7.3.1.4. The measurements referred to above shall be performed by the method described in annex 6 to this Regulation, paragraph 2.

7.3.2. *Fluorescent materials*

7.3.2.1. The luminance factor including the luminance by reflection and fluorescence, shall not be less than 30 per cent.

7.3.2.2. If the colorimetric characteristics have been calculated in the *x*, *y*, *z* system the luminance factor shall be determined by applying the ratio

$$\beta = \frac{Y}{Y_0}$$

where Y is the trichromatic component of the sample and Y_0 that of the perfect diffuser observed in the same conditions.

7.3.2.3. If the colorimetric characteristics have not been calculated, the luminance L shall be determined on a sample taken in the manner described in annex 6, paragraph 1.10.

8. CHECKS AND TESTS

Every advance-warning triangle and its protective cover shall meet the requirements of the checks and tests described in annex 6 to this Regulation.

9. MODIFICATIONS OF THE TRIANGLE TYPE

9.1. Every modification of the triangle type shall be notified to the administrative department which granted approval. The department may then either :

9.1.1. consider that the modifications made are unlikely to have an appreciable adverse effect, and that in any case the triangle still meets the requirements; or

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

9.2. Notice of confirmation of approval, specifying the modifications, or of refusal of approval shall be communicated by the procedure specified in paragraph 5.3 above to the Parties to the Agreement which apply this Regulation.

10. CONFORMITY OF PRODUCTION

10.1. Every advance-warning triangle bearing an approval mark as prescribed under this Regulation shall conform to the type approved and meet the photometric requirements specified above.

10.2. In addition, the stability in time of the optical properties and colour of reflex reflecting optical units of advance-warning triangles conforming to an approved type and in use shall be verified. In the event of a systematic deficiency of the reflex reflecting optical units of advance-warning triangles in use and conforming to an approved type, approval may be withdrawn. A " systematic deficiency " shall be deemed to exist where an approved type of advance-warning triangle fails to meet the requirements of paragraph 6.1 of this Regulation.

11. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

11.1. The approval granted in respect of a type of advance-warning triangle may be withdrawn if the foregoing requirements are not complied with.

11.2. If a Contracting Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith notify the other Contracting Parties applying this Regulation thereof by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation " APPROVAL WITHDRAWN ".

12. NAMES AND ADDRESSES OF TECHNICAL SERVICES CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS

The Contracting Parties to the Agreement applying this Regulation shall communicate to the Secretariat of the United Nations the names and addresses of the technical services 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 refusal or withdrawal of approval)
of a type of advance-warning triangle,
pursuant to Regulation No. 27

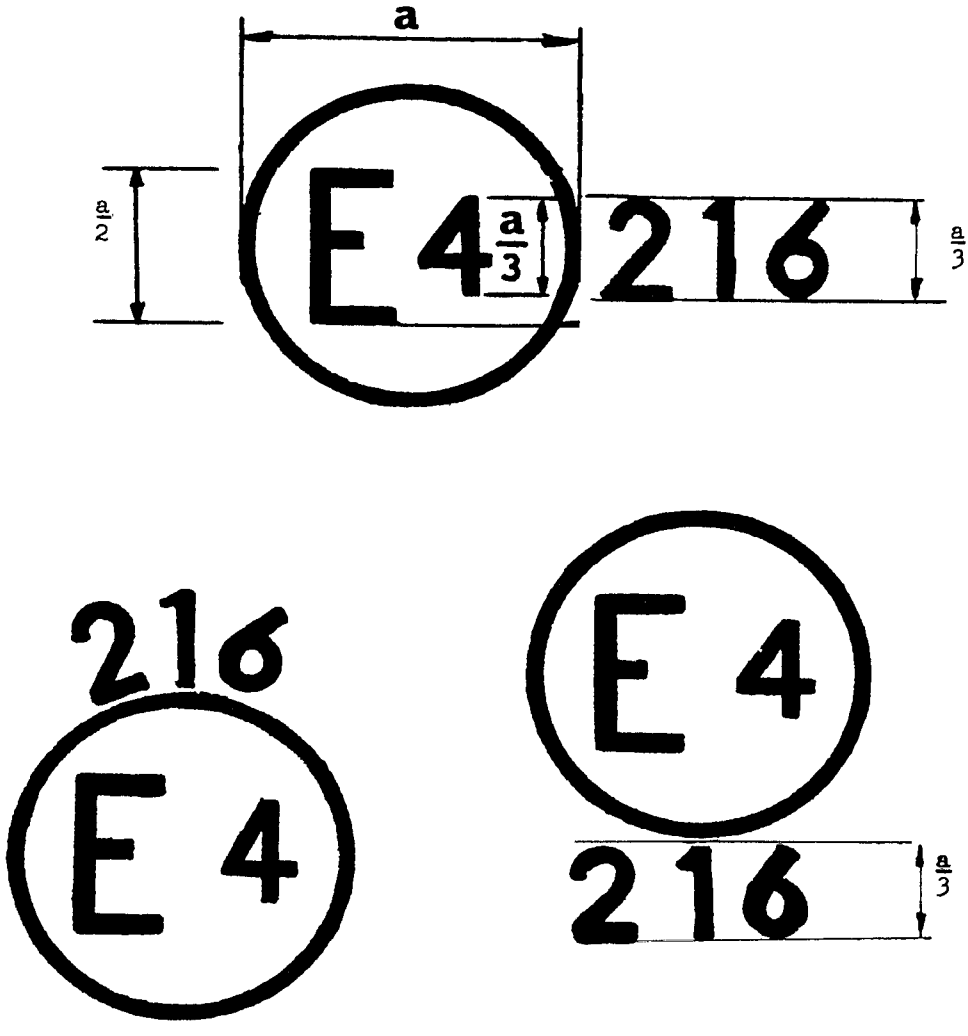
Approval No. . . . . .

1. Trade name or mark . . . . . .
2. Manufacturer's name . . . . . .
3. Address . . . . . .
4. If applicable, name of manufacturer's representative . . . . . .
5. Address . . . . . .
6. Brief description of the advance-warning triangle . . . . . .
7. Submitted for approval on. . . . . .
8. Technical service conducting approval tests . . . . . .
9. Date of report issued by that service . . . . . .
10. Number of report issued by that service . . . . . .
11. Approval granted/refused*
12. Remarks . . . . . .
13. Place . . . . . .
14. Date . . . . . .
15. Signature . . . . . .
16. The following documents, bearing the approval number shown above, are annexed to this communication :
    . . . . . dimensioned drawings
    . . . . . photographs

* Strike out what does not apply.

ANNEX 2

ARRANGEMENT OF THE APPROVAL MARK



The advance-warning triangle bearing one of the above approval marks has been approved in the Netherlands (E4) under approval number 216.

Dimensions : a $\geqslant$ 8 mm

NOTE. The drawings show several possible embodiments and are given by way of example.

ANNEX 3

SHAPE AND DIMENSIONS OF THE ADVANCE-WARNING TRIANGLE AND OF THE SUPPORT

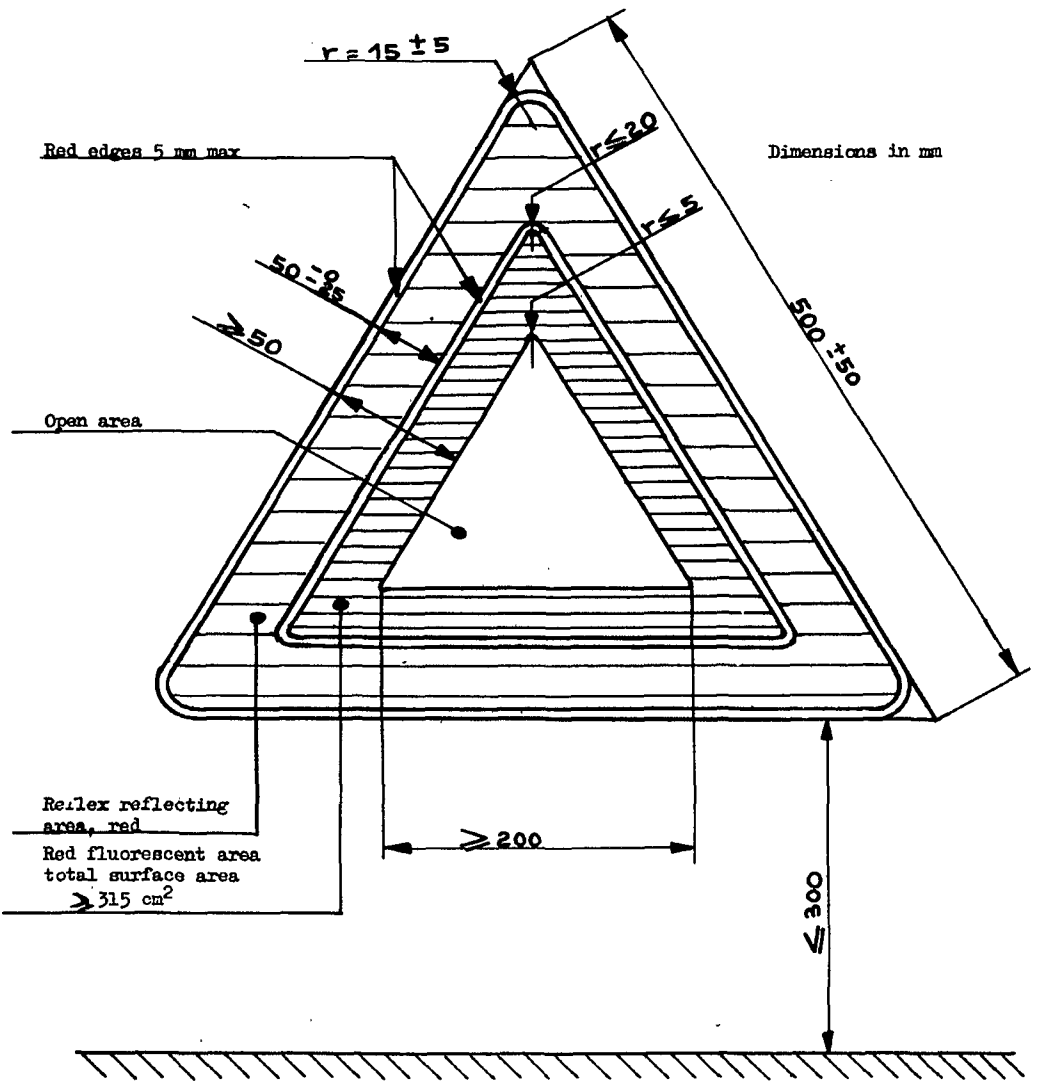
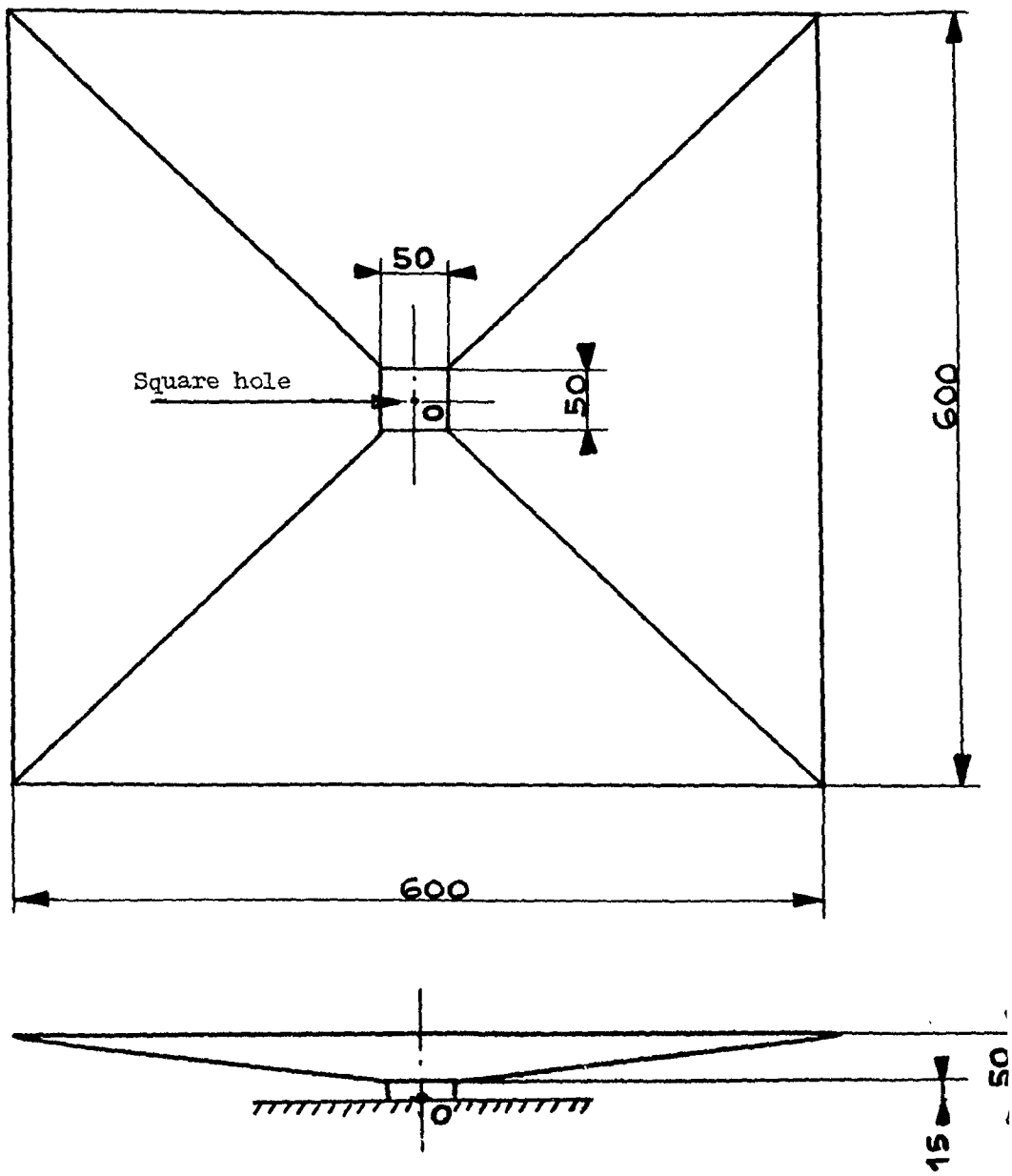


Fig. 1



Dimensions in mm

Fig. 2

No. 4789

ANNEX 4

DETERMINING THE ROUGHNESS OF A ROAD SURFACE

" Sandy beach " method

I. PRINCIPLE OF THE METHOD

A known volume of sand is spread evenly on the surface of the carriageway to form a circular " beach ". The ratio of the volume used to the area covered is conventionally known as the " mean sand depth ", *HS*, and is expressed in mm.

The purpose of the test is to obtain some information about the geometric roughness of a road surface.

II. EQUIPMENT AND MATERIALS

(a) *Special equipment* (see diagram)

—A cylinder, with internal diameter 20 mm and internal height 79.5 mm, closed at one end; its capacity is adjusted so as to equal 25 ml ± 0.15 ml.

—A flat disc, 65 mm in diameter : one surface covered with a 1.5 to 2.5 mm thick sheet of rubber, and the other having a projection forming a handle.

—A supply of round-grain sand (or Fontainebleau sand), grain size 0.160–0.315 mm.

(*b*) *Ordinary equipment*

—a soft brush,
—a rule measuring up to 500 mm,
—a receptacle to keep the sand in,
—a wind-break, to use where necessary (an old tyre, put round the " sandy beach ", does very well).

III. PREPARATION OF SURFACE AND METHOD OF PERFORMING TEST

The surface of the roadway on which the test is to be made must be dry* and should first be brushed with a soft brush to remove any dirt or loose gravel.

The 25 ml cylinder is filled with sand, knocked on its base three times, topped up again with sand and levelled off. Its contents are then poured out on to the road surface in a single heap.

The sand is carefully spread out over the surface by means of repeated circular movements of the rubber-faced disc so as to form the largest possible round " beach ". The sand will then fill all depressions and hollows up to a depth decided by the highest points (and the diameter of the disc).

The rule is used to measure two diameters, at right angles to one another, of the " beach " thus formed.† The mean value of the two is then rounded off to the nearest 5 mm, and the corresponding depth *HS* is read from the table given in the appendix to this annex.

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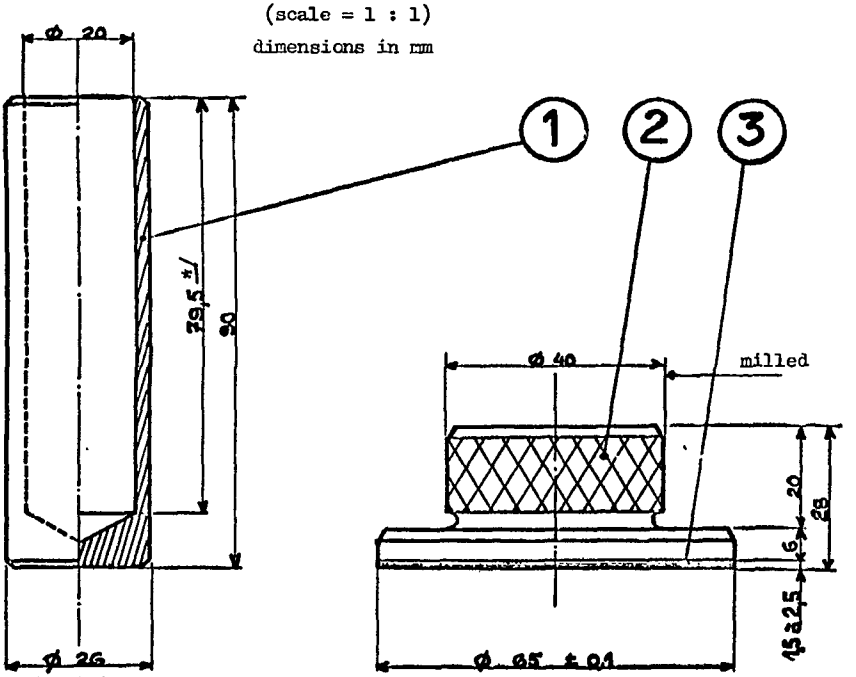
* In the case of surfaces of hydraulic concrete it may be possible to dry the surface with a gas burner of the kind used by campers.

† If the " beach " is elliptical, the two axes of the ellipse must be measured. In other cases it is suggested, for the sake of uniformity, that one of the diameters measured should be the diameter parallel to the axis of the roadway, and the other at right angles to it.

DIAGRAM OF EQUIPMENT FOR MEASURING MEAN SAND DEPTH

(scale = 1 : 1)

dimensions in mm

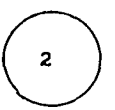


*/ Side to be adjusted to give an internal volume of 25 ml = 0.15 ml

1 — 25 ml container

2 — Disc

3 — Flexible rubber sheet stuck to disc



Five tests of this kind are carried out on one cross-section of road, the test areas being not less than 50 cm apart and 50 cm from the edge of the road surface. The overall mean of the figures obtained from not less than two cross-sections (at least 20 m apart, in this case) is conventionally given as the mean *HS* value of the road surface.

More measuring points may be used where necessary.

IV. PRESENTATION OF RESULTS

(a) *Results*

These will be given in the form of the following table :

Measurement of mean sand depth, HS					
Place where tests made					
Cross-sections	*Individual* HS *values*				
No. 1					
No. 2 . . .					
Overall mean value for the stretch of road : HS = ... mm extreme values : maximum HS = ... minimum HS = ...					

The results will be expressed in mm, to not more than two decimal places.

(b) *Spread of the measurements*

This will depend upon the irregularity of the surface, and upon the operator.

In practice the discrepancy between the mean *HS* values for 10 individual tests on one and the same road surface will be less than *HS*/10.

Similarly, the discrepancy between the mean values determined by two operators will not be greater than *HS*/10.

V. COMMENTS

(a) *Determining exact volume of the cylinder used*

The internal volume of the cylinder is determined by weighing the amount of water it contains. If this is not equal to 25 ml ± 0.15 ml the volume of the cylinder must be corrected accordingly.

The *HS* value is calculated by means of the formula :

$$HS = \frac{\text{volume of sand}}{\text{area of surface covered}} = \frac{V}{\pi D^2/4} = \frac{1.27 \times V}{D^2}$$

The *HS* value is given in the table in the appendix to this annex in mm for a volume, *V*, of 25 ml and for diameters, *D*, increasing in 5 mm steps. The diagram showing the equipment for measuring the *HS* gives the dimensions of a standard set of the equipment.

(b) *Examples of values found*

Two examples, obtained on actual carriageways, are given by way of illustration.

Example 1:

Measurement of depth HS					
Place where tests made A new carriageway of cement concrete regularly textured with jute fabric					
Cross-sections	*Individual* HS *values*				
No. 1	0.31	0.26	0.30	0.25	0.39
No. 2	0.58	0.52	0.39	0.31	0.38
Overall mean value for the stretch of road : *HS* = 0.35 mm extreme values : maximum *HS* = 0.58 mm minimum *HS* = 0.31 mm					

Example 2:

Measurement of depth HS					
Place where tests made A new carriageway of cement concrete brushed by hand with a soft fibre broom					
Cross-sections	*Individual* HS *values*				
No. 1	1.1	1.0	1.5	1.9	2.0
No. 2	0.90	0.95	1.0	0.95	1.3
Overall mean value for the stretch of road : *HS* = 1.25 mm extreme values : maximum *HS* = 2.0 mm minimum *HS* = 0.31 mm					

(c) *Connexion between depth* HS *and height of irregularities*

An attempt may be made to relate the depth *HS* and the height-to-depth measurement, *R*, of a road surface's irregularities. Varying relations

are obtained with the type of irregularities selected and the practical verification is difficult because gravels and road surfaces differ so greatly from one another.

(d) *Classification of surface textures*

The following terminology has been conventionally adopted for the various textures :

Mean sand depth HS (*mm*)	*Surface texture*
$HS \leqslant 0.20$	very fine
$0.20 < HS \leqslant 0.40$	fine
$0.40 < HS \leqslant 0.80$	medium
$0.80 < HS \leqslant 1.20$	rough
$HS > 1.20$	very rough

(e) *Effect of the disc's diameter*

On a completely level carriageway this would have no noticeable effect. Experiments have shown however that there is an average 1.2 fold increase in *HS* where the diameter of the disc is enlarged from 65 mm to 100 mm. It is important, therefore not to depart far from the recommended value of 65 mm.

APPENDIX

Table showing mean sand depth, HS, *as a function of mean diameter of " sandy beach ",* ϕ, *for a volume of 25 ml*

ϕ *mm*	HS *mm*	ϕ *mm*	HS *mm*	ϕ *mm*	HS *mm*
50	12.7	200	0.80	350	0.26
55	10.5	205	0.75	355	0.25
60	8.8	210	0.72	360	0.24
65	7.5	215	0.69	365	0.24
70	6.5	220	0.66	370	0.23
75	5.6	225	0.63	375	0.23
80	5.0	230	0.60	380	0.22
85	4.4	235	0.58	385	0.21
90	4.0	240	0.55	390	0.21
95	3.5	245	0.53	395	0.20
100	3.2	250	0.51	400	0.20
105	2.9	255	0.49	405	0.19
110	2.6	260	0.47	410	0.19
115	2.4	265	0.45	415	0.18
120	2.2	270	0.44	420	0.18

APPENDIX (*continued*)

ϕ *mm*	HS *mm*	ϕ *mm*	HS *mm*	ϕ *mm*	HS *mm*
125	2.0	275	0.42	425	0.18
130	1.9	280	0.41	430	0.17
135	1.7	285	0.39	435	0.17
140	1.6	290	0.38	440	0.16
145	1.5	295	0.36	445	0.16
150	1.4	300	0.35	450	0.16
155	1.3	305	0.34	455	0.15
160	1.25	310	0.33	460	0.15
165	1.20	315	0.32	465	0.15
170	1.10	320	0.31	470	0.14
175	1.05	325	0.30	475	0.14
180	1.0	330	0.29	480	0.14
185	0.95	335	0.28	485	0.13
190	0.90	340	0.27	490	0.13
195	0.85	345	0.27	500	0.13

ANNEX 5

DETERMINING THE FRICTION COEFFICIENT OF A ROAD SURFACE

Pendulum method

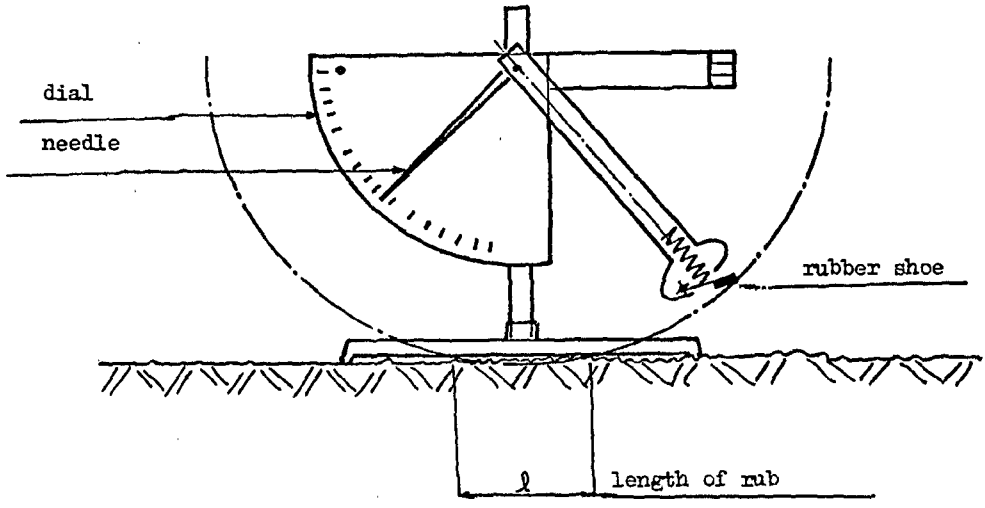
The friction test is effected with an apparatus made from drawings supplied by the Road Research Laboratory (Crowthorne, Berkshire, United Kingdom).

I. BRIEF DESCRIPTION OF APPARATUS

1. *Principle.* The apparatus, based on the principle of Charpy's pendulum, measures the loss of energy by a rubber foot rubbing against the surface studied. From the geometric characteristics of the apparatus and the loss of energy, a " friction coefficient " is calculated conventionally known as the " coefficient of friction determined by the RRL pendulum ".

2. *Component parts.* The apparatus (see diagram) consists of: a foot, pressed downward by a spring, fixed to the end of a pendulum in such a way that the rubbing surface is 50 cm from the axis of rotation; a device for ensuring that the column of the instrument is vertical; a device for raising and lowering the axis of the pendulum; a device for lifting and releasing the arm of the pendulum so that it drops from a horizontal position; and a needle, fixed to the pendulum's axis of rotation, carried along by the pendulum in its movement forward, against a dial.

Diagram showing the principle of portable apparatus
for measuring resistance to skidding
(Road Research Laboratory model)



II. UTILIZATION

After the length of the foot's rub has been adjusted, the pendulum is released a number of times over the surface studied, which has previously been wetted, and the operation is repeated at a number of points. Then the average of the results is taken, a correction being made where necessary for temperature.

III. INTERPRETATION OF RESULTS

The apparatus is designed to measure friction on wet road surfaces. What it does, however, is rather different from what actually happens; the value of the coefficient ascertained only therefore shows one particular characteristic of carriageways' grip.

This friction coefficient chiefly reflects the extent to which the gravel at the top of the road surface has become polished, and it gives an indication of carriageways' grip at low speeds.

ANNEX 6

CHECKS AND TESTS

1. *Test procedures and general checks*

1.1. When compliance with the general specifications (paragraph 6 of this Regulation) and with the requirements as to shape and dimensions (paragraph 7.1) has been verified, the three samples shall be visually inspected at a distance of not less than 30 m by an observer having normal colour-sense, by day in natural daylight and at night by the light of a light providing a uniform illumination of approximately 1 lux, at angles of divergence of 20′ and 1°30′. There shall be no marked difference in colour or luminance between the three samples; if slight differences are observable, the sample whose optical characteristics seem least satisfactory shall undergo the colorimetric and photometric tests.

1.2. One of the samples shall be retained by the laboratory for any subsequent checks which may be found necessary.

1.3. The other two samples shall undergo first the mechanical-strength test, then the heat-resistance test, then the tests of total resistance to water and to motor fuels (paragraphs 4, 5, 6 and 7 below).

1.4. One of the triangles shall then be tested for stability in wind (paragraph 8 below). The other, to be selected in the course of the visual comparison, shall be used for the colorimetric tests and for verifying compliance with the photometric specifications of the reflex reflecting devices (paragraphs 7.2 and 7.3 of this Regulation).

1.5. When the coefficients of luminous intensity (CIL) of the two samples of reflex reflecting optical units have been measured separately at an angle of divergence of 20′ and an illumination angle $V = 0°$, $H = \pm 5°$, the two samples shall be subjected to the tests referred to in paragraphs 9.1 and 9.2 below.

1.6. After these tests the CIL of the two samples, measured in exactly the same conditions, shall not have declined by more than 40 per cent from the values originally recorded.

1.7. Before and after the test referred to in paragraph 10 below, the colorimetric and photometric characteristics (paragraphs 7.2 and 7.3 of this Regulation) of the fluorescent samples shall be verified.

1.8. To determine the luminance L, the sample shall be illuminated at a 45° angle of incidence. The luminance L of the sample in a perpendicular direction shall be verified either visually, using a suitable red filter in the measuring device, or by means of a physical photometer corrected according to the photopic curve $V(\lambda)$ standardized by CIE. The sample shall then be replaced by a white standard illuminant of known luminance factor β_0 in the direction of observation considered, and a value L_0 shall be measured. The luminance factor β of the sample is equal to

$$\beta = \frac{L\beta_0}{L_0}$$

1.9. After the tests prescribed in paragraph 5 below, a visual inspection shall be made to verify on the two samples referred to in paragraph 3.6 of this Regulation that they are similar to the material present on the triangle.

1.10. If the fluorescent material is integral with the triangle, a sample of adequate size shall, when the triangle has undergone the tests prescribed in paragraphs 4, 5 and 10 below, be removed from the most doubtful part of the triangle.

1.11. Whether the sample, illuminated at an angle of incidence of 45° and observed normally, meets the requirements of paragraph 7.2.2.2 of this Regulation shall be verified by a visual test carried out by two observers having normal colour-sense and at levels of illumination in the photopic range, in which test the sample shall be compared with a sample of a film of the same type having known trichromatic co-ordinates.

1.12. If any doubt remains after these tests, compliance with the colorimetric specifications shall be verified by determining the trichromatic co-ordinates of the sample.

1.13. In the course of the test described in paragraph 3 below, a check shall be made in order to verify that the lower part of the triangle or of its support presents sufficient clearance for the triangle to be kept in position even if the surface of the ground is uneven.

1.14. Compliance with the colorimetric specifications shall be verified by a visual test using calibrated limit filters.

1.15. If any doubt remains after this test, compliance with the colorimetric specifications shall be verified by determining the trichromatic co-ordinates of the most doubtful part of the triangle, which part shall first have been removed.

2. *Measurement of the values of the CIL of reflex reflecting optical units*

2.1. With the device in the position of use, the direction of origin adopted for measurements shall be parallel to the base plane and at right angles to the lower side, parallel to the said base plane, of the triangle.

2.2. Measurements shall be performed, the outside dimensions of the advance-warning triangle being taken into account, by the method recommended by Committee E-3.3.5 of CIE appearing in the proceedings of the fourteenth session in 1959, published by the CIE Central Office (volume D).

2.3. If the reflex reflecting optical units are separate, the following procedure may be adopted :

2.3.1. if they are all similar, three which under visual examination appear to have the minimum CIL may be taken as samples. The measurements shall be performed with the units oriented as on the triangle, if that orientation is clearly determined. If it is not, then they shall be rotated about their axis of reference in the position $V = 0°$ and $H = 0°$ or $H = \pm 5°$ until the lowest value of the CIL is obtained. All photometric measurements shall be performed with that orientation. The product of the average value of CIL for the three samples multiplied by the number of units shall be not less than the value of CIL given in the table in paragraph 7.3.1.1 of this Regulation;

2.3.2. if they are different but can be placed in several categories, the same procedure may be applied in respect of each category.

3. *Clearance test*

3.1. The advance-warning triangle shall be required to pass the following test :

3.1.1. The apparatus used shall be that shown in fig. 2. of annex 3 to this Regulation, in the form of a hollow pyramid placed upside down on a horizontal base plane;

3.1.2. The triangle's various points of contact with the ground shall be placed one after another in the centre *O* of the apparatus. At each point of contact it shall be possible to rotate the triangle through 360° about a vertical axis passing through *O* with the triangle resting on the base plane at all its points of contact.

4. *Mechanical-strength test*

4.1. The base of the advance-warning triangle being firmly supported, a force of 2 N (0.2 kfg, 0.44 lbf) shall be applied to the apex of the triangle parallel to the supporting surface and at right angles to the lower side of the triangle.

4.2. The apex of the triangle shall not move more than 5 cm in the direction in which the force is exerted.

4.3. After the test the device shall resume substantially its original position.

5. *Heat-resistance test*

5.1. The advance-warning triangle, in its protective cover, shall be kept for twelve consecutive hours in a dry atmosphere at a temperature of 60° ± 2°C.

5.2. After the test, no cracking or appreciable distortion of the device, and in particular of its reflex reflecting optical units, shall be visible. The protective cover shall be readily openable and shall not adhere to the triangle.

6. *Test of total resistance to water*

The triangle, assembled as for use, shall be placed flat for two hours on the bottom of a tank containing water at a temperature of 25° ± 5°C, the active face of the triangle being uppermost and 5 cm from the surface of the water. It shall then be removed and left to dry. No part of the device shall exhibit clear signs of deterioration which might impair the triangle's effectiveness.

7. *Test of resistance to motor fuels*

The triangle and its protective cover shall be immersed separately in a tank containing a mixture of 90 per cent motor fuel and 10 per cent benzol. After 60 seconds, they shall be removed from the tank and drained of excess liquid. The triangle shall then be placed in its cover and the unit laid flat in a still

atmosphere. When completely dried, the triangle shall not adhere to its protective cover and shall not exhibit any visually discernible change.

8. *Test of stability in wind*

8.1. The advance-warning triangle shall be set up in a wind tunnel, on a base measuring about 1.50 m by 1.20 m and formed of road surfacing prepared by the procedure normally used by the competent services. The surfacing shall be characterized by :

8.1.1. a geometric roughness of 0.5 mm with a tolerance of ±0.05 mm determined by the so-called " sandy beach " method (see annex 4 to this Regulation),

8.1.2. a coefficient of friction (rubber) of 0.60 ± 0.05 determined by the pendulum tester described in annex 5 to this Regulation.

8.2. When so set up, the advance warning triangle shall be subjected for 3 minutes to the impelling force of a horizontal wind from any direction and having a velocity of 60 km/h in standard conditions of temperature and pressure. In the absence of such conditions, the velocity shall be varied to provide equivalent conditions.

8.3. The advance warning triangle shall not

8.3.1. overturn, or

8.3.2. shift. Nevertheless, slight shifting of the points of contact with the road surface by not more than 5 cm shall be allowed.

8.4. The triangular part of the device shall not rotate through more than 10° round a horizontal axis or a vertical axis from its initial position.

9. *Test of resistance of reflex reflecting optical units*

9.1. *Test of resistance to penetration by water*

9.1.1. Separate reflex reflecting optical units supplied by the manufacturer shall be immersed for ten minutes in water at a temperature of 50° ± 5°C, the highest point of the upper part of the illuminating surface being about 20 mm below the surface of the water. This test shall be immediately repeated in water at 25° ± 5°C.

9.1.2. No water shall penetrate to the reflecting surface of the reflex reflecting optical unit. If visual inspection clearly reveals the presence of water, the device shall not be considered to have passed the test.

9.1.3. If visual inspection does not reveal the presence of water, or in case of doubt, the CIL shall be measured (paragraph 1.5 above) after the reflex reflecting unit has been gently shaken to remove excess water from the outside. The CIL shall not have diminished by more than 40 per cent of the values recorded before the test.

9.2. *Test of resistance of the accessible reverse side of the mirror-backed reflex reflecting device*

The reverse side of the reflex reflecting device shall be brushed with a hard nylon brush and then covered or thoroughly wetted for one minute with a mixture of 90 per cent commercial motor fuel and 10 per cent benzol. The fuel shall then be removed and the device allowed to dry. As soon as evaporation is completed, an abrasion test shall be made by brushing the reverse side with the same nylon brush as before. The CIL shall then be measured (paragraph 1.5 above) after

the whole surface of the mirror-backed reverse side has been covered with Indian ink. The CIL shall not have diminished by more than 40 per cent of the values recorded before the test.

10. *Test to check the stability in time of the optical properties and colour of fluorescent materials*

10.1. The sample of fluorescent material taken from the triangle, or the sample of separate coating applied to a surface in accordance with the instructions given by the manufacturer, shall be subjected to a test of resistance to temperature and irradiation by exposure for 300 hours to the standard test described in ISO Recommendation ISO/R 105/V March 1969.

10.2. At the end of this test, its dominant wavelength expressed in manometres shall not have diminished by more than 4 units and its purity of excitation factor by 0.04. Its luminance factor shall be not less than 30 per cent and shall not have increased by more than 5 per cent.

10.3. The sample shall not exhibit visible damage such as cracks, scaling or, in the case of separate coatings, peeling.

10.4. If the fluorescent substance used on the advance-warning triangle takes the form of an adhesive film which has passed the above-mentioned tests, the tests need not be repeated and the fact shall be noted under item 12 (" Remarks ") on the communication concerning approval (annex 1 to this Regulation).