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. 49 *(Uniform provisions concerning approval of diesel engines with regard to the emission of gaseous pollutants)* as an annex to the above-mentioned Agreement

The said Regulation came into force on 15 April 1982 in respect of Czechoslovakia and France, in accordance with article 1 (5) of the Agreement.

1. SCOPE

This Regulation applies to the emission of gaseous pollutants from diesel engines used for driving motor vehicles of categories M_2, M_3, N_2 and N_3,* **

2. DEFINITIONS AND ABBREVIATIONS

For the purposes of this Regulation,

2.1. "*Approval of an engine*" means the approval of an engine type with regard to the level of the emission of gaseous pollutants;

2.2. "*Diesel engine*" means an engine which works on the compression-ignition principle;

2.3. "*Engine type*" means a category of engines which do not differ in such essential respects as engine characteristics as defined in annex 1 to this Regulation;

2.4. "*Gaseous pollutants*" means carbon monoxide, hydrocarbons (assuming a ratio of $C_1H_{1.85}$ and nitrogen oxides, the last-named being expressed in nitrogen dioxide (NO_2) equivalent);

2.5. "*Net power*" means the power in ECE kW obtained on the test bench at the end of the crankshaft, or its equivalent, measured in accordance with the ECE method of measuring the power of internal combustion engines for road vehicles;***

2.6. "*Rated speed*" means the maximum full load speed allowed by the governor as specified by the manufacturer in his sales and service literature;

2.7. "*Per cent load*" means the fraction of the maximum available torque at an engine speed;

* As described in annex 9 to this Regulation.

** Diesel engines used by category N_1 power-driven vehicles are not subject to the requirements of this Regulation, provided that such vehicles satisfy the requirements of Regulation No. 15[1] as amended by the 04 series of amendments (E/ECE/324-E/ECE/TRANS/505/Rev.1/Add.14/Rev.3).[2]

*** As described in Regulation No. 24,[3] as corrected by the 02 series of amendments (E/ECE/324-E/ECE/TRANS/505/Rev.1/Add.23/Rev.1).[4]

[1] United Nations, *Treaty Series*, vol. 740, p. 364.
[2] *Ibid.*, vol. 1253, p. 277.
[3] *Ibid.*, vol. 835, p. 226.
[4] *Ibid.*, vol. 1157, p. 402.

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[1] United Nations, *Treaty Series*, vol. 335, p. 211; for subsequent actions, see references in Cumulative Indexes Nos. 4 to 15, as well as annex A in volumes 951, 955, 958, 960, 961, 963, 966, 973, 974, 978, 981, 982, 985, 986, 993, 995, 997, 1003, 1006, 1010, 1015, 1019, 1020, 1021, 1024, 1026, 1031, 1035, 1037, 1038, 1039, 1040, 1046, 1048, 1050, 1051, 1055, 1059, 1060, 1065, 1066, 1073, 1078, 1079, 1088, 1092, 1095, 1097, 1098, 1106, 1110, 1111, 1112, 1122, 1126, 1130, 1135, 1136, 1138, 1139, 1143, 1144, 1145, 1146, 1147, 1150, 1153, 1156, 1157, 1162, 1177, 1181, 1196, 1197, 1198, 1199, 1205, 1211, 1213, 1214, 1216, 1218, 1222, 1223, 1224, 1225, 1235, 1237, 1240, 1242, 1247, 1248, 1249, 1252, 1253, 1254, 1255, 1256, 1259, 1261 and 1271.

2.8. *"Intermediate speed"* means the speed corresponding to the maximum torque value if such speed is within the range of 60 to 75 per cent of rated speed; in other cases it means a speed equal to 60 per cent of rated speed;

2.9. *Abbreviations and units*

P	kW	net power output non-corrected*
$\overline{CO}$	g/kWh	carbon monoxide emission
$\overline{HC}$	g/kWh	hydrocarbon emission
$\overline{NO_x}$	g/kWh	emission of oxides of nitrogen
conc	ppm	concentration (ppm by volume)
mass	g/h	pollutant mass flow
WF		weighting factor
G_{EXH}	kg/h	exhaust gas mass flow rate on wet basis
V'_{EXH}	m^3/h	exhaust gas volume on dry basis
V''_{EXH}	m^3/h	exhaust gas volume on wet basis
G_{AIR}	kg/h	intake air mass flow rate
V_{AIR}	m^3/h	intake air volume flow rate
G_{FUEL}	kg/h	fuel mass flow rate
FID		flame ionisation detector
NDIR		non-dispersive infrared
CLA		chemiluminescent analyser.

3. APPLICATION FOR APPROVAL

3.1. The application for approval of an engine type with regard to the level of the emission of gaseous pollutants shall be submitted by the engine manufacturer or by his duly accredited representative.

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

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

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

3.3. An engine conforming to the "engine type" characteristics described in annex 1 to this Regulation shall be submitted to the technical service responsible for conducting the approval tests defined in paragraph 5 below.

4. APPROVAL

4.1. If the engine type submitted for approval pursuant to this Regulation meets the requirements of paragraphs 5 and 6 below, approval of that engine type shall be granted.

4.2. An approval number shall be assigned to each type approved. Its first two digits (at present 00 for the Regulation in its original form) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same number to another engine type.

* As described in Regulation No. 24 as corrected by the 02 series of amendments (E/ECE/324-E/ECE/TRANS/505/Rev.1/Add.23/Rev.1).

4.3. Notice of approval or of refusal of approval of an engine 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. Values measured during the type test shall also be shown.

4.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every engine conforming to an engine type approved under this Regulation, an international approval mark consisting of:

4.4.1. A circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval,*

4.4.2. The number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in paragraph 4.4.1.

4.5. If the engine conforms to an engine type approved, under one or more other Regulations annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 4.4.1 need not be repeated; in such a case, the regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 4.4.1.

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

4.7. The approval mark shall be placed close to or on the engine data plate affixed by the manufacturer.

4.8. Annex 3 to this Regulation gives examples of arrangements of approval marks.

5. SPECIFICATIONS AND TESTS

5.1. *General*

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

5.2. *Specifications concerning the emission of pollutants*

The emission of pollutants by the engine submitted for testing shall be measured by the method described in annex 4 to this Regulation. Other methods may be approved if it is found that they yield equivalent results.

5.2.1. The mass of the carbon monoxide, the mass of the hydrocarbons and the mass of the nitrogen oxides obtained shall not exceed the amounts shown in the table below:

Mass of carbon monoxide ($\overline{CO}$) Grammes per kWh	*Mass of hydrocarbons ($\overline{HC}$) Grammes per kWh*	*Mass of nitrogen oxides ($\overline{NO_x}$) Grammes per kWh*
14	3.5	18

* 1 for the Federal Republic of Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for Czechoslovakia, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 for the German Democratic Republic, 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland and 21 for Portugal. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify 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. MODIFICATIONS OF THE ENGINE TYPE

6.1. Every modification of the engine type shall be notified to the administrative department which approved the engine 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 engine still complies with the requirements; or

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

6.2. Confirmation or refusal of approval, specifying the alterations, 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 engine bearing an approval mark as prescribed under this Regulation shall conform, with regard to components affecting the emission of gaseous pollutants, to the engine type approved.

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

7.3. As a general rule, conformity of the engine with the approved type shall be verified on the basis of the description given in the approval form and its annexes, and if necessary an engine shall be subjected to the test referred to in paragraph 5.2 above.

7.3.1. For verifying the conformity of the engine in a test, the following procedure is adopted:

7.3.1.1. An engine is taken from the series and subjected to the test described in annex 4.

7.3.1.2. If the engine taken from the series does not satisfy the requirements of paragraph 5.2.1 above, the manufacturer may ask for measurements to be performed on a sample of engines taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample, in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean $\bar{x}$ of the results obtained with the sample shall then be determined for each gaseous pollutant. The production of the series shall then be deemed to conform if the following condition is met:

$$\bar{x} + k.S \leq L^*$$

where:

L is the limit value laid down in paragraph 5.2.1 for each gaseous pollutant considered; and

k is a statistical factor depending on n and given in the following table:

n	2	3	4	5	6	7	8	9	10
k	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279
n	11	12	13	14	15	16	17	18	19
k	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

If $n \geq 20$, $k = \frac{0.860}{\sqrt{n}}$

* $S^2 = \Sigma \frac{(x - \bar{x})^2}{n - 1}$, where x is any one of the individual results obtained with the sample "n".

7.3.2. The technical service responsible for verifying the conformity of production shall carry out tests on engines which have been run-in partially or completely, according to the manufacturer's specifications.

8. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

8.1. The approval granted in respect of an engine type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 7.1 above are not complied with or if the engine or engines 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 so notify the other Contracting Parties applying this Regulation, by means of a copy of the approval form bearing at the end, in large letters, the signed and dated annotation "APPROVAL WITHDRAWN".

9. PRODUCTION DEFINITELY DISCONTINUED

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

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

The Parties to the Agreement which apply this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and 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 .....

1.2. Type .....

1.3. Cycle: four-stroke/two stroke**

1.4. Bore ..... mm

1.5. Stroke ..... mm

1.6. Number and layout of cylinders and firing order .....

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

1.8. Compression ratio*** .....

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

** Strike out what does not apply.

*** Specify the tolerance.

1.9. Drawings of combustion chamber and piston crown .....

1.10. Minimum cross-sectional area of inlet and outlet ports .....

1.11. *Cooling system*

1.11.1. *Liquid*

Nature of liquid ..... Circulating pumps: yes/no*

Characteristics or make(s) and type(s) .....

Drive ratio .....

Thermostat: setting .....

Radiator: drawing(s) or make(s) and type(s): .....

Relief valve and pressure setting .....

Fan: characteristics or make(s) and type(s): .....

Fan drive system: .....

Drive ratio: .....

Fan cowl: .....

1.11.2. *Air*

Blower: characteristics or make(s) and type(s): .....

Drive ratio: .....

Air ducting (standard production): .....

Temperature regulation system: Yes/no* Brief description .....

1.11.3. *Temperatures permitted by the manufacturer*

1.11.3.1. Liquid cooling: Maximum temperature at outlet .....

1.11.3.2. Air cooling: Reference point .....

Maximum temperature at reference point .....

1.11.3.3. Maximum outlet temperature of the inlet intercooler .....

1.11.3.4. Maximum exhaust temperature at the point in the exhaust pipe(s) adjacent to the outlet flange(s) of the exhaust manifold(s) .....

1.11.3.5. Fuel temperature: min. ..... max. .....

1.11.3.6. Lubricant temperature: min. ..... max. .....

1.12. Supercharger: with/without* Description of the system .....

1.13. *Intake system*

Intake manifold: ..... Description .....

Air filter: ..... Make ..... Type .....

Intake silencer: ..... Make ..... Type .....

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.) .....

* Strike out what does not apply.

3.2. Fuel feed
3.2.1. Feed pump
Pressure* ..... or characteristic diagram* .....
3.2.2. Injection system
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 ..... rpm* 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. 'Opening 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 full 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 or equivalent data .....
4.2. Reference and/or setting ranges* .....

5. EXHAUST SYSTEM
5.1. Description of echaust manifold .....

* Specify the tolerance.
** Strike out what does not apply.

5.2. Description of other parts of the exhaust equipment if the test is made with the complete exhaust equipment provided by the manufacturer, or indication of the maximum back-pressure at maximum power specified by the manufacturer* .....

6. LUBRICATION SYSTEM

6.1. Description of system

6.1.1. Position of lubricant reservoir: .....

6.1.2. Feed system (pump, injection into intake, mixing with fuel, etc.) .....

6.2. Pump*

6.2.1. Make: .....

6.2.2. Type and characteristics .....

6.2.3. Air-cooled, engine pump characteristics* .....

6.3. Mixture with fuel*

6.3.1. Percentage: .....

6.4. Oil cooler: with/without*

6.4.1. Drawing(s) or make(s) and type(s) .....

7. ELECTRICAL EQUIPMENT

Generator/alternator*: characteristics or make(s) and type(s) .....

8. OTHER ENGINE-DRIVEN EQUIPMENT

(Enumeration and brief description if necessary) .....

9. TRANSMISSION

9.1. Moment of inertia of engine flywheel .....

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

10. ADDITIONAL INFORMATION ON TEST CONDITIONS

10.1. Lubricant used .....

10.1.1. Make .....

10.1.2. Type .....

(State percentage of oil in mixture if lubricant and fuel are mixed)

11. ENGINE PERFORMANCES

11.1. Idling speed ..... rpm**

11.2. Power ..... kw at an intermediate engine speed of ..... rpm**

11.3. Maximum power ..... kw at ..... rpm**

* Strike out what does not apply.
** Specify the tolerance.

11.4. Power at the six points of measurement referred to in Regulation No. 24, annex 4, paragraph 2.1 measured in accordance with the provisions of annex 10 to that Regulation

(Test carried out by the manufacturer)*

(Test carried out by the technical service conducting approval tests)*

Measurement points	*Engine speed (n) rpm*	*Measured power (P) kW*
1*	.....	.....
2	.....	.....
3	.....	.....
4	.....	.....
5	.....	.....
6**	.....	.....
Point of greatest measurement	.....	.....

* Corresponds to the highest of the three values:

—45 per cent of maximum n

—1,000 rpm

—Minimum n permitted by idling control

** Corresponds to maximum n permitted by governor at full regulation load

ANNEX 2

(Maximum format: A 4 (210 × 297 mm))

Name of administration

Communication concerning the approval (or refusal or withdrawal of approval or production definitely discontinued) of a diesel engine with regard to the emission of gaseous pollutants pursuant to Regulation No. 49

Approval No. .....

1. Trade name or mark of the engine .....
2. Engine type .....
3. Manufacturer's name and address .....
4. If applicable, name and address of manufacturer's representative .....

* Strike out what does not apply.

5. Emission levels

13 mode emission test values:

CO ..... g/kWh

HC ..... g/kWh

NO_x ..... g/kWh

6. Engine submitted for tests on .....
7. Technical service conducting tests .....
8. Date of test report issued by that service .....
9. Number of test report issued by that service .....
10. Site of test mark on the vehicle .....
11. Place .....
12. Date .....
13. Signature .....
14. The following documents, bearing the test number shown above, are annexed to this communication:

—1 copy of annex 1 to this Regulation completed and with the drawings and diagrams referred to attached

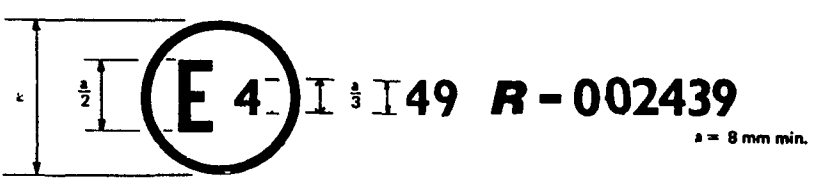
— ..... photograph(s) of the engine and its compartment.

ANNEX 3

ARRANGEMENTS OF APPROVAL MARKS

Model A

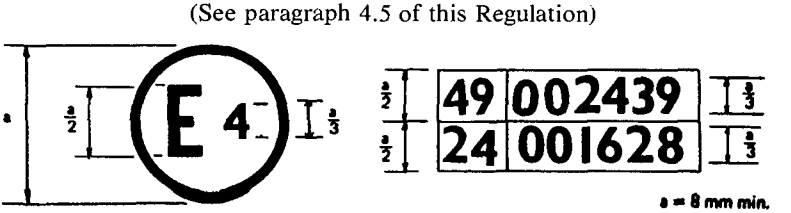
(See paragraph 4.4 of this Regulation)



The above approval mark affixed to an engine shows that the engine type concerned has been approved in the Netherlands (E 4) pursuant to Regulation No. 49. The first two digits of the approval number indicates that the approval was granted according to the requirements of Regulation No. 49 in its original form.

Model B

(See paragraph 4.5 of this Regulation)



The above approval mark affixed to an engine shows that the engine type concerned has been approved in the Netherlands (E 4) pursuant to Regulations Nos. 49 and 24.* The first two digits of the approval numbers indicate that, at the dates when the respective approvals were given, Regulations Nos. 49 and 24 were still in their original form.

ANNEX 4

TEST PROCEDURE

1. INTRODUCTION

1.1. This annex describes the method of determining emissions of gaseous pollutants from the engines to be tested.

1.2. The test shall be carried out with the engine mounted on a test bench and connected to a dynamometer.

2. MEASUREMENT PRINCIPLE

The gaseous emissions from the exhaust of the engine include hydrocarbons, carbon monoxide and oxides of nitrogen. During a prescribed sequence of warmed up engine operating conditions the amounts of the above gases in the exhaust shall be examined continuously. The prescribed sequence of operations consist of a number of speed and power modes which span the typical operating range of diesel engines. During each mode the concentration of each pollutant, exhaust flow and power output shall be determined and the measured values weighted and used to calculate the grams of each pollutant emitted per kilowatt hour, as described in this annex.

3. EQUIPMENT

3.1. *Dynamometer and engine equipment*

The following equipment shall be used for emission tests of engines on engine dynamometers:

3.1.1. An engine dynamometer with adequate characteristics to perform the test cycle described in paragraph 4.1 of this annex;

3.1.2. Measuring instruments for speed, torque, fuel consumption, air consumption, temperature of coolant and lubricant, exhaust gas pressure and section flow resistance, air inlet temperature, atmospheric pressure, fuel temperature and humidity. The accuracy of these instruments shall satisfy the ECE method of measuring the power of the internal combustion engines of road vehicles;

3.1.3. An engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures for the duration of the prescribed engine tests;

3.1.4. A non-insulated and uncooled exhaust system extending at least 0.5 m past the point where the exhaust probe is located, and presenting an exhaust backpressure within ± 650 Pa (± 5 mm Hg) of the upper limit at the maximum rated power, as established by the engine manufacturer's sale and service literature for vehicle application;

3.1.5. An engine air inlet system presenting an air inlet restriction within ± 300 Pa (30 mm H_2O) of the upper limit for the engine operating condition which results in maximum air flow, as established by the engine manufacturer for an air cleaner, for the engine being tested. When an engine is tested for exhaust emissions, the complete engine shall be tested with all standard accessories

* The second number is given merely as an example.

which might reasonably be expected to influence emissions to the atmosphere installed and functioning.

3.2. *Analytical and sampling equipment*

The system shall comprise one FID analyser for the measurement of the unburned hydrocarbons (HC), and NDIR analyser for measurement of carbon monoxide (CO) and a chemiluminescent (CLA) or equivalent analyser for measurement of nitric oxides (NO_x). Due to the heavy hydrocarbons present in the diesel exhaust, the FID system shall be heated and maintained at a temperature between 423K and 473K (150° and 200°C). The accuracy of the analysers shall be ± 2.5 per cent of full-scale deflection or better. The scale of measurement of the analysers shall be selected appropriately in relation to the values measured.

The following span and zero gases may be used:

Analyser	*Span gas*	*Zero gas*
CO	CO in N_2	nitrogen or dry purified air
NO_x	NO_2 in N_2	nitrogen or dry purified air
HC	C_3H_8 in air	dry purified air

Annex 6 describes the analytical systems recommended. Other systems or analysers which have proved to give equivalent results may be used.

4. TEST PROCEDURE

4.1. *Test cycle*

The following 13-mode cycle shall be followed in dynamometer operation on the test engine:

Mode No.	*Engine speed*	*Per cent load*
1	idle	—
2	intermediate	10
3	intermediate	25
4	intermediate	50
5	intermediate	75
6	intermediate	100
7	idle	—
8	rated	100
9	rated	75
10	rated	50
11	rated	25
12	rated	10
13	idle	—

4.2. *Measurement of exhaust gas flow*

For calculation of the emission it is necessary to know the exhaust gas flow (see paragraph 4.8.1.1 below). For determination of exhaust flow either of the following methods may be used:

(*a*) Direct measurement of the exhaust flow by flow nozzle or equivalent metering system.

(*b*) Measurement of the air flow and the fuel flow by suitable metering systems and calculation of the exhaust flow by the following equations:

$$G_{EXH} = G_{AIR} + G_{FUEL}$$

or

$$V'_{EXH} = V_{AIR} - 0.75\ G_{FUEL}$$

or

$$V''_{EXH} = V_{AIR} + 0.77\ G_{FUEL}$$

The accuracy of exhaust flow determination shall be ± 2.5 per cent or better.

The concentration of carbon monoxide and nitric oxide are measured in the dry exhaust. For this reason the CO and NO_x emissions shall be calculated using the dry exhaust gas volume V'_{EXH}. If the exhaust mass flow rate (G_{EXH}) is used in the calculation the CO and NO_x concentrations shall be related to the wet exhaust. Calculation of the HC emission shall include G_{EXH} and V''_{EXH} according to the measuring method used.

4.3. *Operating procedure for analysers and sampling system*

The operating procedure for analysers shall follow the start-up and operating instructions of the instrument manufacturer. The following minimum requirements shall be included.

4.3.1. *Calibration procedure*

The calibration procedure shall be carried out within one month preceding the emission test. The instrument assembly shall be calibrated and calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust.

4.3.1.1. A minimum of two hours shall be allowed for warming up the analysers.

4.3.1.2. A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilization period all flow meters and pressure gauges should read zero. If not, the sampling line(s) shall be checked and the fault corrected.

4.3.1.3. The NDIR analyser shall be tuned, where appropriate, and the flame combustion of the FID analyser optimized.

4.3.1.4. Using purified dry air (or nitrogen), the CO and NO_x analysers shall be set at zero; dry air shall be purified for the HC analyser. Using appropriate calibrating cases, the analysers shall be reset.

4.3.1.5. The zero setting shall be rechecked and the procedure described in paragraph 4.3.1.4 above repeated, if necessary.

4.3.1.6. The NDIR analysers shall be calibrated with calibrating gases that are approximately 25, 50, 75 and 90 per cent of each range used; the CLA and FID analysers shall be calibrated and approximately 50 per cent and 90 per cent of each range used. The concentration of the standards shall be obtained to within ± 2.5 per cent accuracy.

4.3.1.7. The calibration results shall be compared with previous data. Any significant change may reflect a system fault which shall be located, corrected and recalibrated. The best fitting calibration curve shall be selected, taking into account the accuracy of the calibration of standard gases.

4.3.2. *Pre-test checks*

A minimum of two hours shall be allowed for warming up the infrared NDIR analysers, but it is preferable that power be left on continuously in the analysers. The chopper motors may be turned off when not in use.

4.3.2.1. The HC analyser shall be set at zero on dry air or nitrogen and a stable zero obtained on the amplifier meter and recorder.

4.3.2.2. Span gas shall be introduced and the gain set to match the calibration curve. The same flow rate shall be used for calibration, span and exhaust sampling to avoid correction for sample cell pressure. Span gas having a concentration of the constituent that will give a 75-95 per cent full-scale deflection shall be used. Concentration shall be obtained to ± 2.5 per cent.

4.3.2.3. Zero shall be checked and the procedures described in paragraphs 4.3.2.1 and 4.3.2.2 above repeated, if required.

4.3.2.4. Flow rates shall be checked

4.4. *Fuel*

The fuel shall be the reference fuel specified in annex 5 to this Regulation.

4.5. *Test laboratory*

4.5.1. The absolute temperature T of the laboratory expressed in degrees Kelvin and the dry atmospheric pressure ps expressed in Kilopascals shall be measured and the parameter F shall be determined by the formula

$$F = \left(\frac{99}{ps}\right)^{0.65} \left(\frac{T}{298}\right)^{0.5}$$

4.5.2. For a test to be recognized as valid, the parameter F shall be such that

$$0.96 \leq F \leq 1.06$$

4.6. *Test run*

During each mode of the test cycle the specified speed shall be held to within ± 50 rpm and the specified torque shall be held to within ± 2 per cent of the maximum torque at the test speed. The fuel temperature at the injection pump inlet shall be 311 ± 5K (38 ± 5°C). The governor and fuel system shall be adjusted as established by the manufacturer's sales and service literature. The following steps shall be taken for each test:

4.6.1. Instrumentation and sample probes shall be installed as required;

4.6.2. The cooling system shall be started;

4.6.3. The engine shall be started and warmed up until all temperatures and pressures have reached equilibrium;

4.6.4. The torque curve at full load shall be determined by experimentation to calculate the torque values for the specified test modes;

4.6.5. The emission analysers shall be set at zero and spanned;

4.6.6. The test sequence shall be started (see paragraph 4.1 above). The engine shall be operated for six minutes in each mode, completing engine speed and load changes in the first minute. The responses of the analysers shall be recorded on a strip chart recorder for the full six minutes with exhaust gas flowing through the analysers at least during the last three minutes. The engine speed and load, intake air temperature and vacuum exhaust back pressure, fuel flow and air or

exhaust flow shall be recorded during the last five minutes of each mode, with the speed and load requirements being met during the last minute of each mode;

4.6.7. Any additional data required for calculation shall be read and recorded (see paragraph 4.7);

4.6.8. The zero and span settings of the emission analysers shall be checked and reset, as required, at least at the end of the test. The test shall be considered satisfactory if the adjustment necessary after the test does not exceed the accuracy of the analysers prescribed in paragraph 3.2 above.

4.7. *Chart reading*

The last 60 seconds of each mode shall be located, and the average chart reading for HC, CO and NO_x over this period shall be determined. The concentration of HC, CO and NO_x during each mode shall be determined from the average chart readings and the corresponding calibration data.

4.8. *Calculations*

4.8.1. The final reported test results shall be derived through the following steps:

4.8.1.1. The exhaust gas mass flow rate G_{EXH} or V'_{EXH} and V''_{EXH} shall be determined (see paragraph 4.2 above) for each mode;

4.8.1.2. When applying G_{EXH} the measured carbon monoxide and nitric oxide concentration shall be converted to a wet basis according to annex 7;

4.8.1.3. The NO_x concentration shall be corrected according to annex 8;

4.8.1.4. The pollutant mass flow for each mode shall be calculated as follows:

(1) $NO_{x\ mass} = 0.001587 \times NO_{x\ conc} \times G_{EXH}$

(2) $CO_{mass} = 0.000966 \times CO_{conc} \times G_{EXH}$

(3) $HC_{mass} = 0.000478 \times HC_{conc} \times G_{EXH}$

or

(1) $NO_{x\ mass} = 0.00205 \times NO_{x\ conc} \times V'_{EXH}$

(2) $CO_{mass} = 0.00125 \times CO_{conc} \times V'_{EXH}$

(3) $HC_{mass} = 0.000618 \times HC_{conc} \times V''_{EXH}$

4.8.2. The emissions shall be calculated in the following way:

$$\overline{NO_x} = \frac{\Sigma NO_{x\ mass} \times WF}{\Sigma P \times WF}$$

$$\overline{CO} = \frac{\Sigma CO_{mass} \times WF}{\Sigma P \times WF}$$

$$\overline{HC} = \frac{\Sigma HC_{mass} \times WF}{\Sigma P \times WF}$$

The weighting factors used in the above calculation are according to the following table:

Mode No.	*WF*
1	0.25/3
2	0.08
3	0.08

Mode No.	*WF*
4	0.08
5	0.08
6	0.25
7	0.25/3
8	0.10
9	0.02
10	0.02
11	0.02
12	0.02
13	0.25/3

ANNEX 5

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

CEC REFERENCE FUEL RF-03-T-79 (January 1979)

Type: Diesel fuel

	Limits and Units	*ASTM Method (1)*
Density at 15°C	min. 0.835 max. 0.845	1298
Cetane index	min. 51 max. 57	976
Distillation (2)		86
50% vol. point	min. 245°C	
90% vol. point	330 ± 10°C	
Final boiling point	max. 370°C	
Viscosity, 40°C	min. 2.5 cSt (mm^2/s) max. 3.5	445
Sulphur content	min. 0.20% mass max. 0.50	1266, 2622 or 2785
Flash point	min. 55°C	93
Cold filter plugging point	max. − 5°C	CEN Draft or EN116 or IP309
Conradson carbon residue on 10% dist. residue	max. 0.30% mass	189
Ash content	max. 0.01% mass	482
Water content	max. 0.05% mass	95 or 1744
Copper corrosion test at 100°C	max. 1	130
Neutralization (strong acid) number	max. 0.20 mg KOH/g	974

NOTE 1: Equivalent ISO methods will be adopted when issued for all properties listed above.

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

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

The values quoted in the specification are "true values". In establishment of their limit values the terms of ASTM D 3244 "Defining a Basis for Petroleum Product Quality Disputes" have been applied and in fixing a maximum value, a minimum difference of 2 R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4 R (R = Reproducibility).

Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of a fuel should nevertheless aim at a zero value where the stipulated maximum value is 2 R and at the mean value in the case of quotations of maximum and minimum limits.

Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ASTM D 3244 should be applied.

ANNEX 6

ANALYTICAL SYSTEMS

Two analytical systems are described based on the use of FID analyser for the measurement of hydrocarbons, and NDIR analyser for the measurement of CO and the alternative choice of CLA and equivalent analysers for the measurement of NO_x.

System 1

A schematic diagram of the analytical and sampling system using the chemiluminescent analyser for measuring NO_x is shown in fig. 1.

SP	Stainless steel sample probe, to obtain samples from the exhaust system. A closed end, multihold static probe extending at least 80 per cent across the exhaust pipe is recommended. The exhaust gas temperature at the probe shall be not less than 343 K (70°C).
HSL	Heated sampling line, temperature shall be kept between 423 K and 473 K (150°C and 200°C) degrees; the line shall be made in stainless steel or PTFE.
F_1	Heated pre-filter, if used; temperature shall be the same as HSL.
T_1	Temperature readout of sample stream entering oven compartment.
V_1	Suitable valving for selecting sample, span gas or air gas flow to the system. The valve shall be in the oven compartment or heated to the temperature of the sampling line.
V_2, V_3	Needle valves to regulate calibration gas and zero gas.
F_2	Filter to remove particulates. A 70 mm diameter glass fibre type filter disc is suitable. The filter shall be readily accessible and changed daily or more frequently, as needed.
P_1	Heated sample pump.
G_1	Pressure gauge to measure pressure in sample line.
V_4	Pressure regulator valve to control pressure in sample line and flow to detector.

FID	Heated flame ionization detector for hydrocarbons. Temperature of oven shall be kept between 423 K and 473 K (150°C and 200°C).
FL_1	Flow meter to measure sample by-pass flow.
R_1, R_2	Pressure regulators for air and fuel.
SL	Sample line. The line shall be made in PTFE or in stainless steel. It may be heated or unheated.
B	Bath to cool and condense water from exhaust sample. The bath shall be maintained at a temperature of 273 K – 277 K (0°C – 4°C) by ice or refrigeration.
C	Cooling coil and trap to condense and collect water vapour. A coiled 2.5 to 3 mm stainless steel line attached to 25 mm dia, 150 mm length trap would be typical.
T_2	Temperature readout of bath temperature.
V_5, V_6	Toggle valves to drain condensate traps and bath.
V_7	Three-way valve.
F_3	Filter for removing particulate contaminants from sample prior to analysis. A glass fibre type of at least 70 mm dia is suitable.
P_2	Sample pump.
V_8	Pressure regulator to control sample flow.
V_9, V_{10}, V_{11}, V_{12}	Three-way ball valve or solenoid valves to direct sample, zero gas or calibrating gas streams to the analysers.
V_{13}, V_{14}	Needle valves to regulate flows to the analysers.
CO	NDIR analyser for carbon monoxide.
NO_x	CLA analyser for nitric oxides.
FL_2, FL_3, FL_4	By-pass flowmeters.

System 2

A schematic diagram of the analytical and sampling system using the NDIR analyser for measuring NO is shown in fig. 2.

SP	Stainless steel sample probe, to obtain samples from the exhaust system. A closed end, multihole static probe extending at least 80 per cent across the exhaust pipe is recommended; the temperature at the probe shall be at least 373 K (70°C) (in accordance with ECE Regulation No. 24). The probe shall be located in the exhaust line at a distance of 1-5 m from the exhaust manifold outlets flange or the outlet of the turbocharger.
HSL	Heated sampling line, temperature shall be kept between 423 K and 473 K (150°C and 200°C) degrees; the line shall be made in stainless steel or PTFE.
F_1	Heated pre-filter, if used; temperature shall be the same as the HSL.
T_1	Temperature readout of sample stream entering oven compartment.

V_1	Suitable valving for selecting sample, span gas or air zero gas flow to the system. The valve shall be in the oven compartment or heated to the temperature of the sampling line.
V_2, V_3	Needle valves to regulate calibration gas and zero gas.
F_2	Filter to remove particulates. A 70 mm diameter glass fibre type filter disc is suitable. The filter shall be readily accessible and changed daily or more frequently, as needed.
P_1	Heated sample pump.
G_1	Pressure gauge to measure pressure in sample line.
V_4	Pressure regulator valve to control pressure in sample line and flow to detector.
FID	Heated flame ionization detector for hydrocarbons. Temperature of oven shall be kept between 423 K and 473 K (150°C and 200°C).
FL_1	Flowmeter to measure sample by-pass flow.
R_1, R_2	Pressure regulators for air and fuel.
SL	Sample line. The line shall be made in PTFE or in stainless steel.
B	Bath to cool and condense water from exhaust sample. The bath shall be maintained at a temperature of 273 K – 277 K (0°C – 4°C) by ice or refrigeration.
C	Cooling coil and trap to condense and collect water vapour. A coiled 2.5-3 mm stainless steel line attached to 25 mm dia, 150 mm length trap would be typical.
T_2	Temperature readout of bath temperature.
V_5, V_6	Toggle valves to drain condensation trap and bath.
V_7	Three-way valve.
F_3	Filter for removing particulate contaminates from sample prior to analysis. A glass fibre type of at least 70 mm diameter is suitable.
P_2	Sample pump.
V_8	Pressure regulator to control sample flow.
V_9	Ball or solenoid valve to direct sample, zero gas or calibrating gas streams to the analysers.
V_{10}, V_{11}	Three-way valve to by-pass drier.
D	Drier to remove moisture in the sample stream. If a drier is used before NO_x analyser it shall have minimum effect on NO_x concentration.
V_{12}	Needle valve to regulate flow to the analysers.
G_2	Gauge to indicate inlet pressure to the analysers.
CO	NDIR analyser for carbon monoxide.
NO_x	NDIR analyser for nitric oxides.
FL_2, FL_3	By-pass flowmeter.

Figure 1. FLOW DIAGRAM OF EXHAUST GAS ANALYSIS SYSTEM FOR CO, NO_x, HC (NO_x ANALYSIS BY CLA)

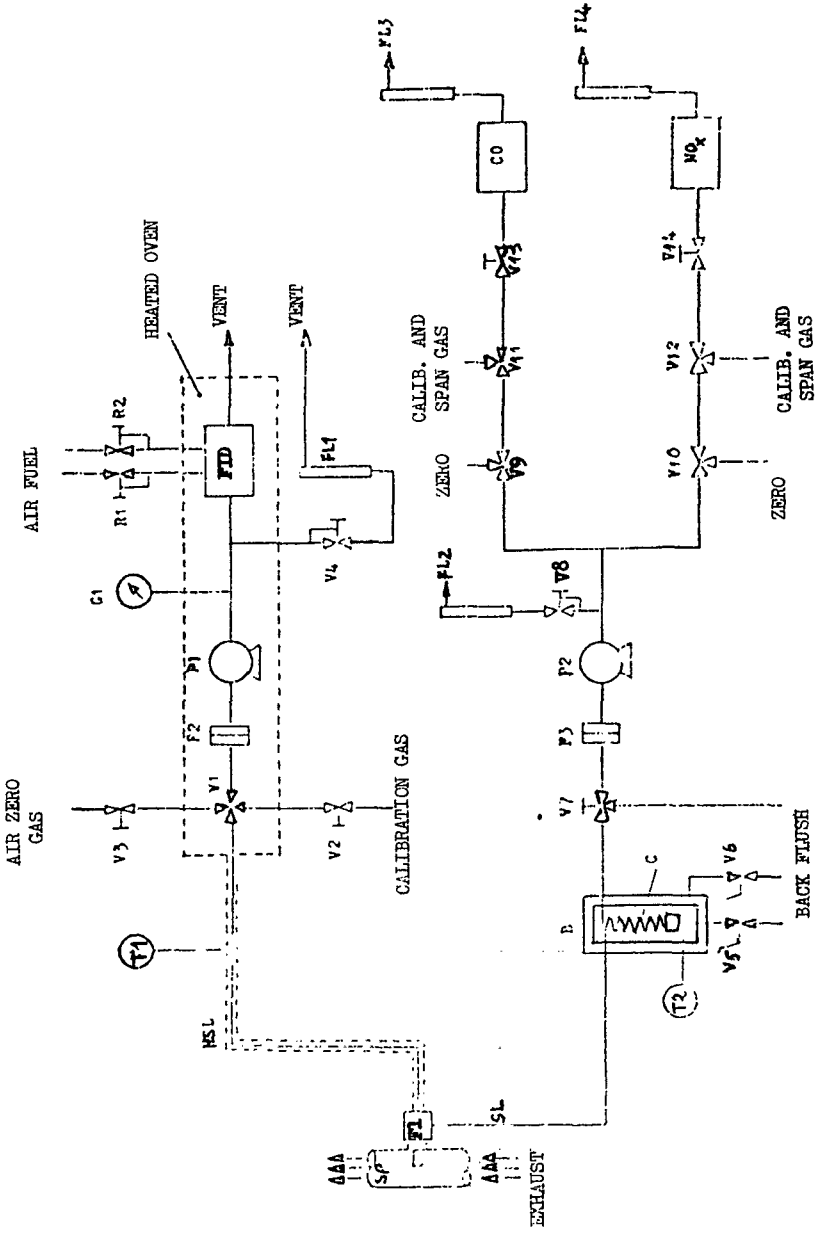
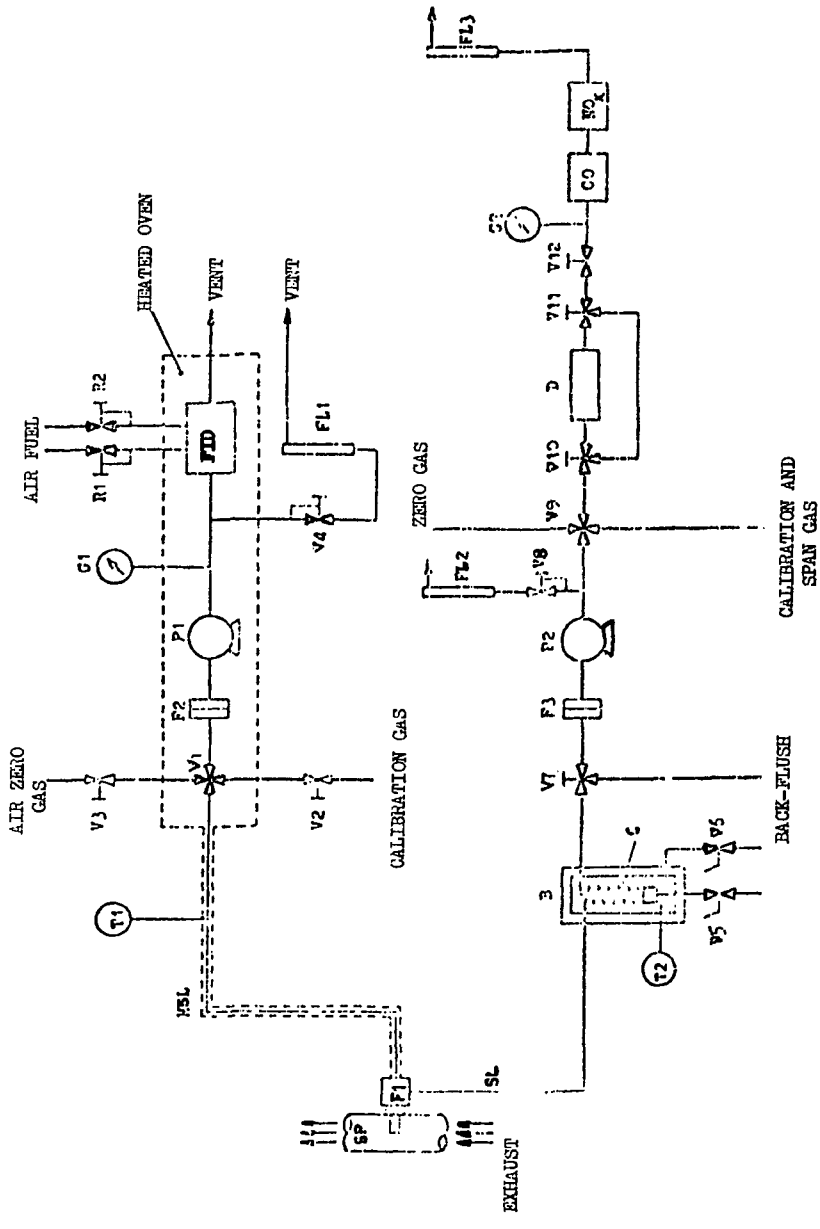


Figure 2. FLOW DIAGRAM OF EXHAUST GAS ANALYSIS SYSTEM FOR CO, NO_x, HC (NO_x ANALYSIS BY NDIR)



ANNEX 7

CONVERSION OF CO AND NO_x CONCENTRATION TO A WET BASIS

The CO and NO_x exhaust gas concentration as measured in this procedure are on a dry basis. To convert the measured values to the concentrations present in the exhaust (wet basis), the following relationship may be employed:

$$\text{ppm (wet basis)} = \text{ppm (dry basis)} \times \left[1 - 1.85 \left(\frac{G_{FUEL}}{G_{AIR}} \right) \right]$$

where:

G_{FUEL} = is the fuel flow (kg/sec) (kg/h)

G_{AIR} = is the air flow (kg/sec) (kg/h)

ANNEX 8

NITRIC OXIDE HUMIDITY CORRECTION FACTOR

The values of the nitric oxides shall be multiplied by the following humidity correction factor:

$$\frac{1}{1 + A(7m - 75) + B \times 1.8(T - 302)}$$

where:

$$A = -0.044 \frac{G_{FUEL}}{G_{AIR}} - 0.0038$$

$$B = -0.116 \frac{G_{FUEL}}{G_{AIR}} + 0.0053$$

m = humidity of the inlet air in grams of water per kilogram of dry air

T = temperature of the air in K

$\frac{G_{FUEL}}{G_{AIR}}$ = Fuel air ratio (dry air basis)

ANNEX 9

CLASSIFICATION OF VEHICLES*

Category M: Power-driven vehicles having at least four wheels or having three wheels when the maximum weight exceeds 1 metric tonne and used for the carriage of passengers**

Category M_2 Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum weight not exceeding 5 metric tonnes.

* In conformity with Regulation No. 13 (E/ECE/TRANS/505/Rev.1/Add.12/Rev.2, paragraph 5.2).[1]

** Articulated vehicles comprising two non-separable but articulated units shall be considered as single vehicles.

[1] United Nations, *Treaty Series*, vol. 730, p. 342.

Category M_3 Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum weight exceeding 5 metric tonnes.

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

Category N_2 Vehicles used for the carriage of goods and having a maximum weight exceeding 3.5 but not exceeding 12 metric tonnes.

Category N_3 Vehicles used for the carriage of goods and having a maximum weight exceeding 12 metric tonnes.

Authentic texts: English and French.

Registered ex officio *on 15 April 1982.*