II

*(Acts whose publication is not obligatory)*

# COUNCIL

## COUNCIL DIRECTIVE

### of 16 June 1983

### amending Council Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles

(83/351/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

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

Having regard to the proposal from the Commission (1),

Having regard to the opinion of the European Parliament (2),

Having regard to the opinion of the Economic and Social Committee (3),

Whereas the first programme of action of the European Community on the protection of the environment, approved by the Council on 22 November 1973, called for account to be taken of the latest scientific advances in combating atmospheric pollution caused by gases emitted from motor vehicles, and amended the Directives already adopted to that end;

Whereas Directive 70/220/EEC (4) lays down the limit values for carbon monoxide and unburnt hydrocarbon emissions from such engines; whereas these limit values were first reduced by Directive 74/290/EEC (5) and supplemented, in accordance with Directive 77/102/EEC (6), by limit values for permissible emissions of nitrogen oxides; whereas the limit values for these three pollutants were further lowered by Directive 78/665/EEC (7);

Whereas advances in motor vehicle design now enable a reduction in these limit values; whereas this appears desirable as a precaution against possible adverse effects on the environment; whereas during the period under consideration such a reduction will not jeopardize the aims of Community policy in other fields, and in particular in that of the rational use of energy;

Whereas, in view of the increasing use of diesel engines in cars and light commercial vehicles, it is advisable to reduce not only soot emissions, which are covered by Directive 72/306/EEC (8), but also the carbon monoxide, unburnt hydrocarbon and nitrogen oxide emissions from such engines; whereas bringing such engines within the scope of Directive 70/220/EEC involves an amendment to the operative part of the said Directive; whereas that amendment also has an effect on the content of the technical Annexes; whereas the Commission has proposed to the Council that in the present Directive it adopt at the same time the amendments to the technical Annexes, by way of derogation from Article 5 of Directive 70/220/EEC,

(1) OJ No C 181, 19. 7. 1982, p. 30.
(2) Opinion delivered on 10 June 1983 (not yet published in the Official Journal).
(3) OJ No C 346, 31. 12. 1982, p. 2.
(4) OJ No L 76, 6. 4. 1970, p. 1.
(5) OJ No L 159, 15. 6. 1974, p. 61.
(6) OJ No L 32, 3. 2. 1977, p. 32.
(7) OJ No L 223, 14. 8. 1978, p. 48.
(8) OJ No L 190, 20. 8. 1972, p. 1.

HAS ADOPTED THIS DIRECTIVE:

*Article 1*

Directive 70/220/EEC is hereby amended as follows:

1. The title of Directive 70/220/EEC shall be replaced by the following:

   'Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from engines of motor vehicles'.

2. Article 1 is replaced by the following:

   *'Article 1*

   For the purposes of this Directive, "vehicle" means any vehicle with a positive-ignition engine or with a compression-ignition engine, intended for use on the road, with or without bodywork, having at least four wheels, a permissible maximum mass of at least 400 kg and a maximum design speed equal to or exceeding 50 km/h, with the exception of agricultural tractors and machinery and public works vehicles.'

3. The Annexes are replaced by the Annexes to this Directive.

*Article 2*

1. From 1 December 1983, no Member State may, on grounds relating to air pollution by gases from an engine:

— refuse to grant EEC type-approval, or to issue the documents referred to in the last indent of Article 10 (1) of Directive 70/156/EEC, or to grant national type-approval for a type of motor vehicle, or

— prohibit the entry into service of such vehicles,

where the level of gaseous pollutants emitted from this type of motor vehicle or from such vehicles meets the requirements of Directive 70/220/EEC, as amended by this Directive.

2. From 1 October 1984, Member States:

— may no longer issue the document provided for in the last indent of Article 10 (1) of Directive 70/156/EEC in respect of a type of motor vehicle which emits gaseous pollutants at levels which do not meet the requirements of Directive 70/220/EEC, as amended by this Directive,

— may refuse national type-approval for a type of motor vehicle which emits gaseous pollutants at levels which do not meet the requirements of Directive 70/220/EEC, as amended by this Directive.

3. From 1 October 1986, Member States may prohibit the entry into service of vehicles which emit gaseous pollutants at levels which do not meet the requirements of Directive 70/220/EEC, as amended by this Directive.

*Article 3*

Member States shall bring into force the necessary provisions in order to comply with this Directive not later than 30 November 1983 and shall forthwith inform the Commission thereof.

*Article 4*

This Directive is addressed to the Member States.

Done at Luxembourg, 16 June 1983.

*For the Council*

*The President*

C.-D. SPRANGER

*ANNEX I*

**SCOPE, DEFINITIONS, APPLICATION FOR EEC TYPE-APPROVAL, EEC TYPE-APPROVAL, SPECIFICATIONS AND TESTS, EXTENSION OF EEC TYPE-APPROVAL, CONFORMITY OF PRODUCTION, TRANSITIONAL PROVISIONS**

1. SCOPE

This Directive applies to the emission of gaseous pollutants from all motor vehicles equipped with positive-ignition engines and from vehicles of categories $M_1$ and $N_1$ (1) equipped with compression-ignition engines, covered by Article 1.

2. DEFINITIONS

For the purposes of this Directive:

2.1. 'Vehicle type', with regard to the emission of gaseous pollutants from the engine, means a category of power-driven vehicles which do not differ in such essential respects as:

2.1.1. the equivalent inertia determined in relation to the reference mass as prescribed in 5.1 of Annex III; and

2.1.2. the engine and vehicle characteristics as defined in 1 to 6 and 8 of Annex II and Annex VII.

2.2. 'Reference mass' means the mass of the vehicle in running order less the uniform mass of the driver of 75 kg and increased by a uniform mass of 100 kg.

2.2.1. 'Mass of the vehicle in running order' means the mass defined under 2.6 of Annex I to Directive 70/156/EEC.

2.3. 'Maximum mass' means the mass defined under 2.7 of Annex I to Directive 70/156/EEC.

2.4. 'Gaseous pollutants' means carbon monoxide, hydrocarbons (assuming a ratio of $CH_{1,85}$), and oxides of nitrogen, the latter being expressed in nitrogen dioxide ($NO_2$) equivalent.

2.5. 'Engine crankcase' means the spaces in or external to an engine which are connected to the oil sump by internal or external ducts through which gases and vapours can escape.

2.6. 'Cold start device' means a device which enriches the air/fuel mixture of the engines temporarily, thus assisting the engine to start.

2.7. 'Starting aid' means a device which assists the engine to start without enrichment of the air/fuel mixture of the engine, e.g. glow plugs, modifications to the injection timing.

3. APPLICATION FOR EEC TYPE-APPROVAL

3.1. The application for approval of a vehicle type with regard to the emission of gaseous pollutants from its engine is submitted by the vehicle manufacturer or by his authorized representative.

3.2. It is accompanied by the following documents in triplicate and by the following particulars:

(1) As defined in 0.4 of Annex I to Directive 70/156/EEC (OJ No L 42, 23. 2. 1970, p. 1).

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

3.2.2. drawings of the combustion chamber and of the piston, including the piston rings;

3.2.3. maximum lift of valves and angles of opening and closing in relation to dead centres.

3.3. A vehicle representative of the vehicle type to be approved is submitted for the tests described in 5 of this Annex to the technical service responsible for the type-approval tests.

4. EEC TYPE-APPROVAL

4.1. A form conforming to the model set out in Annex VII must be attached to the EEC type-approval certificate.

5. REQUIREMENTS AND TESTS

5.1. **General**

The components liable to affect the emission of gaseous pollutants must be so designed, constructed and assembled as to enable the vehicle, in normal use, to comply with the requirements of this Directive, despite the vibration to which they may be subjected.

5.2. **Description of tests**

5.2.1. The vehicle must, according to its category, be subjected to tests of different types, as specified below. The tests are:

— type I, II and III if powered by a positive-ignition engine, and

— type I if powered by a compression-ignition engine.

5.2.1.1. *Type I test* (verifying the average emission of gaseous pollutants after a cold start)

5.2.1.1.1. This test must be carried out on all vehicles referred to in 1, of a maximum mass not exceeding 3,5 tonnes.

5.2.1.1.2. The vehicle is placed on a dynamometer bench equipped with a means of load and inertia simulation. A test lasting a total of 13 minutes and comprising four cycles is performed without interruption. Each cycle comprises 15 phases (idling, acceleration, steady speed, deceleration, etc.). During the test the exhaust gases are diluted and a proportional sample collected in one or more bags. The exhaust gases of the vehicle tested are diluted, sampled and analyzed following the procedure described below; the total volume of the diluted exhaust is measured.

5.2.1.1.3. The test is carried out by the procedure described in Annex III. The methods used to collect and analyze the gases must be those prescribed. Other analysis methods may be approved if it is found that they yield equivalent results.

5.2.1.1.4. Subject to the requirements of 5.2.1.1.4.2 and 5.2.1.1.5, the test is repeated three times. For a vehicle of a given reference mass, the mass of the carbon monoxide and the combined mass of the hydrocarbons and of the nitrogen oxides obtained in the test must be less than the amounts shown in the table below:

| Reference mass RW (kg) | Carbon monoxide $L_1$ (g/test) | Combined emission of hydrocarbons and oxides of nitrogen $L_2$ (g/test) |
|---|---|---|
| RW ≤ 1 020 | 58 | 19,0 |
| 1 020 < RW ≤ 1 250 | 67 | 20,5 |
| 1 250 < RW ≤ 1 470 | 76 | 22,0 |
| 1 470 < RW ≤ 1 700 | 84 | 23,5 |
| 1 700 < RW ≤ 1 930 | 93 | 25,0 |
| 1 930 < RW ≤ 2 150 | 101 | 26,5 |
| 2 150 < RW | 110 | 28,0 |

5.2.1.1.4.1. Nevertheless, for each of the pollutants referred to in 5.2.1.1.4, one of the three results obtained may exceed by not more than 10 % the limit prescribed in that section for the vehicle concerned, provided the arithmetical mean of the three results is below the prescribed limit. Where the prescribed limits are exceeded for more than one pollutant (i.e. carbon monoxide and the combined mass of hydrocarbons and nitrogen oxides) it is immaterial whether this occurs in the same test or in different tests (1).

5.2.1.1.4.2. The number of tests prescribed in 5.2.1.1.4 may, on the request of the manufacturer, be increased to 10 tests provided that the arithemtic mean ($\bar{x}_i$) of the three results performed for carbon monoxide and/or for the combined emissions of hydrocarbons and of oxides of nitrogen falls between 100 and 110 % of the limit. In this case, the decision, after testing, depends exclusively on the average results obtained from all 10 tests ($\bar{x} < L$).

5.2.1.1.5. The number of tests prescribed in 5.2.1.1.4 is reduced in the conditions hereinafter defined, where $V_1$ is the result of the first test and $V_2$ the result of the second test for each of the pollutants referred to in 5.2.1.1.4.

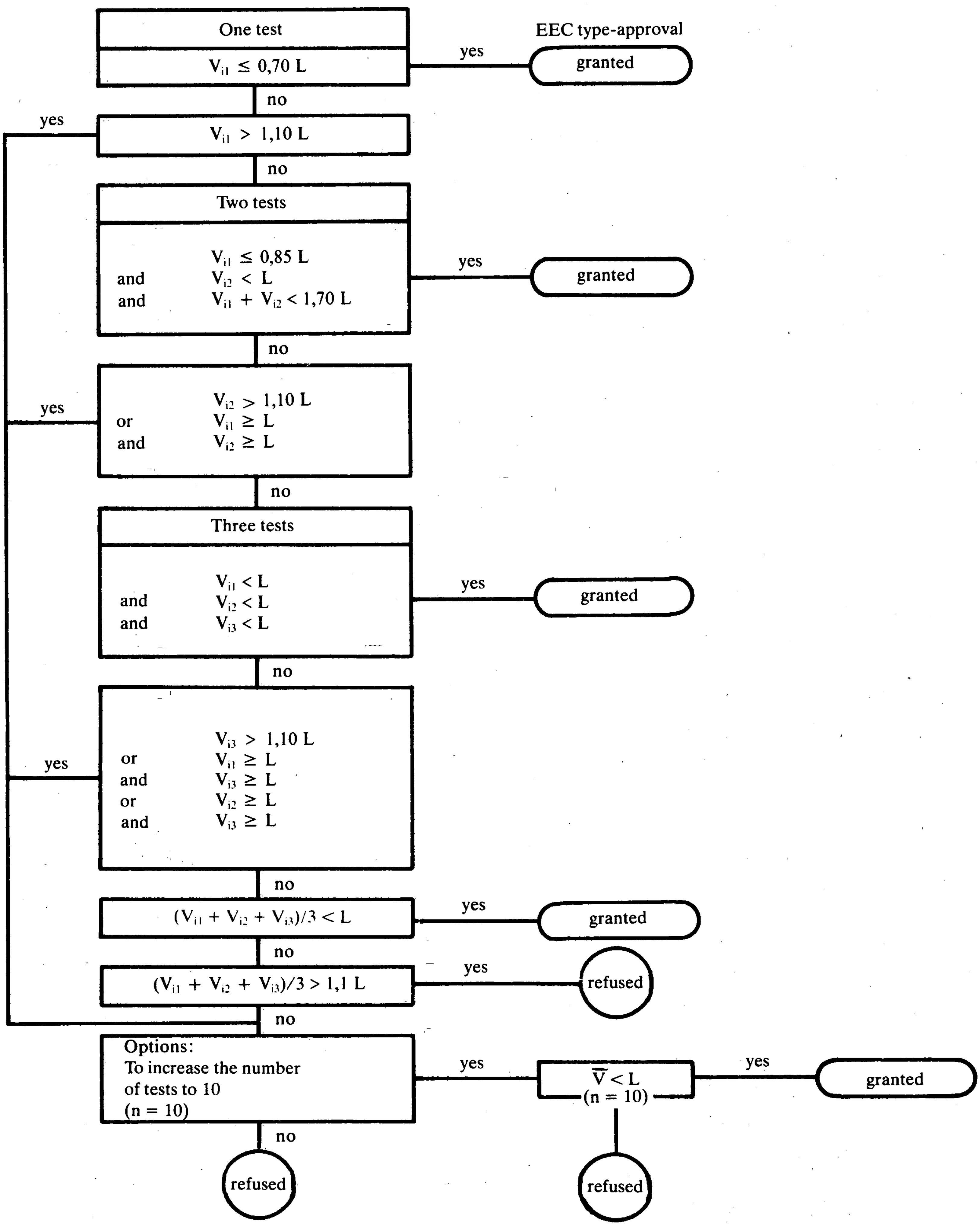
5.2.1.1.5.1. Only one test is performed if $V_1$ readings of carbon monoxide as well as the combined hydrocarbon and oxides of nitrogen reading are less than or equal to 0,70 L.

5.2.1.1.5.2. Only two tests are performed if the results of both the carbon monoxide and the combined value of hydrocarbons and oxides of nitrogen are $V_1 \leq 0{,}85$ L, and if, at the same time, one of these values is $V_1 > 0{,}70$ L. In addition, the $V_2$ readings of both the carbon monoxide emissions and the combined emissions of hydrocarbon and oxides of nitrogen must satisfy the requirement that $V_1 + V_2 \leq 1{,}70$ L, and $V_2 \leq$ L.

(1) If one of the three results obtained of each of the pollutants exceeds by more than 10 % the limit prescribed in 5.2.1.1.4 for the vehicle concerned, the test may be continued as specified in 5.2.1.1.4.2.

*Figure 1*

**Flow sheet for the type-approval of the European test procedure** (see 5.2)



5.2.1.2. *Type II test* (carbon monoxide emission test at idling speed)

5.2.1.2.1. With the exception of vehicles powered by a compression-ignition engine, this test must be carried out on all vehicles referred to in 1.

5.2.1.2.2. The carbon monoxide content by volume of the exhaust gases emitted with the engine idling must not exceed 3,5 %. When a check is made in accordance with the requirements of Annex IV under operating conditions not in conformity with the standards recommended by the manufacturer (configuration of the adjustment components), the maximum content measured by volume must not exceed 4,5 %.

5.2.1.2.3. Conformity with the latter requirement is checked by means of a test carried out using the procedure described in Annex IV.

5.2.1.3. *Type III test* (verifying emissions of crankcase gases)

5.2.1.3.1. This test must be carried out on all vehicles referred to in 1 except those having compression-ignition engines.

5.2.1.3.2. The engine's crankcase ventilation system must not permit the emission of any of the crankcase gases into the atmosphere.

5.2.1.3.3. Conformity with the latter requirement is checked by means of a test carried out using the procedure described in Annex V.

## 6. EXTENSION OF EEC TYPE-APPROVAL

### 6.1. **Vehicle types of different reference masses**

6.1.1. Approval of a vehicle type may under the following conditions be extended to vehicle types which differ from the type approved only in respect of their reference mass.

6.1.1.1. Approval may be extended to vehicle types of a reference mass requiring merely the use of the next higher or next lower equivalent inertia.

6.1.1.2. If the reference mass of the vehicle type for which extension of the approval is requested requires the use of a flywheel of equivalent inertia higher than that used for the vehicle type already approved, extension of the approval is granted.

6.1.1.3. If the reference mass of the vehicle type for which extension of the approval is requested requires the use of a flywheel of equivalent inertia lower than that used for the vehicle type already approved, extension of the approval is granted if the masses of the pollutants obtained from the vehicle already approved are within the limits prescribed for the vehicle for which extension of the approval is requested.

### 6.2. **Vehicle types with different overall gear ratios**

6.2.1. Approval granted to a vehicle type may under the following conditions be extended to vehicle types differing from the type-approval only in respect of their overall transmission ratios:

6.2.1.1. For each of the transmission ratios used in the type I test, it is necessary to determine the proportion $E = \frac{V_2 - V_1}{V_1}$ where $V_1$ and $V_2$ are respectively the speed at 1 000 r/min of the engine of the vehicle type approved and the speed of the vehicle type for which extension of the approval is requested.

6.2.2. If for each gear ratio $E \leq 8$ %, the extension is granted without repeating the type I tests;

6.2.3. If for at least one gear ratio $E > 8\,\%$ and if for each gear ratio $E \leq 13\,\%$, the type I tests are repeated, but may be performed in a laboratory chosen by the manufacturer subject to the approval of the authority granting type-approval. The report of the tests must be sent to the technical service responsible for the type-approval tests.

6.3. **Vehicle types of different reference masses and different overall transmission rating**

Approval granted to a vehicle type may be extended to vehicle types differing from the approved type only in respect of their reference mass and their overall transmission ratios, provided that all the conditions prescribed in 6.1 and 6.2 are fulfilled.

6.4. **Note**

When a vehicle type has been approved in accordance with 6.1 to 6.3, such approval may not be extended to other vehicle types.

7. CONFORMITY OF PRODUCTION

7.1. As a general rule, conformity of production models, with regard to limitation of the emission of gaseous pollutants from the engine, is checked on the basis of the description in the Annex to the type-approval certificate set out in Annex VII and, where necessary, of all or some of the tests of types I, II and III described in 5.2.

7.1.1. Conformity of the vehicle in a type I test is checked as follows:

7.1.1.1. A vehicle is taken from the series and subjected to the test described in 5.2.1.1. However, the limits shown in 5.2.1.1.4 are replaced by the following:

| Reference mass RW (kg) | Carbon monoxide $L_1$ (g/test) | Combined standard for hydrocarbons and oxides of nitrogen $L_2$ (g/test) |
|---|---|---|
| $RW \leq 1\,020$ | 70 | 23,8 |
| $1\,020 < RW \leq 1\,250$ | 80 | 25,6 |
| $1\,250 < RW \leq 1\,470$ | 91 | 27,5 |
| $1\,470 < RW \leq 1\,700$ | 101 | 29,4 |
| $1\,700 < RW \leq 1\,930$ | 112 | 31,3 |
| $1\,930 < RW \leq 2\,150$ | 121 | 33,1 |
| $2\,150 < RW$ | 132 | 35,0 |

7.1.1.2. If the vehicle taken from the series does not satisfy the requirements of 7.1.1.1, the manufacturer may ask for measurements to be performed on a sample of vehicles taken from the series and including the vehicle originally taken. The manufacturer determines the size n of the sample. Vehicles other than the vehicle originally taken are subjected to a single type I test.

The result to be taken into consideration for the vehicle taken originally is the arithmetical mean of the three type I tests carried out on the vehicle. The arithmetic mean ($\bar{x}$) of the results obtained with the sample and the standard deviation S [1] must be determined for both the carbon monoxide emission and for the combined emissions of hydrocarbons and oxides of nitrogen. The production of the series is then deemed to conform if the following condition is met:

$$\bar{x} + k \cdot S \leq L$$

where

L is the limit value laid down in 7.1.1.1 for the emissions of carbon monoxide and the combined emissions of hydrocarbons and oxides of nitrogen;

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 | 0,195 |

$$\text{If } n \geq 20, \quad k = \frac{0{,}860}{\sqrt{n}}$$

7.1.2. In a type II or type III test carried out on a vehicle taken from the series, the conditions laid down in 5.2.1.2.2 and 5.2.1.3.2 must be complied with.

7.1.3. Notwithstanding the requirements of 3.1.1 of Annex III, the technical service responsible for verifying the conformity of production may, with the consent of the manufacturer, carry out tests of types I, II and III on vehicles which have been driven less than 3 000 km.

8. TRANSITIONAL PROVISIONS

8.1. For the type-approval and checking of production conformity of vehicles other than those of category $M_1$ as well as of vehicles of category $M_1$ designed to carry more than six occupants including the driver, the limits for the combined emissions of hydrocarbons and oxides of nitrogen are those resulting from the multiplication of the values $L_2$ given in the tables in 5.2.1.1.4 and 7.1.1.1 by a factor of 1,25.

8.2. For the checking of production conformity of vehicles which were type-approved before 1 October 1984 as far as their emissions of pollutants are concerned, in accordance with the provisions of Directive 70/220/EEC, as amended by Directive 78/665/EEC, the provisions of the abovementioned Directive remain applicable until the Member States make use of Article 2 (3) of this Directive.

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

*ANNEX II*

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

1. **Description of engine**

1.1. Make: ....................................................................................

1.2. Type: ....................................................................................

1.3. Working principle: positive ignition/compression ignition, four stroke/two stroke (2):

1.4. Bore: ............................ mm

1.5. Stroke: ............................ mm

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

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

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

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

1.10. Cooling system: liquid/air cooling (2): ..................................................

1.11. Supercharger: yes/no (2) Description of the system: ........................................

1.12. *Intake system*

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

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

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

1.13. Device for recycling crankcase gases (description and diagrams):

2. **Additional anti-pollution devices** (if any, and if not covered by another heading)

Description and diagrams: ..........................................................

3. **Air intake and fuel feed**

3.1. Description and diagrams of inlet pipes and their accessories (dash-pot, heating device, additional air intakes, etc.): ..........................................................

3.2. Fuel feed

3.2.1. By carburettor(s) (2): .......................... Number: ..........................

3.2.1.1. Make: ....................................................................................

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

3.2.1.2. Type: ....................................................................................

3.2.1.3. Adjustments (1) ....................................................................................

| | | | |
|---|---|---|---|
| 3.2.1.3.1. | Jets: .................................. | or | Curve of fuel delivery plotted against air flow, and settings required to keep to the curve (1)(2) |
| 3.2.1.3.2. | Venturis: .................................. | | |
| 3.2.1.3.3. | Float-chamber level: .................................. | | |
| 3.2.1.3.4. | Mass of float: .................................. | | |
| 3.2.1.3.5. | Float needle: .................................. | | |

3.2.1.4. Manual/automatic choke (2):
Closure setting (1): ....................................................................................

3.2.1.5. Feed pump
Pressure (1): ........................ or characteristic diagram (1): ........................

3.2.2. By fuel injection (2) system description
Working principle: Intake manifold/direct injection
injection prechamber/swirl chamber (2): ....................................................................................

3.2.2.1. Fuel pump: ....................................................................................

3.2.2.1.1. Make: ....................................................................................

3.2.2.1.2. Type: ....................................................................................

3.2.2.1.3. Delivery: ................. $mm^3$ per stroke at a pump speed of ................. r/min (1)(2)
or, alternatively, a characteristic diagram (1)(2): ....................................................................................
Calibration procedure: test bench/engine (2)

3.2.2.1.4. Injection timing: ....................................................................................

3.2.2.1.5. Injection curve: ....................................................................................

3.2.2.2. Injector nozzle: ....................................................................................

3.2.2.3. Governor: ....................................................................................

3.2.2.3.1. Make: ....................................................................................

3.2.2.3.2. Type: ....................................................................................

3.2.2.3.3. Cut-off point under load $min^{-1}$: ....................................................................................

3.2.2.3.4. Maximum speed without load $min^{-1}$: ....................................................................................

3.2.2.3.5. Idle speed: ....................................................................................

3.2.2.4. Cold start device: ....................................................................................

3.2.2.4.1. Make: ....................................................................................

3.2.2.4.2. Type: ....................................................................................

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

3.2.2.4.3. System description: ..........................................................

3.2.2.5. Starting aid: ..........................................................

3.2.2.5.1. Make: ..........................................................

3.2.2.5.2. Type: ..........................................................

3.2.2.5.3. System description: ..........................................................

4. **Valve timing or equivalent data**

4.1. Maximum lift of valves, angles of opening and closing, or timing details of alternative distribution systems, in relation to top dead centre: ..........................................................

..........................................................

4.2. Reference and/or setting ranges (1): ..........................................................

5. **Ignition**

5.1. Ignition system type: ..........................................................

5.1.1. Make: ..........................................................

5.1.2. Type: ..........................................................

5.1.3. Ignition advance curve (2): ..........................................................

5.1.4. Ignition timing (2): ..........................................................

5.1.5. Contact-point gap (2) and dwell-angle (1)(2): ..........................................................

6. **Exhaust system**

6.1. Description and diagrams: ..........................................................

7. **Additional information on test conditions**

7.1. *Sparking plugs*

7.1.1. Make: ..........................................................

7.1.2. Type: ..........................................................

7.1.3. Spark-gap setting: ..........................................................

7.2. *Ignition coil*

7.2.1. Make: ..........................................................

7.2.2. Type: ..........................................................

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

7.3. *Ignition condenser*

7.3.1. Make: ...........................................................................

7.3.2. Type: ...........................................................................

8. **Engine performance** (declared by manufacturer)

8.1. Idle r/min (1): ...........................................................................

8.2. Carbon monoxide content by volume in the exhaust gas with the engine idling — % (manufacturer's standard): ...........................................................................

8.3. R/min at maximum power (1): ...........................................................................

8.4. Maximum power: .................................. kW (according to the method described in Annex I to Directive 80/1269/EEC)

9. **Lubricant used**

9.1. Make: ...........................................................................

9.2. Type: ...........................................................................

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(1) Specify the tolerance.

*ANNEX III*

## TYPE I TEST

**(Verifying the average emission of pollutants in a congested urban area after a cold start)**

1. INTRODUCTION

This Annex describes the procedure for the type I test defined in 5.2.1.1 of Annex I.

2. OPERATING CYCLE ON THE CHASSIS DYNAMOMETER

2.1. **Description of the cycle**

The operating cycle on the chassis dynamometer is that indicated in the following table and depicted in the graph in Appendix 1. The breakdown by operations is also given in the table in the said Appendix.

2.2. **General conditions under which the cycle is carried out**

Preliminary testing cycles must be carried out if necessary to determine how best to actuate the accelerator and brake controls so as to achieve a cycle approximating to the theoretical cycle within the prescribed limits.

2.3. **Use of the gearbox**

2.3.1. If the maximum speed which can be attained in first gear is below 15 km/h, the second, third and fourth gears are used. The second, third and fourth gears may also be used when the driving instructions recommend starting in second gear on level ground, or when first gear is therein defined as a gear reserved for cross-country driving, crawling or towing.

2.3.2. Vehicles equipped with semi-automatic-shift gearboxes are tested by using the gears normally employed for driving, and the gear shift is used in accordance with the manufacturer's instructions.

2.3.3. Vehicles equipped with automatic-shift gearboxes are tested with the highest gear ('Drive') engaged. The accelerator must be used in such a way as to obtain the steadiest acceleration possible, enabling the various gears to be engaged in the normal order. Furthermore, the gear-change points shown in Appendix 1 to this Annex do not apply; acceleration must continue throughout the period represented by the straight line connecting the end of each period of idling with the beginning of the next following period of steady speed. The tolerances given in 2.4 apply.

2.3.4. Vehicles equipped with an overdrive which the driver can actuate are tested with the overdrive out of action.

2.4. **Tolerances**

2.4.1. A tolerance of ± 1 km/h is allowed between the indicated speed and the theoretical speed during acceleration, during steady speed, and during deceleration when the vehicle's brakes are used. If the vehicle decelerates more rapidly without the use of the brakes, only the requirements of 6.5.3 apply. Speed tolerances greater than those prescribed are accepted during phase changes provided that the tolerances are never exceeded for more than 0,5 s on any one occasion.

2.4.2. The time tolerances are ± 0,5 s. The above tolerances apply equally at the beginning and at the end of each gear-changing period [1].

(1) It should be noted that the time of two seconds allowed includes the time for changing gear and, if necessary, a certain amount of latitude to catch up with the cycle.

**Operating cycle on the chassis dynamometer**

| No of operation | Operation | Phase | Acceleration (m/s²) | Speed (km/h) | Duration of each: Operation (s) | Duration of each: Phase (s) | Cumulative time (s) | Gear to be used in the case of a manual gearbox |
|---|---|---|---|---|---|---|---|---|
| 1 | Idling | 1 | | | 11 | 11 | 11 | 6 s PM + 5 s $K_1$ (*) |
| 2 | Acceleration | 2 | 1,04 | 0–15 | 4 | 4 | 15 | 1 |
| 3 | Steady speed | 3 | | 15 | 8 | 8 | 23 | 1 |
| 4 | Deceleration | 4 | −0,69 | 15–10 | 2 | 2 | 25 | 1 |
| 5 | Deceleration, clutch disengaged | | −0,92 | 10–0 | 3 | 3 | 28 | $K_1$ (*) |
| 6 | Idling | 5 | | | 21 | 21 | 49 | 16 s PM + 5 s $K_1$ (*) |
| 7 | Acceleration | 6 | 0,83 | 0–15 | 5 | 12 | 54 | 1 |
| 8 | Gear change | | | | 2 | | 56 | |
| 9 | Acceleration | | 0,94 | 15–32 | 5 | | 61 | 2 |
| 10 | Steady speed | 7 | | 32 | 24 | 24 | 85 | 2 |
| 11 | Deceleration | 8 | −0,75 | 32–10 | 8 | 11 | 93 | 2 |
| 12 | Deceleration, clutch disengaged | | −0,92 | 10–0 | 3 | | 96 | $K_2$ (*) |
| 13 | Idling | 9 | | | 21 | 21 | 117 | 16 s PM + 5 s $K_1$ (*) |
| 14 | Acceleration | 10 | 0,83 | 0–15 | 5 | 26 | 122 | 1 |
| 15 | Gear change | | | | 2 | | 124 | |
| 16 | Acceleration | | 0,62 | 15–35 | 9 | | 133 | 2 |
| 17 | Gear change | | | | 2 | | 135 | |
| 18 | Acceleration | | 0,52 | 35–50 | 8 | | 143 | 3 |
| 19 | Steady speed | 11 | | 50 | 12 | 12 | 155 | 3 |
| 20 | Deceleration | 12 | −0,52 | 50–35 | 8 | 8 | 163 | 3 |
| 21 | Steady speed | 13 | | 35 | 13 | 13 | 176 | 3 |
| 22 | Gear change | 14 | | | 2 | 12 | 178 | |
| 23 | Deceleration | | −0,86 | 32–10 | 7 | | 185 | 2 |
| 24 | Deceleration, clutch disengaged | | −0,92 | 10–0 | 3 | | 188 | $K_2$ (*) |
| 25 | Idling | 15 | | | 7 | 7 | 195 | 7 s PM (*) |

(*) PM = gearbox in neutral, clutch engaged.
$K_1$, $K_2$ = first or second gear engaged, clutch disengaged.

2.4.3. The speed and time tolerances are combined as indicated in Appendix 1 to this Annex.

3. VEHICLE AND FUEL

3.1. **Test vehicle**

3.1.1. The vehicle must be presented in good mechanical condition. It must have been run-in and driven at least 3 000 km before the test.

3.1.2. The exhaust device must not exhibit any leak likely to reduce the quantity of gas collected, which quantity must be that emerging from the engine.

3.1.3. The tightness of the intake system may be checked to ensure that carburation is not affected by an accidental intake of air.

3.1.4. The settings of the engine and of the vehicle's controls must be those prescribed by the manufacturer. This requirement also applies, in particular, to the settings for idling (rotation speed and carbon monoxide content of the exhaust gases), for the cold start device and for the exhaust gas pollutant emission control system.

3.1.5. The vehicle to be tested, or an equivalent vehicle, must be fitted, if necessary, with a device to permit the measurement of the characteristic parameters necessary for chassis dynamometer setting, in conformity with 4.1.1.

3.1.6. The technical service may verify that the vehicle's performance conforms to that stated by the manufacturer, that it can be used for normal driving and, more particularly, that it is capable of starting when cold and when hot.

3.1.7. A vehicle equipped with a catalytic converter must be tested with the catalyst fitted, if the vehicle manufacturer states that the vehicle so equipped and supplied with fuel having a lead content of up to 0,4 grams per litre is capable of complying with the requirements of this Directive for the catalyst life as defined by the vehicle manufacturer.

3.2. **Fuel**

The appropriate reference fuel as defined in Annex VI must be used for testing.

4. TEST EQUIPMENT

4.1. **Chassis dynamometer**

4.1.1. The dynamometer must be capable of simulating road load within one of the following classifications:

— dynamometer with fixed load curve, i.e. a dynamometer whose physical characteristics provide a fixed load curve shape,

— dynamometer with adjustable load curve, i.e. a dynamometer with at least two road load parameters that can be adjusted to shape the load curve.

4.1.2. The setting of the dynamometer must not be affected by the lapse of time. It must not produce any vibrations perceptible to the vehicle and likely to impair the vehicle's normal operations.

4.1.3. It must be equipped with means to simulate inertia and load. These simulators are connected to the front roller in the case of a two-roller dynamometer.

4.1.4. *Accuracy*

4.1.4.1. It must be possible to measure and read the indicated load to an accuracy of ± 5 %.

4.1.4.2. In the case of a dynamometer with a fixed load curve the accuracy of the load setting at 50 km/h must be ± 5 %. In the case of a dynamometer with adjustable load curve, the accuracy of matching dynamometer load to road load must be 5 % at 30, 40, and 50 km/h and 10 % at 20 km/h. Below this, dynamometer absorption must be positive.

4.1.4.3. The total inertia of the rotating parts (including the simulated inertia where applicable) must be known and must be within ± 20 kg of the inertia class for the test.

4.1.4.4. The speed of the vehicle must be measured by the speed of rotation of the roller (the front roller in the case of a two roller dynamometer). It must be measured with an accuracy of ± 1 km/h at speeds above 10 km/h.

4.1.5. *Load and inertia setting*

4.1.5.1. Dynamometer with fixed load curve: the load simulator must be adjusted to absorb the power exerted on the driving wheels at a steady speed of 50 km/h. The means by which this load is determined and set are described in Appendix 3.

4.1.5.2. Dynamometer with adjustable load curve: the load simulator must be adjusted in order to absorb the power exerted on the driving wheels at steady speeds of 20, 30, 40 and 50 km/h. The means by which these loads are determined and set are described in Appendix 3.

4.1.5.3. Inertia

Dynamometers with electrical inertia simulation must be demonstrated to be equivalent to mechanical inertia systems. The means by which equivalence is established is described in Appendix 4.

4.2. **Exhaust gas-sampling system**

4.2.1. The exhaust gas-sampling system is designed to enable the measurements of the true mass emission of pollutants by the vehicle exhaust. The system to be used is the constant volume sampler (CVS) system. This requires that the vehicle exhaust be continuously diluted with ambient air under controlled conditions. In the constant volume sampler concept of measuring mass emissions, two conditions must be satisfied, the total volume of the mixture of exhaust and dilution air must be measured and a continuously proportional sample of the volume must be collected for analysis. Mass emissions are determined from the sample concentrations corrected for the pollutant content of the ambient air, and totalized flow over the test period.

4.2.2. The flow through the system must be sufficient to eliminate water condensation at all conditions which may occur during a test, as defined in Appendix 5.

4.2.3. Figure 1 gives a schematic diagram of the general concept. Appendix 5 gives examples of three types of constant volume sampler system which satisfy the requirements set out in this Annex.

4.2.4. The gas and air mixture must be homogeneous at point S2 of the sampling probe.

4.2.5. The probe must extract a true sample of the diluted exhaust gases.

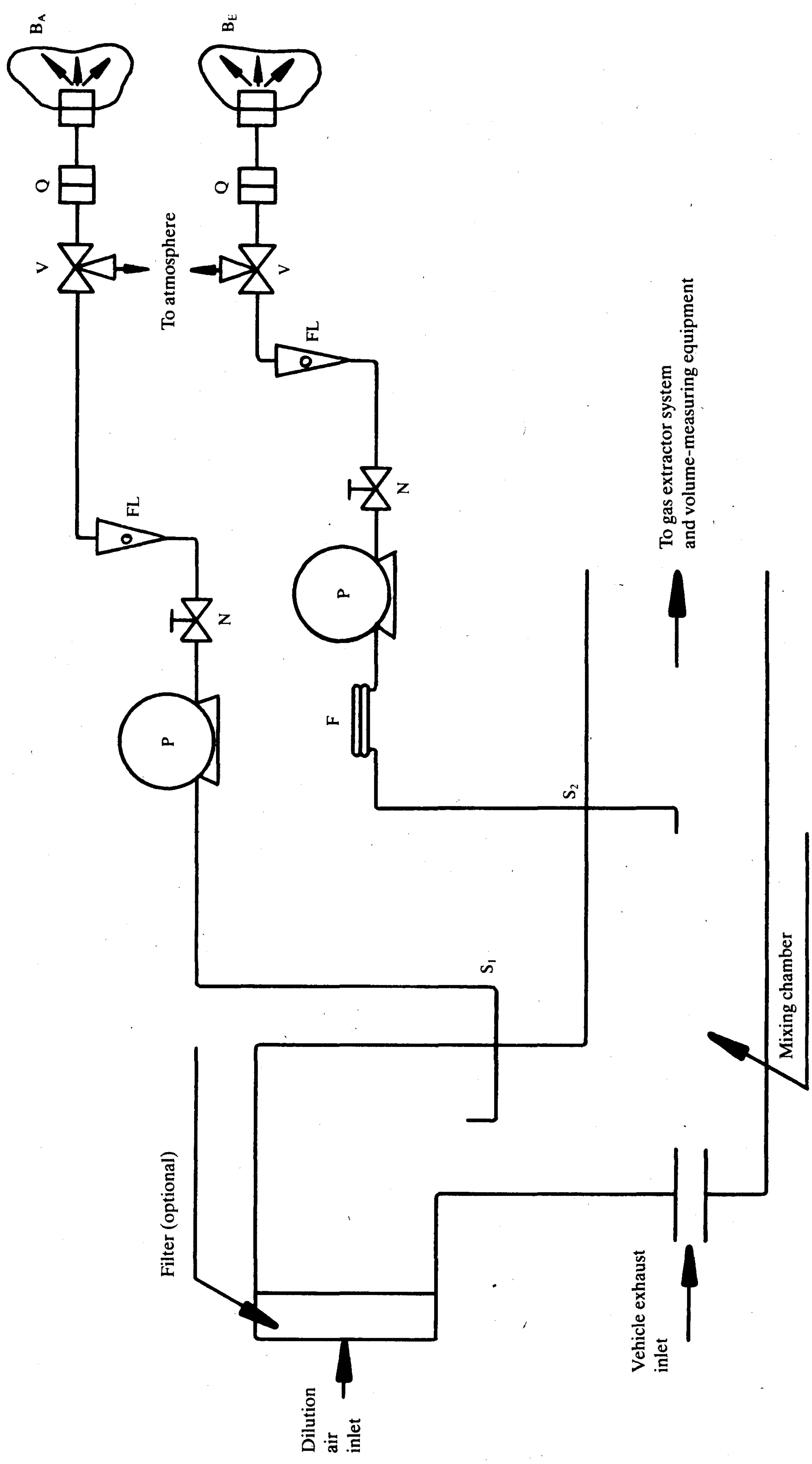
4.2.6. The system must be free of gas leaks. The design and materials must be such that the system does not influence the pollutant concentration in the diluted exhaust gas. Should any component (heat exchanger, blower, etc.) change the concentration of any pollutant gas in the diluted gas, the sampling for that pollutant must be carried out before that component if the problem cannot be corrected.

4.2.7. If the vehicle being tested is equipped with an exhaust pipe comprising several branches, the connecting tubes must be connected as near as possible to the vehicle.

4.2.8. Static pressure variations at the tailpipe(s) of the vehicle must remain within ± 1,25 kPa of the static pressure variations measured during the dynamometer driving cycle with no connection to the tailpipe(s). Sampling systems capable of maintaining the static pressure to within ± 0,25 kPa are used if a written request from a manufacturer to the competent authority issuing the approval substantiates the need for the narrower tolerance. The back-pressure must be measured in the exhaust pipe, as near as possible to its end or in an extension having the same diameter.

*Figure 1*

**Diagram of exhaust-gas sampling system**



4.2.9. The various valves used to direct the exhaust gases must be of a quick-adjustment, quick-acting type.

4.2.10. The gas samples are collected in sample bags of adequate capacity. These bags must be made of such materials as will not change the pollutant gas by more than ± 2 % after 20 minutes of storage.

4.3. **Analytical equipment**

4.3.1. *Requirements*

4.3.1.1. Pollutant gases must be analyzed with the following instruments:

Carbon monoxide (CO) and carbon dioxide ($CO_2$) analysis:

The carbon monoxide and carbon dioxide analyzers must be of the non-dispersive infra-red (NDIR) absorption type.

Hydrocarbons (HC) analysis — spark-ignition engines:

The hydrocarbons analyzer must be of the flame ionization (FID) type calibrated with propane gas expressed equivalent to carbon atoms ($C_1$).

Hydrocarbons (HC) analysis — compression-ignition engines:

The hydrocarbons analyzer must be of the flame ionization type with detector, valves, pipework, etc. heated to 190 ± 10 °C (HFID). It must be calibrated with propane gas expressed equivalent to carbon atoms ($C_1$).

Nitrogen oxide ($NO_x$) analysis:

The nitrogen oxide analyzer must be either of the chemiluminescent (CLA) or of the non-dispensive ultra-violet resonance absorption (NDUVR) type, both with an $NO_x$ — NO converter.

4.3.1.2. Accuracy

The analyzers must have a measuring range compatible with the accuracy required to measure the concentrations of the exhaust gas sample pollutants.

Measurement error must not exceed ± 3 %, disregarding the true value of the calibration gases.

For concentrations of less than 100 ppm the measurement error must not exceed ± 3 ppm. The ambient air sample must be measured on the same analyzer and range as the corresponding diluted exhaust sample.

4.3.1.3. Ice-trap

No gas drying device must be used before the analyzers unless shown to have no effect on the pollutant content of the gas stream.

4.3.2. *Particular requirements for compression-ignition engines*

A heated sample line for a continuous HC-analysis with the flame ionization detector (HFID), including recorder (R) must be used. The average concentration of the measured hydrocarbons must be determined by integration. Throughout the test, the temperature of the heated sample line must be controlled at 190 ± 10 °C. The heated sampling line must be fitted with a heated filter ($F_H$) 99 % efficient with particle ≥ 0,3 μm to extract any solid particles from the continuous flow of gas required for analysis. The sampling system response time (from the probe to the analyzer inlet) must be no more than four seconds.

The HFID must be used with a constant flow (heat exchanger) system to ensure a representative sample, unless compensation for varying CFV or CFO flows is made.

4.3.3. *Calibration*

Each analyzer must be calibrated as often as necessary and in any case in the month before type-approval testing and at least once every six months for verifying conformity of production. The calibration method to be used is described in Appendix 6 for the analyzers referred to in 4.3.1.

4.4. **Volume measurement**

4.4.1. The method of measuring total dilute exhaust volume incorporated in the constant volume sampler must be such that measurement is accurate to ± 2 %.

4.4.2. *Constant volume sampler calibration*

The constant volume sampler system volume measurement device must be calibrated by a method sufficient to ensure the prescribed accuracy and at a frequency sufficient to maintain such accuracy.

An example of a calibration procedure which will give the required accuracy is given in Appendix 6. The method utilizes a flow metering device which is dynamic and suitable for the high flow-rate encountered in constant volume sampler testing. The device must be of certified accuracy in conformity with an approved national or international standard.

4.5. **Gases**

4.5.1. *Pure gases*

The following pure gases must be available, if necessary, for calibration and operation:

— purified nitrogen (purity ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm $CO_2$, ≤ 0,1 ppm NO),

— purified synthetic air (purity ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm $CO_2$, ≤ 0,1 ppm NO); oxygen content between 18 and 21 % vol,

— purified oxygen (purity ≤ 99,5 % vol $O_2$),

— purified hydrogen (and mixture containing hydrogen) (purity ≤ 1 ppm C, ≤ 400 ppm $CO_2$).

4.5.2. *Calibration and span gases*

Gases having the following chemical compositions must be available: mixtures of:

— $C_3H_8$ and purified synthetic air (4.5.1),

— CO and purified nitrogen,

— $CO_2$ and purified nitrogen,

— NO and purified nitrogen.

(The amount of $NO_2$ contained in this calibration gas must not exceed 5 % of the NO content.)

The true concentration of a calibration gas must be within ± 2 % of the stated figure.

The concentrations specified in Appendix 6 may also be obtained by means of a gas divider, diluting with purified $N_2$ or with purified synthetic air. The accuracy of the mixing device must be such that the concentrations of the diluted calibration gases may be determined to within ± 2 %.

4.6. **Additional equipment**

4.6.1. *Temperatures*

The temperatures indicated in Appendix 8 are measured with an accuracy of ± 1,5 °C.

4.6.2. *Pressure*

The atmospheric pressure must be measurable to within ± 0,1 kPa.

4.6.3. *Absolute humidity*

The absolute humidity (H) must be measurable to within ± 5 %.

4.7. The exhaust gas-sampling system must be verified by the method described in 3 of Appendix 7. The maximum permissible deviation between the quantity of gas introduced and the quantity of gas measured is 5 %.

5. PREPARING THE TEST

5.1. **Adjustment of inertia simulators to the vehicle's translatory inertias**

An inertia simulator is used enabling a total inertia of the rotating masses to be obtained proportional to the reference mass within the following limits:

| Reference mass of vehicle RW (kg) | Equivalent inertias I (kg) |
|---|---|
| RW ≤ 750 | 680 |
| 750 < RW ≤ 850 | 800 |
| 850 < RW ≤ 1 020 | 910 |
| 1 020 < RW ≤ 1 250 | 1 130 |
| 1 250 < RW ≤ 1 470 | 1 360 |
| 1 470 < RW ≤ 1 700 | 1 590 |
| 1 700 < RW ≤ 1 930 | 1 810 |
| 1 930 < RW ≤ 2 150 | 2 040 |
| 2 150 < RW ≤ 2 380 | 2 270 |
| 2 380 < RW ≤ 2 610 | 2 270 |
| 2 610 < RW | 2 270 |

5.2. **Setting of dynamometer**

The load is adjusted according to methods described in 4.1.4.

The method used and the values obtained (equivalent inertia — characteristic adjustment parameter) must be recorded in the test report.

5.3. **Conditioning of vehicle**

5.3.1. Before the test, the vehicle must be kept in a room in which the temperature remains relatively constant between 20 and 30 °C. This conditioning must be carried out for at least six hours and continue until the engine oil temperature and coolant, if any, are within ± 2 °C of the temperature of the room.

If the manufacturer so requests, the test must be carried out not later than 30 hours after the vehicle has been run at its normal temperature.

5.3.2. The tyre pressures must be the same as that specified by the manufacturer and used for the preliminary road test for brake adjustment. The tyre pressures may be increased by up to 50 % from the manufacturer's recommended setting in the case of a two-roller dynamometer. The actual pressure used must be recorded in the test report.

6. PROCEDURE FOR BENCH TESTS

6.1. **Special conditions for carrying out the cycle**

6.1.1. During the test, the test cell temperature must be between 20 and 30 °C. The absolute humidity (H) of either the air in the test cell or the intake air of the engine must be such that:

$$5{,}5 \leq H \leq 12{,}2 \text{ g } H_2O/\text{kg dry air}$$

6.1.2. The vehicle must be approximately horizontal during the test so as to avoid any abnormal distribution of the fuel.

6.1.3. The test must be carried out with the bonnet raised unless this is technically impossible. An auxiliary ventilating device acting on the radiator (water-cooling) or on the air intake (air-cooling) may be used if necessary to keep the engine temperature normal.

6.1.4. During the test the speed is recorded against time so that the correctness of the cycles performed can be assessed.

6.2. **Starting-up the engine**

6.2.1. The engine must be started up by means of the devices provided for this purpose according to the manufacturer's instructions, as incorporated in the drivers' handbook of production vehicles.

6.2.2. The engine must be kept idling for a period of 40 seconds. The first cycle must begin at the end of the aforesaid period of 40 seconds at idle.

6.3. **Idling**

6.3.1. *Manual-shift or semi-automatic gearbox*

6.3.1.1. During periods of idling the clutch must be engaged and the gears in neutral.

6.3.1.2. To enable the accelerations to be performed according to the normal cycle the vehicle must be placed in first gear, with the clutch disengaged, five seconds before the acceleration following the idling period considered.

6.3.1.3. The first idling period at the beginning of the cycle consists of six seconds of idling in neutral with the clutch engaged and five seconds in first gear with the clutch disengaged.

6.3.1.4. For the idling periods during each cycle the corresponding times are 16 seconds in neutral and five seconds in first gear with the clutch disengaged.

6.3.1.5. The idling period between two successive cycles comprises 13 seconds in neutral with the clutch engaged.

6.3.2. *Automatic-shift gearbox*

After initial engagement the selector must not be operated at any time during the test except as in the case specified in 6.4.3.

6.4. **Accelerations**

6.4.1. Accelerations must be so performed that the rate of acceleration is as constant as possible throughout the phase.

6.4.2. If an acceleration cannot be carried out in the prescribed time, the extra time required is, if possible, deducted from the time allowed for changing gear, but otherwise from the subsequent steady-speed period.

6.4.3. *Automatic-shift gearboxes*

If an acceleration cannot be carried out in the prescribed time, the gear selector is operated in accordance with requirements for manual-shift gearboxes.

6.5. **Deceleration**

6.5.1. All decelerations are effected by removing the foot completely from the accelerator, the clutch remaining engaged. The clutch is disengaged, without use of the gear lever, at a speed of 10 km/h.

6.5.2. If the period of deceleration is longer than that prescribed for the corresponding phase, the vehicle's brakes are used to enable the timing of the cycle to be complied with.

6.5.3. If the period of deceleration is shorter than that prescribed for the corresponding phase, the timing of the theoretical cycle is restored by constant speed or idling period merging into the following operation.

6.5.4. At the end of the deceleration period (halt of the vehicle on the rollers) the gears are placed in neutral and the clutch engaged.

6.6. **Steady speeds**

6.6.1. 'Pumping' or the closing of the throttle must be avoided when passing from acceleration to the following steady speed.

6.6.2. Periods of constant speed are achieved by keeping the accelerator position fixed.

7. PROCEDURE FOR SAMPLING AND ANALYSIS

7.1. **Sampling**

Sampling begins at the beginning of the test cycle as defined in 6.2.2 and ends at the end of the idling period after the fourth cycle.

7.2. **Analysis**

7.2.1. The exhaust gases contained in the bag must be analyzed as soon as possible and in any event not later than 20 minutes after the end of the test cycle.

7.2.2. Prior to each sample analysis the analyzer range to be used for each pollutant must be set to zero with the appropriate zero gas.

7.2.3. The analyzers are then set to the calibration curves by means of span gases of nominal concentrations of 70 to 100 % of the range.

7.2.4. The analyzers' zeros are then rechecked. If the reading differs by more than 2 % of range from that set in 7.2.2, the procedure is repeated.

7.2.5. The samples are then analyzed.

7.2.6. After the analysis, zero and span points are rechecked using the same gases. If these rechecks are within 2 % of those in 7.2.3, the analysis is considered acceptable.

7.2.7. At all points in this section the flow-rates and pressures of the various gases must be the same as those used during calibration of the analyzers.

7.2.8. The figure adopted for the content of the gases in each of the pollutants measured is that read off after stabilization on the measuring device. Hydrocarbon mass emissions of compression-ignition engines are calculated from the integrated HFID reading, corrected for varying flow if necessary as shown in Appendix 5.

8. DETERMINATION OF THE QUANTITY OF GASEOUS POLLUTANTS EMITTED

8.1. **The volume considered**

The volume to be considered must be corrected to conform to the conditions of 101,33 kPa and 273,2 K.

8.2. **Total mass of gaseous pollutants emitted**

The mass M of each pollutant emitted by the vehicle during the test is determined by obtaining the product of the voluminal concentration and the volume of the gas in question, with due regard for the following densities at the abovementioned reference condition:

— in the case of carbon monoxide (CO) d = 1,25 grams per litre,

— in the case of hydrocarbons ($CH_{1,85}$) d = 0,619 grams per litre,

— in the case of nitrogen oxides ($NO_2$) d = 2,05 grams per litre.

Appendix 8 gives calculations relative to the various methods, followed by examples, to determine the quantity of gaseous pollutants emitted.

*APPENDIX 1*

## BREAKDOWN OF THE OPERATING CYCLE USED FOR THE TYPE I TEST

1. **Breakdown by phases**

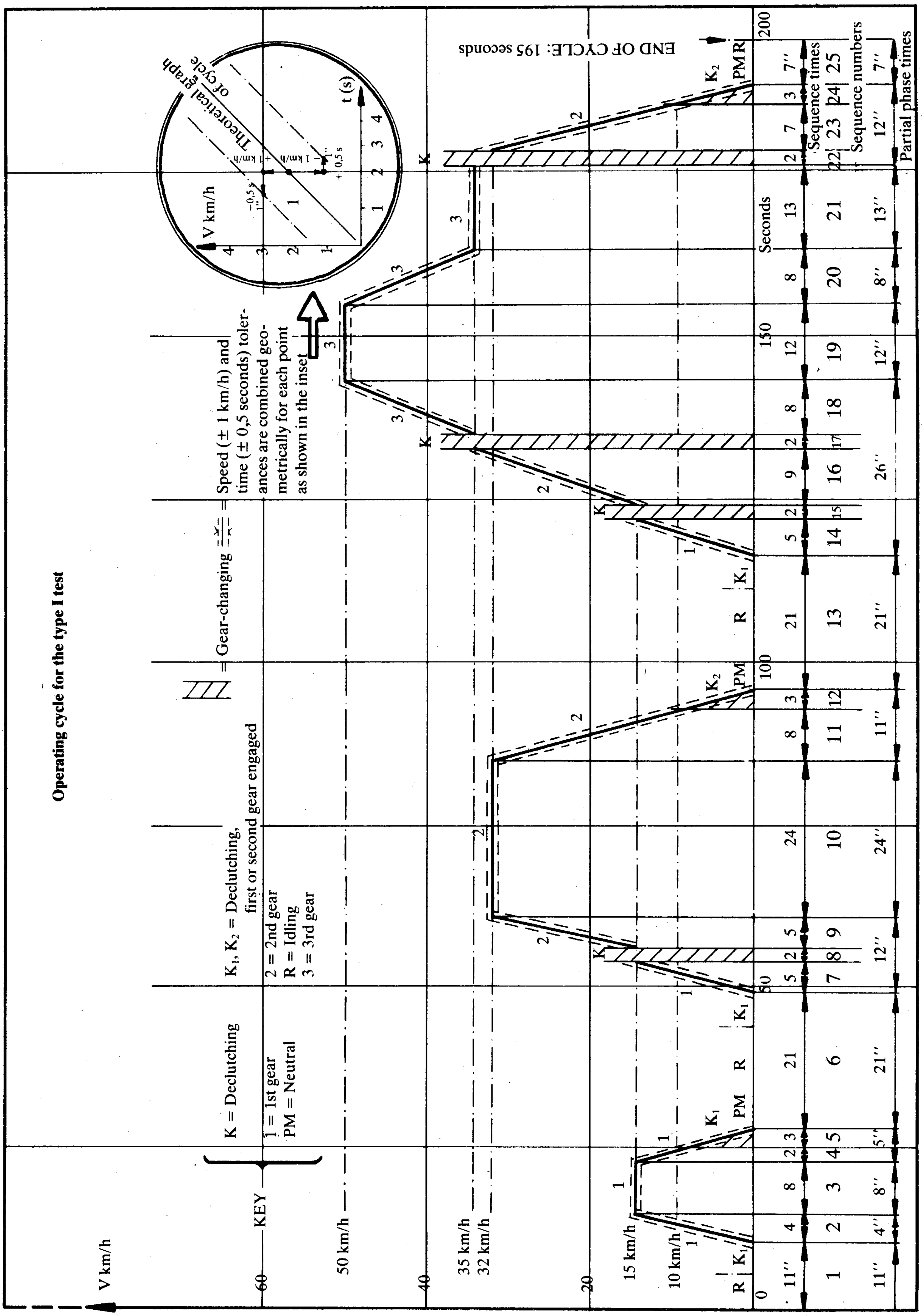
| | Time | % | |
|---|---|---|---|
| Idling: | 60 s | 30,8 | 35,4 |
| Idling, vehicle moving, clutch engaged on one combination: | 9 s | 4,6 | |
| Gear-shift: | 8 s | | 4,1 |
| Accelerations: | 36 s | | 18,5 |
| Steady-speed periods: | 57 s | | 29,2 |
| Decelerations: | 25 s | | 12,8 |
| | 195 s | | 100 |

2. **Breakdown by use of gears**

| | Time | % | |
|---|---|---|---|
| Idling: | 60 s | 30,8 | 35,4 |
| Idling, vehicle moving, clutch engaged on one combination: | 9 s | 4,6 | |
| Gear-shift: | 8 s | | 4,1 |
| First gear: | 24 s | | 12,3 |
| Second gear | 53 s | | 27,2 |
| Third gear: | 41 s | | 21 |
| | 195 s | | 100 |

Average speed during test: 19 km/h.
Effective running time: 195 s.
Theoretical distance covered per cycle: 1,013 km.
Equivalent distance for the test (4 cycles): 4,052 km

**Operating cycle for the type I test**



*APPENDIX 2*

**CHASSIS DYNAMOMETER**

1. DEFINITION OF A CHASSIS DYNAMOMETER WITH FIXED LOAD CURVE

1.1. **Introduction**

In the event that the total resistance to progress on the road cannot be reproduced on the chassis dynamometer between speeds of 10 and 50 km/h, it is recommended to use a chassis dynamometer having the characteristics defined below.

1.2. **Definition**

1.2.1. The chassis dynamometer may have one or two rollers.

The front roller drives, directly or indirectly, the inertia masses and the power absorption device.

1.2.2. Having set the load at 50 km/h by one of the methods described in 3, K can be determined from $P = KV^3$.

The power absorbed ($P_a$) by the brake and the chassis internal frictional effects from the reference setting to a vehicle speed of 50 km/h, are as follows:

If $V > 12$ km/h:

$$P_a = KV^3 \pm 5\,\%\,KV^3 \pm 5\,\%\,PV_{50}$$

(without being negative).

If $V \leq 12$ km/h:

$P_a$ will be between 0 and $P_a = KV_{12}^3 + 5\,\%\,KV_{12}^3 + 5\,\%\,PV_{50}$ where K is a characteristic of the chassis dynamometer and $PV_{50}$ is the power absorbed at 50 km/h.

2. METHOD OF CALIBRATING THE DYNAMOMETER

2.1. **Introduction**

This Appendix describes the method to be used to determine the power absorbed by a dynamometric brake.

The power absorbed comprises the power absorbed by frictional effects and the power absorbed by the power-absorption device. The dynamometer is brought into operation beyond the range of test speeds. The device used for starting up the dynamometer is then disconnected: the rotational speed of the driven roller decreases.

The kinetic energy of rollers is dissipated by the power-absorption unit and by the frictional effects. This method disregards variations in the roller's internal frictional effects caused by rollers with or without the vehicle. The frictional effects of the rear roller shall be disregarded when this is free.

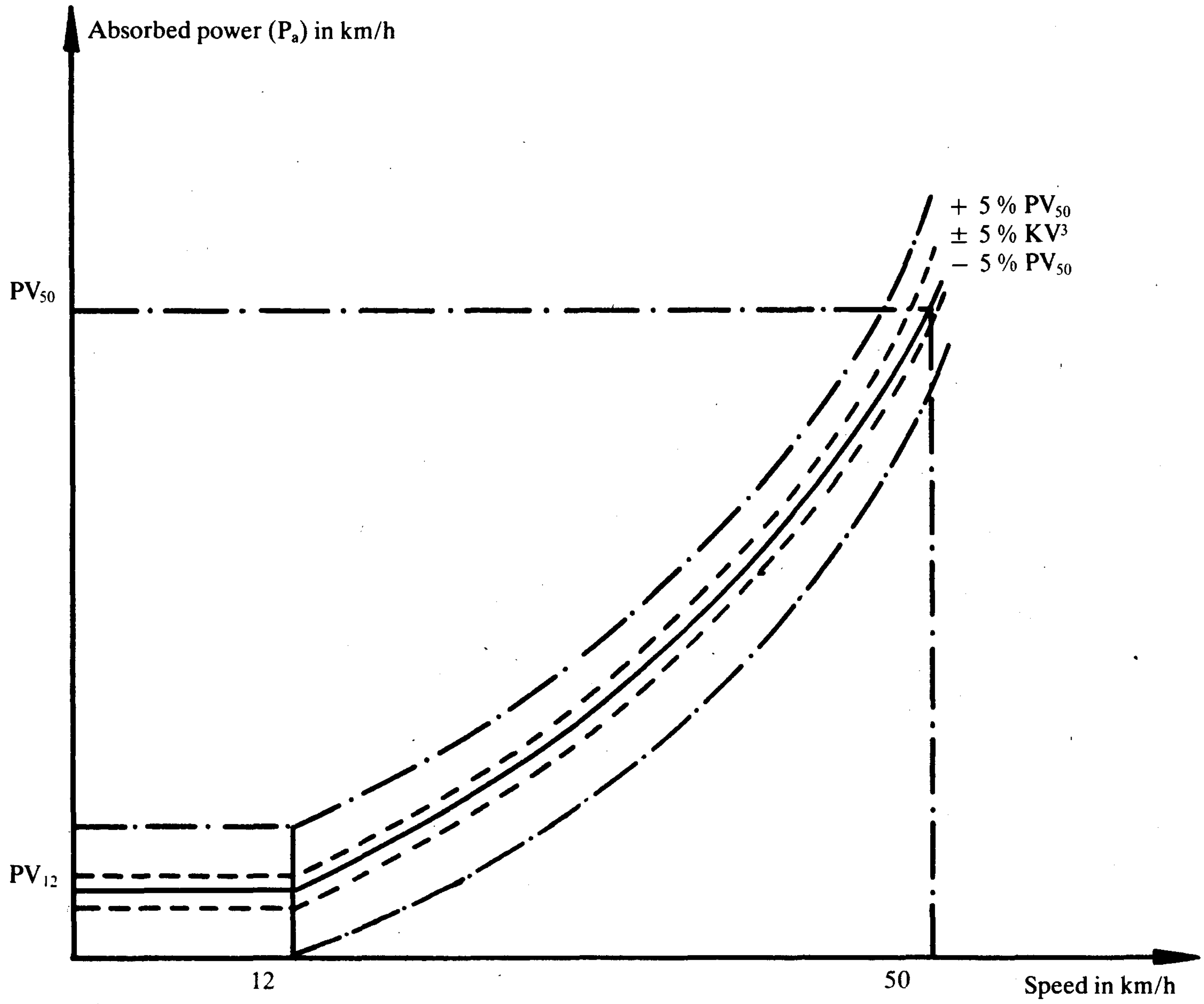
2.2. **Calibrating the power indicator to 50 km/h as a function of the power absorbed**

The following procedure is used.

2.2.1. Measure the rotational speed of the roller if this has not already been done. A fifth wheel, a revolution counter or some other method may be used.

2.2.2. Place the vehicle on the dynamometer or devise some other method of starting up the dynamometer.

2.2.3. Use the fly-wheel or any other system of inertia simulation for the particular inertia class to be used.




2.2.4. Bring the dynamometer to a speed of 50 km/h.

2.2.5. Note the power indicated (Pi).

2.2.6. Bring the dynamometer to a speed of 60 km/h.

2.2.7. Disconnect the device used to start up the dynamometer.

2.2.8. Note the time taken by the dynamometer to pass from a speed of 55 km/h to a speed of 45 km/h.

2.2.9. Set the power-absorption device at a different level.

2.2.10. The requirements of 2.2.4 to 2.2.9 must be repeated sufficiently often to cover the range of road powers used.

2.2.11. Calculate the power absorbed, using the formula:

$$P_a = \frac{M_I (V_1^2 - V_2^2)}{2\,000\,t}$$

where

$P_a$ = power absorbed in kW,

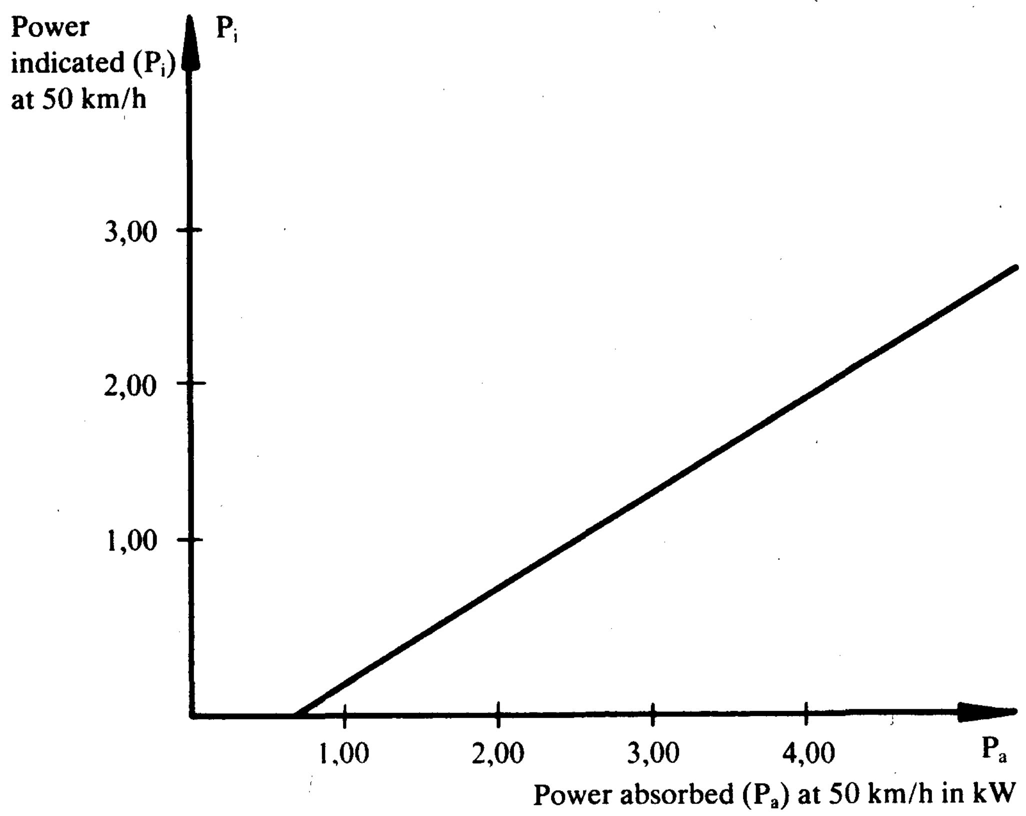
$M_J$ = equivalent inertia in kg (exluding the inertial effects of the free rear roller),

$V_1$ = initial speed in m/s (55 km/h = 15,28 m/s),

$V_2$ = final speed in m/s (45 km/h = 12,50 m/s),

t = time taken by the roller to pass from 55 to 45 km/h.

2.2.12. Diagram showing power indicated at 50 km/h in terms of power absorbed at 50 km/h.




2.2.13. The operations described in 2.2.3 to 2.2.12 must be repeated for all inertia classes to be used.

2.3. **Calibration of the power indicator as a function of the absorbed power for other speeds**

The procedures described in 2.2 must be repeated as often as necessary for the chosen speeds.

2.4. **Verification of the power-absorption curve of the dynamometer from a reference setting at a speed of 50 km/h**

2.4.1. Place the vehicle on the dynamometer or devise some other method of starting up the dynamometer.

2.4.2. Adjust the dynamometer to the absorbed power ($P_a$) at 50 km/h.

2.4.3. Note the power absorbed at 40 — 30 — 20 km/h.

2.4.4. Draw the curve $P_a(V)$ and verify that it corresponds to the requirements of 1.2.2.

2.4.5. Repeat the procedure set out in 2.4.1 to 2.4.4 for other values of power $P_a$ at 50 km/h and for other values of inertias.

2.5. The same procedure must be used for force or torque calibration.

3. SETTING OF THE DYNAMOMETER

3.1. **Vacuum method**

3.1.1. *Introduction*

This method is not a preferred method and must be used only with fixed load curve shape dynamometers for determination of load setting at 50 km/h and cannot be used for vehicles with compression-ignition engines.

3.1.2. *Test instrumentation*

The vacuum (or absolute pressure) in the intake manifold vehicle is measured to an accuracy of ± 0,25 kPa. It must be possible to record this reading continuously or at intervals of no more than one second. The speed must be recorded continuously with a precision of ± 0,4 km/h.

3.1.3. *Road test*

3.1.3.1. Ensure that the requirements of 4 of Appendix 3 are met.

3.1.3.2. Drive the vehicle at a steady speed of 50 km/h recording speed and vacuum (or absolute pressure) in accordance with the requirements of 3.1.2.

3.1.3.3. Repeat procedure set out in 3.1.3.2 three times in each direction. All six runs must be completed within four hours.

3.1.4. *Data reduction and acceptance criteria*

3.1.4.1. Review results obtained in accordance with 3.1.3.2 and 3.1.3.3 (speed must not be lower than 49,5 km/h or greater than 50,5 km/h for more than one second). For each run, read vacuum level at one-second intervals, calculate mean vacuum ($\bar{v}$) and standard deviation (s). This calculation must consist of no less than 10 readings of vacuum.

3.1.4.2. The standard deviation must not exceed 10 % of mean ($\bar{v}$) for each run.

3.1.4.3. Calculate the mean value ($\bar{v}$) for the six runs (three runs in each direction).

3.1.5. *Dynamometer setting*

3.1.5.1. Preparation

Perform the operations specified in 5.1.2.2.1 to 5.1.2.2.4 of Appendix 3.

3.1.5.2. Setting

After warm-up, drive the vehicle at a steady speed of 50 km/h and adjust dynamometer load to reproduce the vacuum reading ($\bar{v}$) obtained in accordance with 3.1.4.3. Deviation from this reading must be no greater than 0,25 kPa. The same instruments are used for this exercise as were used during the road test.

3.2. **Other setting methods**

The dynamometer setting may be carried out at a constant speed of 50 km/h in accordance with the requirements of Appendix 3.

3.3. **Alternative method**

With the manufacturer's agreement the following method may be used:

3.3.1. The brake is adjusted so as to absorb the power exerted at the driving wheels at a constant speed of 50 km/h in accordance with the following table:

| Reference mass of vehicle: RW (kg) | Power absorbed by the dynamometer: $P_a$ (kW) |
|---|---|
| RW ≤ 750 | 1,3 |
| 750 < RW ≤ 850 | 1,4 |
| 850 < RW ≤ 1 020 | 1,5 |
| 1 020 < RW ≤ 1 250 | 1,7 |
| 1 250 < RW ≤ 1 470 | 1,8 |
| 1 470 < RW ≤ 1 700 | 2,0 |
| 1 700 < RW ≤ 1 930 | 2,1 |
| 1 930 < RW ≤ 2 150 | 2,3 |
| 2 150 < RW ≤ 2 380 | 2,4 |
| 2 380 < RW ≤ 2 610 | 2,6 |
| 2 610 < RW | 2,7 |

3.3.2. In the case of vehicles, other than passenger cars, with a reference mass of more than 1 700 kg, or vehicles whose wheels are all driven, the power values given in the table set out in 3.3.1 are multiplied by the factor 1,3.

*APPENDIX 3*

## RESISTANCE TO PROGRESS OF A VEHICLE — MEASUREMENT METHOD ON THE ROAD — SIMULATION ON A CHASSIS DYNAMOMETER

1. OBJECT OF THE METHODS

The object of the methods defined below is to measure the resistance to progress of a vehicle at stabilized speeds on the road and to simulate this resistance on a dynamometer, in accordance with 4.1.4.1 of Annex III.

2. DEFINITION OF THE ROAD

The road must be level and sufficiently long to enable the measurements specified below to be made. The slope must be constant to within ± 0,1 % and must not exceed 1,5 %.

3. ATMOSPHERIC CONDITIONS

3.1. **Wind**

Testing must be limited to wind speeds averaging less than 3 m/s with peak speeds less than 5 m/s. In addition, the vector component of the wind speed across the test road must be less than 2 m/s. Wind velocity must be measured 0,7 m above the road surface.

3.2. **Humidity**

The road must be dry.

3.3. **Pressure — Temperature**

Air density at the time of the test must not deviate by more than ± 7,5 % from the reference conditions, p = 100 kPa and T = 293,2 K.

4. VEHICLE PREPARATION

4.1. **Running in**

The vehicle must be in normal running order and adjustment after having been run-in for at least 3 000 km. The tyres must be run in at the same time as the vehicle or have a tread depth within 90 and 50 % of the initial tread depth.

4.2. **Verifications**

The following checks must be made in accordance with the manufacturer's specifications for the use considered:

— wheels, wheel trims, tyres (make, type, pressure),

— front axle geometry,

— brake adjustment (elimination of parasitic drag),

— lubrication of front and rear axles,

— adjustment of the suspension and vehicle level, etc.

4.3. **Preparation for the test**

4.3.1. The vehicle is loaded to its reference mass. The level of the vehicle must be that obtained when the centre of gravity of the load is situated midway between the 'R' points of the front outer seats and on a straight line passing through those points.

4.3.2. In the case of road tests, the windows of the vehicle must be closed. Any covers of air climatization systems, headlamps, etc., must be in the non-operating position.

4.3.3. The vehicle must be clean.

4.3.4. Immediately prior to the test the vehicle is brought to normal running temperature in an appropriate manner.

5. METHODS

5.1. **Method of energy variation during coast-down**

5.1.1. *On the road*

5.1.1.1. Test equipment and error

— Time must be measured to an error lower than 0,1 s.

— Speed must be measured to an error lower than 2 %.

5.1.1.2. Test procedure

5.1.1.2.1. Accelerate the vehicle to a speed 10 km/h greater than the chosen test speed V.

5.1.1.2.2. Place the gearbox in 'neutral' position

5.1.1.2.3. Measure the time taken for the vehicle to decelerate from

$$V_2 = V + \Delta V \text{ km/h to } V_1 = V - \Delta V \text{ km/h} : t_1 \cdot \Delta V \leq 5 \text{ km/h}$$

5.1.1.2.4. Perform the same test in the opposite direction: $t_2$.

5.1.1.2.5. Take the average $T_1$ of the two times $t_1$ and $t_2$.

5.1.1.2.6. Repeat these tests several times such that the statistical accuracy (p) of the average

$$T = \frac{1}{n} \cdot \sum_{i=1}^{n} Ti \text{ is no more than } 2\,\% \ (p \leq 2\,\%)$$

The statistical accuracy (p) is defined by:

$$p = \frac{ts}{\sqrt{n}} \cdot \frac{100}{T}$$

where:

t = coefficient given by the table below,

s = standard deviation,

n = number of tests.

$$s = \sqrt{\sum_{i=1}^{n} \frac{(Ti - T)^2}{n - 1}}$$

| n | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| t | 3,2 | 2,8 | 2,6 | 2,5 | 2,4 | 2,3 | 2,3 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 |
| $\frac{t}{\sqrt{n}}$ | 1,6 | 1,25 | 1,06 | 0,94 | 0,85 | 0,77 | 0,73 | 0,66 | 0,64 | 0,61 | 0,59 | 0,57 |

5.1.1.2.7. Calculate the power by the formula:

$$P = \frac{M \cdot V \cdot \Delta V}{500\ T}$$

where:

P is expressed in kW,

V = speed of the test in m/s,

Δ V = speed deviation from speed V, in m/s,

M = reference mass in kg,

T = time in seconds.

5.1.2. *On the dynamometer*

5.1.2.1. Measurement equipment and accuracy

The equipment must be identical to that used on the road.

5.1.2.2. Test procedure

5.1.2.2.1. Install the vehicle on the test dynamometer.

5.1.2.2.2. Adjust the tyre pressure (cold) of the driving wheels as required by the dynamometer.

5.1.2.2.3. Adjust the equivalent inertia of the dynamometer.

5.1.2.2.4. Bring the vehicle and dynamometer to operating temperature in a suitable manner.

5.1.2.2.5. Carry out the operations specified in 5.1.1.2 with the exception of 5.1.1.2.4 and 5.1.1.2.5 and with replacing M by I in the formula set out in 5.1.1.2.7.

5.1.2.2.6. Adjust the brake to meet the requirements of 4.1.4.1. of Annex III.

5.2. **Torque measurement method at constant speed**

5.2.1. *On the road*

5.2.1.1. Measurement equipment and error

Torque measurement must be carried out with an appropriate measuring device accurate to within 2 %.

Speed measurement must be accurate to within 2 %.

5.2.1.2. Test procedure

5.2.1.2.1. Bring the vehicle to the chosen stabilized speed V.

5.2.1.2.2. Record the torque C(t) and speed over a period of a least 10 s by means of class 1 000 instrumentation meeting ISO standard No 970.

5.2.1.2.3. Differences in torque C(t) and speed relative to time must not exceed 5 % for each second of the measurement period.

5.2.1.2.4. The torque $C_{t_1}$ is the average torque derived from the following formula:

$$C_{t_1} = \frac{1}{\Delta t} \int_{t}^{t + \Delta t} C(t)dt$$

5.2.1.2.5. Carry out the test in the opposite direction, i.e. $C_{t_2}$.

5.2.1.2.6. Determine the average of these two torques $C_{t_1}$ and $C_{t_2}$ i.e. $C_t$.

5.2.2. *On the dynamometer*

5.2.2.1. Measurement equipment and error

The equipment must be identical to that used on the road.

5.2.2.2. Test procedure

5.2.2.2.1. Perform the operations specified in 5.1.2.2.1 to 5.1.2.2.4.

5.2.2.2.2. Perform the operations specified in 5.2.1.2.1 to 5.2.1.2.4.

5.2.2.2.3. Adjust the brake setting to meet the requirements of 4.1.4.1 of Annex III.

5.3. **Integrated torque over variable driving pattern**

5.3.1. This method is a non-obligatory complement to the constant speed method described in 5.2.

5.3.2. In this dynamic procedure the mean torque value $\overline{M}$ is determined. This is accomplished by integrating the actual torque values with respect to time during operation of the test vehicle with a defined driving cycle. The integrated torque is then divided by the time difference.

The result is:

$$\overline{M} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} M(t) \cdot dt \text{ (with } M(t) > 0)$$

$\overline{M}$ is calculated from six sets of results.

It is recommended that the sampling rate of $\overline{M}$ be not less than two samples per second.

5.3.3. *Dynamometer setting*

The dynamometer load is set by the method described in 5.2. If $\overline{M}$ dynamometer does not then match $\overline{M}$ road, the brake setting is adjusted until the values are equal within ± 5 %.

*Note:*

This method can be used only for dynamometers with electrical inertia simulation or fine adjustment.

5.3.4. *Acceptance criteria*

Standard deviation of six measurements must be no more than 2 % of the mean value.

5.4. **Method of deceleration measurement by gyroscopic platform**

5.4.1. *On the road*

5.4.1.1. Measurement equipment and error

— Speed must be measured with an error lower than 2 %.

— Deceleration must be measured with an error lower than 1 %.

— The slope of the road must be measured with an error lower than 1 %.

— Time must be measured with an error lower than 0,1 s.

The level of the vehicle is measured on a reference horizontal ground; as an alternative, it is possible to correct for the slope of the road ($\alpha_1$).

5.4.1.2. Test procedure

5.4.1.2.1. Accelerate the vehicle to a speed 5 km/h greater than the chosen test speed: V.

5.4.1.2.2. Record the deceleration between V + 0,5 km/h and V − 0,5 km/h.

5.4.1.2.3. Calculate the average deceleration attributed to the speed V by the formula:

$$\bar{\gamma}_1 = \frac{1}{t} \int_{o}^{t} \gamma_1 (t)\, dt - g \cdot \sin \alpha_1$$

where:

$\bar{\gamma}_1$ = average deceleration value at the speed V in one direction of the road,

t = time between V + 0,5 km/h and V − 0,5 km/h,

$\gamma_1$ (t) = deceleration recorded with the time,

g = 9,81 m $s^{-2}$.

5.4.1.2.4. Perform the same test in the other direction: $\bar{\gamma}_2$.

5.4.1.2.5. Calculate the average of $\Gamma i = \frac{\bar{\gamma}_1 + \bar{\gamma}_2}{2}$ for test i.

5.4.1.2.6. Perform a sufficient number of tests as specified in 5.1.1.2.6 replacing T by Γ where:

$$\Gamma = \frac{1}{n} \sum_{1 = i}^{n} \Gamma_i$$

5.4.1.2.7. Calculate the average force absorbed F = M · Γ

where:

M = vehicle reference mass in kg,

Γ = average deceleration calculated beforehand.

5.4.2. *Dynamometer method*

5.4.2.1. Measurement equipment and error

The measurement instrumentation of the dynamometer itself must be used as defined in 2 of Appendix 2 to this Annex.

5.4.2.2. Test procedure

5.4.2.2.1. Adjustment of the force on the rim under steady speed

On chassis dynamometer, the total resistance is of the type:

$(F_{total}) = (F_{indicated}) + (F_{driving\ axle\ rolling})$, with

$(F_{total}) = (F_{road})$,

$(F_{indicated}) = (F_{road}) - (F_{driving\ axle\ rolling})$,

where:

$(F_{indicated})$ is the force indicated on the force indicating device of the chassis dynamometer,

$(F_{road})$ is known,

$(F_{driving\ axle\ rolling})$ can be:

— measured on chassis dynamometer able to work as a motor.

  The test vehicle, gearbox in neutral position, is driven by the chassis dynamometer at the test speed; the rolling resistance of the driving axle is then measured on the force indicating device of the chassis dynamometer;

— determined on chassis dynamometer unable to work as a motor.

  For the two-roller chassis dynamometer, the $R_R$ value is the one which is determined before on the road.

  For the single-roller chassis dynamometer, the $R_R$ value is the one which is determined on the road multiplied by a coefficient (R) which is equal to the ratio between the driving axle mass and the vehicle total mass.

*Note*

$R_R$ is obtained from the curve: $F = f(V)$.

*APPENDIX 4*

## VERIFICATION OF INERTIAS OTHER THAN MECHANICAL

1. OBJECT

The method described in this Appendix makes it possible to check that the simulated total inertia of the dynamometer is carried out satisfactorily in the running phases of the operating cycle.

2. PRINCIPLE

2.1. **Drawing up working equations**

Since the dynamometer is subjected to variations in the rotating speed of the roller(s), the force at the surface of the roller(s) can be expressed by the formula:

$$F = I \cdot \gamma = I_M \cdot \gamma + F_I$$

where:

F = force at the surface of the roller(s),

I = total inertia of the dynamometer (equivalent inertia of the vehicle: cf. table in 5.1),

$I_M$ = inertia of the mechanical masses of the dynamometer,

$\gamma$ = tangential acceleration at roller surface,

$F_I$ = inertia force.

*Note:*

An explanation of this formula with reference to dynamometers with mechanically simulated inertias is appended.

Thus, the total inertia is expressed as follows:

$$I = I_M + \frac{F_I}{\gamma}$$

where:

$I_M$ can be calculated or measured by traditional methods,

$F_I$ can be measured on the dynamometer,

$\gamma$ can be calculated from the peripheral speed of the rollers.

The total inertia (I) is determined during an acceleration or deceleration test with values higher than or equal to those obtained on an operating cycle.

2.2. **Specification for the calculation of total inertia**

The test and calculation methods must make it possible to determine the total inertia I with a relative error ($\Delta I/I$) of less than 2 %.

3. SPECIFICATION

3.1. The mass of the simulated total inertia I must remain the same as the theoretical value of the equivalent inertia (see 5.1 of Annex III) within the following limits:

3.1.1. ± 5 % of the theoretical value for each instantaneous value;

3.1.2. ± 2 % of the theoretical value for the average value calculated for each sequence of the cycle.

3.2. The limit given in 3.1.1 is brought to ± 50 % for one second when starting and, for vehicles with manual transmission, for two seconds during gear changes.

4. VERIFICATION PROCEDURE

4.1. Verification is carried out during each test throughout the cycle defined in 2.1 of Annex III.

4.2. However, if the requirements of 3 are met, with instantaneous accelerations which are at least three times greater or smaller than the values obtained in the sequences of the theoretical cycle, the verification described above is not necessary.

5. TECHNICAL NOTE

Explanation of drawing-up working equations.

5.1. Equilibrium of the forces on the road:

$$CR = k_1 \, Jr_1 \frac{d\Theta 1}{dt} + k_2 \, Jr_2 \frac{d\Theta 2}{dt} + k_3 \, M \, \gamma r_1 + k_3 \, F_s \, r_1$$

5.2. Equilibrium of the forces on dynamometer with mechanically simulated inertias:

$$Cm = k_1 \, Jr_1 \frac{d\Theta 1}{dt} + k_3 \frac{JRm \frac{dWm}{dt}}{Rm} r_1 + k_3 \, F_s \, r_1$$

$$= k_1 \, Jr_1 \frac{d\Theta 1}{dt} + k_3 \, I \, \gamma r_1 + k_3 \, F_s \, r_1$$

5.3. Equilibrium of the forces of dynamometer with non-mechanically simulated inertias:

$$Ce = k_1 \, Jr_1 \frac{d\Theta 1}{dt} + k_3 \left( \frac{JRe \frac{dWe}{dt}}{Re} r_1 + \frac{C_1}{Re} r_1 \right) + k_3 \, F_s \, r_1$$

$$= k_1 \, Jr_1 \frac{d\Theta 1}{dt} + k_3 \, (I_M \, \gamma + F_1) \, r_1 + k_3 \, F_s \, r_1$$

In these formulae:

CR = engine torque on the road,

Cm = engine torque on the dynamometer with mechanically simulated inertias,

Ce = engine torque on the dynamometer with electrically simulated inertias,

$Jr_1$ = moment of inertia of the vehicle transmission brought back to the driving wheels,

$Jr_2$ = moment of inertia of the non-driving wheels,

JRm = moment of inertia of the dynamometer with mechanically simulated inertias,

JRe = moment of mechanical inertia of the dynamometer with electrically simulated inertias,

M = mass of the vehicle on the road,

I = equivalent inertia of the dynamometer with mechanically simulated inertias,

$I_M$ = mechanical inertia of the dynamometer with electrically simulated inertias,

$F_s$ = resultant force at stabilized speed,

$C_1$ = resultant torque from electrically simulated inertias,

$F_1$ = resultant force from electrically simulated inertias,

$\frac{d\Theta 1}{dt}$ = angular acceleration of the driving wheels,

$\frac{d\Theta 2}{dt}$ = angular acceleration of the non-driving wheels,

$\frac{dWm}{dt}$ = angular acceleration of the mechanical dynamometer,

$\frac{dWe}{dt}$ = angular acceleration of the electrical dynamometer,

$\gamma$ = linear acceleration,

$r_1$ = radius under load of the driving wheels,

$r_2$ = radius under load of the non-driving wheels,

Rm = radius of the rollers of the mechanical dynamometer,

Re = radius of the rollers of the electrical dynamometer,

$k_1$ = coefficient dependent on the gear reduction ratio and the various inertias of transmission and 'efficiency',

$k_2$ = ratio transmission X $\frac{r_1}{r_2}$ X 'efficiency',

$k_3$ = ratio transmission X 'efficiency'.

Supposing the two types of dynamometer (5.2 and 5.3) are made equal and simplified, one obtains:

$$k_3 (I_M \cdot \gamma + F_1) r_1 = k_3 I \cdot \gamma \cdot r_1$$

hence,

$$I = I_M + \frac{F_1}{\gamma}$$

*APPENDIX 5*

**DEFINITION OF GAS-SAMPLING SYSTEMS**

1. INTRODUCTION

1.1. There are several types of sampling devices capable of meeting the requirements set out in 4.2 of Annex III.

The devices described in 3.1, 3.2 and 3.3 will be deemed acceptable if they satisfy the main criteria relating to the variable dilution principle.

1.2. In its communications, the laboratory must mention the system of sampling used when performing the test.

2. CRITERIA RELATING TO THE VARIABLE-DILUTION SYSTEM FOR MEASURING EXHAUST-GAS EMISSIONS

2.1. **Scope**

This section specifies the operating characteristics of an exhaust-gas sampling system intended to be used for measuring the true mass emissions of a vehicle exhaust in accordance with the provisions of this Directive. The principle of variable-dilution sampling for measuring mass emissions requires three conditions to be satisfied:

2.1.1. the vehicle exhaust gases must be continuously diluted with ambient air under specified conditions;

2.1.2. the total volume of the mixture of exhaust gases and dilution air must be measured accurately;

2.1.3. a continuously proportional sample of the diluted exhaust gases and the dilution air must be collected for analysis.

Mass emissions are determined from the proportional sample concentrations and the total volume measured during the test. The sample concentrations are corrected to take account of the pollutant content of the ambient air.

2.2. **Technical summary**

Figure 1 gives a schematic diagram of the sampling system.

2.2.1. The vehicle exhaust gases must be diluted with a sufficient amount of ambient air to prevent any water condensation in the sampling and measuring system.

2.2.2. The exhaust-gas sampling system must make it possible to measure the average volume concentrations of the $CO_2$, CO, HC and $NO_x$ contained in the exhaust gases emitted during the vehicle testing cycle.

2.2.3. The mixture of air and exhaust gases must be homogeneous at the point where the sampling probe is located (see 2.3.1.2).

2.2.4. The probe must extract a representative sample of the diluted exhaust gases.

2.2.5. The system must make it possible to measure the total volume of the diluted exhaust gases from the vehicle being tested.

2.2.6. The sampling system must be gas-tight. The design of the variable-dilution sampling system and the materials that go to make it up must be such that they do not affect the pollutant concentration in the diluted exhaust gases. Should any component in the system (heat exchanger, cyclone separator, blower, etc.) change the concentration of any of the pollutants in the diluted exhaust gases and the fault cannot be corrected, then sampling for that pollutant must be carried out before that component.

2.2.7. If the vehicle tested is equipped with an exhaust system comprising more than one tailpipe, the connecting tubes must be connected together by a manifold installed as near as possible to the vehicle.

2.2.8. The gas samples must be collected in sampling bags of adequate capacity so as not to hinder the gas flow during the sampling period. These bags must be made of such materials as will not affect the concentrations of pollutant gases (see 2.3.4.4).

2.2.9. The variable-dilution system must be so designed as to enable the exhaust gases to be sampled without appreciably changing the back-pressure at the exhaust pipe outlet (see 2.3.1.1).

2.3. **Specific requirements**

2.3.1. *Exhaust-gas collection and dilution device*

2.3.1.1. The connection tube between the vehicle exhaust tailpipe(s) and the mixing chamber must be as short as possible; it must in no case:

— cause the static pressure at the exhaust tailpipe(s) on the vehicle being tested to differ by more than ± 0,75 kPa at 50 km/h or more than ± 1,25 kPa for the whole duration of the test from the static pressures recorded when nothing is connected to the vehicle tailpipes. The pressure must be measured in the exhaust tailpipe or in an extension having the same diameter, as near as possible to the end of the pipe,

— change the nature of the exhaust gas.

2.3.1.2. There must be a mixing chamber in which the vehicle exhaust gases and the dilution air are mixed so as to produce a homogeneous mixture at the chamber outlet.

The homogeneity of the mixture in any cross-section at the location of the sampling probe must not vary by more than ± 2 % from the average of the values obtained at at least five points located at equal intervals on the diameter of the gas stream. In order to minimize the effects on the conditions at the exhaust tailpipe and to limit the drop in pressure inside the dilution-air conditioning device, if any, the pressure inside the mixing chamber must not differ by more than ± 0,25 kPa from atmospheric pressure.

2.3.2. *Suction device/volume measuring device*

This device may have a range of fixed speeds as to ensure sufficient flow to prevent any water condensation. This result is generally obtained by keeping the concentration of $CO_2$ in the dilute exhaust-gas sampling bag lower than 3 % by volume.

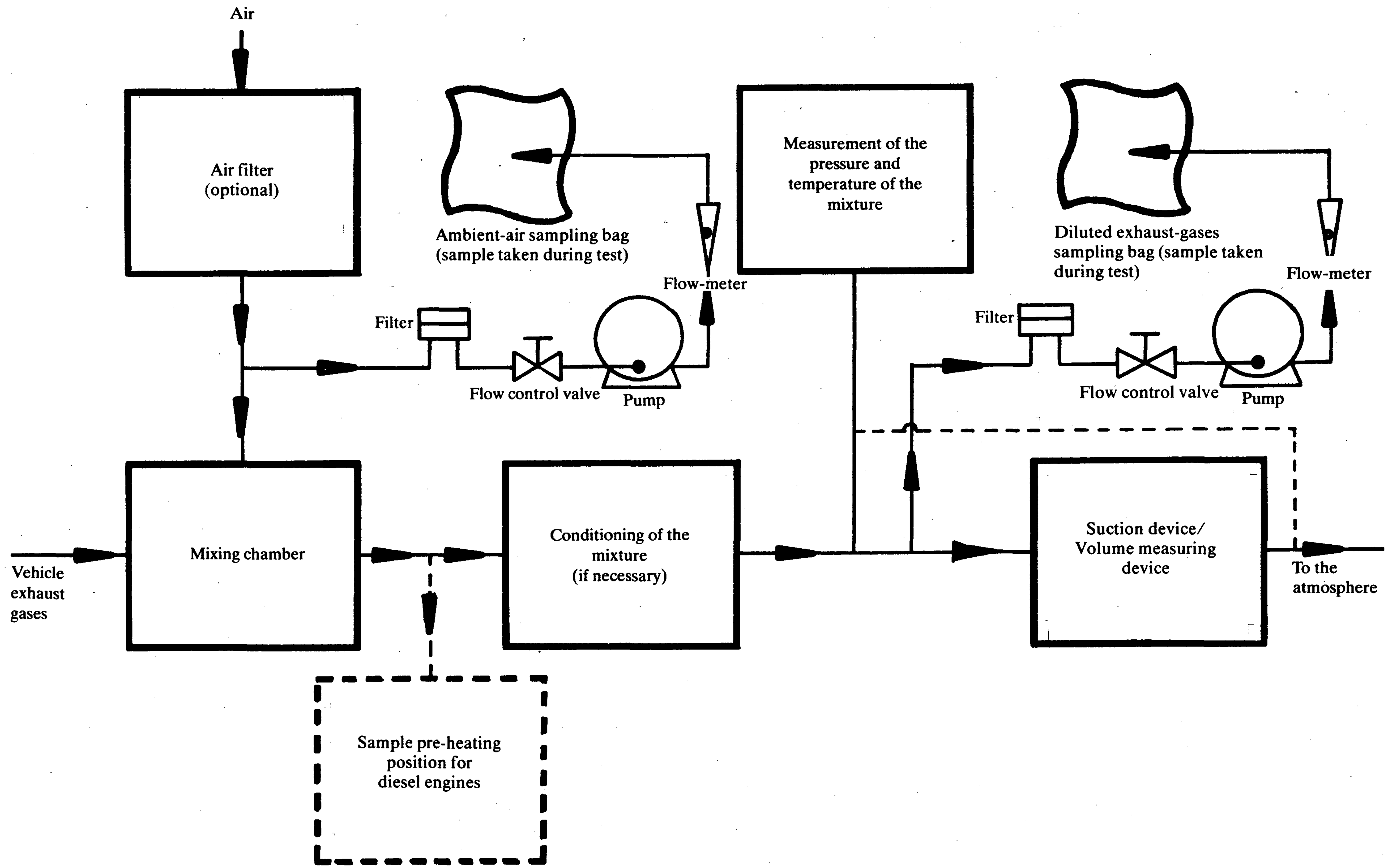
2.3.3. *Volume measurement*

2.3.3.1. The volume measuring device must retain its calibration accuracy to within ± 2 % under all operating conditions. If the device cannot compensate for variations in the temperature of the mixture of exhaust gases and dilution air at the measuring point, a heat exchanger must be used to maintain the temperature to within ± 6 °C of the specified operating temperature.

If necessary, a cyclone separator can be used to protect the volume measuring device.

*Figure 1*

**Diagram of a variable-dilution system for measuring exhaust-gas emissions**



2.3.3.2. A temperature sensor must be installed immediately before the volume measuring device. This temperature sensor must have an accuracy and a precision of ±1 °C and a response time of 0,1 s at 62 % of a given temperature variation (value measured in silicone oil).

2.3.3.3. The pressure measurements must have a precision and an accuracy of ±0,4 kPa during the test.

2.3.3.4. The measurement of the pressure difference from atmospheric pressure is taken before and, if necessary, after the volume measuring device.

2.3.4. *Gas sampling*

2.3.4.1. Dilute exhaust gases

2.3.4.1.1. The sample of dilute exhaust gases is taken before the suction device but after the conditioning devices (if any).

2.3.4.1.2. The flow-rate must not deviate by more than ±2 % from the average.

2.3.4.1.3. The sampling rate must not fall below 5 litres per minute and must not exceed 0,2 % of the flow-rate of the dilute exhaust gases.

2.3.4.1.4. An equivalent limit applies to constant-mass sampling systems.

2.3.4.2. Dilution air

2.3.4.2.1. A sample of the dilution air is taken at a constant flow-rate near the ambient air inlet (after the filter if one is fitted).

2.3.4.2.2. The air must not be contaminated by exhaust gases from the mixing area.

2.3.4.2.3. The sampling rate for the dilution air must be comparable to that used in the case of the dilute exhaust gases.

2.3.4.3. Sampling operations

2.3.4.3.1. The materials used for the sampling operations must be such that they do not change the pollutant concentration.

2.3.4.3.2. Filters may be used in order to extract the solid particles from the sample.

2.3.4.3.3. Pumps are required in order to convey the sample to the sampling bag(s).

2.3.4.3.4. Flow control valves and flow-meters are needed in order to obtain the flow-rates required for sampling.

2.3.4.3.5. Quick-fastening gas-tight connections may be used between the three-way valves and the sampling bags, the connections sealing themselves automatically on the bag side. Other systems may be used for conveying the samples to the analyzer (three-way stop valves, for example).

2.3.4.3.6. The various valves used for directing the sampling gases must be of the quick-adjusting and quick-acting type.

2.3.4.4. Storage of the sample

The gas samples are collected in sampling bags of adequate capacity so as not to reduce the sampling rate. The bags must be made of such a material as will not change the concentration of synthetic pollutant gases by more than ±2 % after 20 minutes.

2.4. **Additional sampling apparatus for testing diesel-engined vehicles**

2.4.1. A sampling point after and close to the mixing chamber

2.4.2. Heated piping and sampling probe

2.4.3. Heated filter and/or pump (the latter may be located in the vicinity of the sample source)

2.4.4. A quick-acting connection for analyzing the sample of ambient air collected in the bag

2.4.5. All heated components must be kept at a temperature of 190 ± 10 °C by the heated system.

2.4.6. If it is not possible to compensate for variations in the flow-rate, there must be a heat exchanger and a temperature control device having the characteristics specified in 2.3.3.1 so as to ensure that the flow-rate in the system is constant and the sampling rate is accordingly proportional.

3. DESCRIPTION OF THE DEVICES

3.1. **Variable dilution device with positive displacement pump (PDP-CVS)** (Figure 1)

3.1.1. The positive displacement pump — constant volume sampler (PDP-CVS) satisfies the requirements of this Annex by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional sample is achieved by sampling with pump, flow-meter and flow control valve at a constant flow-rate.

3.1.2. Figure 1 is a schematic drawing of such a sampling system. Since various configurations can produce accurate results exact conformity with the drawing is not essential. Additional components such as instruments, valves, solenoids and switches may be used to provide additional information and coordinate the functions of the component system.

3.1.3. The collecting equipment consists of:

3.1.3.1. A filter (D) for the dilution air, which can be preheated if necessary. This filter must consist of activated charcoal sandwiched between two layers of paper, and shall be used to reduce and stabilize the hydrocarbon concentrations of ambient emissions in the dilution air.

3.1.3.2. A mixing chamber (M) in which exhaust gas and air are mixed homogeneously.

3.1.3.3. A heat exchanger (H) of a capacity sufficient to ensure that throughout the test the temperature of the air/exhaust-gas mixture measured at a point immediately upstream of the positive displacement pump is within ± 6 °C of the designed operating temperature. This device must not affect the pollutant concentrations of diluted gases taken off after for analysis.

3.1.3.4. A temperature control system (TC), used to preheat the heat exchanger before the test and to control its temperature during the test, so that deviations from the designed operating temperature are limited to ± 6 °C.

3.1.3.5. The positive displacement pump (PDP), used to transport a constant-volume flow of the air/exhaust-gas mixture; the flow capacity of the pump must be large enough to eliminate water condensation in the system under all operating conditions which may occur during a test; this can be generally ensured by using a positive displacement pump with a flow capacity:

3.1.3.5.1. — twice as high as the maximum flow of exhaust gas produced by accelerations of the driving cycle, or

3.1.3.5.2. — sufficient to ensure that the $CO_2$ concentration in the dilute-exhaust sample bag is less than 3 % by volume.

3.1.3.6. A temperature sensor ($T_1$) (accuracy and precision ± 1 °C), fitted at a point immediately upstream of the positive displacement pump; it must be designed to monitor continuously the temperature of diluted exhaust-gas mixture during the test.

3.1.3.7. A pressure gauge ($G_1$) (accuracy and precision ± 0,4 kPa) fitted immediately upstream of the volume meter and used to register the pressure gradient between the gas mixture and the ambient air.

3.1.3.8. Another pressure gauge ($G_2$) (accuracy and precision ± 0,4 kPa) fitted so that the differential pressure between pump inlet and pump outlet can be registered.

3.1.3.9. Two sampling outlets ($S_1$ and $S_2$) for taking constant samples of the dilution air and of the diluted exhaust-gas/air mixture.

3.1.3.10. A filter (F), to extract solid particles from the flows of gas collected for analysis.

3.1.3.11. Pumps (P), to collect a constant flow of the dilution air as well as of the diluted exhaust-gas/air mixture during the test.

3.1.3.12. Flow controllers (N), to ensure a constant uniform flow of the gas samples taken during the course of the test from sampling probes $S_1$ and $S_2$; and flow of the gas samples must be such that, at the end of each test, the quantity of the samples is sufficient for analysis (~ 10 litres per minute).

3.1.3.13. Flow meters (FL), for adjusting and monitoring the constant flow of gas samples during the test.

3.1.3.14. Quick-acting valves (V), to divert a constant flow of gas samples into the sampling bags or to the outside vent.

3.1.3.15. Gas-tight, quick-lock coupling elements (Q) between the quick-acting valves and the sampling bags; the coupling must close automatically on the sampling-bag side; as an alternative, other ways of transporting the samples to the analyzer may be used (three-way stopcocks, for instance).

3.1.3.16. Bags (B), for collecting samples of the diluted exhaust gas and of the dilution air during the test; they must be of sufficient capacity not to impede the sample flow; the bag material must be such as to affect neither the measurements themselves nor the chemical composition of the gas samples (for instance: laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

3.1.3.17. A digital counter (C), to register the number of revolutions performed by the positive displacement pump during the test.

3.1.4. *Additional equipment required when testing diesel-engined vehicles*

To comply with the requirements of 4.3.1.1 and 4.3.2 of Annex III, the additional components within the dotted lines in Figure 1 must be used when testing diesel-engined vehicles:

Fh is a heated filter,

$S_3$ is a sample point close to the mixing chamber,

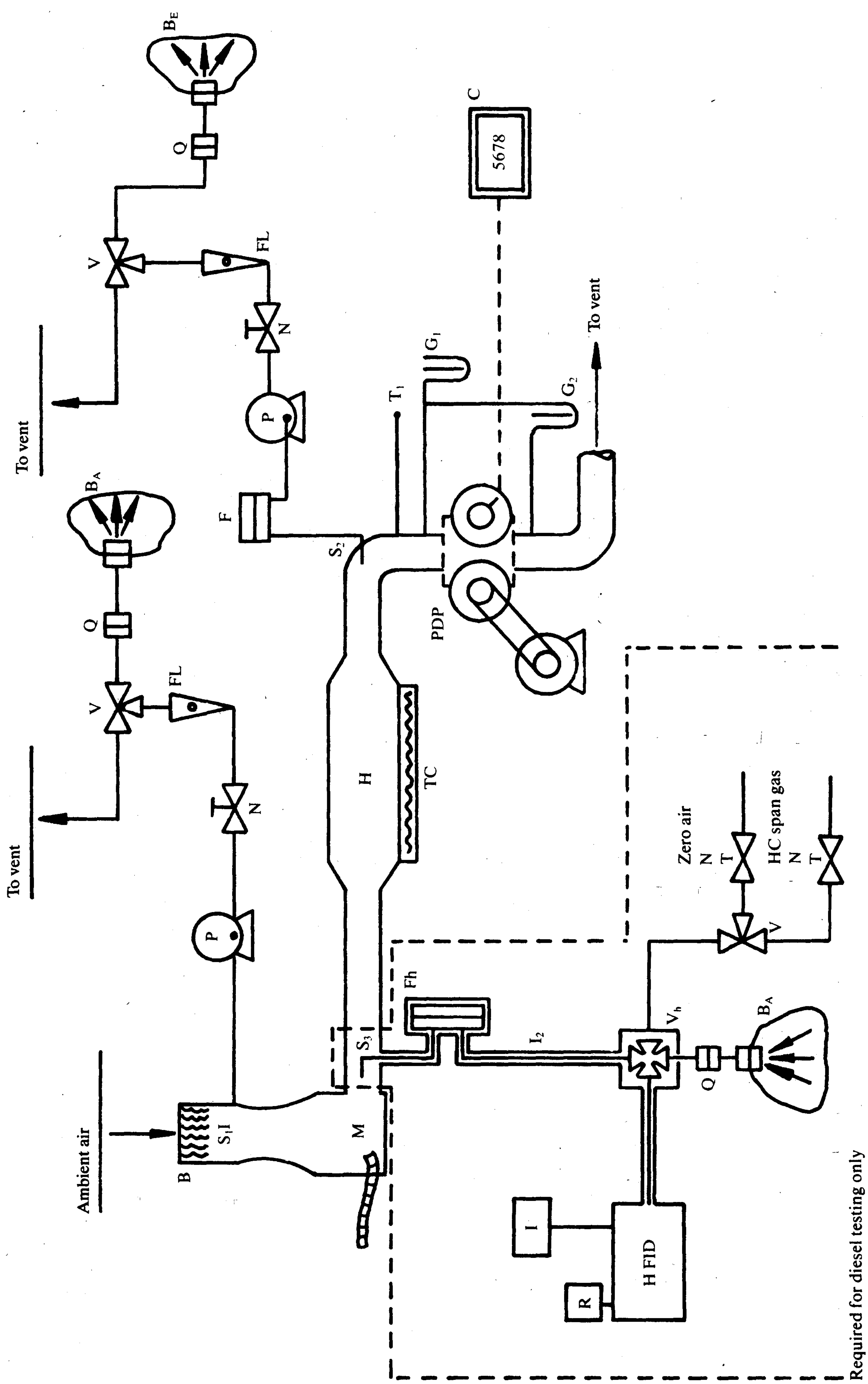
$V_h$ is a heated multiway valve,

Q is a quick connector to allow the ambient air sample BA to be analyzed on the HFID,

HFID is a heated flame ionization analyzer,

*Figure 1*

**Constant volume sampler with positive displacement pump (PDP-CVS)**



R and I are a means of integrating and recording the instantaneous hydrocarbon concentrations,

Lh is a heated sample line.

All heated components must be maintained at 190 ± 10 °C.

3.2. **Critical-flow venturi dilution device (CFV-CVS)** (Figure 2)

3.2.1. Using a critical-flow venturi in connection with the CVS sampling procedure is based on the principles of flow mechanics for critical flow. The variable mixture flow rate of dilution and exhaust gas is maintained at sonic velocity which is directly proportional to the square root of the gas temperature. Flow is continually monitored, computed and integrated over the test.

If an additional critical-flow sampling venturi is used, the proportionality of the gas samples taken is ensured. As both pressure and temperature are equal at the two venturi inlets the volume of the gas flow diverted for sampling is proportional to the total volume of diluted exhaust-gas mixture produced, and thus the requirements of this Annex are met.

3.2.2. Figure 2 is a schematic drawing of such a sampling system. Since various configurations can produce accurate results, exact conformity with the drawing is not essential. Additional components such as instruments, valve, solenoids, and switches may be used to provide additional information and coordinate the functions of the component system.

3.2.3. The collecting equipment consists of:

3.2.3.1. A filter (D) for the dilution air, which can be preheated if necessary: the filter must consist of activated charcoal sandwiched between layers of paper, and must be used to reduce and stabilize the hydrocarbon background emission of the dilution air.

3.2.3.2. A mixing chamber (M), in which exhaust gas and air are mixed homogeneously.

3.2.3.3. A cyclone separater (CS), to extract particles.

3.2.3.4. Two sampling probes ($S_1$ and $S_2$), for taking samples of the dilution air as well as of the diluted exhaust gas.

3.2.3.5. A sampling critical flow venturi (SV), to take proportional samples of the diluted exhaust gas at sampling probe $S_2$.

3.2.3.6. A filter (F), to extract solid particles from the gas flows diverted for analysis.

3.2.3.7. Pumps (P), to collect part of the flow of air and diluted exhaust gas in bags during the test.

3.2.3.8. A flow controller (N), to ensure a constant flow of the gas samples taken in the course of the test from sampling probe $S_1$; the flow of the gas samples must be such that, at the end of the test, the quantity of the samples is sufficient for analysis (~ 10 litres per minute).

3.2.3.9. A snubber (PS), in the sampling line.

3.2.3.10. Flow meters (FL), for adjusting and monitoring the flow of gas samples during tests.

3.2.3.11. Quick-acting solenoid valves (V), to divert a constant flow of gas samples into the sampling bags or the vent.

3.2.3.12. Gas-tight, quick-lock coupling elements (Q), between the quick-acting valves and the sampling bags; the couplings must close automatically on the sampling-bag side; as an alternative, other ways of transporting the samples to the analyzer may be used (three-way stopcocks, for instance).

3.2.3.13. Bags (B), for collecting samples of the diluted exhaust gas and the dilution air during the tests; they must be of sufficient capacity not to impede the sample flow; the bag material must be such as to affect neither the measurements themselves nor the chemical composition of the gas samples (for instance: laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

3.2.3.14. A pressure gauge (G), which is precise and accurate to within $\pm 0{,}4$ kPa.

3.2.3.15. A temperature sensor (T), which is precise and accurate to within $\pm 1$ °C and have a response time of 0,1 seconds to 62 % of a temperature change (as measured in silicon oil).

3.2.3.16. A measuring critical flow venturi tube (MV), to measure the flow volume of the diluted exhaust gas.

3.2.3.17. A blower (BL), of sufficient capacity to handle the total volume of diluted exhaust gas.

3.2.3.18. The capacity of the CFV-CVS system must be such that under all operating conditions which may possibly occur during a test there will be no condensation of water. This is generally ensured by using a blower whose capacity is:

3.2.3.18.1. twice as high as the maximum flow of exhaust gas produced by accelerations of the driving cycle;

3.2.3.18.2. sufficient to ensure that the $CO_2$ concentration in the dilute exhaust sample bag is less than 3 % by volume.

3.2.4. *Additional equipment required when testing diesel-engined vehicles*

To comply with the requirements of 4.3.1.1 and 4.3.2 of Annex III, the additional components shown within the dotted lines of Figure 2 must be used when testing diesel-engined vehicles:

Fh is a heated filter,

$S_3$ is a sample point close to the mixing chamber,

Vh is a heated multiway valve,

Q is a quick connector to allow the ambient air sample BA to be analyzed on the HFID,

HFID is a heated flame ionization analyzer,

R and I are a means of integrating and recording the instantaneous hydrocarbon concentrations,

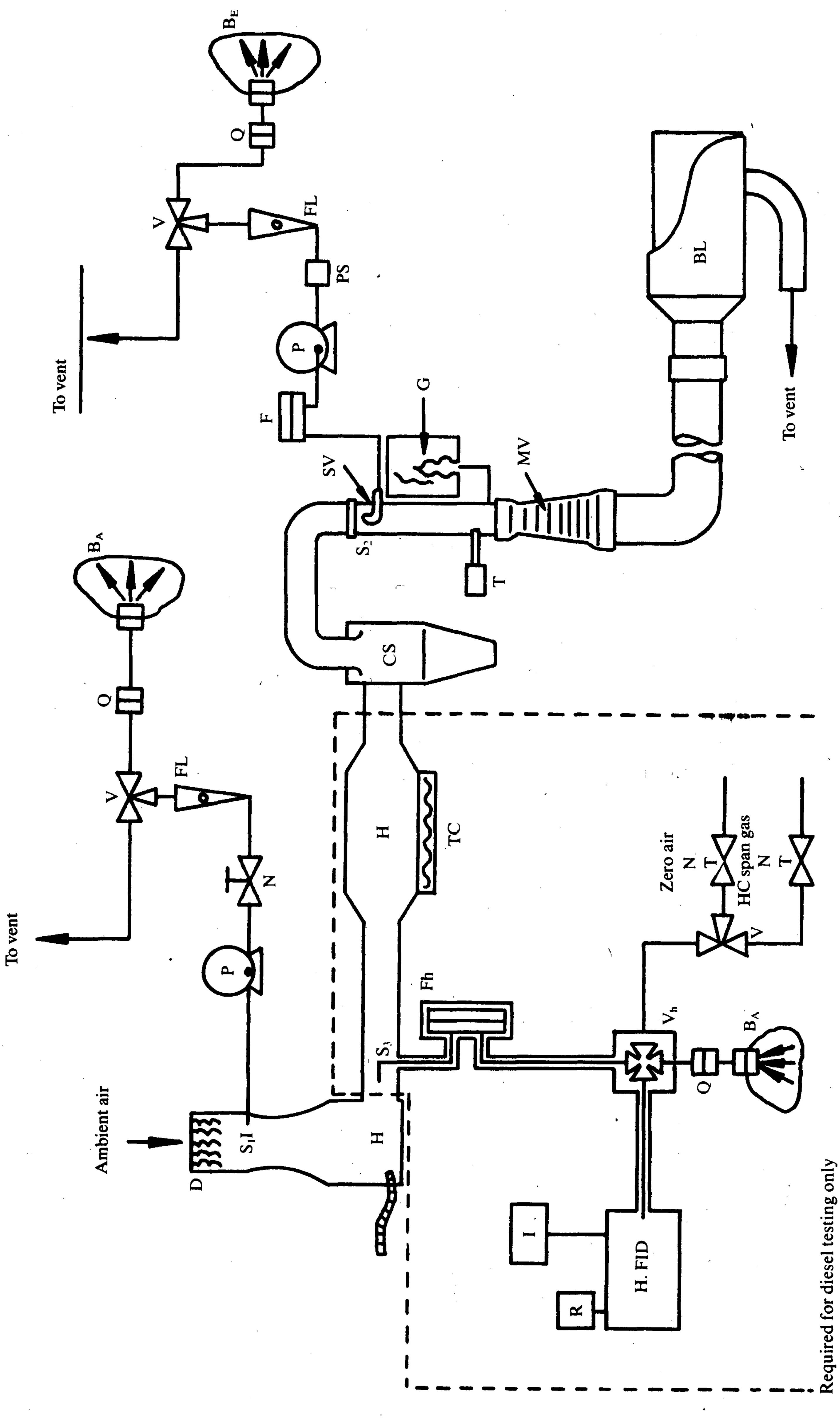
Lh is a heated sample line.

All heated components must be maintained at $190 \pm 10$ °C.

If compensation for varying flow is not possible, then a heat exchanger (H) and temperature control system (TC) as described in 2.2.3 will be required to ensure constant flow through the venturi (MV) and thus proportional flow through $S_3$.

*Figure 2*

**Constant volume sampler with critical-flow venturi (CFV-CVS)**



3.3. **Variable dilution device with constant flow control by orifice (CFO-CVS)** (Figure 3)

3.3.1. The collection equipment consists of:

3.3.1.1. A sampling tube connecting the vehicle's exhaust pipe to the device itself.

3.3.1.2. A sampling device consisting of a pump device for drawing in a diluted mixture of exhaust gas and air.

3.3.1.3. A mixing chamber (M) in which exhaust gas and air are mixed homogeneously.

3.3.1.4. A heat exchanger (H) of a capacity sufficient to ensure that throughout the test the temperature of the air/exhaust-gas mixture measured at a point immediately before the positive displacement of the flow-rate measuring device is within ±6 °C of the designed operating temperature. This device must not alter the pollutant concentration of diluted gases taken off for analysis.

Should this condition not be satisfied for certain pollutants, sampling will be effected before the cyclone for one or several considered pollutants.

If necessary, a device for temperature control (TC) is used to preheat the heat exchanger before testing and to keep up its temperature during the test at ±6 °C.

3.3.1.5. Two probes ($S_1$ and $S_2$) for sampling by means of pumps (P) flow-meters (FL) and, if necessary, filters (F) allowing for the collection of solid particles from gases used for the analysis.

3.3.1.6. One pump for dilution air and another one for diluted mixture.

3.3.1.7. A volume-meter with an orifice.

3.3.1.8. A temperature censor ($T_1$) (accuracy and precision ±1 °C), fitted at a point immediately before the volume measurement device; it must be designed to monitor continuously the temperature of the diluted exhaust-gas mixture during the test.

3.3.1.9. A pressure gauge ($G_1$) (accuracy and precision ±0,4 kPa) fitted immediately before the volume meter and used to register the pressure gradient between the gas mixture and the ambient air.

3.3.1.10. Another pressure gauge ($G_2$) (accuracy and precision ±0,4 kPa) fitted so that the differential pressure between pump inlet and pump outlet can be registered.

3.3.1.11. Flow controllers (N) to ensure a constant uniform flow of gas samples taken during the course of the test from sampling outlets $S_1$ and $S_2$. The flow of the gas samples must be such that, at the end of each test, the quantity of the samples is sufficient for analysis (~ 10 litres per minute).

3.3.1.12. Flow-meters (FL) for adjusting and monitoring the constant flow of gas samples during the test.

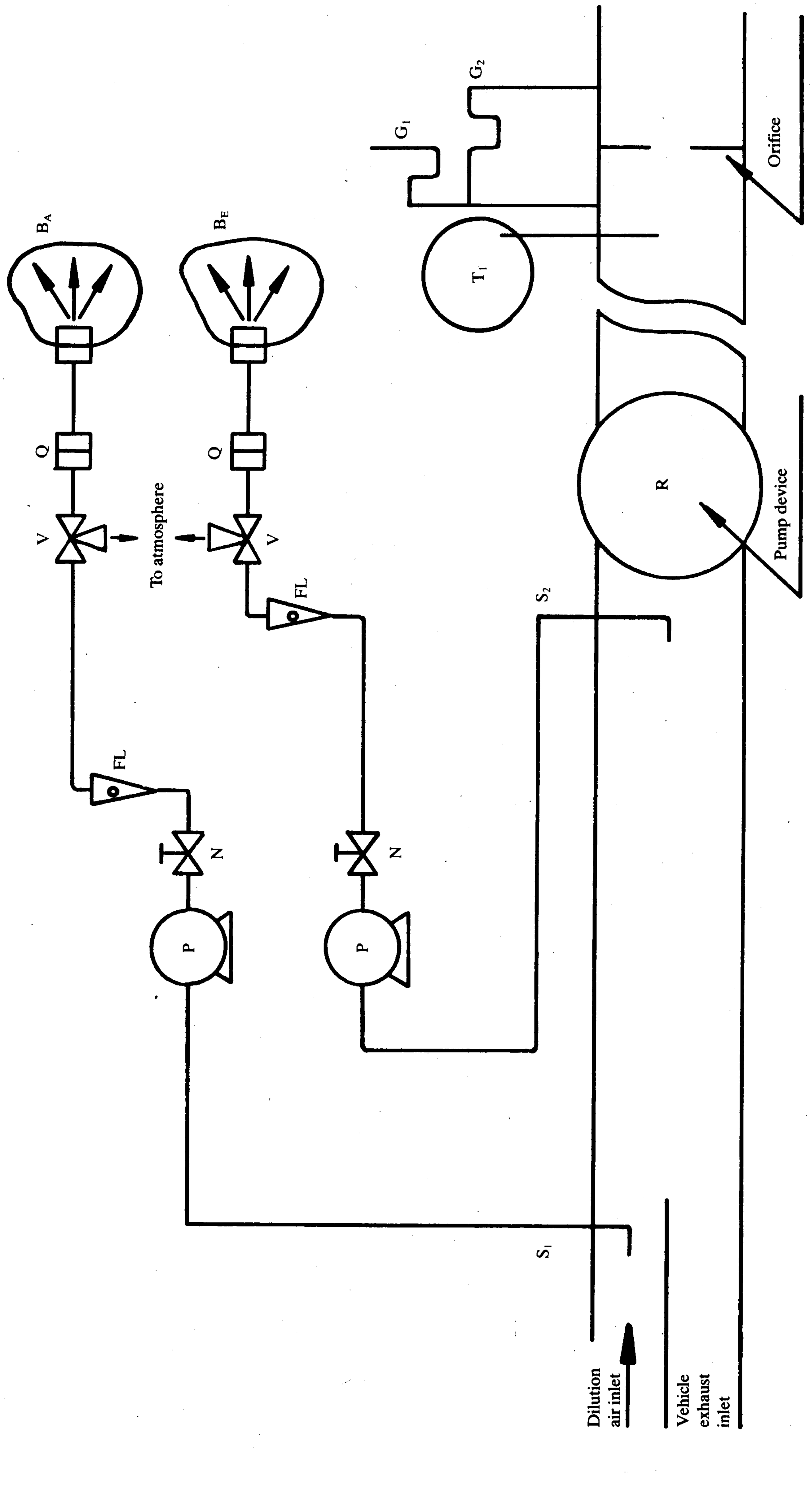
3.3.1.13. Three-way valves (V) to divert a constant flow of gas samples into the sampling bags or to the outside vent.

3.3.1.14. Gas-tight, quick-lock coupling elements (Q) between the three-way valves and the sampling bags; the coupling must close automatically on the sampling-bag side. Other ways of transporting the samples to the analyzer may be used (three-way stopcocks, for instance).

3.3.1.15. Bags (B) for collecting samples of diluted exhaust gas and of dilution air during the test. They must be of sufficient capacity not to impede the sample flow. The bag material must be such as to affect neither the measurements themselves nor the chemical composition of the gas samples (for instance: laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

*Figure 3*

**Diagram of a variable dilution device with constant flow control by orifice (CFO-CVS)**



*APPENDIX 6*

**METHOD OF CALIBRATING THE EQUIPMENT**

1. ESTABLISHMENT OF THE CALIBRATION CURVE

1.1. Each normally used operating range is calibrated in accordance with the requirements of 4.3.3 of Annex III by the following procedure:

1.2. The analyzer calibration curve is established by at least five calibration points spaced as uniformly as possible. The nominal concentration of the calibration gas of the highest concentration must be not less than 80 % of the full scale.

1.3. The calibration curve is calculated by the least squares method. If the resulting polynominal degree is greater than 3, the number of calibration points must be at least equal to this polynomial degree plus 2.

1.4. The calibration curve must not differ by more than 2 % from the nominal value of each calibration gas.

1.5. **Trace of the calibration curve**

From the trace of the calibration curve and the calibration points it is possible to verify that the calibration has been carried out correctly. The different characteristic parameters of the analyzer must be indicated, particularly:

— the scale,

— the sensitivity,

— the zero point,

— the date of carrying out the calibration.

1.6. If it can be shown to the satisfaction of the technical service that alternative technology (e.g. computer, electronically controlled range switch, etc.) can give equivalent accuracy, then these alternatives may be used.

2. VERIFICATION OF THE CALIBRATION

2.1. Each normally used operating range must be checked prior to each analysis in accordance with the following:

2.2. The calibration is checked by using a zero gas and a span gas whose nominal value is near to the supposed value to be analyzed.

2.3. If, for the two points considered, the value found does not differ by more than ± 5 % of the full scale from the theoretical value, the adjustment parameters may be modified. Should this not be the case, a new calibration curve must be established in accordance with 1.

2.4. After testing, zero gas and the same span gas are used for re-checking. The analysis is considered acceptable if the difference between the two measuring results is less than 2 %.

3. EFFICIENCY TEST OF THE $NO_x$ CONVERTER

The efficiency of the converter used for the conversion of $NO_2$ into NO is tested as follows:

Using the test set up as shown in Figure 1 and the procedure described below, the efficiency of converters can be tested by means of an ozonator.

3.1. Calibrate the CLA in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which must amount to about 80 % of the operating range and the $NO_2$ concentration of the gas mixture to less than 5 % of the NO concentration). The $NO_x$ analyzer must be in the NO mode so that the span gas does not pass through the converter. Record the indicated concentration.

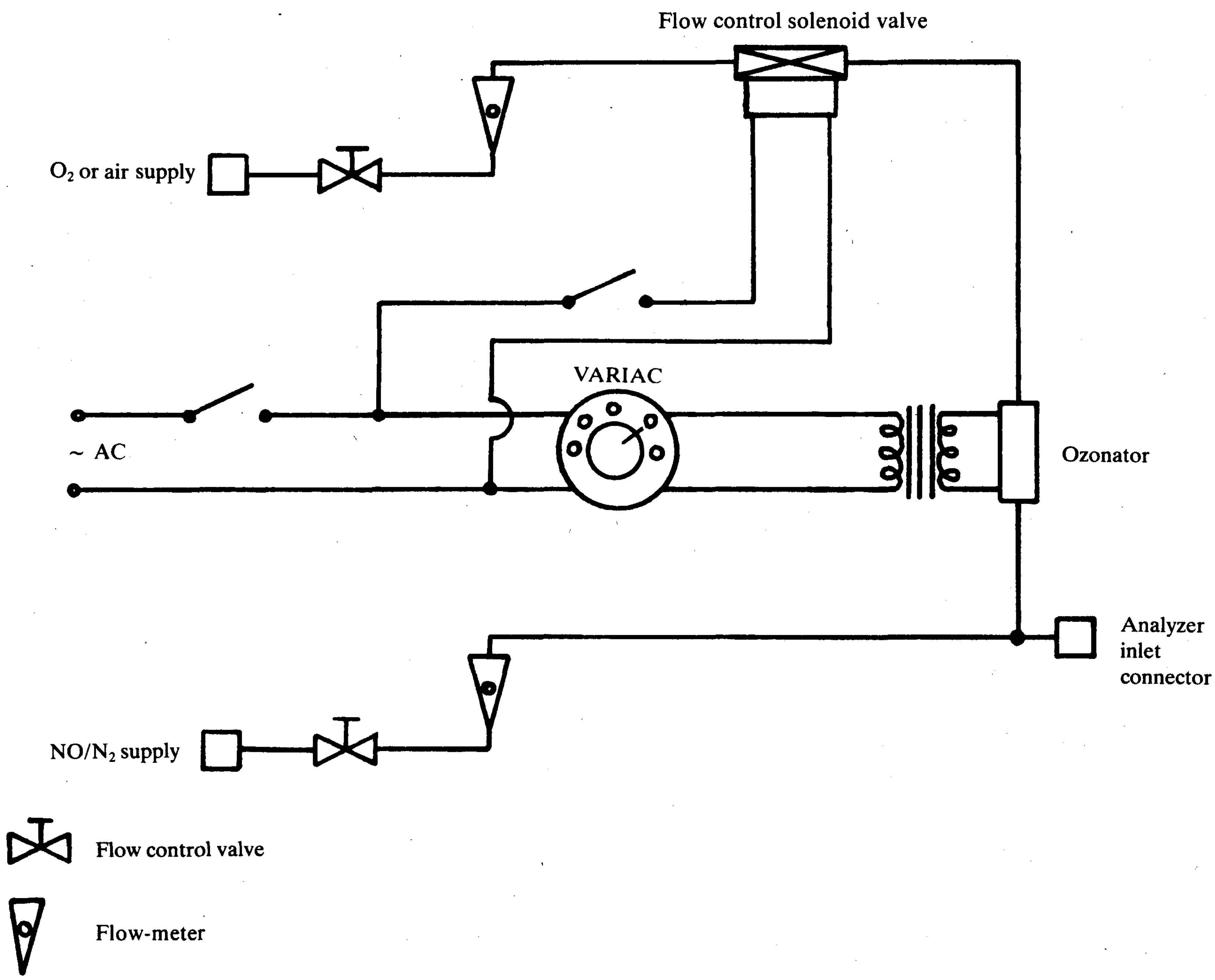
3.2. Via a T-fitting, oxygen or synthetic air is added continuously to the gas flow until the concentration indicated is about 10 % less than the indicated calibration concentration given in 3.1. Record the indicated concentration (C). The ozonator is kept deactivated throughout this process.

3.3. The ozonator is now activated to generate enough ozone to bring the NO concentration down to 20 % (minimum 10 %) of the calibration concentration given in 3.1. Record the indicated concentration (d).

3.4. The $NO_x$ analyzer is then switched to the $NO_x$ mode which means that the gas mixture (consisting of NO, $NO_2$, $O_2$ and $N_2$) now passes through the converter. Record the indicated concentration (a).

3.5. The ozonator is now deactivated. The mixture of gases described in 3.2 passes through the converter into the detector. Record the indicated concentration (b).

*Figure 1*



3.6. With the ozonator deactivated, the flow of oxygen or synthetic air is also shut off. The $NO_x$ reading of the analyzer must then be no more than 5 % above the figure given in 3.1.

3.7. The efficiency of the $NO_x$ converter is calculated as follows:

$$\text{Efficiency (\%)} = (1 + \frac{a - b}{c - d}) \times 100$$

3.8. The efficiency of the converter must not be less than 95 %.

3.9. The efficiency of the converter must be tested at least once a week.

4. CALIBRATION OF THE CVS SYSTEM

4.1. The CVS system must be calibrated by using an accurate flow-meter and a restricting device. The flow through the system must be measured at various pressure readings and the control parameters of the system measured and related to the flows.

4.1.1. Various types of flow-meter may be used, e.g. calibrated venturi, laminar flow-meter, calibrated turbine-meter, provided that they are dynamic measurement systems and can meet the requirements of 4.2.2 and 4.2.3 of Annex III.

4.1.2. The following sections give details of methods of calibrating PDP and CFV units, using a laminar flow-meter, which gives the required accuracy, together with a statistical check on the calibration validity.

4.2. **Calibration of the positive displacement pump (PDP)**

4.2.1. The following calibration procedure outlines the equipment, the test configuration and the various parameters which are measured to establish the flow-rate of the CVS pump. All the parameters related to the pump are simultaneously measured with the parameters related to the flow-meter which is connected in series with the pump. The calculated flow-rate (given in $m^3$/min at pump inlet, absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters. The linear equation which relates the pump flow and the correlation function is then determined. In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

4.2.2. This calibration procedure in based on the measurement of the absolute values of the pump and flow-meter parameters that relate the flow-rate at each point. Three conditions must be maintained to ensure the accuracy and integrity of the calibration curve.

4.2.2.1. The pump pressures must be measured at tappings on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top centre and bottom centre of the pump drive headplate are exposed to the actual pump cavity pressures, and therefore reflect the absolute pressure diffentials.

4.2.2.2. Temperature stability must be maintained during the calibration. The laminar flow-meter is sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes of ± 1 °C in temperature are acceptable as long as they occur over a period of several minutes.

4.2.2.3. All connections between the flow-meter and the CVS pump must be free of any leakage.

4.2.3. During an exhaust emission test, the measurement of these same pump parameters enables the user to calculate the flow-rate from the calibration equation.

4.2.3.1. Figure 2 of this Appendix shows one possible test set-up. Variations are permissible, provided that they are approved by the authority granting the approval as being of comparable accuracy. If the set-up shown in Figure 2 of Appendix 5 is used, the following data must be found within the limits of precision given:

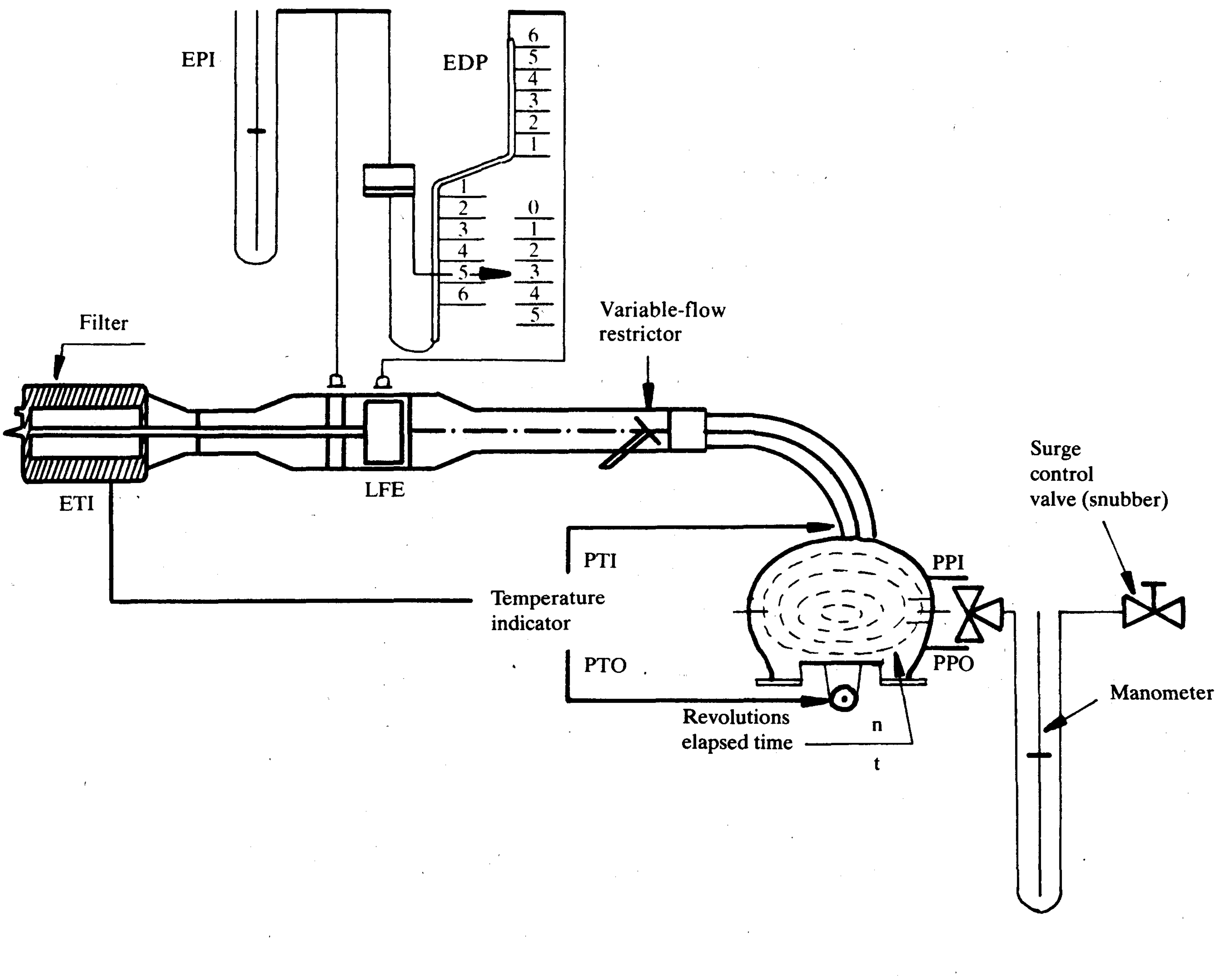
| | |
|---|---|
| barometric pressure (corrected) ($P_B$) | ± 0,03 kPa |
| ambient temperature (T) | ± 0,2 °C |
| air temperature at LFE (ETI) | ± 0,15 °C |
| pressure depression upstream of LFE (EPI) | ± 0,01 kPa |
| pressure drop across the LFE matrix (EDP) | ± 0,0015 kPa |
| air temperature at CVS pump inlet (PTI) | ± 0,2 °C |
| air temperature at CVS pump outlet (PTO) | ± 0,2 °C |
| pressure depression at CVS pump inlet (PPI) | ± 0,22 kPa |
| pressure head at CVS pump outlet (PPO) | ± 0,22 kPa |
| pump revolutions during test period (n) | ± 1 rev |
| elapsed time for period (minimum 250 s) (t) | ± 0,1 s |

4.2.3.2. After the system has been connected as shown in Figure 2, set the variable restrictor in the wide-open position and run the CVS pump for 20 minutes before starting the calibration.

4.2.3.3. Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about 1 kPa) that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for three minutes and repeat the data acquisition.

*Figure 2*

**PDP-CVS calibration configuration**



4.2.4. *Data analysis*

4.2.4.1. The air flow-rate ($Q_S$) at each test point is calculated in standard m³/min from the flow-meter data using the manufacturer's prescribed method.

4.2.4.2. The air flow-rate is then converted to pump flow ($V_o$) in m³/rev at absolute pump inlet temperature and pressure.

$$V_o = \frac{Q_S}{n} \cdot \frac{T_P}{273,2} \cdot \frac{101,33}{P_p}$$

where:

$V_o$ = pump flow-rate at $T_p$ and $P_p$ given in m³/rev,

$Q_S$ = air flow at 101,33 KPa and 273,2 K given in m³/min,

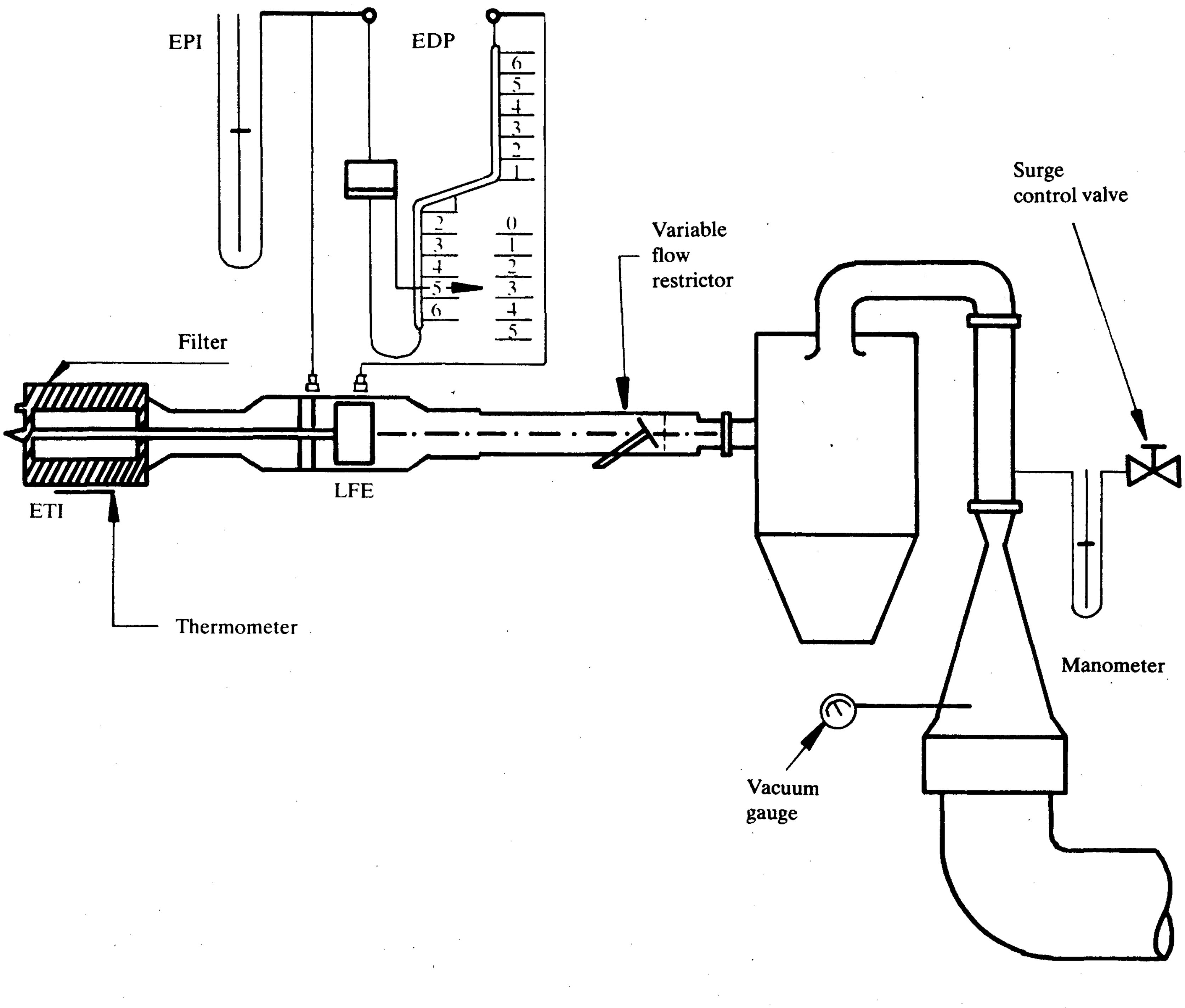
$T_P$ = pump inlet temperature (K),

$P_P$ = absolute pump inlet pressure,

n = pump speed in revolutions per minute.

*Figure 3*

**CFV-CVS calibration configuration**



To compensate for the interaction of pump speed pressure variations at the pump and the pump slip rate, the correlation function ($X_o$) between the pump speed (n), the pressure differential from pump inlet to pump outlet and the absolute pump outlet pressure is then calculated as follows:

$$X_o = \frac{1}{n}\sqrt{\frac{\Delta P_P}{P_e}}$$

where:

$x_o$ = correlation function,

$\Delta P_P$ = pressure differential from pump inlet to pump outlet (kPa),

$P_e$ = absolute outlet pressure (PPO + $P_B$) (kPa).

A linear least-square fit is performed to generate the calibration equations which have the formulae:

$$V_o = D_o - M\,(X_o)$$
$$n = A - B\,(\Delta P_P)$$

$D_o$, M, A and B are the slope-intercept constants describing the lines.

4.2.4.3. A CVS system that has multiple speeds must be calibrated on each speed used. The calibration curves generated for the ranges must be approximately parallel and the intercept values ($D_o$) must increase as the pump flow range decreases.

If the calibration has been performed carefully, the calculated values from the equation will be within ± 0,5 % of the measured value of $V_o$. Values of M will vary from one pump to another. Calibration is performed at pump start-up and after major maintenance.

4.3. **Calibration of the critical-flow venturi (CFV)**

4.3.1. Calibration of the CFV is based upon the flow equation for a critical venturi:

$$Q_s = \frac{K_v \cdot P}{\sqrt{T}}$$

where:

$Q_s$ = flow,

$K_v$ = calibration coefficient,

P = absolute pressure (KPa),

T = absolute temperature (K).

Gas flow is a function of inlet pressure and temperature.

The calibration procedure described below establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

4.3.2. The manufacturer's recommended procedure must be followed for calibrating electronic portions of the CFV.

4.3.3. Measurements for flow calibration of the critical flow venturi are required and the following data must be found within the limits of precision given:

| | |
|---|---|
| barometric pressure (corrected) ($P_B$) | ± 0,03 kPa, |
| LFE air temperature, flow-meter (ETI) | ± 0,15 °C, |
| pressure depression upstream of LFE (EPI) | ± 0,01 kPa, |

| | |
|---|---|
| pressure drop across (EDP) LFE matrix | ± 0,0015 kPa, |
| air flow ($Q_s$) | ± 0,5 %, |
| CFV inlet depression (PPI) | ± 0,02 kPa, |
| temperature at venturi inlet ($T_v$) | ± 0,2 °C. |

4.3.4. The equipment must be set up as shown in Figure 3 and checked for leaks. Any leaks between the flow-measuring device and the critical-flow venturi seriously affect the accuracy of the calibration.

4.3.5. The variable-flow restrictor must be set to the open position, the blower started and the system stabilized. Data from all instruments must be recorded.

4.3.6. The flow restrictor must be varied and at least eight readings across the critical flow range of the venturi must be made.

4.3.7. The data recorded during the calibration must be used in the following calculations. The air flow-rate ($Q_s$) at each test point is calculated from the flow-meter data using the manufacturer's prescribed method.

Calculate values of the calibration coefficient for each test point:

$$K_v = \frac{Q_s \cdot \sqrt{T_v}}{P_v}$$

where:

$Q_s$ = flow-rate in $m^3$/min at 273,2 K and 101,33 kPa,

$T_v$ = temperature at the venturi inlet (K),

$P_v$ = absolute pressure at the venturi inlet (kPa).

Plot $K_v$ as a function of venturi inlet pressure. For sonic flow $K_v$ will have a relatively constant value. As pressure decreases (vacuum increases) the venturi become unchoked and $K_v$ decreases. The resultant $K_v$ changes are not permissible.

For a minimum of eight points in the critical region calculate an average $K_v$ and the standard deviation.

If the standard deviation exceeds 0,3 % of the average $K_v$ take corrective action.

*APPENDIX 7*

## TOTAL SYSTEM VERIFICATION

1. To comply with the requirements of 4.7 of Annex III, the total accuracy of the CVS sampling system and analytical system must be determined by introducing a known mass of a pollutant gas into the system whilst it is being operated as if during a normal test and then analyzing and calculating the pollutant mass according to the formulae in Appendix 8 to this Annex except that the density of propane is taken as 1,967 grams per litre at standard conditions. The following two techniques are known to give sufficient accuracy.

2. METERING A CONSTANT FLOW OF PURE GAS (CO OR $C_3H_8$) USING A CRITICAL FLOW ORIFICE DEVICE

2.1. A known quantity of pure gas (CO or $C_3H_8$) is fed into the CVS system through the calibrated critical orifice. If the inlet pressure is high enough, the flow-rate (q), which is adjusted by means of the critical flow orifice, is independent of orifice outlet pressure (critical flow). If deviations exceeding 5 % occur, the cause of the malfunction must be located and determined. The CVS system is operated as in an exhaust emission test for about 5 to 10 minutes. The gas collected in the sampling bag is analyzed by the usual equipment and the results compared to the concentration of the gas samples which was known beforehand.

3. METERING A LIMITED QUANTITY OF PURE GAS (CO OR $C_3H_8$) BY MEANS OF A GRAVIMETRIC TECHNIQUE

3.1. The following gravimetric procedure may be used to verify the CVS system. The weight of a small cylinder filled with either carbon monoxide or propane is determined with a precision of ±0,01 g. For about 5 to 10 minutes, the CVS system is operated as in a normal exhaust emission test, while CO or propane is injected into the system. The quantity of pure gas involved is determined by means of differential weighing. The gas accumulated in the bag is then analyzed by means of the equipment normally used for exhaust-gas analysis. The results are then compared to the concentration figures computed previously.

*APPENDIX 8*

**CALCULATION OF THE MASS EMISSIONS OF POLLUTANTS**

The mass emissions of pollutants are calculated by means of the following equation:

$$M_i = V_{mix} \times Q_i \times k_H \times C_i \times 10^{-6} \qquad (1)$$

where:

$M_i$ = mass emission of the pollutant i in grams per test,

$V_{mix}$ = volume of the diluted exhaust gas expressed in litres per test and corrected to standard conditions (273,2 K and 101,33 kPa),

$Q_i$ = density of the pollutant i in grams per litre at normal temperature and pressure (273,2 K and 101,33 kPa),

$k_H$ = humidity correction factor used for the calculation of the mass emissions of oxides of nitrogen. There is no humidity correction for HC and CO,

$C_i$ = concentration of the pollutant i in the diluted exhaust gas expressed in ppm and corrected by the amount of the pollutant i contained in the dilution air.

1. VOLUME DETERMINATION

1.1. Calculation of the volume when a variable dilution device with constant flow control by orifice or venturi is used. Record continuously the parameters showing the volumetric flow, and calculate the total volume for the duration of the test.

1.2. Calculation of volume when a positive displacement pump is used. The volume of diluted exhaust gas in systems comprising a positive displacement pump is calculated with the following formula:

$$V = V_o \times N$$

where:

V = volume of the diluted exhaust gas expressed in litres per test (prior to correction),

$V_o$ = volume of gas delivered by the positive displacement pump on testing conditions in litres per revolution,

N = number of revolutions per test.

1.3. Correction of the diluted exhaust-gas volume to standard conditions

The diluted exhaust-gas volume is corrected by means of the following formula:

$$V_{mix} = V \times K_1 \times \frac{P_B - P_1}{T_p} \qquad (2)$$

in which:

$$K_1 = \frac{273,2\ K}{101,33\ kPa} = 2,6961\ (K \times kPa^{-1}) \qquad (3)$$

where:

$P_B$ = barometric pressure in the test room in kPa,

$P_1$ = vacuum at the inlet to the positive displacement pump in kPa relative to the ambient barometric pressure,

$T_p$ = average temperature of the diluted exhaust gas entering the positive displacement pump during the test (K).

2. CALCULATION OF THE CORRECTED CONCENTRATION OF POLLUTANTS IN THE SAMPLING BAG

$$C_i = C_e - C_d \left(1 - \frac{1}{DF}\right) \quad (4)$$

where:

$C_i$ = concentration of the pollutant i in the diluted exhaust gas, expressed in ppm and corrected by the amount of i contained in the dilution air,

$C_e$ = measured concentration of pollutant i in the diluted exhaust gas, expressed in ppm,

$C_d$ = measured concentration of pollutant i in the air used for dilution, expressed in ppm,

DF = dilution factor.

The dilution factor is calculated as follows:

$$DF = \frac{13{,}4}{c_{CO_2} + (c_{HC} + c_{CO})\,10^{-4}} \quad (5)$$

In this equation:

$c_{CO_2}$ = concentration of $CO_2$ in the diluted exhaust gas contained in the sampling bag, expressed in % volume,

$c_{HC}$ = concentration of HC in the diluted exhaust gas contained in the sampling bag, expressed in ppm carbon equivalent,

$c_{CO}$ = concentration of CO in the diluted exhaust gas contained in the sampling bag, expressed in ppm.

3. DETERMINATION OF THE NO HUMIDITY CORRECTION FACTOR

In order to correct the influence of humidity on the results of oxides of nitrogen, the following calculations are applied:

$$k_H = \frac{1}{1 - 0{,}0329\,(H - 10{,}71)} \quad (6)$$

in which:

$$H = \frac{6{,}211 \times R_a \times P_d}{P_B - P_d \times R_a \times 10^{-2}} \quad (6)$$

where:

H = absolute humidity expressed in grams of water per kilogram of dry air,

$R_a$ = relative humidity of the ambient air expressed as a percentage,

$P_d$ = saturation vapour pressure at ambient temperature expressed in kPa,

$P_B$ = atmospheric pressure in the room, expressed in kPa.

4. EXAMPLE

4.1. **Data**

4.1.1. Ambient conditions:

ambient temperature: 23 °C = 296,2 K,

barometric pressure: $P_B$ = 101,33 kPa,

relative humidity: $R_a$ = 60 %,

saturation vapour pressure: $P_d$ = 3,20 kPa of $H_2O$ at 23 °C.

4.1.2. Volume measured and reduced to standard conditions (paragraph 1)

$V = 51,961\ m^3$

4.1.3. Analyzer readings:

| | Diluted exhaust sample | Dilution-air sample |
|---|---|---|
| HC [1] | 92 ppm | 3,0 ppm |
| CO | 470 ppm | 0 ppm |
| $NO_x$ | 70 ppm | 0 ppm |
| $CO_2$ | 1,6 % vol | 0,03 % vol |

[1] In ppm carbon equivalent.

4.2. **Calculation**

4.2.1. Humidity correction factor ($k_H$) (see formulae (6))

$$H = \frac{6,211 \times R_a \times P_d}{P_B - P_d \times R_a \times 10^{-2}}$$

$$H = \frac{6,211 \times 60 \times 3,2}{101,33 - (3,2 \times 0,60)}$$

$$H = 11,9959$$

$$k_H = \frac{1}{1 - 0,0329 \times (H - 10,71)}$$

$$k_H = \frac{1}{1 - 0,0329 \times (11,9959 - 10,71)}$$

$$k_H = 1,0442$$

4.2.2. Dilution factor (DF) (see formula (5))

$$DF = \frac{13,4}{c_{CO_2} + (c_{HC} + c_{CO}) \times 10^{-4}}$$

$$DF = \frac{13,4}{1,6 + (92 + 4,70) \times 10^{-4}}$$

$$DF = 8,091$$

4.2.3. Calculation of the corrected concentration of pollutants in the sampling bag:

HC, mass emissions (see formulae (4) and (1))

$$C_i = C_e - C_d \left(1 - \frac{1}{DF}\right)$$

$$C_i = 92 - 3 \left(1 - \frac{1}{8,091}\right)$$

$$C_i = 89,371$$

$$M_{HC} = C_{HC} \times V_{mix} \times Q_{HC}$$

$$Q_{HC} = 0,619$$

$$M_{HC} = 89,371 \times 51\,961 \times 0,619 \times 10^{-6}$$

$$M_{HC} = 2,88\ \frac{g}{test}$$

CO, mass emissions (see formula (1))

$M_{CO} = C_{CO} \times V_{mix} \times Q_{CO}$

$Q_{CO} = 1{,}25$

$M_{CO} = 470 \times 51\,961 \times 1{,}25 \times 10^{-6}$

$M_{CO} = 30{,}5 \frac{g}{test}$

$NO_x$, mass emissions (see formula (1))

$M_{NO_x} = C_{NO_x} \times V_{mix} \times Q_{NO_x} \times k_H$

$Q_{NO_x} = 2{,}05$

$M_{NO_x} = 70 \times 51\,961 \times 2{,}05 \times 1{,}0442 \times 10^{-6}$

$M_{NO_x} = 7{,}79 \frac{g}{test}$

4.3. **HC measurements with diesel engines**

To calculate HC-mass emissions for diesel engines the average HC concentration is calculated as follows:

$$c_e = \frac{\int_{t_1}^{t_2} c_{HC} \cdot dt}{t_2 - t_1} \qquad (7)$$

where:

$\int_{t_1}^{t_2} c_{HC} \cdot dt$ = integral of the recording of the heated FID over the test $(t_2 - t_1)$,

$c_e$ = concentration of HC measured in the diluted exhaust in ppm of $C_1$,

$c_e$ is substituted directly for $C_{HC}$ in all relevant equations.

4.4. **Example of a calculation**

4.4.1. *Data*

Ambient conditions

| | | |
|---|---|---|
| ambient temperature | 23 °C | = 296,2 K |
| barometric pressure | $P_B$ | = 101,33 kPa |
| relative humidity | $R_a$ | = 60 % |
| saturation vapour pressure of $H_2O$ at 23 °C | $P_d$ | = 3,20 kPa |

*Positive displacement pump (PDP)*

| | | |
|---|---|---|
| pump volume (from calibration data) | $V_o$ | = 2,439 litres per revolution |
| vacuum | $P_i$ | = 2,80 kPa |
| gas temperature | $T_p$ | = 51 °C = 324,2 K |
| number of pump revolutions | n | = 26 000 |

*Analyzer readings*

| | Diluted exhaust sample | Dilution-air sample |
|---|---|---|
| HC | 92 ppm | 3,0 ppm |
| CO | 470 ppm | 0 ppm |
| $NO_x$ | 70 ppm | 0 ppm |
| $CO_2$ | 1,6 % vol | 0,03 % vol |

4.4.2. *Calculation*

4.4.2.1. Gas volume (see formula (2))

$$V_{mix} = K_1 \times V_o \times n \frac{P_B - P_i}{T_P}$$

$$V_{mix} = 2{,}6961 \times 2{,}439 \times 26\,000 \times \frac{98{,}53}{324{,}2}$$

$$V_{mix} = 51\,960{,}89$$

*Note*

For CFV and similar CVS systems the volume may be read directly from the instrumentation.

4.4.2.2. Humidity correction factor (kH) (see formula (6))

$$H = \frac{6{,}211 \times R_a \times P_d}{P_B - (P_d \times \frac{R_a}{100})}$$

$$H = \frac{6{,}211 \times 60 \times 3{,}2}{101{,}33 - (3{,}2 \times 0{,}60)}$$

$$H = 11{,}99589$$

$$k_H = \frac{1}{1 - 0{,}0329 \times (H - 10{,}71)}$$

$$k_H = \frac{1}{1 - 0{,}0329 \times (11{,}9959 - 10{,}71)}$$

$$k_H = 1{,}0442$$

4.4.2.3. Dilution factor (DF) (see formula (5))

$$DF = \frac{13{,}4}{c_{CO_2} + (c_{HC} + c_{CO})\ 10^{-4}}$$

$$DF = \frac{13{,}4}{1{,}6 + (92{,}0 + 470)\ 10^{-4}}$$

$$DF = 8{,}091$$

4.4.2.4. Calculation of the corrected concentration of pollutants in the sampling bag

HC, mass emissions (see formulae (4) and (1))

$$C_i = C_e - C_d \left(1 - \frac{1}{DF}\right)$$

$$C_i = 92{,}0 - 3\left(1 - \frac{1}{8{,}091}\right)$$

$$C_i = 89{,}372$$

$$M_{HC} = C_{HC} \times V_{mix} \times Q_{HC}$$

$$Q_{HC} = 0{,}619$$

$$M_{HC} = 89{,}372 \times 51\,961 \times 0{,}619 \times 10^{-6}$$

$$M_{HC} = 2{,}87 \text{ g/test HC}$$

*ANNEX IV*

## TYPE II TEST

**(Carbon monoxide emission test at idling speed)**

1. INTRODUCTION

This Annex describes the procedure for the type II test defined in 5.2.1.2 of Annex I.

2. CONDITIONS OF MEASUREMENT

2.1. The fuel must be the reference fuel, specifications for which are given in Annex VI.

2.2. The type II test must be carried out immediately after the fourth operating cycle of the type I test, with the engine at idling speed, the cold-start device not being used. Immediately before each measurement of the carbon-monoxide content, a type I test operating cycle as described in Annex 2.1 of Annex III must be carried out.

2.3. In the case of vehicles with manually-operated or semi-automatic-shift gearboxes the test must be carried out with the gear lever in the 'neutral' position and with the clutch engaged.

2.4. In the case of vehicles with automatic-shift gear-boxes the test is carried out with the gear selector in either the 'neutral' or the 'parking' position.

2.5. **Components for adjusting the idling speed**

2.5.1. *Definition*

For the purposes of this Directive, 'components for adjusting the idling speed' means controls for changing the idling conditions of the engine which may be easily operated by a mechanic using only the tools described in 2.5.1.1. In particular, devices for calibrating fuel and air flows are not considered as adjustment components if their setting requires the removal of the set-stops, an operation which cannot normally be performed except by a professional mechanic.

2.5.1.1. Tools which may be used to control components for adjusting the idling speed: screwdrivers (ordinary or cross-headed), spanners (ring, open-end or adjustable), pliers, Allen keys.

2.5.2. *Determination of measurement points*

2.5.2.1. A measurement at the setting used for the type I test is performed first.

2.5.2.2. For each adjustment component with a continuous variation, a sufficient number of characteristic positions are determined.

2.5.2.3. The measurement of the carbon-monoxide content of exhaust gases must be carried out for all the possible positions of the adjustment components, but for components with a continuous variation only the positions defined in 2.5.2.2 are adopted.

2.5.2.4. The type II test is considered satisfactory if at least one of the two following conditions is met:

2.5.2.4.1. none of the values measured in accordance with 2.5.2.3 exceeds the limit values;

2.5.2.4.2. the maximum content obtained by continuously varying one of the adjustment components while the other components are kept stable does not exceed the limit value, this condition being met for the various combinations of adjustment components other than the one which was varied continuously.

2.5.2.5. The possible positions of the adjustment components are limited:

2.5.2.5.1. on the one hand, by the larger of the following two values: the lowest idling speed which the engine can reach; the speed recommended by the manufacturer, minus 100 revolutions per minute;

2.5.2.5.2. on the other hand, by the smallest of the following three values: the highest speed the engine can attain by activation of the idling speed components; the speed recommended by the manufacturer, plus 250 revolutions per minute; the cut-in speed of automatic clutches.

2.5.2.6. In addition, settings incompatible with correct running of the engine must not be adopted as measurement settings, In particular, when the engine is equipped with several carburettors all the carburettors must have the same setting.

3. SAMPLING OF GASES

3.1. The sampling probe is placed in the pipe connecting the exhaust with the sampling bag and as close as possible to the exhaust.

3.2. The concentration in CO ($C_{CO}$) and $CO_2$ ($C_{CO_2}$) is determined from the measuring instrument readings or recordings, by use of appropriate calibration curves.

3.3. The corrected concentration for carbon monoxide regarding four-stroke engines is:

$$C_{CO}\ \text{corr} = C_{CO} \frac{15}{C_{CO} + C_{CO_2}} \quad (\%\ \text{vol})$$

3.4. The concentration in $C_{CO}$ (see 3.2) measured according to the formulae contained in 3.3 need not be corrected if the total of the concentrations measured ($C_{CO} + C_{CO_2}$) is at least 15 for four-stroke engines.

*ANNEX V*

## TYPE III TEST

**(Verifying emissions of crankcase gases)**

1. INTRODUCTION

This Annex describes the procedure for the type III test defined in 5.2.1.3 of Annex I.

2. GENERAL PROVISIONS

2.1. Test III is carried out on the vehicle with gasoline-fuelled engine subjected to the type I and the type II test.

2.2. The engines tested must include leak-proof engines other than those so designed that even a slight leak may cause unacceptable operating faults (such as flat-twin engines).

3. TEST CONDITIONS

3.1. Idling must be regulated in conformity with the manufacturer's recommendations.

3.2. The measurements are performed in the following three sets of conditions of engine operation:

| Condition No | Vehicle speed (km/h) |
|---|---|
| 1 | Idling |
| 2 | 50 ± 2 |
| 3 | 50 ± 2 |

| Condition No | Power absorbed by brake |
|---|---|
| 1 | Nil |
| 2 | That corresponding to the settings for type I tests |
| 3 | That for conditions No 2, multiplied by a factor of 1,7 |

4. TEST METHOD

4.1. For the operation conditions as listed in 3.2 reliable function of the crankcase ventilation system must be checked.

5. METHOD OF VERIFICATION OF THE CRANKCASE VENTILATION SYSTEM

5.1. The engine's apertures must be left as found.

5.2. The pressure in the crankcase is measured at an appropriate location. It is measured at the dipstick hole with an inclined-tube manometer.

5.3. The vehicle is deemed satisfactory if, in every condition of measurement defined in 3.2, the pressure measured in the crankcase does not exceed the atmospheric pressure prevailing at the time of measurement.

5.4. For the test by the method described above, the pressure in the intake manifold is measured to within ± 1 kPa.

5.5. The vehicle speed as indicated at the dynamometer is measured to within ± 2 km/h.

5.6. The pressure measured in the crankcase is measured to within ± 0,01 kPa.

5.7. If in one of the conditions of measurement defined in 3.2 the pressure measured in the crankcase exceeds the atmospheric pressure, an additional test as defined in 6 is performed if so requested by the manufacturer.

6. ADDITIONAL TEST METHOD

6.1. The engine's apertures must be left as found.

6.2. A flexible bag impervious to crankcase gases and having a capacity of approximately five litres is connected to the dipstick hole. The bag must be empty before each measurement.

6.3. The bag must be closed before each measurement. It must be opened to the crankcase for five minutes for each condition of measurement prescribed in 3.2.

6.4. The vehicle is deemed satisfactory if in every condition of measurement defined in 3.2 no visible inflation of the bag occurs.

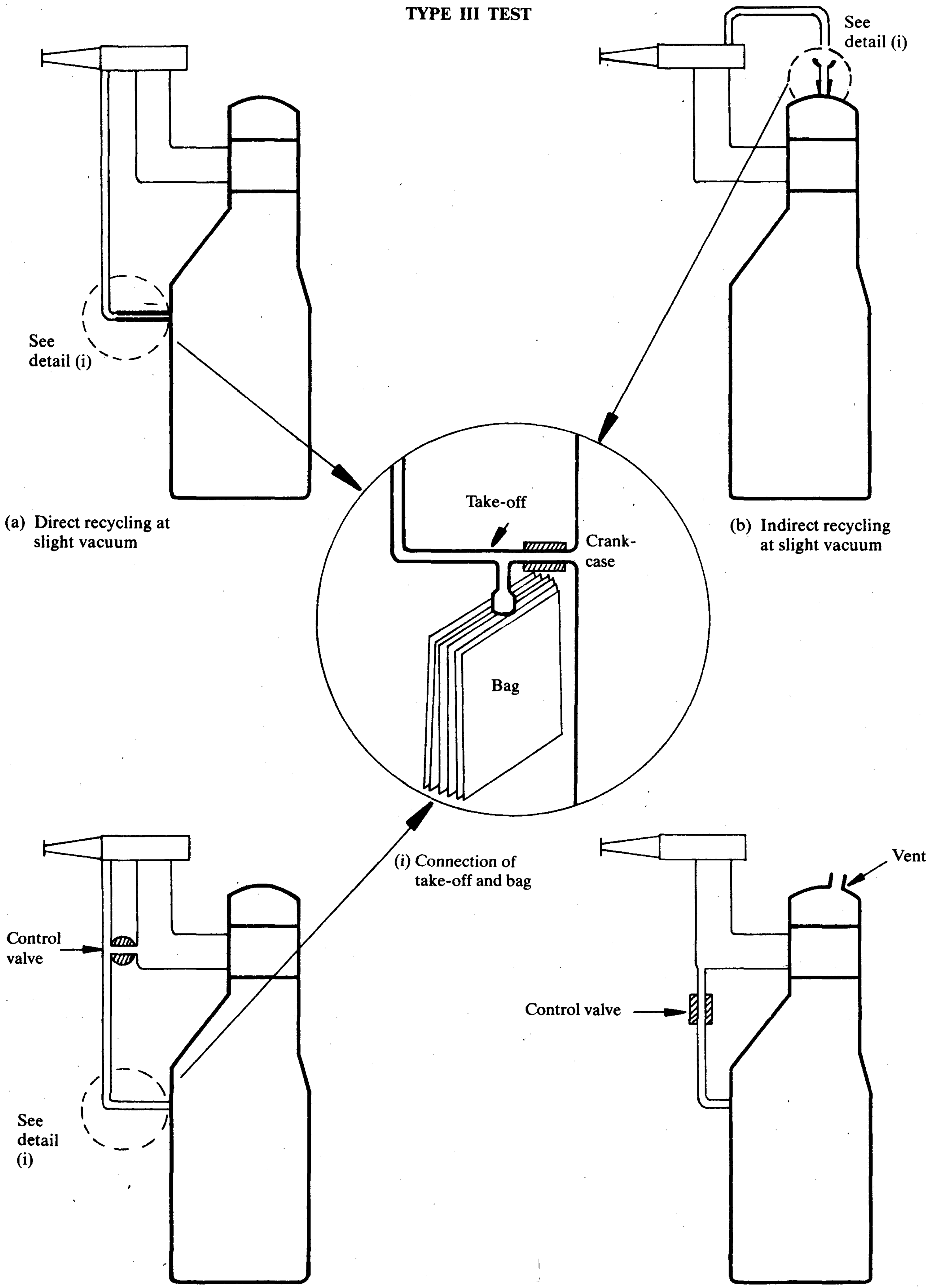
6.5. **Remark**

6.5.1. If the structural layout of the engine is such that the test cannot be performed by the methods described in 6 above, the measurements must be effected by that method modified as follows:

6.5.2. before the test, all apertures other than that required for the recovery of the gases are closed;

6.5.3. the bag is placed on a suitable take-off which does not introduce any additional loss of pressure and is installed on the recycling circuit of the device directly at the engine-connection aperture.

**TYPE III TEST**




(a) Direct recycling at slight vacuum

(b) Indirect recycling at slight vacuum

(i) Connection of take-off and bag

(c) Double-circuit direct recycling

(d) Venting of crank case with control valve (the bag must be connected to the vent)

*ANNEX VI*

## SPECIFICATIONS OF REFERENCE FUELS

1. TECHNICAL DATA OF THE REFERENCE FUEL TO BE USED TESTING VEHICLES EQUIPPED WITH A GASOLINE-FUELLED ENGINE

**CEC reference fuel RF-01-A-80**

Type: Premium gasoline, leaded

| | Limits and units | ASTM method |
|---|---|---|
| Research octane number | Min. 98,0 | 2 699 |
| Density at 15 °C | Min. 0,741 kg/litre<br>Max. 0,755 | 1 298 |
| Reid vapour pressure | Min. 0,56 bar<br>Max. 0,64 | 323 |
| Distillation | | 86 |
| Initial boiling point | Min. 24 °C<br>Max. 40 | |
| 10 % vol point | Min. 42<br>Max. 58 | |
| 50 % vol point | Min. 90<br>Max. 110 | |
| 90 % vol point | Min. 150<br>Max. 170 | |
| Final boiling point | Min. 185<br>Max. 205 | |
| Residue | Max. 2 % vol | |
| Hydrocarbon analysis | | 1 319 |
| Olefins | Max. 20 % vol | |
| Aromatics | Max. 45 | |
| Saturates | Balance | |
| Oxidation stability | Min. 480 minutes | 525 |
| Existent gum | Max. 4 mg/100 ml | 381 |
| Sulphur content | Max. 0,04 % mass | 1 266, 2 622<br>or 2 785 |
| Lead content | Min. 0,10 g/litre<br>Max. 0,40 g/litre | 3 341 |
| Nature of ocavonger | Motor mix | |
| Nature of lead alkyl | Not specified | |

(1) Equivalent ISO methods will be adopted when issued for all properties listed above.
(2) The figures quoted show the total evaporated quantities (% recovered + % loss).
(3) The blonding of this fuel must involve use of only conventional European refinery components.
(4) The fuel may contain oxidation inhibitors and metal de-activators normally used to stabilize refinery gasoline streams, but detergent/dispersant additives and solvent oils must not be added.
(5) 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.

2. TECHNICAL DATA OF THE REFERENCE FUEL TO BE USED TESTING VEHICLES EQUIPPED WITH A DIESEL ENGINE

**CEC reference fuel RF-03-A-80**

Type: Diesel fuel

| | Limits and units | ASTM method |
|---|---|---|
| Density at 15 °C | Min. 0,835<br>Max. 0,845 | 1 298 |
| Cetane Index | Min. 51<br>Max. 57 | 976 |
| Distillation (2) | | 86 |
| 50 % vol point | Min. 245 °C | |
| 90 % vol point | Min. 320<br>Max. 340 | |
| Final boiling point | Max. 370 | |
| Viscosity, 40 °C | Min. 2,5 cSt ($mm^2/s$)<br>Max. 3,5 | 445 |
| Sulphur content | Min. 0,20 % mass<br>Max. 0,50 | 1 266, 2 622 or 2 785 |
| Flash point | Min. 55 °C | 93 |
| Cold filter plugging point | Max. −5 °C | CEN draft pr 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 1 744 |
| Copper corrosion, 100 °C | Max. 1 | 130 |
| Neutralization (strong acid) number | Max. 0,20 mg KOH/g | 974 |

(1) Equivalent ISO methods will be adopted when issued for all properties listed above.
(2) The figures quoted show the total evaporated quantities (% recovered + % loss).
(3) This fuel may be based on straight run and cracked distillates; desulphurization is allowed. It must not contain any metallic additives.
(4) The values quoted in the specification are 'true values'. In establishment of their limit values the terms of ASTM D 3244 'Defining a basis for petroleum product quality disputes' have been applied and in fixing a maximum value, a minimum difference of 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.
(5) If it is required to calculate the thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from:
Specific energy (calorific value) (net) MJ/kg = $(46,423 - 8,792d^2 + 3,170d)\,[1 - (x + y + s)] + 9,420s - 2,449x$ where:
d is the density at 15 °C,
x is the proportion by mass of water (% divided by 100),
y is the proportion by mass of ash (% divided by 100),
s is the proportion by mass of sulphur (% divided by 100).

*ANNEX VII*

MODEL

Maximum size: A4 (210 × 297 mm)

| Name of administration |
|---|

**ANNEX TO THE EEC VEHICLE TYPE-APPROVAL CERTIFICATE WITH REGARD TO THE EMISSION OF GASEOUS POLLUTANTS FROM THE ENGINE**

(Articles 4 (2) and 10 of Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers)

In the light of the amendments made pursuant to Directive 83/351/EEC

EEC type-approval No: ........................................................

1. Category of the vehicle type ($M_1$, $N_1$, etc.): ........................................

2. Trademark or trade name of the vehicle: ........................................

3. Vehicle type: ........................ Engine type: ........................

4. Manufacturer's name and address: ........................................

........................................................................

5. If applicable, name and address of the manufacturer's authorized representative: ........

........................................................................

6. Mass of vehicle in running order: ........................................

6.1. Reference mass of vehicle: ........................................

7. Technically permissible maximum mass of vehicle: ........................................

8. Gearbox: ........................................

8.1. Manual or automatic (1) (2)

8.2. Number of gear ratios: ........................................

8.3. Transmission ratios (1): First gear N/V: ........................................

Second gear N/V: ........................................

Third gear N/V: ........................................

Fourth gear N/V: ........................................

Fifth gear N/V: ........................................

Final drive ratio: ........................................

Tyres: dimensions: ........................................

dynamic rolling circumference: ........................................

Wheel drive: front, rear, 4 × 4 (1)

(1) Delete as inapplicable.
(2) In the case of vehicles equipped with automatic-shift gearboxes, give all pertinent technical data.

8.4. Check of performance referred to in 3.1.6 of Annex III to this Directive ...............

.......................................................................

9. Date vehicle submitted for approval: ...........................................

10. Technical service responsible for type-approval tests: ................................

11. Date of test report issued by that service: .........................................

12. Number of test report issued by that service: .......................................

13. EEC type-approval granted/refused (1)

14. Results of approval tests:

Inertia equivalent mass: ............................................... kg

Absorbed power $P_a$: ........................................ kW at 50 km/h

Method of setting: ......................................................

14.1. Test type I (1):

CO: .......... g/test HC: .......... g/test $NO_x$: .......... g/test

14.2. Test type II (1):

CO: ......... % vol at: ......... idle r/min

14.3. Test type III (1):

.................................................................

15. Gas sampling system used:

15.1. PDP/CVS (1)

15.2. CFV/CVS (1)

15.3. CFO/CVS (1)

16. Place: ..............................................................

17. Date: ...............................................................

18. Signature: ...........................................................

19. The following documents, bearing the EEC type-approval number shown above are attached to this Annex:

— one copy of Annex II to this Directive, duly completed and with the drawings and diagrams referred to attached

— one photograph of the engine and its compartment

— .................................................................

(1) Delete as inapplicable.