COMMISSION OF THE EUROPEAN COMMUNITIES

COM (82) 170 final

Brussels, 5 April 1982

Proposal for a
Council Directive
amending Council Directive No 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 of motor vehicles.

(Submitted to the Council by the Commission)

EXPLANATORY MEMORANDUM

The limit values applicable to emissions of carbon monoxide (CO) and unburnt hydrocarbons (HC) were laid down for the Community as a whole in Council Directive 70/220/EEC of 20 March 1970 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** (1). In the context of adaptation to technical progress, these limit values were reduced in 1974 by Directive 74/290/EEC (2) and maximum values for nitrogen oxide (NO_x) emissions were laid down in 1976 in Directive 77/102/EEC (3). In order to take account of more stringent requirements relating to the protection of public health and the environment, the limit values applicable to these three pollutants were then reduced in 1978 in Directive 78/665/EEC (4).

In order that the progress achieved through the implementation of these measures may not be cancelled out again by increases in traffic density in highly urbanized areas of the Community, a further reduction in the limit values seems to be required. The Commission, in close cooperation with the experts of the national authorities and from the automobile industry, has therefore examined the feasibility of lowering the level of pollutant emissions. It has emerged that the present state of technical development in motor-vehicle construction would make it possible, within a relatively short time and in relation to the limits laid down in Directive 78/665/EEC, to achieve a 23 % reduction in CO emissions and a 20 to 30 % reduction, according to the weight category, in the combined HC and NO_x emissions. This proposal for a Directive is based on those findings.

Establishing a combined limit value for the permissible emissions of HC and MO_x appeared to be advisable because it gives motor-vehicle manufacturers considerable leeway in the choice of engine modifications to be made for the purpose of reducing such emissions. This combined value is also justified from the standpoint of air purity, since the latest information reveals that it is precisely the interaction between these pollutants in the atmosphere that contributes to the formation of photochemical smog.

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(1) OJ L 76, 6.4.1970, p. 1
(2) OJ L 159, 15.6.1974, p. 61
(3) OJ L 32, 3.2.1977, p. 32
(4) OJ L 223, 14.8.1978, p. 48

The proposal also provides for the adoption of the constant-volume sampling and analysis method (CVS) at present used in the United States, Japan and Sweden. With this method it would be possible to increase the accuracy of the measurements and standardize more effectively the metrological facilities used by the technical departments responsible for type-approval tests and by the manufacturers. Owing to the modification made to the measuring procedure, it is no longer possible to compare directly the limit values for HC and NO_x laid down in the preceding directives with those in this proposal.

At the request of the Commission, the manufacturers'associations have assessed the repercussions of reinforcing the Community Directives in terms of construction costs and, in particular, the fuel consumption of the vehicle categories concerned. On the basis of the state of the art required for the application of Directive 78/665/EEC, that study revealed, on the one hand, that the need to improve the ignition and carburation systems will result in higher construction costs and, on the other hand, that fuel consumption is likely to increase by as much as 5 %, depending on the type of vehicle.

The Commission took these arguments into account when it was considering the preparation of this proposal for a Directive. It is not of the opinion that the application of the provisions relating to exhaust gases would prevent the manufacturers from fulfilling the voluntary undertakings to reduce consumption which they entered into at national level and which should, as they indicated to the Commission, result in a reduction of at least 10 % in the fuel consumption of cars sold in the Community in 1985 in comparison with 1978. On the contrary, having regard to the consumption decreases already ascertained or announced, it considers that the options open to manufacturers in this field are much more extensive than those on which these undertakings are based, so that any increase in consumption of up to 5 % resulting from the Community provisions relating to exhaust gases could be offset during the time available.

After taking into consideration all the available information, the Commission is convinced that the objectives of this proposal for a Directive on the protection of the environment and of health justify a possible increase in costs as well as less favourable prospects of reducing consumption to the level indicated.

In view of the increasing use of diesel engines in cars and light commercial vehicles (vehicles in categories M_1 and N_1) it is advisable to bring the

CO, HC and NO_x emissions from such engines within the scope of the Community Directives as a sequel to the limitation of soot emissions from diesel engines by means of the provisions of Directive 72/306/EEC (1). Extending the scope to diesel engines requires an amendment to the operative part of Directive 70/220/EEC. Consequently, such an amendment cannot be made through the procedure of the Committee on the Adaptation of the provisions of the Annexes to Technical Progress, but must be placed before the Council for the purpose of adoption.

As in the case of previous amendments, this proposal is based on the work of the Group of Rapporteurs on Atmospheric Pollution and Energy (GRPE) of the United Nations Economic Commission for Europe, whose Regulation No 15 corresponds in its technical content to Directive 70/220/EEC. Such an approach has the advantage of harmonization which goes beyond the frontiers of the Community and enables the European manufacturers to have access to a much larger market than that of the Community alone.

In view of the work in progress in that body, and of the surveys conducted by the Commission, the Member States had adopted a common attitude within the Permanent Representatives Committee. Their representatives in Geneva won acceptance for that opinion within the GRPE and thus made it possible for the Economic Commission for Europe to notify the 04 series of amendments to Regulation 15 to the Signatory States in May 1981.

In accordance with an undertaking given at the meetings of the Council of Ministers for the Environment held in December 1980 and June 1981, the Commission prepared this draft on the basis of the 04 series of amendments to Regulation 15, as soon as it received the definitive texts from Geneva. As desired by the Member States, this draft corresponds as closely as possible in its technical aspects to the 04 series of amendments. The proposed dates of application take account of the corresponding opinions put forward by the experts from the Member States when the draft proposal

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(1) OJ L 190, 20.8.1972

was being examined by the Working Party on Motor Vehicles at its 68th meeting on 7-9 October 1981. These dates were chosen so that the application of the amended Community provisions would not cause difficulties for either the national authorities or the motor-vehicle manufacturers.

At this meeting the experts concurred with the Commission view that, given the moderate nature of the measures proposed and the urgent need for a decision to be taken in this connection, these measures should be dealt with outside the scope of the general approach described in the Commission's observations on the European automobile industry in 1981 (*). This new approach will apply to all subsequent stages in the formulation of Community rules in this area. The aims of these stages will be determined on the basis of a detailed examination of the economic, environmental and social effects of the measures envisaged. This will, at the same time, ensure greater protection of human health and of the environment and will provide a regulatory framework appropriate to the satisfactory development of the Community automobile industry.

The global approach proposed by the Commission has been accepted by all the national administrations and professional organizations represented within the Working Party on Motor Vehicles. The machinery necessary for launching such an approach was set up in the field of pollution emissions with the creation in January 1982 of the Working Party on Air Pollution. This Working Party has 18 months in which to examine the technical possibilities for reducing pollution emissions and to assess the repercussions thereof, notably with regard to fuel consumption and vehicle manufacturing and servicing costs. Its final report will enable the Commission to forward to the Council, in good time, balanced proposals on the regulatory measures to follow those contained in this draft.

(*) COM(81) 317 final, 11 June 1981.

REMARKS CONCERNING THE PROPOSAL FOR A DIRECTIVE

Article 1 (1) amends Article 1 of Directive 70/220/EEC by providing that diesel engines ('compression-ignition engines') shall henceforth fall within the scope of this Directive. Paragraph (2) substitutes the Annexes to this Directive for the Annexes to Directive 70/220/EEC, including the various amendments. Article 2 lays down the deadlines for the adoption, publication and implementation of the provisions by the authorities in the Member States. Observance of the limit values proposed for HC and NO_x emissions is, on the face of it, impossible at present in the case of vehicles of types other than cars. For this reason, Annex I contains transitional provisions setting out less severe limits for such vehicles.

By the date by which the Member States will have implemented the provisions of Article 2 (3), the vehicles in respect of which type-approval was granted before the entry into force of this Directive may have entered into service for the first time. To enable a manufacturing conformity inspection to be carried out subsequently in respect of these vehicles, the transitional provisions lay down that the corresponding provisions of Directive 70/220/EEC, as amended by Directive 78/665/EEC, shall remain in force until that date.

OPINIONS OF THE EUROPEAN PARLIAMENT AND THE ECONOMIC AND SOCIAL COMMITTEE

Pursuant to the provisions of the second paragraph of Article 100, both of these institutions must be consulted.

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PROPOSAL FOR A COUNCIL DIRECTIVE

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

THE COUNCIL OF THE EUROPEAN COMMUNITIES -

Having regard to the Treaty establishing the European Economic Community,

Having regard to the proposal from the Commission,

Having regard to the Opinion of the European Parliament,

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

Whereas the 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 Council Directive 70/220/EEC(1) lays down the limit values for carbon monoxide and unburnt hydrocarbon emissions from such engines ; whereas these limit values were first reduced by Council Directive 74/290/EEC(2) and supplemented, in accordance with Commission Directive 77/102/EEC(3), by limit values for permissible emissions of nitrogen oxides, whereas the limit values for these three pollutants were further lowered by Commission Directive 78/665/EEC(4);

Whereas the protection of public health and the environment necessitates a further reduction in these limit values ; whereas advances in motor-vehicle engine design now enable such a reduction to be made ; 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 ;

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(1) OJ L 76, 6.4.1970, p. 1
(2) OJ L 159, 15.6.1974, p. 61
(3) OJ L 32, 3.2.1977, p. 32
(4) OJ L 223, 14.8.1978, p. 48

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 Council Directive 72/306/EEC(1), 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 would affect the content of the technical Annexes ; whereas the Commission has proposed to the Council that part of this Directive be adopted by way of derogation from Article 5 of Directive 70/220/EEC.

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(1) OJ L 190, p. 1

Article 1

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

1. 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."

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

Article 2

1. From 1 October 1983, the Member States shall neither, 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 of a type of motor vehicle, nor
   - 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:
   - shall 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 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.

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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 September 1983 and shall forthwith inform the Commission thereof.

Article 4

This Directive is addressed to the Member States.

ANNEX I

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

1. SCOPE

This Directive applies to the emission of gaseous pollutants from all motor vehicles of categories M_1 and N_1 1) equipped with positive ignition engines except two-stroke engines and 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 Annex III, item 5.2., and

2.1.2. the engine and vehicle characteristics as defined in Annex II, items 1-6 and 8 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 item 2.6. of Annex I to Directive 70/156/EEC;

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

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1) As defined in item 0.4 of Annex I to Directive 70/156/EEC (J.O. N° L 42 of 23.2.1970).

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. This, to assist engines start up;

2.7. "Starting aid" means a device which assists engine start up wihtout enrichment of the air fuel mixture of the engine, e.g., glow plugs and glow plug and injection timing changes.

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 shall be submitted by the vehicle manufacturer or by his appointed representative.

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

3.2.1. A description of the engine type comprising all the particulars referred to in Annex 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 shall be submitted for the tests described in section 5 of this annex to the technical service responsible for type-approval tests.

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4. EEC TYPE-APPROVAL

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

5. SPECIFICATIONS AND TESTS

5.1. General

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

5.2. Description of tests

5.2.1. The vehicle shall be subjected, according to its category, 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 shall be carried out on all vehicles referred to in item 1, whose maximum mass does not exceed 3.5 metric tons.

5.2.1.1.2. The vehicle shall be 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 shall be carried out without interruption. Each cycle shall comprise 15 phases (idling, acceleration, steady speed, deceleration, etc.). During the test the exhaust gases shall be diluted and a proportional sample collected in one or more bags. The exhaust gases of the vehicle tested must be diluted, sampled and analysed following the procedure described below; the total volume of the diluted exhaust must be measured.

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5.2.1.1.3. The test shall be carried out by the procedure described in Annex III. The methods used to collect and analyse the gases shall 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 provisions of items 5.2.1.1.4.2. and 5.2.1.1.5., the test shall be 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 shall 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
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 item 5.2.1.1.4., not more than one of the three results obtained may exceed by not more than 10 per cent the limit prescribed in that item 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 shall be immaterial whether this occurs in the same test or in different tests (1).

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

5.2.1.1.4.2. The number of tests prescribed in item 5.2.1.1.4. above may on the request of the manufacturer be increased to 10 tests provided that the arithmetic 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 per cent of the limit. In this case, the decision, after testing, shall depend exclusively on the average results obtained from all 10 tests ($\bar{x} < L$).

5.2.1.1.5. The number of tests prescribed in item 5.2.1.1.4. above shall be 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 item 5.2.1.1.4.

5.2.1.1.5.1. Only one test shall be 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 shall be made 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.

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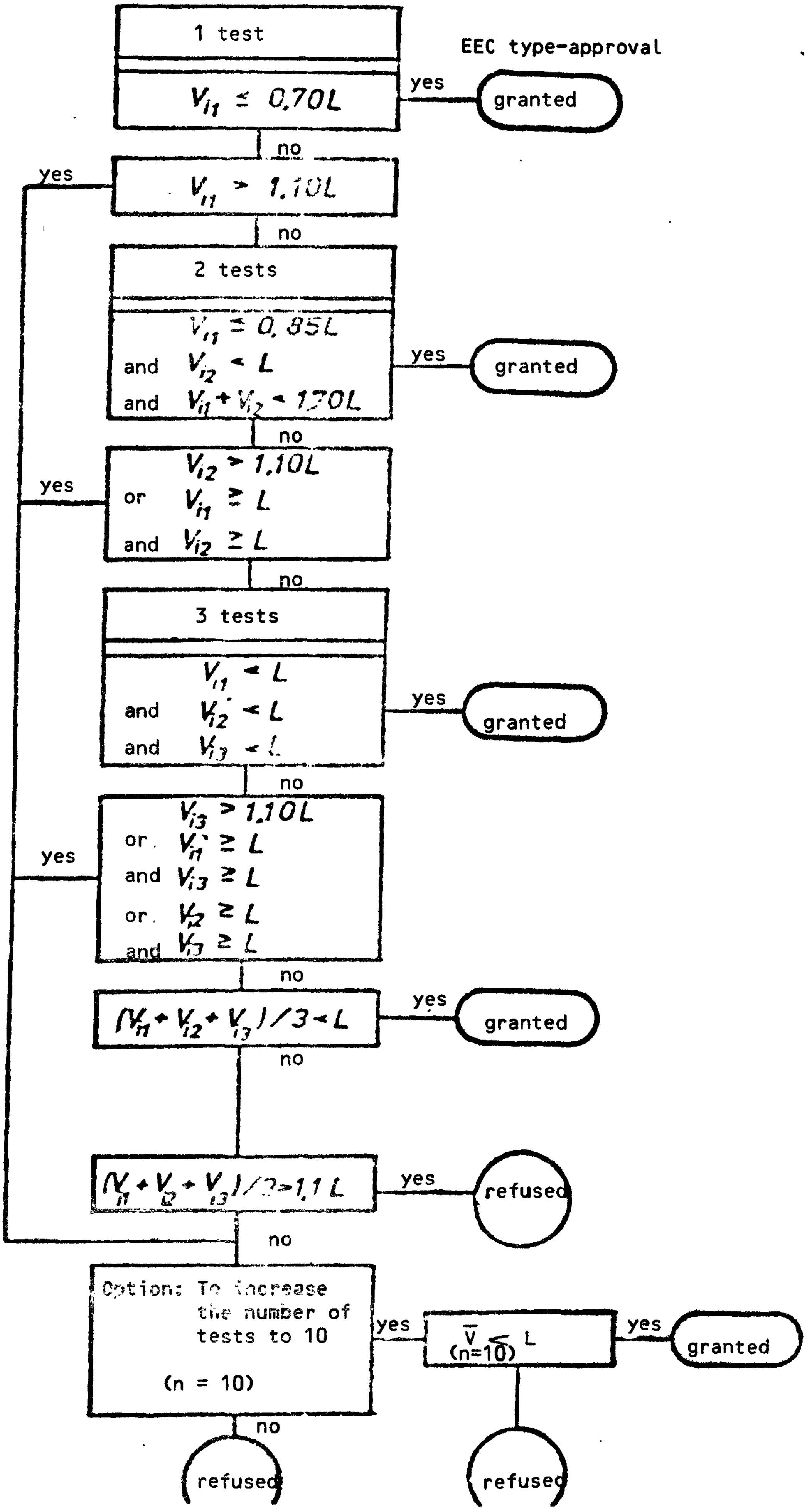

Figure 1: Flow Sheet for the Type-Approval of the European Test Procedure (See item 5.2.)

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 shall be carried out on all vehicles referred to in item 1 above.

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 per cent. When a check is made in accordance with the provisions 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 shall not exceed 4.5 per cent.

5.2.1.2.3. Conformity with the last preceding requirement shall be checked by a test carried out by 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 shall be carried out on all vehicles referred to in item 1. above except those having compression ignition engines.

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

5.2.1.3.3. Conformity with the last preceding requirement shall be checked by a test carried out by the procedure described in Annex V.

6. EXTENSION OF EEC TYPE-APPROVAL

6.1. Vehicle types of different reference weights

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.

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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 shall be 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 shall be 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 over-all 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 over-all transmission ratios:

6.2.1.1. For each of the transmission ratios used in the type I test, it shall be necessary to determine the proportion $E = \frac{V2 - V1}{V1}$ where V1 and V2 are respectively the speed at 1,000 r.p.m. 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 $E \leqslant 8$ per cent, the extension shall be granted without repeating the type I tests.

6.2.3. If for at least one gear ratio $E > 8$ per cent and if for each gear ratio $E \leqslant 13$ per cent, the type I tests shall be repeated, but may be performed in a laboratory chosen by the manufacturer subject to the approval of the Authorities granting approval. The report of the tests shall be sent to the technical service.

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6.3. <u>Vehicle types of different reference masses and different over-all transmission ratios</u>

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 over-all transmission ratios, provided that all the conditions prescribed in items 6.1. and 6.2. are fulfilled.

6.4. <u>Note</u>

When a vehicle type has been approved in accordance with the provisions of items 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, shall be 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 item 5.2.

7.1.1. Conformity of the vehicle in a Type I test shall be checked as follows:

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

Reference weight 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	25,8
$1\,020 < RW \leq 1\,250$	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 item 8.3.1.1., 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 shall determine the size n of the sample. Vehicles other than the vehicle origianlly taken shall be 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) shall be determined for both the carbon monoxide emission and for the combined emissions of hydrocarbons and oxides of nitrogen. The production of the series shall then be deemed to conform if the following condition is met:

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

where
'L' is the limit value laid down in item 8.3.1.1. 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	0,198

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

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 items 5.2.1.2.2. and 5.2.1.3.2. shall be complied with.

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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.

7.1.3. Notwithstanding the provisions of Annex III, point 3.1.1., 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. Concerning 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, 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 of items 5.2.1.1.4. and 7.1.1.1. by a factor of 1.25.

8.2. For checking of production conformity of vehicles which have been type-approved before the 1.10.198. 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 above-mentionned Directive remain applicable until the Member States make use of Article 2, para 3.

ANNEX II

ESSENTIAL CHARACTERISTICS OF THE ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TESTS 1/

1. Description of engine

1.1. Make ....

1.2. Type ....

1.3. Working principle: positive ignition/compression ignition, four stroke/two stroke 3/ ....

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 2/ ....

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

1.10 Cooling system : liquid/air cooling (3)

1.11. Supercharger: yes/no 3/ Description of the system ....

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1.12. Intake system

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

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

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

1.13. Device for recycling crank-case gases (description and diagrams)

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

Description and diagrams ....

(See notes at the end of this annex)

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.)

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3.2. Fuel feed

3.2.1. by carburettor(s) 3/ .... Number ....

3.2.1.1. Make ....

3.2.1.2. Type ....

3.2.1.3. Adjustments 2/

3.2.1.3.1. Jets ....)

3.2.1.3.2. Venturis ....)

3.2.1.3.3. Float-chamber level ......)

3.2.1.3.4. Weight of float ....)

3.2.1.3.5. Float needle ....)

or

Curve of fuel delivery plotted against air flow, and settings required to keep to the curve 3/ 2/

3.2.1.4. Manual/automatic choke 3/ .... Closure setting 2/ ......

3.2.1.5. Feed Pump

Pressure 2/ .... or characteristic diagram 2/..

3.2.2. By fuel injection 3/ system description
Working principle: Intake manifold/direct injection
injection Prechamber/swirl chamber 3/ ....

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 rpm 2/ 3/
or, alternatively, a characteristic diagram 2/ 3/
calibration procedure: test bench/engine 3/ ....

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 ....

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 3/ ....

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 3/ 2/

6. Exhaust system

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 ....

7.3. Ignition condenser

7.3.1. Make ....

7.3.2. Type ....

8 Engine performance (declared by manufacturer)

8.1. Idle r.p.m. 3/ ....

8.2. Carbon monoxide content by volume in the exhaust gas with the engine idling - per cent (manufacturer's standard) ....

8.3. R.p.m. at maximum power 3/ ....

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

9. Lubricant used ....

9.1. Make ....

9.2. Type ....

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

2/ Specify the tolerance.

3/ Strike out what does not apply.

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 **item 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 shall be 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 should 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 gear-box

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 shall be 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 gear-boxes shall be tested by using the gears normally employed for driving, and the gear shift shall be used in accordance with the manufacturer's instructions.

2.3.3. Vehicles equipped with automatic-shift gear-boxes shall be tested with the highest gear ("Drive") engaged. The accelerator shall 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 shall not apply; acceleration shall 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 **item 2.4.** below shall apply.

OPERATING CYCLE ON THE CHASSIS DYNAMOMETER

No of operation	Operation	Phase	Acceleration m/sec^2	Speed km/h	Duration of each		Cumulative time (sec)	Gear to be used in the case of a manual gearbox
					Operation (sec)	Phase (sec)		
1	Idling	1			11	11	11	6 sec PM+5 sec 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	5	25	1
5	Deceleration, clutch disengaged		— 0·92	10–0	3		28	K 1
6	Idling	5			21	21	49	16 sec PM+5 sec 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 sec PM+5 sec 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 sec PM

[1] PM - Gearbox in neutral, clutch engaged.
K_1, K_2 = First or second gear engaged, clutch disengaged.

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

2.4. Tolerances

2.4.1. A tolerance of ± 1 km/h shall be 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 provisions of item 6.5.3. below shall apply. Speed tolerances greater than those prescribed shall be accepted during phase changes provided that the tolerances are never exceeded for more than 0.5 second on any one occasion.

2.4.2. Time tolerances of ± 0.5 second. The above tolerances shall apply equally at the beginning and at the end of each gear-changing period.[1/]

2.4.3. The speed and time tolerances shall be combined as indicated in appendix 1 to this annex.

3. VEHICLE AND FUEL

3.1. Test vehicle

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

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

3.1.3. The tightness of the admission 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 shall 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 cleaning system.

1/ It should be noted that the time of 2 seconds allowed includes the time for changing the combination and, if necessary, a certain amount of latitude to catch up with the cycle.

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

3.1.6. The laboratory may verify that the vehicle conforms to the performances 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 shall be tested with the catalyst fitted, if the vehicle manufacturer states that the vehicle so equipped and supplied with gasoline having a lead content of up to 0.4 g/l is capable of complying with the provisions of this **Directive** for the catalyst life as defined by the car manufacturer.

3.2. Fuel

The appropriate reference fuel as defined in **Annex VI shall 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 shall not be affected by the lapse of time. It shall not produce any vibrations perceptible to the vehicle and likely to impair the vehicle's normal operations.

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

4.1.4. Accuracy

4.1.4.1. It shall be possible to measure and read the indicated load to an accuracy of ± 5 per cent.

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 shall be ± 5 per cent. In the case of a dynamometer with adjustable load curve the accuracy of matching dynamometer load to road load shall be 5 per cent at 30, 40 and 50 km/h and 10 per cent 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 shall be measured by the speed of rotation of the roller (the front roller in the case of a two roller dynamometer). It shall 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 shall 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 shall 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 that shall be used is the Constant Volume Sampler 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 shall be sufficient to eliminate water condensation at all conditions which may occur during a test, as defined in appendix 5 .

4.2.3. Fig. 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 shall be homogeneous at point S2 of the sampling probe.

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

4.2.6. The system should be free of gas leaks. The design and materials shall 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 then sampling for that pollutant shall 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 shall be connected as near as possible to the vehicle.

4.2.8. Static pressure variations at the tailpipe(s) of the vehicle shall remain within ± 1.25 kPa of the static pressure variations measured during the dynamometer driving cycle with no connexion to the tailpipe(s). Sampling systems capable of maintaining the static pressure to within ± 0.25 kPa will be used if a written request from a manufacturer to the Administration granting the approval substantiates the need for the closer tolerance. The back-pressure shall be measured in the exhaust pipe as near as possible to its end or in an extension having the same diameter.

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

4.2.10. The Gas Samples shall be collected in sample bags of adequate capacity. These bags shall be made of such materials as will not change the pollutant gas by more than ± 2 per cent after 20 minutes of storage.

4.3. Analytical equipment

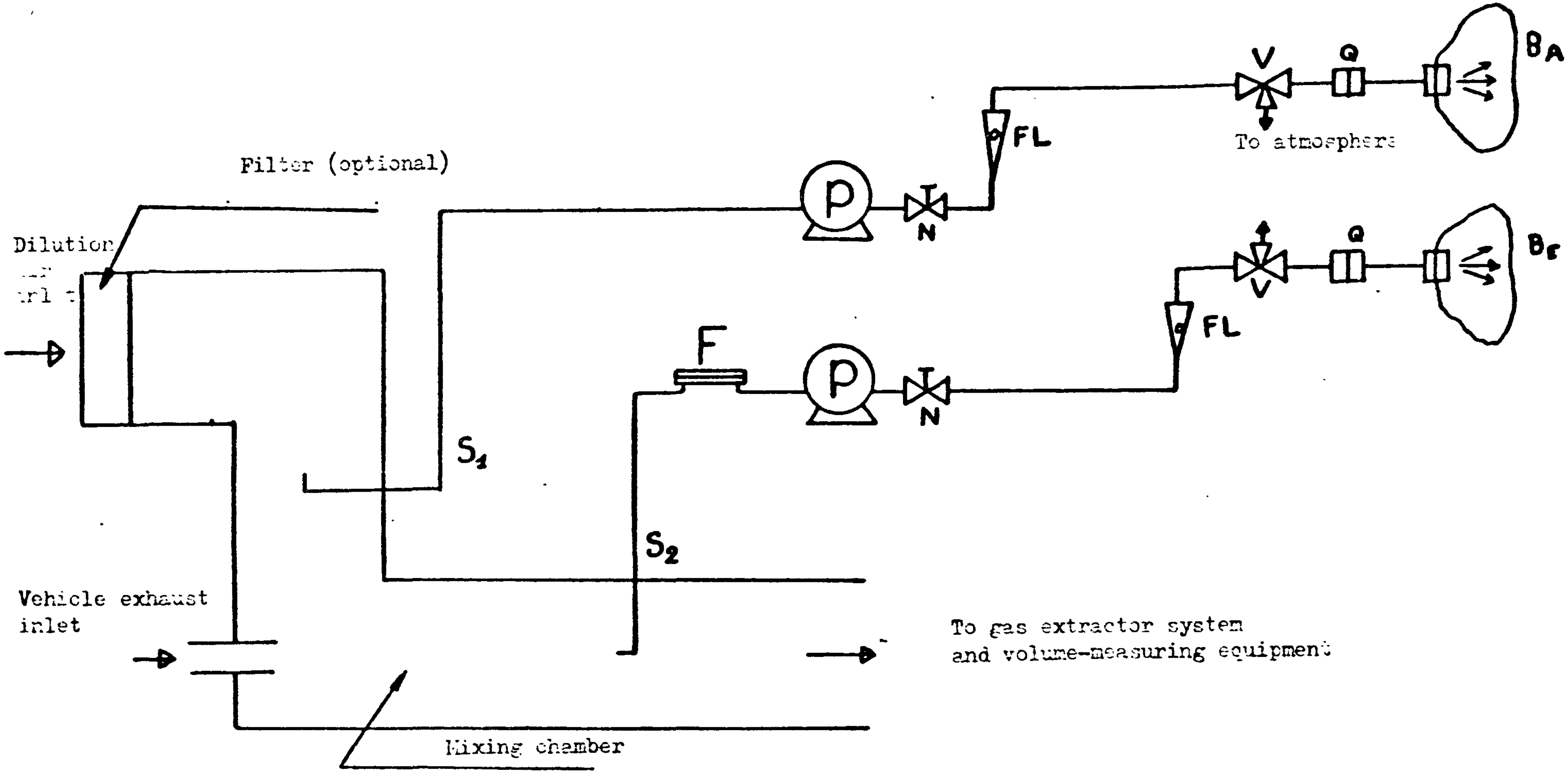
4.3.1. Provisions

4.3.1.1. Pollutant gases shall be analysed with the following instruments:

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

The carbon monoxide and carbon dioxide analysers shall be of the non-dispersive infrared (NDIR) absorption type.

Figure 1 - DIAGRAM OF EXHAUST GAS SAMPLING SYSTEM



Hydrocarbons (HC) analysis - spark ignition engines:

The hydrocarbons analyser shall be of the **flame ionization** (FID) type calibrated with propane gas expressed equivalent to carbon atoms (C).

Hydrocarbons (HC) analysis - **compression ignition engines:**

The hydrocarbons analyser shall be of the **flame ionization** type with Detector, Valves, Pipework, etc. heated to 190 ± 10°C (HFID). It shall be calibrated with propane gas expressed equivalent to carbon atoms (C).

Nitrogen oxide (NO_x) analysis:

The nitrogen oxide analyser shall be either of the chemiluminescent (CLA) or of the non-dispensive ultra-violett resonance absorption (NDUVR) type, both with an NO_x - NO converter.

4.3.1.2. Accuracy

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

Measurement error shall not exceed ± 3 per cent, disregarding the true value of the calibration gases.

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

4.3.1.3. Ice-trap

No gas drying device shall be used before the analysers 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) is to be used. The average** concentration of the measured hydrocarbons shall be determined by integration. Throughout the test, the temperature of the heated sample line shall be controlled at 190 ± 10°C. The heated sampling line shall be fitted with a heated filter (F_H) (99 per cent efficient with particle $\geq 0.3\,\mu m$ to extract any solid particles from the continuous flow of gas required for analysis.

The sampling system **response time (from the probe to the analyser inlet)** shall be no more than 4 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 flow is made.

4.3.3. Calibration -

Each analyser shall 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 that shall be used is described in appendix 6 for the analysers indicated in item 4.3.1.

4.4. Volume measurement

4.4.1. The method of measuring total dilute exhaust volume incorporated in the Constant Volume Sampler shall be such that measurement is accurate to ± 2 per cent.

4.4.2. Constant Volume Sampler Calibration

The Constant Volume Sampler system volume measurement device shall 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 shall utilize a flow metering device which is dynamic and suitable for the high flow rate encountered in Constant Volume Sampler testing. The device shall be of certified accuracy traceable to an approved national or international standard.

4.5. Gases

4.5.1. Pure Gases

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

Purified nitrogen (purity $\leq$ 1 ppm C $\leq$ 1 ppm CO, $\leq$ 400 ppm CO_2, $\leq$ 0.1 ppm NO);

Purified synthetic air (purity $\leq$ 1 ppm C_1 $\leq$ 1 ppm CO, $\leq$ 400 ppm CO_2, $\leq$ 0.1 ppm NO);

oxygen content between 18 and 21 per cent vol;

Purified oxygen (purity $\geq$ 99.5 per cent vol O_2);

Purified hydrogen (and mixture containing hydrogen) (purity $\leq$ 1 ppm C_1, $\leq$ 400 ppm CO_2).

4.5.2. Calibration and span gases

Gases having the following chemical compositions shall be available:

Mixtures of:

C_3H_8 and purified synthetic air (see **item 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 per cent of the NO content);

The true concentration of a calibration gas shall be within ± 2 per cent 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 shall be such that the concentrations of the diluted calibration gases may be determined within ± 2 per cent.

4.6. <u>Additional equipment</u>

4.6.1. Temperatures

The temperatures indicated in appendix 8 shall be measured with an accuracy of ± 1.5°C.

4.6.2. Pressure

The atmospheric pressure shall be measurable to within ± 0.1 kPa.

4.6.3. Absolute humidity

The absolute humidity (H) shall be measurable to within ± 5 per cent.

4.7. The exhaust gas-sampling system shall be verified by the method described in appendix 7, **item 3. The maximum permissible deviation between the quantity of gas introduced and the quantity of gas measured shall be 5 per cent.**

5. PREPARING THE TEST

5.1. <u>Adjustment of inertia simulators to the vehicle's translatory inertias</u>

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

Reference mass of vehicle RW (kg)	Equivalent inertias I (kg)
RW ≤ 750	680
750 < RW ≤ 850	800
850 < RW ≤ 1020	910
1020 < RW ≤ 1250	1130
1250 < RW ≤ 1470	1360
1470 < RW ≤ 1700	1590
1700 < RW ≤ 1930	1810
1930 < RW ≤ 2150	2040
2150 < RW ≤ 2380	2270
2380 < RW ≤ 2610	2270
2610 < RW	2270

5.2. Setting of dynamometer

The load shall be adjusted according to methods described in item 4.1.4.

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

5.3. Conditioning of vehicle

5.3.1. Before the test, the vehicle shall be kept in a room in which the temperature remains relatively constant between 20°C and 30°C.

This conditioning shall be carried out for at least six hours and shall continue until the engine oil temperature and coolant, if any, have reached the temperature of the room to within ± 2°C.

At the request of the manufacturer, the test shall be carried out not later than 30 hours after the vehicle has been run at its normal temperature.

5.3.2. The tyre pressure shall be the same as that indicated by the manufacturer and used for the preliminary road test for brake adjustment.

The tyre pressures may be increased by up to 50 per cent from the manufacturer's recommended setting in the case of a two roll dynamometer.

The actual pressure used shall 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 shall 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 shall be such that:

$$5.5 \leq H \leq 12.2 \text{ gH}_2\text{O/kg dry air.}$$

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

6.1.3. The test shall 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 shall be 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 shall 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 shall be kept idling for a period of 40 seconds. The first cycle shall begin at the end of the aforesaid period of 40 seconds at idle.

6.3. Idling

6.3.1. Manual-shift or semi-automatic gear-box.

6.3.1.1. During periods of idling the clutch shall 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 shall be placed in first gear, with the clutch disengaged, 5 seconds before the acceleration following the idling period considered.

6.3.1.3. The first idling period at the beginning of the cycle shall consist of 6 seconds of idling in neutral with the clutch engaged and 5 seconds in first gear with the clutch disengaged.

6.3.1.4. For the idling periods during each cycle the corresponding times shall be 16 seconds in neutral and 5 seconds in first gear with the clutch disengaged.

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

6.3.2. Automatic-shift gear-box.

After initial engagement the selector shall not be operated at any time during the test except in accordance with item 6.4.3.

6.4. Accelerations

6.4.1. Accelerations shall 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 shall be deducted from the time allowed for changing the combination, if possible, and in any case, from the subsequent steady-speed period.

6.4.3. Automatic-shift gear-boxes

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

6.5. Decelerations

6.5.1. All decelerations shall be effected by removing the foot completely from the accelerator, the clutch remaining engaged. The clutch shall be 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 shall be used to enable the timing of the cycle to be abided by.

6.5.3. If the period of deceleration is shorter than that prescribed for the corresponding phase, the timing of the theoretical cycle shall be 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 shall be placed in neutral and the clutch engaged.

6.6. Steady speeds

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

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

7. PROCEDURE FOR SAMPLING AND ANALYSIS

7.1. Sampling

Sampling shall begin at the beginning of the test cycle as defined in item 6.2.2. and end at the end of the idling period after the fourth cycle.

7.2. Analysis

7.2.1. The exhaust gases contained in the bag shall be analysed 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 analyser range to be used for each pollutant shall be set to zero with the appropriate zero gas.

7.2.3. The analysers shall then be set to the calibration curves by means of span gases of nominal concentrations of 70 to 100 per cent of the range.

7.2.4. The analysers zeros shall then be rechecked. If the reading differs by more than 2 per cent of range from that set in item 7.2.2. the procedure shall be repeated.

7.2.5. The samples shall then be analysed.

7.2.6. After the analysis zero and span points shall be rechecked using the same gases. If these rechecks are within 2 per cent of those in item 7.2.3. then the analysis shall be 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 analysers.

7.2.8. The figure adopted for the content of the gases in each of the pollutants measured shall be that read off after stabilization of the measuring device. **Hydrocarbon mass emissions of compression ignition engines shall be 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 shall 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 shall be 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 above-mentioned reference condition.

In the case of carbon monoxide (CO)d $=$ 1.25 g/l

In the case of hydrocarbons ($CH_{1.85}$) d $=$ 0.619 g/l

In the case of nitrogen oxides (NO_2) d $=$ 2.05 g/l

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

Annex III - Appendix 1

BREAKDOWN OF THE OPERATING CYCLE USED FOR THE TYPE I TEST

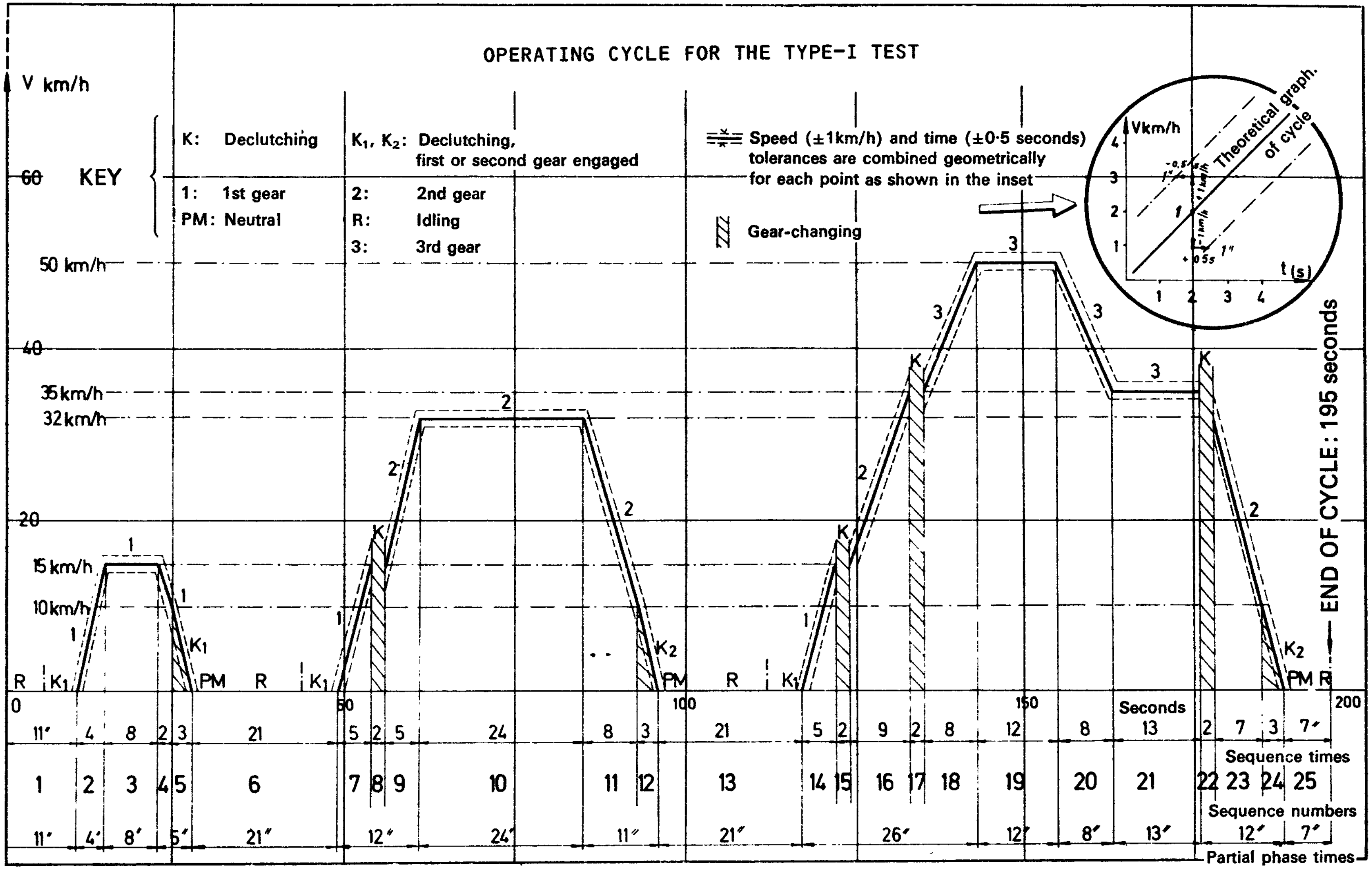
		Time	Percentage	
(1)	Breakdown by phases			
	Idling	60 s	30.8	35.4
	Idling, vehicle moving, clutch engaged on one combination	9 s	4.6	
	Gear-shift	8 s		4.1
	Accelerations	36 s		18.5
	Steady-speed periods	57 s		29.2
	Decelerations	25 s		12.8
		195 s		100 %
(2)	Breakdown by use of gears			
	Idling	60 s	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

APPENDIX 1


OPERATING CYCLE FOR THE TYPE-I TEST
V km/h
KEY
K: Declutching
K₁, K₂: Declutching, first or second gear engaged
1: 1st gear
2: 2nd gear
PM: Neutral
R: Idling
3: 3rd gear
Speed (±1km/h) and time (±0·5 seconds) tolerances are combined geometrically for each point as shown in the inset
Gear-changing
Vkm/h
Theoretical graph of cycle
t (s)
-0,5 s
+0,5 s
+1 km/h
-1 km/h
60
50 km/h
40
35 km/h
32 km/h
20
15 km/h
10 km/h
0
50
100
150
200
Seconds
R
K₁
PM
K
K₂
END OF CYCLE: 195 seconds
11″ 4 8 2 3 21 5 2 5 24 8 3 21 5 2 9 2 8 12 8 13 2 7 3 7″
Sequence times
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Sequence numbers
11″ 4″ 8″ 5″ 21″ 12″ 24″ 11″ 21″ 26″ 12″ 8″ 13″ 12″ 7″
Partial phase times

Annex III - Appendix 2

CHASSIS DYNAMOMETER WITH FIXED LOAD CURVE

1. DEFINITION OF A CHASSIS DYNAMOMETER

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 shall drive, directly or indirectly, the inertial masses and the power absorption device.

1.2.2. Having set the load at 50 km/h by one of the methods described in item 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

$P_a = KV^3_{12} + 5\% \, KV^3_{12} + 5\% \, PV_{50}$

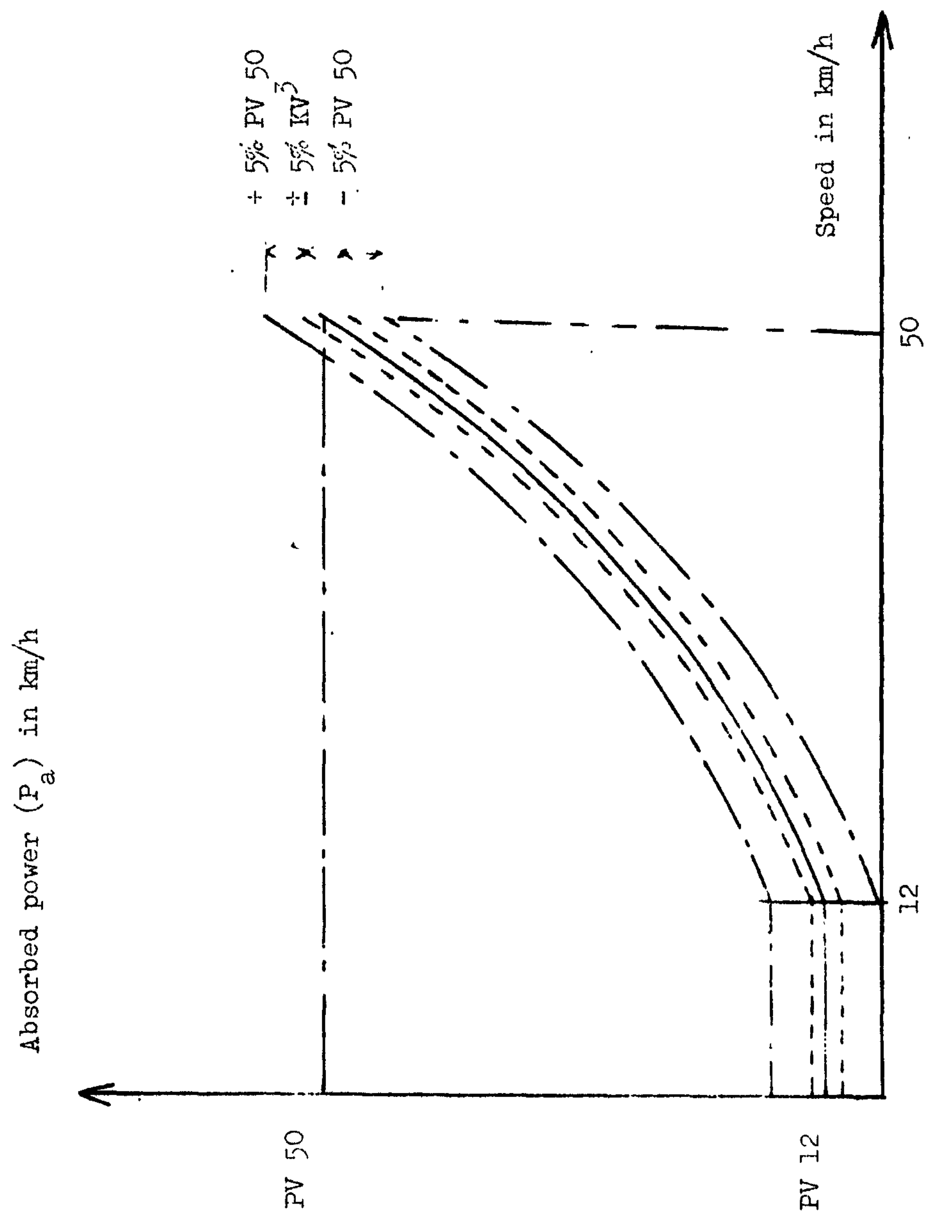
where K is a characteristic of the chassis dynamometer and PV_{50} is the power absorbed at 50 km/h.

2. METHOD OF CALIBRATING THE ROLLER BENCH

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.


+ 5% PV 50
± 5% KV^3
− 5% PV 50
Speed in km/h
50
12
Absorbed power (P$_a$) in km/h
PV 50
PV 12

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 shall be 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 items 2.2.4. to 2.2.9. shall 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;

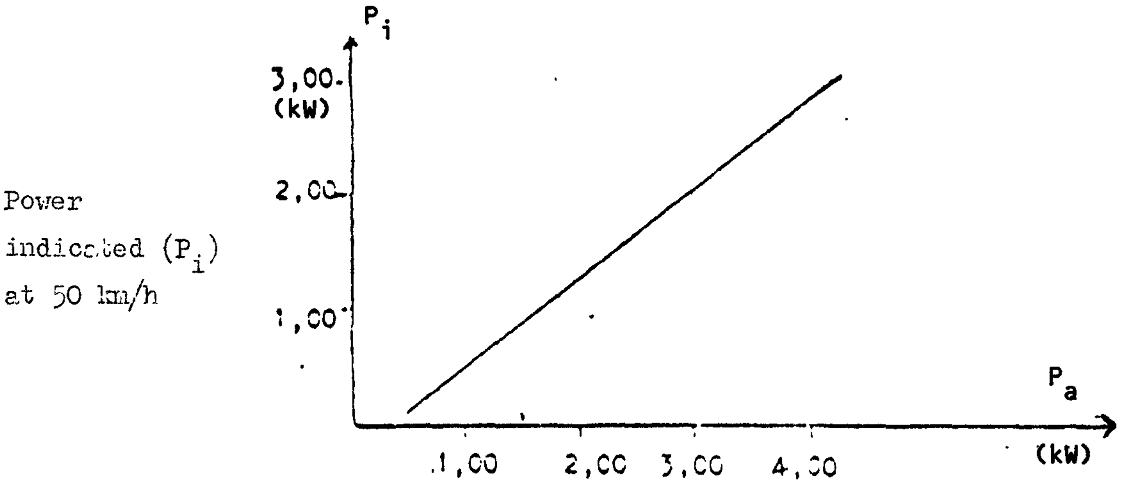
M_I = equivalent inertia in kg (excluding the inertial effects of the free rear roller);

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 km/h to 45 km/h.

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



Power absorbed (P_a) at 50 km/h

2.2.13. The requirements of items 2.2.3. to 2.2.12. shall 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 of item 2.2. shall be repeated as often as necessary for the chosen speeds.

2.4. Verification of the power-absorption curve of the roller bench from a reference setting to 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 prescriptions of item 1.2.2.

2.4.5. Repeat the procedure of items 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 will be used for force or torque calibration.

3. SETTING OF THE BENCH

3.1. Vacuum Method

3.1.1. Introduction

This method is not a preferred method and should 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 shall be measured to an accuracy of ± 0.25 kPa. It shall be possible to record continuously this reading or at intervals of no more than 1 second. The speed shall 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 appendix 3, point 4, are met.

3.1.3.2. Drive the vehicle at a steady speed of 50 km/h recording speed and vacuum (or absolute pressure) within the requirement of item 3.1.2.

3.1.3.3. Repeat procedure of items 3.1.3.2. three times in each direction. All six runs must be completed within 4 hours.

3.1.4. Data Reduction and Acceptance Criteria

3.1.4.1. Review results obtained in accordance with items 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 1 second). For each run, read vacuum level at 1 second intervals, calculate mean vacuum ($\bar{v}$) and standard deviation(S) this calculation shall consist of no less than 10 readings of vacuum.

3.1.4.2. The standard deviation shall not exceed 10 per cent 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 item 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 adjust dynamometer load to reproduce the vacuum reading ($\bar{v}$) obtained in accordance with item 3.1.4.3. Deviation from this reading shall be no greater than 0.25 kPa. The same instruments shall be used for this exercise, as were used during the road test.

3.2. Other setting methods

The bench setting may be carried out at a constant speed of 50 km/h in accordance with the provisions 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 bench: Pa (kW)
$RW \leq 750$	1.3
$750 < RW \leq 850$	1.4
$850 < RW \leq 1020$	1.5
$1020 < RW \leq 1250$	1.7
$1250 < RW \leq 1470$	1.8
$1470 < RW \leq 1700$	2.0
$1700 < RW \leq 1930$	2.1
$1930 < RW \leq 2150$	2.3
$2150 < RW \leq 2380$	2.4
$2380 < RW \leq 2610$	2.6
$2610 < RW$	2.7

3.3.2. In the case of vehicles, other than passenger cars, with a reference weight of more than 1,700 kg, or vehicles whose wheels are all driven, the power values given in the table of item 3.3.1. shall be multiplied by the factor 1.3.

Annex III - Appendix 3

RESISTANCE TO PROGRESS OF A VECHICLE - 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 roller bench, in accordance with item 4.1.4.1. of Annex III.

2. DEFINITION OF THE ROAD

The road shall be level and sufficiently long to enable the measurements specified below to be made.

The slope shall be constant to within ± 0.1 per cent and shall not exceed 1.5 per cent.

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 should be measured 0.7 m above the road surface.

3.2. Humidity

The road shall be dry.

3.3. Pressure - Temperature

Air density at the time of the test shall not deviate by more than ± 7.5 per cent from the reference conditions

p = 100 kPa and T = 293.2 K.

4. VEHICLE PREPARATION

4.1. Running in

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

4.2. Verifications

The following verifications shall 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 shall be loaded to its reference weight. The level of the vehicle shall 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 shall be closed. Any covers of air climatization systems, headlights, etc., shall be in the non-operating position.

4.3.3. The vehicle shall be clean.

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

5. METHODS

5.1 Energy variation during coast-down method

5.1.1. On the road

5.1.1.1. Test equipment and error

- Time shall be measured to an error lower than 0.1 s.
- Speed shall be measured to an error lower than 2 per cent.

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 $V_2 = V + \Delta V$ km/h to $V_1 = V - \Delta V$ km/h : t_1.

$\Delta V \leqslant 5$ km/h

5.1.1.2.4. Make 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 $T = \frac{1}{n} \cdot \sum_{i=1}^{n} Ti$ is equal to or less than 2 per cent ($p \leqslant 2$ per cent)

The statistical accuracy (p) is defined by:

$$p = \frac{t\,s}{\sqrt{n}} \cdot \frac{100}{T}$$

where t = coefficient given by the table below.

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

n = number of tests.

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:

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

where P is expressed in kW

V = speed of the test in m/s

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

M = reference weight in kg

T = time in seconds

5.1.2. On the bench

5.1.2.1. Measurement equipment and accuracy

The equipment shall 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 roller bench.

5.1.2.2.3. Adjust the equivalent inertia of the bench.

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

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

5.1.2.2.6. Adjust the brake to meet the requirements of item 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 shall be carried out with an appropriate measuring device accurate to within 2 per cent.

Speed measurement shall be accurate to within 2 per cent.

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 at least 10 s by means of class 1000 instrumentation meeting ISO standard No. 970.

5.2.1.2.3. Differences in torque $C_{(t)}$ and speed relative to time shall not exceed 5 per cent for each second of the measurement period.

5.2.1.2.4. The torque C_{t1} is the average torque derived from the following formula:

$$C_{t1} = \frac{1}{\Delta t}\int_{t}^{t+\Delta t} C(t)dt$$

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 bench

5.2.2.1. Measurement equipment and error.

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

5.2.2.2. Test procedure

5.2.2.2.1. Perform the operations specified in items 5.1.2.2.1. to 5.1.2.2.4. above.

5.2.2.2.2. Perform the operations specified in items 5.2.1.2.1. to 5.2.1.2.4. above.

5.2.2.2.3. Adjust the brake setting to meet the requirements of point 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 item 5.2. above.

5.3.2. In this dynamic procedure the mean torque value $\bar{M}$ 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:

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

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

It is recommended that the sampling rate of M be not less than 2 samples per second.

5.3.3. Dynamometer setting

The dynamometer load is set by the method described in item 5.2. If $\bar{M}$ dynamometer does not then match $\bar{M}$ road the brake setting shall be adjusted until the values are equal within ± 5 per cent.

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

5.3.4 Acceptance Criteria

Standard deviation of six measurements must be less than or equal to 2 per cent of the mean value.

5.4. Method by deceleration measurement by gyroscopic platform

5.4.1. On the road

5.4.1.1. Measurement equipment and error

speed shall be measured with an error lower than 2 per cent,
deceleration shall be measured with an error lower than 1 per cent,
the slope of the road shall be measured with an error lower than 1 per cent,
time shall be measured with an error lower than 0.1 s,
the measurement of the level of the vehicle on a reference horizontal ground,
by comparison, it is possible to have the slope of the road (α_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:

$$\bar{\gamma}_1 = \frac{1}{t}\int_0^t \gamma(t)\,dt - g \cdot \sin\alpha_1$$

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.
γ_1 (t): declaration 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 $\bar{\gamma}_1$ and $\bar{\gamma}_2 = \Gamma i$ for test i.

5.4.1.2.6. Perform a sufficient number of tests as specified in paragraph 5.1.1.2.6. above 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 $F = M . \Gamma$

where: M = vehicle reference weight in kg

Γ = average deceleration calculated beforehand

5.4.2. <u>Bench method</u>

5.4.2.1. Measurement equipment and error.

The measurement instrumentation of the bench itself shall be used as defined in appendix 2, paragraph 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:

$F_{\text{total}} = F_{\text{indicated}} + F_{\text{driving axle rolling}}$ with

$F_{\text{total}} = F_{\text{road}}$

$F_{\text{indicated}} = F_{\text{road}} - F_{\text{driving axle rolling}}$

$F_{\text{indicated}}$ is the force indicated on the force indicating device of the chassis dynamometer

F_{road} is known

$F_{\text{driving axle rolling}}$ can be:

- measured on chassis dynamometer able to work as generator.

  The test vehicle, gear box 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 generator.

  For the two-rollers-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 'k' which is equal to the ratio between the driving axle mass and the vehicle total mass.

  <u>Note</u>: R_R is obtained from the curve: F = f(V).

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Annex III - 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 bench 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:

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

where:

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

I = total inertia of the bench (equivalent inertia of the vehicle: cf. table paragraph 5.1. below)

I_M = inertia of the mechanical masses of the bench

γ = tangential acceleration at roller surface

F_I = inertia force

N.B.: 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 bench.

γ can be calculated from the peripheral speed of the rollers.

The total inertia "I" will be 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 per cent.

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 **item 5.1. of Annex III) within the following limits:**

3.1.1. ± 5 per cent of the theoretical value for each instantaneous value.

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

3.2. The limit given in **point** 3.1.1. is brought to ± 50 per cent 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 **point 2.1. of Annex III.**

4.2. However, if the provisions of **item 3 are met, with** instantaneous accelerations which are at least three time greater or smaller than the values obtained in the sequences of the theoretical cycle, the verification described above will not be necessary.

5. TECHNICAL NOTE

Explanation of drawing up working equations.

5.1. Equilibrium of the forces on the road

$$CR = k_1 \mathcal{J} r_1 \frac{d\theta 1}{dt} + k_2 \mathcal{J} r_2 \frac{d\theta 2}{dt} + k_3 M \gamma r_1 + k_3 F_s r_1$$

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

$$C_m = k_1 \mathcal{J} r_1 \frac{d\theta 1}{dt} + k_3 \frac{\mathcal{J}_{Wm} \frac{dWm}{dt}}{Wm} r_1 + k_3 F_s r_1$$

$$= k_1 \mathcal{J} r_1 \frac{d\theta 1}{dt} + k_3 I \gamma r_1 + k_3 F_s r_1$$

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

$$Ce = k_1 \mathcal{J} r_1 \frac{d\theta 1}{dt} + k_3 \left(\frac{\mathcal{J}_{We} \frac{dWe}{dt}}{We} r_1 + \frac{C1}{We} r_1 \right) + k_3 F_s r_1$$

$$= k_1 \mathcal{J} r_1 \frac{d\theta 1}{dt} + k_3 (I_M \gamma + F_1) r_1 + k_3 F_s r_1$$

In these formulae:

CR = engine torque on the road

Cm = engine torque on the bench with mechanically simulated inertias

Ce = engine torque on the bench with electrically simulated inertias

$\mathcal{J}r_1$ = Moment of inertia of the vehicle transmission brought back to the driving wheels

$\mathcal{J}r_2$ = Moment of inertia of the non-driving wheels

$\mathcal{J}Rm$ = Moment of inertia of the bench with mechanically simulated inertias

$\mathcal{J}Re$ = Moment of mechanical inertia of the bench with electrically simulated inertias

M = Mass of the vehicle on the road

I = Equivalent inertia of the bench with mechanically simulated inertias

Im = Mechanical inertia of the bench with electrically simulated inertias

Fs = Resultant force at stabilized speed

Cl = Resultant torque from electrically simulated inertias

Fl = Resultant force from electrically simulated inertias

$\frac{d\omega 1}{dt}$ = Angular acceleration of the driving wheels

$\frac{d\omega 2}{dt}$ = Angular acceleration of the non-driving wheels

$\frac{dWm}{dt}$ = Angular acceleration of the mechanical bench

$\frac{dWe}{dt}$ = Angular acceleration of the electrical bench

γ = 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 bench

Re = Radius of the rollers of the electrical bench

k_1 = Coefficient dependent on the gear reduction ratio and the various inertias of transmission and "efficiency"

k_2 = Ratio transmission X $\frac{r1}{r2}$ X "efficiency"

k_3 = Ratio transmission X "efficiency"

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

$$k_3\ (I_M . \gamma + F_1)\ r_1 = k3 I . \gamma . r1$$

hence,

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

Annex III - 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 item 4.2 of Annex III.
The devices described in items 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. **The laboratory shall mention, in its communications, 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 item 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 Annex.
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 continously 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
Fig. 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 item 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 shall be connected together by a manifold installed as near as possible to the vehicle.

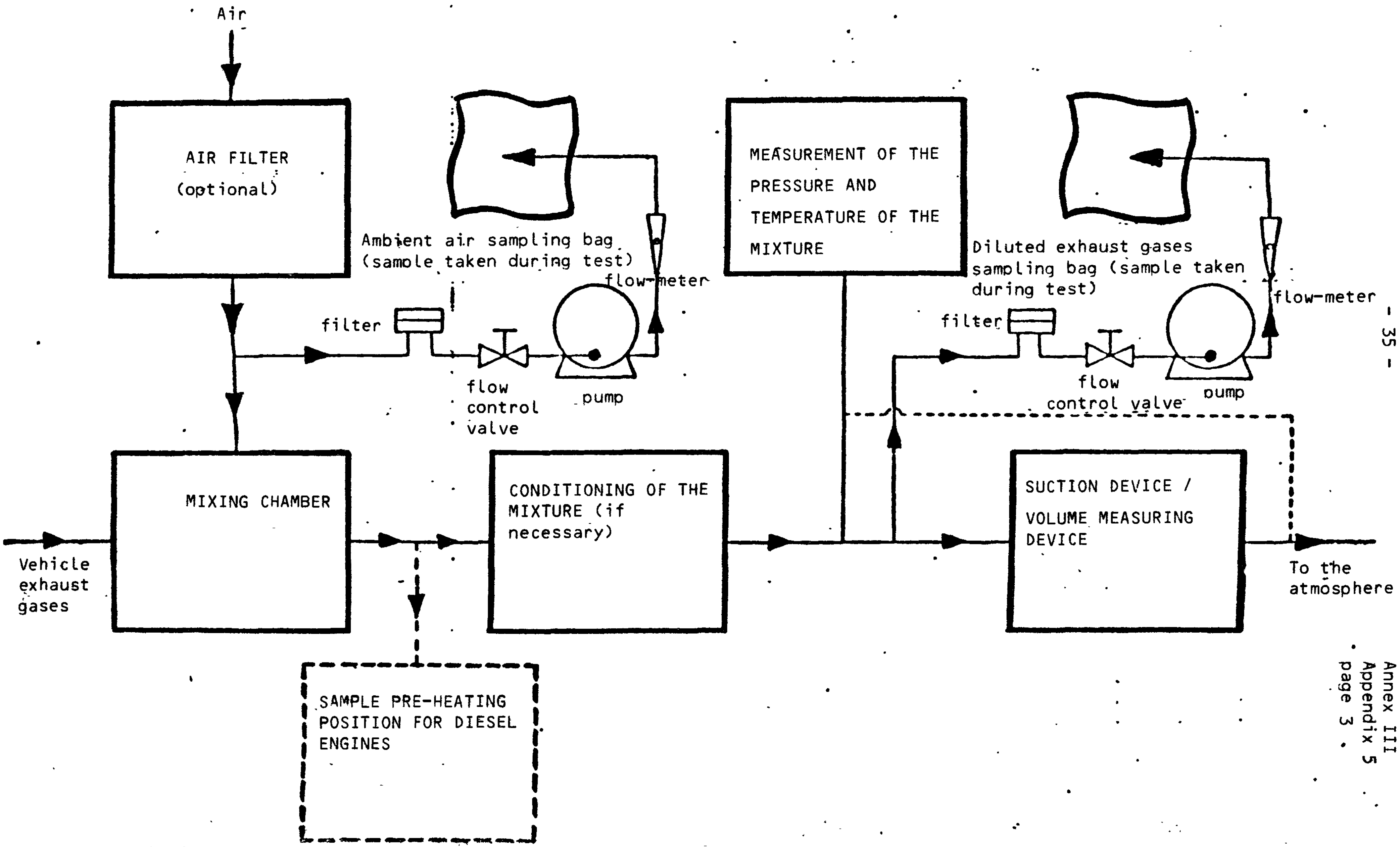
2.2.8. The gas samples shall be collected in sampling bags of adequate capacity as as not to hinder the gas flow during the sampling period. These bags shall be made of such materials as will not affect the concentrations of pollutant gases (see item 2.3.4.4.).

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

.../...

Fig. 1

DIAGRAM OF A VARIABLE DILUTION SYSTEM FOR MEASURING EXHAUST-GAS EMISSIONS



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 shall 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 tahn ± 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 shall 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 shall 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

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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.

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 flowrate must not deviate by more than ± 2 % from the average.

2.3.4.1.3. The sampling rate shall not fall below 5 l/mn and shall not exceed 0.2 % of the flowrate of the dilute exhaust gases.

2.3.4.1.4. An equivalent limit shall apply 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 flowrate 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 flowrates 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 analyser (three-way stop valves, for example).

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

2.3.4.4. Storage of the sample
The gas samples shall be collected in sampling bags of adequate capacity so as not to reduce the sampling rate. The bags shall 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).

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2.4.4. A quick-acting connection for analysing 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 flowrate, there must be a heat exchanger and a temperature control device having the characteristics specified in item 2.3.3.1. so as to ensure that the flowrate 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) (Fig. 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 drawings is not essential. Additional components such as instruments, valves, solenoids, and switches may be used to provide additional information and co-ordinate the functions of the component system.

3.1.3. The collecting equipment shall consist of:

3.1.3.1. A filter (D) for the dilution air, which can be preheated if necessary. This filter shall 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.

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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 shall 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 shall 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 1.

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 CO2 concentration in the dilute-exhaust sample bag is less than 3 per cent 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 shall 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 shall be such that, at the end of each test, the quantity of the samples is sufficient for analysis (∼10 l/min).

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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 shall close automatically on the sampling-bag side; as an alternative, other ways of transporting the samples to the analyser 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 shall be of sufficient capacity not to impede the sample flow; the bag material shall 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 items 4.3.1.1. and 4.3.2. of Annex III the additional components within the dotted lines in fig. 1 shall 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 analysed on the HFID.

HFID is a heated flame ionization analyser.

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

Lh is a heated sample line.

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

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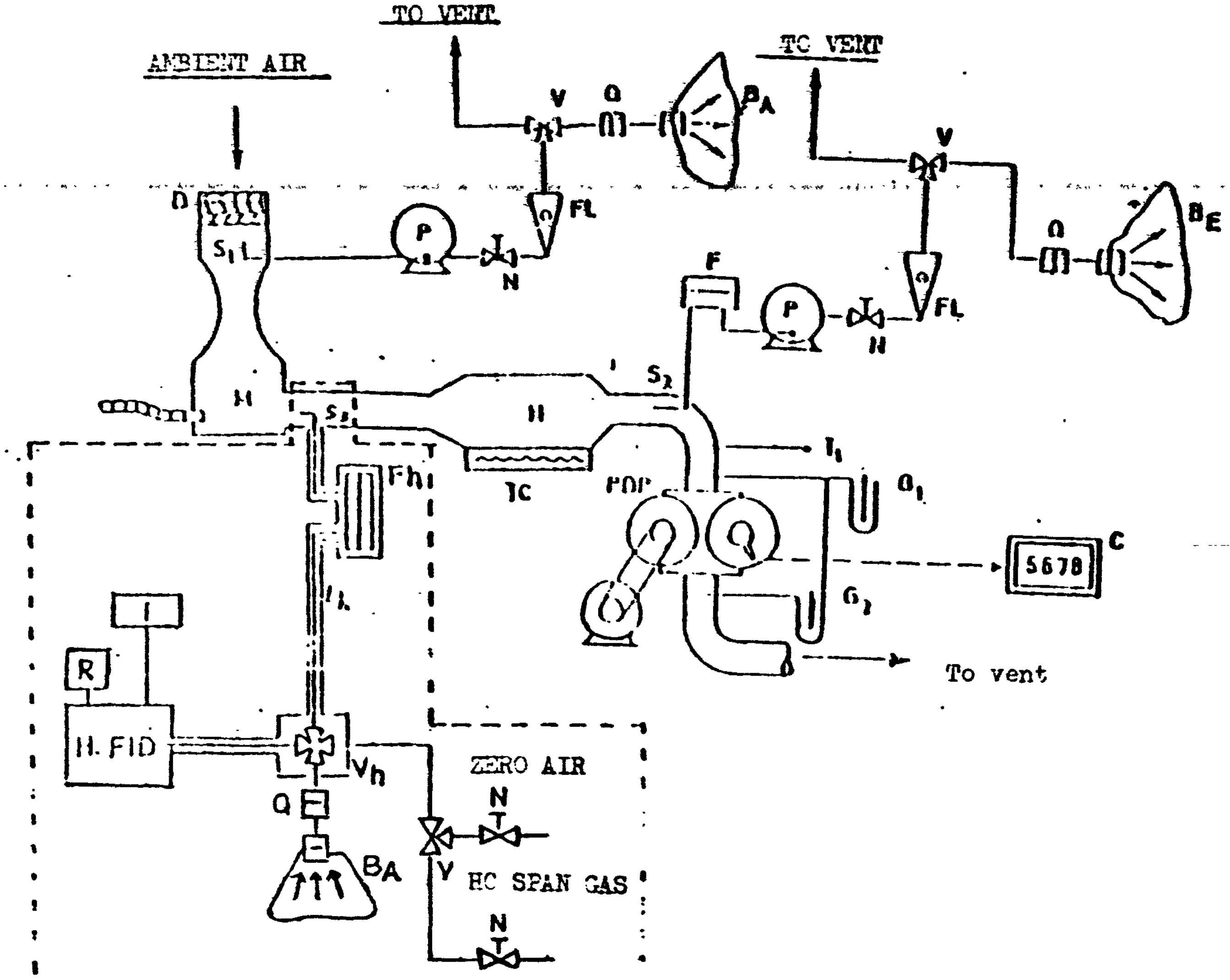
FIGURE 1 CONSTANT VOLUME SAMPLER WITH POSITIVE DISPLACEMENT PUMP (PDP - CVS)



REQUIRED FOR DIESEL TESTING ONLY

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

3.2.1. Using a critical-flow venturi in connexion 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 drawings is not essential. Additional components such as instruments, valve, solenoids, and switches may be used to provide additional information and co-ordinate the functions of the component system.

3.2.3. The collecting equipment shall consist of:

3.2.3.1. A filter (D) for the dilution air, which can be preheated if necessary; the filter shall consist of activated charcoal sandwiched between layers of paper, and shall 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 separator (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.

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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 shall be such that, at the end of the test, the quantity of the samples is sufficient for analysis ($\sim$10 l/min).

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 shall close automatically on the sampling-bag side; as an alternative, other ways of transporting the samples to the analyser 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 shall be of sufficient capacity not to impede the sample flow; the bag material shall 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 shall be precise and accurate to within ± 0.4 kPa.

3.2.3.15. A temperature sensor (T), which shall be precise and accurate to within ± 1°C and have a response time of 0.1 seconds to 62 per cent 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.

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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 shall 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 per cent by volume.

3.2.4. Additional equipment required when testing diesel engined vehicles.

To comply with the requirements of **items 4.3.1.1. and 4.3.2.** of Annex III the additional components shown within the dotted lines of Fig.2 shall 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 analysed on the HFID.

HFID is a heated flame, ionization analyser.

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

Lh is a heated sample line.

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

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

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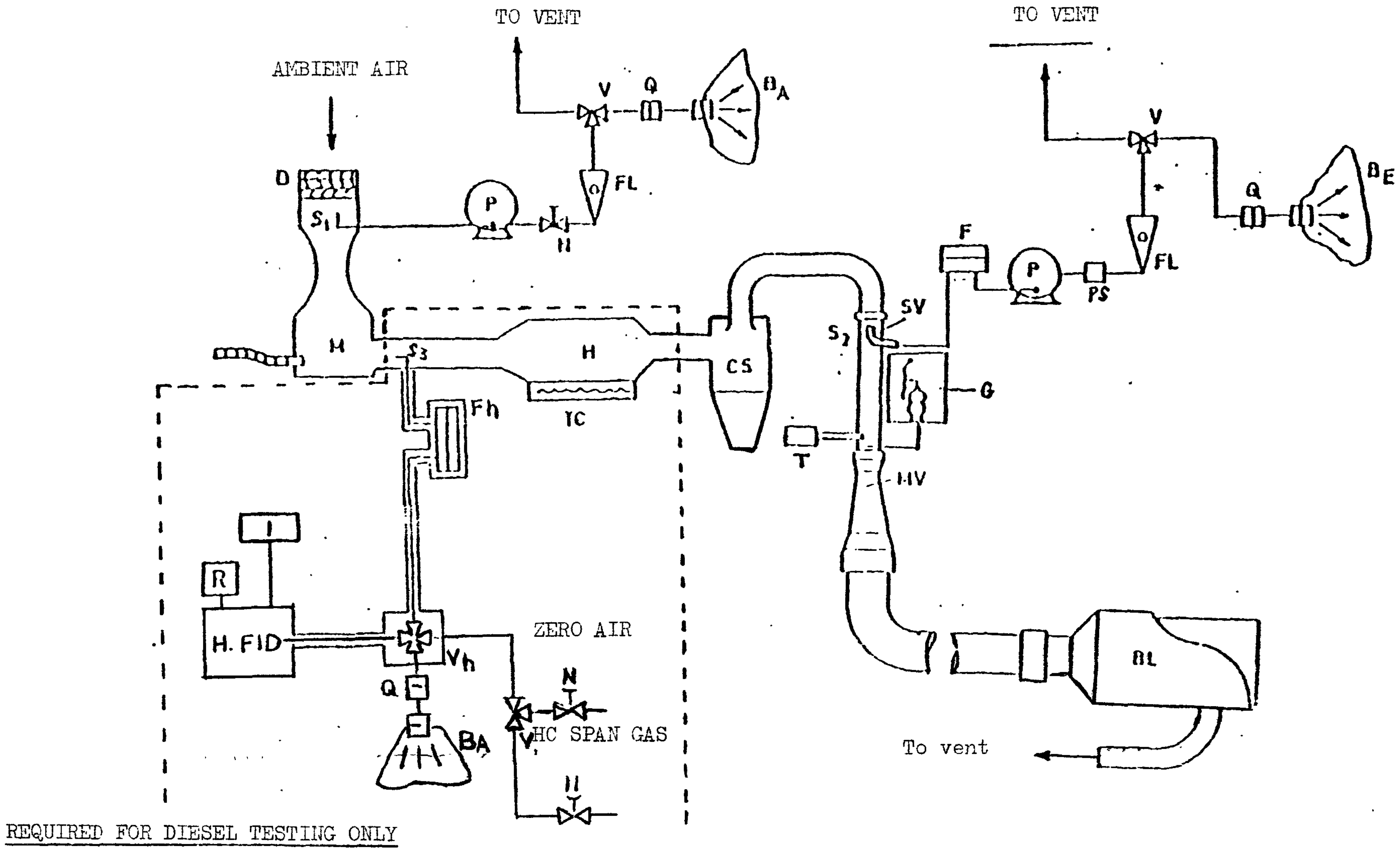
FIGURE 2 CONSTANT VOLUME SAMPLER WITH CRITICAL FLOW VENTRUI (CFV - CVS)



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

3.3.1. The collection equipment shall consist 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 shall 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) flowmeters (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 sensor (T_1) (accuracy and precision ± 1°C), fitted at a point immediately before the volume measurement device; it shall be designed to monitor continuously the temperature of the diluted exhaust gas mixture during the test.**

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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 shall be such that, at the end of each test, the quantity of the samples is sufficient for analysis (∼10 l/min).

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

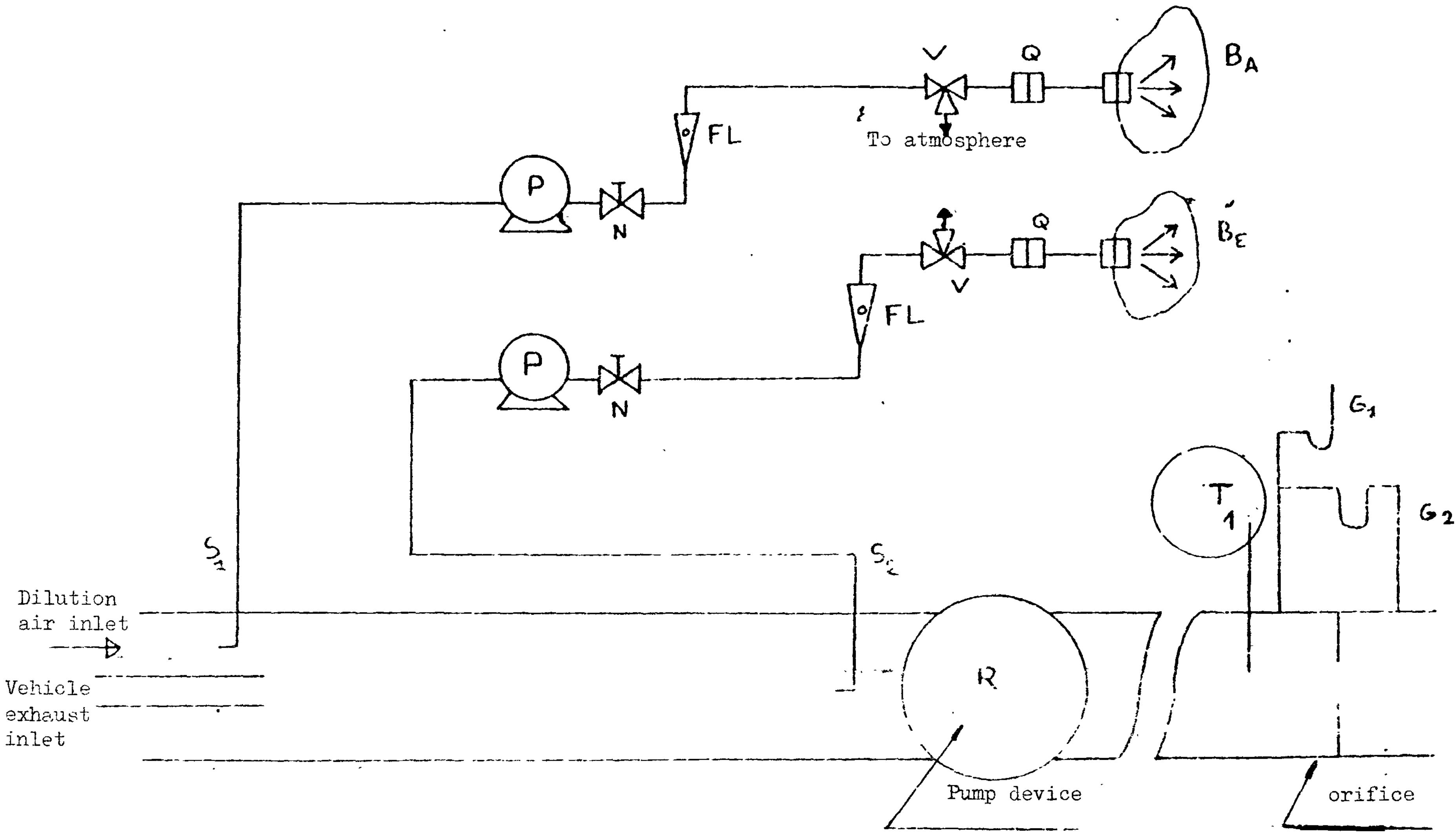
3.3.1.13. Three-way valves (V) to divert a constant flow of gas samples into the sampling bags or to the outside vent.

3.3.1.14. Gas-tight, quick lock coupling elements (Q) between the three-way valves and the sampling bags; the coupling shall close automatically on the sampling-bag side. Other ways of transporting the samples to the analyser 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 shall be of sufficient capacity not to impede the sample flow. The bag material shall 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)



Annex III - 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 item 4.3.3. of Annex III by the following procedure:

1.2. **The analyser 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 shall be at least equal to 80 per cent 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 shall be at least equal to this polynomial degree plus 2.

1.4. The calibration curve shall not differ by more than 2 per cent 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 will be possible to verify that the calibration has been carried out correctly. The different characteristic parameters of the analyser will 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 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

21.1 Each normally used operating range shall 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 analysed.

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

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

3. EFFICIENCY TEST OF THE NOx CONVERTER

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

Using the test set up 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 CLD in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which should amount to about 80 per cent of the operating range and the NO_2 concentration of the gas mixture shall be less than 5 per cent of the NO concentration). The NOx analyser shall 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 per cent less than the indicated calibration concentration given in item 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 per cent (minimum 10 per cent) of the calibration concentration given under paragraph 3.1. above. Record the indicated concentration (d).

3.4. The NO_x analyser 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 item 3.2. passes through the converter into the detector. Record the indicated concentration (b).

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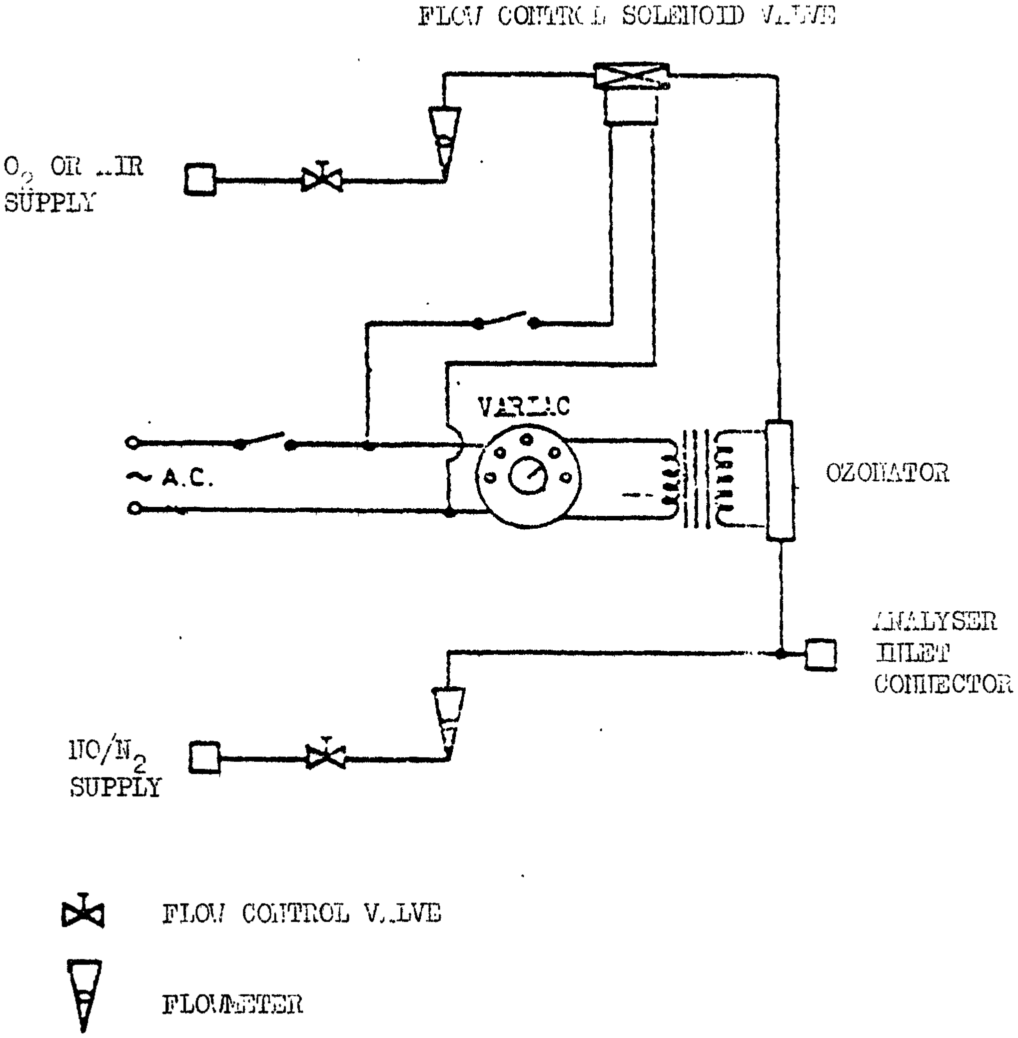
FLOW CONTROL SOLENOID VALVE
O2 OR AIR SUPPLY
VARIAC
~ A.C.
OZONATOR
ANALYSER INLET CONNECTOR
NO/N2 SUPPLY
FLOW CONTROL VALVE
FLOWMETER

Figure 1

3.6. With the ozonator deactivated, the flow of oxygen or synthetic air is also shut off. The NOx reading of the analyser shall then be no more than 5 per cent above the figure in item 3.1.

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

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

3.8. The efficiency of the converter shall not be less than 95 per cent.

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

4. CALIBRATION OF THE CVS SYSTEM

4.1. The CVS system shall be calibrated by using an accurate flow meter and a restricting device. The flow through the system shall 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 Annex III items 4.2.2. and 4.2.3.

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. <u>Calibration of the Positive Displacement Pump (PDP)</u>

4.2.1. The following calibration procedure outlines the equipment, the test configuration, and the various parameters which shall be 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 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 shall be performed.

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4.2.2. This calibration procedure is 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 shall 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 shall be maintained during the calibration. The laminar flowmeter 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 connexions between the flowmeter and the CVS pump shall 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 administration granting the approval as being of comparable accuracy. If the set-up shown in appendix 5, Fig. 2 is used, the following data shall be found within the limits of precision given:

Baromic pressure (corrected) (P_B)	± 0.03kPa
Ambient temperature (t)	± 0.2°C
Air temperature at LFE (ETI)	± 0.15°C
Pressure depression upstream of LFE (EPI)	± 0.01kPa
Pressure drop across the LFE matrix (EDP)	± 0.0015kPa
Air temperature at CVS Pump Inlet (PTI)	± 0.2°C

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Air temperature at CVS Pump outlet (PTO)	± 0.2°C
Pressure depression at CVS pump inlet (PPI)	± 0.22kPa
Pressure head at CVS-pump outlet (PPO)	± 0.22kPa
Pump revolutions during test period (n)	± 1 Rev
Elapsed time for period (min. 250 sec) (t)	± 0.1 sec'

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 stablize for 3 minutes and repeat the data acquisition.

4.2.4. Data analysis

4.2.4.1. The air flow rate, Qs, at each test point is calculated in standard m^3/min from the flowmeter data using the manufacturer's prescribed method.

4.2.4.2. **The air flow rate is then converted to pump flow, Vo, in m^3 per revolution at absolute pump inlet temperature and pressure.**

$$V_o = \frac{Qs}{n} \cdot \frac{\overset{T}{p}}{273{,}2} \cdot \frac{1\,013{,}3}{P_p}$$

where:

V_o = pump flow rate at T_p and P_p given in m^3/rev.

Q_S = air flow at 101.33 Kpa and 273.2 K given in m^3/min.

T_p = pump inlet temperature (K)

P_p = absolute pump inlet pressure.

n = pump speed in revolution per minute

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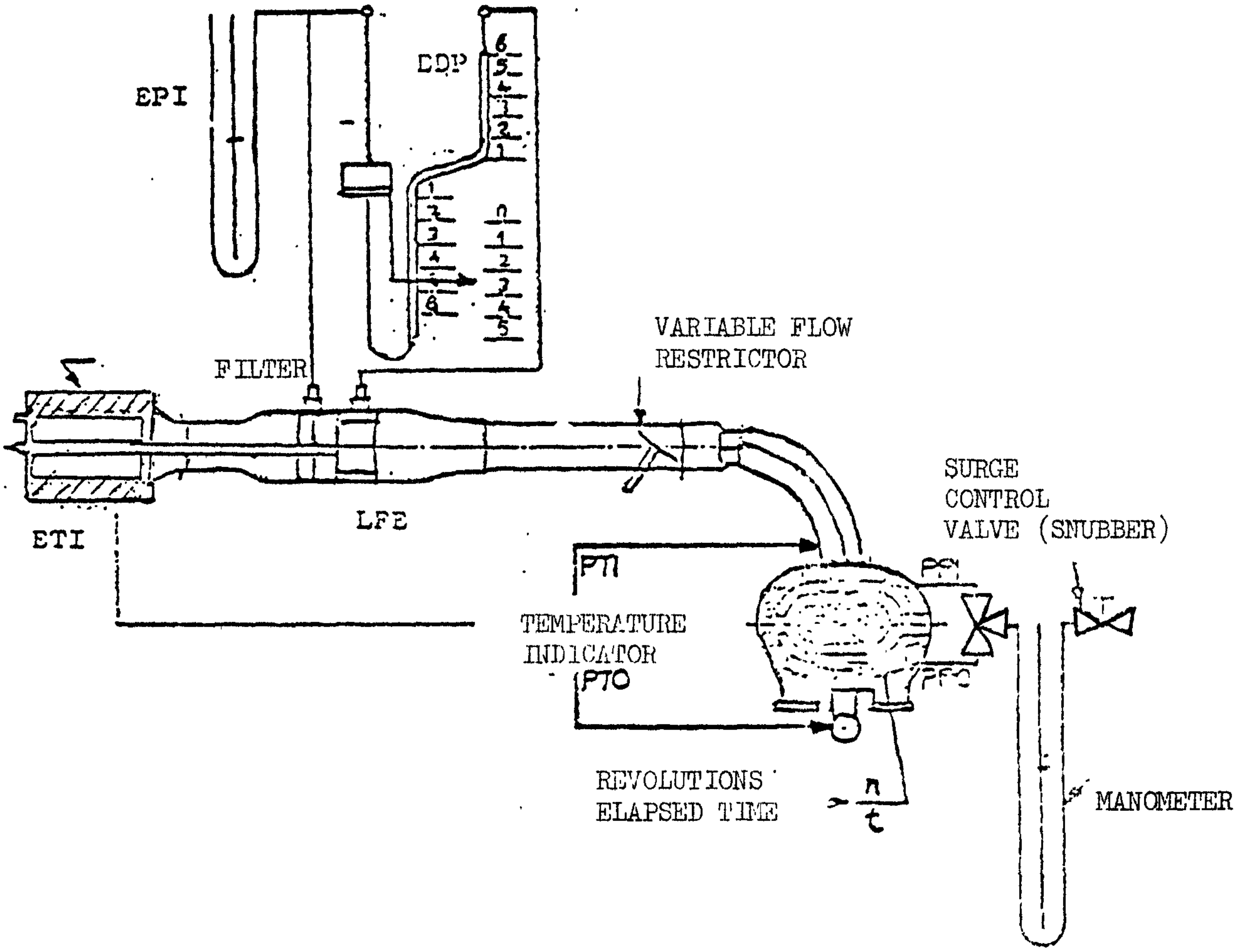

FIGURE 2 PDP - CVS CALIBRATION CONFIGURATION

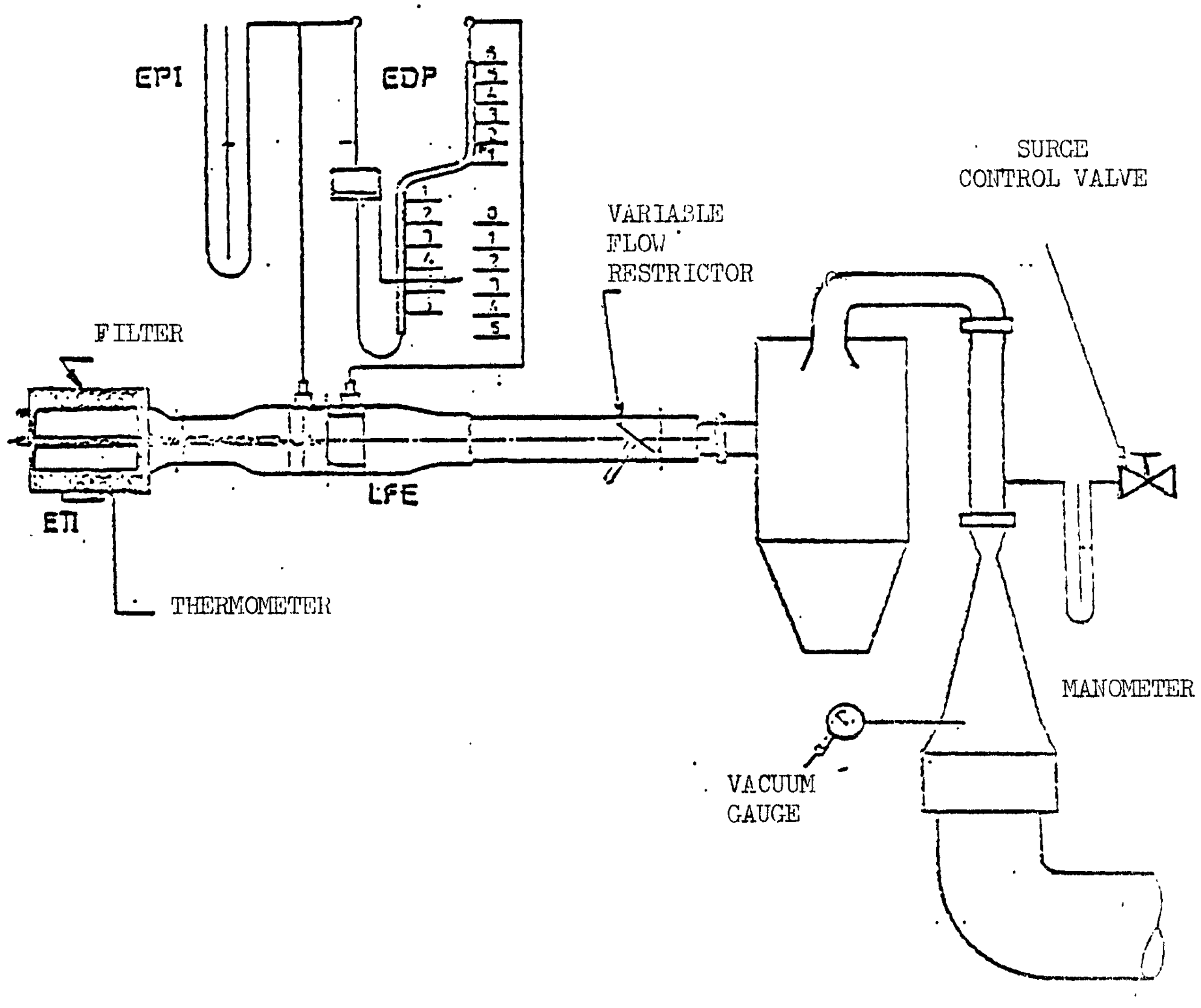

FIGURE 3 CFV CVS CALIBRATION CONFIGURATION

To compensate 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

ΔP_p = pressure differential from pump inlet to pump outlet (Kpa)

P_e = absolute pump outlet pressure (PPO + P_B) (Kpa)

A linear least square fit is performed to generate the calibration equations which have the formula

$V_o = D_o - M (X_o)$

$n = A-B (\Delta P_p)$

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 shall be calibrated on each speed used. The calibration curves generated for the ranges should be approximately parallel and the intercept values, D_o, should increase as the pump flow range decreases.

If the calibration has been performed carefully, the calculated values from the equation should be within ± 0.5 per cent of the measured value of Vo. Values of M should vary from one pump to another. Calibration shall be performed at pump start-up and after major maintenance.

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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 established the value of the calibration coefficient at measured values of pressure, temperature and air flow.

4.3.2. The manufacturer's recommended procedure shall 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 shall be found within the limits of precision given:

Barometric pressure (corrected) (P_B)	± 0.03 kPa
LFE Air temperature, flowmeter (ETI)	± 0.15°C
Pressure depression up-stream of (LFE) (EPI)	± 0.01kPa
Pressure drop across (EDP) LFE matrix	± 0.0015kPa
Air flow (Q_s)	± 0.5%
CFV inlet depression (PPI)	± 0.02kPa
Temperature at venturi inlet (T_v)	± 0.2°C

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

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

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

4.3.7. The data recorded during the calibration shall be used in the following calculations. The air flow rate Qs, 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 = flow rate in m^3/min at 273.2° K and 101.33 kPa

T = 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 8 points in the critical region calculate an average K_v and the standard deviation.

If the standard deviation exceeds 0.3 per cent of the average K_v take corrective action.

Annex III - Appendix 7

TOTAL SYSTEM VERIFICATION

1. To comply with the requirements of **item 4.7. of Annex III the CVS,** sampling system and analytical system total accuracy shall 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 analysing and calculating the pollutant mass according to the formulae in appendix 8 of this annex except that the density of propane shall be taken as 1.967 g/l 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 per cent occur, the cause of the malfunction shall 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 analysed 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 gramme. 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 analysed by means of the equipment normally used for exhaust gas analysis. The results are then compared to the concentration figures computed previously.

Annex III - 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 g/test.

V_{mix} = Volume of the diluted exhaust gas expressed in l/test and corrected to standard conditions (273.2 K and 101.33 kPa).

Q_i = Density of the pollutant i in g/l 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 l/test (prior to correction).

V_o = Volume of gas delivered by the positive displacement pump on testing conditions, in l/rev.

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:

$$K_1 = \frac{273.2\ K}{101.33\ kPa} = 2.6961(K.kP_a{-1}) \qquad (3)$$

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

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

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:

$$DF = \frac{13.4}{c_{CO_2} + (c_{HC} + c_{CO})10^{-4}} \qquad (5)$$

In this equation:

c_{CO_2} = Concentration of CO_2 in the diluted exhaust gas contained in the sampling bag, expressed in per cent 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:

$$k_H = \frac{1}{1 - 0.0329\ (H - 10.71)} \qquad (6)$$

in which:

$$H = \frac{6.211 \times R_a \times P_d}{P_B - P_d \times R_a \times 10^{-2}} \qquad (6)$$

where:

H = Absolute humidity expressed in grammes of water per kg of dry air

R_a = Relative humidity of the ambient air expressed in per cent

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 per cent

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. Analyser readings

	Diluted exhaust sample	Dilution air sample
HC: */	92 ppm	3.0 ppm
CO:	470 ppm	0 ppm
NOx:	70 ppm	0 ppm
CO_2:	1.6 Vol. per cent	0.03 Vol. per cent

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*/ in ppm carbon equivalent.

4.2. Calculation

4.2.1. Humidity correction factor (kH) (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))

$$DF = \frac{13.4}{c_{CO_2} + (c_{HC} + c_{CO})\ 10^{-4}}$$

$$DF = \frac{13.4}{1.6 + (\ 92 + 4\ 70)\ 10^{-4}}$$

$$DF = 8.091$$

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

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

$$C_i = C_o - C_d\ (1 - \frac{1}{DF})$$

$$C_i = 92 - 3\ \ (1 - \frac{1}{8.091})$$

$$C_i = 89.371$$

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

$$Q_{HC} = 0.619$$

$$M_{HC} = 89.371 \times 51961 \times 0.619 \times 10^{-6}$$

$$M_{HC} = 2.88\ \frac{g}{test}$$

CO, mass emissions (see formula (1))

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

$Q_{CO} = 1.25$

$M_{CO} = 470 \times 51961 \times 1.25 \times 10^{-6}$

$M_{CO} = 30.5 \frac{g}{test}$

NOx, mass emissions (see formula (I))

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

$Q_{NOx} = 2.05$

$M_{NOx} = 70 \times 51961 \times 2.05 \times 1.0442 \times 10^{-6}$

$M_{NOx} = 7.79 \frac{g}{test}$

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 (t2 - t1)

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

Ce 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 = 296.2K

Barometric pressure : P_B = 101.33 kPa

Relative humidity : R_a = 60 per cent

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/rev

Vacuum : P_i = 2.80 kPa

Gas temperature : T_P = 51°C = 324.2K

Number of pump revolutions : n = 26.000

Analyser 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. per cent	0.03 Vol. per cent

4.4.2. Calculation

4.4.2.1. Gas Volume (cf. (2)).

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

$$V_{mix} = 2.6961 \times 2.439 \times 26.000 \times \frac{98.53}{324.2}$$

$$V_{mix} = 51960.89$$

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

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

$$H = \frac{6.211 \times R_a \times P_d}{P_B - (P_d \times \frac{Ra}{100})}$$

$$H = \frac{6.211 \times 60 \times 3.2}{101.33 - (3.2 \times 0.60)}$$

$$H = 11.99589$$

$$k_H = \frac{1}{1 - 0.0329 \times (H - 10.71)}$$

$$k_H = \frac{1}{1 - 0.0329 \times (11.9959 - 10.71)}$$

$$k_H = 1.0442$$

4.4.2.3. Dilution factor (DF) (see formula No.5)

$$DF = \frac{13.4}{c_{CO_2} + (c_{HC} + c_{CO})\ 10^{-4}}$$

$$DF = \frac{13.4}{1.6 + (92.0 + 4\ 70\ )\ 10^{-4}}$$

$$DF = 8{,}091$$

4.4.2.4. Calculation of the corrected concentration of pollutants in the sampling bag HC, mass emissions (see formulae No.4 and No.1)

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

$$C_i = 92.0 - 3\ (1 - \frac{1}{8.091})$$

$$C_i = 89.372$$

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

$$Q_{HC} = 0.619$$

$$M_{HC} = 89.372 \times 51961 \times 0.619 \times 10^{-6}$$

$M_{HC} = 2.87$ 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 **item 5.2.1.2. of Annex I.**

2. CONDITIONS OF MEASUREMENT

2.1. The fuel shall be the reference fuel whose specifications are given in annex **VI.**

2.2 The type II test shall 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 **III, item 2.1., shall be carried out.**

2.3. In the case of vehicles with manually-operated or semi-automatic-shift gear-boxes the test shall 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 shall be 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 **item 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: screw drivers (ordinary or cross-headed), spanners (ring, open-end or adjustable), pliers, Allen wrenches.

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