Council Directive of 20 March 1970 on the approximation of the laws of the Member States on measures to be taken against air pollution by emissions from motor vehicles (70/220/EEC) (repealed)

[**F1**ANNEX III   U.K.

TYPE I TEST
(Verifying the average emission of tailpipe emissions after a cold start)

Textual Amendments

F1   Substituted by Council Directive of 26 June 1991 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles (91/441/EEC).

[**F2**1.   INTRODUCTION   U.K.

This Annex describes the procedure for the type I test defined in 5.3.1 of Annex I. When the reference fuel to be used is LPG or NG, the provisions of Annex XII shall apply additionally.]

Textual Amendments

F2   Substituted by Commission Directive 98/77/EC of 2 October 1998 adapting to technical progress 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 emissions from motor vehicles (Text with EEA relevance).

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2.   OPERATING CYCLE ON THE CHASSIS DYNAMOMETER   U.K.

2.1.   Description of the cycle   U.K.

The operating cycle on the chassis dynanometer is described in Appendix 1 to this Annex.

2.2.   General conditions under which the cycle is carried out   U.K.

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

2.3.   Use of gearbox   U.K.

2.3.1.   If the maximum speed which can be attained in first gear is below 15 km/h, the second, third and fourth gears are used for the elementary urban cycles (Part One) and the second, third, fourth and fifth gears for the extra-urban cycle (Part Two). The second, third and fourth gears may also be used for the urban cycle (Part One) and the second, third, four and fifth gears for the extra-urban cycle (Part Two) 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.

[**F3**. . . . .

Textual Amendments

F3   Deleted by Directive 98/69/EC of the European Parliament and of the Council of 13 October 1998 relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directive 70/220/EEC.

F3 . . . .]

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[**F4**[**F5**Vehicles which do not attain the acceleration**] and maximum speed values required in the operating cycle must be operated with the accelerator control fully depressed until they once again reach the required operating curve. Deviations from the operating cycle must be recorded in the test report.**]

Textual Amendments

F4 Substituted by Council Directive 93/59/EEC of 28 June 1993 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles.

F5 Substituted by Directive 98/69/EC of the European Parliament and of the Council of 13 October 1998 relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directive 70/220/EEC.

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

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

2.3.4.   Vehicles equipped with an overdrive which the driver can activate are tested with the overdrive out of action for the urban cycle (Part One) and with the overdrive in action for the extra-urban cycle (Part Two).

[**F6**2.3.5.   At the request of the manufacturer, for a vehicle type where the idle speed of the engine is higher than the engine speed that would occur during operations 5, 12 and 24 of the elementary urban cycle (Part One), the clutch may be disengaged during the previous operation.**]

Textual Amendments

F6 Inserted by Commission Directive 2002/80/EC of 3 October 2002 adapting to technical progress Council Directive 70/220/EEC relating to measures to be taken against air pollution by emissions from motor vehicles (Text with EEA relevance).

2.4.   Tolerances U.K.

2.4.1.   A tolerance of ± 2 km/h is allowed between the indicated speed and the theoretical speed during acceleration, during steady speed, and during deceleration when the vehicle's brakes are used. If the vehicle decelerates more rapidly without the use of the brakes, only the requirements of 6.5.3 apply. Speed tolerances greater than those prescribed are accepted during phase changes provided that the tolerances are never exceeded for more than 0,5 on any one occasion.

2.4.2.   The time tolerances are ± 1,0 s. The above tolerances apply equally at the beginning and at the end of each gear changing period[1] for the urban cycle (Part One) and for the operations Nos 3, 5 and 7 of the extra-urban cycle (Part Two).

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

3.   VEHICLE AND FUEL   U.K.

3.1.   Test vehicle   U.K.

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

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

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

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

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

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

[**F7**3.2.   Fuel   U.K.

When testing a vehicle against the emission limit values given in row A of the table in section 5.3.1.4 of Annex I to this Directive, the appropriate reference fuel must comply with the specifications given in section A of Annex IX or, in the case of gaseous reference fuels, either section A.1 or section B of Annex IXa.

When testing a vehicle against the emission limit values given in row B of the table in section 5.3.1.4 of Annex I to this Directive, the appropriate reference fuel must comply with the specifications given in section B of Annex IX or, in the case of gaseous reference fuels, either section A.2 or section B of Annex IXa.]

[**F8**3.2.1.   Vehicles that are fuelled either with petrol or with LPG or NG shall be tested according to Annex XII with the appropriate reference fuel(s) as defined in Annex IX a.]

Textual Amendments

    F8   Inserted by Commission Directive 98/77/EC of 2 October 1998 adapting to technical progress 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 emissions from motor vehicles (Text with EEA relevance).

Textual Amendments

    F7   Substituted by Commission Directive 2002/80/EC of 3 October 2002 adapting to technical progress Council Directive 70/220/EEC relating to measures to be taken against air pollution by emissions from motor vehicles (Text with EEA relevance).

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4.   TEST EQUIPMENT   U.K.

4.1.   Chassis dynamometer   U.K.

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

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

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

4.1.4. Accuracy   U.K.

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

4.1.4.2. In the case of a dynamometer with a fixed load curve the accuracy of the load setting at 80 km/h must be ± 5 %. In the case of a dynamometer with an adjustable load curve, the accuracy of matching dynamometer load to road load [**F9**must be 5 % at 120, 100, 80, 60 and 40, and 10 % at 20 km/h.] Below this, dynamometer absorption must be positive.

> **Textual Amendments**
> **F9**   Substituted by Commission Directive 96/44/EC of 1 July 1996 adapting to technical progress 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 emissions from motor vehicles (Text with EEA relevance).

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 kilograms of the inertia class for the test.

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

4.1.5. Load and inertia setting   U.K.

4.1.5.1. Dynamometer with fixed load curve: the load simulator must be adjusted to absorb the power exerted on the driving wheels at a steady speed of 80 km/h and the absorbed power at 50 km/h shall be noted. The means by which this load is determined and set are described in Appendix 3.

4.1.5.2. Dynamometer with adjustable load curve: the load simulator must be adjusted in order to absorb the power exerted on the driving wheels at steady [**F9**speeds of 120, 100, 80, 60, 40 and 20 km/h.] The means by which these loads are determined and set are described in Appendix 3.

4.1.5.3. Inertia   U.K.

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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   U.K.

4.2.1.   The exhaust gas sampling system must be able to measure the actual quantities of pollutants emitted in the exhaust gases to be measured. The system to be used is the constant volume sampler (CVS) system. This requires that the vehicle exhaust be continuously diluted with ambient air under controlled conditions. In the constant volume sampler concept of measuring two conditions must be satisfied: the total volume of the mixture of exhaust gases and dilution air must be measured and a continuously proportional sample of the volume must be collected for analysis.

The quantities of pollutants emitted are determined from the sample concentrations, corrected for the pollutant content of the ambient air and the totalized flow over the test period.

The particulate pollutant emission level is determined by using suitable filters to collect the particulates from a proportional part flow throughout the test and determining the quantity thereof gravimetrically in accordance with 4.3.2.

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

4.2.3.   [**F10**Figure III.4.2.3 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.

> **Textual Amendments**
>   **F10**   Deleted by Commission Directive 96/44/EC of 1 July 1996 adapting to technical progress 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 emissions from motor vehicles (Text with EEA relevance).

4.2.4.   The gas and air mixture must be homogeneous at point S_2 of the sampling probe.

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

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

[**F10**

F10 . . . .]

4.2.7.   If the vehicle being tested is equipped with an exhaust pipe comprising several branches, [**F9**the connecting tubes must be connected as near as possible to the vehicle but in such a manner so as not to effect the functioning of the vehicle.]

4.2.8.   Static pressure variations at the tailpipe(s) of the vehicle must remain within ± 1,25 kPa of the static pressure variations measured during the dynamometer driving cycle with no connection to the tailpipe(s). Sampling systems capable of maintaining the static

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pressure to within $\pm$ 0,25 kPa are used if a written request from a manufacturer to the competent authority issuing the approval substantiates the need for the narrower tolerance. The back-pressure must be measured in the exhaust pipe, as near as possible to its end or in an extension having the same diameter.

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

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

4.3. Analytical equipment U.K.

4.3.1. Requirements U.K.

4.3.1.1. Pollutant gases must be analyzed with the following instruments:
Carbon monoxide (CO) and carbon dioxide (CO_2) analysis:

The carbon monoxide and carbon dioxide analysers must be of the non-dispersive infra-red (NDIR) absorption type.
Hydrocarbons (HC) analysis — spark-ignition engines:

The hydrocarbons analyser must be of the flame ionization (FID) type calibrated with propane gas expressed equivalent to carbon atoms (C_1).
Hydrocarbons (HC) analysis — compression-ignition engines:

The hydrocarbons analyser must be of the flame ionization type with detector, valves, pipework, etc, heated to 463 K (190 °C) $\pm$ 10 K (HFID). It must be calibrated with propane gas expressed equivalent to carbon atoms (C_1).
Nitrogen oxide (NO_x) analysis:

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

Particulates:

Gravimetric determination of the particulates collected. These particulates are in each case collected by two series-mounted filters in the sample gas flow. The quantity of particulates collected by each pair of filters must be as follows:

—	V_{ep}:	flow through filters
—	V_{mix}:	flow through tunnel
—	M:	particulates mass (g/km)
—	M_{limit}:	limit mass of particulates (limit mass in force, g/km)
—	m:	mass of particulates collected by filters (g)
—	d:	actual distance corresponding to the operating cycle (km)

	$$M = \frac{V_{mix} \cdot m}{V_{ep} \cdot d}$$ or $$m = M.d \cdot \frac{V_{ep}}{V_{mix}}$$
	The particulates sample rate (V_{ep}/V_{mix}) will be adjusted so that for $M = M_{limit}$, $1 \le m \le 5$ mg (when 47 mm diameter filters are used).
	The filter surface consist of a material that is hydrophobic and inert towards the components of the exhaust gas (fluorocarbon-coated glass-fibre filters or equivalent).

4.3.1.2.   Accuracy   U.K.

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

[**F9**Measurement error must not exceed ± 2 % (intrinsic error of analyser) disregarding the true value for the calibration gases. For concentrations of less than 100 ppm the measurement error must not exceed ± 2 ppm. The ambient air sample msut be measured on the same analyser with an appropriate range.]

[**F10**. . . . .]

Measurement of the particulates collected shall be to a guaranteed accuracy of 1 µg.

[**F9**The microgram balance used to determine the weight of all filters must have an accuracy of 5 µg and readability of 1 µg.]

4.3.1.3.   Ice-trap   U.K.

No gas drying device must 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   U.K.

A heated sample line for a continuous HC-analysis with the flame ionization detector (HFID), including recorder (R) must be used. The average concentration of the measured hydrocarbons must be determined by integration. Throughout the test, the temperature of the heated sample line must be controlled at 463 K (190 °C) ± 10 K. The heated sampling line must be fitted with a heated filter (Fh) 99 % efficient with particle ≥ 0,3 µm to extract any solid particles from the continuous flow of gas required for analysis. The sampling system response time (from the probe to the analyser inlet) must be no more than four seconds.

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

The particulate sampling unit consists of a dilution tunnel, a sampling probe, a filter unit, a partial-flow pump, and a flow rate regulator and measuring unit. The particulate-sampling part flow is drawn through two series-mounted filters. [**F9**The sampling probe for the test gas flow for particulates must be so arranged within the dilution tract that a representative sample gas flow can be taken from the homogeneous air/exhaust mixture and an air/exhaust gas mixture temperature of 325 K (52 °C) is not exceeded immediately before the particulate filter.]. The temperature of the gas flow in the flow meter may not fluctuate more than ± 3 K, nor may the

mass flow-rate fluctuate by more than ± 5 %. Should the volume of flow change unacceptably as a result of excessive filter loading, the test must be stopped. When it is repeated, the rate of flow must be decreased and/or a larger filter used. The filters must be removed from the chamber no earlier than an hour before the test begins.

The necessary particle filters must be conditioned (as regards temperature and humidity) in an open dish which has been protected against dust ingress for at least eight and for not more than 56 hours before the test in an air-conditioned chamber. After this conditioning the uncontaminated filters are weighed and stored until they are used.

If the filters are not used within one hour of their removal from the weighing chamber they must be reweighed.

The one-hour limit may be replaced by an eight-hour limit if one or both of the following conditions are met:

—   a stabilized filter is placed and kept in a sealed filter holder assembly with the ends plugged, or

—   a stabilized filter is placed in a sealed filter holder assembly which is then immediatly placed in a sample line through which there is no flow.

4.3.3.   Calibration   U.K.

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

4.4.   Volume measurement   U.K.

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

4.4.2.   Constant volume sampler calibration   U.K.

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

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

4.5.   Gases   U.K.

4.5.1.   Pure gases   U.K.

The following pure gases must 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, $\leq$ 1 ppm CO, $\leq$ 400 ppm CO_2, $\leq$ 0,1 ppm NO); oxygen content between 18 and 21 % vol,

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

—   purified hydrogen (and mixture containing hydrogen)

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(purity $\leq$ 1 ppm C, $\leq$ 400 ppm CO_2).

4.5.2.　Calibration gases　U.K.

Gases having the following chemical compositions must be available: mixtures of:
— 　C_3H_8 and purified synthetic air (4.5.1),
— 　CO and purified nitrogen,
— 　CO_2 and purified nitrogen,
— 　NO and purified nitrogen.

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

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

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

4.6.　Additional equipment　U.K.

4.6.1.　Temperatures　U.K.

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

4.6.2.　Pressure　U.K.

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

4.6.3.　Absolute humidity　U.K.

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

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

5.　PREPARING THE TEST　U.K.

5.1.　Adjustment of inertia simulators to the vehicle's translatory inertia　U.K.

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

[F9 Reference mass of vehicle RW(kg)	Equivalent inertia I(kg)
RW ≤ 480	455
480 < RW ≤ 540	510
540 < RW ≤ 595	570
595 < RW ≤ 650	625
650 < RW ≤ 710	680
710 < RW ≤ 765	740
765 < RW ≤ 850	800

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850 < RW ≤ 965	910
965 < RW ≤ 1 080	1 020
1 080 < RW ≤ 1 190	1 130
1 190 < RW ≤ 1 305	1 250
1 305 < RW ≤ 1 420	1 360
1 420 < RW ≤ 1 530	1 470
1 530 < RW ≤ 1 640	1 590
1 640 < RW ≤ 1 760	1 700
1 760 < RW ≤ 1 870	1 810
1 870 < RW ≤ 1 980	1 930
1 980 < RW ≤ 2 100	2 040
2 100 < RW ≤ 2 210	2 150
2 210 < RW ≤ 2 380	2 270
2 380 < RW ≤ 2 610	2 270
2 610 < RW	2 270**]**

[**F11**If the corresponding equivalent inertia is not available on the dynamometer, the larger value closest to the vehicle reference mass will be used.**]**

Textual Amendments

F11   Inserted by Commission Directive 96/44/EC of 1 July 1996 adapting to technical progress 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 emissions from motor vehicles (Text with EEA relevance).

5.2.   Setting of dynamometer   U.K.

The load is adjusted according to methods described in 4.1.4.

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

5.3.   Preconditioning of the vehicle   U.K.

5.3.1.   For compression-ignition engine vehicles for the purpose of measuring particulates at most 36 hours and at least six hours before testing, the Part Two cycle described in Appendix 1 must be used. Three consecutive cycles must be driven. The dynamometer setting is as indicated in 5.1 and 5.2.

[**F11**At the request of the manufacturer vehicles with positive ignition engine may be preconditioned with one Part I and two Part II driving cycles.**]**

After this preconditioning specific for compression ignition engines and before testing, compression-ignition and positive ignition engine vehicles must be kept in a room in which the temperature remains relatively constant between 293 and 303 K (20 and 30 °C). This

conditioning must be carried out for at least six hours and continue until the engine oil temperature and coolant, if any, are within ± 2 K of the temperature of the room.

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

[**F8**5.3.1.1 For positive-ignition engined vehicles fuelled with LPG or NG or so equipped that they can be fuelled with either petrol or LPG or NG, between the tests on the first gaseous reference fuel and the second gaseous reference fuel, the vehicle shall be preconditioned before the test on the second reference fuel. This preconditioning is done on the second reference fuel by driving a preconditioning cycle consisting of one part one (urban part) and two times part two (extra-urban part) of the test cycle described in Appendix 1 to this Annex. On the manufacturer's request and with the agreement of the technical service this preconditioning cycle may be extended. The dynamometer setting shall be the one indicated in points 5.1 and 5.2 of this Annex.]

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

6.   PROCEDURE FOR BENCH TESTS U.K.

6.1.   Special conditions for carrying out the cycle U.K.

6.1.1.   During the test, the test cell temperature must be between 293 and 303 K (20 and 30 °C). The absolute humidity (H) of either the air in the test cell or the intake air of the engine must be such that:

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

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

[**F9**6.1.3.   [**F5**A current of air of variable speed is blown over the vehicle.] The blower speed shall be such that, within the operating range of 10 km/h to at least 50 km/h, the linear velocity of the air at the blower outlet is within ± 5 km/h of the corresponding roller speed. The final selection of the blower shall have the following characteristics:
—   Area: at least 0,2 m^2
—   Height of the lower edge above ground: approximately 20 cm
—   Distance from the front of the vehicle: approximately 30 cm

As an alternative the blower speed shall be at least 6m/s (21,6 km/h). At the request of the manufacturer for special vehicles (e.g. vans, off-road) the height of the cooling fan can be modified.]

[**F9**6.1.4.   During the test the speed is recorded against time or collected by the data acquisition system so that the correctness of the cycles performed can be assessed.]

6.2.   Starting-up the engine U.K.

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

6.2.2.   [**F5**The first cycle starts on the initiation of the engine start-up procedure.]

[**F8**6.2.3. In the case of the use of LPG or NG as a fuel it is permissible that the engine is started on petrol and switched to LPG or NG after a predetermined period of time which cannot be changed by the driver.]

6.3.   Idling   U.K.

6.3.1.   Manual-shift or semi-automatic gearbox   U.K.

[**F11**See Appendix tables III.1.2 and III.1.3.]

F106.3.1.1. ·

F106.3.1.2. ·

F106.3.1.3. ·

F106.3.1.4. ·

F106.3.1.5. ·

F106.3.1.6. ·

6.3.2.   Automatic-shift gearbox   U.K.

After initial engagement the selector must not be operated at any time during the test except as in the case specified in 6.4.3 or if the selector can actuate the overdrive, if any.

6.4.   Accelerations   U.K.

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

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

6.4.3.   Automatic-shift gearboxes   U.K.

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

6.5.   Deceleration   U.K.

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

All the decelerations of the extra-urban cycle (Part Two) are effected by removing the foot completely from the accelerator, the clutch remaining engaged. The clutch is disengaged, without use of the gear lever, at a speed of 50 km/h for the last deceleration.

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

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

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

6.6.   Steady speeds   U.K.

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

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

7.   GAS AND PARTICULATE SAMPLING AND ANALYSIS   U.K.

[**F4**7.1.   Sampling   U.K.

[**F5**Sampling begins (BS) before or at the initiation of the engine start-up procedure and ends on conclusion of the final idling period in the extra-urban cycle (part two, end of sampling (ES)) or, in the case of test type VI of the final idling period of the last elementary cycle (part one).**]]**

7.2.   Analysis   U.K.

7.2.1.   The exhaust gases contained in the bag must be analysed as soon as possible and in any event not later than 20 minutes after the end of the test cycle. The spent particulate filters must be taken to the chamber no later than one hour after conclusion of the test on the exhaust gases and must there be conditioned for between two and 36 hours and then be weighed.

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

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

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

7.2.5.   The samples are then analyzed.

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

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

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

8.   DETERMINATION OF THE QUANTITY OF GASEOUS AND PARTICULATE POLLUTANTS EMITTED   U.K.

8.1.   The volume considered   U.K.

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

8.2.   Total mass of gaseous and particulate pollutants emitted   U.K.

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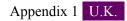*ANNEX III*
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The mass m of each gaseous pollutant emitted by the vehicle during the test is determined by obtaining the product of the volumetric concentration and the volume of the gas in question, with due regard to the following densities under the abovementioned reference conditions:

[**F2**]In the case of carbon monoxide (CO):	d = 1.25 g/l
In the case of hydrocarbons:	
for petrol ($CH_{1.85}$)	d = 0.619 g/l
for diesel ($CH_{1.86}$)	d = 0.619 g/l
for LPG ($CH_{2.525}$)	d = 0.649 g/l
for NG (CH_4)	d = 0.714 g/l
In the case of nitrogen oxides (NO_2):	d = 2.05 g/l]

The mass m of particulate pollutant emissions from the vehicle during the test is defined by weighing the mass of particulates collected by the two filters, m_1 by the first filter, m_2 by the second filter:

—   if $0,95 (m_1 + m_2) \leq m_1$, $m = m_1$,

—   if $0,95 (m_1 + m_2) > m_1$, $m = m_1 + m_2$,

—   if $m_2 > m_1$, the test is cancelled.

Appendix 8 gives the calculations, followed by examples, used in determining the mass emissions of gaseous and particulate pollutants.

Appendix 1 U.K.

BREAKDOWN OF THE OPERATING CYCLE USED FOR THE TYPE I TEST

1.   OPERATING CYCLE U.K.

1.1.   The operating cycle, made up of a Part One (urban cycle) and Part Two (extra-urban cycle), is illustrated at Figure III.1.1.

2.   ELEMENTARY URBAN CYCLE (PART ONE) U.K.

See Figure III.1.2 and Table III.1.2.

2.1.   Breakdown by phases U.K.

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

2.2.   Breakdown by use of gears U.K.

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

2.3.   General information U.K.

Average speed during test: 19 km/h.

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Effective running time: 195 seconds.

Theoretical distance covered per cycle: 1,013 km.

Equivalent distance for the four cycles: 4,052 km.

Table III.1.2   Operating cycle on the chassis dynamometer *(Part One)* U.K.

No of operation	Operation	Phase	Acceleration (m/s²)	Speed (km/h)	Duration of each Operation(s)	Phase(s)	Cumulative time(s)	Gear to be used in the case of a manual gearbox
1	Idling	1			11	11	11	6 s PM + 5 s K_1[a]
2	Acceleration	2	1,04	0-15	4	4	15	1
3	Steady speed	3		15	9	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[a]
6	Idling	5			21	21	49	16 s PM + 5 s K_1[a]
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[a]
13	Idling	9			21	21	117	16 s PM + 5 s K_1[a]
14	Acceleration	10	0-15	0-15	5	26	122	1
15	Gear change				2		124	

[a]   PM = gearbox in neutral, clutch engaged.
K_1, K_2 = first or second gear engaged, clutch disengaged.

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	[F7 35-10]	7		185	2
24	Deceleration,							
	clutch disengaged		-0,92	10-0	3		188	K_2[a]
25	Idling	15				7	7	195	7 s PM[a]

a   PM = gearbox in neutral, clutch engaged.
K_1, K_2 = first or second gear engaged, clutch disengaged.

Elementary urban cycle for the type I test

3.   EXTRA - URBAN CYCLE (Part Two)   U.K.

See Figure III.1.3 and Table III.1.3

3.1.   Breakdown by phases   U.K.

	Time(s)	%
Idling	20	5,0
Idling, vehicle moving, clutch engaged on one combination	20	5,0
Gear-changing	6	1,5
Accelerations	103	25,8
Steady-speed periods	209	52,2
Decelerations	42	10,5
	400	100

3.2.   Breakdown by use of gears   U.K.

	Time(s)	%

Idling	20	5,0
Idling, vehicle moving, clutch engaged on one combination	20	5,0
Gear-changing	6	1,5
First gear	5	1,3
Second gear	9	2,2
Third gear	8	2,0
Fourth gear	99	24,8
Fifth gear	233	58,2
	400	100

3.3.   General information U.K.

Average speed during test: 62,6 km/h.

Effective running time: 400 seconds.

Theoretical distance covered per cycle: 6,955 km.

Maximal speed: 120 km/h.

Maximal acceleration: $0,833 \text{ m/s}^2$.

Maximal deceleration: $- 1,389 \text{ m/s}^2$.

Table III.1.3   Extra-urban cycle *(Part Two)* for the type I test U.K.

No of operation	Operation	Phase	Acceleration (m/s^2)	Speed (km/h)	Duration of each		Cumulative time(s)	Gear to be used in the case of a manual gearbox
					Operation(s)	Phase(s)		
1	Idling	1			20	20	20	K1[a]
2	Acceleration	2	0,83	0-15	5	41	25	1
3	Gear change				2		27	—
4	Acceleration		0,62	15-35	9		36	2

a   PM = gearbox in neutral, clutch engaged.
First or fifth gear engaged, clutch disengaged.

b   Additional gears can be used according to manufacturer recommendations if the vehicle is equipped with a transmission with more than five gears.

5	Gear change				2		38	—
6	Acceleration		0,52	35-30	8		46	3
7	Gear change				2		48	—
8	Acceleration		0,43	50-70	13		61	4
9	Steady speed	3		70	50	50	111	5
10	Deceleration	4	-0,69	70-50	8	8	119	4 s.5 + 4 s.4
11	Steady speed	5		50	69	69	188	4
12	Acceleration	6	0,43	50-70	13	13	201	4
13	Steady speed	7		70	50	50	251	5
14	Acceleration	8	0,24	70-100	35	35	286	5
15	Steady speed	9		100	30	30	316	5[b]
16	Acceleration	10	0,28	100-120	20	20	336	5[b]
17	Steady speed	11		120	10	20	346	5[b]
18	Deceleration	12	-0,69	120-80	16	34	362	5[b]
19	Deceleration		-1,04	80-50	8		370	5[b]
20	Deceleration, clutch disengaged		-1,39	50-0	10		380	K_5[a]
21	Idle	13			20	20	400	PM[a]

[a]   PM = gearbox in neutral, clutch engaged.
First or fifth gear engaged, clutch disengaged.

[b]   Additional gears can be used according to manufacturer recommendations if the vehicle is equipped with a transmission with more than five gears.

Extra-urban cycle *(Part Two)* for the type I test

[F3]4.   EXTRA - URBAN CYCLE (LOW-POWERED VEHICLES)   U.K.

[[F3]. . . . .

4.1.   Breakdown by phases   U.K.

. . . .

4.2.   Breakdown by use of gears   U.K.

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4.3.   General information U.K.

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Table   Extra-urban cycle *(low-powered vehicles)* for the type I test U.K.
III.1.4

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Appendix 2 U.K.

CHASSIS DYNAMOMETER

1.   DEFINITION OF A CHASSIS DYNAMOMETER WITH FIXED LOAD CURVE U.K.

1.1.   Introduction U.K.

In the event that the total resistance to progress on the road is not reproduced on the chassis dynamometer between speeds of 10 and **[F9120 km/h]**, it is recommended to use a chassis dynamometer having the characteristics defined below.

1.2.   Definition U.K.

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

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

[F91.2.2. The load absorbed by the brake and the chassis dynamometer internal frictional effects from the speed of 0 to 120 km/h is as follows:

$F = (a + b \cdot V^2) \pm 0{,}1 \cdot F_{80}$ (without being negative)

where:

F	=	total load absorbed by the chassis dynamometer (N)
a	=	value equivalent to rolling resistance (N)
b	=	value equivalent to coefficient of air resistance $(N/(km/h)^2)$
V	=	speed (km/h)
F_{80}	=	load at the speed of 80 km/h (N).**]**

2.   METHOD OF CALIBRATING THE DYNAMOMETER U.K.

2.1.   Introduction U.K.

[F9 This Appendix describes the method to be used to determine the load absorbed by a dynamometer brake.

The load absorbed comprises the load absorbed by frictional effects and the load absorbed by the power-absorption device.**]**

The dynamometer is brought into operation beyond the range of test speeds. The device used for starting up the dynamometer is then disconnected: the rotational speed of the driven roller decreases.

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

2.2.   **[F9**Calibrating the load indicator to 80 km/h as a function of the load absorbed**]** U.K.

The following procedure is used (see also Figure III.2.2.2).

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 80 km/h.

[**F9**2.2.5.   Note the load indicated F_i (N).**]**

2.2.6.   Bring the dynamometer to a speed of 90 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 85 km/h to a speed of 75 km/h.

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

2.2.10.   The requirements of 2.2.4 to 2.2.9 must be repeated sufficiently often to cover the range of [**F9**load**]** used.

[**F9**2.2.11. Calculate the load absorbed, using the formula:

$$F = \frac{M_i \cdot \Delta V}{t}$$

where

F	=	load absorbed in N
M_i	=	equivalent inertia in kilograms (excluding the inertial effects of free rear roller)
ΔV	=	speed deviation in m/s (10 km/h = 2,775 m/s)
t	=	time taken by the roller to pass from 85 to 75 km/h.**]**

[**F9**2.2.12. Figure III.2.2.12 shows the load indicated at 80 km/h in terms of the load absorbed at 80 km/h.**]**

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

2.3.   [**F9**Calibration of the load indicator as a function of the absorbed load for other speeds**]** **U.K.**

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

2.4.   Verification of the [**F9**load**]**-absorption curve of the dynamometer from a reference setting at a speed of 80 km/h **U.K.**

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 [**F9**load**]** at 80 km/h.

[**F9**2.4.3.   Note the load absorbed at 120, 100, 80, 60, 40 and 20 km/h.**]**

[**F9**2.4.4.   Draw the curve F(V)**]** and verify that it corresponds to the requirements of 1.2.2.

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2.4.5. Repeat the procedure set out in 2.4.1 to 2.4.4 for other values of [**F9**load F] at 80 km/h and for other values of inertia.

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

3. SETTING OF THE DYNAMOMETER U.K.

[**F9**3.1. Setting methods U.K.

The dynamometer setting may be carried out at a constant speed of 80 km/h in accordance with the requirements of Appendix 3.]

3.1.1. Introduction U.K.

This method is not a preferred method and must be used only with fixed load curve shape dynamometers for determination of load setting at 80 km/h and cannot be used for vehicles with compression-ignition engines.

3.1.2. Test instrumentation U.K.

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

3.1.3. Road test U.K.

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

3.1.3.2. Drive the vehicle at a steady speed of 80 km/h recording speed and vacuum (or absolute pressure) in accordance with the requirements of 3.1.2.

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

3.1.4. Data reduction and acceptance criteria U.K.

3.1.4.1. Review results obtained in accordance with 3.1.3.2 and 3.1.3.3 (speed must not be lower than 79,5 km/h or greater than 80,5 km/h for more than one second). For each run, read vacuum level at one-second intervals, calculate mean vacuum (

$\bar{v}$

) and standard deviation(s). This calculation must consist of no less than 10 readings of vacuum.

3.1.4.2. The standard deviation must not exceed 10 % of mean (

$\bar{v}$

) for each run.

3.1.4.3. Calculate the mean value (

$\bar{v}$

) for the six runs (three runs in each direction).

3.1.5. Dynamometer setting U.K.

3.1.5.1. Preparation U.K.

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

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3.1.5.2. Setting U.K.

After warm-up, drive the vehicle at a steady speed of 80 km/h and adjust dynamometer load to reproduce the vacuum reading (v) obtained in accordance with 3.1.4.3. Deviation from this reading must be no greater than 0,25 kPa. The same instruments are used for this exercise as were used during the road test.
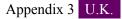
[^{F9}3.2. Alternative method U.K.

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

3.2.1. The brake is adjusted so as to absorb the load exerted at the driving wheels at a constant speed of 80 km/h in accordance with the following table:

Reference mass of vehicles	Equivalent inertia	Power and load absorbed by the dynamometer at 80 km/h		Coefficients	
RW (kg)	kg	kW	N	a	b
				N	N/(km/h)^2
RW ≤ 480	455	3,8	171	3,8	0,0261
480 < RW ≤ 540	510	4,1	185	4,2	0,0282
540 < RW ≤ 595	570	4,3	194	4,4	0,0296
595 < RW ≤ 650	625	4,5	203	4,6	0,0309
650 < RW ≤ 710	680	4,7	212	4,8	0,0323
710 < RW ≤ 765	740	4,9	221	5,0	0,0337
765 < RW ≤ 850	800	5,1	230	5,2	0,0351
850 < RW ≤ 965	910	5,6	252	5,7	0,0385
965 < RW ≤ 1 080	1 020	6,0	270	6,1	0,0412
1 080 < RW ≤ 1 190	1 130	6,3	284	6,4	0,0433
1 190 < RW ≤ 1 305	1 250	6,7	302	6,8	0,046
1 305 < RW ≤ 1 420	1 360	7,0	315	7,1	0,0481
1 420 < RW ≤ 1 530	1 470	7,3	329	7,4	0,0502

1 530 < RW ≤ 1 640	1 590	7,5	338	7,6	0,0515
1 640 < RW ≤ 1 760	1 700	7,8	351	7,9	0,0536
1 760 < RW ≤ 1 870	1 810	8,1	365	8,2	0,0557
1 870 < RW ≤ 1 980	1 930	8,4	378	8,5	0,0577
1 980 < RW ≤ 2 100	2 040	8,6	387	8,7	0,0591
2 100 < RW ≤ 2 210	2 150	8,8	396	8,9	0,0605
2 210 < RW ≤ 2 380	2 270	9,0	405	9,1	0,0619
2 380 < RW ≤ 2 610	2 270	9,4	423	9,5	0,0646
2 610 < RW	2 270	9,8	441	9,9	0,0674

3.2.2.   In the case of vehicles, other than passenger cars, with a reference mass of more than 1 700 kg, or vehicles with permanent all-wheel drive, the power values given in the table set out in 3.2.1 are multiplied by the factor 1,3.**]**

F103.3.   Alternative method   U.K.

[**F10**. . . . .]

3.3.1.   . . . .

3.3.2.   . . . .

Appendix 3 U.K.

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

1. OBJECT OF THE METHODS U.K.

The object of the methods defined below is to measure the resistance to progress of a vehicle at stabilized speeds on the road and to simulate this resistance on a dynamometer, in accordance with section 4.1.5 of Annex III.

2. DEFINITION OF THE ROAD U.K.

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

3. ATMOSPHERIC CONDITIONS U.K.

3.1. Wind U.K.

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

3.2. Humidity U.K.

The road must be dry.

3.3. Pressure — Temperature U.K.

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

4. VEHICLE PREPARATION U.K.

[**F11**4.1. Selection of the test vehicle U.K.

If not all variants of a vehicle type[2] are measured the following criteria for the selection of the test vehicle shall be used.

4.1.1. Body

If there are different types of body, the worst one in terms of aerodynamics shall be chosen. The manufacturer shall provide appropriate data for the selection.

4.1.2. Tyres

The widest tyre shall be chosen. If there are more than three tyre sizes, the widest minus one shall be chosen.

4.1.3. Testing mass

The testing mass shall be the reference mass of the vehicle with the highest inertia range.

4.1.4. Engine

The test vehicle shall have the largest heat exchanger(s).

4.1.5. Transmission

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A test shall be carried out with each type of the following transmissions:

— front wheel drive
— rear wheel drive
— full time 4 × 4
— part time 4 × 4
— automatic gear box
— manual gear box**]**

[^F9 4.2.**]** Running in U.K.

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

[^F9 4.3.**]** Verifications U.K.

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

— wheels, wheel trims, tyres (make, type, pressure),
— front axle geometry,
— brake adjustment (elimination of parasitic drag),
— lubrication of front and rear axles,
— adjustment of the suspension and vehicle level, etc.

[^F9 4.4.**]** Preparation for the test U.K.

[^F9 4.4.1.**]** The vehicle is loaded to its reference mass. The level of the vehicle must be that obtained when the centre of gravity of the load is situated midway between the 'R' points of the front outer seats and on a straight line passing through those points.

[^F9 4.4.2.**]** In the case of road tests, the windows of the vehicle must be closed. Any covers of air climatization systems, headlamps, etc, must be in the non-operating position.

[^F9 4.4.3.**]** The vehicle must be clean.

[^F9 4.4.4.**]** Immediately prior to the test the vehicle is brought to normal running temperature in an appropriate manner.

5. METHODS U.K.

5.1. Method of energy variation during coast-down U.K.

5.1.1. On the road U.K.

5.1.1.1. Test equipment and error: U.K.
— time must be measured to an error lower than 0,1 second,
— speed must be measured to an error lower than 2 %.

5.1.1.2. Test procedure U.K.

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 (t_1) taken for the vehicle to decelerate from

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$V_2 = V + V$ km/h to $V_1 = V - V$ km/h with $V \leq 5$ km/h

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

5.1.1.2.5. Take the average

$$\bar{T}$$

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

$$T = \frac{1}{n} \sum_{i=1}^{n} T_i$$

is not more than 2 % ($p \leq 2$ %)

The statistical accuracy (p) is defined by:

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

where:

t   =   coefficient given by the table below,

s   =   standard deviation,

$$s = \sqrt{\sum_{i=1}^{n} \frac{\left(T_i - \bar{T}\right)^2}{n-1}}$$

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:

[**F5**

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

]

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 mass in kg,

T   =   time in seconds.

[**F11**5.1.1.2.8. The power (P) determined on the track shall be corrected to the reference ambient conditions as follows:

$P_{corrected} = K \cdot P_{measured}$

$$K = \frac{R_R}{R_T} \cdot [1 + K_R (t - t_0)] + \frac{R_{AERO}}{R_T} \cdot \frac{(\rho_0)}{\rho}$$

where

R_R =   rolling resistance at speed V

R_{AERO} =   aerodynamic drag at speed V

R_T	=	total driving resistance = $R_R + R_{AERO}$
[$^{F2}K_R$	=	temperature correction factor of rolling resistance, taken to be equal to: $8,64 \times 10^{-3}/°C$ or the manufacturer's correction factor that is approved by the authority]
t	=	road test ambient temperature in °C
t_0	=	reference ambient temperature = 20 °C
ρ	=	air density at the test conditions
ρ_0	=	air density at the reference conditions (20 °C, 100 kPa)

The ratios R_R/R_T and R_{AERO}/R_T shall be specified by the vehicle manufacturer on the basis of the data normally available to the company.

If these values are not available, subject to the agreement of the manufacturer and the technical service concerned, the figures for the rolling/total resistance ratio given by the following formula may be used:

$$\frac{R_R}{R_T} = a \cdot M + b$$

where:

M   =   vehicle mass in kg

[^{F2}and for each speed the coefficients a and b are shown in the following table:

V (km/h)	a	b
20	$7,24 \times 10^{-5}$	0,82
40	$1,59 \times 10^{-4}$	0,54
60	$1,96 \times 10^{-4}$	0,33
80	$1,85 \times 10^{-4}$	0,23
100	$1,63 \times 10^{-4}$	0,18
120	$1,57 \times 10^{-4}$	0,14]]

5.1.2.   On the dynamometer   U.K.

5.1.2.1.   Measurement equipment and accuracy   U.K.

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

5.1.2.2.   Test procedure   U.K.

5.1.2.2.1. Install the vehicle on the test dynamometer.

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

5.1.2.2.3. Adjust the equivalent inertia of the dynamometer.

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

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

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[**F9**5.1.2.2.6.Adjust the brake to reproduce the corrected power (Section 5.1.1.2.8) and to take into account the difference between the vehicle mass (M) on the track and the equivalent inertia test mass (I) to be used. This may be done by calculating the mean corrected road coast down time from V_2 to V_1 and reproducing the same time on the dynamometer by the following relationship:

$$T_{corrected} = \frac{T_{measured}}{K} \cdot \frac{I}{M}$$

K = specified in 5.1.1.2.8.]

[**F11**5.1.2.2.7.The power P_a to be absorbed by the bench should be determined in order to enable the same power (Section 5.1.1.2.8) to be reproduced for the same vehicle on different days.]

5.2. Torque measurement method at constant speed U.K.

5.2.1. On the road U.K.

5.2.1.1. Measurement equipment and error U.K.

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

Speed measurement must be accurate to within 2 %.

5.2.1.2. Test procedure U.K.

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

[**F9**5.2.1.2.2.Record the torque $C_{(t)}$ and speed over a period of least 20 s. The accuracy of the data recording system shall be at least $\pm$ 1 Nm for the torque and $\pm$ 0,2 km/h for the speed.]

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

5.2.1.2.4.The torque C is the average torque derived from the following formula:

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

[**F9**5.2.1.2.5.The test shall be carried out three times in each direction. Determine the average torque from these six measurements for the reference speed. If the average speed deviates by more than 1 km/h from the reference speed, a linear regression shall be used for calculating the average torque.]

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

[**F11**5.2.1.2.7.The average torque CT determined on the track shall be corrected to the reference ambient conditions as follows:

$C_{Tcorrected} = K \cdot C_{Tmeasured}$

where K is defined in 5.1.1.2.8 of this Appendix.]

5.2.2. On the dynamometer U.K.

5.2.2.1. Measurement equipment and error U.K.

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

5.2.2.2.   Test procedure   U.K.

5.2.2.2.1. Perform the operations specified in 5.1.2.2.1 to 5.1.2.2.4.

5.2.2.2.2. Perform the operations specified in 5.2.1.2.1 to 5.2.1.2.4.

[**F9**5.2.2.2.3 Adjust the power absorption unit to reproduce the corrected total track torque of 5.2.1.2.7.**]**

[**F11**5.2.2.2.4 Proceed with the same operations as in 5.1.2.2.7, for the same purpose.**]**

F105.3.   Integrated torque over variable driving pattern   U.K.

5.3.1.   . . . .

5.3.2.   . . . .

5.3.3.   Dynamometer setting   U.K.

F10 . . . .
Note:

. . . . .

5.3.4.   Acceptance criteria   U.K.

. . . .

F105.4.   Method of deceleration measurement by gyroscopic platform   U.K.

5.4.1.   On the road   U.K.

5.4.1.1.   Measurement equipment and error   U.K.

. . . .

5.4.1.2.   Test procedure   U.K.

5.4.1.2.1. . . . .

5.4.1.2.2. . . . .

5.4.1.2.3. . . . .

5.4.1.2.4. . . . .

5.4.1.2.5. . . . .

5.4.1.2.6. . . . .

5.4.1.2.7. . . . .

5.4.2.   Dynamometer method   U.K.

5.4.2.1.   Measurement equipment and error   U.K.

. . . .

5.4.2.2.   Test procedure   U.K.

5.4.2.2.1. **F10** . . . .

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Note:

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Appendix 4 U.K.

VERIFICATION OF INERTIAS OTHER THAN MECHANICAL

1.   OBJECT U.K.

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.[**F1**The manufacturer of the dynamometer shall provide a method to verify the specifications according to Section 3.]

2.   PRINCIPLE U.K.

2.1.   Drawing up working equations U.K.

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

$F = I \cdot \gamma = I_M \cdot \gamma + F_1$

where:

F	= force at the surface of the roller(s),
I	= total inertia of the dynamometer (equivalent inertia of the vehicle: see table in Annex III section 5.1),
I_M	= inertia of the mechanical masses of the dynamometer,
γ	= tangential acceleration at roller surface,
F_1	= inertia force.

Note:

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

Thus, the total inertia is expressed as follows:

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

where:

I_M can be calculated or measured by traditional methods.

F_i can be measured on the dynamometer, but can also be calculated from the peripheral speed of the rollers. γ may be calculated from the peripheral speed of the rollers.

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

2.2.   Specification for the calculation of total inertia U.K.

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

3.   SPECIFICATION U.K.

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

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

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

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

4.   VERIFICATION PROCEDURE   U.K.

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

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

F105.   TECHNICAL NOTE   U.K.

[**F10**. . . . .]

5.1.   . . . .

5.2.   . . . .

5.3.   . . . .

Appendix 5 U.K.

DESCRIPTION OF TAILPIPE EMISSION-SAMPLING SYSTEMS

1.   INTRODUCTION U.K.

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

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

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

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

2.1.   Scope U.K.

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

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

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

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

The quantity of gaseous pollutants emitted is 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. In addition, where vehicles are equipped with compression-ignition engines, their particulate emissions are plotted.

2.2.   Technical summary U.K.

Figure III.5.2.2 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 be so designed as to make it possible to measure the average volume concentrations of the CO_2, CO, HC and NO_x, and, in addition, in the case of vehicles equipped with compression-ignition engines, of the particulate emissions, contained in the exhaust gases emitted during the vehicle testing cycle.

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

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

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

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

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

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

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

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

2.3.   Specific requirements   U.K.

2.3.1.   Exhaust-gas collection and dilution device   U.K.

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

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

—   change the nature of the exhaust gas.

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

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

2.3.2.   Suction device/volume measuring device   U.K.

This device may have a range of fixed speeds so 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   U.K.

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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 K 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 K and a response time of 0,1 second 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   U.K.

2.3.4.1. Dilute exhaust gases   U.K.

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

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

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

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

2.3.4.2. Dilution air   U.K.

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

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

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

2.3.4.3. Sampling operations   U.K.

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

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

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

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

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

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

2.3.4.4. Storage of the sample U.K.

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

2.4. Additional sampling unit for the testing of vehicles equipped with a compression-ignition engine U.K.

2.4.1. By way of a departure from the taking of gas samples from vehicles equipped with spark-ignition engines, the hydrocarbon and particulate sampling points are located in a dilution tunnel.

2.4.2. In order to reduce heat losses in the exhaust gases between the exhaust tail pipe and the dilution tunnel inlet, the pipe may not be more than 3,6 m long, or 6,1 m long if heat insulated. Its internal diameter may not exceed 105 mm.

Particulate sampling probe configuration

2.4.3. Predominantly turbulent flow conditions (Reynolds number ≥ 4 000) must apply in the dilution tunnel, which consists of a straight tube of electrically-conductive material, in order to guarantee that the diluted exhaust gas is homogeneous at the sampling points and that the samples consist of representative gases and particulates. The dilution tunnel must be at least 200 mm in diameter and the system must be earthed.

2.4.4. The particulate sampling system consists of a sampling probe in the dilution tunnel and two series-mounted filters. Quick-acting valves are located both up and downstream of the two filters in the direction of flow.

The configuration of the sample probe must be as indicated in Figure III.5.2.4.4.

2.4.5. The particulate sampling probe must be arranged as follows:

It must be installed in the vicinity of the tunnel centreline, roughly 10 tunnel diameters downstream of the gas inlet, and have an internal diameter of at least 12 mm.

The distance from the sampling tip to the filter mount must be at least five probe diameters, but must not exceed 1 020 mm.

2.4.6. The sample gas flow measuring unit consists of pumps, gas flow regulators and flow measuring units.

2.4.7. The hydrocarbon sampling system consists of a heated sampling probe, line, filter and pump. The sampling probe must be installed in such a way, at the same distance from the exhaust gas inlet as the particulate sampling probe, that neither interferes with samples taken by the other. It must have a minimum internal diameter of 4 mm.

2.4.8. All heated parts must be maintained at a temperature of 463 K (190 °C) ± 10 K by the heating system.

2.4.9. If it is not possible to compensate for variations in the flow rate there must be a heat exchanger and a temperature control device as specified in 2.3.3.1 so as to ensure

that the flow rate in the system is constant and the sampling rate is accordingly proportional.

3.   DESCRIPTION OF THE DEVICES U.K.

3.1.   Variable dilution device with positive displacement pump (PDP-CVS) *(Figure III.5.3.1.)* U.K.

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 III.5.3.1 is a schematic drawing of such a sampling system. Since various configurations can produce accurate results exact conformity with the drawing is not essential. Additional components such as instruments, valves, solenoids and switches may be used to provide additional information and coordinate the functions of the component system.

3.1.3.   The collecting equipment consists of:

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

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

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

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 K of the designed operating temperature. This device must not affect the pollutant concentrations of diluted gases taken off after for analysis;

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

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

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

3.1.3.5.2.— sufficient to ensure that the CO_2 concentration in the dilute-exhaust sample bag is [**F2**less than 3 % by volume for petrol and diesel, less than 2,2 % by volume for LPG and less than 1,5 % by volume for NG;]

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

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

3.1.3.8. another pressure gauge (G_2) (accuracy and precision ± 0,4 kPa) fitted so that the different 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 the diluted exhaust-gas/air mixture during the test;

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

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

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

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

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

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

3.1.4. Additional equipment required when testing diesel-engined vehicles U.K.

To comply with the requirements of 4.3.1.1 and 4.3.2 of Annex III, the additional components within the dotted lines in Figure III.5.3.1 must be used when testing diesel-engined vehicles:

is a heated filter,
is a sample point close to the mixing chamber,
is a heated multiway valve,
is a quick connector to allow the ambient air sample BA to be analysed on the HFID,
is a heated flame ionization analyzer,
are means of integrating and recording the instantaneous hydrocarbon concentrations,
is a heated sample line.

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All heated components must be maintained at 463 K (190 °C) ± 10 K.

Particulate sampling system

> sampling probe in the dilution tunnel,
>
> filter unit consisting of two series-mounted filters; switching arrangement for further parallel-mounted pairs of filters,
>
> sampling line,
>
> pumps, flow regulators, flow measuring units.

3.2.   Critical-flow venturi dilution device (CFV-CVS) *(Figure III.5.3.2.)* U.K.

3.2.1.   Using a critical-flow venturi in connection with the CVS sampling procedure is based on the principles of flow mechanics for critical flow. The variable mixture flow rate of dilution and exhaust gas is maintained as 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 III.5.3.2 is a schematic drawing of such a sampling system. Since various configurations can produce accurate results, exact conformity with the drawing is not essential. Additional components such as instruments, valve, solenoids, and switches may be used to provide additional information and coordinate the functions of the component system.

3.2.3.   The collecting equipment consists of:

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

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

3.2.3.3. a cyclone separator (CS), to extract particles;

3.2.3.4. two sampling probes (S_1 and S_2) for taking samples of the dilution air and of the diluted exhaust gas/air mixture;

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

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

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

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

3.2.3.9. a snubber (PS), in the sampling line;

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

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

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

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

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

3.2.3.14. a pressure gauge (G), which is precise and accurate to within ± 0,4 kPa;

3.2.3.15. a temperature sensor (T), which is precise and accurate to within ± 1 K and have a response time of 0,1 seconds to 62 % of a temperature change (as measured in silicon oil);

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

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

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

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

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

3.2.4.   Additional equipment required when testing diesel-engined vehicles   U.K.

To comply with the requirements of 4.3.1.1 and 4.3.2 of Annex III, the additional components shown within the dotted lines of Figure III.5.3.2 must be used when testing diesel-engined vehicles:

> is a heated filter,
> is a sample point close to the mixing chamber,
> is a heated multiway valve,
> is a quick connector to allow the ambient air sample BA to be analyzed on the HFID,
> is a heated flame ionization analyzer,
> are a means of integrating and recording the instantaneous hydrocarbon concentrations,
> is a heated sample line.

All heated components must be maintained at 463 K (190 °C) ± 10 K.

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

Particulate sampling system

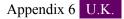> sampling probe in dilution tunnel,
>
> filter unit consisting of two series-mounted filters; switching unit for further parallel-mounted pairs of filters,
>
> sampling line,
>
> pumps, flow regulators, flow measuring units.

F103.3. Variable dilution device with constant flow control by orifice (CFO-CVS) *(Figure III.5.3.3.) (only for spark-ignition-engined vehicles)* U.K.

3.3.1. **F10** . . . .

3.3.1.1. . . . .

3.3.1.2. . . . .

3.3.1.3. . . . .

3.3.1.4. . . . .

3.3.1.5. . . . .

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3.3.1.10. . . . .

3.3.1.11. . . . .

3.3.1.12. . . . .

3.3.1.13. . . . .

3.3.1.14. . . . .

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3.3.1.15. . . . .

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Appendix 6 U.K.

METHOD OF CALIBRATING THE EQUIPMENT

1.   ESTABLISHMENT OF THE CALIBRATION CURVE U.K.

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

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

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

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

1.5.   Trace of the calibration curve U.K.

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

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

1.7.   Verification of the calibration U.K.

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

1.7.2.   The calibration is checked by using a zero gas and a span gas whose nominal value is within 80 to 95 % of the supposed value to be analyzed.

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

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

2.   CHECK FOR FID, HYDROCARBON RESPONSE U.K.

2.1.   Detector response optimization U.K.

The FID must be adjusted, as specified by the instrument manufacturer. Propane in air should be used, to optimize the response, on the most common operating range.

2.2.   Calibration of the HC analyzer   U.K.

The analyzer should be calibrated using propane in air and purified synthetic air. See section 4.5.2 of Annex III (calibration and span gases).

Establish a calibration curve as described in sections 1.1 to 1.5 of this Appendix.

2.3.   Response factors of different hydrocarbons and recommended limits   U.K.

The response factor (Rf) for a particular hydrocarbon species is the ratio of the FID C_1 reading to the gas cylinder concentration, expressed as ppm C_1.

The concentration of the test gas must be at a level to give a response of approximately 80 % of full scale deflection, for the operating range. The concentration must be known, to an accuracy of ± 2 % in reference to a gravimetric standard expressed in volume. In addition the gas cylinder must be pre-conditioned for 24 hours at a temperature between 293 and 303 K (20 and 30 °C).

Response factors are determined when introducing an analyzer into service and thereafter at major service intervals. The test gases to be used and the recommended response factor are:

[**F2**— methane and purified air	1,00 < Rf < 1,15,
	or
	1,00 < Rf < 1,05 for NG-fuelled vehicles,**]**
— propylene and purified air	0,90 < Rf < 1,00,
— toluene and purified air	0,90 < Rf < 1,00.

Relative to a response factor (Rf) of 1,00 for propane and purified air.

2.4.   Oxygen interference check and recommended limits   U.K.

The response factor should be determined as described in 2.3. The test gas to be used and recommended response factor range are:

— Propane and nitrogen	0,95 ≤ Rf ≤ 1,05

3.   EFFICIENCY TEST OF THE NO_x CONVERTER   U.K.

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

Using the test set up as shown in Figure III.6.3 and the procedure described below, the efficiency of converters can be tested by means of an ozonator.

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

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

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

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

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

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

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

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

Diagram of NO_x converter efficiency device

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

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

4.   CALIBRATION OF THE CVS SYSTEM U.K.

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

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

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

4.2.   Calibration of the positive displacement pump (PDP) U.K.

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

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

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

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

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

4.2.3.1.   Figure III.6.4.2.3.1 of this Appendix shows one possible test set-up. Variations are permissible, provided that they are approved by the authority granting the approval as being of comparable accuracy. If the set-up shown in Figure III.5.3.2 of Appendix 5 is used, the following data must be found within the limits of precision given:

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

4.2.3.2.   After the system has been connected as shown in Figure III.6.4.2.3.1, set the variable restrictor in the wide-open position and run the CVS pump for 20 minutes before starting the calibration.

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

PDP-CVS calibration configuration

4.2.4.   Data analysis   U.K.

4.2.4.1.   The air flow-rate (Q_s) at each test point is calculated in standard m^3/min from the flow-meter data using the manufacturer's prescribed method.

4.2.4.2.   The air flow-rate is then converted to pump flow (V_o) in m^3/rev at absolute pump inlet temperature and pressure.

$$V_o = \frac{Q_s}{n} \cdot \frac{T_p}{273,2} \cdot \frac{101,33}{P_p}$$

where:

V_o	=	pump flow-rate at T_p and P_p given in m^3/rev,
Q_s	=	air flow at 101,33 kPa and 273,2 K given in m^3/min,
T	=	pump inlet temperature (K),
P_p	=	absolute pump inlet pressure,
n	=	pump speed in revolutions per minute.

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

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

where:

X_o	=	correlation function,
ΔP_p	=	pressure differential from pump inlet to pump outlet (kPa),
P_e	=	absolute outlet pressure (PPO + P_B (kPa).

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

$$V_o = D_o - M(X_o)$$

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

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

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

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

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

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

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

where:

Q_s	=	flow,
K_v	=	calibration coefficient,
P	=	absolute pressure (kPa),
T	=	absolute temperature (K).

Gas flow is a function of inlet pressure and temperature.

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

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

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

barometric pressure (corrected) (P_B)	± 0,03 kPa,
LFE air temperature, flow-meter (ETI)	± 0,15 K,
pressure depression upstream of LFE (EPI)	± 0,01 kPa,
pressure drop across (EDP) LFE matrix	± 0,0015 kPa,
air flow (Q_s)	± 0,5 %,
CFV inlet depression (PPI)	± 0,02 kPa,
temperature at venturi inlet (T_v)	± 0,2 K.

4.3.4. The equipment must be set up as shown in Figure III.6.4.3.4 and checked for leaks. Any leaks between the flow-measuring device and the critical-flow venturi seriously affect the accuracy of the calibration.

CFV-CVS calibration configuration

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

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

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

Calculate values of the calibration coefficient for each test point:

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

where:

Q_s	=	flow-rate in m/min at 273,2 K and 101,33 kPa,
T_v	=	temperature at the venturi inlet (K),
P_v	=	absolute pressure at the venturi inlet (kPa).

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

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

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

Appendix 7   U.K.

TOTAL SYSTEM VERIFICATION

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

2.   Metering a constant flow of pure gas (CO or C_3H_8) using a critical-flow orifice device

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

3.   Metering a limited quantity of pure gas (CO or C_3H_8) by means of a gravimetric technique

3.1.   The following gravimetric procedure may be used to verify the CVS system. The weight of a small cylinder filled with either carbon monoxide or propane is determined with a precision of ± 0,01 gram. 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 weighting. The gas accumulated in the bag is then analyzed by means of the equipment normally used for exhaust-gas analysis. The results are then compared to the concentration figures computed previously.

Appendix 8 U.K.

CALCULATION OF THE EMISSION OF POLLUTANTS

1. GENERAL U.K.

1.1. Emissions of gaseous pollutants are calculated by means of the following equation:

$$M_i = \frac{V_{mix} \cdot Q_i \cdot k_H \cdot C_i \cdot 10^{-6}}{d}$$

[1]

where:

M_i	=	mass emission of the pollutant i in grams per kilometre,
V_{mix}	=	volume of the diluted exhaust gas expressed in litres per test and corrected to standard conditions (273,2 K and 101,33 kPa),
Q_i	=	density of the pollutant i in grams per litre at normal temperature and pressure (273,2 K and 101,33 kPa),
k_H	=	humidity correction factor used for the calculation of the mass emissions of oxides of nitrogen (there is no humidity correction for HC and CO),
C_i	=	concentration of the pollutant i in the diluted exhaust gas expressed in ppm and corrected by the amount of the pollutant i contained in the dilution air,
d	=	actual distance corresponding to the operating cycle in km.

1.2. Volume determination U.K.

1.2.1. 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.

1.2.2. 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:

$$V = V_o \cdot N$$

where:

V	=	volume of the diluted exhaust gas expressed in litres per test (prior to correction),
V_o	=	volume of gas delivered by the positive displacement pump on testing conditions in litres per revolution,
N	=	number of revolutions per test.

1.2.3. Correction of the diluted exhaust-gas volume to standard conditions. The diluted exhaust-gas volume is corrected by means of the following formula:

$$V_{mix} = V \cdot K_1 \cdot \frac{P_B - P_1}{T_P}$$

[2]

in which:

$$K_1 = \frac{273{,}2 \text{ K}}{101{,}33 \text{ kPa}} = 2{,}6961 \left(\text{K} \cdot \text{kPa}^{-1} \right)$$

$(^3)$

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).

1.3.   Calculation of the corrected concentration of pollutants in the sampling bag   **U.K.**

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

$(^4)$

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.

[**F2**The dilution factor is calculated as follows:

$$DF = \frac{13{,}4}{C_{CO_2} + (C_{HC} + C_{CO})10^{-4}} \text{ for petrol and diesel fuel (5a)}$$

$$DF = \frac{11{,}9}{C_{CO_2} + (C_{HC} + C_{CO})10^{-4}} \text{ for LPG (5b)}$$

$$DF = \frac{9{,}5}{C_{CO_2} + (C_{HC} + C_{CO})10^{-4}} \text{ for natural gas (5c)}$$
]

in this equation:

C_{CO_2}	=	concentration of CO_2 in the diluted exhaust gas contained in the sampling bag, expressed in % volume,
C_{HC}	=	concentration of HC in the diluted exhaust gas contained in the sampling bag, expressed in ppm carbon equivalent,
C_{CO}	=	concentration of CO in the diluted exhaust gas contained in the sampling bag, expressed in ppm.

1.4.   Determination of the NO humidity correction factor   **U.K.**

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

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

$(^6)$

in which:

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

where:

H	=	absolute humidity expressed in grams of water per kilogram of dry air,
R_a	=	relative humidity of the ambient air expressed as a percentage,
P_d	=	saturation vapour pressure at ambient temperature expressed in kPa,
P_B	=	atmospheric pressure in the room, expressed in kPa.

1.5.   Example U.K.

1.5.1.   Data U.K.

1.5.1.1. Ambient conditions:

ambient temperature: 23 °C = 296,2 K,

barometric pressure: P_B = 101,33 kPa,

relative humidity: R_a = 60 %,

[F9 saturation vapour pressure: P_d = 2,81 kPa of H_2O at 23 °C.]

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

V = 51,961 m³

1.5.1.3. Analyzer readings:

	Diluted exhaust	Dilution-air
HC[a]	92 ppm	3,0 ppm
CO	470 ppm	0 ppm
NO$_x$	70 ppm	0 ppm
CO$_2$	1,6 % vol	0,03 % vol

a   In ppm carbon equivalent.

1.5.2.   Calculation U.K.

[F9 1.5.2.1. Humidity correction factor (K_H) (see formula (6))

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

$$H = \frac{6,211 \cdot 60 \cdot 3,2}{101,33 - \left(2,81 \cdot 0,6\right)}$$

$$H = 10,5092$$

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

$$k_H = \frac{1}{1 - 0,0329 \cdot (10,5092 - 10,71)}$$

$k_H = 0{,}9934$]

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

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

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

$DF = 8{,}091$

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

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

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

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

$C = 89{,}371$

$$M_{HC} = C_{HC} \cdot V_{mix} \cdot Q_{HC} \cdot \frac{1}{d}$$

[**F2**$Q_{HC} = 0.619$ in the case of petrol or diesel

$Q_{HC} = 0.649$ in the case of LPG

$Q_{HC} = 0.714$ in the case of NG]

$$M_{HC} = 89{,}371 \cdot 51{,}961 \cdot 0{,}619 \cdot 10^{-6} \cdot \frac{1}{d}$$

$$M_{HC} = \frac{2{,}88}{d} \, g/km$$

CO, mass emissions (see formula (1))

$$M_{CO} = C_{CO} \cdot V_{mix} \cdot Q_{CO} \cdot \frac{1}{d}$$

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

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

$$M_{CO} = \frac{30{,}5}{d} \, g/km$$

NO_x mass emissions (see formula (1))

$$M_{NO_x} = C_{NO_x} \cdot V_{mix} \cdot Q_{NO_x} \cdot k_H \cdot \frac{1}{d}$$

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

[**F9**

$$M_{NOX} = 70 \cdot 51961 \cdot 2{,}05 \cdot 0{,}9934 \cdot 10^{-6} \frac{1}{d}$$

$$M_{NOX} = \frac{7{,}41}{d} \, g/km$$
]

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2.   SPECIAL PROVISIONS RELATING TO VEHICLES EQUIPPED WITH COMPRESSION-IGNITION ENGINES U.K.

2.1.   HC measurement for compression-ignition engines U.K.

The average HC concentration used in determining the HC mass emissions from compression-ignition engines is calculated with the aid of the following formula:

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

(⁷)

where:

$\int_{t_2}^{t_1} c_{HC} \cdot dt$	=	integral of the recording of the heated FID over the test ($t_2 - t_1$),
C_e	=	concentration of HC measured in the diluted exhaust in ppm of C_i,

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

2.2.   Determination of particulates U.K.

Particulate emission M_p (g/km) is calculated by means of the following equation:

$$M_p = \frac{(V_{mix} + V_{ep}) \cdot P_e}{V_{ep} \cdot d}$$

where exhaust gases are vented outside tunnel,

$$M_p = \frac{V_{mix} \cdot P_e}{V_{ep} \cdot d}$$

where exhaust gases are returned to the tunnel,

where:

V_{mix}	:	volume of diluted exhaust gases (see 1.1), under standard conditions,
V_{ep}	:	volume of exhaust gas flowing through particulate filter under standard conditions,
P_e	:	particulate mass collected by filters,
d	:	actual distance corresponding to the operating cycle in km,
M_p	:	particulate emission in g/km.]

(**1**)   [**F1**It should be noted that the time of two seconds allowed includes the time for changing gear and, if necessary, a certain amount of latitude to catch up with the cycle.

(**2**)   [**F11**According to Directive 70/156/EEC.**]]**

Textual Amendments

F1   Substituted by Council Directive of 26 June 1991 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles (91/441/EEC).

F11   Inserted by Commission Directive 96/44/EC of 1 July 1996 adapting to technical progress 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 emissions from motor vehicles (Text with EEA relevance).