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Item 8(c) of the provisional agenda
UN Regulation No. 40 (Emission of gaseous pollutants by motor cycles)

Proposal for the 02 series of amendments to UN Regulation No. 40 (Emission of gaseous pollutants by motor cycles)

Submitted by the Informal Working Group "Environmental and Propulsion Performance Requirements of L-Category Vehicles"

I. Proposal

UN Regulation No. 40

Uniform Provisions Concerning the Approval of Motorcycles Equipped with a Positive-Ignition Engine with regard to the Emission of Gaseous Pollutants by the Engine

Content

1.   **SCOPE**

This Regulation applies to the emission of gaseous pollutants from positive-ignition engines of vehicles of categories L3, L4 and L5.

2.   **DEFINITIONS**

For the purposes of this Regulation,

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

2.2.   "*Vehicle type*" means a category of power-driven vehicles which do not differ in such essential respects as:

2.2.1. the equivalent inertia determined in relation to the reference weight as described in annex 7, appendix 4, to this Regulation, and

2.2.2. the engine and vehicle characteristics as defined in Annex 1 items 1-4 and Annex 2 to this regulation ;

2.3.   "*Engine crank-case*" means the spaces in or external to an engine which are connected to the oil sump by internal or external ducts through which gases and vapours can escape;

2.4.   "*Actuator*" means a converter of an output signal from a control unit into motion, heat or other physical state in order to control the powertrain, engine(s) or drive train;

2.5.   "*Air intake system*" means a system composed of components allowing the fresh-air charge or air-fuel mixture to enter the engine and includes, if fitted, the air filter, intake pipes, resonator(s), the throttle body and the intake manifold of an engine;

2.6.   "*Boost control*" means a device to control the boost level produced in the induction system of a turbocharged or super-charged engine;

2.7.   "*Carburettor*" means a device that blends fuel and air into a mixture that can be combusted in a combustion engine;

2.8.   "*Catalytic converter*" means an emission pollution-control device which converts toxic by-products of combustion in the exhaust of an engine to less toxic substances by means of catalysed chemical reactions;

2.9.   "*CO_2 emissions*" means carbon dioxide;

2.10.   "*Cold-start device*" means a device that temporarily enriches the air/fuel mixture of the engine, or any device or means which can assist to start the engine;

2.11.   "*Defeat device*" means any element of design which senses temperature, vehicle speed, engine rotational speed, drive gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control and exhaust after-treatment system that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use. Such an element of design may not be considered a defeat device if:

(a)   The need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle; or

(b)   The device does not function beyond the requirements of engine starting; or

(c)   Conditions are substantially included in the Type I test procedures.

2.12.   "*Drive train*" means the part of the powertrain downstream of the output of the Propulsion unit(s) that consists if applicable of the torque converter clutches,

the transmission and its control, either a drive shaft or belt drive or chain drive, the differentials, the final drive, and the driven wheel tyre (radius);

2.13. "*Drive train control unit*" means the on-board computer that partly or entirely controls the drive train of the vehicle;

2.14. "*Driver mass*" means the nominal mass of a driver that shall be 75 kg ;

2.15. "*Electronic throttle control*" (ETC) means the control system consisting of sensing of driver input via the accelerator pedal or handle, data processing by the control unit(s), resulting actuation of the throttle and throttle position feedback to the control unit in order to control the air charge to the combustion engine;

2.16. "*Engine and vehicle characteristics*": Subject to the provisions of paragraph 1.1. of Appendix 3 to Annex 7, the engine and vehicle characteristics as defined in Annex 1 to this Regulation;"

2.17. "*Engine capacity*" means:

(a)   For reciprocating piston engines, the nominal engine swept volume [1];

(b)   For rotary-piston (Wankel) engines, double the nominal engine swept volume;

[1] Engine displacement shall be calculated using pi = 3.1416, and bore and stroke dimensions shall be rounded to the nearest tenth of a mm.

2.18. "*Engine control unit*" means an on-board computer that partly or entirely controls the engine(s) and all emission related devices / systems of the vehicle;

2.19. "*Equivalent inertia*" determined in relation to the reference mass as defined in 2.36. to this paragraph;

2.20. "*Exhaust emissions*" means emissions of gaseous pollutants and particulate matter from the tailpipe;

2.21. "*Exhaust gas recirculation (EGR) system*" means a part of the exhaust gas flow led back to the combustion chamber of an engine in order to lower the combustion temperature;

2.22. "*Forced Induction System*" is the process of delivering compressed air / air-fuel mixture to the intake of an internal combustion engine;

2.22.1. "*Super-charger*" means an intake air/air fuel mixture compressor run by any means other than engine exhaust and used for forced induction of a combustion engine, thereby increasing propulsion unit performance;

2.22.2. "*Turbocharger*" means an exhaust gas turbine-powered centrifugal compressor boosting the amount of air charge into the combustion engine, thereby increasing the propulsion unit performance;

2.23. "*Fuel consumption*" means the amount of fuel consumed, calculated by the carbon balance method:

2.24. "*Gaseous pollutants*" means carbon monoxide (CO), oxides of nitrogen (NOx) expressed in terms of nitrogen dioxide (NO_2) equivalence, and hydrocarbons (HC), assuming a ratio of:

$C_1H_{1.85}$ for petrol,

2.25. "*Intercooler*" means a heat exchanger that removes waste heat from the compressed air by a charger before entering into the engine, thereby improving volumetric efficiency by increasing intake air charge density;

2.26. "*Maximum net engine power*" is the maximum net engine power of the vehicle as declared by the manufacturer, measured in accordance with ISO 4106:2012

2.27. "*Maximum vehicle speed*" (Vmax) is the maximum speed of the vehicle as declared by the manufacturer, measured in accordance with ISO 7117:2010

2.28.   "*Parent vehicle*" means a vehicle that is representative of a propulsion unit family set out in Appendix 8 to Annex 7;

2.29.   (Reserved);

2.30.   (Reserved);

2.31.   "*Pollution-control device*" means those components (hardware or software) of a vehicle that control or reduce emissions;

2.32.   "*Positive ignition engine*" or "*PI engine*" means a combustion engine working according to the principles of the "Otto" cycle;

2.33.   "*Powertrain*" means the components and systems of a vehicle that generate power and deliver it to the road surface, including the engine(s), the engine management systems or any other control module, the pollution environmental protection control devices including pollutant emissions and noise abatement systems, the transmission and its control, either a drive shaft or belt drive or chain drive, the differentials, the final drive, and the driven wheel tyre (radius);

2.34.   "*Properly maintained and used*" means that when selecting a test vehicle it satisfies the criteria with regard to a good level of maintenance and normal use according to the recommendations of the vehicle manufacturer for acceptance of such a test vehicle;

2.35.   "*Propulsion unit*" means a combustion engine, an electric motor, any hybrid application or a combination of those engine types or any other engine type;

2.36.   "*Reference mass (m_{ref})*" means the unladen mass of the vehicle increased with the mass of the driver (75 kg);

2.37.   "*Scavenging port*" means a connector between crankcase and combustion chamber of a two-stroke engine through which the fresh charge of air, fuel and lubrication oil mixture enters the combustion chamber;

2.38.   "*Sensor*" means a converter that measures a physical quantity or state and converts it into an electric signal that is used as input to a control unit;

2.39.   "*Stop-start system*" means automatic stop and start of the propulsion unit;

2.40.   "*Tailpipe emissions*" means the emission of gaseous pollutants and particulate matter at the tailpipe of the vehicle;

2.41.   "*Unladen mass (m_k)*" means the nominal mass of a complete vehicle as determined by the following criteria:

Mass of the vehicle with bodywork and all factory fitted equipment, electrical and auxiliary equipment for normal operation of vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks and spare wheel, if fitted.

The fuel tank shall be filled to at least 90 per cent of rated capacity and the other liquid containing systems to 100 per cent of the capacity specified by the manufacturer.

2.42.   "*Useful life*" means the relevant period of distance and/or time over which compliance with the relevant gaseous and particulate emission limits has to be assured.

2.43.   "*Alternative fuel vehicle*" means a vehicle designed to run on at least one type of fuel that is either gaseous at atmospheric temperature and pressure, or substantially non-mineral oil derived;

2.44.   "*Gaseous fuel system*" means a system composed of gaseous fuel storage, fuel supply, metering and control components fitted to an engine in order to allow the engine to run on LPG, CNG or hydrogen as a mono-fuel, bi-fuel or multi-fuel application;

2.45.   "*Mono fuel vehicle*" means a vehicle that is designed to run primarily on one type of fuel;

2.46. "*Mono fuel gas vehicle*" means a mono fuel vehicle that primarily runs on LPG, NG/biomethane, or hydrogen but may also have a petrol system for emergency purposes or starting only, where the petrol tank does not contain more than 2 litres of petrol in case of two- wheeled vehicle and 3 litres in case of three-wheeled vehicle;

2.47. "*LPG*" means liquefied petroleum gas which is composed of propane and butane liquefied by storage under pressure;

2.48. "*NG*" means natural gas containing a very high methane content;

2.49. "*Biomethane*" means a renewable natural gas made from organic sources that starts out as 'biogas' but then is cleaned up in a process called 'biogas to biomethane' which removes the impurities in biogas such as carbon dioxide, siloxanes and hydrogen sulphides (H_2S);

2.50. "*Bi-fuel vehicle*" means a vehicle with two separate fuel storage systems that can run part-time on two different fuels and is designed to run on only one fuel at a time;

2.51. "*Bi-fuel gas vehicle*" means a bi-fuel vehicle that can run on petrol and also on either LPG, NG/biomethane or hydrogen;

2.52. "*Twinned wheels*" means two wheels mounted on the same axle which are considered to be one wheel, whereby the distance between the centres of their areas of contact with the ground is equal to or less than 460 mm. For two-wheeled motorcycles, in case the vehicle is equipped with a "twinned wheels-" configuration, the full vehicle structure or part of the vehicle structure shall tilt when turning."

3. APPLICATION FOR APPROVAL

3.1. The application for approval of a vehicle type with regard to limitation of the emission of gaseous pollutants from its engine shall be submitted by the vehicle manufacturer or by his duly accredited representative.

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

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

3.2.2 particulars concerning the vehicle as shown in annex 2 to this Regulation.

3.3. A vehicle representative of the vehicle type to be approved shall be submitted to the technical service responsible for conducting approval tests, for the tests referred to in paragraph 5. of this Regulation.

4. APPROVAL

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

4.2. An approval number shall be assigned to each type approved, the first two digits of which shall be the highest number of the series of amendments incorporated in the Regulation at the time of issue of the approval. The same Contracting Party may not assign the same number to another vehicle type.

4.3. Notice of approval or extension or refusal or withdrawal of approval or production definitely discontinued of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a form conforming to the model in annex 2 to this Regulation and of drawings and diagrams supplied by the applicant for

approval, in a format not exceeding A 4 (210 x 297 mm) or folded to that format and on an appropriate scale.

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

4.4.1.   a circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval; 1/

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

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

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

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

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

5.   **SPECIFICATIONS AND TESTS**

The Type Approval Authority shall inform the other Type Approval Authorities of Contracting Parties of the circumstances of each type approval granted under this paragraph.

The emissions tests for roadworthiness purposes set out in Annex 5 shall still be required to obtain type approval with regard to emissions under this paragraph.

5.1.   General

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

5.1.2.   The technical measures taken by the manufacturer shall be such as to ensure that in conformity with the provisions of this Regulation, exhaust gas emissions are effectively limited throughout the normal life of the vehicle and under normal conditions of use. This will include the security of those hoses and their joints and connections, used within the emission control systems, which shall be so constructed as to conform with the original design intent. For exhaust emissions, these provisions are deemed to be met if the provisions of paragraph 5.4.1. of this Regulation and paragraph 8. of this Regulation are complied with.

5.1.2.1.   Any strategy that "optimises" the powertrain of the vehicle running the relevant test cycles in an advantageous way, reducing tailpipe emissions and running significantly differently under real-world conditions differently than under emission test laboratory conditions, is considered a defeat strategy and is prohibited, unless the manufacturer has documented and declared it to the satisfaction of the responsible authority.

5.1.2.1.1.   An element of design shall not be considered a defeat device if any of the following conditions is met:

5.1.2.1.1.1. the need for the device is justified in terms of protecting the engine against damage or accident and ensuring safe operation of the vehicle;

5.1.2.1.1.2. the device does not function beyond the requirements of engine starting;

5.1.2.1.1.3. the operating conditions are included to a substantial extent in the test procedures for verifying if the vehicle complies with this Regulation.

5.1.3. It shall be possible to inspect the vehicle for roadworthiness test in order to determine its performance in relation to the data collected in accordance with paragraph 5.4.4. of this Regulation.

If this inspection requires a special procedure, this shall be detailed in the service manual (or equivalent media).

This special procedure shall not require the use of special equipment other than that provided with the vehicle.

5.2. Test procedure

Table 1 illustrates the various possibilities for type approval of a vehicle.

5.2.1. Positive ignition engine-powered vehicles shall be subject to the following tests:

Type I (verifying the exhaust emissions after a cold start);

Type II (Tailpipe emission at idling speed);

Type VII (energy efficiency)

Table 1
Scope with regard to the propulsion unit and fuel type

Propulsion unit and fuel type			*Test Type I*	*Test Type II*	*Test Type VII*
Vehicle with PI engine	Mono-fuel*	Petrol	Yes	Yes	Yes
		LPG	Yes*	Yes*	Yes*
		NG / Biomethane	Yes*	Yes*	Yes*
	Bi-fuel	Petrol / LPG	Yes (Both Fuels)	Yes (Both Fuels)	Yes (Both Fuels)
		Petrol / NG / Biomethane	Yes (Both Fuels)	Yes (Both Fuels)	Yes (Both Fuels)

* Exemption: Type I, Type II and Type VII tests are exempted in petrol mode of a mono-fuel vehicle that is designed primarily for permanent running on LPG or NG / bio-methane, having a petrol system, with a petrol fuel tank capacity not exceeding two litres in the case of two- wheeled motorcycles and motorcycles with sidecar and not exceeding three litres in the case of three- wheeled vehicles, intended for emergency purposes or starting only.

5.2.2. (Reserved)

5.2.3. Upon the choice of the manufacturer vehicles with positive ignition engines may be tested with either E5 or E10 fuels.

5.2.4. Vehicle sub-classification

5.2.4.1. Figure 1 provides a graphical overview of the vehicle sub-classification in terms of engine capacity and maximum vehicle speed if subject to the environmental test types indicated by the (sub-) class numbers in the graph areas. The numerical values of the engine capacity and maximum vehicle speed shall not be rounded up or down. In the case the two-wheeled vehicle of one of the aforementioned classes is equipped with a "twinned wheels-" configuration, the full vehicle structure or part of the vehicle structure shall tilt when turning.

Figure 1
Vehicle sub-classification for environmental testing, Test Types I and VII
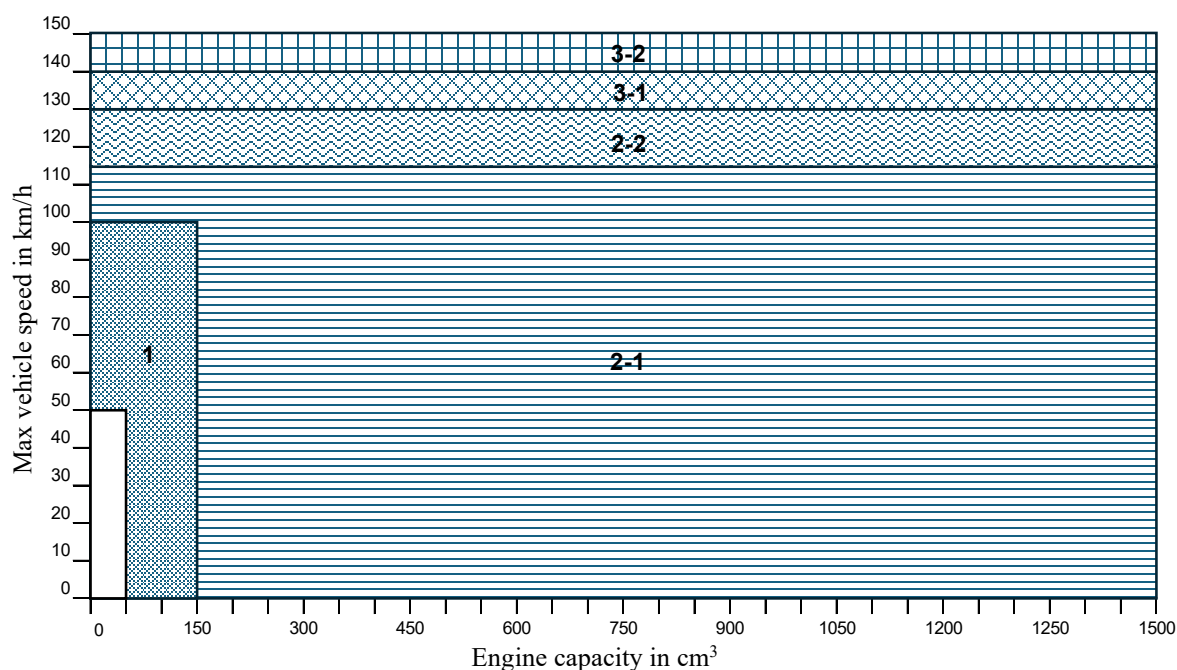
5.2.4.2.   Class 1

Vehicles that fulfil the following specifications in Table 2 belong to class 1

Table 2
Classification criteria for class 1 two- and three- wheeled vehicles

$50cm^3$ < Engine Capacity < $150cm^3$ and $v_{max} \leq 50km/h$ Or Engine Capacity < $150cm^3$ and $50km/h$ < v_{max} < $100km/h$	Class 1

5.2.4.3.   Class 2

Vehicles that fulfil the following specifications in Table 3 belong to class 2 and shall be sub-classified in:

Table 3
Sub-classification criteria for class 2 two- and three- wheeled vehicles

Engine Capacity <$150cm^3$ and $100km/h \leq v_{max}$ <$115km/h$ Or Engine Capacity $\geq 150cm^3$ and v_{max} < $115km/h$	Sub-class 2-1
$115km/h \leq v_{max}$ < $130km/h$	Sub-class 2-2

5.2.4.4.   Class 3

Vehicles that fulfil the following specifications in Table 4 belong to class 3 and shall be sub-classified in:

Table 4
Sub-classification criteria for class 3 two- wheeled vehicles

130km/h ≤ v_{max} < 140km/h	Sub-class 3-1
v_{max} ≥ 140km/h	Sub-class 3-2

5.3.   Nomenclature

5.3.1.   Wherever required, values shall be rounded-off as follows:

When the digit next beyond that last place to be retained, is

(a)   less than 5, retain the last digit unchanged. (E.g. 1.243 becomes 1.24);

(b)   greater than 5, increase the last digit by one. (E.g. 1.246 becomes 1.25);

(c)   equals 5, and there are no digits beyond this, or only zeros, increase the last digit by one, if the last digit is odd (E.g. 1.235 becomes 1.24) and retain the last digit unchanged if it is even (E.g. 1.245 becomes 1.24);

(d)   equals 5, and there are digits beyond this, increase the last digit by one. (E.g. 1.2451 becomes 1.25).

5.3.2.   Throughout this document the decimal sign is a full stop (period) and, if used, the thousands separator is a space.

5.3.3.   Temperature shall be measured in °C.

Wherever temperature conversion is required in K for calculation purpose, the following equivalence shall be used, 0°C = 273.15K.

5.4.   Description of tests

5.4.1.   Type I test (Verifying exhaust emissions after a cold start).

5.4.1.1.   Figure 2 illustrates the routes for Type I test.

This test shall be carried out on all vehicles referred to in paragraph 1. of this Regulation.

5.4.1.2.   The vehicle is placed on a chassis dynamometer equipped with a means of load and inertia simulation.

5.4.1.3.   The test is carried out using the procedure of Type I test as described in Annex 4 to this Regulation. .

5.4.1.4.   Subject to the requirements of paragraph 5.4.1.5. of this Regulation the test shall be repeated three times. The resulting masses of gaseous emissions and the mass of particulates obtained shall be less than the limits shown in Table 5.

Table 5
Limit value

Class	Limits (mg/km) for PI Engines		
	CO	THC (HC)	NOx
1	2 620	750	170
2	2 620	750	170
3	2 620	330	220

5.4.1.4.1.   Where the prescribed limits are exceeded for more than one pollutant, it is immaterial whether this occurs in the same test or in different tests.

5.4.1.4.2.   When the tests are performed with gaseous fuels, the resulting mass of gaseous emissions shall be less than the limits for petrol-engine vehicles in the Table 5.

5.4.1.5.   Number of tests

5.4.1.5.1.   The number of tests shall be determined as shown in Figure 2.

Ri1 to Ri3 describe the final measurement results for the first (No. 1) test to the third (No 3) test and the gaseous pollutant. 5.4.1.5.2. In each test, the

masses of the carbon monoxide, hydrocarbons, nitrogen oxides, carbon dioxide and the fuel consumed during the test shall be determined.

Figure 2
Flowchart for the number of Test Type I
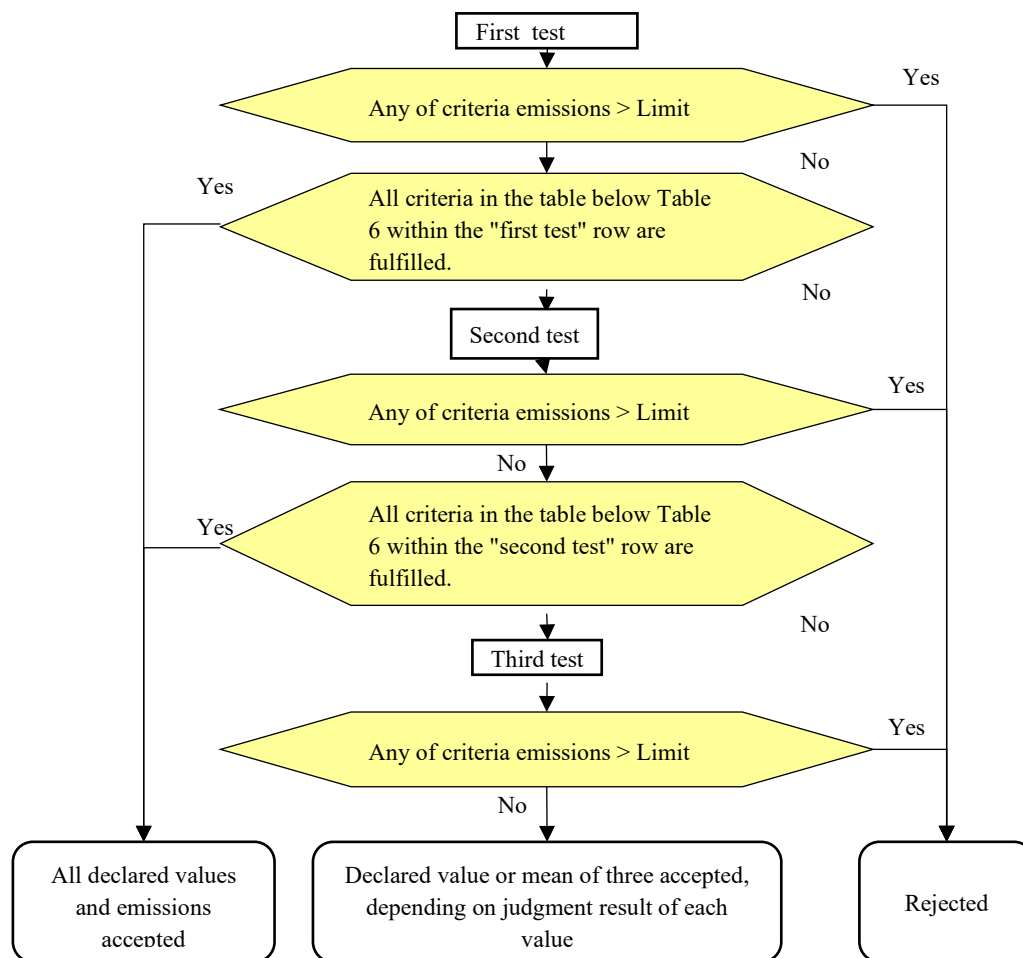
Table 6
Criteria for number of tests

	Test	Judgement parameter	Criteria emission
Row 1	First test	First test results	≤ Regulation limit × 0.9
Row 2	Second test	Arithmetic average of the first and second test results	≤ Regulation limit × 1.0[a]
Row 3	Third test	Arithmetic average of three test results	≤ Regulation limit × 1.0[a]

[a] Each test result shall fulfil the regulation limit

Exhaust emissions may be sampled during preparation tests for Test Type I or during verification tests for Test Types VII but the results of these tests shall not be used for the purpose of exhaust emission certification to satisfy the requirements set out in paragraph 5.4.1.4.

5.4.2.   Type II test (Tailpipe emission test at idling speed)

5.4.2.1. This test is carried out on all vehicles powered by positive ignition engines, in accordance with the test procedure set out in Annex 5:

5.4.2.1.1. Vehicles that can be fuelled either with petrol or with LPG or NG/biomethane shall be tested in the Type II test on both fuels.

5.4.2.1.2. Notwithstanding the requirement of paragraph 5.4.2.1.1., mono-fuel gas vehicles will be regarded for the Type II test as vehicles that can only run on a gaseous fuel.

5.4.3. Type VII test (energy efficiency)

5.4.3.1. Annex 6 sets out requirements with regard to energy efficiency of L-category vehicles, in particular with respect to the measurements of CO_2 emissions, fuel consumption.

The requirements laid down in Annex 6 apply to the following tests of L-category vehicles equipped with associated powertrain configurations:

the measurement of the emission of carbon dioxide (CO_2) and fuel Consumption of L-category vehicles powered by a combustion engine;

5.4.3.2. The components liable to affect CO_2 emissions and fuel consumption shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibrations to which it may be subjected, to comply with the provisions of Annex 6. The test vehicles shall be properly maintained and used.

The emissions of CO_2 and fuel consumption shall be measured according to the test procedure described in Annex 4 and Annex 6.

5.4.4. Emission data required for roadworthiness testing

5.4.4.1 This requirement applies to all vehicles powered by a positive ignition engine for which type approval is sought in accordance with this Regulation.

5.4.4.2 When tested in accordance with Annex 5 to this Regulation (Type II test) at normal idling speed:

(a) The carbon monoxide content by volume of the exhaust gases emitted shall be recorded; and

(b) The engine speed during the test shall be recorded, including any tolerances.

5.4.4.3. When tested at "high idle" speed (i. e. > 2 000 min^{-1})

(a) The carbon monoxide content by volume of the exhaust gases emitted shall be recorded;

(b) (Reserved)

(c) The engine speed during the test shall be recorded, including any tolerances.

(Reserved)

5.4.4.4. The engine oil temperature at the time of the test shall be measured and recorded.

5.4.4.5. The following table shall be completed.

Test	CO value (per cent vol)	(Reserved)	Engine speed (min^{-1})	Engine oil temperature (°C)
Low idle test				
High idle test				

5.4.4.6. An assessment shall be made based on surveys and studies of production vehicles.

6. MODIFICATIONS OF THE VEHICLE TYPE

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

6.1.1. consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still complies with the requirements; or

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

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

7. EXTENSION OF APPROVAL

7.1. Two-wheeled vehicles

Approval granted to a two-wheeled vehicle type may be extended to the same propulsion unit family in accordance with the classification criteria prescribed in paragraph 2. of Annex 7 Appendix 8.

7.2. Three-wheeled vehicles

Approval granted to a two-wheeled vehicle type may be extended to three-wheeled vehicles using the same engine and exhaust system and using a transmission that is either the same or differs only in respect of the over-all transmission ratios.

7.3. Restriction

When a vehicle type has been approved in accordance with the provisions of paragraphs 7.1. and 7.2. above, such approval may not be extended to other vehicle types.

8. CONFORMITY OF PRODUCTION

8.1. Every vehicle bearing an approval mark as prescribed under this Regulation shall conform, with regard to components affecting the emission of gaseous (reserved) by the engine to the vehicle type approved. The conformity of production procedures shall comply with those set out in the 1958 Agreement, Appendix 2 (E/ECE/324-E/ECE/TRANS/505/Rev.2), with the following requirements set out in the paragraphs below.

8.1.1. The tests of Types I, (reserved) shall be performed, as described in Table 1 to this Regulation. The specific procedures for conformity of production are set out in the paragraphs 8.2.

8.2. Checking the conformity of the vehicle for a Type I test

8.2.1. The Type I test shall be carried out on a vehicle of the same specification as described in the type approval certificate. When a Type I test is to be carried out for a vehicle type approval that has one or several extensions, the Type I tests shall be carried out either on the vehicle described in the initial information package or on the vehicle described in the information package relating to the relevant extension.

8.2.2. After selection by the Approval Authority, the manufacturer shall not undertake any adjustment to the vehicles selected.

8.2.2.1. Three vehicles shall be selected at random in the series and tested as described in paragraph.5.4.1. of this Regulation. The limit values are set out in paragraph 5.4.1.4., Table 5.

8.2.2.2.   If the average emissions of the first two vehicles comply with the requirements laid down in paragraph 5.4.1.4 Table 5 then the production conformity is considered as satisfactory.

8.2.2.3.   If the average emissions of the first two vehicles do not comply, the COP procedure continues as follows.

8.2.2.4.   If the Approval Authority is satisfied with the production standard deviation given by the manufacturer, the tests shall be carried out according to Appendix 1 of this Regulation. If the Approval Authority is not satisfied with the production standard deviation given by the manufacturer, the tests shall be carried out according to Appendix 2 of this Regulation.

8.2.2.5.   The production of a series shall be deemed to conform or not to conform on the basis of a sampling test of the vehicles once a pass decision is reached for all the pollutants or a fail decision is reached for one pollutant, according to the test criteria applied in the appropriate appendix.

When a pass decision has been reached for one pollutant, that decision shall not be changed by any additional tests carried out to reach a decision for the other pollutants.

If no pass decision is reached for all the pollutants and no fail decision is reached for one pollutant, a test shall be carried out on another vehicle (see Figure 3).

Figure 3
Checking the conformity of the vehicle

```
            ┌─────────────────────────────┐
            │     Select three vehicles    │
            └─────────────────────────────┘
                          │
            ┌─────────────────────────────┐
            │       Test two vehicles      │
            └─────────────────────────────┘
                          │
        ┌──────────────────────────────────┐   YES   ┌──────────────┐
        │ Do the average emissions comply   │────────▶│    Series     │
        │      with the requirement          │         │   accepted    │
        └──────────────────────────────────┘         └──────────────┘
                          │ NO
            ┌─────────────────────────────┐
            │      Test of third vehicle    │
            └─────────────────────────────┘
                          │
            ┌─────────────────────────────┐
            │ Computation of the test       │
            │          statistic            │
            └─────────────────────────────┘
                          │
     ┌──────────────────────────────────────┐   YES   ┌──────────────┐
     │ According to appropriate Appendix dose │────────▶│    Series     │
     │ the test statistic agrees with the     │         │   rejected    │
     │ criteria for falling the series for at │         └──────────────┘
     │ least one pollutant?                   │
     └──────────────────────────────────────┘
                          │ NO
     ┌──────────────────────────────────────┐
     │ According to appropriate Appendix dose │
     │ the test statistic agrees with the     │
     │ criteria for passing the series for at │
     │ least one pollutant?                   │
     └──────────────────────────────────────┘
                          │ YES
            ┌─────────────────────────────┐
            │  A pass decision is reached   │
            │  for one or more pollutants   │
            └─────────────────────────────┘
                          │
        ┌──────────────────────────────────┐   YES   ┌──────────────┐
        │  Is a pass decision is reached     │────────▶│    Series     │
        │     for all the pollutants?        │         │   accepted    │
        └──────────────────────────────────┘         └──────────────┘
                          │ NO
            ┌─────────────────────────────┐
            │ Test of an additional vehicle │
            └─────────────────────────────┘
```

8.2.3.   Notwithstanding the requirements of paragraph 5.4.1. of this Regulation, the tests shall be carried out on vehicles which have travelled a maximum distance of 100 km after first start at the production line.

8.2.3.1.   However, at the request of the manufacturer, the tests will be carried out on vehicles which have been run in a maximum of 1 000 km.

In this case, the running-in procedure will be conducted by the manufacturer, who shall undertake not to make any adjustments to those vehicles.

8.2.3.2.   If the manufacturer asks to be allowed to conduct a running-in procedure ('x' km, where x ≤ 1 000 km), it may be carried out as follows:

The tailpipe pollutant and CO_2 emissions will be measured at maximum 100 km after first start on the production line and at 'x' km on the first tested vehicle (which can be the type-approval vehicle);

The evolution coefficient (EC) of the emissions between 100 km and 'x' km will be calculated as follows:

$$EC = \frac{Emissions\_at\_x\_km}{Emissions\_at\_Max\_100\_km}$$

The value of EC may be less than 1.

The subsequent vehicles will not be subjected to the running-in procedure, but their 100 km emissions will be modified by the EC.

In this case, the values to be taken will be:

The value at 'x' km for the first vehicle;

The values at maximum 100 km multiplied by the evolution coefficient (EC) for the subsequent vehicles.

8.2.3.3.   As an alternative to this procedure, the vehicle manufacturer can use a fixed EC of 0.92 and multiply all values of tailpipe pollutant and CO_2 emissions measured at zero km by this factor.

8.2.4.   All these tests shall be conducted with commercial fuel. However, at the manufacturer's request, the reference fuels described in Annex7 Appendx2 may be used.

9.   PENALTIES FOR NON-CONFORMITY OF PRODUCTION

9.1.   The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 8.1. are not complied with or if the vehicle or vehicles taken fail to pass the tests prescribed in paragraph 8.3. above.

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

10.   PRODUCTION DEFINITELY DISCONTINUED

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

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

The Parties to the Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

12.   TRANSITIONAL PROVISIONS

12.1.   As from the official date of entry into force of the 02 series of amendments, no Contracting Parties applying this Regulation shall refuse to grant or refuse to accept type approvals under this Regulation as amended by the 02 series of amendments.

12.2.   Contracting Parties applying this Regulation may grant type approvals according to any of the preceding series of amendments to this Regulation.

12.3.   Contracting Parties applying this Regulation shall continue to grant extensions of existing approvals to any of the preceding series of amendments to this Regulation.

12.4.   Approvals granted under this Regulation before the entry into force of the 02 series of amendments and all extensions of such approvals, including those granted subsequently under a preceding series of amendments to this Regulation, shall remain valid indefinitely. If the type of vehicle of category L3, L4 and L5 type approved under the preceding series of amendments meets the requirements of this Regulation as amended by the 02 series of amendments, the Contracting Party which granted the approval shall so notify the other Contracting Parties applying this Regulation.

12.5.   No Contracting Party applying this Regulation shall refuse national type approval of a type of vehicle of category L3, L4 and L5 type approved under the 02 series of amendments to this Regulation or meeting the requirements thereof.

12.6.   As from two years from the entry into force of this series, Contracting Parties applying this Regulation may refuse first national registration (first entry into service) of a type of vehicle of category L3, L4 and L5 which does not meet the requirements of the 02 series of amendments to this Regulation.

Appendix 1

Procedure for verifying the conformity of production requirements if the production standard deviation given by the manufacturer is satisfactory

1. This appendix describes the procedure to be used to verify the production conformity for the Type I Test when the manufacturer's production standard deviation is satisfactory.

2. With a minimum sample size of 3, the sampling procedure is set so that the probability of a lot passing a test with 40 per cent of the production defective is 0.95 (producer's risk = 5 per cent) while the probability of a lot being accepted with 65 per cent of the production defective is 0.l (consumer's risk = 10 per cent).

3. For each of the pollutants given in Table 5 of paragraph 5.4.1.4. of this Regulation, the following procedure is used (see Figure 2 of this Regulation).

   Taking:

   L = the natural logarithm of the limit value for the pollutant,

   xi = the natural logarithm of the measurement for the i-th vehicle of the sample,

   s = an estimate of the production standard deviation (after taking the natural logarithm of the measurements),

   n = the current sample number.

4. Compute for the sample the test statistic quantifying the sum of the standard deviations from the limit and defined as:

$$\frac{1}{s}\sum_{i=1}^{n}(L-x_i)$$

5. Then:

5.1. If the test statistic is greater than the pass decision number for the sample size given in Table App1/1 below, the pollutant is passed;

5.2. If the test statistic is less than the fail decision number for the sample size given in Table App1/1 below, the pollutant is failed; otherwise, an additional vehicle is tested and the calculation reapplied to the sample with a sample size one unit greater.

Table App 1/1
Pass decision number for the sample size

Cumulative number of tested vehicles (current sample size)	Pass Decision threshold	Fail Decision threshold
3	3,327	− 4,724
4	3,261	− 4,79
5	3,195	− 4,856
6	3,129	− 4,922
7	3,063	− 4,988
8	2,997	− 5,054
9	2,931	− 5,12
10	2,865	− 5,185
11	2,799	− 5,251

12	2,733	− 5,317
13	2,667	− 5,383
14	2,601	− 5,449
15	2,535	− 5,515
16	2,469	− 5,581
17	2,403	− 5,647
18	2,337	− 5,713
19	2,271	− 5,779
20	2,205	− 5,845
21	2,139	− 5,911
22	2,073	− 5,977
23	2,007	− 6,043
24	1,941	− 6,109
25	1,875	− 6,175
26	1,809	− 6,241
27	1,743	− 6,307
28	1,677	− 6,373
29	1,611	− 6,439
30	1,545	− 6,505
31	1,479	− 6,571
32	− 2,112	− 2,112

Appendix 2

Procedure for verifying the conformity of production requirements if the production standard deviation given by the manufacturer is either not satisfactory or not available

1. This Appendix describes the procedure to be used to verify the production conformity requirements for the Type I test when the manufacturer's evidence of production standard deviation is either not satisfactory or not available.

2. With a minimum sample size of 3, the sampling procedure is set so that the probability of a lot passing a test with 40 per cent of the production defective is 0.95 (producer's risk = 5 per cent) while the probability of a lot being accepted with 65 per cent of the production defective is 0.1 (consumer's risk = 10 per cent).

3. The measurements of the pollutants given in Table 5 of paragraph 5.4.1.4. of this Regulation are considered to be log normally distributed and shall first be transformed by taking their natural logarithms. Let m0 and m denote the minimum and maximum sample sizes respectively (m0 = 3 and m = 32) and let n denote the current sample number.

4. If the natural logarithms of the measurements in the series are x1,x2..., xi and L is the natural logarithm of the limit value for the pollutant, then define:

$$d_1 = x_1 - L$$

$$\bar{d}_n = \frac{1}{n} \sum_{i=1}^{n} d_i$$

and

$$V_n^2 = \frac{1}{n} \sum_{i=1}^{n} (d_i - \bar{d}_n)^2$$

5. Table App2/1 shows values of the pass (An) and fail (Bn) decision numbers against current sample number. The test statistic is the ratio d_n/V_n and shall be used to determine whether the series has passed or failed as follows:

For $m0 \leq n \leq m$

(i) Pass the series if $\quad \dfrac{\bar{d}_n}{V_n} \leq A_n$

(ii) Fail the series if $\quad \dfrac{\bar{d}_n}{V_n} \geq B_n$

(iii) Take another measurement if $\quad A_n < \dfrac{\bar{d}_n}{V_n} < B_n$

6. Remarks

The following recursive formulae are useful for computing successive values of the test statistic:

$$\bar{d}_n = \left(1 - \frac{1}{n}\right)\bar{d}_{n-1} + \frac{1}{n}d_n$$

$$V_n^2 = \left(1 - \frac{1}{n}\right)V_{n-1}^2 + \left[\frac{\bar{d}_n - d_n}{n-1}\right]^2$$

$$(n = 2, 3, \ldots ; \quad \bar{d}_1 = d_1; \quad V_1 = 0 \;)$$

Table App2/1
Minimum sample size = 3

Sample size (n)	Pass decision threshold (An)	Fail decision threshold (Bn)
3	-0.80381	16.64743
4	-0.76339	7.68627
5	-0.72982	4.67136
6	-0.69962	3.25573
7	-0.67129	2.45431
8	-0.64406	1.94369
9	-0.61750	1.59105
10	-0.59135	1.33295
11	-0.56542	1.13566
12	-0.53960	0.9797
13	-0.51379	0.85307
14	-0.48791	0.74801
15	-0.46191	0.65928
16	-0.43573	0.58321
17	-0.40933	0.51718
18	-0.38266	0.45922
19	-0.35570	0.40788
20	-0.32840	0.36203
21	-0.30072	0.32078
22	-0.27263	0.28343
23	-0.24410	0.24943
24	-0.21509	0.21831
25	-0.18557	0.1897
26	-0.15550	0.16328
27	-0.12483	0.1388
28	-0.09354	0.11603
29	-0.06159	0.0948
30	-0.02892	0.07493
31	0.00449	0.05629
32	0.03876	0.03876

Annex 1

Essential characteristics of the engine and information concerning the conduct of tests

1   The manufacturer shall complete the applicable item numbers of the list below, and submit it as part of the information folder.

0.   **GENERAL INFORMATION**

A   **General information concerning vehicles**

0.1.   Make (trade name of manufacturer):

0.2.   Type:

0.2.1.   Variant(s):

0.2.2.   Version(s):

0.2.3.   Commercial name(s) (if available):

0.3.   Category, subcategory and sub-subcategory of vehicle:

0.4.   Company name and address of manufacturer:

0.4.1.   Name(s) and address(es) of assembly plants:

0.4.2.   Name and address of manufacturer's authorised representative, if any:

0.5.   Location of the vehicle identification number:

0.5.1.   Photographs and/or drawings of the locations of the vehicle identification number (completed example with dimensions):

0.5.1.1.   The serial number of the type begins with:

          General information concerning systems, components or separate technical units

B   **General information concerning systems, components or separate technical units**

0.6.   Make(s) (trade name(s) of manufacturer):

0.7.   Type:

0.7.1.   Commercial name(s) (if available):

0.7.2.   Type-approval number(s) (if available):

0.7.3.   Type-approval(s) issued on (date, if available):

0.8.   Company name and address of manufacturer:

0.8.1.   Name(s) and address(es) of assembly plants:

0.8.2.   Name and address of manufacturer's authorised representative, if any:

0.9.   Vehicle(s) for which the system/separate technical unit is intended for(21):

0.9.1.   Type:

0.9.2.   Variant:

0.9.3.   Version:

0.9.4.   Commercial name(s) (if available):

0.9.5.   Category, subcategory and sub-subcategory of vehicle:

0.10.   Type-approval marks for components and separate technical units:

0.10.1.   Method of attachment:

0.10.2.   Photographs and/or drawings of the location of the type-approval mark (completed example with dimensions):

C   **General information regarding conformity of production**

0.11.   Conformity of production

0.11.1.   Description of overall quality-assurance management systems.

1.   **GENERAL CONSTRUCTION CHARACTERISTICS**

1.1.   Photographs and/or drawings of a representative vehicle:

1.2.   Scale drawing of the whole vehicle:

1.3.   Number of axles and wheels:

1.3.1.   Axles with twinned wheels:

1.3.2.   Powered axles:

1.4.   Chassis (if any) (overall drawing):

1.5.   Position and arrangement of the propulsion unit(s):

1.6.   Vehicle is equipped to be driven in right/left-hand traffic and in countries that use metric/metric and imperial units.(4):

1.7.   Propulsion unit performance

1.7.1.   Declared maximum vehicle speed: km/h

1.7.2.   Maximum net power combustion engine: ...... kW at ...... min^{-1} at A/F ratio:......

1.7.3.   Maximum net torque combustion engine: ......Nm at ......min^{-1} at A/F ratio:......

2.   **MASSES AND DIMENSIONS**

            (in kg and mm.) refer to drawings where applicable

2.1.   Range of vehicle mass (overall)

2.1.1.   Unladen mass (m_k)   kg

2.1.1.1.   Distribution unladen mass (m_k): of between the axles   kg

2.1.2.   Actual mass   kg

2.1.8.   Mass of the optional equipment   kg

2.1.9.   Mass of the superstructure   kg

2.1.10.   Mass of the gaseous fuel system as well as storage tanks for gaseous fuel kg

2.1.11.   Mass of the storage tanks to store compressed air kg

2.1.12.   Reference mass kg

2.2.   Range of vehicle dimensions (overall)

2.2.1.   Length mm

2.2.2.   Width mm

2.2.3.   Height: mm

2.2.4.   Wheelbase: mm

2.2.4.1.   Wheelbase sidecar: ……. Mm

2.2.5.   Track width

2.2.5.1.   Track width front: mm.

2.2.5.2.   Track width rear   mm.

3.   **GENERAL POWERTRAIN CHARACTERISTICS**

3.1.   Manufacturer of the propulsion unit

3.1.1.   Combustion engine

3.1.1.1.   Manufacturer:

3.1.1.2.   Engine code (as marked on the engine or other means of identification):

3.1.1.3.   Fuel identification marking (if available):

3.1.1.4.   Photographs and/or drawings of the location of the code(s) and/or type-approval numbers (completed example with dimensions)(20):

3.2.   Combustion engine

3.2.1.   Specific engine information

3.2.1.1.   Number of combustion engines:

3.2.1.2.   Working principle: internal combustion engine (ICE)/positive ignition//turbine/compressed air(4):

3.2.1.3.   Cycle: four-stroke/two-stroke/rotary/other:

3.2.1.4.   Cylinders

3.2.1.4.1. Number: …..

3.2.1.4.2. Arrangement: ….

3.2.1.4.3. Bore: mm

3.2.1.4.4. Stroke: mm

3.2.1.4.5. Number and configuration of stators in the case of rotary-piston engine:

3.2.1.4.6. Volume of combustion chambers in the case of rotary-piston engine: cm^3

3.2.1.4.7. Firing order:

3.2.1.5.   Engine capacity cm^3

3.2.1.6.   Volumetric compression ratio:

3.2.1.7.   Number of inlet and exhaust valves

3.2.1.8.   Drawings of combustion chamber, cylinder head, piston, piston rings:

3.2.1.9.   Normal warm engine idling speed min^{-1}

3.2.1.10.   Stop-start system: yes/no

3.2.2.   Fuel

3.2.2.1.   Fuel type:

3.2.2.2.   Vehicle fuel configuration: mono-fuel/bi- fuel/flex fuel

3.2.2.2.1. Maximum amount of bio-fuel acceptable in fuel: % by volume

3.2.3.   Fuel pressure delivery and control

3.2.3.1.   Brief description and schematic drawing of low-and/or high-pressure fuelling wet system(s):

3.2.3.2.   Low- and/or high-pressure fuel pump(s): yes/no

3.2.3.2.1. Fuel pump control:

            mechanical/on/off electric/continuous operation/electronically controlled variable operation:

3.2.3.3.   Common rail: yes/no

3.2.3.4.   Fuel distributor/rail/hoses: yes/no

3.2.3.5.   Fuel pressure and/or fuel flow regulator(s): yes/no

3.2.4.   Fuel mass metering and control

3.2.4.1.   By carburettor(s): yes/no

3.2.4.1.1.   Carburettor(s) settings:

3.2.4.1.2.   Carburettor cold-starting system: manual/automatic: yes/no

3.2.4.1.2.1.   Carburettor cold-starting system operating principle(s):

3.2.4.1.3.   Mixture scavenging port: yes/no

3.2.4.1.3.1.   Mixture scavenging port dimensions:

3.2.4.2.   By mechanically/hydraulically controlled fuel injection: yes/no

3.2.4.2.1.   Operation principle:

3.2.4.2.2.   Mechanical/electronic adjustment of maximum fuel mass delivery: yes/no

3.2.4.3.   By electronically controlled fuel injection system: yes/no

3.2.4.3.1.   Operation principle: port injection/direct injection/pre-chamber/swirl chamber:

3.2.4.3.2.   Fuel injector(s): single-/multi-point/direct injection/other (specify):

3.2.4.3.3.   Total and per cylinder amount of fuel injectors:

3.2.4.4.   Air-assisted fuel injector: yes/no:

3.2.4.4.1.   Description and operating pressure of air-assist:

3.2.4.5.   Cold start system: yes/no

3.2.4.5.1.   Description of cold start system:

3.2.4.6.   Auxiliary starting aid: yes/no

3.2.5.   Gaseous fuelling system and control

3.2.5.1.   Brief description and schematic drawing of gaseous fuelling system(s):

3.2.5.2.1.   Type-approval number according to UN Regulation No 67 :

3.2.6.   Air-induction system

3.2.6.1.   Brief description and schematic drawing of gaseous intake air-flow and induction system:

3.2.6.2.   Intake manifold description and working principle (e.g. fixed length/variable length/swirl valves)(4) (include detailed drawings and/or photos):

3.2.6.2.1.   Description and drawings of inlet pipes and their accessories (plenum chamber, heating device with control strategy, additional air intakes, etc.):

3.2.6.3.   Intake air pressure charger: yes/no

3.2.6.3.1   Brief description and schematic drawing of the intake air-pressure charger system:

3.2.6.3.2.   Working and control principles:

3.2.6.3.3.   Type(s) (turbo or supercharger, other):

3.2.6.3.4.   Maximum intake air-charge pressure and flow-rate at maximum torque and power:......kPa and g/s or charge pressure and flow-rate map   kPa and g/s

3.2.6.4.   Waste gate: yes/no

3.2.6.5.   Intercooler: yes/no

3.2.6.5.1.   Type: air-air/air-water/other

3.2.6.6.   Air filter, (drawings, photographs):

3.2.6.7.   Intake air-silencer description (drawings, photographs):

3.2.7.   Air-mass metering and control

3.2.7.1.   Brief description and schematic drawing of air-mass metering and control system:

3.2.7.2.   Mechanical throttle body: yes/no

3.2.7.3.   Electronic throttle control (ETC): yes/no

3.2.7.3.1.   Schematic drawing of electronic throttle control:

3.2.8.   Spark delivery system and control

3.2.8.1.   Brief description and schematic drawing of spark delivery and control system:

3.2.8.1.1.   Working principle:

3.2.8.1.2.   Static ignition timing degrees before TDC at maximum torque and power

3.2.8.2.   Ion sense capability: yes/no

3.2.8.3.   Spark plugs:

3.2.8.3.1.   Gap setting: ……mm

3.2.8.4.   Ignition coil(s):

3.2.9.   Powertrain cooling system and control

3.2.9.1.   Brief description and schematic drawing of powertrain cooling and control system:

3.2.9.2.   Cooling system: liquid: yes/no

3.2.9.2.1.   Maximum temperature at outlet: …… °C

3.2.9.2.2.   Nominal setting of the engine temperature control mechanism:

3.2.9.2.3.   Nature of liquid:

3.2.9.2.4.   Circulating pump(s): yes/no

3.2.9.2.4.1   Characteristics:

3.2.9.2.5.   Drive ratio(s):

3.2.9.2.6.   Description of the fan and its drive mechanism:

3.2.9.3.   Air cooling: yes/no

3.2.9.3.1.   Reference point:

3.2.9.3.2.   Maximum temperature at reference point: ……°C

3.2.9.3.3.   Fan: yes/no

3.2.9.3.3.1. Characteristics:

3.2.9.3.3.2. Drive ratio(s):

3.2.10.   Powertrain lubrication system and control

3.2.10.1.   Brief description and schematic drawing of powertrain lubrication and control system:

3.2.10.2.   Lubrication system configuration(s) (wet sump, dry sump, other, pump/injection into induction system/mixed with the fuel, etc.):

3.2.10.3.   Location of oil reservoir (if any):

3.2.10.4.   Feed system (pump/injection into induction system/mixed with the fuel, etc.):

3.2.10.5.   Lubricating pump: yes/no

3.2.10.6.   Oil cooler: yes/no

3.2.10.6.1.   Drawing

3.2.10.7.   Lubricant(s) characteristics:

3.2.10.8.   Lubricant mixed with the fuel: yes/no:

3.2.10.8.1.   Percentage range of lubricant mixed with the fuel:

3.2.11.   Exhaust system and control

3.2.11.1.   Brief description and schematic drawing of exhaust devices for noise and tailpipe emission control:

3.2.11.2.   Description and drawing of the exhaust manifold:

3.2.11.3.   Description and detailed drawing of the exhaust device:

3.2.11.5.   Type, marking of exhaust noise-abatement device(s):

3.2.11.6.   Location of the exhaust outlet:

3.2.12.   Other electrical systems and control than those intended for the electrical propulsion unit

3.2.12.1.   Rated voltage: V, positive/negative ground

3.2.12.2.   Generator: yes/no:

3.2.12.2.1.   Nominal output   VA

3.2.12.3.   Battery(ies) : yes/no

3.2.12.3.1.   Capacity and other characteristics (mass,…):

3.3.   Other engines, electric motors or combinations (specific information concerning the parts of these motors)

3.3.1.   Cooling system (temperatures permitted by the manufacturer)

3.3.1.1.   Liquid cooling:

3.3.1.1.1.   Maximum temperature at outlet: °C

3.3.1.2.   Air cooling:

3.3.1.2.1.   Reference point:

3.3.1.2.2.   Maximum temperature at reference point: °C

3.3.2.   Lubrication system

3.3.2.1.   Description of lubrication system:

3.3.2.2.   Location of oil reservoir (if any) :

3.3.2.3.   Feed system (pump/injection into induction system/mixed with the fuel, etc.):

3.3.2.4.   Lubricant mixed with the fuel:

3.3.2.4.1.   Percentage:

3.3.2.5.   Oil cooler: yes/no:

3.4.   Drive-train and control

3.4.1.   Brief description and schematic drawing of the vehicle drive-train and its control system (gear shift control, clutch control or any other element of drive-train):

3.4.2.   Clutch

3.4.2.1.   Brief description and schematic drawing of the clutch and its control system:

3.4.3.   Transmission

3.4.3.1.   Brief description and schematic drawing of gear shift system(s) and its control:

3.4.3.2.   Drawing of the transmission:

3.4.3.3.   Type (mechanical, hydraulic, electric, manual/manual automated/automatic/CVT/ other (indicate).):

3.4.3.4.   A brief description of the electrical/electronic components (if any):

3.4.3.5.   Location relative to the engine:

3.4.3.6.   Method of control:

3.4.4.   Gear ratios

Overview gear ratios

Gear	Internal transmission ratios (ratios of engine to transmission output shaft revolutions)	Final drive ratio(s) (ratio of transmission output shaft to driven wheel revolutions)	Total gear ratios	Ratio (engine speed/vehicle speed) for manual transmission only
Maximum for CVT ($^+$) 1 2 3 ... Minimum for CVT($^+$)				
Reverse				
($^+$) Continuously variable transmission				

(+) Continuously variable transmission

3.4.4.1.   Final drive ratio: …….

3.4.4.2.   Overall gear ratio in highest gear:…..

4.   GENERAL INFORMATION ON ENVIRONMENTAL AND PROPULSION PERFORMANCE

4.0.   General information on environmental and propulsion unit performance

4.1.   Tailpipe emission-control system

4.1.1.   Brief description and schematic drawing of the tailpipe emission-control system and its control:

4.1.2.   Catalytic converter

4.1.2.1.   Configuration, number of catalytic converters and elements (information to be provided for each separate unit):

4.1.2.2.   Drawing with dimensions, shape and volume of the catalytic converter(s):

4.1.2.3.   Catalytic reaction:

4.1.2.4.   Location of the catalytic converter(s) (place and reference distance in the exhaust line):

4.1.2.5.   Catalyst heat-shield: yes/no

4.1.2.6   Brief description and schematic drawing of the regeneration system/method of exhaust after-treatment systems and its control system:

4.1.2.6.1. Consumable reagents: yes/no

4.1.2.6.2. Brief description and schematic drawing of the reagent flow (wet) system and its control system:

4.1.2.6.3. Type and concentration of reagent needed for catalytic action:

4.1.2.6.4. Frequency of reagent refill: continuous/maintenance

4.1.2.7.   Identifying part number:

4.1.3.   Oxygen sensor(s)

4.1.3.1.　　Oxygen sensor component(s) drawing(s):

4.1.3.2.　　Drawing of exhaust device with oxygen sensor location(s) (dimensions relative to exhaust valves):

4.1.3.3.　　Control range(s):

4.1.3.4.　　Identifying part number(s):

4.1.3.5.　　Description of oxygen sensor heating system and heating strategy:

4.1.3.6.　　Oxygen sensor heat shield(s): yes/no

4.1.4.　　Secondary air-injection (air-inject in exhaust)

4.1.4.1.　　Brief description and schematic drawing of the secondary air-injection system and its control system:

4.1.4.2.　　Configuration (mechanical, pulse air, air pump etc.):

4.1.4.3.　　Working principle:

4.1.5.　　External exhaust gas recirculation (EGR)

4.1.5.1.　　Brief description and schematic drawing of the EGR system (exhaust flow) and its control system:

4.1.5.2.　　Characteristics:

4.1.5.3.　　Water-cooled EGR system: yes/no

4.1.5.4.　　Air-cooled EGR system: yes/no

4.1.6.　　Particulate filter

4.1.6.1.　　PT component drawing with dimensions, shape and capacity of the particulate filter:

4.1.6.2.　　Design of the particulate filter:

4.1.6.3.　　Brief description and schematic drawing of the particulate filter and its control system:

4.1.6.4.　　Location (reference distance in the exhaust line):

4.1.6.5.　　Method or system of regeneration, description and drawing:

4.1.6.6.　　Identifying part number:

4.1.7.　　Lean NOx trap

4.1.7.1.　　Operation principle of lean NOx trap:

4.1.8.　　Additional tailpipe emission-control devices (if any not covered under another heading)

4.1.8.1.　　Working principle:

5.　　VEHICLE PROPULSION FAMILY

5.1.　　To define the vehicle propulsion unit family, the manufacturer shall submit the information required for classification criteria set out in paragraph 2. of Appendix 8 to Annex 7, if not already provided in the information document.

Annex 2

Communication concerning the approval or extension or refusal or withdrawal of approval or production definitely discontinued of a vehicle of category L3, L4 and L5 with regard to the emission of gaseous pollutants by the engine, pursuant to Regulation No. 40

Approval No.

1.   Trade name or mark of vehicle. . . . .

2.   Vehicle type designation by the manufacturer . . . .

3.   Name and address of the manufacturer . . . .

4.   Name and address of the manufacturer's representative (if applicable) . . . .

5.   Unladen weight of vehicle . . . .

5.1   Reference weight of vehicle . . . .

6.   Maximum weight of vehicle . . . .

7.   Gear box . . . .

7.1.   Manual or automatic 1/ . . . .

7.2.   Number of gear ratios . . . .

7.3.   Gear ratio: 2/ First gear . . . .

           Second gear . . . .

           Third gear . . . .

           Fourth gear . . . .

           Fifth gear . . . .

           Sixth gear . . . .

           Final drive ratio . . . .

           Tyres: dimensions . . . .

           Dynamic rolling circumference . . . .

8.   Reference fuel No. . . . .

9.   Vehicle submitted for approval on . . . .

10.   Technical service responsible for conducting approval tests .

11.   Date of report issued by that service . . . .

12.   Number of report issued by that service . . . .

13.   Approval granted/refused/extended/withdrawn/production definitely discontinued 1/ . . . .

14.   Position of approval mark on the vehicle . . . .

15.   Place . . . .

16.　　　　　Date . . . .

17.　　　　　Signature . . . .

18.　　　　　The following documents, bearing the approval number shown above, are annexed to this communication:

1 copy of annex 1, duly completed and accompanied by the drawings and diagrams referred to.

1 photograph of the engine and its compartment;

1 copy of the test report."

1/ Strike out what does not apply.

2/　In the case of power-driven vehicles equipped with automatic -shift gear boxes, give all pertinent technical data.

Annex 3

Arrangements of approval marks

Model A
(See paragraph 4.4. of this Regulation)
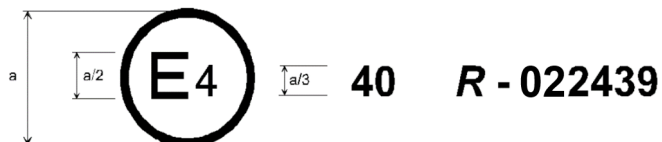
The above approval mark affixed to a vehicle shows that the vehicle type concerned has, with regard to the emission of gaseous pollutants of the engine, been approved in the Netherlands (E 4) pursuant to Regulation No. 40. under approval number 022439. The first two digits of the approval number indicates that the approval was granted in accordance with the requirements of Regulation No. 40 as amended by the 02 series of amendments.

Model B
(See paragraph 4.5. of this Regulation)
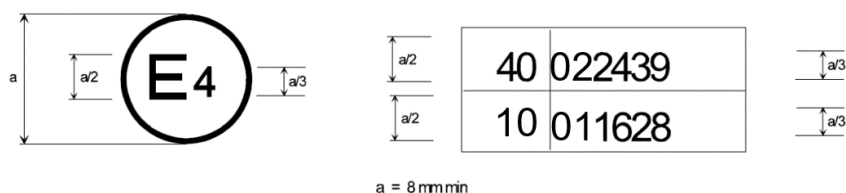
The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in the Netherlands (E 4) pursuant to Regulations Nos. 40 and 10 .. The first two digits of the approval numbers indicate that on the date on which these approvals were granted, Regulation No. 40 included 02 series of amendments and Regulation No.10 included the 01 series of amendments.

Annex 4

Test Type I, exhaust emissions after cold start

(Verifying the emission of gaseous pollutants in a congested urban area)

1.　　　Introduction

1.1.　　　This Annex provides a harmonized method for the determination of the levels of gaseous pollutant emissions (reserved) collected at the tailpipe, the emissions of carbon dioxide and is referred to in Annex 6. to determine the energy efficiency in terms of fuel consumption of the vehicle types within the scope of this Regulation that are representative for real world vehicle operation.

1.2.　　　The results may form the basis for limiting gaseous pollutants, to report carbon dioxide and the energy efficiency of the vehicle in terms of fuel consumption by the manufacturer within the environmental performance approval procedures in a robust and harmonized way.

2.　　　General Requirements

2.1.　　　The components liable to affect the emission of gaseous pollutants, carbon dioxide emissions and affecting the energy efficiency of the vehicle shall be so designed, constructed and assembled as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.

Note 1: The symbols used in Annex 4, Annex 5 and Annex 6. are summarized in Appendix 1 to Annex 7.

3.　　　Test Conditions

3.1.　　　Test room

3.1.1.　　　The test room with the chassis dynamometer and the gas sample collection device shall have a temperature of 25± 5 °C. The room temperature shall be measured in the vicinity of the vehicle cooling blower (fan) before and after the Test Type I.

3.1.2.　　　The absolute humidity (Ha) of either the air in the test cell or the intake air of the engine shall be measured, recorded and correction factors for NOx shall be applied.

3.1.2.1.　　　Humidity correction factor

(Reserved)

3.1.3.　　　The soak area shall have a temperature of 25 ± 5 °C and be such that the test vehicle which has to be preconditioned can be parked in accordance with para.4.2.4. of Annex 4.

3.2.　　　WMTC, test cycle parts

The WMTC test cycle (vehicle speed patterns) for Type I, VII and VIII environmental tests consist of up to three parts as set out in Appendix 11 to Annex 7. Depending on the vehicle classification in terms of engine displacement and maximum design vehicle speed in accordance with paragraph 3. of this Regulation, the following WMTC test cycle parts in Table A4/1 shall be run.

Table A4/1
Applicable parts of WMTC as specified in Appendix 11 to Annex 7

Vehicle Sub classification	Applicable Parts of WMTC as specified in Appendix 11 to Annex 7
Class 1	part 1, reduced vehicle speed in cold condition, followed by part 1, reduced vehicle speed in warm condition
Class 2 subdivide in:	
Sub-class 2-1	part 1, reduced vehicle speed in cold condition, followed by part 2, reduced vehicle speed in warm condition
Sub-class 2-2	part 1, in cold condition, followed by part 2, in warm condition
Class 3 subdivided in:	
Sub-class 3-1	part 1, in cold condition, followed by part 2, in warm condition, followed by part 3, reduced vehicle speed in warm condition
Sub-class 3-2	part 1, in cold condition, followed by part 2, in warm condition, followed by part 3, in warm condition

3.3.   Specification of the reference fuel

The appropriate reference fuels as specified in Appendix 2 to Annex 7 shall be used for conducting Test Type I. However, in case of non-availability of reference fuels for NG/Bio-Methane and LPG, the commercially available NG/Bio-Methane and LPG shall be used for the purpose of Type Approval and Conformity of Production.

Table A4/2
Reference fuels to be used

	Reference fuel specification	
	See	
Petrol E5 (Nominal 95 RON)	Table A7.App2/1	
Petrol E10 (Nominal 95 RON)	Table A7.App2/2	of Appendix 2 to Annex 7
NG/biomethane	Table A7.App2/3	
LPG	Table A7.App2/4	

3.4.   Test Type I procedure

3.4.1.   Driver

The test driver shall have a mass of 75 kg ± 5 kg.

3.4.2.   Test bench specifications and settings

3.4.2.1.   The chassis dynamometer shall have a single roller in the transverse plane with a diameter of at least 400 mm, alternatively, a chassis dynamometer equipped with two rollers on a single axle in the transverse plane (one for each wheel) is permitted when testing a vehicle with two driven wheels.

3.4.2.2.   The dynamometer shall be equipped with a roller revolution counter for measuring actual distance travelled.

3.4.2.3.   Dynamometer flywheels or other means shall be used to simulate the inertia specified in paragraph 4.2.2.

3.4.2.4.   The dynamometer rollers shall be clean, dry and free from anything which might cause the tyre(s) to slip.

3.4.2.5.   Cooling fan specifications as follows:

3.4.2.5.1.   Throughout the test, a variable-rotation speed cooling blower (fan) shall be positioned in front of the vehicle so as to direct the cooling air onto it in a manner that simulates actual operating conditions. The blower rotation speed shall be such that, within the operating range of 10 to 50 km/h, the linear velocity of the air at the blower outlet is within ±5 km/h of the corresponding roller speed (from which the actual vehicle speed is calculated). At the range of over 50 km/h, the linear velocity of the air shall be within ±10 percent. At a desired vehicle speed of less than 10 km/h, air velocity may be zero.

3.4.2.5.2.   The air velocity referred to in paragraph 3.4.2.5.1. shall be determined as an averaged value of nine measuring points which are located at the centre of each rectangle dividing the whole of the blower outlet into nine areas (dividing both horizontal and vertical sides of the blower outlet into three equal parts). The value at each of the nine points shall be within 10 percent of the average of the nine values.

3.4.2.5.3.   The blower outlet shall have a cross-section area of at least 0.4 m2 and the bottom of the blower outlet shall be between 5 and 20 cm above floor level. The blower outlet shall be perpendicular to the longitudinal axis of the vehicle, between 30 and 45 cm in front of its front wheel. The device used to measure the linear velocity of the air shall be located at between 0 and 20 cm from the air outlet.

3.4.2.6.   The detailed requirements regarding the chassis dynamometer are listed in Appendix 6 to Annex 7.

3.4.3.   Exhaust gas measurement system

3.4.3.1.   The gas-collection device shall be a closed-type device that can collect all exhaust gases at the vehicle exhaust outlets on condition that it satisfies the backpressure condition of ± 1.25 kPa. An open system may be used instead if it is confirmed that all the exhaust gases are collected. The gas collection shall be such that there is no condensation which could appreciably modify the nature of exhaust gases at the test temperature. An example of a gas-collection device is illustrated in Figure A4/1a and Figure A4/1b:

Figure A4/1a
An example of closed-type systems for sampling gases and measuring their volume

1	exhaust emissions	P_1	positive displacement pump
2	dilution air	P_2, P_3	sampling pumps
3	dilution air filter	R_2, R_3	flowmeters
4	Dilution tunnel	S_a, S_b	sampling bags
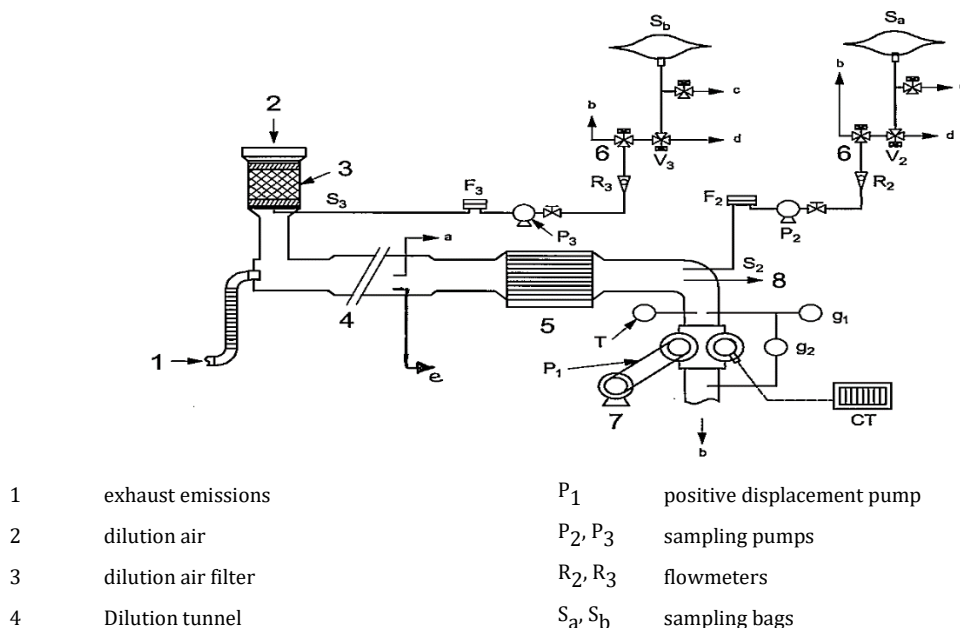
5	heating exchanger	S_2, S_3	sampling probes
6	diversion valve	T	temperature gauge
7	motor	V_2, V_3	valves
8	continuous sampling probe	a	To HFID; special sampling line when HFID is used.
CT	revolution counter	b	To atmosphere.
F_2, F_3	filters	c	To exhaust pump.
g_1, g_2	pressure gauges	d	To analysing system.
		e	To PM special sampling line when PM used.

Schematic diagram for the representative closed type CVS system with PDP
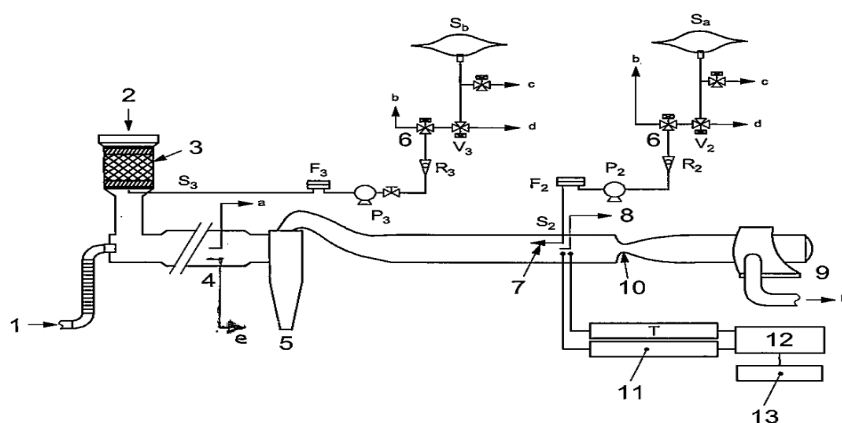
1	exhaust emissions	F_2, F_3	filters
2	dilution air	P_2, P_3	sampling pumps
3	dilution air filter	R_2, R_3	flowmeters
4	dilution tunnel	S_a, S_b	sampling bags
5	cyclone	S_2, S_3	sampling probes
6	diversion valve	T	temperature gauge
7	sampling venturi	V_2, V_3	valves
8	continuous sampling probe	a	To HFID; special sampling line when HFID is used.
9	blower	b	To atmosphere.
10	main critical flow venturi	c	To exhaust pump.
11	pressure gauge	d	To analysing system.
12	calculator	e	To PM special sampling line when PM used.
13	integrator		

Schematic diagram for the representative closed type CVS system with CFV

Figure A4/1b
An example of open-type system for sampling gases and measuring their volume
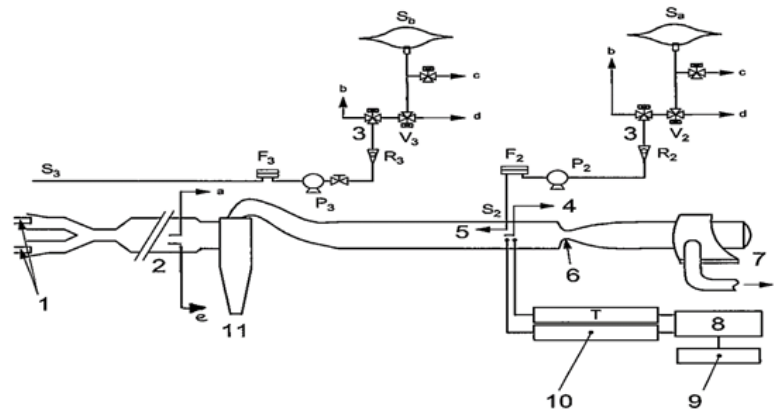
1	exhaust pipes	F_2, F_3	filters
2	dilution tunnel	P_2, P_3	sampling pumps
3	dilution air filter	R_2, R_3	flowmeters
4	continuous sampling probe	S_a, S_b	sampling bags
5	sampling venturi	S_2, S_3	sampling probes
6	main critical flow venturi	T	temperature gauge
7	blower	V_2, V_3	valves
8	calculator	a	To HFID; special sampling line when HFID is used.
9	integrator	b	To atmosphere.
10	pressure gauge	c	To exhaust pump.
11	cyclone	d	To analysing system.
		e	To PM special sampling line when PM used.

Schematic diagram for the representative open type CVS system with CFV

3.4.3.2. A connecting tube shall be placed between the device and the exhaust gas sampling system. This tube and the device shall be made of stainless steel, or of some other material which does not affect the composition of the gases collected and which withstands the temperature of these gases.

3.4.3.3. Positive displacement pump (PDP)

3.4.3.3.1. A positive displacement pump (PDP) full flow exhaust dilution system satisfies the requirements of this Annex by metering the flow of gas through the pump at constant temperature and pressure. 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.

3.4.3.3.2. A heat exchanger capable of limiting the temperature variation of the diluted gases in the pump intake to ± 5 °C shall be in operation throughout the test.

This exchanger shall be equipped with a preheating system capable of bringing the exchanger to its operating temperature (with the tolerance of ± 5 °C before the test begins.

3.4.3.3.3. A positive displacement pump shall be used to draw in the diluted exhaust mixture. This pump shall be equipped with a motor with several strictly controlled uniform rotation speeds. The pump capacity shall be large enough to ensure the intake of the exhaust gases. A device using a critical-flow venturi (CFV) may also be used.

3.4.3.3.4. A device (T) shall be used for the continuous recording of the temperature of the diluted exhaust mixture entering the pump.

3.4.3.3.5. Two gauges shall be used, the first to ensure the pressure depression of the dilute exhaust mixture entering the pump relative to atmospheric pressure, and the second to measure the dynamic pressure variation of the positive displacement pump.

3.4.3.4. Critical flow venturi (CFV)

3.4.3.4.1. The use of a CFV for the full flow exhaust dilution system is based on the principles of flow mechanics for critical flow. The variable mixture flow rate of dilution and exhaust gas is maintained at sonic velocity that is inversely proportional to the square root of the gas temperature and directly proportional to gas pressure. Flow is continually monitored, computed and integrated throughout the test.

3.4.3.4.2. The use of an additional critical flow sampling venturi ensures the proportionality of the gas samples taken from the dilution tunnel. 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.

3.4.3.4.3. A CFV shall measure the flow volume of the diluted exhaust gas.

3.4.3.5. A probe shall be located near to, but outside, the gas-collecting device, to collect samples of the dilution air stream through a pump, a filter and a flow meter at constant flow rates throughout the test.

3.4.3.6. A sample probe pointed upstream into the dilute exhaust mixture flow, upstream of the positive displacement pump, shall be used to collect samples of the dilute exhaust mixture through a pump, a filter and a flow meter at constant flow rates throughout the test. The minimum sample flow rate in the sampling devices described in paragraph 3.4.3.5. shall be at least 150 litre/hour.

3.4.3.7. Three-way valves shall be used on the sampling system described in paragraphs 3.4.3.5. and 3.4.3.6. to direct the samples either to their respective bags or to the outside throughout the test.

3.4.3.8. Gas-tight collection bags

3.4.3.8.1. For dilution air and dilute exhaust mixture the collection bags shall be of sufficient capacity not to impede normal sample flow and shall not change the nature of the pollutants concerned. The bag material shall be such as to affect neither the measurements themselves nor the chemical composition of the gas samples by more than ±2 per cent after 30 minutes (e.g., laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

3.4.3.8.2. The bags shall have an automatic self-locking device and shall be easily and tightly fastened either to the sampling system or the analysing system at the end of the test.

3.4.3.9. A revolution counter shall be used to count the revolutions of the positive displacement pump throughout the test.

Note 2: Attention shall be paid to the connecting method and the material or configuration of the connecting parts, because each section (e.g. the adapter and the coupler) of the sampling system can become very hot. If the measurement cannot be performed normally due to heat damage to the sampling system, an auxiliary cooling device may be used as long as the exhaust gases are not affected.

Note 3: With open type devices, there is a risk of incomplete gas collection and gas leakage into the test cell. There shall be no leakage throughout the sampling period.

Note 4: If a constant volume sampler (CVS) flow rate is used throughout the test cycle that includes low and high vehicle speeds all in one (i.e. part 1, 2 and 3 cycles), special attention shall be paid to the higher risk of water condensation in the high vehicle speed range.

3.4.3.10. (Reserved)

3.4.4.   Driving schedules

3.4.4.1.   Test cycle WMTC

The WMTC test cycles (vehicle speed patterns vs. test time) for the Test Type I consist of up to three parts, as laid down in Appendix 11 to Annex 7. The applicable part of WMTC for each sub category shall be as per paragraph 3.2. of this section.

3.4.4.2.   Vehicle speed tolerances

3.4.4.2.1.   The vehicle speed tolerance at any given time on the test cycles prescribed in Table A7.App11 is defined by upper and lower limits. The upper limit is 3.2 km/h higher than the highest point on the trace within one second of the given time. The lower limit is 3.2 km/h lower than the lowest point on the trace within one second of the given time. Vehicle speed variations greater than the tolerances (such as may occur during gear changes) are acceptable provided they occur for less than two seconds on any occasion. Vehicle speeds lower than those prescribed are acceptable provided the vehicle is operated at maximum available power during such occurrences. Figure A4/6 shows the range of acceptable vehicle speed tolerances for typical points.

Figure A4/6:
Drivers trace, allowable range
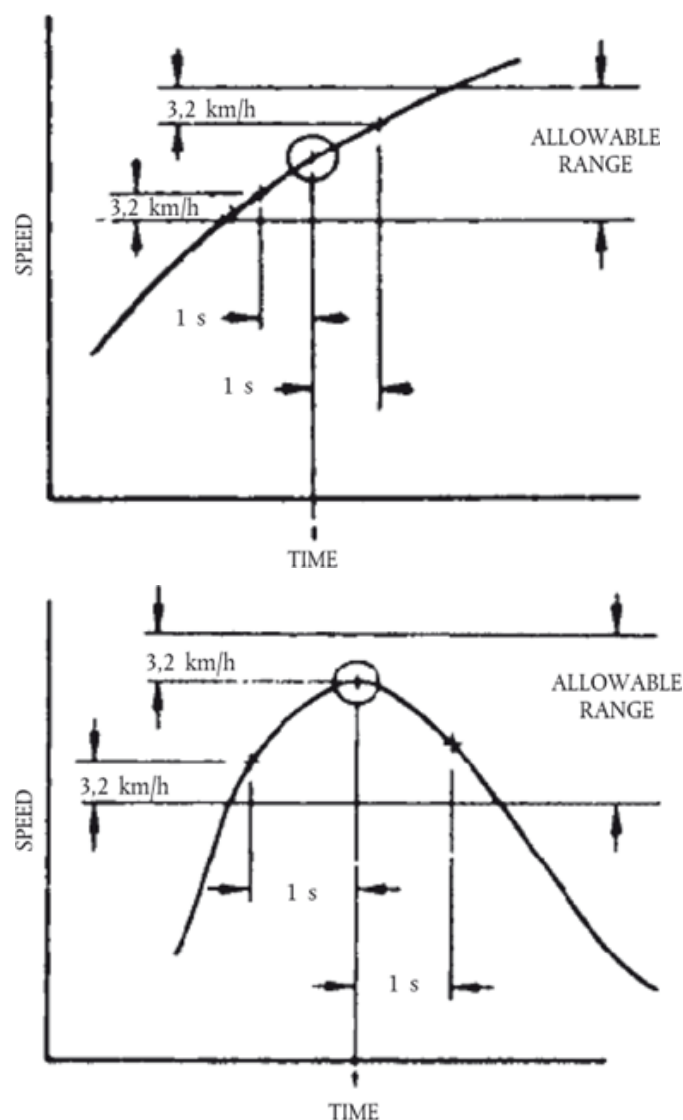
3.4.4.2.2.   If the acceleration capability of the vehicle is not sufficient to carry out the acceleration phases or if the maximum design speed of the vehicle is lower than the prescribed cruising vehicle speed within the prescribed limits of tolerances, the vehicle shall be driven with the throttle fully open until the desired vehicle speed is reached or at the maximum design vehicle speed achievable with fully opened throttle during the time that desired vehicle speed exceeds the maximum design vehicle speed. In both cases, paragraph 3.4.4.2.1. is not applicable. The test cycle shall be carried on normally when desired vehicle speed is again lower than the maximum design speed of the vehicle.

3.4.4.2.3.   If the period of deceleration is shorter than that prescribed for the corresponding phase, due to the vehicle characteristics, desired vehicle speed shall be restored by a constant vehicle speed or idling period merging into succeeding constant vehicle speed or idling operation. In such cases, paragraph 3.4.4.2.1. is not applicable.

3.4.4.2.4.   Apart from these exceptions, the deviations of the roller speed (from which the actual vehicle speed is calculated) in comparison to the desired vehicle speed of the cycles shall meet the requirements described in paragraph 3.4.4.2.1. If not, the test results shall not be used for further analysis and the test run shall be repeated.

3.4.5.   Gearshift prescriptions for the WMTC prescribed for the test cycles set out in Appendix 12 to Annex 7.

3.4.5.1.   Test vehicles equipped with an automatic transmission

3.4.5.1.1.   Vehicles equipped with transfer cases, multiple sprockets, etc., shall be tested in the configuration recommended by the manufacturer for street or highway use.

3.4.5.1.2.   Idle modes shall be run with automatic transmissions in "Drive" and the wheels braked. After initial engagement, the selector shall not be operated at any time during the test.

3.4.5.1.3.   Automatic transmissions shall shift automatically through the normal sequence of gears. The torque converter clutch, if applicable, shall operate as under real-world conditions.

3.4.5.1.4.   The deceleration modes shall be run in gear using brakes or throttle as necessary to maintain the desired vehicle speed.

3.4.5.2.   Test vehicles equipped with a semi-automatic transmission

3.4.5.2.1.   Vehicles equipped with semi-automatic transmissions shall be tested using the gears normally employed for driving, and the gear shift used in accordance with the instructions in the owner's manual.

3.4.5.2.2.   Idle modes shall be run with semi-automatic transmissions in "Drive" and the wheels braked. After initial engagement, the selector shall not be operated at any time during the test.

3.4.5.3.   Test vehicles equipped with manual transmission

3.4.5.3.1.   Mandatory requirements

3.4.5.3.1.1.   Step 1 — Calculation of desired vehicle speeds to shift gear

Upshift desired vehicle speeds ($v_{1\to2}$ and $v_{i\to i+1}$) in km/h during acceleration phases shall be calculated using the following formulae:

$$v_{1\to2} = \left[\left(0.5753 \times e^{\left(-1.9 \times \frac{P_n}{m_{ref}}\right)} - 0.1 \right) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_1}$$

$$\tag{1}$$

$$v_{i\to i+1} = \left[\left(0.5753 \times e^{\left(-1.9 \times \frac{P_n}{m_{ref}}\right)} \right) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_i}$$

$$\tag{2}$$

i = 2 to ng -1

where:

"i" is the gear number (≥ 2)

"ng" is the total number of forward gears

"P_n" is the rated power in kW

"m_{ref}" is the reference mass in kg

"n_{idle}" is the idling engine speed in min^{-1}

"s" is the rated engine speed in min^{-1}

"ndv_i" is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear "i".

Downshift desired vehicle speeds ($v_{i \to i-1}$) in km/h during cruise or deceleration phases in gears 4 (4th gear) to ng shall be calculated using the following formula:

$$v_{i \to i-1} = \left[\left(0.5753 \times e^{\left(-1.9 \times \frac{P_n}{m_{ref}}\right)}\right) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_{i-2}}$$

(3)

i = 4 to ng

where:

i is the gear number (≥ 4)

ng is the total number of forward gears

P_n is the rated power in kW

m_{ref} is the reference mass in kg

n_{idle} is the idling engine speed in min^{-1}

s is the rated engine speed in min^{-1}

ndv_{i-2} is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear i-2

The downshift desired vehicle speed from gear 3 to gear 2 ($v_{3 \to 2}$) shall be calculated using the following equation:

$$v_{3 \to 2} = \left[\left(0.5753 \times e^{\left(-1.9 \times \frac{P_n}{m_{ref}}\right)} - 0.1\right) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_1}$$

(4)

where:

P_n is the rated power in kW

m_{ref} is the reference mass in kg

n_{idle} is the idling engine speed in min^{-1}

s is the rated engine speed in min^{-1}

ndv_1 is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear 1.

The downshift desired vehicle speed from gear 2 to gear 1 ($v_{2 \to 1}$) shall be calculated using the following equation:

$$v_{2 \to 1} = [0.03 \times (s - n_{idle}) + n_{idle}] \times \frac{1}{ndv_2}$$

(5)

where:

ndv_2 is the ratio between engine speed in min^{-1} and vehicle speed in km/h in gear 2.

Since the cruise phases are defined by the phase indicator, slight vehicle speed increases could occur and it may be appropriate to apply an upshift. The upshift desired vehicle speeds ($v_{1 \to 2}$, $v_{2 \to 3}$ and $v_{i \to i+1}$) in km/h during cruise phases shall be calculated using the following equations:

$$v_{1\to2} = [0.03 \times (s - n_{\text{idle}}) + n_{\text{idle}}] \times \frac{1}{ndv_2}$$

(6)

$$v_{2\to3} = \left[\left(0.5753 \times e^{\left(-1.9\times\frac{P_n}{m_{ref}}\right)} - 0.1\right) \times (s - n_{\text{idle}}) + n_{\text{idle}}\right] \times \frac{1}{ndv_1}$$

(7)

$$v_{i\to i+1} = \left[\left(0.5753 \times e^{\left(-1.9\times\frac{P_n}{m_{ref}}\right)}\right) \times (s - n_{\text{idle}}) + n_{\text{idle}}\right] \times \frac{1}{ndv_{i-1}}$$

(8)

i=3 to ng-1

3.4.5.3.1.2.   Step 2 — Gear choice for each cycle sample

In order to avoid different interpretations of acceleration, deceleration, cruise and stop phases, corresponding indicators are added to the vehicle speed pattern as integral parts of the cycles (see tables in Appendix 11 to Annex 7.).

The appropriate gear for each sample shall then be calculated according to the vehicle speed ranges resulting from equations to determine the desired vehicle speeds to shift gears of paragraph 3.4.5.3.1.1. and the phase indicators for the cycle parts appropriate for the test vehicle, as follows:

Gear choice for stop phases:

For the last five seconds of a stop phase, the gear lever shall be set to gear 1 and the clutch shall be disengaged. For the previous part of a stop phase, the gear lever shall be set to neutral or the clutch shall be disengaged.

Gear choice for acceleration phases:

gear 1, if $v \leq v_{1\to2}$

gear 2, if $v_{1\to2} < v \leq v_{2\to3}$

gear 3, if $v_{2\to3} < v \leq v_{3\to4}$

gear 4, if $v_{3\to4} < v \leq v_{4\to5}$

gear 5, if $v_{4\to5} < v \leq v_{5\to6}$

gear 6, if $v > v_{5\to6}$

Gear choice for deceleration or cruise phases

gear 1, if $v < v_{2\to1}$

gear 2, if $v < v_{3\to2}$

gear 3, if $v_{3\to2} \leq v < v_{4\to3}$

gear 4, if $v_{4\rightarrow3} \leq v < v_{5\rightarrow4}$

gear 5, if $v_{5\rightarrow4} \leq v < v_{6\rightarrow5}$

gear 6, if $v \geq v_{4\rightarrow5}$

The clutch shall be disengaged, if:

(a)   the vehicle speed drops below 10 km/h, or

(b)   the engine speed drops below $n_{idle} + 0.03 \times (s - n_{idle})$;

(c)   there is a risk of engine stalling during cold-start phase.

3.4.5.3.1.3.   Step 3 — Corrections according to additional requirements

3.4.5.3.1.3.1. The gear choice shall be modified according to the following requirements:

(a)   no gearshift at a transition from an acceleration phase to a deceleration phase. The gear that was used for the last second of the acceleration phase shall be kept for the following deceleration phase unless the vehicle speed drops below a downshift desired vehicle speed;

(b)   no upshifts or downshifts by more than one gear, except from gear 2 to neutral during decelerations down to stop;

(c)   upshifts or downshifts for up to four seconds are replaced by the gear before, if the gears before and after are identical, e.g. 2 3 3 3 2 shall be replaced by 2 2 2 2 2, and 4 3 3 3 3 4 shall be replaced by 4 4 4 4 4 4;

In the cases of consecutive circumstances, the gear used longer takes over, e.g. 2 2 2 3 3 3 2 2 2 2 3 3 3 will be replaced by 2 2 2 2 2 2 2 2 2 2 3 3 3;

If used for the same time, a series of succeeding gears shall take precedence over a series of preceding gears, e.g. 2 2 2 3 3 3 2 2 2 3 3 3 will be replaced by 2 2 2 2 2 2 2 2 2 3 3 3;

(d)   no downshift during an acceleration phase.

3.4.5.3.2.   Optional provisions

The gear choice may be modified according to the following provisions:

The use of gears lower than those determined by the requirements described in paragraph 3.4.5.2.1. is permitted in any cycle phase. Manufacturers' recommendations for gear use shall be followed if they do not result in gears higher   than determined by the requirements of paragraph 3.4.5.2.1.

3.4.5.3.3.   Optional provisions

Note 5: The calculation programme to be found on the UN website at the following URL may be used as an aid for the gear selection:

http://live.unece.org/trans/main/wp29/wp29wgs/wp29grpe/wmtc.html

Explanations of the approach and the gearshift strategy and a calculation example are given in Appendix 12 to Annex 7.

3.4.5.3.4.   Idle modes shall be run with manual transmissions with wheels braked.

3.4.6.   Dynamometer settings

A full description of the chassis dynamometer and instruments shall be provided in accordance with Appendix 6 to Annex 7. Measurements shall be taken to the accuracies specified in paragraph 3.4.7. The running resistance force for the chassis dynamometer settings can be derived either from on-road coast-down measurements or from a running resistance table, with reference to Appendix 4 or Appendix 5 a to Annex 7 for a vehicle equipped with one wheel on the powered axle and to Appendix 5b to Annex 7 for a vehicle with two wheels on the powered axle.

3.4.6.1.   Chassis dynamometer setting derived from on-road coast-down measurements

To use this alternative, on-road coast-down measurements shall be carried out as specified in Appendix 5 a to Annex 7 for a vehicle equipped with one wheel on the powered axle and Appendix 5b to Annex 7 for a vehicle equipped with two wheels on the powered axle.

3.4.6.1.1.   Requirements for the equipment

The instrumentation for the roller speed (actual vehicle speed), desired vehicle speed and time measurement shall have the accuracies specified in paragraph 3.4.7.

3.4.6.1.2.   Inertia mass setting

3.4.6.1.2.1.   The equivalent inertia mass mi for the chassis dynamometer shall be the flywheel equivalent inertia mass, m_{fi}, closest to the sum of the unladen mass (m_k) of the vehicle and the mass of the driver (75 kg). Alternatively, the equivalent inertia mass mi can be derived from Appendix 4 to Annex 7.

3.4.6.1.2.2.   If the reference mass m_{ref} cannot be equalised to the flywheel equivalent inertia mass m_{fi}, to make the target running resistance force F* equal to the running resistance force F_E (which is to be set to the chassis dynamometer), the corrected coast-down time ΔT_E may be adjusted in accordance with the total mass ratio of the target coast-down time ΔT_{road} in the following sequence:

$$\Delta T_{road} = \frac{1}{3.6}(m_a + m_{r1})\frac{2\Delta v}{F^*} \tag{9}$$

$$\Delta T_E = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{F_E} \tag{10}$$

$$F_E = F^* \tag{11}$$

$$\Delta T_E = \Delta T_{road} \times \frac{m_i + m_{r1}}{m_a + m_{r1}} \tag{12}$$

With

$$0.95 < \frac{m_i + m_{r1}}{m_a + m_{r1}} < 1.05$$

where:

m_{r1} may be measured or calculated, in kilograms, as appropriate. As an alternative, m_{r1} may be estimated as 4 percent of m. For measurement accuracy, see Table A4/4

3.4.6.2.   Running resistance force derived from a running resistance table or on road coast down

3.4.6.2.1.   The chassis dynamometer may be set by the use of the running resistance table instead of the running resistance force obtained by the coast-down method. In this table method, the chassis dynamometer shall be set by the reference mass (m_{ref}) regardless of particular vehicle characteristics.

Note 6: Care shall be taken when applying this method to vehicles with extraordinary characteristics.

3.4.6.2.2.   The flywheel equivalent inertia mass m_{fi} shall be the equivalent inertia mass m_i specified in Appendix 4, 5a or 5b to Annex 7 as applicable. The chassis dynamometer shall be set by the rolling resistance of the non-driven wheels (a) and the aero drag coefficient (b) specified in Appendix 4 to Annex 7 or determined in accordance with the procedures set out in Appendix 5a or 5b to Annex 7.

3.4.6.2.3.   The running resistance force on the chassis dynamometer F_E shall be determined using the following equation:

$$F_E = F_T = a + b \cdot v^2 \tag{13}$$

3.4.6.2.4. The target running resistance force F* shall be equal to the running resistance force obtained from the running resistance table F_T, because the correction for the standard ambient conditions is not necessary.

3.4.7. Measurement accuracies

Measurements shall be taken using equipment that fulfils the accuracy requirements in Table A4/4.

Table A4/4
Required accuracy of measurements

Measurement items	At measured values	Resolution
(a) Running resistance force, F	+ 2 percent	--
(b) Vehicle speed (v_1, v_2)	± 1 percent	0.2 km/h
(c) Coast-down vehicle speed interval ($2\Delta v = v_1 - v_2$)	± 1 percent	0.1 km/h
(d) Coast-down time (Δt)	± 0.5 percent	0.01 s
(e) Total vehicle mass (m_{ref})	± 0.5 percent	1.0 kg
(f) Wind speed	± 10 percent	0.1 m/s
(g) Wind direction	--	5 deg
(h) Temperature	± 1 ºC	
(i) Barometric pressure	--	0.2 kPa
(j) Distance	± 0.1 percent	1 m
(k) Time	± 0.1 s	0.1 s

4. Test procedures

4.1. Description of the Test Type I

The test vehicle shall be subjected, according to its category, to Test Type I requirements as specified in this paragraph 4. and comply with the requirements set out in Appendix 3 to Annex 7.

4.1.1. Test Type I (verifying the average emission of gaseous pollutants, (reserved) CO_2 emissions and fuel consumption in a characteristic driving cycle)

4.1.1.1. The test shall be carried out by the method described in paragraph 4.2. The gases shall be collected and analysed by the prescribed methods.

4.2. Test Type I

4.2.1. Introduction

4.2.1.1. The Test Type I consists of prescribed sequences of dynamometer preparation, fuelling, parking, and operating conditions.

4.2.1.2. The test is designed to determine hydrocarbon, carbon monoxide, oxides of nitrogen, carbon dioxide (reserved) emissions, and fuel consumption while simulating real-world operation. The test consists of engine start-ups and vehicle operation on a chassis dynamometer, through a specified driving cycle. A proportional part of the diluted exhaust emissions is collected continuously for subsequent analysis, using a CVS.

4.2.1.3. Except in cases of component malfunction or failure, all emission-control systems installed on or incorporated in a tested vehicle shall be functioning during all procedures.

4.2.1.4.   Background concentrations are measured for all emission constituents for which emissions measurements are taken. For exhaust testing, this requires sampling and analysis of the dilution air.

4.2.1.5.   (Reserved)

4.2.2.   Dynamometer settings and verification

4.2.2.1.   Test vehicle preparation

The test vehicle shall comply with the requirements set out in Appendix 3 to Annex 7.

4.2.2.1.1.   The manufacturer shall provide additional fittings and adapters, as required to accommodate a fuel drain at the lowest point possible in the tanks as installed on the vehicle, and to provide for exhaust sample collection.

4.2.2.1.2.   The tyre pressures shall be adjusted to the manufacturer's specifications to the satisfaction of the technical service or so that the speed of the vehicle during the road test and the vehicle speed obtained on the chassis dynamometer are equal.

4.2.2.1.3.   The test vehicle shall be warmed up on the chassis dynamometer to the same condition as it was during the road test.

4.2.2.2.   Chassis dynamometer preparation, if settings are derived from on-road coast-down measurements:

Before the test, the chassis dynamometer shall be appropriately warmed up to the stabilised frictional force Ff. The load on the chassis dynamometer FE is, in view of its construction, composed of the total friction loss Ff, which is the sum of the chassis dynamometer rotating frictional resistance, the tyre rolling resistance, the frictional resistance of the rotating parts in the powertrain of the vehicle and the braking force of the power absorbing unit (pau) F_{pau}, as in the following equation:

$$F_E = F_f + F_{pau}$$

(14)

The target running resistance force F*, derived from Appendix 4 to Annex 7 and for a vehicle equipped with one wheel on the powered axle Appendix 5a to Annex 7 or for a vehicle with two wheels on the powered axle Appendix 5b to Annex 7, shall be reproduced on the chassis dynamometer in accordance with the vehicle speed, i.e.:

$$F_E(v_i) = F^*(v_i)$$

(15)

The total friction loss Ff on the chassis dynamometer shall be measured by the method in paragraph 4.2.2.2.1. or 4.2.2.2.2.

4.2.2.2.1.   Motoring by chassis dynamometer

This method applies only to chassis dynamometers capable of driving a vehicle

The test vehicle shall be driven steadily by the chassis dynamometer at the reference vehicle speed v_0 with the drive train engaged and the clutch disengaged. The total friction loss $F_f(v_0)$ at the reference vehicle speed v_0 is given by the chassis dynamometer force.

4.2.2.2.2.   Coast-down without absorption

The method for measuring the coast-down time is the coast-down method for the measurement of the total friction loss Ff. The vehicle coast-down shall be performed on the chassis dynamometer by the procedure described in Appendix 4, 5a or 5b to Annex 4, as applicable, with zero chassis dynamometer absorption. The coast-down time Δt_i corresponding to the reference speed v_0 shall be measured. The measurement shall be carried out at least three times, and the mean coast-down time Δ shall be calculated using the following equation:

$$\overline{\Delta t} = \frac{1}{n}\sum_{i=1}^{n}\Delta t_i \tag{16}$$

4.2.2.2.3.   Total friction loss

The total friction loss $F_f(v_0)$ at the reference vehicle speed v_0 is calculated using the following equation:

$$F_f(v_0) = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t} \tag{17}$$

4.2.2.2.4.   Calculation of power-absorption unit force

The force $F_{pau}(v_0)$ to be absorbed by the chassis dynamometer at the reference vehicle speed v_0 is calculated by subtracting $F_f(v_0)$ from the target running resistance force $F^*(v_0)$ as shown in the following equation:

$$F_{pau}(v_0) = F^*(v_0) - F_f(v_0) \tag{18}$$

4.2.2.2.5.   Chassis dynamometer setting

Depending on its type, the chassis dynamometer shall be set by one of the methods described in paragraphs 4.2.2.2.5.1. to 4.2.2.2.5.4. The chosen setting shall be applied to the pollutant and CO_2 emission measurements as well as fuel consumption laid down in Appendix 1 to Annex 6.

4.2.2.2.5.1.   Chassis dynamometer with polygonal function

In the case of a chassis dynamometer with polygonal function, in which the absorption characteristics are determined by load values at several specified vehicle speed points, at least three specified vehicle speeds, including the reference vehicle speed, shall be chosen as the setting points.   At each setting point, the chassis dynamometer shall be set to the value F_{pau} (vj) obtained in paragraph 4.2.2.2.4.

4.2.2.2.5.2.   Chassis dynamometer with coefficient control

In the case of a chassis dynamometer with coefficient control, in which the absorption characteristics are determined by given coefficients of a polynomial function, the value of F_{pau} (vj) at each specified vehicle speed shall be calculated by the procedure in paragraph 4.2.2.2.

Assuming the load characteristics to be:

$$F_{pau}(v) = a \bullet v^2 + b \bullet v + c \tag{19}$$

where:

the coefficients a, b and c shall be determined by the polynomial regression method. The chassis dynamometer shall be set to the coefficients a, b and c obtained by the polynomial regression method.

4.2.2.2.5.3.   Chassis dynamometer with F* polygonal digital setter

In the case of a chassis dynamometer with a polygonal digital setter, where a central processor unit is incorporated in the system, F* is input directly, and ti, F_f and F_{pau} are automatically measured and calculated to set the chassis dynamometer to the target running resistance force:

$$F^* = f_0 + f_2 \cdot v^2 \tag{20}$$

In this case, several points in succession are directly input digitally from the data set of F*j and vj, the coast-down is performed and the coast-down time Δtj is measured. After the coast-down test has been repeated several times, F_{pau} is   automatically calculated and set at vehicle speed intervals of 0.1 km/h, in the following sequence:

$$F^* + F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i}$$

(21)

$$F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i} - F^*$$

(22)

$$F_{pau} = F^* - F_f$$

(23)

4.2.2.2.5.4.   Chassis dynamometer with f*0, f*2 coefficient digital setter

In the case of a chassis dynamometer with a coefficient digital setter, where a central processor unit is incorporated in the system, the target running resistance force F*j is automatically set on the chassis dynamometer.

In this case, the coefficients f*0 and f*2 are directly input digitally; the coast-down is performed and the coast-down time Δt_i is measured. Fpau is automatically calculated and set at vehicle speed intervals of 0.06 km/h, in the following sequence:

$$F^* + F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i}$$

(24)

$$F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i} - F^*$$

(25)

$$F_{pau} = F^* - F_f$$

(26)

4.2.2.2.6.   Dynamometer settings verification

4.2.2.2.6.1.   Verification test

Immediately after the initial setting, the coast-down time Δt_E on the chassis dynamometer corresponding to the reference speed (v_0) shall be measured by the procedure set out in Appendix 4 or 5a to Annex 7 for a vehicle equipped with one wheel on the powered axle or in Appendix 5b to Annex 7 for a vehicle with two wheels on the powered axle. The measurement shall be carried out at least three times, and the mean coast-down time Δt_E shall be calculated from the results. The set running resistance force at the reference speed, FE (v_0) on the chassis dynamometer is calculated by the following equation:

$$F_E(v_0) = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_E}$$

(27)

4.2.2.2.6.2.   Calculation of setting error

The setting error ε is calculated by the following equation:

$$\varepsilon = \frac{\left| F_E(v_0) - F^*(v_0) \right|}{F^*(v_0)} \times 100$$

(28)

The chassis dynamometer shall be readjusted if the setting error does not satisfy   the following criteria:

$\varepsilon \leq 2$ percent for $v_0 \geq 50$ km/h

$\varepsilon \leq 3$ percent for 30 km/h $\leq v_0 <$ 50 km/h

$\varepsilon \leq 10$ percent for $v_0 <$ 30 km/h

The procedure in paragraphs 4.2.2.2.6.1. to 4.2.2.2.6.2. shall be repeated until the setting error satisfies the criteria. The chassis dynamometer setting and

observed errors shall be recorded. Template record forms are provided in the template in accordance with Appendix 10 to Annex 7.

4.2.2.3. Chassis dynamometer preparation, if settings are derived from a running resistance table

4.2.2.3.1. The specified vehicle speed for the chassis dynamometer

The running resistance on the chassis dynamometer shall be verified at the specified vehicle speed v. At least four specified vehicle speeds shall be verified. The range of specified vehicle speed points (the interval between the maximum and minimum points) shall extend either side of the reference vehicle speed or the reference vehicle speed range, if there is more than one reference vehicle speed, by at least Δv, as defined in Appendix 4 to Annex 7 or Appendix 5a to Annex 7 for a vehicle equipped with one wheel on the powered axle and in Appendix 5b to Annex 7 for a vehicle equipped with two wheels on the powered axle. The specified vehicle speed points, including the reference vehicle speed points, shall be at regular intervals of no more than 20 km/h apart.

4.2.2.3.2. Verification of chassis dynamometer

4.2.2.3.2.1. Immediately after the initial setting, the coast-down time on the chassis dynamometer corresponding to the specified vehicle speed shall be measured. The vehicle shall not be set up on the chassis dynamometer during the coast-down time measurement. The coast-down time measurement shall start when the chassis dynamometer vehicle speed exceeds the maximum vehicle speed of the test cycle.

4.2.2.3.2.2. The measurement shall be carried out at least three times, and the mean coast-down time Δt_E shall be calculated from the results.

4.2.2.3.2.3. The set running resistance force FE(vj) at the specified vehicle speed on the chassis dynamometer is calculated using the following equation:

$$F_E\left(v_j\right) = \frac{1}{3.6} \bullet m_i \bullet \frac{2\,\Delta v}{\Delta t_E}$$

(29)

4.2.2.3.2.4. The setting error $\square$ at the specified vehicle speed is calculated using the following equation:

$$\varepsilon = \frac{\left| F_E\left(v_j\right) - F_T \right|}{F_T} \times 100$$

(30)

4.2.2.3.2.5. The chassis dynamometer shall be readjusted if the setting error does not satisfy the following criteria:

$\varepsilon \le 2$ percent for $v \ge 50$ km/h

$\varepsilon \le 3$ percent for 30 km/h $\le v < 50$ km/h

$\varepsilon \le 10$ percent for $v < 30$ km/h

4.2.2.3.2.6. The procedure described in paragraphs 4.2.2.3.2.1. to 4.2.2.3.2.5. shall be repeated until the setting error satisfies the criteria. The chassis dynamometer setting and the observed errors shall be recorded.

4.2.2.4. The chassis dynamometer system shall comply with the calibration and verification methods laid down in Appendix 6 to Annex 7.

4.2.3. Calibration of analysers

4.2.3.1. Analyser calibration procedures

Each analyser shall be calibrated as specified by the instrument manufacturer or at least as often as described in Table A4/6.

Table A4/6
Instrument calibration intervals

Instrument checks	Interval	Criteria
Gas analyser linearization (calibration)	Every 6 months	± 2 per cent reading
Mid span	Every 6 months	± 2 per cent
CO NDIR: CO$_2$/H$_2$O interface	Monthly	-1 to 3 ppm
NO$_X$ converter check	Monthly	> 95 percent
CH$_4$ cutter check	Reserved	Reserved
FID CH$_4$ response	Reserved	Reserved
FID air/fuel flow	At major maintenance	According to instrument manufacturer
NO/NO$_2$ NDUV: H$_2$O, HC interference	At major maintenance	According to instrument manufacturer
Microgram balance linearity	Reserved	Reserved

Non-dispersive infrared absorption analysers shall be checked at the same intervals using nitrogen/ CO and nitrogen/ CO$_2$ mixtures in nominal concentrations equal to 10, 40, 60, 85 and 90 per cent of full scale.

4.2.3.2.   Each normally used operating range shall be linearized by the following procedure:

4.2.3.2.1.   The analyser linearization curve shall be established by at least five calibration points spaced as uniformly as possible. The nominal concentration of the calibration gas of the highest concentration shall be not less than 80 per cent of the full scale.

4.2.3.2.2.   The calibration gas concentration required may be obtained by means of a gas divider, diluting with purified N$_2$ or with purified synthetic air.

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

4.2.3.2.4.   The linearization curve shall not differ by more than ±2 per cent from the nominal value of each calibration gas.

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

(a)   Analyzer and gas component;

(b)   Range;

(c)   Date of the linearization.

4.2.3.2.6.   If it can be shown to the satisfaction of the responsible authority that alternative technologies (e.g. computer, electronically controlled range switch, etc.) can give equivalent accuracy, these alternatives may be used.

4.2.3.3.   Analyzer zero and calibration verification procedure

4.2.3.3.1.   Each normally used operating range shall be checked prior to each analysis in accordance with the following subparagraphs.

4.2.3.3.1.1.   The calibration shall be checked by use of a zero gas and by use of a calibration gas according to paragraph 5.1.1.2. (a), (b), (c).

4.2.3.3.1.2. After testing, zero gas and the same calibration gas shall be used for rechecking according to paragraph 5.1.1.2. (e).

4.2.3.4. FID hydrocarbon response check procedure

4.2.3.4.1. Detector response optimisation

The FID shall be adjusted as specified by the instrument manufacturer. Propane in air should be used on the most common operating range.

4.2.3.4.2. Calibration of the HC analyser

The analyser shall be calibrated using propane in air and purified synthetic air. A calibration curve as described in paragraph 5.1.1.2. shall be established.

4.2.3.4.3. Response factors of different hydrocarbons and recommended limits

The response factor (R_f), for a particular hydrocarbon compound is the ratio of the FID C1 reading to the gas cylinder concentration, expressed as ppm C1. The concentration of the test gas shall be at a level to give a response of approximately 80 per cent of full-scale deflection, for the operating range. The concentration shall be known to an accuracy of ±2 per cent in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder shall be pre-conditioned for 24 hours at a temperature between 20 and 30°C (293.15K and 303.15K).

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

Methane and purified air: $1.00 < R_f < 1.15$ or $1.00 < R_f < 1.05$ for NG/biomethane-fuelled vehicles

Propylene and purified air: $0.90 < R_f < 1.00$

Toluene and purified air: $0.90 < R_f < 1.00$

These are relative to a response factor (R_f) of 1.00 for propane and purified air.

4.2.3.4.4. NOx converter efficiency test procedure

4.2.3.4.4.1. Using the test set up as shown in Figure A4/7 and the procedure described below, the efficiency of converters for the conversion of NO_2 into NO shall be tested by means of an ozonator as follows:

4.2.3.4.4.1.1. The analyser shall be calibrated in the most common operating range following the manufacturer's specifications using zero and calibration gas (the NO content of which shall amount to approximately 80 per cent of the operating range and the NO_2 concentration of the gas mixture shall be less than 5 per cent of the NO concentration). The NOx analyser shall be in the NO mode so that the calibration gas does not pass through the converter. The indicated concentration shall be recorded.

4.2.3.4.4.1.2. Via a T-fitting, oxygen or synthetic air shall be added continuously to the calibration gas flow until the concentration indicated is approximately 10 per cent less than the indicated calibration concentration given in paragraph 4.2.3.4.4.1.1. above. The indicated concentration (c) shall be recorded. The ozonator shall be kept deactivated throughout this process.

4.2.3.4.4.1.3. The ozonator shall now be activated to generate enough ozone to bring the NO concentration down to 20 per cent (minimum 10 per cent) of the calibration concentration given in paragraph 4.2.3.4.4.1.1. of this Annex. The indicated concentration (d) shall be recorded.

4.2.3.4.4.1.4. The NOx analyser shall then be switched to the NOx mode, whereby the gas mixture (consisting of NO, NO_2, O_2 and N_2) now passes through the converter. The indicated concentration (a) shall be recorded.

4.2.3.4.4.1.5. The ozonator shall now be deactivated. The mixture of gases described in paragraph 4.2.3.4.4.1.2. of this Annex shall pass through the converter into the detector. The indicated concentration (b) shall be recorded.

Figure A4/7
NOx convertor efficiency test configuration
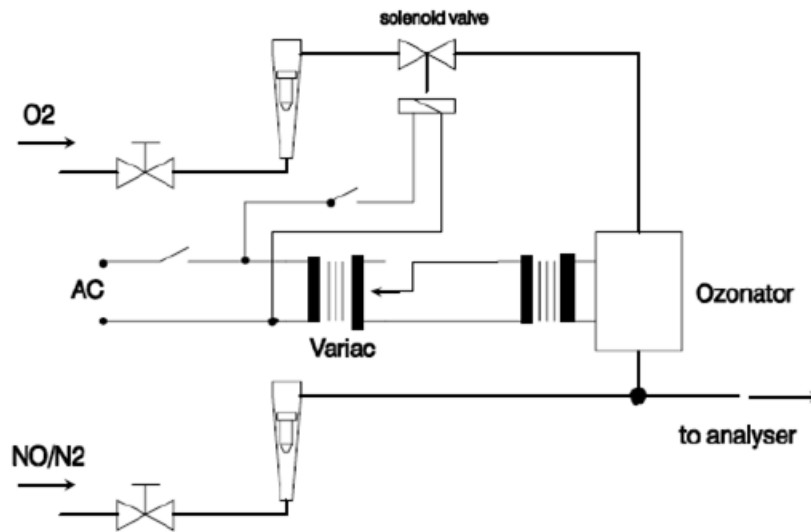
4.2.3.4.4.1.6. With the ozonator deactivated, the flow of oxygen or synthetic air shall be shut off. The NO_2 reading of the analyser shall then be no more than 5 per cent above the figure given in paragraph 4.2.3.4.4.1.1. above.

4.2.3.4.4.1.7. The efficiency of the NOx converter shall be calculated using the concentrations a, b, c and d determined in paragraphs 4.2.3.4.4.1.2. through 4.2.3.4.4.1.5. above as follows:

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

The efficiency of the converter shall not be less than 95 per cent. The efficiency of the converter shall be tested in the frequency defined in Table A4/6.

4.2.3.5. (Reserved)

4.2.3.6. Reference gases

4.2.3.6.1. Pure gases

The following pure gases shall be available, if necessary, for calibration and operation. In the case that gases within the following tolerance of the stated value are not available in the region, a gas with a wider, but the tightest, tolerance available in the region may be used.

Purified nitrogen: (purity: ≤ 1 ppm C1, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO);

Purified synthetic air: (purity: ≤ 1 ppm C1, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO); oxygen content between 18 and 21 per cent by volume;

Purified oxygen: (purity > 99.5 per cent vol. O_2);

Purified hydrogen (and mixture containing helium or nitrogen): (purity ≤ 1 ppm C1, ≤ 400 ppm CO_2, hydrogen content between 39 and 41 per cent volume);

Carbon monoxide: (minimum purity 99.5 percent);

Propane: (minimum purity 99.5 per cent).

4.2.3.6.2. Calibration gases

The true concentration of a calibration gas shall be within ± 1 per cent of the stated value or as given below. Mixtures of gases having the following

compositions shall be available with a bulk gas specification according to paragraphs 4.2.3.6.1.:

(a) C_3H_8 in synthetic air (see paragraph 4.2.3.6.1. above);

(b) CO in nitrogen;

(c) CO_2 in nitrogen;

(d) (Reserved)

(e) NO in Nitrogen (the amount of NO_2 contained in this calibration gas shall not exceed 5 per cent of the NO content);

(f) NO_2 in nitrogen (tolerance ±2 per cent);

4.2.3.7. Calibration and verification of the dilution system

The dilution system shall be calibrated and verified and shall comply with the requirements of Appendix 7 to Annex 7.

4.2.4. Test vehicle preconditioning

4.2.4.1. The test vehicle shall be moved to the test area and the following operations performed:

The fuel tanks shall be drained through the drains of the fuel tanks provided and charged with the test fuel requirement as specified in Appendix 2 to Annex 7 to half the capacity of the tanks.

The test vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through the applicable test cycle as specified for the vehicle (sub-) category in Appendix 11 to Annex 7. The vehicle need not be cold, and may be used to set dynamometer power.

4.2.4.2. Practice runs over the prescribed driving schedule may be performed at test points, provided an emission sample is not taken, for the purpose of finding the minimum throttle action to maintain the proper vehicle speed-time relationship, or to permit sampling system adjustments.

4.2.4.3. Within five minutes of completion of preconditioning, the test vehicle shall be removed from the dynamometer and may be driven or pushed to the soak area to be parked. The vehicle shall be stored for between six and 36 hours prior to the cold start Test Type I or until the engine oil temperature TO or the coolant temperature TC or the sparkplug seat/gasket temperature TP (only for air-cooled engine) equals the air temperature of the soak area within 2 °C.

4.2.4.4. (Reserved)

4.2.4.5. At the request of the manufacturer, vehicles fitted with indirect injection positive-ignition engines may be preconditioned with one Part One, one Part Two and two Part Three driving cycles, if applicable, from the WMTC.

In a test facility where a test on a low particulate emitting vehicle could be contaminated by residue from a previous test on a high particulate emitting vehicle, it is recommended that, in order to pre-condition the sampling equipment, the low particulate emitting vehicle undergo a 20 minute 120 km/h steady state drive cycle or at 70 per cent of the maximum design vehicle speed for vehicles not capable of attaining 120 km/h followed by three consecutive Part Two or Part Three WMTC cycles, if feasible.

After this preconditioning, and before testing, vehicles shall be kept in a room in which the temperature remains relatively constant at 25 ± 5°C. This conditioning shall be carried out for at least six hours and continue until the engine oil temperature and coolant, if any, are within ± 2.0 °C of the temperature of the room.

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

4.2.4.6.   Vehicles equipped with a positive-ignition engine, fuelled with LPG, NG/biomethane or so equipped that they can be fuelled with either petrol, LPG, NG/biomethane between the tests on the first gaseous reference fuel and the second gaseous reference fuel, shall be preconditioned before the test on the second reference fuel. This preconditioning on the second reference fuel shall involve a preconditioning cycle consisting of one Part One, Part Two and two Part Three WMTC cycles, as described in Appendix 11 of Annex 7. At the manufacturer's request and with the agreement of the responsible authority, this preconditioning may be extended. The dynamometer setting shall be as indicated in point 3.4.6 of this Annex.

4.2.5.   Emissions tests

4.2.5.1.   Engine starting and restarting

4.2.5.1.1.   The engine shall be started according to the manufacturer's recommended starting procedures. The test cycle run shall begin when the engine starts.

4.2.5.1.2.   Test vehicles equipped with automatic chokes shall be operated according to the instructions in the manufacturer's operating instructions or owner's manual covering choke-setting and "kick-down" from cold fast idle. In the case of the WMTC set out in Appendix 11 to Annex 7, the transmission shall be put in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

4.2.5.1.3.   Test vehicles equipped with manual chokes shall be operated according to the manufacturer's operating instructions or owner's manual. Where times are provided in the instructions, the point for operation may be specified, within 15 seconds of the recommended time.

4.2.5.1.4.   The operator may use the choke, throttle, etc. where necessary to keep the engine running.

4.2.5.1.5.   If the manufacturer's operating instructions or owner's manual do not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be started by opening the throttle about halfway and cranking the engine until it starts.

4.2.5.1.6.   If, during the cold start, the test vehicle does not start after ten seconds of cranking or ten cycles of the manual starting mechanism, cranking shall cease and the reason for failure to start determined. The revolution counter on the constant volume sampler shall be turned off and the sample solenoid valves placed in the "standby" position during this diagnostic period. In addition, either the CVS blower shall be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period.

4.2.5.1.7.   In case of an operational error, that causes a delay in the starting of sampling collection at the initiation of engine start up procedure, the test vehicle shall be rescheduled for testing from a cold start. If failure to start is caused by vehicle malfunction, corrective action (following the unscheduled maintenance provisions) lasting less than 30 minutes may be taken and the test continued (During the corrective action sampling system shall be deactivated). The sampling system shall be reactivated at the same time cranking is started. The driving schedule timing sequence shall begin when the engine starts. If failure to start is caused by vehicle malfunction and the vehicle cannot be started, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken (following the unscheduled maintenance provisions) and the vehicle rescheduled for test from a cold start. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

4.2.5.1.8.   If the test vehicle does not start during the warm start after ten seconds of cranking or ten cycles of the manual starting mechanism, cranking shall cease, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

4.2.5.1.9. If the engine "false starts", the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.)

4.2.5.2. Stalling

4.2.5.2.1. If the engine stalls during an idle period, it shall be restarted immediately and the test continued. If it cannot be started soon enough to allow the vehicle to follow the next acceleration as prescribed, the driving schedule indicator shall be stopped. When the vehicle restarts, the driving schedule indicator shall be reactivated.

4.2.5.2.2. If the engine stalls during some operating mode other than idle, the driving schedule indicator shall be stopped, the test vehicle restarted and accelerated to the vehicle speed required at that point in the driving schedule, and the test continued. During acceleration to this point, gearshifts shall be performed in accordance with paragraph 3.4.5.

4.2.5.2.3. If the test vehicle will not restart within one minute, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

4.2.6. Drive instructions

4.2.6.1. In case of multi-mode vehicles, the vehicle shall be tested in the worst case based on the different tailpipe emissions. It may be in one mode or more than one mode. The decision for the worst case will be based on the documentation provided by the vehicle manufacturers and mutually agreed by the responsible authority.

4.2.6.2. The test vehicle shall be driven with minimum throttle movement to maintain the desired vehicle speed. No simultaneous use of brake and throttle shall be permitted.

4.2.6.3. If the test vehicle cannot accelerate at the specified rate, it shall be operated with the throttle fully opened until the roller speed (actual vehicle speed) reaches the value prescribed for that time in the driving schedule.

4.2.7. Dynamometer test runs

4.2.7.1. The complete dynamometer test consists of consecutive parts as described in Appendix 11 to Annex 7.

4.2.7.2. The following steps shall be taken for each test:

    (a) Place drive wheel of vehicle on dynamometer without starting engine;

    (b) Activate vehicle cooling fan;

    (c) For all test vehicles, with the sample selector valves in the "standby" position, connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems;

    (d) Start the CVS (if not already on), the sample pumps and the temperature recorder. (The heat exchanger of the constant volume sampler, if used, and sample lines shall be preheated to their respective operating temperatures before the test begins);

    (e) Adjust the sample flow rates to the desired flow rate and set the gas flow measuring devices to zero;

    (i) For gaseous bag (except hydrocarbon) samples, the minimum flow rate is 0.08 litre/second;

    (ii) For hydrocarbon samples, the minimum flame ionisation detection (FID) (or heated flame ionisation detection (HFID) in the case of methanol-fuelled vehicles) flow rate is 0.031 litre/second;

    (f) Attach the flexible exhaust tube to the vehicle tailpipes;

(g)   Start the gas flow measuring device, position the sample selector valves to direct the sample flow into the "transient" exhaust sample bag, the "transient" dilution air sample bag, turn the key on and start cranking the engine;

(h)   Put the transmission in gear;

(i)   Begin the initial vehicle acceleration of the driving schedule;

(j)   Operate the vehicle according to the driving cycles specified in Appendix 11 to Annex 7;

(k)   At the end of part 1 or part 1 in cold condition, simultaneously switch the sample flows from the first bags and samples to the second bags and samples, switch off gas flow measuring device No. 1 and start gas flow measuring device No. 2;

(l)   In case of vehicles capable of running Part 3 of the WMTC, at the end of Part 2 simultaneously switch the sample flows from the second bags and samples to the third bags and samples, switch off gas flow measuring device No. 2 and, start gas flow measuring device No. 3;

(m)   Before starting a new part, record the measured roll or shaft revolutions and reset the counter or switch to a second counter. As soon as possible, transfer the exhaust and dilution air samples to the analytical system and process the samples according to paragraph 5., obtaining a stabilised reading of the exhaust bag sample on all analysers within 30 minutes of the end of the sample collection phase of the test;

(n)   Turn the engine off two seconds after the end of the last part of the test;

(o)   Immediately after the end of the sample period, turn off the cooling fan;

(p)   Turn off the constant volume sampler (CVS) or critical-flow venturi (CFV) or disconnect the exhaust tube from the tailpipes of the vehicle;

(q)   Disconnect the exhaust tube from the vehicle tailpipes and remove the vehicle from the dynamometer;

(r)   For comparison and analysis reasons, second-by-second emissions (diluted gas) data may be monitored as well as the bag results.

5.   Analysis of results

5.1.   Test Type I

5.1.1.   Exhaust emission analysis

5.1.1.1.   Analysis of the samples contained in the bags

The analysis shall begin as soon as possible, and in any event not later than 30 minutes after the end of the tests, in order to determine:

(a)   The concentrations of hydrocarbons, carbon monoxide, nitrogen oxides, particulate matter if applicable and carbon dioxide in the sample of dilution air contained in bag(s) B;

(b)   The concentrations of hydrocarbons, carbon monoxide, nitrogen oxides, carbon dioxide and particulate matter if applicable in the sample of diluted exhaust gases contained in bag(s) A.

5.1.1.2.   Calibration of analysers and concentration results

The analysis of the results has to be carried out in the following steps:

(a)   Prior to each sample analysis, the analyser range to be used for each pollutant shall be set to zero with the appropriate zero gas;

(b)   The analysers are set to the calibration curves by means of span gases of nominal concentrations of 70 to 100 per cent of the range;

(c)   The analysers' zeroes are rechecked. If the reading differs by more than 2 percent of range from that set in (b), the procedure is repeated;

(d)   The samples are analysed;

(e)   After the analysis, zero and span points are rechecked using the same gases. If the readings are within 2 per cent of those in point (c), the analysis is considered acceptable;

(f)   At all paragraphs in this section the flow-rates and pressures of the various gases shall be the same as those used during calibration of the analysers;

(g)   The figure adopted for the concentration of each pollutant measured in the gases is that read off after stabilisation on the measuring device.

5.1.1.3.   Measuring the distance covered

The distance (S) actually covered for a test part shall be calculated by multiplying the number of revolutions read from the cumulative counter (see paragraph 4.2.7.) by the circumference of the roller. This distance shall be expressed in km to three decimal places.

5.1.1.4.   Determination of the quantity of gas emitted

The reported test results shall be computed for each test and each cycle part by use of the following formulae. The results of all emission tests shall be rounded.

5.1.1.4.1.   Total volume of diluted gas (PDP)

The total volume of diluted gas, expressed in m^3/cycle part, adjusted to the reference conditions of 0°C and 101.3 kPa, is calculated by Equation (31):

$$V = \frac{V_0 \times N \times (P_a - P_i) \times 273.15}{101.3 \times (T_P + 273.15)}$$

(31)

where:

V_0 is the volume of gas displaced by pump P during one revolution, expressed in m^3/revolution. This volume is a function of the differences between the intake and output sections of the pump;

N is the number of revolutions made by pump P during each part of the test;

Pa is the ambient pressure in kPa;

Pi is the average under-pressure during the test part in the intake section of pump P, expressed in kPa;

TP is the temperature (expressed in °C) of the diluted gases during the test part, measured in the intake section of pump P.

5.1.1.4.2.   Total volume of diluted gas (CFV)

The calibration procedure described in Appendix 7 to Annex 7 paragraph 2.3.3. to 2.3.7.

Total volume of diluted gas is based on the flow equation for a critical-flow venturi:

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

where:

Qs = flow in m^3/min;

Kv = calibration coefficient;

P = absolute pressure (kPa);

T = absolute temperature, Kelvin (K).

Gas flow is a function of inlet pressure and temperature.

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

where:

Qs = flow-rate in m³/min at 0 °C and 101.3 kPa;

Tv = temperature at the venturi inlet, Kelvin (K);

Pv = absolute pressure at the venturi inlet (kPa).

$$V = Kv \int_0^{te} \frac{Pv(t)}{\sqrt{Tv(t)}} dt$$

te $\square$ measuring time (s)

5.1.1.4.3.   Hydrocarbons (HC)

The mass of unburned hydrocarbons emitted by the exhaust of the vehicle during the test shall be calculated using the following formula:

$$HC_m = \frac{1}{S} \cdot V \cdot d_{HC} \cdot \frac{HC_C}{10^6}$$

(32)

where:

HC_m is the mass of hydrocarbons emitted during the test part, in mg/km;

S is the distance defined in paragraph 5.1.1.3.;

V is the total volume, defined in paragraph 5.1.1.4.1.;

d_{HC} is the density of the hydrocarbons at reference temperature and pressure (0° C and 101.3 kPa);

d_{HC}

= 632x10³mg/m³ for petrol (E5) $C_1H_{1.89}O_{0.016}$;

= 646x10³mg/m³ for petrol (E10) $C_1H_{1.93}O_{0.033}$;

= 649 x10³mg/m³ for LPG $C_1H_{2.525}$

= 714 x10³mg/m³ for NG/biogas C_1H_4

HC_c is the concentration of diluted gases, expressed in parts per million (ppm) of carbon equivalent (e.g. the concentration in propane multiplied by three), corrected to take account of the dilution air by the following equation:

$$HC_C = HC_e - HC_d \cdot \left(1 - \frac{1}{DiF}\right)$$

(33)

where:

HC_e is the concentration of hydrocarbons expressed in parts per million (ppm) of carbon equivalent, in the sample of diluted gases collected in bag(s) A;

HC_d is the concentration of hydrocarbons expressed in parts per million (ppm) of carbon equivalent, in the sample of dilution air collected in bag(s) B;

DiF is the coefficient defined in paragraph 5.1.1.4.9.

5.1.1.4.4.   (Reserved)

5.1.1.4.5.   Carbon monoxide (CO)

The mass of carbon monoxide emitted by the exhaust of the vehicle during the test shall be calculated using the following formula:

$$CO_m = \frac{1}{S} \cdot V \cdot d_{CO} \cdot \frac{CO_C}{10^6}$$

(47)

where:

CO_m is the mass of carbon monoxide emitted during the test part, in mg/km;

S is the distance defined in paragraph 5.1.1.3.;

V is the total volume defined in paragraph 5.1.1.4.1.;

d_{CO} is the density of the carbon monoxide, d_{CO} =1.25·10^6 mg/m^3 at reference temperature and pressure (0 °C and 101.3 kPa);

CO_c is the concentration of diluted gases, expressed in parts per million (ppm) of carbon monoxide, corrected to take account of the dilution air by the following equation:

$$CO_c = CO_e - CO_d \cdot \left[1 - \frac{1}{DiF} \right]$$

(48)

where:

CO_e is the concentration of carbon monoxide expressed in parts per million (ppm), in the sample of diluted gases collected in bag(s) A;

CO_d is the concentration of carbon monoxide expressed in parts per million (ppm), in the sample of dilution air collected in bag(s) B;

DiF is the coefficient defined in paragraph 5.1.1.4.9.

5.1.1.4.6. Nitrogen oxides (NOx)

The mass of nitrogen oxides emitted by the exhaust of the vehicle during the test shall be calculated using the following formula:

$$NO_{Xm} = \frac{1}{S} \cdot V \cdot d_{NO_2} \cdot \frac{NO_{XC} \cdot K_h}{10^6}$$

(49)

where:

NO_{xm} is the mass of nitrogen oxides emitted during the test part, in mg/km;

S is the distance defined in paragraph 5.1.1.3.;

V is the total volume defined in paragraph 5.1.1.4.1.;

dNO_2 is the density of the nitrogen oxides in the exhaust gases, assuming that they will be in the form of nitric oxide, dNO_2=2.05·10^6 mg/m^3 at reference temperature and pressure (0 °C and 101.3 kPa);

NO_{xc} is the concentration of diluted gases, expressed in parts per million (ppm), corrected to take account of the dilution air by the following equation:

$$NO_{xc} = NO_{xe} - NO_{xd} \cdot \left[1 - \frac{1}{DiF} \right]$$

(50)

where:

NO_{xe} is the concentration of nitrogen oxides expressed in parts per million (ppm) of nitrogen oxides, in the sample of diluted gases collected in bag(s) A;

NO_{xd} is the concentration of nitrogen oxides expressed in parts per million (ppm) of nitrogen oxides, in the sample of dilution air collected in bag(s) B;

DiF is the coefficient defined in paragraph 5.1.1.4.9.;

K_h is the humidity correction factor, calculated using the following formula:

$$K_h = \frac{1}{1 - 0.0329 \cdot (H - 10.7)}$$
(51)

where:

H is the absolute humidity in g of water per kg of dry air:

$$H = \frac{6.2111 \cdot U \cdot p_d}{p_a - p_d \cdot \dfrac{U}{100}}$$
(52)

where:

U is the relative humidity as a percentage;

p_d is the saturated pressure of water at the test temperature in kPa;

p_a is the atmospheric pressure in kPa.

5.1.1.4.7.　(Reserved)

5.1.1.4.8.　Carbon dioxide (CO_2)

The mass of carbon dioxide emitted by the exhaust of the vehicle during the test shall be calculated using the following formula:

$$CO_{2m} = \frac{1}{S} \cdot V \cdot d_{CO_2} \cdot \frac{CO_{2C}}{10^2}$$
(57)

where:

CO_{2m} is the mass of carbon dioxide emitted during the test part, in g/km;

S is the distance defined in paragraph 5.1.1.3.;

V is the total volume defined in paragraph 5.1.1.4.1.;

d_{CO2} is the density of the carbon monoxide, $d_{CO2} = 1.964 \cdot 10^3$ g/m^3 at reference temperature and pressure (0 °C) and 101.3 kPa);

CO_{2C} is the concentration of diluted gases, expressed as a percentage of carbon dioxide equivalent, corrected to take account of the dilution air by the following equation:

$$CO_{2c} = CO_{2e} - CO_{2d} \cdot \left[1 - \frac{1}{DiF} \right]$$
(58)

where:

CO_{2e} is the concentration of carbon dioxide expressed as a percentage of the sample of diluted gases collected in bag(s) A;

CO_{2d} is the concentration of carbon dioxide expressed as a percentage of the sample of dilution air collected in bag(s) B;

DiF is the coefficient defined in paragraph 5.1.1.4.9.

5.1.1.4.9.　Dilution factor (DiF)

The dilution factor is calculated as follows:

For each reference fuel, except hydrogen:

$$DiF = \frac{X}{C_{CO_2} + (C_{HC} + C_{CO}) \cdot 10^{-4}}$$
(59)

For a fuel of composition $C_xH_yO_z$, the general formula is:

$$X = 100 \cdot \frac{x}{x + \frac{y}{2} + 3.76 \cdot \left(x + \frac{y}{4} - \frac{z}{2} \right)}$$

(60)

For the reference fuels contained in Appendix 2 to Annex 7, the values of "X" are as follows:

Table A4/7
Factor "X" in formulae to calculate DiF

Fuel	*X*
Petrol (E5, E10)	13.4
LPG	11.9
NG/biomethane	9.5

In these equations:

C_{CO2} = concentration of CO_2 in the diluted exhaust gas contained in the sampling bag, expressed in percent by 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,

5.1.1.5.   Weighting of Test Type I results

5.1.1.5.1.   With repeated measurements (see paragraph 5.4.1,5.), the pollutant (mg/km), and CO_2 (g/km) emission results obtained by the calculation method described in paragraph 5.1.1. and fuel consumption determined according to Annex 6 are averaged for each cycle part.

5.1.1.6.   Weighting of WMTC results

The (average) result of Part 1 or Part 1 reduced vehicle speed is called R1, the (average) result of Part 2 or Part 2 reduced vehicle speed is called R2 and the (average) result of Part 3 or part 3 reduced vehicle speed is called R3. Using these emission (mg/km), CO_2 (g/km) and fuel consumption (litres/100 km) results, the final result R_F, depending on the vehicle category as defined in paragraph 3. of this Regulation, shall be calculated using the following equations:

$$R_F = R_1 \cdot w_1 + R_1 \cdot w_2$$

(61)

$$R_F = R_1 \cdot w_1 + R_2 \cdot w_2$$

(62)

where:

w_1 = weighting factor cold phase

w_2 = weighting factor warm phase

$$R_F = R_1 \cdot w_1 + R_2 \cdot w_2 + R_3 \cdot w_3$$

(63)

where:

w_n = weighting factor phase n (n=1, 2 or 3)

5.1.1.6.1.   For each gaseous pollutant (reserved) and carbon dioxide emission the weightings shown in Tables A4/8 shall be used.

Table A4/8
Test Type I cycles (also applicable for Test Types VII and VIII), applicable weighting equations and weighting factors

Vehicle Class	Equation	Weighting Factor
1	61	$w_1 = 0.30$ $w_2 = 0.70$
2	62	$w_1 = 0.30$ $w_2 = 0.70$
3	63	$w_1 = 0.25$ $w_2 = 0.50$ $w_3 = 0.25$

6.   Records required

6.1.   The following information shall be recorded with respect to each test:

(a)   Test number;

(b)   Vehicle, system or component identification;

(c)   Date and time of day for each part of the test schedule;

(d)   Instrument operator;

(e)   Driver or operator;

(f)   Test vehicle: make, vehicle identification number, model year, drivetrain / transmission type, odometer reading at initiation of preconditioning, engine displacement, engine family, emission-control system, recommended engine speed at idle, nominal fuel tank capacity, inertial loading, reference mass recorded at 0 kilometre, and drive-wheel tyre pressure;

(g)   Dynamometer serial number: as an alternative to recording the dynamometer serial number, a reference to a vehicle test cell number may be used, with the advance approval of the responsible authority, provided the test cell records show the relevant instrument information;

(h)   All relevant instrument information, such as tuning, gain, serial number, detector number, range. As an alternative, a reference to a vehicle test cell number may be used, with the advance approval of the responsible authority, provided test cell calibration records show the relevant instrument information;

(i)   Recorder charts: identify zero point, span check, exhaust gas, and dilution air sample traces;

(j)   Test cell barometric pressure, ambient temperature and humidity;

Note 7: A central laboratory barometer may be used; provided that individual test cell barometric pressures are shown to be within ± 0.1 percent of the barometric pressure at the central barometer location.

(k)   Pressure of the mixture of exhaust and dilution air entering the CVS metering device, the pressure increase across the device, and the temperature at the inlet. The temperature shall be recorded continuously or digitally to determine temperature variations;

(l)   The number of revolutions of the positive displacement pump accumulated during each test phase while exhaust samples are being collected. The number of standard cubic meters metered by a critical-flow venturi (CFV) during each test phase would be the equivalent record for a CFV-CVS;

(m)   The humidity of the dilution air.

Note 8: If conditioning columns are not used, this measurement can be deleted. If the conditioning columns are used and the dilution air is taken from the test cell, the ambient humidity can be used for this measurement;

(n)   The driving distance for each part of the test, calculated from the measured roll or shaft revolutions;

(o)   The actual roller vehicle speed pattern for the test;

(p)   The gear use schedule for the test;

(q)   The emissions results of the Test Type I for each part of the test and the total weighted test results;

(r)   The second-by-second emission values of the Test Type I, if deemed necessary;

(s)   The emissions results of the Test Type II (see Annex 5).

Annex 4 – Appendix 1

Test Type I procedure for two- and three- wheeled vehicles fuelled with LPG and NG/biomethane

1. Introduction

1.1.   This Appendix describes the special requirements as regards the testing of LPG and NG/biomethane for the certification of alternative fuel vehicles that run on those fuels or can run on petrol, LPG or NG/biomethane.

1.2   The composition of these gaseous fuels, as sold on the market, can vary greatly and fuelling systems must adapt their fuelling rates accordingly. To demonstrate this adaptability, the parent vehicle equipped with a representative LPG or NG/biomethane fuel system shall be tested in Test Type I on two extreme reference fuels.

2. Granting of certification for two- and three- wheeled vehicles equipped with a gaseous fuel system

Certification is granted subject to the following requirements:

2.1.   Exhaust emissions certification of a vehicle equipped with a gaseous fuel system It shall be demonstrated that the parent vehicle equipped with a representative LPG or NG/biomethane fuel system can adapt to any fuel composition that may appear on the market and comply with the following:

2.1.1.   In the case of LPG there are variations in C3/C4 composition (test fuel requirement A and B) and therefore the parent vehicle shall be tested on reference fuels A and B referred to in Table A7.App 2/4.

2.1.2.   In the case of NG/biomethane there are generally two types of fuel, high calorific fuel (G20) and low calorific fuel (G25), but with a significant spread within both ranges; they differ significantly in Wobbe index. These variations are reflected in the reference fuels. The parent vehicle shall be tested on both reference fuels referred to in Table A7.App 2/3.

2.1.3.   If the transition from one fuel to another is in practice aided through the use of a switch, this switch shall not be used during certification. In such cases, at the manufacturer's request and with the agreement of the responsible authorities, the pre-conditioning cycle referred in point 4.2.2.1. of Annex I may be extended.

2.1.4.   The ratio of emission results 'r' shall be determined for each pollutant as shown in Table A4.App1/1 for LPG and NG/biomethane vehicles.

2.1.4.1.   In the case of LPG and NG/biomethane vehicles, the ratios of emission results 'r' shall be determined for each pollutant as follows:

Table A4.App1/1
Calculation ratio 'r' for LPG and NG/biomethane vehicles

Type(s) of fuel	Reference fuels	Calculation of 'r'
LPG and petrol (Certification B)	Fuel A	$r = \dfrac{B}{A}$

or LPG only (Certification D)	Fuel B	
NG/biomethane	fuel G20	$r = \dfrac{G25}{G20}$
	fuel G25	

2.2.   Exhaust emissions certification of a member of the propulsion family

For the certification of mono-fuel gas vehicles and bi-fuel vehicles operating in gas mode, fuelled by LPG, NG/biomethane, as a member of the propulsion family in Annex 7 - Appendix 8, a Test Type I shall be performed with one gaseous reference fuel. For LPG and NG/biomethane, this reference fuel may be either of the reference fuels in Annex 7 - Appendix 2. The gas-fuelled vehicle is considered to comply if the following requirements are met:"

2.2.1.   The test vehicle shall comply with the definition of a propulsion family member in Annex 7 - Appendix 8.

2.2.2.   If the test fuel requirement is reference fuel A for LPG or G20 for NG/biomethane, the emission result shall be multiplied by the relevant factor 'r' if r > 1; if r < 1, no correction is needed.

2.2.3.   If the test fuel requirement is reference fuel B for LPG or G25 for NG/biomethane, the emission result shall be divided by the relevant factor 'r' if r < 1; if r > 1, no correction is needed.

2.2.4.   At the manufacturer's request, the Test Type I may be performed on both reference fuels, so that no correction is needed.

2.2.5.   The parent vehicle shall comply with the emission limits for the relevant category set out in paragraph 7. and for both measured and calculated emissions.

2.2.6.   If repeated tests are conducted on the same engine, an average shall first be taken of the results on reference fuel G20, or A, and those on reference fuel G25, or B; the 'r' factor shall then be calculated from these averages.

2.2.7.   During the Test Type I, the vehicle shall use only petrol for a maximum of 60 consecutive seconds directly after engine crank and start when operating in gas-fuelling mode.

Annex 5

Test Type II, tailpipe emissions at (increased) idle and at free acceleration

1. Introduction

This Annex describes the procedure for Type II testing designed to ensure the on- road pollution under control requisite measurement of emissions during for in-use vehicle roadworthiness testing.

The purpose of the requirements laid down in this Annex is to demonstrate that the approved / certified vehicle complies with the minimum requirements with regard to in-use vehicle roadworthiness testing.

2. Scope

2.1. During the environmental performance certification process, it shall be demonstrated to the responsible authority that the vehicles shall comply with the Test Type II requirements prescribed in regional regulation of Contracting Parties applicable at the time of certification.

2.2. Vehicles equipped with a propulsion unit type of which a positive ignition combustion engine forms part shall be subject only to a Type II emission test as set out in paragraphs 3., 4., and 5. of this Annex.

3. General conditions of Type II emission testing

3.1. In general practice, Type II test shall be carried out immediately after Test Type I, if not, a visual inspection of any emission-control equipment shall be conducted prior to start of the Type II emission test in order to check that the vehicle is complete, in a satisfactory condition and that there are no leaks in the fuel, air supply or exhaust systems. The test vehicle shall be properly maintained and used.

3.2. The fuel used to conduct the Type II test shall be the reference fuel applicable for Test Type I.

3.3. During the test, the environmental temperature shall be between 20 °C and 30 °C.

3.4. In the case of vehicles with manually-operated or semi-automatic-shift transmission, the Test Type II test shall be carried out with the gear lever in the "neutral" position and the clutch engaged.

3.5. In the case of vehicles with automatic-shift transmission, the idle Test Type II shall be carried out with the gear selector in either the "neutral" or the "park" position. Where an automatic clutch is also fitted, the powered axle shall be lifted up to a point at which the wheels can rotate freely.

3.6. The Type II emission test shall be conducted immediately after the Type I emission test. In any other event, if Test Type II test is required to be conducted independently of Type-I test, the vehicle shall be warmed up until one of the following conditions is satisfied:

(a) Conditions at the end of type 1 test or, if not feasible;

(b) Conditions according to ISO 17479 or, if not feasible;

(c) Lubricant temperature of at least 70°C; or

(d) Minimum of 600 seconds of continuous driving under normal traffic conditions.

3.7.   The exhaust outlets shall be provided with an air-tight extension, so that the sample probe used to collect exhaust gases may be inserted at least 60 cm into the exhaust outlet without increasing the back pressure of more than 1.25 kPa and without disturbing operation of the vehicle. This extension shall be so shaped as to avoid any appreciable dilution of exhaust gases in the air at the location of the sample probe. Where a vehicle is equipped with an exhaust system with multiple outlets, either these shall be joined to a common pipe or the measured pollutants carbon monoxide content shall be collected from each of them and an arithmetical average taken.

3.8.   The emission test equipment and analysers to perform the Type II testing shall be regularly calibrated and maintained. A flame ionisation detection or nondispersive infrared (NDIR) analyser may be used for measuring hydrocarbons.

3.9.   For vehicles equipped with a stop-start system, the manufacturer shall provide a Test Type II "service mode" that makes it possible to inspect the vehicle for this roadworthiness test on a running fuel-consuming engine, in order to determine its performance in relation to the data collected. Where this inspection requires a special procedure, this shall be detailed in the service manual (or equivalent media). That special procedure shall not require the use of special equipment other than that provided with the vehicle

4.   Test Type II – description of test procedure to measure tailpipe emissions at (increased) idle

4.1.   The possible positions of the adjustment components shall be limited by any of the following:

4.1.1.   The larger of the following two values:

(a)   The lowest idling engine speed which the engine can reach;

(b)   The engine speed recommended by the manufacturer, minus 100 revolutions per minute;

4.1.2.   The smallest of the following three values:

(a)   The highest rotation speed which the crankshaft of the engine can attain by activation of the idling engine speed components;

(b)   The rotation speed recommended by the manufacturer, plus 250 revolutions per minute;

(c)   The cut-in rotation speed of automatic clutches.

4.2.   Settings incompatible with the correct running of the engine shall not be adopted as measurement settings. In particular, if the engine is equipped with several carburettors, all the carburettors shall have the same setting.

4.3.   The following parameters shall be measured and recorded at normal idling engine speed and at high idle engine speed, :

(a)   The carbon monoxide (CO) content by volume of the exhaust gases emitted (in vol%);

(b)   The carbon dioxide (CO_2) content by volume of the exhaust gases emitted (in vol%);

(c)   (reserved)

(d)   (reserved)

(e)   The engine speed during the test, including any tolerances;

(f)   The engine oil temperature at the time of the test. Alternatively, for liquid cooled engines, the coolant temperature shall be acceptable.

Alternatively, for vehicles with air cooling the sparkplug seat/gasket temperature (T_P) shall be acceptable.

4.3.1.   With respect to the parameters under paragraph 4.3. (d), the following shall apply:

4.3.1.1.   the measurement shall only be conducted at high idle engine speed;

4.3.1.2.   vehicles in the scope of this measurement are only those equipped with a closed loop fuel system;

4.3.1.3.   exemptions for vehicle with:

4.3.1.3.1.   engines equipped with a mechanically-controlled (spring, vacuum) secondary air system;

4.3.1.3.2.   two-stroke engines operated on a mix of fuel and lubrication oil

5.   CO concentration calculation in the Type II idle test

5.1.   The CO (C_{CO}) and CO_2 (C_{CO2}) concentration shall be determined from the measuring instrument readings or recordings, by use of appropriate calibration curves.

5.2.   The corrected concentration for carbon monoxide is:

for 4-Stroke vehicles:

$$C_{COcorr} = 15 \times \frac{C_{CO}}{C_{CO} + C_{CO_2}}$$
(1)

for 2-Stroke vehicles:

$$C_{COcorr} = 10 \times \frac{C_{CO}}{C_{CO} + C_{CO_2}}$$
(2)

where:

C_{CO} is the measured concentration of carbon monoxide, in vol. %;

C_{CO2} is the measured concentration of carbon dioxide, in vol. %;

C_{COcorr} is the corrected concentration for carbon monoxide, in vol. %;

5.3.   The C_{CO} concentration (see paragraph 5.1.) shall be measured in accordance with the formula in paragraph 5.2. and does not need to be corrected if the total of the concentrations measured ($C_{CO} + C_{CO2}$) is at least 15% for petrol.

Annex 6

Test type VII, energy efficiency

1. Introduction

1.1. This Annex sets out requirements with regard to energy efficiency of vehicles, in particular with respect to the measurements of CO_2 emissions and fuel consumption.

1.2. The requirements laid down in this Annex apply to the measurement of the emission of carbon dioxide (CO_2) and fuel consumption for vehicles equipped with associated powertrain configurations:

1.3. A standardised method for measuring vehicles' energy efficiency (fuel consumption and carbon dioxide emissions) is necessary to ensure that customers and users are supplied with objective and precise information.

2. Specification and tests

2.1. General

The components liable to affect CO_2 emissions and fuel consumption shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibrations to which it may be subjected, to comply with the provisions of this section. The test vehicles shall be properly maintained and used.

2.2. Description of tests for vehicles powered by a combustion engine only

2.2.1. The emissions of CO_2 and fuel consumption shall be measured according to the test procedure described in Appendix 1 to this Annex. The test procedure, test fuel, conditioning of vehicle, other requirements, etc, are to be followed for Type VII test same as for Test Type I described in Annex 4.

2.2.2. For CO_2 emissions, the test results shall be expressed in grams per kilometre (g/km) rounded to the nearest one decimal place.

2.2.3. Fuel consumption values shall be expressed in terms of both litres per 100 km and also kilometre per litre and their values shall be rounded off to two decimals and one decimal respectively. The values shall be calculated according to paragraph 1.4.3. of Appendix 1 to this Annex by the carbon balance method, using the measured emissions of CO_2 and the other carbon-related emissions (CO and HC).

2.2.4. The appropriate reference fuels as set out in Appendix 2 to Annex 7 shall be used for testing.

For the purpose of the calculation referred in paragraph 2.2.3., the fuel consumption shall be expressed in appropriate units and the following fuel characteristics shall be used:

(a) Density: measured on the test fuel according to ISO 3675:1998 or an equivalent method. For petrol fuel, the density measured at 15 °C and 101.3 kPa shall be used.

(b) Hydrogen-carbon ratio: fixed values will be used, as follows:

$C_{1:1.89} O_{0.016}$ for E_5 petrol;

$C_{1:1.93} O_{0.033}$ for E10 petrol;

$C_{1:2.525}$ for LPG

$C_{1:4}$ for NG/biomethane.

Annex 6 - Appendix 1

Method of measuring carbon dioxide emissions and fuel consumption of vehicles powered by a combustion engine

1. Specification of the test

1.1. The CO_2 emissions and fuel consumption of vehicles powered by a combustion engine only shall be determined according to the procedure for the Test Type I in Annex 4 in force at the time of the certification of the vehicle.

1.2. In addition to the CO_2 emission and fuel consumption results for the entire Test Type I, CO_2 emissions and fuel consumption shall also be determined separately for parts 1, 2 and 3, if applicable, by using the applicable Test Type I procedure.

1.3. In addition to the conditions in Annex 4 in force at the time of the certification of the vehicle, the following conditions shall apply:

1.3.1. Only the equipment necessary for the operation of the vehicle during the test shall be in use. If there is a manually controlled device for the engine intake air temperature, it shall be in the position prescribed by the manufacturer for the ambient temperature at which the test is performed. In general, the auxiliary devices required for the normal operation of the vehicle shall be in use.

1.3.2. If the radiator fan is temperature-controlled, it shall be in normal operating condition. The passenger compartment heating system, if present, shall be switched off, as shall any air-conditioning system, but the compressor for such systems shall be functioning normally.

1.3.3. If a super-charger is fitted, it shall be in normal operating condition for the test conditions.

1.3.4. All lubricants shall be those recommended by the manufacturer of the vehicle and shall be specified in the test report.

1.3.5. The widest tyre shall be chosen, except where there are more than three tyre sizes, in which case the second widest shall be chosen. The pressures shall be indicated in the test report.

1.4. Calculation of CO_2 and fuel consumption values

1.4.1. The mass emission of CO_2, expressed in g/km, shall be calculated from the measurements taken in accordance with the provisions of paragraph 5 of Annex 1.

1.4.1.1. For this calculation, the density of CO_2 shall be assumed to be $QCO_2 = 1. 964 \cdot 10^3$ g/m^3.

1.4.2. The fuel consumption values shall be calculated from the hydrocarbon, carbon monoxide and carbon dioxide emission measurements taken in accordance with the provisions of paragraph 5. of Annex 4 in force at the time of the certification of the vehicle.

1.4.3. Fuel consumption (FC), expressed in litres per 100 km (in the case of petrol) is calculated using the following formulae:

1.4.3.1. for vehicles with a positive ignition engine fuelled with petrol (E5):

$$FC = (0.1180/D) \cdot ((0.848 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)); \qquad (1)$$

1.4.3.2. for vehicles with a positive ignition engine fuelled with petrol (E10):

$$FC = (0.1206/D) \cdot ((0.829 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)); \qquad (2)$$

1.4.4. In these formulae:

FC = the fuel consumption in litres per 100 km in the case of petrol

HC = the measured emission of hydrocarbons in g/km

CO = the measured emission of carbon monoxide in g/km

CO_2 = the measured emission of carbon dioxide in g/km

D = the density of the test fuel.

Annex 7

Common appendixes: Appendixes to Test Type I, II and VII

Annex 7- Appendix 1

Symbols & Abbreviations

Table A7.App 1/1
Symbols used

Symbol	Definition	Unit
a	Coefficient of polygonal function	-
a_T	Rolling resistance force of front wheel	N
A	NG / biomethane quantity within the H_2NG mixture	per cent vol.
b	Coefficient of polygonal function	-
b_T	Coefficient of aerodynamic function	$N/(km/h)^2$
c	Coefficient of polygonal function	-
C_{CO}	Concentration of carbon monoxide	ppm
C_{CO2}	Concentration of CO_2 in the diluted exhaust gas contained in the sampling bag	percent vol.
C_{COcorr}	Corrected concentration of carbon monoxide	percent vol.
CO_{2c}	Carbon dioxide concentration of diluted gas, corrected to take account of diluent air	percent
CO_{2d}	Carbon dioxide concentration in the sample of diluent air collected in bag B	percent
CO_{2e}	Carbon dioxide concentration in the sample of diluent air collected in bag A	percent
CO_{2m}	Mass of carbon dioxide emitted during the test part	mg/km
CO_c	Carbon monoxide concentration of diluted gas, corrected to take account of diluent air	ppm
CO_d	Carbon monoxide concentration in the sample of diluent air, collected in bag B	ppm
CO_e	Carbon monoxide concentration in the sample of diluent air, collected in bag A	ppm
CO_m	Mass of carbon monoxide emitted during the test part	mg/km
C_{H2}	Concentration of hydrogen in the diluted exhaust gas contained in sampling bag	ppm
C_{H2O}	Concentration of H_2O in the diluted exhaust gas contained in the sampling bag	percent vol.
C_{H2O-DA}	Concentration of H_2O in the air used for dilution	percent vol.
C_{HC}	Concentration of HC in the diluted exhaust gas contained in the sampling bag	ppm (carbon equivalent)
d_0	Standard ambient relative air density	-
d_{CO}	Density of carbon monoxide	mg/cm^3
d_{CO2}	Density of carbon dioxide	g/m^3
d_{HC}	Density of hydrocarbon	mg/cm^3
D_{av}	Average distance between two battery recharges	km
D_e	Electric range of the vehicle	km
DiF	Dilution factor	-
D_{OVC}	Distance from externally chargeable vehicle	km
S / d	Distance driven in a cycle part	km
d_{NOx}	Density of nitrogen oxide	mg/m^3
d_T	Relative air density under test condition	-
Δt	Coast-down time	s

Symbol	Definition	Unit
Δta_i	Coast-down time measured in the first road test	s
Δtb_i	Coast-down time measured in the second road test	s
ΔT_E	Coast-down time corrected for the inertia mass	s
Δt_E	Mean coast-down time on the chassis dynamometer at the reference vehicle speed	s
ΔT_i	Average coast-down time at specified vehicle speed	s
Δt_i	Coast-down time at corresponding s vehicle peed	s
ΔT_j	Average coast-down time at specified vehicle speed	s
ΔT_{road}	Target coast-down time	s
$\overline{\Delta t}_t$	Mean coast-down time on the chassis dynamometer without absorption	s
Δv	Coast-down vehicle speed interval ($2\Delta v = v1 - v2$)	km/h
ε	Chassis dynamometer setting error	percent
F	Running resistance force	N
F*	Target running resistance force	N
$F*_{(v0)}$	Target running resistance force at reference vehicle speed on chassis dynamometer	N
$F*_{(vi)}$	Target running resistance force at specified vehicle speed on chassis dynamometer	N
$f*_0$	Corrected rolling resistance in the standard ambient condition	N
$f*_2$	Corrected coefficient of aerodynamic drag in the standard ambient condition	$N/(km/h)^2$
$F*_j$	Target running resistance force at specified vehicle speed	N
f_0	Rolling resistance	N
f_2	Coefficient of aerodynamic drag	$N/(km/h)^2$
F_E	Set running resistance force on the chassis dynamometer	N
$F_{E(v0)}$	Set running resistance force at the reference s vehicle peed on the chassis dynamometer	N
$F_{E(v2)}$	Set running resistance force at the specified vehicle speed on the chassis dynamometer	N
F_f	Total friction loss	N
$F_{f(v0)}$	Total friction loss at the reference vehicle speed	N
F_j	Running resistance force	N
$F_{j(v0)}$	Running resistance force at the reference vehicle speed	N
F_{pau}	Braking force of the power absorbing unit	N
$F_{pau(v0)}$	Braking force of the power absorbing unit at the reference vehicle speed	N
$F_{pau(vj)}$	Braking force of the power absorbing unit at the specified vehicle speed	N
F_T	Running resistance force obtained from the running resistance table	N
H	Absolute humidity	g of water / kg of dry air
HC_c	Concentration of diluted gases expressed in the carbon equivalent, corrected to take account of diluent air	ppm
HC_d	Concentration of hydrocarbons expressed in the carbon equivalent, in the sample of diluent air collected in bag B	ppm
HC_e	Concentration of hydrocarbons expressed in the carbon equivalent, in the sample of diluent air collected in bag A	ppm
HC_m	Mass of hydrocarbon emitted during the test part	mg/km

Symbol	Definition	Unit
i	gear number	-
K_0	Temperature correction factor for rolling resistance	-
K_h	Humidity correction factor	-
L	Certification limit values of gaseous pollutant emission	mg/km
m	Test vehicle mass	kg
ma	Actual mass of the test vehicle	kg
m_{corr}	PM mass corrected for buoyancy	mg
$m_f i$	Flywheel equivalent inertia mass	kg
mi	Equivalent inertia mass	kg
m_{mix}	molar mass of air in balance environment (28.836 $gmol^{-1}$)	$gmol^{-1}$
mr	Equivalent inertia mass of all the wheels	kg
mri	Equivalent inertia mass of all the rear wheel and vehicle parts rotating with wheel	kg
m_k	m_k is unladen mass of the vehicle	kg
m_{ref}	m_{ref} is reference mass of the vehicle	kg
m_{rid}	Rider mass	kg
m_{uncorr}	PM mass uncorrected for buoyancy	mg
M_i	Mass emission of the pollutant i in mg/km	mg
M_{2i}	Average mass emission of the pollutant i with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity)	mg/km
M_{1i}	Average mass emission of the pollutant i with a fully charged electrical energy/power storage device	mg/km
Mp	Particulate mass emission	mg/km
n	Engine speed	min^{-1}
n	Number of data regarding the emission or the test	-
N	Number of revolutions made by pump P	-
nd_{vi}	Ratio between engine speed in min^{-1} and vehicle speed in km/h in gear "i"	-
ng	Number of forward gears	-
n_{idle}	Idling engine speed	min^{-1}
$n\_max\_acc_{(1)}$	Upshift engine speed from gear 1 to gear 2 during acceleration phases	min^{-1}
$n\_max\_acc_{(i)}$	Up shift engine speed from gear i to gear i+1 during acceleration phases, i>1	min^{-1}
$n\_min\_acc_{(i)}$	Minimum engine speed for cruising or deceleration in gear 1	min^{-1}
NO_{xc}	Nitrogen oxide concentration of diluted gases, corrected to take account of diluent air	ppm
NO_{xd}	Nitrogen oxide concentration in the sample of diluent air collected in bag B	ppm
NO_{xe}	Nitrogen oxide concentration in the sample of diluent air collected in bag A	ppm
NO_{xm}	Mass of nitrogen oxides emitted during the test part	mg/km
p_0	Standard ambient pressure	kPa
p_a	Ambient/atmospheric pressure	kPa
p_{abs}	absolute pressure in balance environment	kPa
p_d	Saturated pressure of water at the test temperature	kPa
p_i	Average under-pressure during the test part in the section of pump P	kPa

Symbol	Definition	Unit
p_T	Mean ambient pressure during the test	kPa
P_n	Rated power	kW
Q	Electric energy balance	Ah
ρ_0	Standard relative ambient air volumetric mass	mg/cm^3
ρ_{air}	density of air in balance environment	mg/cm^3
ρ_{weight}	density of calibration weight used to span balance	mg/cm^3
ρ_{media}	density of PM sample medium (filter) with filter medium Teflon coated glass fibre (e.g. TX40): $\rho_{media} = 2\,300\ kg/m^3$	mg/cm^3
$r(i)$	Gear ratio in gear i	-
R	molar gas constant ($8\,314$ $Jmol^{-1}K^{-1}$)	$Jmol^{-1}K^{-1}$
R_f	Response factor to calibrate HC analyser	-
R_F	Final test result of pollutant emissions, carbon dioxide emission or fuel consumption	mg/km g/km, 1/100km
R_1	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 1 with cold start	mg/km g/km, 1/100km
R_2	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 2 with warm condition	mg/km g/km, 1/100km
R_3	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 1 with warm condition	mg/km g/km, 1/100km
Ri_1	First Test Type I results of pollutant emissions	mg/km
Ri_2	Second Test Type I results of pollutant emissions	mg/km
Ri_3	Third Test Type I results of pollutant emissions	mg/km
RS	Reduced speed	-
s	Rated engine speed	min^{-1}
S	Accumulated distance in test cycle (paragraph 5.1.1.3. of Annex 1)	km
T_{amb}	absolute ambient temperature of balance environment	°C
T_C	Temperature of the coolant	°C
T_O	Temperature of the engine oil	°C
T_P	Temperature of the spark-plug seat/gasket	°C
T_0	Standard ambient temperature	°C
T_P	Temperature of the diluted gases during the test part, measured in the intake section of pump P	°C
T_T	Mean ambient temperature during the test	°C
U	Relative humidity	percent
v	Specified vehicle speed	km/h
V	Total volume of diluted gas	m^3
v_{max}	Maximum design vehicle speed of test vehicle	km/h
v_0	Reference vehicle speed	km/h
V_0	Volume of gas displaced by pump P during one revolution	$m^3/rev.$
v_1	Vehicle speed at which the measurement of the coast-down time begins	km/h
v_2	Vehicle speed at which the measurement of the coast-down time ends	km/h
vi	Specified vehicle speed selected for the coast-down time measurement	km/h
w_1	Weighting factor of cycle part 1 with cold start	-
w_{1warm}	Weighting factor of cycle part 1 with warm condition	-

Symbol	Definition	Unit
w_2	Weighting factor of cycle part 2 with warm condition	-
w_3	Weighting factor of cycle part 3 with warm condition	-

Annex 7- Appendix 2

Reference fuels

1.   Specifications of reference fuels for testing vehicles in environmental tests, in particular for tailpipe and evaporative emissions testing

1.1.   The following tables list the technical data on liquid reference fuels that Contracting Parties may require to be used for environmental performance testing of two- and three- wheeled vehicles. These reference fuels were used to define the emission limits set out in paragraph 5. of this Regulation

Table A7.App2/1
Type: Petrol E5 (nominal 95 Octane)

Parameter	Unit	Limits[1] Minimum	Limits[1] Maximum	Test method
Research octane number, RON		95.0	-	EN 25164 / prEN ISO 5164
Motor octane number, MON		85.0	-	EN 25163 / prEN ISO 5163
Density at 15 °C	kg/m^3	743	756	EN ISO 3675 / EN ISO 12185
Vapour pressure	kPa	56.0	60.0	EN ISO 13016-1 (DVPE)
Water content	% v/v		0.015	ASTM E 1064
Distillation:				
– Evaporated at 70 °C	% v/v	24.0	44.0	EN ISO 3405
– Evaporated at 100 °C	% v/v	48.0	60.0	EN ISO 3405
– Evaporated at 150 °C	% v/v	82.0	90.0	EN ISO 3405
– Final boiling point	°C	190	210	EN ISO 3405
Residue	% v/v	—	2.0	EN ISO 3405
Hydrocarbon analysis:				
– Olefins	% v/v	3.0	13.0	ASTM D 1319
– Aromatics	% v/v	29.0	35.0	ASTM D 1319
– Benzene	% v/v	-	1.0	EN 12177
– Saturates	% v/v		Report	ASTM 1319
Carbon/hydrogen ratio			Report	
Carbon/oxygen ratio			Report	
Induction period[2]	minutes	480	-	EN ISO 7536
Oxygen content[4]	% m/m		Report	EN 1601
Existent gum	mg/ml	-	0.04	EN ISO 6246
Sulphur content[3]	mg/kg	-	10	EN ISO 20846 / EN ISO 20884
Copper corrosion		-	Class 1	EN ISO 2160
Lead content	mg/l	-	5	EN 237
Phosphorus content	mg/l	-	1.3	ASTM D 3231
Ethanol[5]	% v/v	4.7	5.3	EN 1601 / EN 13132

[1] The values quoted in the specifications are "true values". For establishing the limit values, the terms of ISO 4259:2006 (Petroleum products — Determination and application of precision data in relation to methods of test) have been applied and for fixing a minimum value, a minimum difference of 2R above zero has been taken into account; for fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility).

Notwithstanding this measure, which is necessary for technical reasons, the fuel manufacturer shall nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value when quoting maximum and minimum limits. Should it be necessary to clarify whether a fuel meets the requirements of the specifications, the terms of ISO 4259:2006 shall be applied.

[2] The fuel may contain oxidation inhibitors and metal deactivators normally used to stabilise refinery petrol streams, but detergent/dispersive additives and solvent oils shall not be added.

[3] The actual sulphur content of the fuel used for the Test Type I shall be reported.

[4] Ethanol meeting the specification of prEN 15376 is the only oxygenate that shall be intentionally added to the reference fuel.

[5] There shall be no intentional addition to this reference fuel of compounds containing phosphorus, iron, manganese or lead.

Table A7.App2/2
Type: Petrol E10 (nominal 95 Octane)

Parameter	Unit	Limits [a]		Test method [b]
		Minimum	Maximum	
Research octane number, RON [c]		95.0	98.0	EN ISO 5164 JIS K2280
Motor octane number, MON [c]		85.0	89.0	EN ISO 5163 JIS K2280
Density at 15 °C	kg/m^3	743.0	756.0	EN ISO 12185 JIS K2249-1,2,3
Vapour pressure	kPa	56.0	60.0	EN 13016-1 JIS K2258
Water content	% v/v		0.05	EN 12937
Appearance at -7 °C		clear and bright		
Distillation:				
— evaporated at 70 °C	% v/v	34.0	46.0	EN-ISO 3405
— evaporated at 100 °C	% v/v	54.0	62.0	EN-ISO 3405
— evaporated at 150 °C	% v/v	86.0	94.0	EN-ISO 3405
— final boiling point	°C	170	195	EN-ISO 3405
Residue	% v/v		2.0	EN-ISO 3405
Hydrocarbon analysis:				
— olefins	% v/v	6.0	13.0	EN 22854 JIS K2536-1,2
— aromatics	% v/v	25.0	32.0	EN 22854 JIS K2536-1,2,3
— benzene	% v/v		1.00	EN 22854 EN 238 JIS K2536-2,3,4
— saturates	% v/v	To be recorded		EN 22854
Carbon/hydrogen ratio		To be recorded		
Carbon/oxygen ratio		To be recorded		
Induction period [d]	minutes	480		EN-ISO 7536
Oxygen content [e]	% m/m	3.3	3.7	EN 22854 JIS K2536-2,4,6
Solvent washed gum (Existent gum content)	mg/100ml		4	EN-ISO 6246 JIS K2261
Sulphur content [f]	mg/kg		10	EN ISO 20846 EN ISO 20884 JIS K2541-1,2,6,7
Copper corrosion			Class 1	EN-ISO 2160
Lead content	mg/l		5	EN 237 JIS K2255
Phosphorus content [g]	mg/l		1.3	ASTM D 3231
Ethanol [e]	% v/v	9.0	10.0	EN 22854 JIS K2536-2,4,6

Parameter	Unit	Limits [a]		Test method [b]
		Minimum	Maximum	

[a] The values quoted in the specifications are 'true values'. In establishing of their limit values the terms of ISO 4259 "Petroleum products - Determination and application of precision data in relation to methods of test" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility).

Notwithstanding this measure, which is necessary for technical reasons, the manufacturer of fuels shall nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify whether a fuel meets the requirements of the specifications, the terms of ISO 4259 shall be applied.

[b] Equivalent EN/ISO methods will be adopted when issued for properties listed above.

[c] A correction factor of 0.2 for MON and RON shall be subtracted for the calculation of the final result in accordance with EN 228:2008.

[d] The fuel may contain oxidation inhibitors and metal deactivators normally used to stabilise refinery gasoline streams, but detergent/dispersive additives and solvent oils shall not be added.

[e] Ethanol is the only oxygenate that shall be intentionally added to the reference fuel. The Ethanol used shall conform to EN 15376.

[f] The actual sulphur content of the fuel used for the Type 1 test shall be recorded.

[g] There shall be no intentional addition of compounds containing phosphorus, iron, manganese, or lead to this reference fuel.

Table A7.App2/3
Type: Natural gas (NG)/biomethane [1]

Parameter	Unit	Limits [3]		Test method
		Minimum	Maximum	
Reference fuel G_{20}				
Methane	percent mole	100	99	100
Balance [2]	percent mole	—	—	1
N_2	percent mole			
Sulphur content [2]	mg/m^3	—	—	10
Wobbe Index [4] (net)	MJ/m^3	48.2	47.2	49.2
Reference fuel G_{25}				
Methane	percent mole	86	84	88
Balance [2]	percent mole	—	—	1
N_2	percent mole	14	12	16

Type: Natural gas (NG)/biomethane [1]

Parameter	Unit	Limits [3]		Test method
		Minimum	Maximum	
Sulphur content [3]	mg/m^3	—	—	10
Wobbe Index (net) [4]	MJ/m^3	39.4	38.2	40.6

[1] Biofuel' means liquid or gaseous fuel for transport, produced from biomass.

[2] Inerts (different from N_2) + C2 + C2+.

[3] Value to be determined at 293.15 K (20 °C) and 101.3 kPa.

[4] Value to be determined at 273.15 K (0 °C) and 101.3 kPa.

Table A7.App2/4
Type: Liquefied petroleum gas (LPG)

Parameter	Unit	Fuel A	Fuel B	Test method
Composition:				ISO 7941
C_3-content	percent vol	30 ± 2	85 ± 2	
C_4-content	percent vol	Balance [1]	Balance [2]	

Type: Liquefied petroleum gas (LPG)

Parameter	Unit	Fuel A	Fuel B	Test method
$< C_3, > C_4$	percent vol	max. 2	max. 2	
Olefins	percent vol	max. 12	max. 15	
Evaporation residue	mg/kg	max. 50	max. 50	ISO 13757 or EN 15470
Water at 0 °C		free	free	EN 15469
Total sulphur content	mg/kg	max. 50	max. 50	EN 24260 or ASTM 6667
Hydrogen sulphide		none	none	ISO 8819
Copper strip corrosion	rating	Class 1	class 1	ISO 6251 [2]
Odour		characteristic	characteristic	
Motor octane number		min. 89	min. 89	EN 589 Annex B

[1]   Balance has to be read as follows: balance = 100 - C3 ≤ C3 ≥ C4.

[2] This method may not accurately determine the presence of corrosive materials if the sample contains corrosion inhibitors or other chemicals which diminish the corrosivity of the sample to the copper strip. Therefore, the addition of such compounds for the sole purpose of biasing the test method is prohibited.

Annex 7- Appendix 3

Test vehicle requirements for Test Types I, II and VII

1.   General

1.1.   All components of the test vehicle shall conform to those of the production series or, if the test vehicle is different from the production series, a full description shall be given in the test report. In selecting the test vehicle, the vehicle manufacturer and the technical service shall agree to the satisfaction of the responsible authority which tested parent vehicle is representative of the related vehicle propulsion unit family as laid down in Appendix 8 to Annex 7

1.2.   Unless specified differently elsewhere within this UN GTR, the vehicle shall be used, adjusted, specified, maintained, fuelled and lubricated as it would be in the production series and as recommended to the user. Parts and consumables shall be used which are or will be commercially available and are permitted for use on the intended roads and for the atmospheric and road conditions experienced while under test.

1.3.   The lighting and signalling and auxiliary devices, except those required for the testing and usual daytime operation of the vehicle, shall be switched off.

1.4.   If the batteries are operated above the ambient temperature, the operator shall follow the procedure recommended by the vehicle manufacturer in order to keep the battery temperature in the normal operating range. The vehicle manufacturer shall be in a position to attest that the thermal management system of the battery is neither disabled nor reduced.

2.   Run-in

The vehicle shall be presented in good mechanical condition, properly maintained and used. It shall have been run in and driven at least 1 000 km before the test. The engine, pollutant emission abatement equipment, drive train, and vehicle shall be properly run in, in accordance with the vehicle manufacturer's requirements.

3.   Adjustments

The test vehicle shall be adjusted in accordance with the vehicle manufacturer's requirements, e.g. as regards the viscosity of the oils, or, if it differs from the production series, a full description shall be given in the test report.

4.   Test mass and load distribution

The test mass, including the masses of the rider and the instruments, shall be measured before the beginning of the tests. The load shall be distributed across the wheels in conformity with the vehicle manufacturer's instructions.

5.   Tyres

The tyres shall be of a type specified as original equipment by the vehicle manufacturer. The tyre pressures shall be adjusted to the specifications of the vehicle manufacturer or to those where the speed of the vehicle during the road test and the vehicle speed obtained on the chassis dynamometer are equalised. The tyre pressure shall be indicated in the test report.

Annex 7- Appendix 4

Classification of equivalent inertia mass and running resistance, applicable for two- and three- wheeled vehicles (table method)

1. The chassis dynamometer can be set using the running resistance table instead of the running resistance force obtained by the coast-down methods set out in Appendix 5a or 5b or Appendix 6 to Annex 7 In this table method, the chassis dynamometer shall be set by the reference mass regardless of particular motor vehicle characteristics.

2. The flywheel equivalent inertia mass mfi shall be the equivalent inertia mass mi specified in paragraph 3.4.6.1.2. of Annex 4. The chassis dynamometer shall be set by the rolling resistance of front wheel "a" and the aerodynamic drag coefficient "b" specified in the following table.

Table A7.App4/1
Classification of equivalent inertia mass and running resistance used for two- and three-wheeled vehicles.

Reference mass m_{ref} (kg)	Equivalent inertia mass mi (kg)	Rolling resistance of front wheel a (N)	Aero drag coefficient b $(N/(km/h)^2)$
$0 < m_{ref} \leq 25$	20	1.8	0.0203
$25 < m_{ref} \leq 35$	30	2.6	0.0205
$35 < m_{ref} \leq 45$	40	3.5	0.0206
$45 < m_{ref} \leq 55$	50	4.4	0.0208
$55 < m_{ref} \leq 65$	60	5.3	0.0209
$65 < m_{ref} \leq 75$	70	6.8	0.0211
$75 < m_{ref} \leq 85$	80	7.0	0.0212
$85 < m_{ref} \leq 95$	90	7.9	0.0214
$95 < m_{ref} \leq 105$	100	8.8	0.0215
$105 < m_{ref} \leq 115$	110	9.7	0.0217
$115 < m_{ref} \leq 125$	120	10.6	0.0218
$125 < m_{ref} \leq 135$	130	11.4	0.0220
$135 < m_{ref} \leq 145$	140	12.3	0.0221
$145 < m_{ref} \leq 155$	150	13.2	0.0223
$155 < m_{ref} \leq 165$	160	14.1	0.0224
$165 < m_{ref} \leq 175$	170	15.0	0.0226
$175 < m_{ref} \leq 185$	180	15.8	0.0227
$185 < m_{ref} \leq 195$	190	16.7	0.0229
$195 < m_{ref} \leq 205$	200	17.6	0.0230
$205 < m_{ref} \leq 215$	210	18.5	0.0232
$215 < m_{ref} \leq 225$	220	19.4	0.0233
$225 < m_{ref} \leq 235$	230	20.2	0.0235
$235 < m_{ref} \leq 245$	240	21.1	0.0236
$245 < m_{ref} \leq 255$	250	22.0	0.0238
$255 < m_{ref} \leq 265$	260	22.9	0.0239
$265 < m_{ref} \leq 275$	270	23.8	0.0241
$275 < m_{ref} \leq 285$	280	24.6	0.0242

$285 < m_{ref} \leq 295$	290	25.5	0.0244
$295 < m_{ref} \leq 305$	300	26.4	0.0245
$305 < m_{ref} \leq 315$	310	27.3	0.0247
$315 < m_{ref} \leq 325$	320	28.2	0.0248
$325 < m_{ref} \leq 335$	330	29.0	0.0250
$335 < m_{ref} \leq 345$	340	29.9	0.0251
$345 < m_{ref} \leq 355$	350	30.8	0.0253
$355 < m_{ref} \leq 365$	360	31.7	0.0254
$365 < m_{ref} \leq 375$	370	32.6	0.0256
$375 < m_{ref} \leq 385$	380	33.4	0.0257
$385 < m_{ref} \leq 395$	390	34.3	0.0259
$395 < m_{ref} \leq 405$	400	35.2	0.0260
$405 < m_{ref} \leq 415$	410	36.1	0.0262
$415 < m_{ref} \leq 425$	420	37.0	0.0263
$425 < m_{ref} \leq 435$	430	37.8	0.0265
$435 < m_{ref} \leq 445$	440	38.7	0.0266
$445 < m_{ref} \leq 455$	450	39.6	0.0268
$455 < m_{ref} \leq 465$	460	40.5	0.0269
$465 < m_{ref} \leq 475$	470	41.4	0.0271
$475 < m_{ref} \leq 485$	480	42.2	0.0272
$485 < m_{ref} \leq 495$	490	43.1	0.0274
$495 < m_{ref} \leq 505$	500	44.0	0.0275
At every 10 kg	At every 10 kg	$a = 0.088 \times m_i$ [*]	$b = 0.000015 \times m_i + 0.02$ [**]

[*] The value shall be rounded to one decimal place.

[**] The value shall be rounded to four decimal places.

Annex 7- Appendix 5a

Road tests of two- and three-wheeled vehicles equipped with one wheel on the powered axle for the determination of test bench settings

1.   Requirements for the rider

1.1.   The rider shall wear a well-fitting (one-piece) suit or similar clothing and a protective helmet, eye protection, boots and gloves.

1.2.   The rider dressed and equipped as described in paragraph 1.1., shall have a mass of 75 kg ± 5 kg and be 1.75 m ± 0.05 m tall.

1.3.   The rider shall be seated on the seat provided, with his feet on the footrests and his arms extended normally. This position shall allow the rider to have proper control of the vehicle at all times during the tests.

2.   Requirement for the road and ambient conditions

2.1.   The test road shall be flat, level, straight and smoothly paved. The road surface shall be dry and free of obstacles or wind barriers that might impede the measurement of the running resistance. The slope of the surface shall not exceed 0.5% between any two points at least 2 m apart.

2.2.   During data collecting periods, the wind shall be steady. The wind speed and the direction of the wind shall be measured continuously or with adequate frequency at a location where the wind force during coast-down is representative.

2.3.   The ambient conditions shall be within the following limits:

- maximum wind speed: 3 m/s

- maximum wind speed for gusts: 5 m/s

- average wind speed, parallel: 3 m/s

- average wind speed, perpendicular: 2 m/s

- maximum relative humidity: 95%

- air temperature: 5 °C to 35 °C

2.4.   Standard ambient conditions shall be as follows:

- pressure, P_0: 101.3 kPa

- temperature, T_0: 20 °C

- relative air density, d_0: 0.9197

- air volumetric mass, ρ_0: 1.189 kg/m^3

2.5.   The relative air density when the vehicle is tested, calculated in accordance with the (1) shall not differ by more than 7.5% from the air density under the standard conditions.

2.6.   The relative air density, d_T, shall be calculated using the following formula:

$$d_T = d_0 \cdot \frac{p_T}{p_0} \cdot \frac{T_0}{T_T} \tag{1}$$

where:

d_0 is the reference relative air density at reference conditions (0.9197)

p_T is the mean ambient pressure during the test, in kPa;

p_0 is the reference ambient pressure (101.3 kPa);

T_T is the mean ambient temperature during test, in K;

T_0 is the reference ambient temperature 20 °C.

3.   Condition of the test vehicle

3.1.   The test vehicle shall comply with the conditions described in paragraph 1.1. of Appendix 6 to Annex 7.

3.2.   When installing the measuring instruments on the test vehicle, care shall be taken to minimise their effects on the distribution of the load across the wheels. When installing the vehicle speed sensor outside the vehicle, care shall be taken to minimise the additional aerodynamic loss.

3.3.   Checks

The following checks shall be made in accordance with the manufacturer's specifications for the use considered: wheels, wheel rims, tyres (make, type and pressure), front axle geometry, brake adjustment (elimination of parasitic drag), lubrication of front and rear axles, adjustment of the suspension and vehicle ground clearance, etc. Check that during freewheeling, there is no electrical braking.

4.   Specified coast-down vehicle speeds

4.1.   The coast-down times shall be measured between v_1 and v_2 as specified in Table A7.App5a/1, depending on the vehicle class as defined in paragraph 5.2.4. of this Regulation.

Table A7.App5a/1
Coast-down time measurement beginning vehicle speed and ending vehicle speed

Vehicle Class	Specified target vehicle speed v_j in (km/h)	v_1 in (km/h)	v_2 in (km/h)
1	50	55	45
	40	45	35
	30	35	25
	20	25	15
2	100	110	90
	80*	90	70
	60*	70	50
	40*	45	35
	20*	25	15
3	120	130	110
	100*	110	90
	80*	90	70
	60*	70	50
	40*	45	35
	20*	25	15

*Specific coast-down speeds for vehicles that have to drive part in the "reduced speed" version

4.2.   When the running resistance is verified in accordance with paragraph 4.2.2.3.2. of Annex 4, the test can be executed at $v_j \pm 5$ km/h, provided that the coast-down time accuracy referred to in paragraph 3.4.7. of Annex 4 is ensured.

5.   Measurement of coast-down time

5.1.   After a warm-up period, the vehicle shall be accelerated to the coast-down starting vehicle speed, at which point the coast-down measurement procedure shall be started.

5.2.   Since shifting the transmission to neutral can be dangerous and complicated by the construction of the vehicle, the coasting may be performed solely with the clutch disengaged. Vehicles that have no means of cutting the transmitted

engine power off prior to coasting may be towed until they reach the coast-down starting vehicle speed. When the coast-down test is reproduced on the chassis dynamometer, the drive train and clutch shall be in the same condition as during the road test.

5.3.   The vehicle steering shall be altered as little as possible and the brakes shall not be operated until the end of the coast-down measurement period.

5.4.   The first coast-down time Δt_{ai} corresponding to the specified vehicle speed v_j shall be measured as the time taken for the vehicle to decelerate from $v_j + \Delta v$ to $v_j - \Delta v$.

5.5.   The procedure described in paragraphs 5.1. to 5.4. shall be repeated in the opposite direction to measure the second coast-down time Δt_{bi}.

5.6.   The average Δt_i of the two coast-down times Δt_{ai} and Δt_{bi} shall be calculated using the following equation:

$$\Delta t_i = \frac{\Delta t_{ai} + \Delta t_{bi}}{2} \tag{2}$$

5.7.   At least four tests shall be performed and the average coast-down time ΔT_j calculated using the following equation:

$$\Delta t_j = \frac{1}{n} \cdot \sum_{i=1}^{n} \Delta t_i \tag{3}$$

5.8.   Tests shall be performed until the statistical accuracy P is equal to or less than 3% (P ≤ 3%).

The statistical accuracy P (as a percentage) is calculated using the following equation:

$$P = \frac{t \cdot s}{\sqrt{n}} \cdot \frac{100}{\Delta t_j} \tag{4}$$

where:

t is the coefficient given in Table A4.App5a/2;

s is the standard deviation given by the following formula:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(\Delta t_i - \Delta t_j)^2}{n-1}} \tag{5}$$

where:

n is the number of tests.

Table A7.App5a/2
Coefficients for statistical accuracy

n	t	$\dfrac{t}{\sqrt{n}}$
4	3.2	1.60
5	2.8	1.25
6	2.6	1.06
7	2.5	0.94
8	2.4	0.85
9	2.3	0.77
10	2.3	0.73
11	2.2	0.66
12	2.2	0.64
13	2.2	0.61
14	2.2	0.59
15	2.2	0.57

5.9. In repeating the test, care shall be taken to start the coast-down after observing the same warm-up procedure and at the same coast-down starting vehicle speed.

5.10. The coast-down times for multiple specified vehicle speeds may be measured in a continuous coast-down. In this case, the coast-down shall be repeated after observing the same warm-up procedure and at the same coast-down starting vehicle speed.

5.11. The coast-down time shall be recorded. A specimen record form is given in the Regulation for administrative requirements.

6. Data processing

6.1. Calculation of running resistance force

6.1.1. The running resistance force F_j, in Newton, at the specified vehicle speed vj shall be calculated using the following equation:

$$F_j = \frac{1}{3.6} \cdot m_{ref} \cdot \frac{2 \cdot \Delta v}{\Delta t} \tag{6}$$

where:

m_{ref} = reference mass (kg);

Δv = vehicle speed deviation (km/h);

Δt = calculated coast-down time difference (s);

6.1.2. The running resistance force F_j shall be corrected in accordance with paragraph 6.2.

6.2. Running resistance curve fitting

The running resistance force F shall be calculated as follows:

6.2.1. The following equation shall be fitted to the data set of v_j and F_j obtained in paragraphs 4. and 6.1. respectively by linear regression to determine the coefficients f0 and f2,

$$F = f_0 + f_2 \times v^2 \tag{7}$$

6.2.2. The coefficients f_0 and f_2 thus determined shall be corrected to the standard ambient conditions using the following equations:

$$f^*{}_0 = f_0 \left[1 + K_0 \left(T_T - T_0 \right) \right] \tag{8}$$

$$f^*{}_2 = f_2 \times \frac{T_T}{T_0} \times \frac{p_0}{p_T} \tag{9}$$

where:

K_0 shall be determined on the basis of the empirical data for the particular vehicle and tyre tests or shall be assumed as follows, if the information is not available: $K_0 = 6 \cdot 10^{-3} \ K^{-1}$.

6.3. Target running resistance force F* for chassis dynamometer setting

The target running resistance force $F^*(v_0)$ on the chassis dynamometer at the reference vehicle speed v_0, in Newton, is determined using the following equation:

$$F^*\left(v_0 \right) = f^*{}_0 + f^*{}_2 \times v_0{}^2 \tag{10}$$

Annex 7- Appendix 5b

Road tests of two- and three- wheeled vehicles equipped with two wheels on the powered axle for the determination of test bench settings

1.   Preparation of the vehicle

1.1.   Running-in

The test vehicle shall be in normal running order and adjustment after having been run in for at least 300km. The tyres shall be run in at the same time as the vehicle or shall have a tread depth within 90 and 50% of the initial tread depth.

1.2   Checks

The following checks shall be made in accordance with the manufacturer's specifications for the use considered: wheels, wheel rims, tyres (make, type and pressure), front axle geometry, brake adjustment (elimination of parasitic drag), lubrication of front and rear axles, adjustment of the suspension and vehicle ground clearance, etc. Check that during freewheeling, there is no electrical braking.

1.3.   Preparation for the Test

1.3.1.   The test vehicle shall be loaded to its test mass including driver and measurement equipment, spread in a uniform way in the loading areas.

1.3.2.   The windows of the vehicle shall be closed. Any covers for air conditioning systems, headlamps, etc. shall be closed.

1.3.3.   The test vehicle shall be clean, properly maintained and used.

1.3.4.   Immediately before the test, the vehicle shall be brought to the normal running temperature in an appropriate manner.

1.3.5.   When installing the measuring instruments on the test vehicle, care shall be taken to minimise their effects on the distribution of the load across the wheels. When installing the speed sensor outside the test vehicle, care shall be taken to minimise the additional aerodynamic loss.

2.   Specified vehicle speed v

The specified speed is required for determining the running resistance at the reference speed from the running resistance curve. To determine the running resistance as a function of vehicle speed in the vicinity of the reference speed v_0 , running resistances shall be measured at the specified speed v. At least four to five points indicating the specified speeds, along with the reference speeds, shall be measured. The calibration of the load indicator referred to in Point 2.2. of Appendix 6 of Annex 7 shall be performed at the applicable reference vehicle speed (v_j) referred to in Table A7.App5b/1.

Table A7.App5b/1
Specified vehicle speeds to perform the coast-down time test as well as the designated reference vehicle speed vj depending on the maximum design vehicle speed (vmax) of the vehicle

Category v_{max}	Vehicle speed (km/h)					
>130	120**	100	80*	60	40	20
130 - 100	90	80*	60	40	20	-
100 - 70	60	50*	40	30	20	-
70-45	50**	40*	30	20	-	-
45-25		40	30*	20		
≤ 25 km/h				20	15*	10
* Applicable reference vehicle speed v_j ** if the vehicle speed can be attained by the vehicle.						

3.   Energy variation during coast-down procedure

3.1.   Total road load power determination

3.1.1.   Measurement Equipment and Accuracy

The margin of measurement error shall be less than 0.1s for time and less than ±0.5km/h for speed. Bring the vehicle and the chassis dynamometer to the stabilised operating temperature, in order to approximate the road conditions.

3.1.2.   Test Procedure

3.1.2.1.   Accelerate the vehicle to a speed of 5km/h greater than the speed at which test measurement begins.

3.1.2.2.   Put the gearbox to neutral or disconnect the power supply.

3.1.2.3.   Measure the time t1 taken by the vehicle to decelerate from:

$v2 = v + \Delta v$ (km/h) to $v1 = v - \Delta v$ (km/h)

where:

$\Delta v < 5$ km/h for nominal vehicle speed < 50 km/h;

$\Delta v < 10$ km/h for nominal vehicle speed > 50 km/h.

3.1.2.4.   Carry out the same test in the opposite direction, measuring time t2.

3.1.2.5.   Take the average ti of the two times t1 and t2.

3.1.2.6.   Repeat these tests until the statistical accuracy (p) of the average ≤ 4 percent:

Equation A7.App5b/1:

$$\Delta t_j = \frac{1}{n} \cdot \sum_{i=1}^{n} \Delta t_i$$

The statistical accuracy (p) is defined by

Equation A7.App5b/2:

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

where:

t is the coefficient in Table A7.App5b/2;

s is the standard deviation.

Equation A7.App5b/3:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(\Delta t_i - \Delta t_j)^2}{n-1}}$$

n is the number of tests

Table A7.App5b/2
Factors t and t/√n depending on the number of coast-down tests performed

n	4	5	6	7	8	9	10
t	3.2	2.8	2.6	2.5	2.4	2.3	2.3
t/√n	1.6	1.25	1.06	0.94	0.85	0.77	0.73

3.1.2.7.   Calculation of the Running Resistance Force

The running resistance force F at the specified vehicle speeds v is calculated as follows:

Equation A7.App5b/4:

$$F = \frac{1}{3.6} \cdot m_{ref} \cdot \frac{2 \cdot \Delta v}{\Delta t}$$

where:

m_{ref} = reference mass (kg);

Δv = vehicle speed deviation (km/h);

Δt = calculated coast-down time difference (s);

3.1.2.8.   The running resistance determined on the track shall be corrected to the reference ambient conditions as follows:

Equation A7.App5b/5:

$F_{corrected} = k \cdot F_{measured}$

Equation A7.App5b/6:

$$k = \frac{R_R}{R_T} \cdot \left[1 + K_R \cdot (t - t_0) \right] + \frac{R_{AERO} \cdot d_0}{R_T \cdot d_t}$$

where:

R_R is the rolling resistance at vehicle speed v (N);

R_{AERO} is the aerodynamic drag at vehicle speed v (N);

R_T is the total road load = $R_R + R_{AERO}$ (N);

K_R is the temperature correction factor of rolling resistance, taken to be equal to: $3.6 \cdot 10^{-3}$/K;

t is the road test ambient temperature in K;

t_0 is the reference ambient temperature (293.2 K);

d_t is the air density at the test conditions (kg/m^3);

d_0 is the air density at the reference conditions (293.2 K, 101.3 kPa) = 1.189 kg/m^3

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 and to the satisfaction of the technical service. If these values are not available or if the technical service or responsible authority do not accept these values, the following figures for the rolling/total resistance ratio given by the following formula may be used:

Equation A7.App5b/7:

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

where:

m_{HP} is the test mass and for each vehicle speed the coefficients a and b are as shown in the following table:

Table A7.App5b/3
Coefficients a and b to calculate rolling resistance ratio

v (km/h)	a	b
20	$7.24 \cdot 10^{-5}$	0.82
40	$1.59 \cdot 10^{-4}$	0.54
60	$1.96 \cdot 10^{-4}$	0.33
80	$1.85 \cdot 10^{-4}$	0.23
100	$1.63 \cdot 10^{-4}$	0.18
120	$1.57 \cdot 10^{-4}$	0.14

3.2.   Setting of the Chassis Dynamometer

The purpose of this procedure is to simulate on the dynamometer the total road load power at a given speed.

3.2.1.   Measurement Equipment and Accuracy

The measuring equipment shall be similar to that used on the test track and shall comply with paragraph 3.4.7. of Annex 4 and paragraph 1.3.5 of this Appendix.

3.2.2.   Test Procedure

3.2.2.1.   Install the vehicle on the chassis dynamometer.

3.2.2.2.   Adjust the tyre pressure (cold) of the driving wheels as required for the chassis dynamometer.

3.2.2.3.   Adjust the equivalent inertia mass of the chassis dynamometer, in accordance with Table A7.App5b/4.

Table A7.App5b/4
Determination of equivalent inertia mass for a two- and three- wheeled vehicle equipped with two wheels on the powered axles

Reference mass (m_{ref}) (kg)	Equivalent inertia mass (m_i) (kg)
$m_{ref} \leq 105$	100
$105 < m_{ref} \leq 115$	110
$115 < m_{ref} \leq 125$	120
$125 < m_{ref} \leq 135$	130
$135 < m_{ref} \leq 150$	140
$150 < m_{ref} \leq 165$	150
$165 < m_{ref} \leq 185$	170
$185 < m_{ref} \leq 205$	190
$205 < m_{ref} \leq 225$	210
$225 < m_{ref} \leq 245$	230
$245 < m_{ref} \leq 270$	260
$270 < m_{ref} \leq 300$	280
$300 < m_{ref} \leq 330$	310

$330 < m_{ref} \leq 360$	340
$360 < m_{ref} \leq 395$	380
$395 < m_{ref} \leq 435$	410
$435 < m_{ref} \leq 480$	450
$480 < m_{ref} \leq 540$	510
$540 < m_{ref} \leq 600$	570
$600 < m_{ref} \leq 650$	620
$650 < m_{ref} \leq 710$	680
$710 < m_{ref} \leq 770$	740
$770 < m_{ref} \leq 820$	800
$820 < m_{ref} \leq 880$	850
$880 < m_{ref} \leq 940$	910
$940 < m_{ref} \leq 990$	960
$990 < m_{ref} \leq 1\,050$	1 020
$1\,050 < m_{ref} \leq 1\,110$	1 080
$1\,110 < m_{ref} \leq 1\,160$	1 130
$1\,160 < m_{ref} \leq 1\,220$	1 190
$1\,220 < m_{ref} \leq 1\,280$	1 250
$1\,280 < m_{ref} \leq 1\,330$	1 300
$1\,330 < m_{ref} \leq 1\,390$	1 360
$1\,390 < m_{ref} \leq 1\,450$	1 420
$1\,450 < m_{ref} \leq 1\,500$	1 470
$1\,500 < m_{ref} \leq 1\,560$	1 530
$1\,560 < m_{ref} \leq 1\,620$	1 590
$1\,620 < m_{ref} \leq 1\,670$	1 640
$1\,670 < m_{ref} \leq 1\,730$	1 700
$1\,730 < m_{ref} \leq 1\,790$	1 760
$1\,790 < m_{ref} \leq 1\,870$	1 810
$1\,870 < m_{ref} \leq 1\,980$	1 930
$1\,980 < m_{ref} \leq 2\,100$	2 040
$2\,100 < m_{ref} \leq 2\,210$	2 150
$2\,210 < m_{ref} \leq 2\,320$	2 270
$2\,320 < m_{ref} \leq 2\,440$	2 380
$2\,440 < RM$	2 490

3.2.2.4. Bring the vehicle and the chassis dynamometer to the stabilised operating temperature, in order to approximate the road conditions.

3.2.2.5. Carry out the operations specified in paragraph 3.1.2., with the exception of those in paragraphs 3.1.2.4. and 3.1.2.5.

3.2.2.6. Adjust the brake to reproduce the corrected running resistance (see paragraph 3.1.2.8.) and to take into account the reference mass. This may be done by calculating the mean corrected road coast-down time from v1 to v2 and reproducing the same time on the dynamometer as follows:

Equation A7.App5b/8:

$$t_{corrected} = m_{ref} \cdot \frac{2 \cdot \Delta v}{F_{corrected}} \cdot \frac{1}{3.6}$$

3.2.2.7. The power P a to be absorbed by the bench shall be determined in order to enable the same total road load power to be reproduced for the same vehicle on different days or on different chassis dynamometers of the same type.

Annex 7- Appendix 6

Chassis dynamometer system

1.   Specification

1.1.   General requirements

1.1.1.   The dynamometer shall be capable of simulating road load within one of the following classifications:

(a)   Dynamometer with fixed load curve, i.e. a dynamometer whose physical characteristics provide a fixed load curve shape;

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

1.1.2.   Dynamometers with electric inertia simulation shall be demonstrated to be equivalent to mechanical inertia systems. The means by which equivalence is established are described in paragraph 4.

1.1.3.   Where the total resistance to progress on the road cannot be reproduced on the chassis dynamometer between vehicle speeds of 10 km/h and 120 km/h, it is recommended that a chassis dynamometer with the characteristics defined in paragraph 1.2. should be used.

1.1.3.1.   The load absorbed by the brake and the chassis dynamometer (internal frictional effects) between the vehicle speeds of 0 and 120 km/h is as follows:

$$F = (a + b \cdot v^2) \pm 0.1 \cdot F_{80} \text{ (without being negative)} \tag{1}$$

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 = vehicle speed (km/h);

F_{80} = load at 80 km/h (N). Alternatively for vehicles that cannot attain 80 km/h the load at the reference vehicle speeds v_j in Table A7.App5a/1 in Appendix 5a to Annex 7 or Table A7.App5b/1 in Appendix 5b to Annex 7 as applicable shall be determined.

1.2.   Specific requirements

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

1.2.2.   The chassis dynamometer may have one roller or two rollers. In such cases, the front roller shall drive, directly or indirectly, the inertial masses and the power-absorption device.

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

1.2.4.   In the case of a dynamometer with a fixed load curve, the accuracy of the load setting at 80 km/h or of the load setting at the reference vehicle speeds (30 km/h, respectively 15 km/h) referred to in paragraph 1.1.3.1. for vehicles that cannot attain 80 km/h, shall be ±5 per cent. In the case of a dynamometer with adjustable load curve, the accuracy of matching dynamometer load to road load shall be ±5 per cent for vehicle speeds > 20 km/h and ± 10 per cent for vehicle speeds ≤ 20 km/h. Below this vehicle speed, dynamometer absorption shall be positive.

1.2.5.   The total inertia of the rotating parts (including the simulated inertia where applicable) shall be known and shall be within ± 10 kg of the inertia class for the test.

1.2.6.   The speed of the vehicle shall be measured by the speed of rotation of the roller (the front roller in the case of a two-roller dynamometer from which the actual speed of the vehicle is calculated). It shall be measured with an accuracy of ±1 km/h at vehicle speeds over 10 km/h. The distance actually driven by the vehicle shall be measured by the movement of rotation of the roller (the front roller in the case of a two-roller dynamometer).

2.   Dynamometer calibration procedure

2.1.   Introduction

This section 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 vehicle speeds. The device used for starting up the dynamometer is then disconnected; the rotational speed of the driven roller decreases. The kinetic energy of the 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 the roller is free.

2.2.   Calibration of the load indicator at 80 km/h or of the load indicator referred to in paragraph 1.1.3.1. for vehicles that cannot attain 80 km/h.

The following procedure shall be used for calibration of the load indicator to 80 km/h or the applicable load indicator referred to in paragraph 1.1.3.1. for vehicles that cannot attain 80 km/h, as a function of the load absorbed (see also Figure A7.App6/1):

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 for starting up the dynamometer.

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

Figure A7.App6/1
Power absorbed by the chassis dynamometer
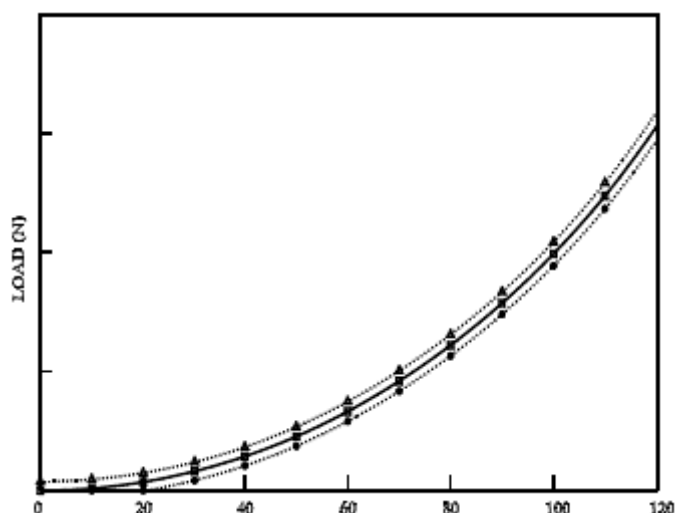
Legend

■ $F = a + b \cdot v^2$ ● $F = (a + b \cdot v^2) - 0.1 \cdot F_{80}$ ▲ $F = (a + b \cdot v^2) + 0.1 \cdot F_{80}$

2.2.4.   Bring the dynamometer to a vehicle speed of 80 km/h or to the reference vehicle speed referred to in paragraph 1.1.3.1. for vehicles that cannot attain 80 km/h.

2.2.5.   Note the load indicated F_i (N).

2.2.6.   Bring the dynamometer to a vehicle speed of 90 km/h or to the respective reference vehicle speed referred to in paragraph 1.1.3.1. plus 5 km/h for vehicles that cannot attain 80 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 vehicle speed of 85 to 75 km/h, or, for vehicles that cannot attain 80 km/h referred to in Table A7.App5a/1 of Appendix 5a to Annex 7 or Table A7.App5b/1 of Appendix 5b to Annex 7 as applicable, note the time between v_j + 5 km/h to v_j- 5 km/h.

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

2.2.10.   The requirements of paragraphs 2.2.4. to 2.2.9. shall be repeated sufficiently often to cover the range of loads used.

2.2.11.   Calculate the load absorbed using the formula:

$$F = \frac{m_i \cdot \Delta v}{\Delta t} \qquad (2)$$

where:

F = load absorbed (N);

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

Δv = vehicle speed deviation in m/s (10 km/h = 2.775 m/s);

Δt = time taken by the roller to pass from 85 km/h to 75 km/h, or for vehicles that cannot attain 80 km/h from 35 – 25 km/h, respectively from 20 – 10 km/h, referred to in Table A7.App5a/2 of Appendix 5a to Annex 7 or Table A7.App5b/2 of Appendix 5b to Annex 7 as applicable.

2.2.12.   Figure A7.App6/2 shows the load indicated at 80 km/h in terms of load absorbed at 80 km/h.

Figure A7.App6/2
Load indicated at 80 km/h in terms of load absorbed at 80 km/h
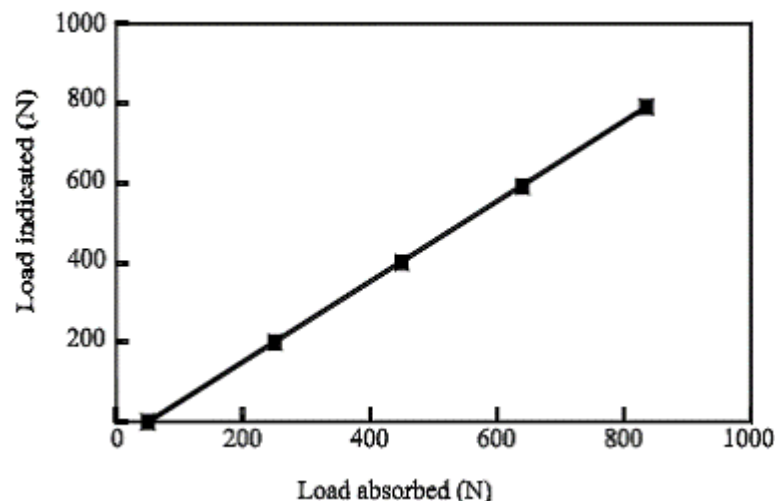
2.2.13.   The requirements laid down in paragraphs 2.2.3. to 2.2.12. shall be repeated for all inertia classes to be used.

2.3.   Calibration of the load indicator at other vehicle speeds

            The procedures described in paragraph 2.2. shall be repeated as often as necessary for the chosen vehicle speeds.

2.4.   Calibration of force or torque

The same procedure shall be used for force or torque calibration.

3.   Verification of the load curve

3.1.   Procedure

The load-absorption curve of the dynamometer from a reference setting at a vehicle speed of 80 km/h or for vehicles that cannot attain 80 km/h at the respective reference vehicle speeds referred to in paragraph 1.1.3.1., shall be verified as follows:

3.1.1.   Place the vehicle on the dynamometer or devise some other method for starting up the dynamometer.

3.1.2.   Adjust the dynamometer to the absorbed load (F_{80}) at 80 km/h, or for vehicles that cannot attain 80 km/h to the absorbed load F_{vj} at the respective target vehicle speed v_j referred to in paragraph 1.1.3.1.

3.1.3.   Note the load absorbed at 120, 100, 80, 60, 40 and 20 km/h or for vehicles that cannot attain 80 km/h absorbed at the target vehicles speeds vj referred to in paragraph 1.1.3.1.

3.1.4.   Draw the curve F(v) and verify that it corresponds to the requirements of paragraph 1.1.3.1.

3.1.5.   Repeat the procedure set out in paragraphs 3.1.1. to 3.1.4. for other values of F_{80} and for other values of inertia.

4.   Verification of simulated inertia

4.1.   Object

The method described in this Annex makes it possible to check that the simulated total inertia of the dynamometer is carried out satisfactorily in the running phase of the operating cycle. The manufacturer of the chassis dynamometer shall specify a method for verifying the specifications according to paragraph 4.3.

4.2.   Principle

4.2.1.   Drawing-up working equations

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

$$F = I \cdot \gamma = I_M \cdot \gamma + F_1 \tag{3}$$

where:

F is the force at the surface of the roller(s) in N;

I is the total inertia of the dynamometer (equivalent inertia of the vehicle);

I_M is the inertia of the mechanical masses of the dynamometer;

γ is the tangential acceleration at roller surface;

F_1 is the inertia force.

Note: An explanation of this formula with reference to dynamometers with mechanically simulated inertia is appended.

Thus, total inertia is expressed as follows:

$$I = I_m + F_1 / \gamma \tag{4}$$

where:

I_m can be calculated or measured by traditional methods;

F_1 can be measured on the dynamometer;

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

The total inertia (I) will be determined during an acceleration or deceleration test with values no lower than those obtained on an operating cycle.

4.2.2.   Specification for the calculation of total inertia

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

4.3.   Specification

4.3.1.   The mass of the simulated total inertia I shall remain the same as the theoretical value of the equivalent inertia (see Appendix 4 to Annex7.) within the following limits:

4.3.1.1.   ±5 per cent of the theoretical value for each instantaneous value;

4.3.1.2.   ±2 per cent of the theoretical value for the average value calculated for each sequence of the cycle.

The limit specified in paragraph 4.3.1.1. is brought to ±50 per cent for one second when starting and, for vehicles with manual transmission, for two seconds during gear changes.

4.4.   Verification procedure

4.4.1.   Verification is carried out during each test throughout the test cycles defined in Appendix 11 to Annex 7.

4.4.2.   However, if the requirements laid down in paragraph 4.3. 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 in paragraph 4.4.1. will not be necessary.

Annex 7- Appendix 7

Exhaust dilution system

1.   System specification

1.1.   System overview

A full-flow exhaust dilution system shall be used. This requires that the vehicle exhaust be continuously diluted with ambient air under controlled conditions. The total volume of the mixture of exhaust and dilution air shall be measured and a continuously proportional sample of the volume shall be collected for analysis. The quantities of pollutants are determined from the sample concentrations, corrected for the pollutant content of the ambient air and the totalised flow over the test period. The exhaust dilution system shall consist of a transfer tube, a mixing chamber and dilution tunnel, a dilution air conditioning, a suction device and a flow measurement device. The mixing chamber described in this point shall be a vessel, such as those illustrated in Figures A7.App7/1 and A7.App7/2, in which vehicle exhaust gases and the dilution air are combined so as to produce a homogeneous mixture at the chamber outlet.

1.2.   General requirements

1.2.1.   The vehicle exhaust gases shall be diluted with a sufficient amount of ambient air to prevent any water condensation in the sampling and measuring system under any conditions which may occur during a test.

1.2.2.   The mixture of air and exhaust gases shall be homogeneous at the point where the sampling probe is located (see paragraph 1.3.3.). The sampling probe shall extract a representative sample of the diluted exhaust gas.

1.2.3.   The system shall enable the total volume of the diluted exhaust gases to be measured.

1.2.4.   The sampling system shall be gas-tight. The design of the variable dilution sampling system and the materials that go to make it up shall 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, sampling for that pollutant shall be carried out upstream from that component.

1.2.5.   All parts of the dilution system that are in contact with raw and diluted exhaust gas shall be designed to minimise deposition or alteration of the particulates or particles. All parts shall be made of electrically conductive materials that do not react with exhaust gas components and shall be electrically grounded to prevent electrostatic effects.

1.2.6.   If the vehicle being tested is equipped with an exhaust pipe comprising several branches, the connecting tubes shall be connected as near as possible to the vehicle without adversely affecting its operation.

1.2.7.   The variable-dilution system shall be designed so as to enable the exhaust gases to be sampled without appreciably changing the back-pressure at the exhaust pipe outlet.

1.2.8.   The connecting tube between the vehicle and dilution system shall be so designed as to minimise heat loss.

1.3.   Specific requirements

1.3.1.   Connection to vehicle exhaust

The connecting tube between the vehicle exhaust outlets and the dilution system shall be as short as possible and satisfy the following requirements:

(a)   The tube shall be less than 3.6 m long, or less than 6.1 m long if heat insulated. Its internal diameter may not exceed 105 mm;

(b)   It shall not cause the static pressure at the exhaust outlets on the test vehicle to differ by more than ±0.75kPa 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 exhaust outlets. The pressure shall be measured in the exhaust outlet or in an extension having the same diameter, as near as possible to the end of the pipe. Sampling systems capable of maintaining the static pressure to within ±0.25 kPa may be used if a written request from a manufacturer to the technical service substantiates the need for the closer tolerance;

(c)   It shall not change the nature of the exhaust gas;

(d)   Any elastomeric connectors employed shall be as thermally stable as possible and have minimum exposure to the exhaust gases.

1.3.2.   (Reserved)

1.3.3.   (Reserved)

1.3.4.   Suction device

This device may have a range of fixed rotation speeds to ensure sufficient flow to prevent any water condensation. This result is generally obtained if the flow is either:

(a)   Twice the maximum flow of exhaust gas produced by accelerations of the driving cycle; or

(b)   Sufficient to ensure that the CO_2 concentration in the dilute exhaust sample bag is less than 3 per cent by volume for petrol.

1.3.5.   Volume measurement in the primary dilution system

The method for measuring total dilute exhaust volume incorporated in the constant volume sampler shall be such that measurement is accurate to ± 2 per cent 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 shall be used to maintain the temperature to within ±6 °C of the specified operating temperature. If necessary, some form of protection for the volume measuring device may be used, e.g. a cyclone separator, bulk stream filter, etc. A temperature sensor shall be installed immediately before the volume measuring device. This sensor shall have an accuracy and a precision of ±1 °C and a response time of 0.1 s at 62 per cent of a given temperature variation (value measured in silicone oil). The difference from atmospheric pressure shall be measured upstream and, if necessary, downstream from the volume measuring device. The pressure measurements shall have a precision and an accuracy of ±0.4 kPa during the test.

1.4.   Recommended system descriptions

Figure A7.App7/1 and Figure A7.App7/2 are schematic drawings of two types of recommended exhaust dilution systems that meet the requirements of this Annex. Since various configurations can produce accurate results, exact conformity with these figures 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.

1.4.1.   Full-flow dilution system with positive displacement pump

Figure A7.App7/1
Positive displacement pump dilution system
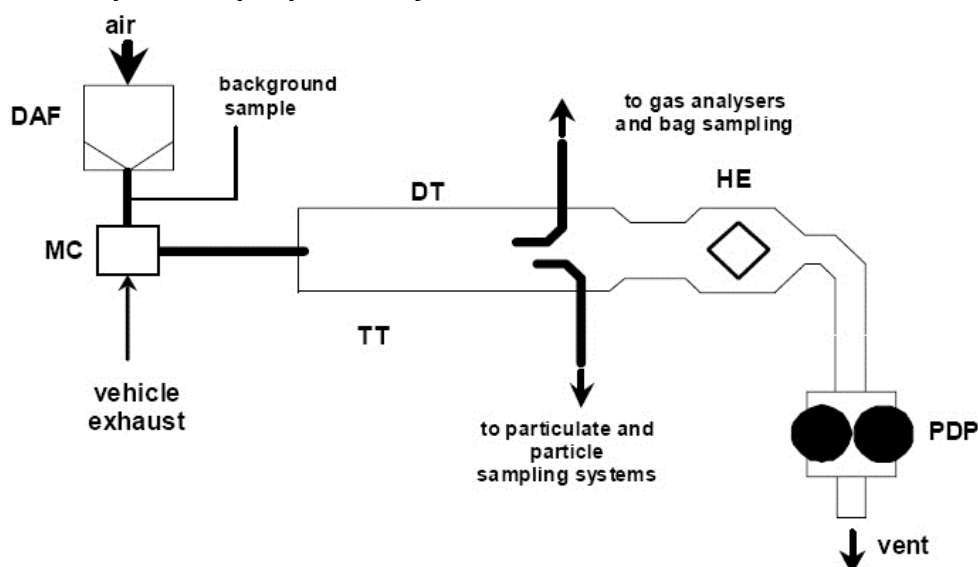
The positive displacement pump (PDP) full-flow dilution system satisfies the requirements of this Annex by metering the flow of gas through the pump at constant temperature and pressure. The total volume is measured by counting the revolutions of the calibrated positive displacement pump. The proportional sample is achieved by sampling with pump, flow meter and flow control valve at a constant flow rate. The collecting equipment consists of:

1.4.1.1.   A filter (refer to DAF in Figure A7.App7/1) for the dilution air shall be installed, which can be preheated if necessary. This filter shall consist of the following filters in sequence: an optional activated charcoal filter (inlet side) and a high efficiency particulate air (HEPA) filter (outlet side). It is recommended that an additional coarse particle filter is situated before the HEPA filter and after the charcoal filter, if used. The purpose of the charcoal filter is to reduce and stabilise the hydrocarbon concentrations of ambient emissions in the dilution air;

1.4.1.2.   A transfer tube (TT) by which vehicle exhaust is admitted into a dilution tunnel (DT) in which the exhaust gas and dilution air are mixed homogeneously;

1.4.1.3.   The positive displacement pump (PDP), producing a constant-volume flow of the air/exhaust-gas mixture. The PDP revolutions, together with associated temperature and pressure measurement, are used to determine the flow rate;

1.4.1.4.   A heat exchanger (HE) 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 6.0 °C of the average operating temperature during the test. This device shall not affect the pollutant concentrations of diluted gases taken off afterwards for analysis.

1.4.1.5.   A mixing chamber (MC) in which exhaust gas and air are mixed homogeneously and which may be located close to the vehicle so that the length of the transfer tube (TT) is minimised.

Figure A7.App7/2
Critical-flow venturi dilution system
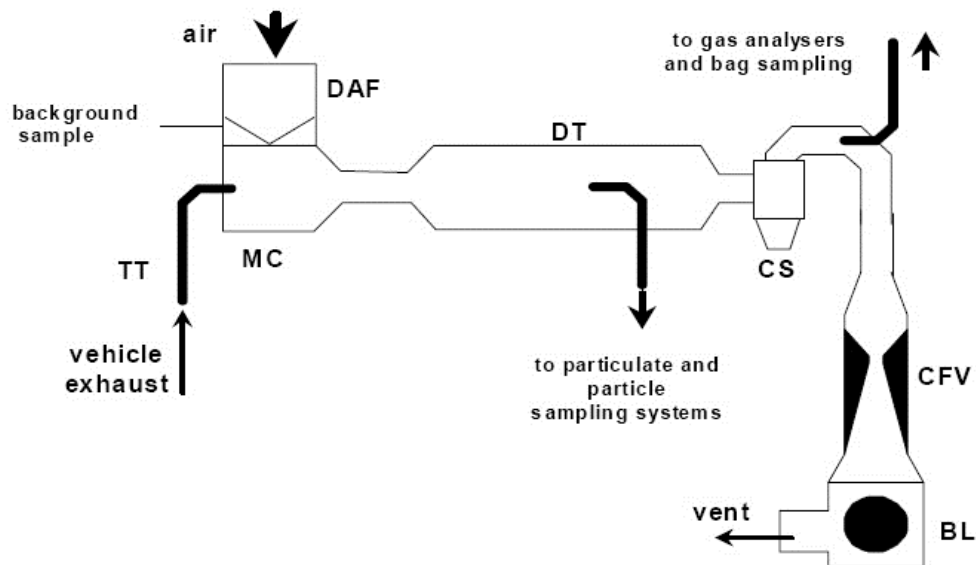
1.4.2.   Full-flow dilution system with critical-flow venturi

The use of a critical-flow venturi (CFV) for the full-flow dilution system is based on the principles of flow mechanics for critical flow. The variable mixture flow rate of dilution and exhaust gas is maintained at sonic velocity which is directly proportional to the square root of the gas temperature. Flow is continually monitored, computed and integrated throughout the test. The use of an additional critical-flow sampling venturi ensures the proportionality of the gas samples taken from the dilution tunnel. As pressure and temperature are both 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. The collecting equipment consists of:

1.4.2.1.   A filter (DAF) for the dilution air which can be preheated if necessary. This filter shall consist of the following filters in sequence: an optional activated charcoal filter (inlet side) and a high efficiency particulate air (HEPA) filter (outlet side). It is recommended that an additional coarse particle filter is situated before the HEPA filter and after the charcoal filter, if used. The purpose of the charcoal filter is to reduce and stabilise the hydrocarbon concentrations of ambient emissions in the dilution air;

1.4.2.2.   A mixing chamber (MC) in which exhaust gas and air are mixed homogeneously and which may be located close to the vehicle so that the length of the transfer tube (TT) is minimised;

1.4.2.3.   A dilution tunnel (DT) from which particulates and particles are sampled;

1.4.2.4.   Some form of protection for the measurement system may be used, e.g. a cyclone separator, bulk stream filter, etc.;

1.4.2.5.   A measuring critical-flow venturi tube (CFV) to measure the flow volume of the diluted exhaust gas;

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

2.   CVS calibration procedure

2.1.   General requirements

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

related to the flows. The flow-meter shall be dynamic and suitable for the high flow-rate encountered in CVS testing. The device shall be of certified accuracy traceable to an approved national or international standard.

2.1.1. 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 paragraph 1.3.5. of this Annex.

2.1.2. The following points 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.

2.2. Calibration of the positive displacement pump (PDP)

2.2.1. The following calibration procedure outlines the equipment, the test configuration and the various parameters that are measured to establish the flow-rate of the CVS pump. All the parameters relating to the pump are simultaneously measured with the parameters relating 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 against a correlation function that is the value of a specific combination of pump parameters. The linear equation that relates the pump flow and the correlation function is then determined. If a CVS has a multiple rotation speed drive, a calibration shall be performed for each range used.

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

2.2.2.1. The pump pressures shall be measured at tappings on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top centre and bottom centre of the pump drive head plate are exposed to the actual pump cavity pressures and therefore reflect the absolute pressure differentials;

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

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

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

2.2.4. Figure A7.App7/3 of this Appendix shows one possible test set-up. Variations are permissible, provided that the technical service approves them as being of comparable accuracy. If the set-up shown in Figure A7.App7/3 is used, the following data shall be found within the limits of precision given:

Barometric pressure (corrected) (Pb) ±0.03 kPa

Ambient temperature (T) ±0.2 °C

Air temperature at LFE (ETI) ± 0.15 °C

Pressure depression upstream of LFE (EPI) ±0.01 kPa

Pressure drop across the LFE matrix (EDP) ±0.0015 kPa

Air temperature at CVS pump inlet (PTI) ±0.2 °C

Air temperature at CVS pump outlet (PTO) ± 0.2 °C

Pressure depression at CVS pump inlet (PPI) ±0.22 kPa

Pressure head at CVS pump outlet (PPO) ±0.22 kPa

Pump revolutions during test period (n) ±1 min⁻¹

Elapsed time for period (minimum 250 s) (t) ±0.1 s

Figure A7.App7/3
PDP calibration configuration
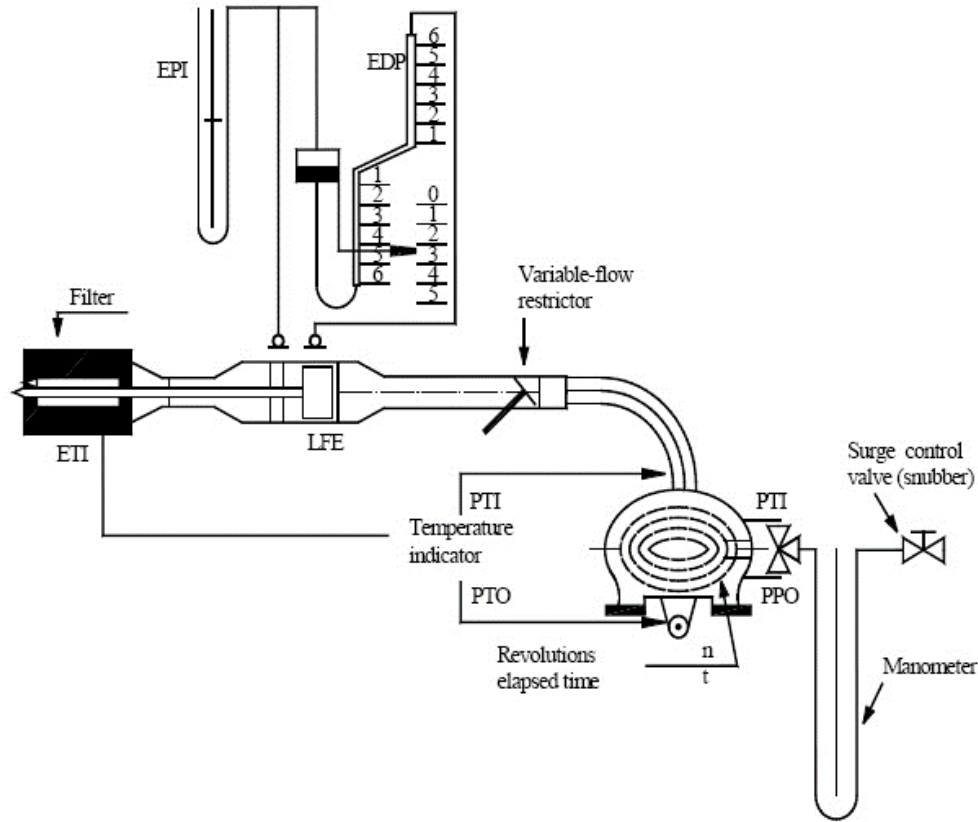
2.2.5. After the system has been connected as shown in Figure A7.App7/3, set the variable restrictor in the wide-open position and run the CVS pump for 20 minutes before starting the calibration.

2.2.6. 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 stabilise for three minutes and repeat the data acquisition.

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

2.2.8. The air flow-rate is then converted to pump flow (V_0) in m³/rev at absolute pump inlet temperature and pressure.

$$V_o = \frac{Q_s}{n} \cdot \frac{T_p}{273.15} \cdot \frac{101.3}{P_p} \tag{1}$$

where:

V_0 = pump flow rate at Tp and Pp (m³/rev);

Q_s = air flow at 101.3 kPa and 0 °C in (m³/min);

T_p = pump inlet temperature, Kelvin (K);

P_p = absolute pump inlet pressure (kPa);

n = pump rotation speed (min⁻¹).

2.2.9. To compensate for the interaction of pump rotation speed pressure variations at the pump and the pump slip rate, the correlation function (x_0) between the

pump rotation speed (n), the pressure differential from pump inlet to pump outlet, and the absolute pump outlet pressure is calculated as follows:

$$x_0 = \frac{1}{n}\sqrt{\frac{\Delta P_p}{P_e}}$$

(2)

where:

x_0 = correlation function;

ΔP_p = pressure differential from pump inlet to pump outlet (kPa);

P_e = absolute outlet pressure (PPO + Pb) (kPa).

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

$V_0 = D_0 - M(x_0)$

(3)

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

D_0, M, A and B are the slope-intercept constants describing the lines.

2.2.10. A CVS system that has multiple pump rotation speeds shall be calibrated on each rotation speed used. The calibration curves generated for the ranges shall be approximately parallel and the intercept values (D_0) shall increase as the pump flow range decreases.

2.2.11. If the calibration has been performed carefully, the calculated values from the equation will be within 0.5 per cent of the measured value of V_0. Values of M will vary from one pump to another. Calibration is performed at pump start-up and after major maintenance.

2.3. Calibration of the critical-flow venturi (CFV)

2.3.1. Calibration of the CFV is based on the flow equation for a critical-flow venturi:

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

(4)

where:

Q_s = flow;

K_v = calibration coefficient;

P = absolute pressure (kPa);

T = absolute temperature, Kelvin (K).

Gas flow is a function of inlet pressure and temperature. The calibration procedure described in paragraphs 2.3.2. to 2.3.7. shall establish the value of the calibration coefficient at measured values of pressure, temperature and air flow.

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

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

Barometric pressure (corrected) (Pb) ±0.03 kPa

LFE air temperature, flow-meter (ETI) ±0.15 °C

Pressure depression upstream of LFE (EPI) ±0.01 kPa

Pressure drop across (EDP) LFE matrix ±0.0015 kPa

Air flow (Qs) ±0.5 percent

CFV inlet depression (PPI) ±0.02 kPa

Temperature at venturi inlet (Tv) ±0.2 °C.

2.3.4. The equipment shall be set up as shown in Figure A7.App7/4 and checked for leaks. Any leaks between the flow-measuring device and the critical-flow venturi will seriously affect the accuracy of the calibration.

Figure A7.App7/4
CFV calibration configuration
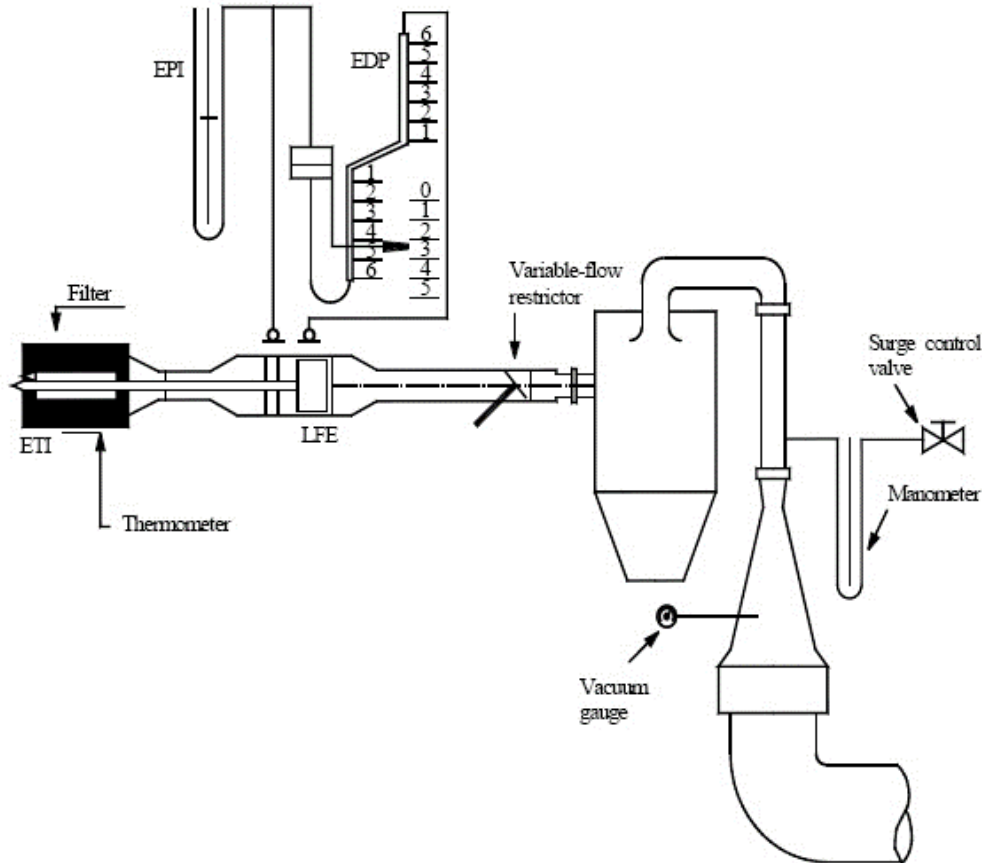
2.3.5. The variable-flow restrictor shall be set to the open position, the blower shall be started and the system stabilised. Data from all instruments shall be recorded.

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

2.3.7. The data recorded during the calibration shall be used in the following calculations. The air flow-rate (Qs) at each test point is calculated from the flow-meter data using the manufacturer's prescribed method. Calculate values of the calibration coefficient (Kv) for each test point:

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

(5)

where:

Q_s = flow-rate in m^3/min at 0 °C and 101.3 kPa;

T_v = temperature at the venturi inlet, Kelvin (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 becomes unchoked and K_v decreases. The resultant K_v changes are not permissible. For a minimum of eight points in the critical region, calculate an average K_v and the standard deviation. If the standard deviation exceeds 0.3 per cent of the average K_v, take corrective action.

3.   System verification procedure

3.1.   General requirements

The total accuracy of the CVS sampling system and analytical system shall be determined by introducing a known mass of a pollutant gas into the system while it is being operated as if during a normal test and then analysing and calculating the pollutant mass according to the formula in paragraph 4., except that the density of propane shall be taken as 1.967 grams per litre at standard conditions. The two techniques described in paragraphs 3.2. and 3.3. are known to give sufficient accuracy. The maximum permissible deviation between the quantity of gas introduced and the quantity of gas measured is 5 percent.

3.2.   CFO method

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

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

3.3.   Gravimetric method

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

3.3.2. The following gravimetric procedure may be used to verify the CVS system. The weight of a small cylinder filled with either carbon monoxide or propane is determined with a precision of ±0.01 g. For about five to ten minutes, the CVS system is operated as in a normal exhaust emission test, while CO or propane is injected into the system. The quantity of pure gas involved is determined by means of differential weighing. The gas accumulated in the bag is analysed using the equipment normally used for exhaust-gas analysis. The results are then compared to the concentration figures computed previously.

Annex 7- Appendix 8

Vehicle propulsion unit family with regard to environmental performance demonstration tests

1.	Introduction

1.1. In order to alleviate the test burden on manufacturers when demonstrating the environmental performance of vehicles these may be grouped as a vehicle propulsion unit family. One or more parent vehicles shall be selected from this group of vehicles by the manufacturer to the satisfaction of the responsible authority that shall be used to demonstrate environmental performance Test Types I, II and VII.

1.2. A two- and three-wheeled vehicle may continue to be regarded as belonging to the same vehicle propulsion unit family provided that the vehicle variant, version, propulsion unit, pollution-control system listed in TableA7.App8/1 are identical or remain within the prescribed and declared tolerances.

1.3. Vehicle and propulsion unit family attribution with regard to environmental tests. For the environmental Test Types I, II and VII a representative parent vehicle shall be selected within the boundaries set by the classification criteria laid down in paragraph 2.

2. Classification criteria

Table A7.App8/1

Classification criteria propulsion unit family with regard to Test Types I, II and VII

	Classification criteria description	*Test Type I*	*Test Type II*	*Test Type VII*
1.				**Vehicle**
1.1.	category;	X	X	X
1.2.	sub-category;	X	X	X
1.3.	the inertia of a vehicle variant(s) or version(s) within two inertia categories above or below the nominal inertia category;	X		X
1.4.	overall gear ratios (+/- 8%);	X		X
2.			**Propulsion family characteristics**	
2.1.	number of cylinders of the combustion engine;	X	X	X
2.2.	engine capacity (+/- 2 %) of the combustion engine;	X	X	X
2.3.	number and control (variable cam phasing or lift) of combustion engine valves;	X	X	X
2.4.	fuel	X	X	X
2.5.	fuel system (carburettor / scavenging port / port fuel injection / direct fuel injection / common rail / pump-injector / other);	X	X	X
2.6.	type of cooling system of combustion engine;	X	X	X
2.7.	combustion cycle (PI / CI / two-stroke / four-stroke / other);	X	X	X
2.8.	intake air system (naturally aspirated / charged (turbocharger / super-charger) / intercooler / boost control) and air induction control (mechanical throttle / electronic throttle control / no throttle);	X	X	X
3.		**Pollution control system characteristics**		
3.1.	propulsion unit exhaust (not) equipped with catalytic converter(s);	X	X	X
3.2.	catalytic converter(s) type;	X	X	X
3.2.1.	number and elements of catalytic converters;	X	X	X
3.2.2.	size of catalytic converters (volume of monolith(s) +/- 15 %);	X	X	X

	Classification criteria description	Test Type I	Test Type II	Test Type VII
3.2.3.	operation principle of catalytic activity (oxidising, three-way, heated, SCR, other.);	X	X	X
3.2.4.	precious metal load (identical or higher);	X	X	X
3.2.5.	precious metal ratio (+/- 15 %);	X	X	X
3.2.6.	substrate (structure and material);	X	X	X
3.2.7.	cell density;	X	X	X
3.2.8.	type of casing for the catalytic converter(s);	X	X	X
3.3.	propulsion unit exhaust (not) equipped with particulate filter (PF);	X	X	X
3.3.1.	PF types;	X	X	X
3.3.2.	number and elements of PF;	X	X	X
3.3.3.	size of PF (volume of filter element +/- 10 %);	X	X	X
3.3.4.	operation principle of PF (partial / wall-flow / other);	X	X	X
3.3.5.	active surface of PF;	X	X	X
3.4.	Propulsion unit (not) equipped with periodically regenerating system;	X	X	X
3.4.1.	periodically regenerating system type;	X	X	X
3.4.2.	operation principle of periodically regenerating system;	X	X	X
3.5.	propulsion (not) equipped with selective catalytic converter reduction (SCR) system;	X	X	X
3.5.1.	SCR system type;	X	X	X
3.5.2.	operation principle of periodically regenerating system;	X	X	X
3.6.	Propulsion unit (not) equipped with lean NOx trap /absorber;	X	X	X
3.6.1.	lean NOx trap / absorber type;	X	X	X
3.6.2.	operation principle of lean NOx trap / absorber;	X	X	X
3.7.	Propulsion unit (not) equipped with a cold-start device or starting aid device(s);	X	X	X
3.7.1.	cold-start or starting aid device type;	X	X	X
3.7.2.	operation principle of cold start or starting aid device(s);	X	X	X
3.7.3.	Activation time of cold-start or starting aid device(s) and /or duty cycle (only limited time activated after cold start / continuous operation);	X	X	X
3.8.	propulsion unit (not) equipped with O_2 sensor for fuel control;	X	X	X
3.8.1.	O_2 sensor types;	X	X	X
3.8.2.	operation principle of O_2 sensor (binary / wide range / other);	X	X	X
3.8.3.	O_2 sensor interaction with closed-loop fuelling system (stoichiometry / lean or rich operation);	X	X	X
3.9.	propulsion unit (not) equipped with exhaust gas recirculation (EGR) system;	X	X	X
3.9.1.	EGR system types;	X	X	X
3.9.2.	operation principle of EGR system (internal / external);	X	X	X
3.9.3.	maximum EGR rate (+/- 5 %);	X	X	X

Note: "X" in the following table means "applicable"

Annex 7- Appendix 9

Template form to record coast-down times

Trade name: Production number (Body):

Date: / /   Place of the test: Name of recorder

Climate: Atmospheric pressure: kPa   Atmospheric temperature: : °C

Wind speed (parallel/perpendicular):   /   m/s

Rider height:…………m

Test Vehicle speed km/h	Coast-down time(s) in s	Statistical accuracy in percent	Average coast-down time in s	Running resistance in N	Target running resistance in N	Note
First						
Second						
First						
Second						
First						
Second						
First						
Second						
First						
Second						
First						
Second						

Note: Curve fitting: $F^* = \underline{} + \underline{} v^2$

Annex 7- Appendix 10

Template form to record chassis dynamometer settings

Trade name:……………..…….………….. Production number (Body):…………………

Date: /   /   Place of the test:……………...Name of recorder…………………..

Test Vehicle speed	Coast -down time(s) in s				Running resistance in N		Setting error, in percent	Note
	Test 1	Test 2	Test 3	Average	Setting value	Target value		

Curve fitting: $F^* = \; + \; v2$

Annex 7 - Appendix 11

Driving cycles for the Test Type I

1. **World Harmonized Motorcycle Test Cycle (WMTC), description of the test cycle**

   The WMTC to be used on the chassis dynamometer shall be as depicted in the following graph and as specified in the following paragraphs:

Figure A7.App11/1
WMTC drive cycle
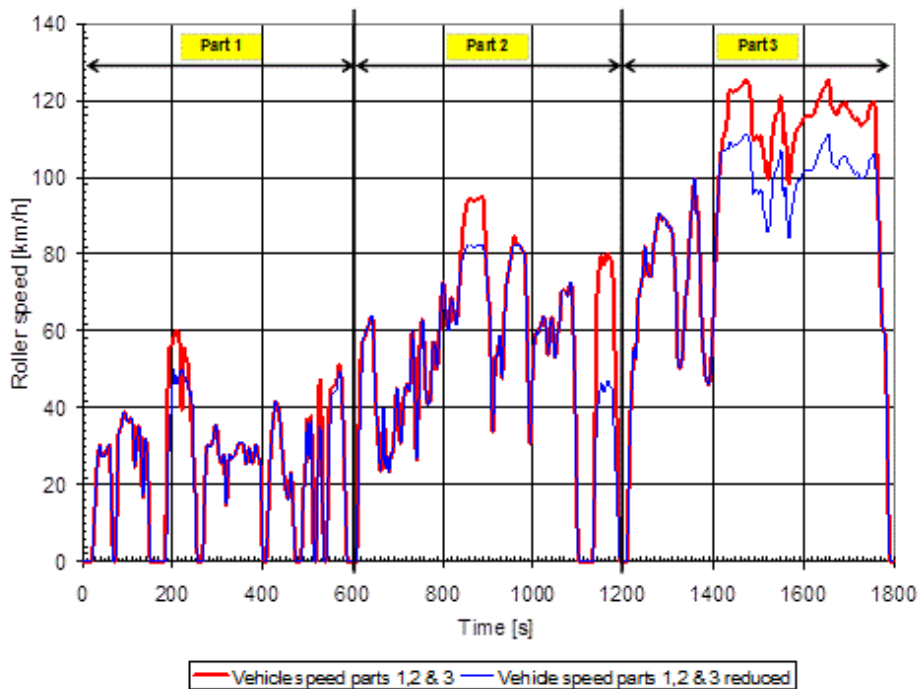
   In Tables A7.App11/1 to A7.App11/24, "acc" means "acceleration", "dec" means "deceleration"

1.1. The WMTC lasts 1800 seconds and consists of three parts to be carried out without interruption. The characteristic driving conditions (idling, acceleration, steady vehicle speed, deceleration, etc.). are set out in the following paragraphs and tables.

1.2. WMTC, cycle part 1

Figure A7.App11/2
WMTC, part 1
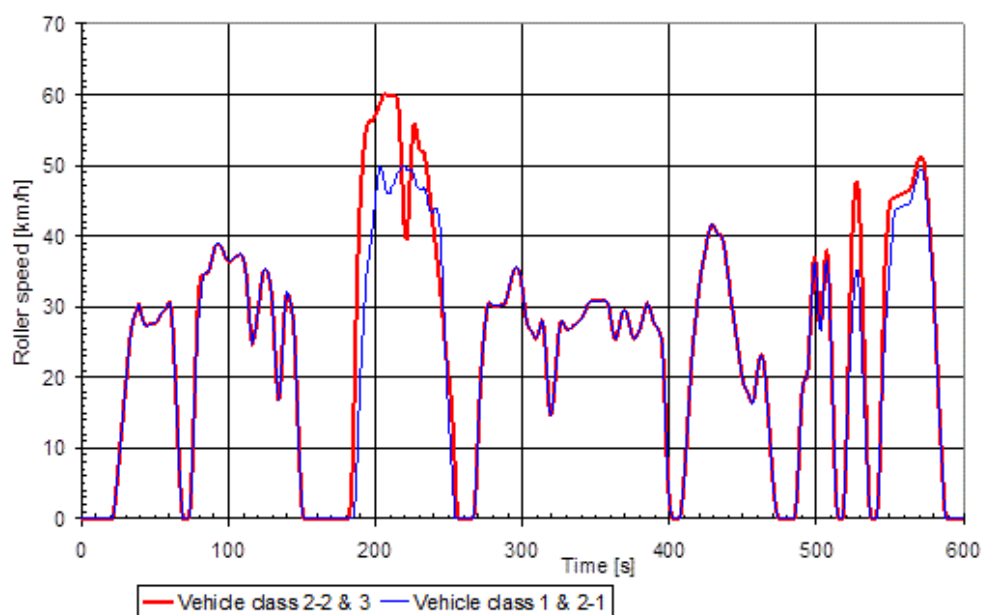
1.2.1. The characteristic desired vehicle speed versus test time of WMTC, cycle part 1 is set out in the following tables.

Table A7.App11/1
WMTC, cycle part 1, reduced vehicle speed for vehicle classes 1 and 2-1, 0 to 180 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
0	0.0	X				33	25.6		X			66	9.3				X
1	0.0	X				34	27.1		X			67	4.8				X
2	0.0	X				35	28.0		X			68	1.9				X
3	0.0	X				36	28.7		X			69	0.0	X			
4	0.0	X				37	29.2		X			70	0.0	X			
5	0.0	X				38	29.8		X			71	0.0	X			
6	0.0	X				39	30.3			X		72	0.0	X			
7	0.0	X				40	29.6			X		73	0.0	X			
8	0.0	X				41	28.7			X		74	1.7		X		
9	0.0	X				42	27.9			X		75	5.8		X		
10	0.0	X				43	27.4			X		76	11.8		X		
11	0.0	X				44	27.3			X		77	17.3		X		
12	0.0	X				45	27.3			X		78	22.0		X		
13	0.0	X				46	27.4			X		79	26.2		X		
14	0.0	X				47	27.5			X		80	29.4		X		
15	0.0	X				48	27.6			X		81	31.1		X		
16	0.0	X				49	27.6			X		82	32.9		X		
17	0.0	X				50	27.6			X		83	34.7		X		
18	0.0	X				51	27.8			X		84	34.8		X		
19	0.0	X				52	28.1			X		85	34.8		X		
20	0.0	X				53	28.5			X		86	34.9		X		
21	0.0	X				54	28.9			X		87	35.4		X		
22	1.0		X			55	29.2			X		88	36.2		X		
23	2.6		X			56	29.4			X		89	37.1		X		
24	4.8		X			57	29.7			X		90	38.0		X		
25	7.2		X			58	30.0			X		91	38.7			X	
26	9.6		X			59	30.5			X		92	38.9			X	
27	12.0		X			60	30.6				X	93	38.9			X	
28	14.3		X			61	29.6				X	94	38.8			X	
29	16.6		X			62	26.9				X	95	38.5			X	
30	18.9		X			63	23.0				X	96	38.1			X	
31	21.2		X			64	18.6				X	97	37.5			X	
32	23.5		X			65	14.1				X	98	37.0			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
		phase indicators						phase indicators						phase indicators			
99	36.7			X		126	35.2				X	154	0.0	X			
100	36.5			X		127	34.7				X	155	0.0	X			
101	36.5			X		128	33.9				X	156	0.0	X			
102	36.6			X		129	32.4				X	157	0.0	X			
103	36.8			X		130	29.8				X	158	0.0	X			
104	37.0			X		131	26.1				X	159	0.0	X			
105	37.1			X		132	22.1				X	160	0.0	X			
106	37.3			X		133	18.6				X	161	0.0	X			
107	37.4			X		134	16.8		X			162	0.0	X			
108	37.5			X		135	17.7		X			163	0.0	X			
109	37.4			X		136	21.1		X			164	0.0	X			
110	36.9				X	137	25.4		X			165	0.0	X			
111	36.0				X	138	29.2		X			166	0.0	X			
112	34.8				X	139	31.6		X			167	0.0	X			
113	31.9				X	140	32.1				X	168	0.0	X			
114	29.0				X	141	31.6				X	169	0.0	X			
115	26.9				X	142	30.7				X	170	0.0	X			
116	24.7			X		143	29.7				X	171	0.0	X			
117	25.4			X		144	28.1				X	172	0.0	X			
118	26.4			X		145	25.0				X	173	0.0	X			
119	27.7			X		146	20.3				X	174	0.0	X			
120	29.4			X		147	15.0				X	175	0.0	X			
						148	9.7				X	176	0.0	X			
121	31.2			X		149	5.0				X	177	0.0	X			
122	33.0			X		150	1.6				X	178	0.0	X			
123	34.4			X		151	0.0	X				179	0.0	X			
124	35.2			X		152	0.0	X				180	0.0	X			
125	35.4				X	153	0.0	X									

Table A7.App11/2
WMTC, cycle part 1, reduced vehicle speed for vehicle classes 1 and 2-1, 181 to 360 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
181	0.0	X				211	46.9			X		241	43.9			X	
182	0.0	X				212	47.2			X		242	43.8				X
183	0.0	X				213	47.8			X		243	43.0				X
184	0.0	X				214	48.4			X		244	40.9				X
185	0.4		X			215	48.9			X		245	36.9				X
186	1.8		X			216	49.2			X		246	32.1				X
187	5.4		X			217	49.6			X		247	26.6				X
188	11.1		X			218	49.9			X		248	21.8				X
189	16.7		X			219	50.0			X		249	17.2				X
190	21.3		X			220	49.8			X		250	13.7				X
191	24.8		X			221	49.5			X		251	10.3				X
192	28.4		X			222	49.2			X		252	7.0				X
193	31.8		X			223	49.3			X		253	3.5				X
194	34.6		X			224	49.4			X		254	0.0	X			
195	36.3		X			225	49.4			X		255	0.0	X			
196	37.8		X			226	48.6			X		256	0.0	X			
197	39.6		X			227	47.8			X		257	0.0	X			
198	41.3		X			228	47.0			X		258	0.0	X			
199	43.3		X			229	46.9			X		259	0.0	X			
200	45.1		X			230	46.6			X		260	0.0	X			
201	47.5		X			231	46.6			X		261	0.0	X			
202	49.0		X			232	46.6			X		262	0.0	X			
203	50.0			X		233	46.9			X		263	0.0	X			
204	49.5			X		234	46.4			X		264	0.0	X			
205	48.8			X		235	45.6			X		265	0.0	X			
206	47.6			X		236	44.4			X		266	0.0	X			
207	46.5			X		237	43.5			X		267	0.5		X		
208	46.1			X		238	43.2			X		268	2.9		X		
209	46.1			X		239	43.3			X		269	8.2		X		
210	46.6			X		240	43.7			X		270	13.2		X		

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
271	17.8		X			301	30.6			X		331	26.6			X	
272	21.4		X			302	29.0			X		332	26.8			X	
273	24.1		X			303	27.8			X		333	27.0			X	
274	26.4		X			304	27.2			X		334	27.2			X	
275	28.4		X			305	26.9			X		335	27.4			X	
276	29.9		X			306	26.5			X		336	27.5			X	
277	30.5			X		307	26.1			X		337	27.7			X	
278	30.5			X		308	25.7			X		338	27.9			X	
279	30.3			X		309	25.5			X		339	28.1			X	
280	30.2			X		310	25.7			X		340	28.3			X	
281	30.1			X		311	26.4			X		341	28.6			X	
282	30.1			X		312	27.3			X		342	29.1			X	
283	30.1			X		313	28.1			X		343	29.6			X	
284	30.2			X		314	27.9				X	344	30.1			X	
285	30.2			X		315	26.0				X	345	30.6			X	
286	30.2			X		316	22.7				X	346	30.8			X	
287	30.2			X		317	19.0				X	347	30.8			X	
288	30.5			X		318	16.0				X	348	30.8			X	
289	31.0			X		319	14.6		X			349	30.8			X	
290	31.9			X		320	15.2		X			350	30.8			X	
291	32.8			X		321	16.9		X			351	30.8			X	
292	33.7			X		322	19.3		X			352	30.8			X	
293	34.5			X		323	22.0		X			353	30.8			X	
294	35.1			X		324	24.6		X			354	30.9			X	
295	35.5			X		325	26.8		X			355	30.9			X	
296	35.6			X		326	27.9		X			356	30.9			X	
297	35.4			X		327	28.0			X		357	30.8			X	
298	35.0			X		328	27.7			X		358	30.4			X	
299	34.0			X		329	27.1			X		359	29.6			X	
300	32.4			X		330	26.8			X		360	28.4			X	

Table A7.App11/3
WMTC. cycle part 1. reduced vehicle speed for vehicle classes 1 and 2-1. 361 to 540 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
		phase indicators						phase indicators						phase indicators			
361	27.1			X		391	27.2			X		421	34.0		X		
362	26.0			X		392	26.9				X	422	35.4		X		
363	25.4			X		393	26.4				X	423	36.5		X		
364	25.5			X		394	25.7				X	424	37.5		X		
365	26.3			X		395	24.9				X	425	38.6		X		
366	27.3			X		396	21.4				X	426	39.6		X		
367	28.3			X		397	15.9				X	427	40.7		X		
368	29.2			X		398	9.9				X	428	41.4		X		
369	29.5			X		399	4.9				X	429	41.7			X	
370	29.4			X		400	2.1				X	430	41.4			X	
371	28.9			X		401	0.9				X	431	40.9			X	
372	28.1			X		402	0.0	X				432	40.5			X	
373	27.1			X		403	0.0	X				433	40.2			X	
374	26.3			X		404	0.0	X				434	40.1			X	
375	25.7			X		405	0.0	X				435	40.1			X	
376	25.5			X		406	0.0	X				436	39.8				X
377	25.6			X		407	0.0	X				437	38.9				X
378	25.9			X		408	1.2		X			438	37.4				X
379	26.3			X		409	3.2		X			439	35.8				X
380	26.9			X		410	5.9		X			440	34.1				X
381	27.6			X		411	8.8		X			441	32.5				X
382	28.4			X		412	12.0		X			442	30.9				X
383	29.3			X		413	15.4		X			443	29.4				X
384	30.1			X		414	18.9		X			444	27.9				X
385	30.4			X		415	22.1		X			445	26.5				X
386	30.2			X		416	24.7		X			446	25.0				X
387	29.5			X		417	26.8		X			447	23.4				X
388	28.6			X		418	28.7		X			448	21.8				X
389	27.9			X		419	30.6		X			449	20.3				X
390	27.5			X		420	32.4		X			450	19.3				X

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
451	18.7				X	481	0.0	X				511	16.7				X
452	18.3				X	482	0.0	X				512	10.7				X
453	17.8				X	483	0.0	X				513	4.7				X
454	17.4				X	484	0.0	X				514	1.2				X
455	16.8				X	485	0.0	X				515	0.0	X			
456	16.3			X		486	1.4		X			516	0.0	X			
457	16.5			X		487	4.5		X			517	0.0	X			
458	17.6			X		488	8.8		X			518	0.0	X			
459	19.2			X		489	13.4		X			519	3.0		X		
460	20.8			X		490	17.3		X			520	8.2		X		
461	22.2			X		491	19.2		X			521	14.3		X		
462	23.0			X		492	19.7		X			522	19.3		X		
463	23.0				X	493	19.8		X			523	23.5		X		
464	22.0				X	494	20.7		X			524	27.3		X		
465	20.1				X	495	23.7		X			525	30.8		X		
466	17.7				X	496	27.9		X			526	33.7		X		
467	15.0				X	497	31.9		X			527	35.2		X		
468	12.1				X	498	35.4		X			528	35.2				X
469	9.1				X	499	36.2				X	529	32.5				X
470	6.2				X	500	34.2				X	530	27.9				X
471	3.6				X	501	30.2				X	531	23.2				X
472	1.8				X	502	27.1				X	532	18.5				X
473	0.8				X	503	26.6		X			533	13.8				X
474	0.0	X				504	28.6		X			534	9.1				X
475	0.0	X				505	32.6		X			535	4.5				X
476	0.0	X				506	35.5		X			536	2.3				X
477	0.0	X				507	36.6				X	537	0.0	X			
478	0.0	X				508	34.6				X	538	0.0	X			
479	0.0	X				509	30.0				X	539	0.0	X			
480	0.0	X				510	23.1				X	540	0.0	X			

Table A7.App11/4
WMTC. cycle part 1. reduced vehicle speed for vehicle classes 1 and 2-1. 541 to 600 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
541	0.0	X			
542	2.8		X		
543	8.1		X		
544	14.3		X		
545	19.2		X		
546	23.5		X		
547	27.2		X		
548	30.5		X		
549	33.1		X		
550	35.7		X		
551	38.3		X		
552	41.0		X		
553	43.6			X	
554	43.7			X	
555	43.8			X	
556	43.9			X	
557	44.0			X	
558	44.1			X	
559	44.2			X	
560	44.3			X	
561	44.4			X	
562	44.5			X	
563	44.6			X	
564	44.9			X	
565	45.5			X	
566	46.3			X	
567	47.1			X	
568	48.0			X	
569	48.7			X	
570	49.2			X	
571	49.4			X	
572	49.3			X	
573	48.7				X

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
574	47.3				X
575	45.0				X
576	42.3				X
577	39.5				X
578	36.6				X
579	33.7				X
580	30.1				X
581	26.0				X
582	21.8				X
583	17.7				X
584	13.5				X
585	9.4				X
586	5.6				X
587	2.1				X
588	0.0	X			
589	0.0	X			
590	0.0	X			
591	0.0	X			
592	0.0	X			
593	0.0	X			
594	0.0	X			
595	0.0	X			
596	0.0	X			
597	0.0	X			
598	0.0	X			
599	0.0	X			
600	0.0	X			

Table A7.App11/5
WMTC. cycle part 1 for vehicle classes 2-2 and 3. 0 to 180 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
0	0.0	X				33	25.6		X			66	9.4				X
1	0.0	X				34	27.1		X			67	4.9				X
2	0.0	X				35	28.0		X			68	2.0				X
3	0.0	X				36	28.7		X			69	0.0	X			
4	0.0	X				37	29.2		X			70	0.0	X			
5	0.0	X				38	29.8		X			71	0.0	X			
6	0.0	X				39	30.4			X		72	0.0	X			
7	0.0	X				40	29.6			X		73	0.0	X			
8	0.0	X				41	28.7			X		74	1.7		X		
9	0.0	X				42	27.9			X		75	5.8		X		
10	0.0	X				43	27.5			X		76	11.8		X		
11	0.0	X				44	27.3			X		77	18.3		X		
12	0.0	X				45	27.4			X		78	24.5		X		
13	0.0	X				46	27.5			X		79	29.4		X		
14	0.0	X				47	27.6			X		80	32.5		X		
15	0.0	X				48	27.6			X		81	34.2		X		
16	0.0	X				49	27.6			X		82	34.4		X		
17	0.0	X				50	27.7			X		83	34.5		X		
18	0.0	X				51	27.8			X		84	34.6		X		
19	0.0	X				52	28.1			X		85	34.7		X		
20	0.0	X				53	28.6			X		86	34.8		X		
21	0.0	X				54	29.0			X		87	35.2		X		
22	1.0		X			55	29.2			X		88	36.0		X		
23	2.6		X			56	29.5			X		89	37.0		X		
24	4.8		X			57	29.7			X		90	37.9		X		
25	7.2		X			58	30.1			X		91	38.6		X		
26	9.6		X			59	30.5			X		92	38.8			X	
27	12.0		X			60	30.7			X		93	38.8			X	
28	14.3		X			61	29.7				X	94	38.7			X	
29	16.6		X			62	27.0				X	95	38.5			X	
30	18.9		X			63	23.0				X	96	38.0			X	
31	21.2		X			64	18.7				X	97	37.4			X	
32	23.5		X			65	14.2				X	98	36.9			X	

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
99	36.6			X		126	35.1				X	154	0.0	X			
100	36.4			X		127	34.6				X	155	0.0	X			
101	36.4			X		128	33.7				X	156	0.0	X			
102	36.5			X		129	32.2				X	157	0.0	X			
103	36.7			X		130	29.6				X	158	0.0	X			
104	36.9			X		131	26.0				X	159	0.0	X			
105	37.0			X		132	22.0				X	160	0.0	X			
106	37.2			X		133	18.5				X	161	0.0	X			
107	37.3			X		134	16.6		X			162	0.0	X			
108	37.4			X		135	17.6		X			163	0.0	X			
109	37.3			X		136	21.0		X			164	0.0	X			
110	36.8			X		137	25.2		X			165	0.0	X			
111	35.8				X	138	29.1		X			166	0.0	X			
112	34.7				X	139	31.4		X			167	0.0	X			
113	31.8				X	140	31.9				X	168	0.0	X			
114	28.9				X	141	31.4				X	169	0.0	X			
115	26.7				X	142	30.6				X	170	0.0	X			
116	24.6			X		143	29.5				X	171	0.0	X			
117	25.2			X		144	28.0				X	172	0.0	X			
118	26.2			X		145	24.9				X	173	0.0	X			
119	27.6			X		146	20.2				X	174	0.0	X			
120	29.2			X		147	14.8				X	175	0.0	X			
						148	9.5				X	176	0.0	X			
121	31.0			X		149	4.8				X	177	0.0	X			
122	32.8			X		150	1.4				X	178	0.0	X			
123	34.3			X		151	0.0	X				179	0.0	X			
124	35.1			X		152	0.0	X				180	0.0	X			
125	35.3				X	153	0.0	X									

Table A7.App11/6
WMTC. cycle part 1 for vehicle classes 2-2 and 3. 181 to 360 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
181	0.0	X				211	59.9			X		241	38.3				X
182	0.0	X				212	59.9			X		242	36.4				X
183	2.0		X			213	59.8			X		243	34.6				X
184	6.0		X			214	59.6				X	244	32.7				X
185	12.4		X			215	59.1				X	245	30.6				X
186	21.4		X			216	57.1				X	246	28.1				X
187	30.0		X			217	53.2				X	247	25.5				X
188	37.1		X			218	48.3				X	248	23.1				X
189	42.5		X			219	43.9				X	249	21.2				X
190	46.6		X			220	40.3				X	250	19.5				X
191	49.8		X			221	39.5				X	251	17.8				X
192	52.4		X			222	41.3		X			252	15.3				X
193	54.4		X			223	45.2		X			253	11.5				X
194	55.6		X			224	50.1		X			254	7.2				X
195	56.1			X		225	53.7		X			255	2.5				X
196	56.2			X		226	55.8		X			256	0.0	X			
197	56.2			X		227	55.8				X	257	0.0	X			
198	56.2			X		228	54.7				X	258	0.0	X			
199	56.7			X		229	53.3				X	259	0.0	X			
200	57.2			X		230	52.3				X	260	0.0	X			
201	57.7			X		231	52.0				X	261	0.0	X			
202	58.2			X		232	52.1				X	262	0.0	X			
203	58.7			X		233	51.8				X	263	0.0	X			
204	59.3			X		234	50.8				X	264	0.0	X			
205	59.8			X		235	49.2				X	265	0.0	X			
206	60.0			X		236	47.5				X	266	0.0	X			
207	60.0			X		237	45.7				X	267	0.5		X		
208	59.9			X		238	43.9				X	268	2.9		X		
209	59.9			X		239	42.0				X	269	8.2		X		
210	59.9			X		240	40.2				X	270	13.2		X		

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
271	17.8		X			301	30.6			X		331	26.6			X	
272	21.4		X			302	28.9			X		332	26.8			X	
273	24.1		X			303	27.8			X		333	27.0			X	
274	26.4		X			304	27.2			X		334	27.2			X	
275	28.4		X			305	26.9			X		335	27.4			X	
276	29.9		X			306	26.5			X		336	27.6			X	
277	30.5		X			307	26.1			X		337	27.7			X	
278	30.5			X		308	25.7			X		338	27.9			X	
279	30.3			X		309	25.5			X		339	28.1			X	
280	30.2			X		310	25.7			X		340	28.3			X	
281	30.1			X		311	26.4			X		341	28.6			X	
282	30.1			X		312	27.3			X		342	29.0			X	
283	30.1			X		313	28.1			X		343	29.6			X	
284	30.1			X		314	27.9				X	344	30.1			X	
285	30.1			X		315	26.0				X	345	30.5			X	
286	30.1			X		316	22.7				X	346	30.7			X	
287	30.2			X		317	19.0				X	347	30.8			X	
288	30.4			X		318	16.0				X	348	30.8			X	
289	31.0			X		319	14.6		X			349	30.8			X	
290	31.8			X		320	15.2		X			350	30.8			X	
291	32.7			X		321	16.9		X			351	30.8			X	
292	33.6			X		322	19.3		X			352	30.8			X	
293	34.4			X		323	22.0		X			353	30.8			X	
294	35.0			X		324	24.6		X			354	30.9			X	
295	35.4			X		325	26.8		X			355	30.9			X	
296	35.5			X		326	27.9		X			356	30.9			X	
297	35.3			X		327	28.1			X		357	30.8			X	
298	34.9			X		328	27.7			X		358	30.4			X	
299	33.9			X		329	27.2			X		359	29.6			X	
300	32.4			X		330	26.8			X		360	28.4			X	

Table A7.App11/7
WMTC. cycle part 1 for vehicle classes 2-2 and 3. 361 to 540 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
361	27.1			X		391	27.3			X		421	34.0		X		
362	26.0			X		392	27.0				X	422	35.4		X		
363	25.4			X		393	26.5				X	423	36.5		X		
364	25.5			X		394	25.8				X	424	37.5		X		
365	26.3			X		395	25.0				X	425	38.6		X		
366	27.3			X		396	21.5				X	426	39.7		X		
367	28.4			X		397	16.0				X	427	40.7		X		
368	29.2			X		398	10.0				X	428	41.5		X		
369	29.5			X		399	5.0				X	429	41.7			X	
370	29.5			X		400	2.2				X	430	41.5			X	
371	29.0			X		401	1.0				X	431	41.0			X	
372	28.1			X		402	0.0	X				432	40.6			X	
373	27.2			X		403	0.0	X				433	40.3			X	
374	26.3			X		404	0.0	X				434	40.2			X	
375	25.7			X		405	0.0	X				435	40.1			X	
376	25.5			X		406	0.0	X				436	39.8				X
377	25.6			X		407	0.0	X				437	38.9				X
378	26.0			X		408	1.2		X			438	37.5				X
379	26.4			X		409	3.2		X			439	35.8				X
380	27.0			X		410	5.9		X			440	34.2				X
381	27.7			X		411	8.8		X			441	32.5				X
382	28.5			X		412	12.0		X			442	30.9				X
383	29.4			X		413	15.4		X			443	29.4				X
384	30.2			X		414	18.9		X			444	28.0				X
385	30.5			X		415	22.1		X			445	26.5				X
386	30.3			X		416	24.8		X			446	25.0				X
387	29.5			X		417	26.8		X			447	23.5				X
388	28.7			X		418	28.7		X			448	21.9				X
389	27.9			X		419	30.6		X			449	20.4				X
390	27.5			X		420	32.4		X			450	19.4				X

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
451	18.8				X	481	0.0	X				511	17.5				X
452	18.4				X	482	0.0	X				512	10.5				X
453	18.0				X	483	0.0	X				513	4.5				X
454	17.5				X	484	0.0	X				514	1.0				X
455	16.9				X	485	0.0	X				515	0.0	X			
456	16.4			X		486	1.4		X			516	0.0	X			
457	16.6			X		487	4.5		X			517	0.0	X			
458	17.7			X		488	8.8		X			518	0.0	X			
459	19.4			X		489	13.4		X			519	2.9		X		
460	20.9			X		490	17.3		X			520	8.0		X		
461	22.3			X		491	19.2		X			521	16.0		X		
462	23.2			X		492	19.7		X			522	24.0		X		
463	23.2				X	493	19.8		X			523	32.0		X		
464	22.2				X	494	20.7		X			524	38.8		X		
465	20.3				X	495	23.6		X			525	43.1		X		
466	17.9				X	496	28.1		X			526	46.0		X		
467	15.2				X	497	32.8		X			527	47.5				X
468	12.3				X	498	36.3		X			528	47.5				X
469	9.3				X	499	37.1				X	529	44.8				X
470	6.4				X	500	35.1				X	530	40.1				X
471	3.8				X	501	31.1				X	531	33.8				X
472	2.0				X	502	28.0				X	532	27.2				X
473	0.9				X	503	27.5		X			533	20.0				X
474	0.0	X				504	29.5		X			534	12.8				X
475	0.0	X				505	34.0		X			535	7.0				X
476	0.0	X				506	37.0		X			536	2.2				X
477	0.0	X				507	38.0				X	537	0.0	X			
478	0.0	X				508	36.1				X	538	0.0	X			
479	0.0	X				509	31.5				X	539	0.0	X			
480	0.0	X				510	24.5				X	540	0.0	X			

Table A7.App11/8
WMTC. cycle part 1 for vehicle classes 2-2 and 3. 541 to 600 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
541	0.0	X			
542	2.7		X		
543	8.0		X		
544	16.0		X		
545	24.0		X		
546	32.0		X		
547	37.2		X		
548	40.4		X		
549	43.1		X		
550	44.6		X		
551	45.2			X	
552	45.3			X	
553	45.4			X	
554	45.5			X	
555	45.6			X	
556	45.7			X	
557	45.8			X	
558	45.9			X	
559	46.0			X	
560	46.1			X	
561	46.2			X	
562	46.3			X	
563	46.4			X	
564	46.7			X	
565	47.2			X	
566	48.0			X	
567	48.9			X	
568	49.8			X	
569	50.5			X	
570	51.0			X	
571	51.1			X	
572	51.0			X	
573	50.4				X

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
574	49.0				X
575	46.7				X
576	44.0				X
577	41.1				X
578	38.3				X
579	35.4				X
580	31.8				X
581	27.3				X
582	22.4				X
583	17.7				X
584	13.4				X
585	9.3				X
586	5.5				X
587	2.0				X
588	0.0	X			
589	0.0	X			
590	0.0	X			
591	0.0	X			
592	0.0	X			
593	0.0	X			
594	0.0	X			
595	0.0	X			
596	0.0	X			
597	0.0	X			
598	0.0	X			
599	0.0	X			
600	0.0	X			

1.3.   WMTC. part 2

Figure A7.App11/3
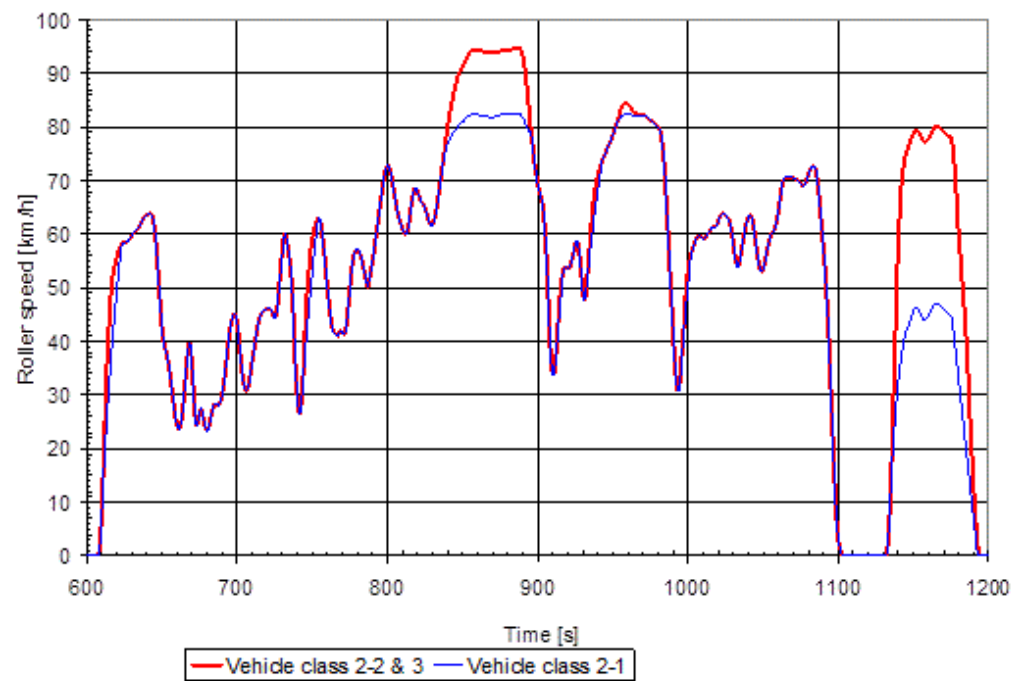
1.3.1.   The characteristic desired vehicle speed versus test time of WMTC. part 2 is set out in the following tables.

Table A7.App11/9
WMTC. cycle part 2. reduced vehicle speed for vehicle class 2-1. 0 to 180 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
0	0.0	X				33	60.8			X		66	33.9		X		
1	0.0	X				34	61.1			X		67	37.3		X		
2	0.0	X				35	61.5			X		68	39.8				X
3	0.0	X				36	62.0			X		69	39.5				X
4	0.0	X				37	62.5			X		70	36.3				X
5	0.0	X				38	63.0			X		71	31.4				X
6	0.0	X				39	63.4			X		72	26.5				X
7	0.0	X				40	63.7			X		73	24.2				X
8	0.0	X				41	63.8			X		74	24.8				X
9	2.3		X			42	63.9			X		75	26.6				X
10	7.3		X			43	63.8			X		76	27.5				X
11	13.6		X			44	63.2				X	77	26.8				X
12	18.9		X			45	61.7				X	78	25.3				X
13	23.6		X			46	58.9				X	79	24.0				X
14	27.8		X			47	55.2				X	80	23.3			X	
15	31.8		X			48	51.0				X	81	23.7			X	
16	35.6		X			49	46.7				X	82	24.9			X	
17	39.3		X			50	42.8				X	83	26.4			X	
18	42.7		X			51	40.2				X	84	27.7			X	
19	46.0		X			52	38.8				X	85	28.3			X	
20	49.1		X			53	37.9				X	86	28.3			X	
21	52.1		X			54	36.7				X	87	28.1			X	
22	54.9		X			55	35.1				X	88	28.1		X		
23	57.5		X			56	32.9				X	89	28.6		X		
24	58.4			X		57	30.4				X	90	29.8		X		
25	58.5			X		58	28.0				X	91	31.6		X		
26	58.5			X		59	25.9				X	92	33.9		X		
27	58.6			X		60	24.4				X	93	36.5		X		
28	58.9			X		61	23.7		X			94	39.1		X		
29	59.3			X		62	23.8		X			95	41.5		X		
30	59.8			X		63	25.0		X			96	43.3		X		
31	60.2			X		64	27.3		X			97	44.5		X		
32	60.5			X		65	30.4		X			98	45.1				X

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
99	45.1				X	126	44.7		X			154	62.9		X		
100	43.9				X	127	46.8		X			155	62.9				X
101	41.4				X	128	49.9		X			156	61.7				X
102	38.4				X	129	52.8		X			157	59.4				X
103	35.5				X	130	55.6		X			158	56.6				X
104	32.9				X	131	58.2		X			159	53.7				X
105	31.3				X	132	60.2				X	160	50.7				X
106	30.7				X	133	59.3				X	161	47.7				X
107	31.0			X		134	57.5				X	162	45.0				X
108	32.2			X		135	55.4				X	163	43.1				X
109	34.0			X		136	52.5				X	164	41.9			X	
110	36.0			X		137	47.9				X	165	41.6			X	
111	37.9			X		138	41.4				X	166	41.3			X	
112	39.9			X		139	34.4				X	167	40.9			X	
113	41.6			X		140	30.0				X	168	41.8			X	
114	43.1			X		141	27.0				X	169	42.1			X	
115	44.3			X		142	26.5		X			170	41.8			X	
116	45.0			X		143	28.7		X			171	41.3			X	
117	45.5			X		144	32.7		X			172	41.5		X		
118	45.8			X		145	36.5		X			173	43.5		X		
119	46.0			X		146	40.0		X			174	46.5		X		
120	46.1			X		147	43.5		X			175	49.7		X		
						148	46.7		X			176	52.6		X		
121	46.2			X		149	49.8		X			177	55.0		X		
122	46.1			X		150	52.7		X			178	56.5		X		
123	45.7			X		151	55.5		X			179	57.1		X		
124	45.0			X		152	58.1		X			180	57.3				X
125	44.3			X		153	60.6		X								

Table A7.App11/10
WMTC. cycle part 2. reduced vehicle speed for vehicle class 2-1. 181 to 360 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
181	57.0				X	211	60.4				X	241	77.5		X		
182	56.3				X	212	60.0		X			242	78.1			X	
183	55.2				X	213	60.2		X			243	78.6			X	
184	53.9				X	214	61.4		X			244	79.0			X	
185	52.6				X	215	63.3		X			245	79.4			X	
186	51.4				X	216	65.5		X			246	79.7			X	
187	50.1		X			217	67.4		X			247	80.1			X	
188	51.5		X			218	68.5		X			248	80.7			X	
189	53.1		X			219	68.7				X	249	80.8			X	
190	54.8		X			220	68.1				X	250	81.0			X	
191	56.6		X			221	67.3				X	251	81.2			X	
192	58.5		X			222	66.5				X	252	81.6			X	
193	60.6		X			223	65.9				X	253	81.9			X	
194	62.8		X			224	65.5				X	254	82.1			X	
195	64.9		X			225	64.9				X	255	82.1			X	
196	67.0		X			226	64.1				X	256	82.3			X	
197	69.1		X			227	63.0				X	257	82.4			X	
198	70.9		X			228	62.1				X	258	82.4			X	
199	72.2		X			229	61.6		X			259	82.3			X	
200	72.8				X	230	61.7		X			260	82.3			X	
201	72.8				X	231	62.3		X			261	82.2			X	
202	71.9				X	232	63.5		X			262	82.2			X	
203	70.5				X	233	65.3		X			263	82.1			X	
204	68.8				X	234	67.3		X			264	82.1			X	
205	67.1				X	235	69.2		X			265	82.0			X	
206	65.4				X	236	71.1		X			266	82.0			X	
207	63.9				X	237	73.0		X			267	81.9			X	
208	62.8				X	238	74.8		X			268	81.9			X	
209	61.8				X	239	75.7		X			269	81.9			X	
210	61.0				X	240	76.7		X			270	81.9			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
271	81.9			X		301	68.3				X	331	47.6		X		
272	82.0			X		302	67.3				X	332	48.4		X		
273	82.0			X		303	66.1				X	333	51.4		X		
274	82.1			X		304	63.9				X	334	54.2		X		
275	82.2			X		305	60.2				X	335	56.9		X		
276	82.3			X		306	54.9				X	336	59.4		X		
277	82.4			X		307	48.1				X	337	61.8		X		
278	82.5			X		308	40.9				X	338	64.1		X		
279	82.5			X		309	36.0				X	339	66.2		X		
280	82.5			X		310	33.9				X	340	68.2		X		
281	82.5			X		311	33.9		X			341	70.2		X		
282	82.4			X		312	36.5		X			342	72.0		X		
283	82.4			X		313	40.1		X			343	73.7		X		
284	82.4			X		314	43.5		X			344	74.4		X		
285	82.5			X		315	46.8		X			345	75.1		X		
286	82.5			X		316	49.8		X			346	75.8		X		
287	82.5			X		317	52.8		X			347	76.5		X		
288	82.4			X		318	53.9		X			348	77.2		X		
289	82.3			X		319	53.9		X			349	77.8		X		
290	81.6			X		320	53.7		X			350	78.5		X		
291	81.3			X		321	53.7		X			351	79.2		X		
292	80.3			X		322	54.3		X			352	80.0		X		
293	79.9			X		323	55.4		X			353	81.0			X	
294	79.2			X		324	56.8		X			354	81.2			X	
295	79.2			X		325	58.1		X			355	81.8			X	
296	78.4				X	326	58.9				X	356	82.2			X	
297	75.7				X	327	58.2				X	357	82.2			X	
298	73.2				X	328	55.8				X	358	82.4			X	
299	71.1				X	329	52.6				X	359	82.5			X	
300	69.5				X	330	49.2				X	360	82.5			X	

Table A7.App11/11
WMTC. cycle part 2. reduced vehicle speed for vehicle class 2-1. 361 to 540 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
361	82.5			X		391	37.0				X	421	63.1			X	
362	82.5			X		392	33.0				X	422	63.6			X	
363	82.3			X		393	30.9				X	423	63.9			X	
364	82.1			X		394	30.9		X			424	63.8			X	
365	82.1			X		395	33.5		X			425	63.6			X	
366	82.1			X		396	37.2		X			426	63.3				X
367	82.1			X		397	40.8		X			427	62.8				X
368	82.1			X		398	44.2		X			428	61.9				X
369	82.1			X		399	47.4		X			429	60.5				X
370	82.1			X		400	50.4		X			430	58.6				X
371	82.1			X		401	53.3		X			431	56.5				X
372	82.1			X		402	56.1		X			432	54.6				X
373	81.9			X		403	57.3		X			433	53.8			X	
374	81.6			X		404	58.1		X			434	54.5			X	
375	81.3			X		405	58.8		X			435	56.1			X	
376	81.1			X		406	59.4		X			436	57.9			X	
377	80.8			X		407	59.8			X		437	59.7			X	
378	80.6			X		408	59.7			X		438	61.2			X	
379	80.4			X		409	59.4			X		439	62.3			X	
380	80.1			X		410	59.2			X		440	63.1			X	
381	79.7				X	411	59.2			X		441	63.6				X
382	78.6				X	412	59.6			X		442	63.5				X
383	76.8				X	413	60.0			X		443	62.7				X
384	73.7				X	414	60.5			X		444	60.9				X
385	69.4				X	415	61.0			X		445	58.7				X
386	64.0				X	416	61.2			X		446	56.4				X
387	58.6				X	417	61.3			X		447	54.5				X
388	53.2				X	418	61.4			X		448	53.3				X
389	47.8				X	419	61.7			X		449	53.0			X	
390	42.4				X	420	62.3			X		450	53.5			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
451	54.6			X		481	72.0			X		511	0.0	X			
452	56.1			X		482	72.6			X		512	0.0	X			
453	57.6			X		483	72.8			X		513	0.0	X			
454	58.9			X		484	72.7			X		514	0.0	X			
455	59.8			X		485	72.0				X	515	0.0	X			
456	60.3			X		486	70.4				X	516	0.0	X			
457	60.7			X		487	67.7				X	517	0.0	X			
458	61.3			X		488	64.4				X	518	0.0	X			
459	62.4			X		489	61.0				X	519	0.0	X			
460	64.1			X		490	57.6				X	520	0.0	X			
461	66.2			X		491	54.0				X	521	0.0	X			
462	68.1			X		492	49.7				X	522	0.0	X			
463	69.7			X		493	44.4				X	523	0.0	X			
464	70.4			X		494	38.2				X	524	0.0	X			
465	70.7			X		495	31.2				X	525	0.0	X			
466	70.7			X		496	24.0				X	526	0.0	X			
467	70.7			X		497	16.8				X	527	0.0	X			
468	70.7			X		498	10.4				X	528	0.0	X			
469	70.6			X		499	5.7				X	529	0.0	X			
470	70.5			X		500	2.8				X	530	0.0	X			
471	70.4			X		501	1.6				X	531	0.0	X			
472	70.2			X		502	0.3				X	532	0.0	X			
473	70.1			X		503	0.0	X				533	2.3		X		
474	69.8			X		504	0.0	X				534	7.2		X		
475	69.5			X		505	0.0	X				535	13.5		X		
476	69.1			X		506	0.0	X				536	18.7		X		
477	69.1			X		507	0.0	X				537	22.9		X		
478	69.5			X		508	0.0	X				538	26.7		X		
479	70.3			X		509	0.0	X				539	30.0		X		
480	71.2			X		510	0.0	X				540	32.8		X		

Table A7.App11/12
WMTC. cycle part 2. reduced vehicle speed for vehicle class 2-1. 541 to 600 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
541	35.2		X		
542	37.3		X		
543	39.1		X		
544	40.8		X		
545	41.8		X		
546	42.5		X		
547	43.3		X		
548	44.1		X		
549	45.0		X		
550	45.7		X		
551	46.2			X	
552	46.3			X	
553	46.1			X	
554	45.6			X	
555	44.9			X	
556	44.4			X	
557	44.0			X	
558	44.0			X	
559	44.3			X	
560	44.8			X	
561	45.3			X	
562	45.9			X	
563	46.5			X	
564	46.8			X	
565	47.1			X	
566	47.1			X	
567	47.0			X	
568	46.7			X	
569	46.3			X	
570	45.9			X	
571	45.6			X	
572	45.4			X	
573	45.2			X	

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
574	45.1			X	
575	44.8				X
576	43.5				X
577	40.9				X
578	38.2				X
579	35.6				X
580	33.0				X
581	30.4				X
582	27.7				X
583	25.1				X
584	22.5				X
585	19.8				X
586	17.2				X
587	14.6				X
588	12.0				X
589	9.3				X
590	6.7				X
591	4.1				X
592	1.5				X
593	0.0	X			
594	0.0	X			
595	0.0	X			
596	0.0	X			
597	0.0	X			
598	0.0	X			
599	0.0	X			
600	0.0	X			

Table A7.App11/13
WMTC. cycle part 2 for vehicle classes 2-2 and 3. 0 to 180 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
0	0.0	X				33	60.8			X		66	33.9		X		
1	0.0	X				34	61.1			X		67	37.3		X		
2	0.0	X				35	61.5			X		68	39.8		X		
3	0.0	X				36	62.0			X		69	39.5				X
4	0.0	X				37	62.5			X		70	36.3				X
5	0.0	X				38	63.0			X		71	31.4				X
6	0.0	X				39	63.4			X		72	26.5				X
7	0.0	X				40	63.7			X		73	24.2				X
8	0.0	X				41	63.8			X		74	24.8				X
9	2.3		X			42	63.9			X		75	26.6				X
10	7.3		X			43	63.8			X		76	27.5				X
11	15.2		X			44	63.2				X	77	26.8				X
12	23.9		X			45	61.7				X	78	25.3				X
13	32.5		X			46	58.9				X	79	24.0				X
14	39.2		X			47	55.2				X	80	23.3			X	
15	44.1		X			48	51.0				X	81	23.7			X	
16	48.1		X			49	46.7				X	82	24.9			X	
17	51.2		X			50	42.8				X	83	26.4			X	
18	53.3		X			51	40.2				X	84	27.7			X	
19	54.5		X			52	38.8				X	85	28.3			X	
20	55.7		X			53	37.9				X	86	28.3			X	
21	56.9			X		54	36.7				X	87	28.1			X	
22	57.5			X		55	35.1				X	88	28.1			X	
23	58.0			X		56	32.9				X	89	28.6			X	
24	58.4			X		57	30.4				X	90	29.8			X	
25	58.5			X		58	28.0				X	91	31.6			X	
26	58.5			X		59	25.9				X	92	33.9			X	
27	58.6			X		60	24.4				X	93	36.5			X	
28	58.9			X		61	23.7		X			94	39.1			X	
29	59.3			X		62	23.8		X			95	41.5			X	
30	59.8			X		63	25.0		X			96	43.3			X	
31	60.2			X		64	27.3		X			97	44.5			X	
32	60.5			X		65	30.4		X			98	45.1				X

GRPE-92-12

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
99	45.1				X	126	44.7		X			154	63.1				X
100	43.9				X	127	46.8		X			155	62.9				X
101	41.4				X	128	50.1		X			156	61.7				X
102	38.4				X	129	53.6		X			157	59.4				X
103	35.5				X	130	56.9		X			158	56.6				X
104	32.9				X	131	59.4		X			159	53.7				X
105	31.3				X	132	60.2				X	160	50.7				X
106	30.7				X	133	59.3				X	161	47.7				X
107	31.0			X		134	57.5				X	162	45.0				X
108	32.2			X		135	55.4				X	163	43.1				X
109	34.0			X		136	52.5				X	164	41.9			X	
110	36.0			X		137	47.9				X	165	41.6			X	
111	37.9			X		138	41.4				X	166	41.3			X	
112	39.9			X		139	34.4				X	167	40.9			X	
113	41.6			X		140	30.0				X	168	41.8			X	
114	43.1			X		141	27.0				X	169	42.1			X	
115	44.3			X		142	26.5		X			170	41.8			X	
116	45.0			X		143	28.7		X			171	41.3			X	
117	45.5			X		144	33.8		X			172	41.5		X		
118	45.8			X		145	40.3		X			173	43.5		X		
119	46.0			X		146	46.6		X			174	46.5		X		
120	46.1			X		147	50.4		X			175	49.7		X		
						148	54.0		X			176	52.6		X		
121	46.2			X		149	56.9		X			177	55.0		X		
122	46.1			X		150	59.1		X			178	56.5		X		
123	45.7			X		151	60.6		X			179	57.1		X		
124	45.0			X		152	61.7		X			180	57.3				X
125	44.3			X		153	62.6		X								

Table A7.App11/14
WMTC. cycle part 2 for vehicle classes 2-2 and 3. 181 to 360 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
181	57.0				X	211	60.4				X	241	81.5		X		
182	56.3				X	212	60.0				X	242	83.1		X		
183	55.2				X	213	60.2			X		243	84.6		X		
184	53.9				X	214	61.4			X		244	86.0		X		
185	52.6				X	215	63.3			X		245	87.4		X		
186	51.4				X	216	65.5			X		246	88.7		X		
187	50.1		X			217	67.4			X		247	89.6		X		
188	51.5		X			218	68.5			X		248	90.2		X		
189	53.1		X			219	68.7				X	249	90.7		X		
190	54.8		X			220	68.1				X	250	91.2		X		
191	56.6		X			221	67.3				X	251	91.8		X		
192	58.5		X			222	66.5				X	252	92.4		X		
193	60.6		X			223	65.9				X	253	93.0		X		
194	62.8		X			224	65.5				X	254	93.6		X		
195	64.9		X			225	64.9				X	255	94.1			X	
196	67.0		X			226	64.1				X	256	94.3			X	
197	69.1		X			227	63.0				X	257	94.4			X	
198	70.9		X			228	62.1				X	258	94.4			X	
199	72.2		X			229	61.6		X			259	94.3			X	
200	72.8				X	230	61.7		X			260	94.3			X	
201	72.8				X	231	62.3		X			261	94.2			X	
202	71.9				X	232	63.5		X			262	94.2			X	
203	70.5				X	233	65.3		X			263	94.2			X	
204	68.8				X	234	67.3		X			264	94.1			X	
205	67.1				X	235	69.3		X			265	94.0			X	
206	65.4				X	236	71.4		X			266	94.0			X	
207	63.9				X	237	73.5		X			267	93.9			X	
208	62.8				X	238	75.6		X			268	93.9			X	
209	61.8				X	239	77.7		X			269	93.9			X	
210	61.0				X	240	79.7		X			270	93.9			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
		phase indicators						phase indicators						phase indicators			
271	93.9			X		301	68.3				X	331	47.6		X		
272	94.0			X		302	67.3				X	332	48.4		X		
273	94.0			X		303	66.1				X	333	51.8		X		
274	94.1			X		304	63.9				X	334	55.7		X		
275	94.2			X		305	60.2				X	335	59.6		X		
276	94.3			X		306	54.9				X	336	63.0		X		
277	94.4			X		307	48.1				X	337	65.9		X		
278	94.5			X		308	40.9				X	338	68.1		X		
279	94.5			X		309	36.0				X	339	69.8		X		
280	94.5			X		310	33.9				X	340	71.1		X		
281	94.5			X		311	33.9		X			341	72.1		X		
282	94.4			X		312	36.5		X			342	72.9		X		
283	94.5			X		313	41.0		X			343	73.7		X		
284	94.6			X		314	45.3		X			344	74.4		X		
285	94.7			X		315	49.2		X			345	75.1		X		
286	94.8			X		316	51.5		X			346	75.8		X		
287	94.9			X		317	53.2		X			347	76.5		X		
288	94.8			X		318	53.9		X			348	77.2		X		
289	94.3				X	319	53.9		X			349	77.8		X		
290	93.3				X	320	53.7		X			350	78.5		X		
291	91.8				X	321	53.7		X			351	79.2		X		
292	89.6				X	322	54.3		X			352	80.0		X		
293	87.0				X	323	55.4		X			353	81.0		X		
294	84.1				X	324	56.8		X			354	82.0		X		
295	81.2				X	325	58.1		X			355	83.0		X		
296	78.4				X	326	58.9				X	356	83.7		X		
297	75.7				X	327	58.2				X	357	84.2			X	
298	73.2				X	328	55.8				X	358	84.4			X	
299	71.1				X	329	52.6				X	359	84.5			X	
300	69.5				X	330	49.2				X	360	84.4			X	

Table A7.App11/15
WMTC. cycle part 2 for vehicle classes 2-2 and 3. 361 to 540 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
361	84.1			X		391	37.0				X	421	63.1			X	
362	83.7			X		392	33.0				X	422	63.6			X	
363	83.2			X		393	30.9				X	423	63.9			X	
364	82.8			X		394	30.9		X			424	63.8			X	
365	82.6			X		395	33.5		X			425	63.6			X	
366	82.5			X		396	38.0		X			426	63.3				X
367	82.4			X		397	42.5		X			427	62.8				X
368	82.3			X		398	47.0		X			428	61.9				X
369	82.2			X		399	51.0		X			429	60.5				X
370	82.2			X		400	53.5		X			430	58.6				X
371	82.2			X		401	55.1		X			431	56.5				X
372	82.1			X		402	56.4		X			432	54.6				X
373	81.9			X		403	57.3		X			433	53.8			X	
374	81.6			X		404	58.1		X			434	54.5			X	
375	81.3			X		405	58.8		X			435	56.1			X	
376	81.1			X		406	59.4		X			436	57.9			X	
377	80.8			X		407	59.8			X		437	59.7			X	
378	80.6			X		408	59.7			X		438	61.2			X	
379	80.4			X		409	59.4			X		439	62.3			X	
380	80.1			X		410	59.2			X		440	63.1			X	
381	79.7				X	411	59.2			X		441	63.6				X
382	78.6				X	412	59.6			X		442	63.5				X
383	76.8				X	413	60.0			X		443	62.7				X
384	73.7				X	414	60.5			X		444	60.9				X
385	69.4				X	415	61.0			X		445	58.7				X
386	64.0				X	416	61.2			X		446	56.4				X
387	58.6				X	417	61.3			X		447	54.5				X
388	53.2				X	418	61.4			X		448	53.3				X
389	47.8				X	419	61.7			X		449	53.0			X	
390	42.4				X	420	62.3			X		450	53.5			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
		\multicolumn{4}{c}{phase indicators}				\multicolumn{4}{c}{phase indicators}				\multicolumn{4}{c}{phase indicators}	
451	54.6			X		481	72.0			X		511	0.0	X			
452	56.1			X		482	72.6			X		512	0.0	X			
453	57.6			X		483	72.8			X		513	0.0	X			
454	58.9			X		484	72.7			X		514	0.0	X			
455	59.8			X		485	72.0				X	515	0.0	X			
456	60.3			X		486	70.4				X	516	0.0	X			
457	60.7			X		487	67.7				X	517	0.0	X			
458	61.3			X		488	64.4				X	518	0.0	X			
459	62.4			X		489	61.0				X	519	0.0	X			
460	64.1			X		490	57.6				X	520	0.0	X			
461	66.2			X		491	54.0				X	521	0.0	X			
462	68.1			X		492	49.7				X	522	0.0	X			
463	69.7			X		493	44.4				X	523	0.0	X			
464	70.4			X		494	38.2				X	524	0.0	X			
465	70.7			X		495	31.2				X	525	0.0	X			
466	70.7			X		496	24.0				X	526	0.0	X			
467	70.7			X		497	16.8				X	527	0.0	X			
468	70.7			X		498	10.4				X	528	0.0	X			
469	70.6			X		499	5.7				X	529	0.0	X			
470	70.5			X		500	2.8				X	530	0.0	X			
471	70.4			X		501	1.6				X	531	0.0	X			
472	70.2			X		502	0.3				X	532	0.0	X			
473	70.1			X		503	0.0	X				533	2.3		X		
474	69.8			X		504	0.0	X				534	7.2		X		
475	69.5			X		505	0.0	X				535	14.6		X		
476	69.1			X		506	0.0	X				536	23.5		X		
477	69.1			X		507	0.0	X				537	33.0		X		
478	69.5			X		508	0.0	X				538	42.7		X		
479	70.3			X		509	0.0	X				539	51.8		X		
480	71.2			X		510	0.0	X				540	59.4		X		

Table A7.App11/16
WMTC. cycle part 2 for vehicle classes 2-2 and 3. 541 to 600 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
541	65.3		X		
542	69.6		X		
543	72.3		X		
544	73.9		X		
545	75.0		X		
546	75.7		X		
547	76.5		X		
548	77.3		X		
549	78.2		X		
550	78.9		X		
551	79.4			X	
552	79.6			X	
553	79.3			X	
554	78.8			X	
555	78.1			X	
556	77.5			X	
557	77.2			X	
558	77.2			X	
559	77.5			X	
560	77.9			X	
561	78.5			X	
562	79.1			X	
563	79.6			X	
564	80.0			X	
565	80.2			X	
566	80.3			X	
567	80.1			X	
568	79.8			X	
569	79.5			X	
570	79.1			X	
571	78.8			X	
572	78.6			X	
573	78.4			X	

time in s	roller speed in km/h	phase indicators			
		stop	Acc	cruise	dec
574	78.3			X	
575	78.0				X
576	76.7				X
577	73.7				X
578	69.5				X
579	64.8				X
580	60.3				X
581	56.2				X
582	52.5				X
583	49.0				X
584	45.2				X
585	40.8				X
586	35.4				X
587	29.4				X
588	23.4				X
589	17.7				X
590	12.6				X
591	8.0				X
592	4.1				X
593	1.3				X
594	0.0	X			
595	0.0	X			
596	0.0	X			
597	0.0	X			
598	0.0	X			
599	0.0	X			
600	0.0	X			

1.4.   WMTC. part 3

Figure A7.App11/4
WMTC. part 3.
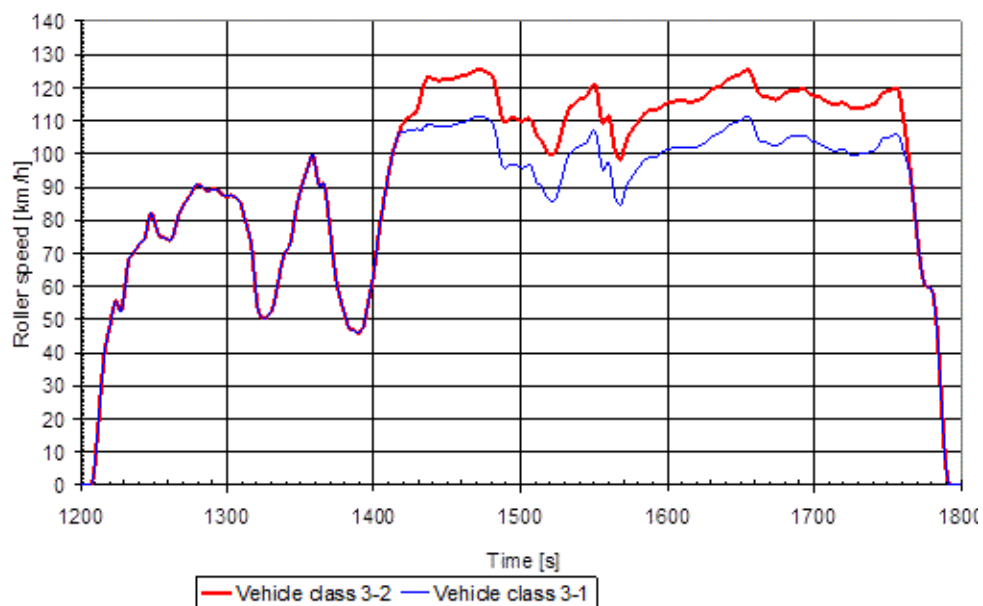
1.4.1.   The characteristic desired vehicle speed versus test time of WMTC. part 3 is set out in the following tables.

Table A7.App11/17
WMTC. cycle part 3. reduced vehicle speed for vehicle class 3-1. 0 to 180 s

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
0	0.0	X				33	68.1		X			66	80.4		X		
1	0.0	X				34	69.1		X			67	81.7		X		
2	0.0	X				35	69.5		X			68	82.6		X		
3	0.0	X				36	69.9		X			69	83.5		X		
4	0.0	X				37	70.6		X			70	84.4		X		
5	0.0	X				38	71.3		X			71	85.1		X		
6	0.0	X				39	72.2		X			72	85.7		X		
7	0.0	X				40	72.8		X			73	86.3		X		
8	0.9		X			41	73.2		X			74	87.0		X		
9	3.2		X			42	73.4		X			75	87.9		X		
10	7.3		X			43	73.8		X			76	88.8		X		
11	12.4		X			44	74.8		X			77	89.7		X		
12	17.9		X			45	76.7		X			78	90.3			X	
13	23.5		X			46	79.1		X			79	90.6			X	
14	29.1		X			47	81.1		X			80	90.6			X	
15	34.3		X			48	82.1				X	81	90.5			X	
16	38.6		X			49	81.7				X	82	90.4			X	
17	41.6		X			50	80.3				X	83	90.1			X	
18	43.9		X			51	78.8				X	84	89.7			X	
19	45.9		X			52	77.3				X	85	89.3			X	
20	48.1		X			53	75.9				X	86	89.0			X	
21	50.3		X			54	75.0				X	87	88.8			X	
22	52.6		X			55	74.7				X	88	88.9			X	
23	54.8		X			56	74.7				X	89	89.1			X	
24	55.8		X			57	74.7				X	90	89.3			X	
25	55.2		X			58	74.6				X	91	89.4			X	
26	53.9		X			59	74.4				X	92	89.4			X	
27	52.7		X			60	74.1				X	93	89.2			X	
28	52.8		X			61	73.9				X	94	88.9			X	
29	55.0		X			62	74.1		X			95	88.5			X	
30	58.5		X			63	75.1		X			96	88.0			X	
31	62.3		X			64	76.8		X			97	87.5			X	
32	65.7		X			65	78.7		X			98	87.2			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
99	87.1			X		126	50.3		X			154	94.6		X		
100	87.2			X		127	50.6		X			155	96.0		X		
101	87.3			X		128	51.2		X			156	97.5		X		
102	87.4			X		129	51.8		X			157	99.0		X		
103	87.5			X		130	52.5		X			158	99.8				X
104	87.4			X		131	53.4		X			159	99.0				X
105	87.1			X		132	54.9		X			160	96.7				X
106	86.8			X		133	57.0		X			161	93.7				X
107	86.4			X		134	59.4		X			162	91.3				X
108	85.9			X		135	61.9		X			163	90.4				X
109	85.2				X	136	64.3		X			164	90.6				X
110	84.0				X	137	66.4		X			165	91.1				X
111	82.2				X	138	68.1		X			166	90.9				X
112	80.3				X	139	69.6		X			167	89.0				X
113	78.6				X	140	70.7		X			168	85.6				X
114	77.2				X	141	71.4		X			169	81.6				X
115	75.9				X	142	71.8		X			170	77.6				X
116	73.8				X	143	72.8		X			171	73.6				X
117	70.4				X	144	75.0		X			172	69.7				X
118	65.7				X	145	77.8		X			173	66.0				X
119	60.5				X	146	80.7		X			174	62.7				X
120	55.9				X	147	83.3		X			175	60.0				X
						148	75.4		X			176	58.0				X
121	53.0				X	149	87.3		X			177	56.4				X
122	51.6				X	150	89.1		X			178	54.8				X
123	50.9				X	151	90.6		X			179	53.3				X
124	50.5				X	152	91.9		X			180	51.7				X
125	50.2				X	153	93.2		X								

Table A7.App11/18
WMTC. cycle part 3. reduced vehicle speed for vehicle class 3-1. 181 to 360 s

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
181	50.2				X	211	96.3		X			241	108.4			X	
182	48.7				X	212	98.4		X			242	108.3			X	
183	47.2			X		213	100.4		X			243	108.2			X	
184	47.1			X		214	102.1		X			244	108.2			X	
185	47.0			X		215	103.6		X			245	108.2			X	
186	46.9			X		216	104.9		X			246	108.2			X	
187	46.6			X		217	106.2			X		247	108.3			X	
188	46.3			X		218	106.5			X		248	108.4			X	
189	46.1			X		219	106.5			X		249	108.5			X	
190	46.1		X			220	106.6			X		250	108.5			X	
191	46.5		X			221	106.6			X		251	108.5			X	
192	47.1		X			222	107.0			X		252	108.5			X	
193	48.1		X			223	107.3			X		253	108.5			X	
194	49.8		X			224	107.3			X		254	108.7			X	
195	52.2		X			225	107.2			X		255	108.8			X	
196	54.8		X			226	107.2			X		256	109.0			X	
197	57.3		X			227	107.2			X		257	109.2			X	
198	59.5		X			228	107.3			X		258	109.3			X	
199	61.7		X			229	107.5			X		259	109.4			X	
200	64.4		X			230	107.3			X		260	109.5			X	
201	67.7		X			231	107.3			X		261	109.5			X	
202	71.4		X			232	107.3			X		262	109.6			X	
203	74.9		X			233	107.3			X		263	109.8			X	
204	78.2		X			234	108.0			X		264	110.0			X	
205	81.1		X			235	108.2			X		265	110.2			X	
206	83.9		X			236	108.9			X		266	110.5			X	
207	86.6		X			237	109.0			X		267	110.7			X	
208	89.1		X			238	108.9			X		268	111.0			X	
209	91.6		X			239	108.8			X		269	111.1			X	
210	94.0		X			240	108.6			X		270	111.2			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
271	111.3			X		301	95.8			X		331	97.4			X	
272	111.3			X		302	95.9			X		332	98.7			X	
273	111.3			X		303	96.2			X		333	99.7			X	
274	111.2			X		304	96.4			X		334	100.3			X	
275	111.0			X		305	96.7			X		335	100.6			X	
276	110.8			X		306	96.7			X		336	101.0			X	
277	110.6			X		307	96.3			X		337	101.4			X	
278	110.4			X		308	95.3				X	338	101.8			X	
279	110.3			X		309	94.0				X	339	102.2			X	
280	109.9			X		310	92.5				X	340	102.5			X	
281	109.3				X	311	91.4				X	341	102.6			X	
282	108.1				X	312	90.9				X	342	102.7			X	
283	106.3				X	313	90.7				X	343	102.8			X	
284	104.0				X	314	90.3				X	344	103.0			X	
285	101.5				X	315	89.6				X	345	103.5			X	
286	99.2				X	316	88.6				X	346	104.3			X	
287	97.2				X	317	87.7				X	347	105.2			X	
288	96.1				X	318	86.8				X	348	106.1			X	
289	95.7			X		319	86.2				X	349	106.8			X	
290	95.8			X		320	85.8				X	350	107.1				X
291	96.1			X		321	85.7				X	351	106.7				X
292	96.4			X		322	85.7				X	352	105.0				X
293	96.7			X		323	86.0			X		353	102.3				X
294	96.9			X		324	86.7			X		354	99.1				X
295	96.9			X		325	87.8			X		355	96.3				X
296	96.8			X		326	89.2			X		356	95.0				X
297	96.7			X		327	90.9			X		357	95.4				X
298	96.4			X		328	92.6			X		358	96.4				X
299	96.1			X		329	94.3			X		359	97.3				X
300	95.9			X		330	95.9			X		360	97.5				X

Table A7.App11/19
WMTC. cycle part 3. reduced vehicle speed for vehicle class 3-1. 361 to 540 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
361	96.1				X	391	99.2			X		421	102.2			X	
362	93.4				X	392	99.2			X		422	102.4			X	
363	90.4				X	393	99.3			X		423	102.6			X	
364	87.8				X	394	99.5			X		424	102.8			X	
365	86.0				X	395	99.9			X		425	103.1			X	
366	85.1				X	396	100.3			X		426	103.4			X	
367	84.7				X	397	100.6			X		427	103.9			X	
368	84.2			X		398	100.9			X		428	104.4			X	
369	85.0			X		399	101.1			X		429	104.9			X	
370	86.5			X		400	101.3			X		430	105.2			X	
371	88.3			X		401	101.4			X		431	105.5			X	
372	89.9			X		402	101.5			X		432	105.7			X	
373	91.0			X		403	101.6			X		433	105.9			X	
374	91.8			X		404	101.8			X		434	106.1			X	
375	92.5			X		405	101.9			X		435	106.3			X	
376	93.1			X		406	102.0			X		436	106.5			X	
377	93.7			X		407	102.0			X		437	106.8			X	
378	94.4			X		408	102.0			X		438	107.1			X	
379	95.0			X		409	102.0			X		439	107.5			X	
380	95.6			X		410	101.9			X		440	108.0			X	
381	96.3			X		411	101.9			X		441	108.3			X	
382	96.9			X		412	101.9			X		442	108.6			X	
383	97.5			X		413	101.8			X		443	108.9			X	
384	98.0			X		414	101.8			X		444	109.1			X	
385	98.3			X		415	101.8			X		445	109.2			X	
386	98.6			X		416	101.8			X		446	109.4			X	
387	98.9			X		417	101.8			X		447	109.5			X	
388	99.1			X		418	101.8			X		448	109.7			X	
389	99.3			X		419	101.9			X		449	109.9			X	
390	99.3			X		420	102.0			X		450	110.2			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
451	110.5			X		481	104.5			X		511	101.3			X	
452	110.8			X		482	104.8			X		512	101.2			X	
453	111.0			X		483	104.9			X		513	101.0			X	
454	111.2			X		484	105.1			X		514	100.9			X	
455	111.3			X		485	105.1			X		515	100.9			X	
456	111.1			X		486	105.2			X		516	101.0			X	
457	110.4			X		487	105.2			X		517	101.2			X	
458	109.3			X		488	105.2			X		518	101.3			X	
459	108.1			X		489	105.3			X		519	101.4			X	
460	106.8			X		490	105.3			X		520	101.4			X	
461	105.5			X		491	105.4			X		521	101.2			X	
462	104.4			X		492	105.5			X		522	100.8			X	
463	103.8			X		493	105.5			X		523	100.4			X	
464	103.6			X		494	105.3			X		524	99.9			X	
465	103.5			X		495	105.1			X		525	99.6			X	
466	103.5			X		496	104.7			X		526	99.5			X	
467	103.4			X		497	104.2			X		527	99.5			X	
468	103.3			X		498	103.9			X		528	99.6			X	
469	103.1			X		499	103.6			X		529	99.7			X	
470	102.9			X		500	103.5			X		530	99.8			X	
471	102.6			X		501	103.5			X		531	99.9			X	
472	102.5			X		502	103.4			X		532	100.0			X	
473	102.4			X		503	103.3			X		533	100.0			X	
474	102.4			X		504	103.0			X		534	100.1			X	
475	102.5			X		505	102.7			X		535	100.2			X	
476	102.7			X		506	102.4			X		536	100.4			X	
477	103.0			X		507	102.1			X		537	100.5			X	
478	103.3			X		508	101.9			X		538	100.6			X	
479	103.7			X		509	101.7			X		539	100.7			X	
480	104.1			X		510	101.5			X		540	100.8			X	

Table A7.App11/20
WMTC. cycle part 3. reduced vehicle speed for vehicle class 3-1. 541 to 600 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
541	101.0			X	
542	101.3			X	
543	102.0			X	
544	102.7			X	
545	103.5			X	
546	104.2			X	
547	104.6			X	
548	104.7			X	
549	104.8			X	
550	104.8			X	
551	104.9			X	
552	105.1			X	
553	105.4			X	
554	105.7			X	
555	105.9			X	
556	106.0			X	
557	105.7				X
558	105.4				X
559	103.9				X
560	102.2				X
561	100.5				X
562	99.2				X
563	98.0				X
564	96.4				X
565	94.8				X
566	92.8				X
567	88.9				X
568	84.9				X
569	80.6				X
570	76.3				X
571	72.3				X
572	68.7				X
573	65.5				X

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
574	63.0				X
575	61.2				X
576	60.5				X
577	60.0				X
578	59.7				X
579	59.4				X
580	59.4				X
581	58.0				X
582	55.0				X
583	51.0				X
584	46.0				X
585	38.8				X
586	31.6				X
587	24.4				X
588	17.2				X
589	10.0				X
590	5.0				X
591	2.0				X
592	0.0	X			
593	0.0	X			
594	0.0	X			
595	0.0	X			
596	0.0	X			
597	0.0	X			
598	0.0	X			
599	0.0	X			
600	0.0	X			

Table A7.App11/21
WMTC. cycle part 3 for vehicle class 3-2. 0 to 180 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
0	0.0	X				33	68.1		X			66	80.4		X		
1	0.0	X				34	69.1		X			67	81.7		X		
2	0.0	X				35	69.5		X			68	82.6		X		
3	0.0	X				36	69.9		X			69	83.5		X		
4	0.0	X				37	70.6		X			70	84.4		X		
5	0.0	X				38	71.3		X			71	85.1		X		
6	0.0	X				39	72.2		X			72	85.7		X		
7	0.0	X				40	72.8		X			73	86.3		X		
8	0.9		X			41	73.2		X			74	87.0		X		
9	3.2		X			42	73.4		X			75	87.9		X		
10	7.3		X			43	73.8		X			76	88.8		X		
11	12.4		X			44	74.8		X			77	89.7		X		
12	17.9		X			45	76.7		X			78	90.3			X	
13	23.5		X			46	79.1		X			79	90.6			X	
14	29.1		X			47	81.1		X			80	90.6			X	
15	34.3		X			48	82.1				X	81	90.5			X	
16	38.6		X			49	81.7				X	82	90.4			X	
17	41.6		X			50	80.3				X	83	90.1			X	
18	43.9		X			51	78.8				X	84	89.7			X	
19	45.9		X			52	77.3				X	85	89.3			X	
20	48.1		X			53	75.9				X	86	89.0			X	
21	50.3		X			54	75.0				X	87	88.8			X	
22	52.6		X			55	74.7				X	88	88.9			X	
23	54.8		X			56	74.7				X	89	89.1			X	
24	55.8		X			57	74.7				X	90	89.3			X	
25	55.2		X			58	74.6				X	91	89.4			X	
26	53.9		X			59	74.4				X	92	89.4			X	
27	52.7		X			60	74.1				X	93	89.2			X	
28	52.8		X			61	73.9				X	94	88.9			X	
29	55.0		X			62	74.1		X			95	88.5			X	
30	58.5		X			63	75.1		X			96	88.0			X	
31	62.3		X			64	76.8		X			97	87.5			X	
32	65.7		X			65	78.7		X			98	87.2			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
99	87.1			X		126	50.3		X			154	94.6		X		
100	87.2			X		127	50.6		X			155	96.0		X		
101	87.3			X		128	51.2		X			156	97.5		X		
102	87.4			X		129	51.8		X			157	99.0		X		
103	87.5			X		130	52.5		X			158	99.8				X
104	87.4			X		131	53.4		X			159	99.0				X
105	87.1			X		132	54.9		X			160	96.7				X
106	86.8			X		133	57.0		X			161	93.7				X
107	86.4			X		134	59.4		X			162	91.3				X
108	85.9			X		135	61.9		X			163	90.4				X
109	85.2				X	136	64.3		X			164	90.6				X
110	84.0				X	137	66.4		X			165	91.1				X
111	82.2				X	138	68.1		X			166	90.9				X
112	80.3				X	139	69.6		X			167	89.0				X
113	78.6				X	140	70.7		X			168	85.6				X
114	77.2				X	141	71.4		X			169	81.6				X
115	75.9				X	142	71.8		X			170	77.6				X
116	73.8				X	143	72.8		X			171	73.6				X
117	70.4				X	144	75.0		X			172	69.7				X
118	65.7				X	145	77.8		X			173	66.0				X
119	60.5				X	146	80.7		X			174	62.7				X
120	55.9				X	147	83.3		X			175	60.0				X
						148	85.4		X			176	58.0				X
121	53.0				X	149	87.3		X			177	56.4				X
122	51.6				X	150	89.1		X			178	54.8				X
123	50.9				X	151	90.6		X			179	53.3				X
124	50.5				X	152	91.9		X			180	51.7				X
125	50.2				X	153	93.2		X								

Table A7.App11/22
WMTC. cycle part 3 for vehicle class 3-2. 181 to 360 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
181	50.2				X	211	96.3		X			241	122.4			X	
182	48.7				X	212	98.4		X			242	122.3			X	
183	47.2			X		213	100.4		X			243	122.2			X	
184	47.1			X		214	102.1		X			244	122.2			X	
185	47.0			X		215	103.6		X			245	122.2			X	
186	46.9			X		216	104.9		X			246	122.2			X	
187	46.6			X		217	106.2		X			247	122.3			X	
188	46.3			X		218	107.5		X			248	122.4			X	
189	46.1			X		219	108.5		X			249	122.5			X	
190	46.1		X			220	109.3		X			250	122.5			X	
191	46.5		X			221	109.9		X			251	122.5			X	
192	47.1		X			222	110.5		X			252	122.5			X	
193	48.1		X			223	110.9		X			253	122.5			X	
194	49.8		X			224	111.2		X			254	122.7			X	
195	52.2		X			225	111.4		X			255	122.8			X	
196	54.8		X			226	111.7		X			256	123.0			X	
197	57.3		X			227	111.9		X			257	123.2			X	
198	59.5		X			228	112.3		X			258	123.3			X	
199	61.7		X			229	113.0		X			259	123.4			X	
200	64.4		X			230	114.1		X			260	123.5			X	
201	67.7		X			231	115.7		X			261	123.5			X	
202	71.4		X			232	117.5		X			262	123.6			X	
203	74.9		X			233	119.3		X			263	123.8			X	
204	78.2		X			234	121.0		X			264	124.0			X	
205	81.1		X			235	122.2			X		265	124.2			X	
206	83.9		X			236	122.9			X		266	124.5			X	
207	86.6		X			237	123.0			X		267	124.7			X	
208	89.1		X			238	122.9			X		268	125.0			X	
209	91.6		X			239	122.8			X		269	125.1			X	
210	94.0		X			240	122.6			X		270	125.2			X	

time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators				time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec			stop	acc	cruise	dec			stop	acc	cruise	dec
271	125.3			X		301	109.8			X		331	111.4			X	
272	125.3			X		302	109.9			X		332	112.7			X	
273	125.3			X		303	110.2			X		333	113.7			X	
274	125.2			X		304	110.4			X		334	114.3			X	
275	125.0			X		305	110.7			X		335	114.6			X	
276	124.8			X		306	110.7			X		336	115.0			X	
277	124.6			X		307	110.3			X		337	115.4			X	
278	124.4			X		308	109.3				X	338	115.8			X	
279	124.3			X		309	108.0				X	339	116.2			X	
280	123.9			X		310	106.5				X	340	116.5			X	
281	123.3				X	311	105.4				X	341	116.6			X	
282	122.1				X	312	104.9				X	342	116.7			X	
283	120.3				X	313	104.7				X	343	116.8			X	
284	118.0				X	314	104.3				X	344	117.0			X	
285	115.5				X	315	103.6				X	345	117.5			X	
286	113.2				X	316	102.6				X	346	118.3			X	
287	111.2				X	317	101.7				X	347	119.2			X	
288	110.1				X	318	100.8				X	348	120.1			X	
289	109.7			X		319	100.2				X	349	120.8			X	
290	109.8			X		320	99.8				X	350	121.1				X
291	110.1			X		321	99.7				X	351	120.7				X
292	110.4			X		322	99.7				X	352	119.0				X
293	110.7			X		323	100.0			X		353	116.3				X
294	110.9			X		324	100.7			X		354	113.1				X
295	110.9			X		325	101.8			X		355	110.3				X
296	110.8			X		326	103.2			X		356	109.0				X
297	110.7			X		327	104.9			X		357	109.4				X
298	110.4			X		328	106.6			X		358	110.4				X
299	110.1			X		329	108.3			X		359	111.3				X
300	109.9			X		330	109.9			X		360	111.5				X

Table A7.App11/23
WMTC. cycle part 3 for vehicle class 3-2. 361 to 540 s

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
361	110.1				X	391	113.2			X		421	116.2			X	
362	107.4				X	392	113.2			X		422	116.4			X	
363	104.4				X	393	113.3			X		423	116.6			X	
364	101.8				X	394	113.5			X		424	116.8			X	
365	100.0				X	395	113.9			X		425	117.1			X	
366	99.1				X	396	114.3			X		426	117.4			X	
367	98.7				X	397	114.6			X		427	117.9			X	
368	98.2			X		398	114.9			X		428	118.4			X	
369	99.0			X		399	115.1			X		429	118.9			X	
370	100.5			X		400	115.3			X		430	119.2			X	
371	102.3			X		401	115.4			X		431	119.5			X	
372	103.9			X		402	115.5			X		432	119.7			X	
373	105.0			X		403	115.6			X		433	119.9			X	
374	105.8			X		404	115.8			X		434	120.1			X	
375	106.5			X		405	115.9			X		435	120.3			X	
376	107.1			X		406	116.0			X		436	120.5			X	
377	107.7			X		407	116.0			X		437	120.8			X	
378	108.4			X		408	116.0			X		438	121.1			X	
379	109.0			X		409	116.0			X		439	121.5			X	
380	109.6			X		410	115.9			X		440	122.0			X	
381	110.3			X		411	115.9			X		441	122.3			X	
382	110.9			X		412	115.9			X		442	122.6			X	
383	111.5			X		413	115.8			X		443	122.9			X	
384	112.0			X		414	115.8			X		444	123.1			X	
385	112.3			X		415	115.8			X		445	123.2			X	
386	112.6			X		416	115.8			X		446	123.4			X	
387	112.9			X		417	115.8			X		447	123.5			X	
388	113.1			X		418	115.8			X		448	123.7			X	
389	113.3			X		419	115.9			X		449	123.9			X	
390	113.3			X		420	116.0			X		450	124.2			X	

time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec	time in s	roller speed in km/h	stop	acc	cruise	dec
451	124.5			X		481	118.5			X		511	115.3			X	
452	124.8			X		482	118.8			X		512	115.2			X	
453	125.0			X		483	118.9			X		513	115.0			X	
454	125.2			X		484	119.1			X		514	114.9			X	
455	125.3			X		485	119.1			X		515	114.9			X	
456	125.1			X		486	119.2			X		516	115.0			X	
457	124.4			X		487	119.2			X		517	115.2			X	
458	123.3			X		488	119.2			X		518	115.3			X	
459	122.1			X		489	119.3			X		519	115.4			X	
460	120.8			X		490	119.3			X		520	115.4			X	
461	119.5			X		491	119.4			X		521	115.2			X	
462	118.4			X		492	119.5			X		522	114.8			X	
463	117.8			X		493	119.5			X		523	114.4			X	
464	117.6			X		494	119.3			X		524	113.9			X	
465	117.5			X		495	119.1			X		525	113.6			X	
466	117.5			X		496	118.7			X		526	113.5			X	
467	117.4			X		497	118.2			X		527	113.5			X	
468	117.3			X		498	117.9			X		528	113.6			X	
469	117.1			X		499	117.6			X		529	113.7			X	
470	116.9			X		500	117.5			X		530	113.8			X	
471	116.6			X		501	117.5			X		531	113.9			X	
472	116.5			X		502	117.4			X		532	114.0			X	
473	116.4			X		503	117.3			X		533	114.0			X	
474	116.4			X		504	117.0			X		534	114.1			X	
475	116.5			X		505	116.7			X		535	114.2			X	
476	116.7			X		506	116.4			X		536	114.4			X	
477	117.0			X		507	116.1			X		537	114.5			X	
478	117.3			X		508	115.9			X		538	114.6			X	
479	117.7			X		509	115.7			X		539	114.7			X	
480	118.1			X		510	115.5			X		540	114.8			X	

Table A7.App11/24
WMTC. cycle part 3 for vehicle class 3-2. 541 to 600 s

time in s	roller speed in km/h	phase indicators			
		stop	Acc	cruise	dec
541	115.0			X	
542	115.3			X	
543	116.0			X	
544	116.7			X	
545	117.5			X	
546	118.2			X	
547	118.6			X	
548	118.7			X	
549	118.8			X	
550	118.8			X	
551	118.9			X	
552	119.1			X	
553	119.4			X	
554	119.7			X	
555	119.9			X	
556	120.0			X	
557	119.7				X
558	118.4				X
559	115.9				X
560	113.2				X
561	110.5				X
562	107.2				X
563	104.0				X
564	100.4				X
565	96.8				X
566	92.8				X
567	88.9				X
568	84.9				X
569	80.6				X
570	76.3				X
571	72.3				X
572	68.7				X
573	65.5				X

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
574	63.0				X
575	61.2				X
576	60.5				X
577	60.0				X
578	59.7				X
579	59.4				X
580	59.4				X
581	58.0				X
582	55.0				X
583	51.0				X
584	46.0				X
585	38.8				X
586	31.6				X
587	24.4				X
588	17.2				X
589	10.0				X
590	5.0				X
591	2.0				X
592	0.0	X			
593	0.0	X			
594	0.0	X			
595	0.0	X			
596	0.0	X			
597	0.0	X			
598	0.0	X			
599	0.0	X			
600	0.0	X			

Annex 7 - Appendix 12

Explanatory note on the gearshift procedure

1. Introduction

    This explanatory note explains matters specified or described in this Regulation. including its Annexes or Appendices. and matters related thereto with regard to the gearshift procedure.

2. Approach

2.1. The development of the gearshift procedure was based on an analysis of the gearshift points in the in-use data. In order to establish generalised correlations between technical specifications of the vehicles and desired vehicle speeds to shift gears. the engine speeds were normalised to the utilisable band between rated engine speed and idling engine speed.

2.2. In a second step. the end speeds (vehicle speed as well as normalised engine speed) for upshifts and downshifts were determined and recorded in a separate table. The averages of these speeds for each gear and vehicle were calculated and correlated with the vehicles' technical specifications.

2.3. The results of these analyses and calculations can be summarised as follows:

    (a) The gearshift behaviour is engine-speed-related rather than vehicle-speed-related;

    (b) The best correlation between gearshift desired vehicle speeds and technical data was found for normalised engine speeds and the power-to-mass ratio (maximum continuous rated power/(reference mass));

    (c) The residual variations cannot be explained by other technical data or by different drive train ratios. They are most probably due to differences in traffic conditions and individual driver behaviour;

    (d) The best approximation between gearshift desired vehicle speeds and power-to-mass ratio was found for exponential functions;

    (e) The gearshift mathematical function for the first gear is significantly lower than for all other gears;

    (f) The gearshift desired vehicle speeds for all other gears can be approximated by one common mathematical function;

    (g) No differences were found between five-gear and six-gear transmissions;

    (h) Gearshift behaviour in Japan is significantly different from the equal-type gearshift behaviour in the European Union (EU) and in the United States of America (USA).

2.4. In order to find a balanced compromise between the three regions. a new approximation function for normalised upshift engine speeds versus power-to-mass ratio was calculated as a weighted average of the EU/USA curve (with 2/3 weighting) and the Japanese curve (with 1/3 weighting). resulting in the following equations for normalised upshift engine speeds:

    Equation (1): Normalised upshift engine speed in 1st gear (gear 1)

$$n\_max\_acc(1) = \left(0.5753 \times e^{\left(-1.9 \times \frac{P_n}{m_k + 75}\right)} - 0.1\right) \times (s - n_{idle}) + n_{idle} \quad (1)$$

Equation (2): Normalised upshift engine speed in gears > 1

$$n\_max\_acc(i) = \left(0.5753 \times e^{\left(-1.9 \times \frac{P_n}{m_k + 75}\right)}\right) \times (s - n_{idle}) + n_{idle} \quad (2)$$

3.   Calculation example

3.1.   Figure A7.App12/1 shows an example of gearshift use for a small vehicle:

(a)   the lines in bold show the gear use for acceleration phases;

(b)   the dotted lines show the downshift points for deceleration phases;

(c)   in the cruising phases. the whole engine speed range between downshift engine speed and upshift engine speed may be used.

Figure A7.App12/1
Example of a gearshift sketch for a small vehicle
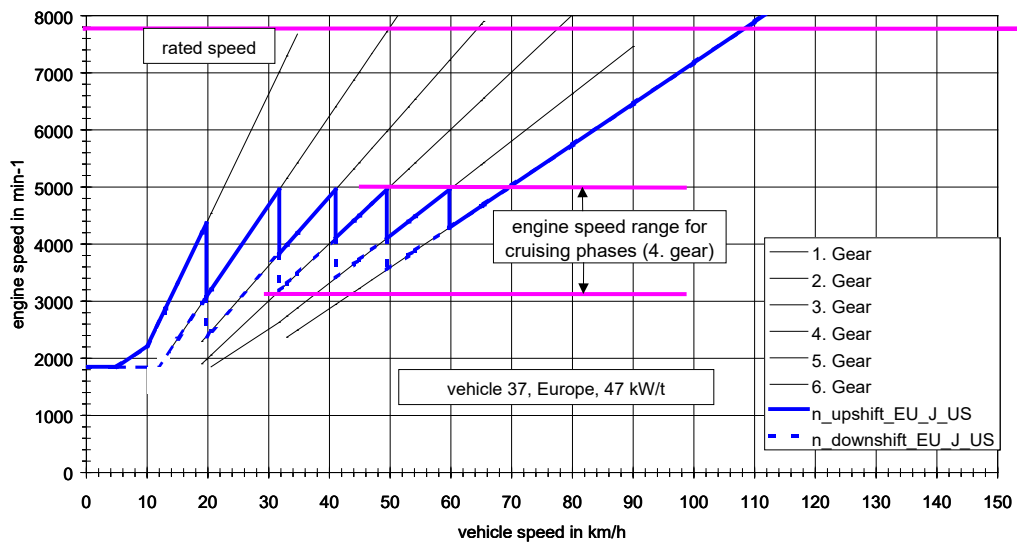
3.2.   Where vehicle speed increases gradually during cruise phases. upshift engine speeds (v1→2. v2→3and vi→i+1) in km/h may be calculated using the following equations:

$$v_{1 \to 2} = \left[0.03 \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_2} \quad (3)$$

$$v_{1 \to 2} = \left[(0.5753 \times e^{\left(-1.9x\frac{P_n}{m_{ref}}\right)} - 0.1) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_1} \quad (4)$$

$$v_{i \to i+1} = \left[(0.5753 \times e^{\left(-1.9x\frac{P_n}{m_{ref}}\right)}) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_{i-1}}, i = 3 \text{ to } ng \quad (5)$$
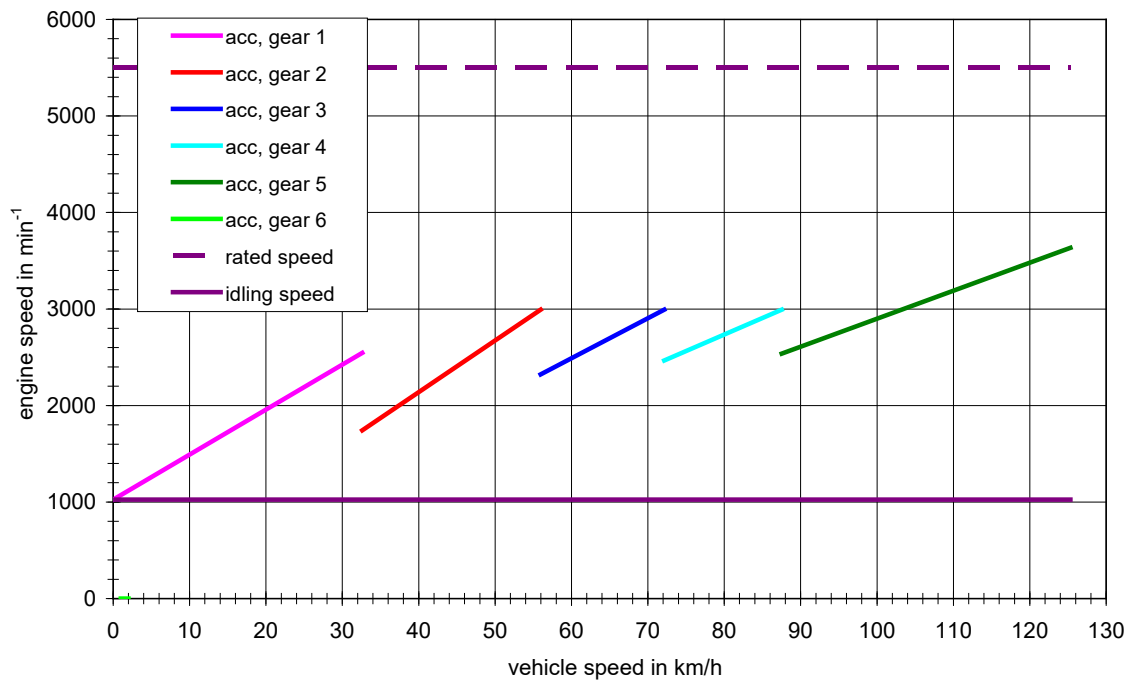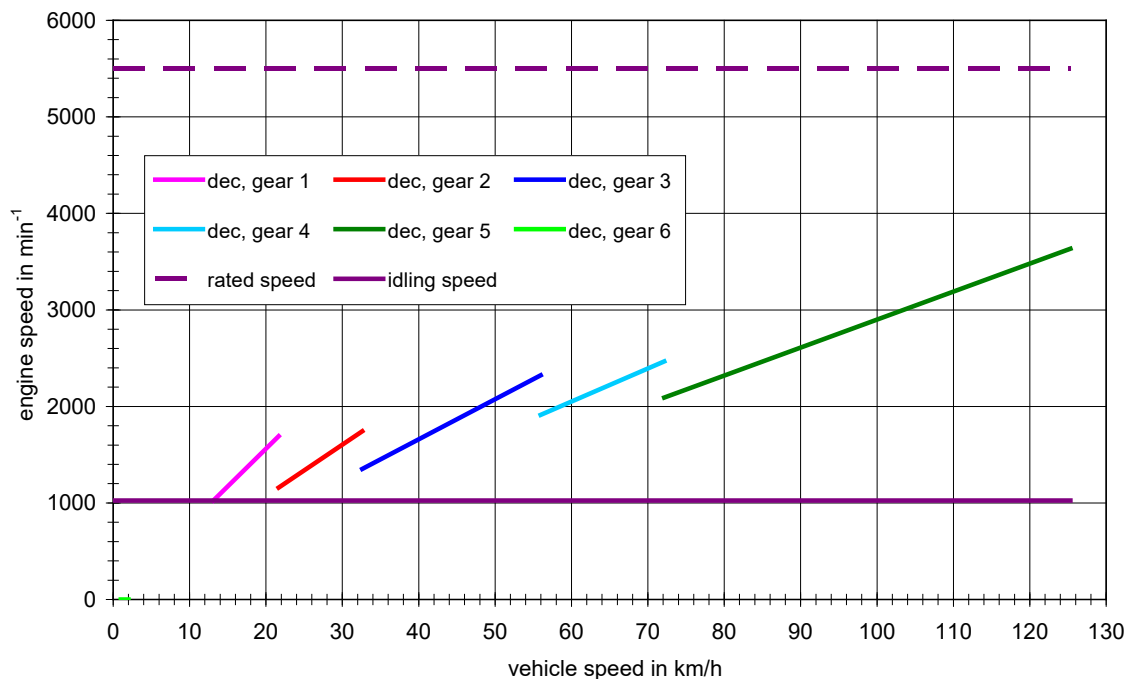
Figure A7.App12/2
Example of a gearshift sketch. Gear use during acceleration phases

Figure A7.App12/3
Example of a gearshift sketch. Gear use during deceleration and cruise phases

3.3.   In order to allow the technical service more flexibility and to ensure driveability. the gearshift regression functions should be considered as lower limits. Higher engine speeds are permitted in any cycle phase.

4.   Phase indicators

4.1.   In order to avoid different interpretations in the application of the gearshift equations and thus to improve the comparability of the test. fixed-phase indicators are assigned to the vehicle speed pattern of the cycles. The

specification of the phase indicators is based on the definition from the Japan Automobile Research Institute (JARI) of the four driving modes as shown in the following table:
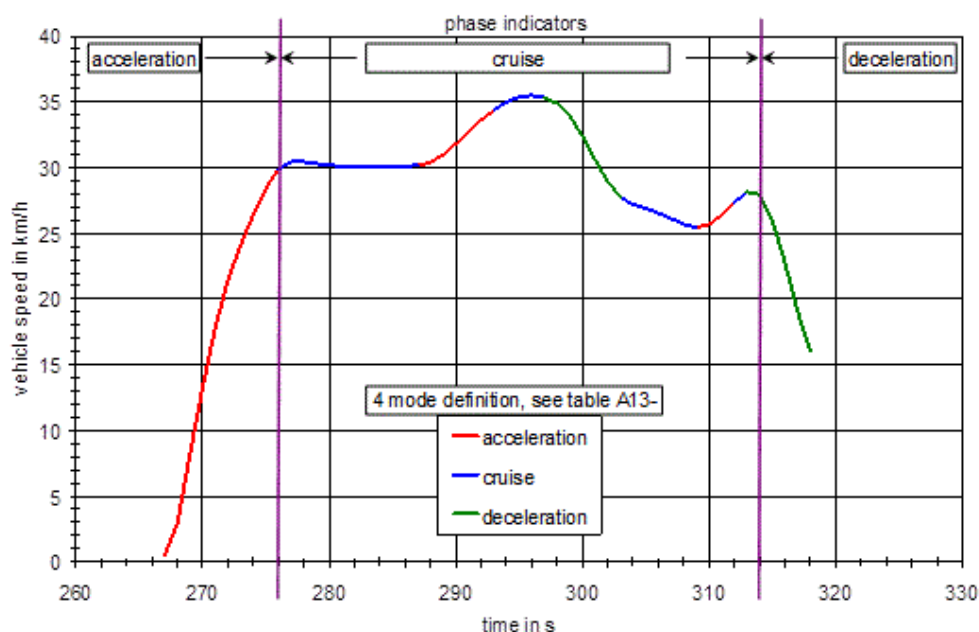
Table A7.App12/1
Definition of driving modes

4 modes	*Definition*
Idle mode	vehicle speed < 5 km/h and
	-0.5 km/h/s (-0.139 m/s^2) < acceleration < 0.5 km/h/s (0.139 m/s^2)
Acceleration mode	acceleration > 0.5 km/h/s (0.139 m/s^2)
Deceleration mode	acceleration < - 0.5 km/h/s (- 0.139 m/s^2)
Cruise mode	vehicle speed ≥ 5 km/h and
	-0.5 km/h/s (-0.139 m/s^2) < acceleration < 0.5 km/h/s (0.139 m/s^2)

4.2.   The indicators were then modified in order to avoid frequent changes during relatively homogeneous cycle parts and thus improve driveability. Figure A7.App12/4 shows an example from cycle part 1.

Figure A7.App12/4
Example for modified phase indicators

5.   Calculation example

5.1.   An example of input data necessary for the calculation of shift engine speeds is shown in Table A7.App12/2. The upshift engine speeds for acceleration phases for first gear and higher gears are calculated using Equations (1) and (2). The denormalisation of engine speeds can be performed using the equation $n = n\_norm \times (s - n_{idle}) + n_{idle}$.

5.2.   The downshift engine speeds for deceleration phases can be calculated using Equations (3) and (4). The ndv values in Table A7.App12/2 can be used as gear ratios. These values can also be used to calculate the corresponding vehicle speeds (vehicle shift speed in gear i = engine shift speed in gear i / ndv$_i$). The results are shown in Tables A7.App12/3 and A7.App12/4.

5.3.   Additional analyses and calculations were conducted to investigate whether these gearshift algorithms could be simplified and. in particular. whether

engine shift speeds could be replaced by vehicle shift speeds. The analysis showed that vehicle speeds could not be brought in line with the gearshift behaviour of the in-use data.

Table A7.App12/2
Input data for the calculation of engine and vehicle shift speeds

Item	Input data
Engine capacity in cm^3	600
Pn in kW	72
m_k in kg	199
s in min^{-1}	11 800
nidle in min^{-1}	1 150
ndv1 */	133.66
ndv2	94.91
ndv3	76.16
ndv4	65.69
ndv5	58.85
ndv6	54.04
pmr **/ in kW/t	262.8

Note: */ndv means the ratio between engine speed in min^{-1} and vehicle speed in km/h

**/pmr means the power-to-mass ratio calculated by Pn / (m_{ref}) · 1 000; Pn in kW. m_k in kg

Table A7.App12/3
Shift engine speeds for acceleration phases for first gear and for higher gears (see Table A7.App12/1)

	EU/USA/Japan driving behaviour		
	EU/USA/Japan driving behaviour	n_acc_max (1)	n_acc_max (i)
n_norm */ in percent	24.9		34.9
n in min^{-1}	3 804		4 869

Table A7.App12/4
Engine and desired vehicle shift speeds based on Table A7.App12/2

Gearshift			*EU/USA/Japan driving behaviour*	
			n_norm (i)	
		v in km/h	*in percent*	*n in* $\mathit{min^{-1}}$
Upshift	1→2	28.5	24.9	3 804
	2→3	51.3	34.9	4 869
	3→4	63.9	34.9	4 869
	4→5	74.1	34.9	4 869
	5→6	82.7	34.9	4 869
Downshift	2→cl */	15.5	3.0	1 470
	3→2	28.5	9.6	2 167
	4→3	51.3	20.8	3 370
	5→4	63.9	24.5	3 762
	6→5	74.1	26.8	4 005

*/"cl" means "Clutch-Off" timing.