AMENDMENT No. 1
TO
Doc. No.: MoRTH/CMVR/ TAP-115/116: Issue No.: 4

Document on Test Methods, Testing Equipment and Related Procedures for Testing Type Approval and Conformity of Production (COP) of Vehicles for Emission as per CMV Rules 115,116 and 126.

Corrected clauses are as follows:

1.0 Part I

1.1 Clause 1.1
Substitute following text for existing text:

This Part applies to the emissions of carbon monoxide and hydro carbon at idling / high idling from in-service vehicles fitted with spark ignition engines, as referred in CMVR-115 (2)(a) and for issue of "Pollution under control certificate" to be issued by authorised agencies under CMVR-115 (7).

1.2 Clause 1.2
Substitute following text for existing text:

This part specifies standard and test procedure for the determination of the volumetric concentration of exhaust carbon monoxide (CO) and hydrocarbon (HC) emissions from road vehicles equipped with spark ignition engines running at idle / high idle speed.

1.3 Clause 3.1.1
Substitute following text for existing text:

The Instrument used for the measurement of CO and HC shall be a type approved instrument as given in CMVR-116 (3) and meeting the requirements specified in Part-VIII. For measurement of idling CO and HC emissions of in-use 2, 3 and 4 wheeler (other than Bharat Stage II and above compliant) vehicles, 2 Gas analyser type approved as per Chapter II Of Part VIII shall be used. For measurement of idling CO and HC emissions of in-use 4 wheeler vehicles (Bharat Stage II and above compliant), 4 Gas analyser type approved as per Chapter III of Part VIII shall be used. The tachometer to measure engine idling g / high idling speed shall have an accuracy of ± 50 rpm.

1.4 Clause 3.3.6
Substitute following text for existing text:

For high idle measurement on Bharat Stage-IV compliant vehicles, the engine shall be accelerated to 2500 + 200 rpm. After the engine speed stabilizes, the values of CO and lambda readings shall be recorded.

1.5 Existing Clause nos. 3.3.6, 3.3.7, & 3.3.8 amended to clause nos. 3.3.7, 3.3.8, & 3.3.9 respectively.

1.6 Clause 4.1

Substitute following text for existing text:

PETROL/CNG/LPG DRIVEN VEHICLES

Sr. No.	Vehicle Type	CO %	HC (n – hexane equivalent) ppm
1.	2&3—Wheeler (2/4-stroke) (Vehicles manufactured on and before 31st March 2000)	4.5	9000
2.	2&3—Wheeler (2/4-stroke) (Vehicles manufactured after 31st March 2000	3.5	6000
3.	2&3 – Wheeler (4-stroke) (Vehicles manufactured after 31st March 2000)	3.5	4500
4.	4-wheelers manufactured as per Pre Bharat Stage-II norms	3.0	1500
5.	4-Wheelers manufactured as per Bharat Stage-II or Bharat Stage-III emission norms	0.5	750

PETROL/CNG/LPG driven vehicle manufactured as per Bharat Stage-IV norms

Sr. No.	Vehicle Type	Idle Emission Limits		High Idle Emission Limits	
		CO (%)	HC (n – hexane equivalent) ppm	**CO (%)**	**Lambda (RPM 2500±200)**
1.	Petrol driven 4-wheelers manufactured as per Bharat Stage-IV norms	0.3%	200 ppm	0.2	1 ± 0.03 or as declared by vehicle manufacturer
2.	Compressed Natural Gas/Liquefied Petroleum Gas driven 4-wheelers	0.3%	200 ppm	-	-

*NOTES:

(i) Idling / high idling emission standards for vehicles when operating on CNG shall replace Hydrocarbon (HC) by Non Methane Hydrocarbon (NMHC). NMHC may be estimated by the following formula:

NMHC = 0.3 x HC
Where HC = Hydrocarbon measured (n – hexane equivalent)

(ii) Idling emission standards for vehicles when operating on LPG shall replace Hydrocarbon (HC) by Reactive Hydrocarbon (RHC). RHC may be estimated by the following formula:

RHC = 0.5 x HC
Where HC = Hydrocarbon measured (n – hexane equivalent)

2.0 Part II

2.1 Clause 3.4.2
Substitute following text for existing text:

In cases where an engine has several exhaust outlets; these shall be connected to a single outlet in which opacity measurement shall be made. If it is not possible, to combine all exhaust outlets in one, the smoke shall be measured in each and an arithmetical mean of the values shall be recorded at each outlet. The test shall be taken as valid only if the extreme values measured do not differ by more than $0.25m^{-1}$

2.2 Clause 4.5.1.1
Substitute following text for existing text:

The test shall be carried out on a vehicle.

Before initiating the test on BS-IV vehicle, it shall be checked for OBD MIL lamp indication. If MIL lamp is ON, the test shall not be carried out and the vehicle owner shall be advised to re-submit the vehicle after the same is repaired / serviced

2.3 Clause 4.5.1.2
Substitute following text for existing text:

The engine of the vehicle shall be sufficiently warmed-up.

2.4 Clause 4.5.1.4
Substitute following text for existing text:

The vehicle gear change control shall be set in the neutral position and the drive between engine and gearbox engaged. With the engine idling, the accelerator control shall be operated quickly, but not violently, so as to obtain maximum delivery from the injection pump. This position shall be maintained until maximum engine speed is reached and the governor comes into action. For vehicles with automatic transmission, the engine speed specified by the vehicle manufacturer shall be achieved. As soon as this speed is reached the accelerator shall be released until the engine resumes its idling speed and the opacimeter reverts to the corresponding conditions. Typically the maximum time for acceleration shall be 5s and for the stabilization at maximum no load speed shall be 2s. The time duration between the two free accelerations shall be between 5-20s.

2.5 Clause 5.0
Substitute following text for existing text:

Method of Test	**Maximum Smoke Density**	
	Light absorption coefficient(1/m)	**Hartridge units**
Free acceleration test for turbo charged engine and naturally aspirated engine complying BSIII and below norms	2.45	65
Free acceleration test for turbo charged engine and naturally aspirated engine complying BSIV and above norms	1.62	50

3.0 Part XI

3.1 Chapter 8

Under clause no. 2.0

Substitute**:**

Q_i = Density of the pollutant i in g/m^3 at normal temperature and pressure (293 K and 101.33 kPa)

For existing text:

Q_i = Density of the pollutant i in kg/m^3 at normal temperature and pressure (293 K and 101.33 kPa)

4.0 Part XIII

4.1 Chapter 4

4.1.1 Substitute clause no. "5.1.1.7" for existing clause no."5.1.1.2.7".

4.1.2 After clause no. 5.1.1.7 insert clause no. 5.1.1.8 as below

5.1.1.8 The power (P) determined on the track shall be corrected to the reference ambient conditions as follows:

P corrected = K * P measured

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

Where
R_R = rolling resistance at speed V
R_{AERO} = aerodynamic drag at speed V
R_T = total driving resistance = R_R + R_{AERO}
K_R = temperature correction factor of rolling resistance, taken to be equal to: 8.64 x 10^{-3} / degrees C or the manufacturer's correction factor that is approved by the authority.

t = road test ambient temperature in degrees C
t_0 = reference ambient temperature = 20 degrees C
ρ = air density at the test conditions
ρ_0 = air density at the reference conditions (20 degrees C, 100 kPa)

The ratios R_R / R_T and R_{AERO}/ R_T shall be specified by the vehicle manufacturer on the basis of the data normally available to the company.
If these values are not available, subject to the agreement of the manufacturer and the technical service concerned, the figures for the rolling/ total resistance ratio given by the following formula may be used:

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

Where:
M= vehicle mass in kg
And for each speed the coefficients a and b are shown in the following table:

V (km /h)	**a**	**b**
20	7.24×10^{-5}	0.82
40	1.59×10^{-4}	0.54
60	1.96×10^{-4}	0.33
80	1.85×10^{-4}	0.23
100	1.63×10^{-4}	0.18
120	1.57×10^{-4}	0.14

4.1.3 After clause no. 5.4.2.2.4

Substitute

"5.5 Deceleration Method applying coast-down techniques: "

For existing text:

"5.7 Deceleration Method applying coast-down techniques: "

4.1.4 Chapter 8

Under clause no. 2.0

Substitute:

Q_i = Density of the pollutant i in g/m^3 at normal temperature and pressure (293 K and 101.33 kPa)

For existing text:

Q_i = Density of the pollutant i in kg/m^3 at normal temperature and pressure (293 K and 101.33 kPa)

5.0 Addition of Part XIIIA: Test procedure for two wheelers to address GSR 515(E)

Part XIII A: Alternate Mass Emission Measurement Procedure For Two-Wheeled Motorcycles Equipped With A Positive Ignition Engine With Regard To The Emission Of Gaseous Pollutants, CO_2 Emissions And Fuel Consumption Effective For Worldwide Harmonized Motorcycle Emissions Certification

Chapter 1 : Overall Requirement

ANNEXES

Annex 1 Symbols used

Annex 2.1 Technical data of the reference fuel to be used for testing vehicles equipped with positive ignition engines (unleaded petrol properties)

Annex 3 Classification of equivalent inertia mass and running resistance

Annex 4 Essential characteristics of the engine, the emission control systems and information concerning the conduct of tests

Annex 5 Driving cycles for type I tests

Annex 6 Chassis dynamometer and instruments description

Annex 7 Road tests for the determination of test bench settings

Annex 8 Form for the record of coast down time

Annex 9 Record of chassis dynamometer setting (by coast down method)

Annex 10 Record of chassis dynamometer setting (by table method)

Annex 11 Record of type I test results

Annex 12 Record of type II test results

Annex 13 explanatory notes on gearshift procedure

Chapter 1

OVERALL REQUIREMENT

1. Purpose

This part provides a worldwide-harmonized method for the determination of the levels of gaseous pollutant emissions, the emissions of carbon dioxide and the fuel consumption of gasoline fuelled two-wheel motor vehicles that are representative for real world vehicle operation.

This is an alternate Mass Emission Test procedure for Bharat Stage III two-wheeled motorcycles based on Global Technical Regulation No 02
This part should be read in conjunction with the applicable Gazette Notification for which the vehicle is subjected to test.

2. Scope

This procedure applies to the emission of gaseous pollutants and carbon dioxide emissions and fuel consumption of two-wheeled motorcycles with an engine cylinder capacity exceeding 50 cm^3 or a maximum design speed exceeding 50 km/h.

3. Definitions

For the purposes of this part,

3.1. "Vehicle type" means a category of two-wheeled motor vehicles that do not differ in the following essential respects as:

3.1.1. "Equivalent inertia" determined in relation to the mass in running order as prescribed in paragraph 3.3, to this regulation, and

3.1.2. "Engine and vehicle characteristics": Subject to the provisions of paragraph 6.2.1, the engine and vehicle characteristics as defined in Annex 4 of this Part.

3.2. "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, standard spare parts, 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 (except those for used water) to 100 per cent of the capacity specified by the manufacturer

3.3. "Mass in running order" (m_{ref}) means the nominal mass of a vehicle as determined by the following criteria:

Sum of unladen vehicle mass and driver's mass. The driver's mass is applied in accordance with paragraph 3.4. below.

3.4. "Driver mass" means the nominal mass of a driver that shall be 75 kg (subdivided into 68 kg occupant mass at the seat and 7 kg luggage mass in accordance with ISO standard 2416-1992)

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

$C_1H_{1.85}$ for petrol,

3.6. "CO_2 emissions" means carbon dioxide.

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

3.8. "Maximum vehicle speed" (v_{max}) is the maximum speed of the vehicle as declared by the manufacturer, measured in accordance with IS 10278:2009

3.9. "Maximum net engine power" is the maximum net engine power of the vehicle as declared by the manufacturer, measured in accordance with IS 14599 : 1999

Note 1 The symbols used are summarized in Annex 1.

4. General requirements

The components liable to affect the emission of gaseous pollutants, carbon dioxide emissions and fuel consumption 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.

5. Performance requirements

This Alternate Mass Emission standards BSIII (Bharat Stage III) based on Worldwide Harmonised Motorcycle Emissions Certification Procedure WMTC (Worldwide Motorcycle Test Cycle) details given in Rule no. 115(Sub Rule 14) (H) of CMVR, as amended from time to time for Gasoline vehicles shall be applicable as notified by the MoRTH Government of India

5.1 **Type I Test :** Verifying the average tailpipe emission
5.2 **Type II Test :** Test for Carbon Monoxide & Hydrocarbons emissions at Idling speed

5.3 **Conformity of Production :**
As prescribed in Clause 8,Chapter 1, Part XIII of this document

6. Test conditions

6.1. Test room and soak area

6.1.1. Test room

The test room with the chassis dynamometer and the gas sample collection device, shall have a temperature of 298 K ± 5 K (25 °C ± 5 °C). The room temperature shall be measured twice in the vicinity of vehicle cooling blower (fan), both before and after the Type I test.

6.1.2. **Soak area**

The soak area shall have a temperature of 298 K ± 5 K (25 °C ± 5 °C) and be able to park the test vehicle (motorcycle) to be preconditioned in accordance with paragraph 7.2.4.

6.2. **Test vehicle (motorcycle)**

6.2.1. **General**

The test vehicle shall conform in all its components with the production series, or, if the motorcycle is different from the production series, a full description shall be given in the test report. In selecting the test vehicle, the manufacturer and test authority shall agree which motorcycle test model is representative for related family of vehicles.

6.2.2. **Run-in**

The motorcycle must be presented in good mechanical condition. It must have been run in and driven at least 1,000 km before the test. The engine, transmission and motorcycle shall be properly run-in, in accordance with the manufacturer's requirements.

6.2.3. **Adjustments**

The motorcycle shall be adjusted in accordance with the manufacturer's requirements, e.g. the viscosity of the oils, or, if the motorcycle is different from the production series, a full description shall be given in the test report.

6.2.4. **Test mass and load distribution**

The total test mass including the masses of the rider and the instruments shall be measured before the beginning of the tests. The distribution of the load between the wheels shall be in conformity with the manufacturer's instructions.

6.2.5. **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 manufacturer or to those where the speed of the motorcycle during the road test and the motorcycle speed obtained on the chassis dynamometer are equalized. The tyre pressure shall be indicated in the test report.

6.3. **Vehicle classification**

Figure 6-1 gives an overview of the vehicle classification in terms of engine capacity and maximum vehicle speed. The numerical values of the engine capacity and maximum vehicle speed shall not be rounded up or down.

6.3.1. **Class 1**

Vehicles that fulfil the following specifications belong to class 1:

50 cm³ < engine capacity < 150 cm³ and vmax ≤ 50 km/h

or class 1

engine capacity < 150 cm³ and 50 km/h < vmax < 100 km/h"

6.3.2. Class 2

Vehicles that fulfil the following specifications belong to class 2:

Engine capacity < 150 cm³ and 100 km/h ≤ v_{max} < 115 km/h or
Engine capacity ≥150 cm³ and v_{max} < 115 km/h subclass 2-1,

115 km/h ≤ v_{max} < 130 km/h subclass 2-2.

6.3.3. Class 3

Vehicles that fulfil the following specifications belong to class 3:

130 ≤ v_{max} < 140 km/h subclass 3-1,

v_{max} ≥ 140 km/h subclass 3-2.

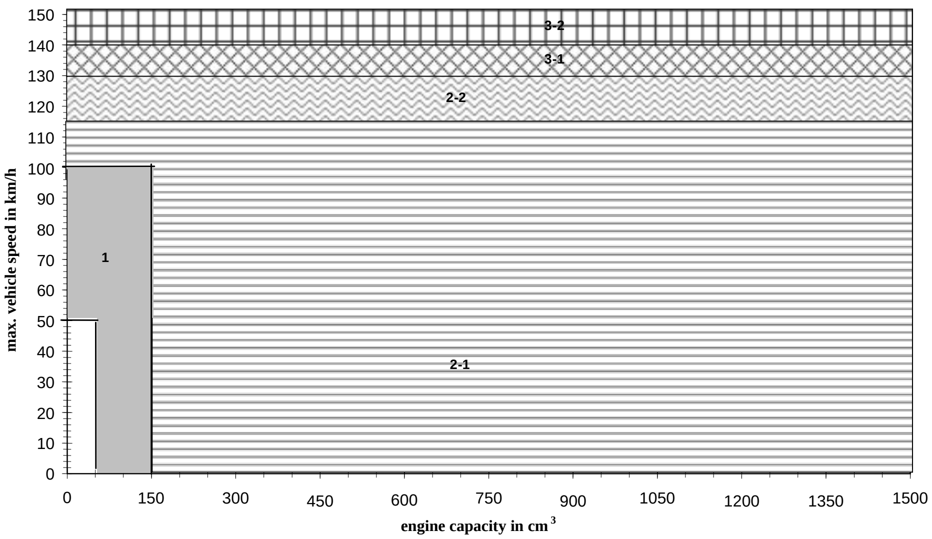

Figure 6-1: vehicle classification

6.4. Specification of the reference fuel

The reference fuel as prescribed in the applicable Gazette notification shall be used. If the engine is lubricated by a fuel oil mixture, the oil added to reference fuel shall comply as to grade and quantity with the manufacturer's recommendation

6.5. Type I tests

6.5.1. Rider

The rider shall have a mass of 75 kg ± 5 kg.

6.5.2. Test bench specifications and settings

6.5.2.1. The dynamometer shall have a single roller with a diameter of at least 0.400 m.

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

6.5.2.3. Flywheels of dynamometer or other means shall be used to simulate the inertia specified in paragraph 7.2.2.

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

6.5.2.5. Cooling fan specifications as follows:

6.5.2.5.1. Throughout the test, a variable speed cooling blower (fan) shall be positioned in front of the motorcycle, so as to direct the cooling air to the motorcycle in a manner, which simulates actual operating conditions. The blower 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. At the range of over 50 km/h, the linear velocity of the air shall be within ±10 per cent. At roller speeds of less than 10 km/h, air velocity may be zero.

6.5.2.5.2. The above mentioned air velocity shall be determined as an averaged value of 9 measuring points which are located at the centre of each rectangle dividing the whole of the blower outlet into 9 areas (dividing both of horizontal and vertical sides of the blower outlet into 3 equal parts). Each value at those 9 points shall be within 10 per cent of the averaged value of themselves.

6.5.2.5.3. The blower outlet shall have a cross section area of at least 0.4 m^2 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 motorcycle 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.

6.5.3. Exhaust gas measurement system

6.5.3.1. The gas-collection device shall be a closed type device that can collect all exhaust gases at the motorcycle exhaust outlet(s) on condition that it satisfies the backpressure condition of ± 125 mm H_2O. An open system may be used as well 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 that nature of exhaust gases at the test temperature. The system of gas-collection device is shown in Figure 6-2, for example.

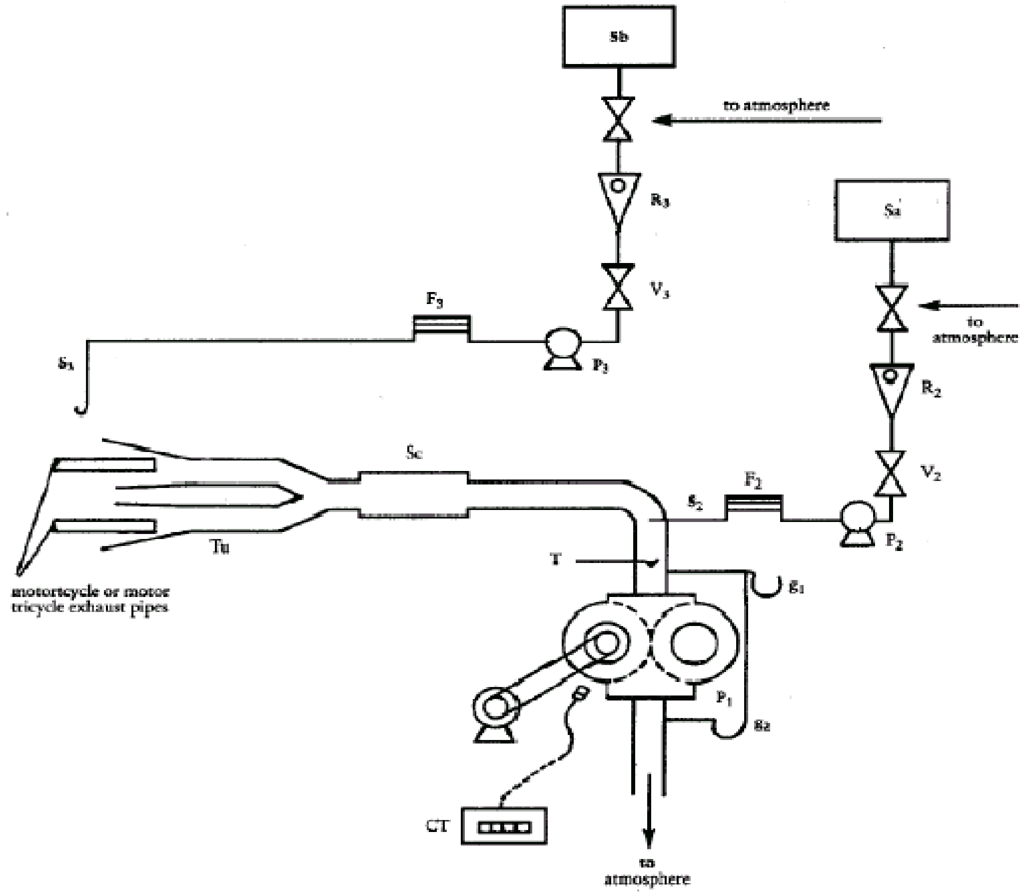

Figure 6-2: Equipment for sampling the gases and measuring their volume

6.5.3.2. A connecting tube 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.

6.5.3.3. A heat exchanger capable of limiting the temperature variation of the diluted gases in the pump intake to ± 5 °C throughout the test. This exchanger shall be equipped with a preheating system able to bring the exchanger to its operating temperature (with the tolerance of ± 5 °C) before the test begins.

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

6.5.3.5. A device (T) to allow continuous recording of the temperature of the diluted exhaust mixture entering the pump.

6.5.3.6. Two gauges; the first to ensure the pressure depression of the dilute exhaust mixture entering the pump, relative to atmospheric pressure, the other to measure the dynamic pressure variation of the positive displacement pump.

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

6.5.3.8. A sample probe pointed upstream into the dilute exhaust mixture flow, upstream of the positive displacement pump to collect, through a pump, a filter and a flow meter, samples of the dilute exhaust mixture, at constant flow rates, throughout the test. The minimum sample flow rate in the two sampling devices described above and in paragraph 6.5.3.7. shall be at least 150 litre/hour.

6.5.3.9. Three way valves on the sampling system described in paragraph 6.5.3.7. and paragraph 6.5.3.8. to direct the samples either to their respective bags or to the outside throughout the test.

6.5.3.10. Gas-tight collection bags

6.5.3.10.1. For dilution air and dilute exhaust mixture of sufficient capacity so as not to impede normal sample flow and which will not change the nature of the pollutants concerned.

6.5.3.10.2. 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.

6.5.3.11. A revolution counter to count the revolutions of the positive displacement pump throughout the test.

Note 2 Good care shall be taken on the connecting method and the material or configuration of the connecting parts because there is a possibility that each section (e.g. the adapter and the coupler) of the sampling system becomes very hot. If the measurement cannot be performed normally due to heat-damages of the sampling system, an auxiliary cooling device may be used as long as the exhaust gases are not affected.

Note 3 Open type devices have risks of incomplete gas collection and gas leakage into the test cell. It is necessary to make sure there is no leakage throughout the sampling period.

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

6.5.4. Driving schedules

6.5.4.1. Test cycles

Test cycles (vehicle speed patterns), for the Type I test consists of up to three parts that are shown in annex 5. Depending on the vehicle class (see paragraph 6.3.) the following test cycle parts have to be run:

Class 1:	part 1, reduced speed in cold condition, followed by part 1 reduced speed in hot condition.
Class 2:	
Subclass 2-1:	part 1, reduced speed in cold condition, followed by part 1 reduced speed in hot condition.
Subclass 2-2:	part 1 in cold condition, followed by part 2 in hot condition.

Class 3:

Subclass 3-1:	part 1 in cold condition, followed by part 2 in hot condition, followed by part 3 reduced speed in hot condition.
Subclass 3-2:	part 1 in cold condition, followed by part 2 in hot condition, followed by part 3 in hot condition.

6.5.4.2. Speed tolerances

6.5.4.2.1. The speed tolerance at any given time on the test cycle prescribed in paragraph 6.5.4.1. is defined by upper and lower limits. The upper limit is 3.2 km/h higher than the highest point on the trace within 1 second of the given time. The lower limit is 3.2 km/h lower than the lowest point on the trace within 1 second of the given time. Speed variations greater than the tolerances (such as may occur during gear changes) are acceptable provided they occur for less than 2 seconds on any occasion. Speeds lower than those prescribed are acceptable provided the vehicle is operated at maximum available power during such occurrences. Figure 6-3 shows the range of acceptable speed tolerances for typical points.

6.5.4.2.2. Apart from these exceptions the deviations of the roller speed from the set speed of the cycles must meet the requirements described above. If not, the test results shall not be used for the further analysis and the run has to be repeated.

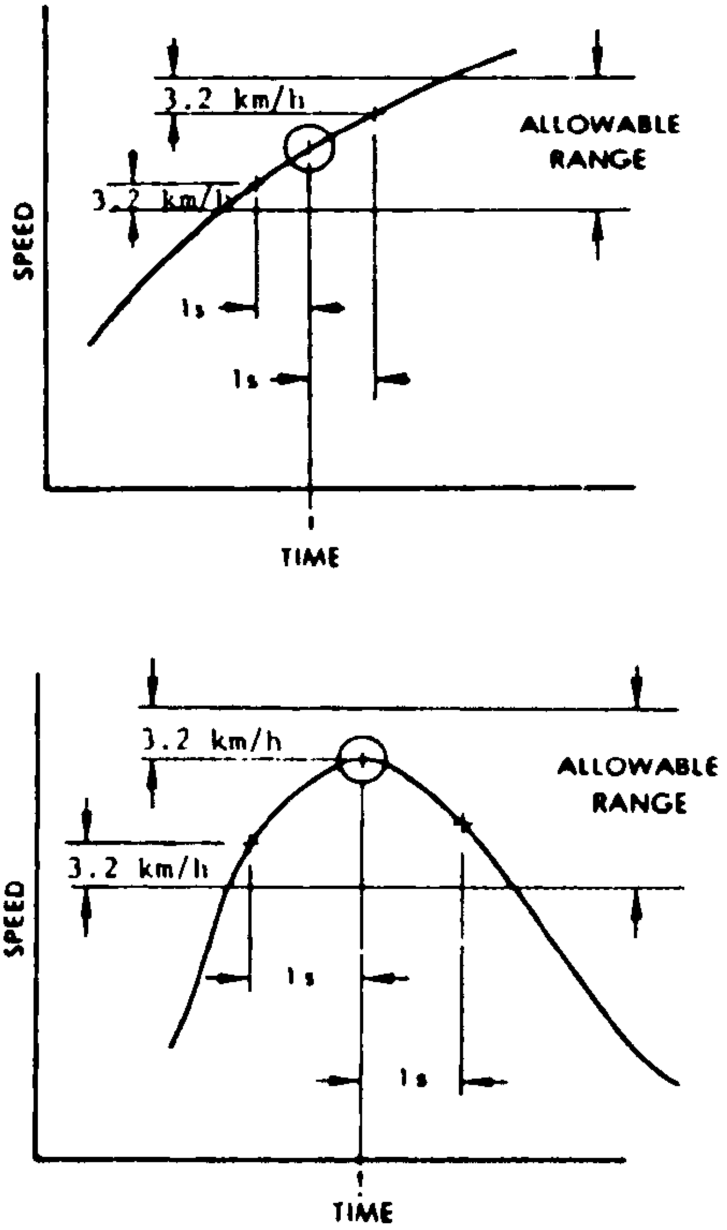

Figure 6-3: Drivers trace, allowable range

6.5.5. **Gearshift prescriptions**

6.5.5.1. Test vehicles (motorcycles) with automatic transmission

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

All tests shall be conducted with automatic transmissions in "Drive" (highest gear). Automatic clutch-torque converter transmissions may be shifted as manual transmissions at the option of the manufacturer.

Idle modes shall be run with automatic transmissions in "Drive" and the wheels braked.

Automatic transmissions shall shift automatically through the normal sequence of gears.

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

6.5.5.2. Test vehicles (motorcycles) with manual transmission

6.5.5.2.1. Mandatory Requirements

6.5.5.2.1.1. Step 1 – Calculation of shift speeds

Upshift speeds ($v_{1\rightarrow 2}$ and $v_{i\rightarrow i+1}$) in km/h during acceleration phases shall be calculated using the following equations:

Equation 6-1:

$$v_{1\rightarrow 2} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_1}$$

Equation 6-2:

$$v_{i\rightarrow i+1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_i}, \ i = 2 \text{ to } ng\text{-}1$$

Where:

i	is the gear number (≥ 2),
ng	is the total number of forward gears,
P_n	is the rated power in kW,
m_k	is the kerb mass in kg,
n_{idle}	is the idling 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 speeds ($v_{i\rightarrow i-1}$) in km/h during cruise or deceleration phases in gear 4 (4^{th} gear) to ng shall be calculated using the following equation:

Equation 6-3:

$$v_{i\rightarrow i-1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_{i-2}}, \ i = 4 \text{ to } ng$$

Where:

i	is the gear number (≥ 4),
ng	is the total number of forward gears,
P_n	is the rated power in kW,
m_k	is the kerb mass in kg,
n_{idle}	is the idling 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 speed from gear 3 to gear 2 ($v_{3\to2}$) shall be calculated using the following equation:

Equation 6-4:

$$v_{3\to2} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_1}$$

Where:

P_n	is the rated power in kW,
m_k	is the kerb mass in kg,
n_{idle}	is the idling 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 speed from gear 2 to gear 1 ($v_{2\to1}$) should be calculated using the following equation:

Equation 6-5:

$$v_{2\to1} = \left[0.03 \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_2}$$

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 speed increases could occur and it may be meaningful to apply an upshift. The upshift speeds ($v_{1\to2}$, $v_{2\to3}$ and $v_{i\to i+1}$) in km/h during cruise phases may be calculated using the following equations:

Equation 6-6:

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

Equation 6-7:

$$v_{2\to3} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_1}$$

Equation 6-8:

$$v_{i\to i+1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle} \right] \times \frac{1}{ndv_{i-1}}, \; i = 3 \text{ to } ng$$

6.5.5.2.1.2. Step 2 – Gear choice for each cycle sample

In order to avoid different interpretations about acceleration, deceleration, cruise and stop phases corresponding indicators are added to the vehicle speed pattern as integral parts of the cycles (see tables in Annex 5).

The appropriate gear for each sample shall then be calculated according to the vehicle speed ranges resulting from the shift speed equations of paragraph 6.5.5.2.1.1. and these phase indicators for the cycle parts appropriate for the test vehicle as follows:

Gear choice for stop phases:

For the last 5 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 $v \leq v_{1\rightarrow 2}$,
gear 2, if $v_{1\rightarrow 2} < v \leq v_{2\rightarrow 3}$,
gear 3, if $v_{2\rightarrow 3} < v \leq v_{3\rightarrow 4}$,
gear 4, if $v_{3\rightarrow 4} < v \leq v_{4\rightarrow 5}$,
gear 5, if $v_{4\rightarrow 5} < v \leq v_{5\rightarrow 6}$,
gear 6, if $v > v_{5\rightarrow 6}$.

Gear choice for deceleration or cruise phases:

gear 1, if $v < v_{2\rightarrow 1}$,
gear 2, if $v < v_{3\rightarrow 2}$,
gear 3, if $v_{3\rightarrow 2} \leq v < v_{4\rightarrow 3}$,
gear 4, if $v_{4\rightarrow 3} \leq v < v_{5\rightarrow 4}$,
gear 5, if $v_{5\rightarrow 4} \leq v < v_{6\rightarrow 5}$,
gear 6, if $v \geq v_{4\rightarrow 5}$.

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.

6.5.5.2.1.3. Step 3 – Corrections according to additional requirements

The gear choice has then to 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 speed drops below a downshift speed.

(b) No upshifts or downshifts by more than 1 gear, except from gear 2 to neutral during decelerations down to stop.

(c) Upshifts or downshifts for up to 4 seconds are replaced by the gear before, if the gears before and after are identical. (Examples: 2 3 3 3 2 will be replaced by 2 2 2 2 2, 4 3 3 3 3 4 will be replaced by 4 4 4 4 4 4).

(d) No downshift during an acceleration phase.

6.5.5.2.2. Optional Provisions

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

(a) The use of lower gears than determined by the requirements described in paragraph 6.5.5.2.1. is permitted in any cycle phase. Manufacturers' recommendations for gear use shall be followed, if they do not result in higher gears than determined by the requirements described in paragraph 6.5.5.2.1.

Note 5 The calculation program to be found on the UN website at the URL below may be used as an aid for the gear selection:
http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/wmtc.html

Explanations about the approach and the gearshift strategy and a calculation example are given in Annex 13.

6.5.6. Dynamometer settings

A full description of the chassis dynamometer and instruments shall be provided in accordance with Annex 6. Measurements shall be made to the accuracies as specified in paragraph 6.5.7. 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 (see Annex 3).

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

To use this alternative on road cost down measurements have to be carried out as specified in Annex 7.

6.5.6.1.1. Requirements for the equipment

The instrumentation for the speed and time measurement shall have the accuracies as specified in paragraph 6.5.7.

6.5.6.1.2. Inertia mass setting

6.5.6.1.2.1. The equivalent inertia mass for the chassis dynamometer shall be the flywheel equivalent inertia mass, m_{fi} , closest to the actual mass of the motorcycle, m_a. The actual mass, m_a, is obtained by adding the rotating mass of the front wheel, m_{rf}, to the total mass of the motorcycle, rider and instruments measured during the road test. Alternatively, the equivalent inertia mass m_i can be derived from Annex 3. The value of m_{rf}, in kilograms, may be measured or calculated as appropriate, or may be estimated as 3 per cent of m.

6.5.6.1.2.2. If the actual mass m_a cannot be equalized to the flywheel equivalent inertia mass m_i, 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:

$$\Delta T_{road} = \frac{1}{3.6}(m_a + m_{r1})\frac{2\Delta v}{F^*}$$ Equation 6-4

$$\Delta T_E = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{F_E}$$ Equation 6-5

$$F_E = F^*$$ Equation 6-6

$$\Delta T_E = \Delta T_{road} \times \frac{m_i + m_{r1}}{m_a + m_{r1}}$$ Equation 6-7

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 per cent of m.

6.5.6.2. Running resistance force derived from a running resistance table

6.5.6.2.1. The chassis dynamometer can 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 mass in running order regardless of particular motorcycle characteristics.

Note 6 Cares should be taken for the application of this method to motorcycles having extraordinary characteristics.

6.5.6.2.2. The flywheel equivalent inertia mass m_{fi} shall be the equivalent inertia mass m_i specified in Annex 3. The chassis dynamometer shall be set by the rolling resistance of the front wheel a and the aero drag coefficient b as specified in Annex 3.

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

$$F_E = F_T = a + b \times v^2$$ Equation 6-8

6.5.6.2.4. 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.

6.5.7. Measurement accuracies

Measurements have to be carried out using equipment that fulfil the accuracy requirements as described in table 6-1 below:

Table 6-1: Required accuracy of measurements

Measurement Items	At measured value	Resolution
a) Running resistance force, F	+ 2 per cent	-
b) Motorcycle speed (v_1, v_2)	± 1 per cent	0.2 km/h
c) Coast down speed interval ($2\Delta v = v_1 - v_2$)	± 1 per cent	0.1 km/h
d) Coast down time (Δt)	± 0.5 per cent	0.01 s
e) Total motorcycle mass ($m_k + m_{rid}$)	± 0.5 per cent	1.0 kg
f) Wind speed	± 10 per cent	0.1 m/s
g) Wind direction	-	5 deg.

h)	Temperatures	± 1 °C	1 °C
i)	Barometric pressure	-	0.2 kPa
j)	Distance	± 0.1per cent	1 m
k)	Time	± 0.1 s	0.1 s

6.6. Type II tests

6.6.1. Application

This requirement applies to all test vehicles (motorcycles) powered by a positive-ignition engine.

The carbon monoxide and Hydrocarbons content by volume of the exhaust gases emitted with the engine idling must not exceed as per the limits mentioned in 4.1 of Part I of this document

6.6.2. Test fuel

The fuel shall be the reference fuel whose specifications are given in paragraph 6.4 to this regulation.

6.6.3. Measured gaseous pollutant

The content by volume of carbon monoxide shall be measured immediately after the Type I test.

6.6.4. Engine test speeds

The test has to be carried out with the engine at normal idling speed and at "high idle" speed. High idle speed is defined by the manufacturer but it has to be higher than 2,000 min^{-1}.

6.6.5. Gear lever position

In the case of test vehicles (motorcycles) with manually operated or semi-automatic shift gearboxes, the test shall be carried out with the gear lever in the "neutral" position and with the clutch engaged. In the case of test vehicles (motorcycles) with automatic-shift gearboxes, the test shall be carried out with the gear selector in either the "zero" or the "park" position.

7. <u>Test procedures</u>

7.1. Description of tests.

The test vehicle (motorcycle) shall be subjected, according to its category, to tests of two types, I and II, as specified below.

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

7.1.1.1. The test shall be carried out by the method described in paragraph 7.2. to this regulation. The gases shall be collected and analysed by the prescribed methods.

7.1.1.2. Number of tests

7.1.1.2.1. The number of tests shall be determined as shown in figure 7-1. R_{i1} to R_{i3} describe the final measurement results for the first (No.1) test to the third (No.3) test and the gaseous pollutant, the carbon dioxide emission or fuel consumption as defined in paragraph 8.1.1.6. L is the limit value as defined in paragraph 5.

7.1.1.2.2. In each test, the mass of the carbon monoxide, the mass of the hydrocarbons, the mass of the nitrogen oxides, the mass of carbon dioxide and the mass of the fuel, consumed during the test shall be determined.

7.1.2. Type II test (test of carbon monoxide at idling speed) and emissions data required for roadworthiness testing.

The carbon monoxide content of the exhaust gases emitted shall be checked by a test with the engine at normal idling speed and at "high idle" speed (i.e. > 2.000 min^{-1}) carried out by the method described in paragraph 7.3. to this regulation.

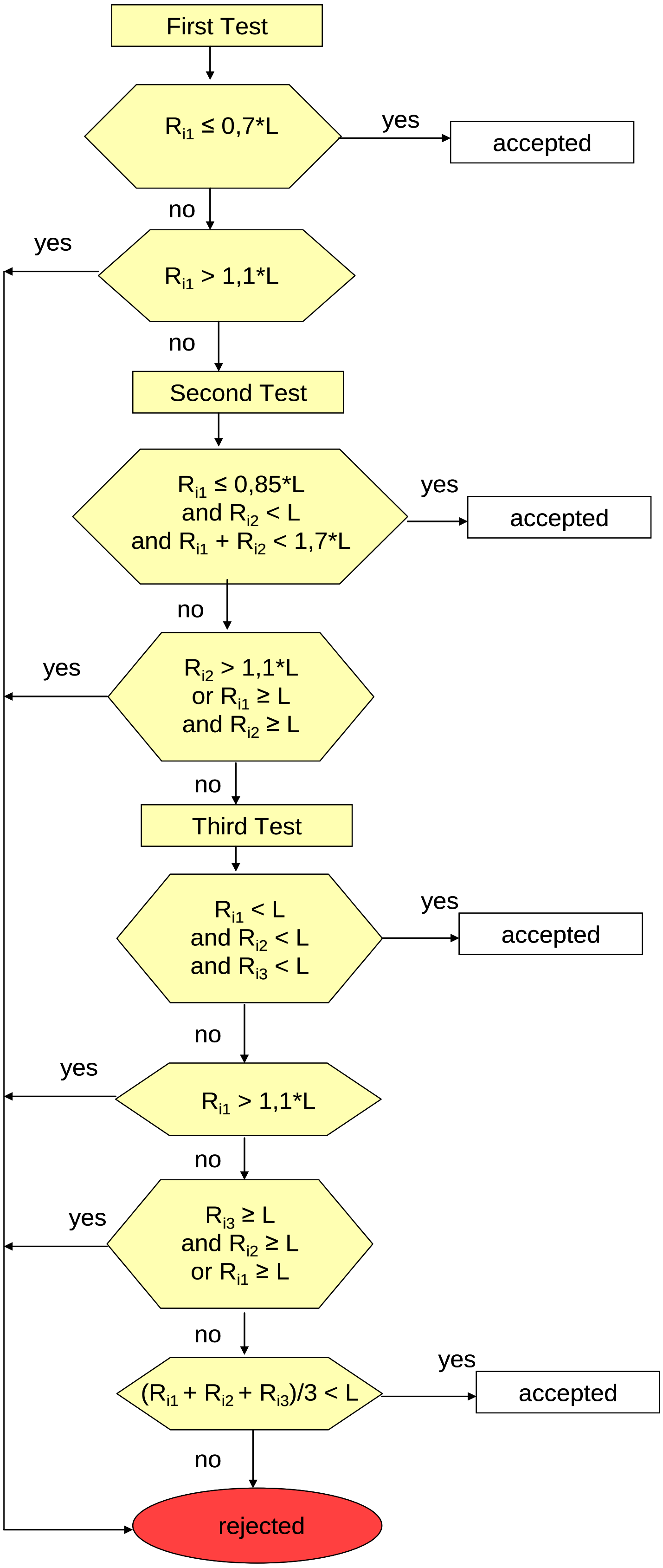

Figure 7-1: Flowchart for the number of Type I tests

7.2. Type I tests

7.2.1. Overview

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

7.2.1.2. The test is designed to determine hydrocarbon, carbon monoxide, oxides of nitrogen, carbon dioxide mass emissions and fuel consumption while simulating real world operation. The test consists of engine start-ups and motorcycle 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 constant volume (variable dilution) sampler (CVS).

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

7.2.1.4. Background concentrations are measured for all species for which emissions measurements are made. For exhaust testing, this requires sampling and analysis of the dilution air.

7.2.2. Dynamometer settings and verification

7.2.2.1. Test vehicle (motorcycle) preparation

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

7.2.2.1.2. The tyre pressures shall be adjusted to the specifications of the manufacturer or to those at which the speed of the motorcycle during the road test and the motorcycle speed obtained on the chassis dynamometer are equal.

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

7.2.2.2. 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 stabilized frictional force F_f. The load on the chassis dynamometer F_E is, in view of its construction, composed of the total friction loss F_f which is the sum of the chassis dynamometer rotating frictional resistance, the tyre rolling resistance, the frictional resistance of the rotating parts in the driving system of the motorcycle and the braking force of the power absorbing unit (pau) F_{pau}, as shown in the following equation:

$$F_E = F_f + F_{pau} \qquad \text{Equation 7-1}$$

The target running resistance force F^* derived from paragraph 6.3 of Annex 7 shall be reproduced on the chassis dynamometer in accordance with the motorcycle speed. Namely:

$$F_E(v_i) = F^*(v_i) \qquad \text{Equation 7-2}$$

The total friction loss F_f on the chassis dynamometer shall be measured by the method in paragraph 7.2.2.2.1. or paragraph 7.2.2.2.2.

7.2.2.2.1. Motoring by chassis dynamometer

This method applies only to chassis dynamometers capable of driving a motorcycle. The motorcycle shall be driven by the chassis dynamometer steadily at the reference speed v_0 with the transmission engaged and the clutch disengaged. The total friction loss F_f (v_0) at the reference speed v_0 is given by the chassis dynamometer force.

7.2.2.2.2. Coast down without absorption

The method of measuring the coast down time is the coast down method for the measurement of the total friction loss F_f. The motorcycle coast down shall be performed on the chassis dynamometer by the procedure described in paragraph 5 of Annex 7 with zero chassis dynamometer absorption, and 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 $\overline{\Delta t}$ shall be calculated by the following equation:

$$\overline{\Delta t} = \frac{1}{n}\sum_{i=1}^{n} \Delta t_i$$ Equation 7-3

7.2.2.2.3. Total friction loss

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

$$F_f(v_0) = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t}$$ Equation 7-4

7.2.2.2.4. Calculation of power absorption unit force

The force $F_{pau}(v_0)$ to be absorbed by the chassis dynamometer at the reference 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:

$$F_{pau}(v_0) = F^*(v_0) - F_f(v_0)$$ Equation 7-5

7.2.2.2.5. Chassis dynamometer setting

According to its type, the chassis dynamometer shall be set by one of the methods described in paragraphs 7.2.2.2.5.1. to 7.2.2.2.5.4. The chosen setting shall be applied to the pollutant emissions measurements as well as to the CO_2 emission measurements.

7.2.2.2.5.1. 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 speed points, at least three specified speeds, including the reference speed, shall be chosen as the setting points. At each setting point, the chassis dynamometer shall be set to the value $F_{pau}(v_j)$ obtained in paragraph 7.2.2.2.4.

7.2.2.2.5.2. 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 $F_{pau}(v_j)$ at each specified speed should be calculated by the procedure in paragraph 7.2.2.2.

Assuming the load characteristics to be:

$$F_{pau}(v) = a \times v^2 + b \times v + c \qquad \text{Equation 7-6}$$

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.

7.2.2.2.5.3. Chassis dynamometer with F^* polygonal digital setter

In the case of a chassis dynamometer with a polygonal digital setter, where a central processor unit (CPU) is incorporated in the system, F^* is input directly, and Δt_i, F_f and F_{pau} are automatically measured and calculated to set the chassis dynamometer to the target running resistance force $F^* = f^* + f^*_2 \times v^2$.

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

$$F^* + F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i} \qquad \text{Equation 7-7}$$

$$F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i} - F^* \qquad \text{Equation 7-8}$$

$$F_{pau} = F^* - F_f \qquad \text{Equation 7-9}$$

7.2.2.2.5.4. Chassis dynamometer with f^*_0, f^*_2 coefficient digital setter

In the case of a chassis dynamometer with a coefficient digital setter, where a CPU (central processor unit) is incorporated in the system, the target running resistance force $F^* = f^*_0 + f^*_2 \times v^2$ 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. F_{pau} is automatically calculated and set at motorcycle speed intervals of 0.06 km/h, in the following sequence:

$$F^* + F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i}$$ Equation 7-10

$$F_f = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_i} - F^*$$ Equation 7-11

$$F_{pau} = F^* - F_f$$ Equation 7-12

7.2.2.2.6. Dynamometer settings verification

7.2.2.2.6.1. 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 same procedure as in paragraph 5 of Annex 7. 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, $F_E(v_0)$ on the chassis dynamometer is calculated by the following equation:

$$F_E(v_0) = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{\Delta t_E}$$ Equation 7-13

7.2.2.2.6.2. Calculation of setting error

The setting error ε is calculated by the following equation:

$$\varepsilon = \frac{\left| F_E(v_0) - F^*(v_0) \right|}{F^*(v_0)} \times 100$$ Equation 7-14

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

$\varepsilon \le 2$ per cent for $v_0 \ge 50$ km/h
$\varepsilon \le 3$ per cent for 30 km/h $\le v_0 < 50$ km/h
$\varepsilon \le 10$ per cent for $v_0 < 30$ km/h

The procedure in paragraphs 7.2.2.2.6.1. to 7.2.2.2.6.2. shall be repeated until the setting error satisfies the criteria. The chassis dynamometer setting and the observed errors shall be recorded. The examples of the record forms are given in Annex 9.

7.2.2.3. Dynamometer preparation, if settings are derived from a running resistance table

7.2.2.3.1. The specified speed for the chassis dynamometer

The running resistance on the chassis dynamometer shall be verified at the specified speed v. At least four specified speeds should be verified. The range of specified speed points (the interval between the maximum and minimum points) shall extend either side of the reference speed or the reference speed range, if there is more than one reference speed, by at least Δv, as defined in paragraph 4. of Annex 7. The specified speed points, including the reference speed point(s), shall be no greater than 20 km/h apart and the interval of specified speeds should be the same.

7.2.2.3.2. Verification of chassis dynamometer

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

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

7.2.2.3.2.3. The set running resistance force $F_E(v_j)$ at the specified speed on the chassis dynamometer is calculated by the following equation:

$$F_E(v_j) = \frac{1}{3.6} \times m_i \times \frac{2\Delta v}{\Delta t_E}$$ Equation 7-15

7.2.2.3.2.4. The setting error ε at the specified speed is calculated by the following equation:

$$\varepsilon = \frac{|F_E(v_j) - F_T|}{F_T} \times 100$$ Equation 7-16

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

$\varepsilon \leq 2$ per cent for $v \geq 50$ km/h

$\varepsilon \leq 3$ per cent for 30 km/h $\leq v <$ 50 km/h

$\varepsilon \leq 10$ per cent for $v <$ 30 km/h

7.2.2.3.2.6. The procedure described above shall be repeated until the setting error satisfies the criteria. The chassis dynamometer setting and the observed errors shall be recorded. An example of the record form is given in Annex 10.

7.2.3. Calibration of analysers

7.2.3.1. The quantity of gas at the indicated pressure compatible with the correct functioning of the equipment shall be injected into the analyser with the aid of the flow metre and the pressure-reducing valve mounted on each gas cylinder. The apparatus shall be adjusted to indicate as a stabilized value the value inserted on the standard gas cylinder. Starting from the setting obtained with the gas cylinder of greatest capacity, a curve shall be drawn of the deviations of the apparatus according to the content of the various standard cylinders used. The flame ionisation analyser shall be recalibrated periodically, at intervals of not more than one month, using air/propane or air/hexane mixtures with nominal hydrocarbon concentrations equal to 50 per cent and 90 per cent of full scale.

7.2.3.2. Non-dispersive infrared absorption analysers shall be checked at the same intervals using nitrogen/C0 and nitrogen/CO_2 mixtures in nominal concentrations equal to 10, 40, 60, 85 and 90 per cent of full scale.

7.2.3.3. To calibrate the NO_X chemiluminescence analyser, nitrogen/nitrogen oxide (NO) mixtures with nominal concentrations equal to 50 per cent and 90 per cent of full scale shall be used. The calibration of all three types of analysers shall be checked before each series of tests, using mixtures of the gases, which are measured in a concentration equal to 80 per cent of full scale. A dilution device can be applied for diluting a 100 per cent calibration gas to required concentration.

7.2.4. Test vehicle (motorcycle) preconditioning

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

- The fuel tank(s) shall be drained through the provided fuel tank(s) drain(s) and charged with the test fuel as specified in paragraph 6.4. to half the tank(s) capacity.

- The test vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through the cycles as specified in paragraph 6.5.4. The vehicle need not be cold, and may be used to set dynamometer power.

7.2.4.2. 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 speed-time relationship, or to permit sampling system adjustments.

7.2.4.3. Within 5 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 not less than 6 hours and not more than 36 hours prior to the cold start Type I test or until the engine oil temperature T^O or the coolant temperature T^C or the sparkplug seat/gasket temperature T^P (only for air cooled engine) equals the air temperature of the soak area.

7.2.5. Emissions tests

7.2.5.1. Engine starting and restarting

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

7.2.5.1.2. Test vehicles equipped with automatic chokes shall be operated according to the instructions in the manufacturer's operating instructions or owner's manual including choke setting and "kick-down" from cold fast idle. The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

7.2.5.1.3. 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.

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

7.2.5.1.5. 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 half way and cranking the engine until it starts.

7.2.5.1.6. If, during the cold start, the test vehicle does not start after 10 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.

7.2.5.1.7. If failure to start is an operational error, 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) of less than 30 minutes duration may be taken and the test continued. The sampling system shall be reactivated at the same time cranking is started. When the engine starts, the driving schedule timing sequence shall begin. 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. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

7.2.5.1.8. If the test vehicle does not start during the hot 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.

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

7.2.5.2. Stalling

7.2.5.2.1. If the engine stalls during an idle period, the engine shall be restarted immediately and the test continued. If the engine 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.

7.2.5.2.2. If the engine stalls during some operating mode other than idle, the driving schedule indicator shall be stopped, the test vehicle shall then be restarted and accelerated to the speed required at that point in the driving schedule and the test continued. During acceleration to this point, shifting shall be performed in accordance with paragraph 6.5.5.

7.2.5.2.3. 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.

7.2.6. Drive instructions

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

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

7.2.7. Dynamometer test runs

7.2.7.1. The complete dynamometer test consists of consecutive parts as described in paragraph 6.5.4.

7.2.7.2. 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 should 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.
- For gaseous bag samples (except hydrocarbon samples), the minimum flow rate is 0.08 litre/second.
- For hydrocarbon samples, the minimum flame ionization detection (FID) (or heated flame ionization 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 tailpipe(s).

(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) Fifteen seconds after the engine starts, place the transmission in gear.

(i) Twenty seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule.

(j) Operate the vehicle according to the driving cycles specified in paragraph 6.5.4.

(k) At the end of the part 1 or part 1 reduced speed 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 class 3 vehicles, 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 8.1.1., obtaining a stabilised reading of the exhaust bag sample on all analysers within 20 minutes of the end of the sample collection phase of the test.

(n) Turn the engine off 2 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 tailpipe(s) of the vehicle.

(q) Disconnect the exhaust tube from the vehicle tailpipe(s) and remove the vehicle from dynamometer.

(r) For comparison and analysis reasons besides the bag results also second by second data of the emissions (diluted gas) have to be monitored."

7.3. Type II tests

7.3.1. Conditions of measurement

7.3.1.1. The Type II test specified in paragraph 6.6. must be measured immediately after the Type I test with the engine at normal idling speed and at high idle.

7.3.1.2. The following parameters must be measured and recorded at normal idling speed and at high idle speed:
(a) the carbon monoxide content by volume of the exhaust gases emitted,
(b) the carbon dioxide content by volume of the exhaust gases emitted,
(c) the engine speed during the test, including any tolerances,
(d) the engine oil temperature at the time of the test.

7.3.2. Sampling of exhaust gases

7.3.2.1. The exhaust outlets shall be provided with an air-tight extension, so that the sample probe used to collect exhaust gases may be inserted into the exhaust outlet at least 60 cm, without increasing the back pressure of more than 125 mm H_20, and without disturbance of the vehicle running. The shape of this extension shall however be chosen in order to avoid, at the location of the sample probe, any appreciable dilution of exhaust gases in the air. Where a motorcycle is equipped with an exhaust system having multiple outlets, either these shall be joined to a common pipe or the content of carbon monoxide must be collected from each of them, the result of the measurement being reached from the arithmetical average of these contents.

7.3.2.2. The concentrations in CO (C_{CO}) and CO2 (C_{CO2}) shall be determined from the measuring instrument readings or recordings, by use of appropriate calibration curves. The results have to be corrected according to paragraph 8.2.

8. <u>Analysis of results</u>

8.1. Type I tests

8.1.1. Exhaust emission and fuel consumption analysis

8.1.1.1. Analysis of the samples contained in the bags

The analysis shall begin as soon as possible, and in any event not later than 20 minutes after the end of the tests, in order to determine:

- the concentrations of hydrocarbons, carbon monoxide, nitrogen oxides and carbon dioxide in the sample of dilution air contained in bag(s) B;

- the concentrations of hydrocarbons, carbon monoxide, nitrogen oxides and carbon dioxide in the sample of diluted exhaust gases contained in bag(s) A.

8.1.1.2. 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 must be set to zero with the appropriate zero gas.
(b) The analysers are then set to the calibration curves by means of span gases of nominal concentrations of 70 per cent to 100 per cent of the range.

(c) The analysers' zeros are then rechecked. If the reading differs by more than 2 per cent of range from that set in b), the procedure is repeated.
(d) The samples are then analysed.
(e) After the analysis, zero and span points are rechecked using the same gases. If these rechecks are within 2 per cent of those in c), the analysis is considered acceptable.
(f) At all points in this section the flow-rates and pressures of the various gases must be the same as those used during calibration of the analysers.
(g) The figure adopted for the concentration of each pollutant measured in the gases is that read off after stabilisation on the measuring device.

8.1.1.3. Measuring the distance covered

The distance actually covered for a test part shall be arrived at by multiplying the number of revolutions read from the cumulative counter (see paragraph 7.2.7.) by the circumference of the roller. This distance shall be measured in km.

8.1.1.4. 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 formulas. The results of all emission tests shall be rounded, using the "Rounding-Off Method" specified in ASTM E 29-67, to the number of places to the right of the decimal point indicated by expressing the applicable standard to three significant figures.

8.1.1.4.1. Total volume of diluted gas

The total volume of diluted gas, expressed in m^3/cycle part, adjusted to the reference conditions of 20 °C (293 K) and 101.3 kPa is calculated by

$$V = \frac{293.15 \times V_0 \times N \times (P_a - P_i)}{101.325 \times (T_P + 273.15)}$$ Equation 8-1

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;

P_a is the ambient pressure in kPa;

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

T_P is the temperature of the diluted gases during the test part in °C, measured in the intake section of pump P.

8.1.1.4.2. Hydrocarbons

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

$$HC_m = \frac{HC_c \times V \times dHC}{dist \times 10^3}$$ Equation 8-2

where:

HC_m is the mass of hydrocarbons emitted during the test part, in g/km
dist is the distance defined in paragraph 8.1.1.3. above;
V is the total volume, defined in paragraph 8.1.1.4.1.,
dHC is the density of the hydrocarbons at a temperature of 20 °C and a pressure of 101.3 kPa, where the average carbon/hydrogen ratio is 1:1.85; dHC = 0.577 kg/m^3 for gasoline
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 3), corrected to take account of the dilution air by the following equation:

$$HC_c = HC_e - HC_d \times (1 - \frac{1}{DF})$$ Equation 8-3

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,
DF is the coefficient defined in paragraph 8.1.1.4.6. below.

8.1.1.4.3. Carbon monoxide

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

$$CO_m = \frac{CO_c \times V \times dCO}{dist \times 10^3}$$ Equation 8-4

where:
CO_m is the mass of carbon monoxide emitted during the test part, in g/km
dist is the distance defined in paragraph 8.1.1.3.,
V is the total volume defined in paragraph 8.1.1.4.1.,
dCO is the density of the carbon monoxide at a temperature of 20 °C and a pressure of 101.3 kPa, dCO = 1.16 kg/m^3,
CO_c s 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:

$$CO_c = CO_e - CO_d \times (1 - \frac{1}{DF})$$ Equation 8-5

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,
DF is the coefficient defined in paragraph 8.1.1.4.6. below.

8.1.1.4.4. Nitrogen oxides

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

$$NO_{x_m} = \frac{NO_{x_c} \times K_h \times V \times dNO_2}{dist \times 10^3}$$ Equation 8-6

where:

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

dist is the distance defined in paragraph 8.1.1.3.,

V is the total volume defined in paragraph 8.1.1.4.1.,

dNO_2 is the density of the nitrogen oxides in the exhaust gases, assuming that they will be in the form of nitric oxide, at a temperature of 20 °C and a pressure of 101.3 kPa, dNO_2 = 1.91 kg/m^3,

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:

$$NO_{x_c} = NO_{x_e} - NO_{x_d} \times (1 - \frac{1}{DF})$$ Equation 8-7

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,

DF is the coefficient defined in paragraph 8.1.1.4.6 below,

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

$$K_h = \frac{1}{1 - 0.0329 \times (H - 10.7)}$$ Equation 8-8

where:

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

$$H = \frac{6.211 \times U \times P_d}{P_a - P_d \times \frac{U}{100}}$$ Equation 8-9

where:

U is the humidity in per cent,

P_d is the saturated pressure of water at the test temperature, in kPa,

P_a is the atmospheric pressure in kPa.

8.1.1.4.5. Carbon dioxide

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

$$CO_{2_m} = \frac{CO_{2_c} \times V \times dCO_2}{dist \times 10}$$ Equation 8-10

where:

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

dist is the distance defined in paragraph 8.1.1.3.,

V is the total volume defined in paragraph 8.1.1.4.1.,

dCO_2 is the density of the carbon dioxide at a temperature of 20 °C and a pressure of 101.3 kPa, dCO_2 = 1.83 kg/m^3,

CO_{2c} is the concentration of diluted gases, expressed in per cent carbon dioxide equivalent, corrected to take account of the dilution air by the following equation:

$$CO_{2c} = CO_{2e} - CO_{2d} \times (1 - \frac{1}{DF})$$ Equation 8-11

where:

CO_{2e} is the concentration of carbon dioxide expressed in per cent, in the sample of diluted gases collected in bag(s) A,

CO_{2d} is the concentration of carbon dioxide expressed in per cent, in the sample of dilution air collected in bag(s) B,

DF is the coefficient defined in paragraph 8.1.1.4.6. below.

8.1.1.4.6. Dilution factor DF

The dilution factor DF (in per cent vol.) is a coefficient expressed for gasoline by the formula

$$DF = \frac{13.4}{CO_2 + (CO + HC) \times 10^{-4}}$$ Equation 8-12

where:

CO, CO_2 and HC are the concentrations of carbon monoxide and hydrocarbons, expressed in parts per million (ppm) and carbon dioxide, expressed in per cent, in the sample of diluted gases contained in bag(s) A.

8.1.1.5. Fuel consumption calculation

The fuel consumption, expressed in litres per 100 km is calculated by means of the following formulae:

8.1.1.5.1. Test vehicles (motorcycles) with a positive ignition engine fuelled with petrol

$$FC = \frac{0.1155}{D} \times (0.866 \times HC + 0.429 \times CO + 0.273 \times CO_2)$$ Equation 8-14

where:

FC is the fuel consumption in litre/100 km

HC is the measured emission of hydrocarbons in g/km

CO is the measured emission of carbon monoxide in g/km

CO_2 is the measured emission of carbon dioxide in g/km

D is the density of the test fuel in kg/litre 15 °C.

8.1.1.6. Weighting of results

8.1.1.6.1. In case of repeated measurements (see paragraph 7.1.1.1.) the emission results in g/km and the fuel consumption in litre/100 km obtained by the calculation method described in paragraph 8.1.1. are averaged for each cycle part.

8.1.1.6.2. The (average) result of part 1 or part 1 reduced speed is named R_1, the (average) result of part 2 or part 2 reduced speed is named R_2 and the (average) result of part 3 or part 3 reduced speed is named R_3. Using these emission results in g/km and the fuel consumption in litre/100 km; the final result R, depending on the vehicle class as defined in paragraph 6.3., shall be calculated by means of the following equation:

Class 1 $R = R_1 \times w_1 + R_{1hot} \times w_{1hot}$

Class 2 $R = R_1 \times w_1 + R_2 \times w_2$

Class 3 $R = R_1 \times w_1 + R_2 \times w_2 + R_3 \times w_3$

Equation 8-16

8.1.1.6.3. For each pollutant, the carbon dioxide emission and the fuel consumption the weightings shown in table 8-1 shall be used.

Table 8-1: Weighting factors for the final emission and fuel consumption results

Vehicle class	Cycle	Weighting	
Class 1 and Sub class 2-1	Part 1, cold	w_1	50 per cent
	Part 1, hot	w_{1hot}	50 per cent
Sub class 2-2	Part 1, cold	w_1	30 per cent
	Part 2, hot	w_2	70 per cent
Class 3	Part 1, cold	w_1	25 per cent
	Part 2, hot	w_2	50 per cent
	Part 3, hot	w_3	25 per cent

8.2. Type II tests

8.2.1. The corrected concentration for carbon monoxide (C_{COcorr} in per cent vol.) calculated by the following equations:

8.2.1.1. For two stroke engines:

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

Equation 8-17

8.2.1.2. For four stroke engines:

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

Equation 8-18

8.2.2. The concentration in C_{CO} measured according to paragraph 7.3.2. need not be corrected if the total of the concentrations measured ($C_{CO} + C_{CO_2}$) is at least 10 for two-stroke engines and 15 for four-stroke engines.

9. Records required

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

(a) Test number,

(b) System or device tested (brief description),

(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, 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, actual curb 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 Administration, provided the test cell records show the pertinent instrument information.
(h) All pertinent 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 Administration, provided test cell calibration records show the pertinent instrument information.
(i) Recorder charts: Identify zero, span, 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 per cent 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 should 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 speed pattern of the test.
(p) The gear use schedule of the test.
(q) The emissions results of the Type I test for each part of the test (see Annex 11).
(r) The second by second emission values of the Type I tests, if necessary.
(s) The emissions results of the Type II test (see Annex 12).

Annex 1

SYMBOLS USED

Symbol	Definition	Unit
a	Coefficient of polygonal function	-
a_T	Rolling resistance force of front wheel	N
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	per cent vol.
$C_{CO\ corr}$	Corrected concentration of carbon monoxide	per cent vol.
$CO_{2\ c}$	Carbon dioxide concentration of diluted gas, corrected to take account of diluents air	per cent
$CO_{2\ d}$	Carbon dioxide concentration in the sample of diluents air corrected to in bag B	per cent
$CO_{2\ e}$	Carbon dioxide concentration in the sample of diluents air corrected to in bag A	per cent
$CO_{2\ m}$	Mass of carbon dioxide emitted during the test part	g/km
CO_c	Carbon monoxide concentration of diluted gas, corrected to take account of diluents air	ppm
CO_d	Carbon monoxide concentration in the sample of diluents air, corrected to in bag B	ppm
CO_e	Carbon monoxide concentration in the sample of diluents air, corrected to in bag A	ppm
CO_m	Mass of carbon dioxide emitted during the test part	g/km
d_0	Standard ambient relative air density	-
d_{CO}	Density of carbon monoxide	kg/m^3
d_{CO_2}	Density of carbon dioxide	kg/m^3
DF	Dilution factor	-
d_{HC}	Density of hydrocarbon	kg/m^3
dist	Distance driven in a cycle part	km
d_{NO_X}	Density of nitrogen oxide	kg/m^3
d_T	Relative air density under test condition	-
Δt	Coast down time	s
$\Delta t_{a\ i}$	Coast down time measured the first road test	s
$\Delta t_{b\ i}$	Coast down time measured the second road test	s
ΔT_E	Corrected coast down time for the inertia mass (m_T+ m_{rf})	s
Δt_E	Mean coast down time on the chassis dynamometer at the reference speed	s
ΔT_i	Average coast down time at specified speed	s
Δt_i	Coast down time corresponding speed	s
ΔT_j	Average coast down time at specified speed	s
ΔT_{road}	Target coast down time	s
$\overline{\Delta t}$	Mean coast down time on the chassis dynamometer without absorption	s

Symbol	Definition	Unit
Δv	Coast down speed interval ($2\Delta v = v_1 - v_2$)	km/h
ε	Chassis dynamometer setting error	per cent
F	Running resistance force	N
F^*	Target running resistance force	N
$F^*(v_0)$	Target running resistance force at reference speed on chassis dynamometer	N
$F^*(v_i)$	Target running resistance force at specified 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 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
$F_E(v_0)$	Set running resistance force at the reference speed on the chassis dynamometer	N
$F_E(v_2)$	Set running resistance force at the specified speed on the chassis dynamometer	N
F_f	Total friction loss	N
$F_f(v_0)$	Total friction loss at the reference speed	N
F_j	Running resistance force	N
$F_j(v_0)$	Running resistance force at the reference speed	N
F_{pau}	Braking force of the power absorbing unit	N
$F_{pau}(v_0)$	Braking force of the power absorbing unit at the reference speed	N
$F_{pau}(v_j)$	Braking force of the power absorbing unit at the specified speed	N
F_T	Running resistance force obtained from the running resistance table	N
H	Absolute humidity	g/km
HC_c	Concentration of diluted gases expressed in the carbon equivalent, corrected to take account of diluents air	ppm
HC_d	Concentration of hydrocarbons expressed in the carbon equivalent, in the sample of diluents air corrected to in bag B	ppm
HC_e	Concentration of hydrocarbons expressed in the carbon equivalent, in the sample of diluents air corrected to in bag A	ppm
HC_m	Mass of hydrocarbon emitted during the test part	g/km
K_0	Temperature correction factor for rolling resistance	-
K_h	Humidity correction factor	-
L	Limit values of gaseous emission	g/km
m	Test motorcycle mass	kg
m_a	Actual mass of the test motorcycle	kg
m_{fi}	Flywheel equivalent inertia mass	kg
m_i	Equivalent inertia mass	kg
m_k	Unladen mass of the vehicle (motorcycle)	kg
m_r	Equivalent inertia mass of all the wheel	kg
m_{ri}	Equivalent inertia mass of all the rear wheel and motorcycle parts	kg

Symbol	Definition	Unit
	rotating with wheel	
m_{ref}	Mass in running order of the vehicle (motorcycle)	kg
m_{rf}	Rotating mass of the front wheel	kg
m_{rid}	Rider mass	kg
n	Engine speed	min^{-1}
n	Number of data regarding the emission or the test	-
N	Number of revolution made by pump P	-
ng	Number of foreward gears	-
n_{idle}	Idling speed	min^{-1}
n_max_acc(1)	Upshift speed from 1 to 2 gear during acceleration phases	min^{-1}
n_max_acc(i)	Upshift speed from i to i+1 gear 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 oxides concentration of diluted gases, corrected to take account of diluents air	ppm
NO_{xd}	Nitrogen oxides concentration in the sample of diluents air corrected to in bag B	ppm
NO_{xe}	Nitrogen oxides concentration in the sample of diluents air corrected to in bag A	ppm
NO_{xm}	Mass of nitrogen oxides emitted during the test part	g/km
P_0	Standard ambient pressure	kPa
P_a	Ambient/Atmospheric pressure	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
P_n	Rated engine power	kW
P_T	Mean ambient pressure during the test	kPa
ρ_0	Standard relative ambient air volumetric mass	kg/m^3
r (i)	Gear ratio in the gear i	-
R	Final test result of pollutant emissions, carbon dioxide or fuel consumption	g/km, 1/100km
R_1	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 1 with cold start.	g/km, 1/100km
R_1 hot	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 2 with hot condition.	g/km, 1/100km
R_2	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 3 with hot condition.	g/km, 1/100km
R_3	Test results of pollutant emissions, carbon dioxide emission or fuel consumption for cycle part 1 with hot condition.	g/km, 1/100km
R_{i1}	First Type I test results of pollutant emissions	g/km
R_{i2}	Second Type I test results of pollutant emissions	g/km
R_{i3}	Third Type I test results of pollutant emissions	g/km
s	Rated engine speed	min^{-1}
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	K

Symbol	Definition	Unit
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	K
U	humidity	per cent
v	Specified speed	
V	Total volume of diluted gas	m^3
v_{max}	Maximum speed of test vehicle (motorcycle)	km/h
v_0	Reference speed	km/h
V_0	Volume of gas displaced by pump P during one revolution	m^3/rev.
v_1	Speed at which the measurement of the coast down time begins	km/h
v_2	Speed at which the measurement of the coast down time ends	km/h
v_i	Specified speed which are selected for the coast down time measurement.	km/h
w_1	Weighting factor of cycle part 1 with cold start	-
$w_{1 hot}$	Weighting factor of cycle part 1 with hot condition	-
w_2	Weighting factor of cycle part 2 with hot condition	-
w_3	Weighting factor of cycle part 3 with hot condition	-

Annex 2

A2.1. TECHNICAL DATA OF THE REFERENCE FUEL TO BE USED FOR TESTING VEHICLES EQUIPPED WITH POSITIVE IGNITION ENGINES (UNLEADED PETROL PROPERTIES)

The reference fuel as prescribed in the applicable Gazette notification shall be used. If the engine is lubricated by a fuel oil mixture, the oil added to reference fuel shall comply as to grade and quantity with the manufacturer's recommendation

Annex 3

CLASSIFICATION OF EQUIVALENT INERTIA MASS AND RUNNING RESISTANCE

Mass in running order m_{ref} in kg	**Equivalent inertia mass m_i in kg**	**Rolling resistance of front wheel a in N**	**Aero drag coefficient b in $N/(km/h)^2$**
$95 < m_{ref} \leq 105$	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

CLASSIFICATION OF EQUIVALENT INERTIA MASS AND RUNNING RESISTANCE (CONTINUED)

Mass in running order m_{ref} in kg	**Equivalent inertia mass m_i in kg**	**Rolling resistance of front wheel a in N**	**Aero drag coefficient b in $N/(km/h)^2$**
$355 < m_{ref} \leq 365$	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 4

ESSENTIAL CHARACTERISTICS OF THE ENGINE, THE EMISSION CONTROL SYSTEMS AND INFORMATION CONCERNING THE CONDUCT OF TESTS

Information is to be provided as per AIS 007 Revision 3 or as amended from time to time Additionally following information shall be provided

1. General

1.1. Make: . . . .

1.2. Type (state any possible variants and versions: each variant and each version must be identified by a code consisting of numbers or a combination of letters and numbers):
……………………………………………………………………………

1.2.1 Commercial name (where applicable): . . . .

1.2.2. Vehicle category [1]/): . . . .

1.3. Name and address of manufacturer: . . . .

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

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

2. Masses (in kg) [2]/)

2.1. Unladen mass [3]/): . . . .

2.2. Mass of vehicle in running order[4]/: . . . .

1/ Classification in accordance with paragraph 6.3.

2/ State tolerance(s)

3/ mass of vehicle ready for normal use and equipped as follows:
- additional equipment required solely for the normal use under consideration,
- complete electrical equipment, including the lighting and light-signalling devices supplied by the manufacturer,
- instruments and devices required by the laws under which the unladen mass of the vehicle has been measured,
- the appropriate amounts of liquids in order to ensure the proper operation of all parts of the vehicle.
- the fuel and the fuel/oil mixture are not included in the measurement, but components such as the battery acid, the hydraulic fluid, the coolant and the engine oil must be included.

4/ unladen mass to which the mass of the following components is added:
- fuel: tank filled to at least 90 per cent of the capacity stated by the manufacturer,
- additional equipment normally supplied by the manufacturer in addition to that needed for normal operation (tool kit, luggage carrier, windscreen, protective equipment, etc.).
- in the case of a vehicle operating with a fuel/oil mixture:
  (a) when the fuel and oil are pre-mixed the word "fuel" must be interpreted as meaning a pre-mixture of fuel and oil of this type;

2.2.1. **Distribution of that mass between the axles: . . . .**

2.3. **Mass of vehicle in running order, together with rider [5]/: . . . .**

2.3.1. **Distribution of that mass between the axles: . . . .**

2.4. **Maximum technically permissible mass declared by the manufacturer [6]/: . . . ..**

2.4.1. **Division of that mass between the axles: . . . .**

2.4.2. **Maximum technically permissible mass on each of the axles: . . . .**

3. **Engine [7]/**

3.1. **Manufacturer: . . . .**

3.2. **Make: . . . .**

3.2.1. **Type (stated on the engine, or other means of identification): . . . .**

3.2.2. **Location of engine number (if applicable): . . . .**

3.3. **Spark- or compression-ignition engine[8]/**

3.3.1. **Specific characteristics of the engine**

3.3.1.1. **Operating cycle (four or two-stroke, spark or compression ignition) 8/**

3.3.1.2. **Number, arrangement and firing order of cylinders: . . . . ….**

3.3.1.2.1. **Bore: mm [9]/**

3.3.1.2.2. **Stroke: mm 9/**

3.3.1.3. **Cylinder capacity: cm^3 [10]/**

3.3.1.4. **Compression ratio 2/: . . . .**

3.3.1.5. **Drawings of cylinder head, piston(s), piston rings and cylinder(s): . . . .**

3.3.1.6. **Idling speed 2/: min^{-1}**

3.3.1.7. **Maximum net power output: kW at min^{-1}**

(b) when the fuel and oil are put in separately the word "fuel" must be interpreted as meaning only the petrol. In this case, the oil is already included in the measurement of the unladen mass.

5/ The mass of the rider is taken to be a round figure of 75 kg.

6/ Mass calculated by the manufacturer for specific operating conditions, taking account of factors such as the strength of the materials, loading capacity of the tyres, etc.

7/ Where unconventional engines and systems are fitted, information equivalent to that referred under this heading must be supplied by their manufacturer.

8/ Delete where inappropriate

9/ This figure should be to the nearest tenth of a millimetre

10/ This value should be calculated with p = 3.1416 to the nearest cm^3

3.3.1.8. **Net maximum torque: Nm at min^{-1}**

3.3.2. **Fuel: diesel/petrol/mixture/LPG/other 8/**

3.3.3. **Fuel supply**

3.3.3.1. **Via carburettor(s): yes/no 8/**

3.3.3.1.1. **Make(s): . . . .**

3.3.3.1.2. **Type(s): . . . .**

3.3.3.1.3. **Number fitted: . . . .**

3.3.3.1.4. **Settings 2/**

i.e. of

3.3.3.1.4.1. **Diffusers: . . . .**

3.3.3.1.4.2. **Level in float chamber: . . . .**

3.3.3.1.4.3. **Mass of float: . . . .**

3.3.3.1.4.4. **Float needle: . . . .**

or

3.3.3.1.4.5. **Fuel curve as a function of the airflow and setting required in order to maintain that curve: . . . .**

3.3.3.1.5. **Cold-starting system: manual/automatic 8/**

3.3.3.1.5.1. **Operating principle(s): . . . .**

3.3.3.2. **By fuel injection (solely in the case of compression ignition): yes/no 8/**

3.3.3.2.1. **Description of system: . . . .**

3.3.3.2.2. **Operating principle: direct/indirect/turbulence chamber injection 8/**

3.3.3.2.3. **Injection pump**

either:

3.3.3.2.3.1. **Make(s): . . . .**

3.3.3.2.3.2. **Type(s): . . . .**

or

3.3.3.2.3.3. **Maximum fuel flow rate 2/ mm^3 /per stroke or cycle 8/ at a pump rotational speed of: min^{-1} or characteristic diagram: . . . .**

3.3.3.2.3.4. **Injection advance 2/:. . . . .**

3.3.3.2.3.5. **Injection advance curve 2/: . . . .**

3.3.3.2.3.6. **Calibration procedure: test bench/engine 8/**

3.3.3.2.4. **Regulator**

3.3.3.2.4.1. **Type: . . . .**

3.3.3.2.4.2. **Cut-off point**

3.3.3.2.4.2.1. **Cut-off point under load: min^{-1}**

3.3.3.2.4.2.2. **Cut-off point under no load: min^{-1}**

3.3.3.2.4.3. **Idling speed: min^{-1}**

3.3.3.2.5. **Injection pipework**

3.3.3.2.5.1. **Length: mm**

3.3.3.2.5.2. **Internal diameter: mm**

3.3.3.2.6. **Injector(s)**

either

3.3.3.2.6.1. **Make(s): . . . .**

3.3.3.2.6.2. **Type(s): . . . .**

or

3.3.3.2.6.3. **Opening pressure 2/: . . . . kPa or characteristic diagram 2/: . . . . …..**

3.3.3.2.7. **Cold starting system (if applicable)**

either:

3.3.3.2.7.1. **Make(s): . . . .**

3.3.3.2.7.2. **Type(s): . . . .**

or

3.3.3.2.7.3. **Description: . . . .**

3.3.3.2.8. **Secondary starting device (if applicable)**

either:

3.3.3.2.8.1. **Make(s): . . . .**

3.3.3.2.8.2. **Type(s): . . . .**

or

3.3.3.2.8.3. **Description of system: . . . .**

3.3.3.3. **By fuel injection (solely in the case of spark-ignition): yes/no 8/**

either:

3.3.3.3.1. **Description of system: . . . .**

3.3.3.3.2. **Operating principle: injection into induction manifold (single/multiple point) 8/ /direct injection/other**

(state which): . . . .

or

3.3.3.3.2.1. **Make(s) of the injection pump: . . . .**

3.3.3.3.2.2. **Type(s) of the injection pump: . . . .**

3.3.3.3.3. **Injectors: opening pressure 2/: kPa**

or characteristic diagram 2/: . . . .

3.3.3.3.4. **Injection advance: . . . .**

3.3.3.3.5. **Cold-starting system**

3.3.3.3.5.1. **Operating principle(s): . . . .**

3.3.3.3.5.2. **Operating/setting limits 8/, 2/: . . . .**

3.3.3.4. **Fuel pump: yes/no 8/**

3.3.4. **Ignition**

3.3.4.1. **Make(s): . . . .**

3.3.4.2. **Type(s): . . . .**

3.3.4.3. **Operating principle: . . . .**

3.3.4.4. **Ignition advance curve or operating set point 2/: . . . . …**

3.3.4.5. **Static timing 2/: before TDC**

3.3.4.6. **Points gap 2/: mm**

3.3.4.7. **Dwell angle 2/: degrees**

3.3.5. **Cooling system (liquid/air) 8/**

3.3.5.1. **Nominal setting for the engine-temperature control device: . . . . ….**

3.3.5.2. **Liquid**

3.3.5.2.1. **Nature of liquid: . . . .**

3.3.5.2.2. **Circulating pump(s): yes/no 8/**

3.3.5.3. **Air**

3.3.5.3.1. **Blower: yes/no 8/**

3.3.6. **Induction system**

3.3.6.1. **Supercharging: yes/no 8/**

3.3.6.1.1. **Make(s): . . . .**

3.3.6.1.2. **Type(s): . . . .**

3.3.6.1.3. **Description of system (example: maximum boost pressure kPa, waste gate (where appropriate))**

3.3.6.2. **Intercooler: with/without 8/**

3.3.6.3. **Description and drawings of induction pipework and accessories (plenum chamber, heating device, additional air intakes, etc.): . . . . ….**

3.3.6.3.1. **Description of induction manifold (with drawings and/or photos): . . . .**

3.3.6.3.2. **Air filter, drawings: . . . .**

or

3.3.6.3.2.1. **Make(s): . . . .**

3.3.6.3.2.2. **Type(s): . . . .**

3.3.6.3.3. **Inlet silencer, drawings: . . . .**

or

3.3.6.3.3.1. **Make(s): . . . .**

3.3.6.3.3.2. **Type(s): . . . .**

3.3.7. **Exhaust system**

3.3.7.1. **Drawing of complete exhaust system: . . . .**

3.3.8. **Minimum cross-section of the inlet and exhaust ports: . . . .**

3.3.9. **Induction system or equivalent data**

3.3.9.1. **Maximum valve lift, opening and closing angles in relation to the dead centres, or data concerning the settings of other possible systems: . . . .**

3.3.9.2. **Reference and/or setting ranges <u>8</u>/: . . . .**

3.3.10. **Anti-air pollution measures adopted**

3.3.10.1. **Crankcase-gas recycling device, solely in the case of four-stroke engines (description and drawings):...**

3.3.10.2. **Additional anti-pollution devices (where present and not included under another heading):**

3.3.10.2.1. **Description and/or drawings: . . . .**

3.3.11. **Location of the coefficient of absorption symbol (compression-ignition engines only): . . . .**

3.4. **Cooling system temperatures permitted by the manufacturer**

3.4.1. **Liquid cooling**

3.4.1.1. **Maximum temperature at outlet: °C**

3.4.2. **Air cooling**

3.4.2.1. **Reference point: . . . .**

3.4.2.2. **Maximum temperature at reference point: °C**

3.5. **Lubrication system**

3.5.1. **Description of system: . . . .**

3.5.1.1. **Location of oil reservoir (if any): . . . .**

3.5.1.2. **Feed system (pump/injection into induction system/mixed with the fuel, etc.) <u>8</u>/**

3.5.2. **Lubricant mixed with the fuel**

3.5.2.1. **Percentage: . . . .**

3.5.3. **Oil cooler: yes/no <u>8</u>/**

3.5.3.1. **Drawing(s): . . . .**

or

3.5.3.1.1. **Make(s): . . . .**

3.5.3.1.2. **Type(s): . . . .**

4. **Transmission** [11]**/**

4.1. **Diagram of transmission system: . . . .**

4.2. **Type (mechanical, hydraulic, electrical, etc.): . . . . ….**

4.3. **Clutch (type): . . . .**

4.4. **Gearbox**

4.4.1. **Type: automatic/manual 8/**

4.4.2. **Method of selection: by hand/foot 8/**

11/ The information requested should be supplied for a possible variant.

4.5. Gear ratios

Number of gear	Ratio 1	Ratio 2	Ratio 3	Ratio t
Minimum continuously variable transmission				
1				
2				
3				
4				
5				
6				
Maximum continuously variable transmission				
Reverse gear				

Ratio 1 = primary ratio (ratio of engine speed to rotational speed of primary gearbox shaft).

Ratio 2 = secondary ratio (ratio of rotational speed of primary shaft to rotational speed of secondary shaft in gearbox).

Ratio 3 = final drive ratio (ratio of rotational speed of gearbox output shaft to rotational speed of driven wheels).

Ratio t = overall ratio.

4.5.1. Brief description of the electrical and/or electronic components used in the transmission: . . . . …………………………………………………………...

4.6. Maximum speed of vehicle and gear in which it is reached (in km/h) [12]/:……….

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[12]/ A tolerance of 5 per cent is permitted

Annex 5

DRIVING CYCLES FOR TYPE I TESTS

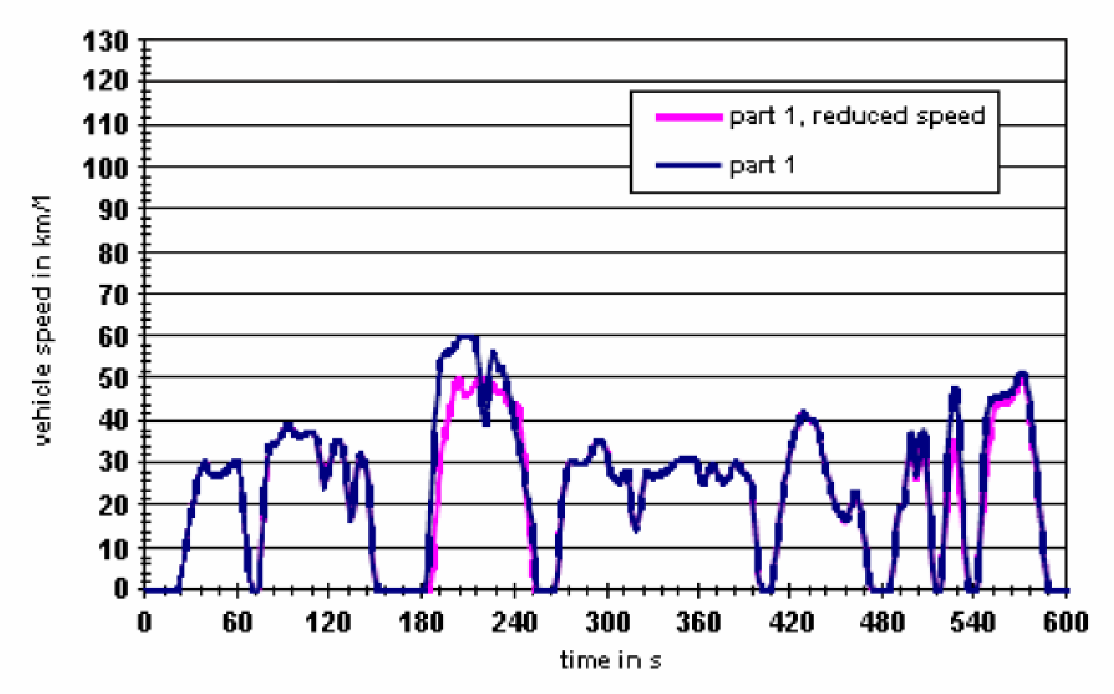


Figure A5-1

Cycle Part 1

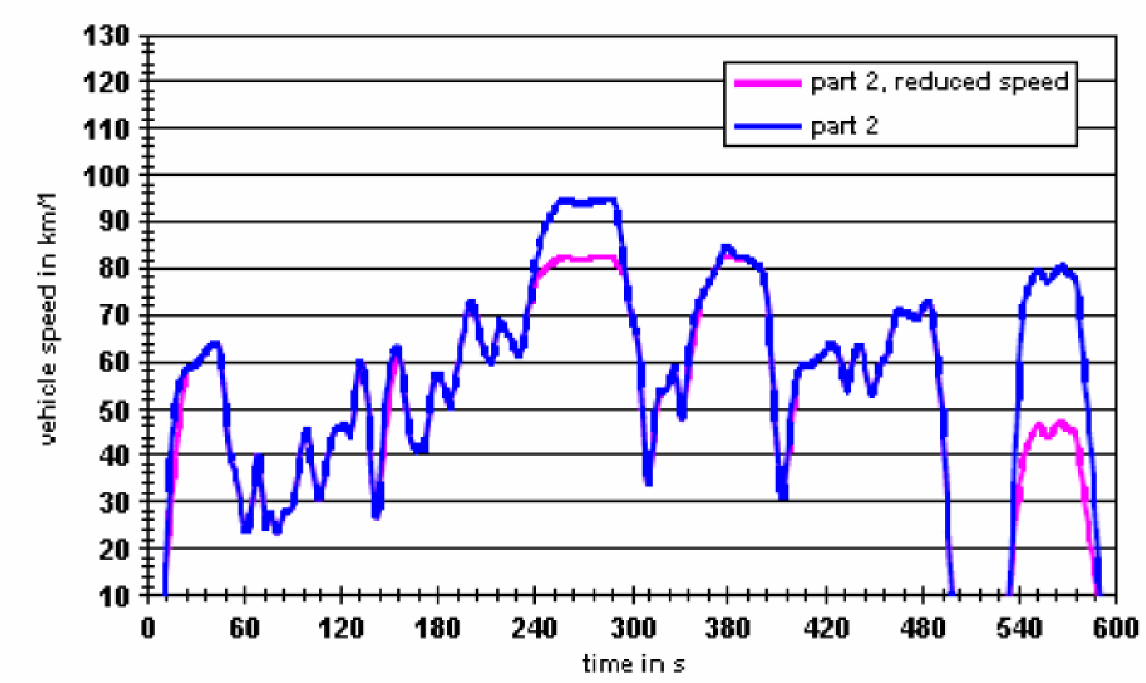


Figure A5-2

Cycle Part 2 for Vehicle Classes 2 and 3

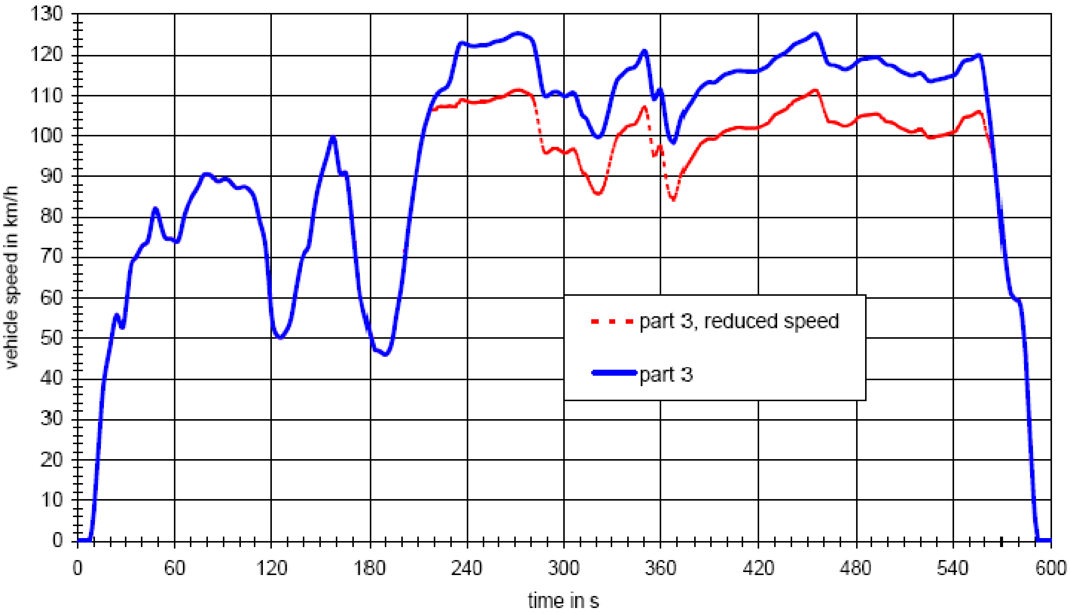


Figure A5-3

Cycle Part 3 for Vehicle Class 3

"Table A5-1: Cycle part 1, reduced speed for vehicle classes 1 and 2-1, 1 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				61	29,6				x	121	31,2			x	
1	0,0	x				62	26,9				x	122	33,0			x	
2	0,0	x				63	23,0				x	123	34,4			x	
3	0,0	x				64	18,6				x	124	35,2			x	
4	0,0	x				65	14,1				x	125	35,4				x
5	0,0	x				66	9,3				x	126	35,2				x
6	0,0	x				67	4,8				x	127	34,7				x
7	0,0	x				68	1,9				x	128	33,9				x
8	0,0	x				69	0,0	x				129	32,4				x
9	0,0	x				70	0,0	x				130	29,8				x
10	0,0	x				71	0,0	x				131	26,1				x
11	0,0	x				72	0,0	x				132	22,1				x
12	0,0	x				73	0,0	x				133	18,6				x
13	0,0	x				74	1,7		x			134	16,8		x		
14	0,0	x				75	5,8		x			135	17,7		x		
15	0,0	x				76	11,8		x			136	21,1		x		
16	0,0	x				77	17,3		x			137	25,4		x		
17	0,0	x				78	22,0		x			138	29,2		x		
18	0,0	x				79	26,2		x			139	31,6		x		
19	0,0	x				80	29,4		x			140	32,1				x
20	0,0	x				81	31,1		x			141	31,6				x
21	0,0	x				82	32,9		x			142	30,7				x
22	1,0		x			83	34,7		x			143	29,7				x
23	2,6		x			84	34,8		x			144	28,1				x
24	4,8		x			85	34,8		x			145	25,0				x
25	7,2		x			86	34,9		x			146	20,3				x
26	9,6		x			87	35,4		x			147	15,0				x
27	12,0		x			88	36,2		x			148	9,7				x
28	14,3		x			89	37,1		x			149	5,0				x
29	16,6		x			90	38,0		x			150	1,6				x
30	18,9		x			91	38,7			x		151	0,0	x			
31	21,2		x			92	38,9			x		152	0,0	x			
32	23,5		x			93	38,9			x		153	0,0	x			
33	25,6		x			94	38,8			x		154	0,0	x			
34	27,1		x			95	38,5			x		155	0,0	x			
35	28,0		x			96	38,1			x		156	0,0	x			
36	28,7		x			97	37,5			x		157	0,0	x			
37	29,2		x			98	37,0			x		158	0,0	x			
38	29,8		x			99	36,7			x		159	0,0	x			
39	30,3			x		100	36,5			x		160	0,0	x			
40	29,6			x		101	36,5			x		161	0,0	x			
41	28,7			x		102	36,6			x		162	0,0	x			
42	27,9			x		103	36,8			x		163	0,0	x			
43	27,4			x		104	37,0			x		164	0,0	x			
44	27,3			x		105	37,1			x		165	0,0	x			
45	27,3			x		106	37,3			x		166	0,0	x			
46	27,4			x		107	37,4			x		167	0,0	x			
47	27,5			x		108	37,5			x		168	0,0	x			
48	27,6			x		109	37,4			x		169	0,0	x			
49	27,6			x		110	36,9				x	170	0,0	x			
50	27,6			x		111	36,0				x	171	0,0	x			
51	27,8			x		112	34,8				x	172	0,0	x			
52	28,1			x		113	31,9				x	173	0,0	x			
53	28,5			x		114	29,0				x	174	0,0	x			
54	28,9			x		115	26,9				x	175	0,0	x			
55	29,2			x		116	24,7			x		176	0,0	x			
56	29,4			x		117	25,4			x		177	0,0	x			
57	29,7			x		118	26,4			x		178	0,0	x			
58	30,0			x		119	27,7			x		179	0,0	x			
59	30,5			x		120	29,4			x		180	0,0	x			
60	30,6				x												

Table A5-2: Cycle part 1, reduced speed for vehicle classes 1 and 2-1, 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	0,0	x				241	43,9			x		301	30,6			x	
182	0,0	x				242	43,8				x	302	29,0			x	
183	0,0	x				243	43,0				x	303	27,8			x	
184	0,0	x				244	40,9				x	304	27,2			x	
185	0,4		x			245	36,9				x	305	26,9			x	
186	1,8		x			246	32,1				x	306	26,5			x	
187	5,4		x			247	26,6				x	307	26,1			x	
188	11,1		x			248	21,8				x	308	25,7			x	
189	16,7		x			249	17,2				x	309	25,5			x	
190	21,3		x			250	13,7				x	310	25,7			x	
191	24,8		x			251	10,3				x	311	26,4			x	
192	28,4		x			252	7,0				x	312	27,3			x	
193	31,8		x			253	3,5				x	313	28,1			x	
194	34,6		x			254	0,0	x				314	27,9				x
195	36,3		x			255	0,0	x				315	26,0				x
196	37,8		x			256	0,0	x				316	22,7				x
197	39,6		x			257	0,0	x				317	19,0				x
198	41,3		x			258	0,0	x				318	16,0				x
199	43,3		x			259	0,0	x				319	14,6		x		
200	45,1		x			260	0,0	x				320	15,2		x		
201	47,5		x			261	0,0	x				321	16,9		x		
202	49,0		x			262	0,0	x				322	19,3		x		
203	50,0			x		263	0,0	x				323	22,0		x		
204	49,5			x		264	0,0	x				324	24,6		x		
205	48,8			x		265	0,0	x				325	26,8		x		
206	47,6			x		266	0,0	x				326	27,9		x		
207	46,5			x		267	0,5		x			327	28,0			x	
208	46,1			x		268	2,9		x			328	27,7			x	
209	46,1			x		269	8,2		x			329	27,1			x	
210	46,6			x		270	13,2		x			330	26,8			x	
211	46,9			x		271	17,8		x			331	26,6			x	
212	47,2			x		272	21,4		x			332	26,8			x	
213	47,8			x		273	24,1		x			333	27,0			x	
214	48,4			x		274	26,4		x			334	27,2			x	
215	48,9			x		275	28,4		x			335	27,4			x	
216	49,2			x		276	29,9		x			336	27,5			x	
217	49,6			x		277	30,5			x		337	27,7			x	
218	49,9			x		278	30,5			x		338	27,9			x	
219	50,0			x		279	30,3			x		339	28,1			x	
220	49,8			x		280	30,2			x		340	28,3			x	
221	49,5			x		281	30,1			x		341	28,6			x	
222	49,2			x		282	30,1			x		342	29,1			x	
223	49,3			x		283	30,1			x		343	29,6			x	
224	49,4			x		284	30,2			x		344	30,1			x	
225	49,4			x		285	30,2			x		345	30,6			x	
226	48,6			x		286	30,2			x		346	30,8			x	
227	47,8			x		287	30,2			x		347	30,8			x	
228	47,0			x		288	30,5			x		348	30,8			x	
229	46,9			x		289	31,0			x		349	30,8			x	
230	46,6			x		290	31,9			x		350	30,8			x	
231	46,6			x		291	32,8			x		351	30,8			x	
232	46,6			x		292	33,7			x		352	30,8			x	
233	46,9			x		293	34,5			x		353	30,8			x	
234	46,4			x		294	35,1			x		354	30,9			x	
235	45,6			x		295	35,5			x		355	30,9			x	
236	44,4			x		296	35,6			x		356	30,9			x	
237	43,5			x		297	35,4			x		357	30,8			x	
238	43,2			x		298	35,0			x		358	30,4			x	
239	43,3			x		299	34,0			x		359	29,6			x	
240	43,7			x		300	32,4			x		360	28,4			x	

<u>Table</u> A5-3: Cycle part 1, reduced speed for vehicle classes 1 and 2-1, 361 to 540 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
361	27,1			x		421	34,0		x			481	0,0	x			
362	26,0			x		422	35,4		x			482	0,0	x			
363	25,4			x		423	36,5		x			483	0,0	x			
364	25,5			x		424	37,5		x			484	0,0	x			
365	26,3			x		425	38,6		x			485	0,0	x			
366	27,3			x		426	39,6		x			486	1,4		x		
367	28,3			x		427	40,7		x			487	4,5		x		
368	29,2			x		428	41,4		x			488	8,8		x		
369	29,5			x		429	41,7			x		489	13,4		x		
370	29,4			x		430	41,4			x		490	17,3		x		
371	28,9			x		431	40,9			x		491	19,2		x		
372	28,1			x		432	40,5			x		492	19,7		x		
373	27,1			x		433	40,2			x		493	19,8		x		
374	26,3			x		434	40,1			x		494	20,7		x		
375	25,7			x		435	40,1			x		495	23,7		x		
376	25,5			x		436	39,8				x	496	27,9		x		
377	25,6			x		437	38,9				x	497	31,9		x		
378	25,9			x		438	37,4				x	498	35,4		x		
379	26,3			x		439	35,8				x	499	36,2				x
380	26,9			x		440	34,1				x	500	34,2				x
381	27,6			x		441	32,5				x	501	30,2				x
382	28,4			x		442	30,9				x	502	27,1				x
383	29,3			x		443	29,4				x	503	26,6		x		
384	30,1			x		444	27,9				x	504	28,6		x		
385	30,4			x		445	26,5				x	505	32,6		x		
386	30,2			x		446	25,0				x	506	35,5		x		
387	29,5			x		447	23,4				x	507	36,6				x
388	28,6			x		448	21,8				x	508	34,6				x
389	27,9			x		449	20,3				x	509	30,0				x
390	27,5			x		450	19,3				x	510	23,1				x
391	27,2			x		451	18,7				x	511	16,7				x
392	26,9				x	452	18,3				x	512	10,7				x
393	26,4				x	453	17,8				x	513	4,7				x
394	25,7				x	454	17,4				x	514	1,2				x
395	24,9				x	455	16,8				x	515	0,0	x			
396	21,4				x	456	16,3			x		516	0,0	x			
397	15,9				x	457	16,5			x		517	0,0	x			
398	9,9				x	458	17,6			x		518	0,0	x			
399	4,9				x	459	19,2			x		519	3,0		x		
400	2,1				x	460	20,8			x		520	8,2		x		
401	0,9				x	461	22,2			x		521	14,3		x		
402	0,0	x				462	23,0			x		522	19,3		x		
403	0,0	x				463	23,0				x	523	23,5		x		
404	0,0	x				464	22,0				x	524	27,3		x		
405	0,0	x				465	20,1				x	525	30,8		x		
406	0,0	x				466	17,7				x	526	33,7		x		
407	0,0	x				467	15,0				x	527	35,2		x		
408	1,2		x			468	12,1				x	528	35,2				x
409	3,2		x			469	9,1				x	529	32,5				x
410	5,9		x			470	6,2				x	530	27,9				x
411	8,8		x			471	3,6				x	531	23,2				x
412	12,0		x			472	1,8				x	532	18,5				x
413	15,4		x			473	0,8				x	533	13,8				x
414	18,9		x			474	0,0	x				534	9,1				x
415	22,1		x			475	0,0	x				535	4,5				x
416	24,7		x			476	0,0	x				536	2,3				x
417	26,8		x			477	0,0	x				537	0,0	x			
418	28,7		x			478	0,0	x				538	0,0	x			
419	30,6		x			479	0,0	x				539	0,0	x			
420	32,4		x			480	0,0	x				540	0,0	x			

Table A5-4: Cycle part 1, reduced 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
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 A5-5: Cycle part 1 for vehicle classes 2-2 and 3, 1 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				61	29,7				x	121	31,0			x	
1	0,0	x				62	27,0				x	122	32,8			x	
2	0,0	x				63	23,0				x	123	34,3			x	
3	0,0	x				64	18,7				x	124	35,1			x	
4	0,0	x				65	14,2				x	125	35,3				x
5	0,0	x				66	9,4				x	126	35,1				x
6	0,0	x				67	4,9				x	127	34,6				x
7	0,0	x				68	2,0				x	128	33,7				x
8	0,0	x				69	0,0	x				129	32,2				x
9	0,0	x				70	0,0	x				130	29,6				x
10	0,0	x				71	0,0	x				131	26,0				x
11	0,0	x				72	0,0	x				132	22,0				x
12	0,0	x				73	0,0	x				133	18,5				x
13	0,0	x				74	1,7		x			134	16,6		x		
14	0,0	x				75	5,8		x			135	17,6		x		
15	0,0	x				76	11,8		x			136	21,0		x		
16	0,0	x				77	18,3		x			137	25,2		x		
17	0,0	x				78	24,5		x			138	29,1		x		
18	0,0	x				79	29,4		x			139	31,4		x		
19	0,0	x				80	32,5		x			140	31,9				x
20	0,0	x				81	34,2		x			141	31,4				x
21	0,0	x				82	34,4		x			142	30,6				x
22	1,0		x			83	34,5		x			143	29,5				x
23	2,6		x			84	34,6		x			144	28,0				x
24	4,8		x			85	34,7		x			145	24,9				x
25	7,2		x			86	34,8		x			146	20,2				x
26	9,6		x			87	35,2		x			147	14,8				x
27	12,0		x			88	36,0		x			148	9,5				x
28	14,3		x			89	37,0		x			149	4,8				x
29	16,6		x			90	37,9		x			150	1,4				x
30	18,9		x			91	38,6		x			151	0,0	x			
31	21,2		x			92	38,8			x		152	0,0	x			
32	23,5		x			93	38,8			x		153	0,0	x			
33	25,6		x			94	38,7			x		154	0,0	x			
34	27,1		x			95	38,5			x		155	0,0	x			
35	28,0		x			96	38,0			x		156	0,0	x			
36	28,7		x			97	37,4			x		157	0,0	x			
37	29,2		x			98	36,9			x		158	0,0	x			
38	29,8		x			99	36,6			x		159	0,0	x			
39	30,4			x		100	36,4			x		160	0,0	x			
40	29,6			x		101	36,4			x		161	0,0	x			
41	28,7			x		102	36,5			x		162	0,0	x			
42	27,9			x		103	36,7			x		163	0,0	x			
43	27,5			x		104	36,9			x		164	0,0	x			
44	27,3			x		105	37,0			x		165	0,0	x			
45	27,4			x		106	37,2			x		166	0,0	x			
46	27,5			x		107	37,3			x		167	0,0	x			
47	27,6			x		108	37,4			x		168	0,0	x			
48	27,6			x		109	37,3			x		169	0,0	x			
49	27,6			x		110	36,8			x		170	0,0	x			
50	27,7			x		111	35,8				x	171	0,0	x			
51	27,8			x		112	34,7				x	172	0,0	x			
52	28,1			x		113	31,8				x	173	0,0	x			
53	28,6			x		114	28,9				x	174	0,0	x			
54	29,0			x		115	26,7				x	175	0,0	x			
55	29,2			x		116	24,6			x		176	0,0	x			
56	29,5			x		117	25,2			x		177	0,0	x			
57	29,7			x		118	26,2			x		178	0,0	x			
58	30,1			x		119	27,6			x		179	0,0	x			
59	30,5			x		120	29,2			x		180	0,0	x			
60	30,7			x													

Table A5-6: Cycle part 1 for vehicle classes 2-2 and 3, 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	0,0	x				241	38,3				x	301	30,6			x	
182	0,0	x				242	36,4				x	302	28,9			x	
183	2,0		x			243	34,6				x	303	27,8			x	
184	6,0		x			244	32,7				x	304	27,2			x	
185	12,4		x			245	30,6				x	305	26,9			x	
186	21,4		x			246	28,1				x	306	26,5			x	
187	30,0		x			247	25,5				x	307	26,1			x	
188	37,1		x			248	23,1				x	308	25,7			x	
189	42,5		x			249	21,2				x	309	25,5			x	
190	46,6		x			250	19,5				x	310	25,7			x	
191	49,8		x			251	17,8				x	311	26,4			x	
192	52,4		x			252	15,3				x	312	27,3			x	
193	54,4		x			253	11,5				x	313	28,1			x	
194	55,6		x			254	7,2				x	314	27,9				x
195	56,1			x		255	2,5				x	315	26,0				x
196	56,2			x		256	0,0	x				316	22,7				x
197	56,2			x		257	0,0	x				317	19,0				x
198	56,2			x		258	0,0	x				318	16,0				x
199	56,7			x		259	0,0	x				319	14,6		x		
200	57,2			x		260	0,0	x				320	15,2		x		
201	57,7			x		261	0,0	x				321	16,9		x		
202	58,2			x		262	0,0	x				322	19,3		x		
203	58,7			x		263	0,0	x				323	22,0		x		
204	59,3			x		264	0,0	x				324	24,6		x		
205	59,8			x		265	0,0	x				325	26,8		x		
206	60,0			x		266	0,0	x				326	27,9		x		
207	60,0			x		267	0,5		x			327	28,1			x	
208	59,9			x		268	2,9		x			328	27,7			x	
209	59,9			x		269	8,2		x			329	27,2			x	
210	59,9			x		270	13,2		x			330	26,8			x	
211	59,9			x		271	17,8		x			331	26,6			x	
212	59,9			x		272	21,4		x			332	26,8			x	
213	59,8			x		273	24,1		x			333	27,0			x	
214	59,6				x	274	26,4		x			334	27,2			x	
215	59,1				x	275	28,4		x			335	27,4			x	
216	57,1				x	276	29,9		x			336	27,6			x	
217	53,2				x	277	30,5		x			337	27,7			x	
218	48,3				x	278	30,5			x		338	27,9			x	
219	43,9				x	279	30,3			x		339	28,1			x	
220	40,3				x	280	30,2			x		340	28,3			x	
221	39,5				x	281	30,1			x		341	28,6			x	
222	41,3		x			282	30,1			x		342	29,0			x	
223	45,2		x			283	30,1			x		343	29,6			x	
224	50,1		x			284	30,1			x		344	30,1			x	
225	53,7		x			285	30,1			x		345	30,5			x	
226	55,8		x			286	30,1			x		346	30,7			x	
227	55,8				x	287	30,2			x		347	30,8			x	
228	54,7				x	288	30,4			x		348	30,8			x	
229	53,3				x	289	31,0			x		349	30,8			x	
230	52,3				x	290	31,8			x		350	30,8			x	
231	52,0				x	291	32,7			x		351	30,8			x	
232	52,1				x	292	33,6			x		352	30,8			x	
233	51,8				x	293	34,4			x		353	30,8			x	
234	50,8				x	294	35,0			x		354	30,9			x	
235	49,2				x	295	35,4			x		355	30,9			x	
236	47,5				x	296	35,5			x		356	30,9			x	
237	45,7				x	297	35,3			x		357	30,8			x	
238	43,9				x	298	34,9			x		358	30,4			x	
239	42,0				x	299	33,9			x		359	29,6			x	
240	40,2				x	300	32,4			x		360	28,4			x	

Table A5-7: Cycle part 1 for vehicle classes 2-2 and 3, 361 to 540 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
361	27,1			x		421	34,0		x			481	0,0	x			
362	26,0			x		422	35,4		x			482	0,0	x			
363	25,4			x		423	36,5		x			483	0,0	x			
364	25,5			x		424	37,5		x			484	0,0	x			
365	26,3			x		425	38,6		x			485	0,0	x			
366	27,3			x		426	39,7		x			486	1,4		x		
367	28,4			x		427	40,7		x			487	4,5		x		
368	29,2			x		428	41,5		x			488	8,8		x		
369	29,5			x		429	41,7			x		489	13,4		x		
370	29,5			x		430	41,5			x		490	17,3		x		
371	29,0			x		431	41,0			x		491	19,2		x		
372	28,1			x		432	40,6			x		492	19,7		x		
373	27,2			x		433	40,3			x		493	19,8		x		
374	26,3			x		434	40,2			x		494	20,7		x		
375	25,7			x		435	40,1			x		495	23,6		x		
376	25,5			x		436	39,8				x	496	28,1		x		
377	25,6			x		437	38,9				x	497	32,8		x		
378	26,0			x		438	37,5				x	498	36,3		x		
379	26,4			x		439	35,8				x	499	37,1				x
380	27,0			x		440	34,2				x	500	35,1				x
381	27,7			x		441	32,5				x	501	31,1				x
382	28,5			x		442	30,9				x	502	28,0				x
383	29,4			x		443	29,4				x	503	27,5		x		
384	30,2			x		444	28,0				x	504	29,5		x		
385	30,5			x		445	26,5				x	505	34,0		x		
386	30,3			x		446	25,0				x	506	37,0		x		
387	29,5			x		447	23,5				x	507	38,0				x
388	28,7			x		448	21,9				x	508	36,1				x
389	27,9			x		449	20,4				x	509	31,5				x
390	27,5			x		450	19,4				x	510	24,5				x
391	27,3			x		451	18,8				x	511	17,5				x
392	27,0				x	452	18,4				x	512	10,5				x
393	26,5				x	453	18,0				x	513	4,5				x
394	25,8				x	454	17,5				x	514	1,0				x
395	25,0				x	455	16,9				x	515	0,0	x			
396	21,5				x	456	16,4			x		516	0,0	x			
397	16,0				x	457	16,6			x		517	0,0	x			
398	10,0				x	458	17,7			x		518	0,0	x			
399	5,0				x	459	19,4			x		519	2,9		x		
400	2,2				x	460	20,9			x		520	8,0		x		
401	1,0				x	461	22,3			x		521	16,0		x		
402	0,0	x				462	23,2			x		522	24,0		x		
403	0,0	x				463	23,2				x	523	32,0		x		
404	0,0	x				464	22,2				x	524	38,8		x		
405	0,0	x				465	20,3				x	525	43,1		x		
406	0,0	x				466	17,9				x	526	46,0		x		
407	0,0	x				467	15,2				x	527	47,5				x
408	1,2		x			468	12,3				x	528	47,5				x
409	3,2		x			469	9,3				x	529	44,8				x
410	5,9		x			470	6,4				x	530	40,1				x
411	8,8		x			471	3,8				x	531	33,8				x
412	12,0		x			472	2,0				x	532	27,2				x
413	15,4		x			473	0,9				x	533	20,0				x
414	18,9		x			474	0,0	x				534	12,8				x
415	22,1		x			475	0,0	x				535	7,0				x
416	24,8		x			476	0,0	x				536	2,2				x
417	26,8		x			477	0,0	x				537	0,0	x			
418	28,7		x			478	0,0	x				538	0,0	x			
419	30,6		x			479	0,0	x				539	0,0	x			
420	32,4		x			480	0,0	x				540	0,0	x			

Table A5-8: 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
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			

Table A5-9: Cycle part 2, reduced speed for vehicle class 2-1 , 1 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				61	23,7		x			121	46,2			x	
1	0,0	x				62	23,8		x			122	46,1			x	
2	0,0	x				63	25,0		x			123	45,7			x	
3	0,0	x				64	27,3		x			124	45,0			x	
4	0,0	x				65	30,4		x			125	44,3			x	
5	0,0	x				66	33,9		x			126	44,7		x		
6	0,0	x				67	37,3		x			127	46,8		x		
7	0,0	x				68	39,8				x	128	49,9		x		
8	0,0	x				69	39,5				x	129	52,8		x		
9	2,3		x			70	36,3				x	130	55,6		x		
10	7,3		x			71	31,4				x	131	58,2		x		
11	13,6		x			72	26,5				x	132	60,2				x
12	18,9		x			73	24,2				x	133	59,3				x
13	23,6		x			74	24,8				x	134	57,5				x
14	27,8		x			75	26,6				x	135	55,4				x
15	31,8		x			76	27,5				x	136	52,5				x
16	35,6		x			77	26,8				x	137	47,9				x
17	39,3		x			78	25,3				x	138	41,4				x
18	42,7		x			79	24,0				x	139	34,4				x
19	46,0		x			80	23,3			x		140	30,0				x
20	49,1		x			81	23,7			x		141	27,0				x
21	52,1		x			82	24,9			x		142	26,5		x		
22	54,9		x			83	26,4			x		143	28,7		x		
23	57,5		x			84	27,7			x		144	32,7		x		
24	58,4			x		85	28,3			x		145	36,5		x		
25	58,5			x		86	28,3			x		146	40,0		x		
26	58,5			x		87	28,1			x		147	43,5		x		
27	58,6			x		88	28,1		x			148	46,7		x		
28	58,9			x		89	28,6		x			149	49,8		x		
29	59,3			x		90	29,8		x			150	52,7		x		
30	59,8			x		91	31,6		x			151	55,5		x		
31	60,2			x		92	33,9		x			152	58,1		x		
32	60,5			x		93	36,5		x			153	60,6		x		
33	60,8			x		94	39,1		x			154	62,9		x		
34	61,1			x		95	41,5		x			155	62,9				x
35	61,5			x		96	43,3		x			156	61,7				x
36	62,0			x		97	44,5		x			157	59,4				x
37	62,5			x		98	45,1				x	158	56,6				x
38	63,0			x		99	45,1				x	159	53,7				x
39	63,4			x		100	43,9				x	160	50,7				x
40	63,7			x		101	41,4				x	161	47,7				x
41	63,8			x		102	38,4				x	162	45,0				x
42	63,9			x		103	35,5				x	163	43,1				x
43	63,8			x		104	32,9				x	164	41,9			x	
44	63,2				x	105	31,3				x	165	41,6			x	
45	61,7				x	106	30,7				x	166	41,3			x	
46	58,9				x	107	31,0			x		167	40,9			x	
47	55,2				x	108	32,2			x		168	41,8			x	
48	51,0				x	109	34,0			x		169	42,1			x	
49	46,7				x	110	36,0			x		170	41,8			x	
50	42,8				x	111	37,9			x		171	41,3			x	
51	40,2				x	112	39,9			x		172	41,5		x		
52	38,8				x	113	41,6			x		173	43,5		x		
53	37,9				x	114	43,1			x		174	46,5		x		
54	36,7				x	115	44,3			x		175	49,7		x		
55	35,1				x	116	45,0			x		176	52,6		x		
56	32,9				x	117	45,5			x		177	55,0		x		
57	30,4				x	118	45,8			x		178	56,5		x		
58	28,0				x	119	46,0			x		179	57,1		x		
59	25,9				x	120	46,1			x		180	57,3				x
60	24,4				x												

Table A5-10: Cycle part 2, reduced speed for vehicle class 2-1 , 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	57,0				x	241	77,5		x			301	68,3				x
182	56,3				x	242	78,1			x		302	67,3				x
183	55,2				x	243	78,6			x		303	66,1				x
184	53,9				x	244	79,0			x		304	63,9				x
185	52,6				x	245	79,4			x		305	60,2				x
186	51,4				x	246	79,7			x		306	54,9				x
187	50,1		x			247	80,1			x		307	48,1				x
188	51,5		x			248	80,7			x		308	40,9				x
189	53,1		x			249	80,8			x		309	36,0				x
190	54,8		x			250	81,0			x		310	33,9				x
191	56,6		x			251	81,2			x		311	33,9		x		
192	58,5		x			252	81,6			x		312	36,5		x		
193	60,6		x			253	81,9			x		313	40,1		x		
194	62,8		x			254	82,1			x		314	43,5		x		
195	64,9		x			255	82,1			x		315	46,8		x		
196	67,0		x			256	82,3			x		316	49,8		x		
197	69,1		x			257	82,4			x		317	52,8		x		
198	70,9		x			258	82,4			x		318	53,9		x		
199	72,2		x			259	82,3			x		319	53,9		x		
200	72,8				x	260	82,3			x		320	53,7		x		
201	72,8				x	261	82,2			x		321	53,7		x		
202	71,9				x	262	82,2			x		322	54,3		x		
203	70,5				x	263	82,1			x		323	55,4		x		
204	68,8				x	264	82,1			x		324	56,8		x		
205	67,1				x	265	82,0			x		325	58,1		x		
206	65,4				x	266	82,0			x		326	58,9				x
207	63,9				x	267	81,9			x		327	58,2				x
208	62,8				x	268	81,9			x		328	55,8				x
209	61,8				x	269	81,9			x		329	52,6				x
210	61,0				x	270	81,9			x		330	49,2				x
211	60,4				x	271	81,9			x		331	47,6		x		
212	60,0		x			272	82,0			x		332	48,4		x		
213	60,2		x			273	82,0			x		333	51,4		x		
214	61,4		x			274	82,1			x		334	54,2		x		
215	63,3		x			275	82,2			x		335	56,9		x		
216	65,5		x			276	82,3			x		336	59,4		x		
217	67,4		x			277	82,4			x		337	61,8		x		
218	68,5		x			278	82,5			x		338	64,1		x		
219	68,7				x	279	82,5			x		339	66,2		x		
220	68,1				x	280	82,5			x		340	68,2		x		
221	67,3				x	281	82,5			x		341	70,2		x		
222	66,5				x	282	82,4			x		342	72,0		x		
223	65,9				x	283	82,4			x		343	73,7		x		
224	65,5				x	284	82,4			x		344	74,4		x		
225	64,9				x	285	82,5			x		345	75,1		x		
226	64,1				x	286	82,5			x		346	75,8		x		
227	63,0				x	287	82,5			x		347	76,5		x		
228	62,1				x	288	82,4			x		348	77,2		x		
229	61,6		x			289	82,3			x		349	77,8		x		
230	61,7		x			290	81,6			x		350	78,5		x		
231	62,3		x			291	81,3			x		351	79,2		x		
232	63,5		x			292	80,3			x		352	80,0		x		
233	65,3		x			293	79,9			x		353	81,0			x	
234	67,3		x			294	79,2			x		354	81,2			x	
235	69,2		x			295	79,2			x		355	81,8			x	
236	71,1		x			296	78,4				x	356	82,2			x	
237	73,0		x			297	75,7				x	357	82,2			x	
238	74,8		x			298	73,2				x	358	82,4			x	
239	75,7		x			299	71,1				x	359	82,5			x	
240	76,7		x			300	69,5				x	360	82,5			x	

Table A5-11: Cycle part 2, reduced speed for vehicle class 2-1 , 361 to 540 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
361	82,5			x		421	63,1			x		481	72,0			x	
362	82,5			x		422	63,6			x		482	72,6			x	
363	82,3			x		423	63,9			x		483	72,8			x	
364	82,1			x		424	63,8			x		484	72,7			x	
365	82,1			x		425	63,6			x		485	72,0				x
366	82,1			x		426	63,3				x	486	70,4				x
367	82,1			x		427	62,8				x	487	67,7				x
368	82,1			x		428	61,9				x	488	64,4				x
369	82,1			x		429	60,5				x	489	61,0				x
370	82,1			x		430	58,6				x	490	57,6				x
371	82,1			x		431	56,5				x	491	54,0				x
372	82,1			x		432	54,6				x	492	49,7				x
373	81,9			x		433	53,8			x		493	44,4				x
374	81,6			x		434	54,5			x		494	38,2				x
375	81,3			x		435	56,1			x		495	31,2				x
376	81,1			x		436	57,9			x		496	24,0				x
377	80,8			x		437	59,7			x		497	16,8				x
378	80,6			x		438	61,2			x		498	10,4				x
379	80,4			x		439	62,3			x		499	5,7				x
380	80,1			x		440	63,1			x		500	2,8				x
381	79,7				x	441	63,6				x	501	1,6				x
382	78,6				x	442	63,5				x	502	0,3				x
383	76,8				x	443	62,7				x	503	0,0	x			
384	73,7				x	444	60,9				x	504	0,0	x			
385	69,4				x	445	58,7				x	505	0,0	x			
386	64,0				x	446	56,4				x	506	0,0	x			
387	58,6				x	447	54,5				x	507	0,0	x			
388	53,2				x	448	53,3				x	508	0,0	x			
389	47,8				x	449	53,0			x		509	0,0	x			
390	42,4				x	450	53,5			x		510	0,0	x			
391	37,0				x	451	54,6			x		511	0,0	x			
392	33,0				x	452	56,1			x		512	0,0	x			
393	30,9				x	453	57,6			x		513	0,0	x			
394	30,9		x			454	58,9			x		514	0,0	x			
395	33,5		x			455	59,8			x		515	0,0	x			
396	37,2		x			456	60,3			x		516	0,0	x			
397	40,8		x			457	60,7			x		517	0,0	x			
398	44,2		x			458	61,3			x		518	0,0	x			
399	47,4		x			459	62,4			x		519	0,0	x			
400	50,4		x			460	64,1			x		520	0,0	x			
401	53,3		x			461	66,2			x		521	0,0	x			
402	56,1		x			462	68,1			x		522	0,0	x			
403	57,3		x			463	69,7			x		523	0,0	x			
404	58,1		x			464	70,4			x		524	0,0	x			
405	58,8		x			465	70,7			x		525	0,0	x			
406	59,4		x			466	70,7			x		526	0,0	x			
407	59,8			x		467	70,7			x		527	0,0	x			
408	59,7			x		468	70,7			x		528	0,0	x			
409	59,4			x		469	70,6			x		529	0,0	x			
410	59,2			x		470	70,5			x		530	0,0	x			
411	59,2			x		471	70,4			x		531	0,0	x			
412	59,6			x		472	70,2			x		532	0,0	x			
413	60,0			x		473	70,1			x		533	2,3		x		
414	60,5			x		474	69,8			x		534	7,2		x		
415	61,0			x		475	69,5			x		535	13,5		x		
416	61,2			x		476	69,1			x		536	18,7		x		
417	61,3			x		477	69,1			x		537	22,9		x		
418	61,4			x		478	69,5			x		538	26,7		x		
419	61,7			x		479	70,3			x		539	30,0		x		
420	62,3			x		480	71,2			x		540	32,8		x		

Table A5-12: Cycle part 2, reduced 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	
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			

1. <u>Table</u> A5-13: Cycle part 2 for vehicle classes 2-2 and 3, 1 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				61	23,7		x			121	46,2			x	
1	0,0	x				62	23,8		x			122	46,1			x	
2	0,0	x				63	25,0		x			123	45,7			x	
3	0,0	x				64	27,3		x			124	45,0			x	
4	0,0	x				65	30,4		x			125	44,3			x	
5	0,0	x				66	33,9		x			126	44,7		x		
6	0,0	x				67	37,3		x			127	46,8		x		
7	0,0	x				68	39,8		x			128	50,1		x		
8	0,0	x				69	39,5				x	129	53,6		x		
9	2,3		x			70	36,3				x	130	56,9		x		
10	7,3		x			71	31,4				x	131	59,4		x		
11	15,2		x			72	26,5				x	132	60,2				x
12	23,9		x			73	24,2				x	133	59,3				x
13	32,5		x			74	24,8				x	134	57,5				x
14	39,2		x			75	26,6				x	135	55,4				x
15	44,1		x			76	27,5				x	136	52,5				x
16	48,1		x			77	26,8				x	137	47,9				x
17	51,2		x			78	25,3				x	138	41,4				x
18	53,3		x			79	24,0				x	139	34,4				x
19	54,5		x			80	23,3			x		140	30,0				x
20	55,7		x			81	23,7			x		141	27,0				x
21	56,9			x		82	24,9			x		142	26,5		x		
22	57,5			x		83	26,4			x		143	28,7		x		
23	58,0			x		84	27,7			x		144	33,8		x		
24	58,4			x		85	28,3			x		145	40,3		x		
25	58,5			x		86	28,3			x		146	46,6		x		
26	58,5			x		87	28,1			x		147	50,4		x		
27	58,6			x		88	28,1			x		148	54,0		x		
28	58,9			x		89	28,6			x		149	56,9		x		
29	59,3			x		90	29,8			x		150	59,1		x		
30	59,8			x		91	31,6			x		151	60,6		x		
31	60,2			x		92	33,9			x		152	61,7		x		
32	60,5			x		93	36,5			x		153	62,6		x		
33	60,8			x		94	39,1			x		154	63,1				x
34	61,1			x		95	41,5			x		155	62,9				x
35	61,5			x		96	43,3			x		156	61,7				x
36	62,0			x		97	44,5			x		157	59,4				x
37	62,5			x		98	45,1				x	158	56,6				x
38	63,0			x		99	45,1				x	159	53,7				x
39	63,4			x		100	43,9				x	160	50,7				x
40	63,7			x		101	41,4				x	161	47,7				x
41	63,8			x		102	38,4				x	162	45,0				x
42	63,9			x		103	35,5				x	163	43,1				x
43	63,8			x		104	32,9				x	164	41,9			x	
44	63,2				x	105	31,3				x	165	41,6			x	
45	61,7				x	106	30,7				x	166	41,3			x	
46	58,9				x	107	31,0			x		167	40,9			x	
47	55,2				x	108	32,2			x		168	41,8			x	
48	51,0				x	109	34,0			x		169	42,1			x	
49	46,7				x	110	36,0			x		170	41,8			x	
50	42,8				x	111	37,9			x		171	41,3			x	
51	40,2				x	112	39,9			x		172	41,5		x		
52	38,8				x	113	41,6			x		173	43,5		x		
53	37,9				x	114	43,1			x		174	46,5		x		
54	36,7				x	115	44,3			x		175	49,7		x		
55	35,1				x	116	45,0			x		176	52,6		x		
56	32,9				x	117	45,5			x		177	55,0		x		
57	30,4				x	118	45,8			x		178	56,5		x		
58	28,0				x	119	46,0			x		179	57,1		x		
59	25,9				x	120	46,1			x		180	57,3				x
60	24,4				x												

2. Table A5-14: Cycle part 2 for vehicle classes 2-2 and 3, 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	57,0				x	241	81,5		x			301	68,3				x
182	56,3				x	242	83,1		x			302	67,3				x
183	55,2				x	243	84,6		x			303	66,1				x
184	53,9				x	244	86,0		x			304	63,9				x
185	52,6				x	245	87,4		x			305	60,2				x
186	51,4				x	246	88,7		x			306	54,9				x
187	50,1		x			247	89,6		x			307	48,1				x
188	51,5		x			248	90,2		x			308	40,9				x
189	53,1		x			249	90,7		x			309	36,0				x
190	54,8		x			250	91,2		x			310	33,9				x
191	56,6		x			251	91,8		x			311	33,9		x		
192	58,5		x			252	92,4		x			312	36,5		x		
193	60,6		x			253	93,0		x			313	41,0		x		
194	62,8		x			254	93,6		x			314	45,3		x		
195	64,9		x			255	94,1			x		315	49,2		x		
196	67,0		x			256	94,3			x		316	51,5		x		
197	69,1		x			257	94,4			x		317	53,2		x		
198	70,9		x			258	94,4			x		318	53,9		x		
199	72,2		x			259	94,3			x		319	53,9		x		
200	72,8				x	260	94,3			x		320	53,7		x		
201	72,8				x	261	94,2			x		321	53,7		x		
202	71,9				x	262	94,2			x		322	54,3		x		
203	70,5				x	263	94,2			x		323	55,4		x		
204	68,8				x	264	94,1			x		324	56,8		x		
205	67,1				x	265	94,0			x		325	58,1		x		
206	65,4				x	266	94,0			x		326	58,9				x
207	63,9				x	267	93,9			x		327	58,2				x
208	62,8				x	268	93,9			x		328	55,8				x
209	61,8				x	269	93,9			x		329	52,6				x
210	61,0				x	270	93,9			x		330	49,2				x
211	60,4				x	271	93,9			x		331	47,6		x		
212	60,0				x	272	94,0			x		332	48,4		x		
213	60,2			x		273	94,0			x		333	51,8		x		
214	61,4			x		274	94,1			x		334	55,7		x		
215	63,3			x		275	94,2			x		335	59,6		x		
216	65,5			x		276	94,3			x		336	63,0		x		
217	67,4			x		277	94,4			x		337	65,9		x		
218	68,5			x		278	94,5			x		338	68,1		x		
219	68,7				x	279	94,5			x		339	69,8		x		
220	68,1				x	280	94,5			x		340	71,1		x		
221	67,3				x	281	94,5			x		341	72,1		x		
222	66,5				x	282	94,4			x		342	72,9		x		
223	65,9				x	283	94,5			x		343	73,7		x		
224	65,5				x	284	94,6			x		344	74,4		x		
225	64,9				x	285	94,7			x		345	75,1		x		
226	64,1				x	286	94,8			x		346	75,8		x		
227	63,0				x	287	94,9			x		347	76,5		x		
228	62,1				x	288	94,8			x		348	77,2		x		
229	61,6		x			289	94,3				x	349	77,8		x		
230	61,7		x			290	93,3				x	350	78,5		x		
231	62,3		x			291	91,8				x	351	79,2		x		
232	63,5		x			292	89,6				x	352	80,0		x		
233	65,3		x			293	87,0				x	353	81,0		x		
234	67,3		x			294	84,1				x	354	82,0		x		
235	69,3		x			295	81,2				x	355	83,0		x		
236	71,4		x			296	78,4				x	356	83,7		x		
237	73,5		x			297	75,7				x	357	84,2			x	
238	75,6		x			298	73,2				x	358	84,4			x	
239	77,7		x			299	71,1				x	359	84,5			x	
240	79,7		x			300	69,5				x	360	84,4			x	

3. <u>Table</u> A5-15: Cycle part 2 for vehicle classes 2-2 and 3, 361 to 540 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
361	84,1			x	
362	83,7			x	
363	83,2			x	
364	82,8			x	
365	82,6			x	
366	82,5			x	
367	82,4			x	
368	82,3			x	
369	82,2			x	
370	82,2			x	
371	82,2			x	
372	82,1			x	
373	81,9			x	
374	81,6			x	
375	81,3			x	
376	81,1			x	
377	80,8			x	
378	80,6			x	
379	80,4			x	
380	80,1			x	
381	79,7				x
382	78,6				x
383	76,8				x
384	73,7				x
385	69,4				x
386	64,0				x
387	58,6				x
388	53,2				x
389	47,8				x
390	42,4				x
391	37,0				x
392	33,0				x
393	30,9				x
394	30,9		x		
395	33,5		x		
396	38,0		x		
397	42,5		x		
398	47,0		x		
399	51,0		x		
400	53,5		x		
401	55,1		x		
402	56,4		x		
403	57,3		x		
404	58,1		x		
405	58,8		x		
406	59,4		x		
407	59,8			x	
408	59,7			x	
409	59,4			x	
410	59,2			x	
411	59,2			x	
412	59,6			x	
413	60,0			x	
414	60,5			x	
415	61,0			x	
416	61,2			x	
417	61,3			x	
418	61,4			x	
419	61,7			x	
420	62,3			x	

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
421	63,1			x	
422	63,6			x	
423	63,9			x	
424	63,8			x	
425	63,6			x	
426	63,3				x
427	62,8				x
428	61,9				x
429	60,5				x
430	58,6				x
431	56,5				x
432	54,6				x
433	53,8			x	
434	54,5			x	
435	56,1			x	
436	57,9			x	
437	59,7			x	
438	61,2			x	
439	62,3			x	
440	63,1			x	
441	63,6				x
442	63,5				x
443	62,7				x
444	60,9				x
445	58,7				x
446	56,4				x
447	54,5				x
448	53,3				x
449	53,0			x	
450	53,5			x	
451	54,6			x	
452	56,1			x	
453	57,6			x	
454	58,9			x	
455	59,8			x	
456	60,3			x	
457	60,7			x	
458	61,3			x	
459	62,4			x	
460	64,1			x	
461	66,2			x	
462	68,1			x	
463	69,7			x	
464	70,4			x	
465	70,7			x	
466	70,7			x	
467	70,7			x	
468	70,7			x	
469	70,6			x	
470	70,5			x	
471	70,4			x	
472	70,2			x	
473	70,1			x	
474	69,8			x	
475	69,5			x	
476	69,1			x	
477	69,1			x	
478	69,5			x	
479	70,3			x	
480	71,2			x	

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
481	72,0			x	
482	72,6			x	
483	72,8			x	
484	72,7			x	
485	72,0				x
486	70,4				x
487	67,7				x
488	64,4				x
489	61,0				x
490	57,6				x
491	54,0				x
492	49,7				x
493	44,4				x
494	38,2				x
495	31,2				x
496	24,0				x
497	16,8				x
498	10,4				x
499	5,7				x
500	2,8				x
501	1,6				x
502	0,3				x
503	0,0	x			
504	0,0	x			
505	0,0	x			
506	0,0	x			
507	0,0	x			
508	0,0	x			
509	0,0	x			
510	0,0	x			
511	0,0	x			
512	0,0	x			
513	0,0	x			
514	0,0	x			
515	0,0	x			
516	0,0	x			
517	0,0	x			
518	0,0	x			
519	0,0	x			
520	0,0	x			
521	0,0	x			
522	0,0	x			
523	0,0	x			
524	0,0	x			
525	0,0	x			
526	0,0	x			
527	0,0	x			
528	0,0	x			
529	0,0	x			
530	0,0	x			
531	0,0	x			
532	0,0	x			
533	2,3		x		
534	7,2		x		
535	14,6		x		
536	23,5		x		
537	33,0		x		
538	42,7		x		
539	51,8		x		
540	59,4		x		

4. Table A5-16: 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	
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			

5. <u>Table</u> A5-17: Cycle part 3, reduced speed for vehicle class 3-1, 1 to 180 s

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
0	0,0	x			
1	0,0	x			
2	0,0	x			
3	0,0	x			
4	0,0	x			
5	0,0	x			
6	0,0	x			
7	0,0	x			
8	0,9		x		
9	3,2		x		
10	7,3		x		
11	12,4		x		
12	17,9		x		
13	23,5		x		
14	29,1		x		
15	34,3		x		
16	38,6		x		
17	41,6		x		
18	43,9		x		
19	45,9		x		
20	48,1		x		
21	50,3		x		
22	52,6		x		
23	54,8		x		
24	55,8		x		
25	55,2		x		
26	53,9		x		
27	52,7		x		
28	52,8		x		
29	55,0		x		
30	58,5		x		
31	62,3		x		
32	65,7		x		
33	68,1		x		
34	69,1		x		
35	69,5		x		
36	69,9		x		
37	70,6		x		
38	71,3		x		
39	72,2		x		
40	72,8		x		
41	73,2		x		
42	73,4		x		
43	73,8		x		
44	74,8		x		
45	76,7		x		
46	79,1		x		
47	81,1		x		
48	82,1				x
49	81,7				x
50	80,3				x
51	78,8				x
52	77,3				x
53	75,9				x
54	75,0				x
55	74,7				x
56	74,7				x
57	74,7				x
58	74,6				x
59	74,4				x
60	74,1				x

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
61	73,9				x
62	74,1		x		
63	75,1		x		
64	76,8		x		
65	78,7		x		
66	80,4		x		
67	81,7		x		
68	82,6		x		
69	83,5		x		
70	84,4		x		
71	85,1		x		
72	85,7		x		
73	86,3		x		
74	87,0		x		
75	87,9		x		
76	88,8		x		
77	89,7		x		
78	90,3			x	
79	90,6			x	
80	90,6			x	
81	90,5			x	
82	90,4			x	
83	90,1			x	
84	89,7			x	
85	89,3			x	
86	89,0			x	
87	88,8			x	
88	88,9			x	
89	89,1			x	
90	89,3			x	
91	89,4			x	
92	89,4			x	
93	89,2			x	
94	88,9			x	
95	88,5			x	
96	88,0			x	
97	87,5			x	
98	87,2			x	
99	87,1			x	
100	87,2			x	
101	87,3			x	
102	87,4			x	
103	87,5			x	
104	87,4			x	
105	87,1			x	
106	86,8			x	
107	86,4			x	
108	85,9			x	
109	85,2				x
110	84,0				x
111	82,2				x
112	80,3				x
113	78,6				x
114	77,2				x
115	75,9				x
116	73,8				x
117	70,4				x
118	65,7				x
119	60,5				x
120	55,9				x

time in s	roller speed in km/h	phase indicators			
		stop	acc	cruise	dec
121	53,0				x
122	51,6				x
123	50,9				x
124	50,5				x
125	50,2				x
126	50,3		x		
127	50,6		x		
128	51,2		x		
129	51,8		x		
130	52,5		x		
131	53,4		x		
132	54,9		x		
133	57,0		x		
134	59,4		x		
135	61,9		x		
136	64,3		x		
137	66,4		x		
138	68,1		x		
139	69,6		x		
140	70,7		x		
141	71,4		x		
142	71,8		x		
143	72,8		x		
144	75,0		x		
145	77,8		x		
146	80,7		x		
147	83,3		x		
148	85,4		x		
149	87,3		x		
150	89,1		x		
151	90,6		x		
152	91,9		x		
153	93,2		x		
154	94,6		x		
155	96,0		x		
156	97,5		x		
157	99,0		x		
158	99,8				x
159	99,0				x
160	96,7				x
161	93,7				x
162	91,3				x
163	90,4				x
164	90,6				x
165	91,1				x
166	90,9				x
167	89,0				x
168	85,6				x
169	81,6				x
170	77,6				x
171	73,6				x
172	69,7				x
173	66,0				x
174	62,7				x
175	60,0				x
176	58,0				x
177	56,4				x
178	54,8				x
179	53,3				x
180	51,7				x

6. <u>Table</u> A5-18: Cycle part 3, reduced 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	241	108,4			x		301	95,8			x	
182	48,7				x	242	108,3			x		302	95,9			x	
183	47,2			x		243	108,2			x		303	96,2			x	
184	47,1			x		244	108,2			x		304	96,4			x	
185	47,0			x		245	108,2			x		305	96,7			x	
186	46,9			x		246	108,2			x		306	96,7			x	
187	46,6			x		247	108,3			x		307	96,3			x	
188	46,3			x		248	108,4			x		308	95,3				x
189	46,1			x		249	108,5			x		309	94,0				x
190	46,1		x			250	108,5			x		310	92,5				x
191	46,5		x			251	108,5			x		311	91,4				x
192	47,1		x			252	108,5			x		312	90,9				x
193	48,1		x			253	108,5			x		313	90,7				x
194	49,8		x			254	108,7			x		314	90,3				x
195	52,2		x			255	108,8			x		315	89,6				x
196	54,8		x			256	109,0			x		316	88,6				x
197	57,3		x			257	109,2			x		317	87,7				x
198	59,5		x			258	109,3			x		318	86,8				x
199	61,7		x			259	109,4			x		319	86,2				x
200	64,4		x			260	109,5			x		320	85,8				x
201	67,7		x			261	109,5			x		321	85,7				x
202	71,4		x			262	109,6			x		322	85,7				x
203	74,9		x			263	109,8			x		323	86,0			x	
204	78,2		x			264	110,0			x		324	86,7			x	
205	81,1		x			265	110,2			x		325	87,8			x	
206	83,9		x			266	110,5			x		326	89,2			x	
207	86,6		x			267	110,7			x		327	90,9			x	
208	89,1		x			268	111,0			x		328	92,6			x	
209	91,6		x			269	111,1			x		329	94,3			x	
210	94,0		x			270	111,2			x		330	95,9			x	
211	96,3		x			271	111,3			x		331	97,4			x	
212	98,4		x			272	111,3			x		332	98,7			x	
213	100,4		x			273	111,3			x		333	99,7			x	
214	102,1		x			274	111,2			x		334	100,3			x	
215	103,6		x			275	111,0			x		335	100,6			x	
216	104,9		x			276	110,8			x		336	101,0			x	
217	106,2			x		277	110,6			x		337	101,4			x	
218	106,5			x		278	110,4			x		338	101,8			x	
219	106,5			x		279	110,3			x		339	102,2			x	
220	106,6			x		280	109,9			x		340	102,5			x	
221	106,6			x		281	109,3				x	341	102,6			x	
222	107,0			x		282	108,1				x	342	102,7			x	
223	107,3			x		283	106,3				x	343	102,8			x	
224	107,3			x		284	104,0				x	344	103,0			x	
225	107,2			x		285	101,5				x	345	103,5			x	
226	107,2			x		286	99,2				x	346	104,3			x	
227	107,2			x		287	97,2				x	347	105,2			x	
228	107,3			x		288	96,1				x	348	106,1			x	
229	107,5			x		289	95,7			x		349	106,8			x	
230	107,3			x		290	95,8			x		350	107,1				x
231	107,3			x		291	96,1			x		351	106,7				x
232	107,3			x		292	96,4			x		352	105,0				x
233	107,3			x		293	96,7			x		353	102,3				x
234	108,0			x		294	96,9			x		354	99,1				x
235	108,2			x		295	96,9			x		355	96,3				x
236	108,9			x		296	96,8			x		356	95,0				x
237	109,0			x		297	96,7			x		357	95,4				x
238	108,9			x		298	96,4			x		358	96,4				x
239	108,8			x		299	96,1			x		359	97,3				x
240	108,6			x		300	95,9			x		360	97,5				x

7. Table A5-19: Cycle part 3, reduced speed for vehicle class 3-1, 361 to 540 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
361	96,1				x	421	102,2			x		481	104,5			x	
362	93,4				x	422	102,4			x		482	104,8			x	
363	90,4				x	423	102,6			x		483	104,9			x	
364	87,8				x	424	102,8			x		484	105,1			x	
365	86,0				x	425	103,1			x		485	105,1			x	
366	85,1				x	426	103,4			x		486	105,2			x	
367	84,7				x	427	103,9			x		487	105,2			x	
368	84,2			x		428	104,4			x		488	105,2			x	
369	85,0			x		429	104,9			x		489	105,3			x	
370	86,5			x		430	105,2			x		490	105,3			x	
371	88,3			x		431	105,5			x		491	105,4			x	
372	89,9			x		432	105,7			x		492	105,5			x	
373	91,0			x		433	105,9			x		493	105,5			x	
374	91,8			x		434	106,1			x		494	105,3			x	
375	92,5			x		435	106,3			x		495	105,1			x	
376	93,1			x		436	106,5			x		496	104,7			x	
377	93,7			x		437	106,8			x		497	104,2			x	
378	94,4			x		438	107,1			x		498	103,9			x	
379	95,0			x		439	107,5			x		499	103,6			x	
380	95,6			x		440	108,0			x		500	103,5			x	
381	96,3			x		441	108,3			x		501	103,5			x	
382	96,9			x		442	108,6			x		502	103,4			x	
383	97,5			x		443	108,9			x		503	103,3			x	
384	98,0			x		444	109,1			x		504	103,0			x	
385	98,3			x		445	109,2			x		505	102,7			x	
386	98,6			x		446	109,4			x		506	102,4			x	
387	98,9			x		447	109,5			x		507	102,1			x	
388	99,1			x		448	109,7			x		508	101,9			x	
389	99,3			x		449	109,9			x		509	101,7			x	
390	99,3			x		450	110,2			x		510	101,5			x	
391	99,2			x		451	110,5			x		511	101,3			x	
392	99,2			x		452	110,8			x		512	101,2			x	
393	99,3			x		453	111,0			x		513	101,0			x	
394	99,5			x		454	111,2			x		514	100,9			x	
395	99,9			x		455	111,3			x		515	100,9			x	
396	100,3			x		456	111,1			x		516	101,0			x	
397	100,6			x		457	110,4			x		517	101,2			x	
398	100,9			x		458	109,3			x		518	101,3			x	
399	101,1			x		459	108,1			x		519	101,4			x	
400	101,3			x		460	106,8			x		520	101,4			x	
401	101,4			x		461	105,5			x		521	101,2			x	
402	101,5			x		462	104,4			x		522	100,8			x	
403	101,6			x		463	103,8			x		523	100,4			x	
404	101,8			x		464	103,6			x		524	99,9			x	
405	101,9			x		465	103,5			x		525	99,6			x	
406	102,0			x		466	103,5			x		526	99,5			x	
407	102,0			x		467	103,4			x		527	99,5			x	
408	102,0			x		468	103,3			x		528	99,6			x	
409	102,0			x		469	103,1			x		529	99,7			x	
410	101,9			x		470	102,9			x		530	99,8			x	
411	101,9			x		471	102,6			x		531	99,9			x	
412	101,9			x		472	102,5			x		532	100,0			x	
413	101,8			x		473	102,4			x		533	100,0			x	
414	101,8			x		474	102,4			x		534	100,1			x	
415	101,8			x		475	102,5			x		535	100,2			x	
416	101,8			x		476	102,7			x		536	100,4			x	
417	101,8			x		477	103,0			x		537	100,5			x	
418	101,8			x		478	103,3			x		538	100,6			x	
419	101,9			x		479	103,7			x		539	100,7			x	
420	102,0			x		480	104,1			x		540	100,8			x	

8. Table A5-20: Cycle part 3, reduced 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
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			

9. <u>Table</u> A5-21: Cycle part 3 for vehicle class 3-2, 1 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				61	73,9				x	121	53,0				x
1	0,0	x				62	74,1		x			122	51,6				x
2	0,0	x				63	75,1		x			123	50,9				x
3	0,0	x				64	76,8		x			124	50,5				x
4	0,0	x				65	78,7		x			125	50,2				x
5	0,0	x				66	80,4		x			126	50,3		x		
6	0,0	x				67	81,7		x			127	50,6		x		
7	0,0	x				68	82,6		x			128	51,2		x		
8	0,9		x			69	83,5		x			129	51,8		x		
9	3,2		x			70	84,4		x			130	52,5		x		
10	7,3		x			71	85,1		x			131	53,4		x		
11	12,4		x			72	85,7		x			132	54,9		x		
12	17,9		x			73	86,3		x			133	57,0		x		
13	23,5		x			74	87,0		x			134	59,4		x		
14	29,1		x			75	87,9		x			135	61,9		x		
15	34,3		x			76	88,8		x			136	64,3		x		
16	38,6		x			77	89,7		x			137	66,4		x		
17	41,6		x			78	90,3			x		138	68,1		x		
18	43,9		x			79	90,6			x		139	69,6		x		
19	45,9		x			80	90,6			x		140	70,7		x		
20	48,1		x			81	90,5			x		141	71,4		x		
21	50,3		x			82	90,4			x		142	71,8		x		
22	52,6		x			83	90,1			x		143	72,8		x		
23	54,8		x			84	89,7			x		144	75,0		x		
24	55,8		x			85	89,3			x		145	77,8		x		
25	55,2		x			86	89,0			x		146	80,7		x		
26	53,9		x			87	88,8			x		147	83,3		x		
27	52,7		x			88	88,9			x		148	85,4		x		
28	52,8		x			89	89,1			x		149	87,3		x		
29	55,0		x			90	89,3			x		150	89,1		x		
30	58,5		x			91	89,4			x		151	90,6		x		
31	62,3		x			92	89,4			x		152	91,9		x		
32	65,7		x			93	89,2			x		153	93,2		x		
33	68,1		x			94	88,9			x		154	94,6		x		
34	69,1		x			95	88,5			x		155	96,0		x		
35	69,5		x			96	88,0			x		156	97,5		x		
36	69,9		x			97	87,5			x		157	99,0		x		
37	70,6		x			98	87,2			x		158	99,8				x
38	71,3		x			99	87,1			x		159	99,0				x
39	72,2		x			100	87,2			x		160	96,7				x
40	72,8		x			101	87,3			x		161	93,7				x
41	73,2		x			102	87,4			x		162	91,3				x
42	73,4		x			103	87,5			x		163	90,4				x
43	73,8		x			104	87,4			x		164	90,6				x
44	74,8		x			105	87,1			x		165	91,1				x
45	76,7		x			106	86,8			x		166	90,9				x
46	79,1		x			107	86,4			x		167	89,0				x
47	81,1		x			108	85,9			x		168	85,6				x
48	82,1				x	109	85,2				x	169	81,6				x
49	81,7				x	110	84,0				x	170	77,6				x
50	80,3				x	111	82,2				x	171	73,6				x
51	78,8				x	112	80,3				x	172	69,7				x
52	77,3				x	113	78,6				x	173	66,0				x
53	75,9				x	114	77,2				x	174	62,7				x
54	75,0				x	115	75,9				x	175	60,0				x
55	74,7				x	116	73,8				x	176	58,0				x
56	74,7				x	117	70,4				x	177	56,4				x
57	74,7				x	118	65,7				x	178	54,8				x
58	74,6				x	119	60,5				x	179	53,3				x
59	74,4				x	120	55,9				x	180	51,7				x
60	74,1				x												

10. <u>Table</u> A5-22: Cycle part 3 for vehicle class 3-2, 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	241	122,4			x		301	109,8			x	
182	48,7				x	242	122,3			x		302	109,9			x	
183	47,2			x		243	122,2			x		303	110,2			x	
184	47,1			x		244	122,2			x		304	110,4			x	
185	47,0			x		245	122,2			x		305	110,7			x	
186	46,9			x		246	122,2			x		306	110,7			x	
187	46,6			x		247	122,3			x		307	110,3			x	
188	46,3			x		248	122,4			x		308	109,3				x
189	46,1			x		249	122,5			x		309	108,0				x
190	46,1		x			250	122,5			x		310	106,5				x
191	46,5		x			251	122,5			x		311	105,4				x
192	47,1		x			252	122,5			x		312	104,9				x
193	48,1		x			253	122,5			x		313	104,7				x
194	49,8		x			254	122,7			x		314	104,3				x
195	52,2		x			255	122,8			x		315	103,6				x
196	54,8		x			256	123,0			x		316	102,6				x
197	57,3		x			257	123,2			x		317	101,7				x
198	59,5		x			258	123,3			x		318	100,8				x
199	61,7		x			259	123,4			x		319	100,2				x
200	64,4		x			260	123,5			x		320	99,8				x
201	67,7		x			261	123,5			x		321	99,7				x
202	71,4		x			262	123,6			x		322	99,7				x
203	74,9		x			263	123,8			x		323	100,0			x	
204	78,2		x			264	124,0			x		324	100,7			x	
205	81,1		x			265	124,2			x		325	101,8			x	
206	83,9		x			266	124,5			x		326	103,2			x	
207	86,6		x			267	124,7			x		327	104,9			x	
208	89,1		x			268	125,0			x		328	106,6			x	
209	91,6		x			269	125,1			x		329	108,3			x	
210	94,0		x			270	125,2			x		330	109,9			x	
211	96,3		x			271	125,3			x		331	111,4			x	
212	98,4		x			272	125,3			x		332	112,7			x	
213	100,4		x			273	125,3			x		333	113,7			x	
214	102,1		x			274	125,2			x		334	114,3			x	
215	103,6		x			275	125,0			x		335	114,6			x	
216	104,9		x			276	124,8			x		336	115,0			x	
217	106,2		x			277	124,6			x		337	115,4			x	
218	107,5		x			278	124,4			x		338	115,8			x	
219	108,5		x			279	124,3			x		339	116,2			x	
220	109,3		x			280	123,9			x		340	116,5			x	
221	109,9		x			281	123,3				x	341	116,6			x	
222	110,5		x			282	122,1				x	342	116,7			x	
223	110,9		x			283	120,3				x	343	116,8			x	
224	111,2		x			284	118,0				x	344	117,0			x	
225	111,4		x			285	115,5				x	345	117,5			x	
226	111,7		x			286	113,2				x	346	118,3			x	
227	111,9		x			287	111,2				x	347	119,2			x	
228	112,3		x			288	110,1				x	348	120,1			x	
229	113,0		x			289	109,7			x		349	120,8			x	
230	114,1		x			290	109,8			x		350	121,1				x
231	115,7		x			291	110,1			x		351	120,7				x
232	117,5		x			292	110,4			x		352	119,0				x
233	119,3		x			293	110,7			x		353	116,3				x
234	121,0		x			294	110,9			x		354	113,1				x
235	122,2			x		295	110,9			x		355	110,3				x
236	122,9			x		296	110,8			x		356	109,0				x
237	123,0			x		297	110,7			x		357	109,4				x
238	122,9			x		298	110,4			x		358	110,4				x
239	122,8			x		299	110,1			x		359	111,3				x
240	122,6			x		300	109,9			x		360	111,5				x

11. <u>Table</u> A5-23: Cycle part 3 for vehicle class 3-2, 361 to 540 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
361	110,1				x	421	116,2			x		481	118,5			x	
362	107,4				x	422	116,4			x		482	118,8			x	
363	104,4				x	423	116,6			x		483	118,9			x	
364	101,8				x	424	116,8			x		484	119,1			x	
365	100,0				x	425	117,1			x		485	119,1			x	
366	99,1				x	426	117,4			x		486	119,2			x	
367	98,7				x	427	117,9			x		487	119,2			x	
368	98,2			x		428	118,4			x		488	119,2			x	
369	99,0			x		429	118,9			x		489	119,3			x	
370	100,5			x		430	119,2			x		490	119,3			x	
371	102,3			x		431	119,5			x		491	119,4			x	
372	103,9			x		432	119,7			x		492	119,5			x	
373	105,0			x		433	119,9			x		493	119,5			x	
374	105,8			x		434	120,1			x		494	119,3			x	
375	106,5			x		435	120,3			x		495	119,1			x	
376	107,1			x		436	120,5			x		496	118,7			x	
377	107,7			x		437	120,8			x		497	118,2			x	
378	108,4			x		438	121,1			x		498	117,9			x	
379	109,0			x		439	121,5			x		499	117,6			x	
380	109,6			x		440	122,0			x		500	117,5			x	
381	110,3			x		441	122,3			x		501	117,5			x	
382	110,9			x		442	122,6			x		502	117,4			x	
383	111,5			x		443	122,9			x		503	117,3			x	
384	112,0			x		444	123,1			x		504	117,0			x	
385	112,3			x		445	123,2			x		505	116,7			x	
386	112,6			x		446	123,4			x		506	116,4			x	
387	112,9			x		447	123,5			x		507	116,1			x	
388	113,1			x		448	123,7			x		508	115,9			x	
389	113,3			x		449	123,9			x		509	115,7			x	
390	113,3			x		450	124,2			x		510	115,5			x	
391	113,2			x		451	124,5			x		511	115,3			x	
392	113,2			x		452	124,8			x		512	115,2			x	
393	113,3			x		453	125,0			x		513	115,0			x	
394	113,5			x		454	125,2			x		514	114,9			x	
395	113,9			x		455	125,3			x		515	114,9			x	
396	114,3			x		456	125,1			x		516	115,0			x	
397	114,6			x		457	124,4			x		517	115,2			x	
398	114,9			x		458	123,3			x		518	115,3			x	
399	115,1			x		459	122,1			x		519	115,4			x	
400	115,3			x		460	120,8			x		520	115,4			x	
401	115,4			x		461	119,5			x		521	115,2			x	
402	115,5			x		462	118,4			x		522	114,8			x	
403	115,6			x		463	117,8			x		523	114,4			x	
404	115,8			x		464	117,6			x		524	113,9			x	
405	115,9			x		465	117,5			x		525	113,6			x	
406	116,0			x		466	117,5			x		526	113,5			x	
407	116,0			x		467	117,4			x		527	113,5			x	
408	116,0			x		468	117,3			x		528	113,6			x	
409	116,0			x		469	117,1			x		529	113,7			x	
410	115,9			x		470	116,9			x		530	113,8			x	
411	115,9			x		471	116,6			x		531	113,9			x	
412	115,9			x		472	116,5			x		532	114,0			x	
413	115,8			x		473	116,4			x		533	114,0			x	
414	115,8			x		474	116,4			x		534	114,1			x	
415	115,8			x		475	116,5			x		535	114,2			x	
416	115,8			x		476	116,7			x		536	114,4			x	
417	115,8			x		477	117,0			x		537	114,5			x	
418	115,8			x		478	117,3			x		538	114,6			x	
419	115,9			x		479	117,7			x		539	114,7			x	
420	116,0			x		480	118,1			x		540	114,8			x	

Table A5-24: 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
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 6

CHASSIS DYNAMOMETER AND INSTRUMENTS DESCRIPTION

Chassis Dynamometer

Trade name (-mark) and model: ....

Diameter of roller: .... m

Chassis dynamometer type: DC/ED

Capacity of power absorbing unit (pau): .... kW

Speed range .... km/h

Power absorption system: polygonal function/coefficient control

Resolution: .... N

Type of inertia simulation system: mechanical /electrical

Inertia equivalent mass: .... kg,

in steps of .... kg

Coast down timer: digital/analogue/stop-watch

Speed sensor

Trade name (-mark) and model: ....

Principle: ....

Range: ....

Position of installed sensor: ....

Resolution: ....

Output: ....

Coast down meter

Trade name (-mark) and model: ....

v_1, v_2 speed: — Speed setting: ....

— Accuracy: ....

— Resolution: ....

— Speed acquisition time: ....

Coast down time: — Range: ....

— Accuracy: ....

— Resolution: ....

— Display output: ....

— Number of channels:

Annex 7

ROAD TESTS FOR THE DETERMINATION OF TEST BENCH SETTINGS

1. Requirements for the rider

1.1. The rider shall wear a well-fitting suit (one-piece) or similar clothing, and a protective helmet, eye protection, boots and gloves.

1.2. The rider in the conditions given in paragraph 1.1. above 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 normally extended. This position shall allow the rider at all times to have proper control of the motorcycle 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 per cent 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 per cent
- air temperature: 278 K to 308 K

2.4. Standard ambient conditions shall be as follows:
- pressure, P_0: 100 kPa
- temperature, T_0: 293 K
- 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 (motorcycle) is tested, calculated in accordance with the formula below, shall not differ by more than 7.5 per cent from the air density under the standard conditions.

2.6. The relative air density, d_T, shall be calculated by the following formula:

$$d_T = d_0 \times \frac{P_T}{\rho_0} \times \frac{T_0}{T_T}$$ Equation A7-1

where:

p_T is the mean ambient pressure during test, in kPa

T_T is the mean ambient temperature during test, in K.

3. Condition of the test vehicle (motorcycle)

3.1. The test vehicle shall comply with the conditions described in paragraph 6.2.

3.2. When installing the measuring instruments on the test motorcycle, care shall be taken to minimise their effects on the distribution of the load between the wheels. When installing the speed sensor outside the motorcycle, care shall be taken to minimise the additional aerodynamic loss.

4. Specified coast down speeds

4.1. The coast down times have to be measured between v_1 and v_2 as specified in table A7-1 depending on the vehicle class as defined in paragraph 6.3.

Table A7-1: Coast down time measurement beginning speed and ending speed.

Motorcycle Class	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

*/ Specified coast down speeds for motorcycles that have to drive the part in the "reduced speed" version

(For reduced speed version specifications see paragraph 6.5.4.)

4.2. When the running resistance is verified in accordance with paragraph 7.2.2.3.2., the test can be executed at vj ± 5 km/h, provided that the coast down time accuracy according to paragraph 6.5.7. in this regulation is ensured.

5. Measurement of coast down time

5.1. After a warm-up period, the motorcycle shall be accelerated to the coast down starting speed, at which point the coast down measurement procedure shall be started.

5.2. Since it can be dangerous and difficult from the viewpoint of its construction to have the transmission shifted to neutral, the coasting may be performed solely with the clutch disengaged. For those motorcycles that have no way of cutting the transmitted engine power off prior to coasting, the motorcycle may be towed until it reaches the coast down starting speed. When the coast down test is reproduced on the chassis dynamometer, the transmission and clutch shall be in the same condition as during the road test.

5.3. The motorcycle 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 speed v_j shall be measured as the elapsed time from the motorcycle speed $v_j + \Delta v$ to $v_j - \Delta v$.

5.5. The above procedure 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 by the following equation:

$$\Delta T_i = \frac{\Delta T_{a\,i} + \Delta T_{b\,i}}{2}$$ Equation A7-2

5.7. At least four tests shall be performed and the average coast down time ΔT_j calculated by the following equation:

$$\Delta T_j = \frac{1}{n} \times \sum_{i=1}^{n} \Delta T_i$$ Equation A7-3

5.8. Tests shall be performed until the statistical accuracy P is equal to or less than 3 per cent ($P \leq 3$ per cent).

The statistical accuracy P as a percentage, is calculated by the following equation:

$$P = \frac{t \times s}{\sqrt{n}} \times \frac{100}{\Delta T_j}$$ Equation A7-4

where:

t is the coefficient given in table A7-2;

s is the standard deviation given by the following formula:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(\Delta T_i - \Delta T_j)^2}{n-1}}$$ Equation A7-5

where:

n is the number of tests.

Table A7-2: Coefficients for the statistical accuracy

n	t	$\frac{t}{\sqrt{n}}$
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 speed.

5.10. The measurement of the coast down times for multiple specified speeds may be made by 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 speed.

5.11. The coast down time shall be recorded. The example of the record form is given in Annex 8.

6. Data processing

6.1. Calculation of running resistance force

6.1.1 The running resistance force F_j, in Newton, at the specified speed v_j shall be calculated by the following equation:

$$F_j = \frac{1}{3.6} \times (m + m_r) \times \frac{2\Delta v}{\Delta T_j}$$ Equation A7-6

where:

m_r should be measured or calculated as appropriate. As an alternative, m_r may be estimated as 7 per cent of the unladen motorcycle mass.

6.1.2. The running resistance force F_j shall be corrected in accordance with paragraph 6.2. below.

6.2. Running resistance curve fitting

The running resistance force, F, shall be calculated as follows:

6.2.1. This following equation shall be fitted to the data set of F_j and v_j obtained above by linear regression to determine the coefficients f_0 and f_2,

$$F = f_0 + f_2 \times v^2$$ Equation A7-7

6.2.2. The coefficients f_0 and f_2 determined shall be corrected to the standard ambient conditions by the following equations:

$$f^*_0 = f_0 \left[1 + K_0 \left(T_T - T_0\right)\right]$$ Equation A7-8

$$f^*_2 = f_2 \times \frac{T_T}{T_0} \times \frac{p_0}{p_T}$$ Equation A7-9

where:
K_0 should be determined based on the empirical data for the particular motorcycle and tyre tests, or should be assumed as follows, if the information is not available: $K_0 = 6 \times 10^{-3}\ K^{-1}$.

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 motorcycle speed v_0, in Newton, is determined by the following equation:

$$F^*(v_0) = f^*_0 + f^*_2 \times v_0^2$$ Equation A7-10

<u>Annex 8</u>

FORM FOR THE RECORD OF COAST DOWN TIME

Trade name:........................... Production number (Body):...

Date: ..../...../..... Place of the test:......................... Name of recorder..........................

Climate:........................ Atmospheric pressure:...........kPa Atmospheric temperature:...........K

Wind speed (parallel/perpendicular):......../........m/s

Rider height:.....................m

Motorcycle speed km/h	Coast down time(s) in s					Statistical accuracy in per cent	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									
	First									
	Second									
	First									
	Second									
	First									
	Second									

Curve fitting: $F^{*} = \ldots + \ldots v^{2}$

Annex 9

RECORD OF CHASSIS DYNAMOMETER SETTING (BY COAST DOWN METHOD)

Trade name: .... Production number (body): ....

Date ..../..../..... Place of the test: .... Name of recorder: ....

Motorcycle speed in km/h	Coast down time(s) in s				Running resistance in N		Setting error, in per cent %	Note
	Test 1	Test 2	Test 3	Average	Setting value	Target value		

Curve fitting: $F^{*} = \ldots + \ldots v^{2}$

Annex 10

RECORD OF CHASSIS DYNAMOMETER SETTING (BY TABLE METHOD)

Trade name:.. Production number (Body):..

Date ..../..../...... Place of the test:...................................... Name of recorder:........................

Motorcycle speed in km/h	Coast down time(s) in s				Running resistance in N		Setting error in per cent	Note
	Test 1	Test 2	Test 3	Average	Setting value	Target value	%	

Curve fitting: $F^* = \dots + \dots v^2$

Annex 11

RECORD OF TYPE I TEST RESULTS

Trade name:.. Production number (Body):.................................

Date: ..../..../..... Place of the test:................................ Name of recorder.......................

Climate:........................ Atmospheric pressure:..............kPa Atmospheric temperature:.........K

Motorcycle Class	Reduced speed Yes/No	Cycle part	Starting cond.	Test number	Distance driven in km	Emission in g				Fuel cons. in litre
						HC	CO	NO_X	CO_2	
1, 2 or 3		1	Cold	1						
				2						
				3						
				Average						
1		1	Hot	1						
				2						
				3						
				Average						
2 or 3		2	Hot	1						
				2						
				3						
				Average						
3		3	Hot	1						
				2						
				3						
				Average						

Motorcycle Class	Reduced speed Yes/No	Cycle part	Starting condition	Weighting in per cent	Average Emission in g/km				Fuel cons. in litre/100 km
					HC	CO	NO_X	CO_2	
1		1	Cold	50					
		1	Hot	50					
	-	-	-	Final Result					
2		1	Cold	30					
		2	Hot	70					
	-	-	-	Final Result					
3		1	Cold	25					
		2	Hot	50					
		3	Hot	25					
	-	-	-	Final Result					

Annex 12

RECORD OF TYPE II TEST RESULTS

Trade name:.. Production number (Body):.................................

Date: ../.../.... Place of the test:............................ Name of recorder..............................

Climate:...................... Atmospheric pressure:..........kPa Atmospheric temperature:.............K

Idling speed in min^{-1}			Engine oil temperature in °C	CO content in per cent vol.	CO_2 content in per cent vol.	Corrected CO content in per cent vol.
Minimum	Average	Maximum				

High idling speed in min^{-1}			Engine oil temperature in °C	CO content in per cent vol.	CO_2 content in per cent vol.	Corrected CO content in per cent vol.
Minimum	Average	Maximum				

Annex 13

EXPLANATORY NOTE ON GEARSHIFT PROCEDURE

This explanatory note is not a part of the standard, but explains matters specified or described in the standard or appendix, and matters related thereto.

1. Approach

1.1. The development of the gearshift procedure was based on an analysis of the gearshift points in the in-use data. In order to get generalised relations between technical specifications of the vehicles and gearshift speeds the engine speeds were normalised to the utilisable band between rated speed and idling speed.

1.2. In a second step the end speeds (vehicle speed as well as normalised engine speed) for upshifts and downshifts were determined and collected in a separate table. The averages of these speeds for each gear and vehicle were calculated and correlated with technical specifications of the vehicles.

1.3. 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 speeds and technical data was found for normalised engine speeds and the power to mass ratio (rated power/(unladen mass + 75 kg)).

(c) The residual variations cannot be explained by other technical data or by different transmission ratios. They are most probably assigned to differences in traffic conditions and individual driver behaviour.

(d) The best approximation between gearshift speeds and power to mass ratio was found for exponential functions.

(e) The gearshift function for the first gear is significantly lower than for all other gears.

(f) The gearshift speeds for all other gears can be approximated by one common function.

(g) No differences were found between five-speed and six-speed gearboxes.

(h) The 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).

1.4. In order to find a balanced compromise between the three regions a new approximation function for normalised upshift speeds versus power to mass ratio was calculated as 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 engine upshift speeds:

Equation A13-1, normalised upshift speed in 1^{st} gear (gear 1).

$$n\_max\_acc\ (1) = (0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle}$$

Equation A13-2, normalised upshift speed in gears > 1

$$n\_max\_acc\ (i) = (0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle}$$

1.5. In use driving behaviour data from India was added to the WMTC database at a later stage. This resulted in modifications of the part 1 cycles and the part 2, reduced speed cycle. Within this modification work also the gearshift behaviour was checked. Fortunately, it could be proven that the WMTC gearshift prescriptions are also suitable for the Indian gearshift behaviour.

2. Example

Figure A13-1 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) The cruising phases the whole speed range between downshift speed and upshift speed may be used.

In case of gradually increase of vehicle speed during cruise phases, upshift speeds ($v_{1\rightarrow2}$, $v_{2\rightarrow3}$ and $v_{i\rightarrow i+1}$) in km/h may be calculated using the following equations:

Equation A13-3:

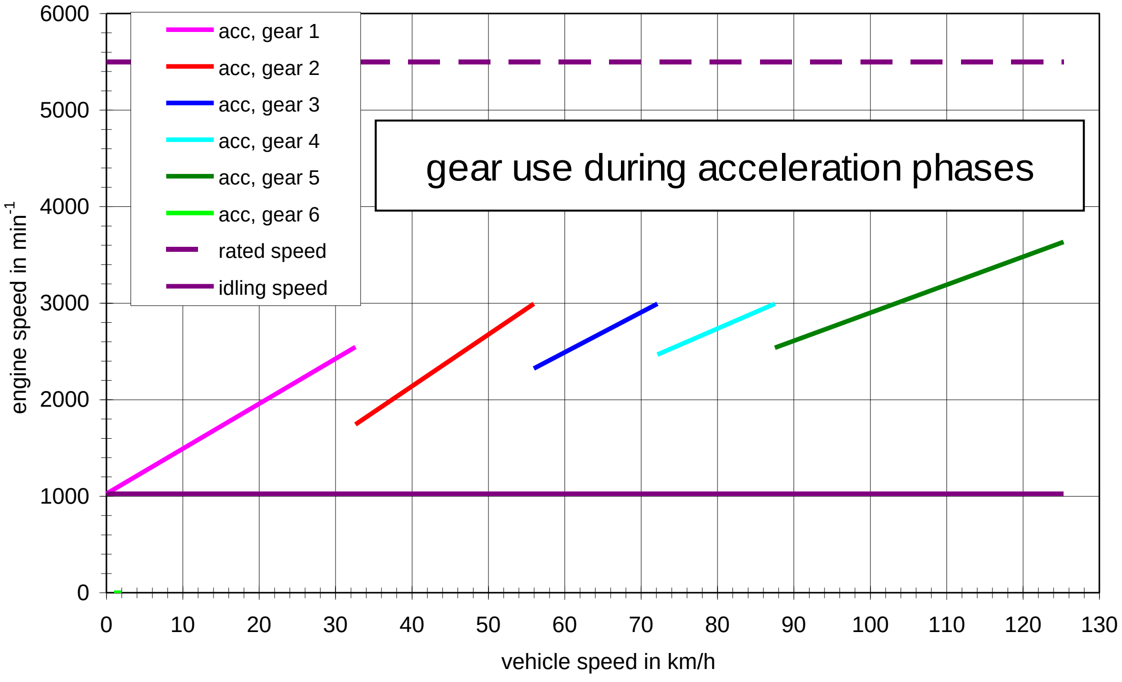
$$v_{1\rightarrow2} = \left[0.03 \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_2}$$

Equation A13-4:

$$v_{2\rightarrow3} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})} - 0.1) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_1}$$

Equation A13-5:

$$v_{i\rightarrow i+1} = \left[(0.5753 \times e^{(-1.9 \times \frac{P_n}{m_k + 75})}) \times (s - n_{idle}) + n_{idle}\right] \times \frac{1}{ndv_{i-1}}, \ i = 3 \text{ to } ng$$



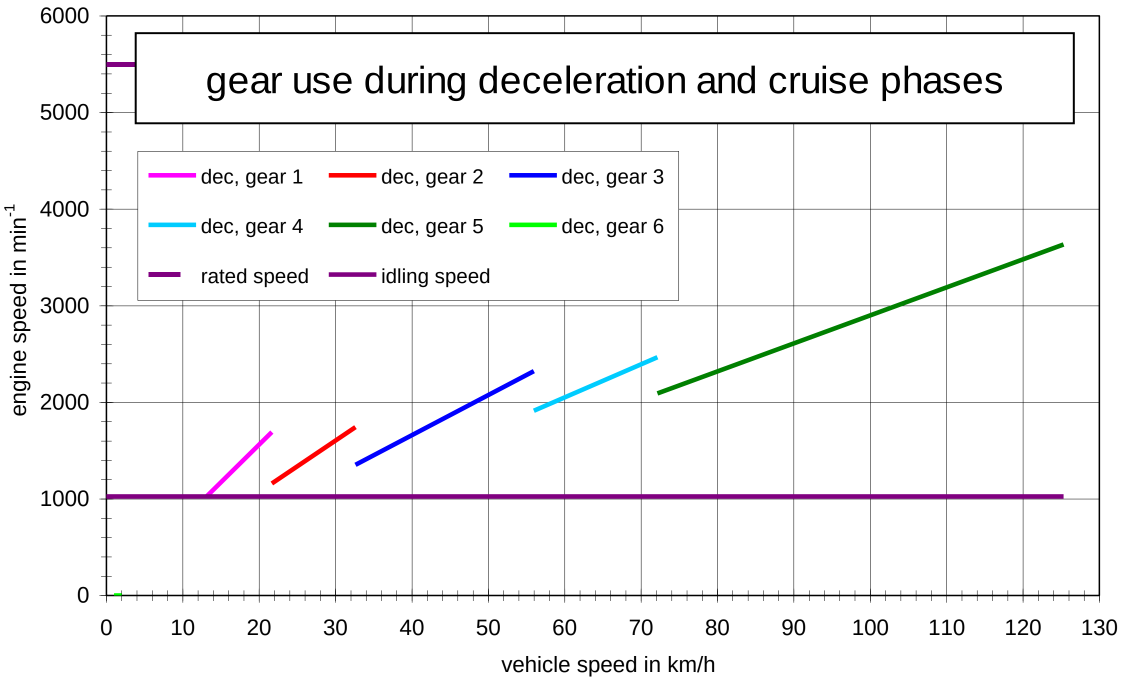


Figure A13-1: Example of a gearshift sketch

In order to allow to the test service more flexibility and to assure driveability the gearshift regression functions should be considered as lower limits. Higher engine speeds are permitted in any cycle phase.

3. Phase indicators

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 speed pattern of the cycles. The specification of the phase indicators is based on JARI's definition of the 4 driving modes as shown in the following table:

Table A13-1: Definition of driving modes

4 modes	Definition
Idle mode	vehicle speed < 5 km/h and -0.5 km/h/s (-0.139 m/s²) < acceleration < 0.5 km/h/s (0.139 m/s²)
Acceleration mode	acceleration ≥ 0.5 km/h/s (0.139 m/s²)
Deceleration mode	acceleration ≤ - 0.5 km/h/s (- 0.139 m/s²)
Cruise mode	vehicle speed ≥ 5 km/h and -0.5 km/h/s (-0.139 m/s²) < acceleration < 0.5 km/h/s (0.139 m/s²)

The indicators were then modified in order to avoid frequent changes during relatively homogeneous cycle parts and thus improve the driveability. Figure A13-2 shows an example from cycle part 1.

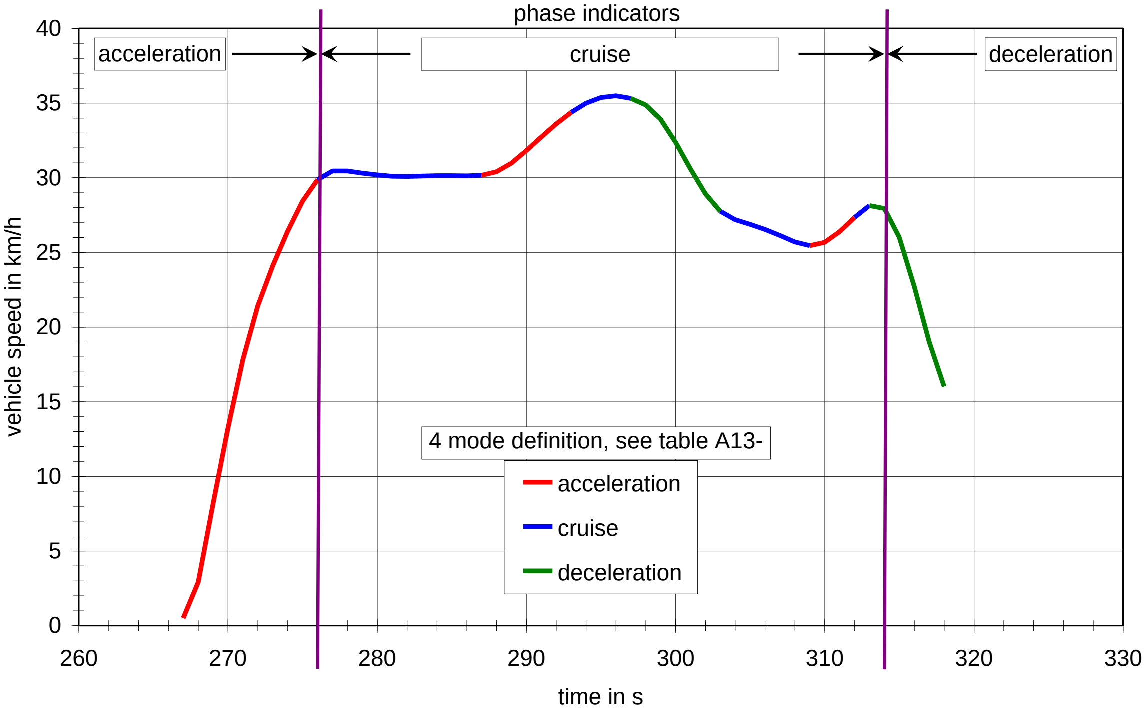


Figure A13-2: Example for modified phase indicators

4. Calculation example

4.1. An example of input data necessary for the calculation of shift speeds is shown in table A13-1. The upshift speeds for acceleration phases for the first gear and higher gears are calculated using equations 6-1 and 6-2. The denormalisation of engine speeds can be performed by using the equation n = n_norm x (s – n_{idle}) + n_{idle}.

4.2. The downshift speeds for deceleration phases can be calculated with equations 6-3 and 6-4. The ndv values in table A13-1 can be used as gear ratios. These values can also be used to calculate the affiliated vehicle speeds (vehicle shift speed in gear i = engine shift speed in gear i / ndv_i). The corresponding results are shown in tables A13-2 and A13-3.

4.3. In a further step the possibility of a simplification of the above-described gearshift algorithms was examined by additional analyses and calculations. It should especially be checked 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 A13-2: Input data for the calculation of engine and vehicle shift speeds

Item	Input Data
Engine capacity in cm^3	600
P_n in kW	72
m_k in kg	199
s in min^{-1}	11,800
n_{idle} in min^{-1}	1,150
ndv_1 */	133.66
ndv_2	94.91
ndv_3	76.16
ndv_4	65.69
ndv_5	58.85
ndv_6	54.04
pmr **/ in kW/t	262.8

*/ 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 P_n / (m_k+75) × 1,000; P_n in kW, m_k in kg

Table A13-3: Shift speeds for acceleration phases for the first gear and for higher gears (according to table A13-2)

Engine Speed	Upshift speeds	
	n_acc_max (1)	n_acc_max (i)
n_norm */ in per cent	24.9	34.9
n in min^{-1}	3,804	4,869

*/ n_norm means the calculated value by equation A13-1 and equation A13-2.

Table A13-4: Engine and vehicle shift speeds according to table A13-2

Gearshift		Shift speeds		
		v in km/h	n_norm (i) in per cent	n in 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. "

6.0 Part XIV

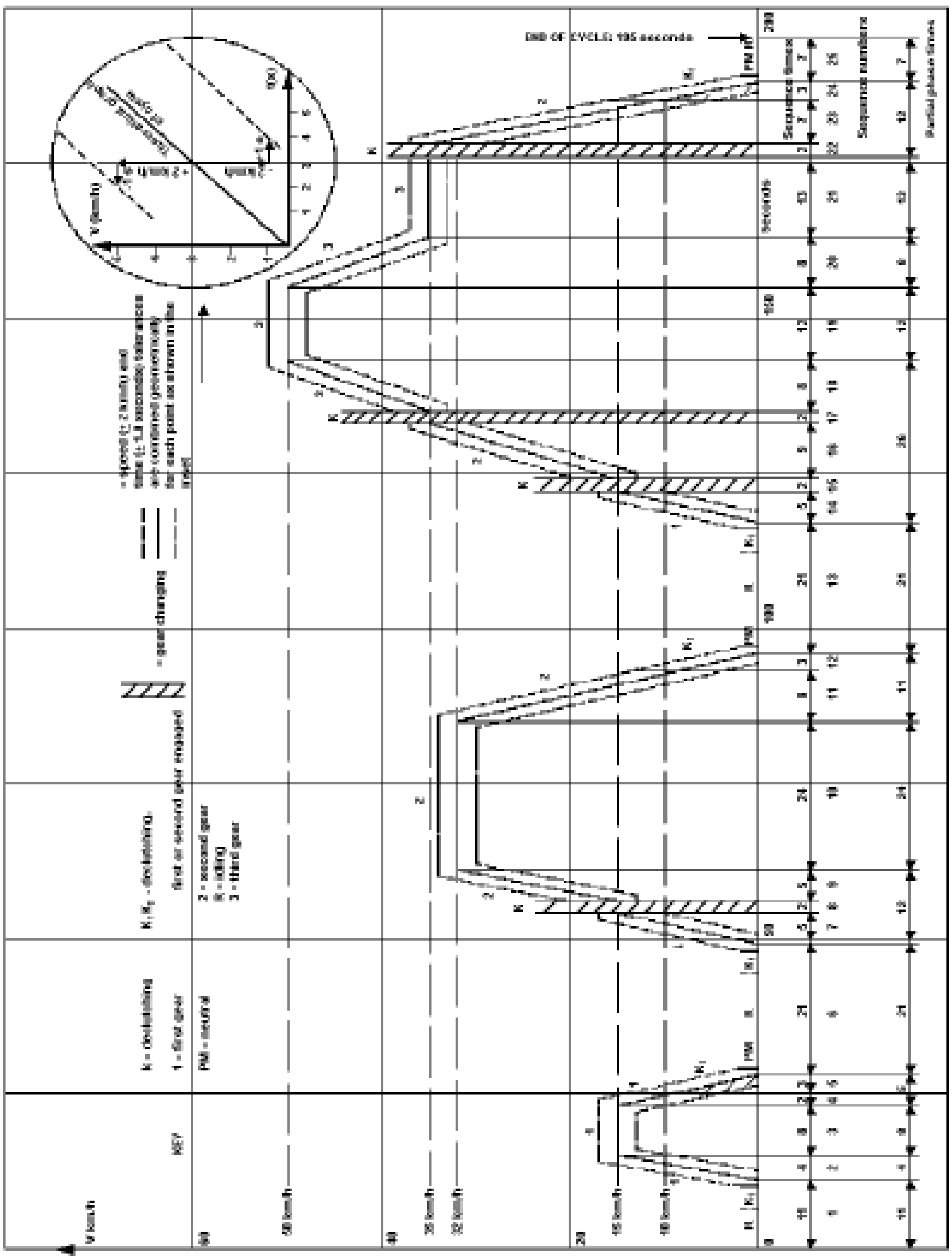
6.1 Chapter 1

6.1.1 **Clause 5.2.3.2**
Add following text as second paragraph to existing text:

"At High Idle speed the carbon monoxide content by volume and Lambda of exhaust gases emitted must not exceed the limits mentioned in 4.1 of Part I of this document."

6.2 Chapter 3

6.2.1 **Fig. 1**
Substitute following fig for existing fig:



6.2.2 In Table II in speed column of operation no 23 substitute “35 -10” for existing “32 – 10”

6.3 Chapter 4 (Section II)

6.3.1 Clause no. 5.1.1.2.7

Substitute following text for existing second paragraph:

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

P corrected = K * P measured

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

Where
R_R = rolling resistance at speed V
R_{AERO} = aerodynamic drag at speed V
R_T = total driving resistance = $R_R + R_{AERO}$
K_R = temperature correction factor of rolling resistance, taken to be equal to: 8.64×10^{-3} / degrees C or the manufacturer’s correction factor that is approved by the authority.
t = road test ambient temperature in degrees C
t_0 = reference ambient temperature = 20 degrees C
ρ = air density at the test conditions
ρ_0 = air density at the reference conditions (20 degrees C, 100 kPa)

The ratios R_R / R_T and R_{AERO}/ R_T shall be specified by the vehicle manufacturer on the basis of the data normally available to the company.
If these values are not available, subject to the agreement of the manufacturer and the technical service concerned, the figures for the rolling/ total resistance ratio given by the following formula may be used:

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

Where:
M= vehicle mass in kg
And for each speed the coefficients a and b are shown in the following table:

V (km /h)	a	b
20	7.24×10^{-5}	0.82
40	1.59×10^{-4}	0.54
60	1.96×10^{-4}	0.33
80	1.85×10^{-4}	0.23
100	1.63×10^{-4}	0.18
120	1.57×10^{-4}	0.14

6.4 Chapter 8

6.4.1 Under clause no. 2.0

Substitute:

Q_i = Density of the pollutant i in g/m^3 at normal temperature and pressure (293 K and 101.33 kPa)

For existing text:

Q_i = Density of the pollutant i in kg/m^3 at normal temperature and pressure (293 K and 101.33 kPa)

6.5 Chapter 14, Annexure 3 added to address requirement & Test Procedure for Bi-fuel vehicle fitted with Master Slave system.

Annexure 3

OBD Requirements & Test for CNG/LPG Fueled vehicles fitted with Master-Slave ECU System

1 This annexure is applicable for those CNG/LPG fueled (both OE fitment & Conversion of in use Gasoline vehicle) vehicles which are fitted with Master Slave ECU System. For the purposes of this annexure, the following definitions shall apply:

LPG/CNG fueled vehicle having other than master slave ECU systems shall be tested for compliance with OBD II as per chapter 14 of part XIV of this document.

1.1 **" Master-slave system"** means a system in which the LPG ECU or CNG ECU is able to translate the petrol ECU control strategy in LPG or CNG operation.

1.2 **"Original emission-related component"** means any component in the air inlet, exhaust or evaporative system which supplies an input to or receives an output from the petrol controller.

1.3 **"LPG/CNG emission-related component"** means any component in the air inlet or in the exhaust system which supplies an input to or receives an output from the LPG/CNG controller.

2. Specific OBD requirements and tests for "master-slave" system:

2.1 Notwithstanding the requirements of the Clause 3.9 and Annexure I of Chapter 14 of part XIV, a "Master-slave" system shall fulfill only the following requirements:

(a) The petrol ECU shall remain activated for engine management in both petrol and LPG/ CNG modes.

(b) During petrol operations the petrol OBD system shall remain the only on- board diagnostic system of the vehicle

(c) During LPG/CNG operations the petrol OBD system shall continue to monitor original emission related components with the exception of those which are not in use

(d) Vehicle shall meet all the requirements of Chapter 14 of Part XIV in Petrol mode of operation.

(e) During LPG/CNG operations the LPG/CNG ECU shall only monitor for the LPG/CNG emission-related components as well as their electrical connections;

2.2 Notwithstanding the requirements of Clause 3.9 and Annexure I of Chapter 14 of part XIV, the Master Slave system shall be submitted to the following tests, which, in the case of Type I tests, shall be performed according to Annexure 1 of this chapter.

2.2.1 For OE Fitment Vehicles:

2.2.1.1 On Petrol Mode of operation Vehicle shall meet requirement of clause 6.4.1 of Annexure I of this chapter

Approval granted to a vehicle type with respect to the Master Slave OBD system may be extended to different vehicle types belonging to the same Master Slave OBD family.

2.2.1.2 On LPG/CNG mode of operation the following tests shall be carried out

(a) During a Type I test, electrical disconnection of one LPG/CNG emission-related component;

(b) During a Type I test, replacement of one LPG/CNG emission-related component with a deteriorated and defective one or electronic simulation of such a failure.

(c) During a Type I test the electrical disconnection of any original emission-related component, which is in use during LPG/CNG operations.

The original MI or automatic switch from LPG/CNG mode to petrol mode shall activate before the end of the tests under any of the conditions above.

2.2.1.3 The LPG/CNG ECU shall follow the petrol ECU on fuel strategies (e.g. injection). This can be demonstrated by a monitoring (diagnostic) program, while modifying the signal of one of the petrol system's sensors with an impact on the injection time.

2.2.2 For Conversion of In-use vehicles:-

2.2.2.1 The following tests shall be carried out on vehicle, equipped with the Master slave system

(a) The LPG/CNG ECU shall follow the petrol ECU on fuel strategies (e.g. injection). This can be demonstrated by a monitoring (diagnostic) program, while modifying the signal of one of the petrol system's sensors with an impact on the injection time.

(b) During a Type I test on petrol the original malfunction indicator (MI) shall activate due to the electrical disconnection of any original emission-related component.

(c) During a Type I test on LPG/CNG the original MI shall activate due to the electrical disconnection of any original emission-related component, which is in use during LPG/CNG operations.

2.2.2.2 The following tests shall be carried out on the vehicle, equipped with the LPG/CNG system, only on LPG/CNG operating mode:

(a) During a Type I test, electrical disconnection of one LPG/CNG emission-related component.

(b) During a Type I test, replacement of one LPG/CNG emission-related component with a deteriorated and defective one or electronic simulation of such a failure.

The original MI or automatic switch from LPG/CNG mode to petrol mode shall activate before the end of the tests under any of the conditions above.

2.2.3 Fault codes due to malfunctions of the LPG/CNG emission-related components and their electrical connections shall be stored in the LPG/CNG ECU.

2.2.4 The vehicle / system manufacturer shall provide specific instructions as to read out the LPG/CNG fault codes referred to in clause 2.2.3

7.0 PART X - SUB PART A

Clause 8.2.1.1

Substitute following text for the existing text:

If the engine taken from the series does not satisfy the requirements of section 2.2 the manufacturer may ask for measurements to be performed on a sample of engines of the same specification taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean (x) of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to confirm if the following condition is met:

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

Where: -

$S^2 = \sum (x_i - x)^2 / (n-1)$

S = Standard Deviation

x_i = any one of the individual results obtained with the sample n.

L = the limit value laid down in Paragraph 2.2 for each gaseous pollutant considered and

k = a statistical factor depending on ‘n’ and given in the following table :-

N	2	3	4	5	6	7	8	9	10
K	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279

N	11	12	13	14	15	16	17	18	19
K	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

For $N \geq 20$, $K = \frac{0.860}{\sqrt{N}}$

8.0 PART X - SUB PART A FOR AGRICULUTARAL TRACTORS MANUFACTURED ON AND FROM 1.4.2010.

Clause 3.2.1.2

Substitute following text for the existing text:

If the engine taken from the series does not satisfy the requirements of section 2.9.3 the manufacturer may ask for measurements to be performed on a sample of engines of the same specification taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean (x) of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to confirm if the following condition is met:

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

Where: -

$S^2 = \sum (x_i - x)^2 / (n-1)$

S = Standard Deviation

x_i = any one of the individual results obtained with the sample n.

L = the limit value laid down in Paragraph 2.9.3 for each gaseous pollutant considered and

k = a statistical factor depending on ‘n’ and given in the following table:-

N	2	3	4	5	6	7	8	9	10
K	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279

N	11	12	13	14	15	16	17	18	19
K	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

For $N \geq 20$, $K = \frac{0.860}{\sqrt{N}}$

9.0 PART X - SUB PART B

Clause 3.2.1.2

Substitute following text for the existing text:

If the engine taken from the series does not satisfy the requirements of section 2.9.3 the manufacturer may ask for measurements to be performed on a sample of engines of the same specification taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean (x) of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to confirm if the following condition is met:

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

Where: -

$S^2 = \sum (x_i - x)^2 / (n-1)$

S = Standard Deviation

x_i = any one of the individual results obtained with the sample n.

L = the limit value laid down in Paragraph 2.9.3 for each gaseous pollutant considered and

k = a statistical factor depending on ‘n’ and given in the following table:-

N	2	3	4	5	6	7	8	9	10
K	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279

N	11	12	13	14	15	16	17	18	19
K	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

For N ≥ 20, $K = \frac{0.860}{\sqrt{N}}$

10.0 PART XV - SUB PART A

Clause 3.2.1.2
Substitute following text for the existing text:

If the engine taken from the series does not satisfy the requirements of section 2.9.3 the manufacturer may ask for measurements to be performed on a sample of engines of the same specification taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean (x) of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to confirm if the following condition is met:

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

Where: -

$S^2 = \sum (x_i - x)^2 / (n-1)$

S = Standard Deviation

x_i = any one of the individual results obtained with the sample n.

L = the limit value laid down in Paragraph 2.9.3 for each gaseous pollutant considered and

k = a statistical factor depending on 'n' and given in the following table:-

N	2	3	4	5	6	7	8	9	10
K	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279

N	11	12	13	14	15	16	17	18	19
K	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

For N ≥ 20, $K = \frac{0.860}{\sqrt{N}}$

11.0 PART XV – Chapter 8

Appendix 1
Clause 1.1 paragraph 3
Substitute following text for the existing text:

In the case of type-approval of an OBD system according to this part, the emissions shall be measured over the ESC test cycle (see Appendix 1 to chapter III to this Part) for diesel engine and ETC test cycle (see Appendix 2 to chapter III to this Part) for NG engine.

12.0 Addition of Part XVI: Test procedure for gasoline driven Power tiller to address GSR 515(E)

PART XVI

CHAPTER I

OVERALL REQUIREMENTS

1. Scope

This part applies to the emission of gaseous pollutants from gasoline engine driven power tiller effective from 01/07/2013 as per Central Motor Vehicle Rules 115 A and enforced as per the Government of India, Ministry of Road Transport and Highways, Notification no. 515 (E) dt. 29/6/2012.

2. Type approval

Every manufacturer of an gasoline driven power tiller shall meet the following requirements for the power tiller model before granting the type approval.

2.1 The gross power of the engine i.e. without fan when tested on engine dynamometer at steady speeds of the full load curve as per IS14599, may differ from the power declared by the manufacturer as follows :
For Type Approval :
For single cylinder engines, 10% at maximum power point including all other measured speeds.
For all other engines, 5% at rated speed and all other measured speeds.
For Conformity of Production :
At maximum power point by 10% for single cylinder engines and –5%+8% for all other engines.

2.2 Every gasoline driven power tiller shall be so manufactured and produced by its manufacturer that it complies with the following standards mentioned below table of mass emission.

Limit Value for Type Approval (TA) and Conformity of Production (COP)

Notification and date of enforcement	CO (g/Kwhr)	HC+Nox (g/Kwhr)
-------------	14	24

2.2.1

1) Engine will be subjected to mass emission in gross condition i.e. w/o fan but inclusive of intake and exhaust system or equivalent in test cells.

2) Cycle will be as per ISO 8178-4 ‘C1’ – 8 mode.

3) Each mode duration will be 10 min

4) Periodicity of COP

For equipment with annual production up to 200 nos., it shall be once in two years per family.
For equipment with annual production exceeding 200 nos., it shall be once in every year per family.

5) Reference fuel shall be as specified in Annexure IV-G of the central motor vehicle rule.

6) Conformity of Production.

6.1 Every produced vehicle of the model approved under this rule shall conform with regard to components affecting the emission of gaseous pollutants by the engine to the vehicle model type approved. The procedure for carrying out conformity of production test is given in Part VI of this document

6.2 For verifying the conformity of the engine in a test, the following procedure is adopted

6.2.1 An engine is taken from the series is subjected to the mass emission test

6.2.1.1 If the engine taken from the series does not satisfy the requirements of Paragraph 2.1 and 2.2 above, the manufacturer may ask for measurements to be performed on a sample of engines taken from the series and including the engine originally taken. The Manufacturer shall specify the size n of the sample subject to n being minimum 2 and maximum 10, including the engine originally taken.The engines other than originally tested shall be subjected to a test. The arithmetical mean ($\bar{x}$) of the results obtained from the sample shall be determined for each pollutant .The production of the series shall then be deemed to conform if the following condition is met:-

$x + k. S \leq L$
Where :-
$S2 = (x i - x) 2 / (n-1)$
S = Standard Deviation
X i= any one of the individual results obtained with the sample n
L = the limit value laid down in Paragraph 2.2 for each gaseous pollutant considered and
k = a statistical factor depending on ‘n’ and given in the following table :-

N	2	3	4	5	6	7	8	9	10
K	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279

N	11	12	13	14	15	16	17	18	19
K	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

For N ≥ 20, K = $\frac{0.860}{\sqrt{N}}$

CHAPTER – II

TEST PROCEDURE FOR SPARK IGNITION ENGINES

1. INTRODUCTION

1.1. This part describes the method of determining emissions of Gaseous pollutants from the engines to be tested.

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

2. TEST CONDITIONS

2.1 Engine test Conditions

The absolute temperature (Ta) of the engine air at the inlet to the engine, expressed in Kelvin, and the dry atmospheric pressure (ps), expressed in kPa, shall be measured and the parameter fa shall be determined according to the following provisions:

$$f_a = \left(\frac{99}{Ps}\right)^{1.2} X \left(\frac{Ta}{298}\right)^{0.6}$$

2.1.1 For a test to be recognized as valid, the parameter f_a shall be such that:

$$0.93 \leq f_a \leq 1.07$$

2.1.2 Engine with charge Air –cooling

The temperature of the cooling medium and the temperature of the chare air have to be recoded.

2.2 Engine Air Inlet system

The test engine shall be equipped with an air inlet system presenting an air inlet restriction within 10 % of the upper limit specified by the manufacturer for a new air cleaner at the engine operating conditions, as specified by the manufacturer, which result in maximum air flow in the respective engine application.

For small spark ignition engines (< 1 000 cm3 displacement) a system representative of the installed engine shall be used.

2.3 Engine Exhaust system

The test engine shall be equipped with an exhaust system presenting an exhaust back pressure within 10 % of the upper limit specified by the manufacturer for the engine operating conditions which result in the maximum declared power in the respective engine application.

For small spark ignition engines (< 1 000 cm3 displacement) a system representative of the installed engine shall be used.

2.4 Cooling system

An engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures prescribed by the manufacturer shall be used. This provision shall apply to units which have to be detached in order to measure the power, such as with a blower where the blower (cooling) fan has to be disassembled to get access to the crankshaft.

2.5 Lubrication Oil

Lubricating oil that meets the engine manufacturer's specifications for a particular engine and intended usage shall be used. Manufacturers must use engine lubricants representative of commercially available engine lubricants.

2.6 Adjustable Carburetors

Engines with limited adjustable carburetors shall be tested at both extremes of the adjustment.

2.7 Test Fuel

Reference fuel shall be as specified in Annexure IV-G of the central motor vehicle rule.

2.8 Determination of Dynamometer Settings

Emissions measurements shall be based on uncorrected brake power. Auxiliaries necessary only for the operation of the machine and which may be mounted on the engine shall be removed for the test. Where auxiliaries have not been removed, the power absorbed by them shall be determined in order to calculate the dynamometer settings except for engines where such auxiliaries form an integral part of the engine (e.g. cooling fans for air cooled engines).

The settings of inlet restriction and exhaust pipe backpressure shall be adjusted, for engines where it shall be possible to perform such an adjustment, to the manufacturer's upper limits, in accordance with sections 2.2 and 2.3. The maximum torque values at the specified test speeds shall be determined by experimentation in order to calculate the torque values for the specified test modes. For engines which are not designed to operate over a speed range on a full load torque curve, the maximum torque at the test speeds shall be declared by the manufacturer. The engine setting for each test mode shall be calculated using the formula:

$$S = \left[(P_M + P_{AE}) X \frac{L}{100}\right] - P_{AE}$$

where:

S is the dynamometer setting [kW],

PM is the maximum observed or declared power at the test speed under the test conditions (see Appendix 2 of this part) [kW],

PAE is the declared total power absorbed by any auxiliary fitted for the test [kW] and not required by Appendix 3 of this part,

L is the percent torque specified for the test mode.

If the ratio

$$\frac{P_{AE}}{P_M} \geq 0.03$$

the value of P_{AE} may be verified by the technical authority granting type- approval.

3. **TEST RUN**

3.1 Installation of the Measuring equipments

The instrumentation and sampling probes shall be installed as required. When using a full flow dilution system for exhaust gas dilution, the tailpipe shall be connected to the system.

3.2 Starting the Dilution System of Engine

The dilution system and the engine shall be started and warmed up until all temperatures and pressures have stabilized at full load and rated speed (section 3.5.2).

3.3 Adjustment of the Dilution Ratio

The total dilution ratio shall not be less than four.

For CO2 or NOx concentration controlled systems, the CO2 or Nox content of the dilution air must be measured at the beginning and at the end of each test. The pre- and post-test background CO2 or Nox concentration measurements of the dilution air must be within 100 ppm or 5 ppm of each other, respectively.

When using a dilute exhaust gas analysis system, the relevant background concentrations shall be determined by sampling dilution air into a sampling bag over the complete test sequence.

Continuous (non-bag) background concentration may be taken at the minimum of three points, at the beginning, at the end, and a point near the middle of the cycle and averaged. At the manufacturer's request background measurements may be omitted.

3.4 Checking the Analysers

Emission analyser shall be set at zero and spanned.

3.5 Test Cycle

3.5.1 Specification of Cycle

Mode Number	Engine Speed	Percent Load	Weighting Factor
1	Rated	100	0.15
2	Rated	75	0.15
3	Rated	50	0.15
4	Rated	10	0.1
5	Intermediate	100	0.1
6	Intermediate	75	0.1
7	Intermediate	50	0.1
8	Idle	---	0.15

3.5.2 Conditioning of the Engine

Warming up of the engine and the system shall be at maximum speed and torque in order to stabilize the engine parameters according to the recommendations of the manufacturer.

Note: The conditioning period should also prevent the influence of deposits from a former test in the exhaust system. There is also a required period of stabilization between test points which has been included to minimize point to point influences

3.5.3 (a) For engines tested with the dynamometer speed control test configuration: During each mode of the test cycle after the initial transition period, the specified speed shall be held to within ± 1 % of rated speed or ± 3 min-1 whichever is greater except for low idle which shall be within the tolerances declared by the manufacturer. The specified torque shall be held so that the average over the period during which the measurements are being taken is within ± 2 % of the maximum torque at the test speed.

(b) For engines tested with the dynamometer load control test configuration: During each mode of the test cycle after the initial transition period, the specified speed shall be within ± 2 % of rated speed or ± 3 min^{-1} whichever is greater, but shall in any case be held within ± 5 %, except for low idle which shall be within the tolerances declared by the manufacturer.

During each mode of the test cycle where the prescribed torque is 50 % or greater of the maximum torque at the test speed the specified average torque over the data acquisition period shall be held within ± 5 % of the prescribed torque. During modes of the test cycle where the prescribed torque is less than 50 % of the maximum torque at the test speed the specified average torque over the data acquisition period shall be held within ± 10 % of the prescribed torque or ± 0,5 Nm whichever is greater.

3.5.4 Analyser Response

The output of the analysers shall be recorded on a strip chart recorder or measured with an equivalent data acquisition system with the exhaust gas flowing through the analysers at least during the last 180 s of each mode. If bag sampling is applied for the diluted CO and CO_2 measurement (see Appendix 1, section 1.4.4), a sample shall be bagged during the last 180 s of each mode, and the bag sample analysed and recorded.

3.5.5 Engine Conditions

The engine speed and load, intake air temperature and fuel flow shall be measured for each mode once the engine has been stabilized. Any additional data required for calculation shall be recorded (see Appendix 3, sections 1.1 and 1.2).

3.6 Rechecking the Analysers

After the emission test a zero gas and the same span gas shall be used for re-checking. The test shall be considered acceptable if the difference between the two measuring results is less than 2 %.

APPENDIX 1

1. MEASUREMENT AND SAMPLING PROCEDURES

Gaseous components emitted by the engine submitted for testing shall be measured by the methods described in MoRTH/CMVR/TAP-115/116 part XII chapter V section 1.1. The methods of MoRTH/CMVR/TAP-115/116 part XII chapter V section 1.1 describe the recommended analytical systems for the gaseous emissions.

1.1. Dynamometer Specification

An engine dynamometer with adequate characteristics to perform the test cycles described in part , section 3.5.1 shall be used. The instrumentation for torque and speed measurement shall allow the measurement of the shaft power within the given limits. Additional calculations may be necessary.

The accuracy of the measuring equipment must be such that the maximum tolerances of the figures given in section 1.3 are not exceeded.

1.2 Fuel Flow and Total diluted Flow

Fuel flow meters with the accuracy defined in section 1.3 shall be used to measure the fuel flow that will be used to calculate emissions (Appendix 3). When using a full flow dilution system, the total flow of the dilute exhaust (GTOTW) shall be measured with a PDP or CFV — MoRTH/CMVR/TAP-115/116 part XII chapter V section 2.3. The calibration of gas flow meters or flow measurement instrument shall be traceable to national and/ or international standards.
The maximum error of the measured vslue shall be within +/- 2% of reading.

1.3 Accuracy

The calibration of all measuring instruments shall be traceable to national (international) standards and comply with the requirements given in tables 2 and 3.

Table 2
Permissible deviations of instruments for engine related parameters

No	Item	Permissible Deviation
1	Engine speed	± 2 % of the reading or ± 1 % of engine's max value whichever is larger
2	Torque	± 2 % of the reading or ± 1 % of engine's max value whichever is larger
3	Fuel consumption (1)	± 2 % of engine's max value
4	Air consumption (1)	± 2 % of the reading or ± 1 % of engine's max value whichever is larger
(1) The calculations of the exhaust emissions as described in this part are, in some cases, based on different measurement and/or calculation methods. Because of limited total tolerances for the exhaust emission calculation, the allowable values for some items, used in the appropriate equations, must be smaller than the allowed tolerances given in ISO 3046-3.		

TABLE 3
Permissible deviations of instruments for other essential parameters

No	Item	Permissible Deviation
1	Temperatures ≤ 600 K	± 2 K absolute
2	Temperatures ≥ 600 K	± 1 % of reading
3	Exhaust gas pressure	± 0,2 kPa absolute
4	Inlet manifold depressions	± 0,05 kPa absolute
5	Atmospheric pressure	± 0,1 kPa absolute
6	Other pressures	± 0,1 kPa absolute
7	Relative humidity	± 3 % absolute
8	Absolute humidity	± 5 % of reading
9	Dilution air flow	± 2 % of reading
10	Diluted exhaust gas flow	± 2 % of reading

1.1 Determination of Gaseous components

1.4.1. General Analyser specifications

The analysers shall have a measuring range appropriate for the accuracy required for measuring the concentrations of the exhaust gas components (section 1.4.1.1). It is recommended that the analysers be operated such that the measured concentration falls between 15 % and 100 % of full scale.
If the full scale value is 155 ppm (or ppm C) or less or if read-out systems (computers, data loggers) that provide sufficient accuracy and resolution below 15 % of full scale are used concentrations below 15 % of full scale are also acceptable. In this case, additional calibrations are to be

made to ensure the accuracy of the calibration curves - Appendix 2, section 1.5.5.2, of this part.

The electromagnetic compatibility (EMC) of the equipment shall be on a level as to minimize additional errors.

1.4.1.3. Accuracy

The analyser shall not deviate from the nominal calibration point by more than ± 2 % of the reading over the whole measurement range except zero, and ± 0,3 % of full scale at zero. The accuracy shall be determined according to the calibration requirements laid down in section 1.3.

1.4.1.4. Repeatability

The repeatability, shall be such that 2,5 times the standard deviation of 10 repetitive responses to a given calibration or span gas is not greater than ± 1 % of full scale concentration for each range used above 100 ppm (or ppmC) or ± 2 % of each range used below 100 ppm (or ppmC).

1.4.1.5. Noise

The analyser peak-to-peak response to zero and calibration or span gases over any 10-s period shall not exceed 2 % of full scale on all ranges used.

1.4.1.6. Zero Drift

Zero response is defined as the mean response, including noise, to a zero gas during a 30-s time interval. The drift of the zero response during a one-hour period shall be less than 2 % of full scale on the lowest range used.

1.4.1.5 Span Drift

Span response is defined as the mean response, including noise, to a span gas during a 30-s time interval. The drift of the span response during a one-hour period shall be less than 2 % of full scale on the lowest range used.

1.4.2 Gas Drying

Exhaust gases may be measured wet or dry. Any gas-drying device, if used, must have a minimal effect on the concentration of the measured gases. Chemical dryers are not an acceptable method of removing water from the sample.

1.4.3 Analyser

Sections 1.4.3.1 to 1.4.3.5 describe the measurement principles to be used. A detailed description of the

measurement systems is given in MoRTH/CMVR/TAP-115/116 part XII chapter V.
The gases to be measured shall be analysed with the following instruments. For non-linear analysers, the use of linearising circuits is permitted.

1.4.3.1Carbon Monoxide (CO) Analysis

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

1.4.3.2 Carbon dioxide (CO2) analysis

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

1.4.3.3.Oxygen (O_2) Analysis

Oxygen analysers shall be of the paramagnetic detector (PMD),zirconium dioxide (ZRDO) or electrochemical sensor (ECS) types.

Note: Zirconium dioxide sensors are not recommended when HC and CO concentrations are high such as for lean burn spark ignited engines. Electrochemical sensors shall be compensated for CO2 and NOX interference.

1.4.3.4Hydrocarbon (HC) Analysis

For direct gas sampling the hydrocarbon analyser shall be of the heated flame ionisation detector (HFID) type with detector, valves, pipework, etc., heated so as to maintain a gas temperature of 463 K ± 10 K (190 oC ± 10 ^{o}C).
For diluted gas sampling the hydrocarbon analyser shall be either the heated flame ionisation detector (HFID) type or the flame ionization detector (FID) type.

1.4.3.5. Oxide s of nitrogen (NO x) analysis

The oxides of nitrogen analyser shall be of the chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD) type with a NO2/NO converter, if measured on a dry basis. If measured on a wet basis, a HCLD with converter maintained above 328 K (55 ^{o}C) shall be used, provided the water quench check (MoRTH/CMVR/TAP-115/116 part XII chapter III, Appendix 5 section 1.9.2.2) is satisfied. For both CLD and HCLD, the sampling path shall be maintained at a wall temperature of 328 K to 473 K (55 ^{o}C to 200 ^{o}C) up to the converter for dry measurement, and up to the analyser for wet measurement.

1.4.4. Sampling for Gaseous Emissions

If the composition of the exhaust gas is influenced by any exhaust after treatment system, the exhaust sample shall be taken downstream of this device.

The exhaust sampling probe should be in a high pressure side of the muffler, but as far from the exhaust port as possible. To ensure complete mixing of the engine exhaust before sample extraction, a mixing chamber may be optionally inserted between the muffler outlet and the sample probe. The internal volume of the mixing chamber must be not less than 10 times the cylinder displacement of the engine under test and should be roughly equal dimensions in height, width and depth, being similar to a cube. The mixing chamber size should be kept as small as practicable and should be coupled as close as possible to the engine. The exhaust line leaving the mixing chamber of muffler should extend at least 610 mm beyond the sample probe location and be of sufficient size to minimize back pressure. The temperature of the inner surface of the mixing chamber must be maintained above the dew point of the exhaust gases and a minimum temperature of 338 oK (65 ^{o}C) is recommended.

All components may optionally be measured directly in the dilution tunnel, or by sampling into a bag and subsequent measurement of the concentration in the sampling bag.

APPENDIX 2

1. CALIBRATION OF ANALYTICAL INSTRUMENTS

1.1. Introduction

Each analyser shall be calibrated as often as necessary to fulfill the accuracy requirements of this standard. The calibration method that shall be used is described in this paragraph for the analysers indicated in Appendix 1, section 1.4.3.

1.2 Calibration Gases

The shelf life of all calibration gases must be respected.
The expiry date of the calibration gases stated by the manufacturer shall be recorded.

1.2.1. Pure Gases

The required purity of the gases is defined by the contamination limits given below. The following gases must be available for operation:

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

— purified oxygen (purity > 99,5 Vol.- % O_2),

— hydrogen-helium mixture (40 ± 2 % hydrogen, balance helium); contamination ≤ 1 ppm C, ≤ 400 ppm CO_2,

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

1.2.2. Calibration and Span Gases

Mixture of gases having the following chemical compositions shall be available:

— C_3H_8 and purified synthetic air (see section 1.2.1),

— CO and purified nitrogen,

— and purified nitrogen (the amount of NO_2 contained in this calibration gas must not exceed 5 % of the NO content),

— CO_2 and purified nitrogen,

— CH_4 and purified synthetic air,

— C_2H_6 and purified synthetic air.

Note: Other gas combinations are allowed provided the gases do not react with one another.

The true concentration of a calibration and span gas shall be within ± 2 % of the nominal value. All concentrations of calibration gas shall be given on a volume basis (volume percent or volume ppm).

The gases used for calibration and span may also be obtained by means of precision blending devices (gas dividers), diluting with purified N2 or with purified synthetic air. The accuracy of the mixing device must be such that the concentration of the diluted calibration gases is accurate to within ± 1,5 %. This accuracy implies that primary gases used for blending must be known to an accuracy of at least ± 1 %, traceable to national or international gas standards. The verification shall be performed at between 15 % and 50 % of full scale for each calibration incorporating a blending device.

Optionally, the blending device may be checked with an instrument, which by nature is linear, e.g. using NO gas with a CLD. The span value of the instrument shall be adjusted with the span gas directly connected to the instrument. The blending device shall be checked at the used settings and the nominal value shall be compared to the measured concentration of the instrument. This difference shall in each point be within ± 0,5 % of the nominal value.

1.2.3. Oxygen Interference Check

Oxygen interference check gases shall contain propane with 350 ppm C ± 75 ppm C hydrocarbon. The concentration value shall be determined to calibration gas tolerances by chromatographic analysis of total hydrocarbons plus impurities or by dynamic blending. Nitrogen shall be the predominant diluent with the balance oxygen. Blend required for gasoline-fuelled engine testing is as follows:

O2 interference concentration	Balance
10 (9 to 11)	Nitrogen
5 (4 to 6)	Nitrogen
0 (0 to 1)	Nitrogen

1.3 Operating procedure for analysers and sampling system

The operating procedure for analysers shall follow the start-up and operating instructions of the instrument manufacturer. The minimum requirements given in sections 1.4 to 1.9 shall be included. For laboratory instruments such as GC and high performance liquid chromatography (HPLC) only section 1.5.4 shall apply.

1.2 Leakage test

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

The maximum allowable leakage rate on the vacuum side shall be 0,5 % of the in-use flow rate for the portion of the system being checked. The analyser flows and bypass flows may be used to estimate the in-use flow rates.

Alternatively, the system may be evacuated to a pressure of at least 20 kPa vacuum (80 kPa absolute). After an initial stabilisation period the pressure increase δp (kPa/min) in the system shall not exceed:

$$\delta p = p/V_{syst} \times 0{,}005 \times fr$$

Where:

V_{syst} = system volume [l]

fr = system flow rate [l/min]

Another method is the introduction of a concentration step change at the beginning of the sampling line by switching from zero to span gas. If after an adequate period of time the reading shows a lower concentration compared to the introduced concentration, this points to calibration or leakage problems.

1.5. Calibration procedure

1.5.1 Instrument assembly

The instrument assembly shall be calibrated and calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust gas.

1.5.2. Warming-up time

The warming-up time should be according to the recommendations of the manufacturer. If not specified, a minimum of two hours is recommended for warming-up the analysers.

1.5.3. NDIR and HFID analyser

The NDIR analyser shall be tuned, as necessary, and the combustion flame of the HFID analyser shall be optimised (section 1.9.1).

1.5.4. GC and HPCL Both instruments shall be calibrated according to good laboratory practice and the recommendations of the manufacturer.

1.5.5. Establishment of the calibration curves

1.5.5.1. General Guideline

(a) Each normally used operating range shall be calibrated.
(b) Using purified synthetic air (or nitrogen), the CO, CO2, NOx and HC analysers shall be set at zero.
(c) The appropriate calibration gases shall be introduced to the analysers, the values recorded, and the calibration curves established.
(d) For all instrument ranges except for the lowest range, the calibration curve shall be established by at least 10 calibration points (excluding zero) equally spaced. For the lowest range of the instrument, the calibration curve shall be established by at least 10 calibration points (excluding zero) spaced so that half of the calibration points are placed below 15 % of the analyser's full scale and the rest are placed above 15 % of full scale. For all ranges the highest nominal concentration must be equal to or higher than 90 % of full scale.
(e) The calibration curve shall be calculated by the method of least squares. A best-fit linear or non-linear equation may be used.
(f) The calibration points must not differ from the least-squares best-fit line by more than ± 2 % of reading or ± 0,3 % of full scale whichever is larger.
(g) The zero setting shall be rechecked and the calibration procedure repeated, if necessary.

1.5.5.2. Alternative Method

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

1.5 Verification of the calibration

Each normally used operating range shall be checked prior to each analysis in accordance with the following procedure.
The calibration is checked by using a zero gas and a span gas whose nominal value is more than 80 % of full scale of the measuring range. If, for the two points considered, the value found does not differ by more than ± 4 % of full scale from the declared reference value, the adjustment parameters may be modified. Should this not be the case, the span gas shall be verified or a new calibration curve shall be established in accordance with section 1.5.5.1.

1.6 Calibration of tracer gas analyser for exhaust flow measurement The analyser for measurement of the tracer gas concentration shall be calibrated using the standard gas. The calibration curve shall be established by at least 10 calibration points (excluding zero) spaced so that half of the calibration points are placed between 4 % to 20 % of the analyser's full scale and the rest are in between 20 % and 100 % of the full scale. The calibration curve shall be calculated by the method of least squares. The calibration curve must not differ by more than ± 1 % of the full scale from the nominal value of each calibration point, in the range from 20 % to 100 % of the full scale. It also must not differ by more than ± 2 % of reading from the nominal value in the range from 4 % to 20 % of the full scale. The analyser shall be set at zero and spanned prior to the test run using a zero gas and a span gas whose nominal value is more than 80 % of the analyser full scale.

1.8 Efficiency test of the NOx Converter

The efficiency of the converter used for the conversion of NO2 into NO shall be tested as given in sections 1.8.1 to 1.8.8 (Figure 6) of this appendix.

1.8.1 Test Set-up

Using the test set-up as shown in Figure 6 (see also chapter III, appendix 4, section 3.3.5 of this part) and the procedure below, the efficiency of converters can be tested by means of an ozonator.

1.8.2 Calibration

The CLD and the HCLD shall be calibrated in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which must amount to about 80 % of the operating range and the NO2 concentration of the gas mixture to less than 5 % of the NO concentration). The NOX analyser must be in the NO mode so that the span gas does not pass through the converter. The indicated concentration has to be recorded.

1.8.3 Calculation

The efficiency of the NOx converter is calculated as follows:

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

where,
a is the NOx concentration according to section 1.8.6
b is the NOx concentration according to section 1.8.7
c is the NO concentration according to section 1.8.4
d is the NO concentration according to section 1.8.5

1.8.4 Adding of Oxygen

Via a T-fitting, oxygen or zero air is added continuously to the gas flow until the concentration indicated is about 20 % less than the indicated calibration concentration given in section 1.8.2 of this appendix (The analyser is in the NO mode). The indicated concentration c shall be recorded. The ozonator is kept deactivated throughout the process.

1.8.5 Activation of the Ozonator

The ozonator is now activated to generate enough ozone to bring the NO concentration down to about 20 % (minimum 10 %) of the calibration concentration given in section 1.8.2 of this appendix. The indicated concentration d shall be recorded (The analyser is in the NO mode).

1.8.6 NOX Mode

The NO analyser is then switched to the NOx mode so that the gas mixture (consisting of NO, NO2, O2 and N2) now passes through the converter. The indicated concentration a shall be recorded. (The analyser is in the NOX mode).

1.8.7 Deactivation of the Ozonator

The ozonator is now deactivated. The mixture of gases described in section 1.8.6 of this appendix passes through the converter into the detector. The indicated concentration b shall be recorded. (The analyser is in the NOX mode).

1.8.8 NO Mode

Switched to NO mode with the ozonator deactivated, the flow of oxygen or synthetic air is also shut off. The NOx reading of the analyser shall not deviate by more than ± 5 % from the value measured according to section 1.8.2. of this appendix (The analyser is in the NO mode).

1.8.9 Test Interval

The efficiency of the converter must be tested prior to each calibration of the NOX analyser.

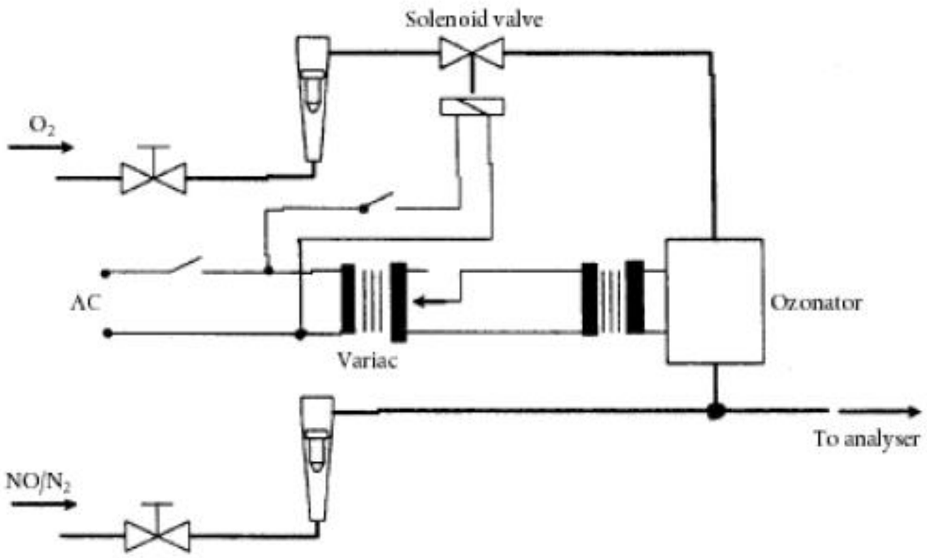
1.8.10 Efficiency Requirement

The efficiency of the converter shall not be less than 90 %, but a higher efficiency of 95 % is strongly recommended.

Note: If, with the analyser in the most common range, the ozonator cannot give a reduction from 80 % to 20 % according to section 1.8.5 of this appendix, then the highest range which will give the reduction shall be used.

Figure 6

Schematic of NO_x converter efficiency device



1.9 Adjustment of the FID

1.9.1 Optimisation of the Detector Response

The FID must be adjusted as specified by the instrument manufacturer. A propane in air span gas should be used to optimise the response on the most common operating range.

With the fuel and air flow rates set at the manufacturer's recommendations, a 350 ± 75 ppm C span gas shall be introduced to the analyser. The response at a given fuel flow shall be determined from the difference between the span gas response and the zero gas response. The fuel flow shall be incrementally adjusted above and below the manufacturer's specification. The span and zero response at these fuel flows shall be recorded. The difference between the span and zero response shall be plotted and the fuel flow adjusted to the rich side of the curve.

1.9.2 Hydrocarbon Response Factors

The analyser shall be calibrated using propane in air and purified synthetic air, according to section 1.5 of this appendix.

Response factors shall be determined when introducing an analyser into service and after major service intervals. The response factor (Rf) for a particular hydrocarbon species is the ratio of the FID C1 reading to the gas concentration in the cylinder expressed by ppm C1.

The concentration of the test gas must be at a level to give a response of approximately 80 % of full scale. The concentration must be known to an accuracy of ± 2 % in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder must be preconditioned for 24 hours at a temperature of 298 K ± 5 K (25 °C ± 5 °C).

The test gases to be used and the recommended relative response factor ranges are as follows:

Methane and purified synthetic air 1,00 < = Rf < = 1,15

Propylene and purified synthetic air 0,90 < = Rf < = 1,10

Toluene and purified synthetic air 0,90 < = Rf < = 1,10

These values are relative to the response factor (Rf) of 1,00 for propane and purified synthetic air.

1.9.3 Oxygen Interference Check

The oxygen interference check shall be determined when introducing an analyzer into service and after major service intervals.

The response factor is defined and shall be determined as described in section 1.9.2 of this appendix. The test gas to be used and the recommended relative response factor range are as follows:

Propane and nitrogen 0,95 ≤ Rf ≤ 1,05

This value is relative to the response factor (Rf) of 1,00 for propane and purified synthetic air.

The FID burner air oxygen concentration must be within ± 1 mole% of the oxygen concentration of the burner air used in the latest oxygen interference check. If the difference is greater, the oxygen interference

1.10 Interference Effects with CO, CO2, and O_2 Analysers

Gases present in the exhaust other than the one being analysed can interfere with the reading in several ways. Positive interference occurs in NDIR instruments where the interfering gas gives the same effect as the gas being measured, but to a lesser degree. Negative interference occurs in NDIR instruments by the interfering gas broadening the absorption band of the measured gas, and in CLD instruments by the interfering gas quenching the radiation. The interference checks in sections 1.10.1 and 1.10.2 of this appendix shall be performed prior to an analyser's initial use and after major service intervals.

1.10.1 CO Analyser Interference Check

Water and CO2 can interfere with the CO analyser performance. Therefore, a CO2 span gas having a concentration of 80 to 100 % of full scale of the maximum operating range used during testing shall be bubbled through water at room temperature and the analyser response recorded. The analyser response must not be more than 1 % of full scale for ranges equal to or above 300 ppm or more than 3 ppm for ranges below 300 ppm.

1.10.2 NOX Analyser Quench Checks

The two gases of concern for CLD (and HCLD) analysers are CO2 and water vapour. Quench responses to these gases are proportional to their concentrations, and therefore require test techniques to determine the quench at the highest expected concentrations experienced during testing.

1.10.2.1 CO2 Quench Check

A CO2 span gas having a concentration of 80 to 100 % of full scale of the maximum operating range shall be passed through the NDIR analyser and the CO2 value recorded as A. It shall then be diluted approximately 50 % with NO span gas and passed through the NDIR and (H)CLD, with the CO2 and NO values recorded as B and C, respectively. The CO2 shall then be shut off and only the NO span gas be passed through the (H)CLD and the NO value recorded as D.

The quench, which must not be greater than 3 % of full scale, shall be calculated as follows:

$$\% \text{ quench} = \left[1 - \left(\frac{C \times A}{(D \times A) - (D \times B)}\right)\right] \times 100$$

where,

A is the undiluted CO_2 concentration measured with NDIR in %

B is the diluted CO_2 concentration measured with NDIR in %

C is the diluted NO concentration measured with (H)CLD in ppm

D is the undiluted NO concentration measured with (H)CLD in ppm

Alternative methods of diluting and quantifying of CO_2 and NO span gas values such as dynamic mixing/blending can be used.

1.10.2.2 Water Quench Check

This check applies to wet gas concentration measurements only. Calculation of water quench must consider dilution of the NO span gas with water vapour and scaling of water vapour concentration of the mixture to that expected during testing.

A NO span gas having a concentration of 80 to 100 % of full scale of the normal operating range shall be passed through the (H)CLD and the NO value recorded as D. The NO span gas shall then be bubbled through water at room temperature and passed through the (H)CLD and the NO value recorded as C. The analyser's absolute operating pressure and the water temperature shall be determined and recorded as E and F, respectively. The mixture's saturation vapour pressure that corresponds to the bubbler water temperature F shall be determined and recorded as G. The water vapour concentration (H, in %) of the mixture shall be calculated as follows:

$$H = 100 \times (G/E)$$

The expected diluted NO span gas (in water vapour) concentration (De) shall be calculated as follows:

$$De = D \times (1 - H/100)$$

For diesel exhaust, the maximum exhaust water vapour concentration (Hm, in %) expected during testing shall be estimated, under the assumption of a fuel atom H/C ratio of 1,8:1, from the undiluted CO_2 span gas concentration (A, as measured in section 1.10.2.1 of this appendix) as follows:

$$Hm = 0{,}9 \times A$$

The water quench, which must not be greater than 3 %, shall be calculated as follows:

$$\% \text{ Quench} = 100 \times ((De - C) / De) \times Hm / H)$$

where,

De= is the expected diluted NO concentration in ppm

C= is the diluted NO concentration in ppm

Hm= is the maximum water vapour concentration in %

H= is the actual water vapour concentration in %

Note: It is important that the NO span gas contains minimal NO2 concentration for this check, since absorption of NO2 in water has not been accounted for in the quench calculations.

1.10.3 O2 analyser interference

Instrument response of a PMD analyser caused by gases other than oxygen is comparatively slight. The oxygen equivalents of the common exhaust gas constituents are shown in table 1.

Tabel 1 — Oxygen equivalents

Gas	O2 equivalent %
Carbon dioxide (CO2)	− 0,623
Carbon monoxide (CO)	− 0,354
Nitrogen oxide (NO)	+ 44,4
Nitrogen dioxide (NO2)	+ 28,7
Water (H2O)	− 0,381

The observed oxygen concentration shall be corrected by the following formula if high precision measurements are to be done:

$$\text{Interference} = \frac{(Equivalent\ \%\ O2\ x\ Obs.Conc.)}{100}$$

1.11 Calibration Interval

The analysers shall be calibrated according to section 1.5 at least every 3 months or whenever a system repair or change is made that could influence calibration.

APPENDIX 3

1. DATA EVALUATION AND CALCULATIONS

1.1. Gaseous Emissions evaluation

For the evaluation of the gaseous emissions, the chart reading for a minimum of the last 120 s of each mode shall be averaged, and the average concentrations (conc) of HC, CO, NOx and CO2 during each mode shall be determined from the average chart readings and the corresponding calibration data. A different type of recording can be used if it ensures an equivalent data acquisition.

The average background concentration (concd) may be determined from the bag readings of the dilution air or from the continuous (non-bag) background reading and the corresponding calibration data

1.2. Calculation of the gaseous emissions

The finally reported test results shall be derived through the following steps.

1.2.1 Dry/wet correction

The measured concentration, if not already measured on a wet basis, shall be converted to a wet basis:

conc (wet) = kw × conc (dry)

For the raw exhaust gas.

$$k_w = k_{w,r} = \frac{1}{1 + \alpha \times 0{,}005 \times (\%\ CO\ [dry] + \%\ CO_2[dry]) - 0{,}01 \times \%\ H_2[dry] + k_{w2}}$$

Where α is the hydrogen to carbon ratio in the fuel.

The H2 concentration in the exhaust shall be calculated:

$$H_2[dry] = \frac{05 \times \alpha \times \%\ CO\ [dry] \times (\%\ CO\ [dry] + \%\ CO_2[dry])}{\%\ CO\ [dry] + (3 \times \%\ CO_2[dry])}$$

The factor kw2 shall be calculated:

$$k_{w2} = \frac{1{,}608 \times H_a}{1\,000 + (1{,}608 \times H_a)}$$

with Ha absolute humidity of the intake air as g of water per kg of dry air.

For the diluted exhaust gas:

for wet CO2 measurement:

$$k_w = k_{w,e,1} = \left(1 - \frac{\alpha \times \%\ CO2[wet]}{200}\right) - k_{w1}$$

or, for dry CO2 measurement

$$k_w = k_{w,e,2} = \left(\frac{(1 - k_{w1})}{1 + \frac{\alpha \times \%\ CO_2[dry]}{200}}\right)$$

where α is the hydrogen to carbon ratio in the fuel.

The factor kw1 shall be calculated from the following equations:

$$k_{w1} = \frac{1{,}608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}{1\,000 + 1{,}608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}$$

where:

Hd absolute humidity of the dilution air, g of water per kg of dry air

Ha absolute humidity of the intake air, g of water per kg of dry air

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

For the dilution air:

kw,d = 1 − kw1

The factor kw1 shall be calculated from the following equations:

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

$$k_{w1} = \frac{1{,}608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}{1\,000 + 1{,}608 \times [H_d \times (1 - 1/DF) + H_a \times (1/DF)]}$$

where:

Hd absolute humidity of the dilution air, g of water per kg of dry air

Ha absolute humidity of the intake air, g of water per kg of dry air

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

For the intake air (if different from the dilution air):

kw,a = 1 − kw2

The factor kw2 shall be calculated from the following equations:

$$k_{w2} = \frac{1{,}608 \times H_a}{1\,000 + (1{,}608 \times H_a)}$$

With Ha absolute humidity of the intake air, g of water per kg of dry air.

1.2.2 Humidity correction for Nox

As the Nox emissions depends on ambient air conditions, the Nox concentration shall be multiplied by the factor K_H taking into account humidity:

$$K_H = 0{,}6272 + 44{,}030 \times 10^{-3} \times H_a - 0{,}862 \times 10^{-3} \times H_a^2 \text{(for 4 stroke engines)}$$

KH = 1 (for 2 stroke engines)

with Ha absolute humidity of the intake air as g of water per kg of dry air.

1.2.3. Calculation of emission Mass flow Rate

The emission mass flow rates Gasmass [g/h] for each mode

shall be calculated as follows.

(a) For the raw exhaust gas [(1):]

$$Gas_{mass} = \frac{MW_{Gas}}{MW_{FUEL}} \times \frac{1}{\{(\%\ CO_2[wet] - \%\ CO_{2AIR}) + \%\ CO\ [wet] + \%\ HC\ [wet]\}} \times \%\ conc \times G_{FUEL} \times 1\,000$$

where:

GFUEL [kg/h] is the fuel mass flow rate;

MW Gas[kg/kmol] is the molecular weight of the individual gas shown in table 1;

Table 1 — Molecular weights

Gas	MW_{Gas} [kg/kmol]
NO_x	46,01
CO	28,01
HC	$MW_{HC} = MW_{FUEL}$
CO_2	44,01

— MWFUEL = 12,011 + α × 1,00794 + β × 15,9994 [kg/kmole] is the fuel molecular weight with α hydrogen to carbon ratio and β oxygen to carbon ratio of the fuel (2);

— CO2AIR is the CO2 concentration in the intake air (that is assumed equal to 0,04 % if not measured).

(b) For the diluted exhaust gas (1):

Gasmass = u × concc × GTOTW

where:

— GTOTW [kg/h] is the diluted exhaust gas mass flow rate on wet basis that, when using a full flow dilution system, shall be determined according to Annex III, Appendix 1, section 1.2.4,

— concc is the background corrected concentration:

concc = conc − concd × (1 − 1/DF)

with

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

The u coefficient is shown in table 2.

Table 2 — Values of u coefficient

Gas	u	conc
NO_x	0,001587	ppm
CO	0,000966	ppm
HC	0,000479	ppm
CO_2	15,19	%

Values of the u coefficient are based upon a molecular weight of the dilute exhaust gases equal to 29 [kg/kmol]; the value of u for HC is based upon an average carbon to hydrogen ratio of 1:1,85.

Note:

(1) In the case of NOx the concentration has to be multiplied by the humidity correction factor KH (humidity correction factor for NOx).

(2) In the ISO 8178-1 a more complete formula of the fuel molecular weight is quoted (formula 50 of Chapter 13.5.1(b)). The formula takes into account not only the hydrogen to carbon ratio and the oxygen to carbon ratio but also other possible fuel components such as sulphur and nitrogen. However, as the SI. engines of the chapter are tested with a petrol (quoted as a reference fuel) containing usually only carbon and hydrogen, the simplified formula is considered.

1.2.4. Calculation of specific Emissions

The specific emission (g/kWh) shall be calculated for all individual components:

$$\text{Individual Gas} = \frac{\sum_{i=1}^{n}(\text{Gas}_{\text{mass}_i} \times \text{WF}_i)}{\sum_{i=1}^{n}(\text{P}_i \times \text{WF}_i)}$$

where Pi = PM,i + PAE,i

When auxiliaries, such as cooling fan or blower, are fitted for the test, the power absorbed shall be added to the results except for engines where such auxiliaries are an integral part of the engine. The fan or blower power shall be determined at the speeds used for the tests either by calculation from standard characteristics or by practical tests.

2.0. EXAMPLES

2.1. Raw Exhaust Gas Data from a 4-stroke SI Engine

With reference to the experimental data (table 3), calculations are carried out first for mode 1 and then are extended to other test modes using the same procedure.

Mode		1	2	3	4	5	6	7	8
Engine Speed	min^{-1}	3600	3608	3597	3595	2401	2405	2402	1871
Power	Kw	8.1	6.0	4.1	0.8	7.0	5.3	3.5	0.0
Load	%	100	75	50	10	100	75	50	---
weighting Factor		0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15
Barometric Presure	Kpa	101	101	101	101	101	101	101	101
Air Temprature	° C	20.5	21.3	22.4	20.7	21.7	21.6	21.5	21.7
Air RelATIVE HUMIDITY	%	38	38	38	37	37	38	37	38
Air absolute Humidity	g / Kg	5.6	5.9	6.3	5.6	5.9	6.0	5.8	6.1
CO dry	ppm	60995	40725	34646	68207	96400	88400	82100	37439
Nox wet	ppm	726	1541	1328	127	169	169	134	85
HC wet	ppmc	1461	1308	1401	3024	3340	3450	3480	9390
Co2 dry	%	11.4098	12.691	13.058	10.822	8.9	9.4	9.8	9.516
Fuel Mass flow	Kg / hr	2.985	2.047	1.654	1.056	2.78	2.02	1.55	0.429
Fuel H / C ratio α		1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Fuel O / C ratio β		0	0	0	0	0	0	0	0

2.1.1. *Dry/wet Correction factor kw*

The dry/wet correction factor kw shall be calculated for converting dry CO and CO2 measurements on a wet basis:

$$k_w = k_{w,r} = \frac{1}{1 + \alpha \times 0{,}005 \times (\%\ CO\ [dry] + \%\ CO_2[dry]) - 0{,}01 \times \%\ H_2[dry] + k_{w2}}$$

Where

$$H_2[dry] = \frac{0{,}5 \times \alpha \times \%\ CO\ [dry] \times (\%\ CO\ [dry] + \%\ CO_2[dry])}{\%\ CO\ [dry] + (3 \times \%\ CO_2[dry])}$$

and

$$k_{w2} = \frac{1,608 \times H_a}{1\,000 + (1{,}608 \times H_a)}$$

Table – 4 CO and CO_2 wet values according to different test modes

Mode		1	2	3	4	5	6	7	8
H_2 Dry	%	0.048	0.038	0.026	0.016	0.041	0.028	0.020	0.058
K_{w2}	-	0.009	0.009	0.010	0.009	0.009	0.010	0.009	0.010
K_w	-	0.896	0.906	0.903	0.907	0.915	0.911	0.909	0.909
CO wet	ppm	0.139	0.112	0.075	0.047	0.120	0.083	0.060	0.168
CO_2 Wet	%	10.23	9.15	9.40	9.16	8.15	8.57	8.91	8.81

2.1.2. HC Emissions

$$HC_{mass} = \frac{MW_{HC}}{MW_{FUEL}} \times \frac{1}{\{(\%\ CO_2[wet] - \%\ CO_{2AIR}) + \%\ CO\ [wet] + \%\ HC\ [wet]\}} \times \%\ conc \times G_{FUEL} \times 1\,000$$

where

MWHC = MWFUEL

MWFUEL = 12,011 + α 1,00794 = 13,876

Table 5 HC emission (g/hr) according ti different test modes.

Mode	1	2	3	4	5	6	7	8
HC_{mass}	41.639	28.623	24.209	33.722	108.467	77.817	58.165	40.770

2.1.3. Nox emission

At first the humidity correction factor K_H of NOx emissions

shall be calculated:

$$K_H = 0{,}6272 + 44{,}030 \times 10^{-3} \times H_a - 0{,}862 \times 10^{-3} \times H_a^2$$

Table 6 Humidity correction factor K_H

Mode	1	2	3	4	5	6	7	8
K_H	0.848	0.858	0.872	0.845	0.858	0.862	0.855	0.863

$$NO_{xmass} = \frac{MW_{NO_x}}{MW_{FUEL}} \times \frac{1}{\{(\%\ CO_2[wet] - \%\ CO_{2AIR}) + \%\ CO\ [wet] + \%\ HC\ [wet]\}} \times \%\ conc \times K_H \times G_{FUEL} \times 1\,000$$

Table 7- Nox Emissions (g/h) according to the different test modes

Mode	1	2	3	4	5	6	7	8
Nox_{mass}	58.195	95.938	66.347	3.970	15.606	10.892	6.350	1.056

2.1.4. CO Emission

$$CO_{mass} = \frac{MW_{CO}}{MW_{FUEL}} \times \frac{1}{\{(\%\ CO_2[wet] - \%\ CO_{2AIR}) + \%\ CO\ [wet] + \%\ HC\ [wet]\}} \times \%\ conc \times G_{FUEL} \times 1\,000$$

Table 8- CO Emissions (g/h) according to the different test modes

Mode	1	2	3	4	5	6	7	8
CO_{mass}	79.840	49.432	26.315	10.637	78.903	37.683	20.084	14.694

2.1.5 CO_2 Emissions

$$CO_{2mass} = \frac{MW_{CO_2}}{MW_{FUEL}} \times \frac{1}{\{(\%\ CO_2[wet] - \%\ CO_{2AIR}) + \%\ CO\ [wet] + \%\ HC\ [wet]\}} \times \%\ conc \times G_{FUEL} \times 1\,000$$

Table 9 CO_2 Emissions (g/h) according to the different test modes

Mode	1	2	3	4	5	6	7	8
CO_{2mass}	41.639	28.623	24.209	33.722	108.467	77.817	58.165	40.770

2.1.6 Specific Emissions

The specific emission (g/kWh) shall be calculated for all

Individual components:

$$\text{Individual gas} = \frac{\sum_{i=1}^{n}(Gas_{mass_i} \times WF_i)}{\sum_{i=1}^{n}(P_i \times WF_i)}$$

Table 10- Emissions (g/h) and weighting Factors according to the test modes

Mode	1	2	3	4	5	6	7	8
HC_{mass}	41.639	28.623	24.209	33.722	108.467	77.817	58.165	40.770
Nox_{mass}	58.195	95.938	66.347	3.970	15.606	10.892	6.350	1.056
CO_{mass}	79.840	49.432	26.315	10.637	78.903	37.683	20.084	14.694
CO_{2mass}	9246.3	6351.9	5149.8	3239.8	8390.6	6129.5	4721.4	1213.8
Power	8.07	6.05	4.07	0.79	6.96	5.26	3.47	0.00
weighting factors WF1	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

$$HC = \frac{41.639x0.15 + 28.623x0.15 + 24.209x0.15 + 33.722 \cdot 0.1 + 108.467x0.1 + 77.817x0.1 + 58.165x0.1 + 40.770x0.15}{8.07 \cdot 0.15 + 6.05x.15 + 4.07x.15 + 0.79x0.1 + 6.96x0.1 + 5.26x0.1 + 3.47x0.1 + 0.00x0.15}$$

= 11.0 g/ kwhr

$$Nox = \frac{58.195x0.15 + 95.938x0.15 + 66.347x0.15 + 3.970x0.1 + 15.606x0.1 + 10.892x0.1 + 6.350x0.1 + 1.056x0.15}{8.07 \cdot 0.15 + 6.05x.15 + 4.07x.15 + 0.79x0.1 + 6.96x0.1 + 5.26x0.1 + 3.47x0.1 + 0.00x0.15}$$

= 8.4 g / Kwhr

$$CO = \frac{79.480x0.15 + 49.432x0.15 + 26.315x0.15 + 10.637x0.1 + 78.903x0.1 + 37.683x0.1 + 20.084x0.1 + 14.694x0.15}{8.07 \cdot 0.15 + 6.05x.15 + 4.07x.15 + 0.79x0.1 + 6.96x0.1 + 5.26x0.1 + 3.47x0.1 + 0.00x0.15}$$

= 9.2 g / kwhr

$$CO_2 = \frac{9246.3x0.15 + 6351.9x0.15 + 5149.8x0.15 + 3239.8x0.1 + 8390.6x0.1 + 6129.5x0.1 + 4721.4x0.1 + 1213.8x0.15}{8.07 \cdot 0.15 + 6.05x.15 + 4.07x.15 + 0.79x0.1 + 6.96x0.1 + 5.26x0.1 + 3.47x0.1 + 0.00x0.15}$$

= 1266.5 g /kwhr

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